

# **BIOLOGY**

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**NOTE:**

MAKAUT course structure and syllabus of 4<sup>th</sup> semester has been changed from 2020. **BIOLOGY** has been introduced as a new subject in present curriculum. Taking special care of this matter we are providing chapterwise model questions and answers, so that students can get an idea about university questions patterns.

## INTRODUCTION

### Chapter at a Glance

The genomic and molecular revolutions in biology, commonly identified by the Human Genome Project, has allowed us to identify all 26,000 genes in the human body and to determine many of their individual sequences. Our sequencing of amino acids in proteins and of bases in nucleic acids spurred the development of bioinformatics, which relies on the use of computers to analyze the sequences for patterns and similarities. The subsequent understanding of the information underlying the sequences resulted in the creation of a comprehensive "Parts List." Cellular molecular components can now be easily identified and manipulated. These advances in the understanding of biology added much knowledge to our toolkit and spurred the growing interface between biology and engineering. For the first time, we can look at biology from a different perspective and with a much greater attention to detail. The operation of biological functions can now be understood as complex "biomolecular machines." The regulation of biological functions can be seen as complex "biomolecular circuits."

The following slides show a few of the many areas today that solicit the knowledge and practical skills of bio-engineers:

1. In the past, only mechanical aspects such as flexibility, durability, and endurance to changes in outside conditions were considered in the design of spacesuits. Now, bioengineers incorporate knowledge of the physiology of the human body into the finalization of their designs.
2. Like the design of space suits, the design and implantation of hip implants was previously solely a branch of mechanical engineering. The mechanics and movements of the hip were studied to produce the best metal substitute. Today, greater emphasis is placed on the understanding of bone composition and tissue-implant suitability.
3. MRI produces images of the body regardless of intervening bone by means of a strong magnetic field and low-energy radio waves.
4. Controlled-release drug delivery as explored in the Langer lab at MIT relies on knowledge of the body's enzymes and whether certain polymers/drugs would be degraded by them.
5. Image-guided surgery records surgical processes with greater detail and allows doctors to consult past steps for comparison and completeness.
6. The quest for an ideal replacement artificial heart continues to baffle the scientific community. In the past, engineers devoted their efforts to designs based on nonbiological materials. They were met with repeated failure as the complex biological systems of the body formed blood clots to signal rejection of foreign substances such as metal, plastic, and polyester. Today, biological engineers are exploring ways to design hearts out of biomaterials and possibly other tissues.
7. Bioprocessing is the method/procedure of preparing a biological material, especially a product of genetic engineering, for commercial use.
8. An increasing emphasis is placed on environmental bioremediation to insure that all chemical processes must be environment friendly.

### Multiple Choice Type Questions

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1. What is biomimicry?
  - a) A type of science
  - b) The act of mimicking nature for technology
  - c) Copycating nature
 Answer: (b) [MODEL QUESTION]
2. Leaves inspired something
  - a) True
  - b) False
 Answer: (a) c) none d) both [MODEL QUESTION]
3. Examples of biomimicry are:
  - a) Sun—sunflower
  - b) Whale—turbine
  - c) Gecko—Gecko tape
  - d) Elephant trunks—robotic arm
 Answer: (b) [MODEL QUESTION]
4. Human genome project was published in
  - a) 1999
  - b) 2008
  - c) 2005
  - d) 2002
 Answer: (c) [MODEL QUESTION]
5. In 1857 it was proved that all fermentations are results of microbial activity by
  - a) Pasteur
  - b) Lmark
  - c) Darwin
  - d) Mendle
 Answer: (a) [MODEL QUESTION]
6. Use of living organisms to serve humans is
  - a) Biotechnology
  - b) Social biology
  - c) Human biology
  - d) Service biology
 Answer: (a) [MODEL QUESTION]
7. Protein content called novel is produced by using
  - a) Bacteria
  - b) Virus
  - c) Fungi
  - d) Micro-organisms
 Answer: (d) [MODEL QUESTION]
8. Protein content which is extracted from mixed or pure cultures of yeasts, bacteria, algae and fungi is called
  - a) triple cell protein
  - b) single cell protein
  - c) double cell protein
  - d) tetra cell protein
 Answer: (b) [MODEL QUESTION]

**Short & Long Answer Type Questions****1. What is the relationship between science and engineering? [MODEL QUESTION]**

**Answer:**  
Science is about knowing and engineering is about doing. Science is synthesis of knowledge by understanding the law of nature, while engineering is the application of knowledge to transform the nature for serving people. Engineers use the scientific knowledge to build processes, structures and equipment. Both engineers and scientists have sound knowledge of science, mathematics and technology, but engineers are trained to use these principles in designing creative solutions to the challenges. Science is about studying what is existing, engineering is about creating what never was. Science and engineering, both complement each other, for to transform nature effectively requires proper understanding, and to discover nature's secrets requires instruments to modify it in experiments.

**2. Why Biology is important for engineers? [MODEL QUESTION]**

**Answer:**  
Biology may not be a typical subject in the traditional engineering disciplines (i.e., civil, electrical, or mechanical), however, it is a fundamental component of disciplines such as biosystems engineering. Biosystems engineering emphasizes the application of engineering principles to biologically-based systems (i.e., systems that include plants, animals, microorganisms, or humans).

**3. What is the difference between biengineering and biological engineering? [MODEL QUESTION]**

**Answer:**  
Biengineering focuses on the application of engineering on biological processes, food, agriculture and environmental processes. On the other hand, biomedical engineering is focus on the application of engineering to biological and medical sciences to improve healthcare delivery systems.

**4. What is Biomimicry? [MODEL QUESTION]**

**Answer:**  
Biomimicry is an approach to innovation that seeks sustainable solutions to human challenges by emulating nature's time-tested patterns and strategies. The goal is to create products, processes, and policies—new ways of living—that are well-adapted to life on earth over the long haul.

**5. How do we use biomimicry? [MODEL QUESTION]**

**Answer:**  
Biomimicry is learning from and then emulating natural forms, processes, and ecosystems to create more circular designs. The core idea is that nature has already solved many of the problems we are grappling with: energy, food production, climate control, benign chemistry, transportation, collaboration, and more.

**[MODEL QUESTION]****6. What are the three levels of biomimicry?**

**Answer:**  
Biomimicry can work on three levels:  
The organism,  
Its behaviour, and  
The ecosystem.  
Buildings on the organism level mimic a specific organism

**7. What is biomimetic design?**

**Answer:**  
Biomimetic refers to human-made processes, substances, devices, or systems that imitate nature. The art and science of designing and building biomimetic apparatus is also known as biomimicry because they mimic biological systems.

**8. Similarities between Camera and eye? [MODEL QUESTION]**

**Answer:**  
Those who are wondering just how similar a camera is to the human eye will be shocked to find out the functions of a camera that work just the same.

- The shutter in a camera can be compared to the iris in a human eye. It controls how much light is able to enter the lens.
- The lens in a camera is similar to the lens in the human eye, which are both used to focus light and create an image.
- With a camera, an image is recorded on a film. In the human eye, the image is displayed on the retina. However, the camera stores the image one time and the retina is constantly passing information along.
- If the human eye were a camera, it would be 576 megapixels. As of yet, the highest megapixel camera ever produced is only 50.6 megapixels.

**9. What are the differences between Camera and Eyes? [MODEL QUESTION]**

**Answer:**  
**Absolute versus subjective measuring of light:** Simply speaking, the human eye is a subjective device. This means that our eyes work in harmony with our brain to create the images you perceive: Our eyes are adjusting the focus (by bending the light through the lens in our eyeballs) and translating photons (light) into an electrical impulse our brain can process. From there onwards, it's all about our brain: It is continuously readjusting its colour balance according to the lighting context. In other words, our eyes know what must be seen as red or white or black etc.

A camera, on the other hand, is an *absolute measurement device* — It is measuring the light that hits a series of sensor, but the sensor is 'dumb', and the signals recorded need to be adjusted to suit the color temperature of the light illuminating the scene, for example

**Lens focus:** In camera, the lens moves closer/further from the film to focus. In our eyes, the lens changes shape to focus: The muscles in our eyes change the actual shape of the lens inside our eyes.

**Sensitivity to light:** A film in a camera is uniformly sensitive to light. The human retina is not. Therefore, with respect to quality of image and capturing power, our eyes have a greater sensitivity in dark locations than a typical camera. There are lighting situations that a current digital cameras 'cannot capture easily'. The photos will come out blurry, or in a barrage of digital noise. As an example, when observing a fluorescence image of cells under a microscope, the image you can see with our eyes would be nigh-on impossible to capture for an ordinary camera. This is mainly because of the fact that the amount of light entering the camera (and our eyes) is so low.

## 10. Write the principle of flying.

**Answer:** According to a principle of aerodynamics called Bernoulli's law, fast-moving air is at lower pressure than slow-moving air, so the pressure above the wing is lower than the pressure below, and this creates the lift that powers the plane upward.

[MODEL QUESTION]

## 11. What are the 4 principles of flight?

**Answer:**  
Principles of Flying

- (I) Lift
- (2) Gravity force or Weight
- (3) Thrust, and
- (4) Drag

Lift and Drag are considered aerodynamics forces because they exist due to the movement of the Airplane through the Air.

[MODEL QUESTION]

## 12. What are the factors of flight?

**Answer:**  
All Four Forces Act on an Airplane

When an airplane is flying straight and level at a constant speed, the lift it produces balances its weight, and the thrust it produces balances its drag. However, this balance of forces changes as the airplane rises and descends, as it speeds up and slows down, and as it turns.

[MODEL QUESTION]

## 13. How do birds inspire airplanes?

**Answer:**  
There have been many changes in airplane designs since innovation, development and in the future. Engineers have been drawing their ideas from nature, and they have been using biomimicry to inspire their designs. Human beings have been trying to fly since over a thousand years ago, and they even tried making planes, kites and flying from cliffs. Most of them fell and hurt themselves.

Airplanes began to use biomimicry as a concept. Engineers looked at birds and mimicked their wings, shape and mode of flying. After some time, men were able to form airplane wings and bodies that looked almost like a bird. The shape of birds helped to solve a

[MODEL QUESTION]

problem that had existed in the world. Human beings needed a way to move from continent to continent, and he used the shape of an animal to inspire an invention that has solved problems in accessibility, trade, business, and transportation.

## 14. Role of biology in our life.

**Answer:**  
Knowledge of nature

Study of biology helps one understand the nature around. One can know what an animal, plant, microbe, etc. It also teaches the structure of different parts of plant and animal bodies. It explains the processes like reproduction, metabolism, food collection, etc. in detail.

[MODEL QUESTION]

## Benefits to man

Learning biology can help one understand the benefits of nature to man. We can learn the source of our food, milk, meat, eggs and other essential in details. One can also learn how nature contributes to agriculture, house construction, travel, etc. For centuries man relies on animals for travel.

## Role in medicine

Knowledge of biology helps one understand the concepts of health and disease better. A student gets an idea of what is the body made of, its physiology, etc. This helps to understand disease state and also chances for improvement. It also helps one understand the useful substances from plants and animals which are used for medicine. Most of the disease condition find a solution by biological knowledge.

## Contribution to research:

Biology contributes a great deal to research. Even space exploration and landing on other planets can be done by the use of animals.

Many drugs, engineering and biomedical studies can be done well by knowledge of biology. The interesting point is that even the destruction capability of powerful bombs was done by the use of animals.

## Safe guard and Conservation of nature:

By knowledge of biology, we can understand the species which are endangered and protect them. This saves them from extinction. Even the soil, forest conservation is possible due to biology.

Study of the plants in botany makes us understand their role in human survival. For details go through the importance of plants.

## 15. What is biology? Write the importance of study of Biology. [MODEL QUESTION]

**Answer:**

Biology is the natural science that studies life and living organisms, including their physical structure, chemical processes, molecular interactions, physiological mechanisms, development and evolution. Despite the complexity of the science, there are

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certain unifying concepts that consolidate it into a single, coherent field. Biology recognizes the cell as the basic unit of life, genes as the basic unit of heredity, and evolution as the engine that propels the creation and extinction of species. Living organisms are open systems that survive by transforming energy and decreasing their local entropy to maintain a stable and vital condition defined as homeostasis. Sub-disciplines of biology are defined by the research methods employed and the kind of system studied: theoretical biology uses mathematical methods to formulate quantitative models while experimental biology performs empirical experiments to test the validity of proposed theories and understand the mechanisms underlying life and how it appeared and evolved from non-living matter about 4 billion years ago through a gradual increase in the complexity of the system.

Biology is the exploration of life. Researcher examine the structure, work, development, starting point, advancement and appropriation of living beings.

Biology is important to study because,

- It helps us get a better understanding about the world in its natural processes
- It is the study of how lives evolves, survives and changes.
- It gives knowledge about the interaction of cells with organs and organisms, environment and ecosystem.
- It teaches how various organs and system works on human body and how everything is connected in our body.
- It is an important subject for medical point of view which includes identifying disease and its cure.
- Knowledge of Biology helps making a better environment to live in.

Despite the profound advances made over recent decades in our understanding of life's fundamental processes, some basic problems have remained unresolved. One of the major unresolved problems in biology is the primary adaptive function of sex, and particularly its key processes in eukaryotes of meiosis and homologous recombination. One view is that sex evolved primarily as an adaptation that promoted increased genetic diversity. An alternative view is that sex is an adaptation for promoting accurate DNA repair in germ-line DNA, and that increased genetic diversity is primarily a by product that may be useful in the long run.

