SRIRAM'S IAS

GENERAL STUDIES

FUNDAMENTAL OF COMPUTERS

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Computer basics

Bits and Bytes

If you have used a computer for more than five minutes, then you have heard the words **bits** and **bytes**. Both RAM and hard disk capacities are measured in bytes, as are file sizes when you examine them in a file viewer.

You might hear an advertisement that says, "This computer has a **32-bit** Pentium processor with 64 **megabytes** of RAM and 2.1 **gigabytes** of hard disk space." And many HowStuffWorks articles talk about bytes (for example, How CDs Work). In this article, we will discuss bits and bytes so that you have a complete understanding.

Computers happen to operate using the base-2 number system, also known as the **binary number system** (just like the base-10 number system is known as the decimal number system). Find out why and how that works in the next section.

The Base-2 System and the 8-bit Byte

The reason computers use the base-2 system is because it makes it a lot easier to implement them with current electronic technology. You could wire up and build computers that operate in base-10, but they would be fiendishly expensive right now. On the other hand, base-2 computers are relatively cheap.

So computers use binary numbers, and therefore use **binary digits** in place of decimal digits. The word **bit** is a shortening of the words "Binary digIT." Whereas decimal digits have 10 possible values ranging from 0 to 9, bits have only two possible values: 0 and 1. Therefore, a binary number is composed of only 0s and 1s, like this: 1011. How do you figure out what the value of the binary number 1011 is? You do it in the same way we did it above for 6357, but you use a base of 2 instead of a base of 10. So:

(1 * 2^3) + (0 * 2^2) + (1 * 2^1) + (1 * 2^0) = 8 + 0 + 2 + 1 = 11

You can see that in binary numbers, each bit holds the value of increasing powers of 2. That makes counting in binary pretty easy. Starting at zero and going through 20, counting in decimal and binary looks like this:

0 = 0
1 = 1
2 = 10
3 = 11
4 = 100
5 = 101
6 = 110

7 = 111
8 = 1000
9 = 1001
10 = 1010
11 = 1011
12 = 1100
13 = 1101
14 = 1110
15 = 1111
16 = 10000
17 = 10001
18 = 10010
19 = 10011
20 = 10100

When you look at this sequence, 0 and 1 are the same for decimal and binary number systems. At the number 2, you see carrying first take place in the binary system. If a bit is 1, and you add 1 to it, the bit becomes 0 and the next bit becomes 1. In the transition from 15 to 16 this effect rolls over through 4 bits, turning 1111 into 10000.

Bits are rarely seen alone in computers. They are almost always bundled together into 8-bit collections, and these collections are called **bytes**. Why are there 8 bits in a byte? A similar question is, "Why are there 12 eggs in a dozen?" The 8-bit byte is something that people settled on through trial and error over the past 50 years.

With 8 bits in a byte, you can represent 256 values ranging from 0 to 255, as shown here:

0 = 00000000
1 = 00000001
2 = 00000010
...
254 = 11111110
255 = 11111111

The Standard ASCII (American Standard Code for Information Interchange) Character Set

Bytes are frequently used to hold individual characters in a text document. In the **ASCII character set**, each binary value between 0 and 127 is given a specific character. Most computers extend the ASCII character set to use the full range of 256 characters available in a byte. The upper 128 characters handle special things like accented characters from common foreign languages.

You can see the 127 standard ASCII codes below. Computers store text documents, both on disk and in memory, using these codes.

Byte Prefixes and Binary Math

When you start talking about lots of bytes, you get into **prefixes** like kilo, mega and giga, as in kilobyte, megabyte and gigabyte (also shortened to K, M and G, as in Kbytes, Mbytes and Gbytes or KB, MB and GB). The following table shows the **binary** multipliers:

Name	**Abbr.**	**Size**
Kilo	K	2^10 = 1,024
Mega	M	2^20 = 1,048,576
Giga	G	2^30 = 1,073,741,824
Tera	T	2^40 = 1,099,511,627,776
Peta	P	2^50 = 1,125,899,906,842,624
Exa	E	2^60 = 1,152,921,504,606,846,976
Zetta	Z	2^70 = 1,180,591,620,717,411,303,424
Yotta	Y	2^80 = 1,208,925,819,614,629,174,706,176

History of computers

Nearly 5,000 years ago the abacus emerged in Asia Minor. The abacus may be considered the first computer. This device allowed its users to make computations using a system of sliding beads arranged on a rack. Early shopkeepers used the abacus to keep up with transactions. The use of pencil and paper spread, the abacus lost its importance. Nearly twelve centuries past before the next important advance in computing devices emerged.

In 1642, Blaise Pascal, the 18-year-old son of a French tax collector, invented what he called a numerical wheel calculator to help his father with his duties. The Pascaline, a brass rectangular box, used eight movable dials to add sums up to eight figures long. Pascal's device used a base of ten to achieve this. The disadvantage to the Pascaline, of course, was its limitation to addition. In 1694, Gottfried Wilhem von Leibniza a German mathematician and philosopher improved the Pascaline by creating a machine that could also multiply. Like its predecessor, Leibniz's mechanical multiplier worked by a system of gears and dials.

It wasn't until 1820, however, that mechanical calculators gained widespread use. A Frenchman, Charles Xavier Thomas de Colmar, invented a machine that could perform the four basic mathematic functions. The arithometer, presented a more systematic approach to computing because it could add, subtract, multiply and divide. With its enhanced versatility, the arithometer was widely used up until World War I.

The real beginnings of computers began with an English mathematics professor, Charles Babbage. Babbage's steam-powered Engine, outlined the basic elements of a modern general purpose computer and was a breakthrough concept. The Analytical Engine consisted of over 50,000 components. The basic design of included input devices in the form of perforated cards containing operating instructions and a "store" for memory of 1,000 numbers of up to 50 decimal digits long.

In 1889, an American inventor, Herman Hollerith, created a machine that used cards to store data information which was fed into a machine and compiled the results mechanically. Each punch on a card represented one number, and combinations of two punches represented one letter. As many as 80 variables could be stored on a single card. Hollerith brought his punch card reader into the business world, founding Tabulating Machine Company in 1896, later to become International Business Machines (IBM) in 1924 after a series of mergers. Other companies also manufactured punch readers for business use. Both business and government used punch cards for data processing until the 1960's.

When World War II began, the governments sought to develop computers to accomplishment their potential strategic importance. This increased funding for computer development projects and hastened technical progress. In 1941, a German engineer Konrad Zuse had developed a computer to design airplanes and missiles. The Allied forces, however, made greater strides in developing powerful computers. American efforts produced a broader achievement. In 1933, Howard H. Aiken, a Harvard engineer working with IBM, succeeded in producing an all-electronic calculator. The purpose of the computer was to create ballistic charts for the U.S. Navy. It was about half as long as a football field and contained about 500 miles of wiring. It used electromagnetic signals to move mechanical parts. The machine was slow taking 3-5 seconds per calculation and inflexible in that sequences of calculations could not change; but it could perform basic arithmetic as well as more complex equations.

Another computer development spurred by the war was the Electronic Numerical Integrator and Computer (ENIAC). It consisted of 18,000 vacuum tubes, 70,000 resistors and 5 million soldered joints, the computer was such a massive piece of machinery that it consumed 160 kilowatts of electrical power. ENIAC was developed by John Presper Eckert and John W. Mauchl. ENIAC was a general-purpose computer.

In 1945, Von Neumann designed the Electronic Discrete Variable Automatic Computer (EDVAC) with a memory to hold both a stored program as well as data. This "stored memory" technique as well as the "conditional control transfer," that allowed the computer to be stopped at any point and then resumed, allowed for greater versatility in computer programming. The key element to the von Neumann architecture was the central processing unit, which allowed all computer functions to be coordinated through a single source. In 1951, the UNIVAC I (Universal Automatic Computer), built by Remington Rand, became one of the first commercially available computers to take advantage of these advances. The first computers were characterized by the fact that operating instructions were made-to-order for the specific task for which the computer was to be used. Each computer had a different binary-coded program called a machine language that told it how to operate. This made the computer difficult to program and limited its versatility and speed. Other unique features of first computers were the use of vacuum tubes and magnetic drums for data storage.

The invention of the transistor greatly changed the computer's development in 1948. The transistor replaced the large, cumbersome vacuum tubes. The transistor was at work in the computer by 1956. Throughout the early 1960's, there were a number of commercially successful computers used in business, universities, and government from companies such as Burroughs, Honeywell, IBM, and others. These computers also contained transistors in place of vacuum tubes. They also contained all the components we associate with the modern day computer: printers, disk storage, memory, tape storage, operating systems, and stored programs.

By 1965, most large business routinely processed financial information using computers. It was the stored program and programming language that gave computers the flexibility to finally be cost effective and productive for business use. Though transistors were clearly an improvement over the vacuum tube, they still generated a great deal of heat, which damaged the computer's sensitive internal parts. Jack Kilby, an engineer with Texas Instruments, developed the integrated circuit in 1958. The IC combined three electronic components onto a small silicon disc, which was made from quartz. Scientists later managed to fit even more components on a single chip, called a semiconductor.

By the 1980's, very large scale integration squeezed hundreds of thousands of components onto a chip. Ultra-large scale integration increased that number into the millions. The ability to fit so much onto an area about half the size of a dime helped diminish the size and price of computers. It also increased their power, efficiency and reliability. By the mid-1970's, computer manufacturers sought to bring computers to general consumers. These minicomputers came complete with user-friendly software packages that offered even non-technical users an arrangement of applications, most popularly word processing and spreadsheet programs..

In 1981, IBM introduced its personal computer (PC) for use in the home, office and schools. The 1980's saw an expansion in computer use in all three arenas as clones of the IBM PC made the personal computer even more affordable. The number of personal computers in use more than doubled from 2 million in 1981 to 5.5 million in 1982. Ten years later, 65 million PCs were being used. As computers became more widespread in the workplace, new ways to harness their potential developed. As smaller computers became more powerful, they could be linked together, or networked, to share memory space, software, information and communicate with each other. Computers continue to grow smaller and more powerful.

Categories of Computers

- Personal computers

Personal computers are desktop computers designed for an individual's use. They run programs designed to help individuals accomplish their work more productively.

- Servers

Servers are not designed to be used directly. They make programs and data available for people hooked up to a computer network, a collection of computers connected together so that they can exchange data.

- Minicomputers

Minicomputers are multi-user systems that can handle the computing needs of a smaller corporation or organization. Many people use them simultaneously by means of remote terminals or personal computers.

- Personal computers

Mainframes are huge, multi-user systems designed to handle gigantic processing jobs in large corporations or government agencies.

Supercomputers

Supercomputers are ultra fast computers designed to process hugh amounts of scientific data then display the underlying patterns that have been discovered.

Input Devices

An input device lets you communicate with a computer. You can use input devices to enter information and issue commands. A keyboard, mouse, scanner, digital camera, touch pads and joystick are examples of input devices.

Some Common Computer Input Devices:

Keyboard

- Used to type data into the computer
- Most common input device today
- Has special keys for giving the computer commands
  - Commands tell the computer to do something, like save the file
  - These special keys are called command or function keys

Pointing Devices

- Pointing devices move some object on the screen and can do some action
- Common pointing devices
  - **Mouse - most common pointing device**
  - Track ball - basically an upside down mouse
  - Joystick
  - Game controller

Scanner

A scanner allows you to scan documents, pictures, or graphics and view them on the computer. You can also use software to edit the items you scan.

- Used to put printed pictures and text into a computer
- Converts an image into dots that the computer can understand
- To scan text, optical character recognition (OCR) software is needed

Digital Camera

- Used to take electronic pictures of an object
- The pictures taken by a digital camera can be used directly by a computer

Microphone

- Used to put sound into a computer
- Need sound recording software

CD-ROM/DVD-ROM

- Can be used to put both sound and images into a computer
- Use a laser to read a Compact Disk (CD) or a DVD disk

Video Capture Card

- Usually place inside the computer's case
- Use to put video into a computer
- Need a video source, either a video camera or video recorder

Output Devices

An output device displays information on a screen, creates printed copies or generates sound. A monitor, printer, and speakers are examples of output devices.

Some Common Output Devices:

Monitors and Displays

- Shows the processed information on a screen
  - A monitor uses a Picture Tube like a television with the image displayed on the front of the tube, which is called the screen.
  - Displays are flat and use plasma, LCD, active-matrix, or some other technology.
- Monitors used to be called Cathode Ray Tubes (CRTs) because of the picture tube, which is a large vacuum tube.
- A monitor or display produce a soft copy. When the device is turned off the information goes away.
- Monitors are slowly being replaced by flat panel displays.

Printers

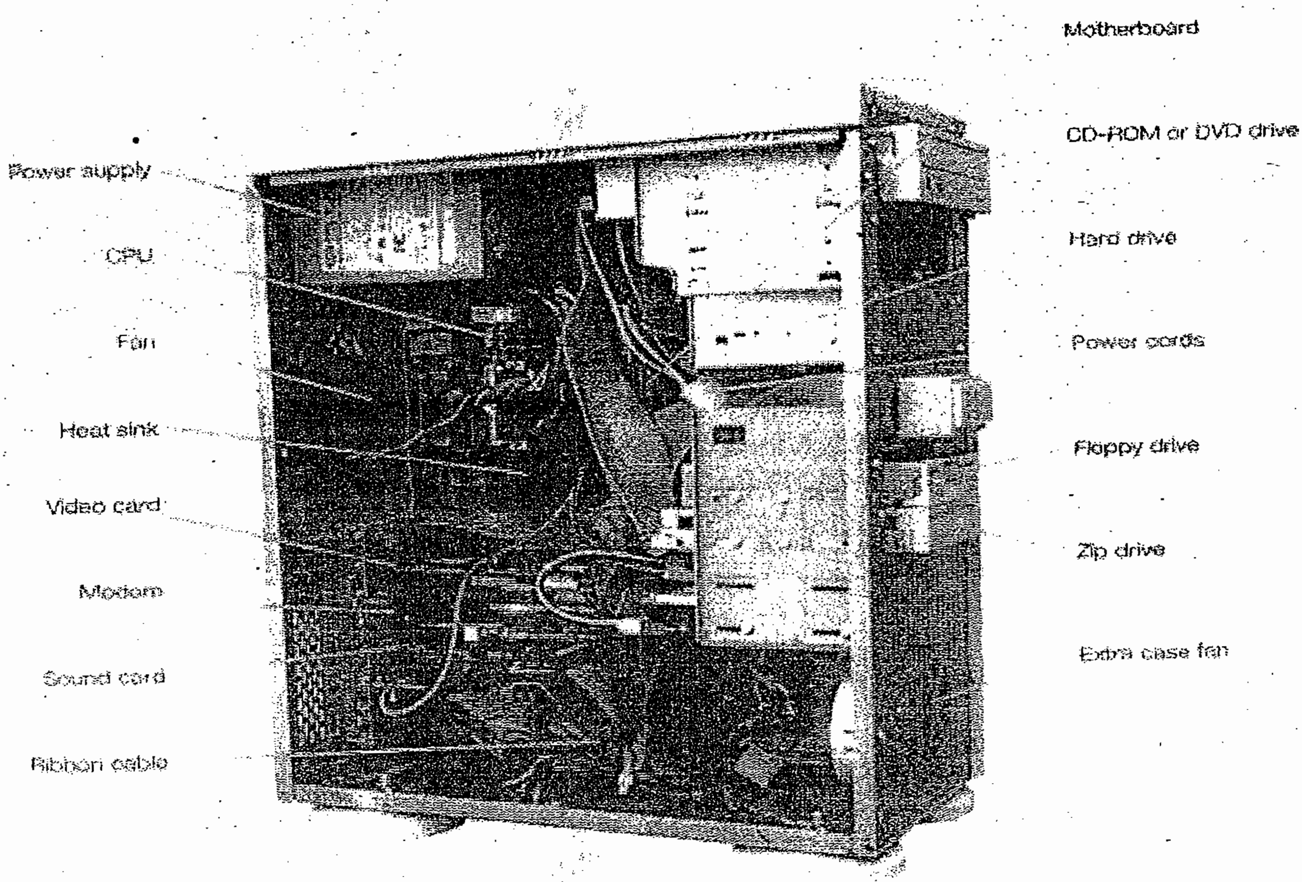
- Printers produce a hard copy
- The information is printed on paper and can be used when the device is off.
- It is also called a printout
- Dot-matrix printers (impact printer)
    - Uses metal pins to strike an inked ribbon to make dots on a piece of paper.
    - Can see the dots that make up the letters or images.
    - Lowest print quality of all of the printers.
    - Very low in cost per page to use.
    - Rarely used today because of the poor print quality, but still used in business to print multi-part forms.
- Ink jet printers (non-impact printer)
    - Use drops of magnetic ink to produce dots on a page to produce text or images.
    - The print quality is almost the same as a laser printer's.
    - Problems with the ink
        - The ink is very expensive
        - The ink is water soluble and will run if the paper gets wet
    - Highest cost per page of all the printers
    - For producing color documents, it has the highest quality at a reasonable price.
- Laser printers (non-impact printer)
    - How the laser printer produces an image
        - A laser or LEDs make dots on a light sensitive drum
        - Toner (very tiny particles of plastic) stick to the drum where the dots where made
        - Paper is pressed against the drum and the toner is placed on the paper
        - The paper is heated and the toner melts into the paper
    - Produces the highest quality printout
    - For black and white printouts, very low cost per page
    - Printout is permanent
    - Color laser printers are still fairly expensive ($3,000 to $10,000)

Speakers

- used to output sound

System Unit

A computer system unit contains many parts.



Motherboard - The motherboard is the main circuit board of a microcomputer. It is also known as the mainboard or system board.

CPU - The CPU is the central electronic chip that determines the processing power of the computer.

Memory - Memory is the part of the computer that temporarily stores applications, documents, and stem operating information.

Bus - A bus is an electronic line that allows 1s and 0s to move from one place to another.

Expansion Slots - Expansions slots appear on the motherboard. They are sockets into which adapters are connected.

Ports and Connectors - A port is a connector located on the motherboard or on a separate adapter.

Bays - A bay is a space inside the computer case where a hard drive, floppy drive or CD-ROM drive sits

Power Supply - A power supply changes normal household electricity into electricity that a computer can use.

Sound Components - A sound card lets a computer play and record high quality sound.

Central Processing Unit (CPU)

Does all of the work for the computer

1. Does all of the mathematics, mainly addition
2. Does all the logical comparisons of values
3. Directs the flow of data in a computer
4. Controls the operation of the parts of the computer

Today, all CPUs are microprocessors

5. A microprocessor is a complete computer on a silicon chip
6. A microprocessor does all of the functions of a computer
   - stores data and instructions waiting to be used
   - follows changeable instructions
   - does input, processing, and output

CPUs have three basic parts

7. The Arithmetic Logic Unit (ALU)
   - does all of the mathematics in a computer
   - does all of the logic comparisons of values
   - some common logic comparison symbols
     - = equal to

- < less than
- > greater than
- <= less than or equal to
- >= greater than or equal to
- <> not equal

8. The Control Unit
    - directs the flow of information into the CPU and/or memory or storage
    - controls which instructions the CPU will do next

9. Registers
    - Used to store data and instructions inside the processor
    - Size of the registers can affect the speed and performance of the processor

Speed of CPUs

10. The speed of CPUs is measured in hertzs.
    - A hertz is on cycle per second.
    - Need to measure time to determine cycles per second
        - All computers have a clock built into them for timing the cycles
        - The clock is usually located in a small metal box on the motherboard.
    - Today, many CPUs can complete over six (6) instructions per second.

11. Speeds of modern CPUs
    - Most computers have a CPU that can do more than 400 MHz.
        - MHz stands for megahertzs
        - A MHz is 1,000,000 cycles per second.
    - Computers will soon be at speeds of over a gigahertz, 1,000,000,000 Hertzs.

Memory

Primary memory can be used directly by the CPU

1. Consists of silicon chips, usually either VLS or VLSI technology is used to create the chips
2. Two forms of Primary Memory
    - Read Only Memory (ROM)

- Random Access Memory (RAM)

3. Primary memory is also called primary storage

Read Only Memory (ROM) Stores instructions that are used by the CPU

- Tells the CPU how to be the kind of computer it is, for example a Windows, Macintosh, or Play Station computers.
- Tells the CPU how to work with the different parts of the computer
- ROM can also hold programs that are directly accessed by the CPU. One such program is the self-test when the computer is first turned on. The self-test tests to seem if all the parts on the main circuit board (mother board) are working correctly.

2. The instructions in ROM can not usually be changed
   - The instructions are built into the electronic circuits of the chips
   - These instructions in ROM are called **firmware**
   - To change the instructions in ROM you need to usually change the chips or do some other special process that is normally not available to an average user.
3. The instructions in ROM are nonvolatile. They stay in ROM even when the computer is turned off.
4. Access to information is random access.
   - Random access means that any piece of information in ROM can be accessed at any given time without access other information first. It is a lot like the tracks on a music CD. You can access any track at any time and in any order.
   - The other kind of access is sequential access. You must access the information in the order that they are located. This is a lot like a music tape. You must play the songs in order, or you have to fast forward past songs to get to the one you want.

Random Access Memory (RAM)

1. Store data and instructions that are used by the CPU to perform some task.
   - These instructions are usually loaded into RAM from a secondary storage device.
   - RAM is also used to store instructions that tell the CPU how to work with its parts. These instructions are usually called drivers.
2. The instructions in RAM are constantly changing, depending on the needs of the CPU.
3. The instructions in RAM are volatile.
   - When the computer is turned off the information in RAM disappears.

- The information in RAM needs to be saved to secondary storage before the computer is turned off.

4. Access to information is random access.

Storage Devices

How a computer stores information

1. The computer stores information as a string of zeros (0) and ones (1)
   - The standard string length is eight 0's or 1's in a row
   - This standard length is called a byte
   - A byte equals one character
     - A character is a letter, number, or symbol - it is about any thing that can be typed on a keyboard
     - There are 256 standard characters used by almost all computers

2. Information size measurements
   - Kilobyte (KB)
     - One kilobyte equals about 1024 bytes
     - 1KB is about 140 words, about a half page of typed double-spaced text (words only)
   - Megabyte (MB)
     - One megabyte equals about 1000 KB
     - One megabyte equals about 1,000,000 bytes
     - One megabyte equals about 500 pages of text, or one large book
   - Gigabyte (GB)
     - One gigabyte equals about 1000 MB
     - One gigabyte equals about 1,000,000 KB
     - One gigabyte equals about 1,000,000,000 bytes
     - One gigabyte equals over 1,000 books of text

Some Common Storage Devices

Hard Drive

The hard drive is the primary device that a computer uses to store information. The hard drive stores programs, data files, saves files, and organizes files. The hard drive is located inside the computer case. The hard drive, magnetically stores data on stacks of rotating disks called platters.

Floppy Drive

The floppy drive stores and retrieves information on a floppy disk.

CD -ROM Drive

CD-ROM is a device that reads information stored on a compact disc. CD-ROM stands for Compact Disc Read Only Memory. One CD is equal to the space in over 40 floppy disc.

Removable Hard Disk

A zip disk is a removable disk that holds a large amount of information. A zip disk can be used to achieve, protect and transfer large amounts of data.

Communications Devices

Specific equipment and programs are needed to connect to the Internet or to communicate with other computers. You can use any type of computer such as IBM compatible or Macintosh to connect to the Internet or communicate with other computers. You need special programs to use the Internet. Most companies that connect you to the Internet provide the programs you need free of charge. You also need a modem to connect to the Internet. A modem translates computer information into a form that can be transmitted over telephone lines. Modems can be used to connect you to the Internet, exchange information, and to send and receive faxes.

Peripheral Devices

A peripheral devices is any piece of hardware attached to a computer. A few examples of peripheral devices are printers, scanners, and digital cameras.

Software

Software – General Information

Computer software provides instruction that tell the computer how to operate.

1. Software are also called programs.
2. Programs are usually created using other software called programming languages.

There are two (2) main types of software

1. System Software
   - Used by the computer to accomplish a task.
   - What system software does:
     - controls the internal function of the computer
     - controls other devices connected to the CPU

2. Application Software
   - Used by people to accomplish a specific task.
   - Some common kinds of application software
     - Word Processor software
     - Database software
     - Spreadsheet software
     - Games
     - Web Page Browsers

Kinds of Software

1. Public Domain Software
   - Has no copyright - no one owns the right to control who can make copies of the software.
   - Free to use or make copies of.
   - Can be copied, used in other programs, or changed by anyone.

2. Freeware
    - Has a copyright - someone owns the right to determine who can make copies of the software.
    - Free to use and make copies of.
    - Can only give away exact copies of the software.
    - Can not be changed or used in another program without the copyright holder's permission.

3. Shareware
    - Has a copyright.
    - Allowed to use the software before paying for it.
        - Can be a demo - which limits some major features like the Save command.
        - Can set an amount of time you can use the software.
        - Can trust that you will pay for it if you like the software.
    - Can only give away exact copies of the software.
    - Can not be changed or used in another program without the copyright holder's permission.

4. Commercial Software
    - Has the most resistive copyright.
    - Have to buy the software before you can use it.
    - Can usually make one copy of the software as a backup copy.
        - A backup copy is used in case something goes wrong with the original software.
        - Can not give away or sell the backup copy.
    - Can not copy, look at the program's code, change, or use the software in another program without the copyright holder's permission.
    - Commercial Software is the best software in the world.

How Software is Inputted Into Computer

1. Built into the computer's circuits, the ROM chips.
2. Loaded into the computer from a secondary storage device, like a floppy disk or hard disk drive.
3. Typed in from the keyboard.
    - Usually need to use a programming language to create the software.
    - Rarely done by most computer users today.

System Software

System software is a type of program that acts like a conductor in an orchestra. It directs all the activities and sets all the rules for how the hardware and software work together. MS DOS and Microsoft Windows are examples of system software or operating system software.

Some System Software is built into the computer.

1. ROM chips and BIOS.
2. Helps to setup the computer and start it.

Operating Systems

1. The operating system is usually located on a disk.
    - Can be on either the hard disk drive, a floppy disk, or CD-ROM disk.
    - Must be loaded into RAM before it can be used.

2. Used by the computer's hardware to work with its parts.
    - Tells the computer how to:
        - display information on the screen.
        - use a printer.
        - store information on a secondary storage device.
    - The system software that controls peripherals are called drivers.

3. An operating system works with application software.
    - Does basic tasks, like printing a document or saving a file
    - The operating system starts (launches) the application software so that it can be used.

User Interfaces

1. The user interface is how the computer's operating system presents information to the user and the user gives instructions (commands) to the computer.

2. There are two kinds of User Interfaces
    - Text Interface

- Presents information to the user in the form of text.
- Have to type in commands or select commands from a menu displayed as text on the screen.
- Hard to use or learn, because the user must memorize and type in commands.
- Examples:
    - MS-Dos (MicroSoft Disk Operating System)
    - ProDos (Professional Disk Operating System)
- Many of the Text Interfaces had shells placed over them.
    - A shell was more of a Graphic User Interface.
    - Made using the Text Interface easier to use.

o Graphic User Interface (GUI)
- Presents information to the use in the form of pull-down menus and icons.
    - Pull-down menus the user clicks on to display the menu
    - Icons are small pictures that stand for something, like a file, volume, trash, or program
- The user gives commands to the computer by selecting items from a menu or by clicking on an icon when using a pointing device.
- GUIs are easy to learn and use
- Examples:
    - Windows 98
    - Windows 2000
    - MacOS

Application Software

Application software programs work with the operating system software to help you use your computer to do specific types of work such as word processing to type a letter.

1. Used by people to solve general problems
    - Can be used to do more than one thing - adapted to a wide variety of tasks
    - Some common tasks done by general purpose application software
        - Planning
        - Writing
        - Record keeping
        - Calculating

    - Communicating
    - Drawing
    - Painting
- What can be done with general purpose application software is only limited by the imagination of the user.

2. Examples of general purpose application software
    - Word Processing Software
    - Database Software
    - Spreadsheet Software
    - Desktop Publishing Software
    - Paint and Draw Software

Utilities

Utilities allow you to complete certain tasks on your computer. Examples of some of these tasks are file organizations.

- Specific purpose application software used to help a computer work better or to avoid problems.
- Some utility programs are built into the operating system
    - Scandisk in the Windows operating system
    - Disk formatting software
- Examples of utility programs
    - Anti-virus software
    - Disk maintenance software
- File management programs
- Security software

Viruses and Worms

In general terms a virus is a program that runs on a system against the owner's or user's wishes and knowledge. Viruses have one or more methods they use to spread. Most commonly they will attach a file to an e-mail message and attempt to trick victims into running the attachment.

Virus Damage

In most cases, viruses can do any amount of damage the creator intends them to do. They can send your data to a third party and then delete your data from your computer. They can also ruin your system and render it unusable without a re-installation of the operating system. Most have not done this much damage in the past, but could easily do this in the future. Usually the virus will install files on your system then will change your system so the virus is run every time you start your system. It will then attempt to replicate itself by sending itself to other potential victims.

The normal effect a virus will have on your system is that over time your system will run slower. Also when you are using the internet your connection may seem to run slower. Eventually you may have trouble running programs on your system, your system may freeze, and in the worst case you may not be able to get it to boot up when you turn your computer on.

Worms and Prevention

Since worms spread by taking advantage of vulnerabilities in operating systems or application programs (remember from earlier discussion, vulnerabilities are software errors that allow some kind of unauthorized access when they are used or exploited). You do not need to do anything special to get a worm except to connect to the internet or an infected network with a system that has vulnerabilities. There are several good defenses against worms.

What is a Firewall?

A firewall is a device that limits access to your system from the outside. A firewall may be a software program running on your computer or it may be a piece of hardware outside your computer. The firewall screens any attempts to access your system and only allows access that you decide to allow. In this way many vulnerabilities that could be used to gain unauthorized access to your system are eliminated.

Spam

Spam is unsolited junk e-mail sent to large numbers of e-mail addresses. It is used to promote some product or service and many spam e-mails are pornographic in nature.

Spam for Webmasters

If you are a webmaster, spammers will send spam to your domain by sending it to general possible accounts such as administration@yourdomain.com. One way to prevent this is to configure your account with your hosting provider not to respond to undeliverable emails and just automatically delete them. This is called a "::blackhole" setting. The only problem with this is that spammers will still use your bandwidth that you pay for to send you their junk, even though your server deletes them. As spam gets more excessive, it may increase bandwidth costs for webmasters thus discouraging some sites from operating.

Computer Terms Glossary

boot

Starting up an OS is booting it. If the computer is already running, it is more often called rebooting.

browser

A browser is a program used to browse the web. Some common browsers include Netscape, MSIE (Microsoft Internet Explorer), Safari, Lynx, Mosaic, Amaya, Arena, Chimera, Opera, Cyberdog, HotJava, etc.

bug

A bug is a mistake in the design of something, especially software. A really severe bug can cause something to crash.

database

A database is a collection of data, typically organized to make common retrievals easy and efficient. Some common database programs include Oracle, Sybase, Postgres, Informix, Filemaker, Adabas, etc.

desktop

A desktop system is a computer designed to sit in one position on a desk somewhere and not move around. Most general purpose computers are desktop systems. Calling a system a desktop implies nothing about its platform. The fastest desktop system at any given time is typically either an Alpha or PowerPC based system, but the SPARC and PA-RISC based systems are also often in the running. Industrial strength desktops are typically called workstations.

format

The manner in which data is stored; its organization.

graphics

Anything visually displayed on a computer that is not text.

hardware

The physical portion of the computer.

hypertext

A hypertext document is like a text document with the ability to contain pointers to other regions of (possibly other) hypertext documents.

Internet

The Internet is the world-wide network of computers. There is only one Internet, and thus it is typically capitalized (although it is sometimes referred to as "the 'net"). It is different from an intranet.

laptop

A laptop is any computer designed to do pretty much anything a desktop system can do but run for a short time (usually two to five hours) on batteries. They are designed to be carried around but are not particularly convenient to carry around. They are significantly more expensive than desktop systems and have far worse battery life than PDAs. Calling a system a laptop implies nothing about its platform. By far the fastest laptops are the PowerPC based Macintoshes.

modem

A modem allows two computers to communicate over ordinary phone lines. It derives its name from **mod**ulate / **dem**odulate, the process by which it converts digital computer data back and forth for use with an analog phone line.

multimedia

This originally indicated a capability to work with and integrate various types of things including audio, still graphics, and especially video. Now it is more of a marketing term and has little real meaning. Historically the Amiga was the first multimedia machine. Today in addition to AmigaOS, IRIX and Solaris are popular choices for high-end multimedia work.

OS

The operating system is the program that manages a computer's resources. Common OSes include Windows '95, MacOS, Linux, Solaris, AmigaOS, AIX, Windows NT, etc.

www

The World-Wide-Web refers more or less to all the publically accessable documents on the Internet. It is used quite loosely, and sometimes indicates only HTML files and sometimes FTP and Gopher files, too. It is also sometimes just referred to as "the web".

AI

Artificial intelligence is the concept of making computers do tasks once considered to require thinking. AI makes computers play chess, recognize handwriting and speech, helps suggest prescriptions to doctors for patients based on imput symptoms, and many other tasks, both mundane and not.

baud

A measure of communications speed, used typically for modems indicating how many bits per second can be transmitted.

bcode

Identical in intent to uucode, bcode is slightly more efficient and more portable across different computer types. It is the preferred method used by MIME.

blog

Short for web log, a blog (or weblog, or less commonly, 'blog) is a web site containing periodic (usually frequent) posts. Blogs are usually syndicated via either some type of RSS or Atom and often supports TrackBacks. It is not uncommon for blogs to function much like newspaper columns. A blogger is someone who writes for and maintains a blog.

C

C is one of the most popular computer languages in the world, and quite possibly *the* most popular. It is a compiled langauge widely supported on many platforms. It tends to be more portable than FORTRAN but less portable than Java

COBOL

The Common Business Oriented Language is a language developed back in 1959 and still used by some businesses. While it is relatively portable, it is still disliked by many professional programmers simply because COBOL programs tend to be physically longer than equivalent programs written in almost any other language in common use.

compression

It is often possible to remove redundant information or capitalize on patterns in data to make a file smaller. Usually when a file has been compressed, it cannot be used until it is uncompressed. Image files are common exceptions, though, as many popular image file formats have compression built-in.

cookie

A cookie is a small file that a web page on another machine writes to your personal machine's disk to store various bits of information.

crash

If a bug in a program is severe enough, it can cause that program to crash, or to become inoperable without being restarted. On machines that are not multitasking, the entire machine will crash and have to be rebooted. On machines that are only partially multitasking the entire machine will sometimes crash and have to be rebooted. On machines that are fully multitasking, the machine should never crash and require a reboot.

Cray

A Cray is a high-end computer used for research and frequently heavy-duty graphics applications. Modern Crays typically have Solaris for their OS and sport sixty-four RISC processors; older ones had various other configurations. Current top-of-the-line Crays can have over 2000 processors.

crippleware

Crippleware is a variant of shareware that will either self-destruct after its trial period or has built-in limitations to its functionality that get removed after its purchase.

DNS

Domain name service is the means by which a name (like www.saugus.net or ftp.saugus.net) gets converted into a real Internet address that points to a particular machine.

download

To download a file is to copy it from a remote computer to your own. The opposite is upload.

driver

A driver is a piece of software that works with the OS to control a particular piece of hardware, like a printer or a scanner or a mouse or whatever.

EDBIC

The EDBIC character set is similar to (but less popular than) the ASCII character set in concept, but is significantly different in layout. It tends to be found only on old machines..

emacs

Emacs is both one of the most powerful and one of the most popular text editing programs in existence.

endian

A processor will be either "big endian" or "little endian" based upon the manner in which it encodes multiple byte values. There is no difference in performance between the two encoding methods, but it is one of the sources of difficulty when reading binary data on different platforms.

extension

Filename extensions originate back in the days of CP/M and basically allow a very rough grouping of different file types by putting a tag at the end of the name. To further complicate matters, the tag is sometimes separated by the name proper by a period "." and sometimes by a tab. While extensions are semi-enforced on CP/M, MS-DOS, and MS-Windows, they have no real meaning aside from convention on other platforms and are only optional.

FireWire

An incredibly fast type of serial port that offers many of the best features of SCSI at a lower price. Faster than most types of parallel port, a single FireWire port is capable of chaining many devices without the need of a terminator. FireWire is similar in many respects to USB but is significantly faster and somewhat more expensive. It is heavily used for connecting audio/video devices to computers, but is also used for connecting storage devices like drives and other assorted devices like printers and scanners.

flash

Flash memory is similar to RAM. It has one significant advantage: it does not lose its contents when power is lost; it has two main disadvantages: it is slower, and it eventually wears out. Flash memory is frequently found in PCMCIA cards.

FTP

The file transfer protocol is one of the most commonly used methods of copying files across the Internet. transfers are capable of transferring both kinds of data without corruption.

gateway

A gateway connects otherwise separate computer networks.

HTML

The Hypertext Mark-up Language is the language currently most frequently used to express web pages (although it is rapidly being replaced by XHTML). Every browser has the built-in ability to understand HTML. Some browsers can additionally understand Java and browse FTP areas. HTML is a proper subset of SGML.

http

The hypertext transfer protocol is the native protocol of browsers and is most typically used to transfer HTML formatted files. The secure version is called "https".

icon

A small graphical display representing an object, action, or modifier of some sort.

infrared communications

A device with an infrared port can communicate with other devices at a distance by beaming infrared light signals. Two incompatible protocols are used for infrared communications: IrDA and ASK. Many devices support both.

Instant Messenger

AOL's Instant Messenger is is a means of chatting over the Internet in real-time. It allows both open group discussions and private conversations. Instant Messenger uses a different, proprietary protocol from the more standard IRC, and is not supported on as many platforms.

intranet

An intranet is a private network. There are many intranets scattered all over the world. Some are connected to the Internet via gateways.

IP

IP is the family of protocols that makes up the Internet. The two most common flavors are TCP/IP and UDP/IP.

IRC

Internet relay chat is a means of chatting over the Internet in real-time. It allows both open group discussions and private conversations. IRC programs are provided by many different companies and will work on many different platforms. AOL's Instant Messenger utilizes a separate incompatible protocol but is otherwise very similar.

IRI

An Internationalized Resource Identifier is just a URI with i18n.

ISDN

An integrated service digital network line can be simply looked at as a digital phone line. ISDN connections to the Internet can be four times faster than the fastest regular phone connection, and because it is a digital connection a modem is not needed. Any computer hooked up to ISDN will typically require other special equipment in lieu of the modem, however. Also, both phone companies and ISPs charge more for ISDN connections than regular modem connections.

ISP

An Internet service provider is a company that provides Internet support for other entities. AOL (America Online) is a well-known ISP.

jiffy

A jiffy is 1/60 of a second. Jiffies are to seconds as seconds are to minutes.

joystick

A joystick is a physical device typically used to control objects on a computer screen. It is frequently used for games and sometimes used in place of a mouse.

load

There are two popular meanings for load. The first means to fetch some data or a program from a disk and store it in memory. The second indicates the amount of work a component (especially a processor) is being made to do.

mainframe

A mainframe is any computer larger than a small piece of furniture. A modern mainframe is more powerful than a modern workstation, but more expensive and more difficult to maintain.

multitasking

Some OSes have built into them the ability to do several things at once. This is called multitasking, and has been in use since the late sixties / early seventies. Since this ability is built into the software, the overall system will be slower running two things at once than it will be running just one thing. A system may have more than one processor built into it though, and such a system will be capable of running multiple things at once with less of a performance hit.

nagware

Nagware is a variant of shareware that will frequently remind its users to register.

nybble

A nybble is half a byte, or four bits. It is a case of computer whimsy; it only stands to reason that a small byte should be called a nybble. Some authors spell it with an "i" instead of the "y", but the "y" is the original form.

office suite

An office suite is a collection of programs including at minimum a word processor, spreadsheet, drawing program, and minimal database program. Some common office suites include MS-Office, AppleWorks, ClarisWorks, GeoWorks, Applixware, Corel Office, and StarOffice.

open source

Open source software goes one step beyond freeware. Not only does it provide the software for free, it provides the original source code used to create the software. Thus, curious users can poke around with it to see how it works, and advanced users can modify it to make it work better for them. By its nature, open souce software is pretty well immune to all types of computer virus.

PCMCIA

The Personal Computer Memory Card International Association is a standards body that concern themselves with PC Card technology. Often the PC Cards themselves are referred to as "PCMCIA cards". Frequently flash memory can be found in PC card form.

Perl

Perl is an interpreted language extremely popular for web applications.

ping

Ping is a protocol designed to check across a network to see if a particular computer is "alive" or not. Computers that recognize the ping will report back their status. Computers that are down will not report back anything at all.

pixel

The smallest distinct point on a computer display is called a pixel.

plug-in

A plug-in is a piece of software designed not to run on its own but rather work in cooperation with a separate application to increase that application's abilities.

Python

Python is an interpreted, object-oriented language popular for Internet applications. It is extremely portable with free versions existing for virtually every platform.

queue

A queue is a waiting list of things to be processed. Many computers provide printing queues, for example. If something is being printed and the user requests that another item be printed, the second item will sit in the printer queue until the first item finishes printing at which point it will be removed from the queue and get printed itself.

real-time

Something that happens in real-time will keep up with the events around it and never give any sort of "please wait" message.

robot

A robot (or 'bot for short) in the computer sense is a program designed to automate some task, often just sending messages or collecting information. A spider is a type of robot designed to traverse the web performing some task (usually collecting data).

SQL

SQL (pronounced **Sequel**) is an interpreted language specially designed for database access. It is supported by virtually every major modern database system.

TCP/IP

TCP/IP is a protocol for computer networks. The Internet is largely built on top of TCP/IP (it is the more reliable of the two primary Internet Protocols -- TCP stands for Transmission Control Protocol).

terminator

A terminator is a dedicated device used to mark the end of a device chain (as is most typically found with SCSI devices). If such a chain is not properly terminated, weird results can occur.

TrackBack

TrackBacks essentially provide a means whereby different web sites can post messages to one another not just to inform each other about citations, but also to alert one another of related resources. Typically, a blog may display quotations from another blog through the use of TrackBacks.

Unicode

The Unicode character set is a superset of the ASCII character set with provisions made for handling international symbols and characters from other languages. Unicode is sixteen bit, so takes up roughly twice the space as simple ASCII, but is correspondingly more flexible.

upload

To upload a file is to copy it from your computer to a remote computer. The opposite is download.

UPS

An uninterrupted power supply uses heavy duty batteries to help smooth out its input power source.

URI

A Uniform Resource Identifier is basically just a unique address for almost any type of resource. It is similar to but more general than a URL; in fact, it may also be a URN.

URL

A Uniform Resource Locator is basically just an address for a file that can be given to a browser. It starts with a protocol type (such as http, ftp, or gopher) and is followed by a colon, machine name, and file name in UNIX style. Optionally an octothorpe character "#" and and arguments will follow the file name; this can be used to further define position within a page and perform a few other tricks. Similar to but less general than a URI.

URN

A Uniform Resource Name is basically just a unique address for almost any type of resource unlike a URL it will probably not resolve with a browser.

USB

A really fast type of serial port that offers many of the best features of SCSI without the price. Faster than many types of parallel port, a single USB port is capable of chaining many devices without the need of a terminator. USB is much slower (but somewhat less expensive) than FireWire.

uucode

The point of uucode is to allow 8-bit binary data to be transferred through the more common 7-bit ASCII channels (most especially e-mail). The facilities for dealing with uucoded files exist for many different machine types, and the most common programs are called "uuencode" for encoding the original binary file into a 7-bit file and "uudecode" for restoring the original binary file from the encoded one. Sometimes different uuencode and uudecode programs will work in subtly different manners causing annoying compatibility problems. Bcode was invented to provide the same service as uucode but to maintain a tighter standard.

virtual memory

This is a scheme by which disk space is made to substitute for the more expensive RAM space. Using it will often enable a comptuer to do things it could not do without it, but it will also often result in an overall slowing down of the system. The concept of swap space is very similar.

virtual reality

Virtual reality (often called VR for short) is generally speaking an attempt to provide more natural, human interfaces to software. It can be as simple as a pseudo 3D interface or as elaborate as an isolated room in which the computer can control the user's senses of vision, hearing, and even smell and touch.

VoIP

VoIP means "Voice over IP" and it is quite simply a way of utilizing the Internet (or even in some cases intranets) for telephone conversations. The primary motivations for doing so are cost and convenience as VoIP is significantly less expensive than typical telephone long distance packages, plus one high speed Internet connection can serve for multiple phone lines.

W3C

The World Wide Web Consortium (usually abbreviated W3C) is a non-profit, advisory body that makes suggestions on the future direction of the World Wide Web, HTML, CSS, and browsers.

WebTV

A WebTV box hooks up to an ordinary television set and displays web pages. It will not display them as well as a dedicated computer.

Windows Vista

Windows Vista is the newest flavor of MS-Windows (specifically the planned replacement for Windows XP). Windows Vista (originally known as Longhorn) currently only runs on x86 processors.

WYSIWYG

What you see is what you get; an adjective applied to a program that attempts to exactly represent printed output on the screen. Related to WYSIWYM but quite different.

WYSIWYM

What you see is what you mean; an adjective applied to a program that does not attempt to exactly represent printed output on the screen, but rather defines how things are used and so will adapt to different paper sizes, etc. Related to WYSIWYG but quite different.

X-Face

X-Faces are small monochrome images embedded in headers for both provides a e-mail and news messages. Better mail and news applications will display them (sometimes automatically, sometimes only per request).

Y2K

The general class of problems resulting from the wrapping of computers' internal date timers is given this label in honor of the most obvious occurrence -- when the year changes from 1999 to 2000 (abbreviated in some programs as 99 to 00 indicating a backwards time movement). Contrary to popular belief, these problems will not all manifest themselves on the first day of 2000, but will in fact happen over a range of dates extending out beyond 2075. A computer that does not have problems prior to the beginning of 2001 is considered "Y2K compliant", and a computer that does not have problems within the next ten years or so is considered for all practical purposes to be "Y2K clean

zip

There are three common zips in the computer world that are completely different from one another. One is a type of removable removable disk slightly larger (physically) and vastly larger (capacity) than a floppy. The second is a group of programs used for running interactive fiction. The third is a group of programs used for compression.

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CONTENTS

ANCIENT INDIAN HISTORY

1. Indus Valley Civilization

Earliest Civilizations of the World

- ★ Around 3500 B.C. the first cities developed in Mesopotamia - Located in the river valley of the Tigris and the Euphrates.
- ★ Followed by Egyptian Civilization in the Nile River Valley beginning around 3400 B.C.
- ★ The Indus Valley Civilization (app. 2500 - 1500 B.C)
- ★ The Chinese Civilization in the Huang Ho or Yellow River Valley, beginning around 15.83 B.C.

Chronology of the Indus Valley Civilization :

Different Opinions

i. Marshall - 3250 to 2750 B.C.

ii. Mockay - 2800 to 2500 B.C.

iii. M.S. Vats - 3500 to 2500 B.C.

iv. C.J. Gadds - 2350 to 1770 B.C.

v. Stuart Piggott and S.M. Wheeler - 2500 - 1500 B.C.

★ **Extent - 1.3m Sq.kms :** The Civilization extended from Sutkagendor on the Makran Coast in the West to Alamgirpur (UP) in the Upper Ganga - Yamuna Doab in the east & Manda in Jammu & Kashmir in the North to Daimabad (Maharashtra) in the South. It was the largest among the ancient civilization.

★ Major Cities		Rivers Associated
Mohenjodaro	-	Sindhu/Indus
Harappa	-	Ravi
Chanhudaro	-	Indus
Kalibangan	-	Ghaggar
Lothal	-	Bhogaro
Banawali	-	Sarasvati

Major Cities & their Special Features

i. **Harappa (Montgomary dt. in Punjab - Pakistan) :** The first Indus site to be discovered & excavated in 1921, which provided conclusive evidence with trial digging by Daya Ram Sahni (1921).

- First recorded by C. Masson in 1826.
- Sir Alexander Cunningham (1853 & 1856)
- M.L. Dames (1886)
- M.S. Vats (1921 to 1934)

Important Finds :

- ★ Six Granaries located outside the citadel & near the river.
- ★ Working Platforms made of bricks.
- ★ Workmen's quarters.
- ★ Stone Sculptures like Male torso of red sand stone; Male dancing figure of grey stone.

ii. **Mohenjodaro (Larkhana dt of Sind - Pakistan) :**

- ★ Literally 'the mound of the dead'
- ★ Largest of all Indus cities.
- ★ Excavated by R.D. Banerjee (1922).
  - Sir John Marshall (1922-1930)
  - E.J.H. Mackay (1927-1931)
  - S.M. Wheeler (1930-1947)

Important Finds :

- ★ Great Bath in the centre of the citadel.
- ★ Great Granary - Largest building.
- ★ Multipillared Assembly Hall.
- ★ Representations of ships, boats, pasupati, Mother Goddess & other animals on seals.
- ★ Fragments of woven cloth.
- ★ Evidence of horse from superficial levels.

Coastal Towns & Ports

i. **Sutkagendor :**

- ★ On the banks of River Dasht near Kabul.
- ★ discovered by Sir Auriel Stein in 1931.
- ★ Belived to be a military post or a transit port to send consignments in various directions.

ii. **Allahdino :**

- ★ Near the confluence of the Indus & the Arabian Sea in Pakistan (Karachi)
- ★ Excavated by W.A. Fairservice.
- ★ Belonged to the Mature Harappan Phase.
- ★ Was a 'Distribution Centre'.

iii. **Lothal :** Dholka taluka of Gujarat, near the Gulf of Cambay, on a level plain between the Bhogara & Sabarmati rivers.

- ★ Excavated by S.R. Rao in 1954-62.
- ★ It was the only site of Indus civilization with an artificial brick dockyard.
- ★ Was better planned than Mohenjodaro in street - living.
- ★ Was surrounded by a massive brick wall, probably as flood protection.

Important Finds :

- ★ Has the evidence for earliest cultivation of rice - 1800 B.C.
- ★ A Doubtful terracotta figurine of horse.
- ★ Impressions of cloth on some sealings.

Other Cities

i. **Dholavira :**

- In the Kutch district of Gujarat.
- Latest site to be discovered.
- Dholarira & Rakhigarhi (Haryana) are the largest settlements of the civilization.
- First explored by Dr. J.P. Joshi and in 1990-91. R.S. Bisht of the ASI excavated it.
- Most unique feature of the city is its division into three parts & not the usual two parts. (Citadel, Middle Town & Lower town).

Important Finds :

- Giant reservoirs holding 2.5 lakh cubic mts.
- Presence of number of water of ethnic groups, each with distinctive customs, indicating a thriving trading community.

ii. Kalibangan :

- Literally means 'black bangles'.
- Located in Rajasthan

Important Finds :

- Series of brick platforms, perhaps used for sacrifices & also fire altars.
- Evidence for the presence of Early & Mature Harappan phases.
- Provides the evidence of the earliest earthquake (2600 B.C).

iii. Banawali :

- On the ancient bed of Saraswati river in Haryana.
- Excavated by R.S. Bisht.

Important Finds :

- Evidences of Pre-Harappan, Harappan & post - Harappan cultures.
- Clay model of a plough.
- Unique feature - In defence work, which is unseen in any other Indus site. A deep & wide moat was made outside the town-wall.

General Characteristics

Town Planning :

It was planned on the lines of the 'grid system'; i.e. streets & lanes cutting across one another almost at right angles. The main roads ran North to South & the by lanes ran West to East, intersecting the main streets.

- The city was divided into two main parts- the 'Citadel' & the 'Lower Town'.
- Excellent Sanitation & Drainage system.
- Total absence of stone buildings & use of only standardized burnt bricks.

Weights :

Smaller weights were calculated in the series of 1,2,4,8 to 64 to 160.

Larger Weights through decimal multiples of 16, 320,640, 1600.... 8000.

Measures :

Length was based on unit of foot of 37.6 cms & a unit of cubit at 51.8 to 53.8 cms.

Religion :

Chief Male deity was Pasupati Mahadeva (Proto - Siva), who is represented on seals surrounded by four animals - elephant, tiger, rhino & buffalo, each facing a different direction.

- Chief Female deity was Mother Goddess represented in terracotta figurines.
- 'Lingam' & 'Yoni' workship was prevalent.
- Worship of Peepal Tree, Snakes, Humped and Humpless bull, 'Ekasringa' or Unicorn, etc.

Script & Language :

- Still undeciphered
- Pictographic in script.
- Harappan Script has 400 to 600 signs of which about 40 to 60 are basic ones.

Decline of the Civilization

The two major cities of the civilization (Harappa & Mahenjodaro) were completely abandoned by 1700 B.C.

Causes as putforth by various scholars :

- Mortimer Wheeler - Aryan invasion.
- E.J.H. Mackay, Lambrick & Sir John Marshal - Floods in R. Indus.
- B.K. Thapar - Environmental & Climatic factors
- Rafique Mughal - Drying up of River Ghanggar-Hakra system.
- W.A. Fairservice & Kenneth Kennedy - deforestation & soil salinity.
- Robert Sharer - Shifts in ancient trade routes.

Economic Conditions :

Largely Agrarian economy.

- Trade & Commerce also major source of income.
- Foreign trade contacts with Afghanistan, Persia, Arabia, Baluchistan, mostly with Mesopotamia & Sumeria (Iraq) & Bahrain.

- The administration & governance of the territories became more complex & various officials came into being.
  ex : Bhagadugha - Collector of taxes.
  Sangrahitri - Treasurer
  Suta - Court Minstreer/ Chronicler
  Sthapati - Provincial administrator
  Adhikrta - Village Officer.
- The king's political functionaries began to be called 'Ratnins' & there was a ceremony earmarked for them called 'Ratnahavimsi'

Society :

Rig Vedic Age :

- The four-fold varna system was absent.
- The Aryans initially distinguished themselves from the indigenous groups by giving them the name 'Dasa' and later 'Dasyus,' based on their physical appearance.
- Three-fold social differentiation-Brahmana, Kshatriya & Vish, without a rigid stratification.
  Ex : A verse in the Rig Veda runs - "I am a poet, my father is a Physician my mother is a grinder of corn".
- No system of 'Sati' or widow burning.
- Polygamy was allowed but monogamy was preferred.

Later Vedic Age :

- Four-fold division of society with Brahmanas at the top.
- Upper three classes were called "Dvija" or Twice born, who alone were entitled to 'Upanayana' ceremony & hence education.
- Gotra became a system of clan exogamy.
- Earliest reference to four ashramas - Brahma, Charya, Grihasta, Vanaprasta & Sanyasa.
- Diet censisted of Rice (Vrihi), Sesamum (tila), millet (Syamaka), Mustard (Sarshapa) etc - While earlier it was 'Yava' (Barley) alone.
- Anuloma & Pratilona marriages were witnessed.

Religion :

- **Rig Vedic Age :** People were mostly 'theists' who had more of a spiritual rather than a Scientific outlook.
- Primitive animism was followed, which is worship of natural forces like wind, rain, etc.
- Various deities in the order of importance given.
- Indra (War), Agni (Fire), Varuna (Water), Yama (Death), Rudra (Healing Herbs), Pushan (Jungle), Surya, Savitri (Solar deity), Aditi (Eternity), Prithvi, Vishnu, Maruts (Storms) & Demi gods like Gandharvas (Musicians), Apsaras, Vishwadevas (Intermediate Gods) etc.
- These gods were classified into three orders
  a. 'Prithvisthana' - Terrestrial - ex : Agni, Soma, etc.
  b. 'Antarakshasthana' - Aerial - ex: Indira, Rudra, Vishnu etc.
  c. 'Dyusthana' - Celestial - ex : Surya, Varuna, Mitra etc.
- The centre of Vedic religious ideas was sacrifice. ex: Griha Karmani ceremonies, Soma sacrifices, etc.

Later Vedic Age :

- With a pantheon of 33 dieties. The sacrifices became more important & elaborate.
- 'Prajapati' became supreme as 'the Creator'.
- Upanishads were compiled, which is the first reaction to Brahmanical dominance, in the land of Panchala & Videha
- Believed in theory of Karma, Gotra & Pravara.
- Important Deities - Vishnu (the preserver & protector).
- Rudra (God of animals)
- Pushan for the Shudras (God of Cattle).
- Age of 'Upanayana' was fixed at
  8 years for Brahmins.
  11 years for Kshatriya
  12 years for Vaishyas
- Rushis to whom Gotras are traced back- Kashyapa, Vashishtha, Bhrigu, Gautama, Bharadwaj, Attri, Visvamitra and Agastya.

Economic Conditions :

Rig Vedic Age :

- Mainly Pastoral.
- Cattle was the Chief measure of wealth & 'Gomat' was the title given to a wealthy man.
- Terms used for conflicts & battles - 'Gavishthi', 'Gavesana' & 'Gavyat' - which imply the importance attached to cattle.
- Did not use iron technology, but were familiar with copper.
- Several stages of agricultural operations, implements used (like Plough- 'Sira') & artificial waterways were mentioned.
- Craft specialists like 'Charmakara' (leather worker). 'Kulala' (Potters), etc.
- Trade & Commerce was carried on barter system & no large scale overseas trade flourished.

Later Vedic Age :

- Agriculture became the main occupation.
- Iron plough, manure, individual properties, came into usage.
- Large scale specialisation took place. Ex: Chariot makers, makers of bows & arrows embroiderers, basket - makers, etc.
- Increased trade & commerce led to organisation of merchants into Corporations (Gana) or Guilds (Shresthins, or the Vaishyas carried on the trade.
- Tin, Lead, Silver, Iron, gold, Coppers & bronze used.
- Niska, Satamana, Krsnala were used as units of value but were not coins.
- Four types of Pottery in use.
  - Black of Red Ware
  - Black Slipped Ware
  - Painted Grey Ware
  - Red Ware.

3. Heterodox Movements

During the 6th C.B.C, Indian religious history witnessed protests against the dominance of priestly class, against the ritualistic form of religion, the inhumane system of caste, etc by heterodox sects like Buddhist, Jain, Ajivika, Charvaka, etc. Among these it was Buddhism & Jainism that had the most profound & long-lasting impact.

Buddhism

★ Buddhism has its foundation on three pillars -
  - i. Gouthama Buddha - founder
  - ii. Dhamma - Principle
  - iii. Sangha - Order of Buddhist monks & nuns

★ Siddhartha or the Gautama, also 'Tathagata' & 'Sakyamuni' was born in 563 A.D. in Lumbini, near Kaprilavastu, the capital of Sakyan Republic, to Suddhodana & Maya.

★ Was brought up by his stepmother Gautami.

★ Married to Yashodhara & had a son, Rahula.

★ Left home (Mahabhinishkrama) at 29 accompanied by Channa (Charioteer), his favourite horse (Karsthaka), after being disturbed by the sight of an old man, a sick man, a dead body & an ascetic.

★ As a wandering ascetic, meditated with two Brahmin religious teachers - Alarakalama & Udraka Ramputra. And then with ascetics like kondana, Vappa, Mahanama, etc.

★ At 35, or Vaisakha Purnima day, he attained Enlightenment & came to be called as 'Buddha' (The Enlightened One).

★ Gave his first sermon at Isipatana (Sarnath) in a Deer Park & hence began his religious discourses ('Dharmachakrapravartana) which continued for the next 45 years.

★ He died at 80 in 483 B.C. at Kushinagara (modern Kasia in U.P) in the Malla Republic, thus attaining 'Parinirvana'.

Five Great Symbols attached to Buddha's Life

Birth	- Lotus
Great Renunciation	- Horse
Nirvana	- Bodhi Tree
First Session	- Wheel
Death	- Stupa

Buddha's Philosophy

Four Noble Truths :

i. The World is full of Sorrows.

ii. The cause of sorrow is desire

iii. If desires are conquered, all sorrows can be removed.

iv. The only way desires can be conquered is by following the Eight Fold Path.

Eight Fold Path - (Ariya - Atthangikamarga) :

i. Right Understanding

ii. Right Thoughts

iii. Right Speech

iv. Right Action

v. Right Livelihood

vi. Right Effort

vii. Right Mindfulness

viii. Right Concentration

★ Buddhist Sangha consists of 'Bhikkhus' (Monks) & 'Upasakas' (Lay Worshipers)

★ Bhikkhu would act as a friend, philosopher & guide to the common man in religious & social matters.

★ Membership of the sangha is open all except lepers, debtors, etc.,

After the death of Buddha, his teachings were sought to be compiled by followers & thus 4 Buddhist Councils.

The four Buddhist Councils

Number	Year	Place	Ruler	Outcome
1.	483 B.C	Rajagriha	Ajatashatru	Sutta & Vinaya Pitakas were compiled by Ananda & Upali respectively.
2.	383 B.C	Vaishali	Kalashoka	Division of Buddhist Sangha into orthodox 'Sthaviravadins' & unorthodox 'Mahasanghikas'
3.	250 B.C	Pataliputra	Ashoka	'Tripritakas' final compilation - Sutta, Vinaya & Abhidamma; sending missionaries abroad.
4.	Ist Cent A.D	Kashmir	Kanishka	Division of Buddhism into Mahayana & Hinayana Buddhism & their spread to countries like China, Burma, Thailand etc.

Buddhist Literature

i. **Vinaya Pitaka :** Rules of Monastic discipline for Bhikkus.

ii. **Sutta Pitaka :** discourses delivered by Buddha

iii. **Abhidamma Pitaka :** Philosophical sayings of the Buddha & their interpretations.

iv. **'Suttanipata' :** Socio-religious conditions in Buddhist India.

v. **'Jataka' :** Stories of Buddha's former lives.

vi. **'Theragatha' & 'Therigatha'** - Songs of Elders. (Men & Women, resp).

Others :

Diparamasa' & 'Maharamsa' of Ceylon. 'Mahavastu' on Himayana Buddhism.

Jainism

A religion of great antiquity, it has 24 'Tirthankaras' (Prophets) in all, most well-known among them are Rishabha & Aristanemi (mentioned in the Rig Veda), Parsvanatha & Mahavira (23rd & 24th Tirthankaras)

★ Mahavira, was born Vardhamana (in Bihar's

Muzaffarpur district presently), at Kundagram near Vaishali in 540 B.C. in the Jnatrika Kshatriya Clan, to Siddhartha & Trisala a Lichhavi Princess.

★ Married to Yashoda & had a daughter, Anojja.

★ Became an ascetic at 30 after the death of his parents & attained perfect knowledge at 42 under a Sal tree at Jrimbhikagrama on the banks of River Rejupalika.

★ During these 12 years he was associated with Parsvanatha & Gusala Maskariputra (Founder of Ajivika Sect).

★ Became the head of a sect called 'Nirgranthas' (Free from Fetters), who were later called as 'Jinas'.

★ His first disciple was Jameli, husband of Anojja.

★ Attained 'Kaivalya' (death) at Pava, near Patna in 527 B.C. at 72.

Teachings of Jainism :

i. Five Cardinal Principles of Jainism.

Ahimsa - Non-Violence

Asteya - No Stealing

Aparigraha - No property

Satya - Truth

Brahmacharya - Celibacy - added by Mahavira.

ii. Ratnatraya (Three Jewels)

Full knowledge, Faith & Action.

Main Teachings of Mahavira :

i. He rejected the authority of the Vedas & its associated rituals & advocated an austere & simple life.

ii. Believed in dualistic philosophy & held that matter & soul are the only two ever existing elements.

iii. Did not believe in the existence of God & for him Universe was a product of nature - the outcome of cause & effect.

iv. Did not oppose Caste System & believed in 'Karma' & transmigration of soul ('atma')

v. 'Syavada' - truth can be approached from different 'view points & thus can be affirmed only with a degree of probability & is never final.

★ Mahavira himself established the Jaina Church & their monastic establishments are called 'Basadis'.

Jaina Scriptures :

The 14 'Purvas' the text books, were taught by Mahavira to his disciples, 'Ganadharas'.

★ Jaina 'Kalpasutra' of Bhadrabahu, the sixth 'Thera', gives the history of Jaina Church.

★ The 14 'Purvas' were perfected by Sambhutarijaya & Bhadrabahu. The former's disciple was Sthulabahu.

Schism in Jainism :

About 300 B.C, Stulabahu called the first Jain couincilin which Jain canons called 'Angas' were compiled. Bhadrabahu, who returned to Magadha from Karnataka where Chandragupta Maurya had performed 'Sallekana' (Starvation to death), did not acknowledge sthulabahu's leadership & the scriptures.

★ And thus the Jain Church was divided to 'Digambara' - led by Bhadrabahu remained naked & Svetambaras' - led by Sthulabahu adopted white garments.

Jaina Canonical Texts :

★ Mahavira taught in Ardha Magadhi & his teachings were classified into 12 books called 'Srutangas'

★ Svetambaras used Arsha form of Prakrit & their Literature is classified into -

12 Angas

12 Upangas

10 Prakirnas

6 Chedasutras

4 Mulasutras

Other Works -

★ 'Samyaktyakaumudi' ; 'Kathakosa'

★ 'Antasakatha - Samgraha by Rajasekhara.

★ 'Trisastisalaka Purushacharita' - by Hemachandra, a 'Mahakarya' in Jainism.

★ 'Prabhandachintamani' by Merutunga.

★ 'Prabhandakosa' by Rajashekara.

★ Dharmasarmabhyudaya' by Hari Chandra

Jaina Architecture :

★ Important sites - Mathura, Bundelkhand, Central & South India.

★ Gomatesvara at Sravanabelagola

★ Udaigiri Hills - Bhilsa, MP

★ Ellora - Maharashtra

★ Hathigumpha Caves - Orissa

★ Mount Abu - Rajasthan

Other Heterodox Sects

Ajivika Sect :

★ Founded by Makkhali Gosala.

★ Was popular between 5th & 3rd cent B.C.

★ He preached the doctrine of 'Niyati' (Pre-determination)

Lokyatism :

★ Founded by Charvaka.

★ Preached total materialism & did not believe in Gods.

★ Enjoyment is the sole goal of man's existence.

★ No heaven, no hell, no final Liberation or death is the Liberator.

Uchhedavada :

★ Materialistic Philosophy.

★ Propagated by Ajita Kesakamblin

Akriya :

★ 'Non-action' sect

★ Preached by Purana Kasyapa.

Asrasvatavada :

★ Preached by Pakuda Kachchayana.

4.MAHAJANAPADAS

- According to 'Anguttara Nikaya' there were 16 Mahajanapadas, among which were 16 Mahapadas :

1. Anga	2. Magadha	3. Kasi
4. Kosala	5. Vajji	6. Malla
7. Chedi	8. Vatsa	9. Kuru
10. Panchala	11. Matsya	12. Surasena
13. Assake	14. Aranti	15. Gandhara
16. Kamboja		

- Most important 'Janapadas' were Magadha, Kosala, Vatsa & Avanti.
- Haryanka dynasty was founded (Magadha) by Bimbisara with its capital at Rajgir (Girivraja)
- He was a contemporary of Buddha.
- Conquered Anga & entered into matrimonial alliance with kosala (sister of Prasenajit), Vijjis & Madra clan.
- Magadha's rival was Avanti, with its capital at Ujjain & ruled by Chandra Pradyota Mahasena.
- Ultimately the two became friends & Bimbisara sent his royal physician, Jivaka to Ujjain.
- Ajatashatru succeeded, by killing his father, Bimbisara.
- Udayin succeded Ajatashatru & founded the city of Pataliputra (Patna) on the confluence of the Ganga & Son.

Shishunaga dynasty :

- founded by Shishunaga, a viceroy of Banaras in 413 B.C.
- Capital at Vaishali.
- Finally made Avanti a part of Magadha.

Magadha :

- Nanda dynasty - whom Chandragupta defeated to found the Mauryan Empire.

5. MAURYAN EMPIRE (321 - 185 B.C)

Origim of the Mauryas -

- Puranas describe them as 'Shudras'.
- Junagarh Rock Inscription of Rudradaman (150 A.D) suggests a Vaishya origin.
- Buddhist works 'Divyaradana' & 'Vamsatha- pakasini' link them with Sakya Kshatriya clan to which Buddha belonged.
- Belonged to the 'Moriya' tribe, which has been suggested be Peacock-tamers by Jaina tradition.

Chandra Gupta Maurya (321-297 B.C) :

Refereed to as 'Kulahina' by 'Mudrarakshasa' of Visakhadatta, Chandra Gupta Maurya rose to become the founder of the first empire of Indian History, the Mauryan Empire, at 25 years of age.

- Finding signs of royalty in him, Chanakya or Vishnu Gupta or Kautilya, brought him up got him educated at Taxila.
- Established the dynasty at Pataliputra in 321 B.C, by defeating Dhana Nanda of the Nanda Dynasty & by 312 B.C. occupied the entire region north of Narmada River.
- Fought Seleukos Nicator in 305 B.C, who was Alexander's General in central Asiatic provinces & thus gained Paropanisadai (Kabul), Aria (Herat), Arachosia (Gandhara) & Gedrosia (Baluchistan) & received Megasthenes as Seleukos' ambassador to the Mauryan Court.
- According to Jaina tradition, Chandragupta adopted Jainism, abdicated the throne in favour of his son, Bindusara & breathed his last at Sravanbelagola.

Bindusara (297 - 272 B.C) :

- Known to Greeks as 'Amitrochates' derived from the Sanskrit word, 'Amitraghata' or Slayer of foes.
- The extended the empire to the land between the two seas, Arabian & Bay of Bengal.
- According to Strabo, Bindusara's Court received Daimiehcus, who was an ambassador of Antiochus I, the king of Syria.
- Asoka was appointed as the Viceroy of Ujjain after being Viceroy of Taxila.

Foreign Authors :

i. Nearchus - Alexander's Navy.
   - Wrote on India.

ii. Daimachus - Antiochu I

iii. Arvian - 'Invasion of Alexander'

iv. Strabo - Greek

v. Diodorus - Greek (earliest account)

vi. Pliny, the Elder - 'Natural History'

vii. Justin - 'Epritome'

viii. Dyonissius - Ambassador of Ptolemy Philadelptius, king of Egypt.

Asoka (268 - 232 B.C) :

- It was only in 1837 when James C. Princep deciphered a 'Brahmi' inscription that Asoka came to light & became most popular ruler of Ancient Indian history.
- 1915 - Maski edict was discovered which makes mention of Asoka Piyadassi.
- According to Buddhist sources, Asoka was the son of Subhadrangi & his most well-known queens are Devi, Karuvaki & Asandhimitra. His only son mentioned in the inscriptions was Tivara.
- 'Divyavadana' & Maharamsa' & 'Diparamsa' mention the killing of his 99 brothers for accession

to the throne. But according to other scholars like Taranatha, he killed only one of them.

★ 260 B.C. - fought the kalinga war, after which he renounced warfare.

★ 21st year of his reign - he visited Lumbini, the birth place of Buddha & fixed the land revenue at a cencessional 1/8th of the produce.

★ Started the institution of 'Dharma Mahamatras'.

★ Ashoka's Hellenistic contemporaries were
  - Antiochus II of Syria
  - Ptolemy II of Egypt
  - Antigonas of Macedonia
  - Magas of Macedonia
  - Alexander of Epirus

★ He organised the third Budhist Council in the 18th year of his (250 B.C) reign at Pataliputra under the presidentship of Mogaliputra Tissa.

★ Sent Buddhist missionaries all over South East Asia, including his son & daughter, Mahinda & Sangharakshita to Ceylon.

★ Was cenverted to Buddhism by Upagupta according to 'Divyaradana'.

Asoka's Edicts

Minor Rock Edicts :

i. Kandhar - in Greek & Aramaic
ii. Barabar - Cave inscription
iii. Queen's Edict - Mentions Tivara
iv. Bairat
v. Bhabru
vi. Lampaka
vii. Maski - 'Asoka Piyadassi'
viii. Sohgaura - Famine
ix. Mahasthan

Pillar Edicts :

i. Lauriya Araraj
ii. Lauriya Nandan Garh
iii. Rampurva
iv. Nigali Sagar
v. Sarnatha
vi. Topara
vii. Meerut

Major Rock Edicts :

I. Prohibition of animal sacrifice.
II. Medical treatment of humans & animals.
III. Liberality towards Brahmanas & Sramanas.
IV. Bheri Ghosha replaced by Dhamma Gosha.
V. Appointment of Dhamma Mahamatras
VI. Mantri Parishad.
VII. Religious tolerance among various sects.
VIII. Visit to Bodh Gaya.
IX. Uselessness of various ceremonies
X. Stress on morality & moral code.
XI. Policy of Dhamma
XII. Mentions Ithijika Mahamatra.
XIII. Kalinga War.
XIV. Purpose of the Rock Edicts.

Ashoka's Dhamma

Principles :

- Self Control
- Bhava Shuddhi - Piety of thought
- Gratefulness
- Strong Devotion
- Mercy
- Cleanliness
- Truth
- Sushruth (Sewa)
- Daan - Charity
- Sampratipathi - To help others
- Aprichitti - To respect others.

Later Mauryas

★ Puranas mention the 9 Mauryan rulers ruled for 139 years (324 - 185 B.C).

★ Rulers like Dasaratha, Sampati, Salisuka, Subhagasena & Brihadratha.

★ The Last ruler Brihadratha was overthrown by his Commander-in-Chief Pushyamitra Sunga.

Mauryan Administration

Central Administration

According to Kautilya's 'Arthashastra' the state consists at Seven Limbs/ or elements 'Saptanga' -

(i) King	(ii) Ministers
(iii) Territory & Population	(iv) Fort
(v) Treasury	(vi) Army
(vii) Artillery	

★ King was at the centre of affairs, assisted by Mantri-Parishad & Amatyas.

Provincial Administration :

The empire was divided into five provinces.

		Capital
Northern	- Uttaranchal	- Taxila
Western	- Avantipatha	- Ujjain
Eastern	- Prachyapatha	- Toshali

Southern - Dakshinapatha - Suvarnagiri
Central - Magadha - Pataliputra

★ Except for capital Pataliputra, the provinces were controlled by a Viceroy, either a Prince or member of the royal family.

★ Provinces were divided into districts & had three main officers -

Pradeshika - Overall administration
Rajuka - Revenue administration & later Judicial affairs in rural areas.
Yukta - Accountant/ Clerk

★ The intermediate level between district & village was a group of 5-10 villages, which were administered by Gopa & Sthanika.

★ Gramika, the village head, was elected by the people & settled disputes in open Panchayats.

★ The administration of the Capital city, Pataliputra was mentioned by Megasthenes. It was administered by 6 boards consisting of 5 members each. They looked after industrial arts, care of foreigners, registration of birth & death, regulation of weights & measurers, public sale of manufactured goods & collecting toll on the article sold - (1/10th of the purchase price)

★ Military administration was also on similar lines with 6 boards taking care of the army, cavalry, elephants, chariots, navy & the transport.

★ Esprionage System was well worked out. 'Samstha & 'Sanchari' were spices. 'Prativedakas' were special reporters of the king.

★ Judicial administration's fountain head was the king. There were Courts, called 'Dharmastheya' for civil matters & 'Kantakashodhana' for criminal matters.

Economy :

★ Land revenue was the main source of income, fixed at 1/4th of the produce. called 'Bhaga' an extra tax called 'Balu' was also collected.

Other taxes :

Pindakara - on groups of village
Kara - fruits & flower gardens
Hiranya - paid in cash.

★ Punch marked silver coins which carry the symbol of Peacock, Hill & Crescent were the imperial currency in usage.

Society :

★ According to Megasthenes Mauryan society was divided into 7 Castes (based on Profession) Philosophers, Farmers, Soldiers, Herdsmen, Artisans, Magistrates & Councillors

★ He believed that there was no slavery. But Indian sources do give evidence of it.

Art & Culture :

★ Stone culture was predominantly seen in Asokan edicts on pillars - mostly made of spotted red & white sandstone (Mathura) or buff coloured fine - grained hard sand stone (Chunar).

★ Pillar's parts - the Prop, Shaft & Capitol

★ Capital - carvings of the four lions at Sarnath & other smaller figures exhibit remarkable talent.

★ Stupas to enshrine the relics of the Buddha were constructed & Asoka is credited with 84,000 of them.

★ More important heritage of the Mauryas were the Caves - Barabar hills near Gaya, Nagarjuni hills in Bihar of Ajivikas.

★ Pottery was abundant - most popular was the Northern Black Polished ware (NBPW).

★ Terracotta objects were also very popular.

6. PRE - GUPTA PERIOD

INDO - GREEKS

★ Demetrius was the first foreign king after Alexander who carried Greek army into India. About 190 B.C. & conquered North Western part of the Mauryan expire.

★ Most famous among Indo-Greek rulers was Menander (165-145 B.C) who reached Pataliputra. His Capital was Sakala or Sialkot.

★ He was converted to Buddhism by Nagasena or Nagarjuna & their conversation was recorded in a book, 'Milindapanho', i.e., Questions of Mitinda.

★ Indo-Greeks are credited with the introductions of -

Gold Coins in India

★ Coins definitely attributed to the kings.

★ Practise of military governorship (Strategos)

★ The Greek Ambassador, Heliodorus set up a prillar in honour of Vishnu at Vidisha in Madhya Pradesh.

★ Heliocles was the last Greek King to rule over Bactria & India.

Sakas :

★ The first Saka King in India was Maures or Moga with Gandhara as his capital.

★ The second king, Azes successfully attracted the Greek king, Hipprostratos.

★ Most famous Saka king in Western India was Rudra Daman I (AD 130 - 152), whose Junagarh inscription (150 A.D) records his achievements. He repaired the Sudarshan Lake of Mauryan times in the Kathiawar area.

Parthians :

★ Gondophernes was the most famous rulers was victorious over Azes II of Sakas.

★ Legend is that St Thomas had visited Gondophernes during his apostolic career & then moved on to South India.

Kushanas :

- ★ The name originally meant a tribe or people or family of the Yuch-Chis or Tocharians.
- ★ Kujula Kadphises was the founder & he minted copper coins with Roman influence.
- ★ Vima Kadphises (65-78 A.D) started the practise of issuing coins by Indian rulers regularly & his coins contained Siva with his long trident & the monarch himself on the other side.
- ★ Succeeded by Kanishka (78-144 A.D), from when the Saka era begins (AD 78). Peshawar was his first Capital & Mathura, the second.
- ★ He Patronised Nagarjuna, exponent of Mahayana doctrine.

  Asvaghosha, poet, musician, scholars. Buddhist monk.
- ★ Charaka, authority on Medical Sciences, esp. Ayurveda.
- ★ Mathara, a meritorious politician.
- ★ Kanishka was a great patron of Buddhism & the Fourth Buddhist Council was held under his patronage at Kashmir under the Presidentship of Vasumitra.
- ★ Succeeded by Vashishka, then Huvishka & so on. & the last ruler of the Kushan dynasty was vasudeva (220 A.D).

Schools of Art

Gandhara Art - School

Flourished from 1st Cent. B.C. to 5th C.A.D. in the Gandhara region & received its greatest patronage from Kanishka.

- ★ Associated with Mahayana Buddhism.
- ★ Also called Greco - Buddhist School.
- ★ Remains found in Taxila & Sites in Afghanistan & North - Western India.
- ★ Mostly in black stone & the statues were represented in thick drapeny with large & bold fold lines.

Mathura School

- ★ Flourished from 2nd Century B.C. to 1st C.A.D, when it was most extensive.
- ★ Spotted red Sandstone was used for making images.
- ★ The Buddhas & Boddhisatvas were largely defricted, improving on the spirituality aspect in the images as years went by thus began the practice of placing a halo behind faces of the images.
- ★ Images of Brahmanical deities were also made like that of Siva, Vishnu, Parvati, Lakshmi etc.
- ★ Most striking images are those of Yakshas & Yakshinis, Naginis & Apsaras.
- ★ Royal Statutes were also made, especially those of Kushan Kings, like Kanishka.

Amaravati School

- ★ Florished between the lower valleys of the Krishna & Godavari between mid 2nd B.C. to 4th C.A.D.
- ★ **Main Centres :** Amaravati, Nagarjuna Konda & Jaggayyapeta.
- ★ Used White marble for images.
- ★ The Stupa of Amaravati was adorned with Limestone reliefs depricting scenes of the Buddha's life & surrounded with free-standing Buddha figures.
- ★ Its secular images outnumber those of religious ones.

7. Satavahanas

- ★ Ruled for 460 years continuously.
- ★ The Kings are mentioned in the 'Puranas' as belonging to the Andhra territory & tribe.
- ★ Simukha was the first ruler of the dynasty with his capital at Pratishthana or Paithan on the Godavari in Aurangabad district, Maharashtra.
- ★ Nanaghat inscription mentions Satakarni I as 'Dakshinapatha - pathi', thus implying their control over the Deccan also.
- ★ The Early Satavahana period after Satakarni I did not witness any remarkable activities except for the composition of 'Gathasaptasathi' by the ruler, Hala.
- ★ Later Satavahana period beginning with Gautamiputra Satakarni was the period of their revival, who defeated the family's greatest rivals, Sakas.
- ★ He was called as 'Ekabrahmana' in the Nasik inscription/ prasasti by his mother, Gautami Balasri.
- ★ Satavahanas were the first rulers to make land grants to the Brahmanas.

Other Minor Dynasties :

- ★ Chetis of Orissa, Audambaras, Kunindas, Trigartas, Yaudheyas, Arjunayanas, etc.
- ★ Kharavela of Kalinga belonged to the Mahameghavahana line of the Chetis/ Chedis.
- ★ He is famous for the Hathigumpha inscription which was engraved on the Udaigiri Hills near Bhuvaneshwar.
- ★ He was a Jaina & got cave shelters excavated for the Jaina monks in the Udaigiri Hills.

8. Sangam Age

★ The Land South of Krishna River was divided into three kingdoms - Chera, Chola & Pandya.

There was continuous warfare between the three.

Cheras :

★ Capital was Vanji or Karur (modern Kerala)

★ Senguttavan, the 'Red Chera' or 'Good Chera' was the greatest Chera king according to the Chera poets.

★ He had invaded the north & crossed the Ganga.

★ He started the 'Pattini' Cutt, which is the worship of Kannagi & built a temple for her, the Goddess of Chastity.

★ 'Silapadikaram', authored by his brother Ilango Adigal, describes his heroics.

★ Under Irumporai (210 A.D) Chera kingdom was captured by Pandyas.

Pandyas :

They were first mentioned by Megasthenes, who referred to it as being ruled by a warman.

★ Capital was Madurai.

★ Nedunjhelian was the most popular king. He defeated the Cheras & Cholas in the Battle of Talaiyalagnam (AD 210).

★ According to 'Silapadikaram', in a fit of passion he ordered the execution of Kovalan, the husband of kannagi & later died broken hearted.

Cholas :

Chola dominion was known as 'Tondai Mandalam' or 'Cholamandalam'.

★ Capital was at Uraiyur, Famous for Cotton trade.

★ A firmer history of Cholas begin int he 2nd C. A.D. with their famous king Karikala, founding the port city of Puhar or Kaveri pattanam.

★ He also got 160 km of embankment constructed along the Cauvery River.

★ Senganan popular for his devotion to Shiva, got built 70 fine temple for Shiva.

Sangam Literature :

★ The word Sangam is associated with South Indian history where a College or Assembly of Tamil Scholars & poets flourished under the patronage of the Pandyan kings at Madurai, between 300 B.C. & 300 A.D.

Three Sangams held were:

No.	Place	Presided by	Work
1.	- Madurai	- Agastya	- None Survived
2.	- Kaptapuram	- Tolkapiyar	- Tolkapiyar (Tamil Grammar)
3.	- Madurai	- Nakkirar	- Entire Corpus of Sangam Literature

★ Sangam Literature that is available was compiled in Circa A.D. 300 - 600 & earlier in 2nd C.A.D.

★ The whole Literature is divided into -

i. 'Melkannakku' or 18 Major Works - Narrative.

ii. 'Kilkannakku' or 18 Minor Works - Didactic

★ 'Thirukural' or 'kural' by Tiruvalluvar is called the 'Fifth Veda' or 'Bible of the Tamil Land'. It contains discussions of Dharma, Artha, Kama & Moksha.

★ 'Silapaddikaram' or the 'Jewelled Anklet' is an epic dealing with the love stories of Kovalan & Madhavi & Kannagi.

★ 'Manimekhalai' is a sequel to it, written by Sattalai Sattanar dealing with the daughter of Kovalan & Madhavi & is considered the 'Odyssus of Tamil Poetry'

★ Roman king built a temple of Augustus at Muziris.

★ Murugan, also called Subrahmanyam or Karthikeya was the most important God of Tamils.

9. Gupta Empire

Based on the evidence provided by the Gupta inscriptions - Sri Gupta is the founder of the empire & he was followed by Ghatotkacha. Both of whom assumed a simple title, 'Maharaja'.

★ Chandragupta I, son of Ghatotkacha was the first independent ruler & called himself 'Maharajadhiraja' (A.D. 320)

★ Married the Lichchavi Princess, Kumaradevi, which was politically very strategic for Gupta empire, which included the present day UP, Bihar & Bengal.

Samudragupta :

★ Son & Successor of Chandragupta.

★ All the information about him is sought from Allahabad's 'Prayaga Prasasti' (originally Asokanpillar) composed by Harisena.

★ His campaigns & Conquests are divided into four lists-

i. 12 States of Dakshinapatha with the names of their kings, who were captured & then Liberated & reinstated.

- Mahendra of Kosala
- Vyaghraraja of Mahakantara
- Mantraya of Kaurata
- Mahendragiri of Pistapura
- Swamidatta of Kottura
- Damana of Erandapalla
- Vishnugopa of Kanchi
- Nilaraja of Aramukta

- Hastivarman of Vengi
- Ugrasena of Vengi
- Ugrasena of Palakka
- Kubera of Devarashtra
- Dhananjaya of Kersthalpura

ii. Eight kings of Aryavarta who were exterminated; including Achyuta, ruler of Ahichchatra; Nagasena of Gwalior; etc.

iii. Rulers of Forest States who were reduced to Servitude & the Chiefs of five 'Pratyantas' (Border States) & 9 Tribal Republics, that were forced to pay all kinds of taxes, obey his orders & visit him to perform obeisance.

Border States - Samtata (East Bengal)

- Daraka (Assam)
- Kamarupa (Assam)
- Nepala
- Kantipura (Kashmir)

Tribal Republics -

Malaras, Arjunayanas, Yaudheyas, Madrakas, Abhiras, Prasjunas. Sarakinakas, kavas & Kharaparikas.

iv. Island States who offered themselves for service to him.

★ Foreign rulers like the later Daivaputra Shahanushahs (kashanas), Sakas & Srilanka remained independent but had to be approved by Samudragupta.

★ Virasena - his commander in Southern Campaign.

★ Samudragupta's Gold coins were of Yupa type.

★ He granted permission to the Buddhist king of Ceylon, Meghavarman to build a monastry at Bodh Gaya & was hence given the title of 'Anukamparan' (Full of Compassion)

★ Adopted the title of 'Kaviraja'

★ Patronised art & Harisena & Vasubandhu.

★ Shown playing the lute or Veena on some of his coins.

★ Called 'Napoleon of India' by V.A. Smith.

★ Chandragupta II (Vikramaditya)

★ Disputed succession followed him between his sons, Ramagupta & Chandragupta Vikramaditya according to a drama, 'Devichandraguptam' by Visakhadatta.

★ Chandragupta Vikramaditya conquered most parts of Western India thus bringing in more trading opportunities with the West.

★ Married Kubera Naga & his daughter, Prabhavati was married to the Vakataka king, Rudrasena II in the Deccan.

★ Fahien, the Chinese prilgrim, visited India.

Kumaragupta - I

★ Ruled for 40 years the entire empire inherited by him from Ahmedabad (West) to Ellichpur (Berar). Bilsad, Karandana, Mandsor & Damodarpur Copper plate inscription.

★ He founded the Nalanda University.

★ Faced the foreign invasions by hordes of Pushyamitras, a tribe allied to the Hunas.

Skandagupta

★ 5^{th} C.A.D - Hunas, called Ephthalties were defeated by him & sent back for a century to come.

★ Junagarh inscription mentions that his Governor, Parhadatta got the Sudarshana Lake repaired.

★ Adopted the title, 'Vikramaditya'.

★ Succeeded by Buddhagupta & Later Vainaya gupta. Bhanugupta & so on... & Vishnugupta was the last ruler of the imperial Guptas.

Inscriptions of Gupta Kings

★ Samudragupta - Eran & Prayag Prashastis.

★ Chandragupta II - Udaigiri, Mathura - Pillars. Garhwa, Sanchi & Mehrauli Prasastis (Iron Pillar)

★ Kumaragupta - Garhwa, Cave inscription of Udaigiri, Dhandeh Copper inscription.

Mandsor : Damodarpur Copper inscription.

★ Skandagupta - Kanhari, Supia, Bhitar - Pillars.

Junagarh Prasasti & Indore inscription

★ Kumaragupta II - Samath Pruddha Murthi inscription.

★ Bhanugupta - Eran

★ Vishnugupta - Damodarpur Copper inscription.

★ Buddhagupta - Paharpur, Damodarpur- Copper Varanasi - Pillar inscription.

Administration

★ The Gupta Empire was divided into various administrative units -

Empire - Central of the king, assisted by 'Mantri' or 'Sachiva' - Chief Minister 'Senapatis' - Military Officers.

↓

Provinces - 'Bhuktis' - under Uparika (Viceroy)

↓

Districts - 'Vishayas' - Under Vishayapati

↓

Sub - Districts - 'Peth'

↓

Villages - 'Grama' - under Gramika & Mahattar

★ Town administration was carried by the Mayor of the city called 'Purapala'.

★ Ownership of Land was under the King.

★ Religious grants, called 'Agraharas' were made to Brahmins, which were hereditary & tax free perpetually - Ex: Nalanda & Gaya grants of Samudragupta.

produce payable in cash or kind.

* Guptas also made 'Devagrahara' & secular grants which led to the beginning of the process of Sub infeudation
* Various Officers

Officer	In-charge of
Sandhivigrahika	War & Peace
Pilupati / Katuka	Elephants
Asrapati	Horses
Narapati	Soldiers
Ranabhandagarika	Stores (Royal)
Akshapataladhikrita	Accounts
Pustapala	Records
Dandapasadhikarana	Police (Law & Order)
Dhruvadhikarana	Land Revenue
Bhangagaradhikrita	Treasury

Gupta Literature :

* Sanskrit was the official language of the Court.
* Final shape to the Smritis, Itihasas & Puranas was given during this age.
* Buddhist work on logic was written by Vasubandhu.
* Jaina work on logic was founded by Siddhasena Divakara.
* Samudragupta's court adorned the 'Navaratnas'

i. Kalidasa - 'Raghuvamsa', 'Vikramurvashi', 'Malvikagnimitra', Abhigyanashakuntalam', 'Meghadutam', 'Kumarasambhava'.

ii. Amarasimha - 'Amarakosa'

iii. Visakhadatta - 'Mudrarakshasa' & 'Devichandra guptam'.

iv. Dhanvantri - 'Nighantu'.

Temple of Gupta Age

* Shiva Temples - Koh & Bhumara (Nagaud)
* Parvati Temple - Nachna Kuthara
* Laxman Temples - Kanpur & Sirpur
* Vishnu Temple - Tigawa (Jabalpur)
* Dasavtar Temple - Deogarh (Jhansi)
* Dhammekh Stupa - Sarnath

Religion :

* Hinduism acquired its present shape during the Gupta Age - with Brahma, Vishnu & Maheswara as the Supreme deities.
* Bhagavatism, which is mainly based on the 'Bhagrad Gita' & later on 'Bhagavata Purana' & Vishnu Purana' became propular.
* Worship of Vishnu (Vasudeva) theory of Karma & idea of Bhakti Ahimsa are basic foundations of Bhagavatism.
* Idol worship in temples became common.
* Concept of Dasavatars of Vishnu or incarnations was preached.
* Durga, Kali, Amba, Chandi came to be regarded as mother goddesses.
* Six Schools of Philosophy were perfected.
* Buddhism lost its royal patronage.

Science & Technology :

* Aryabhatta was the first to use decimal system, though he was not its orignator.
* He formulated the rule for finding out the area of triangle. Which led to the origin of Trignometry.
* He calculated the value of pie & laid down the foundation for Algebra in his book, 'Aryabhattiyam'.
* He found the causes of Lunar & Solar eclipses, Calculated the Circumference of earth which is still almost correct. These & the discovery that the earth rotates round its axis is presented by him in 'Surya Siddhanta'.
* Varamihira's works were

i. 'Brihat Samhita' - on astronomy, physical geography, botany & natural history.
   - It states that moon rotates around the Sun.

ii. 'Pancha Siddhantika' - a summary of five astronomical books current in his time.

iii. 'Bhahat Jataka'

* Brahmagupta - 'Brahmagupta Siddhanta' & 'Khanda Khadyaka'.
* He declared that 'all things fall to the earth by law of nature, for it is the nature of the earth to attract & keep things." even before Newton.
* He developed rules for operating with zero & negative quantities.
* He began to apply algebra to astronomical problems.
* 'Romaka Siddhanta' was compiled during this time & was influenced by Greek Ideas'.
* 'Navanitakam' - Medical work on formulae, recipe & prescription.
* Guptas excelled in metallurgy. The Iron pillar at Mehrauli remains wihout rusting for centuries now.

Foreign Writers :

- Fahien - Chinese
- Cosmos - Greek
- Hiuen Tsang - Chinese
- Itsing - Chinese
- Suleiman - Arabian

Art & Culture :

* Gupta Age marks the beginning of Temple Architecture in India.
* Flat roofed temples are the hallmark of Gupta Architecture.
  Ex : Kankali Devi Temple at Tigawa
  Vishnu & Varaha Temple at Eran.
* 'Nagara' & 'Dravida' styles evolved.
* Salpture 2m high bronze image of Buddha from Sultangang' is a masterpiece.
* Gupta stone sculpture was related to the Mathura School.
* Painting reached its zenith in the Ajanta paintings. *Ex :* 'The Dying Prince' & 'Mother & Child'.
* Rock-cut caves in Ajanta & Ellora (Maharashtra) Bagh (Madhya Pradesh) & Udaigiri (Orissa)
* Literature - Last phase of Smriti Literature - finalization of the efics, 'Ramayana' & 'Mahabharata'.

10. HARSHAVARDHANA (606 - 647 A.D.)

- ★ Belonged to the Pushyabhuti dynasty which was founded by Pushyabhuti. The fourth king in line was Prabhakaravardhan, whose son was Harshavardhan.
- ★ Harsha's sister, Rajyashree was married to Maukhari king - Grihavarman of Kannauj who was killed by Sasanka, the king of Gauda, for Devagupta, the ruler of Malwa.
- ★ Harsha's brother, Rajyavardhana was killed in the battle with Devagupta & thus Harsha became the king of Thaneswar & was also offered the throne at Kannauj by the leading noble, Bana.
- ★ According to Hieun Tsang Vallabhi king, Dhruvasena II was Harsha's son-in-law, who also attended the religious assembly held at Prayag (every 5 years to give away everything that Harsha owned as Charity).
- ★ After conquering most of northern India, he took the title of 'Rajputra Siladitya'.
- ★ The early history of Harsha's reign was reconstructed by his biography, 'Harshacharita' written by his court poet, Banbhatta & Later history by the 'Si-yu-ki' of Hiuen Tsang.
- ★ Harsha had diplomatic relations with the Chinese for his contemporary T'ang emperor sent three embassies to his court & last one arrived under Wang Hiuentse after Harsha's death. (A.D. 647).
- ★ All of north India except Kashmir from where he brought a tooth relic of the Buddha was under his control.
- ★ He was defeated by Chalukyan king, Pulakesin II in A.d. 634, which is mentioned in a Prasasti of Pulakesin.
- ★ By faith, Harsha was a Shaiva in the beginning & gradually embraced Buddhism.
- ★ 2 Grand Assemblies - 'Mahamoksha Parishad' were held at Kannauj & Prayag.
- ★ Harsha wrote three dramas - 'Priyadarshika', 'Ratnavali' & 'Nagananda'.
- ★ Scholars - Bana Bhatta - 'Harsha Charita' & 'Kadambari'
- ★ Matanga, Divakar, Jayasena & Bhartrihari'.
- ★ Harsha founded the 'Harsha era' in 606 A.D.
- ★ Apart from Harshavardhana's empire there were numerous regional kingdoms which florished all over India during Gupta & post-Gupta times.

11. Chalukyas

The origin of Chalukyas of Badami in modern Karnataka, is traced back to Ayodhya by some, to Gurjaras of Gujarat by some & as local kanarese by others.

- ★ Pulakesin I founded the kingdom in A.D. 535 with Vatapipura as the capital & was succeeded by Kirtivarman & Mangalesa.

Pulakesin II (690-642) :

Aihole Prasasti by Ravikirti in a Jaina temple gives account of his reign.

- ★ His greatest achievement was the victory over Harshavardhana.
- ★ He annexed the region from the Pallavas between the Rivers Krishna & Godavari (Vengi) & placed them under his brother, Vishnuvardhana, thus laying the foundation for the kingdom of Eastern Chalukyas or Chalukyas of Vengi.
- ★ Vikramaditya I, son of Pulakesin II re-established his authority over the whole kingdom & defeated three succeesive Pallava kings & captured kanchi. He also defeated Cheras, Cholas & Pandyas.
- ★ Kirtivarman II (744-755) was the last ruler of the dynasty & was defeated by the Rashtrakutas.

CHALUKYAN ART & ARCHITECTURE

- ★ They developed the Deccan Vesara style temples.
- ★ Perfected the art of Stone-building, i.e. stones finely joined without mortar.
- ★ Cave temples by Buddhists, Jainas & Brahmins.
- ★ Cave frescoes perfected by Chalukyas can be witnessed at Ajanta, like a painting depicting the reception given to a Persian embrassy by Pulakesin II.
- ★ Temples - Most popular ones at Aihole & Badami, Lad Khan, Durga, Jaina temples - also popular.
- ★ Pattadakal has 10 temples - represented both by Northern & Southern Styles.

Ex : Papanatha, Virupaksha & Sangamesvara.

12. VAKATAKAS

- ★ Founded by Vindhyashakti, who was succeeded by his son, Pravarasena.
- ★ King Rudrasena II was married to Prabharati Gupta, the daughter of Chandragupta II.
- ★ After Rudrasena's death, Prabhavati carried the administration on as an agent of her-minor son.
- ★ As Kalidasa's poem, 'Meghadutam' is referred to as Kavya of

13. PALLAVAS (A.D. 560-903)

- ★ Origin is linked to Parthians or Vakatakasor Ikshvakus in conclusively.
- ★ Simhavishnu (560-590) is the first important Pallava ruler & captured Chola territory.
- ★ Mahendravarman I was called 'Vichitrachitta' (590-630) & 'Mattavilasa' as he had authored 'Mattavilasa

- He gave up Jainism & took up Shaivism under the influence of Appar.

Narasimhavarman I (630-668)

was called 'Mahamalla' (Wrestler) he adopted the title of 'Vatapikonda' when he defeated Pulakesin II of Badami/ Vatapi Chalukyas.

- Sent two rural expeditions to Ceylon to reinstate Sinhalese Prince, Manaverma.
- He got the Rathas erected at Mahabalipuram.
- Parameswara raman I (670-700) built the temple at Kanchi.
- Narasimha Varma II (700-728) adopted the title of 'Rajasinha'.
- Dandin, the author of 'Dasakumaracharita' lived in his court.
- He built the Kailasanath Temple & the Shore temple at Mahabalipuram.
- He sent an ambassador to China.
- Paramesvara Varman II (728-731) defeated by Chalukya Vikramaditya II.
- Last Pallava ruler - Aparajita was defeated by Aditya Chola in 9th C. A.D.

Pallava Architecture under the Patronage of the kings.

- Mahendravarman - Bhairavakonda, Arcot & Anantesvara temple, Guntur.
- Narasimhavarman - Monolithic temples at Mahabalipuram.
- Rajasimha - Shore temple, Isvara & Mukunda Kailasanatha temple at Kanchi.
- Nandivarman - Vaikunthaperamal temple at Mukteswara & Matangevara Kanchi temples.

Pallava Sculpture with its Buddhist influence is best witnessed in the 'Descent of the Ganga' & 'Arjuna's Penance at Mahabalipuram.

- Literature -

  Bharavi - 'Kiratarjuniya'

  Dandin - 'Dasakumaracharita'

LITERARY ACTIVITIES IN ANCIENT INDIA

- 'Ashtadhyay' - Panini
- 'Mahabbasya' - Patanjali
- Manusmriti - between 200 B.C. & A.D. 200.
- 'Indica' - Megasthenese.
- 'Saundarananda' & 'Sariputra Prakarna' - Asvagosha.
- Naishada Charita' - Sri Harsha.
- 'Shishupala Vadha' - Magha.

Drama :

- 'Natyasastra' - Bharata
- 'Mahaviracharita', 'Uttaramacharita', & 'Malatimadhara' - Bhavabhuti

Lyric Poetry :

- 'Sringarashataka', 'Nitishataka', 'Vairagyashataka' by Bhartrihari
- 'Chaura Panchasila' - Bilhana
- 'Gita Govinda' - Jayadeva

Historical Writing :

- 'Harsha Charita' - Banabhatta
- 'Gaudaraho' - Vakpati
- 'Ramacharita' - Sandhyakara Nandi

Prose :

- Brihat Kathamanjari - Kshemendra
- 'Kathasaritsagar' - Samadeva
- 'Panchatantra' - Vishnu Sharma
- 'Hitopadesa' - Narayana Pandit
- Kamasutra' & 'Aryamanjushree' - Vatsyayana
- 'Parandhoot' - Dhoyi
- Swapnavasavadatta' - Bhasa.
- 'Fo-Kuo-ki' - Fochien
- 'Nitisara' - Kamandaka.
- 'Hastayurveda' - Palkapya
- 'Mitakshara' - Vignaneswara
- 'Dayabhaga' - Jimutavahana
- 'Siddhanta Shiromani' - Bhaskaracharya
- 'Nighanti' - Dhanvantri
- 'Prabhanda Chintamani' - Merutunga
- 'Geography of India' - Ptolemy
- 'Parishistaparvana' - Hemachandra.
- Brihatkatha Kosha' - Harisena.
- Kavyamimamsa' & 'Prabhandakosha' - Rajasekhara.
- 'Prithviraja Vijaya' - Jayanak.
- 'Nala Vemba' - Pugalendi.
- Christian Topography - Cosmos.
- Details of Buddhism - Itsing.

MEDIEVAL INDAN HISTORY

POLITICAL & SOCIAL CONDITIONS (A.D. 800-1200)
SOUTH INDIA - TRIPARTITE STRUGGLE (TRIPARTITE)

1. PRATIHARA

- ★ Belong to the 36 Rajput clains & are a branch of Gurjaras, nomadic Central Asian tribes.
- ★ Nagabhatta I founded the dynasty after he successfully defended Western India from the Arab Invasions.
- ★ The Tripartite struggle, between Pratiharas, Rashtrakutas & Palas, began during Vatsaraja's region. He defeated Dharmapala of Bengal but was defeated by Dhruva of Rashtrakutas.
- ★ Nagabhatta II defeated Dharmapala & also expelled his prodege, Chakrayuddha from Kannauj. But was defeated by Govinda III of Rashtrakutas.
- ★ His exploits are recorded in the Gwalior inscription of his grandson.
- ★ The Pratihara power reached glory under Bhoja I or Mihira Bhoja, who was enthroned in Kannauj in 836 A.D. He won over Bundelkhand, Jodhpur Pratiharas & Kalachuris.
- ★ But his expansion was checked by Sankarvarman of Kashmir. Rashtrakuta Krishna II & Devapala.
- ★ Mihira Bhoja was a devotee of Vishnu & adopted the title, 'Adivaraha'.
- ★ The Chandellas & the Arabs of Sind acknowledged his supremacy & Sulaiman, the Arab traveller visited the kingdom & Al Masudi called him king Baura.
- ★ Mahendrapala I extended his power upto Magadha & Bengal.
- ★ His Court poet was Rajasekhara who wrote 'Karpuramanjari', 'Bala Ramayana', 'Bala' & Bharata', 'Kavyamimamsa', 'Vidhsaala' Bhrinjika', 'Prapancha Pandava, 'Bhurarakosha - Haravilasa.
- ★ Mahipala was defeated by Rashtrakuta king, Indra III
- ★ During Mahmud Ghazni's raid on Kannauj, Rajapala fled from the battle field.
- ★ Yashpala was the last ruler of the dynasty & by AD 1090 the Garhwalas conquered Kannauj.

2. RASHTRAKUTAS

- ★ The term 'Rashtrakutas' means designated officers - incharge of territorial divisions called 'Rashtra'. And they were the feudatories of Chalukyas of Badami.
- ★ Founder was Dantidurga, a feudatory of Vikramaditya II, who made Manyakhet his capital - after defeating the Chalukya king.

Kirtivarman :

- ★ Succeeded by his Uncle, Krishna I who gave the final blow to Chalukya power.
- ★ He got the Kailasa temple Constructed in Ellora, which is a magnificent rock-cut monalithic temple.
- ★ Dhruva defeated Pratihara king, Vatsaraja Pala King, Dharmapala & thus was the first Rashtrakuta ruler to decisively intervene in the tripartite struggle.
- ★ Govinda III (793-814) made incursions into North India & defeated Dharmapala & Nagabhatta II.
- ★ Amoghavarsha I (814-878) fought long drawn battles with Eastern Chalukyas & Gangas.
- ★ He wrote 'Kavirajamarga' which is the earliest Kannada work on Poetics. He also wrote 'Prasnottaramalika'
- ★ Jinasena was patronised by him, who wrote 'Adipurana'.
- ★ Indra III (915-927) defeated Pratihara Mahipala & was called by the Arab traveller, Al Masudi as 'the greatest king of India'.
- ★ Krishna III (939-965) defeated the Chola king, Parantaka I in the battle of Takkolam.
- ★ 974-75 - Karka II was overthrown by Taila II who founded the Chalukya kingdom of Kalayani.
- ★ Rashtrakutas patronized Shaivism, Vaishnavism, Jainism & allowed Islam to persist - highlighting their spirit of religious tolerance.
- ★ In Literature they patronised Sanskrit, Prakrit, 'Apabhramsa', a forerunner of many modern India languages & Kannada.

3. PALAS

- ★ Founded by Gopala in 750 A.D., when he was elected the king by notable men of the realm during a period of anarchy or 'Matsya Nyaya'.
- ★ An ardent Buddhist, he got the monastery at Odantapuri built. Khadga dynasty of Eastern Bengal.
- ★ 780 A.D. - Succeeded by Dharmapala, who defeated Pratihara, Indra raja & conquered Kannauj & placed it under his protege, Chakrayuddha, who was inturn defeated by Pratihara Nagabhatta II.

in the battle against Nagabhatta II.

★ He founded the Sompur Vihara & the Vikramasila Mahavihara (University).

★ Suleiman visited him & called the kingdom & him 'Ruhma' (Dharma).

★ Gave 200 villages as a grant to revive the Nalanda University & the Buddhist Scholars Santarakshita & Dipankar Atisa went to Tibet.

★ Devapala extended his central over Pragjyotishpur (Assam) & parts of Orissa & Nepal.

★ He won against the Huns.

★ Received an embassy from Balaputradeva, ruler of Suvarnadvipa or Sumatra requesting him to grant 5 villages to the monastery which the Latter had built at Nalanda.

★ His 'Camp of Victory' was Monghyr & not Pataliputra as his predecessors.

★ After a decline in the family fortunes, it was revived by Mahipala I (A.D. 980s), but he was defeated by Rajendra Chola according to the Chola Thirumalai inscription.

★ Rampala revived the Pala fortunes & is mentioned in Sandhyakara Nandi's 'Ramacharita' which describes the kairarta peasant rebellian.

★ The last king of the dynasty was Madanapala, who was defeated by Vijayasena, to found the Sena dynasty.

4. Senas

★ Outside of the Tripartite struggle. The Senas capital was at Vikrampura & another at Vijayapura.

★ They called themselves 'Brahmakshatriya', 'Karnatakshtriya' & were the original inhabitants of Dakshinapatha.

★ Vijayasena was succeeded by his son, Ballalasena, who conquered Mithila. He was a Scholar & wrote 'Danasagara' & Adbhutasagara'.

★ Lakshamanasena defeated Jayachandra of the Gahadwala dynasty and was suddenly attacked by Mohammad Bin Bhaktiyar Khalji (as mentioned In 'Tabaqat-i-Nasiri & caputred Nadia).

★ Patronised Jayadeva, the Vaishnava & the author of 'Gita Govinda' & Dhayi, the author of 'Pavanadoota'.

★ Senas were overthrown by Deva dynasty in the middle of the 13th C.

5. Chola Empire

★ Cholas - the feudatories of Pallavas, established their own kingdom under Vijayalaya who defeated the allies of Pandyas. They built the temple Nishumbhasudini (Durga) as a sign of their rise to power (A.D. 850).

★ Aditya Chola murdered the Pallava king, Aparajita.

★ Parantaka I caputred Madurai but he (907-953) was routed by Rashtrakuta Krishna III at the battle of Takkolam.

★ Parantaka II, also called Sundarachola, wrested Tondaimandalam from the Rashtrakutas.

★ Rajaraja I (985-1014) - titles like 'Arumolivarman', 'Mummadi Chodadeva'. 'Jayakonda', 'Martanda Chola', 'Keralanatha'. 'Singhaltanka', 'Pandakulashini' etc.

★ Got the Brihadeswara (Raja Rajeshwara also) temple at Tanjore built.

★ Defeated Mahinda V & established the Chola empire in Northern Ceylon with Polonnaruva as his capital.

★ During his reign the ruler of Srivijaya built a Vihara at Nagapattanam.

★ Rajendra I Gangaikonda (1014-1044) placed the Chila empire in the Zenith of its glory.

★ Completed the conquest of Ceylon & imprisonned Mahindra V.

★ Defeated the Pandyas & rulers of Kerala & made his son, Rajadhiraja, Viceroy with Madurai as capital.

★ He led an expidition to the Ganga Valley & defeated Mahipala I (Palas) & thus assumed the title of (Gangai-konda) & established a new capital, 'Gangai-konda cholapuram'.

★ He built a Shiva temple & excavated an immense artificial tank, called Chodagar, in this new city.

★ Defeated the Shailendra or Sri Vijaya king, Vijayatunga varman & allowed the latter to built the Chudamani Vihara at Nagapattanam.

★ Sent embassies to China.

★ The next important king was Kulottunga II who belonged to Eastern (1070-1122) Chalukya line of Vengi but had more of Chola blood. He united the two kingdoms & subsequently began the Chola-Chalukya' history.

★ He discarded wars & was called 'Sangam tarritta' or 'Abolisher of tolls'. He liberated Sri Lanka & sent an embassy to China in 1077 A.D.

★ Kanban, a reknown Scholar was patronised by him.

★ Kulottunga III, was the last great Chola king & after him Cholas continued to exist but as local chieftains.

Administration :

★ Location self Government was the hallmark of Chola administration, which is the forerunner of our present day panchayat raj system.

Panchayat Raj System :

★ The Uttaramerur (993 - 994) inscription of Dantivarman Pallava & Parantaka - I have thrown sufficient light on this aspect. There were three types of assemblies.

i. Ur - most common.

- land was held by different castes of the village.

- consisted of tax-paying residents.

ii. Sabha or Mahasabha - exclusively Brahmanas, who resided in Agrahara villages.

- given through Brahmadeya grants.

iii. Nagaram - of merchants in the towns. - 'Vyarasthai' was the resolution of the assembly - The Sabha functioned through fairly elaborate committee system (Variyan) with sections of local administration being entrusted to committees of 6 or 12 members.

ex : Totta Variyam - Garden Committee

Eri Variyam - Tank Committee

Pon Variyam - Gold Committee

Nyayattar - Judicial Committee

★ The Sabha possed proprietary rights over communal lands. It controlled private lands, wastelands, roads, tanks etc. It helped in the assessment of land revenue.

General Administration :

★ The Chola empire was divided into -

Principles - under Vassal Chiefs.

6 Mandalas - Under Viceroys (mostly princes)

Valanadus - Divisions

Nadus - districts

Kurrams - Villages

★ Tankerrams - Towns & Townships with separate administration.

★ With the king at the apex - 'Udankuttam' were his immediate attendants (modern cabinet) & 'Olainayaka' was the Chief Secretary who drafted the royal orders.

★ Officials were divided into - Perundanam - Upper ranks - 'Adigarigal', Sirudanam - Lower ranks - 'Karumigal'

★ King appointed his successor during his reign.

★ The assembly of Nadu (district) was called 'Nattar' & that of towns was called ' Nagattar'.

★ 'Dharmasasanam' was the Court of Justice.

★ 'Puravuraritinaik - Kalam' was the Land Revenue department.

★ Land tax was $1/6^{th}$ of the produce (Kadamai).

★ Gold coins were called 'Kasu'.

★ Military administration - Among

Soldiers 'Kaikollar's were men with strong arms who received regular pay.

★ Sangandars were spear wielders.

★ 'Velaikkaras' were kings bodyaguards.

★ 'Kadagams' were army contonments.

★ It is stated that the Chola navy was so grand that it turned the Bay of Bengal into a Chola lake.

★ Local population was divided into

Idangai - left hand castes.

'Valangi' - Right hand castes.

Chola Art & Architecture :

★ Continued the Pallava architectural style.

★ 'Dravida' style reached the pinnacle - with its chief features being the 'Vimana' (Storey). Later eclipsed by 'Gopuram' (Gateway), 'Mandapa' (Meeting Hall), Lion Pillars, bracket & composite pillars.

★ Rajaraja I - Rajarajeshwara Temple,Tanjore has a depiction ofMarco Polo.

★ Cholas are most famous for Nataraja Statue of (Cholapuram) kumbhakenam has a depriction of Marco Polo, Venetian traveller.

6. RAJPUTS (800 - 1200 A.D)

★ They are members of a tribe or clan of Lunar or Solar descent. Which claimed themselves as 'Kshatriyas' & came into prominence after Harshavardhana's dynasty ended.

★ The Four Agnikula Rajputs were

- Pratiharas or Pariharas

- Chalukyas or Solankis

- Paramaras or Pawars

- Chahamanas or Chautians, who are believed to have originated from a sacrifical pit at Mt. Abu.

Paramaras :

★ Upendra, also known as Krishnaraja was one of the founders of the family as Paramaras were divided into several branches.

★ The main branch ruled at Malwa with its capital at Dhara (Upendra)

★ History of Pramaras begins with Siyaka, who defied Rashtrakuta & Pratihara authority.

★ Murija, also called Utpala & Vakparaja II was a great general & won over Chalukya Taila II's invasions on his kingdom.

★ 1008 A.D. - he sent an army to help the Shahi ruler, Anandapala of Punjab against Mahmud of Ghazni.

★ Bhoja was the greatest ruler of the Pramaras, more due to his scholarship (authored 23 books like 'Samaranganasutradhara' & Patronage of learning (Dhianapala, etc).

★ Last known king of Paramaras was Mahlak Deo, who was defeated by Alauddin Khalji.

★ Branches of Paramaras ruled from Mount Abu, Vagada, Jalor & Bhinmal.

7. Chalukyas/ Solankis of Gujarat (950-1300)

- ★ Founded by Mularaja - I at Anhilpataka.
- ★ Bhima I was the grandson & Maharaja & during his reign in A.D. 1025, Mahmud Ghazni overran Gujarat & plundered the wealthy Somnath temple.
- ★ The famous Dilwara temple at Mt Abu was built during his reign.
- ★ He abdicated the throne for his son, Karna in 1064 A.D; who founded the city named Ahmedabad now.
- ★ Most impressive reign was that of Jayasimha Siddharaja, who defeated the Paramaras, Chahamanas, Chandellas & Chalukyas of Kalyani.
- ★ He made Gujarat a famous seat of learning Scholars like Hemachandra (Siddha-Hemachandra on Grammar) were patronised by him.
- ★ 1143 A.D - Kumarapala seized the throne & having come under Jaina influence Hemachandra, he reformed the laws & shopped gambling & other evil practices, like animal sacrifices.
- ★ Mularaja II & his mother bravely opposed the invasion of Muizzuddin Mohammad Ghori in A.D. 1178 & defeated him at Mt. Abu.
- ★ Karma was the last Hindu king of Gujarat, whose queen Kamaladevi & daughter, Devaladevi were carried away by Allaudin Khalji after Karma fled to Devagiri.
- ★ Ministers of Bhima II - Vastupala & Tejapala encouraged arts & architecture.
- ★ Most famous Solanki temples -
  - Surya at Modhera
  - Jaina at Mt. Abu of Vimala

8. Chahamanas/Chauhans

- ★ The Chauhans were the Feudatories of Pratiharas & Vasudeva founded their main line with Ahichchatra as the seat of power (6^{th} C)
- ★ Vigraharaja II defeated Mularaja - I & overran Gujarat.
- ★ Ajayraja was the founder of Ajayameru & ruled from Sakhambhari earlier.
- ★ Prithviraja III began his reign in 1177. Best known for his victory over Mohd. Ghori in the first battle of Tarain, 1192, but was executed the very next year by Ghori in the second battle of Tarain.
- ★ He was the theme of two great poems, 'Prithvirajarijaya' (by Jayanaka) & 'Prithviraj' Raso' (by Chand Bardai).
- ★ Harihara regained Ajmer before 1194 but had to surender it to Qutub-ud-din Aibak.

