SRIRAM'S IAS

GENERAL STUDIES

BIOLOGY

11A/22; 1st Floor; Old Rajender Nagar;New Delhi -60
ph. 011-25825591; 42437002; 9958671553
73-75; 1st Floor; Ring Road ;Beside GTB Metro Station
Kingsway Camp;New Delhi.
Ph. 08447273027

INDEX

S. No	Topic	Page No.
01	Cellular Organization NCERT XI	01-05
02	Transport in and out of Cells NCERT XI	06-07
03	Cell Division NCERT XI	08-12
04	Cellular Metabolism and Fermentation	13-15
05	Photosynthesis	16-20
06	DNA and Molecular Genetics	21-25
07	Plants and their Structure	26-31
08	Plant Hormones, Nutrition and Transport	32-37
09	Animal Cells and Tissues	38-41
10	The Integumentary System	42-44
11	The Circulatory System	45-55
12	Lymphatic system and Immunity	56-62
13.	Digestive System	63-77
14.	Nervous System	78-87
15.	Endocrine System	88-92
16.	Reproductive System	93-101
17.	Muscular and Skeletal Systems	102-107

INDEX

S. No	Topic	Page No.
18.	Respiratory System	108-111
19.	Excretory System	112-115
20.	Classification	116-118
21.	Viruses	119-120
22.	Bacterial diseases of Humans	121-122
23.	Fungal Diseases	123-124
24.	Protozoan Diseases	125-125
25.	Improvement in Food resources	126-136
26.	Fertilizers	137-140
27.	Protection of Crops	141-145
28.	Scientific Storage of grains	146-147
29.	Mixed Cropping	148-150
30.	Plant Breeding	151-152
31.	Biotechnology	153-156
32.	Miscellaneous	157-160

Amnesia → temporary loss of memory.
Cause → Hesitation . & Prolion

Basic source of life → Sun → full of energy.

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

Thumb → opposes to work.
Pentadactile → terminal of arms → 5 fingers.

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.

→ Skin is largest organ in body.

Inorganic [H_2O, CO_2]
↓
Organic [Glucose $C_6H_{12}O_6$]
↓
nucleic acids
↙ ↘
RNA DNA

Composition → unicellular (made of one cell)
→ multicellular (cells are formed into tissues → cells → organs → Organ systems)

Metabolism → individual undergoes growth & development.
growth definite → animals, indefinite → plants.
After growth is complete, reproduction starts.
→ Life constitutes → metabolism, growth & reproduction.

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.

metabolic activities which includes locomotion which is first sign of activity in living organism.

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.

→ Locomotion is defined as movement of individual from one place to another place. Animals locomate in search of food and favourable environment. Favourable environment involves absence of enemies.

→ Every individual has to move from one place to another place in search of mate.

→ for locomotion, a lot of energy is required.

Aerobic Respiration

When oxygen is present (**aerob**ic 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.

→ cell do not dies instantly suddenly except when the pottasium cynide is inhaled which is very poisonous.
→ cell division occurs even after the death till 3 to 4 days.
Response to Stimulus → is characterised by sense organs. Sense organs are only structures that experience pain, Brain do not. (Light) It is basically photosensitiveness,
Ankle is made up of dead tissues. (of cell)

→ Emission of these elements make substances that lead to phenomenon called life. Life is featured by metabolism. Life is featured by organisation. It includes shape, form & size of individuals & composition.

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 $FADH_2$.

Metabolic activities

Response to Stimulus. locomotion nutrition respiration excretion reproduction

Nutrition → procures energy to living individuals. So it is called anabolic process.

Respiration → energy releasing process

Respiration can be controlled by Medulla Oblongata.

Excretion → is process of elimination of nitrogenous waste materials.

Maintenance of ~~pro~~ body require proteins.

Proteins get digested as amino acids in digestive system. There are 20 amino acids that exist in nature that synthesise different proteins under the guidance of DNA. Amino acids gets oxidised and breaks into Ammonia (gas) (NH_3) & acid out of which NH_3 is toxic, pungent & unfoxible gas. And this removal of NH_3 is called excretion. NH_3 is collected instantly by blood and it takes into liver where it is converted into urea which is less toxic & can remain in the blood. Entire blood containing urea goes into kidney from where it is excreted. Excretion requires large amount of water.

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:

$$6H_2O + 6CO_2 \text{----------}> C_6H_{12}O_6 + 6O_2$$

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 dormancy 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).