Another basic unresolved problem in biology is the biologic basis of aging. At present, there is no consensus view on the underlying cause of aging. Various competing theories are outlined in Ageing Theories.

#### **16. Describe the relationship between science and engineering?**

[MODEL QUESTION]

##### **Answer:**

Science and engineering both relate descriptive models to physical systems, sometimes working with similar descriptive models and similar physical systems. Moreover, science and engineering are, in practice, often intermixed, and popular usage often attributes to scientists the accomplishments of engineers (there are many rocket engineers, but no

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(rocket scientists). Nonetheless, science and engineering differ radically in their fundamental nature. Understanding this difference is essential if one is to form a clear understanding of the relationship between present knowledge and future technological possibilities, whether in molecular systems engineering or elsewhere.

How do science and engineering differ? In a sense, they point in opposite directions:

Science starts with a physical system and seeks to develop a descriptive model — a scientific theory. Engineering starts with a descriptive model — an engineering design —

and seeks to develop a physical system. In this, they are opposites, and from this flow

deep differences in thought and goals.

Consider how scientists and engineers choose their objectives. A scientist focuses on what is not yet understood, and studies it. An engineer focuses on what is already understood, and builds with it. Scientists seek simple systems that challenge their understanding; engineers seek to build to build systems of challenging complexity using understandable components. Where a scientist may contemplate solid-state physics and seek to unravel the mysteries of correlated electron phenomena, an engineer will use established principles of solid-state physics to describe the behavior of a set of reliable designs for wires, transistors, and capacitors. A scientist may discover phenomena that enable the creation of a new transistor-like device; an engineer may discover how to organize a million transistors into a new information processing system.

The molecular world has been the province of scientists. Their knowledge provides an essential guide, and engineering efforts in the molecular world will raise questions that spur further scientific study. Whether the people doing the work call themselves "scientists" or "engineers" is of little importance. Regardless of labels, progress in molecular systems engineering, like that in other fields of technology, will require an engineering approach.

#### **17. Compare Engineering Design Process and the Scientific Methods.**

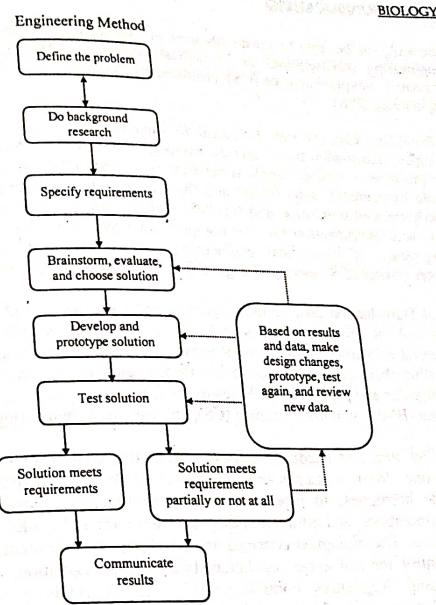
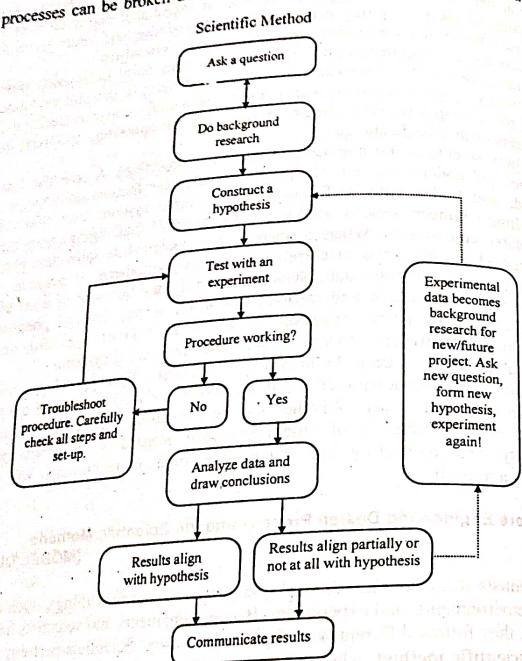
[MODEL QUESTION]

##### **Answer:**

While scientists study how nature works, engineers create new things, such as products, websites, environments, and experiences. Because engineers and scientists have different objectives, they follow different processes in their work. Scientists perform experiments using the scientific method; whereas, engineers follow the creativity-based engineering design process.

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Both processes can be broken down into a series of steps, as seen in the diagram and table.



### 18. Illustrate the role of engineers in the field of Biology. [MODEL QUESTION]

#### Answer:

Biology may not be a typical subject in the traditional engineering disciplines (i.e., civil, electrical, or mechanical), however, it is a fundamental component of disciplines such as biosystems engineering. Bio systems engineering emphasizes the application of engineering principles to biologically-based systems (i.e., systems that include plants, animals, microorganisms, or humans). A biosystems engineering program is designed to give students knowledge of the fundamental principles of engineering and to introduce biological concepts to enable these engineers to successfully interact with relevant professionals when solving engineering problems involving biological systems.

Following are the ways where engineers can contribute:

1. Life's Matrix draws analogies between biological and electronic substrates: information process, transport, and control elements. The biological concepts and principles include fundamental units of life, biological components, and organizational

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hierarchy to be able to create libraries of interchangeable DNA parts. Relevance to engineering subdisciplines of biomedical engineering (BME), chemical engineering (ChemE), computer science (CS), electrical engineering (EE) and industrial and systems engineering (ISE).

2. Biological Circuits and Biological Information Theory uses the central dogma of biological information theory and the exploration of biomolecules and DNA based finite state machine to conduct simple computing logic. The biological concepts and principles include fundamental units of life and the metaphor to computing systems. Process of transcription and translation and regulation for smooth information flow. Application of nucleic acid hybridization for new computational paradigms. Relevance to engineering subdisciplines of biomedical engineering (BME), chemical engineering (ChemE), computer science (CS), electrical engineering (EE) and material science.

3. Signal Transduction uses Cellular signaling pathways that resemble electronic circuits. Proteins and the protein kinase cascade act as amplifiers or switches. The biological concepts and principles include an understanding of the processes and structures needed in converting chemical signals from cell surface to elicit appropriate cellular response at the molecular and protein level. Relevance to engineering subdisciplines of biomedical engineering (BME), computer science (CS), and electrical engineering (EE).

4. Control Systems and Feedback Control reveals that control loops are ubiquitous and can be found from transcriptional (bacterial example) and physiological control (antagonistic hormones) to bioregulation. An introductory description of theoretical modeling, simulations, and bifurcation diagrams to inform and guide experimental design and predictions. The biological concepts and principles include regulatory elements and feedback control for cell cycle regulation, blood sugar regulation, and environmental nutrient sensing. Regulatory control points for DNA synthesis and understanding transport and movement of macromolecules across barriers. Relevance to engineering subdisciplines of biomedical engineering (BME), chemical engineering (ChemE), computer science (CS), electrical engineering (EE), environmental engineering (EnvirnE), industrial and systems engineering (ISE) and material science.

5. Sensors and Detectors conveys elements of communication circuits in bacterial systems as well as our immune system using computer security systems analogy. The biological concepts and principles include Biofilms; quorum sensing characteristics at the molecular level and novel applications to prevent and disrupt biofilm formation. Features of immune system to provide specificity, memory, diversity and self-nonself recognition. Regulation and interaction at the molecular level as well as the physiological perspective. Relevance to engineering subdisciplines of biomedical engineering (BME), chemical engineering (ChemE), computer science (CS), electrical engineering (EE), environmental engineering (EnvirnE), mechanical engineering (ME) and material science.

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6. Human Genome Project focuses on enabling technology advancements in computing, informatics, wafer manufacturing and imaging techniques as well as novel computational tools. Application of computers, databases and computational methods for the acquisition, analysis, visualization and management of biological information. The biological concepts and principles include Molecular biology and genetic engineering techniques for cloning, DNA sequencing, DNA amplification, and hybridization experiments. Microarray applications for personalized medicine. Relevance to engineering subdisciplines of biomedical engineering (BME), chemical engineering (ChemE), computer science (CS), electrical engineering (EE), mechanical engineering (ME) and material science.

19. What are the similarities between camera and eyes?

[MODEL QUESTION]

Answer:

To better understand the answer to this question, let's first have a quick comparison of various similarities and differences found in the working of the human eye and a photo camera.

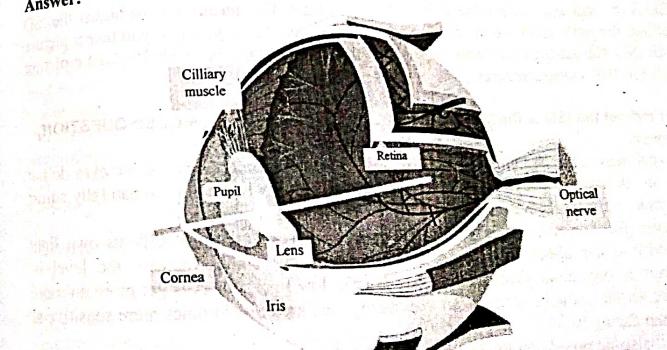
**Image focusing:** Human and camera lenses both focus an inverted image onto light-sensitive surface. In the case of a camera, it's focused onto film or a sensor chip. In Our eyes, the light-sensitive surface is the retina on the inside of our eyeball.

**Light adjustment:** Both the eye and a camera can adjust quantity of light entering. On a camera, it's done with the aperture control built into our lens, whilst in our eye, it's done by having a larger or smaller iris.

20. Describe our eye as a camera.

[MODEL QUESTION]

Answer:



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1. Our Cornea behaves much like the front lens element of a lens. Together with the lens, which is behind the iris, they are the eye's focusing elements. The cornea takes widely diverging rays of light and bends them through the pupil, the cornea opening in the central portion of the coloured iris.
2. Our Iris and pupil act like the aperture of a camera. The iris is a muscle which, when contracted, covers all but a small central portion of the lens, allows adjustable control of the quantity of light entering the eye so that the eye can work well in a wide range of viewing conditions, from dim to very bright light.
3. Finally, our Retina is the sensory layer that lines the very back of our eyes. It acts very much like the imaging sensor chip in a digital camera. The retina has numerous photoreceptor nerve cells that help change the light rays into electrical impulses and send them through the optic nerve to the brain where an image (of what we see) is finally received and perceived. Because of this reception and perception function, retina is, perhaps, the most important component of our eyes. As with the camera, if the "film" is bad in the eye (i.e. the retina), no matter how good rest of the eye is, we will not get a good quality image or picture.

### 21. What is ISO and why is it important?

#### [MODEL QUESTION]

Answer:

ISO is the number signifying the light sensitivity of an imaging sensor; it is measured in numbers (like 100, 200, 400, 800 etc). Sometimes, this number is also known as an "ISO number", or, more commonly, the "film speed". Historically, the lower the ISO number, the lower the sensitivity of the film and the finer the grain in the pictures or shots you are taking. This has translated pretty well into digital photography, too: Higher ISO gives you higher sensitivity, but at the cost of a larger amount of digital noise. ISO is the indication of how sensitive a film is to light. This means that the higher the ISO setting, the more sensitive the camera sensor is to light. Accordingly, if you take a picture with ISO 400 settings, you only need 1/4 of the light that will be needed to take a picture with ISO 100 camera settings.

### 22. Find out the ISO of the human eye.

#### [MODEL QUESTION]

Answer:

The real issue with the human eye is that, unlike film and camera sensors, our eyes do not have any definite ISO levels. However, our eyes do have a great ability to naturally adjust to ambient light levels even under the most severe lighting conditions.

However, the human eye has a mighty trick up its sleeve: it can modify its own light sensitivity. After about 15 seconds in lower light, our bodies increase the level of rhodopsin in our retina. Over the next half hour in low light, our eyes get more and more sensitive. In fact, studies have shown that our eyes are around 600 times more sensitive at night than during the day.

It should also be noted that the human eye is like the greatest, quickest automatic camera in existence. Every time we change where we're looking, our eye (and retina) is changing everything else to compensate — focus, iris, dynamic range are all constantly adjusting to ensure that our eyesight is as good it can be.

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In addition to straight-up light sensitivity (which we'll get back to in just a minute), the dynamic range of the human eye is absolutely astonishing: A human can see objects in starlight or in the brightest of sunlight. The difference between the two extremes is absolutely astonishing — In sunlight, objects receive 1,000,000,000 times more light than on a moonless night — and yet, we are able to see under both circumstances.

#### [MODEL QUESTION]

### 23. What is Shutter speed of our eye?

Answer:

Where our comparison gets complicated is when we mix in shutter speed. In order to do a like-for-like comparison between the human eye and a camera, we can quite easily compare apertures and ISO (which is the most interesting exercise, in my opinion). But shutter speeds makes it complicated, because a camera can stay open for as long as we need it to. In fact, there are examples of photos taken with a 6-month shutter opening, something which the human eye can obviously not match. Exploring what the shutter speed of a human eye is actually surprisingly complicated, but let's look to animation for a start: If you have ever seen any simple animation, you will have noticed that if you don't get enough frames per second, things can look 'stuttery'. If you were to see a football game at 1fps, for example, you would essentially be seeing a series of 1 photo per second (at a maximum of 1 second shutter speed). Obviously, that's not going to do any good, and the human eye has a 'shutter speed' of faster than that. To explore this question in further depth, I highly recommend the "How many frames per second can the human eye see" article over at 100fps.com. Despite the name of the site, their conclusion is that they don't really know, because it depends on how you measure the results.