9. Gahadvalas of Kanauj

- ★ Founded by Yasovigraha, the Gahadvala tradition traces them back to Yayati.
- ★ Chandradeva was the first great ruler, who defeated Rashtrakuta Gopala.
- ★ Govindachandra, considered the greatest in the dynasty, defeated the Muslims & secured the release of his father, Madana Chandra.
- ★ Jayachandra was defeated by Lakshmana Sena of Bengal. 1193 - Mohammad Ghori invaded the kingdom & defeated & killed Jayachandra in the battle of Chandawar.
- ★ Jayachandra is better known for the liberal patronage extended to Sriharsha, the author of 'Naisadha - Charita', 'handana-Khanda-Khadya'.

10. Chandellas

- ★ Nannuka founded the dynasty around Khajuraho in Bundelkhand..
- ★ Dhanga was the most important ruler of the dynasty & extended the kingdom upto the Ganges.
- ★ Khajuraho temples - Viranatha that were constructed under Dhanga. Jinantha & Vaidhyanatha.
- ★ Viravarman II was the last ruler. By 1309 - Alauddin Khalji had conquered most of the empire.

11. Other North Indian Kingdoms

Sind :

At the time of Arab invasions, Sind was under the dynasty founded by Brahman Choch, whose son Dahir faced the invasion under Muhammadbin Qasim (712A.D.).

- ★ Pratiharas were their most formidable rivals of Arabs with the support of Rashtrakutas of Manyakheta.
- ★ 11th Cent - Arabs in Sind were displaced by the Ghaznavids & they were inturn displaced by Hindu Sumoras who ruled till 14^{th} C. A.D.

12. Hindu Shahi Kingdom

- ★ The last king of Turkish Shahiyas kingdom in the North-West was ousted by his Brahmin Minister, (Logaturman being the king & Kallar his minister), who founded the Hindu Brahmana Shahis with Udabhandapura as his capital.
- ★ Kallar was referred to as 'Lalliya Shahi' in Kalhana's

'Rajatarangini'.

- ★ His grandson was Maharajadhiraja Parameswara Shahi Sri Bhimadeva, whose daughter's daughter was the famous Queen, Didda of Kashmir.
- ★ Late 10th cent - Jayapala the ruler of the Hindushahi dynasty. Jayapala, Anandapala, Trilochanapala & Bhimapala fought against Subuktigin & Mahamud, the rulers of Ghazni, who destroyed the kingdom by early 12th cent.

Kashmir :

- ★ Ruled by Karkota, Utpala & Lohara dynasties
- ★ Kashmir's history is made available through Kalhana's 'Rajatarangini'.
- ★ Naga-Karkota dynasty was founded by Durlabh Vardhana, under whose reign Hiuen-Tsang visited Kashmir.
- ★ Lalitaditya Muktaprida (724-760) & Jayapida Vinyaditya (779-810) were the most illustrous kings. Lalitaditya's main success was against Yasovarman of kannauj.
- ★ He built the famous Sun temple at Martand.
- ★ Utpala dynasty was founded by Avantivarman.
- ★ Queen Didda belonged to this dynasty & ruled from 980-1003 A.D.
- ★ Sangramaraja founded the Lohara dynasty.
- ★ Shamsuddin captured the throne of Kashmir.

The Kingdom was finally annexed into the Mughal empire by Akbar in A.D. 1586.

13. Tomaras

- ★ One of the 36 Rajput clans.
- ★ Anangpala Tomar founded Delhi in 736 as their caprital & ruled the Haryana area.
- ★ Greatest rivals were Chahamanas of Sakhambhari, who captured Delhi, under Vigraharaja in 12th C A.D.

14. Provincial Kingdom in the South

Yadavas of Devagiri

- ★ Feudatories of Rashtrakutas.
- ★ Seunachandra I was the first Feudatory & the Yadava kingdom. Later came to be known as 'Seuna-desa'.
- ★ The dynasty was founded by Bhillama V with Devagiri as Capital.
- ★ Jaitugi won against the Kakatiyas, Malavas, Latas & Gurjara kings.
- ★ Simhana was the most powerful ruler of the family, who was unchallenged by the Hoysalas, the Kakatiyas, Paramaras & Chalukyas.
- ★ Patron of music & literature & the important on music, 'Sangitaratnakara' by Sarangadeva was written in his court.
- ★ Changadeva, grandson of Bhaskaracharya established a college of Astronomy in Khandesh.
- ★ 1296 - Ramachandradeva was compelled to sue for peace by/ Alauddin Khalji, to whom he sent tributes till 1304, when Khalji's forces were defeated by Kakatiya Prataparudra Deva.
- ★ The Crown prince, Shankaradeva thus defied the authority of the Sultan, But was made vassal of his kingdom after being defeated by Malik Kafur, Khalji's able general & was later killed on revolting again.
- ★ Yadavas were liberal patrons of all religions Buddhism, Jainism, Virasaiva sect, etc.
- ★ The new religious sect that took birth in Yadava land was 'Mahasambhavas', who worshipped God Krishna, that was founded by Chakradhara in AD 1273.
- ★ Important epoch for the history of Maratha Literature.

Kakatiyas of Warangal

- ★ Feudatories of Western Chalukyas, Beta I being the earliest known.
- ★ It was Prola II who established an independent Kakatiya kingdom.
- ★ Hanumakonda inscription describes the achievements of Rudradeva over Telugu Choda kings & other neighbouring kingdoms.
- ★ Most probably built the Thousand Pillar Temple at Hanumakonda.
- ★ Founded Orugallu, which is Warangal now.
- ★ Ganapatideva's 63 years rule was the greatest eproch in Kakatiya history.
- ★ Won over rulers of Vijayawada, island of Divi & Velanati Chiefs, Telugu Chodas of Nellore, were also defeated by him.
- ★ Motupalli was an important port in contact with foreign merchants & lands also.
- ★ Chose his daughter, Rudramba as the heir- apparent who was married to Virabhadra of Eastern Chalukyas.
- ★ Rudramba successfully faced the internal crisis of rebellions nobles & external threat from Yadava Mahadeva.
- ★ Kumara Rudradeva or Prataparudra & Rudramba defeated their feudatory Ambadeva & regained Tripurantakam.
- ★ Prataparudra faced series of Muslim invasions starting from A.D. 1303.

Administration :

Purohita, Sainadhi - nayaka, Durgapala, Yuvaraja, etc.

- ★ Administration was organised on a military basis by dividing their territory among military chiefs called 'Nayakas'.
- ★ Provincial division

Nadu

↓

Sthalas- consisted of 10 to 60 village

↓

Grama

- ★ Main source of revenue -
  - Land tax
  - Taxes on trade & industry.
  - Forests & timber - yield.
- ★ Religion - Saivism was the most popular faith.

Literature :

- ★ 'Nitisastra - Muktavali' - Baddena.

'Sakalanitisammatamu' - Madiki Singana.

'Nitisara' - Prataparudra.

'Prataparudra - Yasobhushanam' - Vidyanatha.

Telugu - 'Nirvachanottara - Ramayanam' - Tikkana

'Andhra Mahabharata' - begun by Nannay abhatta & completed by Tikkana Somayaji.

- ★ Many inscriptions in Sanskrit & Telugu.

Hoyasalas of Dwarasamudra

- ★ Feudatories of Chalukyas.
- ★ The dynasty was founded by Nripakama, but the Kingdom was established by Bittiga or Vishnuvardhana.
- ★ Ballala II was the ruler who declared independence after A.D. 1189 when the Chalukya Someshwara IV was over thrown by the Yadavas.
- ★ Narasimha II saved the Cholas from the Pandyas & placed Rajaraja III on the throne.
- ★ Ballala III overcame the Yadavas & Pandyas, but lost his kingdom to Alauddin Khalji in 1310 under Malik Kafur's able generalship.
- ★ The Hoyasala dynasty ended with his death in the battle against Madurai Sultan at Trichinapally.

Architecture :

- ★ Hoysala temples are mostly doubled, having all essential parts duplicated.
- ★ Hoysala temples are usually described as sculptor's architecture.

Ex : Hoyasalesvara temple at Halebid.

Kesava at Somnathpur

Chennakesava at Belur

Pandyas of Madurai

- ★ The Pandyan power was revived by Kadungon in the last quarter of 6th C. king Arikeshari Maravarmana extended the kingdom.
- ★ Suffered a brief eclipse again & it was Maravarman Sundara Pandya who revived the Pandyan fortunes.
- ★ Jatavarman Sundara Pandya forced Rajendra Chola III to acknowledge his supremacy. He also defeated the Hoysala king, Someshwara who died in the battle. He invaded ceylon & captured northern portion of it.
- ★ Maravarman kulasekhara Pandya finally annexed the Chola country to his dominion.

Gangas of Orissa

- ★ Anantararman Choda Gangadeva built the Jagannath Temple at Puri.
- ★ Narasimha I built the Sun temple at Konark.
- ★ Kaprilendra founded the Gajapati dynasty.

Kalachuris or Haihayas

- ★ Main branch from Mahismati on the Narmada.
- ★ Others - Tripuri, near Jabalpur, M.P.
- ★ Kokalla I was the real founder & is credited with victories over Pratiharas, Rashtrakutas & Northern konkan area.
- ★ Later had matrimonial alliances with Rashtrakutas.
- ★ Yuvaraja I had to fight back the Rashtrakutas in commemoration of which, famous court, poet, Rajasekhara staged the drama 'Viddhasala Bhanjika'.
- ★ Vijayasimha was the last ruler, defeated by Chandellow.

DELHI SULTANATE (1206-1526)

Earlier Invasions of Muslims

* Mohammad Bin Qasim - Sind - A.D. 712.
* Subuktugin & Mahmud of Ghazni - against Jayapaa, Shahiya ruler.
* At 1608 - Mahmud Ghazni- Anandapala (Shahiya) Battle of Waihind.
* A.D. 1014 - Mahmud Ghazni conquered Thaneshwar & burnt the temple at Mathura.
* A.D. 1018 - He sacked Kanauj.
* A.D. 1022-23 - Sacked Gwalior & Kalinjar.
* A.D. 1025 - destroyed the Somnath temple, Kathiawar.
* Alberuni was the court historian of Mahmud Ghazni & he wrote the famous treatise 'Kitab-ul-Hind' ,along with Firdausi, author of 'Shahnama'.
* Muiz-ud-din Muhammad Ghori earlier made attempts through Sind & Multan (1175) but was defeated by Vaghela Raja of Gujarat, Mularaja II.
* Later came through Bhatinda (1189) & faced Prithviraj Chauhan & the Battles of Tarain followed.
* Ghori's general Bakhtiyar Khalji attacked Bihar & destroyed the Universities of Nalanda & Vikramashila.
* Another slave of Ghori was Qutb-ud-din Aibak, who was instrumental in conquering Kalinvar, Mahoba, Khajuraho, etc.
* After Ghori's death due to assassination by a Kokkhar tribesman, Tajuddin Yalduz became the ruler of Ghazni & Qutb-ud-din Aibak, Ghori's deputy in India became the first independent muslim ruler of India.

Ilbaris (1206 - 1290) Yamini Turks Slave Dynasty (Mamluk Dynasty)

* Qutb-ud-din Aibak (1206-1210) thwarted the challenge of his adversaries, Tajuddin Yalduz & Nasiruddin Qubacha & became the unofficial king in 1206 & formal Sultan in 1209 A.D., with his capital at Lahore.
* He was known as 'Lakh Baksh' for his magnanimity.
* Hasan Nizami, the famous historian was patronised by him.
* He died while playing 'Chaugan' (Polo) & was succeeded by his son, Aram Baksh.

Iltutmish (1211-1236)

* Slave & son-in-law of Qutb-ud-din.
* He belonged to the Ilbari tribe.
* He refused to give asylum to Jalaluddin Mangbarni, the Khwarizmian prince,who entered India on being chased by the notorious, Chengiz khan - thus arrested a major catastrophe for his kingdom & India.
* Iltutmish expanded the kingdom by winning over Bihar & Bengal, Multan & Sindh, Ranthambhor, Ajmer,
* 1228-received the patent of investiture from the Abbasid Caliph in Baghdad.
* He issued the first purely arabic coinage of silver.
* Organised the 'Turkan-i-Chahalgani'.
* Minhaj-us-Siraj was his contemporary historial who praised him.
* Iltutmish declared Razia to be his successor but the amirs disproving his wishes put Rukh-ud-din (1236) on the throne, who was the son of Shah Turkan, mother of Iltutmish eldest surviving son.
* The excesses of Shah Turkan & the incapability of Rukh-ud-din displeased many nobles, thus giving Razia the opportunity.

Raziya Sultan (1236-1240)

* She seized the throne when her brother was out of the capital to suppress a rebellion & later executed him.
* She had many Tajiks in high positions, but placed a Habshi or Ethiopian slave, Jamal-ud-din Yakut as the superintendent of the Royal horses much to the displeasure of the noble (Amir Akhur).
* Altunia, an Iqtadar killed Yaqut & married Razia, but were both killed by robbers while trying to recapture Delhi.

Bahram Shah (1240-42)

* Created the position of Regent - 'Malik who would be the de facto ruler & the Sultan only de jure.
* Masud Shah (1242-1246) was killed through a conspiracy between Balban & Malik-i-Jahan, the next ruler's mother.

Nasir-ud-din Mahmud (1246-1266) :

The real control of the state & administration was under Balban awarded the title 'Ulugh' Khan.

* According to Isami's 'Futch-us-Salatin' Balban poisioned the Sultan (though doubted).

Balban (1266-1287) :

* Knowing well that the Chahalgani was the source of all trouble, Balban introduced rigorous court discipline.
* He introduced the persian (Iranian) customs of Sijda (prostration) & Paibos (kissing the feet).
* He traced his ancestry from Afrasiyab, the persian hero.
* Followed a policy of blood & iron.
* Destroyed the Mewati Rajput brigade.
* Called himself 'Zil-i-Illahi' or Shadow of God on earth & 'Nasir-amir-ul-manin' or Caliphs right hand man.

Bughra Khan as the new Governor of Bengal, who was his son.

- ★ Introduced Persian Nauroz ceremony in the court.
- ★ To control the onslaught of Mongols, he founded the 'Diwan-i-arz' or Military department.
- ★ He was a patron of men of letters & showed special favour to the poet, Amir Khusrau.

Kaiqubad (1287-1290) :

was put on throne by Fakr-ud-din, the Kotwal of Delhi & was succeeded by Kayumars.

- ★ Kayumars was the last Ilbari ruler & was killed by Jalaluddin Khalji for the throne.

KHALJI DYNASTY (1290-1320)

- ★ Jalaluddin Khalji (1290-1296) was assassinated by his nephew, Ali Gurshasp (Alauddin Khalji) at Kara.

Allauddin Khalji (1296-1316) :

★ Military Campaigns -

AD 1297 - Gujarat - under Raikaran
- Sacked Anhilwara & Somnath
- Married Kamaladevi, Queen
- Captured Malik Kafur

★ AD 1300 - Ranthambhor - Raja Hamirdeva
- First person description of women committing 'Jauhar' by Amir Khusrau.

★ AD 1303 - Chittor - Raja Ratan Singh
- Queen Padmni was a possible cause, but mostly considered sensationalisation by the Chroniclers.
- Khizr Khan was made the Governor & renamed it as khizrabad.
- Also captured Marwar & Jalor.

Deccan :

- ★ 1306-07 - Devagiri - Malik Kafur - Ramachandra
- ★ 1310 - Hoysala - Malik Kafur - Veer Ballala.
- ★ 1311 - Pandyas - Malik Kafur - Veer Pandya
- ★ 1313 - Devagiri - Malik Kafur - Sankaradeva.
- ★ 1313 - Malik Kafur was given the title of 'Malik Naib'.

Administration :

- ★ Highly centralised with regulations against the nobility & suppression of rural elite, like Khuts & Muqaddams.
- ★ Mulk-i- Inam & Waqf land were confiscated.
- ★ Barids (News reporters) & Munhis (spies) were appointed to strengthen the tight knits around the nobles, who were prohibited from social gathering, matrimonial alliances between them, without the permission of the Sultan, wine & gambling.
- ★ Abolished the Zamindari in Khalisa land & Iqtadari in Doab area.
- ★ Land Revenue was fixed based on (zabti) measurements of land & fixed at 1/5th of the produce.
- ★ Kismat-i-khuti (Headman's cess) was abolished.
- ★ Ghari (House tax) & Charai (Grazing tax) were levied.
- ★ Military reforms he took up were the introduction of Dagh & Chehra system, branding of horses & soldiers descriptive rolls respectively.
- ★ Payment of salaries to the army in cash (238 tankas) & insistence on a regular standing army.
- ★ Ariz-i-Mammalik was the head of Diwan i-Arz.
- ★ Market reforms were introduced to keep the soldiers sustained on a small salary. Thus Prices were fixed. ex: Wheat at 7.5 jittal.
- ★ Established four separate markets in Delhi for (i) Grain, (ii) Cloth, etc. (iii) Horses, slaves, etc & (iv) Miscellaneous goods.
- ★ Was the first to fix land revenue in Cash.
- ★ Created the department, Diwan-i-Mustakhraj to enquire into revenue arrears & collect them.

Mubarak Khalji :

- ★ After Alauddin's death, his son Mubarak Khalji (1316-1320) succeded, after putting Malik Kafur to death. Mubarak took the title of 'Al Wasiq Billah' & declared himself the Khalifa.
- ★ He was killed by his beloved Khusrau Khan, a Islamicised Baradu (Hindu), who took the title of Nasir-ud-din, 1320 A.D. & became the only Hindu convert to become a Sultan of Delhi.

Nasir-ud-din :

Ghazi Malik, the Governor of Dipalpur & his son, Fakhr-ud-din Jauna beheaded Nasir & Ghazi ascended the throne under the title of Ghiyas-ud-din tughlaq (A.D.1320)

TUGHLAQ DYNASTY (1320-1414)

Ghiyas-ud-din Tughlaq (1320-1325) :

- ★ His son, Jauna Khan (Mohd Bin Tughlaq) was given the title of 'Ulugh' (Great) Khain. who made successful campaigns against Warangal, Jajnagar (Orissa), etc.
- ★ Ghiyas-ud-din was the first Sultan to Start irrigation works also built a strong fort called Tughlaqabad, near Delhi.
- ★ After the Sultan's successful march against Bengal, Ulugh Khan's hastily constructed wooden pavilion for Ghiya's welcome, collapsed & caused the Sultan's death. Suspected as Foul play by Asami & Ibn Batuta on the part of Ulugh Khan.

Muhammad Bin Tughlaq (1325-1351) :

Delhi Sultanat under him was divided into 13 'Maqtas' or provinces, like Lahore, Awadh, Malwa, Jajnagar etc.

* Ziauddin Barani mentions his five experiments, which had failed & thus raised a controversy about his personality.

i. Tughlaq transferred his capital from Delhi to Devagiri (Daulatabad), which was centrally located & strategically better for political control over his entire kingdom.

ii. His Qarachil expedition (1329-30) was launched in Kangra region to counter Chinese incurssions. The huge army successful here, ventured into Tibet, where they suffered severe set backs.

* 1329-30 - introduced token currency (bronze or that remained in circulation till 1331-31. to fill the gap in gold & silver reserves. Lack of proper checks led to minting of coins by all gold smiths.
* Agricultural reforms to enhance the land revenue to half the produce was inworkable as a famine hit the Doab area & the relief reached too late.
* He set up a separate department Diwan-i-Amir Kohi. Advanced huge sums as Taccavi Loans & encouraged farmers to grow superior crops.
* When his kingdom was ravaged by famine plague, he shifted to swargadhami, outside Delhi.
* During his reign Harihara & Bukka founded the Vijayanagara Empire (1336).
* Hasan Gangu founded the Bahmani Empire (1347).
* He died at Thattas when trying to quell one of the many rebellions during his reign & this was by Taghi who took shelter with Sumras of Thatta.

Firoz Tughlaq (1351-1388)

* led two unsuccessful campaigns in Bengal & others against Sind, Kangra, Jajnagar were only barely successful.
* Destroyed the Jagannatha temple at Puri & then desecrated the Jwalamukhi temple during his Nagarkot campaign from where 1300 Sanskrit manuscripts were translated into Persian by Arizuddin Khan under the title, 'Dalail-i-Firoz Shahi'.
* He refused to exempt the brahmins from Jaziya as he sought the return of 'Sharia' laws in full.
* He persecuted a number of heretical muslim sects & banned muslim women worshippers at the graves of Saints.
* He banned inhuman punishments. But a brahman was burnt publicity for questioning the Quran.
* He adopted a propulist appraoch in administration & wrote off all loans granted. Under Mohammad Bin Tughlaq & paid compensation for all those families whose kin were executed by Mohammad.
* Wrote off 23 taxes and substituted them with only four-Kharaj, Zakat, Jaziya & Khams - Sanctioned by Islamic law.
* Kharaj - 10% of the produce

  Zakat - 1lms for Muslims

  Jaziya - tax paid by Non-Muslims

  Khams - 20% of spoils of war.
* He employed a large number of slaves in his Karkhanas through the newly organised Diwani-i-bandagan (dept of slaves)
* He founded many new cities & towns, most famous being Hissar Firuza, Jaunpur & Firuzabad in Delhi.
* Ashokan pillars from Topara & Meerut were brought to Delhi on his orders (Firuzabad)
* Set up a separate department, , Diwan-i-khairat for the poor ,needy & Dar-ul-Shafa (Hospital).
* Got many Canals constructed

  i. Sirsa to Hansi

  ii. Sutlej to Dipalpur

  iii. Namuna to Sixmur.
* He introduced two new coins

  'Adha' - 1/2 Jital

  'Bikh' - 1/4 Jital
* He wrote the book, 'Futuhat-i-Firoz Shahi'.
* Had great respect for the Caliph of Egypt & called himself as his deputy & received robes of honour from the former.
* Revived the Jagir system that was abolished by Alauddin.
* His last years were marked by troubles & mental infirmity & hence the power went to the arrogant Prime Minister, Khan-i-Jahan Jauna Khan.
* Among the Tughlaqs (1388-1414), Nasir-ud-din 'Mahmud was the last ruler, who faced the onslaught of Timur, the great Mongol leader of Central Asia (1398). After this fatal blow the Delhi Sultanate disintegrated into provincial kingdoms & two of the important ones to follow were Sayyids & Lodis.

Sayyids (1414-1451) :

After the death of Nasir-ud-din Mahmud Daulat Khan Lodi became the Sultan, but was defeated by Khizr Khan (1414-1421) who was Timur's Viceroy of Multan & Dipalpur & thus was founded the Sayyid dynasty.

* Mubarak Shah (1421-1434) was the protagonist of Yahya-bin-Ahmad Sirhindi's - Tarikh-i-Mubarak Shahi. He was killed by his own nobles.
* Alam Shah's (1443-1451) throne was seized by Bahlul Lodi & Alam did not even contest it. Thus was founded the Lodi dynasty.

LODHI DYNASTY (1451 - 1526)

Bahlul (1451 - 1489) :

The first Afghan to rule India.

* He defeated the Sharqi Sultan's attempt to seize Delhi & annexed the Sharqi kingdom.

Sikindar Lodhi (1489-1517) :

* Son of Bahlul Lodhi & a Hindu wife, originally

- ★ Won over Sharqis, Rajput uprisings, Bihar & Chanderi, while Gwalior under Raja Man Singh, Tomara king, alluded him.
- ★ Introduced a new measurement yard called 'Ghaz-i-Sikandari'.
- ★ Founded Agra in 1506.
- ★ Wrote Persian verses under the name 'Gulrukhi'.
- ★ Sikandar accomplished the maintenance of markets & control over prices not through excesses like Alauddin Khalji.

Ibrahim Lodi (1517-1526) :

- ★ After succession dispute between two brothers - Jailal was put to death & Ibrahim became the Sultan.
- ★ He was defeated by Rana Sanga of Mewar & Babur (First Battle of Panipat, 1526).
- ★ Babur was invited by the Governor of Punjab, Daulat Khan Lodhi & thus was founded the Mughal empire in India.

Administration

- ★ Mostly based on the Turkish system & was slightly influenced by the existing Rajput system of government.
- ★ Sultan was the centre of all authority though he had gain legitimacy from the Caliphate as they ruled in the name of the Caliph.
- ★ 'Naib Sultan' enjoyed practically all the powers of the Sultan & exercised general central over various departments.
- ★ Wazir - Head of the finance department (Diwan-i-Wizarat).
- ★ Ariz-i-mumalik - Military head. (Diwan-i-Arz)
- ★ Sadr-us-Sudar - Public Charities & Ecclesiastiastical head (Diwan-i-risalat).
- ★ Qasi-ul-quzat - Judicial Head (Mostly Civil)
- ★ Amir-i-dad - Presided over the secular court (Mazalim)
- ★ Amir-i-munshi - Records-in-charge (Dept-Diwan-i-insha).
- ★ Barid-i-mumalik - Information & Intelligence head. (Chief Barid).
- ★ Amir-i-Mujlis - in-charge of assemblies, Feasts & Special celebrations.
- ★ Sar-i-jandar - Chief bodyguard of Sultan.
- ★ Provincial government was a replica of the central government.
- ★ Provinces, called 'Wilyat' or 'Iqlin' were plased under Governors 'Wali', 'Muqti', 'Naib' & Sometimes Sultan. Ex : According to Zia-ud-din Barani. There were 12 provinces under Alauddin Khalji.

  Provinces were divided into

  'Shiqs' - Under Shiqdar

  ↓

  'Paraganas' - Amil & Faujdar

  ↓

  Village - Muqaddam or Chandhari
- ★ Military Organisation was first taken up by Iltutmish, but the greatest interest in it was taken by Alauddin Khalji.
- ★ Alauddin & Ghiasuddin Tughlaq kept the soldiers economically satisfied.
- ★ Firuz Shh Tughlaq granted them hereditary assignments of land.
- ★ Army consisted of - Contingents of nobles
  - the Walis &
  - the Iqtadars
- ★ Iqtadari System took its roots, which is assignment of territorial areas or units whose revenues are given to officials in lieu of salaries.

Architecture

- ★ Qutub-ud-Aibak -
  - i. 'Quwwat-ul-Islam' mosque-raised on a Hindu Temple.
    - first mosque in India built on Indo-Islamic pattern.
  - ii. Arhai din ka Jhonpra - Ajmer
    - Originally a Sanskrit College.
  - iii. Qutb Minor - built in memory of Shaikh Qutb-ud-din Baktiyar Kaki
    - Aibak could complete only one storey
    - Four storeeps by Iltutmish
    - Firoz Tughlaq repaired it (Five Storeys)
    - Sikandar Lodhi also repaired it.

Iltutmish :

- i. Sultan Garhi - on the grave of his son, Nasir-ud-din Mahmud.
- ★ His tomb-near Quwwat-ul-Islam.
- ★ Considered the 'Father of tomb bulding'

Balban :

- ★ Tomb at Dila-i-rai pithora.
- ★ Strong Fortresses (boundry of N-W Sultanate).

Alauddin Khalji :

- ★ Alai Darwaza-entrance to Qutb Minar
  - Siri City
  - Mahal Hazaar Satoon
  - Jamait Khana Mosque

Ghiasuddin Tughlaq -

- ★ 'Tughlaqabad' - third city of Delhi.

Mohamad Bin Tughlaq :

- ★ 'Jahanpanah' - fourth city of Delhi.

Firoz Shah Tughlaq :

- ★ Firozabad - fifth city of Delhi.
  - Hauz Khas - Pleasure resort.
- ★ Jauna Shah - Tomb of Khan-i-Jahan Maqbul.
- ★ Tomb of Sikandar Lodi - has a double dome. Bodhi style - mixture of Turkish, Rajasthani & Gujarati.

Literature

- ★ Al-Beruni - 'Kitab fi tahqiq' (Indian Sciences)
  - 'Qanum-i-Masudi' (Astronomy)
  - 'Jawahir-fil-Jawahir (Mineraloges)
- ★ Hasan Nizami - 'Taj-ul-Maathir' (Ilbaris)
- ★ Minhaj-us-Siraj - 'Tabaqat-i-Nasiri' (History of Muslim Sultanate)
- ★ Amir Khusrau - 'Khzain-ul-Futuh' (Alauddin Khalji)
  - 'Tughlaq - Nama' (Ghiyasuddin)
  - 'Miffah-ul-Futuh' (Jalaluddin)
  - 'Khamsah' - consists of Multha-ul-Anwar, 'Shirin Khusrau', 'Laila Majnu', etc.
- ★ Ibn. Batutah - 'Kitab-ul-Rahla' - travellogue.

VIJAYANAGARA EMPIRE (1336-1569)

★ Founded by Harihara & Bukka of the Sangama dynasty in 1336, who were in the service of the Kakatiya ruler, Prataparudra II.

★ 1323-When Kakatiyas were overrun by Muslim rulers. They shifted over to Kampili, where the two brothers were imprisoned by Mohammad Bin Tughlaq & converted to Islam.

★ Returned into Hindu fold under the initiation of Sage Vidyaranya & founded a new city 'Vijayanagar' or 'Vidyanagar' on the banks of Tungabhadra.

★ Harihara conquered Hoysala & Kadamba kingdoms. Sent expeditions under Prince Savanna & Kumara Kampana. Kumara won over the Sultan of Madura & this was described by his wife, Ganga Devi in 'Madhura Vijayam'.

★ Three major contentious issues for the Vijayanagaras-

★ Tungabhadra Doab - started by Bukka I.

★ Krishna - Godavari delta - Deva Raya I

★ Marthuwada - Konkan area

Devaraya I (1406 - 1422) :

★ Faced the Bahmanis & Anadeva Choda with the support of Katayavema of Reddi kingdom.

★ Kept 1000 muslims in his army, thus becoming the first Vijayanagara king to do so.

★ built a barrage across the Tunga Bhadra for agricultural purposes & on the R. Harihara for irrigation pruposes.

★ Nicolo Conti describes the festivals like Dipavali, Navaratri & the imperial city.

★ Devaraya was the patron of the gifted Telugu poet, Srinatha, the author of 'Haravilasam', etc.

Devaraya II (1423-1446) :

★ Was the greatest of the Sangama dynasty rulers & was called 'Immadi Devaraya' & 'Proudha Devaraya'.

★ Was believed to be the incarnation of God Indra & was given the title 'Gajabetakara' (Elephant-Hunter)

★ An accomplished scholar in Sanskrit, he wrote 'Mahanataka Suddhanidhi' & a commentary on 'Brahma Sutras' of Badarayana.

Saluva Dynasty (1485-1505) :

Saluva Narasimha, ruler of Chandragiri region & a powerful feudatory usurped the throne from the last Sangama saved the kingdom from complete disruption.

★ He was defeated by Purushottama Gajapati.

★ His two sons, Timma & Immadi Narasimha were placed under the regency of Narasa Nayaka, who asserted his authority over Bijapur. Gajapatis & other small chiefs.

Tuluva dynasty (1503-1570) :

★ Narasa Nayaka's son Vira Narasimha established the Tuluva dynasty, when Immadi Narasimha was

★ **Krishnadevaraya (1509-1529)**, brother of Vira Narasimha was undoubtedly one of the most popular emperors of South Indian history.

★ He invaded Gulbarga & Bidar, restored the Bahmani Sultan to the throne & thus assumed the title 'Yavanarajya Sthapanacharya'.

★ Received Portuguese Governor, Alberqueque's ambassadors & gained the sole access to Arab & Persian horses in return for allowing Fort construction at Bhatkal.

★ Internal revolts, like that of Penugonda & extemal, like Gajapatis of Orissa were sucessfully tided over.

★ Great patron of art & Literature & was known as 'Andhra Bhoja', 'Abhinava Bhoja'.

★ His court adomed the 'Ashtadiggajas'

i. Allasani Peddana - 'Andhra Kavita-Pitamaha' works - 'Manuchoritam' - 'Harikatha Saramsamsamu'.

ii. Madayya - 'Rajasekharacharitam'.

iii. Nandi Timmana - 'Parijatapaharanam'.

iv. Dhurjati - 'Sri Kalahasti Mahatyam'.

v. Ayyalaraju Ramabhadra - 'Sakaramatasara Sangraham'.

vi. Pingali Surana ' -Raghova Pandaviyam' 'Prabhavati Pradyumnam','Kalapurnodayam'.

vii. Ramaraja Bhusana-'Vishnuchittam'

viii. Tenali Ramalinga - 'Panduranga Mahatyam'

★ Sri Krishna Deva Raya himself wrote -

'Amuktamalyada' (Telugu)

'Jambavati Kalyanam' (Sanskrit)

★ He built the temples of Krishnaswamy, Hazara Ramaswamy & Vitthalaswamy & Many 'Raya Gopurams' (towers).

★ built a new city, Nagalapura, named after his mother, Nagamba.

He was followed in quick succession by Achyuta Raya (1529-1542) & Sadasiva Raya (1543-1569), when the real power lay in the hands of Rama Raya.

★ Instigated by Rama Raya's foreign policy of setting up one ruler against the other, all the Deccan Sultans, (except Berar) joined hands & defeated the Vijayanagara forces in the Battle of Rakshasi Tangadi (1565).

★ Vijayanagara government shifted to Penukonda & then to Chandragiri whenre Aravidu dynasty (1570-1649) continued to rule under Rama Raya's brother, Tirumala & his successors.

★ The Nayakas of Vijayanagara like that of Tanjore, Madurai, Gingee, etc declared independence.

Administration

- King was at the centre based on the principle of benevolent absolute monarchy.
- Imperial Council - a gathering of Nayakas, from the provinces, feudal vassals, scholars, poets, merchants, artists & ambassadors of foreign kingdoms.
- Council of Ministers - 'Pradhani' was the fore runner.
- Ministers - title 'Dandanayaka'.
- The 'Rajya'kingdom was divided into

↓

Mandalams or Pithikas - Provinces

↓

Kottams / Nadus - Districts.

↓

Sthalas - Sub - Districts.

↓

Agrams/ Gramas - Villages

- Princes of Royal blood or Nayakas were in charge of the provinces.
- Nayakas were those who were granted lands by the king initially & became the officers & a community later down. They had to pay a fixed annual financial contribution to the king & maintain troops & serve him during the wars.

Foreign Travellers	Rulers under whom they visited
Athernius Nikitin-Russian	- Devaraya - I
Nicolo Conti - Venetian	- Devaraya - I
Abdur Razzak - Khurasan	- Devaraya - II
Domingo Paes - Portuguese	- Krishna Deva Raya
Duarte Barbosa - Portuguese	- Krishna Deva Raya
Fernao Nuniz - Portuguese	- Acharya Raya

Important Officials

Mudrakarta	- incharge of Royal Currency
Karanikam	- Accountant
Pradhani	- Chief Justice
Kavalkars	- Provincial Police Officers
Amaranayakas	- Military Feudatories

Bahmani Kingdom

- Came into existence during the rule of Muhammad Bin Tughlaq due to the rebellion of the Amiran-i-Sadahs in the Deccan.
- They elected Ismail Mukh as the Sultan, who assumed the title Alauddin Hasan Bahman Shah (1347-1358), with his capital at Gulbarga.
- Among his successors Taj-ud-din Feroz Shah after Muhammad Shah I were greatest.
- Ahmad Shah Wali (1422-1435) transferred the capital from Gulbarga to Bidar & his regin saw success against Vijayanagars & Malwa empire.

Bidar Phase :

Bahmani Prime Minister Mahmud Gawan (1463-1481) as the regent the Sultan Muhammad Shah III was the most glorious period.

- The rise of this 'Afagi' (West Asian) Prime Minister discontented the nobles (Deccani) & they, with the permission of the Sultan Ahmad Shah II executed Gawan, through a forged letter.
- After Gawan the Bahmani Kingdom disintegrated into five splinter kingdoms.

i. Nizam Shahis of Ahmadnagar (1490-1633).
   Founder - Ahmad Bahri
   Annexed by - Shah Jahan (1633)

ii. Adil Shahis of Bijapur (1490-1686)
   Founder - Yusuf Adil Shah
   Annexed by - Aurangzeb (1686)
   Famous for - Gol Gumbag & its whispering gallery.

iii. Imad Shahis of Berar (1490-1574)
   Founder - Fatullah Khan Imad-ul-mulk
   Annexed by - Nizam Shahis

iv. Barid Shahis of Bidar (1528-1619)
   Founder - Ali Barid
   Annexed by - Adil Shahis

v. Qutb Shahis of Golconda (1518-1687)
   Founder - Quli Qutb Shah
   Annexed by - Aurangzeb
   Famous for - Golconda, Charminar Hyderabad City - Mohammad Quli Qutb Shah.

Administration

- 'Sultan' at the centre of governance.
- Officials - Vakil-i-Sultan - regent
- Wazir-i-kul - Prime Minister
- Amir-i-jumla - Finance Department Head.
- Wazir Ashraf - foreign affairs & Royal Court.
- Peshawar - attached to the Vakil
- Sadr - i - Jahan - Judicial, Ecclesiastical Head.
- Tarafdars - Provincial Governors.

Other Provincial Dynasties

Malwa :

Founded by Dilawar Khan Ghuri, as noble under Firoz Tughlaq & Governor under his son, Nasir-ud-din Mahmud, with Dhar as his capital, after Timur left India.

- In 1406 Alp Khan ascended the throne with the title, Hushang Shah & made Mandu his capital, where his Marble Tomb exists.
- He followed a policy of religious tolerance &

founded the city of Hoshangabad, on the R. Narmada.

- ★ This Ghurid rule was ended by Mahmud Khalji (1436-1469) & thus began the Khalji dynasty rule. Mahmud established centres of Islamic learning & hospitals providing free medicine.
- ★ Ghiyas Shah (1469-1501) had Ethiopian & Turkish slave girls in the army who were his guards.
- ★ Mahmud Khalji II (1511-1531) appointed Medini Rai, the Rajput Chief of Chanderi, as his Wazir. But when this respect vapourized Medini Rai escaped to Gujarat.
- ★ A long war ensued between Rai Sultans of Gujarat, Muzzaffar Shah & Bahadur Shah & Rana Sanga on one side & Mahmud on the other, who was ultimately killed along with his sons.
- ★ Sher Shah Suri conquered Malwa & placed Afghan governors.

Gujarat :

- ★ Zafar Khan Governor of Gujarat under Mohd bin Firoz Tughlaq with the title Muzaffar Khan, founded the Muzaffari dynasty (1391).
- ★ Could come back to the throne only after poisoning, Tatar Khan his son (1407) who had taken over Gujarat.
- ★ Shihabud-din Ahmad Shah (1411-1442), son of Tatar Khan succeeded & ruled for 31 yrs - fighting the confederacy of Rajputs Malwa.
- ★ Founded the city of Ahmedabad & shifted his capital there from Patan.
- ★ Mahmud 'Begarha' (1459-1511) was the greatest Muslim ruler of Gujarat who conquered the two strong Rajput forts (garh) - Girnar & Chanpaner.
- ★ Great patron of architecture.
- ★ Several references to him in the works of Varthema (Italian) & Barbosa (Portuguese).
- ★ His only serious threat was from the portuguese, against whom he allied with Egyptian Mamluk Sultan & Junagarh's Governor but lost out in the battle of Chaul (1508).
- ★ Negotiated for peace with Alberqueque.
- ★ Bahadur Shah (1526-1537) recovered the lost territory to Humayun when the latter had to tackle Sher Shah Suri.
- ★ His master gunner, Rumi Khan helped him to conquer Chittor.
- ★ Porguguese, his allies since 1535 drowned him in the sea while negotiating with him.
- ★ Muzaffar III reign saw the find annexation into Mughal empire by Akbar.

Jaunpur :

- ★ The city was founded by Firuz Tughlaq.
- ★ The last Tughlaq king, Sultan Mahmud conferred on the eunuch, Malik Sarwar the title of 'Malik-us-Sharq' (Chief of the East) powerful kingdom, won against Tirhut, Bengal & Delhi.
- ★ For its promotion of learning & culture, Jaunpur earned the title of 'Siraz of India' or 'Siraz of the East' & was known for its cultural synthesis.

Bengal :

- ★ Submission to the Delhi Sultans was nominal from the time of its conquest by Bakhtiyar Khalji to its complete independence.
- ★ Ghiyasud-din Tughlaq divided the kingdom of Bengal into three administrative divisions-
  - Lakhnauti as the capital of North Bengal
  - Somargaon East Bengal
  - Satgaon - South Bengal
- ★ Bengal was finally united under an independent ruler, Shamsuddin Ilyas Shah (1345-58) & Firuz Shah Tughlaq made peace with him.
- ★ Ghiyasuddin Azam Shah (1390-1410) had diplomatic relations with China & was famous for imparting justice.
- ★ 1415-Raja Ganesh of Dinajpur or kans, a leading noble, asurped the throne for a brief period & was ousted by Ibrahim Shah Sharqi of Jaunpur with the support of the Ulema & Sufis.
- ★ After being ruled by Ethiopia until 1494. Bengal came into the hands of an Arab, **Alauddin Husain Shah(1494-1519)** who was the greatest independent ruler of Bengal.
- ★ He was honoured both by Muslims & Hindus & the latter considered him as an incarnation of krishna, 'Nripati Tilak' (Crown of & 'Jagat Bhushan' (Adornment of the (Kings). Universe)).
- ★ Chaitanya preached Vaishnavism in Bengal & Orissa during his rule.
- ★ Alauddin started the Satyapir movement.
- ★ His Court was adorned by famous writers like Rupa, Sanatan, Maladhar Basu who wrote 'Srikrishna Vijaya' & was given the title of 'Gunraja Khan'.
- ★ Bengal was annexed by Akbar in 1575 A.D.

Assam :

- ★ Two Hindu Kingdoms ruled over Assam during Bakhtiyar Khalji's conquest

  West - Kamata or Kamrup - Guwahati (capital)
  North-East - Ahon - Chiefs called 'Bhuyans'.
- ★ 1515 - Koch tribe established its rule over Kamarupa, which was later divided into Kooch Bihar & kooch Hajo.
- ★ The Ahom kings were related to the 'Shans', & after a spate of Bengali Sultan's invading them, which were all successfully repulsed, came the great Ahom ruler, Suhungmung.

North Eastern hills & made Ahoms very powerful.

Kashmir :

- ★ Attempts to capture were made by Muhammad Bin Qasim & Mahmud Ghazni but were not successful.
- ★ Rinchana, a Tibetan Buddhist Commander-in-chief of the Hindu ruelr of Kashmri, Suhadeva seized the throne, but later converted to Islam & called himself Sadruddin.
- ★ Shah Mir, under the title Shamsuddin established the Shah Shah Mir dynasty in 1339 AD & started the Turkish system of granting Iqtas to his commands, both Hindu & Muslim.

Sikander (1389 - 1413)

- ★ Under his reign Timur had invaded India & entered into a diplomatic negotiation with Kashmir.
- ★ He was an iconoclast, for which he came to be known as 'But Shikan'.
- ★ He sought to enforce the policy of religious conversion and many temples during his reign were descrated.
- ★ He persianised the administration & also the life of the Kashmiri muslims.
- ★ He abolished the practice of 'Sati' & imposed 'Jaziya' for the first time but later himself abolished it.

Zain-ul-Abidin (1420-1470) 'Badshah' (title) :

- ★ Completely reversed all the policies of Sikander by rebuilding temples, encouraging Brahmins to come back to kashmir, removing the prohibition on Sati.
- ★ A patron of education & learning founded Muslim schools in Srinagar with famous scholars & grants to students.
- ★ Established a separate department to translate Sanskrit works into Persian & Vice - versa.

  Ex : 'Mahabharata' & Kalhana's 'Rajatarangini'.
- ★ Jonaraja & Srivara were patronised by him.
- ★ Sent his artisans to Samarkhand to learn the art of Paper - making & Book-binding.
- ★ Patronised stone polishing, stone cutting, window cutting, manufacture of powder for fireworks & other crafts.
- ★ Fostered the development of agriculture by building many canals, tanks & dams.
- ★ 1561-Kashmiri Chake established the dynasty which was won over by Akbar in 1588 A.D & Kashmir was annexed into Mughal empire.

Regional Architecture

- ★ Atala Devi Masjid - built by Ibrahim Shah Sharqi in Jaunpur.
- ★ Manda-has Hushang Shah's tomb, Jami Masjid, Hindola Mahal, Jahaz Mahal.
- ★ Adina Masjid - built by Sikander Shah in Pandua.
- ★ Chota Sona Masjid-by Wali Muhammad in the reign of Hussain Shah at Gaur.
- ★ Bara Sona Majid - by Nusrat Shah in Gaur.
- ★ Qadam Rasul - in Ahmedabad.
- ★ Jami Masjid - Gulbarga.
- ★ Chand Minor - Daulatabad
- ★ College of Mahmud Gawan - Bidar.
- ★ Gol Gumbaz, Bijapur - Tomb of Mohammad Adil Shah.
- ★ Ibrahim Rauza - Tomb of Ibrahim II.

MUGHAL EMPIRE (1526-1862)

Babur (1526-1530) :

- ★ Zahiruddin Muhammad Babur was a descendant of Timur on his father's side & of Chengiz Khan on his mother's side.
- ★ His ancestral kingdom was of Farghana from his father, Umar Shaikh Mirza.
- ★ 1526-Battle of Panipat-defeated Ibrahim Lodi.
- ★ 1527 - Battle of Kanwah - defeated Rana Sanga.
- ★ 1528 - Battle at Chanderi - defeated Medini Rai.
- ★ 1529 - Battle of Ghagra - Afghan chiefs under Mahmud Lodi.
- ★ He wrote his memoir in Turki called 'Tuzuk-i-Baburi' or 'Babarnama', which was translated into Persian by Abdur Rahim Khan-i-Khana, son of Akbar.
- ★ Babur died at Agra was buried in Arambagh, but was later shifted to Kabul.

Humayan (1530-1556) :

- ★ He inherited the kingdom with almost bankrupt treasury & powerful forces like Malwa, Gujarat & Bengal to contend with.
- ★ He divided the empire among his brothers -
  - Kamran - Governor of Kabul, Qandhar & Punjba
  - Hindal - of Alwar & Mewat
  - Mirza Askari - of Sambhal &
  - Mirza Sulaiman - of Badakshan.
- ★ He built a new city, Dinpanah.
- ★ He was defeated by Afghans, under Sher Shah Suri at Chausa near Buxar in 1539 A.D. & at Kannauj in 1540 AD in the Battle of Bilgrama & had to take flight from Delhi.
- ★ After 15 years in exile, Humayun came back & captured Lahore in 1555 AD. He defeated the Afghans near Sirhind in 1555 & thus regained his throne.
- ★ 1556 - Died after falling from the steps of his library.

Akbar (1556-1605) :

- ★ He was born in 1542 at Amarkot in the Palace of

Rana Prasad, to Hamida & Humayun.

- ★ On Humayun's death, Bairam Khan corronated Akbar as the Sultan at Kalanaur & himself became his regent.
- ★ 1556-60 was known as Bairam Khan's regency. who led the Mughal army to victory in the second Battle of Panipat (1556) against Hemu, the wazir of Muhammad Adil Shah of Bihar.
- ★ 1560 - He was slain by Mubariz Khan at Pataw & Akbar married his widow.
- ★ 1562 - on his first pilgrimage to the Shrine of Khwaja Muinuddin Chisti at Ajmer, Raja Bharmal of Amber gave his daughter in marriage to Akbar, which was followed by practically every other Rajput principality, except Mewar, thus establishing the strong Mughal-Rajput alliance.

Military Successes :

- ★ **1567-68 :** Seize of the Fort of Chittor.
- ★ **1569 :** fall of Ranathambore.
- ★ **1570 :** Marwar & Bikaner
- ★ **1572 :** Gujarat
- ★ **1576 :** Battle of Haldighati (Raja Man Singh Vs (Mewar did not give up) Rana Pratap Singh).
- ★ **1581:** Kabul from his half-brother Mirza Hakim
- ★ **1592 :** Orissa
- ★ **1593 :** Khandesh
- ★ **1595 :** Kandhahar
- ★ **1600 :** Ahmadnagar under Chand Bibi.
- ★ **1601 :** Asirgarh (last campaign of Akbar)
- ★ Abdur Rahim, son of Akbar & Bairam Khan's widow, was given the title of Khan-i-Khana after the Supression of revolt at Gujarat.
- ★ Raja Birbal died in a campaign against the Yasu F-Zahis.
- ★ Liberal Measures

  1563 - Abolished the pilgrim tax

  1564 - abolished Jaziya
- ★ Religious Measures -
  - 1575 - Constructed the Ibadatkhana (Hall of Worship)
  - 1578 - Converted the Ibadatkhana into a 'Parliament of Religions' where religious discussions were held. Hindu Scholar-Purushottam Das.

    Parsi - Maharaji Rana

    Jain - Harivijaya Suri

    Christian - Monserette & Aqvariva
  - Akbar read the Khutba composed by Faizi in his own name.

    Declaration or Mazhar by Shaikh Mubarak & Akbar became the Imam-i-Adil.

    Akbar enunciated the order known as 'Din-i-Ilahi' or 'Jauhind-i-Ilahi' (Divine Monotheism)
- ★ The basic purose of this order was 'Sulh-i-kul', which is universal harmony.
- ★ Abdul Fazl, Akbar's most trusted general, was murdered by Bir Singh Bundela.
- ★ 1602 - his son, Salim rebelled.
- ★ Akbar died after an attack of dysentry in 1605.
- ★ He was buried at Sikandara & his tomb also marks the spirit of religious tolerance that he practiced all his life.

Jahangir (1605-1627) :

- ★ Salim, son of Jodhabai & Akbar took the title of Jahangir (World Conquerer) & ascended the throne at Agra in 1605.
- ★ He married Manbai & had a son Khusrau, who revolted against Jahangir in 1605 A.D. at Lahore.
- ★ The fifth Sikh Guru, Arjun Singh was executed for supporting Khusrau.
- ★ 1611-He married Mehrunnisa, daughter of a Persin Mirza Ghiyas Beg & gave her the title of 'Nurmahal' & later 'Nurjahan'.
- ★ 1613 - She was called 'Padshah Begum'.
- ★ Her father got the title 'Itimaduddaulah' & brother - 'Asaf Khan' who was the 'Khan-i-Saman'.
- ★ 1615 - Amar Singh of Mewar submitted.
- ★ Malik Ambar was successful in capturing Ahmadnagar from the Mughals.
- ★ 1620 - Jahangir annexed kangra.
- ★ 1622 - Kandhar was rested from Shah Abbas of Persia.
- ★ The British landed in Machilipatnam during his reign.
- ★ His Court was visited by representatives of King James I of England, Captain Hawkins & Sir Thomas Roe (1615-1619).

Shahjahan (1627-1658) :

- ★ Khurram, son of Jagat Gosain & Jahangir & son-in-law of Asaf Khan, whose daughter was Arjumand Bano Begum or Mumtaz Mahal.
- ★ 1607 - he was granted a mansab of 8000 zat.
- ★ Became the ruler after murdering all possible contenders to the throne.
- ★ Suppressed the rebellions under Bundela Chiefs, Juhar Singh & Khan Jahan Lodi.
- ★ 1632 - ousted Portuguese from Hugli.
- ★ 1636 - annexed the Nizamshahi Kingdom of Ahmadnagar & Aurangzeb was appointed the Viceroy of Deccan.
- ★ 1639 to 1647-tried to capture the Mughal

end.

- ★ His reign was described by French travellers, Bernier & Tavernier & the Italian traveller, Manucci.
- ★ Peter Mundy described the famine that occured during Shah Jahan's time.
- ★ 1638 - Ali Mardan Khan, the Persian Governor of Kandhar surrendered the fort to the Mughal government of Kabul.
- ★ It was lost ot the Persians in 1649, which is called the 'Permanent loss of Quandhar'.

Aurangzeb (1658-1707) :

- ★ In the war of succession after Shah Jahan's death, Shuja, king at Rajmahal was defeated by Sulaiman Shikor, son of Dara.
- ★ Murad crowned himself at Ahmedabad & Aurangzeb & Murad agreed to fight together & then partition the empire.
- ★ 1658 - they defeated Jaswant Singh & Qasim Khan at Dharamat & also Dara Shikov at Samugarh, which decided the issue of succession.
- ★ 1659 - Shuja was defeated by Aurangzeb at Khajwah.
- ★ 1659 - Dara Shikov was defeated at Deorai & Bernier saw Dara being paraded. He was later buried near the tomb of Humayun.
- ★ 1658 Aurangzeb first coronation year as Alamgir & 1659 his second coronation year after which he abolished inland transit duties ('Rahdari') Octroi (pandari) many cesses (abwabs).
- ★ 1659-he issued ordinances to restore the Muslim law of conduct based on Quranic preachings.

  Ex : discontinued inscribing 'Kalima' on the coins
  - abolished 'nauroz' celebrations
  - 'Muhtasibs' or Censors of public morals were appointed.
  - 'Jharokadarshan' discontinued.
- ★ Customs duty on commodities brought in for sale was fixed at 2% and valorem for Muslims & 5% Hindu-Merchants.
- ★ 1679- Jeziah was reimposed.
- ★ Astronomers & Astrologers were dismissed.
- ★ 1662 - Mir Jumla, Aurangzeb's ablest general concluded a favourable treaty with the Ahoms, against whom Shah Jahan also had fought.
- ★ 1663 - Mir Jumla died on his way back to Decca & Ahoms reoccupied Kamarupa.
- ★ His successor Shaista Khan Chastised the Portuguese pirates & annexed the island of Sumadeep & Chittagong.
- ★ 1674 - Aurangzeb himself directed the operations against tribal uprisings in the North-East.
- ★ 1669-70 - Jat Peasantry at Mathura nose under the leadership of Gokala in rebellion.
- ★ 1672 - Satnami peasants in Punjab (Narnaul & Mewat).

  - Bundelas under Champat Rai & Chatrasl Bundela.
- ★ 1667- Afridis revolted under Akmal Khan

  - Khattaks under Khush-hal Khan.
- ★ 1685-Jats revolted again under Rajaram, who plundered Akbar's tomb at Sikandara.
- ★ Aurangzeb's Rajput policy alienated the latter. On the death of Jaswant Singh, Aurangzeb gave the 'tika' of Jodhpur to his nephew, Inder Singh. instead of his posthumous son, Ajit Singh.
- ★ Durga Das Rathore, Rana Raja Singh, Rani Hadi & Ajit Singh rebelled. Akbar II, S/o Aurangzeb also joined them & hence in 1698 Ajit Singh was recognised as the ruler of Marwar.
- ★ But Akbar II took shelter with the Maratha king, Sambhaji, which brought Aurangzeb to the Deccan from where he never left.
- ★ His Deccan policy is divided into four phases
  - i. 1658-68 was led by Jai Singh, his general The Mughals lay seize to Bijapur in 1665 & Sholapur was secured by bribery.
  - ii. 1668-84 was unsuccessful because of a tripartite alliance between Golconda, Shivaji & Bijapur, in which Madanna & Akanna played a crucial role.
  - iii. Capture of Bijapur (1686) & Golconda (1687).
  - iv. Capture of Sambhaji at Sangameshwar, where he was executed.
- ★ 1675 - He executed the Ninth Sikh guru, Teg Bahadur, which led to the Creation of 'Khalsa' under Guru Gobind Singh.

MUGHAL ADMINISTRATION

- ★ Emperor was the supreme commander of the armed forces.
- ★ The Mansabdari System, introduced in 1570, was a means to organise the nobility & the army.
- ★ The Mansabdars were classified into 66 grades, but in practice only 33 grades were constituted.
- ★ Mansabdar meant 'holder of a rank'. There were two ranks -
  - (i) 'Zat' fixed the status & standing in the administration hierarchy.
  - (ii) 'Sawar' fixed the number of troopers held by the mansabdar.
- ★ Classification of Ranks -

  'Zat' rank below 500 - Mansabadar

  between 500 & 2500 - Amir

  more than 2500 - Amir-ir-Umda.

- For every Sawar a mansabdar had to maintain two horses. There were 6 categories of horses & 5 categories of musles.
- Jahangir introduced the Duaspa Sih Aspa system. He reduced the average salary of a Sawar.
- Shahjahan introduced the monthly scale & assigned 'Jagir's were registered & incame assessed.
- Aurangzeb reign witnessed the most number of Mansabdars.

ADMINISTRATION TERMS

- Wakil - Prime Minister - power stripped by Akbar & replaced by a 'Diwan'- the principal revenue advisor.
- Mir Bakshi - Head of Military & Intelligence dept.
- Khan-i-Saman - Head of Imperial household & the 'Karkhanas'.
- Chief Qazi - Head of Judiciary dept.
- Sadr-us-Sudur - Religious endowments & Charities dept in-charge.
  Also the Chief Justice.
- Muhtasib - Censor of public morals.
- Mir Atish or Daroga-i-Topkhana - Head of Artillery.
- Daroga-i-Dak Chowki - Head of Correspondence dept.
- Mir Maal - Lord Priry Seal
- Mustaufi - Auditor - General.
- Nasir - i- Bayutat - Superintendent of imperial workshop.
- Mushrifi - Revenue Secretary
- Mir Bahri - Lord of Admirality.
- Waqia - Navis - News Reporters.
- Mir-i-Arz - Inchar of Petitions
- Mir manzil - Quarter master General
- Mir Tozak - Master of Ceremonies.
- Kotwal - Looked after public order & Quranic rules of morality (Chief of the city Police)

Empire
↓
Provinces - 'Subahs'
↓
Districts - 'Sarkars'
↓
Groups of Villages - 'Paraganas'
↓
Unit for administrative convenience - 'Faujdaris'.
↓
Military Outposts - 'Thanas'.

- Faujdar - maintained law & order in Sarkars.
- Muftis - Expounded Muslims law.
- Mir Adl - Drew up & pronounced judgements

Paraganas.

- Bitakchi - Writer or record - keeper.
- Khazandar - Trasurer.
- Amil - Judicial Officer in civil & revenue disputes.
- Shikdar - Incharge of law & order in Paragans.
- Harkarah - Spy & Courier.

Land Revenue System :

- Sher Shah Suri's administrative set up was followed until Akbar's 8th year of rule (1564) & was established as a separate Mughal set up only in 1580.
- During Akbar's rule there were three kinds of lands in the counrty.
  i. Khalsa or Crown Land.
  ii. Jagir - noble's land who sent a share to the king.
  iii. Sayurghal - free grants
- The Mughal system was a tax and crop set up & not a rent or a land tax.
- 'Nasq' or 'Kankut' was the system, wherein an estimate of the produce was made by the Government officials.
- 'Muqtai' system: It was a fixed revenue demand leased in Cash.
- 'Zabti' or 'Bandobast' System : Under Raja Todar Mal, an important revenue officials a new 'Jama' was calculated based on figures by the 'Qanungos'.
- 'Ain-i-Dahsala' - Todar Mal improved over Zabti system, through these fresh reforms in 1580. Under this, the land was classified into four categories based on its cultivation frequency -
  i. Polaj - annually cultivated
  ii. Parauti - left fallow for 1 to 2 years.
  iii. Chachar - left fallow for 3 to 4 years.
  iv. Banjar - uncultivated for 5 years or more.
- Further, according to Abul Fazl, based on this classification, a 10-year state of every paragana was ascertained, average cash rate of previous 10 years harvest was derived & tax fixed, once for all.
- This system was adopted by the East India Company in the Ryotwari System.
- Land was measured by a new jarib which was bamboo clipped with iron range (earlier rope was used).
- The unit of measurement, introduced by Todar Mal in 1588 was Ilahigaz.
- 'Nankar' 1/10th of the produce given as allowance to the Zamindar.
- 'Malikana' Compensation for imposts &

* 'Muzarian' : Low caste share-croppers.
* 'Khudkashta' - Resident Cultivators called 'Mirasdars' in Maharashtra 'Gaveti' in Rajasthan.
* 'Pahikashta' : Non-resident cultivators.
* 'Begar' : Forced labour
* 'Dhenkali', 'Cholas', 'Saqiya' : used for irrigation.

Mughal Architecture

* Babur - 3 mosques
  i. Sambhal in Rohikhand
  ii. Kabulibagh in Panipat
  iii. In the old Lodhi fort at Agra
* Humayun :
  - Palace at Dinpanah ('World Refuge')
  - Jami Masjid
  - His tomb was built by his widow,Haji Begum - a Proto-type of Taj Mahal
* Akbar
  - Palaces at Agra - Akbari Mahal (based on Man Mandir)
* Forts at Lahore & Allahabad.
* Panch Mahal has the plan of a Buddhist Vihara.
* Shaik Salim Chisti's tombs Mariyam Palace.
* Began his own tomb's construction at Sikandara - completed by Jahangir.
* Jahangir :
  - Moti Masjid in Lahore
  - His own tomb at Shahadra in Lahore
  - Nur Jahan built a tomb for her father, Itimadudaullah at Agra.
  - A new technique was borrowed from the Golmandal temple, Udaipur - Pietradura.
  - Shalimar bagh at Srinagar.

Shah Jahan :

* The Taj Mahal for Muntaz Mahal - Chief architects were Vastad Ahmad Lahori - 'Nadir-ul-Asar' (title), Mir Abdul Karim, Isa Khan & Makkaramat Khan.
* Red Fort with its own Diwan-i-Khas & Rang Mahal.
* Peacock Throne by Bebadal Khan.
* New capital City, Shahjahanabad, which housed the biggest mosque in India-the Jami Masjid.

Aurangazeb :

* Moti Masjid in Red Fort.
* Jami or Badshahi mosque at Lahore.
* His Queen, Rabirud-daurani's tomb, built by their son at Aurangabad.

Mughal Paintings

* Mir Sayyid Ali, the pupil of Bihzad of Herat who has been named the 'Raphael of the East' & Khwaja Abdur Samad were in the court of Humayun & helped prepare the illustrations to the 'Dastan-i-amir-Hamza'.
* During Akbar's reign Abdur Samad, Farukh Beg, Khusrau Quli, Jamshed, Basawan, Lalkesu, Mukund, Haribans & Daswanth were prominent painters.
* Daswanth painted the 'Razm Nana' (Persian Mahabharata)
* Abdul Samad was given the title 'Shingalam'
* Jahangir could tell the names of individual artists in a composite piece of painting.
* In his court Aga Reza, Abul Hasan of Herat, Mohd. Nadir, Mohd. Murad, Ustad Mansur, Bishan Das, Manohar, Govardhan, etc were prominent.
* Miniature painting developed under him.
* European influence also began to be experienced under Jahangir's reign.

Sher Shah Suri's Dynasty (1540-1555)

* Childhood name - Farid
* Entered the service of Bahar Khan Lodi, the Afghan Governor of South Bhar, Who gave him the title 'Sher Khan'.
* Sher Shah's last compaign was against kalinjar where he was victorious, but died due to an accidental explosion (1545).His Masouleum was constructed at Sikandara

  He was the first ruler to use silver 'Rupaiya'
* Succeeded by his son Islam Shah.
* 1555 - Sikandar - Suri was defeated by Humayun.

Sher Shah's Administration :

* Highly centralised government based on autocratic monarchy.
* Divided his empire into 47 Sarkars, which were again divided into several Paraganas & inturn into Villages.
* He made the 'Muqaddam' (Villages head) & Zamindars responsible for local crime.
* Got many Sarais built for resting of travellers & traders, around which 'Qasbahs' or market towns emerged.
* Got the grand trunk road built from Sonargaon to Attock.
* Improved the Land revenue system by adopting 'Zabti-i-har-saal' using 'Gaz- i-Sikandari'
* Introduced two documents 'patta' (amount each peasant had to pay) & 'Qabuliyat' (dead of agreement).

Mughal Literature

* Abdul Fazl - 'Akbarnama' & 'Ain-i-Akbari'
* Gulbadan Begum - 'Humayun - Namah'
* Mulla Daud - 'Tarkish-i-Alfi'.

* Abbas Khan Sherwani - 'Tarikh-i-Sher-Shahi'
* Abdul Qadir Badyuni - 'Mintakhab-ul-Tawarikh'
* Nizamuddin Ahmad - 'Tabaqat-i-Akbari'
* Faizi Sarhindi - 'Akbarnama'
* Abdul Hamid Lahori - 'Padshah Namah'
* Inayat Khan - 'Shah Jahan Namah'
* Khafi Khan - 'Muntakhab-ul-Lubab'
* Mirza Muhammad Kasim - 'Alamgir Nama'
* Iswar Das - 'Futuhat-i-Alamagiri'
* Nimat Khan Ali - 'Waqai-i-Hyderabad'
* Bhimsen - 'Nushka-i-Dilkusha'

FOREIGN TRAVELLERS

* Akbar - Father Antonie Monserrette, Ralph Fitch
* Jahangir - William Hawkins, William Fitch, John Jourdian, Nicholas Downton, Nicholas Withington, Thomas, Cryer, Sir Thomas Roe, Edward Terry, Pietra dela Vale, Poelsart.
* Shah Jahan - Tavernier, Peter Mundy, Bernier
* Aurangzeb - Bernier, Manucci, William Norris

BHAKTI MOVEMENTS

* The concept of 'Bhakti' was put forth right in the 6th C A.D. but became most popular during the medieval times all over India.
* The 'Alvars' (Vaishnavaites) & Nayanars (Shaivites popularized the cult in South India.

Adhi Shankara Charya :

* Born in Kaladi ,Kerala in 788 A.D.
* Propounded Advaita philosophy.
* Wrote commentaries on 'Brahmasutra's 'Upanishads' Gita. .
* Believed in 'Maya' as the world of appearance is illusory.
* The individual soul is absolute in itself & no other.
* 'Gyana' alone can lead to salvation.
* His books - 'Upadesh Shastri', 'Viveka Chudamani' 'Bhaja Govindam' Stotra, etc.
* Established Mathas at Sringeri, Dwaraka, Puri & Badrinath.

Ramanuja (12th C)

* born in Sripenumbur.
* Opposed Mayavada of Shankara & advocated the philosophy of 'Vishishtadvaitavada'
* founded the Shrivaishnava sect.
* Wrote 'Sribhashya', 'Vendanta dipa & 'Gita Bhashya' etc.

Ramananda (1360-1470) :

* born in Allahabad & settled in Varanasi.
* founded Ramanandi sect.
* Had 12 disciples from all castes. Some of whom are - Anantananda, Kabir, Pipa, Bhavananda, Narhari, Raidas, Dhanna, Sena Sursura & wife of Sursura.
* His teachings gave rise to two schools of thought in the orthodox (saguna) represented by Nabhadas & Tulsidas, the author of Ramcharit Manas.
* The liberal school represented by (Nirguna) Kabir, Nanak & others.

Kabir (1440-1510) :

* Born near Benaras & brought up by a Muslim Weaver
* Married to Loi & had 2 children.
* believed to have been persecuted by Sikandar & died oat Maghar (UP).
* His 'Dohas' & 'Sakhi' (poems) are found in the 'Bijak' & are very popular.
* believed in Pantheism, i.e. God is everywhere.
* Wanted inter-religious & intra-religious unity.
* abandoned formal religious practices.
* formulated a code of ethics for every human to follow.
* Was against all forms of sectarianism, but on his death his Muslim disciples organised themselves in Maghar monastery & Hindu disciples formed an order under Surat Gopala at Varanasi.

Guru Nanak (1469-1538) :

* Born near Talwandi (now Nanabana in Pakistan).
* preached Casteless, universal, ethical, anti-ritualistic manotheistic & highly spiritual religion.
* Started free community kitchens called 'Guru ka langar' to inculcate the feeling of equality & brotherhood among his followers.
* Laid stress on the purity of character conduct & also the need of a 'guru' to reach the god, who was 'Nirakara' (formless).
* His mission was to reform Hindu religion on the basis of monotheism.
* His inspiring poems were later collected in the 'Adigrantha'.
* 1538-he died at Kirtarpur.
* His followers founded a new religious sects, Sikhism & it had ten Gurus.

  i. Guru Nanak
  ii. Guru Angad
  iii. Guru Amardas
  iv. Ramdas - Akbar granted him the land at Amritsar, where the Golden Temple now exists.
  v. Arjanmal (1581-1606) - Compiled Adi Granth

vi. Hargobind (1606-1645) - Militarised the Sikh sect & defeated the Mughal army at Sangama near Amritsar.

vii. Har Rai

viii. Har Kishan

ix. Tegh Bahadur - executed by Aurangzeb

x. Govind Singh - instituted the custom of Baptism thus formed the 'Khalsa'.

- compiled 'Daswen Padshah ka Granth'
- stabbed to death by an Afghan fanatic.

Dadu Dayal (1544-1603) :

* Born in Ahmedabad
* Preached in Rajasthan
* Most famous follower of Kabir's teachings.
* founded 'Brahmasampradaya' or 'Parabrahma - Sampradaya' to unite all divergent faiths in one bond of love.
* Believed in self-realization that God is within the hearts of men.

Mulukdasa (1574-1682) (Allahabad)

* disciple of Kabir.
* his manasteries are found from Bihar to Kabul.
* Against the worship of images & other external forms of religion.

Saguna (Orthodox) School :

Chaitanya (1486 - 1533) (Naradvip)

* Originally Vishwambhar Mishra or Nimai & belonged to the Dasmani Sect.
* Started the Achintyabheda Bhedavada
* spent his time preaching in Orissa & Bengal.
* 'Chaitanya Charitarta', his biography was written by Krishnadas Kaviraj.
* expressed himself by 'Sankirtan' or group singing.
* His follows organised themselves into a sect called 'Gaudiya Vaishnavism'.
* settled & died at Puri, Orissa.

Surdas (1483-1563) :

* Devotee of Lord Krishna & Radha and popularised this cult in UP, especially the Childhood glories of Krishna.
* His famous works - 'Sur Sarawali' 'Sahitya Ratna' & 'Sur Sagar'.
* Disciple of Vallabhacharya.

Tulasidas (1532-1623) :

* Born in Varanasi.
* took to life of a hermit due to wife, Ratnavali's taunt.
* Worshipper of Rama & composed the famous 'Ram Charitamanas' in Hindi in 1574.
* Other works - 'Gitawali', 'Kavitawali', 'Vinay Patrika'.
* Considered as a great Vaishnava 'bhakta' & 'acharya'.

Vallabhacharya (1479-1531) :

* Born at Varanasi into a Telugu family.
* Great saint of Krishna cult & called him 'Srinathji'.
* Founder of 'Suddhadvaita' (Pure Non-Dualism) School of philosophy.
* His teachings are also known as 'Pushtimarga' or the path of grace.
* He founded the Rudra Sampradaya.

Madhavacharya (13th C) :

* Born in South Kanara district.
* Founder of the 'Dvaita' (Dualism) school of philosophy.
* According to him, the world is a reality & not an illusion, which is pull of real distinctions.

Nimbarka (13-14th C) :

* 'Dvaitadvaita' (Dualistic Monism)school of Philosophy.
* Established an ashrama of Brja (Mathura).
* founded the Sanak Sampradaya.
* His Philosophy is of Bheda Bhada.

Mirabai (1498-1546)

* Born to Raja Ratna Singh Rathor of Mewar.
* Married to Rana Sanga's eldest son & heir apparent, Bhojraj
* Undertook pilgrimage to Dwaraka & composed her very popular lyrics in Brijbhasha & Rajasthani in the love of her Lord Krishna.

MAHARASHTRA DHARMA

Jnanadeva (13th C) :

* Founder of Bhakti movement in Maharashtra.
* His famous work is 'Jnanesvari', which is a commentary on the Bhagavatgita & is also called 'Bhavarta dipika'.

Namdeva (14th C) :

* Preached gospel of love & opposed caste - system & idol worship.
* His followers belonged to all castes & chief disciles were Gora (potter), Sena (barber), Choka (untouchable), Janbai (maid), etc.

Eknatha (16th C) :

* Opposed Caste distinctions.
* Composed 'abhangas' (lyrical poems) & was reputed for his bhajans & Kirtans.

Tukaram (17th C) :

* Contemporary of Shivaji & a great devotee of Vithal of Pandharpur.
* A Sudra by birth & founded the Varkari sect.

* Worked for Hindu-Muslim unity.
* Against all social distinctions & thus the laid the foundation for Maratha Nationalism.

Somnath Ramdas (17th C) :

* Guru of Shivaji who combined spirituality & practical life
* Was a Dharakari, which was apposed to Varakari
* Author of 'Dasabodha', which gave advice on all (Dasabodha) mothers of Life.

SUFISM

* Sufis are deeply devoted mystics who believed in the basic doctrine of 'Wahadat-ul-Wujud' or the 'Unity of the Being" - between the creator & the created.
* The term 'Sufi' is derived from 'Suf' or Coarse wool
* 'Khanqah' was the auspice where the 'Pir' or preceptor lived.
* They believed in religious music called 'Sama' where they experienced an ecstasy & trance.
* They came to India before the Turkish rule but got established only after Turks started ruling here.
* The Sufis had to pass through ten stages of spiritual development some of which were -

  'Tauba' - Repentance

  'Wara' - Abstinence

  'Sabr' - Patience

  'Tawakkul'- Contentment

  'Riza' - Submission to divine will.
* The Sufis, according to Abul Fazl, were divided into 14 'Silsilahs' or Orders, which were again divided into 'ba-shara' (those who followed the Islamic law) & 'be-shara' (those who were not bound by it).

Chisti Order :

Founder - Sheikh Muin-ud-din Chisti in India

- He was born in Sijistan & settled in Ajmer.

* Other famous Chistis Saints -

  i. Hamid-ud-din Nagauri

  ii. Qutb-ud-din Bhaktiyar Kaki - after whom the Qutub Minar is named)

  iii. Nizam-ud-din Auliya, who had problems with Mubarak Khalji & Ghiyasuddin Tughlaq.

  He was given the popular title, 'Mahbub-i-ilahi', Which meant beloved of the God'.

  His tomb at Delhi was constructed by Muhammad bin Tughlaq.

  iv. Farid-ud-din Mahmud whose disciple Zia Naqshaki translated the 'Sukha Saptati' as 'Tutinama'.

  v. Shaikh Nasir-ud-din Mahmud 'Chirag-i-Delhi' was a Charismatic Saint.

  vi. Syed Muhmmad 'Gesu Daraz' established the Chishti order in Gulbarga, Karnataka.
* He earned the title, 'Bandanawag' (Benefactor of God's Creatures)
* They believed in Simplicity & propriety, non-possession of property & charity & inexcessive austerities or self-mortification.

Suhrawardi Order :

* Founder - Shaikh Shibab-ud-din Suhrawardi.
* In India it was Shaikh Bahauddin Zakaria of Multan.
* Rukn-ud-din Abdul Fath-another prominent Saint.
* Established themselves in the North-West.
* Unlike the Chistis, the Suhrawardis mingled with the Muslim aristocracy & took active part in politics, holding important posts, especially in the ecclesiastical department.

Qadiri Order :

* Founder - Shaikh Abdul Qadir Jilani of Baghdad.
* In India - Shaikh Nizamat Ullah.
* The most famous-Nasir-ud-din Muhammad Jilani.
* Prominent in Sind & Lahore.
* Dara Shikov belonged to this order & a follower of Mullah Shah Badakshahi.

Naqshabandi Order :

* Introduced in India by Khwaja Baqi Billah Shaikh, Ahmad Sarhindi was the most prominent, who was a contemporary of Akbar & Jahangir.
* Sarhindi led the Jaghallab movement & he supported imposition of Jaziya, cow slaughter & was against the Shias.
* Mirza Mazhar & Khwaja Mir Dard revived the Naqshbandi order.
* They tried to harmonise the doctrines of mysticism with the teachings of orthodox Islam.

Other Sects :

* Rishi Order (Kashmir) - Shaikh Nuruddin Rishi influenced by Lalla Ded of Kashmir.
* Kubrawiya Order (Kashmir) - Mir Sayyid Ali Hamadani
* Mahadawi Movement (Jaunpur) - Muhammad Madhi
* Raushniya Sect (Jullunder) - Bayazid Ansari
* Shattari Order - Abdullah Shattari

MARATHA ASCENDANCY

Shivaji (1627-1680) :

★ Belonged to the Bhonsle Clan of Marathas.

★ Born at Shivner to Shahji & Jija Bai, into the family of a military commander under the Nizam Shahi rulers of Ahmadnagar, who later shifted loyalties to Bijapur.

★ In 1637 he received the Jagir of Poona from his father, but it was only in 1647 after the death of his Guardian, Dadaji kondadev, that Shivaji could control it by his own.

★ In 1646 he captured Raigarh, Kondana & Torna from Bijapur, apart from Chakan & Purandhar.

★ 1656 - conquest of Jarli from Chandra Rao, more a Maratha Chief & also acquired port towns of Kalyana & Bhivandi.

★ 1659- murdered Afzal Khan with tiger claws, who was sent by Ali Adil Shah of Bijapur.

★ Shaista Khan, the viceroy of Mughal Deccan was sent by Aurangzeb in 1660 to strike at the Maratha territories.

★ 1663 - Shivaji carried a night attack on the camp of Shaista Khan, who after this defeat was transferred to Bengal as a punishment. Meanwhile Shivaji plundered Surat (1664) & Ahmadnagar.

★ 1665 - Aurangzeb then sent Mirza Raja Jai Singh of Amber & Diler Khan against Shivaji, who sued for peace through the Treaty of Purandhar & surrendered 23 out of 35 forts that he held.

★ Shivaji's son Sambhaji was awarded a mansab of 5000.

★ 1666 - Shivaji visited Agra & was imprisoned, But he managed to escape from the Mughals.

★ 1670 - Second plunder of Surat.

★ 1674 - He was coronated at Raigarh & assumed the title of 'Maharaja Chattrapati'. & 'Haindava Dharmodharak'.

★ 1676-79 - Conquered Jinjee, Vellore, etc from the Bijapur kingdom in alliance with the Qutb-Shahis of Golconda, but did not share the promised territories with the latter.

★ 1680 - Shivaji died.

★ 1680-1689 - Sambhaji succeeded Shivaji, but he was a man of loose morals & was widely unpopular.

★ Kari Kalash, a brahman was his counseller.

★ Prince Akbar, the rebellions son of Aurangzeb took shelter at Sambhaji's court & led to the execution of the Latter at Sangameshwar in 1689 by Muqqarrab Khan, the Mughal Governor.

★ Yesubai, the widow of Sambhaji could not protect the fort of Raigarh & she, along with her son, Shahu were made prisoners.

Rajaram (1689-1706) :

★ Coronated at Raigarh, but he shifted his head quaters to Jinjee, where devoted Maratha Leaders like Ramachandra Pant, Prahlad Niraji, Dhanaji Jadhar, etc created havoc among the Mughals.

★ When Jinjee also fell to Mughals (1698), Satara was made the capital.

★ On his death, (Rajaram's) his wife, Tarabai became the regent of her infant son, Shivaji II.

★ Shivaji II & Tarabai (1700-2707) together attached Berar, Baroda & Aurangabad.

★ 1707 - Azam Shah, the son of Aurangzeb released Shahu, as his advisor Zulfikar Khan felt that it would lead to a civil war among the Marathas.

Shahu (1707-1749) :

★ After Tarabai was defeated at the Battle of Khed (1707), Shanu occupied the throne at Satara & hence began a long drawn civil war till 1714.

★ Rajaram's descendants & his second wife, Rajabai imprisoned Tarabai & her son Sambhaji II & started to rule from Kolhapur.

★ This was sanctioned by the Treaty of Warna in 1731 & Kolhapur began to be called the Southern Maratha confederacy.

ADMINISTRATION

★ Based on the pattern adopted by Malik Amber in Ahmadnagar & Mahmud Gawan in Bahmani kingdom.

★ Maratha kigdom was called 'Swarajya' or 'Mulk-e-Kadim'.

★ Provinces were called 'Mahal' or 'Subah'.

★ The Marathas collected 'Chauth' or 1/4th of the land revenue.

★ The 'Sardeshmukhi' or 1/10th of the standard land revenue was imposed on the entire population of a village or town in token of their recognition of the Maratha king as their 'Sardeshmukh' or Suzerain.

★ Central administration was unique in the sense that the 'Ashtapradhan' were council of Minister who were individually & not collectively responsible to the king, Shivaji.

They were :

i. Peshwa - Finance & General administration - Later Prime Minister & controlled the entire administration.

ii. Majumdar or Amatya - Accountant General - Later Finance Minister.

iii. Senapati or Sar-i-Naubat - Military Chief.

iv. Waqenavis - Intelligence & household affairs.

v. Surunavis & Sachiva or Chitnis - Royal correspondence in-charge.

vi. Dabir or Sumanta - Master of ceremonies.

vii. Nyayadhish - Justice - both Civil & Criminal cases.

viii. Pandit Rao - Charities & Religious affairs.

★ Rajaram created the new post of 'Pratinidhi'.

★ All ministers except Pandit Rao & Nyayadhish participated in war.

★ The 'Swarajya' was divided into revenue divisions called 'prants' & the Revenue Officials were Deshmukhs, Deshpandes, Patils & Kulkarnis.

★ Out of the revenue of Chaut -

25% - Zabti (to central government)
66% - to Mokasa & Saranjam
6% - to Sahotra granted to Sachiva
3% - to Nadgauda

★ Saranjami system was a system of revenue grants given to soldiers instead of their salaries.

The Peshwas (1713-1818)

Balaji Vishwanath (1713-1720) :

helped Shahu in consolidating his position & was thus given the title of 'Sena Karte' in 1708.

★ As the Peshwa, he made the post most powerful & hereditary.

★ 1719 - concluded an agreement with Sayyid Hussain Ali called the Treaty of Delhi by which Farukh Shiyar recognised the 'Swrarajya' & its king.

Baji Rao (1720-1740) :

★ Greatest exponent of Guerilla tactics.

★ Popularised the idea of Hindu pad padshahi or Hindu empire.

★ He defeated the portuguese (1733) & Nizam-ul-Mulk & also succeeded in weakening the Mughals.

★ Under him several Maratha families became porminent & entrenched themselves in various parts.

Balaji Baji Rao (1740-1761) :

★ also called Nana Saheb.

★ Under him the supreme power passed into the hands of the Peshwa, when he imprisoned Ramaraja, the successor to Shahu, at Satara, through the Sangola Agreement (1750).

★ Reached an agreement with the Mughal emperor, Ahmad Shah in protecting the empire from (esp) invasions of Ahmad Shah Abdali of Afghanistan & others.

★ 1761 - Third Battle of Panipat resulted in the death of Nana Saheb, heart broken by the death of his son, Viswas Rao & his cousin, Sadashiv Rao Bhau.

Madhav Rao (1761-62) :

★ Witnessed the division of Maratha kingdom into Semi-independent states -

i. Holkars at Indore

ii. Bhonsles at Nagpur

iii. Scindhias at Gwalior

iv. Gaekwads at Baroda

22. Beginning of European Commerce

The Portuguese :

★ The Cape route or a new sea-route to India was discovered by Vasco da gama, who reached the port of Calicut in 1498.

★ His second trip in 1502 led to the establishment of trading stations at Calicut, Cochin & Cannore, with support from Pedro A Cabral.

★ The First governor of Portuguese in India was Francisco Almeida (1505-1509)

★ Alfonso de Albuquerque (1509-1515) was the second & he captured Goa from the ruler of Bijapur in 1510.

★ Nino-da-Cunha transferred the Portuguese capital in India from Cochin to Goa in 1530 & acquired Diu & Bassein from Bahadur Shah of Gujarat.

★ Portuguese lost Hugli in 1631 to Qasim Khan a noble under Shah Jahan.

★ 1661-the Portuguese king gave Bombay to Charles II of England for marrying his sister.

★ 1739 - Marathas captured Salsette & Bassien.

★ 1961 - Goa, Diu & Daman were freed finally.

★ Causes for the decline of Portuguese in India were their religious intolerance, piracy & clandestine practices in trade & discovery of Brazil.

The Dutch :

★ 1602 - The formation of 'Vereenidge Dostindiseh companie or Dutch East India company.

★ 1605 - Their first factory at Machilipatnam.

★ 1610 - Pulicat their main centre.

★ 1616 - Surat

★ 1641 - Bhimilipatnam

★ 1658 - Nagapatnam - replaced Pulicat as the trade centre.

★ 1663 - Cochin

★ They managed to displace the Portuguese, but thier final collapse came about with the Battle of Bedera in 1759 against the English, who expelled them out of India in 1795.

The English :

★ English East India company was formed by a group of merchants called. 'The Merchant Adventures' in 1599.

★ Sir Thomas Roe was an ambassador of James I to Jahangir's Court. He got the firman to trade & erect factories inthe empire.

★ The company acquired Bombay from Charles II on lease at an annual rental of 10pounds in 1688.

★ Bombay became the head quarters of the company on the

★ 1639 - Francis Day obtained the site of Madras from Raja of Chandragiri, which was named 'Fort St. George'.

★ Madras soon replaced Masulipatnam as their Head Quarters on the Coromandal Coast.

★ 1690 - a factory was established at Sutanati by Job Charnock & the Zamindari of three villages of Sutanati, Kalikota & Govindpur was acquired in 1698. These villages later grew into the city of Calcutta.

★ This fortified settlement at Sutanauti was named 'Fort William'.

★ 1715 - John Surman, Governor of Calcutta & William Hamilton cured Farukh Shiyar of a disease & gained a firman in 1717 called the 'Magnacarta' of the Company.

★ A long drawn rivalry between different groups of merchants from 1635 onwards finally ended in 1708 through their amalgalmation by the Earl of Goldolphin under the title of the United Company of Merchants of England Trading to the East Indies', which continued to exist till 1858. When it ended through the Queen's Proclamation.

The French :

★ Colbert, the Minister of Louis XIV created the 'Compagnie des Indes Orientales' in 1664.

★ 1668 - Francis Caron set up the first French factory at Surat.

★ 1669 - at Masulipatnam by Maracara.

★ First governor of Pondicherry was Francois Martin.

★ Chandernagore in Bengal was acquired from Shaista Khan, Mughal governor in 1690.

★ Arrival of Dupleix as French governor in India in 1742 saw the beginning of Anglo-French conflict (Carnatic Wars) resulting in their final defeat in India.

The Danes :

★ 1616-Formation of the East India Company of Danes. 1620 - Settlement at Tranquebar, Tamil Nadu. 1676-at Serampore (Bengal) which was their Head Quarters in India. 1845 - They were forced to sell all their

MODERN INDIAN HISTORY

I. CIVIL REBELLIONS

I. TRIBAL MOVEMENTS

THE REASONS –

- British land revenue policy, particularly Permanent Settlement in 1793 A.D. was the single most important factor for the tribal movements.
- Lord Hardinge I, the Governor General introduced Forest Laws in 1840 A.D. prohibiting Podu Cultivation (Shifting Cultivation), imposed taxes on forest products and barred the custom of human sacrifice practiced by Khonds of Orissa and Gonds of Adilabad district of A.P.
- New administrative system with police, courts, lawyers was also being resisted by the tribes.
- The Christian missionary activities in the agency areas and the British deploying army in the agency were the other factors for the revolts.

POPULAR TRIBAL REVOLTS -

1. **Chuars - Marabhum And Danabrhum :** were the first to revolt against British land revenue policy, in 1769 A.D.
2. **Khasis - Assam :** revolted in 1828-1832 A.D. under the leadership of Tiruth Singh and Darmanik against the presence of Army in the agency area and British revenue policy.
3. **Kols - Chotanagpur :** revolted in 1832 A.D. under the leadership of Buddho Bhagath against British policy of expansionism.
4. **Khonda - Orissa :** revolted in 1846-48 A.D. under the leadership of Chakra Besai against the British policy of interference when Lord Hardinge I barred the custom of human sacrifice.
5. **Kachanaga : Kacher (Cachar) Dist in Assam :** 1882 A.D. revolted under the British land revenue policy under the leadership of Sambu Dan.
6. **Koya : Godavari Agency Area in A.P. :** revolted in 1992 - 1923 A.D at Rampa - Chodavaran under the leadership of **Alluri Seetha Ramaraj* against the British forest laws and the exploitation of the tribes by the tribal chiefs called Muthadars. Seetha Ramraj attacked Chintapalli police station with his Koya followers and killed notorious officer *"Bastian"*. *Rutherford* was the Commissioner of Operations against Seetha Ramraj. Raju was assassinated at Koyyagudem.
7. **Munda Uprising :** *1899 - 1900 A.D.* revolted under the leadership of Birsa Munda against the Christian missionary activities in the agency area and for their own rights in the soil. Birsa founded a new cult called **Singabonga* and started the *Sons of the Soil Movement* called *Ulgular.* He was deported in 1900 A.D. as political prisoner.
8. **Naikdas - Panchamahal Hills, Gujarat :** *1858 A.D; 1868 A.D;* revolted under the leadership of *Roop Singh* and *Jaria Bhagath* against British policy of expansionism and interference. They declared the formation of the 2nd independent tribal kingdom with Roop Singh as the head of the State and Jaria as the head of the religion.
9. **Oroans - Chotanagpur :** *1915 A.D.* revolted under the leadership of *Jatra Bhagath.* It started as a reform, movement called Bhagath Movement and also *Tanabhagat Movement* preaching Monotheism. Later it became anti-British and part of the freedom struggle.
10. ****Santhal Rebellion - Rajmahal Hills in Bihar :** *1854 A.D - 1856 A.D.* opposed British land revenue policy under the leadership of Siddhu - and Kanhu.

    They defeated the British armies under General Borrough and declared the formation of 1st independent tribal kingdom in modern India in the region between Bhagalpur and Patna. The importance of the revolt was-

    - It was the first revolt that exploded the myth of European invincibility.
    - The revolt had direct impact on 1857 Sepoy Mutiny.

1. **Savara : Srikakulam Asansol Area (A.P.) :** *1857 A.D;* led by *Dundasena* against the British Forest Laws.
2. **Thadou : Kuki : Manipur :** *1917 A.D.;* was led by *Rani Gidinilu* and her cousin Zodanang against the presence of the British in the agency areas. Imprisoned Rani Gidinilu was released in 1957 A.D; called the *Daughter of Indian Independence"* by PM Nehru.
3. **Bhils :** 1913 A.D; was led by Govind Guru against British revenue policy.
4. **Chenchu - Nallamala Hills in A.P. :** *1922 A.D - 1923 A.D.* They revolted against British forest laws under the leadership of *K. Hanumanthu.* He organised *Palanadu* - Forest Satyagraha against British Forest Laws.

II. ZAMINDAR REVOLTS

1. MADRAS PRESIDENCY :

   a. The Zamindar of Bobbili was the first to revolt in Modern India. In 1757 A.D; Ranga Rao, the Zamindar of Bobbili opposed the domination of the French and challenged the French commander Bussey in the *Battle of Bobbili.*

   b. The *Battle of Padmanabhan* in 1794 A.D. - The Raja of Vijayanagaram *Vijay Ramraj* was killed by the British. The richest Zamindar in India, he refused to pay the arrears of Peshcush.

   c. *Veerapandya Kattaboman,* the Zamindar of Panchalakuruchi opposed British revenue policy and revolted during 1792 - 1799 A.D.

   d. *Velutumbi,* the Dewan of Travancore revolted during 1805 - 1809 A.D. against the British land revenue policy; died in the fight and the State of Travancore was occupied.

e. *Kittur Uprising (1824 A.D)* - Rani Chennavva adopted *Shivalinga Rudra.* The British annulled her adoption and Chennavva organised the fight with the support of her cousin, Rayappa. Both were imprisoned in the Vellore Jail.

f. *Raja Rebellion (1827 A.D.)* - Raja Bir Bahadur of Visakhapatnam opposed British revenue Policy, revolted and lost his zamindari.

g. *V. Narasimha Reddy*, the Poligar of Koilkuntla in the Kurnool dist. of A.P. revolted against British revenue policy during 1845 A.D. and 1846 A.D; executed by the *Russell Brigade.*

2. **BENGAL PRESIDENCY :**

a. The Zamindar of Parlakinidi, *Jagannath Gajapathdev* revolted against the land revenue policy and lost his land estate in 1829 A.D.

b. In 1835 A.D. *Dhananjay Banja*, the Zamindar of Gunsur revolted against the revenue policy.

c. *Sambalpur Uprising* (1827 A.D. - 1840 A.D) - It was against the British Policy of interference. Maharaj Sai, the king of Sambalpur died without an heir apparent. The British interfered and declared his queen *Mahan Kumari* as the Queen of Sambalpur. The revolt was led by **Surendra Sai.* The illegitimate son of Maharaj Sai. In 1840 A.D.; Sweendra was deported to Burma as political prisoner.

3. **BOMBAY PRESIDENCY :**

a. **Ramosis Rebellion (1822 A.D) :** The peasant tribe around Pune lost their land holdings with the Third Anglo Maratha war in 1818 AD. They revolted under the leadership of *Chittor Singh and Ummaji.* The revolt ended when British agreed to provide employment to the Ramosis in the British army.

b. **Satavamdi Rebellion :** Khan Satwant, the ruler of Satawandi was deposed by the British in 1839 A.D. In his support, his commander *Pond Sathvanth* organised the revolt.

c. **The Satara Out break Disturbances 1840 A.D. :** Pratap Singh, the king of Satara was deposed by the British in 1840 A.D. In his support, Dharrao, Narsing and Powar organised the revolt. Though the state was restored, it became the first State annexed by Lord Dalhousie under Doctrine of Lapse in 1848 A.D.

d. **Khodkari Rebellion - 1845 A.D. :** Khodkari were the peasant tribes around Kothapur. In 1845 A.D. they revolted against the repressive revenue policy of *Dewan D.K. Pandit* who was supported by the English.

4. **CENTRAL PROVINCES :**

a. **Kutch Rebellion - 1815 A.D. :** *Rao Barmal*, the Dewan of Kutch opposed British revenue policy revolted. The State of Kutch was annexed.

b. **Bundela Uprising - 1842 A.D. :** The Bundelas of Sagar revolted under the leadership of Madhukar shah and Jawahir Singh against the revenue policy. Both the leaders were executed.

III. CIVIL REBELLIONS

1. **SANYASI REBELLION - 1772 A.D. :** was the *first civil rebellion* of Modern India, led by the Sanyasis of Giri order, founded by Adishankara started when Lord Warren Hastings barred the movement of Sanyasi visiting pilgrim centres in naked form.

2. **FARAZI MOVEMENT - 1804 AD :** Started in Faridpur dist. of West Bengal, founded by *Shariatullah* and his son, *Md. Mohisin.* Though a reform movement in the beginning, it became a communal movement opposing Hindu landed aristocracy and the British in Bengal.

3. **WAHABI MOVEMENT :** Actually founded by *Abdul Wahab* at Nazad in W. Punjab. It was introduced into India by Syed Ahmed of Bareilly in U.P. in 1822 A.D. However, Sittana in NWFP became the main centre of its activities. The movement was led by *Vilayat Ali, Inayat Ali and Maqsad Ali.* The Wahabis opposed Sikhs in Punjab and English in the rest of India. They preached Hindu - Muslim unity against the British. They played commendable role in 1857 Sepoy Mutiny. With the failure of Sepoy Mutiny, the movement also ended.

Sydney Cotton, the British commander conducted series of campaigns on Sittana, the stronghold of Wahabis.

4. **PAGAL PANTHI MOVEMENT - 1827 A.D. :** Started by *Karam Shah* and his son Tipu in the Sherpur district of Bengal. The Pagal panthis opposed the exploitation of Hindu Zamindars and attacked British establishments; called *'Pagals'* for they demanded radical land reforms.

5. **NAMDHARI AND KUKA MOVEMENT :**

First started by *Bhagat Jauhari Mal* as a social reform movement in the Sikh community opposing consumption of liquor and male - female inequality. However under Ram Singh, it became Kuka Movement. The Kukas regarded only Guru Gobind as the real Sikh guru, opposed the presence of Muslims in Punjab and attempted to revive the past glory of the Sikhs. In 1872 A.D; *Ram Singh organised the Kuka outbreak*, captured the city Amritsar and declared the formation of Kuka Govt. The movement ended with Ram Singh's capture and being deported to Burma as political prisoner.

IV. PEASANT UPRISINGS

1. **INDIGO REVOLUTION 1858 A.D - 1860 A.D. :** It was against the unjust system of 'advances' called *Tinkathia System.* The Indigo cultivators of Bihar and Bengal organised the rebellion under the leadership of Biswas Brothers, Bishnucharan Biswas and *Digambar Biswas.* *Dinabhandhu Mitra* wrote the popular play, Nildarpan, depicting the plight of Indigo cultivators. The movement ended with the appointment of the 1st Indigo Enquiry Commission in 1860 A.D. It was first Satyagraha Movement in Modern India.

2. **PARNA UPRISING - 1872 A.D. :** The Bengal

of collecting rent in terms of cash. When the prices for agricultural commodities were falling down. It ended with guarantees given by the British over the peasant proprietorship over the soil.

3. **DECCAN RIOTS - 1875 A.D. :** During the Deccan famine in 1875 A.D; riots broke out in Ahmendnagar and Pune districts of Bombay Presidency against the exploitation of Marwari Moneylenders. The riots became armed rebellions under the leadership of *Vasudev Balwant Phadke*, regarding as the "Father of Modern Indian revolutionary terrorism". The riots ended with 1879 A.D. Deccan Peasants Relief Act that provided for guarantees of peasant proprietorship over the soil and imposed restrictions on both borrowing and lending.

2. 1857 REVOLT

The British economic policy was the most important factor for the outbreak. The impoverished peasantry, the deposed zamindars and the unemployed youth in urban centres were the sections who participated in large numbers.

The British policy of expansionism from the beginning was devoid of ethics and values. Lord Warren Hastings followed 'ring fencing policy' (creating friendly states around enemy states and occupying both in course of time). Lord Wellesley introduced *Subsidiary Alliance System* and forced upon the native princess, conquered more than half of British India with the same system. Lord Dalhousie with his *'Doctrine of Lapse'* annexed the Indian States. Satara in 1848 A.D., Jaitpur in 1849 A.D., Sambalpur in 1850 A.D., Hill state of Bhagat in 1852 A.D; Jhansi in 1853 A.D. and Nagpur in 1854 A.D. However the states, Sambalpur and Bhagat were restored back. He abolished the titles of native Nawabs, refused to sanction pension to Nana Sahib, the adopted son of the last Peshwa, Bajirao II after the death of the Peshwa in 1851 A.D., declared that Red Fort belonged to the British and occupied, the state of Ayodhya in 1856 A.D., deposing Wajid Ali Shah, the Nawab, on grounds of mal - administration.

Lord Canning, the successor of Dalhousie declared that Mughal Emperor would not be permitted to use the royal title, Jille illahi (The shadow of God).

- In the social sphere, the progressive legislation of the British was held in contempt and suspicion by the majority Hindus and Muslims.
- In 1802 A.D. Lord Wellesley abolished the custom of female infanticide practiced by the Rajputs with his Regulation VI.
- In 1829 A.D, Lord William Bentinck abolished the custom of Sati at the instance of Ram Mohan Roy with his regulation XVII.
- In 1856 A.D Lord Dalhousie passed Widow Remarriage Act at the instance of Ishwar Chandra Vidyasagar.

However the most controversial Act was the 1856 Religious Disabilities Act or Indian Inheritance Act that retained property rights for the converted against the spirit of Dharmashastras.

Further, the company Administration sanctioned aid to the Christian missionaries in the form of grants.

The company historian William Grant declared in the House of Commons that "it was divinely ordained task to transform India into Christianity".

GRIEVANCES OF THE SEPOYS :

The Sepoys revolted for the first time in 1675 A.D. The Burhampore Regiment was the first to revolt against Robert Clive. It was also called *White Mutiny* as most of the Sepoys who revolted were English.

In 1806 A.D. the *Vellore Sepoy Mutiny* had taken place in support of Tipu Sultan and his family. The reasons for the revolt were-

- Sepoys were discriminated No Indian Sepoy was promoted beyond the rank of a Jatedar.
- Denied additional allowance called *Batta* granted only to English Sepoys.
- In 1856 A.D. *Service Enlistment Act* was passed prohibiting the Sepoys from observing rituals and customs in military camps.

In 1857 Jan The *Royal Enfield Gun* was introduced to be operated by greased cartridges. The Sepoys refused to use the cartridge as they suspected cow and pig fat were used. On March 29, 1857 Mangal Pandey and his cousin Iswar Pandey of the 34 Native Infantry Regiment at Barackpore organised the revolt. On *May 10, 1857*, Capt. Bakth Khan of the 3rd Cavalry Regiment at Meerut led the revolt. On 11th May, 1857, the Sepoys occupied Delhi, declared Bahadur Shah as the Emperor of India and head of the revolt.

CENTRAL REGION :

1. *Arrah* in Bihar - Kunwar Singh and his brother Amar Singh, the zamindars of Jagadishpur organised the revolt.
2. *Bareilly* in UP - Khan Bahadur Khan, the head of the Rohillas was the leader of the revolt.
3. *Delhi* - Bahadur Shah was the titular head. Capt. Bakht Khan was the real head of the revolt.
4. *Faisabad - Maulvi Ahmedullah*, the head of Wahabi sect led the revolt in support of Begum Hazrat Mahal, wife of Nawab Wajid Ali. It was a brilliant example of communal harmony and faint resistance of Hindus and Muslims against the British under his leadership.

   The Muslims handed over the disputed site to the Hindus.
5. *Jhansi - Laxmi Bai*, The widow of Gangadhar Rao organised the revolt for the sake of her adopted son, Manohar Rao.
6. *Kanpur* - The main centre of the revolt. *Nana Sahib*, actually called Dondu Pandit led the revolt assisted by *Anna Saheb, Azimullah and Tantia Tope* Nane perpetuated atrocities on all European in Kanpur.
7. *Lucknow - Begum Hazrat Mahal* led the revolt for the take of her son, Berzis Qadr.

SUPPRESSION OF THE REVOLT -

Lord Canning was the Governor General *Collin Campbell* was the Chief Commander of operations. *Sir John Nicholson* got back Delhi but died in the fight. *William Taylor and Vincent Eyre* defeated Kunwar Singh. Collin Campbell got back Kanpur, *Sir Hugh Rose* defeated Lakshmi Bai. Nana Sahib and Khan Bahadur Khan and Begum Hazrat Mahal took asylum in Nepal. Maulvi Ahmedullah was killed by the Raja of Puwain. Tantia Tope offered guerilla warfare was handed over to the English by Man Singh, a friend of Scindia was executed on April 18, 1858.

The main causes for the failure of the revolt was lack of co-ordination among the leaders.

RESULTS OF THE REVOLT :

- Lord Canning held the Allahabad Durbar and read out the 'Queen's proclamation' which promised no further conquests in India; No further interference in the internal affairs of the Indians and that Indians would be promoted in decision making.

  Accordingly, the *1861 Indian Councils Act, 1861 Indian Judiciary Act and 1861 Indian Executive Act* were passed.
- The administration of the Company ended. Its 2 agencies Count of Directors and Board of Control were abolished.
- The office of the Governor General also became the office of Viceroy (He was Governor General when he administered British India. He acts as Viceroy when he deals with princely States). Lord Canning was the 1st *Governor General - Cum - Viceroy.*

  An agency of 15 members called *Indian Council* was created in London to monitor the functioning of Viceroy and his staff. It was to be headed by a *Secretary of State for India. (Lord Charles Wood* became the 1st Secretary of State for India).

- There was a marked change in the Divide and Rule Policy of British. After 1857, they promoted Muslims against Hindus
- They divided the Indian Army on regional, racial and communal grounds.
- To cover up the losses during the revolt, from 1860 onwards, Income Tax was levied.

The Revolt was described as a mere *"Sepoy Mutiny"* by the British historians like *Col. Malleson.* For Lord Canning it was a "revolution". For nationalist historian, V.D. Savarkar, it was the "First War of *Indian Independence"*. For Tara Chand, it was the last attempt of the medieval order to regain their lost power, prestige *and privileges.*

The Mutiny was -

- Not Indian
- For vested interests
- Geographically centered around Central Provinces, Madras/ Bombay Presidency were largely unaffected.
- Sikhs, Gorkhas, intellectuals, Princely States supported the British.
- All Communities at large didn't participate.

3. 19th CENTURY - INDIAN RENAISSANCE

It was an attempt to reform Indian Society in the light of modernization, westernization and the threat of Christianity. The most important factor for the Renaissance was the introduction of English education with its ideas *of Humanism, Rationalism and Empiricism (Experiment and Experience)*

I. HINDU REFORM MOVEMENTS

1. **ATMIYA SABHA** - founded by *Raja Rammohan Roy* in Kolkata in 1815 A.D. was the first reform organisation. Its main theme was to promote studies on *Indian philosophy (Upanishads).*
2. **YOUNG BENGAL MOVEMENT** - was started by *Henry Vivian Derozio*, an Anglo - Indian teacher in 1824 A.D. His followers called Derozians were the first to start the practice of writing pamphlets of social and economic issues. Derozio inspired his whole generation of Bengali intellectuals including Vidyasagar and Keshab Chandra Sen.
3. **BRAHMA SAMAJ** - Actually called *Brahmo Sabha* was founded by Rammohan Roy in Kolkata in 1828 A.D. as a social reform organisation. Its main theme was *'Nirgunosapna'* (formless worship monotheism).

   Its social programme included -

   a. Eradication of social evils like Sati.

   b. Emancipation of woman.

   c. To demand for progressive education.

   d. To generate awareness an socio-economic and political issues.

   At the instance of Raja Rammohan Roy, the *custom of Sati was abolished in 1829 A.D.* He prevailed upon Lord

   After the death of Raja Rammohan Roy, *Debendranath Tagore* became the head of Brahmo Samaj. In 1866 A.D. Brahmo Samaj was divided for the first time on the issue of defining the relationship between Brahmanism and Brahmo Samaj. The radicals called *Keshab Chandra Sen, Anandamohan Bose and Shivnarayan Shastri* left Brahmo Samaj and founded All - India Brahmo Samaj. The Brahmo Samaj under Debendranath Tagore continued as Adi Brahmo Sabha.

   In 1878, the Brahmo Samaj was divided for the second time. Anand Mohan Bose and Shivnarayan Sastri revolted against Sen and founded Saddharmo Brahmo Samaj. The reasons for the second split were -

   - Keshab Chandra Sen introduced Kirtanas and Bhajans.
   - Declared himself a prophet and encouraged hero worship.
   - Performed child marriage.
4. **DHARMO SABHA** -

   A conservative movement founded by *Radhakanta Deb* in 1829 A.D. in Kolkata, opposed the progressive outlook of Brahmo Samaj.
5. **TATWABODHINI SABHA** -

promote studies on Indian philosophy. He also started the journal *'Tatwabodhini Patrika'*.

6. **MANAVA DHARMA SABHA** -

Founded in 1844 A.D. at Pune by *Durga Ram and Mancharam* to promote Brahmo ideas.

7. **PARAMHANSA MANDALI** -

Founded by Dadoji Pandurang in Bombay in 1849 A.D. to promote Brahmo ideas particularly monotheism.

8. **RADHASWAMY SATSANG/ SOMAJ**

Founded in 1861 A.D. in Agra by *Tulsiram*, also called Shivdayal Shastri. The Satsang apart from Monotheism, emphasized on a disciplined life without vices.

9. **PRARTHANA SAMAJ** -

Founded in 1867 A.D. in Bombay by Atmaram Pandurang as a branch of Brahmo Samaj in Bombay Presidency at the instance of Keshab Chandra Sen. Justice M.G. Ranade joined the Samaj in 1870 and was called *"Architect of the Samaj"*.

Its social program included -

- Imparting education to woman and the downtrodden.
- To establish widow homes

The Samaj spearheaded the lower caste movements in Bombay Presidency.

10. ***ARYA SAMAJ** -

Founded by *Swami Dayanand Sarswati*, first in Bombay in 1875 and later at Lahore in the same year.

The Social program of Arya Samaj included -

- Promoting studies on Vedas.
- The Samaj opposed the domination of priestly classes, encouraged widow remarriages, founded schools and colleges, hospitals, providing social service.

The 2 controversial programs of the Samaj were -

- **Suddhi Movement** - (Purification Movement) by which Arya Samaj tried to bring back the converted into Hinduism.
- **Cow protection movement** - With the 2 movements, the Samaj very often caused communal tensions between Hindus, Christians and Muslims.

After the death of Dayanand, the Samaj was divided on the issue of medium of instruction. *Swami Shraddhananda* demanded Sanskrit as the medium and founded Gurukul at Hardwar. *(Gurukula Section)* Whereas *Lala Hansraj and Lala Lajpat Rai* demanded English as the medium (College Section) - founded Oriental College at Lahore.

11. **THEOSOPHICAL SOCIETY** :

Founded in 1875 at New York by *Madam H.P. Blavadsky and Col. Olcott*. The main purpose of the society was to promote studies on Theosophy (Occult Sciences). In 1878, the Centre was shifted to Adayar in Chennai.

Madam Annie Besant became the President of the Society in 1903 and led the Home Rule Movement demanding self governance for India.

12. **DECCAN EDUCATION SOCIETY** -

Founded in 1884 in Bombay by *Gopal Ganesh Agarkar* to provide education to the downtrodden and depressed classes.

13. **INDIAN NATIONAL SOCIAL CONFERENCE** -

Was founded by *Justice M.G. Ranade* in Bombay in 1887 to strengthen the cause of reformism.

14. **RAMAKRISHNA MATH** -

Was founded by *Swami Vivekananda* at Belur in 1887 to promote the universal religion of Paramahansa. The Swami of the Math are being trained at Belur. Vivekananda also founded the *Ramakrishna Mission* as a social service organisation in 1897.

15. **DEVA SAMAJ** -

Was founded by *Shivnarayan Agnihotri* in Lahore in 1897 as as a branch of Brahmo Samaj. The members of the Samaj however worship the Gurus and Scriptures.

II. SOCIAL SERVICE ORGANISATIONS

1. *Gopal Krishna Gokhale* founded the Servants of India Society in Bombay in 1905.
2. Poona Seva Sadan was founded by *Pandita Rambai, G.K. Devadutt and Maharshi Karve* in 1909 at Poona to provide education and shelter for widows.
3. *Social Service League, founded in 1911 of N.M. Joshi (founder by AITUC) in Bombay for promoting better living conditions of the working classes in the Bombay slums.
4. Seva Samiti - founded by *H.N. Kunzru* in Allahabad in 1914 as a social service organization.

III. ISLAMIC REFORM MOVEMENTS -

1. ***DEOBAND MOVEMENT/ DAR - UL - ULM**

was founded by *Moulana Hussain Ahmed* at Deoband in 1866. It gave a liberal interpretation of Qoran, accepted English education and also preached Hindu Muslim unity.

Maulana Abul Kalam Azad was inspired by the movement.

2. **AHMEDIYA MOVEMENT/ KHIDAYANI MOVEMENT** -

Founded at Khidayan in West Punjab by *Mizra Ghulam Ahmed*. Regarded as Prophet, *Ghulam Ahmed*, encouraged Muslims in trade and commerce. It was the most organised movement against the activities of Arya Samaj and Christian Missionaries in Punjab.

3. **ALIGARH MOVEMENT** -

Refers to all the activities of *Sir Syed Ahmed Khan* for the overall development of the Muslims in India. Sir Syed realised the importance of English education and founded *Anglo - Mohammedan School* at Aligarh in 1875. It became College in 1877, the precursor of AMU. He in the beginning was secular declaring that "Hindus and Muslims were two eyes of Mother India". However, under the influence of the 1st Principal of the College, *Theodore Beck*, Sir Syed became a reactionary and conservative, discouraged "Muslims" to join the Congress Party.

4. **AHARAR MOVEMENT - LUCKNOW**

Was founded by *Maulana Md. Ali, Zafar Ali, and*

Hakim Azmal Khan, against the loyalist politics of Sir Syed Ahmed. The movement gave a call for Hindu - Muslim unity.

CONSERVATIVE MOVEMENTS IN ISLAM :

1. **Ahal - i - Hadis** -

Founded by *Maulana Nazir Hussain,* opposed liberal interpretation of Qoran.

2. **Ahal - i - Khoran** -

Abdullah Chakralavi, opposed English education and modernisation.

3. **Nudwah - ul - Ulema - (Association of Priests)**

Opposed liberal trends in Islam and also English education. The movement was founded by *Maulana Shibili Numani.*

4. **Barelwi Movement/ School**

Was started by Riza Khan; opposing liberal and progressive trends in Islam.

IV. SIKH REFORM MOVEMENTS/ AKALI MOVEMENTS (1920 - 1925) :

Started against the misuse of Sikh gurudwaras by the priestly class called *Mahants.* The Akali movement ended with *1925 Sikh Gurudwara Act* that provided for Shiromani Gurudwara Prabandhak Committee (SGPC).

V. PARSI REFORM MOVEMENT -

Called *Rehnumai Mazdayasan Sabha,* started in 1851 in Bombay by the leaders of the Parsi Community who included *Naoroji Furdomji, S.S. Bengali and Dadabhai Naoroji.*

The Sabha gave a call for overall development of the Parsi Community and also preached male - female equality.

Madam B.R. Cama, called the 'Mother of Indian Revolution' was the product of the movement.

VI. LOWER CASTE MOVEMENTS

Reasons -

- Sanskritisation process was the constant factor.
- Commercialisation of agriculture benefitted intermediate castes who provided leadership to the movements.
- The British introduced for the first time rule of law and equality before the law. Lord Macaulay introduced both the ideas with his Regulation XI.

  In the new administration, caste based occupations were replaced by merit, creating a favourable atmosphere for the lower caste movements.
- The British conducted Census from 1901 on the basis of caste and community for the purpose of reserving jobs, as a result each caste and community came out with claims and counter claims.
- Christianity was equally responsible by imparting education and by infusing a sense of self respect among the lower castes.

MOVEMENTS IN THE MADRAS PRESIDENCY -

1. In 1916, the *South India People's Association,* a political party transformed into a Justice Party; founded by *Petty Tyagaroy Chetty, C.M. Nair and T.N. Mudaliar.* The party opposed the domination of Brahmins in politics, education and govt. services. The party contested the 1923 general elections and formed the first elected government in Madras Presidency it very soon lost its support with the lower castes as it catered more to the interests of the intermediate castes.
2. Self Respect Movement -

   Started by E.V. Ramaswamy Naicker, popular as Periyar. It was the first to start the practice of burning Manusmriti and the marriages without priests. Periyar founded the journal *'Kudi Arasu'* to propagate his ideology. The movement even inspired the formation of political parties DMK, championing the cause of the Dravida culture.
3. In Kerala, *C.V. Raman Pillai* wrote the novel *"Martandavarma"*, exhorting the past glory of Nair Community. *Munnattu Padmanrbha Pillai* founded Nair welfare society.
4. In Kerala, *Narayan guru* championed the cause of untouchables EZAVA Community and demanded temple entry. He started the movement *S.N.D.P.Y.* (Sriman Narayana Dharma Paripalana Yogam) with the slogan *'One God One Religion and One Mankind'.*
5. In Karnataka, Justice C.R. Reddy founded *'Prajamitra Mandali',* political party, an anti - Brahmin Platform.