9. ANIMAL CELLS AND TISSUES

Animals are multicellular heterotrophs whose cells lack cell walls. At some point during their lives, all animals are capable of movement, although not all animals have muscles they use for this. In the most commonly encountered animals, the mobile stage is the adult, although some animals (such as corals and sponges) have sessile (or nonmobile) adult phases and mobile juvenile forms. Both animal and plant evolutionary history show the development of multicellularity and the move from water to land (as well as a secondary adaptation back to water, for example dolphins, whales, duckweed, and elodea).

Animals developed external or internal skeletons to provide support, skin to prevent or lessen water loss, muscles that allowed them to move in search of food, brains and nervous systems for integration of stimuli, and internal digestive systems.

Organs in animals are composed of a number of different tissue types. For example, the stomach has epithelial tissue making linings and secreting gastric juices, connective tissues

Plants are simpler organisms than animals, having three organ systems and fewer organs than do vertebrate animals. Organs are composed of tissues, which are in turn composed of cells. Plants have three tissue types: ground, dermal, and vascular. Animals have four: epithelial, connective, muscle, and bone

Epithelial Tissue

Epithelial tissue covers body surfaces and lines body cavities. Functions include lining, protecting, and forming glands. Three types of epithelium occur:

- Squamous epithelium is flattened cells.
- Cuboidal epithelium is cube-shaped cells.
- Columnar epithelium consists of elongated cells.

Any epithelium can be simple or stratified. Simple epithelium has only a single cell layer. Stratified epithelium has more than one layer of cells. Pseudostratified epithelium is a single layer of cells so shaped that they appear at first glance to form two layers.

Functions of epithelial cells include:

- movement materials in, out, or around the body.
- protection of the internal environment against the external environment.
- Secretion of a product.

Glands can be single epithelial cells, such as the goblet cells that line the intestine. Multicellular glands include the endocrine glands. Many animals have their skin composed of epithelium. Vertebrates have keratin in their skin cells to reduce water loss. Many other animals secrete mucus or other materials from their skin, such as earthworms do.

Connective Tissue

Connective tissue serves many purposes in the body:

- binding
- supporting
- protecting
- forming blood
- storing fats
- filling space

Connective cells are separated from one another by a non-cellular matrix. The matrix may be solid (as in bone), soft (as in loose connective tissue), or liquid (as in blood). Two types of connective tissue are Loose Connective Tissue (LCT) and Fibrous Connective Tissue (FCT). Fibroblasts (LCT) are separated by a collagen fiber-containing matrix. Collagen fibers provide elasticity and flexibility. LCT occurs beneath epithelium in skin and many internal organs, such as lungs, arteries and the urinary bladder. This tissue type also forms a protective layer over muscle, nerves, and blood vessels.

Adipose tissue has enlarged fibroblasts storing fats and reduced intracellular matrix. Adipose tissue facilitates energy storage and insulation.

Fibrous Connective Tissue has many fibers of collagen closely packed together. FCT occurs in tendons, which connect muscle to bone. Ligaments are also composed of FCT and connect bone to bone at a joint.

Cartilage and bone are "rigid" connective tissues. Cartilage has structural proteins deposited in the matrix between cells. Cartilage is the softer of the two "rigid" connective tissues. Cartilage forms the embryonic skeleton of vertebrates and the adult 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