For low light photography, however, we don't need to know the minimum shutter speed of the human eye, but the maximum. Obviously, we can sit perfectly still and stare at a forest in the pitch dark for half an hour, but we might not be able to 'see' anything, even though we, in theory, have had a half-hour exposure. At the same time, a camera might be able to resolve something in that half hour (but it might not). When it comes to our own eyes, it becomes less meaningful to speak of a "shutter speed" as such — our eyes see with an exponential decay, and our vision is a continuous process. In other words, our eyes will take multiple 'exposures', and our brain will combine them into a more meaningful image, much like you might do when you are taking a multi-exposure HDR photograph with our camera.

### 24. What is the ISO when we are talking about cameras, versus the human eye?

#### [MODEL QUESTION]

Answer:

The human eye is extremely good at resolving images in bright light, and it becomes meaningless to speak of 'noise' — not because our eyes aren't misfiring every now and again, but because our brain simply filters out any problems our eyes encounter (Just think about how our brain is constantly filtering out the two blind spots you have — one in each eye — even if you are closing one eye and looking with the other. If you have never experienced our blind spot — give it a shot, it's rather astonishing).

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So, for the sake of argument, let's say that the minimum ISO of our eyes, on a bright sunny day, is ISO 25. Why 25? Because that's the lowest-ISO film that's currently in use, with the least grain and the highest quality around. If the lowest ISO of our eyes is 25, and our eyes are 600 times more sensitive in the dark, that means that the maximum ISO of the human eye would land somewhere around ISO 15,000 or so. If you choose ISO 100 as our base ISO for the human eye (which is equally fair, considering that we're comparing eyes to digital cameras, and most digital SLRs these days start at ISO 100) — our maximum ISO is around 60,000.

When we consider that the highest-ISO cameras (Like the Nikon D3S) can take photos up to ISO 102,000, it becomes clear that our built-in technology is starting to lag behind what the camera manufacturers are cooking up!

25. Write the difference between bird and air craft.

Answer:

Bird	Air Craft
Birds flap their wings to fly	airplanes use a propeller to fly
birds twist their wings to maneuver	Airplanes use cables, and electrical wires to maneuver
Birds wings provides thrust and lift	airplanes wings only gives lift after engines, or gravity would provide electricity

#### [MODEL QUESTION]

## BIOLOGICAL CLASSIFICATION

BIOLOGY

### Chapter at a Glance

Biological classification of plants and animals was first proposed by Aristotle on the basis of simple morphological characters. Linnaeus later classified all living organisms into two kingdoms - Plantae and Animalia. Whittaker proposed an elaborate five kingdom classification - Monera, Protista, Fungi, Plantae and Animalia. The main criteria of the five kingdom classification were cell structure, body organisation, mode of nutrition and reproduction, and phylogenetic relationships.

In the five kingdom classification, bacteria are included in Kingdom Monera. Bacteria are cosmopolitan in distribution. These organisms show the most extensive metabolic diversity. Bacteria may be autotrophic or heterotrophic in their mode of nutrition. Kingdom Protista includes all single-celled eukaryotes such as Chrysophytes, Dinoflagellates, Euglenoids, Slime-moulds and Protozoans. Protists have defined nucleus and other membrane bound organelles. They reproduce both asexually and sexually. Members of Kingdom Fungi show a great diversity in structures and habitat. Most fungi are saprophytic in their mode of nutrition. They show asexual and sexual reproduction. Phycomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes are the four classes under this kingdom. The plantae includes all eukaryotic chlorophyll-containing organisms. Algae, bryophytes, pteridophytes, gymnosperms and angiosperms are included in this group. The life cycle of plants exhibit alternation of generations - gametophytic and sporophytic generations. The heterotrophic eukaryotic, multicellular organisms lacking a cell wall are included in the Kingdom Animalia. The mode of nutrition of these organisms is holozoic. They reproduce mostly by the sexual mode. Some acellular organisms like viruses and viroids as well as the lichens are not included in the five kingdom system of classification.

### Multiple Choice Type Questions

1. Which organelle of the cell below is known as the protein factory?

[MODEL QUESTION]

- a) Golgi body      b) Ribosome      c) Mitochondria      d) Nucleus

Answer: (b)

2. Ribosome in prokaryotic cells is

[MODEL QUESTION]

- a) 80S      b) 70S

- c) 50S      d) 60S

Answer: (b)

3. Which of the following is/are characteristics of prokaryotic cells?

[MODEL QUESTION]

- a) Absence of nucleus  
c) Presence of 70S ribosome

- b) Absence of cell organelles  
d) All of these

Answer: (d)

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4. Plants are  
 a) Autotrophs      b) Heterotrophs      c) Lithotrops      d) Chemotrophs  
 Answer: (a)
5. Respiration of eukaryotic cells takes place in  
 a) Golgi apparatus      b) Vacuoles      c) Lysosomes      d) Mitochondria  
 Answer: (d)
6. Trinomial nomenclature of classification was proposed by  
 a) Linneaus      b) Huxley and Stricklandt      c) John-Ray      d) Theophrastus  
 Answer: (b)
7. Most of the botanical names are drawn from the following language –  
 a) German      b) Greek      c) Latin      d) Spanish  
 Answer: (c)
8. Evolutionary classification is called –  
 a) Artificial system      b) Natural system      c) Phylogenetic system  
 d) None of the above  
 Answer: (c)
9. Which system classifies a plant in more than one groups?  
 a) Practical classification      b) Artificial classification      c) Natural classification      d) Phylogenetic classification  
 Answer: (a)
10. Author of book "Flora British Indica"  
 a) Father Santapau      b) J.D. Hooker      c) William Roxburgh  
 Answer: (b)
11. Kingdom monera comprises the –  
 a) Plants of economic importance      b) All the plants studied in botany  
 c) bidirectional organisms      d) Plants of Thallophyta group  
 Answer: (c)
12. According to Whittaker kingdom monera includes  
 a) Unicellular eukaryotes      b) Prokaryotes & akaryotes  
 c) Slime molds & protozoa      d) Multicellular & eukaryotes  
 Answer: (b)
13. Kingdom of unicellular eukaryotes  
 a) Monera      b) Protista      c) Fungi      d) Plantae  
 Answer: (b)

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14. Engler and Prantl created metachlamydiae to include –  
 a) Polypetalous dicots      b) Gamopetalous dicots  
 c) Gamopetalous monocots      d) Gymnosperm  
 Answer: (b)
15. In two kingdom system of classification Euglena is included in  
 a) Animalia      b) Plantae      c) Both of these      d) Protista  
 Answer: (c)
16. Whittaker placed prokaryotes and eukaryotes in  
 a) Protista      b) Protozoa      c) Plantae      d) Monera  
 Answer: (d)
17. According to four kingdom system of Copeland, the fungi belong to kingdom –  
 a) Protista      b) Mychota      c) Mycota      d) Plantae  
 Answer: (a)
18. According to Copeland the "Red algae" belongs to  
 a) Monera      b) Protista      c) Plantae      d) Animalia  
 Answer: (b)
19. Which of the following organisms were never included in protista?  
 a) Bacteria      b) Red algae      c) Slimemolds      d) Mosses  
 Answer: (d)
20. Among the following organisms point out a completely non-parasitic form  
 a) Sea anemone      b) Leech      c) Tape worm      d) Mosquito  
 Answer: (a)
21. Embryophyta include:  
 a) Algae      b) Fungi      c) Bryophyta      d) All of these  
 Answer: (c)
22. According to four kingdom system of Copeland, the fungi belong to kingdom –  
 a) Protista      b) Mychota      c) Mycota      d) Plantae  
 Answer: (a)
23. Which animal is "Non-chordate-protochordata"  
 a) Herdmania      b) Balanoglossus      c) Branchiostoma      d) Botryllus  
 Answer: (b)

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24. Sometimes parasites themselves are parasitised by other organism, such parasites known as  
 a) Symbionts      b) Endoparasites      c) Ectoparasites      d) Hyperparasites

Answer: (d)

25. On the basis of body organization, animals are grouped as  
 a) Metazoa and eumetazoa      b) Protozoa and parazoa      c) Parazoa and metazoa  
 d) Protozoa and metazoan

Answer: (d)

**Short & Long Answer Type Questions**

1. Distinguish between autotrophs and heterotrophs.

[MODEL QUESTION]

Answer:  
Distinguish between autotrophs and heterotrophs:

Comparison	Autotrophs	Heterotrophs
Produce own food	Yes	No
Food chain level	Primary	Secondary and tertiary
Types	Photoautotroph, Chemoautotroph	Photoheterotroph, Chemoheterotroph
Examples	Plants, algae, and some bacteria	Herbivores, omnivores, and carnivores
Definition	An organism that is able to form nutritional organic substances from simple inorganic substances such as carbon dioxide.	Heterotrophs cannot produce organic compounds from inorganic sources and therefore rely on consuming other organisms in the food chain.
What or How they eat?	Produce their own food for energy.	They eat other organisms to get proteins and energy.

2. What is biological Classification?

[MODEL QUESTION]

Answer:

Biological Classification is the scientific study of arranging organisms into group and subgroup on the basis of their similarities and dissimilarities and placing the group in a hierarchy of categories.

The purpose of biological classification is to organise the vast number of known plants into categories that could be named, remembered and studied.

3. What are the objectives of biological classification?

[MODEL QUESTION]

Answer:

**Objectives of Classification**

- To identify and describe all the possible types of species.

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- To arrange the species in various categories on the basis of their similarities and dissimilarities.
- To evolve a truly natural or phylogenetic system which should indicate origin and evolution of the species.
- Helping in easy identification of organisms.

4. Which branch of biology teaches the classification?

[MODEL QUESTION]

Answer:  
One branch of biology, called taxonomy, focuses on the classification of living things. Taxonomy is the study of relationships between living things and the formal classification of organisms into groups based upon those hypothesized relationships.

5. Who is father of the biological classification?

[MODEL QUESTION]

Answer:  
Carl Linnaeus, also known as Carl von Linné or Carolus Linnaeus, is often called the Father of Taxonomy. His system for naming, ranking, and classifying organisms is still in wide use today (with many changes).

6. What is taxon?

[MODEL QUESTION]

Answer:  
In biology, a taxon (plural taxa; back-formation from taxonomy) is a group of one or more populations of an organism or organisms seen by taxonomists to form a unit.

7. What is Species?

[MODEL QUESTION]

Answer:  
In biology, a species is the basic unit of classification and a taxonomic rank of an organism, as well as a unit of biodiversity. A species is often defined as the largest group of organisms in which any two individuals of the appropriate sexes or mating types can produce fertile offspring, typically by sexual reproduction.

8. Define Kingdom.

[MODEL QUESTION]

Answer:  
It is a taxonomic category of the highest rank, grouping together all forms of life having certain fundamental characteristics in common: in the five-kingdom classification scheme adopted by many biologists, separate kingdoms are assigned to animals (Animalia), plants (Plantae), fungi (Fungi), protozoa and eukaryotic algae.

9. What are the different types of the classification?

[MODEL QUESTION]

Answer:

There are three different types of the biological classification:

- a) Artificial System of Classification
- b) Natural System of Classification
- c) Phylogenetic System of Classification

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**POPULAR PUBLICATIONS****10. State the Artificial System of Classification.****Answer:*****Artificial System of Classification***

It is a system of classification which uses one or two morphological characters for grouping of organisms. Some artificial systems have used habit and habitat for this purpose. Aristotle (c. 350 BC) divided animals into two categories, *anima* (with red blood) and *anima* (without red blood). Aristotle also classified animals on the basis of their habitat- aquatic (e.g. fish, whale), terrestrial (e.g., reptiles, cattle) and aerial (e.g. birds, bat). Pliny the Elder (23-79 A.D.) used artificial systems of classification for both plants and animals dividing them into land, air and water. Pliny distinguished animals into flight band nonflight ones. Flight animals included bats, birds and insects.

**[MODEL QUESTION]****11. State the Natural System of Classification.****Answer:**

It is a system of classification which takes into consideration comparable study of a number of characters so as to bring out nature similarities and dissimilarities and hence nature relationship among the organisms. The system employs those characters which are relatively constant. They include morphological characters, anatomical characters, cytological characters, physiology, ontogeny or development, reproduction, cytochemistry and biochemistry, experimental taxonomy, etc. The characteristics are helpful in bringing out maximum number of similarities in a group and comparable differences with other group of organisms. For example, mammals are characterised by the presence of mammae, birds possess wings, feathers, pneumatic bones, ovipary, 4-chambered. They are coldblooded.

**[MODEL QUESTION]****12. State the Phylogenetic System of Classification.****[MODEL QUESTION]****Answer:*****Phylogenetic System of Classification***

Classification based on evolutionary relationship of organisms is called phylogenetic system of classification. It is based on the evolutionary concept from Darwin's book on the origin of species by means of natural selection. The preservation of favoured races in the struggle for life (1859). It reflects the true relationships among the organisms. First phylogenetic system was proposed by Engler and Prantl (1887-99). Zoologists believe that since similarity in structure represents close evolutionary relationship, their natural classification represents evolutionary and phylogenetic classification.

**13. What is five kingdom classification?****[MODEL QUESTION]****Answer:*****Five Kingdom Classification***

In order to develop phylogenetic classification, R.H. Whittaker (1969), an American taxonomist, divided all the organisms into five kingdoms. As the viruses are on the border line of living and nonliving, they have been left out. Whittaker has used five criteria for delimiting the different kingdoms.