In Andhra Pradesh, *Enugula Veeraswamy Naidu* started anti - bonded labour movement *(Vetti Movement)*

Tripura Neni Ramaswamy Chaudhuri started anti - Brahmin movement called *Brahmana Vyatirekodyamam.*

BOMBAY PRESIDENCY :

Mahatma Jyotibha Phule was the pioneer of the lower caste movements in Bombay Presidency. A mali by profession, Jyotiba championed the cause of untouchable Mahar Community. He founded Satyasodhak Samaj and wrote the famous *Ghulamgiri* and *Sarvajanik Satyadharmadha Pustak.*

In 1904, *V.M. Shinde* founded *Bombay Presidency Depressed Class Mission Society.*

DR. B.R. AMBEDKAR -

The first graduate of the Mahar Community, submitted his thesis on *"Indian Rupee"*. Employed in the service of the State of Baroda, founded the journals *Mukhnayak* (Dumb Man) and Bahishkrita Bharatha (Excommunicated Bharata). He founded the All India Depressed Class Association Federation; organised the famous Mahad Satyagraha, demanding temple entry and usage of common civil amenities for the depressed classes. He participated in all the Three Round Table conferences, demanded separate communal electorates for the depressed classes. Accordingly, the British PM, Ramsay Mac Donald announced **Communal Award* in Aug, 1932, providing seperate communal electorates to the depressed classes. Against the award, Gandhi observed fast unto death as a protest and finally the *Poona Pact* was signed between caste Hindus represented by *Rajendra Prasad* and Manooji with the depressed class leaders Dr. Ambedkar and M.C. Raja. As per the Pact, Congress agreed to reserve double the number of the seats for the depressed classes in the general electorate and depressed classes agreed to forego their claims for seperate communal electorates.

VII. LABOUR CLASS MOVEMENT :

The labour class as such was formed in modern India for the first time in the railway industry. However the first Labou organisation union was *Bombay Mill Hands Association founded by N.M. Lokhande.*

Trade Unionism started in modern India with World War - I and Soviet Russia Revolution in 1917. The first Trade Union in Modern India was the Madras Mill Workers' Association founded by B.P. Wadia in 1918. In 1920, N.M. Joshi founded the AITUC. It held its first session in Bombay, presided over by Lala Lajpat Rai. In 1928, the AITUC was divided for the first time. N.M Joshi left AITUC and founded ITUF *(Indian Trade Union Federation)*. The reasons for the first split was communist domination increased in AITUC; Differences arose between N.M. Joshi and Communists in sending delegates to the Brussels Conference. In 1940, Joshi also founded *Hind Mazdoor Sevak Sangh*, an organisation for the Labour class.

LABOUR CLASS LEGISLATION -

The *Indian Factory Act*, 1881 was the first labour class legislation, introduced by Lord Ripon. It regulated the working hours for women and child labour.

In 1923, *Indian Workmen's Compensation* Act was passed providing compensation.

In 1926, *Indian Trade Union Act* was passed legalising the formation of Trade Unions.

In 1929, the *Koyal Commission on Indian Labour* was appointed under the chairmanship of *J.M. Whitley (Whitley Committee).*

In 1935, the *Royal Delimitation Committee* under the chairmanship of *Hemand Lawry* recommended for seperate electorates for the labour classes.

THINKERS OF MODERN INDIA

RAJA RAMMOHAN ROY :

Father of Modern India, pioneer of Indian Renaissance, Father of Modern Indian Journalism. Founded the journals, *"The Bengal Gazette"*, *"Mirat - ul - Akbar"* (the 1st journal in Persian language), *"Bangadoota" and "Sambandha Kaumudi"* (The 1st journal to discuss politics); wrote two pamphlets *"Some precepts of Jesus Christ, a guide to Peace and Harmony"*, and *"Tufath - ul - Nuwahuddin" (Gift of Monotheists)*. He was the first Indian to oppose the tribal of jury and restrictions imposed on freedom of expression.

AKSHAY KUMAR DUTT :

Was the first Indian marxist social scientist, studied the Indian society in terms of class.

ISWAR CHANDRA VIDYASAGAR :

Called the "Father of Modern Bengali Prose". The Principal of Calcutta Sanskrit College, admitted non - Brahmins and a devoted reformer, championing the cause of widow remarriages and women education. Responsible for Widow Remarriage Act 1856.

KESHAB CHANDRA SEN -

Founded Indian Reform Association in 1870 and instrumental for the 1872 Indian Native Marriage Act that was passed against child marriages; responsible for the branches of Brahmo Samaj in Indian called Prarthana Samaj in Bombay Presidency and Veda Samaj in Madras Presidency.

RAMAKRISHNA PARAMAHANSA :

Actually called Gadadhar Chattopadhyay, popular as the "Sain of Dakshineswar"; preached universal Religion.

SWAMI VIVEKANANDA :

The chief disciple of Ramakrishna, actual name Narendra Dutta; called Vivekananda by the Maharaja of Khetri participated in *World Parliament of Religions in Chicago* in 1893 and the *Congress on the History of World Religions, Paris* Called the "Spiritual Ambassador of India"; founded the journals *'Udbodhana'* in Bengali and *Prabuddha Bharata* in English.

SISTER NIVEDITA -

Was the ardent disciple of Vivekananda, actually called Margaret Nobel.

SWAMI DAYANAND SARASWATI -

His actual name, Mul Shankar. Born at Tankara in Gujarat; disciple of Swami Birajananda.

Founded the journals, *'Veda Bhasya'* and *Veda bhasya bhumika* wrote the famous *Satya Artha Prakash*.

BAL SHASTRI JAMBHEKAR -

Founded the journals, Digdarshan and Bombay Darpan; used journalism to counter child marriages in Bombay Presidency.

GOPAL HARI DESHMUKH -

Popular as **Lokhita Wadi;* by his pen name wrote series of articles against child marriage and encouraging widow remarriages.

KANDUKURI VEERESALINGAM -

Called *'Vidyasagar of the South'* founded *Rajamundry Reform Association* and *Hitakarini SamajaM* to encourage woman education and widow remarriages.

'Father of Modern Telugu prose' - wrote the 1st novel in Telugu literature *Rajasekhara Charitra*.

RAGHUPATI VENKATA RATNAM NAIDU -

called 'Rammohan Roy of South India'; founded *'Kakinada Reform Association'* to encourage widow remarriages and woman education. Also called *Kulapati* (Vice Chancellor)

JUSTICE M.G. RANADE -

Called the "Modern Rishi"; architect of Prarthana Samaj, a moderate Congress leader and also a critique on 'Drain of Wealth'.

4. FREEDOM STRUGGLE

The unique aspects are -

- The largest mass based struggle in the history of mankind and the most prolonged struggle for liberation of a country.
- The only struggle that accepted non - violence or Satyagraha as the means.

The factors responsible were -

The repressive and reactionary policies of Lord Lytton and the progressive liberal politics of Lord Ripon, both substantially contributed for the spirit of nationalism. Lord Lytton held the Grand Imperial Durbar in 1877 in Delhi wasting public money. When Deccan was reeling under severe famine, declared Queen Victoria as the Empress of India (the Queen officially declared the Empress for the first time).

In 1878, he introduced *Vernacular Press Act* for curbing the autonomy of Indian journalism and in 1879, to discourage the Indian middle classes entering into the Civil Services, he reduced the upper age limit from 21 to 19 and also introduced *Statutory Civil Services* (reserving 1/6 of the total number of posts for the Indian princely families and landed aristocracy)

Lord Ripon, on the other hand, introduced series of liberal and progressive reforms. In 1881, the first Indian Factory Act was passed, regulating child and woman labour working hours.

In 1882, the *Statutary Civil Services* were abolished; *Indian Famine* code was introduced (the 1st Indian Famine Commission was aoppointed under Sir Richard Stratchy, 1878).

In 1882, in order to promote primary education, Lord Ripon founded the *1st Indian Education Commission* also called *Hunter Committee*. The committee recommended for privatisation of education. The Vernacular Press Act was abolished.

In 1883, to give an effect to equality before law and the Rule of Law, Lord Ripon introduced *Ilbert Bill*. When the Bill was passed with amendments in Jan 26, 1884; it marked the beginnings of India's national movements.

- The Pre- Congress political organisations were equally responsible for the political consciousness.

- The *Bengal Land Holder's Society* founded by Dwarakanath Tagore in 1830 in Calcutta was the first political party in Modern India.
- In 1852, *Madras Native Association* was founded; the 1st political party in Madras Presidency.
- In 1852 March, the *Bombay Native Association* was founded; the 1st political party in Bombay Presidency, by *Jagannath Shankar Seth.*
- In 1866, Dadabhai Naoroji founded *East India Association* in London.
- In 1867, *Mary Carpenter*, biographer of Raja Rammohan Roy, founded National Indian Association in London.
- In 1870, *Poona Sarvajanik Sabha* was founded by *M.G. Ranade and G.V. Joshi.*
- In 1872, *Indian Society* was founded by Anandamohan Bose in Kolkata. It became *Indian Association* under Surendranath Banerji in 1876. It was the most dynamic political party before the Congress. *Veeraraghachari and P. Anandacharyulu.*
- In 1885, *Bombay Presidency Association* was founded by *Pherozeshah Mehta, Badruddin Tyabji and K.T. Telang.*

Journalism also played a commendable role. The *"Bengal Gazette"* started by James Augustus Hickey was the first journal in Modern India founded in 1780 in Kolkata. The "Bengal Gazette" founded by *"Harishchandra Roy* was the first journal by an Indian in 1818.

"Rastgoftar" was the first journal in Marathi, founded by Dadabhai in 1852.

Sisir Kumar Ghosh started *"Amrit Bazar Patrika"* (1868). *Girish Chandra Ghosh* founded *"Hindu Patriot"*, *Bankim Chandra Chatterjee* founded *"Bangadarshan"*, *Tilak* founded *"Kesari"* and *"Maratha"* (English) (both edited by Kelkar) *G.S. Ayyar and Veeraraghavachari* founded the newspaper, *"The Hindu"* and G.S. Ayyar also started *"Swadeshi Mitran"*.

FORMATION OF CONGRESS :

In 1885, at the instance of A.O. Hume, 72 delegates from different political parties met at Sir Tejpal Sanskrit College, during Dec 28-31 in Bombay. The name 'Indian National Congress' for the new party was suggested by Dadabhai Naoroji. *W.C. Banerji* became the 1st President. A.O. Hume was the General Secretary; called the "Founder Father of the Congress".

The *'Safety Valve Theory'* is actually a criticism against Hume attributing ulterior motives in founding the Congress. Lala Lajpat Rai and Lala Hansraj were the critics of Hume. Hume wrote 2 pamphlets *'A Rising Star in the East'* and *'Old Man's Dream!*

AGE OF MODERATES (1885 - 1905) :

Congress since its inception was dominated by educated middle class, the landed aristocracy and the capitalist classes called the moderates. The *moderate ideology* was -

- The British colonialism and Indian Natinalism were not contradictory, rather complimentary. For the Moderates, development of England was the development of India.
- The British were invincible. As such, by a political of co-operation India could better secure her interests.
- England, mother of Parliamentary institutions, would increase the same in India and as such Indians should remain loyal to British.

The Moderate *method of struggle* was defined as "Constitutional Means of Agitation" (anything except popular means of agitation and seditions). It was well explained by Gokhale in his journal *'Sudhar'*. It is also *"Petition, Prayer and Protest"*.

The demands of the Moderates include -

- Expansion of Legislative Councils
- Meaningful Representation for Indian Members
- Seperation of Executive form Judiciary
- Increasing the upper age limit for Indian Civil Service aspirants and for conducting Civil Service Exams in India and England simultaneously.
- 50% reduction in rent, export duties and military

exploitation of Brahmin Landlords called *Nambudris* (Zenmis). An agrarian crisis became a communal movement leading to riots.

Riots also started in Meerut, Lucknow, Kanpur between Hindus and Muslims. Differences also started between Gandhi and Ali Brothers. On intensifying the movement.

On *Feb 5, 1922, the Chauri - Chaura incident* took place in Gorakhpur district of UP. 22 Police constables were burnt alive. In *Feb 11, Gandhi called off* the movement.

RESULTS -

The movement failed to achieve its objectives - The Hunter Committee appointed to inquire into the excesses of Dyer exonerated him.

- The Khilafat was abolished by the people of Turkey under Mustafa Kamal Pasha.
- No Constitutional reforms were introduced.

The negative effects of the movements were -

- The failure created a permanent gulf between Hindus and Muslims. It was the last movement in the struggle with Hindu - Muslim joint resistance.

The Ali Brothers blamed Gandhi for the failure of the movement.

- Within the Congress, differences arose. Deshbandhu CR Das, the President of the Gaya Session, 1922 criticised Gandhian method of struggle and suggested for contesting the 1923 elections under Montague - Chelmsford reforms. The followers of CR Das, Motilal Nehru, vittalbhai Patel were called the *pro-changers*. They advocated *"Councils Entry"*. The no changers, supoorting Gandhi and opposing Councils Entry were Subhas Chandra Bose, Rajendra Prasad, Jawaharlal Nehru and Vallabhai Patel. The pro - changers founder The *Congress - Khilafat Swaraj Party* under CR DAs and contested the elections. The Swaraj Party emerged as the largest party in Central Legislative Assembly, Motilal Nehru become the first Indian opposition leader. Vitalbhai Patel became the first Indian opposition leader. Vittalbhai Patel became the first Indian elected speaker. CR Das became the first elected Chairman of Calcutta Municipal Corporation. However, with the sudden death of CR Das in 1925. The Swaraj Party got completely merged with Congress.
- In *1924, Alexander Muddyman Committee* was appointed to review the Dyarchy; introduced under the Reforms in 1919.
- In 1924, Gandhi presided over the *Belgaum Session*. The only session, Gandhi acted as President. At the instance of Gandhi, the membership fee of the Congress was fixed at 25p. or 4 annas; in the Belgaum Session.
- In 1925, *All India Hindu Mahasabha* declared officially its formation (actually founded in 1915 by M.M. Malviya and Manooji".
- In *1925, The CPI* (Communist Party of India) declared its formation officially in its Kanpur Session. (actually founded in 1920 by M.N. Roy at Tashkent).

In *1927, Marcourt Butler Committee* was formed to study and promote the relationship beter. British India and Princely States.

In *1927*, PM Ramsay Mac Donald constituted *Simon Commission* under the chairmanship of Sir John Simon with *7* members, all English, to study the implementation of 1919 reforms. All the political parties except *Justice Party* and the *Depressed Class Federation* of Dr. Ambedkar decided to boycott the commission. *Madhav Malgaonko* was the first to organise. *'Simon Glo Back'* movement in Bombay; in Madras, *T. Prakasham* called 'Andrha Kesari' led the anti-Simon Movement, in Lahore, *Punjab Kesari, Lala Lajpat Rai* organised a mammoth really against the Commission, lathicharged by *Saunders* and died of injuries in Dec, 1928.

MOTILAL NEHRU COMMITTEE (JUNE, 1928)

The Secretary of State, Lord Berkinhead challenged the political parties of India to draft, a model constitution, acceptable to all. The All - Party Conference was held in Delhi under the Chairmanship of Z.A. Ansari. *Motilal Nehru* was appointed the *Chairman of the Drafting Committee.*

The *recommendations* of the Committee were -

- A federal government at the Centre with British India and Princely States.
- Abolition of Dyarchy
- Elected govts. in provinces with complete autonomy
- Civil Liberties.

The most controversial parts of the Report was that it denied seperate communal electorates to the Muslims. Instead it provided for a reservation of 1/3rd seats in the general electorate to the Muslims.

Jinnah rejected the report and came out with his *14-point Formula* suggesting measures on minority rights. However Congress served an ultimatim fixing Dec, 1929 as deadline for the implementation of the report.

In Oct 1929, the *Deepanawi Declaration* was made by Viceroy Irwin. It invited all political parties to take part in the Round Table Conferences to be held in London on the recommendations of Simon Commission.

In Dec 1929, the historic *Lahore Session* was held, presided over by Jawaharlal Nehru - *Poorna Swaraj* was declared the highest goal of Congress - The tricolour flag prepared by P. Venkaiah was hoisted for the first time and it was decided to celebrate Jan 26 every year as Independence Day.

In *Feb, 1930*, Gandhi met Irwin with his *11 demands*, that included a right to make salt, 50% reduction in rent, (land tax), export duties, military expenditure and a better exchange ratio between sterling and Indian rupee. The demands were rejected.

CIVIL DISOBEDIENCE MOVEMENT (1930 - 1932) :

On *March 12, 1930*, Gandhi started his *Dandi March* from the Sabarmati Ashram followed by 78 followers; distance *365 km* was covered by Gandhi in *25 days.* Sarojini Naidu represented the woman wing. On *April 6, 1930, Gandhi broke the salt law* at Dandi. In the Madras Presidency, Rajaji organised the Salt Marches from Trichy to Thindivaram. *B. Gopal Reddy* organised the famour Mypadu Salt Satyagraha.

In Bombay *Khan Abdul Gaffar Khan* (Frontier Gandhi) organised the movement with his followers called *'Red Shirts'*; founded the society called *Khudai Khidmatgars* (Servants of God Society).

Gandhi was imprisoned in the Agha Khan Palace, Pune.

ROUND TABLE CONFERENCES -

All the 3 RTCs were held in the Bukingham Palace, London presided over by PM Ramsay Mac Donald. Alexander Muddyman was the General Secretary.

- Congress participated only in the 2nd RTC.
- Muslim League was represented by *Maulana Md. Ali, Md. Shafi*, and *Jinnah* (participated in all 3 RTC like Ambedkar). The League appointed Asaf Ali as its permanent member in London.
- The Hindu Mahasabha Federation, the party of the princely states, was represented by *Tej Bahadur Sapru, C.Y. Chinatamani* and *Mirza Ismail Khan*.
- The Depressed Classes represented by *Dr. Ambedkar* and *M.C. Raja*.

In the absence of Congress Party, The 1st RTC failed to arrive at Consensus on constitutional reforms.

Tej Bahadur Sapru and M.R. Jayekar mediated better. Gandhi and Irwin. As a result on *Mar 5, 1931, The Gandhi - Irwin Pact* was signed. Irwin agreed to release all the political prisoners except those found guilty of violence (Bhagat Singh, Rajguru and Sukhdev) and to restore the property of the prisoners imprisoned. Salt Law was revoked. Gandhi, on his part, agreed to take part in the 2nd RTC and suspend the movement. Gandhi left for London as the sole representative of the Congress in the ship called INS Rajput, assisted by Sarojini Naidu.

The 2nd RTC ended abruptly as Communal Parties criticised Congress and no agreement could reach on the form of govt. to be formed and constitutional reforms. Dejected Gandhi blamed Ramsay MacDonald for the failure, returned to India, threatened to revive the movement and was imprisoned.

The 1931 Karachi Session was presided over by Sardar Vallabhai Patel (the only session, Patel acted as President). Socialism declared highest goal of Congress.

In *Aug. 1932*, PM Ramsay Macdonald announced *Communal Award* providing seperate Communal eletorates to the depressed classes. Gandhi protested against the Award with his fast unto death. In *Sep. 1932, Poona Pact was* was signed between caste Hindus and the depressed classes.

In *1933* Parliament published *White Paper* disclosing the discussions taken place and decisions arrived at in all 3 RTCs. It was the basis for the Govt. of India Act, 1935.

In the *1934 Bombay Session, The Congress Socialist Party* founded by Acharya Narendra Dev, Jai Parakash Narayan, Achuta Patwardhan, Aruna Asaf Ali and Minoo Masani. However, the CSP continued to remain within the Congress Party. Its main purpose was to transform Congress gradually into socialism. The Govt. of *India Act, 1935 came into effect from Apr 1, 1937*. All the political parties including congress contested the 1937 elections. Congress formed govts. in 8 out of 11 provinces. The league formed govts. in Punjab, Sind and Bengal.

Differences started within Congress between Bose and Gandhi on the issues -

- Implementation of Land Reforms.
- Bose was the elected President in the *1938 Haripura Session* and decided to contest for the 2nd time in the *1939 Tripura Session* Bose defeated Gandhi's candidate B.P. Sitaramaiah (the author of *'The History of Congress'*)
- Regarding the strategy of the Congress in the wake of World War II.

Bose's proposal for a mass movement was turned down by

- In the constitution of CWC also, differences started. Bose resigned and founded the *Forward Bloc Party in 1940*.

COMMUNAL POLITICS -

- Chaudhari Rehmat Ali, a Combridge University Law Graduate was the first to draw the map of Pakistan in 1933.
- The League's proposal for a coalition govt. in UP was turned down by Congress in the 1937 elections.
- The League appointed the *Raja of Pirpur Committee* to inquire into the atrocities perpetuated on minorities under Congress govt.
- In the 1939 Allahabad Session of the League, *Md. Iqbal*, the author of Sare Jahan Se Achha proposed the idea of Pakistan.
- In 1939, when congress govts. resigned as a protest against involving India win World War - II, in a provocative act, Muslim League gave a call for celebrating "Day of Deliverance" or *Thanks giving Day* (Dec 22, 1939).
- In the *Lahore Session* of Muslim League, 1940, Jinnah came out with the *Two - Nation Theory* providing ideological basis for the demand Pakistan.

The *Resolution on Pakistan* was passed on *March 21, 1940*

AUGUST OFFER (AUG 6, 1940) :

Viceroy *Lord Linlithgow* on Aug 6, 1940 made the offer in order to in the support of Indians in the war effort. It proposed for.

War Cabinet with all the partfolios under the Indians except defence.

Dominion Status to India after the war.

A Constituent Assembly after the war.

Congress rejected the offer as the proposals were not time bound. Congress gave a call for *Individual Satyagraha*. Acharya Vinoba Bhave was the first to perform Individual Satyagraha on behalf of Congress. In 1942, PM Winston Churchill announced the *Cripps Mission Plan*. In *March, 1942, Cripps* came to India and made the proposals just the same as August offer. Further, Cripps provided for *Right of Self Determination'*. Gandhi observed the proposal as *"Post - dated leagues on a crumbling bank"*.

QUIT INDIA MOVEMENT (AUG, 1942)

The CWC met in Bombay as Aug 6, 1942. Gandhi himself trafted the *Quit India Resolution* with the Slogan *'Do or Die'*. The last struggle in the Movement was a leaderless one. The peasant communities founded the parallel govts. called *Praja Sarkars*. in the Balia district of UP; under the leadership of *Chitu Pandey*; in Monghut under the leadership of *Saratchandra* and at Satara under *Nana Patil*. The CSP leaders, JP Narayan and Axuna Asaf Ali carried out underground activities providing indirect leadership to the movement. The CPI played a controversial role by supporting the British.

Gandhi was imprisoned in the Yaravada Jail in Pune and was trialled for 1942 August distubances, under the Charges of Sedition. Gandhi observed fast into death as a protest. During the inprisonment, his wife Kasturba, Secy Mahadev Desai died in the imprisonment.

In 1944, on health grounds Gandhi was released.

INA -

Bose escaped from house imprisonment, first went by PM Toja. INA was actually founded by *Cap. Mohan Singh* consisted of 20,000 Indian war prisoners captured by Japan. Bose took over the commandership of INA, changed its name to *Azad Hind Facy'* divided INA into 4 regiments; *Mahatma, Azad, Jawahar and Netaji*, gave the Slogans. 'Unto Delhi' and *Jai Hind.* The InA Commandership included *Cap. Shahnawaz Khan, Prem Sehgal, Cap. Dhillion* and *Cap. Laxmi.*

The INA founded the 1st provincial govt of free India at Singapore. It entered Burma and destroyed Mandalay Sail in Burma came upto Kohima in Assam. As Japan withdrew its forces in the WN front, INA was defeated and its commanders were imprisoned in the Red Fort. The *INA trials* were held in Red Fort, Congress constituted a Defence Council for the INA officers headed by *Asaf Ali* & other members being *Jawaharlal Nehru* and *Tej Bahadur Sapru. Bhulabhai Desai* was the Secy. of the Defence Council.

CR FORMULA - (JUNE 1944) :

CR or Rajaji drafted the formula providing for -

CR Formula - (June 1944)

- CR or Rajaji drafted the formula providing for -
- A plebiscite in the demarcated Muslim majority provinces in the NW & East on the issue of Pakistan. If the plebiscite favours Pakistan, Pakistan would be granted.
- In the event of Pakistan becoming a reality, there would be joint control of India and Pakistan on *currency, communications and defence.*
- Jinnah rejected the CR Formula as he was not confident of the support of the Muslims for the idea of Pakistan.

In *Sep. 1944, Gandhi - Jinnah talks* were held but they failed & Jinnah insisted on being recognised as the sole leader of the Muslims.

Wavell Plan and Shimla Conference :

In June 1945, Lord Wavell, the Governor General proposed for tentative arrangement at the Centre with the League and Congress sharing power on the *principle of parity.* In the Shimla Conference, Congress was represented by *Nehru* and League by *Jinnah.* Though Jinnah agreed at the beginning to share power with the Congress, the conference failed when Jinnah insisted on that Congress not to dominate any Muslim member without his consent in its share of portfolios.

In 1945, elections were held after World War - II. The conservative party under Churchill lost the elections. Labour Party under *Clemant Atlee* came to power. In India, Congress formed Govts in 8 provinces and the League in Punjab, Sidh and Bengal.

In Jan, 1945, PM Atlee announced that an All - Party Delegation of the Parliament would visit India to decide the question of transfer of power. In *Feb, 1945, The All - Party Delegation* visited India and favoured for transfer of power. In *Feb, 1946, the Indian Navy* officers in *Bombay, Kolaba, Cochin, Karachi* and *Kandla revolted* at a time against the racial discrimination of the British military administration. The riots that followed were called *"Bombay Naval Ratings".* It was the last act of protest in the freedom struggle. In March, 1946, PM Atlee announced that a Cabinet Mission would visit India to decide the modalities of transfer of power.

Cabinet Mission Plan -

The Cabinet Mission consisted of *Sir A. V. Alexander*, its Chairman, and other member being *Pethik Lawrence* and *Sir Stafford Cripps.* Its recommendations were -

- A Union govt. of India, to be constituted
- A Centre with limited subjects of power : Defence, currency and communications.
- Provinces with complete autonomy.
- A Constituent Assembly consisted of the members elected by Provincial Legislative Assemblies and members nominated by the Princely States.
- The most controversial recommendation was its *'Grouping Pattern'* of dividing the provinces of India into 3 groups.

  Group A - except Group B and Group C

  Group B - Punjab, Sindh and NWFP

  Group C - Bengal and Assam
- The Cabinet Mission outrightly rejected the idea of "Pakistan", as the creation of a small province of Pakistan would result in tremendous dislocation of resources and hence not viable.
- In *July, 1946* elections were held for the Constituent Assembly. *Congress got 205 members* elected and the *League 73.*
- In Aug, 1946, The Muslim League rejected the Cabinet Mission Plan and boycotted the Constituent Assembly.

Aug, 16, 1946 was observed by Muslim League as the "Direct Action Day" for Pakistan. Communal riots started first at *Noakhali* in Calcutta, spreading to different parts of India very soon. Syed Suhrawardy, the Chief Minister of Bengal openly supported Direct Action Day.

On *Sep 2, 1946*, Governor General Lord Wavell formed *Interim govt.* with himself as President and Jawaharlal Nehru as Vice President. Patel was the Home Minister.

When the League joined the Interim Govt, its candidate, *Liaqat Ali* was given the key *Finance* portfolio. Later, the League boycotted the Interim Govt. also in Oct, 1946.

On Dec 9, 1946, the Constituent Assembly met for the first time, elected *Rajendra Prasad as President* and *Dr. B.R. Ambedkar* was made *Chairman of the Drafting Committee.*

In Feb. 1947, PM Atlee announced that power would be transferred to India by not later than June 1948 and for that Lord Mountbatten would be sent as the last Governor General to India.

In March 1947, Mountbatten came to India. In *April 1947,* he drafted his plan of partitioning India into 2 dominions called India and Pakistan, the plan called *April Plan, Balkan Plan, Dickie Bird Plan.* The Plan was approved by Parliament with modifications called *June 3rd Plan* providing for -

- Demarcation Committees between India and Pakistan
- Plebiscite in the Muslim Majority provinces in Punjab, NWFP in the West and Sylhet district of Assam on the question of joining either India or Pakistan.
- The princely states were given the right of self determination, either to join India or Pakistan or to remain

independent.

A *Bill on the Transfer of Power to India and Pakistan*, called the *Indian Independence Act* was introduced in the Parliament. Approved by Parliament on July 18, 1947, fixing the deadline for transfer of power on Aug 15 and its also provided for the appointment of 2 governor generals each for India and Pakistan.

Rajaji became 1st Indian Governor General and *Jinnah*, first governor general in Pakistan. *Liaqat Ali* became the first PM of Pakistan.

5. REVOLUTIONARY ACTIVITIES

Bombay Presidency -

The 1st revolutionary act was assassination of two British officers. Iryst and Rand by *Chapekar Brothers* (Balakrishna and Damodar) in 1897 for their indifference during the *Cholera Operations* in Pune.

In *1899*, the Savarkar Brother founded *Abhinav Bharat*, the 1st revolutionary organisation in India as a secret society. In 1907, Ganesh Savarkar founded *Mitra Mela*, another revolutionary organisation. The Savarkar Brothers were tried under *Nasik Conspiracy Case, 1908* for attempting on the life of Steverson, the District Magistrate of Nasik and were deported for life.

Bengal Presidency -

Anushilan Samiti was the first revolutionary organisation founded in *1902 by Barindra Kumar Ghosh, Bhupendranath Dutta, Prafulla Chaki, Khudiram Bose* and *Parmotarak Mitra.* Aurobindo Ghost also belonged to Anushilan Samiti. In 1902, *Anushilan Samiti of Dacca*, another secret society was founded by *Pulin Das.* The Samiti attempted on the life of Lt. Governor of Bengal, Fuller in 1904. In 1906, all Anushilan Samiti members were tried on the charges of attempting on the life of *Kingsford*. The district magistrate of Muzaffarpur. Except Aurobindo, all were deported for life. Aurobindo settled at Pondicherry and founded Krishna Ashram.

Bagha Jatin (Jatin Mukherjee), the most popular revolutionary in West Bengal planned an attack on Writers' Building and was killed in an encounter at Balasore in 1915.

Surya Sen was the most popular revolutionary from East Bengal. He founded *'Hindustan People's Republican Army'* and conducted *Chittagong Armoury Raid in 1930.*

Pritilata Wadekar and *Kalpana Dutta* were his two women comrades involved in the explosion of the European Club in Decca with the executor of Surya in 1933, terrorism ended in Bengal.

United Provinces -

The Roorke Engineering College was the main centre of activities. In *1912, Rashbehari Bose* attempted on the life of viceroy Lord Hardinge II; when the Viceroy was entering the new capital city Delhi, called *Delhi Conspiracy Case.*

In 1924, *Sachin Sanyal* and *Jogesh Chandra Chatterjee* founded the *Hindustan People's Republican Party*, first revolutionary organisation at All India level. At the instance of *Bhagat Singh*, its name was changed as *Socialist Party.* In 1926, *Ram Prasad Bismil* and *Ashwaqullar Khan* of the Republican Party conducted the *Kakori train dacoity.* In Dec, 1928, *Bhagat Singh and Rajguru* killed Sauders.

On April 14, 1929, Bhagat Singh, Rajguru, Batukeswar Dutt and Vijay Kumar Sinha hurled bombs in Central Legislative Assembly (Parliament) in protest against the Public Safety Bill and Indian Trade Disputes Bill; tried under *Lahore Conspiracy Case*, Bhagat Singh, Rajguru and Sukhdev were executed on 23rd March, 1931 on the banks of River Ravi. Lahore Jail for better living conditions for the prisoners.

Madras Presidency -

Bharata Mata Sangam was the Popular revolutionary organisation founded by *Subramanya Sivam* and *Neelakanta Brahmachari* in 1908. The Sangam was involved in *Thirunelvelli Conspiracy Case*. The District Collector Aash was assassinated.

Darsi Chenchaiah, the only member of the Ghadar Party from the South, involved in the *Ongole Conspiracy Case.*

Terrorism Abroad -

Shyamji Krishnavarma founded *Indian Society*, a secret society in London and also started the journals *Indian Sociologist. Mandanlal Dhingra* of the Indian Society assassinated Curzon Veille; a spy on Indian House.

B.R. Cama called 'Mother of Indian Revolution' started Vande Mataram Movement in Paris and also founded the journal *'Vande Mataram'.*

In 1913, revolutionaries like *Lala Hardayal, Sohan Singh Bakna* founded the *Ghadar Party* at San Fransisco. The other members were *Rashbehari Bose, Keshar Singh, Jwala Singh, Ramachandra Bharadwaj, Ajit Singh, Mahendra Pratap* (15 Ghadarites).

In 1915, Mahendra Pratap and Barkatullah Khan of the Ghadar Party founded *the first provincial govt. of free India in Kabul.

In *1914-15 the Kamagata Maru incident* took place. It was a Japan based ship sailing to Vancouver, commanded by Capt. Gurdeet Singh. The ship was not allowed to enter Vancouver on the suspicion that it was carrying revolutionaries and explosives.

In 1940, Udham Singh killed Dyer in London. In 1942, *Birendranadh Chattopadhyay* founded *Indian Independence Committee* in Berlin. Under *Zimmerman Plan*, the Committee tried to mobilize support of the Nazi Party for India's liberation.

In 1942, Rashbehari Bose of Ghadar Party founded *Indian Independence League* in Tokyo and mobilised resources for INA.

Revolutionary Journals :

Barindra Kumar Ghosh and *Bhupendranath Dutta* founded the Journal *Yugantar.*

Sandhya, founded by *Brahmobandhab Upadhyay.*

Kirti was founded by *Santokh Singh*

Langal and *Ganabani* were founded by *S.S. Mirzakar* and *Jolekar.*

Kranti was founded by *Dharani Goswani* and *Gopu chakraborty.*

Bhagat Singh wrote a pamphlet - *'Why I am an*

6. CONSTITUTIONAL REFORMS

Regulating Act, 1773 -

The first Constitutional Reform.

It provided for -

A *Court of Directors* for the East India Company (60 members). The Governor of Bengal was made Governor General of Fort William. Governors of Bombay and Madras were placed under Governor General of Fort William.

A Legislative body called *Governor General - in -Council* with *4* members was created.

A Supreme Court of Calcutta was provided with 3 Judges and a Chief Justice (Elize Imphey - First Chief Justice)

The Company's servants were barred from accepting bribes, and presentations.

Pitts India Act, 1784 -

Was passed to rectify the drawbacks of Regulating Act. It was also the first attempt on the part of Parliament to control the company indirectly. The Act provided for -

Board of Control with 6 members called *commissioners* and a *President* to monitor the functioning of Court of Director; the President answerable to Parliament.

The Governors of Bombay and Madras were clearly been insubordinated to the Governor General of Fort William.

The membership of the Legislative Body was reduced to *3* from 4.

The Supreme Court of Calcutta was meant only for English Subjects.

The Act authorised Court of Directors to make all the recruitments in India.

Charter Act, 1813 -

- Started *Free Trade Policy* ending the monopoly on all items except Tea and Opium.
- The Act made training compulsory for all civil servants before joining the Service.
- It provided for Rs 1 lac for promoting education in British India.

Charter Act, 1833 -

- Completely ended the monopoly on all items of trade including tea and opium, *(Complete Free Trade Policy)*
- **Centralisation* of legislation started. The laws made by Governor General - in - Council in Kolkata were made applicable automatically for Bombay and Madras Presidencies.
- Governor General of Fort William was made Governor General of British India *(William Bentinck* -First Governor of British India.
- A *law member* was appointed for the first time in the Governor General - in - Council *(T.B. Macaulay* -The First Law Member)
- *The Act for the first time recommended for the appointment of India to the *Civil Services.*

Charter Act, 1853 -

- Relieved the Governor General from the responsibility of the Governor of Bengal *(Lord Dalhousie* became the 1st Governor General without the additional responsibility of being the Governor of Bengal). A Lt. Governor was appointed for Bengal *(Andrew Fraser)*
- The recruitment and recalling rights were transferred from the Court of Directors to Board of Control (Written competitive exams started from 1854).

Indian Councils Act, 1861 -

- Provided for *Legislative Councils* in Bombay, Madras & Calcutta and for the nomination of Indian Members called **non official members.*
- Under the Act, Lord Canning introduced **Portfolio System* (allocation of departments for the frist time).

Indian Councils Act, 1892 -

- *Provided for the first time for *indirect elections.*
- Indian members were permitted to ask questions but were not given the right to vote.

Minto - Morley Reforms 1909 / Govt. of India Act, 1909

- Separate communal electorates to the Muslims.
- For the first time, Indians were allowed to be appointed in the Viceroy's Executive Council *(Lord S.P. Sinha* became the 1st Indian appointed to the Executive Council and was given Law portfolio)

Montague - Chelmsford Reforms/ Govt. of India Act, 1919 -

- *Dyarchy* at the provincial level. Under dyarchy, the subjects of power were divided into reserved and transferred. Under *reserved* subjects, *Finance, Internal Order, Jails, Revenue* were administered by Governor and his Executive Council. The *Transferred* subjects like *Education, Public Health, Sanitation, Municipal Administration; Irrigation* and *Industries* were to be administered by Governor and his Council of Ministers.
- *The Act provided for the First time, *general (direct) elections.* The elected govts. at the provincial level would administer the transferred subjects.
- *Bicameral Legislature* (Council of States - The Upper House and Central Legislative Assembly - The Lower House) were introduced at the Central level.
- **Devolution of Power* was made for the first time dividing the powers into Central and Provincial.
- The office of the *Indian High Commissioner* was created for the first time in London to promote cultural, trade & commercial contacts between England and India.

Government of India Act, 1935 -

The last Constitutional reform of the British, provided for -

- A *Federal Govt.* with British India and princely states but federation never materialised as princely states never joined the federation.
- Dyarchy was abolished.
- Elected/ Responsible govts. at the provinces were given all the subjects of power under Provincial List.

- *Division of Power* took place for the first time dividing the powers into Central, Provincial and Concurrent (Residency)
- Bicameral Legislatures were introduced in 6 provinces (Madras, Bombay, Bihar, U.P., Assam and Bengal)
- Separate communal electorates were given to *Sikhs, Anglo - Indians and Parsis.*
- A *Federal Court of Justice* with 6 Judges and One Chief Justice was provided which later became Supreme Court of India (The Federal Court was founded in 1937)
- *Federal Reserve Bank* and a *Federal Service Commission* were being provided.
- The Governor General at the Centre and Governors in provinces were given *Absolute Veto Powers.*

7. ADMINISTRATIVE POLICIES

1. Civil Services -

The Word *'Civil Servant'* for the first time appeared in the records from *1757* The office of the *District Collector* was created for the first time *in 1771* by Lord Warren Hastings. However, it was *Lord Cornwallis,* regarded as the *'Founder Father of Modern Indian Civil Services'.* He created the Police Service, Judicial and Revenue Services formulated the *Code of Conduct* for the civil servants and laid down the procedure for their promotions. In 1800, Lord Wellesley founded the *Fort William College* to train the Civil Servants. However from *1805,* the Fort William College was replaced by Haileybury College, London to train the civil servants.

The 1813 Charter Act defined the office of civil servant as the Civil Service with an annual salary of 500 pounds.

Lord William Bentinck restored, and revived magisterial powers for the District Collector (Lord Cornwallis divested the magisterial powers of Collector).

In 1868, *Satyendranath Tagore* became the first Indian ICS officer. The *1886, Aitchison Committee,* appointed by Lord Dufferin recommended for increase in upper age limit from 19 to 22 *(Lord Lytton reduced* the upper age limit from 21 to 19 & introduced *Statutory Civil Services) Lord Mayo* introduced *Scholarship Scheme* in 1868, to enable meritorious Indians to go for Civil Services. The Montague Chelmsford Reforms provided for a recruitment for 1/3 of the posts in India only. In 1922, the Civil Service exams were held both in England and Indian together. In *1924, Lord Lee Committee* was appointed to study the Civil Services in India. It recommended for bifurcation of services into *Imperil, Provincial* and *Subordinate.* It also recommended for a Federal Service Commission and Provincial Service Commission.

2. Judicial Services / Reforms

Lord Warren Hastings was the first to form local courts called *Munsif Courts,* presided over by the Indians.

At the district level, he created *Diwani Courts* for civil cases and *Nizamat Courts,* for criminal cases to be presided over by Civil Servants called Judges. The higher courts of appeal called *Sadr Diwani Adalat* for civil cases and *Sadr Nizamat Adalat* for Criminal cases were also founded by Warren Hastings.

Lord Cornwallis introduced *Code de Cornwallis,* a judicial procedure code. He founded *4 Circuit Courts* at Patna, Dacca, Murshidabad and Calcutta.

Under Charter Act, 1833, *J.B. Macaulay* became the First Law member. It was Macaulay that codified the Hindu Law and Islami Law.

In *1859, Indian Civil Procedure Code, 1860 Indian Civil Code* and in *1861, Indian Criminal Procedure code* were introduced. In *1865,* at the instance of Sir John Lawrence, the *Madras , Bombay* and *Calcutta High Courts* were founded.

3. Education Policy

Lord Warren Hastings founded Calcutta Madrasa to impart Persian language for the civil servants. *Jonathan Duncan* founder the *Sanskrit College* at Varanasi.

Sir William Jones founded the *Royal Asiatic Society in 1784* in Calcutta to promote studies on Indian languages and Culture. He translated Manusmriti and Abhignana Shakuntalam into English.

Wycline was the first to translate *Bhagawad Gita into English.*

The 1813 Charter Act provided Rs 1 lakh for education in British India. The *Anglicist and Orientalist Controversy* was related to the spending of 1 lakh whether for English education or native education and in the medium of English or mother tongue. The controversy ended once for all with **'Macaulay Minute'* passed on March 7, 1831. Macaulay as the Chairman of the Committee on Public Instruction made English the official medium of instruction. He also introduced *'Downward Infiltration Theory'* which means imparting English education to a selected few of Indians who in turn would spread it to others.

In 1840, Lord Hardinge I made English compulsory for all the competitive exams.

*In 1854, Charles Wood, the President of the Board of control drafted his education policy called **Woods' Despatch,* popular as the *'Magna Carta of the English Education'* and also *'Intellectual Charter of India'* It provided for woman education, primary education and vocational courses. it rejected the 'Downward Infiltration Theory' of Macaulay, providing education for all.

In 1857, **3 Universities* were founded at a time in Bombay, Madras and Calcutta.

In 1882, Lord Ripon appointed *W.W. Hunter Committee* called 1st Indian Education Commission to promote primary education.

In 1902, Lord Curzon appointed *Thomas Raleigh (Reiley) Committee* to study the university education. The Committee recommended for bringing universities under the control of govt. with 1904 Calcutta University Act.

In 1917, Saddler Committee was appointed to study higher education. It made Degree Course - 3 years.

In 1928, Harligh Committee was appointed by the Simon Commission to study education in India. It recommended for separate Boards for primary, secondary and intermediate education.

The **Wardha Scheme of Education* , also called *Naithalin* means a series of ideas expressed by Gandhi in his journal 'Harijan' on Indian Education.

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MODERN INDIAN HISTORY

MODERN INDIAN HISTORY

I. CIVIL REBELLIONS

I. TRIBAL MOVEMENTS

THE REASONS –

- ✦ British land revenue policy, particularly Permanent Settlement in 1793 A.D. was the single most important factor for the tribal movements.
- ✦ Lord Hardinge I, the Governor General introduced Forest Laws in 1840 A.D. prohibiting Podu Cultivation (Shifting Cultivation), imposed taxes on forest products and barred the custom of human sacrifice practiced by Khonds of Orissa and Gonds of Adilabad district of A.P.
- ✦ New administrative system with police, courts, lawyers was also being resisted by the tribes.
- ✦ The Christian missionary activities in the agency areas and the British deploying army in the agency were the other factors for the revolts.

POPULAR TRIBAL REVOLTS –

1. **Chuars - Marabhum And Danabrhum :** were the first to revolt against British land revenue policy, in 1769 A.D.
2. **Khasis - Assam :** revolted in 1828-1832 A.D. under the leadership of Tiruth Singh and Darmanik against the presence of Army in the agency area and British revenue policy.
3. **Kols - Chotanagpur :** revolted in 1832 A.D. under the leadership of Buddho Bhagath against British policy of expansionism.
4. **Khonda - Orissa :** revolted in 1846-48 A.D. under the leadership of Chakra Besai against the British policy of interference when Lord Hardinge I barred the custom of human sacrifice.
5. **Kachanaga : Kacher (Cachar) Dist in Assam :** 1882 A.D. revolted under the British land revenue policy under the leadership of Sambu Dan.
6. **Koya : Godavari Agency Area in A.P. :** revolted in 1992 - 1923 A.D at Rampa - Chodavaran under the leadership of **Alluri Seetha Ramaraj* against the British forest laws and the exploitation of the tribes by the tribal chiefs called Muthadars. Seetha Ramraj attacked Chintapalli police station with his Koya followers and killed notorious officer *"Bastian"*. *Rutherford* was the Commissioner of Operations against Seetha Ramraj. Raju was assassinated at Koyyagudem.
7. **Munda Uprising :** *1899 - 1900 A.D.* revolted under the leadership of Birsa Munda against the Christian missionary activities in the agency area and for their own rights in the soil. Birsa founded a new cult called **Singabonga* and started the *Sons of the Soil Movement* called *Ulgular*. He was deported in 1900 A.D. as political prisoner.
8. **Naikdas - Panchamahal Hills, Gujarat :** *1858 A.D; 1868 A.D:* revolted under the leadership of *Roop Singh* and *Jaria Bhagath* against British policy of expansionism and interference. They declared the formation of the 2nd independent tribal kingdom with Roop Singh as the head of the State and Jaria as the head of the religion.
9. **Oroans - Chotanagpur :** *1915 A.D.* revolted under the leadership of *Jatra Bhagath*. It started as a reform movement called Bhagath Movement and also *Tanabhagat Movement* preaching Monotheism. Later it became anti-British and part of the freedom struggle.
10. ****Santhal Rebellion - Rajmahal Hills in Bihar :** *1854 A.D - 1856 A.D.* opposed British land revenue policy under the leadership of Siddhu - and Kanhu.

They defeated the British armies under General Borrough and declared the formation of 1st independent tribal kingdom in modern India in the region between Bhagalpur and Patna. The importance of the revolt was-

- It was the first revolt that exploded the myth of European invincibility.
- The revolt had direct impact on 1857 Sepoy Mutiny.

1. **Savara : Srikakulam Asansol Area (A.P.) :** *1857 A.D;* led by *Dundasena* against the British Forest Laws.
2. **Thadou : Kuki : Manipur :** *1917 A.D.;* was led by *Rani Gidinilu* and her cousin Zodanang against the presence of the British in the agency areas. Imprisoned Rani Gidinilu was released in 1957 A.D; called the *Daughter of Indian Independence"* by PM Nehru.
3. **Bhils :** 1913 A.D; was led by Govind Guru against British revenue policy.
4. **Chenchu - Nallamala Hills in A.P. :** *1922 A.D - 1923 A.D.* They revolted against British forest laws under the leadership of *K. Hanumanthu*. He organised *Palanadu* - Forest Satyagraha against British Forest Laws.

II. ZAMINDAR REVOLTS

1. **MADRAS PRESIDENCY :**

a. The Zamindar of Bobbili was the first to revolt in Modern India. In 1757 A.D; Ranga Rao, the Zamindar of Bobbili opposed the domination of the French and challenged the French commander Bussey in the *Battle of Bobbili*.

b. The *Battle of Padmanabhan* in 1794 A.D. - The Raja of Vijayanagaram *Vijay Ramraj* was killed by the British. of Pesheush.

c. *Veerapandya Kattaboman*, the Zamindar of Panchalakuruchi opposed British revenue policy and revolted during 1792 - 1799 A.D.

d. *Velutumbi*, the Dewan of Travancore revolted during 1805 - 1809 A.D. against the British land revenue policy; died in the fight and the State of

e. *Kittur Uprising (1824 A.D)* - Rani Chennavva adopted *Shivalinga Rudra.* The British annulled her adoption and Chennavva organised the fight with the support of her cousin, Rayappa. Both were imprisoned in the Vellore Jail.

f. *Raja Rebellion (1827 A.D.)* - Raja Bir Bahadur of Visakhapatnam opposed British revenue Policy, revolted and lost his zamindari.

g. *V. Narasimha Reddy,* the Poligar of Koilkuntla in the Kurnool dist. of A.P. revolted against British revenue policy during 1845 A.D. and 1846 A.D; executed by the *Russell Brigade.*

2. **BENGAL PRESIDENCY :**

a. The Zamindar of Parlakinidi, *Jagannath Gajapathdev* revolted against the land revenue policy and lost his land estate in 1829 A.D.

b. In 1835 A.D. *Dhananjay Banja,* the Zamindar of Gunsur revolted against the revenue policy.

c. *Sambalpur Uprising* (1827 A.D. - 1840 A.D) - It was against the British Policy of interference. Maharaj Sai, the king of Sambalpur died without an heir apparent. The British interfered and declared his queen *Mahan Kumari* as the Queen of Sambalpur. The revolt was led by **Surendra Sai.* The illegitimate son of Maharaj Sai. In 1840 A.D.; Sweendra was deported to Burma as political prisoner.

3. **BOMBAY PRESIDENCY :**

a. **Ramosis Rebellion (1822 A.D) :** The peasant tribe around Pune lost their land holdings with the Third Anglo Maratha war in 1818 AD. They revolted under the leadership of *Chittor Singh and Ummaji.* The revolt ended when British agreed to provide employment to the Ramosis in the British army.

b. **Satavamdi Rebellion :** Khan Satwant, the ruler of Satawandi was deposed by the British in 1839 A.D. In his support, his commander *Pond Sathvanth* organised the revolt.

c. **The Satara Out break Disturbances 1840 A.D. :** Pratap Singh, the king of Satara was deposed by the British in 1840 A.D. In his support, Dharrao, Narsing and Powar organised the revolt. Though the state was restored, it became the first State annexed by Lord Dalhousie under Doctrine of Lapse in 1848 A.D.

d. **Khodkari Rebellion - 1845 A.D. :** Khodkari were the peasant tribes around Kothapur. In 1845 A.D. they revolted against the repressive revenue policy of *Dewan D.K. Pandit* who was supported by the English.

4. **CENTRAL PROVINCES :**

a. **Kutch Rebellion - 1845 A.D. :** *Rao Barmal,* the Dewan of Kutch opposed British revenue policy revolted. The State of Kutch was annexed.

b. **Bundela Uprising - 1842 A.D. :** The Bundelas of Sagar revolted under the leadership of Madhukar shah and Jawahir Singh against the revenue policy. Both the leaders were executed.

III. CIVIL REBELLIONS

1. **SANYASI REBELLION - 1772 A.D. :** was the *first civil rebellion* of Modern India, led by the Sanyasis of Giri order, founded by Adishankara started when Lord Warren Hastings barred the movement of Sanyasi visiting pilgrim centres in naked form.

2. **FARAZI MOVEMENT - 1804 AD :** Started in Faridpur dist. of West Bengal, founded by *Shariatullah* and his son, *Md. Mohisin.* Though a reform movement in the beginning, it became a communal movement opposing Hindu landed aristocracy and the British in Bengal.

3. **WAHABI MOVEMENT :** Actually founded by *Abdul Wahab* at Nazad in W. Punjab. It was introduced into India by Syed Ahmed of Bareilly in U.P. in 1822 A.D. However, Sittana in NWFP became the main centre of its activities. The movement was led by *Vilayat Ali, Inayat Ali and Maqsad Ali.* The Wahabis opposed Sikhs in Punjab and English in the rest of India. They preached Hindu - Muslim unity against the British. They played commendable role in 1857 Sepoy Mutiny. With the failure of Sepoy Mutiny, the movement also ended. Sydney Cotton, the British commander conducted series of campaigns on Sittana, the stronghold of Wahabis.

4. **PAGAL PANTHI MOVEMENT - 1827 A.D. :** Started by *Karam Shah* and his son Tipu in the Sherpur district of Bengal. The Pagal, panthis opposed the exploitation of Hindu Zamindars and attacked British establishments; called *'Pagals'* for they demanded radical land reforms.

5. **NAMDHARI AND KUKA MOVEMENT :**

First started by *Bhagat Jauhari Mal* as a social reform movement in the Sikh community opposing consumption of liquor and male - female inequality. However under Ram Singh, it became Kuka Movement. The Kukas regarded only Guru Gobind as the real Sikh guru, opposed the presence of Muslims in Punjab and attempted to revive the past glory of the Sikhs. In 1872 A.D; *Ram Singh organised the Kuka outbreak,* captured the city Amritsar and declared the formation of Kuka Govt. The movement ended with Ram Singh's capture and being deported to Burma as political prisoner.

IV. PEASANT UPRISINGS

1. **INDIGO REVOLUTION 1858 A.D - 1860 A.D. :** It was against the unjust system of 'advances' called *Tinkathia System.* The Indigo cultivators of Bihar and Bengal organised the rebellion under the leadership of Biswas Brothers, Bishnucharan Biswas and *Digambar Biswas.* The main centres of the revolt were Darbhanga in Bihar, Nadia and Jessore in Bengal. The Bengali intellectual, *Dinabhandhu Mitra* wrote the popular play, Nildarpan, depicting the plight of Indigo cultivators. The movement ended with the appointment of the 1st Indigo Enquiry Commission in 1860 A.D. It was first Satyagraha Movement in Modern India.

2. **PABNA UPRISING - 1872 A.D. :** The Bengal peasantry at Pabna revolted against the revenue policy

of collecting rent in terms of cash. When the prices for agricultural commodities were falling down. It ended with guarantees given by the British over the peasant proprietorship over the soil.

3. **DECCAN RIOTS - 1875 A.D. :** During the Deccan famine in 1875 A.D; riots broke out in Ahmendnagar and Pune districts of Bombay Presidency against the exploitation of Marwari Moneylenders. The riots became armed rebellions under the leadership of *Vasudev Balwant Phadke*, regarding as the "Father of Modern Indian revolutionary terrorism". The riots ended with 1879 A.D. Deccan Peasants Relief Act that provided for guarantees of peasant proprietorship over the soil and imposed restrictions on both borrowing and lending.

2.1857 REVOLT

The British economic policy was the most important factor for the outbreak. The impoverished peasantry, the deposed zamindars and the unemployed youth in urban centres were the sections who participated in large numbers.

The British policy of expansionism from the beginning was devoid of ethics and values. Lord Warren Hastings followed 'ring fencing policy' (creating friendly states around enemy states and occupying both in course of time). Lord Wellesley introduced *Subsidiary Alliance System* and forced upon the native princess, conquered more than half of British India with the same system. Lord Dalhousie with his *'Doctrine of Lapse'* annexed the Indian States. Satara in 1848 A.D., Jaitpur in 1849 A.D., Sambalpur in 1850 A.D., Hill state of Bhagat in 1852 A.D; Jhansi in 1853 A.D. and Nagpur in 1854 A.D. However the states, Sambalpur and Bhagat were restored back. He abolished the titles of native Nawabs, refused to sanction pension to Nana Sahib, the adopted son of the last Peshwa, Bajirao II after the death of the Peshwa in 1851 A.D., declared that Red Fort belonged to the British and occupied, the state of Ayodhya in 1856 A.D., deposing Wajid Ali Shah, the Nawab, on grounds of mal - administration.

Lord Canning, the successor of Dalhousie declared that Mughal Emperor would not be permitted to use the royal title, Jille illahi (The shadow of God).

- In the social sphere, the progressive legislation of the British was held in contempt and suspicion by the majority Hindus and Muslims.
- In 1802 A.D. Lord Wellesley abolished the custom of female infanticide practiced by the Rajputs with his Regulation VI.
- In 1829 A.D, Lord William Bentinck abolished the custom of Sati at the instance of Ram Mohan Roy with his regulation XVII.
- In 1856 A.D Lord Dalhousie passed Widow Remarriage Act at the instance of Ishwar Chandra Vidyasagar.

However the most controversial Act was the 1856 Religious Disabilities Act or Indian Inheritance Act that retained property rights for the converted against the spirit of Dharmashastras.

Further, the company Administration sanctioned aid to the Christian missionaries in the form of grants.

The company historian William Grant declared in the House of Commons that "it was divinely ordained task to transform India into Christianity".

GRIEVANCES OF THE SEPOYS :

The Sepoys revolted for the first time in 1675 A.D. The Burhampore Regiment was the first to revolt against Robert Clive. It was also called *White Mutiny* as most of the Sepoys who revolted were English. support of Tipu Sultan and his family. The reasons for the revolt were-

- Sepoys were discriminated No Indian Sepoy was promoted beyond the rank of a Jatedar.
- Denied additional allowance called *Batta* granted only to English Sepoys.
- In 1856 A.D. *Service Enlistment Act* was passed, prohibiting the Sepoys from observing rituals and customs in military camps.

In 1857 Jan The *Royal Enfield Gun* was introduced to be operated by greased cartridges. The Sepoys refused to use the cartridge as they suspected cow and pig fat were used. On March 29, 1857 Mangal Pandey and his cousin Iswar Pandey of the 34 Native Infantry Regiment at Barackpore organised the revolt. On *May 10, 1857*, Capt. Bakth Khan of the 3rd Cavalry Regiment at Meerut led the revolt. On 11th May, 1857, the Sepoys occupied Delhi, declared Bahadur Shah as the Emperor of India and head of the revolt.

CENTRAL REGION :

1. *Arrah* in Bihar - Kunwar Singh and his brother Amar Singh, the zamindars of Jagadishpur organised the revolt.
2. *Bareilly* in UP - Khan Bahadur Khan, the head of the Rohillas was the leader of the revolt.
3. *Delhi* - Bahadur Shah was the titular head. Capt. Bakht Khan was the real head of the revolt.
4. *Faisabad - Maulvi Ahmedullah*, the head of Wahabi sect led the revolt in support of Begum Hazrat Mahal, wife of Nawab Wajid Ali. It was a brilliant example of communal harmony and faint resistance of Hindus and Muslims against the British under his leadership.

   The Muslims handed over the disputed site to the Hindus.
5. *Jhansi - Laxmi Bai*, The widow of Gangadhar Rao organised the revolt for the sake of her adopted son, Manohar Rao.
6. *Kanpur* - The main centre of the revolt. *Nana Sahib*, actually called Dondu Pandit led the revolt assisted by *Anna Saheb, Azimullah and Tantia Tope* Nane perpetuated atrocities on all European in Kanpur.
7. *Lucknow - Begum Hazrat Mahal* led the revolt for the take of her son, Berzis Qadr.

SUPPRESSION OF THE REVOLT -

Lord Canning was the Governor General *Collin Campbell* got back Delhi but died in the fight. *William Taylor and Vincent Eyre* defeated Kunwar Singh. Collin Campbell got back Kanpur, *Sir Hugh Rose* defeated Lakshmi Bai. Nana Sahib and Khan Bahadur Khan and Begum Hazrat Mahal took asylum in Nepal. Maulvi Ahmedullah was killed by the Raja of Puwain. Tantia Tope offered guerilla warfare was handed over to the English by Man Singh, a friend of Scindia was executed on April 18, 1858.

The main causes for the failure of the revolt was lack of co-ordination among the leaders.

RESULTS OF THE REVOLT :

- Lord Canning held the Allahabad Durbar and read out the 'Queen's proclamation' which promised no further conquests in India; No further interference in the internal affairs of the Indians and that Indians would be promoted in decision making.

  Accordingly, the *1861 Indian Councils Act, 1861 Indian Judiciary Act and 1861 Indian Executive Act* were passed.
- The administration of the Company ended. Its 2 agencies Count of Directors and Board of Control were abolished.
- The office of the Governor General also became the office of Viceroy (He was Governor General when he administered British India. He acts as Viceroy when he deals with princely States). Lord Canning was the 1st *Governor General - Cum - Viceroy.*

  An agency of 15 members called *Indian Council* was created in London to monitor the functioning of Viceroy and his staff. It was to be headed by a *Secretary of State for India. (Lord Charles Wood* became the 1st Secretary of State for India).
- There was a marked change in the Divide and Rule Policy of British. After 1857, they promoted Muslims against Hindus
- They divided the Indian Army on regional, racial and communal grounds.
- To cover up the losses during the revolt, from 1860 onwards, Income Tax was levied.

The Revolt was described as a mere *"Sepoy Mutiny"* by the British historians like *Col. Malleson*. For Lord Canning it was a "revolution". For nationalist historian, V.D. Savarkar, it was the "First War of Indian *Independence"*. For Tara Chand, it was the last attempt of the medieval order to regain their lost power, prestige *and privileges.*

The Mutiny was -

- Not Indian
- For vested interests
- Geographically centered around Central Provinces, Madras/ Bombay Presidency were largely unaffected.
- Sikhs, Gorkhas, intellectuals, Princely States supported the British.
- All Communities at large didn't participate.

3. 19th CENTURY - INDIAN RENAISSANCE

It was an attempt to reform Indian Society in the light of modernization, westernization and the threat of Christianity. The most important factor for the Renaissance was the introduction of English education with its ideas *of Humanism, Rationalism and Empiricism (Experiment and Experience)*

I. HINDU REFORM MOVEMENTS

1. **ATMIYA SABHA** - founded by *Raja Rammohan Roy* in Kolkata in 1815 A.D. was the first reform organisation. Its main theme was to promote studies on *Indian philosophy (Upanishads).*
2. **YOUNG BENGAL MOVEMENT** - was started by *Henry Vivian Derozio*, an Anglo - Indian teacher in 1824 A.D. His followers called Derozians were the first to start the practice of writing pamphlets of social and economic issues. Derozio inspired his whole generation of Bengali intellectuals including Vidyasagar and Keshab Chandra Sen.
3. **BRAHMA SAMAJ** - Actually called *Brahmo Sabha* was founded by Rammohan Roy in Kolkata in 1828 A.D. as a social reform organisation. Its main theme was *'Nirgunosapna'* (formless worship monotheism).

   Its social programme included -

   a. Eradication of social evils like Sati.

   b. Emancipation of woman.

   c. To demand for progressive education.

   d. To generate awareness an socio-economic and political issues.

   At the instance of Raja Rammohan Roy, the *custom of Sati was abolished in 1829 A.D.* He prevailed upon Lord T.B. Macaulay in introducing English education.

   After the death of Raja Rammohan Roy, *Debendranath Tagore* became the head of Brahmo Samaj. In 1866 A.D. Brahmo Samaj was divided for the first time on the issue of defining the relationship between Brahmanism and Brahmo Samaj. The radicals called *Keshab Chandra Sen, Anandamohan Bose and Shivnarayan Shastri* left Brahmo Samaj and founded All - India Brahmo Samaj. The Brahmo Samaj under Debendranath Tagore continued as Adi Brahmo Sabha.

   In 1878, the Brahmo Samaj was divided for the second time. Anand Mohan Bose and Shivnarayan Sastri revolted against Sen and founded Saddharmo Brahmo Samaj. The reasons for the second split were -

   - Keshab Chandra Sen introduced Kirtanas and Bhajans.
   - Declared himself a prophet and encouraged hero worship.
   - Performed child marriage.
4. **DHARMO SABHA** -

   A conservative movement founded by *Radhakanta Deb* in 1829 A.D. in Kolkata, opposed the progressive outlook of Brahmo Samaj.
5. **TATWABODHINI SABHA** -

promote studies on Indian philosophy. He also started the journal *'Tatwabodhini Patrika'*.

6. **MANAVA DHARMA SABHA -**

Founded in 1844 A.D. at Pune by *Durga Ram and Mancharam* to promote Brahmo ideas.

7. **PARAMHANSA MANDALI -**

Founded by Dadoji Pandurang in Bombay in 1849 A.D. to promote Brahmo ideas particularly monotheism.

8. **RADHASWAMY SATSANG/ SOMAJ**

Founded in 1861 A.D. in Agra by *Tulsiram,* also called Shivdayal Shastri. The Satsang apart from Monotheism, emphasized on a disciplined life without vices.

9. **PRARTHANA SAMAJ -**

Founded in 1867 A.D. in Bombay by Atmaram Pandurang as a branch of Brahmo Samaj in Bombay Presidency at the instance of Keshab Chandra Sen. Justice M.G. Ranade joined the Samaj in 1870 and was called *"Architect of the Samaj"*.

Its social program included -

- Imparting education to woman and the downtrodden.
- To establish widow homes

The Samaj spearheaded the lower caste movements in Bombay Presidency.

10. ***ARYA SAMAJ -**

Founded by *Swami Dayanand Sarswati,* first in Bombay in 1875 and later at Lahore in the same year.

The Social program of Arya Samaj included -

- Promoting studies on Vedas.
- The Samaj opposed the domination of priestly classes, encouraged widow remarriages, founded schools and colleges, hospitals, providing social service.

The 2 controversial programs of the Samaj were -

- **Suddhi Movement** - (Purification Movement) by which Arya Samaj tried to bring back the converted into Hinduism.
- **Cow protection movement** - With the 2 movements, the Samaj very often caused communal tensions between Hindus, Christians and Muslims.

After the death of Dayanand, the Samaj was divided on the issue of medium of instruction. *Swami Shraddhananda* demanded Sanskrit as the medium and founded Gurukul at Hardwar *(Gurukula Section)* Whereas *Lala Hansraj and Lala Lajpat Rai* demanded English as the medium (College Section) - founded Oriental College at Lahore.

11. **THEOSOPHICAL SOCIETY :**

Founded in 1875 at New York by *Madam H.P. Blavadsky and Col. Olcott.* The main purpose of the society was to promote studies on Theosophy (Occult Sciences). In 1878, the Centre was shifted to Adayar in Chennai.

Madam Annie Besant became the President of the Society in 1903 and led the Home Rule Movement demanding self governance for India.

12. **DECCAN EDUCATION SOCIETY -**

Agarkar to provide education to the downtrodden and depressed classes.

13. **INDIAN NATIONAL SOCIAL CONFERENCE -**

Was founded by *Justice M.G. Ranade* in Bombay in 1887 to strengthen the cause of reformism.

14. **RAMAKRISHNA MATH -**

Was founded by *Swami Vivekananda* at Belur in 1887 to promote the universal religion of Paramahansa. The Swami of the Math are being trained at Belur. Vivekananda also founded the *Ramakrishna Mission* as a social service organisation in 1897.

15. **DEVA SAMAJ -**

Was founded by *Shivnarayan Agnihotri* in Lahore in 1897 as as a branch of Brahmo Samaj. The members of the Samaj however worship the Gurus and Scriptures.

II. SOCIAL SERVICE ORGANISATIONS

1. *Gopal Krishna Gokhale* founded the Servants of India Society in Bombay in 1905.
2. Poona Seva Sadan was founded by *Pandita Rambai, G.K. Devadutt and Maharshi Karve* in 1909 at Poona to provide education and shelter for widows.
3. *Social Service League, founded in 1911 of N.M. Joshi (founder by AITUC) in Bombay for promoting better living conditions of the working classes in the Bombay slums.
4. Seva Samiti - founded by *H.N. Kunzru* in Allahabad in 1914 as a social service organization.

III. ISLAMIC REFORM MOVEMENTS

1. ***DEOBAND MOVEMENT/ DAR - UL - ULM**

was founded by *Moulana Hussain Ahmed* at Deoband in 1866. It gave a liberal interpretation of Qoran, accepted English education and also preached Hindu Muslim unity.

Maulana Abul Kalam Azad was inspired by the movement.

2. **AHMEDIYA MOVEMENT/ KHIDAYANI MOVEMENT -**

Founded at Khidayan in West Punjab by *Mizra Ghulam Ahmed.* Regarded as Prophet, *Ghulam Ahmed,* encouraged Muslims in trade and commerce. It was the most organised movement against the activities of Arya Samaj and Christian Missionaries in Punjab.

3. **ALIGARH MOVEMENT -**

Refers to all the activities of *Sir Syed Ahmed Khan* for the overall development of the Muslims in India. Sir Syed realised the importance of English education and founded *Anglo - Mohammedan School* at Aligarh in 1875. It became College in 1877, the precursor of AMU. He in the beginning was secular declaring that "Hindus and Muslims were two eyes of Mother India". However, under the influence of the 1st Principal of the College, *Theodore Beck,* Sir Syed became a reactionary and conservative, discouraged "Muslims" to join the Congress Party.

4. **AHARAR MOVEMENT - LUCKNOW**

Was founded by Maulana Md. Ali, Zafar Ali and

Hakim Azmal Khan, against the loyalist politics of Sir Syed Ahmed. The movement gave a call for Hindu - Muslim unity.

CONSERVATIVE MOVEMENTS IN ISLAM :

1. **Ahal - i - Hadis -**

   Founded by *Maulana Nazir Hussain*, opposed liberal interpretation of Qoran.

2. **Ahal - i - Khoran -**

   Abdullah Chakralavi, opposed English education and modernisation.

3. **Nudwah - ul - Ulema - (Association of Priests)**

   Opposed liberal trends in Islam and also English education. The movement was founded by *Maulana Shibili Numani*.

4. **Barelwi Movement/ School**

   Was started by Riza Khan; opposing liberal and progressive trends in Islam.

IV. SIKH REFORM MOVEMENTS/ AKALI MOVEMENTS (1920 - 1925) :

Started against the misuse of Sikh gurudwaras by the priestly class called *Mahants*. The Akali movement ended with *1925 Sikh Gurudwara Act* that provided for Shiromani Gurudwara Prabandhak Committee (SGPC).

V. PARSI REFORM MOVEMENT -

Called *Rehnumai Mazdayasan Sabha*, started in 1851 in Bombay by the leaders of the Parsi Community who included *Naoroji Furdomji, S.S. Bengali and Dadabhai Naoroji.*

The Sabha gave a call for overall development of the Parsi Community and also preached male - female equality.

Madam B.R. Cama, called the 'Mother of Indian Revolution' was the product of the movement.

VI. LOWER CASTE MOVEMENTS

Reasons -

- Sanskritisation process was the constant factor.
- Commercialisation of agriculture benefitted intermediate castes who provided leadership to the movements.
- The British introduced for the first time rule of law and equality before the law. Lord Macaulay introduced both the ideas with his Regulation XI.

  In the new administration, caste based occupations were replaced by merit, creating a favourable atmosphere for the lower caste movements.
- The British conducted Census from 1901 on the basis of caste and community for the purpose of reserving jobs, as a result each caste and community came out with claims and counter claims.
- Christianity was equally responsible by imparting education and by infusing a sense of self respect among the lower castes.

MOVEMENTS IN THE MADRAS PRESIDENCY -

1. In 1916, the *South India People's Association*, a political party transformed into a Justice Party; founded by *Petty Tyagaroy Chetty, C.M. Nair and T.N. Mudaliar.* The party opposed the domination of Brahmins in politics, education and govt. services. The party contested the 1923 general elections and formed the first elected government in Madras Presidency under Subburayulu Reddiyar as the Chief Minister. However it very soon lost its support with the lower castes as it catered more to the interests of the intermediate castes.

2. Self Respect Movement -

   Started by E.V. Ramaswamy Naicker, popular as Periyar. It was the first to start the practice of burning Manusmriti and the marriages without priests. Periyar founded the journal *'Kudi Arasu'* to propagate his ideology. The movement even inspired the formation of political parties DMK, championing the cause of the Dravida culture.

3. In Kerala, *C.V. Raman Pillai* wrote the novel *"Martandavarma"*, exhorting the past glory of Nair Community. *Munnattu Padmanrbha Pillai* founded Nair welfare society.

4. In Kerala, *Narayan guru* championed the cause of untouchables EZAVA Community and demanded temple entry. He started the movement *S.N.D.P.Y.* (Sriman Narayana Dharma Paripalana Yogam) with the slogan *'One God One Religion and One Mankind'.*

5. In Karnataka, Justice C.R. Reddy founded *'Prajamitra Mandali'*, political party, an anti - Brahmin Platform.

   In Andhra Pradesh, *Enugula Veeraswamy Naidu* started anti - bonded labour movement *(Vetti Movement)*

   Tripura Neni Ramaswamy Chaudhuri started anti - Brahmin movement called *Brahmana Vyatirekodyamam.*

BOMBAY PRESIDENCY :

Mahatma Jyotibha Phule was the pioneer of the lower caste movements in Bombay Presidency. A mali by profession, Jyotiba championed the cause of untouchable Mahar Community. He founded Satyasodhak Samaj and wrote the famous *Ghulamgiri* and *Sarvajanik Satyadharmadha Pustak.*

In 1904, *V.M. Shinde* founded *Bombay Presidency Depressed Class Mission Society.*

DR. B.R. AMBEDKAR -

The first graduate of the Mahar Community, submitted his thesis on *"Indian Rupee"*. Employed in the service of the State of Baroda, founded the journals *Mukhnayak* (Dumb Man) and Bahishkrita Bharatha (Excommunicated Bharata). He founded the All India Depressed Class Association Federation; organised the famous Mahad Satyagraha, demanding temple entry and usage of common civil amenities for the depressed classes. He participated in all the Three Round Table conferences, demanded separate communal electorates for the depressed classes. Accordingly, the British PM, Ramsay Mac Donald announced **Communal Award* in Aug, 1932, providing seperate communal electorates to the depressed classes. Against the award, Gandhi observed fast unto death as a protest and finally the *Poona Pact* was signed between caste Hindus represented by *Rajendra Prasad* and Manooji with the depressed class leaders Dr. Ambedkar and M.C. Raja. As per the Pact, Congress agreed to reserve double the number of the seats for the depressed classes in the general electorate and depressed classes agreed to forego their claims for seperate communal electorates.

VII. LABOUR CLASS MOVEMENT :

The labour class as such was formed in modern India for the first time in the railway industry. However the first Labour organisation union was *Bombay Mill Hands Association founded by N.M. Lokhande.*

Trade Unionism started in modern India with World War - I and Soviet Russia Revolution in 1917. The first Trade Union in Modern India was the Madras Mill Workers' Association founded by B.P. Wadia in 1918. In 1920, N.M. Joshi founded the AITUC. It held its first session in Bombay, presided over by Lala Lajpat Rai. In 1928, the AITUC was divided for the first time. N.M. Joshi left AITUC and founded ITUF *(Indian Trade Union Federation)*. The reasons for the first split was communist domination increased in AITUC; Differences arose between N.M. Joshi and Communists in sending delegates to the Brussels Conference. In 1940, Joshi also founded *Hind Mazdoor Sevak Sangh*, an organisation for the Labour class.

LABOUR CLASS LEGISLATION -

The *Indian Factory Act*, 1881 was the first labour class legislation, introduced by Lord Ripon. It regulated the working hours for women and child labour.

In 1923, *Indian Workmen's Compensation* Act was passed providing compensation.

In 1926, *Indian Trade Union Act* was passed legalising the formation of Trade Unions.

In 1929, the *Royal Commission on Indian Labour* was appointed under the chairmanship of *J.M. Whitley (Whitley Committee).*

In 1935, the *Royal Delimitation Committee* under the chairmanship of *Hemand Lawry* recommended for seperate electorates for the labour classes.

THINKERS OF MODERN INDIA

RAJA RAMMOHAN ROY :

Father of Modern India, pioneer of Indian Renaissance. Father of Modern Indian Journalism. Founded the journals, *"The Bengal Gazette"*, *"Mirat - ul - Akbar"* (the 1st journal in Persian language), *"Bangadoota" and "Sambandha Kaumudi"* (The 1st journal to discuss politics); wrote two pamphlets *"Some precepts of Jesus Christ, a guide to Peace and Harmony"*, and *"Tufath - ul - Nuwahuddin" (Gift of Monotheists)*. He was the first Indian to oppose the tribal of jury and restrictions imposed on freedom of expression.

AKSHAY KUMAR DUTT :

Was the first Indian marxist social scientist, studied the Indian society in terms of class.

ISWAR CHANDRA VIDYASAGAR :

Called the "Father of Modern Bengali Prose". The Principal of Calcutta Sanskrit College, admitted non - Brahmins and a devoted reformer, championing the cause of widow remarriages and women education. Responsible for Widow Remarriage Act, 1856.

KESHAB CHANDRA SEN -

Founded Indian Reform Association in 1870 and instrumental for the 1872 Indian Native Marriage Act that was passed against child marriages; responsible for the branches of Brahmo Samaj in Indian called Prarthana Samaj in Bombay Presidency and Veda Samaj in Madras Presidency.

RAMAKRISHNA PARAMAHANSA :

Actually called Gadadhar Chattopadhyay, popular as the "Saint of Dakshineswar"; preached universal Religion.

SWAMI VIVEKANANDA :

The chief disciple of Ramakrishna, actual name Narendra Dutta; called Vivekananda by the Maharaja of Khetri; participated in *World Parliament of Religions in Chicago* in 1893 and the *Congress on the History of World Religions, Paris* Called the "Spiritual Ambassador of India"; founded the journals *'Udbodhana'* in Bengali and *Prabuddha Bharata* in English.

SISTER NIVEDITA -

Was the ardent disciple of Vivekananda, actually called Margaret Nobel.

SWAMI DAYANAND SARASWATI -

His actual name, Mul Shankar. Born at Tankara in Gujarat; disciple of Swami Birajananda.

Founded the journals, *'Veda Bhasya'* and *Veda bhasya bhumika* wrote the famous *Satya Artha Prakash.*

BAL SHASTRI JAMBHEKAR -

Founded the journals, Digdarshan and Bombay Darpan; used journalism to counter child marriages in Bombay Presidency.

GOPAL HARI DESHMUKH -

Popular as **Lokhita Wadi;* by his pen name wrote series of articles against child marriage and encouraging widow remarriages.

KANDUKURI VEERESALINGAM -

Called *'Vidyasagar of the South'* founded *Rajamundry Reform Association* and *Hitakarini SamajaM* to encourage woman education and widow remarriages.

'Father of Modern Telugu prose' - wrote the 1st novel in Telugu literature *Rajasekhara Charitra.*

RAGHUPATI VENKATA RATNAM NAIDU -

called 'Rammohan Roy of South India'; founded *'Kakinada Reform Association'* to encourage widow remarriages and woman education. Also called *Kula[illegible]* (Vice Chancellor)

JUSTICE M.G. RANADE -

Called the "Modern Rishi", architect of Pra[illegible] Samaj, a moderate Congress leader and also a [illegible] on 'Drain of Wealth'.

4 FREEDOM STRUGGLE

The unique aspects are -

- The largest mass based struggle in the history of mankind and the most prolonged struggle for liberation of a country.
- The only struggle that accepted non - violence or Satyagraha as the means.

The factors responsible were -

The repressive and reactionary policies of Lord Lytton and the progressive liberal politics of Lord Ripon, both substantially contributed for the spirit of nationalism. Lord Lytton held the Grand Imperial Durbar in 1877 in Delhi wasting public money. When Deccan was reeling under severe famine, declared Queen Victoria as the Empress of India (the Queen officially declared the Empress for the first time).

In 1878, he introduced *Vernacular Press Act* for curbing the autonomy of Indian journalism and in 1879, to discourage the Indian middle classes entering into the Civil Services, he reduced the upper age limit from 21 to 19 and also introduced *Statutory Civil Services* (reserving 1/6 of the total number of posts for the Indian princely families and landed aristocracy)

Lord Ripon, on the other hand, introduced series of liberal and progressive reforms. In 1881, the first Indian Factory Act was passed, regulating child and woman labour working hours.

In 1882, the *Statutary Civil Services* were abolished; *Indian Famine* code was introduced (the 1st Indian Famine Commission was aoppointed under Sir Richard Stratchy, 1878).

In 1882, in order to promote primary education, Lord Ripon founded the *1st Indian Education Commission* also called *Hunter Committee*. The committee recommended for privatisation of education. The Vernacular Press Act was abolished.

In 1883, to give an effect to equality before law and the Rule of Law, Lord Ripon introduced *Ilbert Bill*. When the Bill was passed with amendments in Jan 26, 1884: it marked the beginnings of India's national movements.

- The Pre- Congress political organisations were equally responsible for the political consciousness.

- The *Bengal Land Holder's Society* founded by Dwarakanath Tagore in 1830 in Calcutta was the first political party in Modern India.
- In 1852, *Madras Native Association* was founded; the 1st political party in Madras Presidency.
- In 1852 March, the *Bombay Native Association* was founded; the 1st political party in Bombay Presidency, by *Jagannath Shankar Seth.*
- In 1866, Dadabhai Naoroji founded *East India Association* in London.
- In 1867, *Mary Carpenter*, biographer of Raja Rammohan Roy, founded National Indian Association in London.
- In 1870, *Poona Sarvajanik Sabha* was founded by *M.G. Ranade and G.V. Joshi.*
- In 1872, *Indian Society* was founded by Anandamohan Bose in Kolkata. It became *Indian Association* under Surendranath Banerji in 1876. It was the most dynamic political party before the Congress.
- In 1884, *Madras Mahajanasabha* was founded by *G.S. Iyer, Veeraraghachari and P. Anandacharyulu.*
- In 1885, *Bombay Presidency Association* was founded by *Pherozeshah Mehta, Badruddin Tyabji and K.T. Telang.*

Journalism also played a commendable role. The *"Bengal Gazette"* started by James Augustus Hickey was the first journal in Modern India founded in 1780 in Kolkata. The "Bengal Gazette" founded by *"Harishchandra Roy* was the first journal by an Indian in 1818.

"Rastgoftar" was the first journal in Marathi, founded by Dadabhai in 1852.

Sisir Kumar Ghosh started *"Amrit Bazar Patrika"* (1868). *Girish Chandra Ghosh* founded *"Hindu Patriot"*; *Bankim Chandra Chatterjee* founded *"Bangadarshan"*, *Tilak* founded *"Kesari" and "Maratha"* (English) (both edited by Kelkar) *G.S. Ayyar and Veeraraghavachari* founded the newspaper, *"The Hindu"* and G.S. Ayyar also started *"Swadeshi Mitran"*.

FORMATION OF CONGRESS :

In 1885, at the instance of A.O. Hume, 72 delegates from different political parties met at Sir Tejpal Sanskrit College, during Dec 28-31 in Bombay. The name 'Indian National Congress' for the new party was suggested by Dadabhai Naoroji. *W.C. Banerji* became the 1st President. A.O. Hume was the General Secretary; called the "Founder Father of the Congress".

The *'Safety Valve Theory'* is actually a criticism against Hume attributing ulterior motives in founding the Congress. Lala Lajpat Rai and Lala Hansraj were the critics of Hume. Hume wrote 2 pamphlets *'A Rising Star in the East'* and *'Old Man's Dream!*

AGE OF MODERATES (1885 - 1905) :

Congress since its inception was dominated by educated middle class, the landed aristocracy and the capitalist classes called the moderates. The *moderate ideology* was -

- The British colonialism and Indian Natinalism were not contradictory, rather complimentary. For the Moderates, development of England was the development of India.
- The British were invincible. As such, by a political of co-operation India could better secure her interests.
- England, mother of Parliamentary institutions, would increase the same in India and as such Indians should remain loyal to British.

The Moderate *method of struggle* was defined as "Constitutional Means of Agitation" (anything except popular means of agitation and seditions). It was well explained by Gokhale in his journal *'Sudhar'*. It is also *"Petition, Prayer and Protest"*.

The demands of the Moderates include -

- Expansion of Legislative Councils
- Meaningful Representation for Indian Members
- Seperation of Executive form Judiciary
- Increasing the upper age limit for Indian Civil Service aspirants and for conducting Civil Service Exams in India and England simultaneously.
- 50% reduction in rent, export duties and military expenditure.

Lord Dufferin, the Governor General and Lord Gross the Secretary of State welcomed the formation of INC.

MODERATE POLITICS -

The relations between the moderates and the British were strained for the first time in Madras Session in 1887, presided over by *Badruddin Tyabji* (the first Muslim president of INC). The word *'self - governance'* was mentioned for the first time. Lord Dufferin criticised Congress as *"Microscopic Minority"*.

The 1888 Allahabad Session of INC was presided over by George Yule; the 1st Englishman to preside over INC.

ACHIEVEMENTS OF MODERATES

- On the request of the Moderates in 1886, Lord Dufferin appointed *Aitchison Committie* on Indian Civil Services. The upper age limit was increased to 22 yrs; On the recommendations of the Committee.
- The 1892 Indian Councils Act was passed, expanding Legislative Councils.
- On the request of the Moderates, the Calcutta University Act, 1904 and Calcutta Municipal Corporation Act, 1904; the 2 Acts that affected the autonomy of local bodies were revoked by Lord Curzon.
- The most important achievement of the Moderates was their economic critique of colonialism, called the *Drain Theory* that exposed the exploitative nature of colonialism.

Failure of the Moderates -

- They restricted the social bases of the Congress only for the elite.
- They failed to understand the clash of interests between colonialism and nationalism.
- Their major failure was stopping the Partition of Bengal, done much against the public will.

AGE OF EXTREMISTS - (1905 - 1915) :

Aurobindo Ghosh was the founder father of extremist thought. His pamphlet *'New Lamps for the Old'* is regarded as the 'Bible of Extremism'. He wrote series of articles in Bangadarshan. The journal of Bakim Chandra Chatterjee, exiticising the moderate method of struggle as 'political mendicancy'. He portrayed India as 'Mother' and appealed to the emotional aspects of Indian Nationalism.

Rajnarayan Bose and *Ashwini Kumar Dutta* were the other early extremists. Vishnu Shastri Chiplunkar wrote *Nibandhamala*, as collection of poems with extremist thought. Within the Congress, *Bal Gangadhar Tilak*, the Lokmanya was the foremost extremist, called the Father of Indian Unrest by *Valentine Chirole*; founded Ganesh festival committee in 1893, organised no tax compaigns in the famine affected Bombay Presidency in 1894; founded Shivaji festival committee in 1895; sentenced for 18 months imprisonment for supporting the Chapekar brothers who killed the English officers, Iryst and Rand in 1897; wrote *'Gita Rahasya'*.

Lala Lajpat Rai called the Punjab Kesari wrote *'Unhappy India'* and *Bipin Chandra Pal*, editor of Bengali opinion and founder of the journal *'New India'* were the other extremists in the Congress.

The extremist thought derived its support from the teachings of Vivekananda and Dayanand Saraswati. The extremist slogan, *'Swarajya'* was first introduced by Arya Samaj.

The events outside India like Abyssinia defeating Italy, Japan defeating Russia in 1905, did have their impact on extremist movement in India.

VANDE MATARAM MOVEMENT (1905 - 1909) :

Lord Curzon announced officially the Partition of Bengal on July 4, 1905. On Oct 16, 1905, Partition came into effect. The official version for Partition was "administrative convenience". However, the real reason was to divide Indian society into Hindus & Muslims and futher to divide Congress by accentuating differences between Moderates and Extremists.

Bipin Chandra Pal started the movement with Kali Puja and festival and became the 1st Indian leader to tour India before Gandhi. Rabindranath Tagore and Nabakrishna Chakravarty composed patriotic songs. The slogans of the movement were *'Swadeshi and Swaraj'*. Under Swadeshi, Rabindranath Tagore founded Shanti - Niketan and Satish Mukherjee founded *Dawn Society* to impart native education. Tagore gave a call for Rakhi Bandhan as token of Hindu - Muslim unity and wrote articles under the title *"Atma Shakti"*.

While the movement was going on, differences started between Moderates and Extremists for the 1st time in the Calcutta Session in 1906 on the question of whether to make the movement national or restrict it only to Bengal and on the issue of President of the Session. The extremists wanted Tilak to be President. However, Dadabhai Naoroji became President as compromise candidate (Presided over max. no. of times - 3). The Calcutta Session was a victory for extremism for ;

1. The extremist ideas "Swadeshi" and "Swaraj" were accepted by the Congress for the first time.
2. Congress condemned the decision of Partition.
3. Tilak became Chairman of Reception Committee.

In 1906, the *All India Muslim League* was founded by *Salimulah*, the Nawab of Dacca and Aga Khan.

In 1907, the *Surat Session* was held. Congress was divided for the first time (First split) on the issue of election of President. The extremist candidate Tilak was defeated by the moderate candidate *Rasbehari Ghosh*. The moderates expelled the extremists from the Congress. The extremists founded *Liberal Party* and called themselves **Neo - Nationalists*. Tilak was trialled on charges of disturbing public order and sentenced for 6 years imprisonment, departed to Mandalay Jail in Rangoon. Bipin Chandrapal withdrew from active politics. Lala Lajpat Rai was also sentenced and extremism suffered a setback.

The Vande Mataram Movement ended with Morley - Minto Reforms in 1909.

Differences between Moderates and Extremists -

- Moderates demanded self governance; extremists demanded Swaraj.
- Moderates believed in co-operation; extremists confrontation.
- Moderates followed constitutional means of agitation; extremists followed popular means of agitation and passive resistance (Non - cooperation)

In 1911, Governor General Lord Hardinge II annulled the partition of Bengal.

In 1911, Imperial Capital City was shifted from Calcutta to Delhi. Muslim League was not consulted when these 2 things materialised. In 1914, World War I started.

Turkey predominantly Islamic, supported Germany against England.

In 1915, Gandhi returned from South Africa on the invitation of his guru, Gokhale; Tilak returned from Mandalay Jail and Madam Anne Besant announced her entry into Indian politics.

HOME RULE MOVEMENT (1916 - 1917) :

Madam Anne Besant suggested the idea "Home Rule" for the first time in 1915 Bombay Session, presided over by Lord S.P. Sinha.

However, Tilak was the first to form 'Home Rule League' in April, 1916. Madam Anne Besant started her ' Home Rule League' in Madras in Oct, 1916. Tilak gave his historical statement, *"Swaraj is my birthright"* during the Home Rule Movement. Anne Besant was supported by George Arundale, Indulal Yagnik and B.P. Wadia. She started 2 journals - *'New India'* and *'Common Weal'* for promoting the ideas of Home Rule. The movement demanded self governance and native education. At the instance of Anne Besant national colleges and schools were founded, particularly at Madanapalli and she was instrumental for Varanasi Sanskrit Vidyapith in association with M.M. Malviya.

The movement attracted Md. Ali Jinnah and Motilal Nehru. The Sindhi Community entered freedom struggle for the 1st time with the Home Rule Movement. The movement ended with the *'August Declaration'*, 1917 made by Viceroy Lord Chelmsford, promissing self - governance after World War - I.

LUCKNOW PACT (1916) :

In the Lucknow Session in 1916, presided over by A.C. Majumdar, the expelled extremists were welcomed to join back Congress. At the instance of Anne Besant, Lucknow Pact was also signed by Congress and Muslim League, extending mutual support against the British. The Congress were represented by Rajendra Prasad and League by Jinnah.

In 1917, the Calcutta Session was presided over by Anne Besant, the first woman President of the Congress.

GANDHIAN ERA (1915 ONWARDS) :

Gandhi left for S. Africa to plead for Abdullah & Co; effectively championed the cause of Indian indenture labour against the white racist regime; thoroughly influenced by *Leo Tolstoy's The Kingdom of God is within you', John Ruskin's 'Unto This Last' Edwin Arnold's 'Song Celestial'* (Commentry on Bhagawad Gita) and French Philospher *Thoreau's 'Civil Disobedience'*. Near Durban, founded the *'Phoenix Ashram'* (Tolstoy Ashram); also founded the journals *'The Indian opinion* and *'Hind Swaraj'* in S. Africa.

In India, in 1916, founded Sabarmati Ashram near Ahmedabad. *In 1917*, he started his first political camaign at *Champaran* in Bihar suppoting the cause of indigo cultivators. He was invited to Champaran by Rajendra Prasad and was assisted by *A.N. Sinha and Mahadev Desai.*

In 1917, his 2nd campaign started at Kheda in Gujarat called *Kheda Satyagraha* against the hike in land revenue demand.

In *1918*, Gandhi mediated between the workers and the management in the *Ahmedabad mill workers' strike*. With the 3 movements he emerged as the *messaiah of the working classes.*

***NON- COOPERATION MOVEMENT - (1921 - 1922) -**

Gandhi supported the British in World War - I and was given the title *Kaiser - i - Hind.* (Tiger of India) and nicknamed *Recruiting Sergeant'.*

Reasons -

- In 1917, a *Sedition Committee* was constituted under Justice Rowlatt called *Rowlatt Committee* to Suggest ways and means in handling. The problem of terrorism. The Committee recommended for 4 Acts called *"Black Acts"* as they severely undermined the civil liberties. Justice Shankaran Nair, the Indian member of the Committee and the member of Viceroy's Executive Council resigned as a protest against the Acts. Gandhi gave a call for National Protest Day against the Acts on Apr 6, 1919.
- On Apr, 13, 1919 on the Baisakhi festival day, The *Jallianwala Bagh Massacre* took place in Amritsar. General Dyre, ordered for indiscriminate finding that left more than 540 dead and many more injured - Rabindranadh Tagore surrendered his knighthood as a protest against the act.
- *The 1919 Govt. of India Act*, also called *Montague - Chelmsford Reforms* announced in 1918, disappointed the Indian leadership as they did not provide for self governance. Instead, Dyarchy was provided against the spirit of August Declaration, 1919.
- **KHILAFAT ISSUE -**

After World War - I in the Paris Peace Conference, England threatened to abolish the office of Calipha. In protest, the Ali Brothers *(Moulana Md. Ali and Shaukat Ali)* founded the All India Khilafat Committee. The Khilafat Committee held its first session in Lucknow in 1919 and made Seth Chotani of Bombay as its President. The *1920 Delhi Session* of Khilafat Committee was addressed by *Shankaracharya of Puri* extending the support of the Hindus. In the same session, Gandhi was made President of the Khilafat com.

The the Non - Cooperation Movement was organised for meaningful Constitutional reforms, to punish the guilty in Punjab excesses and for protecting the Khilafat.

Gandhi's proposals for the movement were accepted by the Congress Working Committee met under Lala Lajpat Rai in Calcutta. *The Nagpur Session in 1920*, presided over by Veeraraghayachari, endorsed the resolution and made Gandhi the sole leader of the movement.

COURSES OF NON - CO - OPERATION MOVEMENT -

Gandhi drafted the programme of the movement with the slogans *'Swadeshi', Satyagraha, Total boycott* and *No Tax Campaigns* (passive resistance). Charkas became the symbol of the movement. No - Tax campaigns were organised in the Madras Presidency at Chirala - Perala by D. Gopalakrishnaiah and at Pedanandipadu by P. Veeraiah Chaudhari. Under the idea 'Swadeshi', *Jamia Milia Islamia'* was founded in Delhi by the Ali Brothers. To discourage the movement, the British announced the goodwill mission of Prince of Wales.

The anti - Non - Cooperation Movement was also started by Thakur Singh with the support of the British. *Moplah Uprising* (1921) - When the NCM was going on; Moplah, Muslim agricultural labourers in the Malabar Coast of Kerala revolted against the exploitation of Brahmin Landlords called *Nambudris* (Zenmis). An agrarian crisis became a communal movement leading to riots.

Riots also started in Meerut, Lucknow, Kanpur between Hindus and Muslims. Differences also started between Gandhi and Ali Brothers. On intensifying the movement.

On *Feb 5, 1922, the Chauri - Chaura incident* took place in Gorakhpur district of UP. 22 Police constables were burnt alive. In *Feb 11, Gandhi called off* the movement.

RESULTS -

The movement failed to achieve its objectives - The Hunter Committee appointed to inquire into the excesses of Dyer exonerated him.

- The Khilafat was abolished by the people of Turkey under Mustafa Kamal Pasha.
- No Constitutional reforms were introduced.

The negative effects of the movements were -

- The failure created a permanent gulf between Hindus and Muslims. It was the last movement in the struggle with Hindu - Muslim joint resistance.

The Ali Brothers blamed Gandhi for the failure of the movement.

- Within the Congress, differences arose. Deshbandhu CR Das, the President of the Gaya Session, 1922 criticised Gandhian method of struggle and suggested for contesting the 1923 elections under Montague - Chelmsford reforms. The followers of CR Das, Motilal Nehru, vittalbhai Patel were called the *pro-changers*. They advocated *"Councils Entry"*. The no changers, supoorting Gandhi and opposing Councils Entry were Subhas Chandra Bose, Rajendra Prasad, Jawaharlal Nehru and Vallabhai Patel. The pro - changers founder The *Congress - Khilafat Swaraj Party* under CR DAs and contested the elections. The Swaraj Party emerged as the largest party in Central Legislative Assembly, Motilal Nehru become the first Indian opposition leader. Vitalbhai Patel became the first Indian opposition leader. Vittalbhai Patel became the first Indian elected speaker. CR Das became the first elected Chairman of Calcutta Municipal Corporation. However, with the sudden death of CR Das in 1925. The Swaraj Party got completely merged with Congress.
- In *1924, Alexander Muddyman Committee* was appointed to review the Dyarchy; introduced under the Reforms in 1919.
- In 1924, Gandhi presided over the *Belgaum Session*. The only session, Gandhi acted as President. At the instance of Gandhi, the membership fee of the Congress was fixed at 25p. or 4 annas; in the Belgaum Session.
- In 1925, *All India Hindu Mahasabha* declared officially its formation (actually founded in 1915 by M.M. Malviya and Manooji".
- In *1925, The CPI* (Communist Party of India) declared its formation officially in its Kanpur Session. (actually founded in 1920 by M.N. Roy at Tashkent).

In *1927, Marcourt Butler Committee* was formed to study and promote the relationship beter. British India and Princely States.

In *1927*, PM Ramsay Mac Donald constituted *Simon Commission* under the chairmanship of Sir John Simon with 7 members, all English, to study the implementation of 1919 reforms. All the political parties except *Justice Party* and the *Depressed Class Federation* of Dr. Ambedkar decided to boycott the commission. *Madhav Malgaonko* was the first to organise. *'Simon Glo Back'* movement in Bombay; in Madras, *T. Prakasham* called 'Andrha Kesari', led the anti-Simon Movement, in Lahore, *Punjab Kesari, Lala Lajpat Rai* organised a mammoth really against the Commission, lathicharged by *Saunders* and died of injuries in Dec, 1928.

MOTILAL NEHRU COMMITTEE (JUNE, 1928)

The Secretary of State, Lord Berkinhead challenged the political parties of India to draft, a model constitution, acceptable to all. The All - Party Conference was held in Delhi under the Chairmanship of Z.A. Ansari. *Motilal Nehru* was appointed the *Chairman of the Drafting Committee.*

The *recommendations* of the Committee were -

- A federal government at the Centre with British India and Princely States.
- Abolition of Dyarchy
- Elected govts. in provinces with complete autonomy
- Civil Liberties.

The most controversial parts of the Report was that it denied seperate communal electorates to the Muslims. Instead it provided for a reservation of 1/3rd seats in the general electorate to the Muslims.

Jinnah rejected the report and came out with his *14-point Formula* suggesting measures on minority rights. However Congress served an ultimatim fixing Dec, 1929 as deadline for the implementation of the report.

In Oct 1929, the *Deepanawi Declaration* was made by Viceroy Irwin. It invited all political parties to take part in the Round Table Conferences to be held in London on the recommendations of Simon Commission.

In Dec 1929, the historic *Lahore Session* was held, presided over by Jawaharlal Nehru - *Poorna Swaraj* was declared the highest goal of Congress - The tricolour flag prepared by P. Venkaiah was hoisted for the first time and it was decided to celebrate Jan 26 every year as Independence Day.

In *Feb, 1930*, Gandhi met Irwin with his *11 demands* that included a right to make salt, 50% reduction in rent, (land tax), export duties, military expenditure and a better exchange ratio between sterling and Indian rupee. The demands were rejected.

CIVIL DISOBEDIENCE MOVEMENT (1930 - 1932) :

On *March 12, 1930*, Gandhi started his *Dandi March* from the Sabarmati Ashram followed by 78 followers; distance *365 km* was covered by Gandhi in *25 days*. Sarojini Naidu represented the woman wing. On *April 6, 1930, Gandhi broke the salt law* at Dandi. In the Madras Presidency, Rajaji organised the Salt Marches from Trichy to Thindivaram. *B. Gopal Reddy* organised the famour Mypadu Salt Satyagraha.

In Bombay *Khan Abdul Gaffar Khan* (Frontier Gandhi) organised the movement with his followers called *'Red Shirts'*; founded the society called *Khudai Khidmatgars* (Servants of God Society).

Gandhi was imprisoned in the Agha Khan Palace, Pune.

ROUND TABLE CONFERENCES -

— All the 3 RTCs were held in the Bukingham Palace, London presided over by PM Ramsay Mac Donald. Alexander Muddyman was the General Secretary.

- Congress participated only in the 2nd RTC.
- Muslim League was represented by *Maulana Md. Ali, Md. Shafi,* and *Jinnah* (participated in all 3 RTC like Ambedkar). The League appointed Asaf Ali as its permanent member in London.
- The Hindu Mahasabha Federation, the party of the princely states, was represented by *Tej Bahadur Sapru, C.Y. Chinatamani* and *Mirza Ismail Khan.*
- The Depressed Classes represented by *Dr. Ambedkar* and *M.C. Raja.*

In the absence of Congress Party, The 1st RTC failed to arrive at Consensus on constitutional reforms.

Tej Bahadur Sapru and M.R. Jayekar mediated better. Gandhi and Irwin. As a result on *Mar 5, 1931, The Gandhi - Irwin Pact* was signed. Irwin agreed to release all the political prisoners except those found guilty of violence (Bhagat Singh, Rajguru and Sukhdev) and to restore the property of the prisoners imprisoned. Salt Law was revoked. Gandhi, on his part, agreed to take part in the 2nd RTC and suspend the movement. Gandhi left for London as the sole representative of the Congress in the ship called INS Rajput, assisted by Sarojini Naidu.

The 2nd RTC ended abruptly as Communal Parties criticised Congress and no agreement could reach on the form of govt. to be formed and constitutional reforms. Dejected Gandhi blamed Ramsay MacDonald for the failure, returned to India, threatened to revive the movement and was imprisoned.

The 1931 Karachi Session was presided over by Sardar Vallabhai Patel (the only session, Patel acted as President). Socialism declared highest goal of Congress.

In *Aug, 1932,* PM Ramsay Macdonald announced *Communal Award* providing seperate Communal cletorates to the depressed classes. Gandhi protested against the Award with his fast unto death. In *Sep, 1932, Poona Pact was* was signed between caste Hindus and the depressed classes.

In *1933* Parliament published *White Paper* disclosing the discussions taken place and decisions arrived at in all 3 RTCs. It was the basis for the Govt. of India Act, 1935.

In the *1934 Bombay Session,* The *Congress Socialist Party* founded by Acharya Narendra Dev, Jai Parakash Narayan, Achuta Patwardhan, Aruna Asaf Ali and Minoo Masani. However, the CSP continued to remain within the Congress Party. Its main purpose was to transform Congress gradually into socialism. The Govt. of *India Act, 1935 came into effect from Apr 1, 1937.* All the political parties including congress contested the 1937 elections. Congress formed govts. in 8 out of 11 provinces. The league formed govts. in Punjab, Sind and Bengal.

Differences started within Congress between Bose and Gandhi on the issues -

- Implementation of Land Reforms.
- Bose was the elected President in the *1938 Haripura Session* and decided to contest for the 2nd time in the *1939 Tripura Session* Bose defeated Gandhi's candidate B.P. Sitaramaiah (the author of *'The History of Congress'*)
- Regarding the strategy of the Congress in the wake of World War II.

  Bose's proposal for a mass movement was turned down by Gandhi on moral grounds.
- In the constitution of CWC also, differences started. Bose resigned and founded the *Forward Bloc Party in 1940.*

COMMUNAL POLITICS -

- Chaudhari Rehmat Ali, a Combridge University Law Graduate was the first to draw the map of Pakistan in 1933.
- The League's proposal for a coalition govt. in UP was turned down by Congress in the 1937 elections.
- The League appointed the *Raja of Pirpur Committee* to inquire into the atrocities perpetuated on minorities under Congress govt.
- In the 1939 Allahabad Session of the League, *Md. Iqbal,* the author of Sare Jahan Se Achha proposed the idea of Pakistan.
- In 1939, when congress govts. resigned as a protest against involving India win World War - II, in a provocative act, Muslim League gave a call for celebrating "Day of Deliverance" or *Thanks giving Day* (Dec 22, 1939).
- In the *Lahore Session* of Muslim League, 1940, Jinnah came out with the *Two - Nation Theory* providing ideological basis for the demand Pakistan.

  The *Resolution on Pakistan* was passed on *March 21, 1940*

AUGUST OFFER (AUG 6, 1940) :

Viceroy *Lord Linlithgow* on Aug 6, 1940 made the offer in order to in the support of Indians in the war effort. It proposed for.

War Cabinet with all the partfolios under the Indians except defence.

Dominion Status to India after the war.

A Constituent Assembly after the war.

Congress rejected the offer as the proposals were not time bound. Congress gave a call for *Individual Satyagraha.* Acharya Vinoba Bhave was the first to perform Individual Satyagraha on behalf of Congress. In 1942, PM Winston Churchill announced the *Cripps Mission Plan.* In *March, 1942, Cripps* came to India and made the proposals just the same as August offer. Further, Cripps provided for *Right of Self Determination'.* Gandhi observed the proposal as *"Post - dated leagues on a crumbling bank".*

QUIT INDIA MOVEMENT (AUG, 1942)

The CWC met in Bombay as Aug 6, 1942. Gandhi himself trafted the *Quit India Resolution* with the Slogan *'Do or Die'.* The last struggle in the Movement was a leaderless one. The peasant communities founded the parallel govts. called *Praja Sarkars.* in the Balia district of UP; under the leadership of *Chitu Pandey;* in Monghut under the leadership of *Saratchandra* and at Satara under *Nana Patil.* The CSP leaders, JP Narayan and Axuna Asaf Ali carried out underground activities providing indirect leadership to the movement. The CPI played a controversial role by supporting the British.

Gandhi was imprisoned in the Yaravada Jail in Pune and was trialled for 1942 August distubances, under the Charges of Sedition. Gandhi observed fast into death as a protest. During the inprisonment, his wife Kasturba, Secy Mahadev Desai died in the imprisonment.

In 1944, on health grounds Gandhi was released.

INA -

Bose escaped from house imprisonment, first went to Russia, from there to Germany. He was invited to japan by PM Toja. INA was actually founded by *Cap. Mohan Singh* consisted of 20,000 Indian war prisoners captured by Japan. Bose took over the commandership of INA, changed its name to *Azad Hind Facy'* divided INA into 4 regiments; *Mahatma, Azad, Jawahar and Netaji*, gave the Slogans. 'Unto Delhi' and *Jai Hind*. The InA Commandership included *Cap. Shahnawaz Khan, Prem Sehgal, Cap. Dhillion* and *Cap. Laxmi*.

The INA founded the 1st provincial govt of free India at Singapore. It entered Burma and destroyed Mandalay Sail in Burma came upto Kohima in Assam. As Japan withdrew its forces in the WN front, INA was defeated and its commanders were imprisoned in the Red Fort. The *INA trials* were held in Red Fort. Congress constituted a Defence Council for the INA officers headed by *Asaf Ali* & other members being *Jawaharlal Nehru* and *Tej Bahadur Sapru*. *Bhulabhai Desai* was the Secy. of the Defence Council.

CR FORMULA - (JUNE 1944) :

CR or Rajaji drafted the formula providing for -

CR Formula - (June 1944)

- CR or Rajaji drafted the formula providing for -
- A plebiscite in the demarcated Muslim majority provinces in the NW & East on the issue of Pakistan. If the plebiscite favours Pakistan, Pakistan would be granted.
- In the event of Pakistan becoming a reality, there would be joint control of India and Pakistan on *currency, communications and defence*.
- Jinnah rejected the CR Formula as he was not confident of the support of the Muslims for the idea of Pakistan.

In *Sep, 1944, Gandhi - Jinnah talks* were held but they failed & Jinnah insisted on being recognised as the sole leader of the Muslims.

Wavell Plan and Shimla Conference :

In June 1945, Lord Wavell, the Governor General proposed for tentative arrangement at the Centre with the League and Congress sharing power on the *principle of parity*. In the Shimla Conference, Congress was represented by *Nehru* and League by *Jinnah*. Though Jinnah agreed at the beginning to share power with the Congress, the conference failed when Jinnah insisted on that Congress not to dominate any Muslim member without his consent in its share of portfolios.

In 1945, elections were held after World War - II. The conservative party under Churchill lost the elections. Labour Party under *Clemant Atlee* came to power. In India, Congress formed Govts in 8 provinces and the League in Punjab, Sidh and Bengal.

In Jan, 1945, PM Atlee announced that an All - Party Delegation of the Parliament would visit India to decide the question of transfer of power. In *Feb, 1945, The All - Party Delegation* visited India and favoured for transfer of power. In *Feb, 1946, the Indian Navy* officers in *Bombay, Kolaba, Cochin, Karachi* and *Kandla revolted* at a time against the racial discrimination of the British military administration. The riots that followed were called *"Bombay Naval Ratings"*. It was the last act of protest in the freedom struggle. In March, 1946, PM Atlee announced that a Cabinet Mission would visit India to decide the modalities of transfer of power.

Cabinet Mission Plan -

The Cabinet Mission consisted of *Sir A. V. Alexander*, its Chairman, and other member being *Pethik Lawrence* and *Sir Stafford Cripps*. Its recommendations were -

- A Union govt. of India. to be constituted
- A Centre with limited subjects of power : Defence, currency and communications.
- Provinces with complete autonomy.
- A Constituent Assembly consisted of the members elected by Provincial Legislative Assemblies and members nominated by the Princely States.
- The most controversial recommendation was its *'Grouping Pattern'* of dividing the provinces of India into 3 groups.

  Group A - except Group B and Group C

  Group B - Punjab, Sindh and NWFP

  Group C - Bengal and Assam
- The Cabinet Mission outrightly rejected the idea of "Pakistan", as the creation of a small province of Pakistan would result in tremendous dislocation of resources and hence not viable.
- In *July, 1946* elections were held for the Constituent Assembly. *Congress got 205 members* elected and the *League 73*.
- In Aug, 1946, The Muslim League rejected the Cabinet Mission Plan and boycotted the Constituent Assembly.

Aug, 16, 1946 was observed by Muslim League as the "Direct Action Day" for Pakistan. Communal riots started first at *Noakhali* in Calcutta, spreading to different parts of India very soon. Syed Suhrawardy, the Chief Minister of Bengal openly supported Direct Action Day.

On *Sep 2, 1946*, Governor General Lord Wavell formed *Interim govt.* with himself as President and Jawaharlal Nehru as Vice President. Patel was the Home Minister.

When the League joined the Interim Govt, its candidate, *Liaqat Ali* was given the key *Finance* portfolio. Later, the League boycotted the Interim Govt. also in Oct, 1946.

On Dec 9, 1946, the Constituent Assembly met for the first time, elected *Rajendra Prasad as President* and *Dr. B.R. Ambedkar* was made *Chairman of the Drafting Committee*.

In Feb. 1947, PM Atlee announced that power would be transferred to India by not later than June 1948 and for that Lord Mountbatten would be sent as the last Governor General to India.

In March 1947, Mountbatten came to India. In *April 1947*, he drafted his plan of partitioning India into 2 dominions called India and Pakistan, the plan called *April Plan, Balkan Plan, Dickie Bird Plan*. The Plan was approved by Parliament with modifications called *June 3rd Plan* providing for -

- Demarcation Committees between India and Pakistan
- Plebiscite in the Muslim Majority provinces in Punjab, NWFP in the West and Sylhet district of Assam on the question of joining either India or Pakistan.
- The princely states were given the right of self determination, either to join India or Pakistan or to remain

independent.

A *Bill on the Transfer of Power to India and Pakistan,* called the *Indian Independence Act* was introduced in the Parliament. Approved by Parliament on July 18, 1947, fixing the deadline for transfer of power on Aug 15 and its also provided for the appointment of 2 governor generals each for India and Pakistan.

Rajaji became 1st Indian Governor General and *Jinnah,* first governor general in Pakistan. *Liaqat Ali* became the first PM of Pakistan.

5. REVOLUTIONARY ACTIVITIES

Bombay Presidency -

The 1st revolutionary act was assassination of two British officers. Iryst and Rand by *Chapekar Brothers* (Balakrishna and Damodar) in 1897 for their indifference during the *Cholera Operations* in Pune.

In *1899,* the Savarkar Brother founded *Abhinav Bharat,* the 1st revolutionary organisation in India as a secret society. In 1907, Ganesh Savarkar founded *Mitra Mela,* another revolutionary organisation. The Savarkar Brothers were tried under *Nasik Conspiracy Case, 1908* for attempting on the life of Steverson, the District Magistrate of Nasik and were deported for life.

Bengal Presidency -

Anushilan Samiti was the first revolutionary organisation founded in *1902 by Barindra Kumar Ghosh, Bhupendranath Dutta, Prafulla Chaki, Khudiram Bose* and *Parmotarak Mitra.* Aurobindo Ghost also belonged to Anushilan Samiti. In 1902, *Anushilan Samiti of Dacca,* another secret society was founded by *Pulin Das.* The Samiti attempted on the life of Lt. Governor of Bengal, Fuller in 1904. In 1906, all Anushilan Samiti members were tried on the charges of attempting on the life of *Kingsford.* The district magistrate of Muzaffarpur. Except Aurobindo, all were deported for life. Aurobindo settled at Pondicherry and founded Krishna Ashram.

Bagha Jatin (Jatin Mukherjee), the most popular revolutionary in West Bengal planned an attack on Writers' Building and was killed in an encounter at Balasore in 1915.

Surya Sen was the most popular revolutionary from East Bengal. He founded *'Hindustan People's Republican Army'* and conducted *Chittagong Armoury Raid in 1930.*

Pritilata Wadekar and *Kalpana Dutta* were his two women comrades involved in the explosion of the European Club in Decca with the executor of Surya in 1933, terrorism ended in Bengal.

United Provinces -

The Roorke Engineering College was the main centre of activities. In *1912, Rashbehari Bose* attempted on the life of viceroy Lord Hardinge II; when the Viceroy was entering the new capital city Delhi, called *Delhi Conspiracy Case.*

In 1924, *Sachin Sanyal* and *Jogesh Chandra Chatterjee* founded the *Hindustan People's Republican Party,* first revolutionary organisation at All India level. At the instance of *Bhagat Singh,* its name was changed as *Socialist Party.* In 1926. *Ram Prasad Bismil* and *Ashwaqullar Khan* of the Republican Party conducted the *Kakori train dacoity.* In Dec, 1928, *Bhagat Singh and Rajguru* killed Sauders.

On April 14, 1929, Bhagat Singh, Rajguru, Batukeswar Dutt and Vijay Kumar Sinha hurled bombs in Central Legislative Assembly (Parliament) in protest against the Public Safety Bill and Indian Trade Disputes Bill; tried under *Lahore Conspiracy Case,* Bhagat Singh, Rajguru and Sukhdev were executed on 23rd March, 1931 on the banks of River Ravi.

Jatin Das undertook fast unto death for 63 days in the Lahore Jail for better living conditions for the prisoners.

Madras Presidency -

Bharata Mata Sangam was the Popular revolutionary organisation founded by *Subramanya Sivam* and *Neelakanta Brahmachari* in 1908. The Sangam was involved in *Thirunelvelli Conspiracy Case.* The District Collector Aash was assassinated.

Darsi Chenchaiah, the only member of the Ghadar Party from the South, involved in the *Ongole Conspiracy Case.*

Terrorism Abroad -

Shyamji Krishnavarma founded *Indian Society,* a secret society in London and also started the journals *Indian Sociologist. Mandanlal Dhingra* of the Indian Society assassinated Curzon Veille; a spy on Indian House.

B.R. Cama called 'Mother of Indian Revolution' started Vande Mataram Movement in Paris and also founded the journal *'Vande Mataram'.*

In 1913, revolutionaries like *Lala Hardayal, Sohan Singh Bakna* founded the *Ghadar Party* at San Fransisco. The other members were *Rashbehari Bose, Keshar Singh, Jwala Singh, Ramachandra Bharadwaj, Ajit Singh, Mahendra Pratap* (15 Ghadarites).

In 1915, Mahendra Pratap and Barkatullah Khan of the Ghadar Party founded *the first provincial govt. of free India in Kabul.

In *1914-15 the Kamagata Maru incident* took place. It was a Japan based ship sailing to Vancouver, commanded by Capt. Gurdeet Singh. The ship was not allowed to enter Vancouver on the suspicion that it was carrying revolutionaries and explosives.

In 1940, Udham Singh killed Dyer in London. In 1942, *Birendranadh Chattopadhyay* founded *Indian Independence Committee* in Berlin. Under *Zimmerman Plan,* the Committee tried to mobilize support of the Nazi Party for India's liberation.