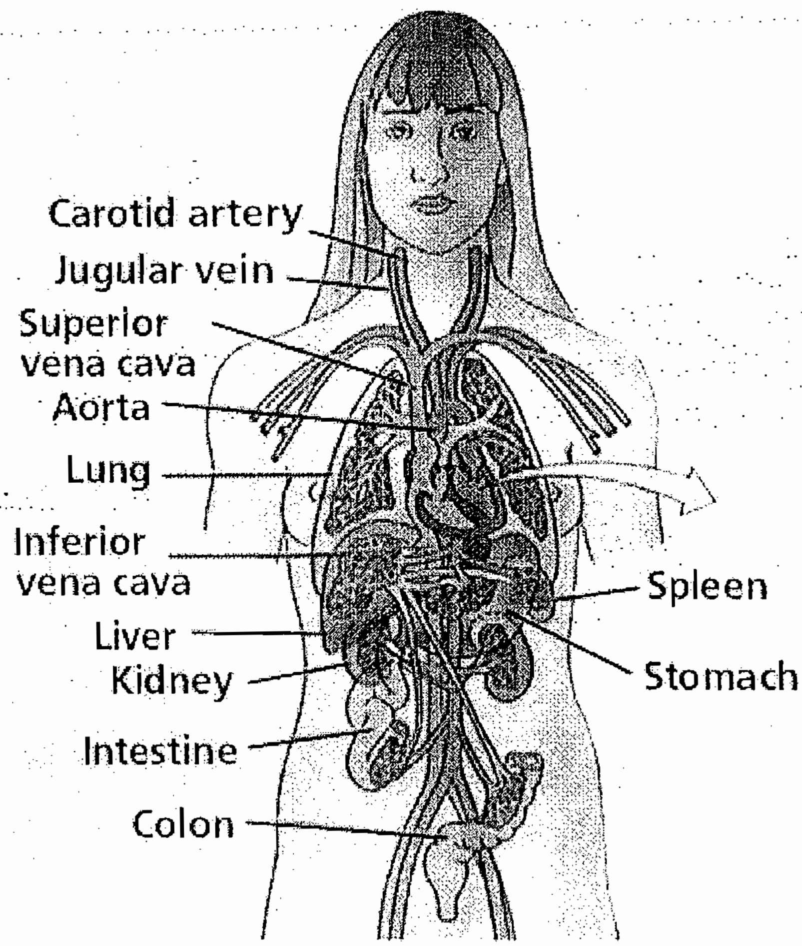
The skin is selectively soluble to fat-soluble substances such as vitamins A, D, E, and K, as well as steroid hormones such as estrogen. These substances enter the bloodstream through the capillary networks in the skin. Patches have been used to deliver a number of therapeutic drugs in this manner. These 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

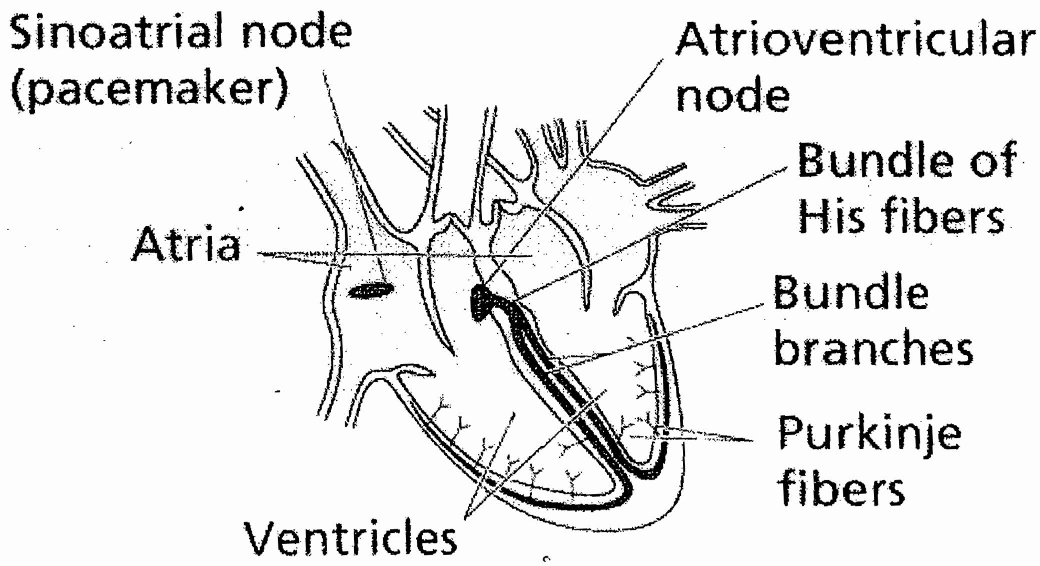
Vertebrates, and a few invertebrates, have a closed circulatory system. Closed circulatory systems (evolved in echinoderms and vertebrates) have the blood closed at all times within vessels of different size and wall thickness. In this type of system, blood is pumped by a heart through vessels, and does 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.