I) Complexity of cell structure, prokaryotic and eukaryotic.

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- 2) Complexity of body structure or structural organization, unicellular and multicellular.
- 3) Mode of nutrition which is divergent in multicellular kingdoms- photoautotrophy in plantae, absorptive heterotrophy in fungi and ingestive heterotropy in animalia. Photoautotrophy is known as holozoic nutrition. Absorptive heterotropy is saprobiotic (saprophytic) nutrition.
- 4) Ecological life style like producers (plantae), decomposers (fungi) and consumers (animalia).
- 5) Phylogenetic relationships.

**14. Describe the Characteristics of five kingdom.****[MODEL QUESTION]****Characteristics of five kingdom**

Characters	Monera	Protista	Fungi	Plantae	Animalia
1 Cell type	prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
2 Cell wall	Non-cellulosic polysaccharide + amino acid)	Present in some (various types)	Present (non-cellulosic)	Present (cellulose)	absent
3 Chloroplast	Absent	Present in some	Absent	Present	Absent
4 Mitochondria	Absent	Present in some	Present	Present	Present
5 Nuclear membrane	Absent	Present	Present	Present	Present
6 Tissue or multicellularity	Absent	Absent	Present but limited	Present in all forms	Present in all forms
7 Motility	Bacterial flagella, amoeboid or gliding or non-motile	Cilia, flagella or contractile fibrils	Cilia, flagella in some, none in most of the forms	Cilia and flagella in lower forms, absent in most of the forms	Cilia and flagella, contractile fibrils
8 Mode of nutrition	Autotrophic - chemosynthetic and photosynthetic, heterotrophic (saprophytic and parasitic)	Photosynthesis and heterotrophic	Heterotrophic, saprophytic and parasitic absorptive	Autotrophic by photosynthesis	Heterotrophic by ingestion
9 Reproduction/means of	Conjugation and transduction	Syngamy and meiosis, conjugation	Fertilization and meiosis	Fertilization and meiosis	Fertilization and meiosis

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Characters	Monera	Protista	Fungi	Plantae	Animalia
genetic recombination	transform on or none	tion or none	dikaryosis or none		
10 Nervous system	Absent	Primitive conduction stimuli	Absent	Absent	Present, often complex

15. What is 'Three domains of life'? Why it is called Six Kingdom Classification? [MODEL QUESTION]

Answer:

**Three Domains of Life**

The three-domain system is a biological classification which was introduced by Carl Woese, a professor in the department of microbiology, university of Illinois, Urbana-Champaign in 1990 that divides cellular life forms into archaea, bacteria and eukarya domains.

It emphasizes the separation of prokaryotes into two groups, originally called eubacteria (now bacteria) and archaeabacteria (now archaea) because of their fundamental differences, Woese argued that each of the two arose separately from an ancestor with poorly developed genetic machinery, often called a progenote. In fact the three-domain system is loosely based on the traditional five- kingdom system but divides the monera into two "domains", leaving the remaining eukaryotic kingdoms in the third domain. So it is called Six Kingdom Classification.

16. Describe the three domain classification. [MODEL QUESTION]

Answer:

**(1) Archaea domain:**

The domain contains prokaryotic organisms which have a monolayer core of lipids in the cell membrane and distinct nucleotides in their 16S RNA. It contains a single kingdom. Kingdom archaeabacteria

The kingdom contain early prokaryotes which live in extreme environments,

For Example:

(a) Methanogens: metabolize hydrogen and carbon dioxide into methane.

(b) Halophiles: live in salt.

(c) Thermoacidophiles: live in acid high temperatures (upto 110 degrees Celsius).

**(2) Bacteria domain:**

The domain contains prokaryotes which lack membrane covered cell organelles but do have a sort of micro chambers for separating various activities. There is a single kingdom.

**(3) Eukarya domain.** The domain contains eukaryotic organisms which originated by endosymbiotic association between some archaeabacteria and eubacteria. It has four kingdoms- protista, fungi, plantae and animalia.

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**[MODEL QUESTION]**

17. Describe the Kingdom Monera.

Answer:

(1) Bacteria are the sole members of the Kingdom Monera.  
 (2) Bacteria are grouped under four categories based on their shape: the spherical Coccus, the rod shaped Bacillus, the comma-shaped Vibium and the spiral Spirillum.  
 (3) Compared to many other organisms, bacteria as a group show the most extensive metabolic diversity.  
 (4) They may be photosynthetic autotrophic or chemosynthetic autotrophic. Some of the bacteria are autotrophic, i.e., they synthesise their own food from inorganic substrates.  
 (5) The vast majority of bacteria are heterotrophs, i.e.; they do not synthesise their own food but depend on other organisms or on dead organic matter for food.

18. Describe the characteristic feature of Monera. [MODEL QUESTION]

Answer:

**Characteristics of Monera**

Monera (Monos - single) includes prokaryotes and shows the following characters:

- They are typically unicellular organisms (but one group is mycelial).
- The genetic material is naked circular DNA, not enclosed by nuclear envelope. Ribosomes and simple chromatophores are the only subcellular organelles in the cytoplasm.
- The ribosomes are 70 S.
- Mitochondria, plastids, golgi apparatus, lysosomes, endoplasmic reticulum, centrosome, etc., are lacking.
- Sap vacuoles do not occur. Instead, gas vacuole may be present.
- The predominant mode of nutrition is absorptive but some groups are photosynthetic (holophytic) and chemosynthetic.
- The organisms are non-motile or move by beating of simple flagella or by gliding. Flagella, if present, are composed of many, intertwined chains of a protein flagellin. They are not enclosed by any membrane and grow at the tip.
- Moneran cells are microscopic (1 to few microns' in length).
- Most organisms bear a rigid cell wall (Peptidoglycan).
- Reproduction is primarily asexual by binary fission' or budding.
- Mitotic apparatus is not formed during cell division.

19. How bacteria can be classified on the basis of their shape? [MODEL QUESTION]

Answer:

- Cocci: They are oval or spherical in shape. They are called micrococcus when occur singly as in Micrococcus, diplococcus when found in pairs as in Diplococcus pneumoniae, tetracoccus in fours, streptococcus when found in chains as in Streptococcus lactis staphylococcus when occurring in grape like clusters as in Staphylococcus aureus and Sarcina, when found in cubical packets of 8 or 64 , as in Sarcina.

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- **Bacilli:** They are rod-shaped bacteria with or without flagella. They may occur singly (bacillus), in pairs (diplobacillus) or in chain (streptobacillus).
- **Vibrios:** These are small and 'comma' or 'kidney' like. They have a flagellum at one end and are motile, vibrio bacteria has curve in its cell e.g., *Vibrio cholerae*.
- **Spirillum:** They are spiral or coiled like a corkscrew. The spirillar forms are usually rigid and bear two or more flagella at one or both the ends e.g., *Spirillum*, *Spirochaetes* etc.
- **Filament:** The body of bacterium is filamentous like a fungal mycelia. The filaments are very small e.g., *Beggiaea*, *Thiotricha* etc.
- **Stalked:** The body of bacterium possesses a stalk e.g., *Caulobacter*.
- **Budded:** The body of bacterium is swollen at places e.g., *Rhodomicrobium*

#### 20. Describe the structure of bacteria?

#### [MODEL QUESTION]

**Answer:**

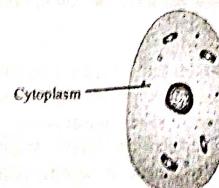
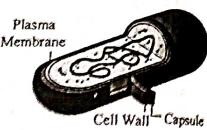
##### *Structure of Bacteria*

(1) **Capsule:** In a large number of bacteria, a slimy capsule is present outside the cell wall. It is composed of polysaccharides and the nitrogenous substances (amino acids) are also present in addition. This slime layer becomes thick, called, capsule. The bacteria, which form a capsule, are called capsulated or virulent bacteria. The capsule is usually found in parasitic forms e.g., *Bacillus*, *anthrax*, *Diplococcus pneumoniae*, *Mycobacterium tuberculosis*.

(2) **Cell wall:** All bacterial cells are covered by a strong, rigid cell wall. Therefore, they are classified under plants. Inner to the capsule cell wall is present. It is made up of polysaccharides, proteins and lipids. In the cell wall of bacteria there are two important sugar derivatives i.e., NAG and NAM (N-acetyl glucosamine and N-acetyl muramic acid) and besides L or D-alanine, D-glutamic acid and diaminopimelic acid are also found.

(3) **Plasma membrane:** Each bacterial cell has plasma membrane situated just internal to the cell wall. It is a thin, elastic and differentially or selectively permeable membrane. It is composed of large amounts of phospholipids, proteins and some amounts of polysaccharides but lacks sterols. It is characterised by possessing respiratory enzymes.

(4) **Cytoplasm:** The cytoplasm is a complex aqueous fluid or semifluid ground substance (matrix) consisting of carbohydrates, soluble proteins, enzymes, co-enzymes, vitamins, lipids, mineral salts and nucleic acids. The organic matter is in the colloidal state. The cytoplasm is granular due to presence of a large number of ribosomes. Ribosomes in bacteria are found in the form of polyribosome. Membranous organelles such as mitochondria, endoplasmic reticulum, golgi bodies, lysosomes and vacuoles are absent. In some photosynthetic bacteria the plasma



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membrane gives rise to large vesicular thylakoids which are rich in bacteriochlorophylls and proteins.

(5) **Nucleoid:** It is also known as genophore, naked nucleus, incipient nucleus. There is nuclear material DNA which is double helical and circular. It is surrounded by some typical protein (polyamine) but not histone proteins. Histones (basic proteins) are altogether absent in bacteria. This incipient nucleus or primitive nucleus is named as nucleoid or genophore.

(6) **Plasmid:** In addition to the normal DNA chromosomes many bacteria (e.g., *E.coli*) have extra chromosomal genetic elements or DNA. These elements are called plasmids. Plasmids are small circular double stranded DNA molecules. The plasmid DNA replicates independently maintaining independent identity and may carry some important genes. Plasmid terms was given by Lederberg (1952). Some plasmids are integrating into the bacterial DNA chromosome called episomes.

(7) **Flagella:** These are fine, thread-like, protoplasmic appendages which extend through the cell wall and the slime layer of the flagellated bacterial cells. These help in bacteria to swim about in the liquid medium. Bacterial flagella are the most primitive of all motile organs. Each is composed of a single thin fibril as against the 9+2-fibrillar structure of eukaryotic cells. The flagellum is composed entirely of flagellin protein.



(8) **Pili or Fimbriae:** Besides flagella, some tiny or small hair-like outgrowths are present on bacterial cell surface. These are called pili and are made up of pilin protein. They measure about 0.5-2mm in length and 3-5nm in diameter. These are of 8 types I, II, III, IV, V, VI, VII, and F types. I to F are called sex pili. These are present in all most all gram -ve bacteria and few gram +ve bacteria. Fimbriae take part in attachment like holding the bacteria to solid surfaces. The function of pili is not in motility but they help in the attachment of the bacterial cells. Some sex pili acts as conjugation canals through which DNA of one cell passes into the other cell.

#### [MODEL QUESTION]

**Answer:**

All single-celled eukaryotes are placed under Protista, but the boundaries of this kingdom are not well defined.

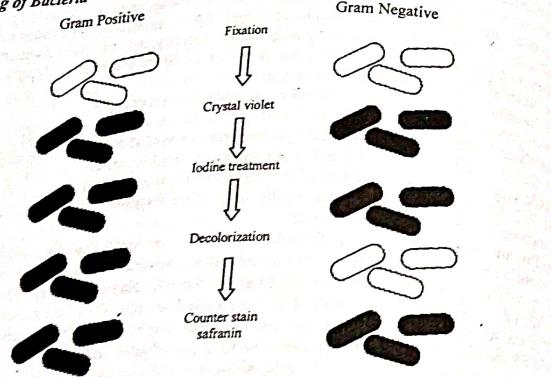
- Members of Protista are primarily aquatic.
- This kingdom forms a link with the others dealing with plants, animals and fungi.
- Being eukaryotes, the protistan cell body contains a well defined nucleus and other membrane-bound organelles.
- Some have flagella or cilia.
- Protists reproduce asexually and sexually by process involving cell fusion and zygote formation.
- It may be photosynthetic, holotrophic, saprotrophic, parasitic and symbionts. Some have mixotrophic nutrition (holotrophic + saprobic).
- The photosynthetic, floating protists are collectively called phytoplankton.
- The free-floating, holozoic protozoans are collectively termed zooplankton.

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- Unicellular protists have been broadly divided into three major groups:
  - (a) Photosynthetic Protists: Example: Dinoflagellates, Diatoms, Euglenoids
  - (b) Consumer Protists: Example: Slime moulds or Myxomycetes
  - (c) Protozoan Protists: Example: Zooflagellata, Sarcodina, Sporozoa, Ciliata

**22. What is Staining of Bacteria?**

**Answer:**  
**Staining of Bacteria**



**[MODEL QUESTION]**

**23. What is Cyanobacteria? How it is different from bacteria? [MODEL QUESTION]**

**Answer:**

- Cyanobacteria**  
(Blue green algae, Cyanophyceae, Myxophyceae)
- Cyanobacteria or blue-green algae are gram (=) photosynthetic prokaryotes which perform oxygenic photosynthesis.
  - Photosynthetic pigments include chlorophyll a, carotenoids and phycobilins.