In 1942, Rashbehari Bose of Ghadar Party founded *Indian Independence League* in Tokyo and mobilised resources for INA.

Revolutionary Journals :

Barindra Kumar Ghosh and *Bhupendranath Dutta* founded the Journal *Yugantar.*

Sandhya, founded by *Brahmobandhab Upadhyay.*

Kirti was founded by *Santokh Singh*

Langal and *Ganabani* were founded by *S.S. Mirzakar* and *Jolekar.*

Kranti was founded by *Dharani Goswani* and *Gopu chakraborty.*

Bhagat Singh wrote a pamphlet - *'Why I am an atheist?'*

6. CONSTITUTIONAL REFORMS

Regulating Act, 1773 -

- The first Constitutional Reform.

It provided for -

A *Court of Directors* for the East India Company (60 members). The Governor of Bengal was made Governor General of Fort William. Governors of Bombay and Madras were placed under Governor General of Fort William.

A Legislative body called *Governor General - in -Council* with *4* members was created.

A Supreme Court of Calcutta was provided with 3 Judges and a Chief Justice (Elize Imphey - First Chief Justice)

The Company's servants were barred from accepting bribes, and presentations.

Pitts India Act, 1784 -

Was passed to rectify the drawbacks of Regulating Act. It was also the first attempt on the part of Parliament to control the company indirectly. The Act provided for -

Board of Control with 6 members called *commissioners* and a *President* to monitor the functioning of Court of Director; the President answerable to Parliament.

The Governors of Bombay and Madras were clearly been insubordinated to the Governor General of Fort William.

The membership of the Legislative Body was reduced to *3* from 4.

The Supreme Court of Calcutta was meant only for English Subjects.

The Act authorised Court of Directors to make all the recruitments in India.

Charter Act, 1813 -

- Started *Free Trade Policy* ending the monopoly on all items except Tea and Opium.
- The Act made training compulsory for all civil servants before joining the Service.
- It provided for Rs 1 lac for promoting education in British India.

Charter Act, 1833 -

- Completely ended the monopoly on all items of trade including tea and opium, *(Complete Free Trade Policy)*
- **Centralisation* of legislation started. The laws made by Governor General - in - Council in Kolkata were made applicable automatically for Bombay and Madras Presidencies.
- Governor General of Fort William was made Governor General of British India *(William Bentinck* -First Governor of British India.
- A *law member* was appointed for the first time in the Governor General - in - Council *(T.B. Macaulay* -The First Law Member)
- *The Act for the first time recommended for the appointment of India to the *Civil Services.*

Charter Act, 1853 -

- Relieved the Governor General from the responsibility of the Governor of Bengal *(Lord Dalhousie* became the 1st Governor General without the additional responsibility of being the Governor of Bengal). A Lt. Governor was appointed for Bengal *(Andrew Fraser)*
- The recruitment and recalling rights were transferred from the Court of Directors to Board of Control (Written competitive exams started from 1854).

Indian Councils Act, 1861 -

- Provided for *Legislative Councils* in Bombay, Madras & Calcutta and for the nomination of Indian Members called **non official members.*
- Under the Act, Lord Canning introduced **Portfolio System* (allocation of departments for the frist time).

Indian Councils Act, 1892 -

- *Provided for the first time for *indirect elections.*
- Indian members were permitted to ask questions but were not given the right to vote.

Minto - Morley Reforms 1909 / Govt. of India Act, 1909

- Separate communal electorates to the Muslims.
- For the first time, Indians were allowed to be appointed in the Viceroy's Executive Council *(Lord S.P. Sinha* became the 1st Indian appointed to the Executive Council and was given Law portfolio)

Montague - Chelmsford Reforms/ Govt. of India Act, 1919 -

- *Dyarchy* at the provincial level. Under dyarchy, the subjects of power were divided into reserved and transferred. Under *reserved* subjects, *Finance, Internal Order, Jails, Revenue* were administered by Governor and his Executive Council. The *Transferred* subjects like *Education, Public Health, Sanitation, Municipal Administration; Irrigation* and *Industries* were to be administered by Governor and his Council of Ministers.
- *The Act provided for the First time, *general (direct) elections.* The elected govts. at the provincial level would administer the transferred subjects.
- *Bicameral Legislature* (Council of States - The Upper House and Central Legislative Assembly - The Lower House) were introduced at the Central level.
- **Devolution of Power* was made for the first time dividing the powers into Central and Provincial.
- The office of the *Indian High Commissioner* was created for the first time in London to promote cultural, trade & commercial contacts between England and India.

Government of India Act, 1935 -

The last Constitutional reform of the British, provided for -

- A *Federal Govt.* with British India and princely states but federation never materialised as princely states never joined the federation.
- Dyarchy was abolished.
- Elected/ Responsible govts. at the provinces were given all the subjects of power under Provincial List.

- *Division of Power* took place for the first time dividing the powers into Central. Provincial and Concurrent (Residency)
- Bicameral Legislatures were introduced in 6 provinces (Madras, Bombay, Bihar, U.P., Assam and Bengal)
- Separate communal electorates were given to *Sikhs, Anglo - Indians and Parsis.*
- A *Federal Court of Justice* with 6 Judges and One Chief Justice was provided which later became Supreme Court of India (The Federal Court was founded in 1937)
- *Federal Reserve Bank* and a *Federal Service Commission* were being provided.
- The Governor General at the Centre and Governors in provinces were given *Absolute Veto Powers.*

7. ADMINISTRATIVE POLICIES

1. Civil Services -

The Word *'Civil Servant'* for the first time appeared in the records from *1757*. The office of the *District Collector* was created for the first time *in 1771* by Lord Warren Hastings. However, it was *Lord Cornwallis*, regarded as the *'Founder Father of Modern Indian Civil Services'*. He created the Police Service, Judicial and Revenue Services formulated the *Code of Conduct* for the civil servants and laid down the procedure for their promotions. In 1800, Lord Wellesley founded the *Fort William College* to train the Civil Servants. However from *1805*, the Fort William College was replaced by Haileybury College, London to train the civil servants.

The 1813 Charter Act defined the office of civil servant as the Civil Service with an annual salary of 500 pounds.

Lord William Bentinck restored, and revived magisterial powers for the District Collector (Lord Cornwallis divested the magisterial powers of Collector).

In 1868, *Satyendranath Tagore* became the first Indian ICS officer. The *1886, Aitchison Committee*, appointed by Lord Dufferin recommended for increase in upper age limit from 19 to 22 *(Lord Lytton reduced* the upper age limit from 21 to 19 & introduced *Statutory Civil Services) Lord Mayo* introduced *Scholarship Scheme* in 1868, to enable meritorious Indians to go for Civil Services. The Montague Chelmsford Reforms provided for a recruitment for 1/3 of the posts in India only. In 1922, the Civil Service exams were held both in England and Indian together. In *1924, Lord Lee Committee* was appointed to study the Civil Services in India. It recommended for bifurcation of services into *Imperil, Provincial* and *Subordinate.* It also recommended for a Federal Service Commission and Provincial Service Commission.

2. Judicial Services / Reforms

Lord Warren Hastings was the first to form local courts called *Munsif Courts*, presided over by the Indians.

At the district level, he created *Diwani Courts* for civil cases and *Nizamat Courts*, for criminal cases to be presided over by Civil Servants called Judges. The higher courts of appeal called *Sadr Diwani Adalat* for civil cases and *Sadr Nizamat Adalat* for Criminal cases were also founded by Warren Hastings.

Lord Cornwallis introduced *Code de Cornwallis*, a judicial procedure code. He founded *4 Circuit Courts* at Patna, Dacca, Murshidabad and Calcutta.

Under Charter Act, 1833, *J.B. Macaulay* became the First Law member. It was Macaulay that codified the Hindu Law and Islami Law.

In *1859, Indian Civil Procedure Code, 1860 Indian Civil Code* and in *1861, Indian Criminal Procedure code* were introduced. In *1865*, at the instance of Sir John Lawrence, the *Madras , Bombay* and *Calcutta High Courts* were founded.

3. Education Policy

Lord Warren Hastings founded Calcutta Madrasa to impart Persian language for the civil servants. *Jonathan Duncan* founder the *Sanskrit College* at Varanasi.

Sir William Jones founded the *Royal Asiatic Society in 1784* in Calcutta to promote studies on Indian languages and Culture. He translated Manusmriti and Abhignana Shakuntalam into English.

Wycline was the first to translate *Bhagawad Gita into English.*

The 1813 Charter Act provided Rs 1 lakh for education in British India. The *Anglicist and Orientalist Controversy* was related to the spending of 1 lakh whether for English education or native education and in the medium of English or mother tongue. The controversy ended once for all with **'Macaulay Minute'* passed on March 7, 1831. Macaulay as the Chairman of the Committee on Public Instruction made English the official medium of instruction. He also introduced *'Downward Infiltration Theory'* which means imparting English education to a selected few of Indians who in turn would spread it to others.

In 1840, Lord Hardinge I made English compulsory for all the competitive exams.

*In 1854, Charles Wood, the President of the Board of control drafted his education policy called **Woods' Despatch*, popular as the *'Magna Carta of the English Education'* and also *'Intellectual Charter of India'* It provided for woman education, primary education and vocational courses. it rejected the 'Downward Infiltration Theory' of Macaulay, providing education for all.

In 1857, **3 Universities* were founded at a time in Bombay, Madras and Calcutta.

In 1882, Lord Ripon appointed *W.W. Hunter Committee* called 1st Indian Education Commission to promote primary education.

In 1902, Lord Curzon appointed *Thomas Raleigh (Reiley) Committee* to study the university education. The Committee recommended for bringing universities under the control of govt. with 1904 Calcutta University Act.

In 1917, Saddler Committee was appointed to study higher education. It made Degree Course - 3 years.

In 1928, Harligh Committee was appointed by the Simon Commission to study education in India. It recommended for separate Boards for primary, secondary and intermediate education.

The **Wardha Scheme of Education* , also called *Naithalin* means a series of ideas expressed by Gandhi in his journal 'Harijan' on Indian Education.

8.BRITISH POLICY TOWARDS NATIVE PRINCELY STATES

Along with the rise of British colonialism and the spread of British imperialism, the policies, followed by the British from time to time also underwent change according to conditions and exigencies. One such example is their very policy towards the Native Princely States.

The whole policy of the British towards the Native Princely States can be studies under three broad phases. The first phase may be termed as the "Age of Relative Isolations" or the "Phase of Ring Fencing". The second one the policy of 'Subordinate Isolation" and the third "Subordinate Union".

During the first phase, the _policy of relative isolationism_ was conspicuously followed. Since the British were more commercial and enterprising company, and they still did not consolidate their position, they had to maintain, the policy of isolationism. For, the Mughals continued to be the paramount ruling dynasty in India, and for that matter, no Indian prince was less completely, to challenge the might of the British. Secondly commercial interests of the British compelled them often to depend upon the native princes. Also, the British were cautious to the fact that they were aliens on the soil of India and hence any aggressive policy towards native princely states would mean devastation.

During this phase, till the situation warranted, the time and condition required, the British remained isolated. When there interests were endangered, they immediately interfered and sorted out the matter. Best example was, Robert Clive's attitude towards the Nawabs of Bengal, establishment of dual government, suspension of it later in 1772 and assuming directly the power shows a deliberate and systematic policy. Clive rejected the proposal to took over the administration in 1776 and denied for it would mean interference and the people might not accept the change of power immediately. The policy was further refined and modified by Warren Hastings. All through his administration isolation was maintained and at the same time. British interests were taken care of.

A shift in the policy was envisaged by Warren Hastings, as the changing conditions demanded it. In the North, Constant threat of Marathas remained and in the South Hyder Ali became a scourge to the British imperialism. A new policy was required to tackle this situation, as a result, _ring fencing policy_ was introduced. According to this, buffer states, would be created between the British and there enemies. From these states, the British would operate against their enemies. Secondly, the buffer states would constitute a ring fencing against the British empire and protect it from the onslaught of the enemies. This was put into practice in the Anglo Mysore wars when Hyderabad was used as the buffer state. Similarly. Avadh and Rohikhand were used as buffer states against the Marathas.

During the times of Wellesley, the policy of relative isolation was all together given up and the ring fencing policy was modified. He saw to it that, the buffer states and the ring fencing provinces would not any longer remain the same, rather, they were first brought under the control of the British and from there the policy of expansionism would be carried out effectively. For instance subsidiary alliance system when introduced in 1799 the Nizam was the first to be forced to sign. Later the same system was thrust on the other princely states. For the first time, attempt was made, to bring the princely states systematically under the British control, by creating such conditions, that could not assure autonomy to the states. British banked upon the mutual rivalry and suspicion among the native princes and gradually brought one after the other under their control.

The change in the attitude was clearly reflected when Lord Hastings became the governor general. With him the second stage of the relations between the Native Princely States and Britihs, namely _"Subordinate Isolation"_ started. He replaced, the policy of 'mutual reciprocity and amicability' followed till then. Rather, in this stage isolation of the NPS continued at each and every level. First they were made to accept the British overlordship or paramountacy. Later British interfered in the administration. Even after the conquest and annexation, isolation took place as the British never treated, the N.P.S. as a part of British empire in India. Rather, what they did was, they controlled each and every aspect of the administration and name sake retained the princes.

The policy of subordinate isolation was effectively carried out by Dalhousie with his Doctrine of Lapse. It was carried out at three stages. First, undermining the prestige of the NPS, secondly negating their traditional and hereditary rights and by suspending their privileges. The states of Satara, Sambalpur, Jhansi, Bhagat, Udaipur were conquered under Doctrine of Lapse. The titles of the Nawabs of Travancore, Arcot were suspended.

Lord canning further carried out the audacity and declared that, after Bahadur Shah, Mughals would not be allowed to stay in Red Fort. The Indian princes would be merely addressed as princes.

The policy of subordinate isolation was intolerable and much more exploitative, as it humiliated the princes at every level. Precisely, this was why the 1857 revolt took place, and the British had to change their attitude and tactics towards Native Princely States.

The third phase called "Subordinate Union", was characterized by, at the outset, no interference of the

British in internal politics, no political conquest under any pretext, autonomy to NPS's in the internal administration, perfect amicability between the princes and the British.

Lord canning made explicit the basic idea of subordinate union, as it reflected in the 'Queen's Proclamation Act". Infact, this was the basis on which the British policy was drafted, towards the NPS. However, in reality the Britihs did not follow the basic tenets of the Act and rather acted according to the time and condition. They interfaced when the matters got warrented, for instance Lord Mayo, sternly warned, the nawabs of Anand (Madhukar Shah and Jawahar Singh) to ensure better administration. In the same way, the territory of Nawab of Kurnool was annexed in 1878. The conquest of Burma, the British policy in Afghanistan and Sindh, go against to the spirit of queen's proclamation. Further, in 1878, the British made it clear, to the native princes that the crown was the empresses of India by proclaiming Queen Victoria as the overlord of Indian territory.

The policy of 'Subordinate Union' subserved the British interests, in so far as to say, that, the Association of Indian native princes was founded with the intention of winning the support of the princes. After 1858 particularly, the British required the support of princes against the educated middle classes. As a result perfect understanding was reached between princes and the British. British extended all their support and sympathies to the princely states, all though the freedom movement. From the Round Table Conferences to Mountbatten plan, they were accorded, the "Right of Self-determination". In turn the princely states solidly stood behind the British government and suppressed all the nationalist struggles, taking plce in their respective states. Thus, even in the last phase, though an understanding of interest reached betwen British and princes, the British controlled every aspect of the princely states and made use of them. All though the course, "isolation and subordinate", existed one way or the other.

9. COMMUNALISM

Communalism may be defined as a socio-politico-economic and cultural ideology represented by people of some community, to satisfy all their ends. The means and the ends in communalism would invariably come from religion and get strengthened on the grounds of religious identify.

GROWTH OF COMMUNALISM :

Just as the freedom movement underwent different phases, communalism also, saw different phases from time to time. The very emergence of communalism and its development upto 1906 may be termed as the phase of moderate communalism. From 1906 to 1938, extreme communalism from 1938-47 it was millitant communalism.

Under *moderate communalism,* it did not take a radical view of the politics. Rather, it stood for, certain legitimate rights and protection of the minority interests. Upto the formation of the Muslim league, the communal politics, both within congress and the Muslim league, remained rather mild and democratic in there nature. The Aligarh movement of Sir Syed Ahmed Khan intended to promote Muslims, not at the cost of the Hindus, rather the movement was assisted by Hindus also. Likewise the moderate leadership of congress, tried to promote the spirit of Nationalism and succeeded in winning such nationalists like Bhaduruddin Tyabji, Hassan Nizami and Hakim Azamal Khan and other. Even though Tilak performed Ganesh and Shivaji festivals, it was not his intention to offend the sentiments of the Muslims. Just as that when Muslim league was founded in 1906, it did not intend to wage a struggle against the Hindus.

EXTREME COMMUNALISM :

The instances that lead to the change from Moderatism to extremism in communal politics were separate electorates to Muslims in 1909, congress trying to win the support of the league in Lucknow pact 1916, the Khilafat issue championed by Gandhi, failure of the non-cooperation movement and the communal riots such as moplah rebellion (on the method of struggle and when gandhi suspended the movement without consulting the Muslims) the differences between the two became severe. From 1924 religion became a source of practical politics for Jinnah.

Motilal Nehru committee report was rejected by league on the grounds that it did not favour communal electorates, and inturn made Jinnah to put forth the 14 point formula. During the courses of Civil Disobedience Movement and round table conferences league kept itself separated from the freedom movement and insisted on constitutional guarantees and separate electorates to the Muslims.

When Government of India, 1935 Act was passed and elections were held in 1937, league came to power in three provinces on the ground of communal ideology, whereas congress in eight provinces where Hindus constitute majority. The congress refused to form coalition governments with the league was also a potent factor for widening the differences,between the two.

League took an offensive stand against congress, criticised its government's as they were violating minority rights and appointed Raja of Pirpur committees. The committee exaggerated the atrocities and this further created serious differences, between congress and league. When congress ministries resigned. Jinnah instigated Muslim to celebrate, "the day of deliverance" October, 16th 1939, an act that provoke congress and Hindus. the extreme communalism reached its peak point when a separate geographical identity called Pakistan was conceived for the Muslims by Rahmat Ali in 1933 and was championed by Mohammed Iqbal in the Allahabad league session in 1938, and by Jinnah in 1940 Lahore session.

MILITANT COMMUNALISM :

During this phase communalism assumed a violent turn and militancy characterizing the Indian politics. It so happened for the league gave a clear-cut idea called Pakistan. Further, it remained adamant on whatever the proposal, either in the form of constitutional reform or guaranteeing the minority rights proposed by the British government. For instance the August of Lord Linlithgow was rejected by the league on the grounds that, either in the viceroys executive council or in the war cabinet, Muslims be given a parity share, regarding portfolios. Further in the formation of the constituent assembly also, the league insisted that, no legislation or any reform be introduced on a minorities religion, without the consent of at least reform be introduced on a minorities religion, without the consent of at least 1/3rd of the total members.

During the *cripps proposals* also, there was no understanding between the Congress and the League. In the proposals, congress found an element for unity to prevail, whereas for the League, even though the provinces were given the right of self determination, there was no mentioning of Pakistan. Further, Jinnah was not confident that the provincial assemblies would support the idea of separation from India and the creation of Pakistan.

All though the *Quit India Movement*, the Muslims remained isolated and didn't take part in the movement at all. During the Gandhi Jinnah talks (1944), the inevitable clash between the congress and the league took place on the issue of leadership representation, in the sense that Jinnah insisted that, he should be recognised, as the sole representative of the Muslims of Indians, as Gandhi for the Hindus and the congress.

The C.R. formula (1944), was rejected by Jinnah, as 'moth eaten', 'maimed' and mutilated'. For, conducting plebiscite in the majority Muslim areas was never been asked by the Muslim league nor was there any guarantee that, the league would win a mandate for Pakistan.

Lord Wavell plan and the consequent Simla conference in 1945 could not solve the political deadlock between the league and congress. According to this plan the portfolios in viceroys cabinet would be divided equally, between the Congress and Muslim League. Even though the proposal was initially accepted by the congress, it rejected the whole plan later, 'when Jinah insisted that he should have the sole right to appoint the Mulsim members in the viceroy's executive council. The fear of the congress was, that, if once it accepts it, the nationalist Muslims like Moulana Abdul Kalam Azad and Ansari would be denied a respectable position in the politics. Secondly, it would mean, acknowledging Jinnah as the sole leader of the Muslims.

In 1945, General elections were held congress formed governments in eight provinces and the league in three. It demonstrated the communal division of India. In 1946 when Cabinet mission plan rejected the proposal of creating Pakistan, the militancy in communalism reached its culmination point. The direct Action Day for Pakistan (August 16th 1946), virtually saw a blood bath. Communal riots shook Calcutta, Muradabad, Patna and Lucknow.

The League also resorted to 'dodging tactics'. This further tested the patience of secularists and much more liberal leaders, both in congress and the factions like Hindu Mahasabha also. The Muslim league first refused to join the interim government. Later joined the interim government. In the same way, when the Constituent Assembly was formed, first it refused to join and later joined the assembly, only to obstruct the proceedings. The fear that, it was outnumbered and its voice would not be heard, made the league to take much more stern and obstinate stand against congress. The failure of congress to deal with this situation, was mainly responsible for the partition of India and accepting Mountbatten plan. Leaders were convinced that it was difficult to get away along with the Muslim League and there was no guarantee, that the league would not repeat the same in future course of time.

Partition of India could have been avoided, at two levels, first the congress would have given its consent to the league in sharing the portfolios equally, for time being, during the Simla conference. This would have made the league more responsible to congress. Secondly Nehru as the acting vice president of the interim government could have avoided partition by not giving consent to the Mountbatten plan. Thirdly atleast the understanding reached between Bhulabhai Patel, Mahadev Desai and Liaquat Ali in 1946 could have been endorsed by congress.

Partition proved inevitable, for no leader was confident, that a safe and secured administration would be possible in India by cooperating with the Muslims. Also, all the leaders became prays to the time and condition. They could not rise above the time and think of future consequences.

NATURE OF COMMUNAL PARTIES :

1. The communal parties surprisingly never represented anything connected with their community, in terms of religious identity or the preservation of cultural identity. In most of these demands, either political grievances or financial concessions or things connected with material well being dominated. In short, the communal parties all together ignored, not only the religious aspect, but the problem of the masses also.
2. In contrast to the spirit of Nationalism and anti

imperialism, invariably, the communal parties opposed freedom movement. There concept of freedom struggle was restricted to satisfy, the grievances of their community, particularly in political and economic aspects.

3. In Indian Freedom Movement, the communal factions never hesitated to join bands against congress.
4. The communal politics never proved to be genuine in any aspect, as there were organized on false consciousness. Their demands differed from time to time, changed with the condition and got nurtured purely in the atmosphere of suspicion. The whole issue of communalism as such, was a reaction to the false issues and misconceptions. Islamic fundamentalism started against Hindus and inturn Hindu extremism reacted sharply. It was a chain of action that multiplied the complexity, promoted suspicious and hatred finally leading to a catastrophe.

COMMUNALISM RISE & GROWTH :

The unique feature of Indian Freedom Movement was the rise and growth of Nationalism and Communalism simultaneously with the freedom movement. The phenomena of communalism, even though was not new under the British, but definitely assumed serious proportions with devastating consequences. The study of the origin of communalism in modern times requires a through understanding of the socio-economic and political conditions of modern India ever since the British became the masters of India.

Even though the pre-British times witnessed communal clashes between the Hindus and the Muslims, particularly under the Mughals, they were characterized more by the political and economic factors. The same Mughal dynasty against which other communities revolted had the distinction of producing one of the greatest secular personalities namely Akbar. However, the whole fabric of India society remained harmonious till the advent of the British.

In the assessment of different factors responsible for the growth of communalism the first comes, *the overall backwardness of the Muslims as a minority.* This happened so as, "the Muslims remained, as the traditional and conservative elite classes of the feudal medieval times. With the ascendancy of British imperialism, the Muslim aristocratic classes lost their estates and gradually improverished. Also when English replaced Persian as the official language in 1840's it partically, deprived the Muslims of any prospects of employment opportunities in the government services. The reason was that they remained orthodox and clung to either Persian or Arabic. Consequently, they could not compete with Hindus in securing jobs in the government offices. *Secondly,* the so called process of modernization and overall economic development benefited the Hindus. The Muslims could not compete along with the Hindus in trade and commercial enterprises. *Thirdly,* the existing framework of colonialism could not accomodate itself the requirements of both Hindus and Muslims at a time. As a result, a feeling was generated amongst, the Muslims that, they lagged behind the Hindus and the developed Hindu majority would take advantage of the situation and dominate them.

The so called process of Indian Renaissance and the religious reform movements did have their role in promoting communalism. Almost all the Hindu reform movements instead of promoting secularism, looked backwards, and derived inspiration from the Vedas. For, most of the reformers social reform was religious reform. As a result, obviously the Muslims were given the impressino that the reform movements were revivalistic than reformistic. Particularly Arya Samaj and its ideology (cow protection and Sudhi movement), directly affected the sentiments of the Muslims. On the other hand, Islam also underwent revivalistic movements like, Ahal-I-Hadis, and Ahal-I-Quarran. These movements nurtured communalism. Unfortunately the thinkers of modern India failed to acknowledge the contribution made by Islam in enriching the Indian culture. Thus, the failure of the reform movement in promoting secularism directly lead to the emergence of communalism from the 19th century itself.

The policy of divide and rule, followed by the British from time to time further added stimulus to communalism. It started first with, dividing the Indian history on the communal grounds, ancient India was identified with Hindu, medieval with Islam and modern with the British by the colonial historian like J.S. Mill. Till 1870, the British held the Muslims as the most dangerous community, against there rule in India. And as such, Muslims were humiliated and were deliberately been denied any opportunities for further development. but from 1870's Britih sensed threat from the educated middle classes of the Hindus. This was why, Muslims like Sir Syed Ahmed Khan were encouraged against Hindus, partition of Bngal was carried out, comunal electorates for the Muslims were granted and constitutional guarantees were accorded to them against the majority Hindus.

The failure of congress leadership to alley the fears of the minority Muslims and to promote a secular ideology was also responsible for the growth of communalism. Particularly, extremists like Tilak organized Ganesh and Shivaji festivals in Maharashtra, Bipinchandra Pal organized Durga festivals in Calcutta. During the Vandemataram movement Bankimchandra Chatterjee projected the Muslim landlords as tyrants and exploiters. This created a fear psychosis amongst the Muslims.

Further, bringing religion into politics also gave a spur to the communal activity. Congress leaders like Tilak tried to win the cooperation of the Muslims through the Lucknow pact by accepting communal electorates. Likewise, Gandhi tried to bank upon the Khilafat issue during non-cooperation movement. The same had became a precedence for Jinnah later, and the whole course of Muslim league politics were characterized by religion.

More than anything. "*It was the false consciousness", generated by the British and cultivated by the Muslims* that nurtured the ~~communal politics and communalism. It was the~~ unconfounded fear that congress was dominated by the Hindus and hence would bring about he rule of the Hindus, was felt by Sir Syed Ahmed Khan in 1885. Likewise the Muslims demanded, separate communal electorates under the false consciousness that, if adult franchise was given on the basis of property and education, most of the Hindus would get right to vote. As educationally backward and financially impoverished the Muslims might not get the proportionate representation in voting. This would mean less representation for the Muslims, and this was precisely why they stood for separate comunal electorate. Behind ~~every communal event~~, including demand for constitutional guarantees, the unconfounded fears and false consciousness reflected time and again.

10. GROWTH OF THE CIVIL ADMINISTRATION

The British once became the masters of bengal their utmost prerogative was to introduce an administrative system that would subserve the interest of the colonialism. It was also motivated by breeding a class of administrators that would remain loyal to the British and assure a smooth functioning of the system. Further the British also envisaged a policy of extending control effectively over the colonial subjects.

Frantic attempts in this regard where made by Robert Clive and Warren Hastings. However neither clive nor Hastings could effectively curb the increasing corruption among the civil servants and check the unhealthy practices. Primarily the whole administration system was manned by the servants of East India Company. The Regulating Act 1773 for the first time assured an effective control over the administrative system.

Under Lord Cornwallis whole civil administration was given a new impetus. For the first time the administrative services were categorise, salaries of the employees and conditions of services were clearly laid down. All the services where declared "*covenanted services of EIC*". For the first time the principle of seniority was followed regarding promotions. However, the entry into the civil services was not open to the Indian subject, as Cornwallis held them, in a low profile.

Under Lord Wellesley a concerted effort was made to train the civil servants of EIC on the basic issues of Indian society, culture and economy. A schol was founded in this regard at Fort Williams at Calcutta in 1800. Later in 1806 Hailey bury college was founded in London to train EIC servants.

All the appointments to the covenanted services under EIC were restricted for the English only till a provision was made in 1854 Charter Act. The Act also examinations. Further it effectively brought all the appointments made to the different services under the control of the Board of Control which was under the control of the British Cabinet. It was queen's proclamation Act 1858 that assured the induction of the Indian into the decision making and other covenanted services under the government. All the appointments were to be made by the Secretary of State for India on the recommendations of the civil services board. However Indians could not avail the privileges as British deliberately restricted the scope by reducing the age limit from 22 to 21 in 1866 and from 21 to 19 in 1978.

Satyander Nath Tagore and Subhas Gupta could become the earliest civil servants by 1863.

Under Lord Lytton much more stringent measures were taken against the Indians. Categorically, he refused to hold the examinations simultaneously in India and England. It was during his time, "the statutory services" were created for the first time. They were meant for the elite sections of the Indians to be appointed in the covenanted services, not less than 1/3rd of the total vacancies. However in 1884 the statutory services were abolished under Lord Dufferin.

The congress since its formation in 1885 advocated for increasing the age limit and to hold the examinations at a time in England and India. In 1886 Dufferin promised to induct more Indians into the civil services and appointed Lord Aitchison committee go into the details and suggest ways and means for the particular purpose. The committee recommended for.

1. Abolition of the differences between covenanted and uncovenanted services. It divided all the services into three categories.
   a. imperial Indian civil services
   b. provincial services
   c. subordinate services

It also increased the age limti to 22 years. However

Indians in India. Further, Indians had to satisfy more with subordinate services and provincial services.

In 1894 the House of Commons recommended for holding the civil services exams both in England and India at a time. However this could not materialize due to protest from the conservative party.

The Montague Chelmsford reforms started a new phase in the history of the civil services. For the first time, services were brought under the effective control of the provincial Governments. They also conceded the demand for creating separate provincial recruitment boards.

In 1927 Lord Lee committee was appointed to provide equal opportunities for the Indians to get into the imperial services. The committee recommended for the 'Principle of party recruitment' between the Indians and the English. It also suggested that, not less than 1/3rd of the total civil services posts must be reserved for the Indians even though the British Government continued to discriminate the Indians against the British officers.

The Government of India Act 1935 provided for a Federal Service Commissions and also Provincial Service Commissions.

11. RISE AND GROWTH OF INDIAN LEFT WING

The rise and growth of socialist thinking and Marxism as concrete ideology with leftist orientation started developing in India from the 2nd decade of 20th century. The overall development of Indian left is to be studied under two broad headings:

1. Left wing within congress
2. Left wing outside congress

The gradual courses of development of the leftist movements and ideology was a byproduct of series of drastic changes, taking place in the Indian polity and economy.

The post world war - I, economic scenario created lot of frustration among the rural youth and urban working classes. The economic depression affected badly both the workers and peasants alike. It was at this juncture, *the Soviet Russia Revolution* participated by the masses proved to be an eye-opening factor for most of the Indian intellectuals.

Marxism and scientific socialism the popular concepts started infuencing the intellectual thinking of the Indians from the 2nd decade of 20th century. They found in Marxism solutions to all the social and economic problems Indians were facing particularly thinkers like *M.N.Roy were a convinced that, no political struggle is meaningful without social and economic equality and for this, socialism was the correct ideology.*

The existing congress leadership disgusted the workers and peasnts alike. Rather it continued to be dominated by the landlorded aristocrats and commercial bourgeoisie. At this juncture an alternative leadership was required to protect the interests of the workers and the peasants. Further even within the congress, a faction lead by J. Nehru and Bose started criticizing the techniques of Gandhi and were disenchanted with the satyagraha movement. The failure of congress to stand upto the expectations of masses in large number and providing solution to the social and economic inequalities in India were directly responsible for the growth of left wing within congress and outside.

The practical conditions also satisfied for the growth of left movement in India. Already by that time (20's) labour class unions were formed, AITUC came into being and peasant unrest also required a cohesive network and ideology. To satisfy all this the Leftist thinking proved to be the most amenable solution.

THE LEFT BEYOND CONGRESS :

The origins of left wing can be traced as far back as 1920's when radical humanist M.N. Roy effected an escape to Afghanistan and there from to Soviet Russia along with the Afghanistani Mujaheeds namely Shaukat Osmani and Ahmed Jaferi. It was due to his attempts communist ideology continued to spread in India. He maintained contacts with, Nalini Gupta and other nascent and embryonic communist groups in different parts of India.

Communism as an ideology started developing at the instance of S.A. Dange in Bombay, Sringaravelu in Madras, Gulam Hussain in Lahore and Ahmed Jaferi in Calcutta. Journals like 'Socialist' founded by Dange in Bombay, 'Navayuga' in Guntur, 'Atmasakshi' and 'Dhumkheta' in Bengal continued to spread the left ideology. It was all with the concrete efforts of Roy and other thinkers like Dange and Gulam Hussaini the Communist party was founded, in Tashkent in 1925. Even before its inception the communists came under severe repression, by the British government. Way back in 1922, prosecutions were leveled against M.N. Roy and Nalini Gupta in the famous 'Peshawar conspiracy case'.

In 1924 Dange and all other popular communists were prosecuted under 'Kanpur conspiracy case'. However the left movement as such did not receive any set back with these conspiracy cases. Rather it got further strengthened with the support from communists from England like Peter Harlot who came to India, mobilized finances and strengthened the party membership.

The attitude of the communists towards congress and the national movement was quiet cordial *till the end of the first phase i.e. 1928.* During this period, the communists accepted the congress as the main representative party of the Indians and extended their support to congress. Rather they remained within congress and extended there loyalties to the Nationalistic movement.

From the second stage that was from 1929 to 34 the attitude of the communists was changed. They started criticizing congress as a party dominated by bourgeoisie. They also found fault with the ideology of the congress for not being pro-working classes. They cited the example of suspending the Civil Disobedience Movement by Gandhi as an attempt to protect the interests of bourgeoisie.

It was during this phase ~~communists tried to formulate~~ different sub-organs like workers and peasant parties in different parts of India. They succeeded in capturing the leadership of labour organization. However it was also during this phase the party incurred the wrath of the British for organizing All India mill workers strike in 1934 and as a result banned.

During the third stage (35-39), the communists retracted on there attitude towards congress and again started, approaching the congress leadership. The basis for this change was the Broadley 'Dutt debate 1936 in the sixth communist international held in Moscow. There it was decided to extend support to all the bourgeoisie national movements against British colonialism. However, the communists were welcomed by the Congress socialists particularly like J.P. Narain and Bose. But when they tried to surpass and dominate the politics within congress they were expelled from congress party. Moreover the year 1939 was particularly not favourable for the left wing within congress which could not mobilize support to S.C. Bose and its attempt to capture power in the congress leadership was foiled, by the Right wing under the leadership of Gandhi in 1939. *In the fourth phase,* the communist politics made them extremely unpopular with the masses; for, they shifted there stands from time to time. As long as Russia did not join the war, the communists supported the National movement. But when Russia joined hands with England against Germany, Indian communists also joined hands with British bureaucracy and in some cases even acted as informers against congress leaders. Their withdrawal from Q.I.M. made them very unpopular in the eye of public.

CONGRESS SOCIALIST PARTY :

The origins of CSP and left wing within congress go way back to 1922 when Non-Cooperation Movement was suspended by Gandhi. A section within congress that came under the influence of Marxism and socialism expressed its, faith in socialism and found fault with Gandhian techniques. This was the faction represented by Jawaharlal Nehru and S.C. Bose in the beginning.

Jawaharlal Nehru came under the strong influence of socialism from 1924. He found in socialism, practical solution to India's social and economic problems. His visit to soviet Russia in 1924 and participation in Brussels conference in 1927 had created tremendous impact on the mind of Nehru. Second important factor that prompted Nehru to accept socialism was the idea that the so called modernisation and transformation would not be possible in India without socialism. The followers of Nehru and Boss known as congress radicals influenced the congress politics till 1933. It was at their instances socialism was accepted as the goal of congress in 1931 Karachi session. The very election of Nehru as ~~the president of congress~~ in 1929 shows the strength of socialists within congress.

The congress socialists realized the importance of founding a party within congress, so as to give more impetus to the socialist movement. In 1934 the CSP was founded by Acharya Narendra Dev, J.P. Narain and Minu Massani in Bombay.

The ideology of CSP was, giving more importance to imperialist struggle against British frist. Secondly to transform gradually the congress into the manifold of socialism. Thirdly to organize peasant and working class movement, independent from the leadership of congress.

The CSP desperately tried to occupyt important positions within congress and influence the decision making. It proved successful in 1938 when Bose was elected as President of Haripora session. However the CSP attempt to capture congress leadership was resisted by the right wing and Bose had to resign in 1939, by yielding to the pressure from the right wing within congress.

It was to the credit of congress socialist that anti zamindari movements were organized in different provinces. They were also responsible for implementing the land reforms. However their failure to implement the contents of the agenda proclaimed in the Wardha session 1934, particularly distribution of land to the working classes did not materialise. As a result serious differences arose between the Right and left wing within congress making Bose to have the congress party.

The significant contribution of CSP was also found during Quit India Movement of 1942 when all the leaders were put behind the bars, it was the CSP that provided the leadership. J.P. Narayana, Arouna Asaf Ali and Narendra Dev continued the underground activities, inspired the people and kept the spirit of Nationalism infact.

The problems for the Congress Socialist Party were; it could not exercise its independence rather it remained as another organ of the congress party and merely reflected the socialist inclination of some of its leaders. *Secondly* it failed in successfully exposing the drawbacks of the right wing leadership and ideology.

12 STATE PEOPLE'S MOVEMENT

With the growth of British paramountacy in India, more than one-third of the people of India came under indirect influence of the British government through the existence of the native princely states. They very creation of the native princely states, was meant to subserve the colonial interests of the British government often the British referred to the princely states as 'the bull works of the British colonialism'. However the growth of popular movements in the native princely states was a result of much a suppression of the British as that of the princely states.

CAUSES FOR STATE PEOPLE'S MOVEMENT :

1. *The general distres among the different sections of the society in the native princely states was alarmingly high;* by the end of the ninoteenth century, the conditions of the peasants were deplorable, than their counterparts in British India. The artisans were the worst affected sections in the native states on accounts of general stagnation in the domestic echonomy and as well dur to the disindustrialisation of the British all over India. However it was the middle class that spearheaded the mass movements in princely states, championing the causes of peasants and workers, against the native princes.
2. The process of modernization and westernization spread also to the native princely states. As a result of English education, a new educated intelligentia came into being, generated awareness and lead the popular movements.
3. *The very formation of Indian National Congress in 1885* gave an impetus to the state's people's movement. The All India character of the congress, its popular programmes like Swadeshi and Vandemataram movements and the concept of poorna swaraj had profound impact on the minds of the people of the princely states. In congress, they found an expression for these hopes and ambitions. Infact at every movement, the princely states looked upon at congress for guidance and inspiration.
4. *The role of the British government and* its high-handedness, in the administration of princely states, gave a new spur to the peoples movements. The British in association with the princes, resorted to all soughts of exploitation and suppression of the people. The very creation of the chamber of Indian princes in 1911 was meant to express the solidarity between the British and the native princes.

ORIGIN OF STATES PEOPLES MOVEMENT :

The origin of the SPM's lay in the very popular agrarian and civil rebellions that took place in India in the later part of the nineteenth century. Even though all the movements were suppressed ruthlessly by the British and the native princes, they undoubtedly marked a beginning in a new direction, finally culminating in the formation of series of democratic organizations and associations. A first step in this regard took place int he formation of praja parishad, a first political organization of its kind, in Baroda in 1917, to focus on all political, social and economic isues of the princely states. From 1918 the example of Baroda was very much followed by the other princely states and different local committees, were formed.

The H. Buttler was appointed for the promotion of better relations between, the native princess and the British. However it was a move to curb the increasing tide of democracy and popular institutions. As a result, the committees' recommendations were opposed by the people of pincely states.

With the formation of the *All India States People's Conference in 1927* at the instance of Balwant Rai Mehta, Manmaya Lal Kotari and G.R. Abayankar in the state of Kathiawar, the SPM got more strengthened. The first meeting of AISPC resolved to fight for

1. distinction between private and public finances as per the expenditure of the princes was concerned.
2. local self-governments be established with elected representatives
3. seperation of judiciary from the executive
4. no arbitrary taxation on the people.

The conference stood for the overall development of the princely states and further for civil liberties. However the AISPC suffered from its dual character. It could be anti-feudal but could not be anti-colonial altogether. Its fight against native princes, was against the traditional feudal order. Till the outbreak of the Quit India movement the princely states did not experience anti-colonialism.

13. POPULAR MOVEMENTS

Even though there were 500 princely states, and series of popular uprisings took place amongst them, the most important ones being. Rajkot in 1939, in Mysore 1938, the famous Orissa uprising 1939 and the famous Hyderabad state peoples uprising in 1940's.

The famous Rajkot state peoples movement was organized under the leadership of Jamunalal Bajaj and Vallabhai Patel at the instance of Gandhi at Rajkot in 1939. It was against the heavy taxation policy of the princely states, against the peasant. Gandhi resorted to a fast unto death in Rajkot in 1939 and compelled the Goekwar ruling family to revise its policy on more moderate and considerate lines towards the peasants.

In the *state of Mysore,* a popular movement was organized in 1939 demanding responsible government. It was organized by Bashyam, one of the founders of state congress, in association with the peoples federation of new Brahmins founded by K.C. Reddy and H.C. Dasappa. The movement started in the city Mysore and soon became violent. Riots took place in Kolar district. At the instance of INC, Vallabhai Patel entered into an agreement with Mirza Ismail Khan, the Diwan of Mysore, to introduce responsible government. Further, the state congress unit of Mysore, also came to be recognised by the princely state of Mysore.

In Orissa, the peoples movement championed the cause of forced labour and heavy taxation. In 1939 Naba Kishore Choudary organized a popular movement Dhenkanel. The movement spread to, Banapur and Rampur. The British agent Berzel Gatte was murdered by the people. At the instance of Gandhi, the movement was pacified, forced labour was abandoned, and a moderate taxation was introduced.

In Hyderabad the SPM started with the formation of Hyderabad state congress unit by Swami Ramananda Teertha in 1939. In 1939, the students of Osmania University organized the Vandemataram movement as a token of support to congress. However, the movement remained as merely anti-feudal, against the suppression of Nizam.

With the formation of communist party in 1939 in Hyderabad state the peoples movement got a momentum. The famous Telangana Rytanga Poratamu was organized under the leadership of the communists. Added to this, the Telugus of Nizam state founded in 1939, the Nizam Andhra Mahasabha and demanded a representative and responsible government. The people's movement was characterized by not only anti Nizam atrocities but also for the recognition of the Teugu language in the Nizam state. With the police action, the problem was settled once for all.

In the state of Travancore, A.K. Gopala Krishna Pillai and E.M.S. Namboodripad founded the local congress committee in 1939. A movement was started against the autocracy of C.P. Ramaswamy Iyengar, the diwan of Travncore. The movement was successful and diwan was forced to do away with the oppressive land revenue policy and initiated a liberal process of forming the representative government.

14. CONGRESS AND AISPC

The relations between the congress and AISPC were quiet normal as from the beginning congress followed a policy of relative isolation and relative interference. Way back in 1920 Nagpur session, the question of SPM's came to the notice of congress. However congress resolved to maintain neutrality and isolation, and further felt that, the SPM's be carried out independently. In the first Round Table Conference meeting the AISPC demanded its right to represent the poeple. However its request was turned down by the British government. It was congress that supported AISPC and endorsed its proposal.

In 1939 Haripur session, the congress resolved to bring the different SPMs into the mainstream of freedom struggle. In 1939 Tripuri session congress welcomed the proposal and suggestion of Nehru to forge an alliance with the SPMs and to form an untied front against the British and later Nehru was elected honorary President of AISPC. He pronounced the interests of AISPC were not different from the congress.

However congress was particular about the union of princely states with the British India. In 1942, when Cripps proposed for a federation and conceded the right of self determination to princely states, the congress outrightly rejected the proposal as the question of autonomy of the princely states was against the national interest. In 1946, the cabinet mission plan, categorized the different provinces of India, much against to the displeasure of congress. The chamber of princes on the other hand welcomed the proposals of Cripps and Cabinet mission plan and made desperate attempts to retain their control over the native princely states.

It was to the credit of such leaders of AISPC like Shaik Abdulla of Kashmir, T.T. Krishnamachari of Kerala, Krishna Menon of Travancore, that public opionion was mobilized in favour of the merger of the native princely states with Indian dominion. Even leaders like Taj Bahadur Sapru and M.R. Jayakar stood for an integrated approach between princely states and Indian dominion. Finally it was left to Sardar Patel to accomplish the task of merging the princely states with the Indian Union.

The state peoples movements in different parts of India did have there share in the freedom movement in so far as mobilizing the consciousness among the people. Though in the beginning they remained anti feudal, later they becmae anti-colonial once they came under the influence of the congress. They strengthened the cause of Nationalism and the idea of Nation making. Had there not been cooperation between AISPC and congress it would have definitely been difficult for the architects of modern India to see a India united.

IDEAS AND TERMS

Advaita : Doctrine of monism 'No second' maintaining that the phenomenal universe with its multifariousness and the whole hierarchy of being from the greatest of the gods downwards were not absolutely real, but were the secondary emanations of the one ultimate absolute being, the impersonal unchanging entity, Brahman, characterised by the three attributes of being (sat), consciousness (chit), and bliss (ananda). The quest of man according to Advaita is the final realization of the identity of his soul or inmost self (atma) with Brahman through spiritual training and meditation. The doctrine was first suggested by Vyasa but developed brilliantly by Sankara.

Akal Takhat : Epitomising the supreme religious authority for the Sikhs, takhats decide issues referred to them in connection with the panth. The verdicts (hukumanama) of the takhats are binding on the Sikhs. There are four main takhats. The "Akal takhat" at Amritsar is held in highest esteem by Sikhs. The Takhat Keshgarh Saheb at Anandpur in Punjab, Takhat Patna Sahib at Patna, and Takhat Huzur Sahib at Nanded in Maha - rashtra.

Bodhisattva : According to Mahayana Buddhists, people do not have to rely on their own efforts to become enlightened. They can be helped by a bodhisattva, a person who has come into this world to guide others to salvation. A bodhisattva is one who strives to become a Buddha by leading a life of virtue and wisdom. Works to take all beings to nirvana with him, and may even postpone attaining nirvana in order to relieve suffering through acts of love and compassion. The bodhisattvas traditionally well - known are Avalokiteshwara, Amitabha, Vairochana, Manjusri and Sumantabhadra. Maitreya is supposed to be in the Tushita heaven, waiting to come into this world to save humanity in the event of some great peril.

Din - I -Ilahi : Akbar formulated an order called Din - I - Ilahi (earlier, Tauhit-i-Ilahi) in 1582. It required belief in one supreme God, and enjoined a code of conduct comprising ten virtues and some principles of social reform. Incorporating elements drawn from all religions. Din - i - Ilahi was based on Sul-i-Kul or universal harmony. The cult centred around Akbar himself and faded away after his death.

Dvaita : Madhva in the 13th century found the philosophy of dualism according to which Brahman, the self and the world are completely distinct. Based on the Upanishads, Madhva's theory postulates that the individual soul is created by God and, in the state of highest bliss, draws infinitely close to godhead but it is always aware of its difference from God.

Hijrah : The Hijrah refers to the flight of Muhammad from Mecca to Medina in 622 AD and marks the beginning of the Muslim calender.

Lokayata : A school of thought associated with Charvaka, it denied the existence of any soul or pure consciousness, which is admitted by all schools of Hindu thought. Consciousness, it held, was an emergent function of matter mixtures, and hence nothing remained of man after death. The school of materialism denied the infallibility of the Vedas, the doctrine of Karma and rebirth.

Mimamsa : One out of the six schools of Hindu philosophy, Mimamsa (or Purva Mimamsa), derives its inspiration from the Vedas. Founded by "Jaimini" around 200 BC, this system believes that the Vedas are revealed and therefore true and accurate; their injunctions must be obeyed. It concerns itself with the verses dealing with rites and ceremonies, hymns and prayers rather than with the theology or the ethics of the Vedas. It propounds that the soul which is eternal and distinct from the body must be active through performing rituals without which knowledge is useless. It does not consider belief in God as necessary.

Nirankari : A sect of the Sikhs founded by Bhai Dayas Das in the 1840s, the name derives from nitrankar (formless), a term used by Guru Nanak with regard to the nature of God.

Nyaya : One of the six schools of Hindu philosophy, formulated by Gautama in around the beginning of the Christian era, the Nyaya School was essentially a school of logic, maintaining the view that clear thinking was essential for salvation. Nyaya deals with proof and that which is to be proved. It propounds the idea that the soul is eternal and has a parallel existence with God and the world.

Sankhya : Sankhya forms one of the six schools of Hindu Philosophical thought. Founded by Kapila, it rejects rites and sacrifices Sankhya regards body and soul as real but does not believe in a universal being or God. According to Sankhya, the soul as long as it is associated with the body, is subject to passions and desires and afficiatedby pain. Even after death the soul is caught in the cycle of rebirth with the body. Realisation of the true nature of the body and soul helps one to cast off the body and attain freedom from pain.

Tantricism : The cults and sects of Tantricism laid emphasis on the importance of the body, the continuous use of sensual symbolism, and the use of sensual rites. The Buddhist Siddhar, certain Saiva setcs such as Natha Yogis, Kapalikas certain Vaishnava sects such as Pancharatra and Sahajayana took to Tantricism which involved magical ceremonies.

Thirthankara : Literally a 'maker of fords', a reference to the role of building crossing points for the spirtual journey over the river of life, a Thirthankara is a Jain prophet or Jina who has passed out of the cycle of transmigration and helps others to cross over similarly. Jains believe in twentyfour Thirthankaras. The Kalpa-sutra recounts their lives.

Urs : Death anniversaries of Muslim saints are celebrated at their graves by devotees - these days are called Urs. Prayers and recitation from the Quran, singing of qawwalis, and offerings of flowers and costly sheets at the tombs mark these occasions.

Uttaramimamsa : More commonly known as Vedanta it is one of the six systems of Hindu philosophy. Based on, Badarayana's Brahma Sutras this sytem stressed the significance of the Upanishads. The attempt was to harmonise the Upanishadic teachings into a consistent body of doctrine. There are several interpretations of which Sankara's Advaita, Ramanuja's Visishtadvatta and Madhva's Dvaita are the most famous.

Vaiseshika : Originated by Kanada (though some say the Rishi Kashyapa founded it) around the beginning of the Christian era, Vaiseshika is one of the six schools of Hindu philosophy. It is close to the Nyaya School. The school was based on a system of atomism, explaining the cosmic process in which the soul is involved. Like the Sankhyas the Vaiseshikas held that the soul was wholly different from the cosmos and that its salvation lay in fully realizing this difference. The first stage is to realize the atomic character of the universe, that the universe is a complex, endlessly changing pattern of atoms, combining and dissolving according to certain principles. At the end of the cosmic cycle the atoms revert to a state of complete equilibrium.

Visishtadvaita : In the 12th century AD Ramanuja gave bhakti a philosophical base by interpreting Vedanta in a different light from Sankara. He formulated Visishtadvaita ('Qualified Monism') which transformed the idea of God from an impersonal force to a personal God. The supreme person God Vishnu, enternal and absolute, had diversified himself at the beginning of time and produced the cosmos; being the work of a real creator, the cosmos could not be ultimately unreal, but shared in God's reality. Similarly, the individual soul, created by God as an individual, could not wholly lose its individuality and even in the highest state of bliss was always conscious of itself as being part of God and the recipient of God's grace and love. Devotion, according to this school of thought, is of central importance to achieving liberation.

Yoga : One of the six schools of Hindu philosophy said to have been propounded by the rishi Yajnavalkya, and later systematised by Patanjali. Yoga may be considered a sequel to Sankhya. Unlike Sankhya, however, Yoga believes in the existence of God, who is associated with an absolutely pure mind. Otherwise, all the ideas about psychology and the theory of knowledge found in Patanjali are taken from Sankhya. According to Yoga the human soul should free itself from the bonds of nature, from its own body, from karma and samsara (cycle of rebirth) and attain the realization of truth and the state of absolute peace of mind (or Yoga). This state of peace can be attained by means of prayer and spiritual exercise. A definite system of moral and religious restraints is the first step towards the ultimate achievement of complete detachment and perfect peace.

PERSONALITIES

Guru Arjun Dev : Fifth in the line of Sikh Gurus, and youngest son of Guru Ram Das, Guru Arjun Dev compiled the Adi Granth. He completed the construction of the holy tank begun by his father at Amritsar, besides getting the Harmandir built. Jahangir ordered his execution in 1606 at Lahore for having supported Prince Khusro who had rebelled against the Emperor, his father.

Chaitanya : Viswambar Misra, or Chaitanya (1485-1533) was unique in medieval Vaishnava bhakti history in that he was the initiator of a very broad movement covering Bengal and practically all of east India. His movement involved an organised sect, a theology, and a broad-based popular cult. The theology of the sect was worked out at *Vrinavan*. According to it Krishna is considered not merely as an incarnation of Vishnu but as the highest aspect of the divine, its true essence'. In this aspect he is united with the highest shakti manifest in Radha. The devote's aim is to attain through bhakti the supreme state of bliss in which he emotionally identifies with Radha and achieves happy union with Krishna. Chaitanya expressed himself in the sankirtan, a session of hymn singing by a group of devotees. The Chaitanya movement left a lasting impact on Bengali life and literature and inspired later socio-religious reformers. Though no social reformers themselves, the Chaitanyites rejected all distinction of caste and disregarded the Veda and vedantists.

Chandidas : Chandidas (fourteenth century) was a pioneer in Bengali bhakti literature. He holds that the only way to salvation is the love of God. This love must be based on an earthly passion for a particular person, but as this passion needs to be sublimated, the object of this passion should be somebody inaccessible.

Kwajah Muinuddin Chisti: He brought the Sufi order of Chisti to India. He settled in Ajmer about 1206.

Shaikh Salim Chisti : Sufi saint who lived in the reign of Akbar, he prophesied the birth of three sons to the Emperor. Akbar named his eldest son Salim after the saint. Fatehpur Sikri was built near the saint's dwelling place, Sikri.

Dadu : Considered an important exponent of the Nirguna School, Dadu, a weaver from Ahmedabad, was a disciple of Kabir. Living in the sixteenth century, he preached love and devotion of God, opposed discrimination on basis of caste, and spoke for Hindu - Muslim unity.

Eknath : Marathi saint and philosopher of the sixteenth century, he revived the *bhakti* Vaishnava spirit and tradition in Maharashtra. He was free of caste prejudices. He brought out the first reliable edition of Jnanadeva's *Jnaneshvari*. He wrote a commentary on the Ramayana and the eleventh book of the Bhagavata Purana. He was a mystic who showed how one could aspire to the deepest experience of religion within the ordinary framework of life. His songs have become part of the Marathi heritage.

Gokulnath : A notable religious reformer of medieval India, Gokulnath belonged to the Acharya tradition of the Vallabha sect and was an important figure in the *Varta Sahitya* in Hindi literature. He wrote the well-known *Chaurasi Vaishnavan ki Varta* and *Do Sau Bavan Vaishnavan ki Varta*.

Gorakhnath : The founder of the *Kanphata Yogi* sect, lived in the 12th century. He advocated exercise of certain ascetic practices to gain mastery over matter. Gorakhpur, which was the centre of his teaching, was probably named after him. His cult gained notoriety for fearsome and malignant practices as ritual.

Guru Gobind Singh : The tenth and last Guru of the Sikhs, Guru Gobind singh (1666-1708) founded the new brotherhood Khalsa (the pure) on April 15, 1699. An inner core of the faithful, accepted by baptism, the Khalsa were enjoined to maintain the *'five ks' - kesh, kangha, kachacha, kara* and *kirpan*. He fought valiantly with the Mughals to avenge the death of Guru Tegh Bahadur, his father. He was assassinated at Nanded in Maharashtra.

Jnandeva : Among the Indo - Aryan languages, *'bhakti'* first appeared in Marathi in the 13th century with Jnanesvara (or Jnandeva). He wrote a Marathi commentary on the Bhgavad Gita, more commonly known as Jnanesvari. His bhakti was due to his connection with Varkari sect which instituted regular pilgrimages to the Vithoba Shrine in Pandharpur. The Jnanesvari made pioneering effort by using the vernacular language and thus revived the contact with the masses. It used a form meant for *Kirtan* chanting and drew examples and metaphors from the simple life of the village.

Kabir : Born a weaver in the 15th century, was brought up in a Muslim home. He was the renowed disciple of the Vaishnava reformer, Ramananda. His teachings of humanity, love & self-discipline are incorporated Adi 'Adi Granths'. Kabir founded a community, the Kabirpanthi, who consider, *Bijak*, a collection of his verse, as their scripture.

Lokacharya : He lived in the 12th - 13th centuries and propounded the *Tengali School of Vaishnavism*. He said that God's grace is to be sought not only through bhakti and effort but also by accepting that grace.

Madhva : A brahmin from Karnataka, Madhva in the thirteenth century propounded the dvaita philosophy, opposing Sankara's advaita. He founded the Madhva sect at Udipi, his place of birth. He is supposed to have learnt Persian in order to argue and justify his ideas before Muslim theologians. His *Sarva - Darsana Sangraha* is a philosophical work analysing of Indian philosophy.

Mirabai : A sixteenth century Rajput chief's daughter, Mira was married to Lakha, Rana of Udaipur (capital of Mewar). Widowed at an early age, she left the court of the Rana to devote herself to the worship of Krishna. She became a disciple of *'Ravidas'*. She was a wandering mystic and a poet, composing lyrics in honour of Krishna in Brajbhasha mixed with Rajasthani. Her verses have been included in the Adi Granth.

Nagarjuna : One of India's great philosophers originating in Andhra Pradesh. Nagarjuna (c.150 AD) systematised the Madhyamika school of Mahayana Buddhism. Nagarjuna is believed to have been a contemporary of Kanishka. He propounded 'SUNYAVADA' and wrote *Rasaratnakara, Dvadasa Sastra and Sata Sastra.*

Namdev : A contemporary of Jnanesvara, Namdev (1270-1350) was a tailor who became a great poet of the bhakti marga in Maharashtra. The object of his devotion was Vithoba, the form of Vishnu in the temple at Pandharpur. Vithoba was the god of the Varkari Panth, a sect that was averse to asceticism and whose membership cut across the whole caste structure. The [illegible] of Namdeva and Jnandesvara are connected with the spread of this sect all over Maharashtra. Namdev founded a sect and monastery in Gurdaspur, Punjab.

Guru Nanak : Born at Talwandi (now called Nankana in Pakistan) in 1469, was instrumental in the development of Sikhism. He was influenced by Kabir, and spoke against caste discrimination, polytheism and priestcraft. He tried for Hindu-Muslim unity. He wandered about with his companion, Mardana, who played on a string instrument for Nanak's hymns. His disciples were called Sakhi. Nanak considered God as without form (hirankar), eternal (akal), and ineffable (alakh). The enlightened man, awakened by the guru, perceives a divinely - bestowed harmony and salvation lies in bringing oneself within this pattern of harmony. The *'Janam Sakhi'* gives details of Guru Nanak's life.

Nand Rishi : Muslim Sufi poet, Nuruddin, came to be called Nand Rishi. He founded the order of the Rishis and is the patron saint of Kashmiri Muslims. Rishinama and Nurnama contain his poems.

Nimbarka : A *Vaishnava* philosopher and mystic of the 11th century, Nimbarka founded the Nimandi sect in Mathura region. His only extant work is the Dasaloka, but he is known to have given a commentary on Badarayana's Brahmasutra and systematically expounded the schools of Vedanta thought.

Ramana Maharishi : A spiritual experience in 1896 led 20-year-old Venkataraman to abandon home and seek enlightenment. He achieved spiritual understanding at Thiruvannamalai. Hence- forth he became known as Ramana Maharishi. He died in 1950.

Ramananda : In his early days Ramananda (1400-70) probably lived in South India as a follower of Ramanuja's Srivaishnava sect. He returned to the north and settled down at Varanasi and established his own sect, the Ramanandis. He looks upon Rama as the supreme God who is to be adored with his *Shakti, Sita* and whose close companions like Hanuman should also be venerated. He was strongly opposed to caste discriminations and opened his sect to all, irrespective of caste, sex and community as in God's eyes, all are equal. The egalitarian attitude and the exclusive use of the vernacular made the sect different from others. The sect has historical significance for having initiated several other sects and movements in north India. The Kabirpanthis and the Sikhs owe much to Ramananda's teachings.

Ramanuja : A Tamil brahmin who flourished about 1100 AD was born at Sriperumbudur in Tamil Nadu. He gave the rising piety of the times a firm philosophical basis with his idea of bhakti-marga and interpreted Vedanta a produce the system known as Visishtadvaita. He took Vishnu to be the 'supreme person', and founded the Vaishnava sect. He admitted the outcastes too in his sect and encouraged an egalitarian social system encouraging female education. His *"Sribhashya"* is an authoritative text for the Vaishnava.

Ramdas : The last of the great Maharashtrian hymn-makers, Ramdas (1608-81) was orphaned as a child. After years of wandering and spiritual training, he settled on the banks of River Krishna where he built a temple to Rama whose devotee he was. Ramdas was not only a theologian, but also a reformer concerned with the state of society in the wake of Islam's impact. Shivaji was his pupil. In Ramdas devotionalism and activism combined. The Dasabodha is a compilation of his writings and sermons produced over several years.

Ravidas : A disciple of Ramananda, Ravidas came from a leather - worker family and became a great Vaishnava devotee in the fifteenth century. His disciples included Mirabai. His sect is known as Sadnami and their creed prohibits idolatry and enjoins the members to constantly think of God. Ravidas wrote intensely devotional hymns which greatly influenced Hindi literature, and some of which were included in the Granth Sahib.

Sankara : A brahmin born in Kaladi, Kerala. Sankara became a sanyasin at an early age. After studying under the philosopher Govindapala, he set out on his own and propounded Advaita philosophy. He is said to have founded four Peethas - at Sringeri, Dwarka, Puri and Badrinath.

Sankaradeva : Vaishnava poet and reformer who brought Vaishnavism to Assam to counter Tantric Shaktism. Sankaradeva's poetic compositions include Rukmini Harana Kavya, Kirtan Gosha, Kaliya Damana and Ram Vijaya. He encouraged an egalitarian society and welcomed tribesmen to Hinduism.

Surdas : A brilliant disciple of Vallabha, Surdas (1483-1563) was a blind musician attached to the temples at Agra and Mathura. His songs are suffused with tender bhakti and deal with the love of Krishna the child and the lover. His songs are collected in *'Sursagar'*.

Guru Tegh Bahadur : He was the ninth Sikh Guru. He laid the foundation of Anandpur in 1665. He was tried and executed by Auranzeb as an unbeliever Gurudwara Sis Ganj in Delhi marks the place of his execution. His body was taken by a Labana Sikh and cremated at a site where the Gurudwara Rakabganj in New Delhi now stands.

Tukaram : Seventeenth century devotee of Vithoba who came from a Sudhra family, Tukaram composed hymns which are sung to this day in Maharashtra and other places.

Tulsidas : A spiritual heir of Ramananda, Tulsidas (1532-1623) is famous for his Ramcharitmanas, a new Ramayana in the vernacular. His bhakti is the love of a servant for his loving master; his work is totally free of sensuality. He inspired a great devotion to Rama.

Vallabha : A Telugu born at Varanasi, Vallabha (1479-1531) wielded great influence through his sect in Gujarat and Rajputana. Surdas was one of his disciples. A devotee of Krishna he expounded his own doctrine of pure monism.

Yajnavalkya : Ancient sage and law-giver who presented a code of law in Yajnavalkya Smriti, Yajnavalkya is also said to have composed the Yajurveda, Satapatha Brahmana and Brihandaranyaka.

Amir Khusrau : Poet and musician at the court of Alauddin Khilji, (c.1300) he considered the music of India the finest in the world. The qawwali is said to have begun with Amir Khusrau who is also supposed to have invented the sitar and the khayal, though he himself does not mention this. He wrote in Persian and in Braj.

Vishnu Narayan Bhatkhande : Interested in music from boyhood, Bhatkhande devoted his life to research in the field. He was the first to organise a full-fledged conference of musicians and musicologists at Baroda. He also reorganised the Baroda State Music School. His ambition to get a music college opened was realised with the inauguration of the Marris College of Music at Lucknow. He made significant contribution to the field of music by pioneering the publication of a collection of compositions in Hindustani music. He composed some songs himself, under the signature "Chatur". He wrote the famous Hindustani Sangeet Paddhati in Marathi, trying to bridge the gap between theory and practice. He classified ragas into ten thatas (parental scales) now widely accepted in north India. He edited several classics besides authoring Abhinava Raga Manjari and A Short Historical Survey of the Music of Upper India.

Vishnu Digambar Paluskar : A great musician, a good teacher, Paluskar is most well-known for having opened the Gandharva Mahavidyalaya. His Ramdhun- *Raghupati Raghava Raja Ram* was sung during Dandi March in 1930, and it was a favourite with Gandhi whose prayer meetings always included a rendering of it.

Swami Haridas : Deeply learned and widely acquainted with the music of his days, Swami Haridas of the sixteenth century was a strong force in the spread of the dhrupad. He belonged to the tradition of *madhura bhakti* - adoration expressed in erotic terms. He began the Haridasi school of mysticism.

Tansen : Ramtanu or Tanna Misra, the boy who came to be known as Tansen later, was from childhood interested and proficient in music. The first real patron of the singer was Raja Ramchandra Baghela of Rewa who conferred the honorific title 'Tansen' on him. Being subordinate to Emperor Akbar, the Raja had to agree to Akbar's request that Tansen be sent to the Imperial

Court at Agra. Tansen thus became one of the 'nine gems' at Akbar's court in 1562. His compositions and style of singing were in the dhrupad tradition. He is supposed to have authored Sangeet Sar, Raga Mala and Sri Ganesha Stotra. He is traditionally considered to have created the new ragas bearing the prefix Miyan - Miyan ki Todi, Miyan ki Malhar. Darbari Kanada is also attributed to him. The musical tradition created by Tansen has come to be known by the name of *Senia gharana*.

Purandaradasa : Sreenivasa Nayaka born in what is now South Maharashtra in 1484 was a miser according to legend till enlightenment came under the tutelage of Vyasaraya, a guru of Vijayanagara emperors. Becoming a member of the order of Haridasas, he turned into Purandaradasa. He postulated Maya Malavagaula as the standard scale for teaching; even today this is the first raga to be taught to beginners in the Karnataka music style. He also devised graded lessons of basic scale exercises (svaravali), exercises with paired notes (janta varisai), note patterns (alankara) etc. for training students. He is called *Adi Guru* and the *"father of Karnataka music"*.

Kshetrayya : Born probably in the 17th century in Andhra, Varadayya or Kshetrayya composed *padams* of great beauty marked by strikingly direct language and simple lyricism. The songs express the love of Kshetrayya himself (as a woman) for the lover, Muvva Gopala (also Kshetrayya's signature) or Lord Krishna.

Muthuswami Dikshitar : Highly proficient in music from his very childhood, Muthuswami was born in Thiruvarur in Thanjavur and was trained mainly by his father. His well-known compositions are - *Tirtuttani kritis, Navavarana Kritis*. He has composed certain pieces in uncommon ragas such as Saranga Nata, Kumudakriya and Amritavarshini which are references for use of these ragas. He innovated musical techniques with certain complex use of varying tempo. Some of his pioneering innovations were: introduction of the violin (for long considered a Western instrument) into the Karnataka music ensemble; He is considered one of the 'trinity' in Karnataka music, the other two being *Thyagaraja and Shyama Shastri*.

Shyama Shastri : Venkata Subramania born in 1762 to a priest in Tiruvarur in Thanjavur came to be known as Shyama Shastri. A great scholar and a composer, his works are intricate and difficult in musical technique, particularly the rhythmic aspect. One of the 'trinity' of Karnataka music, his songs have the signature 'Shyam Krishna'. He was a superb master of tala and is said to have defeated the redoutable Kesavayya in a musical contest by employing the complicated Sarabhanandana tala.

Swati Tirunal : Swati Tirunal Rama Varma was a nineteenth century Maharaja of Travancore, well-versed in nearly thirteen languages in many of which he was able to write poems. His well-known works include Kuchelopakhyanam and Padmanabha Satakam. He composed varnams, kritis, padams and javalis. His genius extended to Hindustani music, for he composed drupads, khayals and thumris, too. Vadivelu, who, with the help of his guru, Muthuswami Dikshitar, had popularised the violin in Karnataka music, was at his court.

Tyagaraja : Born in Thiruvarur in 1759 (or 1767) Thanjavur District of Tamil Nadu, Thyagaraja became one of the Trinity of Karnataka music. He spent most of his life at Thiruvayyuru, where he attained samadhi. A scholar and poet, Thyagaraja gave a new direction to Karnataka music. His famous works include the *Panchanama kritis, Utsava Sampradaya Keertanai*, two operas, *Prahlada Bhakti Vijayam and Nauka Chairtram*, besides innumerable kritis, mostly in Telugu. He created ragas from simple melodies, for example Karaharapriya, Harikambhoji, Devagandhari.

DRAMATISTS

Bhasa : Scholars variously place Bhasa as early as fourth century B.C. and as late as 10th century A.D. he lived in the northern region, and created plays mainly on themes drawn from the Mahabharata and the Ramayana.

In *Madhyamavyayoga*, a one - act play, Bhima is involved in a conflict with his son Ghatotkacha who is unaware of Bhima's identify;

Urubhangam depicts the death of Duryodhana whose thigh is broken by Bhima in the Mahabharata war.

Pratijnya Yaugandharayana and *Swapnavasavadatta* based on the Katha literature, deal with the Udayana cycle of stories.

Kalidasa : The most famous poet and dramatist in Sanskrit. Generally he is placed in 4th - 5th century A.D. Some scholars believe he was a court poet of Vikramaditya of Ujjaini - one of the "navaratnas" of the court. He wrote splendid poems like *Raghuvamsha, Ritusamhara, Kumarasambhava and Meghaduta*, besides three well known plays. *Malavikagnimitra* is a comedy of love depicting the romance of the Vidarbha princess Malavika and king Agnimitra is the love story of Urvashi, the heavenly nymph, and king Pururava. *Abhijnanasakuntalam*, presents the story of king Dushyanta and Sakuntala, how the two meet, fall in love, get married, how the ring, a token of the king gets lost and with it the king's memory of the young Sakuntala, how the ring is found and brings recognition to the king and finally the reunion of Dushyanta, Sakuntala and their son Bharata.

Shudraka : The details of who Shudraka was, are obscure. But his Mricchakatika has a prologue which indicates that he was a king. He modified and extended the play CHARUDATTA, to create MRICCHAKATIKA (The Little Clay Cart), a beautiful drama full of vitality. It depicts the love between a beautiful intelligent courtesan Vasantasena and a poor brahmin, Charudatta. A subplot of political revolution is also woven into the play. The characterization is remarkable, with even a minor character having a distinct personality. The scenes are well-laid out and there are poetic descriptions of beauty.

Vishakadatta : Probably of the sixth century, Vishakadatta was the dramatist of politics. His only surviving play, Mudraraksasa (Signet ring of Raksasa) deals with the schemes of Chanakya to foil the plots of Raksasa, the minister of the last of the nanda rulers, and to place Chandragupta Maurya on the throne. The complicated plot is worked out skilfully and the play is beautifully constructed to lead up to a brilliant scene where one of the chief characters is saved from death at the last moment. His Devichandragupta about the rise to power of Chandragupta II exists only in fragments.

Harsha : Three plays are supposed to have been written by Harshavardhana the ruler of Kanauj. *Ratnavali* is the love story of King Udayana and princess Ratnavali who lives in disguise in the king's harem. *Priyadarshika* has a similar theme concerning king Udayana. *Nagananda* has a Buddhist theme, telling of prince Jimutavahana, who gives his own body to stops the sacrifice of snakes to the divine Garuda.

Mahendravikraman : The Pallava king, a contemporary of Harsha, wrote a delightful farce, *Mattavilasa* (Sport of Drunkards). It depicts the degeneration that had come into different religious cults.

Bhavabhuti : Held second only to Kalidasa Bhavabhuti (early 8th century) lived at Kanyakubja, and marks the last of the greatest Sanskrit dramatists. His *Mahaveeracharita* and *Uttara ramacharita* are based on the story from his marriage to coronation, and the second depicts the later part of the Rama story- from Sita's exile to the reunion with Rama at Valmiki's hermitage. *Malati - Madhava* is a romantic comedy of two young lovers who are finally united by the clever moves of a Buddhist nun, Kamandaki. There are spectacles of terrible tantric rituals and human sacrifice - unusual in Sanskrit literature.

beautiful temples display the Vijayanagar architectural style, prominent being the Minakshi Temple. It is the centre of Chungadi craft - a traditional tie - and - dye craft.

Marble Rocks : South - west of jabalpur (MP) is the gorge on the River Narmada, which surges down to the marble rocks below creating clouds of spray - the Dhuandhar. Nearby are the Madanpur Temple with 64 statues of female ascetics, and Madan Mahal, the Gond kings fort.

Mathura : A sacred city of the Hindus situated on the Yamuna River, north-west of Agra (UP) associated with the Krishna legend - Krishna was born, and lived, here and made it his capital. It has been mentioned by ancient writers such as Ptolemy and the travellers, Fa Hien ahd Hiuen Tsang. The city witnessed destructive activities by Mahmud of Ghazni and others. It was also a Buddhist centre especially during the rule of the Kushana kings.

Nagarjunakonda : Located in Guntur district (AP) on the Krishna River, it was earlier Vijayapura. It was an important Buddhist centre during the ancient times. It receives its present name from Nagarjuna, a famous Buddhist monk who lived around second century A.D. and founded the reputed Madhyamika school. It became the 'hill of Nagarjuna' in the 3rd century A.D.

Discovered in 1926, excavations at the site have revealed pottery, viharas, stupas, chaitanyas, Buddhist sculptures as well as an amphitheatre of the Ikshvaku times. It was found that the site has been continuously occupied from early Stone Age era. The valley was excavated in order to construct the Nagarjunasagar dam at the site.

Nalanda : South of Patna, it was once one of the most renowned centres of Buddhism. This site, presented to the Buddha, was where he preached the Law. Here are the ruins of the world's oldest university, founded in the 5th century AD. The university flourished till the 12th century when Muslim invaders destroyed the monasteries. When Hiuen Tsang visited the university in the 7th century, it had about 10,000 students and monks and attracted scholars from China, Japan, Korea, Sumatra and other places.

Excavations begun around 1916 have revealed the Great Stupa, some eleven monasteries and a number of chaityas.

Nathdwara : A magnificent marble temple near Udaipur and close to River Banas which is dedicated to Shri nathji.

Ootacamund : At 2,286 m above sea level in the Nilgiri Hills is this mountain resort famous for its rolling hills. it was founded by the British in the 19th century as a summer retreat. It has palaces, a fine lake offering boating and fishing, a botanical garden and a golf course. Its native inhabitants are the tribal Todas

Panipat : (Haryana). It is a battlefield town near the old bank of the Yamuna River. The main battles were fought here: Babur defeated King of Delhi, Ibrahim Lodi in 1526 to establish Mughal rule in India: Akbar defeated Hemu, general of Afghan Sher Shah in 1556; the Afghans under Ahmad Shah Durrani vanquished the Marathas in 1761.

Periyar Game Sanctuary : (Thekkadi, Kerala). The wild life and bird sanctuary near the Tamil Nadu border in a beautiful setting by the lakeside was created in 1934 by building a dam over Periyar River. A part of Project Tiger. it is famous mainly for its wild elephants. Bisons, sambars. wild oxen, wild bear and spotted deer are to be found.

Pinjore Gardens : 20 km from Chandigarh and set against the lower range of Himalayas. they are one of the oldest Mughal gardens in north India. A replica of the Shalimar gardens (Srinagar), the beautiful gardens were designed by the same man - Fidai Khan, foster brother of Aurangzeb.

Plassey : A village near Calcutta famous for the Battle of Plassey. Which is said to mark the beginning of the British rule defeated the Nawab of Bengal in 1757.

Puri : A popular destination for the devout, it is famous for the Jagannath Temple dedicated to Jagannath (Lord of the Universe). All Hindus are allowed to visit the temple, without any caste distinctions being made. Every June or July, the famous Rath Yatra (Car Festival) - one of India's greatest annual festivals - takes place when massive raths (chariots) set forth from the temple to commemorate Krishna's journey from Gokul to Mathura.

Pushkar : A centre of pilgrimage 11 km from Ajmer which has one of the country's most sacred lakes. It is believed that a dip in the sacred waters is a must for deriving the full benefit of visiting other pilgrimage sites. The only temple dedicated to Brahma in India is here. The town is world famous for its huge camel and cattle fair held every October/November.

Rajgir : South-east of Patna is this Buddhist and Jain pilgrim centre. Buddha spent 12 years of his life here. It is also the site of the First Buddhist Council. It has the Saptaparni and other caves, the Maniyar Math, the Gridhrakuta ('Hill of Vultures') - believed to be one of Buddha's favourite places where he converted King Bimbisara to Buddhism, hot mineral springs Jain temples and a Japanese stupa. The place features in Hindu epics as well.

Ramesvaram : An island in the Gulf of Mannar at the southern tip of the mainland and called 'Varanasi of the south', it is a major pilgrimage centre. It has the Ramanathaswamy temple, one of the most important temples, which was founded by the Cholas but mostly built in the Nayaka period (16th and 17th centuries). The over 45-m-high-magnificent edifice has long corridors and beautifully sculptured pillars with intricate designs and carvings. Rama is said to have made the place sacred by worshiping Lord Shiva here after defeating Ravana. Another important temple is the Kothandaraswamy Temple.

Ranakpur : Set in the Aravalis near Udaipur, it has some of the best Jain temples in India the main temple the Adinatha Temple, built of marble in 1439, with 29 halls bearing 1444 pillars every one distinct from the rest. The Parsvanatha Temple and the Surya Narayana Temple are also noteworthy.

Santiniketan : (District Birbhum, West Bengal). Founded by Debendranath Tagore, it was here that in 1901 Rabindranath Tagore set up classroom in the open with only 5 pupils. The school went on to be come the Vishva Bharati University (1921) which became a central university campus has a large collection of sculptures, paintings and Murals and bhavans such as the Kala bhavana for promoting study and research in painting and sculpture.

Sarnath : Near Varanasi, it is a holy Hindu city and a major Buddhist centre as well. Buddha preached his first sermon after attaining nirvana at the Deer Park here. The first Buddhist Sangha was founded here. Asoka built the Dhamekh stupa, and the Dhamarajika stupa to contain relics of the Buddha. The 'Main Shrine' is where Asoka is said to have meditated and where Buddha settled when in Sarnath. Near this is the Asokan Pillar - the main portion of which has been moved to the Sarnath Museum. Sarnath was a centre of Hinayana Buddhism during the Kushana rule (1st century AD). There is a temple commemorating the 11th Jain Tirthankara, Shreyam - shanatha who died at the Deer Park.

Sravanabelagola : (District Hassan, Karnataka). One of the most ancient and important Jain pilgrimage centres famous for its 17-m high monolithic nude Jain statue representing Bahubali, son of the first Trithankara, after he attained enlightenment. The statue, said to be the world's tallest monolithic statue, stands on the Indragiri hill and is sculptured from a single, solid, vertical rock. Once every 12 years, Jain pilgrims from all over the country flock to the site to witness the Mahamastakabhisheka - the sacred head - annointing ceremony and turmetic paste, vermillion powder and flowers are poured over it.

St. Thomas Mount : (Madras). An important Christian shrine housing the remains of St. Thomas the Apostle (Doubting Thomas) who was martyred at the Great Mount in AD 52. Built in 1504 but rebuilt in 1893, it is one of the few churches constructed over the tomb of an apostle.

Salarjung Museum : (Hyderabad). One of the three national museums of India. It stores the art collection of Yusuf Ali Salarjung III, the wazir to the Nizam between 1899 and 1949. The art collection is said to be the largest in the world. The museum has 35,000 exhibits from all over the world arranged countrywise in its rooms. It has a library with a vast collection of Oriental manuscripts.

Sidi Saiyad Mosque : (Ahmadabad). Constructed by Ahmad Shah's slave, SidiSaiyad, the structureis famous for its beautifully carved central windows (a work of Gujarati craftsmen) that are highly artistic. These also exhibit fine stone tracery with tree and floral designs skillfully executed.

Sis Ganj : (Delhi). Sikh shrine in Chandni Chowk dedicated to the ninth Sikh Guru, Tegh Bahadur who was beheaded under the orders of Emperor Aurangzeb in 1675.

Somnath : (Saurashtra, Gujarat). Famous for the Somnath Temple, a major place of pilgrimage. It is dedicated to Shiva and houses one of thd 12 sacred Jyotirlingas, which are believed to derive Shakti from within themselves. Said to have been earlier built of gold by the Moon God, Somraj, it was later rebuilt in silver, wood and stone. Because of its richness it was plundered by Mahmud of Ghazni (AD 1024) and others but rebuilt each time. The final reconstruction began in the 1950s.

Sravasti : Between the Gonda and the Bahraich districts. this ancient site in modern UP was the second capital of the Kosala Kingdom. It is sacred to Buddhists and Jains. Buddha preached at the Jetavana preached at the Jetavana monastery. It is said that he performed the miracle of multiplying himself a million times over while seated on a lotus at Sravasti.

Srinagar : (Capital of Jammu and Kashmi). Flanked by the Himalayan ranges, the 'beautiful city' stands on the Jhelum River and a number of lakes, Dal Lake being the main one. The city, divided into two by the river, was built in the 6th century by Raja Pravarasen. The Mughals constructed beautiful terraced gardens such as the Shalimar Gardens, Nishat Bagh, Naseem Bagh, Chashma Shahi. Hari Parbat and Takht - i - Suleman - on which stands the Shankaracharya Temple - are two famous hills.

Srirangapatnam : 16 km from Mysore and situated on a rocky island in the Cauvery River, it was the capital of the Hindu Wodeyars of Mysore and later, of Haider Ali and his son Tipu - from whom it was captured by the British (1799). Its main attractions are the town fort, built by the Vijayanagar kings in 1454; the Sri Ranga nathaswamy Temple, with a black stone figure of Vishnu at rest, which is a Hindu pilgrimage centre; Daria Daulat Bagh (Tipu's summer palace and garden); and the Gumbaz, Tipu's family mausoleum.

St. Paul's Cathedral : (Calcutta). Built in gothic architectural style between 1839 and 1847, it is one of the important churches in India. It was the first Angli can cathedral to be set up in India. Hence its importance for the Christian Anglicans in the land.

Talwandi Sabo : (also, Damdama Sahib), Bhatinda (Punjab). The holy book of the Sikhs, the Granth Sahib was dictaed from memory by Guru Gobind Singh to Mani Singh at this place.

Tanjore : (also, Thanjavur) City of temples in Tamil Nadu which was the ancient capital fo the Chola kings. Of its 93 templess, of main attraction is the 63-m-high Brihadeshwara Temple built by Raja Raja (AD 985-1014) from a single piece of granite. The Gangaikonda Cholapuram temple, Kampaharesvara Temple, the city palace and the Saraswati Mahal Library are famous. Tanjore is well-known for a special style of painting in which glass is painted with bright colours.

Taran Taran : (south of Amritsar). The shrine of the fourth Sikh Guru. Ram Das was built here by Arjun Dev but the structure was completed in the 19th century only. Decorated with marble and well-ornamented, the rooms of the structure bear frescoes related to the lives of the Sikh Gurus. A fair is held here every Amavasya.

Thyagaraja Temple : (Thiruvarur). The temple, dedicated to Thyagaraja (Shiva), is one of the largest is South India. It was founded by the Cholas but took over three centuries (beginning 13th century) to get completed owing to periodic additions. It has magnificent gopurams and inscriptions dating from the Chola time to the period of Maratha rule. Its status is unique in the history of Shaivism in South India.

Tirukkalukundram : A few km from Nahabalipuram is this pilgrimage centre with the famous hilltop temple dedicated to Bhaktavatsleesvara (Shiva) which has a beaconshaped gopuram. A strange sight is the daily visit of two Neophran vultures to the temple for feeding. A legend holds that the birds are the spirits of two saints and they have been visiting the hill from times immemorial. A dip in the temple tank is of special significance.

Tirumalai : (A.P.) The holy hill 20 km from Tirupati has the Sri Venkateswara Temple, a pilgrim centre of extreme importance, dating from the 10th century. Of all Indian temples, this one draws the largest number of pilgrims and is the richest - in terms of the income it earns. To Lord Venkateswara (Vishnu) is ascribed the power of granting any wish made by the visiting pilgrims.

Udaipur : Called the 'Venice of the East', it is set in the Girwa Valley in Aravalli Hills (S. Rajasthan) by the side of the beautiful Pichola Lake. It was founded by Maharana Udai Singh in 1586 who named it 'the city of sunrise'. It has shinning marble and granite palaces, with the huge City Palace being the largest palace complex in the state. The Choti Chitrasala is famous for its peacock mosaic and the Moti Mahal for its mirror decorations. The two island palaces, Jog Niwas and Jog Mandir, stand in Lake Pichola.

The city is well-known for wooden toys and textiles.

Ujjain : (M.P.) One of the seven holy cities of the Hindus, it is one of the four centres of the triennial Kumbh Mela. It is on the banks of River Shipra. Legend reveals that Shiva, after defeating the demon of Tripuri, changed the name of his capital from Avantika to Ujjaiyini (one conquering with pride) and thus the city derived its name. At one time, even Jainism and Buddhism flourished in this place.

Vaishno Devi : 48 km from Jammu, this pilgrimage site is a cave temple dedicated to the three mother goddesses of Hinduism - Mahalaxmi, Mahkali and Mahasaraswathi. Pilgrims are required to visit the nearby temple of Bhairon as well.

Varanasi : (UP) The pilgrim centre on River Ganga's banks is one of the seven sacred cities of Hinduism. It is also called Kashi (the city of light) after Kasya or Kasa - an ancient king. A legend holds that the name is owing to the shining (kasi) lingam in this place. The Dasasvamedha Ghat is where Brahma is believed to have performed the 10-horse sacrifice and where Shiva performed many austerities. It is important for Jains and Buddhists also as the 23rd Jain Tirthankara, Parsvanath was born - and lived - here and nearby Sarnath is well - linked to Buddha's life. Varanasi derives its name from the Varuna and the Assi rivers which flow on its northern and southern borders respectively.

Vasco Da Gama's Church : Also St. Francis Church, it was the first in India to be built in the European tradition. The original wooden building of 1510 was later replaced by another of stone. Vasco da Gama was buried here in 1524 though his remains were removed to Lisbon in 1538.

Vikramasila : (Bihar). An ancient Buddhist centre of learning with many Vajrayana monasteries. From here, Vajrayana Buddhism was carried to Tibet in the 11th century AD by missionaries

Vivekananda Memorial : (Kanyakumari). At the southern end of India, the memorial was built in 1970 on a rock projection where Swami Vivekananda meditated before leaving for the Parliament of Religions meeting in Chicago. The granite memorial which was built combining varied Indian architectural styles has a large statue of Vivekananda.

FAMOUS LITERARY PERSONALITIES

Abul Fazl : Sixteenth century Muslim scholar and historian of Akbar's time.

Alberuni : Born as Abu Rihan Mohammad, he came to India with Sultan Mahmud. His *'Tarikh-i-Hind'* gives much information about the Hindus, their thoughts and customs.

Bharavi : Sixth century Sanskrit poet who wrote *'Kiratarjuniyam'*.

Bhartrihari : Sanskrit writer of seventh century who is credited with three Satakas. He was also a philospher and grammarian.

Bhatti : Probably a poet of the 6th - 7th centuries. Bhatti's BhattiKavya or Ravanavadha was written mainly to illustrate rules of grammar and rhetoric.

Bilhana : A Sanskrit writer of 11th - 12th centuries, he was at the court of the Chalukyan king where he wrote *"Vikramankadeva"* - charita. He also wrote the poem *Chaurapanchasika.*

Bankim Chandra Chateerjee : Nineteenth century Bengali Novelist. His Ananda Math provided India's national song - *Vande Mataram.* Other novels - Devi Chaudharani, *Sitaram, Kamala kanta.*

Sarat Chandra Chatterjee : Social thinker and Bengali novelist of the 19th - 20th centuries, his work is marked by humanism and critical analysis of age-worn social customs. His major novels: Srikanta, Pilli Samaj Pandit Mashai. Sesh Prashna.

Subhara Kumari Chauhan : The first woman to take part in the satyagraha at Mahakoshal. This poetess is most famous for her stirring ballad, *Jhansi ki Rani.* She was awarded the Seksaria Prize for her collection of poems, Mukul and for her short stories, *Bhikre Moti.*

Dandin : Seventh Century Sanskrit writer who is famous as a literary critic. He also wrote *Avantisundari*, a novel, a part of which has been circulated separately as *Dasakumaracharita.*

Assadullah Khan Ghalib : Great Urudu poet of the nineteenth century, Mirza Ghalib is famous for his ghazals and diwans. He also wrote a history of the Mughal dynasty, Dastanbo, an account of events during the 1857 Revolt and literary criticism, *Qati Burhan.*

Gunadhya : Writer of 1st or 2nd century, his Brihatkatha in Paisachi dialect is a collection of stories which are amusing. It became a prototype of many romantic tales.

Hala : First century Satavahana king and Sanskrit poet who wrote *"Gadhe Saptasati"*

Kabir : Fifteenth century mystic poet, he wrote his poems in a mixed dialect and evolved a rich vocabulary which included Perso - Arabic words.

Kalhana : Poet of 12th century whose Rajatarangini in Sanskrit gives the history of Kashmir's kings.

Kalidasa : Associated with 'Vikramaditya of Ujjain, Kalidasa was a Sanskrit dramatist and lyric poet. His *Meghadoota* is a fine piece of poetry. *Raghuvamsa* and *Kumara Sambhava* are epics. His work shows a remarkable sensitivity to beauty and has fine descriptions of nature.

Katyayana : A Sanskrit grammarian of great repute who wrote around the 3rd or 2nd century BC, his Vartika is a Ashtadhyayi.

Kautilya : Also known as Chanakya and Vishnugupta, he was the Chief Minister of Chandragupta Maurya (4th century BC) and writer of Arthashastra, a treatise on administration which gives righteousness and important role in the king's duties. Kautilya is often called the Indian counter part of the Italian Machiavelli who wrote The Prince.

Kumaran Asan : A follower of Sri Narayana Guru, he was a staunch opposer of casteism and social injustice. His poems, *Nalini and Leela* and *the Fallen flower* are well-known.

Magha : Seventh century Sanskrit poet who wrote the epic *Sisupala Vadham* which is striking for its lyrical passages.

Panini : Sanskrit scholar who wrote Ashtadhyayi, the earliest extant grammer in the world. The discovery of the work by Europeans in the 18th century gave impetus to the new science of philology.

Patanjali : Sanskrit scholar whose *Mahabhashyam* is an erudite commentary of Panini's work. He was instrumental in bringing Sanskrit back as the language of literature.

Premchand : Renowed Hindi and Urdu writer of modern India, Dhanpat Rai (Premchand) was a government official who left service to join the freedom struggle, His works: *Rangabhumi, Godan, Gaban, Premashram.*

Sarkar Jadunath : A historian whose main interest was the reign of Aurangzeb, his works of note are The *Study of Auranzeb, Shivaji and his Times* and *The fall of the Mughal Empire.* He also completed William Irwin's study of Later Mughals.

Somadeva : Sanskrit poet whose *Katha-saritasagara* is a famous collection of stories.

Subandhu : 7th century Sanskrit poet who wroter *Vasavadatta.*

Surdas : Blind poet of the 16th century who wrote in Braj - bhasha with deep devotion and love for Lord Krishna. His *Sur Sagar* and *Sur Saravati* are highly respected and appreciated.

Thiruvalluvar : Poet philosopher of the early Christian era in Tamil. His Kural, a poetical wrok on ethical and other issues of the day, is a Tamil classic free of caste and class prejudices.

Suryakant Tripathi : Called 'Nirala' for his innovative poetic style, this Hindi poet was a mystic observer of nature. His important poems: *Juhi Ki Kali and Shefalike.* Other works: Anamika, Geetika, Apsara, Sakhi.

Vakpati : 8th century Sanskrit poet, he wrote *Gandavadha* which describes the exploits of Yasovarman, king of Kanyakubja.

Vagbhatta : 7th century writer, he summarised the 8 sections of the original Ayurveda.

Valmiki : Legend has it that he was a brahmin who lived as a robber but changed his way of life on the advice of some sages. It is said that the sight of a heron, grief stricken at the loss of its mate shot by a hunter, inspired him to poetic expression, and he created the sloka that led him to his epic *Ramayana.*

Vatsyayana : 5th century Sanskrit writer, his *Kama Sutra* is a world - famous treatise on the amorous arts.

Vemana : 17th century Telugu poet. He had a keen social and ethical vision and criticised social discrimination with humour. His work : Vemanasatakam.

Mahadevi Verma : One of the Chhayavadi poets, she wrote poetry of a high literary quality in which romanticism and mysticism are combined. Themes are humanity, nature, separation, union and ecstasy.

Vidyapati : Bhakti poet who wrote in Maithili. His works are *Kirthilatha, Kirthipathaka*, and a manual of letter writing in Sanskrit, *Likhanavali.*

Mirza Ghalib : Famous Urdu poet of Ghazals, he wrote authentic history of Mughals. His poems show aesthetic sense and intellectual self - assertion.

Braratendu Harishchandra : Contributed to development of Hindi prose and poetry. His writings represent the agonies of the people and unrest of middle classes.

Vallanthal Narayan Menon : Romantic poet of Kerala who wrote against caste instructions and religious orthodoxies. He founded Kerala Kolamandalam and revived Kathakali dance.

Prem Chand : Famous Hindi writer who inspired the independence struggle through his writing. His famous books are 'Godan' and 'Rangabhumi'.

Janini Roy : A folk artist of Bengal whose work was a rebellion against the delicate drawing and lazy colouring of Bengal School.

Ambar Palace : Deserted capital near Jaipur. it contains the finest specimen of Rajput architecture. It has the heaviest canon.

Auroville : An international township constructed in Pondicherry with the help of UNESCO. It is named after Sri Aurobindo and is also known as the 'city of dawn'.

Bijapur : The Gol Gumbaj, the second largest dome in the world, is located in this town of Karnataka.

Buland Darwaza : The Gateway of Fatehpur Sikri, built by Akbar to commemorate Akbar's victory in Gujarat. The style is of half dome portal. It shows Iranian influence.

Ellora and Ajanta : Located in Aurangabad (Maharashtra), it is famous for wondeful Buddhist cave temples richly ornamented and carved with paintings of exceptional skills.

Gomateshwar : Located in Karnataka, it is famous for the 2000-year-old statue of Jain sage 'Bahubali' carved out of single stone.

Hampi : Located in Karnataka is a site of ruins of Vijayanagar ancient capital of Vijayanagar empire.

Jantar Mantar : Located in Delhi, it is an observatory constructed in 1724 during the days of maharaja Jai Singh of Amber.

Kanchi : Located near Madras, it was the capital of ancient Pallavas. It is famous for ancient Kailashnath temple.

Lumbini : A village in Kapilvastu along Indo - Nepal border where Mahatma Buddha was born.

Nalanda : An ancient city located in Bihar, famous for Buddhist teaching at Nalanda University. Hiuan - Tsang studied here for 5 years.

Sanchi : Located in Madhya Pradesh, it is famous for the largest and the most well preserved Buddhist Stupa. William Taylor rediscovered it in 1818.

Sarnath : Situated 8 km outside Varanasi, Sarnath is famous as a Buddhist centre. In the Deer Park of Sarnath, Buddha preached his first sermon. It has Ashoka Pillar with the Lion capital.

Dilwara Temples : Built between 11th and 12th century, it is famous for Jain temples. The temples are constructed of Makaran Marble and are the perfect examples of Jain temple architecture.

Vijay Stambh : The viceroy tower, 37m high structure of 9 stories was built by Maharana Kumbha in commemoration of his victory over the Muslim rulers of Malawa and Gujarat.

Kandariya Mahadeo Temple : The largest and architecturally the most impressive of all temples at Khajuraho is dedicated to Lord Shiva. It is decorated with nearly 900 figures of various sizes.

Lauriya Nandagarh : Situated in Bihar, it is known for the lion pillar of Ashoka made up of 8.3m single block of polished sandstone. There are also remains of huge stupa called Nandangarh.

Abhijnana Shakuntalam : A play written by Kalidas. The subject is taken from Mahabharata which depicts the meeting of Dushyant and Shakuntala.

Mrichhakatikam : A play written by Shudraka which depicts the love between a Brahmin Charudutta and 'ganita Vasantsena'.

Aryabhatta : An astrologist and mathematician during 4th century AD. His works are 'Aryabhattiyan' and 'Suryasiddhantam'. He said that earth is spherical and it moves on its axis.

Vishakhadutta : A writer during 4th century AD who wrote 'Mudrarakshasa' and 'Devi Chandra Guptam'.

Amar Kosa : Written by Amar Singh who was among the nine ratnas of Chandragupta II. It depicted the Gupta society, economy and culture.

Buddhacharita : Written by Ashwaghosa who was contemporary to Kusan ruler Kansishka. It depicts about the life of Buddha.

Swapna Vasovadattam : A play written by 'Bhasa,' which depicts the story of King Udain and Vasavadatta.

Malvika Agnimitra : A play written by Kalidas which gives an account of Shunga rulers.

Megasthenes : A Greek ambassador in the court of Chandragupta Maurya, he wrote 'Indica' which gives an account of Mauryan rule.

Babarnama : Written by Babar in Turkish language, it gives an account of India during 16th century AD and the life of Babar.

Ain - e- Akbari : A book written by Abul Fazal. It gives an account of Akbar's reign.

Tukaram : A bhakti saint in Maharashtra who was contemporary to Shivaji. He popularized Bhakti cult in Maharashtra.

Sri Rampur : It was the headquarters of Danish East India Company. It was located in Bengal.

Astapradhan : A body of eight ministers to help Shivaji in administration. It included Peshwa, Shar - e - naubat and Majumdar etc.

Amir Khushro : A sufi saint related to Chistiya cult who represented seven Sultanae rulers like Mohammed Bin Tuglaq, Alauddin Khilji etc. His famous works are Nur Sipihr, Laila Majnu, Tughlaqnama etc.

Badyuni : A famous writer during Akbar's reign who wrote Munteekhab - al - Tawarikh. He was a critic of Akbar's policies.

Dara - Shikoh : The eldest son of Shah Jahan, who wrote several books on Sufi culture.

Chhatrapati Shivaji Terminus : Formerly known as Victoria Terminus in Mumbai, it is an outstanding example of Victorian Gothic Revival architecture. It has been included in the UNESCO's world heritage list.

Champaner - Pavagadh Archaeological Park : A concentration of ancient Hindu architecture, temples and special water retaining installations in Panch Mahal district of Gujarat dates back to 16th century. It has been included in the UNESCO's heritage list.

Bhimbetka Caves : Located along the foothills of Vindhyan Mountains in MP, it has massive sandstone structure displaying paintings dating back to Mesolithic age. It has been included in the UNESCO's heritage list.

Darjeeling Himalayan Railways : Located in Tamil Nadu, it is at an elevation of 326m to 2,203m and is still in use today. It was constructed in 1908 and has been included in the UNESCO's heritage list.

Kuchipudi : Originated in Andhra Pradesh as dance drama, it depicts Krishna's life by dance and drama. Famous dancers are Swapna Sundri and Yamini Krishnamurti.

Manipuri : Originated from South Indian temples out of fusion of Tamil, Kannada and Telugu cultures. Famous performers are Rukmini Devi, Mrinalini Sarabhai etc.

Kathakali : Known as the ballet of the east, it is famous in Kerala. It requires control of body and emotion. The themes are Ramayana and Mahabharata.

Dravidian Temple Architecture : Famous in South India, its main features are sanction sanctorum, huge gopuram, high boundary wall, pillared hall, Antarala etc.

Nagara Style of Temple Architecture : Famous mainly in North India, its main features are curvilinear Shikhara, absence of enclosure etc. Main temple is Lingaraja temple.

Rabindra Sangeet : A new style evolved by Ravindra Nath Tagore by fusion of Hindustani music and folk music of Bengal.

Arjun Dev : Fifth guru of Sikhs who compiled the Adi Granth. He was executed by Jahangir as he supported Khusro who rebelled against the emperor.

Chaitanya : A Vaishnava Bhakti saint who promoted the worship of Lord Krishna and Radha in Bengal and east India.

Kabir : Born as weaver and was a bhakti saint who emphasized on righteousness, humility, self - discipline and love to attain god.

Nagarjuna : A philosopher, who systematized the Madhyamika School of Mahayana Buddhism, was the contemporary of Kanishka.

Deogarh : A Gupta Age site in Jhansi district where the Dasavatara temple was built.

Alai Darwaza : Forms a part of ambitious scheme of Alaud - Din - Khilji to enlarge the Quwwat - ul - Islam mosque in Delhi. Considered as a gem of Indo - Islamic architecture using red sandstone and white marble.

Fatehpur Sikri : Located about 36 km west of Agra and was built by Jahangir. The buildings in the city are Panch Mahal, Palace of Jodha Bai, Diwan - i - Khas, Buland Darwaza etc.

Nagarjunakonda : Located in Guntur district on the Krishna river was an important Buddhist centre during ancient times.

Gandhara Art : Known as Indo - Greek art, depicted Buddha's life. It used blue grey schist lime plaster and stucco. It was spread in Peshawar, Bunar, Gandhara etc.

Humayun's tomb : Shows first real Mughal style of architecture, it used marbles and depicts dome and high neck.

Mohiniattam : Solo dance with graceful movement and involves use of sober and attractive costumes, popular in Kerala.

Mathura School : Originated around 2nd century BC, prospered under Kushanas, had the following features - depicted real life image of Buddha, votive pillars, Buddha's image was in Abhaya posture.

Odissi : Classical dance of Orissa, originated during Kharvela period and lyrical in nature. The basic theme is Lord Krishna's love with Radha.

Rangoli : A painting popular in Maharashtra and Gujarat. The white stone is used for making colours and the designs are made on the ground.

Goa Churches and Convents : Built during 16th to 17th century, is in the list of world heritage monuments.

Khajuraho : Monuments were built by the Chandelas in the 10th century AD. It consists of lofty temples of sculptural grace and architectural splendour.

Brihadesvara temple : The celebrated Shiv temple is located at Tanjavur and was built by Chola emperor Raja - Raja during 985-1012 AD.

Sanchi : Located in Madhya Pradesh is famous for its magnificent stupa originally built by Ashoka and later embellished during Sunga period. The panels depict Buddha's life.

Dakshineswar : About 81 km from Calcutta where Swami Vivekananda was initiated into religious life by Sri Ramakrishna Paramhansa.

Belur Math : A monastery near Calcutta, was founded by Swami Vivekananda.

Eagles nest : Name given to the historic fort at Raigarh in the Kolaba district of Maharashtra where Shivaji was crowned around three hundred years ago.

Lepakshi : An important place of worship in Andhra Pradesh, famous for temple architecture and paintings of Vijayanagara art.

Parsvanath hills : Situated in Jharkhand, named after 23rd Tirthankara is an important Jain pilgrimage. It is where Mahavira attained enlightenment.

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The Rio+20 Earth Summit

The United Nations Conference on Sustainable Development (Rio+20 Conference) took place from 20 to 22 June 2012 in Rio de Janeiro, Brazil. The conference marked the 20th anniversary of the Rio de Janeiro United Nations Conference on Environment and Development (UNCED) of 1992 and the 10th anniversary of the 2002 Johannesburg World Summit on Sustainable Development (WSSD).

The conference agenda was divided into two main themes: (a) a green economy in the context of sustainable development poverty alleviation; and (b) the institutional framework for sustainable development. The seven areas identified for priority attention at the conference were decent jobs, energy, sustainable cities, food security and sustainable agriculture, water, oceans and disaster readiness. The expected outcome of the conference was the adoption by all participating governments of practical measures to implement sustainable development. Although a lengthy document was drafted at the conclusion of the conference, various participants were disappointed with the outcome, criticising the lack of progress made since the Earth Summit in 1992 when conventions were adopted on climate change, biodiversity and desertification.

As far as India is concerned, the outcome document takes into consideration India's interests and concerns and India has expressed satisfaction with the overall package. India was constructive at Rio and in addition to its own proposals, which met with widespread support, the Indian delegation played a crucial role in bridging differences and building consensus on many important issues.

Further, world leaders agreed to set up two important mechanisms, one for Technology Transfer and another for Finance. Both were Indian proposals, which received strong support from G77 countries, including from Africa, LDCs and small island states. India was satisfied that no specific goals and targets were laid down. Another significant development at the summit was the restoration of the centrality of the principle of Common But Differentiated Responsibilities (CBDR) in the environmental discourse, which is of great significance to developing countries, not least in the climate change context. India also succeeded in getting the outcome document recognise poverty eradication as the greatest global challenge, placing it squarely at the centre of the global development agenda.

The conference will also be remembered for kick-starting the process on Sustainable Development Goals (SDG). Since they are expected to become a part of the post-2015 global development agenda, SDGs will hopefully guide the international community towards inclusive sustainable development.

What is Green Economy?

A green economy is described as one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. Practically speaking, a green economy is one whose growth in income and employment is driven by public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services. These investments need to be catalysed and supported by targeted public expenditure, policy reforms and regulation changes. This development path should maintain, enhance and, where necessary, rebuild natural capital as a critical economic asset and source of public benefits, especially for poor people whose livelihoods and security depend strongly on nature. In other words, we can think of a green economy as an economic environment that achieves low carbon emissions, resource efficiency and at the same time is socially inclusive.

It has been suggested that regardless of the environmental benefits and options for sustainability, investment into a green economy can lead to creation of millions of new jobs. One of the main engines for economic growth is a higher rate of employment, which both reduces a burden on the economy and gives consumers the purchasing power to sustain lives through supporting industries.

The UNEP-led Green Economy Initiative, launched in late 2008, provides a comprehensive and practical working mechanism, through analysis and policy support for investing in green sectors and in greening environmental unfriendly sectors. For the purposes of the Green Economy Initiative, UNEP has developed a working definition of a green economy as one that "results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities." In its simplest expression, a green economy can be thought of as one which is low carbon, resource efficient and socially inclusive.

Within UNEP, the Green Economy Initiative includes three sets of activities:

1. Producing a Green Economy Report and related research materials, which will analyse the macroeconomic, sustainability, and poverty reduction implications of green investment in a range of sectors from renewable energy to sustainable agriculture and providing guidance on policies that can catalyse increased investment in these sectors.

2. Providing advisory services on ways to move towards a green economy in specific countries.

3. Engaging a wide range of research, non-governmental organizations, business and UN partners in implementing the Green Economy Initiative.

One of the main engines for economic growth is a higher rate of employment, which both reduces a burden on the economy and gives consumers the purchasing power to sustain lives through supporting industries.

By 2008, over 2.3 million people in just six leading countries in green jobs were employed in this low-carbon sector (China, Denmark, Germany, India, Spain, and the United States). The Green Economy is therefore not just a passing environmental fad but can be said to be one of the best solutions available for sustainable economic growth that recognises the social component.

Rainwater harvesting

In big towns and cities water is mostly available from taps. The water is taken from nearby rivers or lakes and treated before it is supplied to homes through pipes. But in many big cities river or lake water is not enough to meet the total demand for water. So water drawn from deep tube wells has to be used in addition. In villages water is mostly obtained from open wells, tube wells and hand pumps. This water comes from groundwater, which is an underground source of water. About 92 per cent ground water extracted is used in the agricultural sector, 5 and 3 per cent respectively for industrial and domestic rectors.

Groundwater is found below the ground in the cracks and spaces in soil, sand and rock. The spaces where groundwater is stored and through which it moves slowly are called aquifers. Aquifers are made up of layers of soil, sand and rocks, which are quite porous and through which water can flow slowly.

Interestingly, all groundwater is actually stored rainwater. When rain falls to the ground, most of the rainwater flows along the surface to streams or lakes and some evaporates and returns to the atmosphere. But some of the rainwater also seeps into the ground and is stored as groundwater. The process of seeping of water into the ground is called infiltration. Groundwater that is taken out by pumping is normally made up or recharged by the process of infiltration. As long as the volume of recharge water remains the same or is more than the volume pumped out, groundwater can be used almost indefinitely. But the problem is that more groundwater is being pumped out than is being replenished.

Nearly 80 per cent of the rural and 50 per cent of the urban population in India today depend on groundwater for drinking water. And large quantities of groundwater are also used for irrigation, especially in north India. This has led to a sharp drop in the water table in many parts of the country, which is a matter of concern.

According to a study published in 2009, scientists using satellite data have calculated that more than 109 cubic kilometres of groundwater disappeared from northern India's aquifers between 2002 and 2008. It was double the capacity of India's largest surface-water reservoir, the Upper Wainganga in Madhya Pradesh.

It is true that the region has seen an enormous increase in water use since the 1960s. Part of that is because of the growing population. But the rise in water consumption was mainly due to the so-called Green Revolution, which dramatically increased India's agricultural production in part by rapid expansion of the use of groundwater for irrigation. In fact, the northern Indian states of

Rajasthan, Punjab and Haryana have all of the ingredients for groundwater depletion: staggering population growth, rapid economic development and water-hungry farms, which account for about 95 per cent of groundwater use in the region. According to the scientists, groundwater in the region is being pumped and consumed by human activities – principally to irrigate cropland – faster than the aquifers can be replenished by natural processes.

The storage of rainwater on surface has been a traditional technique and structures used were underground tanks, ponds, check dams, weirs, etc. Recharging of ground water is a new concept of rainwater harvesting.

Rainwater harvesting is an effective method of increasing the availability of water by storing the water or by using it to recharge groundwater. Normally, a large part of the rainwater received during monsoon just flows away into rivers and into the seas. This water is not used in any way and is wasted. In rainwater harvesting, the rainwater is collected either in tanks, ponds, or traditional *bawris*, or is used to recharge groundwater. In many cities today, rainwater harvesting structures have been made mandatory in all new buildings to save as much rainwater as possible. In many Indian cities, the use of harvested rainwater to recharge groundwater has led to substantial rise in the water table.

Rainwater harvesting can enable households, factories, schools and offices to overcome their problems of irregular and inadequate water supply or water supply of poor quality. By using equipment that is easily available, rainwater is diverted towards existing underground tanks or terrace fitted tanks and then supplied to the taps. The purification methods used by households, factories and offices can be used to treat rainwater. Treated rainwater is safe not just for cleaning and washing but also for cooking and personal consumption.

Clean energy prospects for India

India is perceived as a developing country, but it is developing at a pace that is not matched by many others. The country has experienced significant economic growth, yet the fact remains that our growth is constrained by energy supply and availability. Although there has been an impressive growth in installed capacity addition, from barely about 1,350 MW at the time of independence (1947) to about 160,000 MW today, over 90,000 MW of new generation capacity is required in the next seven years. Meeting this requirement may not be possible without adequate addition of generation capacity from non-conventional sources, not only because the rapidly diminishing conventional sources like coal and oil but also the growing concern about greenhouse emission and consequent impact on global climate.

Fortunately, India today stands among the top five countries in the world in terms of renewable energy capacity. We have an installed base of over 15 gigawatts, which is around 9% of India's total power generation capacity and contributes over 3% in the electricity mix. While the significance of renewable energy from the twin perspectives of energy security and environmental sustainability is usually well appreciated, what is often overlooked is the capacity to usher in energy access for all, including the most disadvantaged and the remotest of our habitations.

As a decentralised source of energy, renewable sources such as solar and wind energy provide the most appropriate, scalable, and optimal solution for providing power to thousands of remote and hilly villages and hamlets. Already, millions of decentralised energy systems, solar lighting systems, irrigation pumps, aero-generators, biogas plants, solar cookers, biomass gasifiers, and improved cook stoves, are in use in the remotest, inaccessible corners of the country, providing energy access to be most disadvantaged and remote communities in the country.

The National Action Plan on Climate Change in June 2008 identified the development of solar energy technologies in the country as a priority item to be pursued as a National Mission. In November 2009, the Government of India approved the Jawaharlal Nehru National Solar Mission. This is a unique and ambitious transformational objective that aims to establish India as a global leader in solar energy by creating the policy conditions for its diffusion across the country, as quickly as possible. The Mission aims at creating a generating capacity of 20,000 MW of solar energy in the country by 2022. In the very first year of its existence, the Mission has succeeded in catalysing investments in 200MW of grid-connected solar power plants, with another 500 MW expected to roll in shortly.

India has an installed capacity of over 11,000 MW of wind energy, and occupies the fifth position in the world, after USA, Germany, China and Spain. The Ministry of New and Renewable Energy has recently taken the decision to introduce generation-based incentives, a scheme whereby investors, as well as getting the tariff as determined by the respective state regulatory commissions, will also receive a financial incentive per unit of electricity generated over ten years.

Biomass, which is an eco-friendly source for production of electricity, also holds considerable promise for India. Our estimates indicate that, with the present utilisation pattern of crop residues, the amount of surplus biomass materials is about 150 million tonnes, which could generate about 16,000 MW of power.

The challenge in the renewable energy sector generally, and in India particularly, is to reduce the per-unit cost of renewable energy. Hence, there is a continuous need to innovate to increase efficiencies and bring down costs. Innovations can be brought about in various ways – it is possible to harness lower wind speeds; the energy of tides and waves can be channelled to produce electricity; alternate transport fuels can make our journeys less carbon intensive; hydrogen can be an ideal energy storage and carrier; and it is possible to have a larger grid with lower losses of electricity.

Organic farming

Organic farming is a form of agriculture, which avoids the use of synthetic inputs such as synthetic fertilisers, pesticides, herbicides, and genetically modified organisms, plant growth regulators and livestock feed additives. Organic farming works in harmony with nature by using simple techniques and material: recycled and composted crop waste and animal manure; crop rotation; legumes to fix soil nitrogen; encouraging useful predators that eat pests and natural pesticides; and a careful management of water resources. Organic farming methods combine scientific knowledge and modern technology with traditional farming practices based on thousands of years of agriculture. Organic farming relies heavily on the natural breakdown of organic matter, using techniques like green manure and composting, to maintain nutrients taken from the soil by the previous crops. Organic farming, when practised properly, reduces the input costs for fertilisers, pesticides and seeds, dramatically improves farmer health and enhances the fertility and resilience of their land. Organic farming is developing rapidly and is now practised in more than 130 countries of the world. Globally 30.4 million hectares of the agricultural land are currently managed organically. A large number of farmers' groups and NGOs are involved in organic farming in India.

In response to the large global market for organic foods, the Indian Government had set up a National Institute of Organic Farming in October 2003 in Ghaziabad, Uttar Pradesh. The mandate of this institute is to formulate rules, regulations and certification of organic farm products in conformity with international standards. The National Programme for Organic Production proposes to provide an institutional mechanism for the implementation of National Standards for Organic Production, through a National Accreditation Policy and Programme. In India, APEDA (Agricultural and Processed Food Products Export Development Authority), the Tea Board, the Spices Board, the Coconut Development Board, and the Directorate of Cashew and Cocoa are the certifying agencies for organic farm products in India. They are accountable for confirming that any product sold with the "India organic" logo is in accordance with international criteria.