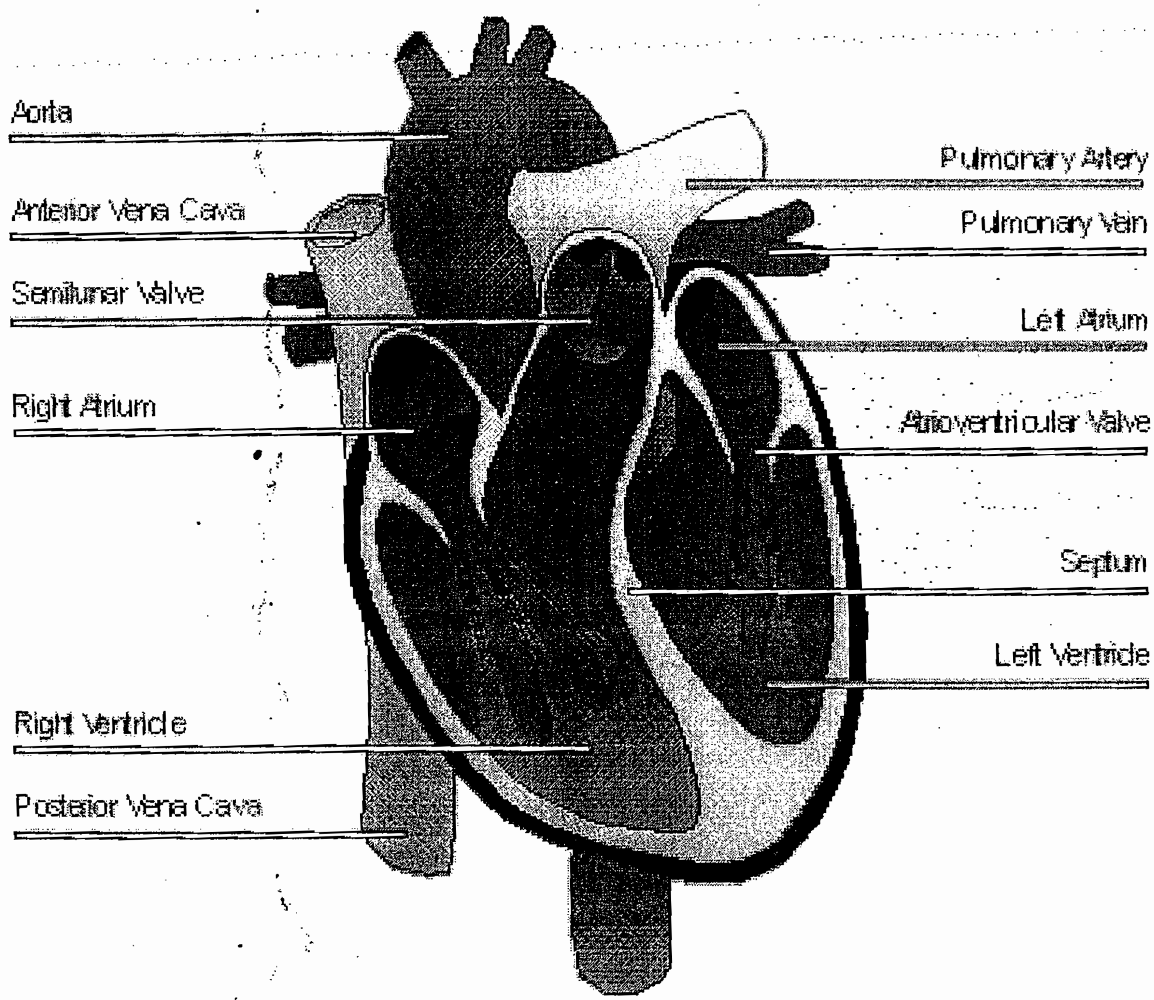
Vertebrate Vascular Systems

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.