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- Food is stored in the form of cyanophycean starch, lipid globules and protein granules.
- Cyanobacteria evolved more than 3 billion years back.
- They added oxygen to the atmosphere and paved the path for evolution of aerobic forms, including aerobic bacteria.

**Difference between Bacteria and Cyanobacteria**

Bacteria	Cyanobacteria
1. The cells are comparatively smaller.	The cells are comparatively larger.
2. The cell wall is 1-2 layered.	The cell wall is four layered.
3. Plasmodesmata and pores do not occur in cell walls.	They are often present.
4. They exhibit lesser structural elaboration.	They show higher degree of morphological complexity as well as structural elaboration.
5. Bacteria are both autotrophic and heterotrophic.	Cyanobacteria contain chlorophyll a as found in eukaryotic autotrophs.
6. Autotrophic bacteria possess bacteriochlorophyll.	Cyanobacteria contain chlorophyll a found in eukaryotic autotrophs.
7. Photosynthesis is anoxygenic.	Photosynthesis is oxygenic.
8. Photoautotrophic bacteria do not contain phycobilins.	They possess accessory water soluble photosynthetic pigments known as phycobilins.
9. Flagella may be present.	Flagella are absent.
10. Carbohydrate reserve food is glycogen.	Carbohydrate reserve food is a special starch known as cyanophycean starch.

**24. What is Life cycle? What are the different types of Life cycle of Protista?**

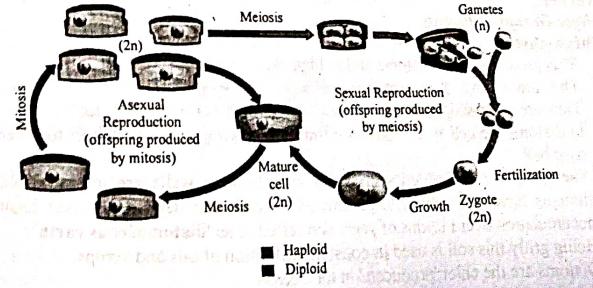
**[MODEL QUESTION]**

**Answer:**

The sequence of events between any given phase in one generation and that similar phase in the next succeeding generation constitute a life cycle."

Two types of life cycle are found in protists:

**(a) Life Cycle Showing Zygotic Meiosis:**



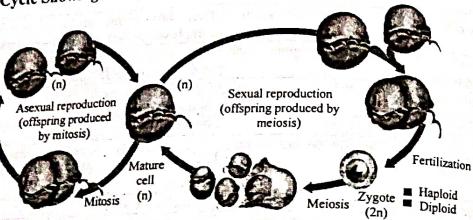
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- It occurs in some dinoflagellates (Example: *Ceratium*, *Gymnodinium*; von Stosch, 1973) and cellular slime moulds.
- The zygote is  $2n$  that divides by meiosis (also called zygotic meiosis) and produces vegetative cells with  $1n$  chromosome number.
- These cells divide repeatedly by mitosis and all the resulting daughter cells maintain the  $1n$  number of chromosomes.
- Some of the vegetative cells produce gametes.
- When these gametes combine in fertilization, a zygote is formed and the life cycle is completed.

(b) Life Cycle Showing Gametic Meiosis:



- This is found in the majority of protozoan protists, diatoms and acellular slime moulds.
- The organism spends most of its life cycle in the  $2n$  condition.
- The gametes are only  $1n$  (haploid) that are produced by meiosis (also called gametic meiosis).
- The gametes fuse to form zygote that grows to form the diploid individual.

25. What are the major groups of Protists?

[MODEL QUESTION]

Answer:

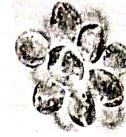
**Major Groups of Protists**

**Chrysophytes**

- This group includes diatoms and golden algae (desmids).
- They are found in fresh water as well as in marine environments.
- They are microscopic and float passively in water currents (plankton).
- In diatoms the cell walls form two thin overlapping shells, which fit together as in a soap box.
- The walls are embedded with silica and thus the walls are indestructible. Thus, diatoms have left behind large amount of cell wall deposits in their habitat; this accumulation over billions of years is referred to as 'diatomaceous earth'.
- Being gritty this soil is used in polishing, filtration of oils and syrups.
- Diatoms are the chief 'producers' in the oceans.

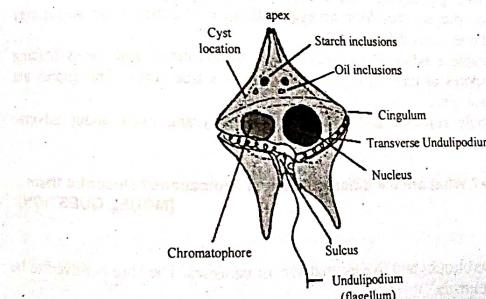
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**BIOLOGY**



**Dinoflagellates**

- These organisms are mostly marine and photosynthetic.
- They appear yellow, green, brown, blue or red depending on the main pigments present in their cells.
- The cell wall has stiff cellulose plates on the outer surface.
- Most of them have two flagella; one lies longitudinally and the other transversely in a furrow between the wall plates.
- Very often, red dinoflagellates (Example: *Gonyaulax*) undergo such rapid multiplication that they make the sea appear red (red tides).
- Toxins released by such large numbers may even kill other marine animals such as fishes.
- Dinoflagellates reproduce asexually through cell division or by the formation of zoospores and cysts.
- The cell division starts from posterior end. During cell division, centromeres and spindle are not seen. The spindle is replaced by cytoplasmic microtubules.
- During mitosis, the chromosomes break up into pairs of chromatids. The nuclear envelope and nucleolus persists during division.
- If sexual reproduction occurs, it is isogamous or anisogamous.
- Two cells conjugate by a conjugation canal where the two amoeboid gametes fuse to form a diploid zygote.
- Life cycle involves zygotic meiosis (Example: *Ceratium*, *Gymnodinium* etc.) or gametic meiosis (Example: *Noctiluca*).



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### POPULAR PUBLICATIONS

#### Euglenoids

- Majority of them are fresh water organisms found in stagnant water.
- Instead of a cell wall, they have a protein rich layer called pellicle which makes body flexible.
- They have two flagella, a short and a long one. The two flagella join with each other at a swelling called parflagellar body. An orange red coloured eye-spot or stigma is located at the base of flagellum attached to the membrane of reservoir at the level of parflagellar body.
- Both parflagellar body and eye spot act as photoreceptors and direct the organism towards the optimum light.
- Though they are photosynthetic in the presence of sunlight, when deprived of sunlight they behave like heterotrophs by preying on other smaller organisms. Interestingly, the pigments of euglenoids are identical to those present in higher plants. Example: Euglena. They contain red pigment astaxanthin.
- Euglena is holophytic (photolithotrophic), saprobic (e.g., Rhizomonas) or holomix (e.g., Peranema). Even holomix forms can pick up organic compounds from the outside medium. Such a mode of nutrition is called mixotrophic.
- Euglena is a connecting link between animals and plants. Nutrition in Euglena is mixotrophic, when light is available it is photosynthetic, in darkness it is saproxytic absorbing food from surrounding water.



*Figure 1.10 Euglena*

#### Slime Moulds

- Slime moulds are saprophytic protists.
- The body moves along decaying twigs and leaves engulfing organic material.
- Under suitable conditions, they form an aggregation called plasmodium which may grow and spread over several feet.
- During unfavourable conditions, the plasmodium differentiates and forms fruiting bodies bearing spores at their tips. The spores possess true walls. The spores are dispersed by air currents.
- They are extremely resistant and survive for many years, even under adverse conditions.

26. What is Protozoa? What are the different types of Protozoans? Describe them.  
[MODEL QUESTION]

#### Answer:

##### Protozoans

All protozoans are heterotrophs and live as predators or parasites. They are believed to be primitive relatives of animals.

### BIOLOGY

There are four major groups of protozoan  
Group 1. Flagellated Protozoans

#### Characters:

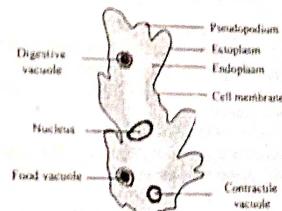


- They possess flagella for locomotion.
- They may be free living aquatics, parasites, commensals or symbionts.
- Zoothamellates are generally uninucleate, occasionally multinucleate.
- The body is covered by a firm pellicle.
- Nutrition is holozoic, saprotrophic and parasitic.
- Asexual reproduction is by binary fission.

#### Examples:

- **Trypanosome gambiense:** The parasite of sleeping sickness. It was first observed by Forde in 1901. Fruse discovered that the parasite of sleeping sickness is transmitted by tse-tse fly. It causes Gambian sleeping sickness. The disease, also called Gambian trypanosomiasis, is found in western and central parts of Africa.
- **Trypanosome rhodesiense:** It causes Rhodesian sickness. The disease is also called Rhodesian trypanosomiasis. The parasite is transmitted by the bites of tse-tse fly (glossina palpalis and glossina morsitans). Initially parasite is present in the blood of man but later on it enters the cerebrospinal fluid.
- **Trypanosome cruzi:** It causes South American trypanosomiasis (also called Chagas disease). The symptoms of the disease are fever, diarrhea, anaemia and enlargement of lymphoid glands.

#### Group 2. Amoebid Protozoans



#### Characters:

- They develop pseudopodia which are temporary protoplasmic outgrowths. They are of four types- lobopodia (broad and blunt), filopodia (slender, unsupported, independent), axopodia (slender with axial support) and reticulopodia (slender, reticular).
- Pseudopodia are used for locomotion and engulfing food articles.

#### POPULAR PUBLICATIONS

- (iii) Sarcodines are mostly free living, found in fresh water, sea water and on damp soil.  
 Only a few are parasitic.  
 (iv) The body may be covered with plasmalemma or a shell.

**Examples:** Amoeba, pelomyxa, entamoeba, radiolarians, foraminiferans, heliozoans.

#### **Group 3. Sporozoans**

##### **Characters:**

- (i) All sporozoans are endoparasites.
- (ii) Some sporozoans such as *Eimeria* cause several diseases like coccidiosis in the birds.
- (iii) Locomotory organelles (cilia, flagella, pseudopodia, etc.) are absent.
- (iv) Nutrition is parasitic (absorptive). Phagotrophy is rare.
- (v) The body is covered with an elastic pellicle or cuticle.
- (vi) Contractile vacuoles are absent.
- (vii) Asexual reproduction occurs through syngamy.
- (ix) Life cycle consists of two distinct asexual and sexual phases. They may be passed in one (monogenetic) or two different hosts (digenetic).

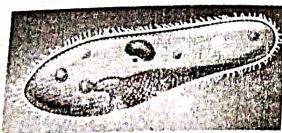
##### **Examples:**

Plasmodium, monocystis, eimeria.

#### **Group 4. Ciliated Protozoans**

##### **Characters:**

- (i) Ciliates are protozoan protists which develop a number of cilia during a part or whole of the life cycle.



(ii) Cilia are used for locomotion and driving food.

(iii) There is a high degree of morphological and physiological specialization.

(iv) Most ciliates are free living individuals in fresh and marine waters. A few are parasitic.

(v) The body is covered by a pellicle.

(vi) Nutrition is holozoic except in the parasitic forms.

(vii) There are definite regions for ingestion and egestion. The region of ingestion consists of an oral groove, cytostome (mouth) and gullet.

##### **Examples:**

Paramecium, vorticella, opalina, balantidium.

#### **27. What are the differences between Gram +ve Bacteria and Gram -ve Bacteria?**

[MODEL QUESTION]

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#### **BIOLOGY**

##### **Answer: Differences Between Gram +ve Bacteria and Gram -ve Bacteria**

Sl. No.	Gram +ve Bacteria	Gram -ve Bacteria
1.	They remain coloured blue or purple with gram stain even washing with absolute alcohol or acetone.	The bacteria do not retain the stain when washed with absolute alcohol.
2.	The wall is single layered. Outer membrane is absent.	The wall is two layered. Outer membrane is present.
3.	The thickness of the wall is 20-80nm.	It is 8-12nm.
4.	The lipid content of the wall is quite low.	The lipid content of the wall is 20-30%.
5.	The wall is straight.	The wall is wavy and comes in contact with plasmalemma only at a few places.
6.	Murein or mucopeptide content is 70-80%	It is 10-20%.
7.	Basal body of the flagellum has two rings of swellings.	Four rings of swellings occur in the basal body.
8.	Mesosomes are more prominent.	Mesosomes are less prominent.
9.	The bacteria are more susceptible to antibiotics.	They are more resistant to antibiotics.
10.	Fewer pathogenic bacteria belong to Gram +ve group.	Most of the pathogenic bacteria are Gram -ve.
11.	Porins are absent.	Porins or hydrophilic channels occur in outer membrane of cell wall.
12.	Cell wall contains teichoic acids.	Teichoic acids are absent.