The major Indian organic products sold in the global markets include dried fruits and nuts, cocoa, spices, herbs, oil crops, and derived products. Non-food items include cotton, cut flowers, and potted plants. India ranks 33rd in the world in total area under organic cultivation. India has now become a leading supplier of organic herbs, organic spices, organic basmati rice, etc.. to the developed nations. The export realisation during 2007-08 was around US $ 78 million, registering a 200% growth over the previous year.

A number of Indian states, including Mizoram, Uttarakhand and Sikkim intend to go 100% organic, with many more adopting policies to promote organic farming. There is a growing dialogue around the potential for India's organic market both within and outside India. One study has estimated it could grow by about 15% between 2011 and 2013.

Incidentally, a large number of India's farmers are still mostly practising organic methods, passed down for millennia. Organic fertiliser and natural pest control are the only tools available to most of these farmers, who have always lacked the financial resources to explore chemical solutions. But these farmers, whose produce is as organic as they come, cannot afford to pay the fees required to gain official certification.

India must find a way to keep the strict international organic standards intact if it wants to compete in the international market for organic foods – but is there a way to do it without leaving small farmers out in the cold? One obvious solution is for the government would be to subsidise these certification fees enough to make it a viable option for ordinary farmers, not just for neo-organic factory farms and greenhouses. Banks also could provide a more level playing field for small farmers – currently, almost all bank loans are for conventional crop farmers.

However, organic farming alone cannot feed the billion population of India. To ensure the food and nutritional security, rather than promoting organic farming en masse and universally, it would be desirable to carefully delineate areas for organic farming. In India, there is ample scope for pure organic farming in the rain-fed areas, where there is little or no use of fertilisers and other agro-chemicals.

Banana genome sequenced

An international consortium of plant scientists has completed the first sequencing of the banana genome, which has been found to contain more than 36,000 genes, slightly more than in the human genome. The genome that has been sequenced ran to 523 million 'bases,' the chemical units that make up DNA and encode the genetic information. Banana is an important crop in developing countries that provides food and economic security for more than 400 million people in some of the poorest parts of the globe, but they are under constant pressure from a range of parasites. The completion of the genome sequence is important for India, which is the world's largest producer of bananas.

The banana is the first non-grassy plant in its botanical class, the monocotyledons, or monocots, whose entire genome has been sequenced. Monocots include grasses, palms, lilies and orchids. Dicotyledons, or monocots, on the other hand, comprise more evolutionary recent plants including the majority of flowering plants and all true trees. Knowledge of the banana genome is important because bananas that are cultivated, unlike their wild relatives, are seedless and develop without going through a process of pollination, fertilisation and seed production. These domesticated forms are mostly propagated by using a part of the parent plant. As a result, the offspring are genetically similar to the parent and such similarity makes most of the present day cultivated varieties susceptible to fungal, bacterial and viral diseases. From the knowledge of the entire genome of the plant it may be possible to identify the genes responsible for disease resistance as well as ones for other important traits such as fruit quality.

The international team has sequenced the genome of a banana variety called DH-Pahang, found in south-east Asia, which is not good to eat but is able to resist the devastating 'Panama disease' fungus that attack the roots of the banana plant and has been spreading in Asia. If the genes that provide such resistance could be characterised, they could be transferred to other cultivated varieties to protect them, because today pests and diseases were an "imminent danger" for global banana production. No wonder the sequencing of the banana genome has been described as a crucial stepping-stone for genetic improvement of banana.

Transit of Venus – the rarest astronomical event

The world was witness to one of the rarest astronomical events on 6 June when planet Venus passed in front of the Sun during its last transit in this century. The next transit of Venus will be visible only in the next century, on 11 December 2117 – after a gap of 105½ years. A transit occurs when any of the two inner planets of the solar system – Mercury and Venus – happens to come in a straight line with the Earth and the Sun. Such an alignment, however, occurs very rarely – 13 times in a century for Mercury and only twice in a century for Venus. This is what makes the transit of Venus a much awaited celestial event.

Transits of Venus follow a regular pattern beginning with two transits in December eight years apart. Then follows a gap of 121½ years. Then two more transits occur in June, again eight years apart, followed by a gap of 105½ years. Then the cycle repeats. The transit of 8 June 2004 and the coming one on 6 June 2012 constitute a June pair of transits.

Since the discovery of the telescope, there have been only seven transits of Venus – in 1631, 1639, 1761, 1769, 1874, 1882, and 2004. The coming June transit will be only the eighth one and the ninth one will not be seen till the 22nd century.

Historically, transits of Venus were eagerly awaited and extensively studied because it helped in determination of the Astronomical Unit – the distance between the Sun and Earth – by measuring the parallax of Venus from widely separated locations on Earth. Today, however, it is more of a curiosity, as it offers a unique opportunity to watch one of the rarest astronomical events. Unlike the transit of 8 June 2004, when the entire transit was visible from India, the June transit was visible partially from India. The transit this time started long before the Sunrise in India. But, still, for millions it was a memorable experience.

El Niño-Southern Oscillation (ENSO) effect

El Niño is a 'warm' ocean current that develops along the coast of Peru in South America in December every few years, replacing the usual 'cold' Peru or Humboldt Current. This warm surface water reaching towards the coast of Peru with El Niño is pushed westward by the trade winds thereby raising the temperature of the southern Pacific Ocean. A reverse condition is known as La Niña.

Southern Oscillation is a phenomenon first observed by Sir Gilbert Thomas Walker, Director-General of Observatories in India, which refers to the see-saw relationship of atmospheric pressures between Tahiti in South Pacific and Darwin in Australia. He noticed that when it was high pressure in Tahiti, it was low pressure in Darwin and vice versa. A Southern Oscillation Index (SOI), based on the pressure difference between Tahiti and Darwin, has been formulated by the Bureau of Meteorology (Australia) to measure the strength of the Oscillation. Walker noticed that the quantity of rainfall in the Indian subcontinent was often negligible in the years of high pressure at Darwin (and low pressure at Tahiti). Conversely, low pressure at Darwin bode well for the precipitation quantity in India. Thus he established the relationship of Southern Oscillation with quantities of monsoon rains in India.

It was later realised that the Southern Oscillation is just the corresponding atmospheric component of the El Niño/La Niña effect (which happens in the ocean). Therefore in the context of the monsoon, the two cumulatively came to be known as the ENSO. The ENSO is known to have a pronounced effect on the strength of SW monsoon over India with the monsoon being weak (causing less rainfall in India) during the El Niño years whereas La Niña years had particularly good monsoon rains over India.

Although in June 2012, India Meteorological Department had maintained there was a very slim chance of El Nino affecting the 2012 monsoon, later in July models clearly showed El Nino effect was going to be significant. As a consequence, the total monsoon rainfall recorded in the country till the middle of July was 22 % less than normal, creating in some states drought-like situation and a fall in total food grain production.

The future of India's nuclear power programme

Despite a few accidents like the Chernobyl and Fukushima nuclear plant mishaps and public agitations against it, nuclear power remains one of the safest and cleanest options for power generation today. This is especially so in view of the growing evidence of the deleterious effect of greenhouse gases emitted by burning fossil fuels. Nuclear power plants pose much less risk – health or otherwise – to the population than many other forms of modern technology. For a country like India, which suffers from gross deficit in power generation, nuclear energy offers a viable solution when combined with non-conventional sources such as solar and wind energy. That is why the government has taken a conscious decision to go for nuclear power and drawn up a road map to attain the targeted goals.

Nuclear power is the fourth-largest source of electricity in India after thermal, hydroelectric and renewable sources of electricity. As of 2010, India had 20 nuclear reactors in operation in six nuclear power plants, generating 4,780 MW while seven other reactors are under construction and are expected to generate an additional 5,300 MW. Plans have been drawn up to increase the nuclear power generating capacity to 63,000 MW by 2032.

All the reactors operating in India's nuclear power plants today are pressurised heavy water reactors (PHWRs) which use uranium as fuel. However, in view of the limited uranium resources that the country possesses, a three-stage nuclear power programme was formulated by Dr. Homi Bhabha in the 1950s to secure the country's long-term energy independence, through the use of uranium and thorium reserves found in the monazite sands of coastal regions of South India. The three stages involve PHWRs in the first stage; fast breeder reactors (FBRs) using plutonium and uranium in the second stage; and advanced heavy water reactors (AHWRs) using uranium-233 obtained from thorium in the third stage. The ultimate focus of the programme is on utilising India's vast reserves of thorium present in monazite sand on the beaches of Kerala to meet the country's energy requirements.

Except two, all the reactors used to generate electricity in India's nuclear power plants use natural uranium as fuel in PHWRs. The second stage, which envisages use of fast breeder reactors, is scheduled to take off by next year when the prototype fast breeder reactor (PFBR) is going to be commissioned at Kalpakkam near Chennai. The PFBR is a 500MW sodium-cooled nuclear reactor which will make use of a mixture of plutonium oxide and uranium-235 oxide as fuel and liquid sodium as coolant. It will produce more plutonium fuel from uranium-238 than it would consume. Future breeder reactors would be used to convert thorium-232 into uranium-233, which can be used as a nuclear fuel. Indian nuclear scientists already have more than 14 years' experience in operating the fast breeder test reactor (FBTR), a 10 MW experimental breeder reactor, at Kalpakkam without any problem.

For the third stage, India has been making advances in the field of thorium-based fuels, working to design and develop a prototype for an atomic reactor using thorium and low-enriched uranium, a key part of India's three-stage nuclear power programme. The development of the Advanced Heavy Water Reactor, AHWR300-LEU, at the Bhabha Atomic Research Centre near Mumbai is an effort to realise these futuristic objectives through innovative configuration of present day technologies. The reactor fuel on an average contains 19.75 per cent of enriched uranium and the balance thorium oxide. A significant fraction of the reactor power, about 39 per cent, comes from the fission of Uranium-233 derived from in-situ conversion of thorium-232. With an estimated design life of 100 years, the AHWR300-LEU is a boiling light water-cooled, heavy water-moderated reactor with reduced environmental impact. The design of the AHWR300-LEU contains numerous cost saving features. It has many features which are likely to reduce both its capital and operating costs, making it attractive for the less well developed nations of Asia, Africa and Latin America. Careful attention has also been paid to design of the AHWR300-LEU fuel mix in order to prevent nuclear proliferation using spent fuel, and to minimise problems related to the long term storage of spent fuel. The reactor is likely to achieve commercial operation by 2020.

Are mobile phones dangerous?

The widespread use of mobile telephones in recent years has heightened public concern about possible adverse health effects. Mobile phones work on microwave frequencies and are known to emit low-level radiofrequency electromagnetic fields, which some people think can cause brain tumour. But any link between the use of mobile phone and brain tumour has always been controversial. Despite claims in support and against any link between the two, scientific studies have been few and far between. The largest study so far on mobile phones and cancer was a Danish study in 2006, which looked at over 420,000 people who had been using mobile phones for many years. It found no link between mobile phones and any type of cancer including brain cancers and leukaemia, but it was confined to only one country. A multinational study in 2010 has also found no evidence for an association between tumour risk and mobile phone use. The study was carried out by an international collaboration called INTERPHONE, run by the International Agency for Research on Cancer in Lyon, France, part of World Health Organization the findings of which were published in the International Journal of Epidemiology in May 2010.

The INTERPHONE study was aimed at establishing whether usage of mobile phones increased the risk of the two main types of brain tumour. It involved 5,117 people with brain tumour and 7,658 matched controls without brain tumour. The subjects were drawn from 13 countries. Detailed information on past mobile phone use was collected during face-to-face interviews with the study subjects. The study included substantial numbers of subjects who had used mobile phones for more than 10 years. The study found no increase in risk of brain tumour in association with use of mobile phones.

However, the International Agency for Research on Cancer (IARC), a global authority on cancer, recently concluded that radiation from mobile phones is a 'possible' head cancer risk. But scientific opinion is split on the issue – many different studies have reached different conclusions based on the same evidence. One reason scientists disagree is because the mechanisms by which the radiations from mobile phones could cause cancer are not yet understood.

In India, an inter-ministerial committee formed by the Ministry of Communications and Information Technology to study the hazards posed by mobile phones has found, "radiation from mobile phones and towers poses serious health risks, including loss of memory, lack of concentration, disturbance in the digestive system and sleep disturbances". The committee has also attributed the disappearance of butterflies, bees, insects and sparrows vanishing from big cities to mobile phone-related radiation. It has suggested that mobile towers should not be installed near high density residential areas, schools, playgrounds and hospitals. The committee has suggested that children, adolescents and pregnant women should avoid excessive use of cell phones. It has recommended that mobile phones not adhering to standard levels of specific absorption rate (SAR) – a measure of the amount of radiofrequency energy absorbed by the body while using a phone – should be barred. It has further recommended amendment in the Indian Telegraph Act 1885 and rules so that only mobile handsets satisfying radiation standards should be permitted in the country.

RISAT – India's all-weather remote-sensing satellite

India's first indigenous all-weather Radar Imaging Satellite (*RISAT*-1) was launched on board the PSLV-C19 on 26 April 2012. It carries an indigenously developed C-band Synthetic Aperture Radar (SAR) sensor which enables the satellite to collect data during both day and night in all weather conditions. *RISAT*-1 has launched India into elite league of nations who possess such technology. The objective of the *RISAT* mission is to use the all-weather as well as the day-and-night SAR observation capability in applications such as agriculture, forestry, soil moisture, geology, sea ice, coastal monitoring, object identification, and flood monitoring. The *RISAT* series of satellites are the first all-weather Earth observation satellites from ISRO. Previous Indian observation satellites relied primarily on optical and spectral sensors which were hampered by cloud cover. The first satellite of the series, *RISAT*-2, which was launched in 2009 in the aftermath of the 2008 Mumbai attacks, used an X-band SAR sensor procured from Israel.

Since it is capable of imaging through cloud cover, *RISAT*-1 enables monitoring of crop health, particularly paddy monitoring in *kharif* season, through remote sensing throughout the monsoon months when large parts of India remains under cloud cover. The high-resolution pictures and microwave imaging from *RISAT*-1 can also be used for defence surveillance purposes as it can look through the clouds and fog for any suspicious activity along the borders.

India-based Neutrino Observatory (INO)

The India-based Neutrino Observatory (INO) Project is a multi-institutional effort aimed at building a world-class underground laboratory for non-accelerator-based high-energy and nuclear physics research in India. he study of neutrinos is important because neutrinos are by far the most numerous of all the particles in the universe (other than photons of light) and so even a tiny mass for the neutrinos can enable them to have an effect on the evolution of the Universe through their gravitational effects. There are other recent astrophysical measurements that provide information on the evolution of the Universe and it is crucial to seek complementary information by direct determinations of the masses of neutrinos and their other properties. In a sense, neutrinos hold the key to several important and fundamental questions on the origin of the Universe and the energy production in stars. We have some partial answers but many details are still awaited from future experiments.

INO would be an underground laboratory, with a rock cover of about 1,200 metres, being set up in Theni district of Tamil Nadu. It would equipped with an Iron Calorimeter (ICAL) detector, consisting of 50,000 tons of magnetised iron plates arranged in stacks with gaps in between, for studying neutrinos. The detector will be set up in a large cavern measuring 132 m X 26 m X 20 m in size and several smaller caverns, which will be accessed by a 2,100-m long and 7.5-m wide tunnel. The ICAL detector to be installed in the INO laboratory will be the world's most massive detector of its kind. The facility is likely to be operational by 2017.

The initial goal of INO is to study neutrinos - fundamental particles which have no charge and almost no mass, although recent experiments indicate that these charge-neutral fundamental particles have finite but small mass, which is unknown. Determination of neutrino masses is one of the most important open problems in physics today. The ICAL detector is designed to address some of these key open problems in a unique way. Over the years this underground facility is expected to develop into a full-fledged underground science laboratory for other studies in physics, biology, geology, hydrology, etc.

ITER: Promise of fusion power

There are two kinds of nuclear reactions that can be used to generate energy - fission and fusion. Fission involves break-up of a heavy nucleus such as uranium while fusion involves the joining of two light nuclei such as deuterium and tritium. The Hiroshima and Nagasaki bombs were examples of uncontrolled nuclear fission while in nuclear power plants energy is generated by controlled nuclear fission. Hydrogen bomb is an example of uncontrolled nuclear fusion.

Fusion reaction is a nuclear process by which nuclei of two light elements fuse to produce a heavier nucleus, which has a mass slightly less than the total mass of the fusing nuclei. This small mass difference, say m, between the initial and the final reaction products gets converted into energy through Einstein's equation $E=mc^2$, c being the speed of light. This energy comes out in the form of heat and can be converted into electricity by conventional technologies.

However, for such a reaction to occur, the reacting nuclei need to have enough kinetic energy to overcome the electrostatic repulsion between any two of them. For this to happen in laboratory experiments, the reacting particles need to be heated to very high temperatures – more than 50 million degrees Celsius – at which matter turns into the plasma – a collection of charged particles. The main problem in harnessing fusion energy arises out of the difficulty in holding the plasma at such high temperature. Since plasma is made up of charged particles torus-shaped magnetic field has been used to contain the hot plasma in experimental fusion reactors. Known as 'tokamak', it is a device that uses magnetic field to confine plasma in the shape of a torus. India has a large tokamak at the Institute of Plasma Research in Ahmedabad which is being used mainly for research.

All stars including our Sun generate enormous amounts of energy through nuclear fusion. But generation of energy on Earth through fusion has been possible only on experimental scale using tokamaks. A fusion reactor capable of generating power on a commercial scale still remains a distant dream. Fusion energy, when it becomes available, will practically be a source of unlimited amount of energy, as the only fuel needed for a fusion reactor would be hydrogen and deuterium, which are available in plenty in Earth's oceans. The experiments to be carried out at the International Thermonuclear Experimental Reactor (ITER) being set up in France would be a major step in harnessing fusion energy for power generation. ITER is an international project to develop an experimental reactor that can demonstrate the feasibility of fusion energy for the power grid. The project aims to produce 10 times as much energy as it uses. The ITER experimental reactor is set to begin operations in 2020.

American researchers, part of the ITER research team, have already completed an important step in developing a key technology that could lead to clean nuclear fusion power. They have successfully tested a technology that will insulate and provide structural integrity to the 1,000-ton central solenoid, the reactor's "backbone." In a fusion reactor the central solenoid, which consists of six giant coils stacked on top of one another, plays a vital role by both igniting and steering the plasma current.

India will be contributing, like other partners except the host EU, about 10% of the ITER construction cost. EU will pay about 40%. Most of this will be in the form of components made by the Indian industry and delivered to ITER.

India's supercomputers

Supercomputers are high-performance computing machine, designed to have extremely fast processing speed – measured in trillions of floating point operations per second or teraFLOPS.

Supercomputers are used in areas where fast processing of a huge amount of variable data is required, as in weather forecasting, nuclear research, missile design, and 3-D graphics.

The Indian Space Research Organisation (ISRO) has recently built India's fastest supercomputer in terms of theoretical peak performance of 220 trillion floating point operations per second (FLOPS). Named SAGA-220 (Supercomputer for Aerospace with GPU Architecture-220 TeraFLOPS), the supercomputer was fully designed and built by the space centre using commercially available hardware and open-source software components. It has been set up at the newly established supercomputing facility, named after Satish Dhawan, of the Vikram Sarabhai Space Centre in Thiruvananthapuram. Space scientists are using it for solving complex aerospace problems. The supercomputer cost about Rs.14 crore. The system is environmentally green and consumed only 150 kW of power. This system can be easily scaled to many PetaFLOPS (1,000 TeraFLOPS), it added.

A still faster supercomputer with a speed of 250 teraFLOPS is to be set up at the Centre for Mathematical Modelling and Computer Simulation (C-MMACS), a unit of Council of Scientific and Industrial Research (CSIR), in Bangalore. When operational, it will be India's fastest supercomputer. The yet-to-be-named high-performance computing system will be used for genome informatics, geo-science informatics (earth, ocean and atmosphere), and engineering sciences (aerodynamics of planes, development of smart materials and computer-aided drug design).

The supercomputer is expected to deliver a sustained performance in excess of 250 teraflops. The new supercomputer will be utilised for modelling earthquakes, ocean currents, quantum chemistry and astrophysics. In the 12th five-year plan (2012-17), the Central Government has decided to allocate Rs.6,000 crore to propel India into the elite supercomputing club. Over the next few years, CSIR plans to upgrade its supercomputing capacity to 10 petaflops (10×10^{15}). A data centre is being planned at the CMMACS facility in Belur, near the old Bangalore airport. Such a facility would play a crucial role in empowering data intensive scientific discovery in the fourth paradigm of science.

The Ministry of Science and Technology has also sanctioned Rs.5,000 crore for a national supercomputing development project to enhance the nation's supercomputing capacity and bring Indian institutions within the top 100 supercomputing countries in the world. Bangalore-based Indian Institute of Science (IISc) will spearhead the ambitious project.

Today, all 40 CSIR labs in India are interconnected using the National Knowledge Network, which enables all scientists to access the supercomputing facility remotely. The new system would enhance the capabilities in areas such as genome analysis, weather modelling, computational fluid dynamics and the like.

Why is India falling behind China in S&T?

In his inaugural address at the 99th India Science Congress in January this year, Prime Minister Manmohan Singh had noted that India's position in the field of science has been overtaken by China and he sought an increase in spending on scientific research to at least two per cent of GDP and enhanced contribution from industry. He said the fraction of the GDP spent on R&D in India has been too low and stagnant.

The Prime Minister's concern is corroborated by statistics. According to data available, China has been rapidly strengthening its innovation capabilities, having increased research and development (R&D) spending from US$2.65 billion in 1985 to US$104.48 billion in 2010. That translates into 0.71 per cent of gross domestic product in 1985 and 1.76 per cent in 2010. Its science and technology (S&T) manpower also increased from 33.80 million in 2001 to 49.6 million in 2008. In contrast, India has been struggling to achieve a threshold level in its R&D spending, which increased from US$1.38 billion in 1985 to US$9.45 billion in 2007. Its S&T manpower increased from 21.4 million in 2001 to 31.4 million in 2007.

Further, while China's scientific publications rose 15 times from 6,509 papers in 1990 to 94,800 in 2007, India could only increase output from 10,103 papers in 1990 to 30,000 in 2007. Although according to a recent study, India is well ahead of China in the quality of its scientific papers, though it lags in growth in the number of papers. India also lags far behind China in the number of patents granted: in China patents increased from 12,683 in 2000 to 93,706 in 2008, while in India they rose from 1,318 in 2000 to 7,539 in 2006.

There is no doubt that over the past few decades, India's position in the world of science had been declining and we have been overtaken by countries like China. There is need to do much more to change the fate of Indian science. To reverse the trend the Prime Minister called for an increase in the total R&D spending as a percentage of the GDP to 2 per cent by the end of the 12th Plan period from the current level of about 0.9 per cent. But this can only be achieved if industry, which contributes about one third of the total R&D expenditure today, increases its contribution. Public sector undertakings, especially in the engineering sector, need to play a major role in this expansion.

In a bid to push research in niche areas, the Prime Minister said the government was examining a proposal to build national capacity and capability in supercomputing which will be implemented by the Indian Institute of Science, Bangalore at an estimated cost of Rs 5,000 crore. He said there is another proposal for setting up a Neutrino Observatory at Theni in Tamil Nadu at a cost of Rs 1,350 crore to study the fundamental particles that form the universe.

R&D budgets, as well as the number of scientific papers published or patents won, are important indicators of a country's progress in science, but they are not the only ones that matter nor are they a satisfactory index of a country's innovative progress. This depends on how efficiently funds are utilised, and in the required direction.

India has a strong foundation in basic research and S&T manpower, particularly in the areas of biotechnology, chemicals and pharmaceuticals, nuclear energy for civilian use, information technology and business management on which it can build a strong edifice. At the same time its weak point is primarily the translation of research results into innovative and value-added products. The Council of Scientific and Industrial Research and Indian Institutes of Technology are doing great research, but they lack the push to deliver world class technologies. This shortcoming needs to be addressed.

SpaceX Dragon

A new chapter was opened in the history of space missions in May when the first private commercial mission to ferry supplies to the International Space Station was completed successfully with the return of space capsule *Dragon* to Earth. The *Dragon* spacecraft was designed and built by Space Exploration Technologies Corporation, or SpaceX – a private space transport company based in California, USA. SpaceX also designed and built the Falcon 9 rockets, which was used to launch *Dragon*. The *Dragon* capsule is a solar powered spacecraft that performed almost flawlessly during the flight, which was its second test flight.

Dragon was launched on 22 May from Cape Canaveral on way to ISS. On the 24 May, two days after launch, NASA gave the go-ahead for the *Dragon* to attempt docking with the space station and on 25 May, the spacecraft successfully docked with ISS – the first ever docking by a private space vehicle. After six days at the International Space Station, Dragon departed for its return to Earth, carrying a load of cargo for NASA. SpaceX completed its historic mission when *Dragon* splashed down safely in the Pacific on 31 May. The remote-controlled Dragon had separated from the space station about seven hours before splashdown, eventually firing rockets to slow it enough so that it would descend through the atmosphere. Before separation, the station's astronauts loaded it with about 700 kg of used equipment, experiment samples and other items. The recent success clears the way for the start of routine cargo delivery missions later this year.

SpaceX and NASA had originally planned three test flights before beginning routine space station resupply missions under a $1.6 billion contract calling for at least 12 missions. After the initial 2010 test flight, the first time a commercial entity had successfully recovered a spacecraft from orbit, it was decided to combine the objectives of the second and third planned test flights into a single mission. The *Dragon* vehicle is the only space station cargo craft designed to return to Earth, giving NASA the ability to send home experiment samples and hardware for the first time since the space shuttle's retirement last year. What the *Dragon* mission really does is it heralds the dawn of a new era of space exploration, one where there is a significant commercial space element.

First dedicated military satellite for Indian Navy

The Indian Navy is soon going to have its first-ever dedicated military satellite for naval surveillance and communications. It is to be used for networking the Indian naval ships in the Indian Ocean region. The geo-stationary satellite would fulfil the Navy's 'Rukmani' project which is aimed at achieving full networking capability to achieve enhanced maritime domain awareness. It is expected to add a huge technological leap for a navy that is already a formidable force to reckon with.

The satellite will have over a 1,000 nautical mile footprint over the Indian Ocean Region, stretching from Africa's east coast right till Malacca Strait, will enable the Navy to network all its warships, submarines and aircraft with operational centres ashore through high-speed data-links. Ground based infrastructure and installation of equipment on warships has already been tested thoroughly. With the commissioning of the new satellite, the ships operating in the Bay of Bengal would get real-time data from ships operating in the Arabian Sea. There are around 300 dedicated or dual-use military satellites orbiting around the earth at present, with the US operating over 50% of them, followed by Russia and China.

Dark energy and the expansion of the universe

The "astounding" discovery that the expansion of the universe is speeding up by three astronomers - Saul Perlmutter, Brian Schmidt and Adam Riess – got them the 2011 Nobel Prize in physics. Their work gave birth to the theory of dark energy, a kind of inverse gravity that causes the expansion to accelerate. Up to three quarters of the universe seems to comprise dark energy - but nobody knows as yet what this dark energy is. It is still a matter of speculation and experiments being conducted at facilities like the Large Hadron Collider at Geneva may provide an answer to reconcile apparent anomalies in physics.

Until the idea of dark energy was developed, physicists were convinced that gravity should be causing the expansion rate of the universe to slow. But by studying the light from distant supernovae, astronomers saw that the supernovae's host galaxies are flying away from each other at increasing speed, which meant that something was acting against gravity.

The Nobel-winning astronomers studied dozens of exploding stars, known as type 1a supernovae, expecting to confirm theories dating back to the 1920s that the universe has expanded for 14 billion years since Big Bang, but ever more slowly. Type 1a supernova results from having a white dwarf star in a binary system. Matter transfers from the normal star to the white dwarf until the white dwarf attains a critical mass (the Chandrasekhar limit) and undergoes a thermonuclear explosion. Because all white dwarfs achieve the same mass before exploding, they all achieve the same luminosity and can be used by astronomers as "standard candles". Thus by observing their apparent brightness, astronomers can determine their distance using the $1/r^2$ law.

By knowing the distance to these supernovae, astronomers know how long ago they occurred. In addition, by measuring this redshift from the spectrum of the supernova, astronomers can determine how much the universe has expanded since the supernova explosion. The astronomers expected that the expansion would be slowing, which would be indicated by the supernovae being brighter than their redshifts would indicate. Instead, they found the supernovae to be fainter than expected. Hence, the expansion of the universe was in fact accelerating! This acceleration is now believed to be due to dark energy.

We still don't know what dark energy is, but some astronomers identify dark energy with Einstein's 'Cosmological constant'. Einstein introduced this constant into his general relativity when he saw that his theory was predicting an expanding universe, which was contrary to the evidence for a static universe that he and other physicists had in the early 20th century. This constant balanced the expansion and made the universe static. But when Edwin Hubble discovered the expansion of the universe, Einstein dismissed his constant. Maybe, Einstein was right.

Quantum computing

The term 'quantum' generally refers to a discrete amount of a specific physical quantity, such as energy or momentum. However, this term also refers to anything that operates using quantum mechanics – the laws governing the smallest particles, such as photons, electrons and the Higgs boson, which differ from 'classical' or Newtonian laws. So, a 'quantum computer' is a computer that works using quantum mechanics. The subject of quantum computing brings together ideas from classical information theory, computer science, and quantum physics. Combining physics, mathematics and computer science, quantum computing has developed in the past two decades from a visionary idea to one of the most fascinating areas of quantum mechanics.

The computers we use today use binary code – a series of 1s and 0s – called 'bits' to represent numbers and letters. They are the basic building blocks of computing information. They have got two states – 0 or 1, on or off. A bunch of 8 bits is known as a 'byte'.

Quantum computing operates by a different kind of logic – it actually uses the rules of quantum mechanics to compute. Quantum bits, called qubits, are different from regular bits, because they don't just have two states. They can have multiple states, superpositions – they can be 0 or 1 or 0-1 or 0+1 or 0 and 1, all at the same time. Here the 1s and 0s are represented by particle states. It is possible to change the states of these particles (e.g., changing a 1 to 0) through entanglement, where one particle is 'connected' to another and can influence its state. Entanglement – a quantum state that is all about tight correlations between systems – is the key factor here. A qubit's ability to exist in multiple states – the combination of all those being a superposition – opens up enormous possibilities of computational power, because it can factor numbers at much faster speeds than standard computers. This new kind of computer would be able to process multiple tasks much more quickly, as it is able to perform multiple tasks simultaneously, and promises a leap forward in technology in the near future.

Three new elements added to the Periodic Table

Three new elements, including one named after famous astronomer Nicolaus Copernicus, have been added to the Periodic Table. The General Assembly of the International Union of Pure and Applied Physics (IUPAP) approved the names darmstadtium (Ds), roentgenium (Rg), and copernicium (Cn) for the new elements numbered 110, 111, and 112, respectively. The General Assembly, which consists of 60 members from different countries, approved the new names at its meeting held at the Institute of Physics (IOP) in London in November 2011. Although the names of the new elements have only just been approved for inclusion in the Period Table, the elements were discovered a long time ago. All man-made elements heavier than uranium decay radioactively, and generally speaking, the heavier the element, the faster the decay. The three recently named elements belong to the same category. But latest analytical techniques make it possible for scientists to study even a few atoms of a short-lived chemical element. The first atom of the chemical element with atomic number 110 was produced by bombarding a target of lead isotope with a beam of nickel nuclei in November 1994. The creation of element with atomic number 111, with a nucleus containing 111 protons and 161 neutrons, by bombarding a target of bismuth with a beam of nickel atoms, was announced in December 1994. The element 112 was created by bombardment of zinc ions onto a lead target in 2009 by an international team of scientists. All the three discoveries were made at the Institute for Heavy Ion Research in Darmstadt, Germany and only a few atoms of the three short-lived isotopes were produced. So now the Periodic Table is left with only five elements with atomic numbers 113 to 117, which have been discovered but not yet named.

Why Higgs boson is important

On 4 July 2012, two groups of researchers at CERN, the particle physics laboratory in Geneva, made a historic announcement of the detection of a particle consistent with the long-sought Higgs boson. After analysing trillions of high-energy proton-proton collisions, signals corresponding to a boson in the mass region 125-126 GeV, as predicted for the Higgs boson, were recorded by both ATLAS and CMS detectors of the Large Hadron Collider, the world's most powerful particle accelerator. But the CERN teams described the results as 'preliminary' and stated that a more complete picture will emerge later this year after the LHC provides the experiments with more data.

The historic discovery of the Higgs particle has a significant India connection. As many as 17 Indian scientific institutions including Raja Ramanna Centre for Advanced Technology in Indore, Institute of Physics in Bhubaneshwar, Panjab University, Universities of Guwahati and Rajasthan, Saha Institute of Nuclear Physics, Variable Energy Cyclotron Centre, and Bose Institute in Kolkata, and IIT, Mumbai have supplied vital parts including magnets and detectors for the LHC as well as developed software for analysis of the data.

Higgs boson was postulated as the carrier particle, or boson, of the Higgs field, a theoretical field that permeates space and endows all elementary subatomic particles with mass through its interactions with them. The field and the particle – named after Peter Higgs of the University of Edinburgh, one of the physicists who first proposed this mechanism – provide a testable hypothesis for the origin of mass in elementary particles.

The term "boson" is derived from Satyendra Nath Bose, an Indian physicist from Kolkata who, in 1924, realised that the statistical method used to analyse most 19th-century work on the thermal behaviour of gases was inadequate. He first sent off a paper on quantum statistics to a British journal, which turned it down. He then sent it to Albert Einstein, who immediately grasped its immense importance, and published it in a German journal. Bose's innovation came to be known as the Bose-Einstein statistics, and became a basis of quantum mechanics. Einstein saw that it had profound implications for physics; that it had opened the way for this subatomic particle, which he named, after his Indian collaborator, "boson."

The Higgs particle is very hard to detect, because it does not live long. Once formed it decays in a burst of energy and other particles extremely rapidly. It is also massive, with a mass about 125 times that of the proton. That is why the only way to create the massive particle is to smash other particles such as protons together at incredibly high energies, and look at the resulting collisions. If the Higgs is formed, then it will decay and give off a characteristic bit of energy. The problem is, lots of things give off that much energy, so the researchers have to see the Higgs signal on top of all that noise.

Actually, the researchers at CERN have found a previously undiscovered particle which, as it happens, is within the range of mass the Standard Model predicts for the Higgs particle. Now technically, that's all the physicists can say: the particle is definitely there. But is it the Higgs? Well, to be fair, they can't actually say that. But if it behaves like a Higgs, it could as well be.

The ATLAS (A Toroidal LHC Apparatus) collaboration at CERN has announced the sighting of a Higgs boson-like particle in the energy window of 125.3 ± 0.6 GeV. The observation has been made with a statistical significance of 5 sigma (99.99994% chance). This means the chances of error in their measurements are 1 in 3.5 million, sufficient to claim a discovery and publish papers detailing the efforts in the hunt.

Another collaboration called CMS (Compact Muon Solenoid) announced the mass of the Higgs-like particle with a 4.9 sigma result. While insufficient to claim a discovery, it does indicate only a one-in-two-million chance of error.

The LHC will continue to run its experiments so that results revealed on 4 July can be revalidated before it shuts down at the end of the year for maintenance. Even so, by 2013, scientists are confident that a conclusive result will be out. Moreover, discovery of the Higgs boson may offer clues to the next mystery down the line, which is why individual particles have the masses that they do.

The Standard Model is the reigning theory of particle physics that describes the universe's very small constituents. Every particle predicted by the Standard Model has been discovered – except one: the Higgs boson. According to the Standard Model, the Higgs boson is the only manifestation of an invisible force field, a cosmic molasses that permeates space and imbues elementary particles with mass.

While the discovery of the Higgs boson would complete the Standard Model, and fulfil all its current predictions, the Standard Model itself isn't thought to be complete. It doesn't encompass gravity and leaves out the dark matter thought to make up 98 per cent of all matter in the universe.

A confirmation of the existence of the Higgs boson would also help explain how two of the fundamental forces of the universe – the electromagnetic force and the weak force that's responsible for radioactive decay – can be unified.

The weak, nuclear, electromagnetic, and gravitational forces were born in the first few moments succeeding the Big Bang 13.75 billion years ago. Of these, the weak force is, for some reason, almost 1 billion, trillion, trillion times stronger than the gravitational force! Called the hierarchy problem, it evades a Standard Model explanation.

The magic of quasicrystals

A crystal is defined as "a piece of a homogeneous solid substance having a natural geometrically regular form with symmetrically arranged plane faces". Inside a crystal, atoms are ordered in repeating patterns, and depending on the chemical composition, they have different symmetries. It may be a 3-fold symmetry where if the image is rotated 120 degrees the same pattern will appear. The same principle applies to 4-fold symmetries, where the same pattern repeats itself if the image is rotated 90 degrees; and to 6-fold symmetries where the pattern repeats itself when the image is rotated 60 degrees. But the same is not true with 5-fold symmetry, as distances between certain atoms will be shorter than between others. The pattern does not repeat itself, which was proof enough to scientists that it was not possible to obtain 5-fold symmetries in crystals.

It was thus taken for granted that a 5-fold symmetry was s incompatible with translational symmetry, and hence with crystallinity. But the 2011 Nobel laureate in chemistry, Dan Shechtman of the Technion-Israel Institute of Technology in Haifa showed that it was indeed possible to have crystalline material with 5-fold symmetry.

The unusual materials that Shechtman observed were not real crystals; they were named "quasicrystals" or "crystal-like" – materials with a mosaic-like atomic array that never quite repeats, thus flouting the established rules of crystal structure. (This is similar to "quasi-stellar objects" or quasars, which are not stars but "star-like" objects.) Quasicrystals represent a new state of matter that was not expected to be found with some properties of crystals and others of non-crystalline matter, such as glass. Quasicrystals are curious solids whose atomic structures are very regular but which never quite repeat.

Shechtman discovered quasicrystal in course of routine study of metal alloys in his lab using electron diffraction. He had prepared the alloy sample by rapidly chilling the glowing molten metal, and the sudden change in temperature should have created complete disorder among the atoms, producing a non-crystalline mass. But the pattern he observed told a completely different story: the atoms were arranged in a manner that was contrary to the then accepted laws of nature. The diffraction pattern showed that the atoms inside the metal were packed into an ordered crystal, but a 10-fold symmetry was unknown in nature. Science plainly stipulated that a diffraction pattern with 10 dots in a circle was impossible. Further experiments showed that the crystal itself did not have 10-fold symmetry like the diffraction pattern, but was instead based on an equally impossible 5-fold symmetry.

Revolutionary though the discovery was, Shechtman had a tough time convincing his colleagues and peers. But Shechtman had full confidence in his own findings. In November 1984, together with three other physicists, Shechtman finally got to publish his data in Physical Review Letters. When Shechtman published his discovery, he still had no clear grasp of what the strange crystal actually looked like on the inside. Evidently its symmetry was 5-fold, but there was no clue as to how the atoms were packed in the crystal. That understanding came later, from a combination of mathematics and art.

The answer was provided by the British mathematician Roger Penrose. He had created aperiodic mosaics with just two different tiles, for example, a fat and a thin rhombus. In fact, understanding the structure of quasicrystals was only possible thanks to Roger Penrose's discovery of that beautiful set of aperiodic tiles. What had started out as a mathematical idea, explored by Penrose "just for fun", unexpectedly provided the answer to a question from a very different, and very applied, area of study.

Shechtman's discovery indeed revolutionised chemistry; scientists have succeeded in producing other kinds of quasicrystals in the lab. Quasicrystals have also been found in many other materials, including a naturally occurring mineral from a Russian river. Materials scientists have been exploring quasicrystals because of their distinct properties – they are hard, brittle, slippery and, unlike most metals, poor conductors of electricity.

One kind of highly resilient steel, consisting of hard steel quasicrystals embedded within softer steel, is now used in razor blades and thin needles for eye surgery. A Swedish company has also found quasicrystals in a certain form of steel, where the crystals reinforce the material like armour. Scientists are currently experimenting with using quasicrystals in different products such as frying pans and diesel engines.

Particles moving faster than light a myth

The idea that nothing can travel faster than light in a vacuum is the cornerstone of Albert Einstein's special theory of relativity, which forms the foundation of modern physics. But in September 2011 results of an experiment with electrically neutral, almost massless, fundamental particles called muon neutrinos showed them to be travelling faster than light. The startling observation was made by researchers working with a particle detector called OPERA, situated 1,400 metres underground in the Gran Sasso National Laboratory in Italy. Detector is specifically designed to study a beam of neutrinos coming from the Super Proton Synchrotron accelerator at CERN, Europe's premier high-energy physics laboratory located 730 kilometres away near Geneva, Switzerland. The researchers claim to have measured the 730-kilometre trip between CERN and its detector to within 20 centimetres and the time of the trip to within 10 nanoseconds, and have found that the neutrinos were arriving 60 nanoseconds faster than the speed of light allows. They claimed to have seen the effect in more than 16,000 events measured between 2009 and 2011.

Not everyone was, however, convinced with the results, and for obvious reasons. If neutrinos could indeed travel faster than light, then one of the most fundamental assumptions of science – that the rules of physics are the same for all observers – would be invalidated.

Not surprisingly, the claim of neutrinos travelling faster than light could not be substantiated. In March 2012, CERN announced that the earlier result could have been an artefact of the measurement. After re-measuring the speed of the neutrinos in a different experiment called ICARUS, CERN found that the earlier timings could have been flawed, likely caused by a faulty cable. The ICARUS measurement, using last year's short pulsed beam from CERN, indicates that the neutrinos do not exceed the speed of light on their journey between the two laboratories. The ICARUS experiment thus provided an important cross check of the anomalous result reports from OPERA last year. The new results should put to rest all doubts about the validity of Einstein's theory.

SORS – a technique to check liquids in hand baggage

The present airline security rules do not allow passengers to carry liquids – a large bottle of shampoo, perfume, or even drinks – in their hand baggage on flight because the scanners used for checking hand baggage do not reveal the contents of packaged items, especially liquids. But all that might change soon. Researchers in Europe have developed a scanner for use at airports that uses modified Raman spectroscopy to screen liquids in opaque or translucent bottles. The scanner is currently on trial at several European airports and might allow the ban on liquids of more than 100 ml in hand luggage to be lifted as early as next year. The new scanner uses a technology known as 'Spatially Offset Raman Spectroscopy', or SORS, which has turned out to be a powerful new technique for the non-invasive detection and identification of concealed substances, especially explosives and drugs.

Detection of explosives and their precursors through containers or packaging presents a big challenge to security personnel at airports. The problem is compounded by the wide variety of packaging in which the explosives can be concealed. SORS overcomes this problem and allows a chemical analysis deep within a sample that can be used to scan everything from drugs in plastic packs to liquids in opaque bottles.

The basic SORS technique relies on the fact that most materials are neither completely transparent to light nor completely block it, but that they tend to scatter the light. An example is when a red laser pointer illuminates the tip of a finger – the light scatters throughout all of the tissue in the finger. Wherever the light goes there will be some inelastic scattering due to the Raman Effect. So, at some point, most parts of an object will generate a detectable Raman signal, even if it is not at the surface. The trick with SORS is to make a measurement that avoids the strongest signals emanating from the packaging materials. A simple analogy would be looking at the sky during the day. Although we know that there are stars in the sky throughout the day, we cannot see them because they are masked by the bright light of the Sun. But if a total eclipse blocks the light of the Sun, the stars become visible. So also with SORS; the surface signals are blocked out to see the pure signal from the sample body. The researchers use SORS to collect scattered photons from a spot a few millimetres away from the illuminated area – a "spatially offset" spot. That is why it is called spatially offset Raman spectroscopy.

SORS is versatile technique. Apart from detecting explosives and drugs, it is already being used in the pharmaceutical industry to test and identify raw materials as they come into a processing plant without needing to open the packaging, and to check in a non-invasive manner if the concentration of active chemical ingredients in a drug is accurate.

Kepler discovers first Earth-like planet

NASA's *Kepler* spacecraft has discovered the first Earth-like planet yet outside our solar system. The new planet is located within the "habitable zone" of a Sun-like star where liquid water could exist on a planet's surface. The newly confirmed planet, named Kepler-22b, is about 2.4 times the radius of Earth and is the smallest yet found to orbit in the middle of the habitable zone of a star similar to our Sun. Scientists do not know yet if the new planet has a predominantly rocky, gaseous or liquid composition, but its discovery is considered a significant step in the on-going search for Earth-like planets. Though Kepler-22b is not the first such planet to be detected in recent years, it is the first one orbiting a star similar to our Sun and at a distance where it is capable of possessing liquid water, which most scientists regard as essential for life to exist.

To look for planets *Kepler* routinely measures dips in the brightness of more than 150,000 stars to search for planets that cross in front, or "transit," the host stars. *Kepler* requires at least three transits to verify a signal as a planet. Candidates require follow-up observations to verify they are actual planets. The *Kepler* science team uses ground-based telescopes and the Spitzer Space Telescope to review observations on planet candidates the *Kepler* spacecraft finds. The star field that *Kepler* observes in the constellations Cygnus and Lyra can only be seen from ground-based observatories between March and September every year. The data from these other observations help determine which candidates can be validated as planets. Of the 54 habitable zone planet candidates reported in February 2011, Kepler-22b is the first to be confirmed.

Kepler-22b is located 600 light-years away. While the planet is larger than Earth, its orbit of 290 days around a Sun-like star resembles that of our world. The temperature on the newly announced planet could be just right for life — about 22°C, a perfect spring day on Earth. The planet's host star belongs to the same class as our Sun, called G-type, although it is slightly smaller and cooler. According to the project scientists, Kepler-22b marks the best candidate yet for a life-bearing world beyond our solar system.

What is gene therapy?

Gene therapy is a therapeutic technique aimed at correcting some genetic deficiency by inserting a normal copy of the gene to replace the defective one and restore normal functioning of the cell. With the advances in recombinant DNA technology it is possible to isolate specific genes from the DNA for insertion into living cell, but a gene that is inserted directly into a cell usually does not function. Instead, a carrier called a vector is genetically engineered to deliver the gene. Certain viruses are often used as vectors because they can deliver the new gene by infecting the cell. The viruses are modified so they cannot cause disease when used in humans. Some types of virus, such as retroviruses (an RNA virus that is duplicated in a host cell using the reverse transcriptase enzyme to produce DNA from its RNA genome), integrate their genetic material (including the new gene) into a chromosome in the human cell. Other viruses, such as adenoviruses (DNA viruses that commonly cause respiratory infections), introduce their DNA into the nucleus of the cell, but the DNA is not integrated into a chromosome.

Experimental treatment involves introducing genetic material into a person's cells to fight or prevent disease. The vector can be injected or given intravenously directly into a specific tissue in the body, where it is taken up by individual cells. Alternately, a sample of the patient's cells can be removed and exposed to the vector in a laboratory setting. The cells containing the vector are then returned to the patient. If the treatment is successful, the new gene delivered by the vector will make a functioning protein.

The latest research concerns gene therapy for thalassemia and haemophilia, which affect Indians in large numbers. Thalassemia is an inherited blood disorder in which the body makes an abnormal form of haemoglobin, while haemophilia is a bleeding disorder and blood takes a long time to clot. Both haemophilia and thalassemia are single gene defects and congenital diseases which unfortunately have no cure. The only option is blood transfusion for life.

Though regular treatment could be still distant, a gene for thalassemia has been found and so too the vector to introduce it into the body. But in animal studies it has been found that when the gene transfer is done, the inserted gene does not settle permanently but is transient. Scientists are studying how it can be done permanently and then applied to cure thalassemia.

Although some success has been reported in treating children with X-linked Severe Combined Immune Deficiency (SCID), leaves them with almost zero immunity, through gene therapy, gene therapy still remains an experimental technique. Scientists have still to find better ways to deliver genes and target them to particular cells. They must also ensure that new genes are precisely controlled by the body because targeting a gene to the correct cells is crucial to the success of any gene therapy treatment. Just as important, though, is making sure that the gene is not incorporated into the wrong cells. Delivering a gene to the wrong tissue would be inefficient and could cause health problems for the patient.

Gene therapy is currently only being tested for the treatment of diseases that have no other cures. In the future, this technique may allow doctors to treat a disorder by inserting a gene into a patient's cells instead of using drugs or surgery.

Native anti-malaria drug launched

India has launched its first indigenously launched anti-malaria new-age drug 'Synriam'. The drug has been developed by Ranbaxy in collaboration with the Department of Science and Technology and supported by the Indian Council for Medical Research. Synriam was produced as a combination therapy to follow World Health Organization (WHO) guidelines on delaying the appearance of drug resistance. Malaria claims half a million lives every year globally and India accounts for more than 75 per cent malaria cases of the 2.5 million cases of malaria reported annually from South East Asia. In clinical trials in India, Tanzania, and Thailand have suggested that the drug yields a cure rate of over 95 per cent when three tablets were taken over the course of three days – a simpler drug regimen than other treatments.

Synriam is the first recently developed antimalarial that is not based on artemisinin, one of the most effective treatments for malaria, which has begun to suffer from problems with resistance in recent years. The new drug is a combination of two molecules — piperaquine and arterolane, which replaces artemisinin. It has been approved for treating uncomplicated "Plasmodium falciparum" malaria in adults. The standard therapy for uncomplicated falciparum malaria involves artemisinin-based drugs which are substances derived from plants whose availability hinges on crop output. However, arterolane production can be scaled up whenever required because of its synthetic origin.

In clinical trials Synriam has been found to be efficacious in providing relief from most malaria-related symptoms, including fever. Further, it has the advantage that it can be taken at any time before or after meals. Moreover, unlike artemisinin-based drugs, it has a synthetic source, the production of which can be scaled up whenever required and a consistent supply of the drug can be maintained at low cost. Synriam would cost Rs 130 for a complete course (one tablet each for three days).

Membrane separation

Membrane separation is a technology which selectively separates materials via pores and/or minute gaps in the molecular arrangement of a continuous structure (membrane) which may be natural or synthetic. Membrane separations are classified by pore size and by the separation driving force. These classifications are: Microfiltration (MF), Ultrafiltration (UF), Ion-Exchange (IE), and Reverse Osmosis (RO).

Membrane filters are widely used for purification of water. For drinking water, membrane filters can remove virtually all particles larger than 0.2 um—including certain parasites that cause diarrhoea. They are widely used in industry, particularly for beverage preparation (including bottled water). However, no filtration can remove substances that are actually dissolved in the water such as phosphorus, fluorides, nitrates and metal ions such as cadmium and arsenic.

Ultrafiltration membranes use polymer membranes with chemically formed microscopic pores that can be used to filter out dissolved substances of certain molecular size, avoiding the use of coagulants. The type of membrane media determines how much pressure is needed to drive the water through and what sizes of molecules or micro-organisms can be filtered out.

Ion exchange membranes use ion exchange resins in the form of thin membranes to replace unwanted ions in water. The most common case is water softening where Ca^{2+} and Mg^{2+} ions present in hard water are replaced with Na^{+} or K^{+} ions. Ion exchange resins are also used to remove toxic ions such as nitrate, nitrite, lead, mercury, arsenic and many others from water.

Semipermeable membranes are special membranes that allow some molecules to pass through but not others. Most cell membranes are semipermeable and allow unrestricted passage of water, but not solute molecules or ions, by a process called osmosis. Osmosis is the net movement of water across a semipermeable membrane driven by a difference in solute concentrations on the two sides of the membrane.

Reverse osmosis (RO) is the reversal of water flow through a semipermeable membrane by application of a pressure greater than the natural osmotic pressure of the raw water. Major advantages of the RO technology include removal of all impurities in a single step, low operating cost and high production capacity.

Indian Institute of Chemical Technology, Hyderabad has put in significant efforts in utilisation of RO process for defluoridation of ground water and has set up RO-based defluoridation plants in several villages affected with high levels of fluoride in groundwater.

The promise of bionics

Bionics (also known as biomimicry, biomimetics) is the application of biological methods and systems found in nature to the study and design of engineering systems and modern technology. Examples of bionics in engineering include the sonar, radar, and medical ultrasound imaging imitating the echolocation of bats; Velcro fasteners imitating the burr sticking to animal fur; or sticking tapes imitating use of microscopic hair on gecko feet.

In medicine, bionics usually means the replacement or enhancement of organs or other body parts by mechanical or electromechanical versions. Bionic implants differ from mere prostheses by mimicking the original function very closely, or even surpassing it.

Plastic hearts have been designed consisting of two chambers, with valves that let blood in and out. A pump housed in a backpack pushes the blood to the heart along tubes that enter the body below the rib cage. Air is rhythmically pumped into the artificial heart, forcing out blood round the body in much the same way that a beating heart would. Such artificial hearts have enabled patients to survive for up to three years.

Thousands of people with incurable Parkinson's disease have been relieved of tremor, rigidity and slow movement by stimulating small areas with electrical impulses. An operation to place electrodes deep inside the brain has enabled some wheelchair users to walk. Other research, on rats, is focused on trying to replace damaged parts of the brain with microchips. In the field of computer science, the study of bionics has produced artificial neurons, artificial neural networks, and swarm intelligence.

One of the greatest challenges in bionics is to replicate skin – its ability to feel pressure, temperature and pain is incredibly difficult to reproduce. Scientists are trying to develop an "e-skin" a material that mechanically has the same properties as skin. A composite skin has already been designed which is a woven web of complex electronics and pressure sensors into a plastic which can bend and stretch. The dream is to fit e-skins to bionic limbs.

The world's first eye implant is being developed where a light-sensitive chip is attached under the retina at the back of the eye. It converts light into electrical impulses which are then sent to the brain. The patient is then able to interpret the light falling onto the tiny 1,500 pixel implant as recognisable images. Clinical trials in Germany have restored sight to some patients who were completely blind due to retinal disease. They were able to read and see basic shapes after the chip was fitted.

The bionic ear – or cochlear implant – is one of the most commonly used bionic body parts. It has returned some level of hearing to tens of thousands of people around the world. Patients have been fitted with a single implant which can restore hearing to both ears.

A university in the US has developed one of the most advanced bionic arms with military funding. It has nearly as much dexterity as a natural arm and independent finger movement. It responds to the user's muscles that remain in their residual limb.

Use of light hi-tech materials and technological advancements has led to the development of bionic legs that are closely replicating natural movement. The artificial leg can respond differently to walking backwards, climbing stairs and various walking speeds. In May 2012, the first successful trial of thought-controlled robotic legs was carried out in the UK.

A new generation of bionics are being developed which can connect wirelessly with the nervous system and feel. Animal tests have already been conducted in which devices are implanted directly into the nerve to process and transmit signals wirelessly to an external device.

Stem cell therapy

Stem cells are unspecialised human or animal cells that have the ability to self-replicate and give rise to specialised cells. Stem cells can be found at different stages of foetal development and are present in a wide range of adult tissues. Looking from a different point of view, stem cells are the building blocks of the human blood and immune systems. They form the leucocytes (white blood corpuscles) that fight infection, erythrocytes (red blood corpuscles) that carry oxygen, and platelets that promote healing. Stem cells are also present in bone marrow and they generate new cells throughout life. The blood in the umbilical cord (cord blood) also has stem cells, which are easier to gather than stem cells from the bone marrow.

Stem cell therapy is a treatment that uses stem cells, or cells that come from stem cells, to replace or to repair a patient's cells or tissues that are damaged. The stem cells might be put into the blood, or transplanted into the damaged tissue directly, or even recruited from the patient's own tissues for self-repair. One of the earliest instances of stem cell therapy is bone marrow transplant to treat leukaemia. In a bone marrow transplant, the patient's bone marrow stem cells are replaced with those from a healthy, matching donor. To do this, all of the patient's existing bone marrow and abnormal leukocytes are first killed using a combination of chemotherapy and radiation. Next, a sample of donor bone marrow containing healthy stem cells is introduced into the patient's bloodstream. Doctors have been transferring stem cells by bone marrow transplant for more than 50 years, and advanced techniques for collecting blood stem cells are now used clinically.

There has been a rapid surge in clinical trials involving stem cell therapies over the last few years and those trials are establishing the clinical pathways for an emergent new medicine. These early trials are showing roles for stem cells both in replacing damaged tissue as well as in providing extracellular factors that can promote endogenous cellular salvage and replenishment.

However, there are particular challenges in preparing stem cells for use as a medicine. Unlike drugs, stem cells cannot necessarily be produced and tested for quality in large batches, and treatments may even be specific to one patient. For most diseases, it is still being determined which cells will work best to repair a particular damaged or diseased tissue, and how to get those cells to the right place in the body. Side effects and long-term safety of such treatment also remains largely unknown, which makes it necessary to make provision for careful monitoring and extended follow-up of patients who receive stem cell treatments.

One of the earliest applications of stem cell therapy in India has been to treat a wide range of medical conditions in clinical trials on patients from all over the world. Some of these conditions include diabetes, spinal cord injury, Parkinson's, multiple sclerosis, amyotrophic lateral sclerosis (ALS, also referred to as motor neuron disease), chronic Lyme disease, cerebral palsy, autism, etc. Stem cell therapy has also been successfully used to treat corneal blindness in more than 800 patients at the LV Prasad Eye Institute in Hyderabad.

In 2009 it was reported that a previously incurable blood disorder – sickle-cell disease -- has been successfully treated in 9 of 10 adults who received stem cells transplanted from tissue-matched siblings. The inherited disease causes the bone marrow to produce blood cells that are shaped like crescents, or sickles, rather than the round shape of healthy cells. This causes painful blockages in blood vessels, depletion of blood and severe anaemia.

Although still mostly experimental and in various stages of clinical trials, stem cell therapy has shown its potential in treating several medical conditions. In some cases, as in treating corneal blindness, the success rate has been encouraging. However, in a few cases only animal tests have been done, which need to be extended to human subjects. Nevertheless, looking at the fast growing pace of research in the field, stem cell therapy offers a unique route to treating many disorders using the body's own cells.

Dengue-resistant mosquitoes bred

Dengue fever, also known as break-bone fever, is an infectious tropical disease caused by the dengue virus. It can cause debilitating high fever, severe headaches, and pain in the muscles and joints. Although in most cases the fever is self-limiting and usually uncomplicated, in a small proportion of cases the disease develops into the life-threatening dengue haemorrhagic fever, resulting in bleeding, low levels of blood platelets and blood plasma leakage, or into dengue shock syndrome, where dangerously low blood pressure occurs. At present no vaccine or specific treatment is available against dengue.

Dengue is transmitted by several species of mosquito within the genus Aedes, mainly *A. aegypti*, and all current efforts centre around elimination of the mosquito vector, which preferentially breeds in clean water. Traditional control measures aimed at reducing populations of the main transmission vector, *A. aegypti*, have had little success in solving the global dengue problem, which affects more than 50 million people a year in 100 countries in tropical and subtropical areas, including India. Two recent reports of success with bacteria-infected *A. aegypti* mosquito to stop the transmission of the dengue virus bring a ray of hope.

Researchers have found that injecting bacteria into mosquitoes can block them from transmitting the dengue virus and help control the spread of a disease that kills 20,000 annually. Female mosquitoes infected with the *Wolbachia pipientis* bacteria passed the bug easily to their offspring, making them all dengue-free.

To test whether these resistant mosquitoes could displace their ordinary cousins in the wild, thus reducing the number of dengue-spreading mosquitoes, the researchers started setting the infected mosquitoes loose in two towns in northern Australia. They released between 10,000 and 20,000 mosquitoes a week in each location for about 10 weeks. The *Wolbachia* infection spread rapidly, exactly as the researchers had hoped, and it continued to expand even after they stopped releasing mosquitoes. Some six weeks after the last release, the infection rate was very close to 100% in both towns, the team reported.

According to the researchers, these results suggest a viable strategy to control dengue fever, although the present study was confined to Australia where dengue occurs only as sporadic outbreaks. Using infected mosquitoes could nonetheless provide a cheap and sustainable way to reduce transmission of dengue, which is important because many endemic regions are located in poor countries. To test the effectiveness of the technique in areas where dengue is endemic, the researchers next plan to test the technique in areas such as Indonesia and Vietnam, where dengue is more prevalent.

Geotextiles

Geotextiles can be defined as "a fabric or synthetic material placed between the soil and a pipe, or retaining wall, to enhance water movement and retard soil movement and act as a blanket to add reinforcement and separation." Also known by other names such as 'industrial textiles', 'high-performance textiles', 'engineered textiles', 'technical textiles', and 'industrial fabrics', these materials are specially designed and engineered fabrics that are generally used in processes and services of non-textile industries. These are materials and products manufactured primarily for their technical and performance properties rather than for aesthetic and decorative characteristics.

Geotextiles can be woven, knitted or non-woven. Different fabric composition and construction are suitable for different applications. The non-woven geotextile is an arrangement of fibres either oriented or randomly patterned in a sheet, resembling felt. These geotextiles provide planar water flow in addition to stabilization of soil. Typical applications include access roads, aggregate drains, asphalt pavement overlays, and erosion control. Today, geo-textiles are the largest group of geo-synthetics in terms of volume and are used in geo-technical engineering, heavy construction, building and pavement construction, hydro-geology, environment engineering.

Geotextiles can improve soil strength at a lower cost than conventional soil nailing, which involves the insertion of relatively slender reinforcing metal bars into pre-drilled holes in the slope. In addition, geotextiles allow planting on steep slopes, further securing the slope. Coir (coconut fibre) geotextiles are a popular solution for erosion control, slope stabilisation and bioengineering, due to the fabric's substantial mechanical strength. Coir geotextiles last approximately 3 to 5 years depending on the fabric weight. The product degrades into humus, enriching the soil. Geotextiles are used as matting to stabilise flow in stream channels.

Geotextiles are increasingly being used to control soil erosion on hillsides and embankments in India because the country faces a high level of soil loss each year due to its monsoon seasons. The Rajiv Gandhi Setu Bridge in Daman, for example, used 82,000 m² of high-strength polyester woven geotextile to reinforce the embankment and provide a separation layer.

Global Positioning System (GPS)

Global Positioning System (GPS) Global Positioning System (GPS) refers to a satellite constellation network comprising of around 24 satellites orbiting the Earth at an altitude of about 20,000 km. Global Positioning System satellites transmit signals to equipment on the ground. GPS receivers passively receive satellite signals; they do not transmit. GPS receivers require an unobstructed view of the sky, so they are used only outdoors and they often do not perform well within forested areas or near tall buildings. GPS operations depend on a very accurate time reference, which is provided by atomic clocks on board each GPS satellite.

Each GPS satellite transmits data that indicates its location and the current time. The signals, moving at the speed of light, arrive at a GPS receiver at slightly different times because some satellites are farther away than others. The distance to the GPS satellites can be determined by estimating the amount of time it takes for their signals to reach the receiver. When the receiver estimates the distance to at least four GPS satellites, it can calculate its position in three dimensions and thus determine the location of the receiver.

In India, GPS services are used to control and manage vehicular flow in many cities. Automatic Vehicle Locater System is a hardware device that uses GPS technology to monitor vehicle movements. Using this, one can well track a fleet of vehicles. Vehicle tracking system is made up of two units. The mobile vehicle unit and the fixed base station units.

GPS technology is also used for harvesting. Tractors provided with GPS guidance systems are used for accurate ploughing, harvesting, spraying insecticides and fertilisers on specified areas, location and tagging of soil samples etc. Other uses of GPS include weather forecasting and monitoring of Earth's plate movements.

GPS can also be used for tourism and adventure sports purposes. With GPS enabled hardware technologies, one can not only receive route signals on mountain terrains; one can also get information about terrain altitudes and future weather conditions. Enhancement of GPS technology in India is mainly supported by the Department of Electronics (DOE), Defence Research & Development Organization (DRDO), Department of Space (DOS), Ministry of Civil Aviation and other space research bodies. GPS together with Russian GLONASS satellite technology has been working together in combination for several years. Integration of both these satellite constellation networks has resulted in the production of a receiver that monitors satellite signalling more perfectly.

Biosimilars

A biosimilar is a successor to a biologic medicine that has lost patent protection or exclusivity. After the patent expires other companies may start production of similar drugs. These similar drugs are known as biosimilars or follow-on drugs. The term 'biosimilars' denotes that drug is similar but not the copy of existing original drug. The term is also used to describe officially-approved subsequent versions of innovator biopharmaceutical products made by a different sponsor following patent and exclusivity expiry on the innovator product. Due to their relative complexity, something they share with all biologic drugs, biosimilars represent a separate class of generic medicines.

A major hurdle for biosimilar manufacturers is that they don't have access to cell bank, molecular blueprint and data of manufacturing, purification and exact fermentation process that were used to develop the original drug. Also, two cell lines developed independently cannot be exactly identical to each other. This makes things tougher for biosimilar producers to develop exact copy of an original drug.

Also, unlike the more common small-molecule drugs, biosimilars generally exhibit high molecular complexity, and may be quite sensitive to changes in manufacturing processes. Follow-on manufacturers do not have access to the originator's starting molecules or knowledge of the exact fermentation and purification process. As a result, differences in impurities and/or breakdown products can have serious health implications. This has created a concern that biosimilars might perform differently than the original branded version of the product. That is why biosimilars need approval before they can be marketed. To win approval, they need to demonstrate both highly analogous structure (via robust analytical characterisation) and comparable quality, safety, and efficacy (via appropriate clinical trials). Manufacturing of a biosimilar drug includes 210 tests, while a chemical drug has to pass through 60-70 tests.

India's definition of a biosimilar or similar biologic is: a biological product or drug produced by genetic engineering techniques and claimed to be "similar" in terms of quality, safety, efficacy to a reference innovator product, which has been granted a marketing authorisation in India by a competent authority on the basis of a complete dossier, and with a history of safe use in India. However, till recently there was no separate set of guidelines for biosimilars in India and the Review Committee on Genetic Manipulation used to approve these similar biologics on a case-to-case basis. India has so far approved over 20 similar biologics that include recombinant therapeutics, monoclonal antibodies based on abridged regulatory requirements.

In June 2012, the Indian Government released its biosimilars guidelines, which is considered a major step towards ensuring entry of cheaper biotech drugs into India. The document, prepared by the Department of Biotechnology and the Central Drugs Standard Control Organisation, lists a host of provisions from pre-marketing approval to quality comparisons and post marketing surveillance for generic biotech drugs. The guidelines provide insights into preclinical evaluation of those recombinant products that are claimed to be already approved biopharmaceutical products, referred to as "similar biologics" and therefore partly rely on the data from the already approved products for approving safety, purity, potency and effectiveness. The guidelines are aimed at providing a "clear" regulatory pathway for manufacturers of biosimilars and will be applied to new filings now. The new guidelines are also expected to give a boost to the industry in the international space by buying credibility for drugs developed and manufactured in India. The guidelines are to come into effect from 15 August 2012.

A new rapid test for TB

A new rapid test for tuberculosis (TB) has received an important endorsement from the World Health Organization (WHO), a move expected to lead to its worldwide rollout over the next few years. The new test, in which a device the size of a carry-on suitcase looks for bacterial DNA in a person's sputum, is cheaper, faster, and more accurate than standard TB tests used in both developed and developing countries. The new system allows doctors to test the patient while the patient sits there.

There is a huge difference between the existing tests and the new test. The current diagnostic test for TB has been used for 125 years. It involves microscopic examination of a sputum sample cultured for 4 to 6 weeks to check for the presence of the disease-causing bacteria Mycobacterium tuberculosis, and is far from ideal because it does not easily detect the growing number of strains that are resistant to antibiotics, or TB where the patient is co-infected with HIV. Some patients have to wait as long as three months to be diagnosed, which means their treatment is delayed and their recovery prospects reduced. The long wait also increases the chances they will infect others and, if they are given the wrong antibiotics for the strain of TB they have, drug-resistance can worsen and spread. The long time it takes for the test is especially problematic for people who are immunosuppressed and who cannot wait two months before going on treatment.

The new TB test was developed by Cepheid, a company in Sunnyvale, California, USA in partnership with the Foundation for Innovation New Diagnostics (FIND) and the University of Medicine and Dentistry of New Jersey, USA. It is a fully automated system, which even health workers in developing countries can operate after a minimum of training. The new fully automated NAAT (nucleic acid amplification test) test helps in the early diagnosis of TB, as well as multidrug-resistant TB (MDR-TB) and TB complicated by HIV infection, which are more difficult to diagnose. The test, which takes just 90 minutes, would detect TB bacteria by looking for characteristic genetic signatures. The test can also detect whether the microbes carry a gene that confers resistance to Rifampicin, a drug commonly used to treat TB. According to the researchers, that's an important piece of information for doctors; if the patient is also resistant to a second drug called Isoniazid - it takes a separate test to find out - the strain is considered multi-drug resistant (MDR), and it requires a different cocktail of drugs to treat. Trials and demonstration studies have been carried out over 18 months in a number of different countries, involving more than 8,000 patients. WHO estimates that there were 440,000 new cases of MDR TB in 2008. The new test is also expected to lead to twice as many TB diagnoses among HIV-infected people; roughly 12% of those with the disease are also HIV-positive.

For nongovernmental organisations and low- and middle-income countries, the cost per test is about Rs.750, a price that is expected to fall to about Rs.650 within a year and to Rs.450 within two years. South Africa, India, Uganda, and several other countries plan to roll out the test immediately. A crucial question is how well it performs in the field, where tropical temperatures and lack of electricity and Internet access – which the machine needs to signal that it needs maintenance – could pose problems. A trial of a version of the machine running on batteries is already under way in India and Pakistan, among other countries, and results are expected soon.

'Super rice' for the under-nourished

Rice is the primary source of food for roughly half of the world's population, yet the commonly consumed polished grain contains insufficient levels of the key micronutrients iron, zinc and vitamin A to meet daily dietary requirements. Rice has the lowest iron concentration of the cultivated cereal crops, with concentration of iron being as low as 5 micrograms/gram. Experts estimate that a rice-based diet should contain 14.5 micrograms/gram of iron in endosperm, the main constituent of polished grain, but breeding programs have failed to achieve even half of that value. As a result, micronutrient deficiencies afflict billions of people throughout that world and are particularly prevalent in developing countries where cereals are widely consumed. Currently, iron deficiency affects more than two billion people worldwide, with symptoms ranging from poor mental development and depressed immune function to anaemia, and is the most widespread nutritional deficiency in the world.

The development of new cereal varieties containing increased concentrations of iron and other essential micronutrients – an approach known as 'biofortification' – offers an inexpensive and sustainable solution to the chronic micronutrient malnutrition problems that currently plague people in developing countries. Recently, scientists from Adelaide have pioneered a breakthrough to increase the iron and zinc content of rice to provide a solution to the iron and zinc deficiency disorders for the world's under-nourished. The genetically modified rice has up to four times more iron and twice as much zinc as conventional rice.

Conventional breeding techniques use a plant virus to boost the activity of a gene that naturally occurs in rice but were not quite effective. So the scientists turned to biotechnology. The researchers were able to target the genes responsible for picking up iron and zinc in the rice plant, and used biotechnology to enhance activity of that particular gene. They just tricked the plant into thinking it doesn't have enough iron, which made it take up more iron and zinc put more of these micronutrients into the grain. Having made this breakthrough in laboratory and greenhouse environments, the next phase of this research is to test the iron- and zinc-fortified rice plants in the field.

Bonobo genome sequenced

The bonobo, also known as pygmy chimpanzee, is a chimpanzee with a black face and black hair, found in the rainforests of the Democratic Republic of Congo (Zaire). It is believed to be the closest living relative of humans. Recently, in a project led by the Max Planck Institute for Evolutionary Anthropology in Leipzig, an international team of scientists has completed the sequencing and analysis of the genome of the bonobo, making this the final genome of a great ape to be sequenced. The achievement marks a milestone. Adding the bonobo genome to the already-sequenced human, chimpanzee, gorilla and orang-utan genomes gives scientists a complete catalogue of the DNA of all of the so-called great apes. That should help researchers better understand how humans evolved. For example, with all the great ape sequences complete, scientists can better use genetics to help determine whether a particular trait cropped up for the first time in humans.

The comparison of the genome sequences of bonobo, chimpanzee, and human show that humans differ by approximately 1.3% from both bonobo and chimpanzee. Chimpanzees and bonobos are more closely related, differing by only 0.4%. Bonobo and chimpanzee territories in central Africa are close to one another and separated only by the Congo River. It has been hypothesized that the formation of the Congo River separated the ancestors of chimpanzees and bonobos, leading to these distinct apes. Bonobos and chimps – which are very closely related but behave in strikingly different ways – split from each other about 1 million years ago.

Aridipithecus ramidus

In October 2009, the discovery of the oldest fossil skeleton of a human ancestor called *Ardipithecus ramidus* was announced. The discovery revealed that our human ancestors underwent a previously unknown stage of evolution more than a million years before Lucy, the iconic early human ancestor specimen that walked the Earth 3.2 million years ago. The newly found fossils belonged to a small-brained, 50-kilogram female.

The 4.4 million-year-old fossils puts to rest the notion, popular since Darwin's time, that a chimpanzee-like missing link – resembling something between humans and today's apes – would eventually be found at the root of the human family tree. Indeed, the new evidence suggests that the study of chimpanzee anatomy and behaviour – long used to infer the nature of the earliest human ancestors – is largely irrelevant to understanding our beginnings. According to the researchers *Ardipithecus ramidus* was bipedal when on the ground, but went on all fours when climbing trees, as is, of course, the case with modern humans. However, unlike modern humans, this hominid had a big toe that could grasp branches.

Although the announcement of the discovery was made in 2009, the first fragments of fossil bones of the new species were found as early as 1992. But it was not enough for identification. Later, between 1999 and 2003, fragmentary remains from nine separate individuals of the same species were found. Only then comprehensive study of the fossils could be done and it was identified as a distinct species and given the name *Aridipithecus ramidus*.

Security and life sciences

Research in life sciences has always been fraught with danger. Genetic engineering not only makes it possible to produce food with better nutrient content and better drugs, but it can also give rise to substances that can be used for bioterrorism. A recent research finding has galvanised and divided the international scientific and security communities. While the creation of a version of H5N1 influenza (bird flu) virus that can be transmitted by respiratory droplets or aerosol between mammals raises hopes that a vaccine can be made, it also raises fears that humans will speed up the process by which this new virus will be unleashed. Research has been suspended while scientists debate the proper course to take.

Till recently, the H5N1 virus was not known to be transmissible through air or aerosols; that is, by sneezing or breathing. To become a pandemic, the virus would have to be able to spread via tiny droplets spewed out during coughing or sneezing, as happens with the human flu virus. And that is what recent research has shown is possible – that the virus may mutate easily and become transmissible through respiratory droplets. If that happens, it could start a deadly worldwide epidemic. It is for this reason that the publication two research papers on H5N1 was withheld for several months because of concern that it could open up the possibility of misuse of the published data for bioterrorism. However, ensuring freedom in scientific research and attracting cutting-edge scientists are essential components of the global efforts to develop life science research.

Scientists have expressed concerns over censorship of scientific research. While enhancing safety and security within and beyond laboratories is critical to preventing the accidental release of pathogens/toxins or their intentional use for illicit purposes, free exchange of information is a pre-requisite for progress of science, even in life sciences. According to some sources, rather than being a cause of concern, the findings about H5N1 will help national public health agencies that monitor influenza viruses, allowing them to make plans to cope with the next epidemic or pandemic flu that may emerge in humans.

Quantum machine

Quantum mechanics deals with the realm of the extremely small where looks nothing like our everyday world. Quantum theory dictates that a very tiny thing can absorb energy only in discrete amounts, can never sit perfectly still, and can literally be in two places at once. Scientists have observed such quantum effects and weirder ones in countless experiments with atoms, molecules, subatomic particles, light, electric currents, and even liquid helium. But nobody had seen such effects in the motion of a human-made object. At last, in March 2009, a group of researchers designed a mechanical gadget that moves in ways that can only be described by quantum mechanics – the set of rules that governs the behaviour of tiny things like molecules, atoms, and subatomic particles.

The scientists designed the machine – which is basically a tiny metal strip of semiconductor, with width in nanometres and length in micrometres – and coaxed it into behaving according to quantum laws. First, they cooled the paddle until it reached its "ground state," or the lowest energy state permitted by the laws of quantum mechanics. Then they raised the widget's energy by a single quantum to produce a purely quantum-mechanical state of motion. They even managed to put the gadget in both states at once, so that it literally vibrated a little and a lot at the same time – a bizarre phenomenon allowed by the weird rules of quantum mechanics. The quantum machine proves that the principles of quantum mechanics can apply to the motion of macroscopic objects, as well as atomic and subatomic particles. However, a quantum machine is different from a quantum computer which is a purely electronic device.

Handmade cloning

The world's first transgenic sheep, named Peng Peng, produced via a simplified cloning technique, known as handmade cloning, was born in China in April 2012. Traditional cloning techniques used for cloning animals suffered from several problems and the success rate was very low. Over the past decade, a small alternative group of procedures, called hand-made cloning (HMC), has emerged that involves the removal of the *zona pellucida* – the strong membrane that forms around an ovum as it develops in the ovary – prior to insertion of the nucleus in the egg and fusion. The procedure does away with the requirement for micromanipulators. Compared with traditional cloning, the benefits of handmade cloning are many, such as, low equipment costs, a simple and rapid procedure and an in vitro efficiency comparable with or higher than that of traditional nuclear transfer. Embryos created by the new techniques can be cryopreserved and are capable of establishing pregnancies and resulting in the birth of calves. Consequently, the handmade cloning technique may become a useful alternative to traditional cloning, either in special situations or generally for the standardisation and widespread application of somatic cell nuclear transfer.

A revolution in botanical nomenclature

The International Code of Botanical Nomenclature (ICBN) has dropped the requirement to describe newly found species in Latin in favour of "descriptive statements in English". As of 1 January 2012, the new ICBN allows botanists the options of writing descriptive statements in English and of publishing papers electronically. The changes follow the amendments ratified at the International Botanical Congress (IBC) held in Melbourne, Australia in July of last year. The binomial system of botanical nomenclature – an outstanding system contributed by the Swedish botanist Carolus Linnaeus – has been in use for centuries. However, the Latin names are quite complicated and are difficult to remember. Moreover, the earlier code, which required botanists both to write diagnoses in Latin and to publish only in print journals, made the documentation of new taxa a laborious process.

The main reason behind this change in the way plant species are catalogued is to ensure that each plant species enter the vast system of classification, in as speedy and easy a manner as possible, receiving a name and being assigned to uniquely human purposes. The decision to streamline the naming process was not based on efficiency alone. The threat of biodiversity loss was also a major source of motivation. As many as two-thirds of the world's 350,000 plant species are in danger of extinction during the course of the 21st century. English nomination facilitates, precisely, this harnessing of vegetal potential under the assumption that plants cannot possess any intrinsic value, unrelated to human uses.

European Pressurised Reactor

The European Pressurised Water Reactor (EPR) belongs to the advanced 3rd generation of the most widely used type of reactor in the world, the Pressurised Water Reactor (PWR). It is an evolutionary technology that draws on the experience acquired over 20 years by the French and German nuclear industry in design, engineering, equipment manufacturing, construction, maintenance, and plant operation. The EPR combines all the latest robust technology relating to safety, environmental protection, technical and economic performance.

The EPR reactor has an electrical generation capacity of more than 1650 MW, which places it among the most powerful reactors in the world. A direct descendant of previous models, the EPR pressurised water reactor is based on tried-and-tested technologies and principles. From a safety point of view, the EPR reactor ensures an unequalled safety level thanks to a drastic reduction of the probability of severe accidents as well as of their consequences on the environment. In addition, it is particularly resistant to external incidents (airplane crashes, etc.). Economically, it achieves an unrivalled level of competitiveness because electricity production costs are reduced by 10%, compared with current plants. It also produces less waste. The proposed nuclear power station at Jaitapur in India is to have EPRs.

Short answers

Fundamental Physics Prize

Ashoke Sen, a theoretical physicist and professor at Harish Chandra Research Institute (HRI) in Allahabad, is among nine scientists picked by a Russian billionaire entrepreneur, Yuri Milner, for the inaugural Fundamental Physics Prize, announced recently by Milner's not-for-profit foundation. Sen has spent two decades refining a mathematical idea called the string theory that seeks to unify two bedrock theories of physics - quantum mechanics and gravity - and to complete an unfinished task initiated by Einstein. Sen will receive US$3 million as prize money.

Millennium Technology Prize

Japanese stem cell scientist Dr. Shinya Yamanaka has been awarded the Millennium Technology Prize for 2012 for discovering how to reprogram human cells to mimic embryonic stem cells, which can become any cell in the body. The Millennium Technology Prize is the largest technology prize in the world. It is awarded once every two years by Technology Academy Finland, an independent fund established by Finnish industry and the Finnish state in partnership. The Prize celebrates innovations that have a favourable impact on quality of life and well-being or on sustainable development. The prize is awarded in recognition of technological innovations that contribute to the improved quality of human life and encourage sustainable development. The main prize is worth 800,000 euros. The previous winners of the Millennium Technology Prize include Tim Berners-Lee, inventor of the World Wide Web.

BMP7

Bone morphogenetic protein 7 or BMP7, also known as osteogenic protein-1 or OP-1, is a protein that plays a key role in the formation of cartilage and bone in humans. It is so named because it is encoded by the BMP7 gene. Human recombinant BMP7 has been used surgically to aid in the treatment of spinal cord injuries and also in the repair of fractured tibia – the thick bone of lower leg – where a bone graft has failed. BMP7 also has the potential for treatment of chronic kidney disease. BMP7 administration has also been proposed as a possible treatment for human infertility.

HPTN 052

HPTN 052 is a Phase III, multi-site, randomised trial to determine the effectiveness of two treatment strategies in preventing the sexual transmission of HIV in serodiscordant couples – couples in which one partner is HIV positive and the other is HIV negative. The trial was organised by the HIV Prevention Trials Network (HPTN). Based on data collected in Africa and Thailand, it has been found that there is a correlation between blood levels of HIV virus and HIV transmission. Antiretroviral therapy (ART) reduces the viral load in the blood and other body fluids in both men and women. All of this information strongly suggests that ART may make HIV-infected people less contagious. HPTN 052 compares the HIV-infection rates of two groups of HIV-serodiscordant couples. Both groups receive HIV primary care and couples counselling sessions to teach them how to reduce their risk of transmission.

Graphene: Carbon in two dimensions

Carbon is a unique element; in fact, it is one of the most intriguing elements in the Periodic Table. The entire living world is built around carbon thanks to its unique ability to join together to make long chains. Carbon exhibits remarkable properties, some of which are paradoxical. For example, one of its allotropes – diamond – is the hardest naturally occurring substances known, while another – graphite – is one of the softest substances known. Both are three-dimensional forms of carbon. During the past two decades new allotropes like fullerenes (zero-dimensional), and nanotubes (one-dimensional) have been discovered. But till recently two-dimensional molecular forms of carbon were unknown. Now, two-dimensional carbon is also known.

The discovery of a two-dimensional allotrope of carbon was first reported in the journal *Science* in 2004 by a group of physicists from Manchester University, UK, led by Andre Geim and Kostya Novoselov of Institute for Microelectronics Technology, Chernogolovka, Russia. The paper described the existence of a new class of materials – strictly two-dimensional atomic crystals – which can be seen as individual atomic planes pulled out from bulk crystals. This single layer of carbon atoms densely packed into a benzene-ring structure was named 'graphene'. In other words, graphene is a two-dimensional, giant, flat sheet of carbon atoms which is still only the thickness of an atom.

The planar, hexagonal arrangement of carbon atoms in graphene can be considered as nothing but a single layer peeled off from the three-dimensional graphite crystal. The single-layered honeycomb structure of graphene makes it the "mother" of all carbon-based systems: the graphite we find in our pencils is simply a stack of graphene layers; carbon nanotubes are made of rolled up sheets of graphene; and fullerene molecules, or buckyballs are nanometre-size spheres of wrapped-up graphene. These forms of carbon were isolated long before graphene and have been used in many applications, but their electric, magnetic and elastic properties all originate in the properties of graphene.

What is most surprising about graphene is its stability. It has been long believed that two-dimensional atomic crystals cannot be stable under ambient conditions because of thermodynamic constraints. But the Manchester team has, for the first time, demonstrated that they are not only fairly easy to make but also quite stable. The high stability of graphene is explained by its surface roughness. Already scientists have discovered remarkable electronic properties of the new material that could be used in place of silicon for making ultra-fast and stable transistors. In fact, graphene exhibits exceptionally high crystal and electronic quality, and, despite its short history, has already revealed a cornucopia of new physics and potential applications.

Physicists at University of California, Riverside, USA, have demonstrated that the atom-thin sheets of graphene can act as an atomic-scale 'billiard table', with electric charges acting as billiard balls. In other words, in graphene electrons do not flow through the material, as in silicon circuits, but on the surface.

It was also found that in graphene electrons travel much faster than electrons in other semiconductors. The finding underscores graphene's potential for serving as an excellent electronic material that could be used in place of silicon for making ultra-fast and stable transistors based on quantum physics. Because they encounter no obstacles, the electrons in graphene roam freely across the sheet of carbon, conducting electric charge with extremely low resistance. In other words, this means that graphene never stops conducting. Thus graphene could provide the foundation for a new generation of nanometre scale devices that manipulate electrons as waves – much like photonic systems control light waves.

Carbon nanotubes are also known to conduct electricity with virtually no resistance, and have attracted strong interest for use in transistors and other devices. However, the discrete nature of nanotubes – and variability in their properties – poses significant obstacles to their use in practical devices. By contrast, continuous graphene circuitry can be produced using standard microelectronics processing techniques.

Researchers have also discovered that graphene exhibits far better thermal conductivity than carbon nanotubes. Thermal conductivity defines how well a given material conducts heat. Single-layer graphene has been found to have a thermal conductivity almost 40 times as high as the thermal conductivity of silicon near room temperature.

One problem with today's silicon-based computer processors is that they can perform only a certain number of operations per second without overheating, which puts a limit on their processing speed. In view of its high thermal conductivity, processors based on graphene could solve this problem, as electrons move through graphene with almost no resistance, generating little heat. These results open a new window to graphene applications in electronics, where materials that can manage heat are vital. Moreover, since it can transport electrons extremely quickly, which could allow very fast switching speeds in electronics, graphene-based transistors could run at speeds a hundred to a thousand times faster than today's silicon transistors.

Physicists in the US made the fastest graphene transistor ever in 2010, with a cut-off frequency of 100 GHz. The device can be further miniaturised and optimised so that it could soon outperform conventional devices made from silicon. The transistor could find application in microwave communications and imaging systems.

Its unique electrical characteristics could make graphene the successor to silicon in a whole new generation of microchips, surmounting basic physical constraints limiting the further development of ever-smaller, ever-faster silicon chips. But that's only one of the material's potential applications. Because of its single-atom thickness, pure graphene is transparent, and can be used to make transparent electrodes for light-based applications such as light-emitting diodes (LEDs) or improved solar cells.

Graphene could also substitute for copper to make the electrical connections between computer chips and other electronic devices, providing much lower resistance and thus generating less heat. And it also has potential uses in quantum-based electronic devices that could enable a new generation of computation and processing.

However, many obstacles still remain to making graphene processors on a large scale, which need to be overcome before the material's full potential can be realised. According to researchers in the field, the best way to make graphene electronics may be to take advantage of the fact that graphene can be grown in large sheets. For example, if better lithography methods are developed to pattern these sheets into narrow ribbons and circuits, this could provide a reliable way of making complex graphene-based electronics.

Smart grid

A smart grid (also known as intelligent grid) delivers electricity from suppliers to consumers using two-way digital technology to control appliances at consumers' homes to save energy, reduce cost and increase reliability and transparency. It overlays the electricity distribution grid with an information and net metering system and links electricity with communications and computer control to create a highly automated, responsive and resilient power delivery system. A smart grid will make possible simultaneous monitoring and control of millions of devices through software. Such a modernised electricity network is being promoted by many governments as a way of addressing issues like energy independence, global warming and emergency resilience.

The smart grid is made possible by applying sensing, measurement and control devices with two-way communications to electricity production, transmission, distribution and consumption parts of the power grid that communicate information about grid condition to system users, operators and automated devices, making it possible to dynamically respond to changes in grid condition.

A smart grid includes an intelligent monitoring system that keeps track of all electricity flowing in the system. Using real-time information from embedded sensors and automated controls to anticipate, detect, and respond to system problems, a smart grid can automatically avoid or mitigate power outages, power quality problems, and service disruptions. Smart grid technologies better identify and respond to man-made or natural disruptions. Real-time information enables grid operators to isolate affected areas and redirect power flows around damaged facilities. Besides, it will allow consumers to make the most cost-efficient use of power. When power is least expensive the user can allow the smart grid to turn on selected home appliances such as washing machines or factory processes that can run at arbitrary hours. At peak times it could turn off selected appliances to reduce demand.

A smart grid replaces analogue mechanical meters with digital meters that record usage in real time. Smart meters provide a communication path extending from generation plants to electrical outlets (smart socket) and other smart grid-enabled devices. By customer option, such devices can shut down during times of peak demand.

A smart grid also incorporates the use of superconductive transmission lines for less power loss, as well as the capability of integrating renewable electricity such as solar and wind. Climate change and environmental concerns will increase the amount of renewable energy resources, which are for the most part intermittent in nature. Smart grid technologies will enable power systems to operate with larger amounts of such energy resources since they enable both the suppliers and consumers to compensate for such intermittency. For the average Indian city- or town-dweller, the development of the smart grid would mean better quality of power. Voltage and frequency fluctuations would be eliminated, especially the low voltage and frequency conditions of summer, making power outages and load-shedding relics of a dark past.

The Central Government has mandated generation and use of non-conventional green energy resources and formulated comprehensive policies in keeping with the mandate, so that our unique ecosystems are protected and marginalised populations in poverty-stricken communities can avail themselves of energy at low costs. The smart grid technology goes a long way in addressing the technical complexities introduced by green energy resources-based generation as well as in increasing the efficiency of generation and distribution systems.

Eight new pilots to be taken up to develop smart grid in the country

The Working Groups formed under the India Smart Grid Task Force (ISGTF) have come out with a number of recommendations for development of the smart grid system in the country. The highlights of the recommendations are as follows:

- Eight different pilots will be taken up within next 18 months to establish knowledge base and as proof of concept in various categories in all parts of the country.
- Smart Grid standards will be established/adopted by BIS.
- Supervisory control and data acquisition (SCADA) and metering intervention will be introduced in more towns under Restructured Accelerated Power Development & Reforms Programme (RAPDRP).
- Critical Cyber Security Assets will be identified and audit will be undertaken on regular basis.
- Regulators will be engaged to introduce Time of Day Tariffs and feed in tariffs to entice consumer participation in demand management.

- Low cost smart meter will be developed to ensure that 100% metering is achieved within distribution companies' resources.

- Smart Transmission Grid through Wide Area Monitoring System (WAMS) project with Power Management Unite (PMU) deployment will be achieved by Power Grid all over Indian extra high voltage (EHV) system.

India Smart Grid Task Force chaired by Sam Pitroda, Adviser to the Prime Minister on Public Information, Infrastructure and Innovations was set up in May 2010 under the aegis of Ministry of Power to develop a roadmap and standards for the development and implementation of Smart Grid related technologies in the country. Its main functions are to create awareness, ensure coordination and integration of diverse activities relating to smart grid technologies, facilitate research and development activities and coordinate the inter-departmental activities related to smart grid. The Task Force would also issue guidelines relating to interoperability framework and evolve national guidelines for the implementation of smart grid in the country.
Seven guiding principles are being followed for developing smart grid in India:

- Be an Indian model developed indigenously complete with required hardware equipments local production and skill development through training for maintenance.

- Focus on addressing the problem of power shortage.

- Focus on theft prevention and loss reduction

- Access of power to rural areas to the poor

- Develop alternative sources of power and enhance reliability of power to urban areas

- Affordable and sustainable power production

The recommendations of the Working Groups will be hosted on the ISGTF website for review/ comments/feedback by public and other industry experts for wider consultations.

National Mission on Hybrid and Electric Vehicles

The Government has approved setting up of a national mission for electric mobility (NCEM), which is likely to boost manufacture of electric vehicles. The main objective of the mission will be development of a sustainable and environment friendly transport system. At present the contribution of electric vehicles in the automobile sector in India is less than one per cent, but is likely to increase with the implementation of the NCEM.

Second fastest growing Indian automobile market which has reported 30% growth in last year has considerable impacts on the environment. Exhaust gases resulting from the burning of fossil fuels in vehicles increases environmental pollution and subsequently raise the level of greenhouse gas in the atmosphere. Hence the transport sector cannot be neglected in government policies on environmental protection and climate change. Depleting natural resources for the petroleum products and increasing prices of the crude oil in international market are also the driving force for this provision of incorporating green and clean technologies in the sector of transportation. As a result finance minister has decided to give the Indian auto sector enough incentives to go green.

In November 2010, Ministry of New and Renewable Energy resources (MNRE) announced a 20% incentive to electric vehicle manufacturers. This financial incentive is applicable on the ex-factory price for each electric vehicle sold in India. According to the 2011 budget, concessional rate of central excise duty would be applicable on specific parts of electrical vehicles like batteries and other components. Most of these parts are presently imported in the country. This budget also implies concessional rate of 5 % on excise duty on hybrid vehicles as incentive for their domestic production.

Hybrid vehicles use more than one energy source for starting and driving, and the option to switch between powering sources makes hybrid vehicles a truly alternative option to the conventional ones. The term most commonly use as a Hybrid Electric Vehicle (HEVs), a combination of an internal combustion engine and one or more electric motors.

Some hybrid vehicles use fuel cells for generating electricity. A fuel cell is an electrochemical cell that converts chemical energy from a fuel into electric energy. Electricity is generated from the reaction between a fuel supply and an oxidising agent. The reactants flow into the cell, and the reaction products flow out of it, while the electrolyte remains within it. Fuel cells can operate continuously as long as the necessary reactant and oxidant flows are maintained.

Fuel cells are different from conventional electrochemical cell batteries in that they consume reactant from an external source, which must be replenished – a thermodynamically open system. By contrast, batteries store electric energy chemically and hence represent a thermodynamically closed system.

Many combinations of fuels and oxidants are possible. A hydrogen fuel cell uses hydrogen as its fuel and oxygen (usually from air) as its oxidant. Other fuels include hydrocarbons and alcohols. Other oxidants include chlorine and chlorine dioxide.

Hydrogen has the potential to become an environment-friendly fuel of the future. Hydrogen can be used in to run fuel cells to power hybrid vehicles and electric devices. In a fuel cell hydrogen reacts with oxygen from air in presence of a catalyst to generate electricity and produces water as a waste product.

Pure hydrogen does not occur naturally; it takes energy to manufacture. The current leading technology for producing hydrogen in large quantities is steam reforming of methane gas (CH_4). In addition, obtaining hydrogen from electrolysis using renewable resources is being studied as a viable way to produce it domestically at a low cost. This process involves the use of wind—or solar—generated electricity to power an electrolyser which would split water into hydrogen and oxygen. At present, however, there is not a sufficient technical and economic infrastructure to support widespread use.

Various research and development activities have been carried out and still going on in finding efficient technology to power the vehicle without losing its capacity and speed as compare to conventional counterparts. The following energy sources have been identified to fuel the hybrid vehicles: Rechargeable energy sources, CNG, hydrogen (fuel cell powered vehicle), and waste heat from the internal combustion engine.

National Optical Fibre Network

The Government is expected to connect five lakh villages with the internet broadband services under the National Optical Fibre Network (NOFN) in the next two years. The optical fibre network would help various service providers and users get broadband through a variety of wired and wireless solutions. Till now, the broadband facility has been limited to metros and major cities.

The Telecom Commission has recommended creating a National Optical Fibre Network (NOFN) to provide broadband connectivity to panchayats. The objective of the scheme is to extend initially the existing optical fibre network that extends up to districts headquarters up to gram panchayat level by utilising the universal service obligation fund. The benefits from the scheme are expected through additional employment, e-education, e-health, e-agriculture and reduction in migration of rural population to urban areas. The proposed NOFN will enable effective and faster implementation of various mission mode e-governance projects amounting to approx Rs.50,000 crore initiated by department of IT. As per a World Bank study, with every 10 percent increase in broadband penetration, there is an increase in GDP growth by 1.4 percent.

The proposal is to be placed before the cabinet for approval. The cost of the initial phase of the scheme would be around Rs.20,000 crore and a similar investment is likely to be made by the private sector to complement the NOFN infrastructure while providing services to individual users. A special purpose vehicle (SPV) will assume the responsibility for execution of the project after approval of the scheme by the cabinet. The state-owned BSNL has been entrusted with the task of undertaking the preparatory activity for project execution and establishment of the special purpose vehicle. The SPV will be finally owned by the government.

A committee to look into creation and implementation of NOFN was set up by the telecom department April 26 under the co-chairmanship of Sam Pitroda, adviser to the prime minister, and Nandan Nilekani, chairman of the Unique Identification Authority of India.

Global Framework for Climate Services

World Climate Conference-3, which brought together more than 2 000 climate scientists, sectoral experts and decision-makers in Geneva, Switzerland, in 2009, established a Global Framework for Climate Services, "to strengthen production, availability, delivery and application of science-based climate prediction and services." The Declaration establishing the Global Framework was adopted by high-level policy-makers from more than 150 countries.

The World Meteorological Congress that ended on 3 June 2011, placed the Global Framework for Climate Services among its top five priorities for the next four years, and will meet in 2012 for the purpose of reviewing and adopting a draft implementation plan. The Framework will operate as an intergovernmental board, with a governance structure similar to the Intergovernmental Panel on Climate Change, and will be hosted by the World Meteorological Organisation. India has pledged to support Global Framework for Climate Services Secretariat with a grant of US $ 1,25,000.

The Global Framework for Climate Services is an important step toward strengthening the application of climate science in local, regional, national and international decision-making. It envisions a coordinated effort on the part of such organisations as National Meteorological and Hydrological Services, oceanographic and agricultural institutes, satellite operators and research centres that already produce climate information and services. The Framework will enable these producers to improve the quality and volume of climate services worldwide, to help people manage climate risks and opportunities.

Among the potential users of these services are farmers, water managers, planners, energy specialists, marine operators, construction managers, disaster managers and insurance experts. While the primary goal is to improve climate services for all countries, a priority of the Framework is building capacity in climate-vulnerable developing countries. In India, two million farmers are already utilising weather service which has helped them improve agricultural practices.

To develop a global framework for climate services, it will be essential to build upon many of the capabilities and shared responsibilities which are already in place today. The following points would be important:

- Efforts to provide effective climate services globally will only be successful if capacity is systematically built to enable all countries to manage climate risk effectively
- Support to climate services, high quality observations are required across the entire climate system and of relevant socioeconomic variables
- Further effort by governments and others to overcome the currently significant restrictions concerning sharing of, and access to climate and other relevant data
- To be useful, climate information must be tailored to meet the needs of users.

The following actions would be needed for a successful framework:

- Establishing mechanisms to strengthen the global cooperative system for collecting, processing and exchanging observations and for using climate-related information
- Designing and implementing a set of projects that target the needs of developing countries, particularly those currently least able to provide climate services
- Developing strategies for external communications, resource mobilisation and capacity building programmes
- Establishing internal working methods, particularly for communications and for debating and deciding on implementation priorities
- Setting targets and establishing procedures for monitoring and evaluating the performance of the global framework

GAGAN

The Ministry of Civil Aviation has decided to implement an indigenous Satellite-Based Regional GPS Augmentation System also known as Space-Based Augmentation System (SBAS) as part of the Satellite-Based Communications, Navigation and Surveillance (CNS)/Air Traffic Management (ATM) plan for civil aviation. The Indian SBAS system has been given an acronym GAGAN – GPS Aided GEO Augmented Navigation. A national plan for satellite navigation including implementation of Technology Demonstration System (TDS) over the Indian air space as a proof of concept has been prepared jointly by Airports Authority of India (AAI) and ISRO. TDS was successfully completed during 2007 by installing eight Indian

Reference Stations (INRESs) at eight Indian airports and linked to the Master Control Centre (MCC) located near Bangalore.

The Rs.774-crore project is being implemented in three phases through 2008 by the Airport Authority of India with the help of the Indian Space Research Organisation's (ISRO) technology and space support. The goal is to provide navigation system for all phases of flight over the Indian airspace and in the adjoining area. It is applicable to safety-to-life operations, and meets the performance requirements of international civil aviation regulatory bodies. The final, operational phase of GAGAN is likely to be completed by 2011.

The next major milestone in GAGAN is the conduct of PSAT (Preliminary System Acceptance Testing) which has been successfully completed in December 2010. The first GAGAN navigation payload is slated on *GSAT*-8 which was launched on May 21, 2011. The second GAGAN payload is scheduled to be launched on *GSAT*-10 in the first quarter of 2012. The third GAGAN payload is planned on another geosynchronous satellite.

High Definition Television (HDTV)

High-definition television (or HDTV) refers to video display having resolution substantially higher than traditional television systems (standard-definition TV, or SDTV, or SD). HD has one or two million pixels per frame; roughly five times that of SD. Early HDTV broadcasting used analogue techniques, but today HDTV is digitally broadcast using video compression.

High definition is the top-level resolution offered within the digital television category. Digital cable comes in three formats – standard, enhanced, and high definition. Standard has a resolution of 480i, enhanced is 480p, and high definition is 720p and 1080i, where p and i stand for progressive and interlaced types of scanning respectively. Therefore, HD is digital, but not all digital is HD.

When we watch television, the picture we see is composed of many independently scanned lines. Put together, they compose the image on the screen. Interlaced and progressive are the two scanning techniques used. Lines of resolution vary for digital televisions - 480, 720, and 1080. Therefore, the resolution of a television is defined by the lines and types of scanning. A 720p resolution is a television with 720 progressive scanned lines. A 1080i resolution has 1080 interlaced scanned lines. Progressive scan gives a clearer picture than interlaced, but most HD programming is shown in the 1080i resolution.

A high definition signal is transmitted in 16:9 aspect ratio. 16:9 is also known as widescreen or letter box - like the screen in movie theatres. One can buy high-definition televisions with either a standard (4:3) or widescreen aspect ratio. Really, it's a matter of preference, whether one likes the square or rectangular screen. Most programming can be formatted to fit whatever aspect ratio one prefers.

HDTV broadcast systems are identified with three major parameters:

(i) Frame size in pixels, which is defined as number of horizontal pixels × number of vertical pixels, for example 1280 × 720 or 1920 × 1080. Often the number of horizontal pixels is implied from context and is omitted, as in the case of 720p and 1080p.

(ii) Scanning system, which is identified with the letter p for progressive scanning, and i for interlaced scanning.

(iii) Frame rate, which is identified as number of video frames per second. For interlaced systems an alternative form of specifying number of fields per second is often used.

First results from the 1000 Genome Project published

The most comprehensive map of the small genetic differences between individuals, called variations, were published in the journal *Nature* (28 October 2010) as part of the '1000 Genomes Project' – an international public-private consortium. The map contains an estimated 95 percent of the genetic variation of any person on Earth. The map was produced by the researchers using next-generation DNA sequencing technologies to systematically characterise human genetic variation in 180 people in three pilot studies.

Launched in January 2008, the 1000 Genomes Project is an international research effort to produce an extensive catalogue of human genetic variation that will support future medical research studies. Under the project it is planned to sequence the genomes of at least one thousand anonymous participants from a number of different ethnic groups within three years, using newly developed technologies which are faster and less expensive. The *Nature* report brings out the findings of the pilot phase. The full scale-up from the pilots is already under way, with data collected from more than 1,000 people.

Small genetic differences between individuals help explain why some people have a higher risk than others for developing illnesses such as diabetes or cancer. Genetic variation between people refers to differences in the order of the chemical units – called bases (A, T, C, G) – that make up DNA in the human genome. These differences can be as small as a single base being replaced by a different one – which is called a 'single nucleotide polymorphism' (SNP) – or can be as large as whole sections of a chromosome being duplicated or relocated to another place in the genome. Some of these variations are common in the population and some are rare.

One of the primary objectives of the 1000 Genome Project is to understand populations. For instance, by comparing lots of genomes researchers will be able to identify points at which one genome differs from the next. For projects examining how populations commonly differ, sequencing a large number of individuals at relatively low accuracy or 'depth of coverage' is enough. Researchers can create a map of all types of genetic variation by comparing the base sequences in the genome of many individuals to one another and by comparing one population to other populations.

Measurement of human DNA variation is an essential prerequisite for carrying out human genetics research. The 1000 Genomes Project represents a step towards a complete description of human DNA polymorphism (the presence of genetic variation within a population, upon which natural selection can operate). The project aims at providing a deep characterisation of human genome sequence variation as a foundation for investigating the relationship between genotype and phenotype. The larger data set that will be available from the full 1000 Genomes Project will provide a comprehensive public resource that can help researchers intending to study all types of genetic variation that might cause human disease. Already, these data have been used in studies of the genetic basis for disease.

Till now, populations with European, West African and East Asian ancestry have been studied. Using the newest technologies for sequencing DNA, the project's nine centres sequenced the whole genome of 179 people and the protein-coding genes of 697 people. Each region was sequenced several times, so that more than 4.5 million million (45×10^{11}) bases of DNA sequence were collected. The work was carried out by a consortium involving academic centres on multiple continents and technology companies that developed the sequencing equipment.

Under the 1000 Genomes Project about 900 genomes have been sequenced so far. Although far from comprehensive, the latest tally indicates that at least 2,700 human genomes will have been completed by the end of November 2010, and that the total will rise to more than 30,000 by the end of 2011.

Hundred years of superconductivity

The year 2011 marks the 100th anniversary of the discovery of superconductivity – the ability of materials to carry electrical current with no loss. It was in 1911 that superconductivity was first observed in mercury by Dutch physicist Heike Kamerlingh Onnes of Leiden University. When he cooled mercury to the temperature of liquid helium, 4 degrees Kelvin (-269°C), its resistance suddenly disappeared. In 1913, Kamerlingh Onnes was awarded the Nobel Prize in physics for his research on superconductivity.

Currents set up in superconducting wires can thus exist for years without any measurable decay. Because of this property, superconductors have unique features that can be exploited in many ways. They can carry enormous amounts of current, making them ideal for urban power grids. And, when wound into coils, they can produce extremely strong magnetic fields.

Such superconducting magnets have been applied in a variety of technologies. The best-known examples are the magnets that drive the magnetic resonance imaging (MRI) machines found in most hospitals. Perhaps the most exotic are the huge magnets used to accelerate particles in the Large Hadron Collider, which seeks to discover the fundamental principles of matter. Despite their great promise, however, superconductors have limits, the primary one being that most superconduct at very low temperatures – indeed, near absolute zero (-273°C). Such temperatures can be achieved only through liquid-helium cooling.

In 1986, Swiss researchers caused excitement by announcing the discovery of superconductivity in an oxide of copper at twice the temperature of the previous record holder. Shortly thereafter, researchers in the United States found a related material that superconducts above the temperature at which air liquefies. The discovery of these so-called "high-temperature superconductors" raised high hopes of more widespread use of superconductors. But the hopes were soon dashed when it was discovered that the new high-temperature superconductors, which are ceramic-like materials called cuprates, are notoriously difficult materials to work with, because they are very brittle. As such, they are a challenge for industry, though applications are beginning to appear.

Since the high-temperature superconductors first appeared, a variety of other "high temperature" superconductors have been discovered – one is a simple compound of magnesium and boron, and another involves a mixture of iron and arsenic. Although none of them superconducts at temperatures as high as liquid air, they may ultimately be better materials to work with. Given the vast number of combinations of elements that can form compounds, there is a good chance that better superconductors await our discovery.

In the coming years, superconductors are expected to play a growing role in technology. Already, "second generation" cuprate wires are being used to make high-capacity cables for electric-power transmission, and lighter-weight generators for wind turbines. Stronger superconducting magnets are leading to the development of MRIs with more sophisticated diagnostic capabilities. Superconductors are being used for levitated trains in high-speed rail transport, and as microwave filters for improved signal bandwidth in cellular base stations. The discovery of a new superconductor with enhanced properties could lead to even greater technological innovation.

Cloud computing

Cloud computing is the delivery of computing as a service rather than a product, whereby shared resources, software and information are provided to computers and other devices as a utility (like the electricity grid) over a network (typically the Internet). Cloud computing provides computation, software, data access, and storage services that do not require end-user knowledge of the physical location and configuration of the system that delivers the services. It is about putting more of your material out there and less on PCs or servers that a business runs for itself. Parallels to this concept can be drawn with the electricity grid, wherein end-users consume power without needing to understand the component devices or infrastructure required to provide the service.

The concept of cloud computing fills a perpetual need of Information Technology users: a way to increase capacity or add capabilities without investing in new infrastructure, training new personnel, or licensing new software. Cloud computing encompasses any subscription-based or pay-per-use service that, in real time over the Internet, extends IT's existing capabilities. Cloud computing providers deliver applications via the Internet, which are accessed from a Web browser, while the business software and data are stored on servers at a remote location.

These services are broadly divided into three categories: Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), and Software-as-a-Service (SaaS). The name cloud computing was inspired by the cloud symbol that's often used to represent the Internet in flowcharts and diagrams.

A cloud service has three distinct characteristics that differentiate it from traditional hosting. It is sold on demand, typically by the minute or the hour; it is elastic -- users can have as much or as little of a service as they want at any given time; and the service is fully managed by the provider (the consumer needs nothing but a personal computer and Internet access). The consumer does not need to install software or updates on computer. Significant innovations in virtualisation and distributed computing, as well as improved access to high-speed Internet, have accelerated interest in cloud computing.

A cloud can be private or public. A public cloud sells services to anyone on the Internet. A private cloud is a proprietary network or a data center that supplies hosted services to a limited number of people. When a service provider uses public cloud resources to create their private cloud, the result is called a virtual private cloud. Private or public, the goal of cloud computing is to provide easy, scalable access to computing resources and IT services.

Infrastructure-as-a-Service like Amazon Web Services deliver computer infrastructure – typically a platform virtualisation environment – as a service, along with raw (block) storage and networking. Rather than purchasing servers, software, data-centre space or network equipment, clients instead buy those resources as a fully outsourced service. In the enterprise, cloud computing allows a company to pay for only as much capacity as is needed, and bring more online as soon as required. Because this pay-for-what-you-use model resembles the way electricity, fuel and water are consumed, it's sometimes referred to as utility computing.

Platform-as-a-Service in the cloud is defined as a set of software and product development tools hosted on the provider's infrastructure. Developers create applications on the provider's platform over the Internet. PaaS providers may use application programming interfaces (APIs), website portals or gateway software installed on the customer's computer. Force.com, and GoogleApps are examples of PaaS. Developers need to know that currently, there are not standards for interoperability or data portability in the cloud. Some providers will not allow software created by their customers to be moved off the provider's platform.

In the Software-as-a-Service cloud model, the vendor supplies the hardware infrastructure, the software product and interacts with the user through a front-end portal. SaaS is a very broad market. Services can be anything from Web-based email to inventory control and database processing. Because the service provider hosts both the application and the data, the end user is free to use the service from anywhere.

Cloud seeding

Cloud seeding is a form of weather modification. It is usually used as a technique of increasing rainfall. Cloud seeding is usually done by spreading either dry ice, or more commonly, silver iodide aerosols, into the upper part of clouds to try to stimulate the precipitation process and form rain. Cloud seeding is actually a very complex process. In the simplest terms, it introduces other particles into a cloud to serve as cloud condensation nuclei and aid in the formation of precipitation. Since most rainfall starts through the growth of ice crystals from super-cooled cloud droplets in the upper parts of clouds, the silver iodide particles are meant to encourage the growth of new ice particles and cause rain.

However, there is no certainty that cloud seeding indeed induces rainfall because it can never be known whether a cloud that rains after seeding might have rained anyway. This is because seeding is performed on clouds that look like they have some potential for producing rain.

In a joint exercise, three nodal meteorological agencies led by a team of scientists from the Indian Institute of Tropical Meteorology (IITM) carried out the final phase of a cloud seeding research programme during the 2011 monsoon for a possible application in the rain shadow regions in Maharashtra, Karnataka and Andhra Pradesh. To aid the project undertaken as part of CAIPEX (Cloud Aerosol Interaction and Precipitation Enhancement Experiment) programme of the Ministry of Earth Sciences, two aircraft, fitted with specialised instruments, was hired from South Africa and Israel, and have an operational base in Hyderabad. The other two agencies involved in the two-year Rs 50-crore project envisaged to benefit the rain-starved regions of the three states, are Indian Meteorological Department and National Centre for Medium Range Weather Forecasting.

The second and the final operational phase of the project included warm cloud seeding through salt and hygroscopic flares. The seeding impact was measured and analysed with automatic rain gauges. According to the scientists, the experiment will help in understanding as to how aerosols interact with cloud leading to enhancement of rain. If the technology being developed by Indian weather scientists – which is similar to the one used by other countries – is found successful, it will help farmers in the rain shadow regions vulnerable to drought. It can also be instrumental in effecting weather modification such as hail suppression and cloud dispersion, the scientist added. Phase I of the project was carried out last year.

Magnetoresistive random access memory

MRAM (magnetoresistive random access memory) is a method of storing data bits using magnetic charges instead of the electrical charges used by DRAM (dynamic random access memory). Scientists define a metal as magnetoresistive if it shows a slight change in electrical resistance when placed in a magnetic field. In MRAM, the elements are formed from two ferromagnetic plates, each of which can hold a magnetic field, separated by a thin insulating layer. One of the two plates is a permanent magnet set to a particular polarity, the other's field can be changed to match that of an external field to store memory. This configuration is known as a spin valve and is the simplest structure for a MRAM bit. A memory device is built from a grid of such "cells".

By combining the high speed of static RAM and the high density of DRAM, proponents say MRAM could be used to significantly improve electronic products by storing greater amounts of data, enabling it to be accessed faster while consuming less battery power than existing electronic memory.

Conventional random access memory (RAM) computer chips store information as long as electricity flows through them. Once power is turned off, the information is lost unless it has been copied to a hard drive or floppy disk. MRAM, however, retains data after a power supply is cut off. Replacing DRAM with MRAM could prevent data loss and enable computers that start instantly, without waiting for software to boot up.

Development of MRAM basically followed two scientific schools: 1) spin electronics, the science behind giant magnetoresistive heads used in disk drives, and 2) tunnelling magnetic resistance, or TMR, which is expected to be the basis of future MRAM. Its proponents believe that the advantages are so overwhelming that MRAM will eventually become dominant for all types of memory, becoming a true universal memory.

Artificial Intelligence

Artificial Intelligence is a branch of science which deals with helping machines find solutions to complex problems in a more human-like fashion. This generally involves borrowing characteristics from human intelligence, and applying them as algorithms in a computer-friendly way. A more or less flexible or efficient approach can be taken depending on the requirements established, which influences how artificial the intelligent behaviour appears.

The birth of the field can be traced back to the early 1950s. Arguably, the first significant event in the history of AI was the publication of a paper entitled "Computing Machinery and Intelligence" by the British Mathematician Alan Turing. In this paper, Turing argued that if a machine could past a certain test (which has become known as the 'Turing test') then we would have grounds to say that the computer was intelligent. The Turing test involves a human being (known as the 'judge') asking questions via a computer terminal to two other entities, one of which is a human being and the other of which is a computer. If the judge regularly failed to correctly distinguish the computer from the human, then the computer was said to have passed the test. In this paper Turing also considered a number of arguments for, and objections to, the idea that computers could exhibit intelligence.

The field of artificial intelligence was founded on the claim that a central property of humans, intelligence — the sapience of *Homo sapiens* — can be so precisely described that it can be simulated by a machine. This raises philosophical issues about the nature of the mind and the ethics of creating artificial beings, issues which have been addressed by myth, fiction and philosophy since antiquity. Artificial intelligence has been the subject of optimism, but has also suffered setbacks and, today, has become an essential part of the technology industry, providing the heavy lifting for many of the most difficult problems in computer science.

In the 1990s and early 21st century, AI achieved its greatest successes, albeit somewhat behind the scenes. Artificial intelligence is used for logistics, data mining, medical diagnosis and many other areas throughout the technology industry. On 11 May 1997, Deep Blue became the first computer chess-playing system to beat a reigning world chess champion, Garry Kasparov. In 2005, a Stanford robot won the DARPA Grand Challenge by driving autonomously for more than 200 km along an unrehearsed desert trail. In February 2011, in a Jeopardy! quiz show exhibition match, IBM's question answering system, Watson, defeated the two greatest Jeopardy! champions Brad Rutter and Ken Jennings, by a significant margin.