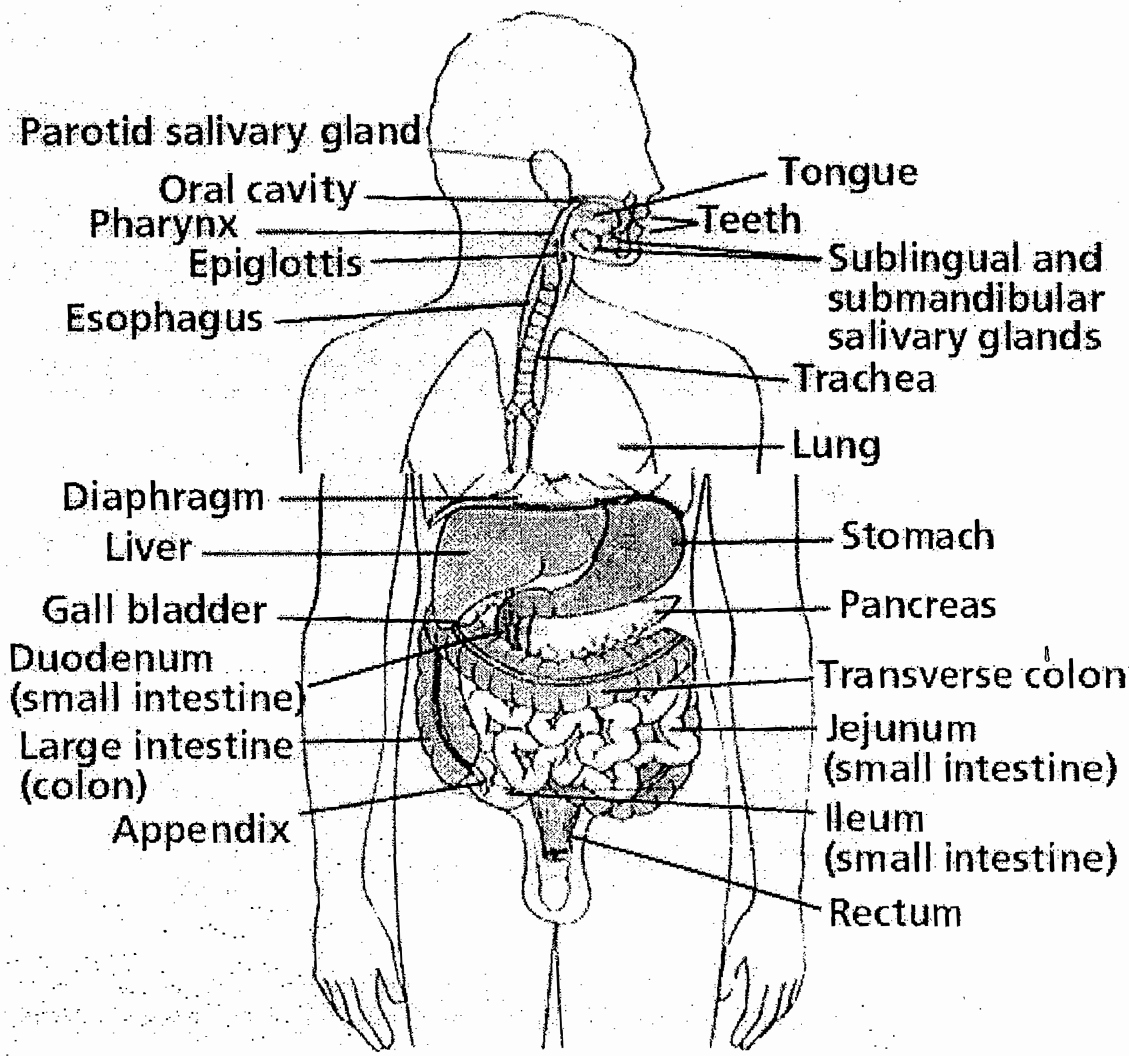
Plans and Locations

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 diseas
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 problem
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 threshol
Vitamin B_{12}	Cyanocobalamin, hydroxycobalamin, methylcobalamin	Water	Megaloblastic anaemia	No known toxicit
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.

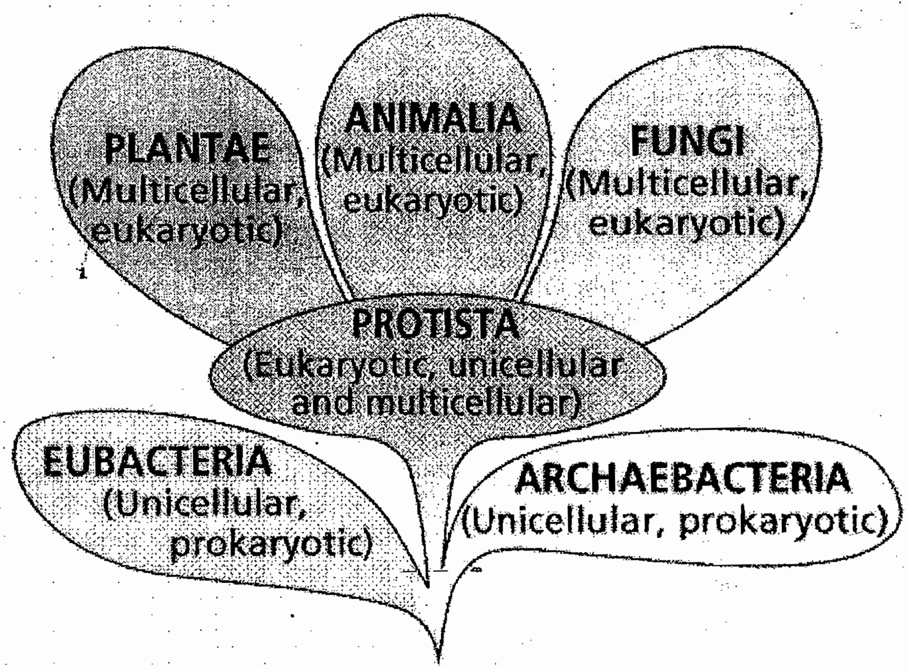
Some general rules for nomenclature:

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.