#### **28. What are the characteristic features Fungi?**

[MODEL QUESTION]

##### **Answer: Characteristics of Fungi**

##### **Thallus Organization**

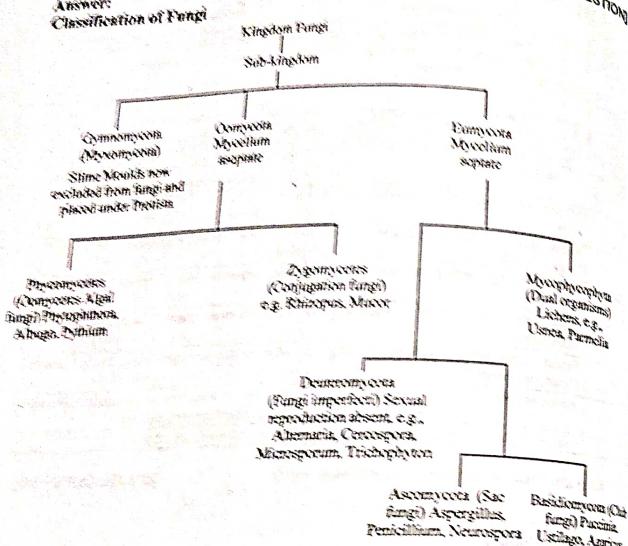
- The plant body of true fungi (Eumycota), the plant body is a thallus.
- It may be non-mycelial or mycelial. The non-mycelial forms are unicellular; however, they may form a pseudomycelium by budding. In mycelial forms, the plant body is made up of thread-like structures called hyphae (sing. hypha).
- The mycelium may be aseptate (non-septate) or septate. When non-septate and multinucleate, the mycelium is described as coenocytic.
- In lower fungi the mycelium is non-septate e.g., Phycomycetida. In higher forms it is septate e.g., Ascomycotina, Basidiomycotina and Deuteromycotina.
- In some forms the plant body is unicellular at one stage and mycelial at the other. Their organization is sometimes described as dimorphic.

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**POPULAR PUBLICATIONS**

28. Describe the classification of Fungi.  
Answer:  
Classification of Fungi



30. Describe characters of plantae.

Answer:

Kingdom Plantae includes green, brown and red algae, liverworts, mosses, ferns and seed plants with or without flowers. They have the following characters.

- (1) Multicellular organisms with walled and frequently vacuolated eukaryotic cells.
- (2) They contain photosynthetic pigment in plastids.
- (3) Principal mode of nutrition is photosynthesis but number of plants have become absorptive.
- (4) Primarily non-motile, living anchored to a substrate.
- (5) Structural differentiation leading towards organs of photosynthesis, anchorage and support and in higher forms towards specialised photosynthetic, vascular and covering tissues.

**[MODEL QUESTION]**

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**BIOLOGY**

(a) Reproduction is primarily asexual or sexual. The reproductive organs are multicellular.

(b) A multicellular embryo is formed during development from the zygote. Algae lack embryo stage. Life cycle consists of alternating haploid gametophyte and diploid sporophyte generation. This phenomenon is called alternation of generation.

31. Describe the classification of Plantae.

**[MODEL QUESTION]**

Answer:  
Classification of Plantae  
August Wilhelm Eichler (1883) a Vinnean botanist, divided plant kingdom into two sub-

kingdoms mainly on the basis of presence or absence of seeds.

(1) Cryptogamiae (Gr. Cryptos = hidden; gamos = marriage): Lower plants in which sex organs are hidden and seeds and flowers absent. It includes Thallophytes, Bryophytes, Peridophytes.

(2) Phanerogamae (Gr. Phaneros = visible; gamos = marriage): Higher plants in which sex organs are evident; seeds present. It includes Gymnosperms and Angiosperms.

**Thallophyta**

- Comprises the simplest plants which possess undifferentiated or thallus like forms.
- Reproductive organs single celled no jacketed called gametangia.
- Embryo stage, vascular and mechanical tissues are all absent.
- Differentiation of true roots, stems and leaves is also absent.
- Asexual reproduction by accessory spores is very common. Presently, it includes only Algae.

**Bryophytes**

These are nonvascular terrestrial plants of moist habitats in which a multicellular diploid sporophyte lives as a parasite on an independent multicellular haploid gametophyte that develops multicellular jacketed sex organs.

**Peridophytes- pteridophyta**

Pteridophytes are seedless vascular or cryptogamic plants that have sporophytic plant body, inconspicuous gametophytes containing small sessile antheridia and partially embedded archegonia with 4- rowed neck.

**Gymnosperms**

Gymnosperms are those seed plants in which the seeds remain exposed over the surface of the megasporophylls because the latter are not folded to form pistils.

**Angiosperms**

Angiosperms are those seed plants in which seeds are formed inside fruits and the sporophylls are organized into flowers.

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**POPULAR PUBLICATIONS****32. Describe the Kingdom Animalia.****Answer:****Kingdom Animalia**

- This kingdom is characterised by heterotrophic eukaryotic organisms that are multicellular and their cells lack cell walls.
- They directly or indirectly depend on plants for food. They digest their food in an internal cavity and store food reserves as glycogen or fat.
- Their mode of nutrition is holozoic - by ingestion of food.
- They follow a definite growth pattern and grow into adults that have a definite shape and size.
- Higher forms show elaborate sensory and neuromotor mechanism.
- The sexual reproduction is by copulation of male and female followed by embryological development.

**33. Define the following terms.****[MODEL QUESTION]****Answer:**

- Anaemia:** Animals without red blood e.g., sponges, cnidaria, mollusca, arthropoda, echinodermata, etc.
- Enaima:** Animals with red blood e.g., vertebrate
- Vivipara:** Animals which give birth to young ones are included in this subgroup e.g., man, dogs, cows, etc.
- Ovipara:** Animals which lay eggs are included in this subgroup e.g., frogs, toads, lizards, snakes, birds, etc.
- Anamniotes:** Vertebrates without embryonic membranes e.g., fishes, amphibians.
- Amniotes:** Vertebrates with embryonic membranes (chorion, amnion, allantois, yolk sac) e.g., reptiles, birds, mammals.
- Acraniata or Protostomata:** Chordates without cranium (brain box). It includes urochordata and cephalochordata.
- Chordates:** Animals with notochord dorsal tubular nerve cord, paired pharyngeal gill slits.
- All urochordates, cephalochordates and vertebrates are called chordates.
- Craniata or Vertebrate:** Chordates with cranium.
- It includes cyclostomes, pisces, amphibians, reptiles, birds and mammals.
- Nonchordates:** Animals without notochord (a rod like elastic structure which supports the body). Phylum Porifera to phylum Hemichordata are called nonchordates.
- Invertebrates:** Animals without vertebral column (backbone). All the nonchordates, urochordates and cephalochordates are collectively called invertebrates.

**BIO-38****[MODEL QUESTION]****34. What are the features of Virus?****Answer:**

- Viruses are obligate parasites.
- In addition to proteins viruses also contain genetic material, that could be either RNA or DNA.
- No virus contains both RNA and DNA.
- A virus is a nucleoprotein and the genetic material is infectious. In general, viruses that infect plants have single stranded RNA and viruses that infect animals have either single or double stranded RNA or double stranded DNA. Bacterial viruses or bacteriophages (viruses that infect the bacteria) are usually double stranded DNA viruses.
- The protein coat called capsid made of small subunits called capsomeres, protects the nucleic acid. These capsomeres are arranged in helical or polyhedral geometric forms.
- Viruses cause diseases like mumps, small pox, herpes and influenza. AIDS in humans is also caused by a virus. In plants, the symptoms can be mosaic formation, leaf rolling and curling, yellowing and vein clearing, dwarfing and stunted growth.

**35. What is Viroids and what is Lichens?****Answer:**

- Viroids:** In 1971 T.O. Diener discovered a new infectious agent that was smaller than viruses and caused potato spindle tuber disease. It was found to be a free RNA; it lacked the protein coat that is found in viruses, hence the name viroid. The RNA of the viroid was of low molecular weight.
  - Lichens:** Lichens are symbiotic associations i.e., mutually useful associations, between algae and fungi. The algal component is known as phycobiont and fungal component as mycobiont, which are autotrophic and heterotrophic, respectively. Algae prepare food for fungi and fungi provide shelter and absorb mineral nutrients and water for its partner.
- Lichens are very good pollution indicators - they do not grow in polluted areas.

**36. State the difference between Unicellular and Multicellular Organisms.****[MODEL QUESTION]****Answer:**

Unicellular Organisms	Multicellular Organisms
The body of the unicellular organism is composed of a single cell.	The body of the multicellular organism is composed of numerous cells.
Irregular in shape.	Have a definite shape.
Simple body organization.	Complex body organization.
A single cell is responsible to carry the life processes.	Different cells are specialized to perform different functions.
The total cell body is exposed to the environment.	Only the outer cells are exposed to the environment.

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BIOLOGICAL CLASSIFICATIONS	
Prokaryotic Organisms	Multicellular Organisms
Division of labour is at the cellular level	Division of labour is at cellular, tissue, organ and organ system level
Includes prokaryotes and protists	Includes eukaryotes
A division of a unicellular organism is usually seen	These multicellular organisms have a longer lifespan
This leads to the death of the cell	Death to a cell does not cause the cell to die in a multicellular organism
Reproduction by sexual reproduction	Reproduction by sexual reproduction
Cell differentiation is absent	Cell differentiation is obvious
They can be autotrophs or heterotrophs	They include both autotrophs and heterotrophs
They are unicellular in nature	They are multicellular in nature
All forms of bacteria, archaea, paramecium, yeasts are examples of unicellular organisms	Human beings, animals, plants, fish, insects are a few examples of multicellular organisms

### 20. What is Prokaryotic Cell?

Answer:

The term "prokaryote" is derived from the Greek word "pro", (meaning: before) and "karyon" (meaning: kernel). It translates to "before nucleus". Prokaryotic cells are comparatively smaller and much simpler than eukaryotic cells. The main defining characteristic of prokaryotic cells is that it does not possess membrane-bound cell organelles such as a nucleus. Reproduction happens through the process of binary fission.

Structurally, prokaryotes have a capsule enveloping its entire body, and it functions as a protective coat. This is crucial for preventing the process of phagocytosis (where the bacteria gets engulfed by other eukaryotic cells such as macrophages.) The pilus is a hair-like appendage found on the external surface of most prokaryotes and it helps the organism to attach itself to various environments. The pilus essentially resists being flushed, hence, it is also called attachment pili. It is commonly observed in bacteria. Right below the protective coating lies the cell wall, which provides strength and rigidity to the cell. Further down lies the cytoplasm that helps in cellular growth, and this is contained within the plasma membrane, which separates the interior contents of the cell from the outside environment. Within the cytoplasm, ribosomes exist and it plays an important role in protein synthesis. It is also one of the smallest components within the cell.

Some prokaryotic cells contain special structures called mesosomes which assist in cellular respiration. Most prokaryotes also contain plasmids, which contains small, circular pieces of DNA. And to help with locomotion, flagella are present, though, pili can also serve as an aid for locomotion. Common examples of Prokaryotic organisms are bacteria and archaea. Also, all members of Kingdom Monera are prokaryotes.

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### 38. What is Eukaryotic Cell?

BIOLOGY  
[MODEL QUESTION]

Answer:  
The term "Eukaryotes" is derived from the Greek word "eu", (meaning: good) and "karyon" (meaning: kernel), therefore, translating to "good or true nuclei". Eukaryotes are more complex and much larger than the prokaryotes. They include almost all the main kingdoms except kingdom monera.

Generally, eukaryotes possess a cell wall, which supports and protects the plasma membrane. The cell is surrounded by the plasma membrane and it controls the entry and exit of certain substances.

The nucleus contains DNA, which is responsible for storing all genetic information. The nucleus is surrounded by the nuclear membrane. Within the nucleus exists the nucleolus, and it plays a crucial role in synthesising proteins. Eukaryotic cells also contain mitochondria, which are responsible for the creation of energy, which is then utilized by the cell.

Present in only plant cells, chloroplasts are the subcellular sites of photosynthesis. Endoplasmic reticulum helps in the transportation of materials. Besides these, there are also other cell organelles that perform various other functions and these include ribosomes, lysosomes, Golgi bodies, cytoplasm, chromosomes, vacuoles, and centrosomes.

Examples of eukaryotes include almost every unicellular organism with a nucleus and all multicellular organisms.

### 39. Define ammonotelic, uricotelic and ureotelic.

[MODEL QUESTION]

Answer:

An ammonotelic organism excretes nitrogenous waste as soluble ammonia. Most of the aquatic animals including protozoans, crustaceans, platyhelminths, cnidarians, poriferans, echinoderms, fishes, larvae / tadpoles of amphibians are ammonotelic.

A ureotelic organism excretes excess nitrogen as urea. Urea is less toxic and needs less water in comparison to Ammonia. Ureotelic organisms include cartilaginous fish, few bony fishes, adult amphibians and mammals including humans. The uricotelic organism excretes uric acid or its salts. In comparison to Ammonia and Urea, Uric acid is the least toxic and the least soluble in water. It can be stored in cells and body tissues without toxic effects and thus needs least water and is highly efficient mode of excretion in comparison to two other methods.

Uricotelic organisms include terrestrial arthropods (including insects), lizards, snakes, and birds. The excreta of uricotelic organisms is typically white paste.

### 40. What is Molecular Classification?

[MODEL QUESTION]

Answer:

The classification of organism on the basis of distribution and composition of chemical substances in them is called Molecular Classification.