Over the past five decades, AI research has mostly been focussing on solving specific problems. Numerous solutions have been devised and improved to do so efficiently and reliably. This explains why the field of Artificial Intelligence is split into many branches, ranging from Pattern Recognition to Artificial Life, including Evolutionary Computation and Planning.

Many futurists believe that artificial intelligence will ultimately transcend the limits of progress. It is predicted that by 2045 artificial intelligence will reach a point where it is able to improve itself at a rate that far exceeds anything conceivable in the past. Some experts have predicted that humans and machines will merge in the future into cyborgs that are more capable and powerful than either.

Humanoid robot

A humanoid robot is a robot with its overall appearance based on that of the human body, allowing interaction with made-for-human tools or environments. In general humanoid robots have a torso with a head, two arms and two legs, although some forms of humanoid robots may model only part of the body, for example, from the waist up. Some humanoid robots may also have a 'face', with 'eyes' and 'mouth'.

A humanoid robot is an autonomous robot, because it can adapt to changes in its environment or itself and continue to reach its goal. This is the main difference between humanoid and other kinds of robots. In this context, some of the capacities of a humanoid robot may include, among others:

- self-maintenance (like recharging itself)
- autonomous learning (learn or gain new capabilities without outside assistance, adjust strategies based on the surroundings and adapt to new situations)
- avoiding harmful situations to people, property, and itself
- safe interacting with human beings and the environment

Like other mechanical robots, humanoid refer to the following basic components too, viz., Sensing, Actuating and Planning, and Control. Since they try to simulate the human structure and behaviour and they are autonomous systems, generally humanoid robots are more complex than other kinds of robots.

An android is a robot or synthetic organism designed to look and act like a human. Although "android" is used almost universally to refer to both sexes, and those of no particular sex, "Android" technically refers to the male form, while "Gynoid" is the feminine form. Until recently, androids have largely remained within the domain of science fiction, frequently seen in film and television.

White-space spectrum for wireless

Technically, "white spaces" is a term used to indicate "those parts of the spectrum used for communication applications (like radio, television and Internet) available in a given geographical area that work without causing interference to the primary users of spectrum." It is a bit like the public walkways in a garden. For example, these walkways can accommodate about 50 people at a given time; after that there is no space for more. But these 50 could be replaced by another 50, who could walk once the previous people are done.

The primary users are the licensed users of spectrum band. They often do not use the allocated spectrum to the maximum. A device intended to use these available channels is a "white-space device" (WSD). These are designed to detect the presence of existing signals, such as TV stations and other wireless users, and to then avoid the use of these channels. Early ideas proposed including GPS receivers and programming each WSD with a database of all TV stations in an area; however, this would not have avoided other non-stationary or unlicensed users in the area, or any stations licensed or altered after the device was made. White-space devices could help find the spectrum's under-utilised aspects and make the secondary users utilise them without causing any interference to the primary users. Simply, the technology works by sensing the spectrum that remains unused and uses it to transmit wireless products.

In Microsoft's Richmond Campus, researcher Ranveer Chandra is working to harness the enormous potential of the white-space spectrum to deliver broadband wireless that help people stay better connected. His work focusses on examining how large-scale networks could be used to deliver wireless Internet over large areas. The problem is one of determining the frequencies that differ from geographical locations. Mr. Chandra's method is looking into using the GPS system to determine the location and change to backup slices of unused spectrum identified. His prototypes have already been examined by researchers from India.

Indian researchers have identified potential for shared use of the India's television white-space spectrum by several applications. Devices like mobile phones, personal media players, wi-fi cards can use the space thus identified. The Department of Telecommunications (DoT) is looking at this technology with interest, but India does not have any policy in this frequency and it is illegal to import or own any such wireless device. The analogue TV is still quite alive in our country.

Cryptography

Cryptography is the science of analysing and deciphering codes of encrypted messages. Encryption can be defined as the conversion of data into a scrambled code that can be sent across a public or private network and can be deciphered only by the end user. Encryption has long been used by militaries and governments to facilitate secret communication. It is now commonly used in protecting information within many kinds of civilian systems.

Cryptography uses two main styles or forms of encrypting data; symmetrical and asymmetrical. Symmetric encryptions, or algorithms, use the same key for encryption as they do for decryption. Other names for this type of encryption are secret-key, shared-key, and private-key. The encryption key can be loosely related to the decryption key; it does not necessarily need to be an exact copy.

Symmetric cryptography is susceptible to plain text attacks and linear cryptanalysis meaning that they are hackable and at times simple to decode. With careful planning of the coding and functions of the cryptographic process these threats can be greatly reduced. Asymmetric cryptography uses different encryption keys for encryption and decryption. In this case an end user on a network, public or private, has a pair of keys; one for encryption and one for decryption. These keys are labelled or known as a public and a private key; in this instance the private key cannot be derived from the public key.

The asymmetrical cryptography method has been proven to be secure against computationally limited intruders. The security is a mathematical definition based upon the application of said encryption. Essentially, asymmetric encryption is as good as its applied use; this is defined by the method in which the data is encrypted and for what use. The most common form of asymmetrical encryption is in the application of sending messages where the sender encodes and the receiving party decodes the message by using a random key generated by the public key of the sender.

Data mashup

A mashup is a web application that combines data from more than one source via a single, unified tool. The term implies easy, fast integration, frequently using open application programming interfaces (APIs) and data sources to produce enriched results that were not necessarily the original reason for producing the raw source data. (API is a set of routines, protocols, and tools for building software applications.) The main characteristics of data mashup are combination, visualisation, and aggregation to make existing data more useful for personal and professional use.

Mashups are often about data visualisation, but they can also be creative products of other kinds – indeed, the term "mashup" originates from the music industry – such as assorted film and music clips assembled into parodies of well-known productions, for instance. Data mashups are powerful tools for navigating and visualizing datasets; understanding connections between different dimensions such as time, distance, and location; juxtaposing data from different sources to reveal new relationships; and other purposes.

Geotagging, the practice of adding geographical metadata like latitude, longitude, altitude, and/or place names to images, websites, or other media, has already ushered in compelling forms of data mashups that illustrate the potential of this practice for education.

Mashups are very common on the Internet today, and new authoring tools are being developed that will enable non-technical users to create sophisticated products without programming. As tools like these become more robust, we will see increasing use of data mashups in teaching and learning.

Nanomedicine

Nanomedicine is the medical application of nanotechnology. Nanomedicine ranges from the medical applications of nanomaterials, to nanoelectronic biosensors, and even possible future applications of molecular nanotechnology. Current problems for nanomedicine involve understanding the issues related to toxicity and environmental impact of nanoscale materials.

An important application of nanomedicine would be in the area of drug delivery. It would involve developing nanoscale particles or molecules to improve drug bioavailability. Bioavailability refers to the presence of drug molecules where they are needed in the body and where they will do the most good. Drug delivery focusses on maximising bioavailability both at specific places in the body and over a period of time. This can potentially be achieved by molecular targeting by nanoengineered devices. It is all about targeting the molecules and delivering drugs with cell precision.

Drug delivery systems, lipid- or polymer-based nanoparticles, can be designed to improve the pharmacological and therapeutic properties of drugs. Nanoparticles have unusual properties that can be used to improve drug delivery. Where larger particles would have been cleared from the body, cells take up these nanoparticles because of their size. Complex drug delivery mechanisms are being developed, including the ability to get drugs through cell membranes and into cell cytoplasm.

A drug may cause tissue damage, but with nanoencapsulated drug delivery, regulated drug release can eliminate the problem. If a drug is cleared too quickly from the body, this could force a patient to use high doses, but with drug delivery systems clearance can be reduced. Poor biodistribution is a problem that can affect normal tissues through widespread distribution, but the particulates from nanoscale drug delivery systems can lower the volume of distribution and reduce the effect on non-target tissue. Potential nanodrugs will work by very specific and well-understood mechanisms; one of the major impacts of nanotechnology and nanoscience will be in leading development of completely new drugs with more useful behaviour and less side effects.

Biosensors

A biosensor is a device that detects, records, and transmits information regarding a physiological change or the presence of various chemical or biological materials in the environment. More technically, a biosensor is a probe that integrates a biological component, such as a whole bacterium or a biological product (e.g., an enzyme or antibody) with an electronic component to yield a measurable signal. Biosensors, which come in a large variety of sizes and shapes, are used to monitor changes in environmental conditions. They can detect and measure concentrations of specific bacteria or hazardous chemicals; they can measure acidity levels (pH). In short, biosensors can use bacteria and detect them, too.

Genetically engineered bacteria can also be useful because of their ability to monitor and divulge information about the environment. Such commonly used bacteria have been designed to give off a detectable signal, such as light, in the presence of a specific pollutant they like to eat. They may glow in the presence of toluene, a hazardous compound found in gasoline and other petroleum products. They can indicate whether an underground fuel tank is leaking or whether the site of an oil spill has been cleaned up effectively. These informer bacteria are called bioreporters.

One type of biosensor has only five components: a biological sensing element, a transducer, a signal conditioner, a data processor, and a signal generator. The essential component must produce a signal that is related to the concentration of a specific chemical or biological substance in complex systems. This component takes advantage of the ability of a biomolecule, such as an antibody or enzyme, to specifically recognize the target substance.

Bioethics

Bioethics is the discipline dealing with the ethical implications of both biological research and the applications of that research, especially in medicine. It is a newer, broader field of study that has arisen during the past twenty or thirty years. It will become increasingly more important to the future as the biological revolution opens up new powers, new choices, and new dilemmas. Practitioners of bioethics are concerned with the ethical questions that arise in the relationships among life sciences, biotechnology, medicine, politics, law, and philosophy.

Such moral issues as racial and sexual equality, human rights, and justice have become prominent, as have questions about the value of human life raised by controversies over abortion and euthanasia. The ethical implications of various developments in regard to reproduction as, for example, *in vitro* fertilisation, sperm banks, gene manipulation, and cloning, are related to the latter. This field of applied ethics, known as bioethics, frequently involves the cooperative efforts of philosophers, physicians, scientists, lawyers, and theologians.

Bioethics is concerned with questions about basic human values such as the rights to life and health, and the rightness or wrongness of certain developments in healthcare institutions, life technology, medicine, the health professions and about society's responsibility for the life and health of its members. It also involves issues relating to the beginning and end of human life, all the way from issues relating to in vitro fertilisation and abortion to euthanasia and palliative care.

Endosulfan

Endosulfan is an off-patent organochlorine pesticide that is being phased out globally. Endosulfan became a highly controversial agrichemical due to its acute toxicity, potential for bioaccumulation, and role as an endocrine disruptor. Endosulphan accumulates in organic tissue due to the inability of organisms to process often causing acute toxicity. It also causes disruption in endocrine function. Because of its threats to human health and the environment, a global ban on the manufacture and use of endosulfan was negotiated under the Stockholm Convention in April 2011. The ban will take effect in mid 2012, with certain uses exempted for 5 additional years. More than 80 countries, including the European Union, Australia and New Zealand, several West African nations, the United States, Brazil and Canada have already banned it or announced phase outs by the time the Stockholm Convention ban was agreed upon.

Endosufan is still manufactured and used extensively in India, China, and few other countries and India is currently the largest exporter of the pesticide in the world. In a major change of position at the Stockholm convention, India accepted that Endosulfan is a health hazard, but it made no commitment to ban it, although the Indian Supreme Court had put a temporary 8-week ban on its use in May 2011. The court had also directed the statutory authorities to freeze the production licences granted to the manufacturers of the controversial pesticide till its further order, and ordered two separate detailed studies on the adverse effects of Endosulfan on human life and environment by two committees, headed respectively by the Director General of Indian Council Medical Research (ICMR) and the agricultural commissioner and sought their reports within eight weeks.

The biggest worries of the Indian government is that a ban on Endosulfan would kill a domestic pesticide industry worth Rs.1,000 crore and lead to a further rise in food prices even if safer alternative are found.

Nanorobots

Nanorobotics is the emerging technology of creating machines or robots at or close to the scale of a nanometre (10^{-9} metres). Typically, an atom has a diameter of a few Ångstroms (1 Å = 0.1 nm = 10^{-10} m), a molecule's size is a few nm, and clusters or nanoparticles formed by hundreds or thousands of atoms have sizes of tens of nm. Therefore, Nanorobotics is concerned with interactions with atomic- and molecular-sized objects and is sometimes called 'molecular robotics'. More specifically, nanorobotics refers to the still largely theoretical nanotechnology engineering discipline of designing and building nanorobots.

Nanorobots (also called nanobots or nanoids) are typically devices ranging in size from 0.1-10 micrometres and constructed of nanoscale or molecular components. As no artificial non-biological nanorobots have so far been created, they remain a hypothetical concept at this time.

Another definition sometimes used is a robot which allows precision interactions with nanoscale objects, or can manipulate with nanoscale resolution. Following this definition even a large apparatus such as an atomic force microscope can be considered a nanorobotic instrument when configured to perform nanomanipulation. Also, macroscale robots or microrobots which can move with nanoscale precision can also be considered nanorobots.

Nanomachines are largely in the research-and-development phase, but some primitive molecular machines have been tested. An example is a sensor having a switch approximately 1.5 nanometers across, capable of counting specific molecules in a chemical sample. The first useful applications of nanomachines might be in medical technology, which could be used to identify and destroy cancer cells.

Touchscreens

A touchscreen is an electronic visual display that can detect the presence and location of a touch within the display area. The term generally refers to touching the display of the device with a finger or hand. Touchscreens can also sense other passive objects, such as a stylus. Touchscreens are common in devices such as all-in-one computers, tablet computers, and smartphones.

The touchscreen has two main attributes. First, it enables one to interact directly with what is displayed, rather than indirectly with a pointer controlled by a mouse or touchpad. Secondly, it lets one do so without requiring any intermediate device that would need to be held in the hand. Touchscreens first gained some visibility with the invention of the computer-assisted learning terminal, which came out in 1972. Touchscreens have subsequently become familiar in everyday life.

The development of multipoint touchscreens facilitated the tracking of more than one finger on the screen; thus, operations that require more than one finger are possible. These devices also allow multiple users to interact with the touchscreen simultaneously. Some touchscreens employed in smartphones use transparent plastic protectors to prevent any scratches that might be caused by day-to-day use from becoming permanent.

Desalination by electrodialysis

Electrodialysis is a dialysis process in which the movement of ions is aided by an electric field applied across the semi-permeable membrane. This is done in an electrodialysis cell, which consists of a feed (diluate) compartment and a concentrate (brine) compartment formed by an anion exchange membrane and a cation exchange membrane placed between two electrodes. Electrodialysis processes are different compared to distillation techniques and other membrane based processes (such as reverse osmosis) in that dissolved species are moved away from the feed stream rather than the reverse. Electrodialysis can be used to turn seawater into drinking water using less than half the energy required by the most efficient previous method.

To make seawater fit for human consumption its salt content of approximately 3.5% must be reduced to 0.5% or less. Existing desalination plants do this in one of two ways. Some employ distillation, which needs about 10 kilowatt-hours (kWh) of energy per cubic metre of seawater processed. Brine is heated, and the resulting water vapour is condensed. Other plants employ reverse osmosis. This uses molecular sieves that pass water molecules while holding back the ions such as sodium and chloride that make water salty. Generating the pressure needed to do this sieving consumes about 4kWh per cubic metre. An electrodialysis system, by contrast, consumes 1.8kWh per cubic metre, which can be further reduced to 1.5kWh.

For desalination, seawater is pumped into a series of channels walled by membranes that have slightly different properties from those used in reverse osmosis. Instead of passing water molecules, these membranes pass ions. Moreover, the membranes employed in electrodialysis are of two types. One passes positively charged ions and the other passes negatively charged ones. The two types alternate, so that each channel has one wall of each type. Two electrodes flanking the system of channels then create a voltage that pulls positively charged ions such as sodium in one direction and negatively charged ions such as chloride in the other.

The process, however, does not produce potable water in a single operation. In the first stage, the ions concentrate in half of the channels, creating strong brine, while fresher water accumulates in the other half. As the brine emerges, it is thrown away. The fresher water is put through the same process twice more and eventually has its salt concentration reduced to 1%. That is not bad, but is still double what is potable. There is therefore one further step, which is carried out using an ion-exchange resin in addition to the membranes. Such resins increase the electrical conductivity of the system and allow one more passage, bringing the salt concentration below 0.5%.

Drug-resistant "superbugs"

Some of the world's most powerful medicines are losing the war against drug-resistant strains of HIV, gonorrhoea, tuberculosis and other microbes. People assume that antibiotics will always be there to fight the worst infections, but antimicrobial resistance is robbing us of that certainty and new drug-resistant pathogens are emerging.

Antimicrobial resistance occurs when germs change in a way that reduces or eliminates the effectiveness of drugs to treat them. This happens when antibiotics, antivirals, antifungals and other medications are used too liberally. About half of antimicrobial drugs – antibiotics in particular – are often sold without prescription and used unnecessarily or inappropriately. The best approach to preserving those drugs is to use them only when needed.

Studies suggest 4 to 20 percent of newly diagnosed HIV patients have transmitted a drug-resistant infection. A 2007 study of HIV patients in the United States found one of every six newly diagnosed infections was drug-resistant. Doctors can help by testing for resistance before prescribing drugs, and patients can help by taking their drugs as prescribed and practising safe sex.

Worldwide, there were an estimated 225 million malaria infections and 780,000 deaths in 2009. Most deaths were of children in Africa. *Plasmodium falciparum*, the most dangerous of the malaria parasites, has developed resistance in nearly all areas of the world where it is transmitted.

About 12 percent of all TB cases In India reported in 2007 were multiple drug-resistant, or MDR, TB. With MDR-TB, the standard cocktail of antibiotics does not work and stronger medicines must be used, often for a longer time. Surgery may also be required to remove pockets of infection. To prevent the spread of drug-resistant TB, patients need to take all of their medications exactly as prescribed.

Other drug-resistant microbes of concern today include methicillin-resistant *Staphylococcus aureus* (MRSA) bacteria, which increasingly seen not only in hospitals and healthcare settings (hospital acquired or HA-MRSA) but also in the wider community, especially among people in close contact such as athletes.

Vancomycin-resistant *Enterococci* (VRE) bacteria are resistant to vancomycin, an antibiotic regarded as a drug of last resort. Among microbes increasingly resistant to drugs are food-borne bacteria such as *E. coli*, *Salmonella*, and *Campylobacter* that can cause diarrhoea and gastroenteritis; sexually transmitted bacteria that cause gonorrhoea; Penicillin-resistant *Streptococci* responsible for pneumonia; and influenza.

Graphene solar cells

A new device that combines graphene with special metallic nanostructures could lead to better solar cells and optical communications systems. That is the claim of researchers in the UK who have measured a 20-fold enhancement in the amount of light captured by graphene when it is covered by such nanostructures. The work provides further evidence that the material might be ideal for making photonics and optoelectronics devices, despite the fact that it does not have an electronic band gap.

Graphene also shows great promise as a candidate for photonics applications – especially optical communications, where speed is an issue. The material has an ideal "internal quantum efficiency" because almost every photon absorbed by graphene generates an electron-hole pair that could, in principle, be converted into electric current.

Researchers have also already shown that they can make basic solar cells, light-emitting devices, touch screens, photodetectors and mode-lock ultrafast lasers from graphene. The nanostructures are fabricated on top of graphene samples to concentrate the electromagnetic field in the region of the material where light is converted to electrical current, so as to dramatically increase the generated photovoltage. The new devices have an external quantum efficiency of almost 50%, the highest value to date for graphene.

GLONASS

Russia has launched a next-generation navigation satellite for its GLObal NAvigation Satellite System (GLONASS). The new satellite has a longer design life, more navigation channels and is smaller than previous GLONASS-M spacecraft. This launch will increase the deployed GLONASS grouping to 23 satellites, one short of the minimum needed to provide 100-per cent global coverage. The operational space segment of GLONASS consists of 21 satellites in 3 orbital planes, with 3 on-orbit spares. Each satellite operates in circular 19,100-km orbits at an inclination angle of 64.8 degrees and each satellite completes an orbit in approximately 11 hours 15 minutes. In December the launch of three GLONASS-M satellites failed when the carrier rocket crashed into the ocean.

GLONASS is a counterpart to the US Global Positioning System (GPS) and both systems share the same principles in the data transmission and positioning methods. It is to be integrated with the US GPS as well as with the European Union's Galileo system and China's Compass network when they are deployed. Experts said the use of a two-signal receiver that supports both GPS and GLONASS would increase reliability by 15 per cent.

Under a 2007 accord, Russia has agreed to share the GLONASS signal with India. India will be the only country to have access to the military segment of the GLONASS system, which will enable the Indian military to greatly improve the accuracy of its land-, sea-, air and space-launched weapon systems. In September the two countries signed a deal to jointly manufacture GLONASS/GPS twin system receivers and other navigational equipment.

Methane hydrates

Methane hydrate isn't a familiar term to most, but it is gaining popularity in the energy sector. In the realm of energy R&D, methane hydrates are being evaluated as a potential fuel for the future. Some believe there is enough methane in the form of hydrates – methane locked in ice – to supply energy for hundreds, maybe thousands, of years. Methane hydrates are a promising natural gas resource, which are believed to reside throughout the globe in sea-floor sediments and permafrost.

Gas hydrates are clathrate compounds. A clathrate is simply a structure in which water molecules under certain conditions bond to form an ice-like cage that encapsulates a gas molecule, known as a guest molecule. When that guest is a methane molecule, you have methane hydrate.

Methane hydrates, which form at low temperature and high pressure, are found in sea-floor sediments and the arctic permafrost. They can be scattered through several-hundred-metre depths and at various concentrations. Although some research has been carried out in the past, little is known about the location, formation, decomposition, or actual quantities of methane hydrates. However, national and international research and exploration over the last 20 years by various governmental and industrial entities have resulted in general agreement that methane hydrates should be evaluated as a potential primary energy source for the future.

Methane hydrates occur abundantly in nature, both in Arctic regions and in marine sediments. Methane hydrate is a crystalline solid consisting of gas molecules, usually methane, each surrounded by a cage of water molecules. It looks very much like water ice. Methane hydrate is stable in ocean floor sediments at water depths greater than 300 metres, and where it occurs, it is known to cement loose sediments in a surface layer several hundred metres thick. The worldwide amounts of carbon bound in methane hydrates is conservatively estimated to total twice the amount of carbon to be found in all known fossil fuels on Earth.

Since methane is a greenhouse gas, understanding methane as a primary gas or a trace gas will be important in today's climate change initiatives. Hydrates are being evaluated as a potential storage mechanism for CO_2 sequestration and for storing methane for use as a transportation fuel. Although methane when burned is a clean fuel, more information is needed on the emissions from various methane sources to fully understand its atmospheric implications.

The oil and gas industry continues to explore deeper beneath the ocean floor. Industry has concerns about drilling through hydrate zones, which can destabilise supporting foundations for platforms and production wells. The disruption to the ocean floor also could result in surface slumping or faulting, which could endanger work crews and the environment.

Carbon footprint (For General Essay as well)

Carbon footprint is a measure of the impact of our activities on the environment, and in particular on climate change. It relates to the amount of greenhouse gases we are producing in our day-to-day lives through burning fossil fuels for electricity, heating, transportation etc. Our 'carbon footprint' is a measurement of all greenhouse gases we individually produce. It is measured in units of tonnes (or kg) of carbon dioxide equivalent.

A carbon footprint is made up of the sum of two parts, the primary foot print and the secondary footprint.

1. The primary footprint is a measure of our direct emissions of CO_2 from the burning of fossil fuels including domestic energy consumption and transportation (e.g. car and plane). We have direct control of these.

The secondary footprint is a measure of the indirect CO_2 emissions from the whole lifecycle of products we use - those associated with their manufacture and eventual breakdown. To put it very simply – the more we buy the more emissions will be caused on our behalf. Our decisions on the following add up to our secondary footprint.

1. We eat vegetarian food - or non vegetarian food.
2. We buy / grow organic food - or not.
3. We use mostly seasonal food - or not.
4. We buy local food and goods - or not.
5. We buy second hand clothes – or new.
6. We think of packaging while buying things - or not.
7. We buy new furniture and appliances - or second hand
8. The things we use get recycled or composted - or not.
9. We try to avoid burning of fuel on transportation - or not.
10. We try to use common vehicles for travel - or not.
11. We bring a bag when we go shopping - or require a plastic bag from each shop

The direct consequence of increased carbon foot print is Global Warming and Climate Change. Global Warming is the gradual increase in temperature of the Earth's surface.

Over the past two decades the effect has become more marked. Considerable evidence exists that most of this warming has been caused by human activities. That is to say we have altered the chemical composition of the atmosphere through a build up of greenhouse gases – primarily carbon dioxide, methane, and nitrous oxide.

This means that a 'cloud' is building up around the earth under which heat is accumulating instead of dispersing in the atmosphere.

If we do nothing, rising global temperatures will cause sea level to rise and alter local climate conditions, affecting forests, crop yields, and water supplies. It may also affect human health, animals, and many types of ecosystems. Deserts may expand and some of our countryside may be permanently altered.

So we need to recognise our personal impact on global warming. Calculation of "Carbon Footprint" will show how to minimise our impact - starting today - and show us how to make the right product choices in the future.

The actions of individuals, companies and nations as a whole are all generating carbon emissions, which are unequivocally linked to the climate change crisis the planet is facing. The first step to taking effective action is to reduce your carbon footprint. However being totally carbon neutral through personal lifestyles changes or changes to business practices may not at present be achievable for the majority of us. What's left over after implementing low carbon practices can be offset through a variety of methods?(For Kirit Parikh report, see in Economy Updates)

Using trees to offset carbon

Tree planting has been shown to be a viable way to offset carbon emissions. However planting trees to offset carbon has been the centre of some fierce debate over the years. Nonetheless through such constructive debate the consensus is that tree planting is a valid tool to tackle climate change and one of only a few methods that actually remove existing CO2 from the atmosphere. Through quality research on carbon forestry we are now able to determine criteria that influence the success and benefits achieved through tree planting. For example low latitude tropical forests sequester far more carbon than a northern latitude temperate forest.

IRNSS

The Indian Space Research Organisation (ISRO) plans to implement the Indian Regional Navigation Satellite System (IRNSS) to provide India and neighbouring countries with the Position Navigation and Timing (PNT) service.

The government had approved the project, which would be implemented in the next few years. Initially, the system would have seven satellites and then 11.

At present, two space navigation systems operate in the world — the U.S. Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS). The Galileo of Europe and China's COMPASS (Beidou) are likely to start working in five to 10 years.

ISRO's GPS-Aided Geo Augmented Navigation (GAGAN) project was being implemented for the benefit of civil aviation. It would especially be useful in aircraft landing.

LTE

3GPP Long Term Evolution (LTE) is a standard for wireless communication of high-speed data. It is based upon GSM/EDGE and UMTS/HSPA network technologies. The standard is maintained as a project of the 3rd Generation Partnership Project (3GPP), operating under a name trademarked by one of the associations within the partnership, the European Telecommunications Standards Institute(ETSI).

The goal of LTE is to increase the capacity and speed of wireless data networks utilizing cutting-edge hardware and DSP techniques that have recently been developed. Its wireless interface is incompatible with 2G and 3G networks, and so it must be operated on separatewireless spectrum. Features of LTE include an all-IP flat network architecture, end-to-end QoS including provisions for low-latency communications, peak download rates nearing 300 mbps and upload rates of 75 mbps, capacity exceeding 200 active users per cell, the ability to manage fast-moving mobiles, and support for multi-cast and broadcast streams.

Clean coal

It is commonly used to refer to technologies for reducing emissions of ash, sulfur, and heavy metals from coal combustion; the term is now used to refer to carbon capture and storage (CCS) technology. Clean coal is an umbrella term used primarily to describe technologies that may reduce emissions of carbon dioxide (CO_2) and other greenhouse gases that arise from the burning of coal for electrical power. Typically, clean coal is used by coal companies in reference to carbon capture and storage, which pumps and stores CO_2 emissions underground, and to plants using an Integrated gasification combined cycle which gasifies coal to reduce CO_2 emissions.

National Knowledge Network

In 2010 the Government approved the establishment of the National Knowledge Network (NKN) at an outlay of Rs.5990 crore, to be implemented by National Informatics Centre (NIC) over a period of 10 years.

The objective of the National Knowledge Network is to bring together all the stakeholders in Science, Technology, Higher Education, Research & Development and Governance.

Network will consist of an ultra-high speed Core (multiples of 10Gbps and upwards), and over 1500 nodes. It is scalable to higher speed and more nodes also. The Core shall be complemented with a distribution layer at appropriate speeds. The participating institutions can directly or through distribution layer connect to the National Knowledge Network at speeds of 100 Mbps /1 Gbps.

The application areas envisaged under the National Knowledge Network cover

- Agriculture
- Education
- Health
- e-governance
- Grid Computing (High Performance Computing)

The output of the National Knowledge Network project will be a high capacity countrywide Infrastructure at education & research Institute level, to support education and research applications, and other application as envisaged by these institutions which require very high bandwidth. A high speed data communication network would be established, which would interconnect Institutions of higher learning.

National Knowledge Network will facilitate creation, acquisition and sharing of Knowledge resources among the large participating Institutions; collaborative research; country wide classrooms (CWCR) etc. and help the country to evolve as Knowledge Society.

Current Status

- A core Backbone consisting of 18 Points of Presence (PoPs) have been established with 2.5 Gbps capacity. A total 96 number of Institutions have been connected to National Knowledge Network and 15 virtual classrooms were setup.
- Trans Eurasia Information Network (TEIN3) links is integrated with National Knowledge Network.
- MoU has been signed between the National Knowledge Network (NKN), Tata Institute of Fundamental Research (TIFR) and GLORIAD (The Global ring network for advanced applications development).

Rare earths

India, Asia's third-largest economy has stepped up efforts to boost domestic production of rare earth minerals. Rare earth elements (REEs) can be used for both civilian and military purposes, including in nuclear applications. REEs such as lanthanum, cerium, neodymium, europium and yttrium are vital for a wide range of technologies like iPhones, X-ray machines and military applications like precision-guided munitions and lasers. They also show up in hybrid vehicles and wind turbines.

REEs are also used in many modern technological devices, including superconductors, samarium-cobalt and neodymium-iron-boron high-flux rare-earth magnets, electronic polishers, and refining catalysts. Phosphorus with rare earth dopants is also widely used in cathode ray tube technology such as television sets.

China is currently responsible for about 97 percent of the world's rare-earth production. However, deposits are also found in India, the US, Australia, Greenland and Canada, but these countries produced no material last year. In 2009, India, which was second to China in rare earth ore production, producing 2,700 tons compared to China's 129,000 tons.

In India, rare earths are found in monosites, which are reserved for the Department of Atomic Energy. Its mining unit, Indian Rare Earth, had stopped production of rare earths in 2004, not having operated since. Currently, Indian Rare Earth is setting up a processing plant in Chhatrapur in Orissa with capacity to produce 11,000 tons of rare earth chloride. The plant will be operational by early 2012.

In China, rare earths are also found in non-radioactive bastnasite. In India, the exploration mandate for bastnasite lies with the Geological Survey of India. Reports suggest that most of the China's supply of rare earths comes from a single mine near the city of Baotou, which is located in Inner Mongolia.

Toyota Tsusho, a part of Toyoto Motors, is setting up a rare earth processing plant in Vishakapatnam in the south Indian state of Andhra Pradesh; with a partial supply of mixed rare earth chloride from Indian Rare Earths. German chemical giant BASF and Indian Oil Corporation are have announced plans to produce rare earth minerals from catalysts used in the petroleum refinery sector.

The free-trade agreement with Japan(Cepa) also includes provisions that could make it easier for Japanese companies to invest in the development of rare earths in India. Japan's technology industry makes it the world's largest importer of rare earths, needed for products from mobile phones to military hardware. It has sought alternative supplies since China reduced shipments last year. China produces 97% of the minerals.

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1. CELLULAR ORGANIZATION

Life exhibits varying degrees of organization. Atoms are organized into molecules, molecules into organelles, and organelles into cells, and so on. According to the Cell Theory, all living things are composed of one or more cells, and the functions of a multicellular organism are a consequence of the types of cells it has. Cells fall into two broad groups: prokaryotes and eukaryotes. Prokaryotic cells are smaller (as a general rule) and lack much of the internal compartmentalization and complexity of eukaryotic cells. No matter which type of cell we are considering, all cells have certain features in common, such as a cell membrane, DNA and RNA, cytoplasm, and ribosomes. Eukaryotic cells have a great variety of organelles and structures.

Cell Size and Shape

The shapes of cells are quite varied with some, such as neurons, being longer than they are wide and others, such as parenchyma (a common type of plant cell) and erythrocytes (red blood cells) being equidimensional. Some cells are encased in a rigid wall, which constrains their shape, while others have a flexible cell membrane (and no rigid cell wall).

The size of cells is also related to their functions. Eggs (or to use the latin word, *ova*) are very large, often being the largest cells an organism produces. The large size of many eggs is related to the process of development that occurs after the egg is fertilized, when the contents of the egg (now termed a zygote) are used in a rapid series of cellular divisions, each requiring tremendous amounts of energy that is available in the zygote cells.

Cells range in size from small bacteria to large, unfertilized eggs laid by birds and dinosaurs.

The Cell Membrane

The cell membrane functions as a semi-permeable barrier, allowing a very few molecules across it while fencing the majority of organically produced chemicals inside the cell.

Cholesterol aids in the flexibility of a cell membrane. proteins function as gateways that will allow certain molecules to cross into and out of the cell by moving through open areas of the protein channel. These integral proteins are sometimes known as gateway proteins. The outer surface of the membrane will tend to be rich in glycolipids, which have their hydrophobic tails embedded in the hydrophobic region of the membrane and their heads exposed outside the cell. These, along with carbohydrates attached to the integral proteins, are thought to function in the recognition of self, a sort of cellular identification system.

The contents (both chemical and organelles) of the cell are termed protoplasm, and are further subdivided into cytoplasm (all of the protoplasm except the contents of the nucleus) and nucleoplasm (all of the material, plasma and DNA etc., within the nucleus).

The Cell Wall

Not all living things have cell walls, most notably animals and many of the more animal-like protistans. Bacteria have cell walls containing the chemical peptidoglycan. Plant cells have a variety of chemicals incorporated in their cell walls. Cellulose, a nondigestible (to humans anyway) polysaccharide is the most common chemical in the plant primary cell wall. Some plant cells also have lignin and other chemicals embedded in their secondary walls.

The cell wall is located outside the plasma membrane. Plasmodesmata are connections through which cells communicate chemically with each other through their thick walls. Fungi and many protists have cell walls although they do not contain cellulose, rather a variety of chemicals (chitin for fungi).

Animal cells lack a cell wall, and must instead rely on their cell membrane to maintain the integrity of the cell. Many protistans also lack cell walls, using variously modified cell membranes o act as a boundary to the inside of the cell.

The nucleus

The nucleus occurs only in eukaryotic cells. It is the location for most of the nucleic acids a cell makes, such as DNA and RNA. Deoxyribonucleic acid, DNA, is the physical carrier of inheritance and with the exception of plastid DNA (cpDNA and mDNA, found in the chloroplast and mitochondrion respectively) all DNA is restricted to the nucleus. Ribonucleic acid, RNA, is formed in the nucleus using the DNA base sequence as a template. RNA moves out into the cytoplasm where it functions in the assembly of proteins. The nucleolus is an area of the nucleus (usually two nucleoli per nucleus) where ribosomes are constructed. The nuclear envelope is a double-membrane structure. Numerous pores occur in the envelope, allowing RNA and other chemicals to pass, but the DNA not to pass.

Cytoplasm

The cytoplasm was defined earlier as the material between the plasma membrane (cell membrane) and the nuclear envelope. Fibrous proteins that occur in the cytoplasm referred to as the cytoskeleton maintain the shape of the cell as well as anchoring organelles, moving the cell and controlling internal movement of structures. Microtubules function in cell division and serve as a "temporary scaffolding" for other organelles. Actin filaments are thin threads that function in cell division and cell motility. Intermediate filaments are between the size of the microtubules and the actin filaments.

Vacuoles and vesicles

Vacuoles are single-membrane organelles that are essentially part of the outside that is located within the cell. The single membrane is known in plant cells as a tonoplast. Many organisms will use vacuoles as storage areas. Vesicles are much smaller than vacuoles and function in transporting materials both within and to the outside of the cell.

Ribosomes

Ribosomes are the sites of protein synthesis. They are not membrane-bound and thus occur in both prokaryotes and eukaryotes. Eukaryotic ribosomes are slightly larger than prokaryotic ones. Biochemically, the ribosome consists of ribosomal RNA (rRNA) and some 50 structural proteins. Often ribosomes cluster on the endoplasmic reticulum, in which case they resemble a series of factories adjoining a railroad line .

Endoplasmic reticulum

Endoplasmic reticulum is a mesh of interconnected membranes that serve a function involving protein synthesis and transport. Rough endoplasmic reticulum (Rough ER) is so-named because of its rough appearance due to the numerous ribosomes that occur along the ER. Rough ER connects to the nuclear envelope through which the messenger RNA (mRNA) that is the blueprint for proteins travels to the ribosomes. Smooth ER; lacks the ribosomes characteristic of Rough ER and is thought to be involved in transport and a variety of other functions.

Golgi Apparatus

Golgi Complexes are flattened stacks of membrane-bound sacs. Italian biologist Camillo Golgi discovered these structures in the late 1890s, although their precise role in the cell was not deciphered until the mid-1900s . Golgi function as a packaging plant, modifying vesicles produced by the rough endoplasmic reticulum. New membrane material is assembled in various cisternae (layers) of the golgi.

Lysosomes

Lysosomesare relatively large vesicles formed by the Golgi. They contain hydrolytic enzymes that could destroy the cell. Lysosome contents function in the extracellular breakdown of materials.

Mitochondria

Mitochondria contain their own DNA (termed mDNA) and are thought to represent bacteria-like organisms incorporated into eukaryotic cells over 700 million years ago (perhaps even as far back as 1.5 billion years ago). They function as the sites of energy release (following glycolysis in the cytoplasm) and ATP formation (by chemiosmosis). The mitochondrion has been termed the powerhouse of the cell...

Plastids

Plastids are also membrane-bound organelles that only occur in plants and photosynthetic eukaryotes. Leucoplasts, also known as amyloplasts store starch, as well as sometimes protein or oils. Chromoplasts store pigments associated with the bright colors of flowers and/or fruits. Chloroplasts are the sites of photosynthesis in eukaryotes. They contain chlorophyll, the green pigment necessary for photosynthesis to occur, and associated accessory pigments (carotenes and xanthophylls) in photosystems embedded in membranous sacs, thylakoids (collectively a stack of thylakoids are a granum [plural = grana]) floating in a fluid termed the stroma. Chloroplasts contain many different types of accessory pigments, depending on the taxonomic group of the organism being observed.

Cell Movement

Cell movement; is both internal, referred to as cytoplasmic streaming, and external, referred to as motility. Internal movements of organelles are governed by actin filaments and other components of the cytoskeleton. These filaments make an area in which organelles such as chloroplasts can move. Internal movement is known as cytoplasmic streaming. External movement of cells is determined by special organelles for locomotion.

In animal cells and most protists, a structure known as a centrosome occurs. The centrosome contains two centrioles lying at right angles to each other. Centrioles are short cylinders with a 9 + 0 pattern of microtubule triplets. Centrioles serve as basal bodies for cilia and flagella. Plant and fungal cells have a structure equivalent to a centrosome, although it does not contain centrioles.

Cilia are short, usually numerous, hairlike projections that can move in an undulating fashion (e.g., the protzoan *Paramecium*, the cells lining the human upper respiratory tract). Flagella are longer, usually fewer in number, projections that move in whip-like fashion (e.g., sperm cells). Cilia and flagella are similar except for length, cilia being much shorter. They both have the characteristic 9 + 2 arrangement of microtubules Cilia and flagella move when the microtubules slide past one another. Both of these locomotion structures have a basal body at base with the same arrangement of microtubule triples as centrioles. Cilia and flagella grow by the addition of tubulin dimers to their tips.

Flagella work as whips pulling (as in *Chlamydomonas* or *Halosphaera*) or pushing (dinoflagellates, a group of single-celled Protista) the organism through the water. Cilia work like oars on a viking longship (*Paramecium* has 17,000 such oars covering its outer surface).

Not all cells use cilia or flagella for movement. Some, such as *Amoeba*, *Chaos (Pelomyxa)* and human leukocytes (white blood cells), employ pseudopodia to move the cell. Unlike cilia and flagella, pseudopodia are not structures, but rather are associated with actin near the moving edge of the cell.

2. TRANSPORT IN AND OUT OF CELLS

Water and Solute Movement

Cell membranes act as barriers to most, but not all, molecules. Development of a cell membrane that could allow some materials to pass while constraining the movement of other molecules was a major step in the evolution of the cell. Cell membranes are differentially (or semi-) permeable barriers separating the inner cellular environment from the outer cellular (or external) environment.

Water molecules move according to differences in potential energy between where they are and where they are going. Gravity and pressure are two enabling forces for this movement.

Diffusion is the net movement of a substance (liquid or gas) from an area of higher concentration to one of lower concentration. Since the molecules of any substance (solid, liquid, or gas) are in motion when that substance is above absolute zero (0 degrees Kelvin or -273 degrees C), energy is available for movement of the molecules from a higher potential state to a lower potential state, just as in the case of the water discussed above. The majority of the molecules move from higher to lower concentration, although there will be some that move from low to high.

Cells and Diffusion

Water, carbon dioxide, and oxygen are among the few simple molecules that can cross the cell membrane by diffusion (or a type of diffusion known as osmosis). Diffusion is one principle method of movement of substances within cells, as well as the method for essential small molecules to cross the cell membrane. Gas exchange in gills and lungs operates by this process. Carbon dioxide is produced by all cells as a result of cellular metabolic processes. Since the source is inside the cell, the concentration gradient is constantly being replenished/re-elevated, thus the net flow of CO_2 is out of the cell. Metabolic processes in animals and plants usually require oxygen, which is in lower concentration inside the cell, thus the net flow of oxygen is into the cell.

Osmosis is the diffusion of water across a semi-permeable (or differentially permeable or selectively permeable) membrane. The cell membrane, along with such things as dialysis tubing and cellulose acetate sausage casing, is such a membrane. The presence of a solute decreases the water potential of a substance. Thus there is more water per unit of volume in a glass of fresh-water than there is in an equivalent volume of sea-water. In a cell, which has so many organelles and other large molecules, the water flow is generally into the cell.

Hypertonic solutions are those in which more solute (and hence lower water potential) is present. Hypotonic solutions are those with less solute (again read as higher water potential). Isotonic solutions have equal (iso-) concentrations of substances. Water potentials are thus equal, although there will still be equal amounts of water movement in and out of the cell, the net flow is zero.

Active and Passive Transport

Passive transport requires no energy from the cell. Examples include the diffusion of oxygen and carbon dioxide, osmosis of water, and facilitated diffusion.

Active transport requires the cell to spend energy, usually in the form of ATP. Examples include transport of large molecules (non-lipid soluble) and the sodium-potassium pump.

Vesicle-mediated transport

Vesicles and vacuoles that fuse with the cell membrane may be utilized to release or transport chemicals out of the cell or to allow them to enter a cell. Exocytosis is the term applied when transport is out of the cell..

Endocytosis is the case when a molecule causes the cell membrane to bulge inward, forming a vesicle. Phagocytosis is the type of endocytosis where an entire cell is engulfed. Pinocytosis is when the external fluid is engulfed. Receptor-mediated endocytosis occurs when the material to be transported binds to certain specific molecules in the membrane. Examples include the transport of insulin and cholesterol into animal cells.

3. CELL DIVISION: BINARY FISSION AND MITOSIS

The Cell Cycle

Despite differences between prokaryotes and eukaryotes, there are several common features in their cell division processes. Replication of the DNA must occur. Segregation of the "original" and its "replica" follow. Cytokinesis ends the cell division process. Whether the cell was eukaryotic or prokaryotic, these basic events must occur.

Cytokinesis is the process where one cell splits off from its sister cell. It usually occurs after cell division. The Cell Cycle is the sequence of growth, DNA replication, growth and cell division that all cells go through. Beginning after cytokinesis, the daughter cells are quite small and low on ATP. They acquire ATP and increase in size during the G1 phase of Interphase. Most cells are observed in Interphase, the longest part of the cell cycle. After acquiring sufficient size and ATP, the cells then undergo DNA Synthesis (replication of the original DNA molecules, making identical copies, one "new molecule" eventually destined for each new cell) which occurs during the S phase. Since the formation of new DNA is an energy draining process, the cell undergoes a second growth and energy acquisition stage, the G2 phase. The energy acquired during G2 is used in cell division (in this case mitosis).

Regulation of the cell cycle is accomplished in several ways. Some cells divide rapidly (beans, for example take 19 hours for the complete cycle; red blood cells must divide at a rate of 2.5 million per second). Others, such as nerve cells, lose their capability to divide once they reach maturity. Some cells, such as liver cells, retain but do not normally utilize their capacity for division. Liver cells will divide if part of the liver is removed. The division continues until the liver reaches its former size.

Cancer cells are those which undergo a series of rapid divisions such that the daughter cells divide before they have reached "functional maturity". Environmental factors such as changes in temperature and pH, and declining nutrient levels lead to declining cell division rates. When cells stop dividing, they stop usually at a point late in the G1 phase, the R point (for restriction).

Prokaryotic Cell Division

Prokaryotes are much simpler in their organization than are eukaryotes. There are a great many more organelles in eukaryotes, also more chromosomes. The usual method of prokaryote cell division is termed binary fission. The prokaryotic chromosome is a single DNA molecule that first replicates, then attaches each copy to a different part of the cell membrane. When the cell begins to pull apart, the replicate and original chromosomes are separated. Following cell splitting (cytokinesis), there are then two cells of identical genetic composition (except for the rare chance of a spontaneous mutation).

Eukaryotic Cell Division

Due to their increased numbers of chromosomes, organelles and complexity, eukaryote cell division is more complicated, although the same processes of replication, segregation, and cytokinesis still occur.

Mitosis

Mitosis is the process of forming (generally) identical daughter cells by replicating and dividing the original chromosomes, in effect making a cellular xerox. Commonly the two processes of cell division are confused. Mitosis deals only with the segregation of the chromosomes and organelles into daughter cells.

Eukaryotic chromosomes occur in the cell in greater numbers than prokaryotic chromosomes. The condensed replicated chromosomes have several points of interest. The kinetochore is the point where microtubules of the spindle apparatus attach. Replicated chromosomes consist of two molecules of DNA (along with their associated histone proteins) known as chromatids. The area where both chromatids are in contact with each other is known as the centromere the kinetochores are on the outer sides of the centromere. Remember that chromosomes are condensed chromatin (DNA plus histone proteins).

During mitosis replicated chromosomes are positioned near the middle of the cytoplasm and then segregated so that each daughter cell receives a copy of the original DNA (if you start with 46 in the parent cell, you should end up with 46 chromosomes in each daughter cell). To do this cells utilize microtubules (referred to as the spindle apparatus) to "pull" chromosomes into each "cell". The microtubules have the 9+2 arrangement discussed earlier. Animal cells (except for a group of worms known as nematodes) have a centriole. Plants and most other eukaryotic organisms lack centrioles. Prokaryotes, of course, lack spindles and centrioles; the cell membrane assumes this function when it pulls the by-then replicated chromosomes apart during binary fission. Cells that contain centrioles also have a series of smaller microtubules, the aster, that extend from the centrioles to the cell membrane. The aster is thought to serve as a brace for the functioning of the spindle fibers. The phases of mitosis are sometimes difficult to separate. Remember that the process is a dynamic one, not the static process displayed of necessity in a textbook

Different phases of Mitosis

1. Prophase

Prophase is the first stage of mitosis proper. Chromatin condenses (remember that chromatin/DNA replicate during Interphase), the nuclear envelope dissolves, centrioles (if present) divide and migrate, kinetochores and kinetochore fibers form, and the spindle forms.

2. Metaphase

Metaphase follows Prophase. The chromosomes (which at this point consist of chromatids held together by a centromere) migrate to the equator of the spindle, where the spindles attach to the kinetochore fibers.

3. Anaphase

Anaphase begins with the separation of the centromeres, and the pulling of chromosomes (we call them chromosomes after the centromeres are separated) to opposite poles of the spindle.

4. Telophase

Telophase is when the chromosomes reach the poles of their respective spindles, the nuclear envelope reforms, chromosomes uncoil into chromatin form, and the nucleolus (which had disappeared during Prophase) reform. Where there was one cell there are now two smaller cells each with exactly the same genetic information. These cells may then develop into different adult forms via the processes of development.

5. Cytokinesis

Cytokinesis is the process of splitting the daughter cells apart. Whereas mitosis is the division of the nucleus, cytokinesis is the splitting of the cytoplasm and allocation of the golgi, plastids and cytoplasm into each new cell.

MEIOSIS AND SEXUAL REPRODUCTION

Meiosis

Sexual reproduction occurs only in eukaryotes. During the formation of gametes, the number of chromosomes is reduced by half, and returned to the full amount when the two gametes fuse during fertilization.

Ploidy

Haploid and diploid are terms referring to the number of sets of chromosomes in a cell. Gregor Mendel determined his peas had two sets of alleles, one from each parent. Diploid organisms are those with two (di) sets. Human beings (except for their gametes), most animals and many plants are diploid. We abbreviate diploid as 2n. Ploidy is a term referring to the number of sets of chromosomes. Haploid organisms/cells have only one set of chromosomes, abbreviated as n. Organisms with more than two sets of chromosomes are termed polyploid. Chromosomes that carry the same genes are termed homologous chromosomes. The alleles on homologous chromosomes may differ, as in the case of heterozygous individuals. Organisms (normally) receive one set of homologous chromosomes from each parent.

Meiosis is a special type of nuclear division which segregates one copy of each homologous chromosome into each new "gamete". Mitosis maintains the cell's original ploidy level (for example, one diploid 2n cell producing two diploid 2n cells; one haploid n cell producing two haploid n cells; etc.). Meiosis, on the other hand, reduces the number of sets of chromosomes by half, so that when gametic recombination (fertilization) occurs the ploidy of the parents will be reestablished.

Most cells in the human body are produced by mitosis. These are the somatic (or vegetative) line cells. Cells that become gametes are referred to as germ line cells. The vast majority of cell divisions in the human body are mitotic, with meiosis being restricted to the gonads.

Life Cycles

Life cycles are a diagrammatic representation of the events in the organism's development and reproduction. When interpreting life cycles, pay close attention to the ploidy level of particular parts of the cycle and where in the life cycle meiosis occurs. For example, animal life cycles have a dominant diploid phase, with the gametic (haploid) phase being a relative few cells. Most of the cells in your body are diploid, germ line diploid cells will undergo meiosis to produce gametes, with fertilization closely following meiosis.

Plant life cycles have two sequential phases that are termed alternation of generations. The sporophyte phase is "diploid", and is that part of the life cycle in which meiosis occurs. However, many plant species are thought to arise by polyploidy, and the use of "diploid" in the last sentence was meant to indicate that the greater number of chromosome sets occur in this phase. The gametophyte phase is "haploid", and is the part of the life cycle in which gametes are produced (by mitosis of haploid cells). In flowering plants (angiosperms) the multicelled visible plant (leaf, stem, etc.) is sporophyte, while pollen and ovaries contain the male and female gametophytes, respectively. Plant life cycles differ from animal ones by adding a phase (the haploid gametophyte) after meiosis and before the production of gametes.

Many protists and fungi have a haploid dominated life cycle. The dominant phase is haploid, while the diploid phase is only a few cells (often only the single celled zygote, as in *Chlamydomonas*). Many protists reproduce by mitosis until their environment deteriorates, then they undergo sexual reproduction to produce a resting zygotic cyst.

Phases of Meiosis

Two successive nuclear divisions occur, Meiosis I (Reduction) and Meiosis II (Division). Meiosis produces 4 haploid cells. Mitosis produces 2 diploid cells. The old name for meiosis was reduction/ division. Meiosis I reduces the ploidy level from 2n to n (reduction) while Meiosis II divides the remaining set of chromosomes in a mitosis-like process (division). Most of the differences between the processes occur during Meiosis I.

Gametogenesis

Gametogenesis is the process of forming gametes (by definition haploid, n) from diploid cells of the germ line. Spermatogenesis is the process of forming sperm cells by meiosis (in animals, by mitosis in plants) in specialized organs known as gonads (in males these are termed testes). After division the cells undergo differentiation to become sperm cells. Oogenesis is the process of forming an ovum (egg) by meiosis (in animals, by mitosis in the gametophyte in plants) in specialized gonads known as ovaries. Whereas in spermatogenesis all 4 meiotic products develop into gametes, oogenesis places most of the cytoplasm into the large egg. The other cells, the polar bodies, do not develop. This all the cytoplasm and organelles go into the egg. Human males produce 200,000,000 sperm per day, while the female produces one egg (usually) each menstrual cycle.

4. CELLULAR METABOLISM AND FERMENTATION

Glycolysis

Nine reactions, each catalyzed by a specific enzyme, makeup the process we call glycolysis. ALL organisms have glycolysis occurring in their cytoplasm.

At steps 1 and 3 ATP is converted into ADP, inputting energy into the reaction as well as attaching a phosphate to the glucose. At steps 6 and 9 ADP is converted into the higher energy ATP. At step 5 NAD^+ is converted into NADH + H^+.

The process works on glucose, a 6-C, until step 4 splits the 6-C into two 3-C compounds. Glyceraldehyde phosphate (GAP, also known as phosphoglyceraldehyde, PGAL) is the more readily used of the two. Dihydroxyacetone phosphate can be converted into GAP by the enzyme Isomerase. The end of the glycolysis process yields two pyruvic acid (3-C) molecules, and a net gain of 2 ATP and two NADH per glucose.

Anaerobic Pathways

Under anaerobic conditions, the absence of oxygen, pyruvic acid can be routed by the organism into one of three pathways: lactic acid fermentation, alcohol fermentation, or cellular (anaerobic) respiration. Humans cannot ferment alcohol in their own bodies, we lack the genetic information to do so. These biochemical pathways, with their myriad reactions catalyzed by reaction-specific enzymes all under genetic control, are extremely complex. Alcohol fermentation is the formation of alcohol from sugar. Yeast, when under anaerobic conditions, convert glucose to pyruvic acid via the glycolysis pathways, then go one step farther, converting pyruvic acid into ethanol, a C-2 compound.

Many organisms will also ferment pyruvic acid into, other chemicals, such as lactic acid. Humans ferment lactic acid in muscles where oxygen becomes depleted, resulting in localized anaerobic conditions. This lactic acid causes the muscle stiffness couch-potatoes feel after beginning exercise programs. The stiffness goes away after a few days since the cessation of strenuous activity allows aerobic conditions to return to the muscle, and the lactic acid can be converted into ATP via the normal aerobic respiration pathways.

Aerobic Respiration

When oxygen is present (aerobic conditions), most organisms will undergo two more steps, Kreb's Cycle, and Electron Transport, to produce their ATP. In eukaryotes, these processes occur in the mitochondria, while in prokaryotes they occur in the cytoplasm.

Acetyl Co-A: The Transition Reaction

Pyruvic acid is first altered in the transition reaction by removal of a carbon and two oxygens (which form carbon dioxide). When the carbon dioxide is removed, energy is given off, and NAD+ is converted into the higher energy form NADH. Coenzyme A attaches to the remaining 2-C (acetyl) unit, forming acetyl Co-A. This process is a prelude to the Kreb's Cycle.

Kreb's Cycle (Citric Acid Cycle)

The Acetyl Co-A (2-C) is attached to a 4-C chemical (oxaloacetic acid). The Co-A is released and returns to await another pyruvic acid. The 2-C and 4-C make another chemical known as Citric acid, a 6-C. Kreb's Cycle is also known as the Citric Acid Cycle. The process after Citric Acid is essentially removing carbon dioxide, getting out energy in the form of ATP, GTP, NADH and $FADH_2$, and lastly regenerating the cycle. Between Isocitric Acid and □-Ketoglutaric Acid, carbon dioxide is given off and NAD+ is converted into NADH. Between □-Ketoglutaric Acid and Succinic Acid the release of carbon dioxide and reduction of NAD^+ into NADH happens again, resulting in a 4-C chemical, succinic acid. GTP (Guanine Triphosphate, which transfers its energy to ATP) is also formed here (GTP is formed by attaching a phosphate to GDP).

The remaining energy carrier-generating steps involve the shifting of atomic arrangements within the 4-C molecules. Between Succinic Acid and Fumaric Acid, the molecular shifting releases not enough energy to make ATP or NADH outright, but instead this energy is captured by a new energy carrier, Flavin adenine dinucleotide (FAD). FAD is reduced by the addition of two H's to become $FADH_2$. $FADH_2$ is not as rich an energy carrier as NADH, yielding less ATP than the latter.

The last step, between Malic Acid and Oxaloacetic Acid reforms OA to complete the cycle. Energy is given off and trapped by the reduction of NAD^+ to NADH. The carbon dioxide released by cells is generated by the Kreb's Cycle, as are the energy carriers (NADH and $FADH_2$) which play a role in the next step.

Electron Transport Phosphorylation

Whereas Kreb's Cycle occurs in the matrix of the mitochondrion, the Electron Transport System (ETS) chemicals are embedded in the membranes known as the cristae. Kreb's cycle completely oxidized the carbons in the pyruvic acids, producing a small amount of ATP, and reducing NAD and FAD into higher energy forms. In the ETS, those higher energy forms are cashed in, producing ATP. Cytochromes are molecules that pass the "hot potatoes" (electrons) along the ETS chain. Energy released by the "downhill" passage of electrons is captured as ATP by ADP molecules. The ADP is reduced by the gain of electrons. ATP formed in this way is made by the process of oxidative phosphorylation. The mechanism for the oxidative phosphorylation process is the gradient of H^+ ions discovered across the inner mitochondrial membrane. This mechanism is known as chemiosmotic coupling. This involves both chemical and transport processes. Drops in the potential energy of electrons moving down the ETS chain occur at three points. These points turn out to be where ADP + P are converted into ATP. Potential energy is captured by ADP and stored in the pyrophosphate bond. NADH enters the ETS chain at the beginning, yielding 3 ATP per NADH. $FADH_2$ enters at Co-Q, producing only 2 ATP per $FADH_2$.

5. PHOTOSYNTHESIS

Photosynthesis is the process by which plants, some bacteria, and some protistans use the energy from sunlight to produce sugar, which cellular respiration converts into ATP, the "fuel" used by all living things. The conversion of unusable sunlight energy into usable chemical energy, is associated with the actions of the green pigment chlorophyll. Most of the time, the photosynthetic process uses water and releases the oxygen that we absolutely must have to stay alive. We can write the overall reaction of this process as:

$6H_2O + 6CO_2$ ----------> $C_6H_{12}O_6 + 6O_2$

Leaves and Leaf Structure

Plants are the only photosynthetic organisms to have leaves (and not all plants have leaves). A leaf may be viewed as a solar collector crammed full of photosynthetic cells.

The raw materials of photosynthesis, water and carbon dioxide, enter the cells of the leaf, and the products of photosynthesis, sugar and oxygen, leave the leaf

Water enters the root and is transported up to the leaves through specialized plant cells known as xylem (pronounces zigh-lem). Land plants must guard against drying out (desiccation) and so have evolved specialized structures known as stomata to allow gas to enter and leave the leaf. Carbon dioxide cannot pass through the protective waxy layer covering the leaf (cuticle), but it can enter the leaf through an opening (the stoma; plural = stomata; Greek for hole) flanked by two guard cells. Likewise, oxygen produced during photosynthesis can only pass out of the leaf through the opened stomata. Unfortunately for the plant, while these gases are moving between the inside and outside of the leaf, a great deal water is also lost. Cottonwood trees, for example, will lose 100 gallons of water per hour during hot desert days. Carbon dioxide enters single-celled and aquatic autotrophs through no specialized structures.

Chlorophyll and Accessory Pigments

A pigment is any substance that absorbs light. The color of the pigment comes from the wavelengths of light reflected (in other words, those not absorbed). Chlorophyll, the green pigment common to all photosynthetic cells, absorbs all wavelengths of visible light except green, which it reflects to be detected by our eyes. Black pigments absorb all of the wavelengths that strike them. White pigments/lighter colors reflect all or almost all of the energy striking them. Pigments have their own characteristic absorption spectra, the absorption pattern of a given pigment

Chlorophyll is a complex molecule. Several modifications of chlorophyll occur among plants and other photosynthetic organisms. All photosynthetic organisms (plants, certain protistans, prochlorobacteria, and cyanobacteria) have chlorophyll a. Accessory pigments absorb energy that chlorophyll a does not absorb. Accessory pigments include chlorophyll b (also c, d, and e in algae and protistans), xanthophylls, and carotenoids (such as beta-carotene). Chlorophyll a absorbs its energy from the Violet-Blue and Reddish orange-Red wavelengths, and little from the intermediate (Green-Yellow-Orange) wavelengths

Carotenoids and chlorophyll b absorb some of the energy in the green wavelength. Why not so much in the orange and yellow wavelengths? Both chlorophylls also absorb in the orange-red end of the spectrum (with longer wavelengths and lower energy). The origins of photosynthetic organisms in the sea may account for this. Shorter wavelengths (with more energy) do not penetrate much below 5 meters deep in sea water. The ability to absorb some energy from the longer (hence more penetrating) wavelengths might have been an advantage to early photosynthetic algae that were not able to be in the upper (photic) zone of the sea all the time.

The action spectrum of photosynthesis is the relative effectiveness of different wavelengths of light at generating electrons. If a pigment absorbs light energy, one of three things will occur. Energy is dissipated as heat. The energy may be emitted immediately as a longer wavelength, a phenomenon known as fluorescence. Energy may trigger a chemical reaction, as in photosynthesis. Chlorophyll only triggers a chemical reaction when it is associated with proteins embedded in a membrane (as in a chloroplast) or the membrane infoldings found in photosynthetic prokaryotes such as cyanobacteria and prochlorobacteria.

Stages of Photosynthesis

Photosynthesis is a two stage process. The first process is the Light Dependent Process (Light Reactions), requires the direct energy of light to make energy carrier molecules that are used in the second process. The Light Independent Process (or Dark Reactions) occurs when the products of the Light Reaction are used to form C-C covalent bonds of carbohydrates. The Dark Reactions can usually occur in the dark, if the energy carriers from the light process are present. Recent evidence suggests that a major enzyme of the Dark Reaction is indirectly stimulated by light, thus the term Dark Reaction is somewhat of a misnomer. The Light Reactions occur in the grana and the Dark Reactions take place in the stroma of the chloroplasts.

Light Reactions

In the Light Dependent Processes (Light Reactions) light strikes chlorophyll a in such a way as to excite electrons to a higher energy state. In a series of reactions the energy is converted (along an electron transport process) into ATP and NADPH. Water is split in the process, releasing oxygen as a by-product of the reaction. The ATP and NADPH are used to make C-C bonds in the Light Independent Process (Dark Reactions).

In the Light Independent Process, carbon dioxide from the atmosphere (or water for aquatic/marine organisms) is captured and modified by the addition of Hydrogen to form carbohydrates (general formula of carbohydrates is $[CH_2O]_n$). The incorporation of carbon dioxide into organic compounds is known as carbon fixation. The energy for this comes from the first phase of the photosynthetic process. Living systems cannot directly utilize light energy, but can, through a complicated series of reactions, convert it into C-C bond energy that can be released by glycolysis and other metabolic processes.

Photosystems are arrangements of chlorophyll and other pigments packed into thylakoids. Many Prokaryotes have only one photosystem, Photosystem II (so numbered because, while it was most likely the first to evolve, it was the second one discovered). Eukaryotes have Photosystem II plus Photosystem I. Photosystem I uses chlorophyll a, in the form referred to as P700. Photosystem II uses a form of chlorophyll a known as P680. Both "active" forms of chlorophyll a function in photosynthesis due to their association with proteins in the thylakoid membrane

Photophosphorylation is the process of converting energy from a light-excited electron into the pyrophosphate bond of an ADP molecule. This occurs when the electrons from water are excited by the light in the presence of P680. The energy transfer is similar to the chemiosmotic electron transport occurring in the mitochondria. Light energy causes the removal of an electron from a molecule of P680 that is part of Photosystem II. The P680 requires an electron, which is taken from a water molecule, breaking the water into H^+ ions and O^{-2} ions. These O^{-2} ions combine to form the diatomic O_2 that is released. The electron is "boosted" to a higher energy state and attached to a primary electron acceptor, which begins a series of redox reactions, passing the electron through a series of electron carriers, eventually attaching it to a molecule in Photosystem I. Light acts on a molecule of P700 in Photosystem I, causing an electron to be "boosted" to a still higher potential.

The electron is attached to a different primary electron acceptor (that is a different molecule from the one associated with Photosystem II). The electron is passed again through a series of redox reactions, eventually being attached to $NADP^+$ and H^+ to form NADPH, an energy carrier needed in the Light Independent Reaction. The electron from Photosystem II replaces the excited electron in the P700 molecule. There is thus a continuous flow of electrons from water to NADPH. This energy is used in Carbon Fixation. Cyclic Electron Flow occurs in some eukaryotes and primitive photosynthetic bacteria. No NADPH is produced, only ATP. This occurs when cells may require additional ATP, or when there is no $NADP^+$ to reduce to NADPH. In Photosystem II, the pumping to H ions into the thylakoid and the conversion of ADP + P into ATP is driven by electron gradients established in the thylakoid membrane.

Halobacteria, which grow in extremely salty water, are facultative aerobes, they can grow when oxygen is absent. Purple pigments, known as retinal (a pigment also found in the human eye) act similar to chlorophyll. The complex of retinal and membrane proteins is known as bacteriorhodopsin, which generates electrons which establish a proton gradient that powers an ADP-ATP pump, generating ATP from sunlight without chlorophyll. This supports the theory that chemiosmotic processes are universal in their ability to generate ATP.

Dark Reaction

Carbon-Fixing Reactions are also known as the Dark Reactions (or Light Independent Reactions). Carbon dioxide enters single-celled and aquatic autotrophs through no specialized structures, diffusing into the cells. Land plants must guard against drying out (desiccation) and so have evolved specialized structures known as stomata to allow gas to enter and leave the leaf. The Calvin Cycle occurs in the stroma of chloroplasts (where would it occur in a prokaryote?). Carbon dioxide is captured by the chemical ribulose biphosphate (RuBP). RuBP is a 5-C chemical. Six molecules of carbon dioxide enter the Calvin Cycle, eventually producing one molecule of glucose. The reactions in this process were worked out by Melvin Calvin (shown below).

The first stable product of the Calvin Cycle is phosphoglycerate (PGA), a 3-C chemical. The energy from ATP and NADPH energy carriers generated by the photosystems is used to attach phosphates to (phosphorylate) the PGA. Eventually there are 12 molecules of glyceraldehyde phosphate (also known as phosphoglyceraldehyde or PGAL, a 3-C), two of which are removed from the cycle to make a glucose. The remaining PGAL molecules are converted by ATP energy to reform 6 RuBP molecules, and thus start the cycle again. Remember the complexity of life, each reaction in this process, as in Kreb's Cycle, is catalyzed by a different reaction-specific enzyme.

C-4 Pathway

Some plants have developed a preliminary step to the Calvin Cycle (which is also referred to as a C-3 pathway), this preamble step is known as C-4. While most C-fixation begins with RuBP, C-4 begins with a new molecule, phosphoenolpyruvate (PEP), a 3-C chemical that is converted into oxaloacetic acid (OAA, a 4-C chemical) when carbon dioxide is combined with PEP. The OAA is converted to Malic Acid and then transported from the mesophyll cell into the bundle-sheath cell, where OAA is broken down into PEP plus carbon dioxide. The carbon dioxide then enters the Calvin Cycle, with PEP returning to the mesophyll cell. The resulting sugars are now adjacent to the leaf veins and can readily be transported throughout the plant

The capture of carbon dioxide by PEP is mediated by the enzyme PEP carboxylase, which has a stronger affinity for carbon dioxide than does RuBP carboxylase When carbon dioxide levels decline below the threshold for RuBP carboxylase, RuBP is catalyzed with oxygen instead of carbon dioxide. The product of that reaction forms glycolic acid, a chemical that can be broken down by photorespiration, producing neither NADH nor ATP, in effect dismantling the Calvin Cycle. C-4 plants, which often grow close together, have had to adjust to decreased levels of carbon dioxide by artificially raising the carbon dioxide concentration in certain cells to prevent photorespiration. C-4 plants evolved in the tropics and are adapted to higher temperatures than are the C-3 plants found at higher latitudes. Common C-4 plants include crabgrass, corn, and sugar cane. Note that OAA and Malic Acid also have functions in other processes, thus the chemicals would have been present in all plants, leading scientists to hypothesize that C-4 mechanisms evolved several times independently in response to a similar environmental condition, a type of evolution known as convergent evolution.

6. DNA AND MOLECULAR GENETICS

The physical carrier of inheritance

Friedrich Meischer in 1869 isolated DNA from fish sperm and the pus of open wounds. Since it came from nuclei, Meischer named this new chemical, nuclein. Subsequently the name was changed to nucleic acid and lastly to deoxyribonucleic acid (DNA). ***Robert Feulgen***, in 1914, discovered that fuchsin dye stained DNA. DNA was then found in the nucleus of all eukaryotic cells.

During the 1920s, biochemist P.A. Levene analyzed the components of the DNA molecule. He found it contained four nitrogenous bases: cytosine, thymine, adenine, and guanine; deoxyribose sugar; and a phosphate group. He concluded that the basic unit (nucleotide) was composed of a base attached to a sugar and that the phosphate also attached to the sugar

The Structure of DNA

Watson and Crick gathered all available data in an attempt to develop a model of DNA structure.

DNA is a double helix, with bases to the center (like rungs on a ladder) and sugar-phosphate units along the sides of the helix (like the sides of a twisted ladder). The strands are complementary (deduced by Watson and Crick from Chargaff's data, A pairs with T and C pairs with G, the pairs held together by hydrogen bonds). Notice that a double-ringed purine is always bonded to a single ring pyrimidine. Purines are Adenine (A) and Guanine (G). We have encountered Adenosine triphosphate (ATP) before, although in that case the sugar was ribose, whereas in DNA it is deoxyribose. Pyrimidines are Cytosine (C) and Thymine (T). The bases are complementary, with A on one side of the molecule you only get T on the other side, similarly with G and C. If we know the base sequence of one strand we know its complement

DNA Replication

DNA replication involves a great many building blocks, enzymes and a great deal of ATP energy (remember that after the S phase of the cell cycle cells have a G phase to regenerate energy for cell division). Only occurring in a cell once per (cell) generation, DNA replication in humans occurs at a rate of 50 nucleotides per second, 500/second in prokaryotes. Nucleotides have to be assembled and available in the nucleus, along with energy to make bonds between nucleotides. DNA polymerases unzip the helix by breaking the H-bonds between bases. Once the polymerases have opened the molecule, an area known as the replication bubble forms (always initiated at a certain set of nucleotides, the origin of replication). New nucleotides are placed in the fork and link to the corresponding parental nucleotide already there (A with T, C with G). Prokaryotes open a single replication bubble, while eukaryotes have multiple bubbles. The entire length of the DNA molecule is replicated as the bubbles meet.

HUMAN GENETICS

The human karyotype

There are 44 autosomes and 2 sex chromosomes in the human genome, for a total of 46

Human chromosomal abnormalities

A common abnormality is caused by nondisjunction, the failure of replicated chromosomes to segregate during Anaphase II. A gamete lacking a chromosome cannot produce a viable embryo. Occasionally a gamete with n+1 chromosomes can produce a viable embryo.

In humans, nondisjunction is most often associated with the 21st chromosome, producing a disease known as Down's syndrome (also referred to as trisomy 21). Sufferers of Down's syndrome suffer mild to severe mental retardation, short stocky body type, large tongue leading to speech difficulties, and (in those who survive into middle-age), a propensity to develop Alzheimer's Disease. Ninety-five percent of Down's cases result from nondisjunction of chromosome 21. Occasional cases result from a translocation in the chromosomes of one parent. Remember that a translocation occurs when one chromosome (or a fragment) is transferred to a non-homologous chromosome. The incidence of Down's Syndrome increases with age of the mother, although 25% of the cases result from an extra chromosome from the father..

Sex-chromosome abnormalities may also be caused by nondisjunction of one or more sex chromosomes. Any combination (up to XXXXY) produces maleness. Males with more than one X are usually underdeveloped and sterile. XXX and XO women are known, although in most cases they are sterile.

Prenatal detection of chromosomal abnormalities is accomplished chiefly by **amniocentesis.** A thin needle is inserted into the amniotic fluid surrounding the fetus (a term applied to an unborn baby after the first trimester). Cells are withdrawn have been sloughed off by the fetus, yet they are still fetal cells and can be used to determine the state of the fetal chromosomes, such as Down's Syndrome and the sex of the baby after a karyotype has been made.

RNA Links the Information in DNA to the Sequence of Amino Acids in Protein :

RNA occurs in the nucleus as well as in the cytoplasm (also remember that it occurs as part of the ribosomes that line the rough endoplasmic reticulum).

Crick's central dogma: Information flow (with the exception of reverse transcription) is from DNA to RNA via the process of transcription, and thence to protein via translation. Transcription is the making of an RNA molecule off a DNA template. Translation is the construction of an amino acid sequence (polypeptide) from an RNA molecule. Although originally called dogma, this idea has been tested repeatedly with almost no exceptions to the rule being found (save retroviruses).

Messenger RNA (mRNA) is the blueprint for construction of a protein. Ribosomal RNA (rRNA) is the construction site where the protein is made. Transfer RNA (tRNA) is the truck delivering the proper amino acid to the site at the right time.

RNA has ribose sugar instead of deoxyribose sugar. The base uracil (U) replaces thymine (T) in RNA. Most RNA is single stranded, although tRNA will form a "cloverleaf" structure due to complementary base pairing.

Transcription: making an RNA copy of a DNA sequence

RNA polymerase opens the part of the DNA to be transcribed. Only one strand of DNA (the template strand) is transcribed. RNA nucleotides are available in the region of the chromatin (this process only occurs during Interphase) and are linked together similar to the DNA process

The Genetic Code: Translation of RNA code into protein

The code consists of at least three bases, according to astronomer George Gamow. To code for the 20 essential amino acids a genetic code must consist of at least a 3-base set (triplet) of the 4 bases. If one considers the possibilities of arranging four things 3 at a time (4X4X4), we get 64 possible code words, or codons (a 3-base sequence on the mRNA that codes for either a specific amino acid or a control word).

Protein Synthesis :

Prokaryotic gene regulation differs from eukaryotic regulation, but since prokaryotes are much easier to work with, we focus on prokaryotes at this point. Promoters are sequences of DNA that are the start signals for the transcription of mRNA. Terminators are the stop signals. mRNA molecules are long (500- 10,000 nucleotides).

Ribosomes are the organelle (in all cells) where proteins are synthesized. They consist of two-thirds rRNA and one-third protein. Ribosomes consist of a small (in *E. coli*, 30S) and larger (50S) subunits. The length of rRNA differs in each. The 30S unit has 16S rRNA and 21 different proteins. The 50S subunit consists of 5S and 23S rRNA and 34 different proteins. The smaller subunit has a binding site for the mRNA. The larger subunit has two binding sites for tRNA

Transfer RNA (tRNA) is basically cloverleaf-shaped. tRNA carries the proper amino acid to the ribosome when the codons call for them. At the top of the large loop are three bases, the anticodon, which is the complement of the codon. There are 61 different tRNAs, each having a different binding site for the amino acid and a different anticodon. For the codon UUU, the complementary anticodon is AAA. Amino acid linkage to the proper tRNA is controlled by the aminoacyl-tRNA synthetases. Energy for binding the amino acid to tRNA comes from ATP conversion to adenosine monophosphate (AMP).

Translation is the process of converting the mRNA codon sequences into an amino acid sequence. The initiator codon (AUG) codes for the amino acid N-formylmethionine (f-Met). No transcription occurs without the AUG codon. f-Met is always the first amino acid in a polypeptide chain, although frequently it is removed after translation. The intitator tRNA/mRNA/small ribosomal unit is called the initiation complex. The larger subunit attaches to the initiation complex. After the initiation phase the message gets longer during the elongation phase.

New tRNAs bring their amino acids to the open binding site on the ribosome/mRNA complex, forming a peptide bond between the amino acids. The complex then shifts along the mRNA to the next triplet, opening the A site. The new tRNA enters at the A site. When the codon in the A site is a termination codon, a releasing factor binds to the site, stopping translation and releasing the ribosomal complex and mRNA.

Mutations

We define mutations as any change in the DNA. We now can refine this definition: a mutation is a change in the DNA base sequence that results in a change of amino acid(s) in the polypeptide coded for by that gene. Alleles are alternate sequences of DNA bases (genes), and thus at the molecular level the products of alleles differ (often by only a single amino acid, which can have a ripple effect on an organism by changing). Addition, deletion, or addition of nucleotides can alter the polypeptide. Point mutations are the result of the substitution of a single base. Frame-shift mutations occur when the reading frame of the gene is shifted by addition or deletion of one or more bases. With the exception of mitochondria, all organisms use the same genetic code. Powerful evidence for the common ancestry of all living things

Genes, Viruses and Cancer

Cancer is a disease in which cells escape the restraints on normal cell growth. Cancer is an inheritable disease (at least from cell to daughter cells). Once a cell has become cancerous, all of its descendant cells are cancerous. Gross chromosomal abnormalities are often visible in cancerous cells. Most carcinogens (cancer-generating factors) are also mutagens (mutation-generating factors). Oncogenes are genes resembling normal genes but in which something has gone wrong, resulting in a cancer. Fifty oncogenes have thus far been discovered.

Viruses seem able to cause cancer in three ways. Presence of the viral DNA may disrupt normal host DNA functions. Viral proteins needed for virus replication may also affect normal host gene regulation. Since most cancer-causing viruses are retroviruses, the virus may serve as a vector for oncogene insertion. Transfers of genes between eukaryotic cells will allow doctors, who have historically been limited to phenotypic cures, to attack disease at the genotypic level. SV40 virus has been used to inject the rabbit beta-globin gene into monkeys. Viruses can thus serve as a possible vector to place healthy (non-mutated) alleles into eggs.

7. PLANTS AND THEIR STRUCTURE

A plant has two organ systems: 1) the shoot system, and 2) the root system. The shoot system is above ground and includes the organs such as leaves, buds, stems, flowers (if the plant has any), and fruits (if the plant has any).

The root system includes those parts of the plant below ground, such as the roots, tubers, and rhizomes

Plant cells are formed at meristems, and then develop into cell types which are grouped into tissues. Plants have only three tissue types: 1) Dermal; 2) Ground; and 3) Vascular.

Dermal tissue covers the outer surface of herbaceous plants. Dermal tissue is composed of epidermal cells, closely packed cells that secrete a waxy cuticle that aids in the prevention of water loss.

The ground tissue comprises the bulk of the primary plant body. Parenchyma, collenchyma, and sclerenchyma cells are common in the ground tissue.

Vascular tissue transports food, water, hormones and minerals within the plant. Vascular tissue includes xylem, phloem, parenchyma, and cambium cells.

Plant cell types rise by mitosis from a meristem. A meristem may be defined as a region of localized mitosis. Meristems may be at the tip of the shoot or root (a type known as the apical meristem) or lateral, occurring in cylinders extending nearly the length of the plant. A cambium is a lateral meristem that produces (usually) secondary growth. Secondary growth produces both wood and cork (although from separate secondary meristems

Parenchyma

A generalized plant cell type, parenchyma cells are alive at maturity. They function in storage, photosynthesis, and as the bulk of ground and vascular tissues. Palisade parenchyma cells are elogated cells located in many leaves just below the epidermal tissue. Spongy mesophyll cells occur below the one or two layers of palisade cells. Ray parenchyma cells occur in wood rays, the structures that transport materials laterally within a woody stem. Parenchyma cells also occur within the xylem and phloem of vascular bundles. The largest parenchyma cells occur in the pith region, often, as in corn (*Zea*) stems, being larger than the vascular bundles.

Collenchyma

Collenchyma cells support the plant. These cells are charcterized by thickenings of the wall, the are alive at maturity. They tend to occur as part of vascular bundles or on the corners of angular stems.

Sclerenchyma

Sclerenchyma cells support the plant. They often occur as bundle cap fibers. Sclerenchyma cells are characterized by thickenings in their secondary walls. They are dead at maturity.

Xylem

Xylem is a term applied to woody (lignin-impregnated) walls of certain cells of plants. Xylem cells tend to conduct water and minerals from roots to leaves. While parenchyma cells do occur within what is commonly termed the "xylem" the more identifiable cells, tracheids and vessel elements. Tracheids are the more primitive of the two cell types, occurring in the earliest vascular plants. Tracheids are long and tapered, with angled end-plates that connect cell to cell. Vessel elements are shorter, much wider, and lack end plates. They occur only in angiosperms, the most recently evolved large group of plants.

Phloem

Phloem cells conduct food from leaves to rest of the plant. They are alive at maturity and tend to stain green (with the stain fast green). Phloem cells are usually located outside the xylem. The two most common cells in the phloem are the companion cells and sieve cells. Companion cells retain their nucleus and control the adjacent sieve cells. Dissolved food, as sucrose, flows through the sieve cells.

Epidermis

The epidermal tissue functions in prevention of water loss and acts as a barrier to fungi and other invaders. Thus, epidermal cells are closely packed, with little intercellular space. To further cut down on water loss, many plants have a waxy cuticle layer deposited on top of the epidermal cells.

Guard Cells

To facilitate gas exchange between the inner parts of leaves, stems, and fruits, plants have a series of openings known as stomata (singular stoma). Obviously these openings would allow gas exchange, but at a cost of water loss. Guard cells are bean-shaped cells covering the stomata opening. They regulate exchange of water vapor, oxygen and carbon dioxide through the stoma.

Flowering Plant Reproduction

The plant life cycle has mitosis occurring in spores, produced by meiosis, that germinate into the gametophyte phase. Gametophyte size ranges from three cells (in pollen) to several million (in a "lower plant" such as moss). Alternation of generations occurs in plants, where the sporophyte phase is succeeded by the gametophyte phase. The sporophyte phase produces spores by meiosis within a sporangium. The gametophyte phase produces gametes by mitosis within an antheridium (producing sperm) and/or archegonium (producing eggs). Within the plant kingdom the dominance of phases varies. Nonvascular plants, the mosses and liverworts, have the gametophyte phase dominant. Vascular plants show a progression of increasing sporophyte dominance from the ferns and "fern allies" to angiosperms.

Angiosperms (flowering plants)

All flowering plants produce flowers and if they are sexually reproductive, they produce a diploid zygote and triploid endosperm. The classical view of flowering plant evolution suggests early angiosperms were evergreen trees that produced large Magnolia-like flowers.

Flowers

Flowers are collections of reproductive and sterile tissue arranged in a tight whorled array having very short internodes. Sterile parts of flowers are the sepals and petals. When these are similar in size and shape, they are termed tepals. Reproductive parts of the flower are the stamen (male, collectively termed the androecium) and carpel (often the carpel is referred to as the pistil, the female parts collectively termed the gynoecium

Androecium

The individual units of the androecium are the stamens, which consist of a filament which supports the anther. The anther contains four microsporangia within which microspores (pollen) are produced by meiosis. *Stamens* are thought to represent modified sporophylls (leaves with sporangia on their upper surface).

Pollen

Pollen grains (from the greek *palynos* for dust or pollen) contain the male gametophyte (microgametophyte) phase of the plant. Pollen grains are produced by meiosis of microspore mother cells that are located along the inner edge of the anther sacs (microsporangia). The outer part of the pollen is the exine, which is composed of a complex polysaccharide, sporopollenin. Inside the pollen are two (or, at most, three) cells that comprise the male gametophyte. The tube cell (also referred to as the tube nucleus) develops into the pollen tube. The germ cell divides by mitosis to produce two sperm cells. Division of the germ cell can occur before or after pollination

Gynoecium

The gynoecium consists of the stigma, style, and ovary containing one or more ovules. These three structures are often termed a pistil or carpel. In many plants, the pistils will fuse for all or part of their lengthLike the stamen, the carpel is thought to be a modified leaf.

The Stigma and Style

The stigma functions as a receptive surface on which pollen lands and germinates its pollen tube. Corn silk is part stigma, part style. The style serves to move the stigma some distance from the ovary. This distance is species specific.

The Ovary

The ovary contains one or more ovules, which in turn contain one female gametophyte, also referred to in angiosperms as the embryo sac. Some plants, such as cherry, have only a single ovary which produces two ovules. Only one ovule will develop into a seed.

Pollination

The transfer of pollen from the anther to the female stigma is termed pollination. This is accomplished by a variety of methods. Entomophyly is the transfer of pollen by an insect. Anemophyly is the transfer of pollen by wind. Other pollinators include birds, bats, water, and humans. Some flowers (for example garden peas) develop in such a way as to pollinate themselves. Others have mechanisms to ensure pollination with another flower.

Flower color is thought to indicate the nature of pollinator: red petals are thought to attract birds, yellow for bees, and white for moths. Wind pollinated flowers have reduced petals, such as oaks and grasses.

The Gametophytes

The male gametophyte develops inside the pollen grain. The female gametophyte develops inside the ovule. In flowering plants, gametophyte phases are reduced to a few cells dependant for their nutrition on the sporophyte phase. This is the reverse of the pattern seen in the nonvascular plant groups liverworts, mosses, and hornworts (the Bryophyta).

Angiosperm male gametophytes have two haploid nuclei (the germ nucleus and tube nucleus) contained within the exine of the pollen grain (or microspore).

Female gametophytes of flowering plants develop within the ovule (megaspore) contained within an ovary at the base of the pistil of the flower. There are usually eight (haploid) cells in the female gametophyte: a) one egg, two synergids flanking the egg (located at the micropyle end of the embryo sac); b) two polar nuclei in the center of the embryo sac; and three antipodal cells (at the opposite end of the embryo sac from the egg).

Double Fertilization

The process of pollination being accomplished, the pollen tube grows through the stigma and style toward the ovules in the ovary. The germ cell in the pollen grain divides and releases two sperm cells which move down the pollen tube. Once the tip of the tube reaches the micropyle end of the embryo sac, the tube grows through into the embryo sac through one of the synergids which flank the egg. One sperm cell fuses with the egg, producing the zygote which will later develope into the next-generation sporophyte. The second sperm fuses with the two polar bodies located in the center of the sac, producing the nutritive triploid endosperm tissue that will provide energy for the embryo's growth and development.

Fruit

The ovary wall, after fertilization has occurred, develops into a fruit. Fruits may be fleshy, hard, multiple or single. Seeds germinate, and the embryo grows into the next gemeration sporophyte.

Vegetative Propagation

Many plants also have an asexual method of reproduction. Often some species, such as many orchids, are more frequently propagated vegetatively than via seeds. Tubers are fleshy underground stems, as in the Irish potato. Leaflets are sections of leaf will develop roots and drop off the plant, effectively cloning the plant. Runners are shoots running along or over the surface of the ground that will sprout a plantlet, which upon settling to the ground develop into a new independant plant.

8. PLANT HORMONES, NUTRITION, AND TRANSPORT

A hormone is any chemical produced in one part of the body that has a target elsewhere in the body. Plants have *five* classes of hormones. Animals, especially chordates, have a much larger number. Hormones and enzymes serve as control chemicals in multicellular organisms. One important aspect of this is the obtaining of food and/or nutrients

Auxins

Auxins promote stem elongation, inhibit growth of lateral buds (maintains apical dominance). They are produced in the stem, buds, and root tips. Example: Indole Acetic Acid (IA). Auxin is a plant hormone produced in the stem tip that promotes cell elongation. Auxin moves to the darker side of the plant, causing the cells there to grow larger than corresponding cells on the lighter side of the plant. This produces a curving of the plant stem tip toward the light, a plant movement known as phototropism.

Auxin also plays a role in maintaining apical dominance. Most plants have lateral (sometimes called axillary) buds located at nodes (where leaves attach to the stem). Buds are embryonic meristems maintained in a dormant state. Auxin maintains this dormancy. As long as sufficient auxin is produced by the apical meristem, the lateral buds remain dormant. If the apex of the shoot is removed (by a browsing animal or a scientist), the auxin is no longer produced. This will cause the lateral buds to break their dormancey and begin to grow. In effect, the plant becomes bushier. When a gardener trims a hedge, they are applying apical dominance.

Gibberellins

Gibberellins promote stem elongation. They are not produced in stem tip. Gibberellic acid was the first of this class of hormone to be discovered.

Cytokinins

Cytokinins promote cell division. They are produced in growing areas, such as meristems at tip of the shoot. Zeatin is a hormone in this class, and occurs in corn .

Abscisic Acid

Abscisic Acid promotes seed dormancy by inhibiting cell growth. It is also involved in opening and closing of stomata as leaves wilt.

Ethylene

Ethylene is a gas produced by ripe fruits. Why does one bad apple spoil the whole bunch? Ethylene is used to ripen crops at the same time. Sprayed on a field it will cause all fruits to ripen at the same time so they can be harvested.

Plant Nutrition

Unlike animals (which obrtain their food from what they eat) plants obtain their nutrition from the soil and atmosphere. Using sunlight as an energy source, plants are capable of making all the organic macromolecules they need by modifications of the sugars they form by photosynthesis. However, plants must take up various minerals through their root systems for use.

A (plant) balanced diet

Carbon, Hydrogen, and Oxygen are considered the essential elements. Nitrogen, Potassium, and Phosphorous are obtained from the soil and are the primary macronutrients. Calcium, Magnesium, and Sulfur are the secondary macronutrients needed in lesser quantity. The micronutrients, needed in very small quantities and toxic in large quantities, include Iron, Manganese, Copper, Zinc, Boron, and Chlorine. A complete fertilizer provides all three primary macronutrients and some of the secondary and micronutrients. The label of the fertilizer will list numbers, for example 5-10-5, which refer to the percent by weight of the primary macronutrients.

Soils play a role

Soil is weathered, decomposed rock and mineral (geological) fragments mixed with air and water. Fertile soil contains the nutrients in a readily available form that plants require for growth. The roots of the plant act as miners moving through the soil and bringing needed minerals into the plant roots.

Plants use these minerals in:

1. Structural components in carbohydrates and proteins
2. Organic molecules used in metabolism, such as the Magnesium in chlorophyll and the Phosphorous found in ATP
3. Enzyme activators like potassium, which activates possibly fifty enzymes
4. Maintaining osmotic balance

Mycorrhizae, bacteria, and minerals

Plants need nitrogen for many important biological molecules including nucleotides and proteins. However, the nitrogen in the atmosphere is not in a form that plants can utilize. Many plants have a symbiotic relationship with bacteria growing in their roots: organic nitrogen as rent for space to live. These plants tend to have root nodules in which the nitrogen-fixing bacteria live.

Roots have extensions of the root epidemal cells known as root hairs. While root hairs greatly enhance the surface area (hence absorbtion surface), the addition of symbiotic mycorrhizae fungi vastly increases the area of the root for absorbing water and minerals from the soil.

Water and Mineral Uptake

Animals have a circulatory system that transports fluids, chemicals, and nutrients around within the animal body. Some plants have an analogous system: the vascular system in vascular plants; trumpet hyphae in bryophytes.

Root hairs are thin-walled extensions of the epidermal cells in roots. They provide increased surface area and thus more efficient absorption of water and minerals. Water and dissolved mineral nutrients enter the plant via two routes.

Water and selected solutes pass through only the cell membrane of the epidermis of the root hair and then through plasmodesmata on every cell until they reach the xylem: intracellular route (apoplastic). Water and solutes enter the cell wall of the root hair and pass between the wall and plasma membrane until the encounter the endodermis, a layer of cells that they must pass through to enter the xylem: extracellular route (symplastic)

The endodermis has a strip of water-proof material (containing suberin) known as the Casparian strip that forces water through the endodermal cell and in such a way regulates the amount of water getting to the xylem. Only when water concentrations inside the endodermal cell fall below that of the cortex parenchyma cells does water flow into the endodermis and on into the xylem.

Xylem and Transport

Xylem is the water transporting tissue in plants that is dead when it reaches functional maturity. Tracheids are long, tapered cells of xylem that have end plates on the cells that contain a great many crossbars.

Water is pulled up the xylem by the force of transpiration, water loss from leaves. Mature corn plants can each transpire four gallons of water per week. Transpiration rates in arid-region plants can be even higher. Water molecules are hydrogen bonded to each other. Water lost from the leaves causes diffusion of additional water molecules out of the leaf vein xylem, creating a tug on water molecules along the water columns within the xylem. This "tug" causes water molecules to rise up from the roots to eventually the leaves. The loss of water from the root xylem allows additional water to pass throught the endodermis into the root xylem.

Cohesion is the ability of molecules of the same kind to stick together. Water molecules are polar, having slight positive and negative sides, which causes their cohesion. Inside the xylem, water molecules are in a long chain extending from the roots to the leaves. •

Adhesion is the tendency of molecules of different kinds to stick together. Water sticks to the cellulose molecules in the walls of the xylem, counteracting the force of gravity and aiding the rise of water within the xylem.

Cohesion-Adhesion Theory

Transpiration exerts a pull on the water column within the xylem. The lost water molecules are replaced by water from the xylem of the leaf veins, causing a tug on water in the xylem. Adhesion of water to the cell walls of the xylem facilitates movement of water upward within the xylem. This combination of cohesive and adhesive forces is referred to as the Cohesion-Adhesion Theory.

Guard Cells Regulate Transpiration

In most environments, the water concentration outside the leaf is less than that inside the leaf, causing a loss of water through openings in the leaf known as stomata (singular = stoma). Guard cells are crescent-shaped cells of the epidermis that flank the stoma and regulate the size of the opening. Together, the guard cells and stoma comprise the stomatal apparatus. The inner wall of the guard cell is thicker than the rest of the wall. When a guard cell takes up potassium ions, water moves into the cell, causing the cell to become turgid and swell, opening the stoma. When the potassium leaves the guard cell, the water also leaves, causing plasmolysis of the cells, and a closing of the stoma. Stomata occupy 1% of the leaf surface, but account for 90% of the water lost in transpiration.

Transportation and Storage of Nutrients

Plants make sugar by photosynthesis, usually in their leaves. Some of this sugar is directly used for the metabolism of the plant, some for the synthesis of proteins and lipids, some stored as starch. Other parts of the plant also need energy but are not photosynthetic, such as the roots. Food must therefore be transported in from a source, an action accomplished by the phloem tissue.

Phloem, Sugar, and Translocation

Phloem consists of several types of cells: sieve tube cells (aka sieve elements), companion cells, and the vascular parenchyma. Sieve cells are tubular cells with endwalls known as sieve plates. Most lose their nuclei but remain alive, leaving an empty cell with a functioning plasma membrane.

Companion cells load sugar into the sieve element (sieve elements are connected into sieve tubes). Fluids can move up or down within the phloem, and are translocated from one place to another. Sources are places where sugars are being produced. Sinks are places where sugar is being consumed or stored.

Food moves through the phloem by a Pressure-Flow Mechanism. Sugar moves (by an energy-requiring step) from a source (usually leaves) to a sink (usually roots) by osmotic pressure. Translocation of sugar into a sieve element causes water to enter that cell, increasing the pressure of the sugar/water mix (phloem sap). The pressure causes the sap to flow toward an area of lower pressure, the sink. In the sink, the sugar is removed from the phloem by another energy-requiring step and usually converted into starch or metabolized.

Plants Respond to External Stimuli

One plant response to environmental stimulus involves plant parts moving toward or away from the stimulus, a movement known as a tropism. Nastic movements are plant movements independent of the direction of the stimulus.

Alterations in Growth Patterns Generate Tropisms

We now know that auxin, a plant hormone produced in the stem tip (auxins promote cell elongation), moves to the darker side of the plant, causing the cells there to grow larger than corresponding cells on the lighter side of the plant. This produces a curving of the plant stem tip toward the light, a plant movement known as phototropism.

Geotropism is plant response to gravity. Roots of plants show positive geotropism, shoots show negative geotropism. Geotropism was once thought a result of gravity influencing auxin concentration. Several new hypotheses are currently under investigation.

Thigmotropism is plant response to contact with a solid object. Tendrils of vines warp around objects, allowing the vine to grow upward.

Nastic movements, such as nyctinasty, result from several types of stimuli, including light and touch. Legumes turn their leaves in response to day/night conditions. Mimosa, also known as the sensitive plant, has its leaves close up when touched.

Photoperiodism is the plant response to the relative amounts of light and dark in a 24 hour period, and controls the flowering of many plants. Short-day plants flower during early spring or fall, when the nights are relatively longer and the days are relatively shorter. Long-day plants flower mostly in summer, when the nights are relatively shorter and the days are relatively longer. Day-neutral plants flower without respect for the day length. Phytochrome is a plant pigment in the leaves of plants that detects the day length and generates a response.

Plant Secondary Compounds

Plants produce primary compounds important in their metabolism. They also produce secondary compounds that serve to attract pollinators, kill parasites, and prevent infectious diseases. Pea plants produce pisatin, a chemical that protects them from most strains of parasitic fungi. Some strains of the fungus (*Fusarium*) contain enzymes that inactivate pisatin, allowing them to infect pea plants.

Some plants produce ***natural insecticides***, such as pyrethrum, a chemical produced by chrysanthemums that is also commercially available to gardeners. Antinutrients are chemical produced when plants are under attack. These compounds inhibit the action of enzymes in the insect's digestive system.

More that 10,000 defensive chemicals have been identified, including caffeine, phenol, tannin, nicotine, and morphine.

Some plant secondary compounds are useful to humans as

1. pesticides
2. medicines (salicylic acid, the main component in aspirin)
3. stimulants (caffeine, the most widely used psychoactive drug in the world)
4. chewing gum (chicle, a compound from the ***sapodilla tree*** in Mexico was used in the first chewing gum).

skeleton of ***sharks and rays***. It also occurs in the human body in the ears, tip of the nose, and at joints such as the knee and between bones of the spinal column.

Bone has calcium salts in the matrix, giving it greater rigidity and strength. Bone also serves as a reservoir (or sink) for calcium. Protein fibers provide elasticity while minerals provide elasticity. Two types of bone occur. Dense bone has osteocytes (bone cells) located in lacunae connected by canaliculi. Lacunae are commonly referred to as Haversian canals. Spongy bone occurs at the ends of bones and has bony bars and plates separated by irregular spaces. The solid portions of spongy bone pick up stress.

Blood is a connective tissue of cells separated by a liquid (plasma) matrix. Two types of cells occur. Red blood cells (erythrocytes) carry oxygen. White blood cells (leukocytes) function in the immune system. Plasma transports dissolved glucose, wastes, carbon dioxide and hormones, as well as regulating the water balance for the blood cells. Platelets are cell fragments that function in blood clotting.

Muscle Tissue

Muscle tissue facilitates movement of the animal by contraction of individual muscle cells (referred to as muscle fibers). Three types of muscle fibers occur in animals (the only taxonomic kingdom to have muscle cells):

- skeletal (striated)
- smooth
- cardiac

Muscle fibers are multinucleated, with the nuclei located just under the plasma membrane. Most of the cell is occupied by striated, thread-like myofibrils. Within each myofibril there are dense Z lines. A sarcomere (or muscle functional unit) extends from Z line to Z line. Each sarcomere has thick and thin filaments. The thick filaments are made of myosin and occupy the center of each sarcomere. Thin filaments are made of actin and anchor to the Z line.

Skeletal (striated) muscle fibers have alternating bands perpendicular to the long axis of the cell. These cells function in conjunction with the skeletal system for voluntary muscle movements. The bands are areas of actin and myosin deposition in the cells

Smooth muscle fibers lack the banding, although actin and myosin still occur. These cells function in involuntary movements and/or autonomic responses (such as breathing, secretion, ejaculation, birth, and certain reflexes). Smooth muscle fibers are spindle shaped cells that form masses. These fibers are components of structures in the digestive system, reproductive tract, and blood vessels.

Cardiac muscle fibers are a type of striated muscle found only in the heart. The cell has a bifurcated (or forked) shape, usually with the nucleus near the center of the cell. The cells are usually connected to each other by intercalated disks.

Nervous Tissue

Nervous tissue functions in the integration of stimulus and control of response to that stimulus. Nerve cells are called neurons. Each neuron has a cell body, an axon, and many dendrites. Nervous tissue is composed of two main cell types: neurons and glial cells. Neurons transmit nerve messages. Glial cells are in direct contact with neurons and often surround them.

The neuron is the functional unit of the nervous system. Humans have about 100 billion neurons in their brain alone! While variable in size and shape, all neurons have three parts. Dendrites receive information from another cell and transmit the message to the cell body. The cell body contains the nucleus, mitochondria and other organelles typical of eukaryotic cells. The axon conducts messages away from the cell body.

Homeostasis

Homeostasis is the maintenance of a stable internal environment. Homeostasis is a term coined to describe the physical and chemical parameters that an organism must maintain to allow proper functioning of its component cells, tissues, organs, and organ systems.

10. THE INTEGUMENTARY SYSTEM

Skin or Integument is the outermost protective layer. It prevents water loss from and invasion of foreign microorganisms and viruses into the body.

The skin is the largest organ in the body: 12-15% of body weight, with a surface area of 1-2 meters. Skin is continuous with, but structurally distinct from mucous membranes that line the mouth, anus, urethra, and vagina. Two distinct layers occur in the skin: the dermis and epidermis. The basic cell type of the epidermis is the keratinocyte, which contain keratin, a fibrous protein. Basal cells are the innermost layer of the epidermis. Melanocytes produce the pigment melanin, and are also in the inner layer of the epidermis. The dermis is a connective tissue layer under the epidermis, and contains nerve endings, sensory receptors, capillaries, and elastic fibers.

The integumentary system has multiple roles in homeostasis, including protection, temperature regulation, sensory reception, biochemical synthesis, and absorption. All body systems work in an interconnected manner to maintain the internal conditions essential to the function of the body.

Follicles and Glands

Hair follicles are lined with cells that synthesize the proteins that form hair. A sebaceous gland (that secretes the oily coating of the hair shaft), capillary bed, nerve ending, and small muscle are associated with each hair follicle. If the sebaceous glands becomes plugged and infected, it becomes a skin blemish (or pimple). The sweat glands open to the surface through the skin pores. Eccrine glands are a type of sweat gland linked to the sympathetic nervous system; they occur all over the body. Apocrine glands are the other type of sweat gland, and are larger and occur in the armpits and groin areas; these produce a solution that bacteria act upon to produce "body odor".

Hair and Nails

Hair, scales, feathers, claws, horns, and nails are animal structures derived from skin. The hair shaft extends above the skin surface, the hair root extends from the surface to the base or hair bulb. Genetics controls several features of hair: baldness, color, texture.

Nails consist of highly keratinized, modified epidermal cells. The nail arises from the nail bed, which is thickened to form a lunula (or little moon). Cells forming the nail bed are linked together to form the nail.

Skin and Homeostasis

Skin functions in homeostasis include protection, regulation of body temperature, sensory reception, water balance, synthesis of vitamins and hormones, and absorption of materials. The skin's primary functions are to serve as a barrier to the entry of microbes and viruses, and to prevent water and extracellular fluid loss. Acidic secretions from skin glands also retard the growth of fungi. Melanocytes form a second barrier: protection from the damaging effects of ultraviolet radiation. When a microbe penetrates the skin (or when the skin is breached by a cut) the inflammatory response occurs.

Heat and cold receptors are located in the skin. When the body temperature rises, the hypothalamus sends a nerve signal to the sweat-producing skin glands, causing them to release about 1-2 liters of water per hour, cooling the body. The hypothalamus also causes dilation of the blood vessels of the skin, allowing more blood to flow into those areas, causing heat to be convected away from the skin surface. When body temperature falls, the sweat glands constrict and sweat production decreases. If the body temperature continues to fall, the body will engage in thermiogenesis, or heat generation, by raising the body's metabolic rate and by shivering.

Water loss occurs in the skin by two routes.

1. evaporation
2. sweating

In hot weather up to 4 liters per hour can be lost by these mechanisms. Skin damaged by burns is less effective at preventing fluid loss, often resulting in a possibly life threatening problem if not treated.

Skin and Sensory Reception

Sensory receptors in the skin include those for pain, pressure (touch), and temperature. Deeper within the skin are Meissner's corpuscles, which are especially common in the tips of the fingers and lips, and are very sensitive to touch. Pacinian corpuscles respond to pressure. Temperature receptors: more cold ones than hot ones.

Skin and Synthesis

Skin cells synthesize melanin and carotenes, which give the skin its color. The skin also assists in the synthesis of vitamin D. Children lacking sufficient vitamin D develop bone abnormalities known as rickets.

Skin Is Selectively Permeable

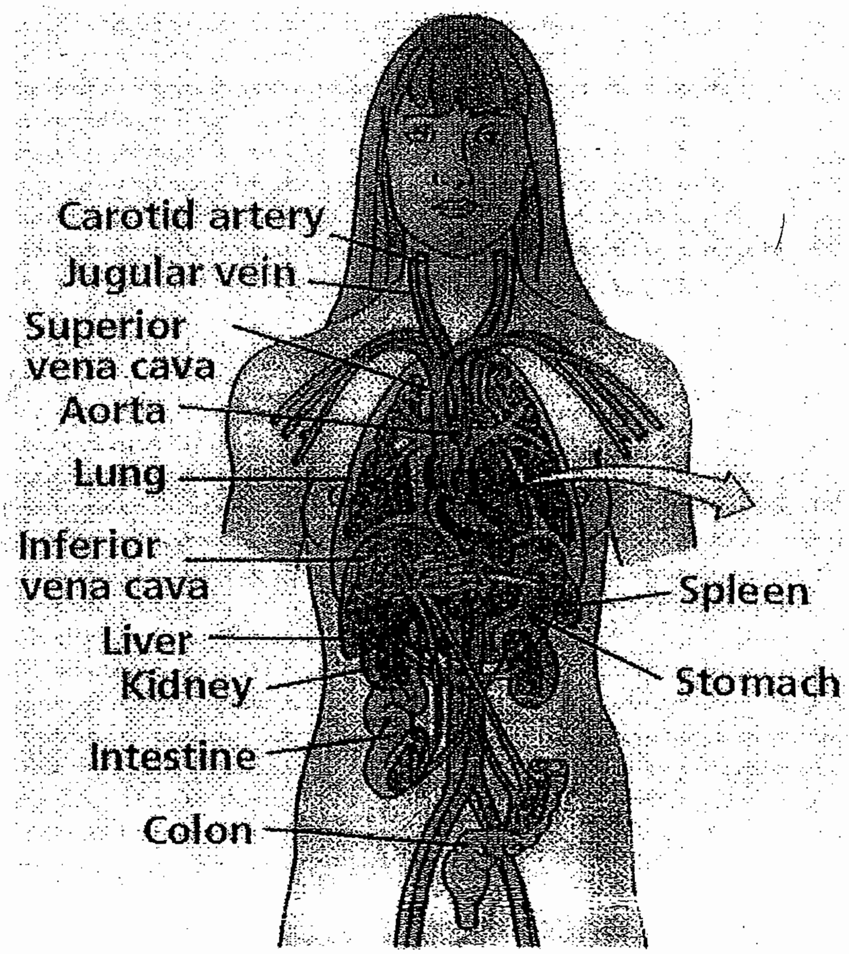
The skin is selectively soluble to fat-soluble substances such as vitamins A, D, E, and K, as well as steroid hormones such as estrogen. These substances enter the bloodstream through the capillary networks in the skin. Patches have been used to deliver a number of therapeutic drugs in this manner. These include estrogen, scopolamine (motion sickness), nitroglycerin (heart problems), and nicotine (for those trying to quit smoking).

11. THE CIRCULATORY SYSTEM

Types of Circulatory Systems

Living things must be capable of transporting nutrients, wastes and gases to and from cells. Single-celled organisms use their cell surface as a point of exchange with the outside environment. Multicellular organisms have developed transport and circulatory systems to deliver oxygen and food to cells and remove carbon dioxide and metabolic wastes. Sponges are the simplest animals, yet even they have a transport system. Seawater is the medium of transport and is propelled in and out of the sponge by ciliary action. Simple animals, such as the hydra and planaria lack specialized organs such as hearts and blood vessels, instead using their skin as an exchange point for materials. This, however, limits the size an animal can attain. To become larger, they need specialized organs and organ systems.

The relationship of the heart and circulatory system to major visceral organs



Multicellular animals do not have most of their cells in contact with the external environment and so have developed circulatory systems to transport nutrients, oxygen, carbon dioxide and metabolic wastes. Components of the circulatory system include

- blood: a connective tissue of liquid plasma and cells
- heart: a muscular pump to move the blood
- blood vessels: arteries, capillaries and veins that deliver blood to all tissues

There are several types of circulatory systems. The open circulatory system is common to molluscs and arthropods. Open circulatory systems (evolved in insects, mollusks and other invertebrates) pump blood into a hemocoel with the blood diffusing back to the circulatory system between cells. Blood is pumped by a heart into the body cavities, where tissues are surrounded by the blood. The resulting blood flow is sluggish

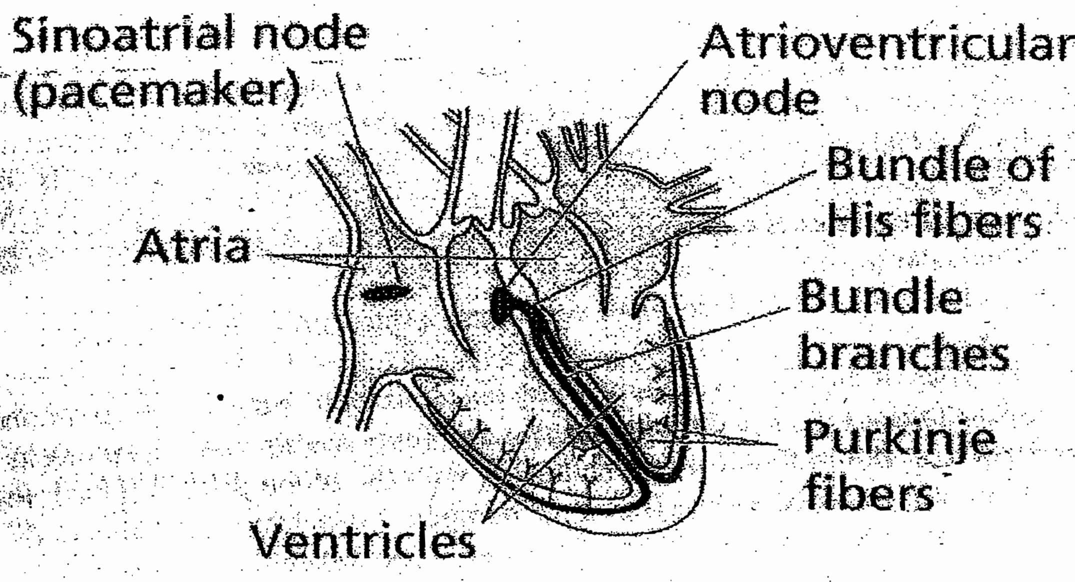
Vertebrates, and a few invertebrates, have a closed circulatory system. Closed circulatory systems (evolved in echinoderms and vertebrates) have the blood closed at all times within vessels of different size and wall thickness. In this type of system, blood is pumped by a heart through vessels, and does not normally fill body cavities. Blood flow is not sluggish. Hemoglobin causes vertebrate blood to turn red in the presence of oxygen; but more importantly hemoglobin molecules in blood cells transport oxygen. The human closed circulatory system is sometimes called the cardiovascular system.

A secondary circulatory system, the lymphatic circulation, collects fluid and cells and returns them to the cardiovascular system.

Vertebrate Cardiovascular System

The vertebrate cardiovascular system includes a heart, which is a muscular pump that contracts to propel blood out to the body through arteries, and a series of blood vessels. The upper chamber of the heart, the atrium (pl. atria), is where the blood enters the heart. Passing through a valve, blood enters the lower chamber, the ventricle. Contraction of the ventricle forces blood from the heart through an artery. The heart muscle is composed of cardiac muscle cells.

Arteries are blood vessels that carry blood away from heart. Arterial walls are able to expand and contract. Arteries have three layers of thick walls. Smooth muscle fibers contract, another layer of connective tissue is quite elastic, allowing the arteries to carry blood under high pressure.



Heart at rest

The aorta is the main artery leaving the heart. The pulmonary artery is the only artery that carries oxygen-poor blood. The pulmonary artery carries deoxygenated blood to the lungs. In the lungs, gas exchange occurs, carbon dioxide diffuses out, oxygen diffuses in. Arterioles are small arteries that connect larger arteries with capillaries. Small arterioles branch into collections of capillaries known as capillary beds

Capillaries are thin-walled blood vessels in which gas exchange occurs. In the capillary, the wall is only one cell layer thick. Capillaries are concentrated into capillary beds. Some capillaries have small pores between the cells of the capillary wall, allowing materials to flow in and out of capillaries as well as the passage of white blood cells. Changes in blood pressure also occur in the various vessels of the circulatory system. Nutrients, wastes, and hormones are exchanged across the thin walls of capillaries. Capillaries are microscopic in size, although blushing is one manifestation of blood flow into capillaries. Control of blood flow into capillary beds is done by nerve-controlled sphincters.

The circulatory system functions in the delivery of oxygen, nutrient molecules, and hormones and the removal of carbon dioxide, ammonia and other metabolic wastes. Capillaries are the points of exchange between the blood and surrounding tissues. Materials cross in and out of the capillaries by passing through or between the cells that line the capillary
The extensive network of capillaries in the human body is estimated at between 50,000 and 60,000 miles long. Thoroughfare channels allow blood to bypass a capillary bed.

These channels can open and close by the action of muscles that control blood flow through the channels

Blood leaving the capillary beds flows into a progressively larger series of venules that in turn join to form veins. Veins carry blood from capillaries to the heart. With the exception of the pulmonary veins, blood in veins is oxygen-poor. The pulmonary veins carry oxygenated blood from lungs back to the heart. Venules are smaller veins that gather blood from capillary beds into veins. Pressure in veins is low, so veins depend on nearby muscular contractions to move blood along. The veins have valves that prevent back-flow of blood

Ventricular contraction propels blood into arteries under great pressure. Blood pressure is measured in mm of mercury; healthy young adults should have pressure of ventricular systole of 120mm, and 80 mm at ventricular diastole. Higher pressures (human 120/80 as compared to a 12/1 in lobsters) mean the volume of blood circulates faster (20 seconds in humans, 8 minutes in lobsters).

As blood gets farther from the heart, the pressure likewise decreases. Each contraction of the ventricles sends pressure through the arteries. Elasticity of lungs helps keep pulmonary pressures low.

Systemic pressure is sensed by receptors in the arteries and atria. Nerve messages from these sensors communicate conditions to the medulla in the brain. Signals from the medulla regulate blood pressure.