→ virus are parasites but All bacterias are not parasites.
→ Virus present outside the body of plant or animal is called non-living.

→ Antibiotic is taken to kill bacteria not virus and so Antibiotic is anti-viral.

21. VIRUSES

intermediate structure b/w living & non-living.

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.

Viral multiplication is possible only in living cells. Thats why virus attacks the cells in living organisms.
Incubation Period → Time period acquired by the virus that enters to body & acts as parasites

... is used to stop the multiplication of virus.

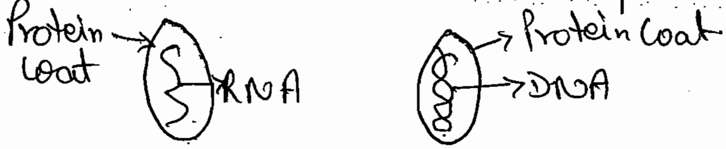
Emergent Viruses

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).

→ Virus has tough protein coat on surface inside of which RNA or DNA is present.
If structure contained is single, it is RNA otherwise DNA.



Normal viruses → whose genetic material is DNA and if it hits a person, it does not have any adverse effect.

Retroviruses → whose genetic material is RNA.
DNA → funⁿ → protein synthesis → protein present in hair ↓ Keratin.

→ Enzymes are proteins produced by DNA that digest food.
→ Chromosomal no. is constant for species → 23 pairs → 46.
Eg → Dog can ~~give~~ produce puppy but not donkey bcoz of chromosomal consistency.
→ Human Genome Project (HGP) →
→ Retroviruses → ~~Drams~~ Reverse Transcriptase Enzyme
↓ converts
RNA → DNA → multiple RNA's

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)

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	Karnataka
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

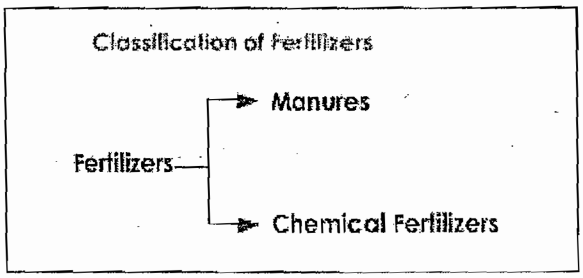
This is production of some food fishes like carps. The fish are cultured in ponds and tanks.

Disease and Control

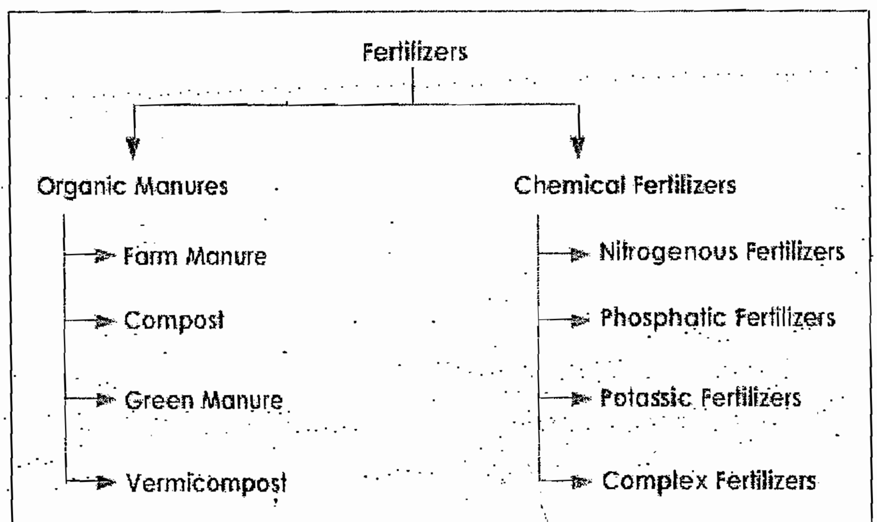
The main causes for disease in fishes are viruses and bacteria. IPN (Infectious Pancreatic Necrosis) and VHS (Viral Haemorrhagic Septicaemia) are well known diseases. Pollution of water causes great harm to the fish population. Fertilizers, pesticides, effluents and chemical wastes from factories contribute 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.



These can be further classified as shown below:



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.

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).