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**POPULAR PUBLICATIONS**

41. State the Difference between Prokaryotic and Eukaryotic Cells.

[MODEL QUESTION]

Answer:	Prokaryotes	Eukaryotes
Type of Cell	Always unicellular	Unicellular and multi-cellular
Cell size	Ranges in size from 0.2 $\mu\text{m}$ – 2.0 $\mu\text{m}$ in diameter	Size ranges from 10 $\mu\text{m}$ – 100 $\mu\text{m}$ in diameter
Cell wall	Usually present; chemically complex in nature	When present, chemically simple in nature
Nucleus	Absent	Present
Ribosomes	Present. Smaller in size and spherical in shape	Present. Comparatively larger in size and linear in shape
DNA arrangement	Circular	Linear
Mitochondria	Absent	Present
Cytoplasm	Present, but cell organelles absent	Present, cell organelles present
Endoplasmic reticulum	Absent	Present
Plasmids	Present	Very rarely found in eukaryotes
Ribosome	Small ribosomes	Large ribosomes
Lysosome	In this, the lysosome, mesosome, and centrosome is absent	Mesosome, Lysosomes, and centrosomes are present
Cell division	Through binary fission	Through mitosis
Flagella	The flagella are smaller in size	The flagella are larger in size
Reproduction	Asexual	Both asexual and sexual
Example	Bacteria and Archaea	Plant and Animal cell

42. Classify the organism on the basis of C source and N source.

[MODEL QUESTION]

Answer:

Type	Sub Type	C source	N source	Example
Heterotroph	Photoheterotroph	Preformed organic molecules e.g. sugars	Sunlight	Purple non-sulfur bacteria
	chemolithoheterotroph	Preformed organic molecules e.g. sugars	Oxidation of inorganic compounds e.g. H <sub>2</sub> S	
	chemoorganoheterotroph	Preformed organic molecules e.g. sugars	Oxidation of organic compounds	
Autotroph (lithotroph)	Photoautotroph	Carbon dioxide	Sunlight	
	Chemoautotroph	Carbon dioxide	Oxidation of inorganic compounds	methanogens

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**BIOLOGY**

43. What is Model organism? What is the significance of model organism?

[MODEL QUESTION]

Answer:  
A model organism is a non-human species that is extensively studied to understand particular biological phenomena, with the expectation that discoveries made in the model organism will provide insight into the workings of other organisms. Model organisms are widely used to research human disease when human experimentation would be unfeasible or unethical. This strategy is made possible by the common descent of all living organisms, and the conservation of metabolic and developmental pathways and genetic material over the course of evolution.

Studying model organisms can be informative, but care must be taken when generalizing from one organism to another.

In researching human disease, model organisms allow for better understanding the disease process without the added risk of harming an actual human. The species chosen will usually meet a determined taxonomic equivalency to humans, so as to react to disease or its treatment in a way that resembles human physiology as needed. Although biological activity in a model organism does not ensure an effect in humans, many drugs, treatments and cures for human diseases are developed in part with the guidance of animal models. There are three main types of disease models: homologous, isomorphic and predictive. Homologous animals have the same causes, symptoms and treatment options as would humans who have the same disease. Isomorphic animals share the same symptoms and treatments. Predictive models are similar to a particular human disease in only a couple of aspects, but are useful in isolating and making predictions about mechanisms of a set of disease features.

44. Why Escherichia Coli is selected as model organism? [MODEL QUESTION]

Answer:

*Escherichia coli*, or *E. coli* for short, is a Gram-negative, rod-shaped bacteria that is a normal inhabitant of the lower gastrointestinal tract of warm-blooded animals. Scientists estimate that *E. coli* first evolved between 120 and 160 million years ago, about the same time as the appearance of mammals. It is likely that *E. coli* has been living in the colons of mammals for the entire history of both groups. Further evidence for this symbiosis is the relatively rare ability of *E. coli* to utilize lactose, which is the sugar of milk, found only in mammals. Also, *E. coli* are able to survive in the presence of bile salts, which are caustic and used in digestion.

In addition to thriving in the colon, *E. coli* can also survive outside the body. Environmental *E. coli* can be spread through feces as the bacteria pass out of the body. These two habitats are about as opposite as you can get. The colon is relatively stable, warm, anaerobic, and nutrient-rich. Outside of the colon, conditions can be extremely harsh and variable, much colder, aerobic, and provide fewer nutrients.

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**Model Organism**

The fact that *E. coli* is able to survive such variable conditions is one advantage that led to its use as a **model organism**. A model organism is a species that is extensively studied to understand a specific phenomenon, expecting that the knowledge gained can be applied to other species as well.

*E. coli* has many attributes that make it an ideal candidate for use as a model organism.

Let's discuss the five major attributes that make *E. coli* an excellent model organism.

**Attribute 1:** *E. coli* is a **single-celled organism**. There are no ethical concerns about growing, manipulating, and killing bacterial cells, unlike multicellular model organisms like mice or chimps. They are also tiny cells, so in a small laboratory you can have flasks containing billions of cells that take up very little room, allowing many experiments.

**Attribute 2:** *E. coli* is **able to reproduce and grow very rapidly**, doubling its population

about every 20 minutes. This is helpful in a lab situation where waiting for subsequent generations to produce experimental data can be the rate-limiting step. With *E. coli* it is as easy and fast as letting them grow overnight. Trying to study the same process in subsequent generations of elephants, for example, would require several generations of scientists and more elephants than we have on the planet!

**Attribute 3:** *E. coli* can **survive in variable growth conditions**. As we discussed earlier, this leads to it being very adaptive yet forgiving in lab situations. Culture media containing simple and inexpensive ingredients and nutrients can successfully spur *E. coli* to grow and divide.

**Attribute 4:** Most naturally occurring strains of *E. coli* are **harmless**. Those food-poisoning *E. coli* that sprang to mind earlier are the exception, not the rule. When scientists first started using *E. coli* for lab experiments, they chose a strain that was harmless. This means that studying *E. coli* poses little threat to researchers and the public.

**45. Describe *Saccharomyces cerevisiae*. Why it is considered as model organism?** [MODEL QUESTION]

**Answer:**

*Saccharomyces cerevisiae* (commonly known as baker's yeast) is a single-celled eukaryote that is frequently used in scientific research. *S. cerevisiae* is an attractive model organism due to the fact that its genome has been sequenced, its genetics are easily manipulated, and it is very easy to maintain in the lab. Because many yeast proteins are similar in sequence and function to those found in other organisms, studies performed in yeast can help us to determine how a particular gene or protein functions in higher eukaryotes (including humans).

*S. cerevisiae* has developed as a model organism because it scores favourably on a number of these criteria.

- As a single-cell organism, *S. cerevisiae* is small with a short generation time (doubling time 1.25–2 hours at 30 °C or 86 °F) and can be easily cultured. These are all positive characteristics in that they allow for the swift production and maintenance of multiple specimen lines at low cost.

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**BIOLOGY**

- S. cerevisiae* divides with meiosis, allowing it to be a candidate for sexual genetics research.
- S. cerevisiae* can be transformed allowing for either the addition of new genes or deletion through homologous recombination. Furthermore, the ability to grow *S. cerevisiae* as a haploid simplifies the creation of gene knockout strains.
- As a eukaryote, *S. cerevisiae* shares the complex internal cell structure of plants and animals without the high percentage of non-coding DNA that can confound research in higher eukaryotes.
- S. cerevisiae* research is a strong economic driver, at least initially, as a result of its established use in industry.

**46. Describe *Drosophila melanogaster*. Why it is considered as model organism?** [MODEL QUESTION]

**Answer:**

*Drosophila melanogaster* is a species of fly (the taxonomic order Diptera) in the family Drosophilidae. The species is known generally as the common fruit fly (though inaccurately) or vinegar fly. Starting with Charles W. Woodworth's proposal of the use of this species as a model organism, *D. melanogaster* continues to be widely used for biological research in genetics, physiology, microbial pathogenesis, and life history evolution.

*D. melanogaster* is typically used in research because it can be readily reared in the laboratory, has only four pairs of chromosomes, breeds quickly, and lays many eggs. Its geographic range includes all continents, including islands. *D. melanogaster* is a common pest in homes, restaurants, and other places where food is served.

Flies belonging to the family Tephritidae are also called "fruit flies". This can cause confusion, especially in the Mediterranean, Australia, and South Africa, where the Mediterranean fruit fly *Ceratitis capitata* is an economic pest.

*D. melanogaster* remains one of the most studied organisms in biological research, particularly in genetics and developmental biology.

**Reasons for model organism**

***D. melanogaster* types (clockwise):** Brown eyes with black body, cinnabar eyes, sepia eyes with ebony body, vermilion eyes, white eyes, and wild type eyes with yellow body

There are many reasons the fruit fly is a popular choice as a model organism:

- Its care and culture require little equipment, space, and expense even when using large cultures.
- It can be safely and readily anesthetized (usually with ether, carbon dioxide gas, by cooling, or with products such as FlyNap).
- Its morphology is easy to identify once anesthetized.
- It has a short generation time (about 10 days at room temperature), so several generations can be studied within a few weeks.

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- It has a high fecundity (females lay up to 100 eggs per day, and perhaps 2000 in a lifetime).
- Males and females are readily distinguished, and virgin females are easily isolated, facilitating genetic crossing.
- The mature larva has giant chromosomes in the salivary glands called polytene chromosomes, "puffs", which indicate regions of transcription, hence gene activity.
- It has only four pairs of chromosomes — three autosomes, and one pair of sex chromosomes.
- Males do not show meiotic recombination, facilitating genetic studies.
- Recessive lethal "balancer chromosomes" carrying visible genetic markers can be used to keep stocks of lethal alleles in a heterozygous state without recombination due to multiple inversions in the balancer.
- The development of this organism—from fertilized egg to mature adult—is well understood.
- Genetic transformation techniques have been available since 1987.
- Its complete genome was sequenced and first published in 2000.
- Sexual mosaics can be readily produced, providing an additional tool for studying the development and behaviour of these flies.

#### Genetic markers

Genetic markers are commonly used in *Drosophila* research, for example within balancer chromosomes or P-element inserts, and most phenotypes are easily identifiable either with the naked eye or under a microscope. In the list of a few common markers below, the allele symbol is followed by the name of the gene affected and a description of its phenotype. (Note: *Recessive alleles are in lower case, while dominant alleles are capitalised.*)

- Cy: Curly; the wings curve away from the body, flight may be somewhat impaired
- e: Ebony; black body and wings (heterozygotes are also visibly darker than wild type)
- Sb: Stubble; bristles are shorter and thicker than wild type
- w: White; eyes lack pigmentation and appear white
- bw: Brown; eye color determined by various pigments combined.
- y: Yellow; body pigmentation and wings appear yellow, the fly analog of albinism

#### Classic genetic mutations

*Drosophila* genes are traditionally named after the phenotype they cause when mutated. For example, the absence of a particular gene in *Drosophila* will result in a mutant embryo that does not develop a heart. Scientists have thus called this gene *tinman*, named after the Oz character of the same name. Likewise changes in the *Shavenbaby* gene cause the loss of dorsal cuticular hairs in *Drosophila sechellia* larvae. This system of nomenclature results in a wider range of gene names than in other organisms.

#### Similarity to humans

A March 2000 study by National Human Genome Research Institute comparing the fruit fly and human genome estimated that about 60% of genes are conserved between the two species. About 75% of known human disease genes have a recognizable match in the genome of fruit flies, and 50% of fly protein sequences have a recognizable match in the online database called *Homologues*. An online database called *Homologues* is available to search for human disease gene homologues in flies and vice versa. *Drosophila* is being used as a genetic model for several human diseases including the neurodegenerative disorders Parkinson's, Huntington's, spinocerebellar atrophy and Alzheimer's disease. The fly is also being used to study mechanisms underlying aging and oxidative stress, immunity, diabetes, and cancer, as well as drug abuse.

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#### [MODEL QUESTION]

##### Answer:

*Caenorhabditis elegans* is a free-living, transparent nematode, about 1 mm in length, that lives in temperate soil environments. It is the type species of its genus. The name is a blend of the Greek *caeno-* (recent), *rhabditis* (rod-like) and Latin *elegans* (elegant). In 1900, Maupas initially named it *Rhabditides elegans*, Osche placed it in the subgenus *Caenorhabditis* in 1952, and in 1955, Dougherty raised *Caenorhabditis* to the status of genus.

*C. elegans* is an unsegmented pseudocoelomate and lacks respiratory or circulatory systems. Most of these nematodes are hermaphrodites and a few are males. Males have specialised tails for mating that include spicules.

#### 47. Describe *Caenorhabditis elegans*.

#### [MODEL QUESTION]

##### Answer:

*Arabidopsis thaliana*, the thale cress, mouse-ear cress or arabiadopsis, is a small flowering plant native to Eurasia and Africa. *A. thaliana* is considered a weed; it is found by roadsides and in disturbed land.

A winter annual with a relatively short life cycle, *A. thaliana* is a popular model organism in plant biology and genetics. For a complex multicellular eukaryote, *A. thaliana* has a relatively small genome of approximately 135 megabase pairs (Mbp). It was the first plant to have its genome sequenced, and is a popular tool for understanding the molecular biology of many plant traits, including flower development and light sensing.

*A. thaliana* is now widely used for studying plant sciences, including genetics, evolution, population genetics, and plant development. Although *A. thaliana* has little direct significance for agriculture, it has several traits that make it a useful model for understanding the genetic, cellular, and molecular biology of flowering plants.