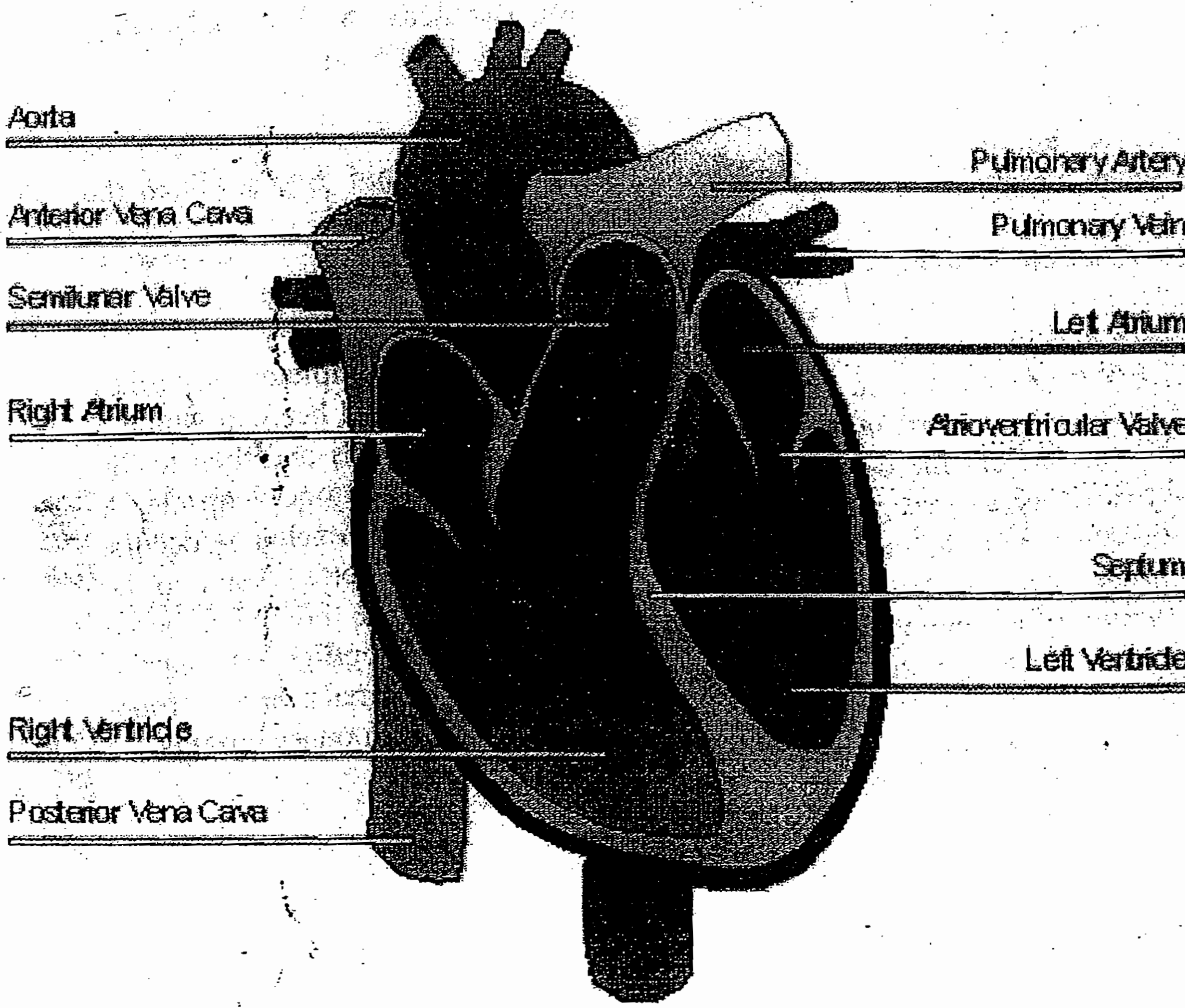
Vertebrate Vascular Systems

Humans, birds, and mammals have a four-chambered heart that completely separates oxygen-rich and oxygen-depleted blood. Fish have a two-chambered heart in which a single-loop circulatory pattern takes blood from the heart to the gills and then to the body. Amphibians have a three-chambered heart with two atria and one ventricle. A loop from the heart goes to the pulmonary capillary beds, where gas exchange occurs. Blood then is returned to the heart. Blood exiting the ventricle is diverted, some to the pulmonary circuit, some to systemic circuit. The disadvantage of the three-chambered heart is the mixing of oxygenated and deoxygenated blood. Some reptiles have partial separation of the ventricle. Other reptiles, plus, all birds and mammals, have a four-chambered heart, with complete separation of both systemic and pulmonary circuits.

The Heart

The human heart is a two-sided, four-chambered structure with muscular walls. An atrioventricular (AV) valve separates each auricle from ventricle. A semilunar (also known as arterial) valve separates each ventricle from its connecting artery.

The heart beats or contracts approximately 70 times per minute. The human heart will undergo over 3 billion contraction cycles during a normal lifetime. The cardiac cycle consists of two parts: systole (contraction of the heart muscle) and diastole (relaxation of the heart muscle). Atria contract while ventricles relax. The pulse is a wave of contraction transmitted along the arteries. Valves in the heart open and close during the cardiac cycle. Heart muscle contraction is due to the presence of nodal tissue in two regions of the heart. The SA node (sinoatrial node) initiates heartbeat. The AV node (atrioventricular node) causes ventricles to contract. The AV node is sometimes called the pacemaker since it keeps heartbeat regular. Heartbeat is also controlled by nerve messages originating from the autonomic nervous system.



Blood flows through the heart from veins to atria to ventricles out by arteries. Heart valves limit flow to a single direction. One heartbeat, or cardiac cycle, includes atrial contraction and relaxation, ventricular contraction and relaxation, and a short pause. Normal cardiac cycles (at rest) take 0.8 seconds. Blood from the body flows into the vena cava, which empties into the right atrium. At the same time, oxygenated blood from the lungs flows from the pulmonary vein into the left atrium. The muscles of both atria contract, forcing blood downward through each AV valve into each ventricle.

Diastole is the filling of the ventricles with blood. Ventricular systole opens the SL valves, forcing blood out of the ventricles through the pulmonary artery or aorta. The sound of the heart contracting and the valves opening and closing produces a characteristic "lub-dub" sound. Lub is associated with closure of the AV valves, dub is the closing of the SL valves.

Human heartbeats originate from the sinoatrial node (SA node) near the right atrium. Modified muscle cells contract, sending a signal to other muscle cells in the heart to contract. The signal spreads to the atrioventricular node (AV node). Signals carried from the AV node, slightly delayed, through bundle of His fibers and Purkinjie fibers cause the ventricles to contract simultaneously.

An electrocardiogram (ECG) measures changes in electrical potential across the heart, and can detect the contraction pulses that pass over the surface of the heart. Positive deflections are the Q and S waves. The P wave represents the contraction impulse of the atria, the T wave the ventricular contraction. ECGs are useful in diagnosing heart abnormalities.

Diseases of the Heart and Cardiovascular System

Cardiac muscle cells are serviced by a system of coronary arteries. During exercise the flow through these arteries is up to five times normal flow. Blocked flow in coronary arteries can result in death of heart muscle, leading to a heart attack.

Blockage of coronary arteries is usually the result of gradual buildup of lipids and cholesterol in the inner wall of the coronary artery. Occasional chest pain, angina pectoralis, can result during periods of stress or physical exertion. Angina indicates oxygen demands are greater than capacity to deliver it and that a heart attack may occur in the future. Heart muscle cells that die are not replaced since heart muscle cells do not divide.

The Vascular System

Two main routes for circulation are the pulmonary (to and from the lungs) and the systemic (to and from the body). Pulmonary arteries carry blood from the heart to the lungs. In the lungs gas exchange occurs. Pulmonary veins carry blood from lungs to heart. The aorta is the main artery of systemic circuit. The vena cavae are the main veins of the systemic circuit. Coronary arteries deliver oxygenated blood, food, etc. to the heart. Animals often have a portal system, which begins and ends in capillaries, such as between the digestive tract and the liver.

Fish pump blood from the heart to their gills, where gas exchange occurs, and then on to the rest of the body. Mammals pump blood to the lungs for gas exchange, then back to the heart for pumping out to the systemic circulation. Blood flows in only one direction.

Blood

Plasma is the liquid component of the blood. Mammalian blood consists of a liquid (plasma) and a number of cellular and cell fragment components as shown in Figure 21. Plasma is about 60 % of a volume of blood; cells and fragments are 40%. Plasma has 90% water and 10% dissolved materials including proteins, glucose, ions, hormones, and gases. It acts as a buffer, maintaining pH near 7.4. Plasma contains nutrients, wastes, salts, proteins, etc. Proteins in the blood aid in transport of large molecules such as cholesterol.

Red blood cells, also known as erythrocytes, are flattened, doubly concave cells about 7 µm in diameter that carry oxygen associated in the cell's hemoglobin. Mature erythrocytes lack a nucleus. They are small, 4 to 6 million cells per cubic millimeter of blood, and have 200 million hemoglobin molecules per cell. Humans have a total of 25 trillion red blood cells (about 1/3 of all the cells in the body). Red blood cells are continuously manufactured in red marrow of long bones, ribs, skull, and vertebrae. Life-span of an erythrocyte is only 120 days, after which they are destroyed in liver and spleen. Iron from hemoglobin is recovered and reused by red marrow. The liver degrades the heme units and secretes them as pigment in the bile, responsible for the color of feces. Each second two million red blood cells are produced to replace those thus taken out of circulation.

White blood cells, also known as leukocytes, are larger than erythrocytes, have a nucleus, and lack hemoglobin. They function in the cellular immune response. White blood cells (leukocytes) are less than 1% of the blood's volume. They are made from stem cells in bone marrow. There are five types of leukocytes, important components of the immune system. Neutrophils enter the tissue fluid by squeezing through capillary walls and phagocytozing foreign substances. Macrophages release white blood cell growth factors, causing a population increase for white blood cells. Lymphocytes fight infection. T-cells attack cells containing viruses. B-cells produce antibodies. Antigen-antibody complexes are phagocytized by a macrophage. White blood cells can squeeze through pores in the capillaries and fight infectious diseases in interstitial areas

Platelets result from cell fragmentation and are involved with clotting, as is shown by Figures 17 and 18. Platelets are cell fragments that bud off megakaryocytes in bone marrow. They carry chemicals essential to blood clotting. Platelets survive for 10 days before being removed by the liver and spleen. There are 150,000 to 300,000 platelets in each milliliter of blood. Platelets stick and adhere to tears in blood vessels; they also release clotting factors. A hemophiliac's blood cannot clot. Providing correct proteins (clotting factors) has been a common method of treating hemophiliacs. It has also led to HIV transmission due to the use of transfusions and use of contaminated blood products.

The Lymphatic System

Water and plasma are forced from the capillaries into intracellular spaces. This interstitial fluid transports materials between cells. Most of this fluid is collected in the capillaries of a secondary circulatory system, the lymphatic system. Fluid in this system is known as lymph.

Lymph flows from small lymph capillaries into lymph vessels that are similar to veins in having valves that prevent backflow. Lymph vessels connect to lymph nodes, lymph organs, or to the cardiovascular system at the thoracic duct and right lymphatic duct.

Lymph nodes are small irregularly shaped masses through which lymph vessels flow. Clusters of nodes occur in the armpits, groin, and neck. Cells of the immune system line channels through the nodes and attack bacteria and viruses traveling in the lymph.

Blood groups

There are different ways to classify blood. The two major forms of classification include the ABO system and the Rhesus (Rh) type system, characteristics that are inherited independently. Together, they comprise the eight main blood groups. Other blood group systems exist and, to date, researchers have identified around 300 minor factors.

The ABO group

The four different blood groups are A, B, AB and O. A person's blood group is determined by a pair of genes, one each inherited from their mother and father. Each blood group is identified by its own set of complicated chemical substances - called antigens - located on the surfaces of red blood cells. When a person needs a blood transfusion, it is important that the donated blood matches their particular blood group. A mismatch can cause serious complications

The Rhesus factor

A person's Rhesus type is also determined by a pair of genes, each one inherited from one parent. Blood is either Rh-positive or Rh-negative, depending on whether or not certain molecules are present. A person who is Rh-negative will experience a severe immune system reaction if Rh-positive blood gets into their bloodstream. This can happen during childbirth, if an Rh-negative woman gives birth to an Rh-positive baby. Hemolytic disease of the newborn (HDN) results from Rh incompatibility between an Rh^- mother and Rh^+ fetus. If blood cells from the baby travel across the placenta, the woman's immune system will regard the Rh-positive cells as a threat. Specialised white blood cells will make antibodies designed to kill Rh-positive blood cells. If the woman subsequently conceives another Rh-positive baby, her immune system will flood her child with antibodies. These antibodies then destroy the baby's red blood cells. If left untreated, this can result in severe anaemia or even death.

Preventing Rhesus disease

Rhesus disease is now rare, since Rh-negative mothers who give birth to Rh-positive babies are immunised within 72 hours of giving birth. The immuneglobulin preparation works by killing the baby's red blood cells inside the mother's bloodstream before her immune system has time to react.

Blood transfusion

A blood transfusion is the transfer of blood from one person to another. The donated blood must match the recipient's blood type, or complications will occur. Generally, both receiving and donating blood are safe medical procedures. For instance, O negative blood can be given to anybody if necessary, but it is always preferable to match the exact blood group. The different types of blood transfusion include homologous (whole blood transfusion) and aphaeresis (only certain components - such as platelets - are transfused).

Important Facts

Blood Type frequency in percentage of total population:

Blood Type	% Frequency
O	46%
A	40%
B	10%
AB	4%

Blood types are not evenly distributed throughout the human population. O+ is the most common, AB- is the rarest. There are also variations in blood-type distribution within human subpopulations:

Blood Type	Abbr	% Frequency
O Rh-positive	O+	38%
O Rh-negative	O-	7%
A Rh-positive	A+	34%
A Rh-negative	A-	6%
B Rh-positive	B+	9%
B Rh-negative	B-	2%
AB Rh-positive	AB+	3%
AB Rh-negative	AB-	1%

Alloimunization Most people, on average, will only need blood one time in their lives, to help fight a disease, restore blood lost during surgery or because of traumatic injury. But some patients, like sickle cell patients, may need blood many times during their lives. If the blood they receive is not a very close match, they will begin to reject transfusions, and an important source of help and hope will be gone. To prevent that, blood for these patients should be closely matched. Often, this will be a rare blood type. For sickle cell patients, the best match will come from donors of African descent. Fully one third of requests for rare blood received by the Red Cross is for a blood type found exclusively among African Americans.

Universal donor Type O negative donors are known as universal donors because their blood may be transfused to patients of any other blood type in an emergency situation or if the specific needed blood type is unavailable. Because any patient can receive O negative blood, there is a constant need for O negative donors to give more often and shortages of type O blood can have critical consequences in national disasters. Whatever a person's blood type, they can be very important to someone in emergency crisis.

12. LYMPHATIC SYSTEM & IMMUNITY

The Lymphatic System

The lymphatic system is composed of lymph vessels, lymph nodes, and organs. The functions of this system include the absorbtion of excess fluid and its return to the blood stream, absorption of fat (in the villi of the small intestine) and the immune system function.

Lymph vessels are closely associated with the circulatory system vessels. Larger lymph vessels are similar to veins. Lymph capillaries are scatted throughout the body. Contraction of skeletal muscle causes movement of the lymph fluid through valves.

Lymph organs include the bone marrow, lymph nodes, spleen, and thymus. Bone marrow contains tissue that produces lymphocytes. B-lymphocytes (B-cells) mature in the bone marrow. T-lymphocytes (T-cells) mature in the thymus gland. Other blood cells such as monocytes and leukocytes are produced in the bone marrow. Lymph nodes are areas of concentrated lymphocytes and macrophages along the lymphatic veins. The spleen is similar to the lymph node except that it is larger and filled with blood. The spleen serves as a reservoir for blood, and filters or purifies the blood and lymph fluid that flows through it. If the spleen is damaged or removed, the individual is more susceptible to infections. The thymus secretes a hormone, thymosin, that causes pre-T-cells to mature (in the thymus) into T-cells.

Immunity

Immunity is the body's capability to repel foreign substances and cells. The nonspecific responses are the first line of defense. Highly specific responses are the second line of defense and are tailored to an individual threat. The immune response includes both specific and nonspecific components. Nonspecific responses block the entry and spread of disease-causing agents. Antibody-mediated and cell-mediated responses are two types of specific response. The immune system is associated with defense against disease-causing agents, problems in transplants and blood transfusions, and diseases resulting from over-reaction (autoimmune, allergies) and under-reaction (AIDS).

General Defenses

Barriers to entry are the skin and mucous membranes. The skin is a passive barrier to infectious agents such as bacteria and viruses. The organisms living on the skin surface are unable to penetrate the layers of dead skin at the surface. Tears and saliva secrete enzymes that breakdown bacterial cell walls. Skin glands secrete chemicals that retard the growth of bacteria. Mucus membranes lining the respiratory, digestive, urinary, and reproductive tracts secrete mucus that forms another barrier. Physical barriers are the first line of defense.

When microorganisms penetrate skin or epithelium lining respiratory, digestive, or urinary tracts, inflammation results. Damaged cells release chemical signals such as histamine that increase capillary blood flow into the affected area (causing the areas to become heated and reddened). The heat makes the environment unfavorable for microbes, promotes healing, raises mobility of white blood cells, and increases the metabolic rate of nearby cells. Capillaries pass fluid into interstitial areas, causing the infected/injured area to swell. Clotting factors trigger formation of many small blood clots. Finally, monocytes (a type of white blood cell) clean up dead microbes, cells, and debris.

The inflammatory response is often strong enough to stop the spread of disease-causing agents such as viruses, bacteria, and fungi. The response begins with the release of chemical signals and ends with cleanup by monocytes. If this is not enough to stop the invaders, the complement system and immune response act.

Protective proteins that are produced in the liver include the complement system of proteins. The complement system proteins bind to a bacterium and open pores in its membrane through which fluids and salt move, swelling and bursting the cell.

The complement system directly kills microbes, supplements inflammatory response, and works with the immune response. It complements the actions of the immune system. Complement proteins are made in the liver and become active in a sequence (C1 activates C2, etc.). The final five proteins form a membrane-attack complex (MAC) that embeds itself into the plasma membrane of the attacker. Salts enter the invader, facilitating water to cross the membrane, swelling and bursting the microbe. Complement also functions in the immune response by tagging the outer surface of invaders for attack by phagocytes

Interferon is a species-specific chemical produced by cells that are viral attack. It alerts nearby cells to prepare for a virus. The cells that have been contacted by interferon resist all viral attacks.

Specific Defenses

The immune system also generates specific responses to specific invaders.

The immune system is more effective than the nonspecific methods, and has a memory component that improves response time when an invader of the same type (or species) is again encountered.

Immunity results from the production of antibodies specific to a given antigen (antibody-generators, located on the surface of an invader). Antibodies bind to the antigens on invaders and kill or inactivate them in several ways. Most antibodies are themselves proteins or are a mix of protein and polysaccharides. Antigens can be any molecule that causes antibody production.

Lymphocytes

White blood cells known as lymphocytes arise from by mitosis of stem cells in the bone marrow. Some lymphocytes migrate to the thymus and become T cells that circulate in the blood and are associated with the lymph nodes and spleen. B cells remain in the bone marrow and develop before moving into the circulatory and lymph systems. B cells produce antibodies

Antibody-mediated (humoral immunity)

Antibody-mediated (humoral) immunity is regulated by B cells and the antibodies they produce. Cell-mediated immunity is controlled by T cells. Antibody-mediated reactions defend against invading viruses and bacteria. Cell-mediated immunity concerns cells in the body that have been infected by viruses and bacteria, protect against parasites, fungi, and protozoans, and also kill cancerous body cells.

Antibody-mediated Immunity

Stages in this process are:

1. antigen detection
2. activation of helper T cells
3. antibody production by B cells

Each stage is directed by a specific cell type.

Macrophages

Macrophages are white blood cells that continually search for foreign (nonself) antigenic molecules, viruses, or microbes. When found, the macrophages engulfs and destroys them. Small fragments of the antigen are displayed on the outer surface of the macrophage plasma membrane.

Helper T Cells

Helper T cells are macrophages that become activated when they encounter the antigens now displayed on the macrophage surface. Activated T cells identify and activate B cells.

B Cells

B cells divide, forming plasma cells and B memory cells. Plasma cells make and release between 2000 and 20,000 antibody molecules per second into the blood for the next four or five days. B memory cells live for months or years, and are part of the immune memory system.

Antibodies

Antibodies bind to specific antigens in a lock-and-key fashion, forming an antigen-antibody complex. Antibodies are a type of protein molecule known as immunoglobulins. There are five classes of immunoglobulins: IgG, IgA, IgD, IgE, and IgM.

Antibodies are Y-shaped molecules composed of two identical long polypeptide (Heavy or H chains) and two identical short polypeptides (Light or L chains). Function of antibodies includes:

1. Recognition and binding to antigens
2. Inactivation of the antigen

A unique antigenic determinant recognizes and binds to a site on the antigen, leading to the destruction of the antigen in several ways. The ends of the Y are the antigen-combining site that is different for each antigen.

Helper T cells activate B cells that produce antibodies. Supressor T cells slow down and stop the immune response of B and T cells, serving as an off switch for the immune system. Cytotoxic (or killer) T cells destroy body cells infected with a virus or bacteria. Memory T cells remain in the body awaiting the reintroduction of the antigen.

A cell infected with a virus will display viral antigens on its plasma membrane. Killer T cells recognize the viral antigens and attach to that cell's plasma membrane. The T cells secrete proteins that punch holes in the infected cell's plasma membrane. The infected cell's cytoplasm leaks out, the cell dies, and is removed by phagocytes. Killer T cells may also bind to cells of transplanted organs.

The immune system is the major component of this defense. Lymphocytes, monocytes, lymph organs, and lymph vessels make up the system. The immune system is able to distinguish self from non-self. Antigens are chemicals on the surface of a cell. All cells have these. The immune system checks cells and identifies them as "self" or "non-self". Antibodies are proteins produced by certain lymphocytes in response to a specific antigen. B-lymphocytes and T-lymphocytes produce the antibodies. B-lymphocytes become plasma cells which then generate antibodies. T-lymphocytes attack cells which bear antigens they recognize. They also mediate the immune response.

The immune system and memory of infections

Secondary immunity, the resistance to certain diseases after having had them once, results from production of Memory B and T cells during the first exposure to the antigen. A second exposure to the same antigen produces a more massive and faster response. The secondary response is the basis for vaccination.

Vaccination

Vaccination is a term derived from the Latin *vacca* (cow, after the cowpox material used by Edward Jenner in the first vaccination). A vaccine stimulates the antibody production and formation of memory cells without causing of the disease. Vaccines are made from killed pathogens or weakened strains that cause antibody production but not the disease. Recombinant DNA techniques can now be used to develop even safer vaccines.

The immune system can develop long-term immunity to some diseases. Man can use this to develop vaccines, which produce induced immunity. Active immunity develops after an illness or vaccine. Vaccines are weakened (or killed) viruses or bacteria that prompt the development of antibodies. Application of biotechnology allows development of vaccines that are the protein (antigen) which in no way can cause the disease. Passive immunity is the type of immunity when the individual is given antibodies to combat a specific disease. Passive immunity is short-lived.

Allergies and Disorders of the Immune System

The immune system can overreact, causing allergies or autoimmune diseases. Likewise, a suppressed, absent, or destroyed immune system can also result in disease and death.

Allergies result from immune system hypersensitivity to weak antigens that do not cause an immune response in most people. Allergens, substances that cause allergies, include dust, molds, pollen, cat dander, certain foods, and some medicines (such as penicillin

After exposure to an allergen, some people make IgE antibodies as well as B and T memory cells. Subsequent exposure to the same allergen causes a massive secondary immune response that releases plenty of IgE antibodies. These bind to mast cells found usually in connective tissues surrounding blood vessels. Mast cells then release histamine, which starts the inflammatory response. In some individuals the histamine release causes life-threatening anaphylaxis or anaphylactic shock.

The immune system usually distinguishes "self" from "nonself". The immune system learns the difference between cells of the body and foreign invaders. Autoimmune diseases result when the immune system attacks and destroys cells and tissues of the body. Juvenile diabetes, Grave's disease, Multiple sclerosis, Systemic lupus erythematosus, and Rheumatoid arthritis are some of the autoimmune diseases.

Myasthenia gravis (MG) is a muscle weakness caused by destruction of muscle-nerve connections. Multiple sclerosis (MS) is caused by antibodies attacking the myelin of nerve cells. Systemic lupus erythematosis (SLE) has the person forming a series of antibodies to their own tissues, such as kidneys (the leading cause of death in SLE patients) and the DNA in their own cellular nuclei. In systemic lupus erythematosus (SLE), the immune system attacks connective tissues and major organs of the body. Rheumatoid Arthritis; sufferers have damage to their joints. Some evidence supports Type I diabetes as an auto immune disease. Juvenile diabetes results from the destruction of insulin-producing cells in the pancreas.

Immunodeficiency diseases result from the lack or failure of one or more parts of the immune system. Affected individuals are susceptible to diseases that normally would not bother most people. Genetic disorders, Hodgkin's disease, cancer chemotherapy, and radiation therapy can cause immunodeficiency diseases.

Severe Combined Immunodeficiency (SCID) results from a complete absence of the cell-mediated and antibody-mediated immune responses. Affected individuals suffer from a series of seemingly minor infections and usually die at an early age. A small group suffering from adenosine deaminase (ADA) deficiency, a type of SCID, are undergoing gene therapy to provide them with normal copies of the defective gene.

Acquired Immunodeficiency Syndrome (AIDS) is currently receiving the most attention among the immunodeficiency diseases. AIDS is a collection of disorders resulting from the destruction of T cells by the Human Immunodeficiency Virus (HIV), a retrovirus. When HIV replicates in the human T cells, it buds from the T cell plasma membrane encased in a coat derived from the T cell plasma membrane. HIV selectively infects and kills T4 helper cells. The viral RNA is converted into DNA by the enzyme reverse transcriptase; this DNA can become incorporated into a human chromosome for months or years.

When the infected T cell is needed in the immune response, the viral genes are activated and the virus replicates, killing the infected cell and producing a new round on T4 cell infection. Gradually the number of T4 cells, the master on switch for the immune system, decline. The immune response grows less powerful, eventually failing. Premature death results from a series of rare diseases (such as fungal pneumonia and Kaposi's sarcoma, a rare cancer) that overwhelm the body and its compromised immune system.

13. THE DIGESTIVE SYSTEM

Digestive System

Single-celled organisms can directly take in nutrients from their outside environment. Multicellular animals, with most of their cells removed from contact directly with the outside environment, have developed specialized structures for obtaining and breaking down their food. Animals depend on two processes: feeding and digestion.

Animals are heterotrophs, they must absorb nutrients or ingest food sources. Ingestive eaters, the majority of animals, use a mouth to ingest food. Absorptive feeders, such as tapeworms, live in a digestive system of another animal and absorb nutrients from that animal directly through their body wall. Filter feeders, such as oysters and mussels, collect small organisms and particles from the surrounding water. Substrate feeders, such as earthworms and termites, eat the material (dirt or wood) they burrow through. Fluid feeders, such as aphids, pierce the body of a plant or animal and withdraw fluids.

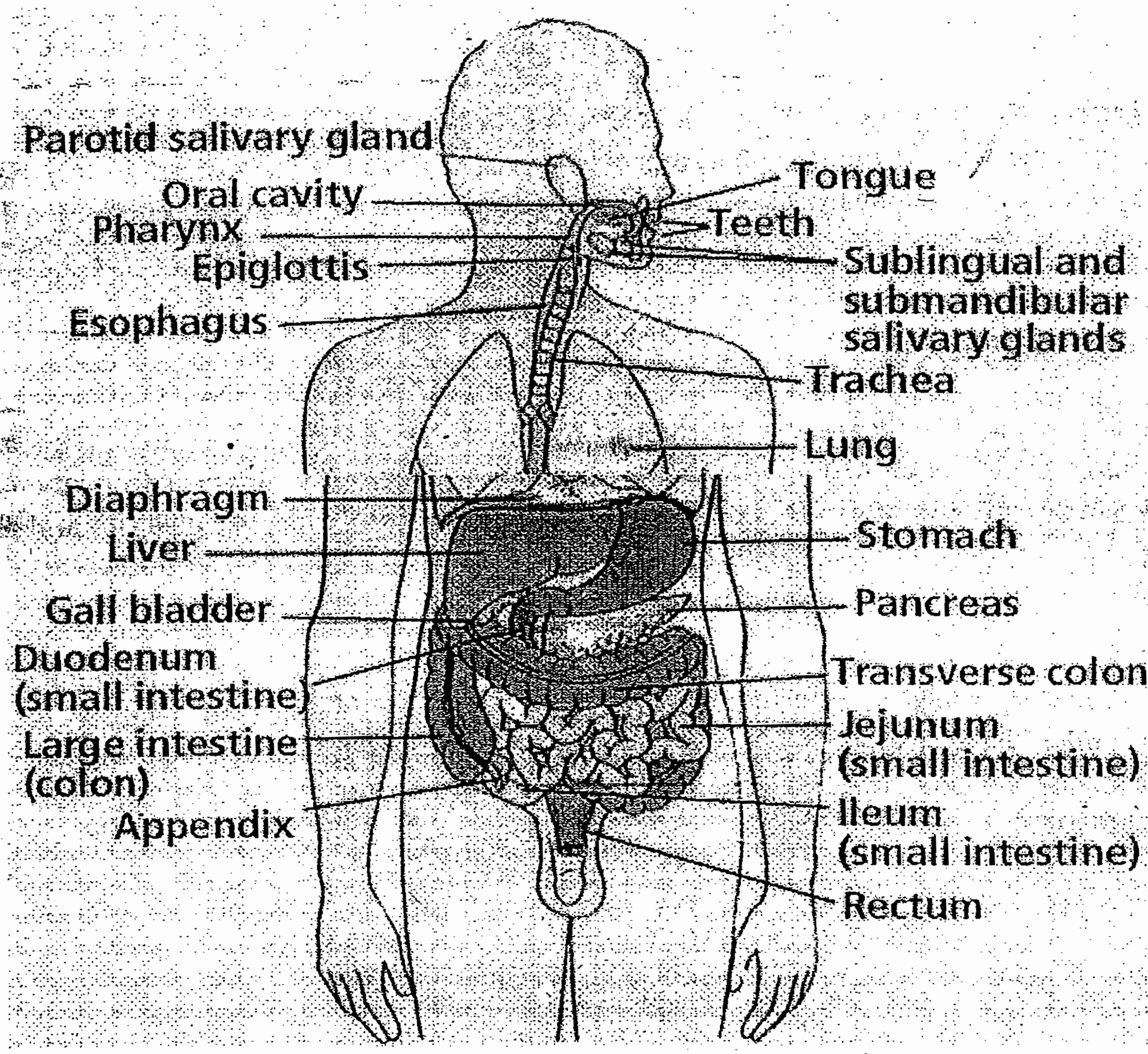
Plans and Locations

The digestive system uses mechanical and chemical methods to break food down into nutrient molecules that can be absorbed into the blood. Once in the blood, the food molecules are routed to every cell in the animal's body.

There are two types of animal body plans as well as two locations for digestion to occur. Sac-like plans are found in many invertebrates, who have a single opening for food intake and the discharge of wastes. Vertebrates, the animal group humans belong to, use the more efficient tube-within-a-tube plan with food entering through one opening (the mouth) and wastes leaving through another (the anus).

Where the digestion of the food happens is also variable. Some animals use intracellular digestion, where food is taken into cells by phagocytosis with digestive enzymes being secreted into the phagocytic vesicles. This type of digestion occurs in sponges, coelenterates (corals, hydras and their relatives) and most protozoans. Extracellular digestion occurs in the lumen (or opening) of a digestive system, with the nutrient molecules being transferred to the blood or some other body fluid. This more advanced type of digestion occurs in chordates, annelids, and crustaceans.

The human digestive system



Stages in the Digestive Process

Food for the most part consists of various organic macromolecules such as starch, proteins, and fats. These molecules are polymers made of individual monomer units. Breaking these large molecules into smaller components involves:

1. movement: propels food through the digestive system
2. secretion: release of digestive juices in response to a specific stimulus
3. digestion: breakdown of food into molecular components small enough to cross the plasma membrane
4. absorption: passage of the molecules into the body's interior and their passage throughout the body

5. elimination: removal of undigested food and wastes

Components of the Digestive System

The human digestive system is a coiled, muscular tube (6-9 meters long when fully extended) stretching from the mouth to the anus. Several specialized compartments occur along this length: mouth, pharynx, esophagus, stomach, small intestine, large intestine, and anus. Accessory digestive organs are connected to the main system by a series of ducts: salivary glands, parts of the pancreas, and the liver and gall bladder (bilary system).

The Mouth and Pharynx

Mechanical breakdown begins in the mouth by chewing (teeth) and actions of the tongue. Chemical breakdown of starch by production of salivary amylase from the salivary glands. This mixture of food and saliva is then pushed into the pharynx and esophagus. The esophagus is a muscular tube whose muscular contractions (peristalsis) propel food to the stomach.

In the mouth, teeth, jaws and the tongue begin the mechanical breakdown of food into smaller particles. Most vertebrates, except birds (who have lost their teeth to a hardened bill), have teeth for tearing, grinding and chewing food. The tongue manipulates food during chewing and swallowing; mammals have tastebuds clustered on their tongues.

Salivary glands secrete salivary amylase, an enzyme that begins the breakdown of starch into glucose. Mucus moistens food and lubricates the esophagus. Bicarbonate ions in saliva neutralize the acids in foods.

Swallowing moves food from the mouth through the pharynx into the esophagus and then to the stomach.

- Step 1: A mass of chewed, moistened food, a bolus, is moved to the back of the moth by the tongue. In the pharynx, the bolus triggers an involuntary swallowing reflex that prevents food from entering the lungs, and directs the bolus into the esophagus.
- Step 2: Muscles in the esophagus propel the bolus by waves of involuntary muscular contractions (peristalsis) of smooth muscle lining the esophagus.
- Step 3: The bolus passes through the gastroesophogeal sphincter, into the stomach. Heartburn results from irritation of the esophagus by gastric juices that leak through this sphincter.

The Stomach (or Churn, Churn, Churn)

During a meal, the stomach gradually fills to a capacity of 1 liter, from an empty capacity of 50-100 milliliters. At a price of discomfort, the stomach can distend to hold 2 liters or more.

Epithelial cells line inner surface of the stomach, as shown in Figure 5, and secrete about 2 liters of gastric juices per day. Gastric juice contains hydrochloric acid, pepsinogen, and mucus; ingredients important in digestion. Secretions are controlled by nervous (smells, thoughts, and caffeine) and endocrine signals. The stomach secretes hydrochloric acid and pepsin. Hydrochloric acid (HCl) lowers pH of the stomach so pepsin is activated. Pepsin is an enzyme that controls the hydrolysis of proteins into peptides. The stomach also mechanically churns the food. Chyme, the mix of acid and food in the stomach, leaves the stomach and enters the small intestine

Hydrochloric acid does not directly function in digestion: it kills microorganisms, lowers the stomach pH to between 1.5 and 2.5; and activates pepsinogen. Pepsinogen is an enzyme that starts protein digestion. Pepsinogen is produced in cells that line the gastric pits. It is activated by cleaving off a portion of the molecule, producing the enzyme pepsin that splits off fragments of peptides from a protein molecule during digestion in the stomach.

Carbohydrate digestion, begun by salivary amylase in the mouth, continues in the bolus as it passes to the stomach. The bolus is broken down into acid chyme in the lower third of the stomach, allowing the stomach's acidity to inhibit further carbohydrate breakdown. Protein digestion by pepsin begins.

Alcohol and aspirin are absorbed through the stomach lining into the blood.

Epithelial cells secrete mucus that forms a protective barrier between the cells and the stomach acids. Pepsin is inactivated when it comes into contact with the mucus. Bicarbonate ions reduce acidity near the cells lining the stomach. Tight junctions link the epithelial stomach-lining cells together, further reducing or preventing stomach acids from passing.

Ulcers

Peptic ulcers result when these protective mechanisms fail. Bleeding ulcers result when tissue damage is so severe that bleeding occurs into the stomach. Perforated ulcers are life-threatening situations where a hole has formed in the stomach wall. At least 90% of all peptic ulcers are caused by *Helicobacter pylori*. Other factors, including stress and aspirin, can also produce ulcers.

The Small Intestine

The small intestine is where final digestion and absorption occur. The small intestine is a coiled tube over 3 meters long. Coils and folding plus villi give this 3m tube the surface area of a 500-600m long tube. Final digestion of proteins and carbohydrates must occur, and fats have not yet been digested. Villi have cells that produce intestinal enzymes which complete the digestion of peptides and sugars. The absorption process also occurs in the small intestine. Food has been broken down into particles small enough to pass into the small intestine. Sugars and amino acids go into the bloodstream via capillaries in each villus. Glycerol and fatty acids go into the lymphatic system. Absorption is an active transport, requiring cellular energy.

Food is mixed in the lower part of the stomach by peristaltic waves that also propel the acid-chyme mixture against the pyloric sphincter. Increased contractions of the stomach push the food through the sphincter and into the small intestine as the stomach eempties over a 1 to 2 hour period. High fat diets significantly increase this time period.

The small intestine is the major site for digestion and absorption of nutrients. The small intestine is up to 6 meters long and is 2-3 centimeters wide. The upper part, the duodenum, is the most active in digestion. Secretions from the liver and pancreas are used for digestion in the duodenum. Epithelial cells of the duodenum secrete a watery mucus. The pancreas secretes digestive enzymes and stomach acid-neutralizing bicarbonate. The liver produces bile, which is stored in the gall bladder before entering the bile duct into the duodenum.

Digestion of carbohydrates, proteins, and fats continues in the small intestine. Starch and glycogen are broken down into maltose by small intestine enzymes. Proteases are enzymes secreted by the pancreas that continue the breakdown of protein into small peptide fragments and amino acids.

Bile emulsifies fats, facilitating their breakdown into progressively smaller fat globules until they can be acted upon by lipases. Bile contains cholesterol, phospholipids, bilirubin, and a mix of salts. Fats are completely digested in the small intestine, unlike carbohydrates and proteins.

Most absorption occurs in the duodenum and jejeunum (second third of the small intestine). The inner surface of the intestine has circular folds that more than triple the surface area for absorption. Villi covered with epithelial cells increase the surface area by another factor of 10. The epithelial cells are lined with microvilli that further increase the surface area; a 6 meter long tube has a surface area of 300 square meters.

Each villus has a surface that is adjacent to the inside of the small intestinal opening covered in microvilli that form on top of an epithelial cell known as a brush border. Each villus has a capillary network supplied by a small arteriole. Absorbed substances pass through the brush border into the capillary, usually by passive transport.

Maltose, sucrose, and lactose are the main carbohydrates present in the small intestine; they are absorbed by the microvilli. Starch is broken down into two-glucose units (maltose) elsewhere. Enzymes in the cells convert these disaccharides into monosaccharides that then leave the cell and enter the capillary. Lactose intolerance results from the genetic lack of the enzyme lactase produced by the intestinal cells.

Peptide fragments and amino acids cross the epithelial cell membranes by active transport. Inside the cell they are broken into amino acids that then enter the capillary. Gluten enteropathy is the inability to absorb gluten, a protein found in wheat.

Digested fats are not very soluble. Bile salts surround fats to form micelles that can pass into the epithelial cells. The bile salts return to the lumen to repeat the process. Fat digestion is usually completed by the time the food reaches the ileum of the small intestine. Bile salts are in turn absorbed in the ileum and are recycled by the liver and gall bladder. Fats pass from the epithelial cells to the small lymph vessel that also runs through the villus.

The Liver and Gall Bladder

The liver produces and sends bile to the small intestine via the hepatic duct. Bile contains bile salts, which emulsify fats, making them susceptible to enzymatic breakdown. In addition to digestive functions, the liver plays several other roles:

1) detoxification of blood
2) synthesis of blood proteins
3) destruction of old erythrocytes and conversion of hemoglobin into a component of bile
4) production of bile
5) storage of glucose as glycogen, and its release when blood sugar levels drop and
6) production of urea from amino groups and ammonia.

The gall bladder stores excess bile for release at a later time. We can live without our gall bladders, in fact many people have had theirs removed. The drawback, however, is a need to be aware of the amount of fats in the food they eat since the stored bile of the gall bladder is no longer available.

Glycogen is a polysaccharide made of chains of glucose molecules. In plants starch is the storage form of glucose, while animals use glycogen for the same purpose. Low glucose levels in the blood cause the release of hormones, such as glucagon, that travel to the liver and stimulate the breakdown of glycogen into glucose, which is then released into the blood(raising blood glucose levels). When no glucose or glycogen is available, amino acids are converted into glucose in the liver. The process of deamination removes the amino groups from amino acids. Urea is formed and passed through the blood to the kidney for export from the body. Conversely, the hormone insulin promotes the take-up of glusose into liver cells and its formation into glycogen.

Liver diseases

Jaundice occurs when the characteristic yellow tint to the skin is caused by excess hemoglobin breakdown products in the blood, a sign that the liver is not properly functioning. Jaundice may occur when liver function has been impaired by obstruction of the bile duct and by damage caused by hepatitis.

Hepatitis A, B, and C are all viral diseases that can cause liver damage. Like any viral disease, the major treatment efforts focus on treatment of symptoms, not removal of the viral cause.

Hepatitis A is usually mild malady indicated by a sudden fever, malaise, nausea, anorexia, and abdominal discomfort. Jaundice follows up for several days. The virus causing Hepatitis A is primarilly transmitted by fecal contamination, although contaminated food and water also can promote transmission. A rare disease in the United States, hepatitis B is endemic in parts of Asia where hundreds of millions of individuals are possibly infected.

Hepatitis B may be transmitted by blood and blood products as well as sexual contact.

Hepatitis C affects approximately 170 million people worldwide and 4 million in the United States. The virus is transmitted primarily by blood and blood products. Sexual transmission can occur between monogamous couples (rare) but infection is far more common in those who are promiscuous. In rare cases, Hepatitis C causes acute disease and even liver failure. About twenty percent of individuals with Hepatitis C who develop cirrhosis of the liver will also develop severe liver disease. Cirrhosis caused by Hepatitis C is presently the leading cause of the need for liver transplants in the United States. Individuals with cirrhosis from Hepatitis C also bear increased chances of developing primary liver cancer. All current treatments for Hepatitis C employ of various ***preparations of the potent antiviral interferon alpha.***

Cirrhosis of the liver commonly occurs in alcoholics, who place the liver in a stress situation due to the amount of alcohol to be broken down. Cirrhosis can cause the liver to become unable to perform its biochemical functions. Chemicals responsible for blood clotting are synthesized in the liver, as is albumin, the major protein in blood.

The liver also makes or modifies bile components. Blood from the circulatory system passes through the liver, so many of the body's metabolic functions occur primarily there including the metabolism of cholesterol and the conversion of proteins and fats into glucose. Cirrhosis is a disease resulting from damage to liver cells due to toxins, inflammation, and other causes. Liver cells regenerate in an abnormal pattern primarily forming nodules that are surrounded by fibrous tissue. Changes in the structure of the liver can decrease blood flow, leading to secondary complications. Cirrhosis has many cuses, including alcoholic liver disease, severe forms of some viral hepatitis, congestive heart failure, parasitic infections (for example schistosomiasis), and long term exposure to toxins or drugs.

The Pancreas

The pancreas sends pancreatic juice, which neutralizes the chyme, to the small intestive through the pancreatic duct. In addition to this digestive function, the pancrease is the site of production of several hormones, such as glucagon and insulin.

The pancreas contains exocrine cells that secrete digestive enzymes into the small intestine and clusters of endocrine cells (the pancreatic islets). The islets secrete the hormones insulin and glucagon, which regulate blood glucose levels.

After a meal, blood glucose levels rise, prompting the release of insulin, which causes cells to take up glucose, and liver and skeletal muscle cells to form the carbohydrate glycogen. As glucose levels in the blood fall, further insulin production is inhibited. Glucagon causes the breakdown of glycogen into glucose, which in turn is released into the blood to maintain glucose levels within a homeostatic range. Glucagon production is stimulated when blood glucose levels fall, and inhibited when they rise.

Diabetes results from inadequate levels of insulin. Type I diabetes is characterized by inadequate levels of insulin secretion, often due to a genetic cause. Type II usually develops in adults from both genetic and environmental causes. Loss of response of targets to insulin rather than lack of insulin causes this type of diabetes. Diabetes may cause impairment in the functioning of the eyes, circulatory system, nervous system, and failure of the kidneys. Diabetes is the second leading cause of blindness in the United States. Treatments might involve daily injections of insulin, oral medications such as metformin, monitoring of blood glucose levels, and a controlled diet. Type I diabetes may one day be cured by advances in gene therapy/stem cell research. On recently recognized condition is known as prediabetes, in which the body gradually loses its sensitivity to insulin, leading eventually to Type II diabetes. Oral medications, diet and behavior changes are thought to delay if not outright postpone the onset of diabetes if corrected soon enough.

The Large Intestine

The large intestine is made up by the colon, cecum, appendix, and rectum. Material in the large intestine is mostly indigestible residue and liquid. Movements are due to involuntary contractions that shuffle contents back and forth and propulsive contractions that move material through the large intestine. The large intestine performs three basic functions in vertebrates:

1) recovery of water and electrolytes from digested food;

2) formation and storage of feces; and

3) microbial fermentation:

The large intestine supports an amazing flora of microbes. Those microbes produce enzymes that can digest many of molecules indigestible by vertebrates.

Secretions in the large intestine are an alkaline mucus that protects epithelial tissues and neutralizes acids produced by bacterial metabolism. Water, salts, and vitamins are absorbed, the remaining contents in the lumen form feaces (mostly cellulose, bacteria, bilirubin). Bacteria in the large intestine, such as *E. coli*, produce vitamins (including vitamin K) that are absorbed.

Regulation of Appetite

The hypothalamus in the brain has two centers controlling hunger. One is the appetite center, the other the satiety center.

Gastrin, secretin, and cholecystokinin are hormones that regulate various stages of digestion. The presence of protein in the stomach stimulates secretion of gastrin, which in turn will cause increased stomach acid secretion and mobility of the digestive tract to move food. Food passing into the duodenum causes the production of secretin, which in turn promotes release of alkaline secretions from the pancreas, stops further passage of food into the intestine until the acid is neutralized. Cholecystokinin (CCK) is released from intestinal epithelium in response to fats, and causes the release of bile from the gall bladder and lipase (a fat digesting enzyme) from the pancreas.

Nutrition

Nutrition deals with the composition of food, its energy content, and slowly (or not at all) synthesized organic molecules. Chemotrophs are organisms (mostly bacteria) deriving their energy from inorganic chemical reactions. Phototrophs convert sunlight energy into sugar or other organic molecules. Heterotrophs eat to obtain energy from the breakdown of organic molecules in their food.

Macronutrients are foods required on a large scale each day. These include carbohydrates, lipids, and amino acids. Water is essential, correct water balance is a must for proper functioning of the body.

About 60% of the diet should be carbohydrates, obtained from foods such as milk, meat, vegetables, grains and grain products. The diet should contain at least 100 grams of carbohydrate every day. Recently, however, new recommendations have been developed that suggest a lowering of the amount of carbohydrate.

Sources of Carbohydrates

The main sources of carbohydrates are plants, e.g., starch (storage forms carbohydrate of chlorophyll containing plants), sugars, cereals, potatoes, legumes, millets, roots and other vegetables. Sugars are found in fruits, juice, cane, honey, palm, milk, etc.

Carbohydrates Deficiency Diseases

- Hyperglycemia
- Glycosuria
- Galactosemia
- Pentosuria
- Diarrhoea and flatulence
- Ketone
- Under weight.

Proteins are polymers composed of amino acids. Proteins are found in meat, milk, poultry, fish, cereal grains and beans. They are needed for cellular growth and repair. Twenty amino acids are found in proteins, of which humans can make eleven. The remaining nine are the essential amino acids which must be supplied in the diet. Normally proteins are not used for energy, however during starvation (or a low-carb diet) muscle proteins are broken down for energy. Excess protein can be used for energy or converted to fats.

Sources of Proteins

Peas, beans, poultry, cereals, lentils, milk, cheese, eggs, meat, wet and dry fishes, pulses, and nuts.

Protein Deficiency Diseases

- Abdominal enlargement, excessive loss in urine and disease to lower urinary tracts-

- Vomiting
- Diarrhea
- Nephrosis
- Lassitude
- Oedema
- Kwashiorkor (Protein malnutrition)
- Marasmic - Kwashiorkor
- Negative nitrogen balance

Lipids and fats generate the greatest energy yield, so a large number of plants and animals store excess food energy as fats. Lipids and fats are present in oils, meats, butter, and plants (such as avocado and peanuts). Some fatty acids, such as linoleic acid, are essential and must be included in the diet. When present in the intestine, lipids promote the uptake of vitamins A, D, E, and K.

Vitamins are organic molecules required for metabolic reactions. They usually cannot be made by the body and are needed in trace amounts. Vitamins may act as enzyme cofactors or coenzymes. Some vitamins are soluble in fats, some in water.

Minerals are trace elements required for normal metabolism, as components of cells and tissues, and for nerve conduction and muscle contraction. They can only be obtained from the diet. Iron (for hemoglobin), iodine (for thyroxin), calcium (for bones), and sodium (nerve message transmission) are examples of minerals.

There is a quantitative relationship between nutrients and health. Imbalances can cause disease. Many studies have concluded nutrition is a major factor in cardiovascular disease, hypertension, and cancer.

vitamins and their sources

Vitamin	Source
Vitamin A (Retinol)	Cod liver oil
Vitamin B_1 (Thiamin)	Rice bran
Vitamin C (Ascorbic	Lemons

acid)	
Vitamin D (Calciferol)	Cod liver oil
Vitamin B_2 (Riboflavin)	Eggs
Vitamin E (Tocopherol)	Wheat germ oil, Cosmetic and Liver
Vitamin B_{12} (Cyanocobalamin)	Liver
Vitamin K (Phylloquinone)	Alfalfa
Vitamin B_5 (Pantothenic acid)	Liver
Vitamin B_7 (Biotin)	Liver
Vitamin B_6 (Pyridoxine)	Rice bran
Vitamin B_3 (Niacin)	Liver
Vitamin B_9 (Folic acid)	Liver

List of vitamins

Vitamin	chemical name(s)	Solubility	Deficiency disease	Overdose disease
Vitamin A	Retinoids (retinol, retinoids and carotenoids)	Fat	Night-blindness and Keratomalacia	Hypervitaminosis A
Vitamin B_1	Thiamine	Water	Beriberi	Rare hypersensitive reactions resembling anaphylactic shock-- injection only; Drowsiness
Vitamin B_2	Riboflavin	Water	Ariboflavinosis	
Vitamin B_3	Niacin, niacinamide	Water	Pellagra	Liver damage (doses > 2g/day) and other problems
Vitamin B_5	Pantothenic acid	Water	Paresthesia	
Vitamin B_6	Pyridoxine, pyridoxamine, pyridoxal	Water	Anaemia	Impairment of proprioception, nerve damage (doses > 100 mg/day)
Vitamin B_7	Biotin(vit H)	Water	Dermatitis, enteritis	
Vitamin B_9	Folic acid, folinic acid	Water	Deficiency during pregnancy is associated with birth defects, such as neural tube defects	Possible decrease in seizure threshold
Vitamin B_{12}	Cyanocobalamin, hydroxycobalamin, methylcobalamin	Water	Megaloblastic anaemia	No known toxicity
Vitamin C	Ascorbic acid	Water	Scurvy	Vitamin C megadosage

Vitamin D	Ergocalciferol, cholecalciferol	Fat	Rickets and Osteomalacia	Hypervitaminosis D
Vitamin E	Tocopherols, tocotrienols	Fat	Deficiency is very rare; mild hemolytic anemia in newborn infants.	Increased congestive heart failure seen in one large randomized study.
Vitamin K	phylloquinone, menaquinones	Fat	Bleeding diathesis	Increases coagulation in patients taking warfarin(an anticoagulant)

Mineral Deficiency and Its Symptoms:

Nutrient	**Typical Symptoms and Diseases**
Calcium	Brittle nails, cramps, delusions, depression, insomnia, irritability, osteoporosis, palpitations, peridontal disease, rickets, tooth decay
Chromium	Anxiety, fatigue, glucose intolerance, adult-onset diabetes
Copper	Anemia, arterial damage, depression, diarrhea, fatigue, fragile bones, hair loss, hyperthyroidism, weakness
Essential fatty acids	Diarrhea, dry skin and hair, hair loss, immune impairment, infertility, poor wound healing, premenstrual syndrome, acne, eczema, gall stones, liver degeneration
Folic acid	Anemia, apathy, diarrhea, fatigue, headaches, insomnia, loss of appetite.

	neural tube defects in fetus, paranoia, shortness of breath, weakness
Iodine	Cretinism, fatigue, hypothyroidism, weight gain
Iron	Anemia, brittle nails, confusion, constipation, depression, dizziness, fatigue, headaches, inflamed tongue, mouth lesions
Magnesium	Anxiety, confusion, heart attack, hyperactivity, insomnia, nervousness, muscular irritability, restlessness, weakness
Manganese	Atherosclerosis, dizziness, elevated cholesterol, glucose intolerance, hearing loss, loss of muscle control, ringing in ears
Potassium	Acne, constipation, depression, edema, excessive water consumption, fatigue, glucose intolerance, high cholesterol levels, insomnia, mental impairment, muscle weakness, nervousness, poor reflexes
Zinc	Acne, amnesia, apathy, brittle nails, delayed sexual maturity, depression, diarrhea, eczema, fatigue, growth impairment, hair loss, high cholesterol levels, immune impairment, impotence, irritability, lethargy, loss of appetite, loss of sense of taste, low stomach acid, male infertility, memory impairment, night blindness, paranoia, white spots on nails, wound healing impairment

14. The Human Nervous System

The Neuron

Nervous tissue is composed of two main cell types: neurons and glial cells. Neurons transmit nerve messages. Glial cells are in direct contact with neurons and often surround them

The neuron is the functional unit of the nervous system. Humans have about 100 billion neurons in their brain alone! While variable in size and shape, all neurons have three parts. Dendrites receive information from another cell and transmit the message to the cell body. The cell body contains the nucleus, mitochondria and other organelles typical of eukaryotic cells. The axon conducts messages away from the cell body
Three types of neurons occur.
1. Sensory neurons typically have a long dendrite and short axon, and carry messages from sensory receptors to the central nervous system.
2. Motor neurons have a long axon and short dendrites and transmit messages from the central nervous system to the muscles (or to glands).
3. Interneurons are found only in the central nervous system where they connect neuron to neuron

Some axons are wrapped in a myelin sheath formed from the plasma membranes of specialized glial cells known as Schwann cells. Schwann cells serve as supportive, nutritive, and service facilities for neurons. The gap between Schwann cells is known as the node of Ranvier, and serves as points along the neuron for generating a signal. Signals jumping from node to node travel hundreds of times faster than signals traveling along the surface of the axon. This allows the brain to communicate with toes in a few thousandths of a second.

The Nerve Message

The plasma membrane of neurons, like all other cells, has an unequal distribution of ions and electrical charges between the two sides of the membrane. The outside of the membrane has a positive charge, inside has a negative charge. This charge difference is a resting potential and is measured in millivolts. Passage of ions across the cell membrane passes the electrical charge along the cell. The voltage potential is -65mV (millivolts) of a cell at rest (resting potential). Resting potential results from differences between sodium and potassium positively charged ions and negatively charged ions in the cytoplasm. Sodium ions are more concentrated outside the membrane, while potassium ions are more concentrated inside the membrane. This imbalance is maintained by the active transport of ions to reset the membrane known as the sodium potassium pump. The sodium-potassium pump maintains this unequal concentration by actively transporting ions against their concentration gradients.

Changed polarity of the membrane, the action potential, results in propagation of the nerve impulse along the membrane. An action potential is a temporary reversal of the electrical potential along the membrane for a few milliseconds

Steps in an Action Potential

1. At rest the outside of the membrane is more positive than the inside.
2. Sodium moves inside the cell causing an action potential; the influx of positive sodium ions makes the inside of the membrane more positive than the outside.
3. Potassium ions flow out of the cell, restoring the resting potential net charges.
4. Sodium ions are pumped out of the cell and potassium ions are pumped into the cell, restoring the original distribution of ions.

Synapses

The junction between a nerve cell and another cell is called a synapse. Messages travel within the neuron as an electrical action potential. The space between two cells is known as the synaptic cleft. To cross the synaptic cleft requires the actions of neurotransmitters. Neurotransmitters are stored in small synaptic vessicles clustered at the tip of the axon.

Arrival of the action potential causes some of the vesicles to move to the end of the axon and discharge their contents into the synaptic cleft. Released neurotransmitters diffuse across the cleft, and bind to receptors on the other cell's membrane, causing ion channels on that cell to open. Some neurotransmitters cause an action potential, others are inhibitory.

Neurotransmitters tend to be small molecules, some are even hormones. The time for neurotransmitter action is between 0,5 and 1 millisecond. Neurotransmitters are either destroyed by specific enzymes in the synaptic cleft, diffuse out of the cleft, or are reabsorbed by the cell. More than 30 organic molecules are thought to act as neurotransmitters. The neurotransmitters cross the cleft, binding to receptor molecules on the next cell, prompting transmission of the message along that cell's membrane. Acetylcholine is an example of a neurotransmitter, as is norepinephrine, although each acts in different responses. Once in the cleft, neurotransmitters are active for only a short time. Enzymes in the cleft inactivate the neurotransmitters. Inactivated neurotransmitters are taken back into the axon and recycled.

Diseases that affect the function of signal transmission can have serious consequences. Parkinson's disease has a deficiency of the neurotransmitter dopamine. Progressive death of brain cells increases this deficit, causing tremors, rigidity and unstable posture. L-dopa is a chemical related to dopamine that eases some of the symptoms (by acting as a substitute neurotransmitter) but cannot reverse the progression of the disease.

The bacterium *Clostridium tetani* produces a toxin that prevents the release of GABA. GABA is important in control of skeletal muscles. Without this control chemical, regulation of muscle contraction is lost; it can be fatal when it effects the muscles used in breathing.

Clostridium botulinum produces a toxin found in improperly canned foods. This toxin causes the progressive relaxation of muscles, and can be fatal. A wide range of drugs also operate in the synapses: cocaine, LSD, caffeine, and insecticides

Nervous Systems

Multicellular animals must monitor and maintain a constant internal environment as well as monitor and respond to an external environment. In many animals, these two functions are coordinated by two integrated and coordinated organ systems: the nervous system and the endocrine system. Three basic functions are prformed by nervous systems:

1. Receive sensory input from internal and external environments
2. Integrate the input
3. Respond to stimuli

Sensory Input

Receptors are parts of the nervous system that sense changes in the internal or external environments. Sensory input can be in many forms, including pressure, taste, sound, light, blood pH, or hormone levels, that are converted to a signal and sent to the brain or spinal cord.

Integration and Output

In the sensory centers of the brain or in the spinal cord, the barrage of input is integrated and a response is generated. The response, a motor output, is a signal transmitted to organs than can convert the signal into some form of action, such as movement, changes in heart rate, release of hormones, etc.

Endocrine Systems

Some animals have a second control system, the endocrine system. The nervous system coordinates rapid responses to external stimuli. The endocrine system controls slower, longer lasting responses to internal stimuli. Activity of both systems is integrated.

Divisions of the Nervous System

The nervous system monitors and controls almost every organ system through a series of positive and negative feedback loops.

The Central Nervous System (CNS) includes the brain and spinal cord.

The Peripheral Nervous System (PNS) connects the CNS to other parts of the body, and is composed of nerves (bundles of neurons).

Not all animals have highly specialized nervous systems. Those with simple systems tend to be either small and very mobile or large and immobile. Large, mobile animals have highly developed nervous systems: the evolution of nervous systems must have been an important adaptation in the evolution of body size and mobility.

Coelenterates, cnidarians, and echinoderms have their neurons organized into a nerve net. These creatures have radial symmetry and lack a head. Although lacking a brain or either nervous system (CNS or PNS) nerve nets are capable of some complex behavior.

Bilaterally symmetrical animals have a body plan that includes a defined head and a tail region. Development of bilateral symmetry is associated with cephalization, the development of a head with the accumulation of sensory organs at the front end of the organism. Flatworms have neurons associated into clusters known as ganglia, which in turn form a small brain. Vertebrates have a spinal cord in addition to a more developed brain

Chordates have a dorsal rather than ventral nervous system. Several evolutionary trends occur in chordates: spinal cord, continuation of cephalization in the form of larger and more complex brains, and development of a more elaborate nervous system. The vertebrate nervous system is divided into a number of parts. The central nervous system includes the brain and spinal cord. The peripheral nervous system consists of all body nerves.

Motor neuron pathways are of two types: somatic (skeletal) and autonomic (smooth muscle, cardiac muscle, and glands). The autonomic system is subdivided into the sympathetic and parasympathetic systems.

Peripheral Nervous System

The Peripheral Nervous System (PNS)contains only nerves and connects the brain and spinal cord (CNS) to the rest of the body. The axons and dendrites are surrounded by a white myelin sheath. Cell bodies are in the central nervous system (CNS) or ganglia. Ganglia are collections of nerve cell bodies. Cranial nerves in the PNS take impulses to and from the brain (CNS). Spinal nerves take impulses to and away from the spinal cord. There are two major subdivisions of the PNS motor pathways: the somatic and the autonomic.

Two main components of the PNS:

1. sensory (afferent) pathways that provide input from the body into the CNS.
2. motor (efferent) pathways that carry signals to muscles and glands (effectors).

Most sensory input carried in the PNS remains below the level of conscious awareness. Input that does reach the conscious level contributes to perception of our external environment.

Somatic Nervous System

The Somatic Nervous System (SNS) includes all nerves controlling the muscular system and external sensory receptors. External sense organs (including skin) are receptors. Muscle fibers and gland cells are effectors. The reflex arc is an automatic, involuntary reaction to a stimulus. When the doctor taps your knee with the rubber hammer, she/he is testing your reflex (or knee-jerk). The reaction to the stimulus is involuntary, with the CNS being informed but not consciously controlling the response. Examples of reflex arcs include balance, the blinking reflex, and the stretch reflex.

Sensory input from the PNS is processed by the CNS and responses are sent by the PNS from the CNS to the organs of the body.

Motor neurons of the somatic system are distinct from those of the autonomic system. Inhibitory signals, cannot be sent through the motor neurons of the somatic system.

Autonomic Nervous System

The Autonomic Nervous System is that part of PNS consisting of motor neurons that control internal organs. It has two subsystems. The autonomic system controls muscles in the heart, the smooth muscle in internal organs such as the intestine, bladder, and uterus. The Sympathetic Nervous System is involved in the fight or flight response. The Parasympathetic Nervous System is involved in relaxation. Each of these subsystems operates in the reverse of the other (antagonism). Both systems innervate the same organs and act in opposition to maintain homeostasis. For example: when you are scared the sympathetic system causes your heart to beat faster; the parasympathetic system reverses this effect.

Motor neurons in this system do not reach their targets directly (as do those in the somatic system) but rather connect to a secondary motor neuron which in turn innervates the target organ.

Central Nervous System

The Central Nervous System (CNS) is composed of the brain and spinal cord. The CNS is surrounded by bone-skull and vertebrae. Fluid and tissue also insulate the brain and spinal cord.

The brain is composed of three parts: the cerebrum (seat of consciousness), the cerebellum, and the medulla oblongata (these latter two are "part of the unconscious brain").

The medulla oblongata is closest to the spinal cord, and is involved with the regulation of heartbeat, breathing, vasoconstriction (blood pressure), and reflex centers for vomiting, coughing, sneezing, swallowing, and hiccuping. The hypothalamus regulates homeostasis. It has regulatory areas for thirst, hunger, body temperature, water balance, and blood pressure, and links the Nervous System to the Endocrine System. The midbrain and pons are also part of the unconscious brain. The thalamus serves as a central relay point for incoming nervous messages.

The cerebellum is the second largest part of the brain, after the cerebrum. It functions for muscle coordination and maintains normal muscle tone and posture. The cerebellum coordinates balance.

The conscious brain includes the cerebral hemispheres, which are are separated by the *corpus callosum*. In reptiles, birds, and mammals, the cerebrum coordinates sensory data and motor functions. The cerebrum governs intelligence and reasoning, learning and memory. While the cause of memory is not yet definitely known, studies on slugs indicate learning is accompanied by a synapse decrease. Within the cell, learning involves change in gene regulation and increased ability to secrete transmitters.

The Brain

During embryonic development, the brain first forms as a tube, the anterior end of which enlarges into three hollow swellings that form the brain, and the posterior of which develops into the spinal cord. Some parts of the brain have changed little during vertebrate evolutionary history. Vertebrate evolutionary trends include

1. Increase in brain size relative to body size.
2. Subdivision and increasing specialization of the forebrain, midbrain, and hindbrain.
3. Growth in relative size of the forebrain, especially the cerebrum, which is associated with increasingly complex behavior in mammals.

The Brain Stem and Midbrain

The brain stem is the smallest and from an evolutionary viewpoint, the oldest and most primitive part of the brain. The brain stem is continuous with the spinal cord, and is composed of the parts of the hindbrain and midbrain. The medulla oblongata and pons control heart rate, constriction of blood vessels, digestion and respiration.

The midbrain consists of connections between the hindbrain and forebrain. Mammals use this part of the brain only for eye reflexes.

The Cerebellum

The cerebellum is the third part of the hindbrain, but it is not considered part of the brain stem. Functions of the cerebellum include fine motor coordination and body movement, posture, and balance. This region of the brain is enlarged in birds and controls muscle action needed for flight.

The Forebrain

The forebrain consists of the diencephalon and cerebrum. The thalamus and hypothalamus are the parts of the diencephalon. The thalamus acts as a switching center for nerve messages. The hypothalamus is a major homeostatic center having both nervous and endocrine functions.

The cerebrum, the largest part of the human brain, is divided into left and right hemispheres connected to each other by the corpus callosum. The hemispheres are covered by a thin layer of gray matter known as the cerebral cortex, the most recently evolved region of the vertebrate brain. Fish have no cerebral cortex, amphibians and reptiles have only rudiments of this area.

The cortex in each hemisphere of the cerebrum is between 1 and 4 mm thick. Folds divide the cortex into four lobes: occipital, temporal, parietal, and frontal. No region of the brain functions alone, although major functions of various parts of the lobes have been determined.

The occipital lobe (back of the head) receives and processes visual information. The temporal lobe receives auditory signals, processing language and the meaning of words. The parietal lobe is associated with the sensory cortex and processes information about touch, taste, pressure, pain, and heat and cold. The frontal lobe conducts three functions:

1. motor activity and integration of muscle activity
2. speech
3. thought processes

Most people who have been studied have their language and speech areas on the left hemisphere of their brain. Language comprehension is found in Wernicke's area. Speaking ability is in Broca's area. Damage to Broca's area causes speech impairment but not impairment of language comprehension. Lesions in Wernicke's area impairs ability to comprehend written and spoken words but not speech. The remaining parts of the cortex are associated with higher thought processes, planning, memory, personality and other human activities.

The Spinal Cord

The spinal cord runs along the dorsal side of the body and links the brain to the rest of the body. Vertebrates have their spinal cords encased in a series of (usually) bony vertebrae that comprise the vertebral column.

The gray matter of the spinal cord consists mostly of cell bodies and dendrites. The surrounding white matter is made up of bundles of interneuronal axons (tracts). Some tracts are ascending (carrying messages to the brain), others are descending (carrying messages from the brain). The spinal cord is also involved in reflexes that do not immediately involve the brain.

The Brain and Drugs

Some neurotransmitters are excitory, such as acetylcholine, norepinephrine, serotonin, and dopamine. Some are associated with relaxation, such as dopamine and serotonin. Dopamine release seems related to sensations of pleasure. Endorphins are natural opioids that produce elation and reduction of pain, as do artificial chemicals such as opium and heroin. Neurological diseases, for example **Parkinson's disease** and Huntington's disease, are due to imbalances of neurotransmitters. Parkinson's is due to a dopamine deficiency. Huntington's disease is thought to be cause by malfunctioning of an inhibitory neurotransmitter. **Alzheimer's disease** is associated with protein plaques in the brain. Drugs are stimulants or depressants that block or enhance certain neurotransmitters. Dopamine is thought involved with all forms of pleasure. Cocaine interferes with uptake of dopamine from the synaptic cleft. Alcohol causes a euphoric "high" followed by a depression.

Marijuana, material from the Indian hemp plant (*Cannabis sativa*), has a potent chemical THC (tetrahydracannibinol) that in low, concentrations causes a euphoric high (if inhaled, the most common form of action is smoke inhalation). High dosages may cause severe effects such as hallucinations, anxiety, depression, and psychotic symptoms.

Cocaine is derives from the plant *Erthoxylon coca*. Inhaled, smoked or injected. Cocaine users report a "rush" of euphoria following use. Following the rush is a short (5-30 minute) period of arousal followed by a depression. Repeated cycle of use terminate in a "crash" when the cocaine is gone. Prolonged used causes production of less dopamine, causing the user to need more of the drug.

Heroin is a derivative of morphine, which in turn is obtained from opium, the milky secretions obtained from the opium poppy, *Papaver somniferum*. Heroin is usually injected intravenously, although snorting and smoking serve as alternative delivery methods. Heroin binds to ophioid receptors in the brain, where the natural chemical endorphins are involved in the cessation pain. Heroin is physically addictive, and prolonged use causes less endorphin production. Once this happens, the euphoria is no longer felt; only dependence and delay of withdrawal symptoms.

Senses

Input to the nervous system is in the form of our five senses: pain, vision, taste, smell, and hearing. Vision, taste, smell, and hearing input are the special senses. Pain, temperature, and pressure are known as somatic senses. Sensory input begins with sensors that react to stimuli in the form of energy that is transmitted into an action potential and sent to the CNS.

Sensory Receptors

- Sensory receptors are classified according to the type of energy they can detect and respond to.
- Mechanoreceptors: hearing and balance, stretching.
- Photoreceptors: light.
- Chemoreceptors: smell and taste mainly, as well as internal sensors in the digestive and circulatory systems.
- Thermoreceptors: changes in temperature.

- Electroreceptors: detect electrical currents in the surrounding environment.

Mechanoreceptors vary greatly in the specific type of stimulus and duration of stimulus/action potentials. The most adaptable vertebrate mechanoreceptor is the hair cell. Hair cells are present in the lateral line of fish. In humans and mammals hair cells are involved with detection of sound and gravity and providing balance.

Hearing

Hearing involves the actions of the external ear, eardrum, ossicles, and cochlea. In hearing, sound waves in air are converted into vibrations of a liquid then into movement of hair cells in the cochlea. Finally they are converted into action potentials in a sensory dendrite connected to the auditory nerve. Very loud sounds can cause violent vibrations in the membrane under hair cells, causing a shearing or permanent distortion to the cells, resulting in permanent hearing loss.

Orientation and Gravity

Orientation and gravity are detected at the semicircular canals. Hair cells along three planes respond to shifts of liquid within the cochlea, providing a three-dimensional sense of equilibrium. Calcium carbonate crystals can shift in response to gravity, providing sensory information about gravity and acceleration.

Photoreceptors Detect Vision and Light Sensitivity

The human eye can detect light in the 400-700 nanometer (nm) range, a small portion of the electromagnetic spectrum, the visible light spectrum. Light with wavelengths shorter than 400 nm is termed ultraviolet (UV) light. Light with wavelengths longer than 700 nm is termed infrared (IR) light.

Eye

In the eye, two types of photoreceptor cells are clustered on the retina, or back portion of the eye. These receptors, rods and cones, apparently evolved from hair cells. Rods detect differences in light intensity; cones detect color. Rods are more common in a circular zone near the edge of the eye. Cones occur in the center (or fovea centralis) of the retina. Light reaching a photoreceptor causes the breakdown of the chemical rhodopsin, which in turn causes a membrane potential that is transmitted to an action potential. The action potential transfers to synapsed neurons that connect to the optic nerve. The optic nerve connects to the occipital lobe of the brain. Humans have three types of cones, each sensitive to a different color of light: red, blue and green. Opsins are chemicals that bind to cone cells and make those cells sensitive to light of a particular wavelength (or color). Humans have three different form of opsins coded for by three genes on the X chromosome. Defects in one or more of these opsin genes can cause color blindness, usually in males.

15. THE ENDOCRINE SYSTEM

The nervous system coordinates rapid and precise responses to stimuli using action potentials. The endocrine system maintains homeostasis and long-term control using chemical signals. The endocrine system works in parallel with the nervous system to control growth and maturation along with homeostasis

Hormones

The endocrine system is a collection of glands that secrete chemical messages we call hormones. These signals are passed through the blood to arrive at a target organ, which has cells possessing the appropriate receptor. Exocrine glands (not part of the endocrine system) secrete products that are passed outside the body. Sweat glands, salivary glands, and digestive glands are examples of exocrine glands.

Hormones are grouped into three classes based on their structure:

1. steroids
2. peptides
3. amines

Steroids

Steroids are lipids derived from cholesterol. Testosterone is the male sex hormone. Estradiol, similar in structure to testosterone, is responsible for many female sex characteristics. Steroid hormones are secreted by the gonads, adrenal cortex, and placenta.

Peptides and Amines

Peptides are short chains of amino acids; most hormones are peptides. They are secreted by the pituitary, parathyroid, heart, stomach, liver, and kidneys. Amines are derived from the amino acid tyrosine and are secreted from the thyroid and the adrenal medulla. Solubility of the various hormone classes varies.

Synthesis, Storage, and Secretion

Steroid hormones are derived from cholesterol by a biochemical reaction series. Defects along this series often lead to hormonal imbalances with serious consequences. Once synthesized, steroid hormones pass into the bloodstream; they are not stored by cells, and the rate of synthesis controls them.

Peptide hormones are synthesized as precursor molecules and processed by the endoplasmic reticulum and Golgi where they are stored in secretory granules. When needed, the granules are dumped into the bloodstream. Different hormones can often be made from the same precursor molecule by cleaving it with a different enzyme.

Amine hormones (notably epinephrine) are stored as granules in the cytoplasm until needed.

Evolution of Endocrine Systems

Most animals with well-developed nervous and circulatory systems have an endocrine system. Most of the similarities among the endocrine systems of crustaceans, arthropods, and vertebrates are examples of convergent evolution. The vertebrate endocrine system consists of glands (pituitary, thyroid, adrenal), and diffuse cell groups scattered in epithelial tissues.

More than fifty different hormones are secreted. Endocrine glands arise during development for all three embryologic tissue layers (endoderm, mesoderm, ectoderm). The type of endocrine product is determined by which tissue layer a gland originated in. Glands of ectodermal and endodermal origin produce peptide and amine hormones; mesodermal-origin glands secrete hormones based on lipids.

Endocrine Systems and Feedback Cycles

The endocrine system uses cycles and negative feedback to regulate physiological functions. Negative feedback regulates the secretion of almost every hormone. Cycles of secretion maintain physiological and homeostatic control. These cycles can range from hours to months in duration.

Mechanisms of Hormone Action

The endocrine system acts by releasing hormones that in turn trigger actions in specific target cells. Receptors on target cell membranes bind only to one type of hormone. More than fifty human hormones have been identified; all act by binding to receptor molecules. The binding hormone changes the shape of the receptor causing the response to the hormone. There are two mechanisms of hormone action on all target cells.

Nonsteroid Hormones

Nonsteroid hormones (water soluble) do not enter the cell but bind to plasma membrane receptors, generating a chemical signal (second messenger) inside the target cell. Five different second messenger chemicals, including cyclic AMP have been identified. Second messengers activate other intracellular chemicals to produce the target cell response

Steroid Hormones

The second mechanism involves steroid hormones, which pass through the plasma membrane and act in a two step process. Steroid hormones bind, once inside the cell, to the nuclear membrane receptors, producing an activated hormone-receptor complex. The activated hormone-receptor complex binds to DNA and activates specific genes, increasing production of proteins.

Endocrine-related Problems

1. Overproduction of a hormone
2. Underproduction of a hormone
3. Nonfunctional receptors that cause target cells to become insensitive to hormones

The Nervous and Endocrine Systems

The pituitary gland (often called the master gland) is located in a small bony cavity at the base of the brain. A stalk links the pituitary to the hypothalamus, which controls release of pituitary hormones. The pituitary gland has two lobes: the anterior and posterior lobes. The anterior pituitary is glandular

The hypothalamus contains neurons that control releases from the anterior pituitary. Seven hypothalamic hormones are released into a portal system connecting the hypothalamus and pituitary, and cause targets in the pituitary to release eight hormones.

Growth hormone (GH) is a peptide anterior pituitary hormone essential for growth. GH-releasing hormone stimulates release of GH. GH-inhibiting hormone suppresses the release of GH. The hypothalamus maintains homeostatic levels of GH. Cells under the action of GH increase in size (hypertrophy) and number (hyperplasia). GH also causes increase in bone length and thickness by deposition of cartilage at the ends of bones. During adolescence, sex hormones cause replacement of cartilage by bone, halting further bone growth even though GH is still present. Too little or two much GH can cause dwarfism or gigantism, respectively.

Hypothalamus receptors monitor blood levels of thyroid hormones. Low blood levels of Thyroid-stimulating hormone (TSH) cause the release of TSH-releasing hormone from the hypothalamus, which in turn causes the release of TSH from the anterior pituitary. TSH travels to the thyroid where it promotes production of thyroid hormones, which in turn regulate metabolic rates and body temperatures.

Gonadotropins and prolactin are also secreted by the anterior pituitary. Gonadotropins (which include follicle-stimulating hormone, FSH, and luteinizing hormone, LH) affect the gonads by stimulating gamete formation and production of sex hormones. Prolactin is secreted near the end of pregnancy and prepares the breasts for milk production.

The Posterior Pituitary

The posterior pituitary stores and releases hormones into the blood. Antidiuretic hormone (ADH) and oxytocin are produced in the hypothalamus and transported by axons to the posterior pituitary where they are dumped into the blood. ADH controls water balance in the body and blood pressure. Oxytocin is a small peptide hormone that stimulates uterine contractions during childbirth.

Other Endocrine Organs

The Adrenal Glands

Each kidney has an adrenal gland located above it. The adrenal gland is divided into an inner medulla and an outer cortex. The medulla synthesizes amine hormones, the cortex secretes steroid hormones. The adrenal medulla consists of modified neurons that secrete two hormones: epinephrine and norepinephrine. Stimulation of the cortex by the sympathetic nervous system causes release of hormones into the blood to initiate the "fight or flight" response. The adrenal cortex produces several steroid hormones in three classes: mineralocorticoids, glucocorticoids, and sex hormones. Mineralocorticoids maintain electrolyte balance. Glucocorticoids produce a long-term, slow response to stress by raising blood glucose levels through the breakdown of fats and proteins; they also suppress the immune response and inhibit the inflammatory response.

The Thyroid Gland

The thyroid gland is located in the neck. Follicles in the thyroid secrete thyroglobulin, a storage form of thyroid hormone. Thyroid stimulating hormone (TSH) from the anterior pituitary causes conversion of thyroglobulin into thyroid hormones T4 and T3. Almost all body cells are targets of thyroid hormones.

Thyroid hormone increases the overall metabolic rate, regulates growth and development as well as the onset of sexual maturity. Calcitonin is also secreted by large cells in the thyroid; it plays a role in regulation of calcium.

The Pancreas

The pancreas contains exocrine cells that secrete digestive enzymes into the small intestine and clusters of endocrine cells (the pancreatic islets). The islets secrete the hormones insulin and glucagon, which regulate blood glucose levels.

After a meal, blood glucose levels rise, prompting the release of insulin, which causes cells to take up glucose, and liver and skeletal muscle cells to form the carbohydrate glycogen. As glucose levels in the blood fall, further insulin production is inhibited. Glucagon causes the breakdown of glycogen into glucose, which in turn is released into the blood to maintain glucose levels within a homeostatic range. Glucagon production is stimulated when blood glucose levels fall, and inhibited when they rise.

Diabetes results from inadequate levels of insulin. Type I diabetes is characterized by inadequate levels of insulin secretion, often due to a genetic cause. Type II usually develops in adults from both genetic and environmental causes. Loss of response of targets to insulin rather than lack of insulin causes this type of diabetes. Diabetes causes impairment in the functioning of the eyes, circulatory system, nervous system, and failure of the kidneys.

Other Chemical Messengers

Interferons are proteins released when a cell has been attacked by a virus. They cause neighboring cells to produce antiviral proteins. Once activated, these proteins destroy the virus. Prostaglandins are fatty acids that behave in many ways like hormones. They are produced by most cells in the body and act on neighboring cells. Pheromones are chemical signals that travel between organisms rather than between cells within an organism. Pheromones are used to mark territory, signal prospective mates, and communicate. The presence of a human sex attractant/pheromone has not been established conclusively.

Biological Cycles

Biological cycles ranging from minutes to years occur throughout the animal kingdom. Cycles involve hibernation, mating behavior, body temperature and many other physiological processes. Rhythms or cycles that show cyclic changes on a daily (or even a few hours) basis are known as circadian rhythms. Many hormones, such as ACTH-cortisol, TSH, and GH show circadian rhythms. The menstrual cycle is controlled by a number of hormones secreted in a cyclical fashion. Thyroid secretion is usually higher in winter than in summer. Childbirth is hormonally controlled, and is highest between 2 and 7 AM. Internal cycles of hormone production are controlled by the hypothalamus, specifically the suprachiasmic nucleus (SCN). According to one model, the SCN is signaled by messages from the light-detecting retina of the eyes.The SCN signals the pineal gland in the brain to signal the hypothalamus, etc.

16.THE REPRODUCTIVE SYSTEM

The ability to reproduce is one of the unifying characteristics of all living things. Sexual reproduction produces offspring that are genetically different from their parents. Asexual reproduction produces offspring genetically identical to their parent.

Asexual Reproduction

Fission, budding, fragmentation, and the formation of rhizomes and stolons are some of the mechanisms that allow organisms to reproduce asexually. The hydra produces buds; starfish can regenerate an entire body from a fragment of the original body. Asexual reproduction allows an organism to rapidly produce many offspring without the time and resources committed to courtship, finding a mate, and mating. The lack of genetic variability in asexually reproducing populations can be detrimental when environmental conditions (for which all the clones are so well adapted) change quickly.

Sexual Reproduction

In sexual reproduction new individuals are produced by the fusion of haploid gametes to form a diploid zygote. Sperm are male gametes, ova (ovum singular) are female gametes. Meiosis produces cells that are genetically distinct from each other; fertilization is the fusion of two such distinctive cells that produces a unique new combination of alleles, thus increasing variation on which natural selection can operate.

Rotifers will reproduce asexually when conditions are favorable by having females produce eggs by mitosis. When conditions deteriorate, rotifers will reproduce sexually and encase their zygotes inside a resistant shell. Once conditions improve, these eggs hatch into diploid individuals. Rotifers thus use sexual reproduction as way to survive a deteriorating environment.

Human Reproduction and Development

Human reproduction employs internal fertilization, and depends on the integrated action of hormones, the nervous system, and the reproductive system. Gonads are sex organs that produce gametes. Male gonads are the testes, which produce sperm and male sex hormones. Female gonads are the ovaries, which produce eggs (ova) and female sex hormones.

The Male Reproductive System

Testes are suspended outside the abdominal cavity by the scrotum, a pouch of skin that keeps the testes close or far from the body at an optimal temperature for sperm development. Seminiferous tubules are inside each testis, and are where sperm are produced by meiosis. About 250 meters (850 feet) of tubules are packed into each testis. Spermatocytes inside the tubules divide by meiosis to produce spermatids that in turn develop into mature sperm.

Spermatogenesis

Sperm production begins at puberty at continues throughout life, with several hundred million sperm being produced each day. Once sperm form they move into the epididymis, where they mature and are stored.

Male Sex Hormones

The anterior pituitary produces follicle-stimulating hormone (FSH) and luteinizing hormone (LH). Action of LH is controlled by the gonadotropin-releasing hormone (GnRH). LH stimulates cells in the seminiferous tubules to secrete testosterone, which has a role in sperm production and developing male secondary sex characteristics. FSH acts on cells to help in sperm maturation. Negative feedback by testosterone controls the actions of GnRH.

Sexual Structures

Sperm pass through the vas deferens and connect to a short ejaculatory duct that connects to the urethra. The urethra passes through the penis and opens to the outside. Secretions from the seminal vesicles add fructose and prostaglandins to sperm as they pass. The prostate gland secretes a milky alkaline fluid. The bulbourethral gland secretes a mucus-like fluid that provides lubrication for intercourse. Sperm and secretions make up semen.

The Female Reproductive System

The female gonads, ovaries, are located within the lower abdominal cavity.

The ovary contains many follicles composed of a developing egg surrounded by an outer layer of follicle cells. Each egg begins oogenesis as a primary oocyte. At birth each female carries a lifetime supply of developing oocytes, each of which is in Prophase I. A developing egg (secondary oocyte) is released each month from puberty until menopause, a total of 400-500 eggs.

Ovarian Cycles

After puberty the ovary cycles between a follicular phase (maturing follicles) and a luteal phase (presence of the corpus luteum). These cyclic phases are interrupted only by pregnancy and continue until menopause, when reproductive capability ends. The ovarian cycle lasts usually 28 days. During the first phase, the oocyte matures within a follicle. At midpoint of the cycle, the oocyte is released from the ovary in a process known as ovulation. Following ovulation the follicle forms a corpus luteum which synthesizes and prepares hormones to prepare the uterus for pregnancy.

The secondary oocyte passes into the oviduct (fallopian tube or uterine tube). The oviduct is connected to the uterus.

The uterus has an inner layer, the endometrium, in which a fertilized egg implants. At the lower end of the uterus the cervix connects the uterus to the vagina. The vagina receives the penis during intercourse and serves as the birth canal.

External Genitals

The female external genitals are collectively known as the vulva. The labia minora is a thin membrane of folded skin just outside the vaginal opening. The labia majora cover and protect the genital area. A clitoris, important in arousal, is a short shaft with a sensitive tip covered by a fold of skin.

Hormones and Female Cycles

The ovarian cycle is hormonally regulated in two phases. The follicle secretes estrogen before ovulation; the corpus luteum secretes both estrogen and progesterone after ovulation. Hormones from the hypothalamus and anterior pituitary control the ovarian cycle. The ovarian cycle covers events in the ovary; the menstrual cycle occurs in the uterus.

Menstrual cycles vary from between 15 and 31 days. The first day of the cycle is the first day of blood flow (day 0) known as menstruation. During menstruation the uterine lining is broken down and shed as menstrual flow. FSH and LH are secreted on day 0, beginning both the menstrual cycle and the ovarian cycle. Both FSH and LH stimulate the maturation of a single follicle in one of the ovaries and the secretion of estrogen. Rising levels of estrogen in the blood trigger secretion of LH, which stimulates follicle maturation and ovulation (day 14, or midcycle). LH stimulates the remaining follicle cells to form the corpus luteum, which produces both estrogen and progesterone. Estrogen and progesterone stimulate the development of the endometrium and preparation of the uterine inner lining for implantation of a zygote. If pregnancy does not occur, the drop in FSH and LH cause the corpus luteum to disintegrate. The drop in hormones also causes the sloughing off of the inner lining of the uterus by a series of muscle contractions of the uterus.

Sexually Transmitted Diseases

Sexually transmitted diseases (STDs) can affect the sex partners, fetus, and newborn infants. STDs are grouped into three categories.

Category One

STDs that produce inflammation of the urethra, epididymis, cervix, or oviducts. Gonorrhea and chlamydia are the most common STDs in this category. Both diseases can be treated and cured with antibiotics, once diagnosed.

Category Two

STDs that produce sores on the external genitals. Genital herpes is the most common disease in this class. Symptoms of herpes can be treated by antiviral drugs, but the infection cannot be cured. Syphilis is a bacterially caused infection, and can, if left untreated, cause serious symptoms and death. However, the disease is curable with antibiotics.

Category Three

This class of STDs includes viral diseases that affect organ systems other than those of the reproductive system. AIDS and hepatitis B are in this category. Both can be spread by sexual contact or blood. Infectious individuals may appear symptom-free for years after infection.

Reproduction: New and Improved

New techniques have been developed to enhance or reduce the chances of conception. Social conventions and governing laws have developed far slower than this new technology, leading to controversy about moral, ethical, and legal grounds for the uses of such technologies.

The separation of intercourse from pregnancy uses methods blocking one of the three stages of reproduction"

- release and transport of gametes
- fertilization
- implantation

Effectiveness

Various contraceptive methods have been developed; none of which is 100% successful at preventing pregnancy or the transmission of STDs. Abstinence is the only completely effective method.

Methods

Physical prevention (most effective) include vasectomy and tubal ligation. Vasectomy: the vas deferens connecting the testes with the urethra is cut and sealed to prevent the transport of sperm. Tubal ligation: the oviduct is cut and ends tied off to prevent eggs from reaching the uterus.

Oral contraceptives (birth control pills) usually contain a combination of hormones that prevent release of FSH and LH, inhibiting development of the follicle so that no oocytes are released. Time-release capsules (Norplant) can be implanted under the skin and offer long-term suppression of ovulation. RU-486, the so-called morning after pill, interferes with implantation of the blastula into the uterine wall. Its use as a contraceptive is very controversial.

Barrier methods employ physical (condom, diaphragm) or chemical (spermacides) means to separate the sperm from the egg. Male condoms are fitted over the erect penis; female condoms are placed inside the vagina. Only latex condoms prevent the spread of STDs. Diaphragms cap the cervix and block passage of the sperm into the uterus. Spermicidal jellies or foams kill sperm on contact and must be placed in the vagina prior to intercourse.

Reproductive Technologies Can Enhance Fertility

Blocked oviducts (often from untreated STDs) are the leading cause of infertility in females. Low sperm count, low motility, or blocked ducts are common causes of male infertility.

Hormone therapy can cause increased egg production. Surgery can open blocked ducts. About 40 of the cases are due to male problems, 40 due to female problems and the remaining 20% are caused by some unknown agent(s). In vitro fertilization (test-tube babies) is a widely used technique to aid infertile couples.

Fertilization and Cleavage

Fertilization has three functions:

1. transmission of genes from both parents to offspring
2. restoration of the diploid number of chromosomes reduced during meiosis
3. initiation of development in offspring

Steps in Fertilization

- Contact between sperm and egg
- Entry of sperm into the egg
- Fusion of egg and sperm nuclei
- Activation of development

Cleavage

Cleavage is the first step in development of ALL multicelled organisms. Cleavage converts a single-celled zygote into a multicelled embryo by mitosis. Usually, the zygotic cytoplasm is divided among the newly formed cells. Frog embryos divide to produce 37,000 cells in a little over 40 hours.

The blastula is produced by mitosis of the zygote, and is a ball of cells surrounding a fluid-filled cavity (the blastocoel). The decreasing size of cells increases their surface to volume ratio, allowing for more efficient oxygen exchange between cells and their environment. RNA and information carrying molecules are distributed to various parts of the blastula, and this molecular differentiation sets the stage for the layering of the body in the next phases of development.

Gastrulation

Gastrulation involves a series of cell migrations to positions where they will form the three primary cell layers.

- Ectoderm forms the outer layer.
- Endoderm forms the inner layer.
- Mesoderm forms the middle layer.

Ectoderm

Ectoderm forms tissues associated with outer layers: skin, hair, sweat glands, epithelium. The brain and nervous system also develop from the ectoderm.

Mesoderm

The mesoderm forms structures associated with movement and support: body muscles, cartilage, bone, blood, and all other connective tissues. Reproductive system organs and kidneys form from mesoderm.

Endoderm

The endoderm forms tissues and organs associated with the digestive and respiratory systems. Many endocrine structures, such as the thyroid and parathyroid glands, are formed by the endoderm. The liver, pancreas, and gall bladder arise from endoderm.

Invagination

Immediately after gastrulation, the body axis of the embryo begins to appear. Chordates have the cells that will form the nervous system fold into a neural tube (which will eventually form the spinal cord). The mesoderm forms the notochord (which will eventually form the vertebrae). The mesoderm at this time forms somites, which form segmented body parts, such as the muscles of the body wall.

Pattern Formation and Induction

Blastulation and gastrulation establish the main body axis. Organ formation occurs in the next stage of the development of the embryo. During organ formation, cell division is accomplished by migration and aggregation.

Pattern formation is the result of cells "sensing" their position in the embryo relative to other cells and to form structures appropriate to that position. Gradients of informational molecules within the embryo have been suggested to provide the positional information to cells. Homeobox genes are pattern genes; they coordinate with gradients of information molecules to establish the body plan and development of organs.

Induction is the process in which one cell or tissue type affects the developmental fate of another cell or tissue. As a cell begins to form certain structures, certain genes are turned on, others are turned off. Induction affects patterns of gene expression through physical contact or chemical signals. Formation of the vertebrate eye is a well known example.

Human Development

Fertilization, the fusion of the sperm and egg, usually occurs in the upper third of the oviduct. Thirty minutes after ejaculation, sperm are present in the oviduct, having traveled from the vagina through the uterus and into the oviduct. Sperm traverse this distance by the beating of their flagellum. Of the several hundred million sperm released in the ejaculation, only a few thousand reach the egg.

Only one sperm will fertilize the egg. One sperm fuses with receptors on the surface of the secondary oocyte, triggering a series of chemical changes in the outer oocyte membrane that prevent any other sperm from entering the oocyte. The entry of the sperm initiates Meiosis II in the oocyte. Fusion of the egg and sperm nuclei forms the diploid zygote.

Travels of a Young Zygote

Cleavage of the zygote begins while it is still in the oviduct, producing a solid ball of cells (morula). The morula enters the uterus, continuing to divide and becomes a blastocyst.

Implantation

The uterine lining becomes enlarged and prepared for implantation of the embryo in the trophoblast layer. Twelve days after fertilization, the trophoblast has formed a two-layered chorion. Human chorionic gonadotropin (hCG) is secreted by the chorion, and prolongs the life of the corpus luteum until the placenta begins to secrete estrogen and progesterone. Home pregnancy tests work by detecting elevated hCG levels in the woman's urine.

Placenta

Maternal and embryonic structures interlock to form the placenta, the nourishing boundary between the mother's and embryo's systems. The umbilical cord extends from the placenta to the embryo, and transports food to and wastes from the embryo.

Stages

The period of time from fertilization to birth (usually 9 months) is divided into trimesters, each about three months long. During pregnancy the zygote undergoes 40 to 44 rounds of mitosis, producing an infant containing trillions of specialized cells organized into tissues and organs.

The First Trimester

The three embryonic tissue layers form. Cellular differentiation begins to form organs during the third week. After one month the embryo is 5 mm long and composed mostly of paired somite segments. During the second month most of the major organ systems form, limb buds develop. The embryo becomes a fetus by the seventh week. Beginning the eighth week, the sexually neutral fetus activates gene pathways for sex determination, forming testes in XY fetuses and ovaries in XX fetuses. External genitalia develop.

The Second Trimester

The fetus increases in size during this trimester, and bony parts of the skeleton begin to form. Fetal movements can be felt by the mother.

The Last Trimester

During this trimester the fetus increases in size. Circulatory and respiratory systems mature in preparation for air breathing. Fetal growth during this time uses large parts of its mother's protein and calcium intake. Maternal antibodies pass to the fetus during the last month, conferring temporary immunity.

Birth

Birth is a positive feedback hormonal mechanism. During birth the cervix dilates to allow passage of the fetus. Uterine contractions propel the fetus through the birth canal, usually head first. Hormonal control of the birth process involves the release of oxytocin and prostaglandins, which are stimulated by uterine contractions, which stimulate more hormones that cause more contractions....etc.

The first stage of birth lasts from beginning of contractions to the full (10 cm) dilation of the cervix. Membranes of the amniotic fluid rupture, lubricating the vagina .Second Stage:Strong uterine contractions of a minute in duration separated by two to three minute intervals propel the fetus down the birth canal. Abdominal muscles relax in synchrony with the uterine contractions. Third Stage:After delivery of the baby, the umbilical cord is clipped and cut. The placenta (or afterbirth) in expelled through the vagina.

Milk Production

Nursing mothers have their hormone levels and uterine size return to normal much faster than non-nursing mothers. Breasts develop the capability for milk secretion about the mid point of pregnancy. Secretion of milk does not occur until delivery, and the action of prolactin. Suckling by the infant causes production of oxytocin to promote release of milk into the ducts emptying into the nipple.

17.MUSCULAR AND SKELETAL SYSTEMS

Types of Skeletal Systems

Movement is a major characteristic of animals. This movement is a result of contraction of muscles. The skeleton helps transmit that movement. Skeletons are either a fluid-filled body cavity, exoskeletons, or internal skeletons.

Hydrostatic skeletons consist of fluid-filled closed chambers. Internal pressures generated by muscle contractions cause movement as well as maintain the shape of the animals, such as the sea anemone and worms.

Exoskeletons are characteristic of the Phylum Arthropoda. Exoskeletons are hard segments that cover the muscles and visceral organs. Muscles for movement attach to the inner surface of the exoskeleton. Exoskeletons restrict the growth of the animal, thus it must shed its exoskeleton (or molt) to form a new one that has room for growth. The bulk and weight of the exoskeleton and associated mechanical problems limits the size animals can attain. Spiders use a combination of an exoskeleton for protection and fluid pressure for movement

Vertebrates have developed an internal mineralized (in most cases) endoskeleton composed of bone and/or cartilage. Muscles are on the outside of the endoskeleton. Cartilage and bone are types of connective tissue. Sharks, and rays have skeletons composed entirely of cartilage; other vertebrates have an embryonic cartilage skeleton progressively replaced by bone as they mature and develop. Some areas of the human body, however, retain cartilage in the adult: in joints and flexible structures such as the ribs, trachea, nose and ears.

Functions of Muscles and Bones

The skeleton and muscles function together as the musculoskeletal system. This system (often treated as two separate systems, the muscular, and skeletal) plays an important homeostatic role: allowing the animal to move to more favorable external conditions. Certain cells in the bones produce immune cells as well as important cellular components of the blood. Bone also helps regulate blood calcium levels, serving as a calcium sink. Rapid muscular contraction is important in generating internal heat, another homeostatic function.

The Axial and Appendicular Skeletons

The axial skeleton consists of the skull, vertebral column, and rib cage. The appendicular skeleton contains the bones of the appendages (limbs, wings, or flippers/fins), and the pectoral and pelvic girdles.

The human skull, or cranium, has a number of individual bones tightly fitted together at immovable joints. At birth many of these joints are not completely sutured together as bone, leading to a number of "soft spots" or fontanels, which do not completely join until the age of 14-18 months.

The vertebral column has 33 individual vertebrae separated from each other by a cartilage disk. These disks allow a certain flexibility to the spinal column, although the disks deteriorate with age, producing back pain. The sternum is connected to all the ribs except the lower pair. Cartilage allows for the flexibility of the rib cage during breathing.

The arms and legs are part of the appendicular skeleton. The upper bones of the limbs are single: humerus (arm) and femur (leg). Below a joint (elbow or knee), both limbs have a pair of bones (radius and ulna in the arms; tibia and fibula in legs) that connect to another joint (wrist or ankle). The carpals makeup the wrist joint; the tarsals are in the ankle joint. Each hand or foot ends in 5 digits (fingers or toes) composed of metacarpals (hands) or metatarsals (feet).

Limbs are connected to the rest of the skeleton by collections of bones known as girdles. The pectoral girdle consists of the clavicle (collar bone) and scapula (shoulder blade). The humerus is joined to the pectoral girdle at a joint and is held in place by muscles and ligaments. A dislocated shoulder occurs when the end of the humerus slips out of the socket of the scapula, stretching ligaments and muscles. The pelvic girdle consists of two hipbones that form a hollow cavity, the pelvis. The vertebral column attaches to the top of the pelvis; the femur of each leg attaches to the bottom. The pelvic girdle in land animals transfers the weight of the body to the legs and feet. Pelvic girdles in fish, which have their weight supported by water, are primitive; land animals have more developed pelvic girdles. Pelvic girdles in bipeds are recognizable different from those or quadrupeds.

Bone Tissue

Although bones vary greatly in size and shape, they have certain structural similarities. Bones have cells embedded in a mineralized (calcium) matrix and collagen fibers. Compact bone forms the shafts of long bones; it also occurs on the outer side of the bone. Spongy bone forms the inner layer.

Compact bone has a series of Haversian canals around which concentric layers of bone cells (osteocytes) and minerals occur. New bone is formed by the osteocytes. The Haversian canals form a network of blood vessels and nerves that nourish and monitor the osteocytes.

Spongy bone occurs at the ends of long bones and is less dense than compact bone. The spongy bone of the femur, humerus, and sternum contains red marrow, in which stem cells reproduce and form the cellular components of the blood and immune system. Yellow marrow, at the center of these bones, is used to store fats. The outer layer of the bones is known as the periosteum. The inner layer of the periosteum forms new bone or modifies existing bone to meet new conditions. It is rich in nerve endings and blood and lymphatic vessels. When fractures occur, the pain is carried to the brain by nerves running through the periosteum.

Bone Growth

Endochondral ossification is the process of converting the cartilage in embryonic skeletons into bone. Cartilage is deposited early in development into shapes resembling the bones-to-be. Cells inside this cartilage grow and begin depositing minerals.

The spongy bone forms, and osteoblasts attach and lay down the mineral portions of spongy bone. Osteoclasts remove material from the center of the bone, forming the central cavity of the long bones. The perichondrium, a connective tissue, forms around the cartilage and begins forming compact bone while the above changes are occurring. Blood vessels form and grow into the perichondrium, transporting stem cells into the interior. Two bands of cartilage remain as the bone develops, one at each end of the bone. During childhood, this cartilage allows for growth and changes in the shape of bones. Eventually the elongation of the bones stops and the cartilage is all converted into bone.

Bones continue to change as adults, to adapt to the stresses generated by physical activity. Exercise can increase the diameter and strength of bone; inactivity can decrease them.

osteoporosis is a disease that primarily affects older, postmenopausal women. Increasing calcium intake, reducing protein intake, exercise and low doses of estrogen are effective treatments for osteoporosis.

Joints

There are three types of joints: immovable, partly movable, and synovial. Immovable joints, like those connecting the cranial bones, have edges that tightly interlock. Partly movable joints allow some degree of flexibility, and usually have cartilage between the bones; example: vertebrae. Synovial joints permit the greatest degree of flexibility and have the ends of bones covered with a connective tissue filled with synovial fluid; example: hip.

The outer surface of the synovial joints contains ligaments that strengthen joints and hold bones in position. The inner surface (the synovial membrane) has cells producing synovial fluid that lubricates the joint and prevents the two cartilage caps on the bones from rubbing together. Some joints also have tendons (connective tissue linking muscles to bones). Bursae are small sacs filled with synovial fluid that reduce friction in the joint. The knee joint contains 13 bursae

Skeletal Disorders

Injury, degenerative wear and tear, and inflammatory disorders affect joints. Sprains are common injuries that cause ligaments to rip of separate from the bone. Tendinitis (such as tennis elbow) and bursitis are inflammations of the tendon sheaths.

Osteoarthritis is a degenerative condition associated with the wearing away of the protective caps of cartilage covering the bone-ends. Bony growths or spurs develop as the cartilage degenerates, causing restriction of movement and pain. The cause is not known and may just be wear-and-tear associated with aging.

Rheumatoid arthritis is a severely damaging arthritis that begins with inflammation and thickening of the synovial membrane followed by bone degeneration and disfigurement. More women than men are affected. There may be a genetic predisposition to rheumatoid arthritis. Joint replacement may in some cases restore function.

Skeletal Muscle Systems

Vertebrates move by the actions of muscles on bones. Tendons attach many skeletal muscles across joints, allowing muscle contraction to move the bones across the joint. Muscles generally work in pairs to produce movement: when one muscle flexes (or contracts) the other relaxes, a process known as antagonism

Muscles have both electrical and chemical activity. There is an electrical gradient across the muscle cell membrane: the outside is more positive than the inside. Stimulus causes an instantaneous reversal of this polarity, causing the muscle to contract (the mechanical characteristic) producing a twitch or movement.

Skeletal Muscle Structure

Muscle fibers are multinucleated, with the nuclei located just under the plasma membrane. Most of the cell is occupied by striated, thread-like myofibrils. Within each myofibril there are dense Z lines. A sarcomere (or muscle functional unit) extends from Z line to Z line. Each sarcomere has thick and thin filaments. The thick filaments are made of myosin and occupy the center of each sarcomere. Thin filaments are made of actin and anchor to the Z line

Muscles contract by shortening each sarcomere. The sliding filament model of muscle contraction has thin filaments on each side of the sarcomere sliding past each other until they meet in the middle. Myosin filaments have club-shaped heads that project toward the actin filaments

Myosin heads attach to binding sites on the actin filaments. The myosin heads swivel toward the center of the sarcomere, detach and then reattach to the nearest active site of the actin filament. Each cycle of attachment, swiveling, and detachment shortens the sarcomere 1%. Hundreds of such cycles occur each second during muscle contraction.

Energy for this comes from ATP, the energy coin of the cell. ATP binds to the cross bridges between myosin heads and actin filaments. The release of energy powers the swiveling of the myosin head. Muscles store little ATP and so must recycle the ADP into ATP rapidly. Creatine phosphate is a muscle storage product involved in the rapid regeneration of ADP into ATP.

Calcium ions are required for each cycle of myosin-actin interaction. Calcium is released into the sarcomere when a muscle is stimulated to contract. This calcium uncovers the actin binding sites. When the muscle no longer needs to contract, the calcium ions are pumped from the sarcomere and back into storage

Control of Muscle Contraction

Neuromuscular junctions are the point where a motor neuron attaches to a muscle. Acetylcholine is released from the axon end of the nerve cell when a nerve impulse reaches the junction. A wave of electrical changes are produced in the muscle cell when the acetylcholine binds to receptors on its surface. Calcium is released from its storage area in the cell's endoplasmic reticulum. An impulse from a nerve cell causes calcium release and brings about a single, short muscle contraction called a twitch.

Skeletal muscles are organized into hundreds of motor units, each of which is a motor neuron and a group of muscle fibers. A graded response to a circumstance will involve controlling the number of motor units. While individual muscle units contract as a unit, the entire muscle can contract on a graded basis due to their organization into motor units

Contraction of Nonmuscular Cells

Actin and myosin, whose interaction causes muscle contraction, occur in many other cells. Actin is attached to the inner surface of the plasma membrane. The interaction of cytoplasmic myosin and this actin causes contraction of the cell, such a the coordinated contractions of intestinal cells to absorb nutrients.

Some fish have modified muscles that discharge electricity. These fish have electric organs consisting of modified muscles known as electroplates. The South American electric eel has more than 6000 plates arranged into 70 columns. Maximum discharge is 100 watts.

18. THE RESPIRATORY SYSTEM

The Respiratory System and Gas Exchange

Cellular respiration involves the breakdown of organic molecules to produce ATP. A sufficient supply of oxygen is required for the aerobic respiratory machinery of Kreb's Cycle and the Electron Transport System to efficiently convert stored organic energy into energy trapped in ATP. Carbon dioxide is also generated by cellular metabolism and must be removed from the cell. There must be an exchange of gases: carbon dioxide leaving the cell, oxygen entering. Animals have organ systems involved in facilitating this exchange as well as the transport of gases to and from exchange areas.

Bodies and Respiration

Single-celled organisms exchange gases directly across their cell membrane. However, the slow diffusion rate of oxygen relative to carbon dioxide limits the size of single-celled organisms. Simple animals that lack specialized exchange surfaces have flattened, tubular, or thin shaped body plans, which are the most efficient for gas exchange. However, these simple animals are rather small in size.

Respiratory Surfaces

Large animals cannot maintain gas exchange by diffusion across their outer surface. They developed a variety of respiratory surfaces that all increase the surface area for exchange, thus allowing for larger bodies. A respiratory surface is covered with thin, moist epithelial cells that allow oxygen and carbon dioxide to exchange. Those gases can only cross cell membranes when they are dissolved in water or an aqueous solution, thus respiratory surfaces must be moist.

Methods of Respiration

Sponges and jellyfish lack specialized organs for gas exchange and take in gases directly from the surrounding water. Flatworms and annelids use their outer surfaces as gas exchange surfaces. Arthropods, annelids, and fish use gills; terrestrial vertebrates utilize internal lungs.

The Body Surface

Flatworms and annelids use their outer surfaces as gas exchange surfaces. Earthworms have a series of thin-walled blood vessels known as capillaries. Gas exchange occurs at capillaries located throughout the body as well as those in the respiratory surface.

Amphibians use their skin as a respiratory surface. Frogs eliminate carbon dioxide 2.5 times as fast through their skin as they do through their lungs. Eels (a fish) obtain 60% of their oxygen through their skin. Humans exchange only 1% of their carbon dioxide through their skin. Constraints of water loss dictate that terrestrial animals must develop more efficient lungs.

Gills

Gills greatly increase the surface area for gas exchange. They occur in a variety of animal groups including arthropods (including some terrestrial crustaceans), annelids, fish, and amphibians. Gills typically are convoluted outgrowths containing blood vessels covered by a thin epithelial layer. Typically gills are organized into a series of plates and may be internal (as in crabs and fish) or external to the body (as in some amphibians).

Gills are very efficient at removing oxygen from water: there is only 1/20 the amount of oxygen present in water as in the same volume of air. Water flows over gills in one direction while blood flows in the opposite direction through gill capillaries. This countercurrent flow maximizes oxygen transfer.

Tracheal Systems

Many terrestrial animals have their respiratory surfaces inside the body and connected to the outside by a series of tubes.Tracheae are these tubes that carry air directly to cells for gas exchange. Spiracles are openings at the body surface that lead to tracheae that branch into smaller tubes known as tracheoles. Body movements or contractions speed up the rate of diffusion of gases from tracheae into body cells. However, tracheae will not function well in animals whose body is longer than 5 cm

Lungs

Lungs are ingrowths of the body wall and connect to the outside by as series of tubes and small openings. Lung breathing probably evolved about 400 million years ago. Lungs are not entirely the sole property of vertebrates, some terrestrial snails have a gas exchange structures similar to those in frogs

The Human Respiratory System

This system includes the lungs, pathways connecting them to the outside environment, and structures in the chest involved with moving air in and out of the lungs.

Air enters the body through the nose, is warmed, filtered, and passed through the nasal cavity. Air passes the pharynx (which has the epiglottis that prevents food from entering the trachea).The upper part of the trachea contains the larynx. The vocal cords are two bands of tissue that extend across the opening of the larynx. After passing the larynx, the air moves into the bronchi that carry air in and out of the lungs.

Bronchi are reinforced to prevent their collapse and are lined with ciliated epithelium and mucus-producing cells. Bronchi branch into smaller and smaller tubes known as bronchioles. Bronchioles terminate in grape-like sac clusters known as alveoli. Alveoli are surrounded by a network of thin-walled capillaries. Only about 0.2 µm separate the alveoli from the capillaries due to the extremely thin walls of both structures.

The lungs are large, lobed, paired organs in the chest (also known as the thoracic cavity). Thin sheets of epithelium (pleura) separate the inside of the chest cavity from the outer surface of the lungs. The bottom of the thoracic cavity is formed by the diaphragm.

Ventilation is the mechanics of breathing in and out. When you inhale, muscles in the chest wall contract, lifting the ribs and pulling them, outward. The diaphragm at this time moves downward enlarging the chest cavity. Reduced air pressure in the lungs causes air to enter the lungs. Exhaling reverses theses steps.

Diseases of the Respiratory System

The condition of the airways and the pressure difference between the lungs and atmosphere are important factors in the flow of air in and out of lungs. Many diseases affect the condition of the airways.

- Asthma narrows the airways by causing an allergy-induced spasms of surrounding muscles or by clogging the airways with mucus.
- Bronchitis is an inflammatory response that reduces airflow and is caused by long-term exposure to irritants such as cigarette smoke, air pollutants, or allergens.
- Cystic fibrosis is a genetic defect that causes excessive mucus production that clogs the airways.

The Alveoli and Gas Exchange

Diffusion is the movement of materials from a higher to a lower concentration. The differences between oxygen and carbon dioxide concentrations are measured by partial pressures. The greater the difference in partial pressure the greater the rate of diffusion.

Respiratory pigments increase the oxygen-carrying capacity of the blood. Humans have the red-colored pigment hemoglobin as their respiratory pigment. Hemoglobin increases the oxygen-carrying capacity of the blood between 65 and 70 times. Each red blood cell has about 250 million hemoglobin molecules, and each milliliter of blood contains 1.25 X 10^{15} hemoglobin molecules. Oxygen concentration in cells is low (when leaving the lungs blood is 97% saturated with oxygen), so oxygen diffuses from the blood to the cells when it reaches the capillaries.

Carbon dioxide concentration in metabolically active cells is much greater than in capillaries, so carbon dioxide diffuses from the cells into the capillaries. Water in the blood combines with carbon dioxide to form bicarbonate. This removes the carbon dioxide from the blood so diffusion of even more carbon dioxide from the cells into the capillaries continues yet still manages to "package" the carbon dioxide for eventual passage out of the body.

In the alveoli capillaries, bicarbonate combines with a hydrogen ion (proton) to form carbonic acid, which breaks down into carbon dioxide and water. The carbon dioxide then diffuses into the alveoli and out of the body with the next exhalation.

Control of Respiration

Muscular contraction and relaxation controls the rate of expansion and constriction of the lungs. These muscles are stimulated by nerves that carry messages from the part of the brain that controls breathing, the medulla. Two systems control breathing: an automatic response and a voluntary response. Both are involved in holding breath.

Although the automatic breathing regulation system allows to breathe while sleeping, it sometimes malfunctions. Apnea involves stoppage of breathing for as long as 10 seconds, in some individuals as often as 300 times per night. This failure to respond to elevated blood levels of carbon dioxide may result from viral infections of the brain, tumors, or it may develop spontaneously. A malfunction of the breathing centers in newborns may result in SIDS (sudden infant death syndrome).

As altitude increases, atmospheric pressure decreases. Above 10,000 feet decreased oxygen pressures causes loading of oxygen into hemoglobin to drop off, leading to lowered oxygen levels in the blood. The result can be mountain sickness (nausea and loss of appetite). Mountain sickness does not result from oxygen starvation but rather from the loss of carbon dioxide due to increased breathing in order to obtain more oxygen.

19. THE EXCRETORY SYSTEM

Cells produce water and carbon dioxide as by-products of metabolic breakdown of sugars, fats, and proteins. Chemical groups such as nitrogen, sulfur, and phosphorous must be stripped, from the large molecules to which they were formerly attached, as part of preparing them for energy conversion. The continuous production of metabolic wastes establishes a steep concentration gradient across the plasma membrane, causing wastes to diffuse out of cells and into the extracellular fluid.

Single-celled organisms have most of their wastes diffuse out into the outside environment. Multicellular organisms, and animals in particular, must have a specialized organ system to concentrate and remove wastes from the interstitial fluid into the blood capillaries and eventually deposit that material at a collection point for removal entirely from the body.

Regulation of Extracellular Fluids

Excretory systems regulate the chemical composition of body fluids by removing metabolic wastes and retaining the proper amounts of water, salts, and nutrients. Components of this system in vertebrates include the kidneys, liver, lungs, and skin.

Not all animals use the same routes or excrete their wastes the same way humans do. Excretion applies to metabolic waste products that cross a plasma membrane. Elimination is the removal of feaces.

Nitrogen Wastes

Nitrogen wastes are a by product of protein metabolism. Amino groups are removed from amino acids prior to energy conversion. The NH_2 (amino group) combines with a hydrogen ion (proton) to form ammonia (NH_3).

Ammonia is very toxic and usually is excreted directly by marine animals. Terrestrial animals usually need to conserve water. Ammonia is converted to urea, a compound the body can tolerate at higher concentrations than ammonia. Birds and insects secrete uric acid that they make through large energy expenditure but little water loss. Amphibians and mammals secrete urea that they form in their liver. Amino groups are turned into ammonia, which in turn is converted to urea, dumped into the blood and concentrated by the kidneys.

Water and Salt Balance

The excretory system is responsible for regulating water balance in various body fluids. Osmoregulation refers to the state aquatic animals are in: they are surrounded by freshwater and must constantly deal with the influx of water. Animals, such as crabs, have an internal salt concentration very similar to that of the surrounding ocean. Such animals are known as osmoconformers, as there is little water transport between the inside of the animal and the isotonic outside environment.

Marine vertebrates, however, have internal concentrations of salt that are about one-third of the surrounding seawater. They are said to be osmoregulators. Osmoregulators face two problems: prevention of water loss from the body and prevention of salts diffusing into the body. Fish deal with this by passing water out of their tissues through their gills by osmosis and salt through their gills by active transport. Cartilaginous fish have a greater salt concentration than seawater, causing water to move into the shark by osmosis; this water is used for excretion. Freshwater fish must prevent water gain and salt loss. They do not drink water, and have their skin covered by a thin mucus. Water enters and leaves through the gills and the fish excretory system produces large amounts of dilute urine.

Terrestrial animals use a variety of methods to reduce water loss: living in moist environments, developing impermeable body coverings, production of more concentrated urine. Water loss can be considerable: a person in a 100 degree F temperature loses 1 liter of water per hour.

Invertebrate Excretory Organs

Many invertebrates such as flatworms use a nephridium as their excretory organ. At the end of each blind tubule of the nephridium is a ciliated flame cell. As fluid passes down the tubule, solutes are reabsorbed and returned to the body fluids.

Body fluids are drawn into the Malphigian tubules by osmosis due to large concentrations of potassium inside the tubule. Body fluids pass back into the body, nitrogenous wastes empty into the insect's gut. Water is reabsorbed and waste is expelled from the insect.

Vertebrates Have Paired Kidneys

All vertebrates have paired kidneys. Excretion is not the primary function of kidneys. Kidneys regulate body fluid levels as a primary duty, and remove wastes as a secondary one.

The Human Excretory System

The urinary system is made-up of the kidneys, ureters, bladder, and urethra. The nephron, an evolutionary modification of the nephridium, is the kidney's functional unit. Waste is filtered from the blood and collected as urine in each kidney. Urine leaves the kidneys by ureters, and collects in the bladder. The bladder can distend to store urine that eventually leaves through the urethra.

The Nephron

The nephron consists of a cup-shaped capsule containing capillaries and the glomerulus, and a long renal tube. Blood flows into the kidney through the renal artery, which branches into capillaries associated with the glomerulus. Arterial pressure causes water and solutes from the blood to filter into the capsule. Fluid flows through the proximal tubule, which include the loop of Henle, and then into the distal tubule. The distal tubule empties into a collecting duct. Fluids and solutes are returned to the capillaries that surround the nephron tubule.

The nephron has three functions:

1. Glomerular filtration of water and solutes from the blood.
2. Tubular reabsorption of water and conserved molecules back into the blood.
3. Tubular secretion of ions and other waste products from surrounding capillaries into the distal tubule.

Nephrons filter 125 ml of body fluid per minute; filtering the entire body fluid component 16 times each day. In a 24 hour period nephrons produce 180 liters of filtrate, of which 178.5 liters are reabsorbed. The remaining 1.5 liters forms urine.

Urine Production

1. Filtration in the glomerulus and nephron capsule.
2. Reabsorption in the proximal tubule.
3. Tubular secretion in the Loop of Henle.

Components of The Nephron

- Glomerulus: mechanically filters blood
- Bowman's Capsule: mechanically filters blood
- Proximal Convoluted Tubule: Reabsorbs 75% of the water, salts, glucose, and amino acids
- Loop of Henle: Countercurrent exchange, which maintains the concentration gradient
- Distal Convoluted Tubule: Tubular secretion of H ions, potassium, and certain drugs.

Kidney Stones

In some cases, excess wastes crystallize as kidney stones. They grow and can become a painful irritant that may require surgery or ultrasound treatments. Some stones are small enough to be forced into the urethra.

Kidney Function

Kidneys perform a number of homeostatic functions:

1. Maintain volume of extracellular fluid
2. Maintain ionic balance in extracellular fluid
3. Maintain pH and osmotic concentration of the extracellular fluid.
4. Excrete toxic metabolic by-products such as urea, ammonia, and uric acid.

Hormone Control of Water and Salt

Water reabsorption is controlled by the antidiuretic hormone (ADH) in negative feedback. ADH is released from the pituitary gland in the brain. Dropping levels of fluid in the blood signal the hypothalamus to cause the pituitary to release ADH into the blood. ADH acts to increase water absorption in the kidneys. This puts more water back in the blood, increasing the concentration of the urine. When too much fluid is present in the blood, sensors in the heart signal the hypothalamus to cause a reduction of the amounts of ADH in the blood. This increases the amount of water absorbed by the kidneys, producing large quantities of a more dilute urine.

Aldosterone, a hormone secreted by the kidneys, regulates the transfer of sodium from the nephron to the blood. When sodium levels in the blood fall, aldosterone is released into the blood, causing more sodium to pass from the nephron to the blood. This causes water to flow into the blood by osmosis. Renin is released into the blood to control aldosterone.

Disruption of Kidney Function

Infection, environmental toxins such as mercury, and genetic disease can have devastating results by causing disruption of kidney function. Many kidney problems can be treated by dialysis, where a machine acts as a kidney. Kidney transplants are an alternative to dialysis.

20. CLASSIFICATION

Nomenclature

The naming of species and other taxa follows a set of rules, the International Code of Botanical Nomenclature (ICBN) for plants, the International Code of Zoological Nomenclature (ICZN) for animals.

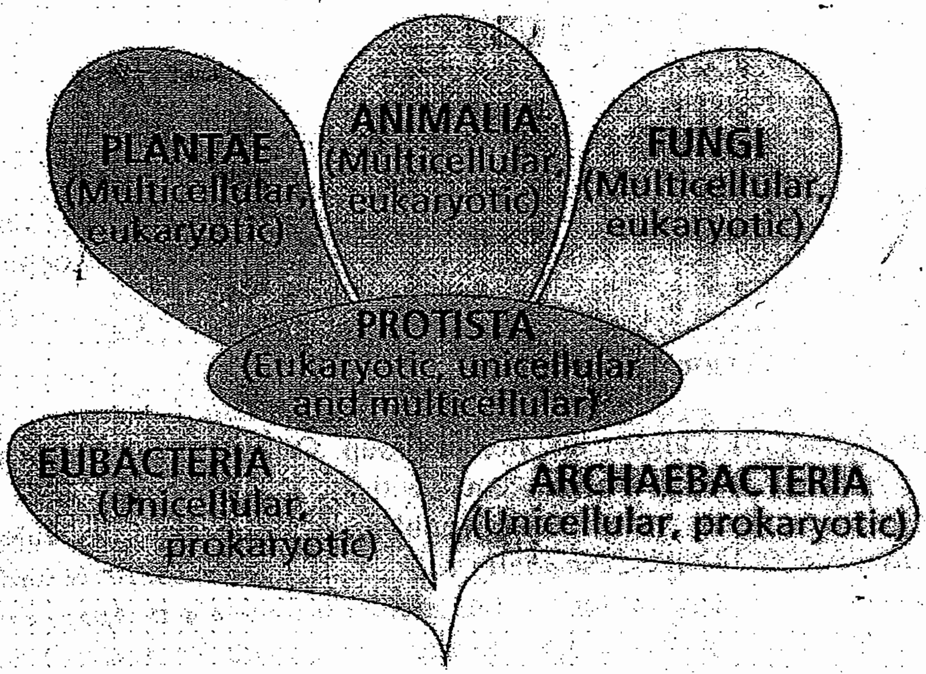
Some general rules for nomenclature:

1. All taxa must belong to a higher taxonomic group. Often a newly discovered organism is the sole species in a single genus, within a single family...etc.
2. The first name to be validly and effectively published has priority. This rule has caused numerous name changes, especially with fossil organisms: *Brontosaurus* is invalid, and the correct name for the big sauropod dinosaur is *Apatosaurus*, *Eohippus* (the tiny "dawn horse") is invalid and should be referred to as *Hyracotherium*. Sometime, however, names can be conserved if a group of systematists agrees.
3. All taxa must have an author. When you see a scientific name such as *Homo sapiens* L, the L stands for Linneus, who first described and named that organism. Most scientists must have their names spelled out, for example *Libopollis jarzenii* Farabee et al. (an interesting fossil pollen type I stumbled across a very long time ago!).

The Kingdoms of Life

Linnaeus originally placed all living things into either the plant or animal kingdoms. As scientists learned more about the biology of many organisms, this constraining into two kingdoms became less and less defensible.

Evolutionary theory and the cell theory provide us with a basis for the interrelation of all living things. We also utilize Linneus' hierarchical classification system, adopting (generally) five kingdoms of living organisms. Viruses, are not considered living. Recent studies suggest that there might be a sixth Kingdom, the Archaea.



Monera

Monera are the only kingdom composed of prokaryotic organisms, they have a cell wall, and lack both membrane-bound organelles and multicellular forms. The Archaebacteria, the most ancient of this kingdom, are so different that they may belong to a separate kingdom. Other groups of Monera include the cyanobacteria (autotrophic) and eubacteria (heterotrophic).

Protista

The most ancient eukaryotic kingdom, protists include a variety of eukaryotic body (single-celled-colonial-multicellular) and nutritional heterotrophic, autotrophic, and both) forms. Perhaps they are best defined as eukaryotes that are NOT fungi, animals, or plants.

Fungi

Fungi are a eukaryotic, heterotrophic, usually multicellular group having multinucleated cells enclosed in cells with cell walls. They obtain their energy by decomposing dead and dying organisms and absorbing their nutrients from those organisms. Some fungi also cause disease (yeast infections, rusts, and smuts), while others are useful in baking, brewing, as foods, drugs and sources for antibiotics.

Plantae

Plants are immobile, multicellular eukaryotes that produce their food by photosynthesis and have cells encased in cellulose cell walls. Plants are important sources of oxygen, food, and clothing/construction materials, as well as pigments, spices, dyes, and drugs.

Animalia

Animals are multicellular, heterotrophic eukaryotes that are capable of mobility at some stage during their lives, and that have cells lacking cell walls. Animals provide food, clothing, fats, scents, companionship, and labor.

21. VIRUSES

A virus is a submicroscopic infectious particle composed of a protein coat and a nucleic acid core. Viruses are similar in size to a large protein macromolecule, generally smaller than 200 nm in diameter. Viruses, like cells, carry genetic information encoded in their nucleic acid, and can undergo mutations and reproduce; however, they cannot carry out metabolism, and thus are not considered alive. Viruses are classified by the type of nucleic acid they contain, and the shape of their protein capsule

Retroviruses

Retroviruses use RNA instead of DNA as their nucleic acid core. They also contain the enzyme reverse transcriptase, which will detranscribe the RNA sequence into a DNA strand. Once the retroviral RNA and reverse transcriptase are inside the host cell the enzyme reverses transcription by making a single stranded DNA from the retroviral RNA. Viral DNA can be integrated into the host DNA. It remains in the genome and is replicated whenever the host DNA replicates. If viral DNA is transcribed, new viruses are produced by biosynthesis, maturation, and release by budding. Retroviruses include HIV and also cause certain forms of cancer.

Viruses and Diseases

Viruses cause a variety of diseases among all groups of living things. Viral plant diseases can be controlled solely by burning those plants that show symptoms of disease. Viral diseases in humans are controlled by preventing transmission, administering vaccines, and only recently by the administration of antiviral drugs. Virally caused human diseases include the flu, common cold, herpes, measles, chicken pox, small pox, and encephalitis. Antibiotics are not effective against viruses. Vaccination offers protection for uninfected individuals. Frequent hand washing and condom use may help prevent transmission. Vaccines are substances that stimulate an immune response **without** causing the illness. Commonly used virus vaccines include polio, measles, and mumps.

Antibiotics do not cure viral infections because viruses use enzymes produced by the host cell, rather than produce not their own. A few antiviral drugs are available that interfere with viral replication without interfering with host metabolism in cells free of the virus. Antivirals include acyclovir for herpes and AZT for AIDS. Despite recent successes with antiviral drugs, vaccination and the prevention of exposure remain the most effective ways to deal with viral infections.

Emergent Viruses

Viruses are usually quite specific as to their hosts and even to the types of cells they infect in a multicellular host. Recently, some viruses appear to have shifted their host: HIV, hantavirus, and ebola appear to be either viruses shifting to a new (human) host or else viruses whose existence and effects are just now being realized by scientists and the general public.

Viroids and Prions

Viruses would appear to be the simplest form of infectious particle. The discovery of viroids, nucleic acid without a protein capsule, and prions, infectious proteins, subtracts another level of complexity. Both viroids and prions can cause diseases, the most famous of which is mad cow disease (caused by a prion).

22. Bacterial Diseases of Humans

Gram$^+$ Cocci:

Staphylococci, including Toxic Shock Syndrome (TSS):

The main pathogenic species is *Staphylococcus aureus* (**aure** = gold, golden), which causes most hospital-acquired infections. Multiple-drug-resistant strains have become a problem due to overuse of antibiotics

Streptococci:

Not all streptococci are bad: many are beneficial. *Streptococcus thermophilus* (**thermo** = heat; **philia** = brotherly love) is one of the bacteria that help turn milk into yogurt. *Streptococcus pyogenes* causes strep throat (**pyo** = pus, inflammation; **gen** = bear, produce).

Streptococcus pneumoniae:

This is a diplococcus (**pneumo** = lungs) which infects the lungs, causing **pneumonia**, and is spread by coughing. Penicillin is effective for most of these, except where overuse has caused resistant strains. This is especially a problem with *S. aureus* in hospitals.

Gram$^-$ Cocci:

Gonorrhea:

(**gono** = seed, generation, offspring; **rrhea** = flow, current) This disease is a sexually-transmitted disease (STD), and is caused by a bacterium of this type. One symptom is a pussy discharge from the genital area.

Meningitis:

(**meninges, meninx** = a membrane [around the brain]; **-itis** = inflammation) This is an infection of the membranes covering the brain and/or spinal cord, and is life-threatening because of proximity of these membranes to the brain/spine.

Various Bacilli:

Salmonella:

(**-ella** = small) This disease is named after a Dr. Salmon who discovered it, and causes a type of food poisoning which has been in the news recently when it has made people sick after eating eggs, hamburger, etc. which contained it.

***Escherichia coli*:**

This is a normal part of our intestinal flora, and is non-pathogenic if living in its normal environment in someone's large intestine. However, if it gets elsewhere in the body, like the upper GI tract, it can make a person sick. This usually happens by the "fecal-oral route," in other words, when someone drinks water or eats food washed in water containing untreated sewage.

Cholera:

Epidemics of this disease can be prevented by proper sewage handling

Bubonic Plague:

(**bubo** = groin, swollen gland) This is also known as **Black Death**, and is infamous for wiping out about a third of the population of Europe in the Middle Ages

Other Bacteria:

Clostridium sp.:

Two common pathogens in this genus cause botulism and tetanus (the disease). **Botulism (botulus** = sausage) is a type of food poisoning, and is often found in undercooked meats.

Tetanus (tetano = rigid, tense) is a disease in which all the person's muscles stiffen and contract due to the presence of a toxin secreted by the bacteria. It's not the rust on a rusty nail that's the problem, it's the possibility of tetanus bacteria living there.

tuberculosis:

(**tuberculum** = a little knob, swelling) This disease was at a low for a long time, but now is a problem again because of multiple-drug-resistant strains that have evolved due to the overuse of antibiotics. These bacteria live in the lungs and destroy lung tissue.

Hansen's Disease:

This is a disease, better known by another name, with an ancient history. It's not very contagious, but ancient and Medieval people didn't know that, so people with this disease were required to live outside of town and not associate with "normal" people, much the way some AIDS victims have been treated today. the original name of this disease was **leprosy**. This affects the person's nerves, so (s)he loses his/her sense of feeling in affected body parts, often resulting in a greater danger of injury to those body parts (imagine not being able to tell when something is too hot to touch, thus not instinctively pulling back your hand). Armadillos can carry the leprosy bacterium.

Syphilis:

This bacterium is spread by intercourse (it is an STD). The initial symptom is a sore on the genitalia followed later by a serious, general infection. A baby can become blind if (s)he gets syphilis in his/her eyes as (s)he is being born.

Lyme Disease:

This bacterium is spread by the bite of a deer tick, thus is more common around wooded, rural areas. It is named after the town of Lyme, Conn., where it was first observed. There may be some inflammation around the site of the bite, but not always. However, if untreated at that stage, the main symptom is an arthritis-like condition that can last for months.

23.Fungal Diseases

Fungal diseases are called mycoses and those affecting humans can be divided into four groups based on the level of penetration into the body tissues:

1. Superficial mycoses are caused by fungi that grow only on the surface of the skin or hair.
2. Cutaneous mycoses or dermatomycoses include such infections as athlete's foot and ringworm, in which growth occurs only in the superficial layers of skin, nails, or hair.
3. Subcutaneous mycoses penetrate below the skin to involve the subcutaneous, connective, and bone tissue.
4. Systemic or deep mycoses are able to infect internal organs and become widely disseminated throughout the body. This type is often fatal.

Common fungal diseases, Athletes foot, Ringworm & Thrush

Seriousness, In most healthy people fungal infections are mild, involving only the skin, hair, nails.

Ringworm, infection of the skin, hair, or nails caused by fungi that belong to the genera *Trichophyton, Epidermophyton,* and *Microsporum.* Ringworm tends to infect moist areas of the body. The affected area usually becomes inflamed and itchy because of sensitivity to the fungus or a secondary infection by bacteria. In the most serious cases, ringworm results in an acute infection that produces running sores on the scalp or painful blisters on the feet.

Ringworm on the limbs, trunk, and face causes raised circular patches, which heal in the centres out as the patches widen. The condition derives its name from this circular pattern, though in the groin or armpit the patches may suggest butterfly wings, and at times the pattern is completely irregular. Ringworm of the beard usually occurs on only one side of the face and is often irritated by shaving. Ringworm may also affect the fingernails and toenails, causing thickening and deformation.

To diagnose ringworm, portions of the affected areas are scraped off and examined under a microscope. If a fungus is present, a characteristic type of growth will be evident.

Ringworm infections are often difficult to treat. Keeping the infected area clean and dry helps prevent growth and spread of fungus. Scraping of overgrown skin or nail tissue may be helpful, and various antifungal medications may be applied.

Athlete's Foot, also called tinea pedis or ringworm of the foot, a contagious fungal infection occurring most often between the toes and on the soles of the feet. A condition that tends to recur, athlete's foot is caused by several kinds of fungi that thrive in warm, damp places, such as the floors of showers, swimming pools, and gymnasiums. The fungi most likely to cause athlete's foot include several species of the genus *Trichophyton* and *Epidermophyton floccosum*.

The symptoms of athlete's foot are reddened, cracked, and peeling skin, accompanied by itching or burning and stinging sensations. In severe cases the skin may thicken, like a callus, and begin to scale. Bacteria may thrive as a secondary infection in athlete's foot, which worsens the symptoms of the disorder and makes it more difficult to cure. Sometimes the fungal infection spreads to the toenails, which become thick and distorted.

Athlete's foot is best prevented by keeping the feet dry and cool, especially during warm weather, which encourages fungal growth. Mild cases of athlete's foot are improved by keeping the feet dry and using foot powder—especially between the toes—and changing socks frequently. Antifungal medications are commonly used to cure the infection.

Thrush, fungal infection characterised by creamy-white, curdlike patches on the tongue and other mucosal surfaces of the mouth. The disease is caused by an overgrowth of *Candida albicans,* a species of yeast that normally inhabits the mucous membranes as a benign saprophyte. Those most susceptible to thrush include adults whose immune systems have been weakened by antibiotics, steroids, or, most commonly, AIDS. Infants can become infected during birth if the mother has a vaginal yeast infection.

When the curdlike discharge is removed from patches of thrush, raw and bleeding areas are visible and can be especially painful. If left untreated, these superficial lesions may allow the yeast to spread to other areas of the body. Diagnosis requires microscopic identification of the *pseudomycelial* (branching-arms) forms. Generally, thrush is treated with a surface agent.

The growing number of cases of thrush and other diseases caused by *Candida* can be attributed mainly to medical advances in antibiotic and immunosuppressive treatments. The onset of AIDS, a severe immunosuppressive disease, has also played a role in the increased incidence of thrush.

24. Protozoan Diseases

Disease	Casual Agent	Motion by	Transmission
Amoebiasis	Entamoeba Histolytica (sarcodina)	Pseudopodia	Water, Food
Giardiasis	Giardia Lambila (Mastigophora)	Flagella	Water, Contact
Trichomoniasis	Trichomonas Vaginalis (Mastigophora)	Flagella	Sexual,Contact
African Sleeping Sickness	Trypanosoma Brucei (Mastigophora)	Flagella	Tsetse fly (Glossina)
American Sleeping Sickness	T.Cruzi (Mastigophora)	Flagella	Triatomid bug (Triatoma)
Leishmaniasis (Kala - azar)	Leishmania Donovani (Mastigophora)	Flagella	Sandfly (phlemotomus)
Balantidiasis	Balantidium Coli (Ciliophora)	Cilia	Food, Water
Toxoplasmosis	Toxoplasma Gondii (Sporozoa)	NA	Domestic Cats, Food
Malaria	Plasmodium Spp. (Sporozoa)	NA	Mosquito (Anopheles)
Babesiosis	Babesia Microti (Sporozoa)	NA	Tick (Ixodes)

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25. Improvement in Food Resources

Livestock

Livestock refers to all domestic animals that are used to produce food and other valuable products for man. It includes cattle, buffaloes, sheep, goats and pigs. Livestock may be milk producing or meat providing.

Milk Producing Livestock

These are milch animals. The milk-producing animals reared in our country are cows, buffaloes, goats and camels. Goat's milk is very nutritious. Goats can be milked anytime of the day. However, the production of goat's milk is far less compared to that of cows and buffaloes. Buffalo's milk has higher fat content than cow's milk. Buffaloes are the major source of milk in our country.

Cows breeds and their distribution

Cattle Breed	Distribution
Milch Breeds	
Gir	Gujarat, Rajasthan
Sahiwal	Punjab, Haryana, Uttar Pradesh
Red Sindhi	Andhra Pradesh
Draught Breeds	
Malvi	Rajasthan, Madhya Pradesh
Nageri	Delhi, Haryana, Uttar Pradesh
Hallikar	Kamataka
Kangayam	Tamilnadu and other parts of South India
General Utility Breeds	
Haryana	Haryana, Bihar, Punjab, Gujarat Madhya Pradesh
Ongole	Andhra Pradesh
Kankrej	Gujarat
Tharparkar	Andhra Pradesh

Draught Breeds

Draught breeds are basically beasts of burden. They are used for drawing bullock carts, ploughing land and transporting material from one place to another. They are strong and sturdy but give less milk.

Dairy Breeds

These cows are reared for yielding milk. The bullocks are not suitable for draught purposes.

Milk production during lactation

Dairy Breeds of Cow	Average Milk Production (Litres)	Lactation Period (Days)
Sahiwal	2800	300
Holestein-Friesian	16000	365
Frieswal	5000	326

Indian Breeds

Red Sindhi

This cow is medium in size and red in colour with dark and light shades of red.

Sahiwal

This is a large, heavily built cow and is of a superior breed.

Gir

This breed is found in Gujarat in the Gir forest. This cow is medium in size and is a good milk yielder.

Other well known breeds are Dangi, Deoni, Tharparker and Haryana. They are dual purpose breeds and fairly good milk yielders.

Foreign Breeds

The following are some exotic breeds of cows that have been successfully crossbred in India.

- Jersey hails from Island of Jersey, USA
- Holstein Friesian hails from Holland
- Brown Swiss hails from Switzerland

Cross Breeds

The following are some improved breeds of dairy cows that have been developed in our country at the National Dairy Research Institute (NDRI), Karnal, Haryana.

- Karan Swiss : This is a crossbreed between Brown Swiss and Sahiwal
- Karan Fries: This is a cross breed between Holstein-Friesian and Tharparkar
- Frieswal: This is a cross breed between Holstein-Friesian and Sahiwal

With cross breeding the yield of milk has increased by two or three times more than the yield from Indian cows.

Buffaloes

Buffaloes are reared in large numbers in India. There are more than ten different breeds of buffaloes in India. Of them, the high milk yielding breeds are:

Murrah

This originally belongs to Punjab and Haryana. The average yield of milk is 1800 to 2500 litres with 7% fat.

Mehsana

This breed hails from Vadodara and Mehsana districts of Gujarat. The average yield is 1200 to 2500 litres. They start yielding milk at a young age and have regular breeding intervals.

Surti

This breed is a native of Kaira and Vadodara districts of Gujarat. The average yield is 1600 to 1800 litres. The fat content is about 8-12%. This breed is highly adaptable.

Distribution of Buffaloes

Buffaloes	Distribution
Nili Ravi	Punjab, Haryana
Nagpuri	Central and South India
Mehsana	Gujarat
Surti	Rajasthan, Gujarat
Jaffarabadi	Gujarat
Bhadawari	Uttar Pradesh and Madhya Pradesh
Murrah	Punjab, Haryana and Uttar Pradesh

- **Milch Animal Management**

For effective livestock management and improvement in yield the following steps should be taken care of.

Shelter

Shelters should be constructed in such a way that it provides a comfortable resting place for the animals. It must contain facilities for feeding, watering and protection from rain, wind, Sun, cold and dampness. A shed measuring six square metres is ideal for Indian cows. Buffaloes require a little more space. Proper cleaning of the shelter is necessary not only for the production of clean milk but also for the health of the animal. The floor of the shed must be sloping, to facilitate cleaning and keeping their resting place dry. The shed should have cross ventilation with sufficient number of inlets and outlets.

Nutrition

The food of dairy animals needs to serve two basic purposes:

Maintenance

This is the food required to support the basic functions of life of the animal.

Milk Production

This is the type of food required during the lactation period.

Animal feeds have two main contents:

Roughage

This includes fibres like green fodder, silage, hay and leguminous plants like berseem, lucerne and cowpea.

Concentrates

This contains high content of proteins and other nutrients but is low in fibres. These include grains of maize, oats, barley, jowar, gram and by-products of agriculture like wheat bran, rice bran, gram husk, oil seedcakes and molasses. A balanced feed, which contains all the nutrients in the right proportion, is supplied to the cattle. On an average the daily ration for a cow is 15-20 kg of green fodder and 4-5 kg of grain mixture. In addition nutrients in the form of additives are mixed with the feed. These additives contain antibiotics, minerals and hormones. They increase the yield of milk and protect them from diseases. Finally cows need 30-40 litres of water to drink.

Diseases of Cattle and Their Control

Bacterial Disease		
Disease	**Symptoms**	**Prevention and Control**
Tuberculosis	Loss of weight Persistent diarrhoea is intestinal tuberculosis Intermittent fever with a dry husky cough in lung tuberculosis Breast glands if infected by tuberculosis bacteria, the milk is rendered thin and watery	Vaccination Use of suitable antibiotic
Mastitis	Udders get swollen Milk becomes watery and shows clot Loss of appetite	Use of suitable antibiotic Proper sanitation
Brucellosis (Caused by Brucella)	Restiveness Ultimately death occurs Abortion is caused May lead to sterility	Isolation of infected animal Maintenance of proper hygienic conditions Vaccination Carcasses should be burnt after death
Salmonellosis	No hunger High temperature Diarrhoea with blood clots	Isolation Vaccination

Viral Disease		
Disease	**Symptoms**	**Prevention and Control**
Foot and mouth diseases	Eruptions in the mouth and on the feet	Isolation
	Decrease of functional efficiency and breeding capacity	Vaccination
Blue tongue	High fever	Vaccination
	Blue appearance onmucosa of mouth and, tongue	
	Severe depression	
	Erosions in the mouth, tongue, nostrils etc.	
Rinderpest or cattle plague	Congested conjunctiva	Isolation
	Loss of appetite	Avoid direct or indirect contact with diseased animal
	Diarrhoea	Inoculation with rinderpest antiserum
	Faeces are stained with blood	
	Lesions appear on the buccal mucosa, lips and gums and finally animal dies'	

Protozoan Disease		
Disease	**Symptoms**	**Prevention and Control**
Trypanosomiasis	High Fever	Isolation
	Death within a day or two of development of fever	Drugs like suramin, antrypol and antrycide are effective
Coccidysis	Thin faeces mixed with mucus and blood.	
	Affects sheep, goat, cattle and buffaloes	
Babesiosis	Also known as cattle tick and affects cattle and sheep	
	High fever with brown or red urine	

Fungal Disease		
Disease	**Symptoms**	**Prevention and Control**
Ringworm	Rounded rough scabs on neck and head Spores of fungi germinate and cause scabs on the skin	Isolation Suitable fungicide should be applied on the scabs

- Spread of several diseases can be controlled by proper preventive and sanitary measures. Diseases like rinderpest, anthrax, cowpox, tuberculosis, bovine abortion, calf diphtheria and other contagious diseases can be checked with vaccinations. Applying a dilute solution of lindane can control external parasites like lice. Internal parasites like worms, intestine and flukes damage the stomach, intestine and liver of the animals. Proper deworming measures must be taken. A farmer who loves his cattle will easily be able to recognise if an animal is sick by observing its feeding habit, its normal posture, its definite body temperature, pulse and respiration rates.

Animal	Normal Body Temperature	Pulse	Respiration
Cow	38.3°C	40-60/min	15-30/min
Buffalo	37.2 - 38.2°C	40-45/min	16-18/min

Diseases of Animals Transmitted to Human Beings

Viral	Rabies, Cow pox, Encephalitis
Bacterial	Anthrax, Tuberculosis, Brucellosis
Fungal	Actinomycosis, Asperigillosis, Ringworm
Parasitic	Amoebiasis, Trypanosomiasis, Ascariasis

Control Measures
Periodical screening of animals for diseases
Compulsory vaccination of animals
Proper disposal of dead animal and animal waste
Hygienic handling of all animal products and by-products

Breeding

Indigenous dairy breeds produce 6-8 litres of milk a day where as foreign exotic breeds produce 60 litres of milk a day. Even the lactation period (period when milk is produced) is longer. To improve the production of milk of our Indian cows, crossbreeding programmes are conducted at various dairy research centres. The different types of breeding methods are:

Inbreeding

The process of mating among closely related individuals is known as inbreeding. Bulls that are healthy and strong are allowed to breed at random with grazing cows. Bulls unsuitable for breeding are castrated. These are called steers and are used for draught power.

Out Breeding

This involves breeding among unrelated animals. To increase the milk yield, Indian cows are crossbred with European breeds like Jersey, Holstein, Red Dane, Brown Swiss etc.

Artificial Insemination

In this process semen is collected from a bull of desirable breed and stored at freezing temperature. This semen is injected into the vagina of cows during the period of heat of the animal, for fertilization. This method has many advantages.

- As many as 3000 cows can be fertilized by the semen collected from one bull
- Frozen semen can be stored for a long period and transported to remote parts of the country
- This method is economical

Goat

There are twenty different breeds of goat in India. Some of the well known breeds are Jamunapari, Himalayan, Bengal, Assam, Decanny, Osmanaabadi and Kathiyabari. Some of the exotic breeds are Alpine, Toggenberg and Sannen.

Sheep

Sheep are reared for wool, skin and meat. They are domesticated in Rajasthan, Kutch, Saurashtra, North Gujarat, Deccan Plateau, Kashmir, Himachal Pradesh, hilly districts of Uttar Pradesh, Sikkim and Arunachal Pradesh. The important breeds in our country are Nellore and Mandya. Crossbreeding of Indian sheep with exotic mutton breeds such as Dorset and Suffolk have been very successful and resulted in 30-50% increase in body weight.

Diseases of Goats and Sheep and Their Control

Some of the bacterial diseases are Black-quarter, Brucellosis and Vibriosis. Viral infections include sore mouth, goat pox and rinderpest. Additives to the feed prevent nutritional deficiencies. Deworming periodically will control parasitic infections in the food tract. Regular vaccinations and periodic consultations with veterinarians will prevent many bacterial and viral diseases.

Breeding of Sheep and Goats

For breeding to start, the female should be 14-18 months and the male should be 2 ½ yrs of age. For effective breeding it is important to select ewes and ram or goats that are best suited for local conditions. Different breeds are known for the quality of wool and meat yield. Improvement in the quality of wool of Indian sheep is achieved through crossbreeding with exotic breeds of sheep such as **Dorset Horn, Suffolk and Merino**.

Pigs

Pigs provide high quality meat called pork. Pork is used to prepare ham, bacon, sausages and chops. The management of pigs is known as piggery.

Disease - Prevention and Control

Pig is the intermediate host for the intestinal parasite called tapeworm. The cyst of the worm embeds itself in the flesh of the animal. When man consumes pork that is infested, it can cause tapeworm infestation in him. Hygienic conditions while domesticating pigs and also regular vaccinations will keep the animal healthy and will ensure healthy meat for our consumption

Poultry

Poultry includes all domestic birds - chicken, ducks, geese and turkey. They are reared for their meat and eggs. Poultry farming in India has made rapid strides as poultry management is being done on scientific lines. The three indigenous breeds of fowls are Arlee or Indian Game (provides good meat but is a poor egg layer). The most popular varieties of this breed are Pella (golden red), Yakub (black and red), Nurie (white) and Kajal (black). The other Indian breeds are Karaknath and Busra. The exotic breeds are:

White Leghorn

This is a highly reputed breed, which produces long white eggs. The body size is small and consumes less feed.

Rhode Island Red

This breed has high yield of meat and is a good egg layer.

Shelter and Nutrition

Maximum yield of eggs is obtained by keeping the poultry in comfortable, well ventilated, dry, clean and properly lighted houses. Birds of different ages should be kept separately.

The first phase in the life of poultry is called the growing period and the chickens are called growers. During this stage the chickens require enough space. Overcrowding supresses their growth. The feed given is restricted and calculated.

The second phase in the life of the poultry is called the laying period. This period is from the time of sexual maturity till the end of egg laying period. The chickens are now called layers. The layers require enough space and proper lighting. These factors have a direct effect on the laying output of the hen. The feed given to the poultry consists of cereals and cereal by-products of corn, wheat, rice and millets like jowar, ragi and bajra. Oil cake or meal, protein concentrates, fishmeal or meat meal, minerals and greens are included in the feed. The primary objective of feeding poultry is to convert low quality feeds into high quality food like meat and eggs. The birds act as small manufacturing factories to convert the raw materials into final finished products.

Disease and Control

Poultry fowls suffer from a number of diseases caused by virus, bacteria, fungi, parasites and nutritional deficiencies. Some of the diseases are fowl cholera, salmonellosis, fowl fox and parasitic infestations like roundworm, tapeworm and threadworm. Appropriate vaccinations and other preventive measures can prevent loss of poultry during an outbreak of disease.

Breeding

White Leghorn, Rhode Island Red, Plymouth rock, Barred Plymouth, Sussex and Minorcha are some of the exotic breeds utilized for the improvement of egg production and yield of meat in our country.

Fish Farming

This includes inland and marine fisheries, aquaculture and pisiculture. Fish is a source of high quality animal protein and a rich source of minerals like calcium, phosphorus and iron. India abounds in fish, both fresh water and marine.

Freshwater Fisheries

There are fish that are sustained in water bodies like ponds, tanks, lakes, rivers, back waters and marshy swamps. Inland or fresh water fisheries can be divided into:

Culture fishery - In culture fishery, the fish seed has to be sown, tended, nursed, reared and finally harvested when grown to table size.

Capture fishery - Capture fishery does not involve sowing fish seeds. It involves capturing fish naturally available in fresh water bodies.

Marine Fisheries

These are fish that are sustained in salt-water bodies like seas and oceans. This requires mechanisation. Fishing trawlers fitted with sophisticated electronic fish locating equipment are used for deep-sea fishing. Some marine fish are Bombay duck, Catfish, Mackerels, Red mullet, Sardine etc.

Aquaculture

This involves production of fishes, prawns, shrimps, lobsters, crabs and molluscs.

Pisiculture

This is production of some food fishes like carps. The fish are cultured in ponds and tanks.

Disease and Control

The main causes for disease in fishes are viruses and bacteria. IPN (Infectious Pancreatic Necrosis) and VHS (Viral Haemorrhagic Septicaemia) are well known diseases. Pollution of water causes great harm to the fish population. Fertilizers, pesticides, effluents and chemical wastes from factories contribute largely to pollution of water bodies. In order to maintain the population of fish, regular monitoring of the oxygen level, carbon dioxide level and pH of the water is important.

26. Fertilizers

Constant use of the soil leads to the loss of its important nutrients particularly nitrogen, phosphorus and potassium and thus the soil loses its fertility. For the healthy growth of the plant these deficiencies in the soil have to be replenished with the use of certain materials called fertilizers. These can be classified under two groups.

Classification of Fertilizers

- Fertilizers
  - Manures
  - Chemical Fertilizers

These can be further classified as shown below:

- Fertilizers
  - Organic Manures
    - Farm Manure
    - Compost
    - Green Manure
    - Vermicompost
  - Chemical Fertilizers
    - Nitrogenous Fertilizers
    - Phosphatic Fertilizers
    - Potassic Fertilizers
    - Complex Fertilizers

Manures

Manures are organic materials added to the soil to increase crop production. They are biological in origin. The organic matter content is bulky and large and the nutrient content is small. They have the following effect on the soil:

- They supply nutrients to the soil. Since the manures contain nutrients in small quantities they have to be used in bulk
- Since the manure contains a lot of organic matter, it increases the water holding capacity in sandy soils and drainage in clayey soils

- Organic manures provide food for soil organisms like earthworms which are responsible for improving soil quality.

Organic manures include (i) Farmyard manure (FYM), (ii) Compost, (iii) Green manure, (iv) Vermi compost

Farmyard Manure (FYM)

This is the decomposed mixture of excreta (dung) and urine of farm animals like cow, horse, goat and sheep along with leftover hay and fodder. They are readymade manures and contain nitrogen, phosphorus and potassium. Farmyard manure when collected in the field and stored in an exposed condition over a long period shows considerable loss of ammonia which is a loss of fertilizing value. To prevent this loss the dung is stored in pits which are about a metre deep. When the pits are filled to the top, the surface is sealed with mud slurry. The manure is ready for use in about 4-5 months. Microbes play an important role in decomposing the dung and converting it into manure.

Compost

This consists of a variety of farm wastes such as farm weeds, straw, sugarcane refuse, rotting vegetables, kitchen wastes, crop stubble, ground nut and rice husk. Composting is a biological process in which aerobic and anaerobic microorganisms decompose organic matter. A trench of suitable size 4-5 m long, 1.5 to 1.8 m broad and 1.0 to 1.8 m deep is dug. A layer of well mixed refuse of about 30 cm thickness is spread in the pit. A slurry of cow dung, earth and water is poured over this layer to keep it moist. Another layer of the mixed refuse is spread in the pit till the heap rises to a height of 45 to 60 cm above ground level. Finally the top is covered with a thin layer of mud. After three months of decomposition the layers are well mixed and covered again. Three months later the compost is ready to be used in the fields.

Nutrient content of farm and town compost

Compost	N	P_2O_5	K_2O
Farm Compost	0.5%	0.15%	0.5%
Town Refuse	1.4%	1.0%	1.4%

Green Manure

Green manuring is the practice of growing and ploughing in, the green crops, into the soil. It is a cheap and effective method that increases soil fertility as it can supplement farmyard and other organic manures and is more cost effective. Green manures add nitrogen and organic matter to the soil for improving crop productivity. They also improve soil aeration and drainage conditions. Both leguminous and non-leguminous plants are grown for making green manure.

The following is a list of plants used as green manure:

English and Hindi Names	Botanical Name
Sunn hemp (Sanai)	Crotalaria juncea
Lentil (Masur)	Lens esculenta
Egyptian clover (Berseem)	Trifolium alexandrium
Sesbania (Dhaincha)	Sesbania aculeate
Cluster bean (Gaur ki phalli)	Cyamopris tetragonoloba
Cowpea (Lobiya)	Vigna sinensis
Horse-gram	Macrotyloma uniflorum
Senj	Melilotus parvifora

This type of manuring is used in fields in which crops like rice, maize, sugarcane, cotton, wheat etc., which require high nutrient input are raised. There is 30 - 50% increase in the crop yield by using green manure.

The green manure crops are grown in the field for about 6 - 8 weeks and ploughed into the soil during the flowering stage. The plants are allowed to remain buried for about 1 - 2 months. During this period, the plant gets totally decomposed. The soil is then tilled and the next food crop is sowed. By alternating the green manure crop with food crop the nitrogen and organic content of the soil is maintained.

Vermicompost

Vermicompost is a type of soil made by earthworms and microorganisms as they eat through organic wastes. The soil thus produced is mainly worm excreta and finely ground soil. Organic wastes can be collected and fed on by worms so that the end product is the broken down version of the original organic wastes. Worm castings (excreta) in the vermicompost have nutrients that are 97% utilizable by plants. Besides providing nutrients to plants, worms also upturn the soil thus making the soil lighter.

Chemical Fertilizers

These are nutrient supplements for plants manufactured in fertilizer factories from chemicals. They are nutrient specific i.e., they may provide only nitrogen, only phosphorus or only potassium to the soil. They are often used when a particular nutrient is required in the soil for a particular crop. Chemical fertilizers contain a higher amount of nutrients as against manures and so are used in very small quantities.

Based on the availability of nutrients in them chemical fertilizers are divided into four groups:

- Nitrogenous fertilisers
- Phosphatic fertilisers
- Potassic fertilisers
- Complex fertilisers

Nitrogenous Fertilisers

Fertilisers that contain the macronutrient nitrogen come under this group.

Example: Ammonium sulphate, ammonium nitrate, sodium nitrate, urea.

Phosphatic Fertilisers

Fertilisers that contain phosphorus come under this group.

Example: Superphosphate, ammonium phosphate, calcium phosphate (bone meal), ammonium hydrogen phosphate

Potassic Fertilisers

Fertilisers that contain potassium come under this group.

Example: Potassium chloride, potassium sulphate, potassium nitrate

Complex Fertilisers

When a fertilizer contains two or more nutrients it is called a complex fertilizer.

Example: Nitrophosphate, ammonium phosphate, and urea ammonium phosphate.

Note: Although chemical fertilizers do increase crop yield, their chemicals get washed away through irrigation, rainfall and drainage and reach rivers, lakes and streams. They pollute them and disturb the ecosystem. Therefore chemical fertilizers should not be used indiscriminately.

27. Protection of Crops

Insect - Pest Control

If insect pests attack the plant by cutting and destroying the root an insecticide like chloropyrophos is mixed in the soil to control it. If insect pests attack the plant by cutting the stem and leaves and it is a boring type of insect, it can be controlled by dusting or spraying contact insecticides like malathion, lindane and thiodax. If the insect pests suck the sap from various parts of the plant, it can be controlled by spraying systemic insecticides like dimethoate and metasystox.

Control measures of the insect-pests of major crops

Name of the Crop	Name of Insect-Pest	Nature of Damage	Control Measure
Rice	Gundhy bug	Attack during post flowering period	Spray monocrotophos
	Leaf hopper	Attack on Leaves	Spray monocrotophos
Wheat	Gujhia weevil	Grubs feed on the roots and adults cut the growing points	Aldrin dust in the soil before sowing
	Shoot fly	Attack seedling and kill the central shoots	Soil application of phorate at sowing

Sugarcane	Top borer	Larvae bore into the midrib of leaves and make tunnel. Later on enter into growing point and damage it	Apply phorate granules at the base of shoot
	Shoot borer	The caterpillars bore into the central shoot and make tunnel downwards. They feed inside the soft tissue	Apply lindane in water in furrows on sets before planting
	Pyrilla	Both nymph and adult suck sap from underside of the leaf	Spray endosulfan
Chickpea	Pod border	The caterpillars first feed on tender leaves. Later on make holes in the pods and feed on the developing grain	Spray carbaryl
Ground Nut	White grub	The grubs feed on roots. Adult beetles feed on leaves	Apply thimet granules before sowing
Mustard	Aphids	Both nymph and adult suck the sap of all the plant parts	Spray metasystox solution in water
	Painted bug	Both nymph and adult suck the sap of leaves	Dusting with malathion

Disease Control

Plants often get infested with disease causing pathogens. The entire crop can be destroyed if they are not controlled in time.

Control measures for the disease of major crops

Name of the Crop	Name of Disease	Symptoms	Control Measure
Rice	Blast	Brown boat-shaped lesions appear on the leaves	Seed treatment with thiram solution in water. Spray bavistin at 10 days interval
Wheat	Rust	Yellow, brown or black elongated spots appear on leaves	Spray dithane solution in water at 10 days interval
Sugarcane	Red rot	Small red spots on leaf mid rib appear	Dip the sets in 0.25 percent a gallol solution for 5 minutes before sowing.
	Grassy shoot	Production of numerous thin tillers from the base	Treat seed with hot air at 54°C for 8 hours
Chickpea	Wilt	The leaves become yellow and dry up	Deep sowing at 8-10 cm depth in the light soil

Pigeon pea	Stem rot	Development of brown to dark brown lesions on the stem near soil surface. They girdle the stem and plant dies	Grow sorghum and pigeon pea as mixed cropping. Avoid water logging

Weed Control

Weeds are unwanted plants that grow in the fields where crops grow. The growth of weeds in fields has an adverse affect on crops because they compete with the crops for space, light, nutrients and water. The yield becomes poor and so also the quality of the crop. The weed could be another crop plant or a plant of another variety of the same crop. So if a mustard plant grows in a wheat field it has grown out of place and so is considered to be a weed. Often weeds harbour many insects, pest and diseases. Warm and humid climate being more congenial for the growth of weeds, they are more during the Kharif season than the Rabi crop.

Based on the structure of the leaf, weeds are classified into narrow-leaf and broad-leaf. The following are some of the weeds of the Kharif season and the Rabi season.

Kharif Season

Narrow Leaf
Example: 1) Nutgrass (motha),
2) Wild Sorghum (Wild jowar)

Broad Leaf
Example: 1) Amaranthus (chaulai)
2) Trianthema (Saathi)

Rabi Season

Narrow Leaf
Example: 1) Phalaris (Mandoori),
2) Wild oat (Jangali jaii)

Broad Leaf
Example: 1) Chenopodium (Bathua)
2) Convolvulus (Hirankhwci)

During Kharif season, short duration maize and millets, short statured groundnut and slow growing pigeon pea crops are more prone to weeds.

Methods For Controlling Weeds

Mechanical Method

Removal of weeds by mechanical methods are:

- pulling them out (uprooting) with hand
- removal by using a hoe or trowel
- interculture
- ploughing
- burning and
- flooding

Cultural Method

Cultural methods of controlling weeds include:

- proper seed bed preparation
- timely sowing of crops
- intercropping and
- crop rotation

Chemical Method

Spraying of special chemicals called weedicides or herbicides is a chemical method.
Example: atrazine; 2, 4-D, fluchloralin; isoproturon

Biological Method

The biological method involves the use of some appropriate insects or some other organisms on the crop field having weeds. They selectively destroy the weed plants but do not harm the crop plants.

Example: Cochneal insects are used to eradicate opuntia (a weed, commonly called prickly pear). Aquatic weeds are controlled by grass carp (a kind of fish).

28. Scientific Storage of Grains

Besides crop production, good crop management involves storage of grains before distribution. During storage, grains and seeds are subjected to spoilage by various agencies. These agencies are either biotic or abiotic. Some examples are:

- Biotic - insects, rodents, birds, fungi, mites, bacteria
- Abiotic - moisture and temperature

The loss due to spoilage has been assessed to be to the tune of 9.3% annually. Besides wastage, there is also degradation in quality, loss in weight, poor germinability, discolouration and finally poor marketability. Therefore, it is important to protect grains from loss during storage.

Measures to Prevent Loss During Storage
Drying

At the time of harvesting the moisture content in grains and seeds varies from 15-35%. Besides, grains have a tendency to absorb moisture from the atmosphere. If the moisture content is high, seeds are prone to be infested with pests and this in turn will decrease their quality. Hence moisture content in grains and seeds must be reduced to below 9% for their safe storage. To achieve this seeds have to be spread out and dried in the sun before drying in the shade. Mechanical hot air driers could also be used.

Hygiene

Granaries, godowns and stores should be well cleaned before stacking fresh grains. Any refuse, dirt, cobwebs and husk of the previous grain should be swept. The premises should be well maintained and any crack or hole in the wall, floor or ceiling should be sealed. Before reusing old gunny bags, they should be turned inside out, dusted thoroughly, exposed to sun and fumigated. If earthen pots are used, they should also be cleaned well and exposed to sun before storing fresh grains.

Prophylactic Treatment

As a preventive measure godowns should be treated with insecticides and pesticides. Gunny bags should also be sprayed. Grains that have to be used for seed purpose must be mixed with fungicide and insecticide.

Modern Storage Structures

Research organizations have developed improved storage structures which have proved comparatively safe for the storage of grains. In these structures, temperature, moisture, oxygen and carbon dioxide can be adjusted to protect the grains. The structures are airtight, moisture impervious, thermally insulated and rodent proof. Changes in outside temperature do not affect the grains stored in these structures. Some of these storage structures are Pusa Bin, Pusa Cubicle, Pusa Kothar and Pant Kuthla.

Pest Control

It is not safe to mix insecticides and pesticides with grains meant for human or animal consumption. If any of these are used they should be within safety norms.

Chemical Control

Spraying of BHC wettable power, pyrethrum and malathion at 3 weeks interval can be done as a prophylactic treatment of the surface area of the store house.

- The dosage recommended is as follows.
- BHC WP (50%) 31/100m^2 area in 1:25 dilution
- Pyrethrum (2.5 EC)'31/100 m^2 area in 1:300 dilution
- Malathion (50 EC) 31/100m^2 area in 1:300 dilution

Fumigation

Fumigants are chemicals that can exist in sufficient concentration to be lethal to pests. The following are well known fumigants.

The recommended concentration is given alongside.

- Aluminum phosphide tablets (black poison) 3 grams each, to be used at the rate of 2 tablets per tonne of grain or 160 tablets/100 cubic metre volume of grain
- Methyl bromide at 16 gram/cubic metre
- Ethyl dichloride carbon tetrachloride (EDCT) 3:1 mixture at 30 ml/100 kg produce

Plant Products

Often a small quantity of vegetable oil or mineral oil is added to grains of legumes to protect them from insects. The treatment prevents laying of eggs, reduction in egg hatching and prevention of larval development. Some of the plant products used for this purpose are neem kernel powder, crushed pepper etc.

29. Mixed Cropping

Mixed cropping is growing of two or more crops simultaneously on the same piece of land. It is also known as multiple cropping. This type of cropping leads to an improvement in the fertility of the soil and hence, increase in crop yield because when the two crops are properly chosen the products and refuse from one crop plant help in the growth of the other crop plant and vice-versa. Mixed cropping is an insurance against crop failure due to abnormal weather conditions.

Some successful mixed cropping practices are:

Soyabean + Pigeon pea

Maize + udad dal (Black gram)

Pigeon pea + Mung dal (Green gram)

Groundnut + Sunflower

Sorghum + Pigeon pea

Wheat + Chickpea

Barley + Chickpea.

Wheat + Mustard

Cotton + Groundnut

Mixed cropping has proved successful because of the right selection of crops.

Criteria For Selection of Crops
Agriculturists and farmers select component crops for mixed cropping based on the following criteria:

Duration of Crops
One crop is of long duration and the other is of short duration.

Growth Habit
The two-component crops grow to different heights with different canopy.

Root Pattern
One crop component is deep rooted whereas the other is shallow rooted.

Water Need
One crop component requires comparatively lesser water than the other.

Nutrients Demand
One crop component requires more nutrients and the other requires lesser nutrients.

Mixed cropping is done to reduce the competition between component crops for light, nutrients and water. If one crop fails due to shortage of moisture or insufficient availability of nutrients, the other crop can cover the risk of complete failure.

Advantages of Mixed Cropping

No Risk of Crop Failure

The risk of total crop failure due to uncertain monsoon is reduced if two crops of different nature are grown simultaneously as a mixed crop.

Variety of Produce

A variety of produce could be obtained from a single crop to meet the varying requirements of the family like cereals, pulses, vegetables etc.

Increase in Yield

Component crops have a complimentary effect on one another. For example, legume crops have a beneficial effect on cereal or non-legume crops as they help in fixing nitrogen in the soil. There is higher yield by this method.

Improvement in Soil Fertility

The growth of cereal crops depletes the soil of nutrients. Growing legumes will help increase the nitrogen content in the soil. Thus, by the right choice of component crops soil fertility is improved.

Minimizing Pest Damage

Crops of a particular species are more prone to a particular type of pest (weed, insects, diseases) infestation. When different types of crops are grown together chances of pest infestations are reduced or diluted.

Due to increasing needs and reducing available land resources, there is a need for increasing productivity per unit area and time. In this context, traditional mixed cropping has been retailored and the system of inter-cropping has been introduced. Intercropping is a specialized type of mixed farming wherein two or more crops are grown simultaneously in the same field in definite rows. They are grown in ratios 1:1, 1:2, 1:3.

Selection of Crops for Rotation

Type	Rotations
One-year rotation	1. Maize mustard 2. Rice-wheat
Two-year rotation	1. Maize-mustard-sugarcane-fenugreek (Methi) 2. Maize-potato-sugarcane-peas
Three-year rotation	1. Rice-wheat-mung-mustard-sugarcane-berseem 2. Cotton-oat-sugarcane-peas-maize-wheat

30. Plant Breeding

Crop production can be improved by breeding new varieties of crops having higher yield. The main aim of plant breeding is to produce new crops superior to the existing ones. By this method new varieties of crops, having higher yield, resistant to pests and disease can be grown. Hence, plant breeding can be defined as a science as well as art of improving genetic make-up of plants in relation to their economic use. The various approaches used for genetic improvement of crop plants are referred to as plant breeding methods or techniques.

Introduction

The process of introducing new plants from the place of their cultivation to a place with different climate is termed as plant introduction. The adjustment of such plants to this new locality is called acclimatization. The new crops are introduced in the form of seeds, bulbs or cuttings. This is an easy and rapid method for crop improvement.

Several plants have been successfully introduced to India and they have got well adapted to the new climatic and soil conditions.

Examples:

- Groundnut was introduced from Philippines
- Cinchona was introduced from Peru
- Papaya was introduced from West Indies
- Potato was introduced from South America
- Date-palm was introduced from Brazil

Selection

Selection is an important technique in plant breeding. It involves picking the healthiest and the best ones out of the entire crop and reproducing them under controlled conditions.

Hybridisation

Hybridisation is the technique of introducing characters of two desirable plants into a single offspring (hybrid) by means of artificial pollination. This involves crossing of genetically dissimilar plants.

- **Intervarietal Hybridization (Between Two Different Varieties)** Most of the hybrid varieties of cereals have been evolved by this type of hybridization. The hybrid varieties thus evolved give good yield, are resistant to disease, are of better quality and have higher nutritive value.

Interspecific Hybridization (Between Two Species Of The Same Genus)

Several disease, pest and drought resistant varieties of wheat, tomato, sugarcane have been evolved by this method.

Intergeneric Hybridization (Between Two Plants Belonging To Two Different Genera)

This type of hybridization is more for scientific interest than for any other use. Raphonobrassica (rabbage) is a cross between cabbage and radish, Triticale is a cross between wheat and rye, sugarcane-sorghum hybrids are some examples of this type of crossing.

Improved Varieties of Some Important Crops

Commodities	Crops	Varieties
Cereals	Rice	Ir36, Pusa Basmati 1, Kasturi, Vikas, PNR-591-18
	Wheat	HD2678, HD2285, C306, PBW154, HW157
	Maize	Ganga 5, HIM128, Shakti, Navjot, Vikram
Pulses	Chickpea	K850, H208, Pusa 240, Pant 114
	Pigeonpea	Pusa Ageti, UPAS 120, Pusa 84, Manak, T21
	Uradbean	T9, Pant 430, PS1, CO5
	Mungbean	PS16, S8, T44, K851, Aasha
Oil Seeds	Ground nut	MH2, ICGS1, M37, GG11, TMV12, Kaushal
	Mustard	Pusa Bold, Kranti, Pusa Agarni, RLM 514, RH30
	Soyabean	PK262, PK327, Pusa 24, Durga, Gaurav
	Sunflower	BSH1, MSFH8, Mordern, Arun, Paras

31. Biotechnology

Biotechnology is science of manufacturing useful substances, chemicals, medicines by use of living organisms and their life process. In fact, biotechnology is not a new science. Alcohol was the first product manufactured by ancient biotechnologist.

In recent years, biotechnology is growing as a separate science - after recognizing its importance in many fields. It has attracted the attention of many intellectuals from diverse fields like agriculture, medicine, microbiology, organic chemistry besides a batch of industrial/chemical engineers. It is a multidisciplinary field wherein the principles of microbiology and chemistry are made useful to produce a useful substance by an industrial process developed for specific situations. Many more fields like molecular biology, genetic engineering, immunology have also added new folds of potentiality to biotechnology.

The scope for biotechnology is so wide that it is possibly difficult to recognize the limits. Large number of microorganisms - large number of useful chemicals - great number of applications have made innumerable combinations of opportunities in the field of biotechnology.

Some areas of application of biotechnology include:

- Food industry - production of fermented / malted food.
- Diary industry - production of microbe assisted dairy products like yogurt, different types of cheese.
- average industry - production of wine, beer, whisky, etc.,
- Sewage treatment - To treat sewage water to purify.
- Organic acids like lactic, gluconic, acetic and citric acid.
- Production of enzymes for industrial and medicinal use.
- Production of vitamins.
- Production of medicines - antibiotics.
- Production of vaccines - against specific disease.
- Production of hormones - for human and animal welfare.
- Production of antibodies - against specific pathogens.
- Production of steroids - used as antifertility formulation.

Some of them draw special interest in modern world.

Transgenic Crop Products

- **Soybean:** Herbicide tolerant soybeans are the most widely adopted biotechnology product with wide range of processed food based on soybeans is available in the market like oil, flour, protein extracts etc. Approximately three fourth of the total soybean produced in USA was the GM variety for the year 2002. According to Frost & Sullivan, the total USA GM soybean market is expected to be $ 811.7 millions in 2009. In Argentina, the majority of the production is GM variety for total soybean production in the same year. It has been observed that countries active into GM crop production are the major contributors to the worldwide exports for soybean.

- **Corn:** The insect resistant and herbicide tolerant varieties are the commercial transgenic corn crops. GM corn was first adopted in Canada and USA in 1996 and is now also being considered for approval by EU governments. Argentina and USA are the major GM corn producers. According to Frost and Sullivan, the total revenues for total USA GM corn market are expected to be $ 1069.9 million for the year 2009. Japan and South Korea are the major importers of corn to which major part is contributed by the GM varieties.

- **Cotton:** BT cotton, the insect resistant cotton, was first introduced in US, Mexico and Australia in 1995, and further adopted by other countries China, India, Argentina, Indonesia and South Africa. According to Frost and Sullivan, the total revenues for total USA GM cotton market are expected to be $ 477.4 million for the year 2009. Glyphosate (Roundup-Ready Cotton) and bromoxynil (BXN cotton) are two herbicide tolerant cotton varieties. Herbicide tolerant cotton and soybeans, insect resistant corn and cotton accounts for most of the transgenic crop acreage. Other commercial transgenic crops include herbicide tolerant canola and corn. The pest control problems associated with different countries have influenced the adoption of the cost effective BT cotton technology. A rapid adoption has been witnessed where farmers have faced the Bollworms with their property of high resistance to chemical pesticides as a primary pest problem.

- **Canola:** Its a major oil seed crop on which the biotechnological studies have been focused to improve the quality. Herbicide tolerant Canola, High Laurate content and High Oleic Acid content varieties are available worldwide. Canada, primarily the region of Western Canada is the principle producer for GM canola worldwide. Japan and China are the main importers for canola accounting to nearly half of total. For production, food and feed use, canola is already been approved in Japan, Australia, Canada and US.

- **Rice:** Virus resistant, iron rich and golden rice varieties are available. The Golden rice variety, the genetically engineered crop with β-carotene gene to produce vitamin A was developed by Swiss Federal Institute of Technology and the International Rice Research Institute in Los Baños and University of Freidburg in Germany. The estimations have been made that the benefits associated with this Indica rice is approximately double the cost associated with the A deficiency disease production and field/safety trials thus making it a more cost effective alternative to other therapies for vitamin. China is likely to be the leading producer of Golden rice. Virus resistant varieties are more of the agronomic benefits to the areas where viruses infecting rice plants causes lowering of the rice yields, especially areas of most suffering South Africa.

- **Tomato:** Glyphosphate and glufosinate herbicide tolerance delayed ripening and salt resistant varieties were developed. The delayed ripening variety was first GM food variety to be developed in industrial countries. They have been approved for food and feed purpose in Japan, Canada, Mexico and US.

Other Products: Genetically modified apple, mango, banana, pineapple, sweet potato, coconut, squash, sugar beet, papaya, potato, melon, cranberry, grapevine, kiwifruit, strawberries, raspberries, cauliflower, cucumber, cassava, carrots, onions, barley, coffee etc. are other transgenic crops. Some of them are under research at various institutes and are not yet commercially available in the market. Fungal disease (Scab) resistant, Bacterial disease (Fire blight) resistant and insect resistant varieties are under research in various universities in USA. Apple also has been modified to incorporate delayed ripening trait. GM mangos have been in development to incorporate delayed ripening traits and with improved flavor properties. Research is going on in different countries such as India, Africa, Indonesia, USA, Philippines and Indonesia for improving banana traits using biotechnology. GM bananas is in development with the traits like delayed ripening, fungal resistance, nematode resistance, and viral resistance. GM banana is also being modified to use as edible vaccine, carrying small portion of antigens to work against some dire diseases. Pineapples are also modified genetically to introduce pest and viral resistance, with delayed ripening trait. Important for livestock feed purpose, barley is under research to include traits such as fungal and viral resistance. Monsanto Co. and Kenya Agriculture Research Institute (KARI) have developed the virus resistant sweet potato, which is the first transgenic crop to be grown in Kenya.

GM Coconut is under research in various countries such as Philippines, India, Brazil, Thailand, Sri Lanka and Indonesia. Philippines plays an important role in the biotechnology research for coconut. Mainly virus resistant varieties of squash are available and in use within Canada and USA for food and feed purpose but they are very less in use. Sugar beet is a major source of sugar allowed for food and/or feed at Canada, USA, Japan and Australia. Mainly virus resistant varieties of papaya developed at University of Hawaii are available and are in use at Canada and USA for food and feed purpose. Insect resistant GM potato allowed for food and feed at

Canada, Japan and US for food purpose and the virus resistant variety was approved only in Canada and US.

Tomato paste, new leaf potatoes and many others. Thus the agriculture research companies like Monsanto, Dupont, Syngenta, Dow Agro, Bayer Crop Science and research institutes should have a more consumer-oriented approach in GM crop technology design introducing more tangible benefits for them. Other then consumer-oriented benefits, the research should be focussed on agronomic and environmental benefits. Harmonization of international standards and trade policies across all the countries is a must for the GM crop market growth and with that a internationally focussed public attitude comparison studies are required to better perceive the concerns raised by them and also it is important for a successful consumer-oriented approach.

32. MISCELLANEOUS

Azolla

Azolla is a fast growing aquatic plant often observed in many water bodies. It itself is not much useful, except that it can add organic matter on decomposition. But an algae called Anabaena Azollae inhabits in the cavities of Azolla leaves and fix atmospheric nitrogen. Thus, Azolla leaves acts as excellent source of nitrogen, besides their capacity to act as source of organic matter.

Use of Azolla is standardised and recommended in paddy cultivation mainly due to aquatic condition prevailing in paddy fields. Before paddy seedlings are transplanted, Azolla is grown for 40 - 45 days in standing water and on full leaf growth, they are dried and incorporated in soil. Use of Azolla is reported to have increased the yields of paddy by 30 - 35%.

Blue Green Algae (BGA)

Blue green algae are autotrophic and nitrogen fixing organisms unlike heterotrophic and symbiotic nitrogen fixing microbes discussed above. They manufacture their food by photosynthesis, as they have chloroplasts. Hence, they can live independently. BGA like Anabaena and Nostoc are found to live on soil, rocks. They have potentiality to fix large atmospheric nitrogen (upto 20 - 25 kg/ha). On completion of their life cycle, they add large quantity of nitrogen to the soil. Conditions necessary to grow BGA (light, adequate moisture, 20-30°C temperature, 70-75% humidity) must be maintained in the soil, in order to grow BGA successfully.

Phosphate Solubalising Bacteria

Some bacteria like Aspergillus awamori have the capacity to solubalise the phosphates fixed in soil. It must be recalled here that most of applied phosphorus is fixed in soil, and a small part of it is available to plants every year as labile phosphorous. When such bacteria are grown in large quantity in soil during the plant growth they release large quantities of phosphorus from fixed sources and make it available to crop roots. Recently such bacterial fertilizers are also made available in the market. Phosphate solubalising bacteria have potentiality to solubalise 10 - 20kg phosphorus per hectare - there by avoiding the necessity to apply phosphatic fertilizers.

Vesicular Arbuscular Mycorrhizae (VAM)

Mycorrhizae is a type of fungus living in association with plant roots. Hyphae of such fungi are found in between cortical cells of roots and protrude outside the roots also. The Mycorrhizae lives in close association with roots without disturbing their normal physiology. These hyphae form swollen vesicles or finely branched mass of hyphae called arbuscules. VAM is also known for release of fixed phosphorous in soils, as it can secrete special p-solubalising hormones. VAM culture is being commercially used in many crops to avoid use of phosphatic fertilizers.

Bio - war

Bio - war refers to biological war. It means that biological organisms are used as weapons to carry out the war. It is latest form of war. It is carried out by spreading the pathogens in specific part of geographical region to deliberately spread a deadly disease. The diseases spread through bio war may bring skin disorders, respiratory disorders, muscular disorders or digestive disorders.

An important feature of bio war is to ensure that pathogens load on society is so large that it brings about an epidemic - so that large part of population suffer from same disease and medical care becomes more difficult to manage such a menace.

The information about the use of pathogens as weapons is necessary because of many reasons.

a) Bio weapons can be used as means of terrorism.
b) Bio weapons produce diseases that one difficult to diagnose because they rarely occur naturally and often mimic other diseases.
c) Public health workers must be aware of the threat of bio war and terrorism to minimize the effects of the biological attack.
d) Physicians have to recognize the diseases resulting from bio weapons.
e) Public has to adopt safety measures against bio war.

Realities of biological warfare and terrorism

1. They are more threatening than the conventional weapons.
2. They are easy to obtain and are inexpensive.
3. Their detection and prohibition are very difficult.

Potential biological weapon agents

Disease	Pathogen
Anthrax	Bacillus anthracis
Small pox	Variola virus
Plague	Versinia pestis
Q. Fever	Coxiella brunette
Tularemia	Francisella tularensis
Viral hemorrhagic fever	Variety of RNA viruses
Viral encephalitides	Alpha virus
Botulism	Clostridium botulism

Why countries and terrorists choose bio weapons

1. Bio weapons are very cheap.
2. They kill large number of people.
Example: 10 gms of anthrax can kill 1.3 million people.
3. They are invisible, odorless, tasteless when released.

A popular example of such bio-war is Anthrax. It was recently used by followers of Osama Bin laden on American population in response to their attack on Afghanistan. Number of diseases - which can be easily spread by air, water or contact have the potentiality to infect large section of population in such bio - wars, unscrupulous and antisocial people engage in large-scale production of spores responsible for such diseases and use them to wage bio wars.

Antibiotics
Antibiotics are substances obtained from microorganisms - which are antagonistic to growth of other pathogenic bacteria.

Antibiotics are widely used in the field of medicines to cure number of diseases. Some of the antibiotics - which can be produced by use of microorganisms on large scale are listed in below table.

List of antibiotics

Name of antibiotic	Obtained from
Erythromycin	Streptomyces erythaeraeus
Aureomycin	Streptomyces aurofaciens
Terramycin	Streptomyces ramosus
Chloromycetin	Streptomyces Venezuela
Streptomycin	Streptomyces griseus
Penicillin	Pencillium notatum
Actinomycetin	Micromonospora spp
Tetramycin	Streptomyces grisens
Neomycin, novaboium	Streptomyces spp

Some Important Facts to know

Scientists connected with improvement of crop varieties are called Plant Breeders.

- ✓ Triticale has been developed through hybridization between Wheat and Rye.
- ✓ A Gene Bank is an institution where valuable plant material likely to be lost in cultivation is preserved in a viable condition, as seeds, vegetative dormant organs or as frozen eggs or sperms.
- ✓ Neem serves as most effective in repelling beetles and leaf eating pests.
- ✓ Autoclave is the instrument used to sterilize culture media.
- ✓ Biological weapons are invisible, odourless and tasteless when released.
- ✓ In 1972, Biological weapons convention and Treaty was signed.
- ✓ Haberlandt was the first to culture isolated plant cells in vitro on artificial medium (1902).

ECOLOGY & ENVIRONMENT

Slide 1

- The Earth sustains the living creatures through energy and material cycles.
- Ecology the branch of the biology that deals with the relationship between living individuals and environment.
- On the planet of Earth the plants and animals can not live in an isolated condition.
- As such they are organized in to groups like

  * Populations

  * Communities

  * Biomes and

  * Biosphere

Slide 2

POPULATIONS.

*Population is defined as an aggregation of individuals of a particular species in a definite territorial area.

*The study of species is known as Auto ecology

The populations are featured by density, which again depends on birthrate, death rate, emigration and immigration.

Slide 3

POPULATIONS

- The density of population depends on the availability of food, abundant the food more the density.

- The population density also depends on the space factor, as home range, territory and nest.
- Home range refers to a large area in which the individuals restrict their activity in search of food and mate.
- The territory is a smaller area in which defended activity against other members of the same species.

While the nest is the ultimate dwelling or resting place

Slide 4

COMMUNITIES

- Ecologically the study of communities is known as synecology.
- The whole community containing several populations of different species is called as biota.
- The community is featured by the following features.
  - * Trophic organization
  - *Stratification
  - *Dominance
  - * variety
  - *Interaction and
  - *Succession.

Slide 5

COMMUNITY- Trophic organization

- Trophic organization is featured by the following features :
  - **1. Producers** : All green plants in a community are producers. By photosynthesis they convert the solar radiation in to chemical energy.
  - 2.**Primary consumers :** All herbivorous animals come under this category.
  - 3.**Secondary consumers :** All carnivorous animals come in this category.

- 4.**Decomposers** :They are also called as osmo trophs. Are the most efficient converters. Ex bacteria and fungi, they facilitate the return of nitrates, phosphates and co2 back to environment.

Slide 6

Relationship in community

- the following are the types of relationship in a community.
  - 1. **Predation:** It is the relationship between the prey and predator. Ex. deer and lion and rat and snake ect.
  - 2. **Competition** : this must for the survival of the species, which is of two types a).Intraspecific and b) Interspecific competition.
  - 3. **Mutualism** :In this association two organisms live and obtain benefit from each other, however they can live separately also. Ex. Tick bird and Rhinoceros.

Slide 7

- 4. **Commensalism** : It is the relationship between a beneficial organism and an unaffected organism. Ex Epiphytes and Sea anemone, gastropod shell and Eupagarus.
- 5. **Symbiosis** : In this two organisms are associated and live together, however they can't survive without the other. Ex. Bacteria and leguminous plants.
- 6. **Parasitism** : It is always an association of two organisms out of which only one gets the benefit and the other one is harmed Ex. Host and parasite
- 7. **Scavenging** : they provide natural sanitation to environment. Ex. Vultures, Hyna and jaklas

Slide 8

Energy flow in an environment

- In an ecosystem the energy flows from physical environment (solar radiation) in to biological system and gets converted in to chemical energy(Photosynthesis), sustaining the life in terms of growth and reproduction. However after the death of the living individual energy is released back to. environment. This is called as energy flow in an ecosystem.
- The energy flow is always unidirectional, featured by numerous food chains, which are inter connected by food web.

Slide 9

Food chains

- There are 3 types of food chains.
  - 1. Predator chain consisting of plants and animals.
  - 2. Parasitic chain. Larger to smaller organisms.
  - 3. Detritus chain. Dead matter by
  - Micro organisms

Slide 10

Food webs

Many food chains existing in a community is called as food web.

All these are interconnected forming a net work of species constitute the food web.

Food Pyramid : Pyramid base is formed by producers (plants) and the apex is last order, the consumer.

Slide 11

Physical energy cycles in ecosystem

- 1. Carbon cycle : Atmosphere contain co2(0.04%).Producers trap it for making carbohydrates.
- 2. Oxygen cycle : Atmosphere contains 21% oxygen, which is utilized by animals for the release of energy through respiration.
- 3. Hydrogen cycle :most hydrogen is present in water which reaches plants for photosynthesis.

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Marine scientists at Copenhagen are of the opinion that seas are absorbing dangerous levels of CO2 from unchecked CO2 emissions.

If this continues in the marine environment particularly corals algae and plankton become extinct by 2050.

Plank tonic whales lack food and die.

Dolphins find it difficult to navigate as seas become noisy(due to constant drilling and boat engineering.

Brittle stars have spend more energy as maintenance of skeleton and gradually face the extinction.

Clacidiscus leptophorus a tiny algae for fishes like salmon.

Clown fishes will be loosing their olfactory ability towards smelling anemones which shelter them.

Slide 15

Environment –bioremidiation.

- Bioremidiation is a process that uses microorganisms, fungi, green plants or their enzymes to return to natural environment.
- Specific contaminants such as cholrinated hydrocarbons by bacteria cleaning up the oil spills facilitate the decomposition of crude oil by exogenon bacteria. This comes under phytoremidiation.
- Some heavy metals like cadbium and lead are not absorbed by plants.
- Transgenic plants can absorb them.
- Deinococcus radiolarian can digest touline and ionic mercury from radioactive nuclear wasts.

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BIODIVERSITY

Slide 1

- The biodiversity is defined as the degree of variation of life forms with in the ecosystem, Biome or planet.
- It is a measure of the health of ecosystem.

* It is directly associated with climate.(Tropical regions are enriched with flora & fauna than compared with polar regions).

- Rapid environmental changes cause extinctions have appeared leading to sudden drop in biodiversity.
- Again in phanerozoic era (last 540 million years)rapid growth of biodiversity occurred.
- In Cambrian period explosion of metazoa followed by rain forest collapse, lead to the loss of plants and animals.

Slide 2

- The vertebrate recovery took 30 million years and recently it is suffered by Dinosaurs extinction.
- Fall of biodiversity got minimized ever since the human intervention.
- After some period human impact also caused loss in biodiversity, particularly through habitat destruction
  - Historical account : The term biodiversity was used by RAYMOND F. DASMANN (wild life scientist) in 1968 advocated the conservation of species and was studied as CONSERVATION BIOLOGY.
  - Officially the term is applied in 1985 by W. G. Rosen (National forum of biodiversity).
  - Biodiversity can be interpreted as
  - Species diversity and species richness.
  - Ecosystem diversity and genetic diversity.

Slide 3

- The biodiversity is not uniform as far as flora and fauna is concerned.

- The climate, soil and temperature and geography are not uniform of given place.
- Normally the terrestrial biodiversity is 25 times more than ocean biodiversity.
  - Latitudinal gradients: Mean the gradual increase of biodiversity from poles to tropics. The lower latitudes have more species, leading to LATITUDINAL GRADIENT SPECIES BIODIVERSITY.
  - HOT SPOTS IN BIODIVERSITY : Featured by high level of endemic species (Dr. Norman Myer, 1988).They are near by human populations like majority of the forests located in tropics.
  - Today's biodiversity is the result of 3.5 billions of years of evolution.

Slide 4

Human benefits of biodiversity

- 1. It supports ecosystem
  - A. Air quality, B. Climate, C. Water. D. Pollution and prevention of erosion.

2. Other benefits include

Agriculture

Business and industry

Species loss rate

Habitat destruction

Introduction of invasive species

genetic pollution

Over exploitation

Hybridization and food security

Climate change

Over population

resourse allocation

Government's Efforts for Biodiversity (Slide 6)

- Issues related to conservation & protection of Biodiversity are considered among various agencies, are being reviewed and monitored.
- A comprehensive project was established, the NBSAP- National Biodiversity Strategy Action plan. Launched and prepared documents for Ecological security. (people were included depending on natural resources).
- The National Biodiversity Authority is set up in Chennai
- The act has provides the establishment of State & local level of Biodiversity Committees.
- 17 countries have formulated LMMC(Like minded

Slide7

  - Mega Countries) in which India has chaired at expert level of meeting at Delhi in Jan,20004.

- The Cartagena protocol in biodiversity : The first International regulatory frame work for Safety transfer, handling and use of Living modified organisms (LMOS).
- Local Biodiversity Act-2002
  - To regulate access to Biological resources
  - Conserve the sustainable use of BD
  - Respect & protect the local knowledge of communities
  - Conservation & development of heritages of Biodiversity
  - Protection and rehabilitation of threatened species

Biosphere reserves (Slide 8)

- These are the special category protected areas of land and costal management, as a part of UNESCO's man and biosphere program.
- The objectives of Biosphere reserves.
  - To conserve biodiversity of species
  - Promote ecological research
  - To provide facilities to educate and train public.
  - To establish research stations to be monitored by Social welfare dept.

Slide 5

- Protection and species restoration techniques
- Legal status (political and judicial decisions)
- Endangered species
- Genetic engineering
- Genetically modified organisms
- Global arguments
- Taxonomic and size relationship (less than 1% of the species described on the basis of existence..Macroscopic)
- Vast majority of the earth's species are microbial (Microbial life is physically simple and metabolically complex) forms, are more diverse than multicellular life.

Slide 9

BIORESOURCES in India are 14 as follows

Nilagiries (Karnataka,1986)

Nandadev (Uttaranchal, 1988)

Nokrek (Meghalaya,1988)

Manas (Assam,1989)

- Sunderbans (West Bengal,1989).
- Gulf of Mannar (T.Nadu,19890
- The great Nicobar,1989.
- Simlipal (Orrisa,1994)
- Panchamarhi (MP, 1999)
- Kanchenjunga (Sikki,2000)
- Agasthyamalai (Kerala,2001)
- Dehong Deband(Arunachal Pradesh).
- Achanakmar (MP,2005)

HOT SPOTS OF Biodiversity

There are 25 terrestrial hot spots of Biodiversity and 2 are among India. (Western &Eastern Ghats)

1. Mangroves

2. Wet lands and 3.coral reefs

Biodiversity and Mangroves (Slide 10)

- The mangroves are naturally vegetated estuaries
- They preserve both cost and costal inhabitants.
- They protect us from natural disasters.
- India is having 7% of Mangroves (4461 sq Kms)
- The ministry has set up National Mangrove genetic Resource Center (NMGRC in Orrisa)
- Threats for mangroves :
  - Subjected to anthropogenic as well as biotic pressures.
  - Habitat destruction
  - Loss of biodiversity
  - Bird migration is effected
  - Weed infestation and discharge of waste effluents

Biodiversity- wet lands (slide11).

- India is rich in wet land and fresher water resources
- Due to great biodiversity
- Wet lands are impoltant from economic point of view, aesthetic and scientific angels, playing an important role in food control, pollution and treatment of waste water treatment.
- It influences the micro habitat of a locality.
- It is a habitat of endangered and rare species of birds mammals, plants and insects

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GENERAL STUDIES

GEOGRAPHY-I

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Geography Index

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GEOGRAPHY

Background : Eratosthenes, a 3rd century B.C. chief librarian at the famous Library of Alexandria, is credited as the first person to use the word "geography." While the word geography is derived from Greek and literally means "to write about the earth". Geography is an all-encompassing discipline that seeks to understand the world - its human and physical features - through an understanding of place and location. Being able to view the world geographically is a fundamental skill for everyone. Understanding the connection between the environment and people, geography ties together diverse sciences as geology, biology, and climatology with economics, history, and politics based on location. Geographers understand conflict around the world because so many factors are involved. The Greek scholar Eratosthenes, who measured the circumference of the earth and was the first to use the word "geography," is commonly called the father of geography.

Branches of Geography : 1. Physical geography : Physical geography aims to understand the physical lithosphere, hydrosphere, atmosphere, pedosphere, and global flora and fauna patterns (biosphere). 2. **Human geography :** Human geography is a branch of geography that focuses on the study of patterns and processes that shape human interaction with various environments. It encompasses human, political, cultural, social, and economic aspects. Environmental geography is the branch of geography that describes the spatial aspects of interactions between humans and the natural world. 3. **Geomatics :** Geomatics is a branch of geography that has emerged since the quantitative revolution in geography in the mid 1950s. Geomatics involves the use of traditional spatial techniques used in cartography and topography and their application to computers. Geomatics has become a widespread field with many other disciplines using techniques such as GIS and remote sensing. Geomatics has also led to a revitalization of some geography departments especially in Northern America where the subject had a declining status during the 1950s. Geomatics encompasses a large area of fields involved with spatial analysis, such as Cartography, Geographic information systems (GIS), Remote sensing, and Global positioning systems (GPS). 4. **Regional geography :** Regional geography is a branch of geography that studies the regions of all sizes across the Earth. The main aim is to understand or define the uniqueness or character of a particular region which consists of natural as well as human elements. 5. **Geographic information systems :** Geographic information systems (GIS) deal with the storage of information about the Earth for automatic retrieval by a computer, in an accurate manner appropriate to the information's purpose. In addition to all of the other subdisciplines of geography, GIS specialists must understand computer science and database systems. GIS has revolutionized the field of cartography; nearly all mapmaking is now done with the assistance of some form of GIS software. GIS also refers to the science of using GIS software and GIS techniques to represent, analyze and predict spatial relationships. In this context, GIS stands for Geographic Information

Science. 6. **Remote sensing :** Remote sensing can be defined as the art and science of obtaining information about Earth features from measurements made at a distance. Remotely sensed data comes in many forms such as satellite imagery, aerial photography and data obtained from hand-held sensors. Geographers increasingly use remotely sensed data to obtain information about the Earth's land surface, ocean and atmosphere because it: a) supplies objective information at a variety of spatial scales (local to global), b) provides a synoptic view of the area of interest, c) allows access to distant and/or inaccessible sites, d) provides spectral information outside the visible portion of the electromagnetic spectrum, and e) facilitates studies of how features/areas change over time. Remotely sensed data may be analyzed either independently of, or in conjunction with, other digital data layers (e.g., in a Geographic Information System).

PHYSICAL GEOGRAPHY

ORIGIN OF THE EARTH

The earth is believed to have been formed from a small part of the sun. Most of the theories concerned with the origin of the earth emphasise that the planet originated as a hot gaseous mass which on cooling, turned, first into a liquid and then into a solid. One of the earliest theories was put forth by Kant, which is popularly known as the **gaseous hypothesis**. A more popular theory was advanced by *Laplace* which is called the **nebular hypothesis**. This theory considers earth as having been formed through the solidification of a ring thrown away by a cooling and rotating nebula (sun). This ring was one of the nine such rings which formed various planets. A more plausible theory put forth by Jeans and Jeffreys assumed the presence of two nebulae instead of one as assumed by Laplace. The theory advanced by Jeans and Jeffreys is called the **tidal hypothesis** and it belongs to the group of the **binary star theories** (the theories explaining the origin of the earth and the other planets on the basis of the presence of two nebulae). According to this theory a large nebula wandering in the space came very close to another smaller nebula (sun) and its gravitational pull caused a huge tidal upsurge of matter on the surface of the smaller nebula. As the larger nebula moved away from the smaller one, the matter rising as a tidal wave from the surface of the smaller nebula was pulled towards it and was drawn to a distance from which it could not come back to the parent body. However, it could not follow the larger nebula also and as the larger nebula moved away, the rising tongue of matter was detached from the smaller nebula. On cooling, this matter condensed to form the planets, including the earth, and they started revolving around the sun. This hypothesis is considered to be highly probable and close to reality. The cigar-shaped arrangement of the planets going away from the sun, with the smallest planets located closest and farthest from the sun and the larger ones occupying intermediate positions, strengthens this view.

MODERN THEORIES : However, scientists in later period took up the problems of origin of universe rather than that of just the earth or the planets. The most popular argument regarding the origin of the universe is the **Big Bang Theory**. It is also called **expanding universe** hypothesis

The Big Bang Theory

The Big Bang Theory consider the following stages in the development of the Universe:

■ All matter forming the universe existed in one place in the form of a tiny ball (singular atom). ➜ At the Big Bang, the tiny ball exploded violently. This led to a huge expansion, which continues even today. Within the first three minutes from the Big Bang event, the first atom began to form. ➜ Within 300,000 years from the Big Bang the temperature dropped to 4500 K and gave rise to atomic matter. The Universe became transparent.

With greater evidence becoming available about the expanding Universe, the scientific community at present favours the expanding Universe hypothesis.

Solar System

The **Solar System** consists of the ***Sun and those celestial objects*** bound to it by gravity. These objects are the eight planets, their 166 known moons, five dwarf planets, and billions of small bodies. The small bodies include asteroids, icy Kuiper belt objects, comets, meteoroids, and interplanetary dust. The charted regions of the Solar System are the Sun, four terrestrial inner planets, the asteroid belt, four gas giant outer planets, the Kuiper belt, the scattered disc, and the hypothetical Oort cloud. As of mid-2008, five smaller objects are classified as dwarf planets. Ceres is in the asteroid belt, and four orbit the Sun beyond Neptune: Pluto (formerly classified as the ninth planet), Haumea, Makemake, and Eris.

Discovery and exploration : For many thousands of years, humanity, with a few notable exceptions, did not recognise the existence of the Solar System. They believed the Earth to be stationary at the centre of the universe and categorically different from the divine or ethereal objects that moved through the sky. Although the Indian mathematician-astronomer Aryabhata and the Greek philosopher Aristarchus of Samos had speculated on a heliocentric reordering of the cosmos, Nicolaus Copernicus was the first to develop a mathematically predictive heliocentric system.

Rotation about axis — anti clock wise

Structure : The relative masses of the Solar planets. Jupiter at 71% of the total and Saturn at 21% dominate the system. Mercury and Mars, which together are less than 0.1%, are not visible at this scale. The principal component of the Solar System is the Sun, a main sequence G2 star that contains 99.86 percent of the system's known mass and dominates it gravitationally. Jupiter and Saturn, the Sun's two largest orbiting bodies, account for more than 90 percent of the system's remaining mass. Most large objects in orbit around the Sun lie near the plane of Earth's orbit, known as the ecliptic. The planets are very close to the ecliptic while comets and Kuiper belt objects are usually at significantly greater angles to it. All of the planets and most other objects also orbit with the Sun's rotation (counter-clockwise, as viewed from above the Sun's north pole). There are exceptions, such as Halley's Comet.

Kepler's laws of planetary motion describe the orbits of objects about the Sun. According to Kepler's laws, each object travels along an ellipse with the Sun at one focus. Objects closer to the Sun (with smaller semi-major axes) have shorter years. On an elliptical orbit, a body's distance from the Sun varies over the course of its year. A body's closest approach to the Sun is called its ***perihelion***, while its most distant point from the Sun is called its ***aphelion***. Each body moves fastest at its perihelion and slowest at its aphelion. The orbits of the planets are nearly circular, but many comets, asteroids and Kuiper belt objects follow highly elliptical orbits.

To cope with the vast distances involved, many representations of the Solar System show orbits the same distance apart. In reality, with a few exceptions, the farther a planet or belt is from the Sun, the larger the distance between it and the previous orbit. For example, Venus is approximately 0.33 astronomical units (AU) farther out than Mercury, while Saturn is 4.3 AU out from Jupiter, and Neptune lies 10.5 AU out from Uranus. Informally, the Solar System is sometimes divided into separate regions. The inner Solar System includes the four terrestrial planets and the main asteroid belt. The outer Solar System is beyond the asteroids, including the four gas giant planets. Since the discovery of the Kuiper belt, the outermost parts of the Solar System are considered a distinct region consisting of the objects beyond Neptune. A planet is any body in orbit around the Sun that has enough mass to form itself into a spherical shape and has cleared its immediate neighbourhood of all smaller objects. By this definition, the Solar System has eight known planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. Pluto was demoted from planetary status, as it has not cleared its orbit of surrounding Kuiper belt objects.

A dwarf planet is a celestial body orbiting the Sun that is massive enough to be rounded by its own gravity but which has not cleared its neighbouring region of planetesimals and is not a satellite. By this definition, the Solar System has five known dwarf planets: Ceres, Pluto, Haumea, Makemake, and Eris. Other objects that may become classified as dwarf planets are Sedna, Orcus, and Quaoar. Dwarf planets that orbit in the trans-Neptunian region are called "plutoids."

Peri — fast

Aperi

revolution
around → west to east
dum

The regions (or zones) of the Solar system: the *inner solar system*, the *asteroid belt*, the *giant planets* (Jovians) and the *Kuiper belt*.

Sun : The Sun is the Solar System's *parent star*, and far and away its chief component. Its large mass gives it an interior density high enough to sustain nuclear fusion, which releases enormous amounts of energy, mostly radiated into space as electromagnetic radiation such as visible light. The Sun is classified as a moderately large yellow dwarf, but this name is misleading as, compared to stars in our galaxy, the Sun is rather large and bright. Stars are classified by *the Hertzsprung-Russell diagram*, a graph which plots the brightness of stars against their surface temperatures. Generally, hotter stars are brighter. Stars following this pattern are said to be on the main sequence; the Sun lies right in the middle of it. However, stars brighter and hotter than the Sun are rare, while stars dimmer and cooler are common. It is believed that the Sun's position on the main sequence puts it in the "prime of life" for a star, in that it has not yet exhausted its store of hydrogen for nuclear fusion. The Sun is growing brighter; early in its history it was 75 percent as bright as it is today. The Sun is a population I star; it was born in the later stages of the universe's evolution. It contains more elements heavier than hydrogen and helium ("metals" in astronomical parlance) than older population II stars. Elements heavier than hydrogen and helium were formed in the cores of ancient and exploding stars, so the first generation of stars had to die before the universe could be enriched with these atoms. The oldest stars contain few metals, while stars born later have more. This high metallicity is thought to have been crucial to the Sun's developing a planetary system, because planets form from accretion of metals.

Inner planets : The inner planets are Mercury, Venus, Earth, and Mars. The four inner or terrestrial planets have dense, rocky compositions, few or no moons, and no ring systems. They are composed largely of minerals with high melting points, such as the silicates which form their crusts and mantles, and metals such as iron and nickel, which form their cores. Three of the four inner planets (Venus, Earth and Mars) have substantial atmospheres; all have impact craters and tectonic surface features such as rift valleys and volcanoes. *The term inner planet should not be confused with inferior planet, which designates those planets which are closer to the Sun than Earth is (i.e. Mercury and Venus).*

Mercury : Mercury (0.4 AU) is the closest planet to the Sun and the smallest planet (0.055 Earth masses). Mercury has no natural satellites, and its only known geological features besides impact craters are lobed ridges or rupes, probably produced by a period of contraction early in its history. Mercury's almost negligible atmosphere consists of atoms blasted off its surface by the solar wind. Its relatively large iron core and thin mantle have not yet been adequately explained. Hypotheses include that its outer layers were stripped off by a giant impact, and that it was prevented from fully accreting by the young Sun's energy.

Venus : Venus (0.7 AU) is close in size to Earth, (0.815 Earth masses) and like Earth, has a thick silicate mantle around an iron core, a substantial atmosphere and evidence of internal geological activity. However, it is much drier than Earth and its atmosphere is ninety times as dense. Venus has no natural satellites. It is the hottest planet, with surface temperatures over 400 °C, most likely due to the amount of greenhouse gases in the atmosphere. No definitive evidence of current geological activity has been detected on Venus, ~~but it has no magnetic field that would prevent depletion of its substantial atmosphere, which suggests that its atmosphere is regularly replenished by volcanic eruptions~~.

Earth : Earth (1 AU) is the largest and densest of the inner planets, the only one known to have current geological activity, and the only planet known to have life. Its liquid hydrosphere is unique among the terrestrial planets, and it is also the only planet where plate tectonics has been observed. Earth's atmosphere is radically different from those of the other planets, having been altered by the presence of life to contain 21% free oxygen. It has one natural satellite, the Moon (Latin: Luna), the only large satellite of a terrestrial planet in the Solar System.

refer to geology studies the folding & faulting of earth's crust

Mars : Mars (1.5 AU) is smaller than Earth and Venus (0.107 Earth masses). It possesses a tenuous atmosphere of mostly carbon dioxide. Its surface, peppered with vast volcanoes such as Olympus Mons and rift valleys such as Valles Marineris, shows geological activity that may have persisted until very recently. Its red color comes from rust in its iron-rich soil. Mars has two tiny natural satellites (Deimos and Phobos) thought to be captured asteroids.

Asteroid belt : Asteroids are mostly small Solar System bodies composed mainly of rocky and metallic non-volatile minerals. The main asteroid belt occupies the orbit between Mars and Jupiter, between 2.3 and 3.3 AU from the Sun. It is thought to be remnants from the Solar System's formation that failed to coalesce because of the gravitational interference of Jupiter. Asteroids range in size from hundreds of kilometres across to microscopic. All asteroids save the largest, Ceres, are classified as small Solar System bodies, but some asteroids such as Vesta and Hygieia may be reclassed as dwarf planets if they are shown to have achieved hydrostatic equilibrium.

A small part or portion that remains after the main part no longer exists

fuse or cause to grow together

The asteroid belt contains tens of thousands, possibly millions, of objects over one kilometre in diameter. Despite this, the total mass of the main belt is unlikely to be more than a thousandth of that of the Earth. The main belt is very sparsely populated; spacecraft routinely pass through without incident. Asteroids with diameters between 10 and 10^{-4} m are called ***meteoroids.***

In a Not dense manner

Ceres : Ceres (2.77 AU) is the largest body in the asteroid belt and is classified as a dwarf planet. It has a diameter of slightly under 1000 km, large enough for its own gravity to pull it into a spherical shape. Ceres was considered a planet when it was discovered in the 19th century, but was reclassified as an asteroid in the 1850s as further observation revealed additional asteroids. It was again reclassified in 2006 as a dwarf planet.

Outer Solar System : The outer region of the Solar System is home to the gas giants and their planet-sized satellites. Many short period comets, including the centaurs, also orbit in this region. The solid objects in this region are composed of a higher proportion of volatiles (such as water, ammonia, methane, often called *ices* in planetary science) than the rocky denizens of the inner Solar System.

Outer planets : The four outer planets. or gas giants (sometimes called Jovian planets), collectively make up 99 percent of the mass known to orbit the Sun. Jupiter and Saturn consist overwhelmingly of hydrogen and helium; Uranus and Neptune possess a greater proportion of ices in their makeup. Some astronomers suggest they belong in their own category, "ice giants." All four gas giants have rings, although only Saturn's ring system is easily observed from Earth. The term *outer planet* should not be confused with *superior planet*, which designates planets outside Earth's orbit (the outer planets and Mars).

Jupiter : Jupiter (5.2 AU), at 318 Earth masses, masses 2.5 times all the other planets put together. It is composed largely of hydrogen and helium. Jupiter's strong internal heat creates a number of semi-permanent features in its atmosphere, such as cloud bands and the Great Red Spot. Jupiter has sixty-three known satellites. The four largest, Ganymede, Callisto, Io, and Europa, show similarities to the terrestrial planets, such as volcanism and internal heating. Ganymede, the largest satellite in the Solar System, is larger than Mercury.

Saturn: Saturn (9.5 AU), distinguished by its extensive ring system, has similarities to Jupiter, such as its atmospheric composition. Saturn is far less massive, being only 95 Earth masses. Saturn has sixty known satellites (and three unconfirmed); two of which, Titan and Enceladus, show signs of geological activity, though they are largely made of ice. Titan is larger than Mercury and the only satellite in the Solar System with a substantial atmosphere.

Uranus : Uranus (19.6 AU), at 14 Earth masses, is the lightest of the outer planets. Uniquely among the planets, it orbits the Sun on its side; its axial tilt is over ninety degrees to the ecliptic. It has a much colder core than the other gas giants, and radiates very little heat into space. Uranus has twenty-seven known satellites, the largest ones being Titania, Oberon, Umbriel, Ariel and Miranda.

Neptune : Neptune (30 AU), though slightly smaller than Uranus, is more massive (equivalent to 17 Earths) and therefore more dense. It radiates more internal heat, but not as much as Jupiter or Saturn. Neptune has thirteen known satellites. The largest, Triton, is geologically active, with geysers of liquid nitrogen.[41] Triton is the only large satellite with a retrograde orbit. Neptune is accompanied in its orbit by a number of minor planets, termed Neptune Trojans, that are in 1:1 resonance with it.

dry carbon

short

eccentric orbit

Comets : Comets are small Solar System bodies, usually only a few kilometres across, composed largely of volatile ices. They have highly eccentric orbits, generally a perihelion within the orbits of the inner planets and an aphelion far beyond Pluto. When a comet enters the inner Solar System, its proximity to the Sun causes its icy surface to sublimate and ionise, creating a coma: a long tail of gas and dust often visible to the naked eye. *Short-period comets* have orbits lasting less than two hundred years. Long-period comets have orbits lasting thousands of years. Short-period comets are believed to originate in the Kuiper belt, while long-period comets, such as Hale-Bopp, are believed to originate in the Oort cloud. Many comet groups, such as the Kreutz Sungrazers, formed from the breakup of a single parent. Some comets with hyperbolic orbits may originate outside the Solar System, but determining their precise orbits is difficult. Old comets that have had most of their volatiles driven out by solar warming are often categorised as asteroids.

Meteors: When we speak of "*shooting stars*" we mean meteors. These are not stars at all. They are believed to come from two different sources. The majority of them are small fragments like those in the belt of asteroids between Mars and Jupiter. Another source appears to be the tails of comets, for each time the earth crosses the path of a comet, swarms of meteors are seen. Meteors enter the earth's atmosphere with such speed (approximately 30-60 times the speed of sound) that the heat generated from friction with the air causes them to vaporise with a brief flash of brilliantly glowing gas.

Centaurs : The centaurs are icy comet-like bodies with a semi-major axis greater than Jupiter (5.5 AU) and less than Neptune (30 AU). The largest known centaur, 10199

$\frac{1}{2}$ the major axis of an ellipse !

Chariklo, has a diameter of about 250 km. The first centaur discovered, 2060 Chiron, has also been classified as comet (95P) since it develops a coma just as comets do when they approach the Sun. Some astronomers classify centaurs as inward-scattered Kuiper belt objects along with the outward-scattered residents of the scattered disc.

Trans-Neptunian region : The area beyond Neptune, or the "trans-Neptunian region", is still largely unexplored. It appears to consist overwhelmingly of small worlds (the largest having a diameter only a fifth that of the Earth and a mass far smaller than that of the Moon) composed mainly of rock and ice. This region is sometimes known as the "outer Solar System", though others use that term to mean the region beyond the asteroid belt.

Trans Neptune region

Kuiper belt : The Kuiper belt, the region's first formation, is a great ring of debris similar to the asteroid belt, but composed mainly of ice. It extends between 30 and 50 AU from the Sun. It is composed mainly of small Solar System bodies, but many of the largest Kuiper belt objects, such as Quaoar, Varuna, and Orcus, may be reclassified as dwarf planets. There are estimated to be over 100,000 Kuiper belt

Pluto and Charon : Pluto (39 AU average), a dwarf planet, is one of the largest known object in the Kuiper belt. When discovered in 1930, it was considered to be the ninth planet; this changed in 2006 with the adoption of a formal definition of planet. Pluto has a relatively eccentric orbit inclined 17 degrees to the ecliptic plane and ranging from 29.7 AU from the Sun at perihelion (within the orbit of Neptune) to 49.5 AU at aphelion.

Pluto and its three known moons : It is unclear whether Charon, Pluto's largest moon, will continue to be classified as such or as a dwarf planet itself. Both Pluto and Charon orbit a barycenter of gravity above their surfaces, making Pluto-Charon a binary system. Two much smaller moons, Nix and Hydra, orbit Pluto and Charon. Pluto lies in the resonant belt and has a 3:2 resonance with Neptune, meaning that Pluto orbits twice round the Sun for every three Neptunian orbits. Kuiper belt objects whose orbits share this resonance are called plutinos.[51]

Haumea and Makemake : Haumea (43.34 AU average), and Makemake (45.79 AU average) are the largest known objects in the classical Kuiper belt. Haumea is an egg-shaped object with two moons. Makemake is the brightest object in the Kuiper belt after Pluto. Originally designated 2003 EL_{61} and 2005 FY_9 respectively, they were granted names (and the status of dwarf planet) in 2008. Their orbits are far more inclined than Pluto's (28° and 29°) and unlike Pluto are not affected by Neptune, being part of the classical KBO population.

Sedna: 90377 Sedna (525.86 AU average) is a large, reddish Pluto-like object with a gigantic, highly elliptical orbit that takes it from about 76 AU at perihelion to 928 AU at aphelion and takes 12,050 years to complete. Mike Brown, who discovered the object in 2003, asserts that it cannot be part of the scattered disc or the Kuiper belt as its perihelion is too distant to have been affected by Neptune's migration. He and other astronomers consider it to be the first in an entirely new population, which also may include the object 2000 CR_{105}, which has a perihelion of 45 AU, an aphelion of 415 AU, and an orbital period of 3420 years. Brown terms this population the "Inner Oort cloud," as it may have formed through a similar process, although it is far closer to the Sun. Sedna is very likely a dwarf planet, though its shape has yet to be determined with certainty.

The Earth

Earth is the third planet from the Sun. Earth is the largest of the terrestrial planets in the Solar System in diameter, mass and density. It is also referred to as *the World* and *Terra*. Home to millions of species, including humans, Earth is the only place in the universe where life is known to exist. Scientific evidence indicates that the planet formed 4.54 billion years ago, and life appeared on its surface within a billion years. Since then, Earth's biosphere has significantly altered the atmosphere and other abiotic conditions on the planet, enabling the proliferation of aerobic organisms as well as the formation of the ozone layer which, together with Earth's magnetic field, blocks harmful radiation, permitting life on land. The physical properties of the Earth, as well as its geological history and orbit, allowed life to persist during this period. The world is expected to continue supporting life for another 1.5 billion years, after which the rising luminosity of the Sun will eliminate the biosphere.

Earth's outer surface is divided into several rigid segments, or tectonic plates, that gradually migrate across the surface over periods of many millions of years. About 71% of the surface is covered with salt-water oceans, the remainder consisting of continents and islands; liquid water, necessary for all known life, is not known to exist on any other planet's surface. Earth's interior remains active, with a thick layer of relatively solid mantle, a liquid outer core that generates a magnetic field, and a solid iron inner core.

At present, Earth orbits the Sun once for every roughly 366.26 times it rotates about its axis. This length of time is a sidereal year, which is equal to 365.26 solar days The Earth's axis of rotation is tilted 23.4° away from the perpendicular to its orbital plane, producing seasonal variations on the planet's surface with a period of one tropical year (365.24 solar days). Earth's only known natural satellite, the Moon, which began orbiting it about 4.53 billion years ago, provides ocean tides, stabilizes the axial tilt and gradually slows the planet's rotation.

History: Scientists have been able to reconstruct detailed information about the planet's past. About 4.54 billion years ago (within an uncertainty of 1%), the Earth and the other planets in the Solar System formed out of the solar nebula—a disk-shaped mass of dust and gas left over from the formation of the Sun. This assembly of the Earth through accretion was largely completed within 10–20 million years. Initially molten, the outer layer of the planet Earth cooled to form a solid crust when water began accumulating in the atmosphere. The Moon formed soon afterward, possibly as the result of a Mars-sized object (sometimes called Theia) with about 10% of the Earth's mass impacting the Earth in a glancing blow. Some of this object's mass would have merged with the Earth and a portion would have been ejected into space, but enough material would have been sent into orbit to form the Moon. Outgassing and volcanic activity produced the primordial atmosphere. Condensing water vapor, augmented by ice and liquid water delivered by asteroids and the larger proto-planets, comets, and trans-Neptunian objects produced the oceans. The highly energetic chemistry is believed to have produced a self-replicating molecule around 4 billion years ago, and half a billion years later, the last common ancestor of all life existed. The present pattern of ice ages began about 40 mya and then intensified during the Pleistocene about 3 mya. The polar regions have since undergone repeated cycles of glaciation and thaw, repeating every 40–100,000 years. The last ice age ended 10,000 years ago.

Composition and structure : Earth is a terrestrial planet, meaning that it is a rocky body, rather than a gas giant like Jupiter. It is the largest of the four solar terrestrial planets, both in terms of size and mass. Of these four planets, Earth also has the highest density, the highest surface gravity, the strongest magnetic field, and fastest rotation. It also is the only terrestrial planet with active plate tectonics.

Shape : The Earth's shape is very close to an oblate spheroid—a rounded shape with a bulge around the equator—although the precise shape (the geoid) varies from this by up to 100 meters. The average diameter of the reference spheroid is about 12,742 km. More approximately the distance is 40,000 km/π because the meter was originally defined as 1/10,000,000 of the distance from the equator to the north pole through Paris, France. The rotation of the Earth creates the equatorial bulge so that the equatorial diameter is 43 km larger than the pole to pole diameter. The largest local deviations in the rocky surface of the Earth are Mount Everest (8,848 m above local sea level) and the Mariana Trench (10,911 m below local sea level). Hence compared to a perfect ellipsoid, the Earth has a tolerance of about one part in about 584, or 0.17%, which is less than the 0.22% tolerance allowed in billiard balls. Because of the bulge, the feature farthest from the center of the Earth is actually Mount Chimborazo in Ecuador.

Chemical composition : The mass of the Earth is approximately 5.98×10^{24} kg. It is composed mostly of iron (32.1%), oxygen (30.1%), silicon (15.1%), magnesium (13.9%), sulfur (2.9%), nickel (1.8%), calcium (1.5%), and aluminum (1.4%); with the remaining 1.2% consisting of trace amounts of other elements. Due to mass segregation, the core region is believed to be primarily composed of iron (88.8%), with smaller amounts of nickel (5.8%), sulfur (4.5%), and less than 1% trace elements. The geochemist F. W. Clarke calculated that a little more than 47% of the Earth's crust consists of oxygen. The more common rock constituents of the Earth's crust are nearly all oxides; chlorine, sulfur and fluorine are the only important exceptions to this and their total amount in any rock is usually much less than 1%. The principal oxides are silica, alumina, iron oxides, lime, magnesia, potash and soda. The silica functions principally as an acid, forming silicates, and all the commonest minerals of igneous rocks are of this nature. From a computation based on 1,672 analyses of all kinds of rocks, Clarke deduced that 99.22% were composed of 11 oxides . All the other constituents occur only in very small quantities

Internal structure : The interior of the Earth, like that of the other terrestrial planets, is divided into layers by their chemical or rheological properties. The Earth has an outer silicate solid crust, a highly viscous mantle, a liquid outer core that is much less viscous than the mantle, and a solid inner core. The crust is separated from the mantle by the Mohorovičić discontinuity, and the thickness of the crust varies: averaging 6 km under the oceans and 30–50 km on the continents. The inner core may rotate at a slightly higher angular velocity than the remainder of the planet, advancing by 0.1–0.5° per year.

Geologic layers of the Earth[44]

	Depth km	Component Layer	Density g/cm³
	0–60	Lithosphere	—
	0–35	... Crust[47]	2.2–2.9
	35–60	... Upper mantle	3.4–4.4
Earth cutaway from core to exosphere. Not to scale.	35–2890	Mantle	3.4–5.6
	100–700	... Asthenosphere	—
	2890–5100	Outer core	9.9–12.2
	5100–6378	Inner core	12.8–13.1

The internal heat of the planet is probably produced by the radioactive decay of potassium-40, uranium-238 and thorium-232 isotopes. All three have half-life decay periods of more than a billion years. At the center of the planet, the temperature may be up to 7,000 K and the pressure could reach 360 GPa. A portion of the core's thermal energy is transported toward the crust by Mantle plumes; a form of convection consisting of upwellings of higher-temperature rock. These plumes can produce hotspots and flood basalts.

Tectonic plates : According to plate tectonics theory, the outermost part of the Earth's interior is made up of two layers: the lithosphere, comprising the crust, and the solidified uppermost part of the mantle. Below the lithosphere lies the asthenosphere, which forms the inner part of the upper mantle. The asthenosphere behaves like a superheated material that is in a semi-fluidic, plastic-like state. The lithosphere essentially *floats* on the asthenosphere and is broken up into what are called tectonic plates. These plates are rigid segments that move in relation to one another at one of three types of plate boundaries: convergent, divergent and transform. The last occurs where two plates move laterally relative to each other, creating a strike-slip fault. Earthquakes, volcanic activity, mountain-building, and oceanic trench formation can occur along these plate boundaries.

Notable minor plates include the Indian Plate, the Arabian Plate, the Caribbean Plate, the Nazca Plate off the west coast of South America and the Scotia Plate in the southern Atlantic Ocean. The Australian Plate actually fused with Indian Plate between 50 and 55 million years ago. The fastest-moving plates are the oceanic plates, with the Cocos Plate advancing at a rate of 75 mm/yr and the Pacific Plate moving 52–69 mm/yr. At the other extreme, the slowest-moving plate is the Eurasian Plate, progressing at a typical rate of about 21 mm/yr.

Surface : The Earth's terrain varies greatly from place to place. About 70.8% of the surface is covered by water, with much of the continental shelf below sea level. The submerged surface has mountainous features, including a globe-spanning mid-ocean ridge system, as well as undersea volcanoes, oceanic trenches, submarine canyons, oceanic plateaus and abyssal plains. The remaining 29.2% not covered by water consists of mountains, deserts, plains, plateaus, and other geomorphologies. The planetary surface undergoes reshaping over geological time periods due to the effects of tectonics and erosion. The surface features built up or deformed through plate tectonics are subject to steady weathering from precipitation, thermal cycles, and chemical effects. Glaciation, coastal erosion, the build-up of coral reefs, and large meteorite impacts also act to reshape the landscape. As the tectonic plates migrate across the planet, the ocean floor is subducted under the leading edges. At the same time, upwellings of mantle material create a divergent boundary along mid-ocean ridges. The combination of these processes continually recycles the oceanic crustal material. Most of the ocean floor is less than 100 million years in age. The oldest oceanic crust is located in the Western Pacific, and has an estimated age of about 200 million years. By comparison, the oldest fossils found on land have an age of about 3 billion years.

The continental crust consists of lower density material such as the igneous rocks granite and andesite. Less common is basalt, a denser volcanic rock that is the primary constituent of the ocean floors. Sedimentary rock is formed from the accumulation of sediment that becomes compacted together. Nearly 75% of the continental surfaces are covered by sedimentary rocks, although they form only about 5% of the crust. The third form of rock material found on Earth is metamorphic rock, which is created from the transformation of pre-existing rock types through high pressures, high temperatures, or both. The most abundant silicate minerals on the Earth's surface include quartz, the feldspars, amphibole, mica, pyroxene and olivine. Common carbonate minerals include calcite (found in limestone), aragonite and dolomite.

The pedosphere is the outermost layer of the Earth that is composed of soil and subject to soil formation processes. It exists at the interface of the lithosphere, atmosphere, hydrosphere and biosphere. Currently the total arable land is 13.31% of the land surface, with only 4.71% supporting permanent crops. Close to 40% of the Earth's land surface is presently used for cropland and pasture, or an estimated 1.3×10^7 km² of cropland and 3.4×10^7 km² of pastureland. The elevation of the land surface of the Earth varies from the low point of −418 m at the Dead Sea, to a 2005-estimated maximum altitude of 8,848 m at the top of Mount Everest. The mean height of land above sea level is 840 m.

Continents and Oceans: A continent is a part of the earth's surface that forms some of the great land masses of the world. The main continents are Europe, Asia, Africa, Australia, North America, South America and Antarctica. Oceans and seas together form a single mass of water called the World Ocean, above which rise continents forming, as it were, separate islands. (The major oceans of the earth are the Pacific, the Atlantic, the Indian, the Arctic and the Antarctic. The Pacific Ocean is the largest and the deepest, covering one-third of the globe).

Distribution of Land and Water: Our planet, the Earth, is in fact a watery planet. The continents form only 29 per cent while the greater part, 71 per cent, is covered by the ocean. There is an antipodal arrangement of land and sea. This means that for nearly every land-mass on one side of the globe there is sea on the part of the earth which is on the opposite side.

The Motions of the Earth : The earth has two important motions: - It rotates on its axis once in 24 hours and it Revolves around the Sun once in 365¼ days.

Rotation is turning on an axis. The earth is rotating on its axis. The evidence of this is found in the rising and setting of the Sun. The direction of this rotation is from **west to east**. Rotation gives us periods of heat and light as well as darkness. The change from **day** to **night** causes variations in temperature. During the day the sun's heat raises the temperature. At night a part of this heat accumulated during the day is given off and the temperature comes down.

Earth's rotation period relative to the Sun—its mean solar day—is 86,400 seconds of mean solar time. Each of these seconds is slightly longer than an SI second because Earth's solar day is now slightly longer than it was during the 19th century due to tidal acceleration. Earth's rotation period relative to the fixed stars, called its *stellar day* by the International Earth Rotation and Reference Systems Service (IERS), is 86164.098903691 seconds of mean solar time (UT1), or $23^h\ 56^m\ 4.098903691^s$. Earth's rotation period relative to the precessing or moving mean vernal equinox, misnamed its *sidereal day*, is 86164.09053083288 seconds of mean solar time (UT1) ($23^h\ 56^m\ 4.09053083288^s$). Thus the sidereal day is shorter than the stellar day by about 8.4 ms. The length of the mean solar day in SI seconds is available from the IERS for the periods 1623–2005 and 1962–2005. Apart from meteors within the atmosphere and low-orbiting satellites, the main apparent motion of celestial bodies in the Earth's sky is to the west at a rate of 15°/h = 15'/min. This is equivalent to an apparent diameter of the Sun or Moon every two minutes; the apparent sizes of the Sun and the Moon are approximately the same.

Revolution: The next important motion of the earth is its Revolution round the Sun in the course of its yearly journey. It takes approximately 365 ¼ days to complete a revolution. The revolution of the Earth causes four seasons : namely, Spring, Summer, Autumn and Winter. Earth orbits the Sun at an average distance of about 150 million kilometers every 365.2564 mean solar days, or one sidereal year. From Earth, this gives an apparent movement of the Sun eastward with respect to the stars at a rate of about 1°/day, or a Sun or Moon diameter every 12 hours. Because of this motion, on average it takes 24 hours—a solar day—for Earth to complete a full rotation about its axis so that the Sun returns to the meridian. The orbital speed of the Earth averages about 30 km/s (108,000 km/h), which is fast enough to cover the planet's diameter (about 12,600 km) in seven minutes, and the distance to the Moon (384,000 km) in four hours.

The Moon revolves with the Earth around a common barycenter every 27.32 days relative to the background stars. When combined with the Earth–Moon system's common revolution around the Sun, the period of the synodic month, from new moon to new moon, is 29.53 days. Viewed from the celestial north pole, the motion of Earth, the Moon and their axial rotations are all counter-clockwise. Viewed from a vantage point above the north poles of both the Sun and the Earth, the Earth appears to revolve in a counterclockwise direction about the Sun. The orbital and axial planes are not precisely aligned: Earth's axis is tilted some 23.5 degrees from the perpendicular to the Earth–Sun plane, and the Earth–Moon plane is tilted about 5 degrees against the Earth-Sun plane. Without this tilt, there would be an eclipse every two weeks, alternating between lunar eclipses and solar eclipses.

The Hill sphere, or gravitational sphere of influence, of the Earth is about 1.5 Gm (or 1,500,000 kilometers) in radius. This is maximum distance at which the Earth's gravitational influence is stronger than the more distant Sun and planets. Objects must orbit the Earth within this radius, or they can become unbound by the gravitational perturbation of the Sun.

Earth, along with the Solar System, is situated in the Milky Way galaxy, orbiting about 28,000 light years from the center of the galaxy, and about 20 light years above the galaxy's equatorial plane in the Orion spiral arm

Solstices and Equinoxes: At any one time only half the earth's surface receives light from the Sun and the imaginary line that separates the lighted from the darkened half of the earth is known as the **circle of Illumination.** In the Northern Hemisphere the sun shines vertically over the Tropic of Cancer on June 21^{st}, this is the **Summer Solstice** in the Northern Hemisphere. As a result the Northern Hemisphere becomes hot and the season is called as the summer season. At the same time, the southern hemisphere the conditions are opposite to that of the northern hemisphere and it is the winter season there. On December 22^{nd}, the Sun shines vertically over the tropic of Capricorn. This is the winter solstices and leads to winter in the northern hemisphere and summer in the southern hemisphere. On March 21^{st} and September 23^{rd} the days are nearly equal to the nights all over the world and these are called as **Equinoxes.**

Location of Places on the Earth : A grid is a series of crossing lines used for locating places on a map or a globe. On a true sphere it would not be possible to indicate the exact point where we could begin marking the lines of the grid because there are no corners, no sides, no beginning or end. But on a rotating earth it is easy as it is spinning round its axis. Each end of the axis is known as **"Pole"** and midway between these poles lies the **"Equator"**. So we draw one series of lines from the north pole to the south pole and another series of lines parallel to the equator. This complete network of meridians and parallels, called the Earth Grid, enables us to determine the location of any point on the earth.

Magnetic field of the Earth