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##### **Reasons for model organism**

###### **Genomics**

###### **Nuclear genome**

The small size of its genome, and the fact that it is diploid, makes *Arabidopsis thaliana* useful for genetic mapping and sequencing — with about 135 mega base pairs and five chromosomes. *A. thaliana* has one of the smallest genomes among plants. It was long thought to have the smallest genome of all flowering plants, but that title is now considered to belong to plants in the genus *Gentisea*, order Lamiales, with *Gentisea tuberosa*, a carnivorous plant, showing a genome size of approximately 61 Mbp. It was the first plant genome to be sequenced, completed in 2000 by the Arabidopsis Genome Initiative. The most up-to-date version of the *A. thaliana* genome is maintained by the Arabidopsis Information Resource (TAIR). Much work has been done to assign functions to its 27,000 genes and the 35,000 proteins they encode. Post-genomic research, such as metabolomics, has also provided useful insights to the metabolism of this species and how environmental perturbations can affect metabolic processes.

###### **Chloroplast genome**

The plastome of *Arabidopsis thaliana* is a 154,478 base pair long DNA molecule, a size typically encountered in most flowering plants. It comprises 136 genes coding for small subunit ribosomal proteins (*rps*, in yellow), large subunit ribosomal proteins (*rpl*, orange), hypothetical chloroplast open reading frame proteins (*ycf*, lemon), proteins involved in photosynthetic reactions (green) or in other functions (red), ribosomal RNAs (*rrn*, blue), and transfer RNAs (*trn*, black).

###### **Mitochondrial genome**

The mitochondrial genome of *Arabidopsis thaliana* is 367,808 base pairs long and contains 57 genes. There are many repeated regions in the *Arabidopsis* mitochondrial genome. The largest repeats recombine regularly and isomerize the genome. Like most plant mitochondrial genomes, the *Arabidopsis* mitochondrial genome exists as a complex arrangement of overlapping branched and linear molecules *in vivo*.

Genetic transformation of *A. thaliana* is routine, utilizing *Agrobacterium tumefaciens* to transfer DNA into the plant genome. The current protocol, termed "floral dip", involves simply dipping flowers into a solution containing *Agrobacterium* carrying a plasmid of interest and a detergent. This method avoids the need for tissue culture or plant regeneration.

###### **Genetics**

The *A. thaliana* gene knockout collections are a unique resource for plant biology made possible by the availability of high-throughput transformation and funding for genomics resources. The site of T-DNA insertions has been determined for over 300,000 independent transgenic lines, with the information and seeds accessible through online T-

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DNA databases. Through these collections, insertional mutants are available for most genes in *A. thaliana*.

**Q9. Describe *Mus musculus*. Why it is considered as model organism since long time?**

**Answer:** The house mouse (*Mus musculus*) is a small mammal of the order Rodentia, characterized by having a pointed snout, large rounded ears, and a long and hairy tail. It is one of the most abundant species of the genus *Mus*. Although a wild animal, the house mouse has benefited significantly from associating with human habitation to the point that truly wild populations are significantly less common than the semi-tame populations near human activity.

The house mouse has been domesticated as the pet or fancy mouse, and as the laboratory mouse, which is one of the most important model organisms in biology and medicine. The complete mouse reference genome was sequenced in 2002.

Mice have been used in biomedical research since the 16th Century when William Harvey used them for his studies on reproduction and blood circulation and Robert Hooke used them to investigate the biological consequences of an increase in air pressure. During the 18th century Joseph Priestley and Antoine Lavoisier both used mice to study respiration. In the 19th century Gregor Mendel carried out his early investigations of inheritance on mouse coat color but was asked by his superior to stop breeding in his cell "smelly creatures that, in addition, copulated and had sex". He then switched his investigations to peas but, as his observations were published in a somewhat obscure botanical journal, they were virtually ignored for over 35 years until they were rediscovered in the early 20th century. In 1902 Lucien Cuenot published the results of his experiments using mice which showed that Mendel's laws of inheritance were also valid for animals — results that were soon confirmed and extended to other species.

In the early part of the 20th century, Harvard undergraduate Clarence Cook Little was conducting studies on mouse genetics in the laboratory of William Ernest Castle. Little and Castle collaborated closely with Abbie Lathrop who was a breeder of fancy mice and rats which she marketed to rodent hobbyists and keepers of exotic pets, and later began selling in large numbers to scientific researchers. Together they generated the DBA (Dilute, Brown and non-Agouti) inbred mouse strain and initiated the systematic generation of inbred strains. The mouse has since been used extensively as a model organism and is associated with many important biological discoveries of the 20th and 21st Centuries.

The Jackson Laboratory in Bar Harbor, Maine is currently one of the world's largest suppliers of laboratory mice, at around 3 million mice a year. The laboratory is also the world's source for more than 8,000 strains of genetically defined mice and is home of the Mouse Genome Informatics database.

**GENETICS****Chapter at a Glance**

According to the cell theory, cells arise from preexisting cells. The process by which this occurs is called cell division. Any sexually reproducing organism starts its life cycle from a single-celled zygote. Cell division does not stop with the formation of the mature organism but continues throughout its life cycle.

The stages through which a cell passes from one division to the next is called the cell cycle. Cell cycle is divided into two phases called (i) Interphase – a period of preparation for cell division, and (ii) Mitosis (M phase) – the actual period of cell division. Interphase is further subdivided into G<sub>1</sub>, S and G<sub>2</sub>. G<sub>1</sub> phase is the period when the cell grows and carries out normal metabolism. Most of the organelle duplication also occurs during this phase. S phase marks the phase of DNA replication and chromosome duplication. G<sub>2</sub> phase is the period of cytoplasmic growth. Mitosis is also divided into four stages namely prophase, metaphase, anaphase and telophase. Chromosome condensation occurs during prophase. Simultaneously, the centrioles move to the opposite poles. The nuclear envelope and the nucleolus disappear and the spindle fibres start appearing. Metaphase is marked by the alignment of chromosomes at the equatorial plate. During anaphase the centromeres divide and the chromatids start moving towards the two opposite poles. Once the chromatids reach the two poles, the chromosomal elongation starts, nucleolus and the nuclear membrane reappear. This stage is called the telophase. Nuclear division is then followed by the cytoplasmic division and is called cytokinesis. Mitosis thus, is the equational division in which the chromosome number of the parent is conserved in the daughter cell.

In contrast to mitosis, meiosis occurs in the diploid cells, which are destined to form gametes. It is called the reduction division since it reduces the chromosome number by half while making the gametes. In sexual reproduction when the two gametes fuse the chromosome number is restored to the value in the parent. Meiosis is divided into two phases – meiosis I and meiosis II. In the first meiotic division the homologous chromosomes pair to form bivalents, and undergo crossing over. Meiosis I has a long prophase, which is divided further into five phases. These are leptotene, zygotene, pachytene, diplotene and diakinesis. During metaphase I the bivalents arrange on the equatorial plate. This is followed by anaphase I in which homologous chromosomes move to the opposite poles with both their chromatids. Each pole receives half the chromosome number of the parent cell. In telophase I, the nuclear membrane and nucleolus reappear. Meiosis II is similar to mitosis. During anaphase II the sister chromatids separate. Thus at the end of meiosis four haploid cells are formed.

**Multiple Choice Type Questions**

1. The tendency of an offspring to resemble its parent is known as  
 a) Variation      b) Heredity  
 c) Resemblance      d) Inheritance      [MODEL QUESTION]  
 Answer: (b)
2. Who is known as the "Father of Genetics"?  
 a) Morgan      b) Mendel      c) Watson      d) Bateson      [MODEL QUESTION]  
 Answer: (b)
3. The alternate form of a gene is  
 a) Alternate type      b) Recessive character  
 c) Dominant character      d) Allele      [MODEL QUESTION]  
 Answer: (b)
4. The genotypic ratio of a monohybrid cross is  
 a) 1:2:1      b) 3:1      c) 2:1:1      d) 9:3:3:1      [MODEL QUESTION]  
 Answer: (a)
5. The crossing of F<sub>1</sub> to any of the parent is known as  
 a) Test cross      b) Back cross  
 c) F<sub>1</sub> cross      d) All of the above      [MODEL QUESTION]  
 Answer: (d)
6. Which of the following statements is true regarding the "law of segregation"?  
 a) Law of segregation is the law of purity of genes  
 b) Alleles separate from each other during gametogenesis  
 c) Segregation of factors is due to the segregation of chromosomes during meiosis  
 d) All of the above      [MODEL QUESTION]  
 Answer: (d)
7. Homozygosity and heterozygosity of an individual can be determined by  
 a) Back cross      b) Self-fertilization  
 c) Test cross      d) All of the above      [MODEL QUESTION]  
 Answer: (a)
8. An exception to Mendel's law is  
 a) Independent assortment      b) Linkage  
 c) Dominance      d) Purity of gametes      [MODEL QUESTION]  
 Answer: (b)

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9. Pea plants were used in Mendel's experiments because  
 a) They were cheap  
 b) They had contrasting characters  
 c) They were available easily  
 d) All of the above [MODEL QUESTION]

Answer: (b)

10. The smallest unit of genetic material which produces a phenotypic effect on mutation is  
 a) Mutation  
 b) Gene  
 c) Recon  
 d) Nucleic acid [MODEL QUESTION]

Answer: (c)

11. Mendel's findings were rediscovered by  
 a) Correns  
 b) De Vries  
 c) Tschermak  
 d) All [MODEL QUESTION]

Answer: (d)

12. Alleles are  
 a) Alternate forms of genes  
 b) Linked genes  
 c) Chromosomes that have crossed over  
 d) Homologous chromosomes [MODEL QUESTION]

Answer: (a)

13. When the activity of one gene is suppressed by the activity of a non-allelic gene, it is known as  
 a) Pseudo-dominance  
 b) Hypostasis  
 c) Epistasis  
 d) Incomplete dominance [MODEL QUESTION]

Answer: (c)

14. Cystic fibrosis is  
 a) Sex-linked recessive disorder  
 b) Autosomal dominant disorder  
 c) Autosomal recessive disorder  
 d) Sex-linked dominant disorder [MODEL QUESTION]

Answer: (c)

15. 9:7 ratio in the F<sub>2</sub> generation represents  
 a) Incomplete dominance  
 b) Co-dominance  
 c) Epistasis  
 d) Complementary interaction [MODEL QUESTION]

Answer: (c)

16. A small amount of lethal mutation is always present in the population due to  
 a) Positive selection  
 b) Negative selection  
 c) Frequency-dependent selection  
 d) Mutation-selection balance [MODEL QUESTION]

Answer: (d)

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17. If a plant with genotype AaBb is selfed, the probability of getting AABB genotype will be (A and B are not linked)  
 a)  $\frac{1}{2}$   
 b)  $\frac{1}{4}$   
 c)  $\frac{1}{8}$   
 d) 1/16 [MODEL QUESTION]

Answer: (b)

18. How many phenotypes can occur in the human blood group ABO with alleles I<sup>A</sup>I<sup>B</sup>?  
 a) 2  
 b) 3  
 c) 4  
 d) 1 [MODEL QUESTION]

Answer: (d)

19. The geometrical device that helps to find out all the possible combinations of male and female gametes is known as  
 a) Bateson Square  
 b) Mendel Square  
 c) Punnett Square  
 d) Mendel Square [MODEL QUESTION]

Answer: (c)

20. Which term represents a pair of contrasting characters?  
 a) Heterozygous  
 b) Homozygous  
 c) Codominant genes  
 d) Allelomorphs [MODEL QUESTION]

Answer: (d)

Short & Long Answer Type Questions

1. Explain how DNA is packaged in a eukaryotic chromosome with suitable diagrams. [MODEL QUESTION]

Answer:

When comparing prokaryotic cells to eukaryotic cells, prokaryotes are much simpler than eukaryotes in many of their features. Most prokaryotes contain a single, circular chromosome that is found in an area of the cytoplasm called the nucleoid. The size of the genome in one of the most well-studied prokaryotes, *E. coli*, is 4.6 million base pairs (approximately 1.1 mm, if cut and stretched out). So how does this fit inside a small bacterial cell? The DNA is twisted by what is known as supercoiling. Supercoiling means that DNA is either under-wound (less than one turn of the helix per 10 base pairs) or over-wound (more than 1 turn per 10 base pairs) from its normal relaxed state. Some proteins are known to be involved in the supercoiling; other proteins and enzymes such as DNA gyrase help in maintaining the supercoiled structure. Eukaryotes, whose chromosomes each consist of a linear DNA molecule, employ a different type of packing strategy to fit their DNA inside the nucleus. At the most basic level, DNA is wrapped around proteins known as histones to form structures called nucleosomes. The histones are evolutionarily conserved proteins that are rich in basic amino acids and form an octamer. The DNA (which is negatively charged because of the phosphate groups) is wrapped tightly around the histone core. This nucleosome is linked to the next one with the help of a linker DNA. This is also known as the "beads on a string" structure. This is further compacted into a 30 nm fiber, which is the diameter of

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the structure. At the metaphase stage, the chromosomes are at their most compact, are approximately 700 nm in width, and are found in association with scaffold proteins. In interphase, eukaryotic chromosomes have two distinct regions that can be distinguished by staining. The tightly packaged region is known as heterochromatin, and the less dense region is known as euchromatin. Heterochromatin usually contains genes that are not expressed, and is found in the regions of the centromere and telomeres. The euchromatin usually contains genes that are transcribed, with DNA packaged around nucleosomes but not further compacted.

#### [MODEL QUESTION]

##### 2. What is Genetics?

Answer:

Genetics is a branch of biology concerned with the study of genes, genetic variation, and heredity in organisms.

##### 3. Define Mendel's Law.

Answer:

Mendel's Law of Segregation states individuals possess two alleles and a parent passes only one allele to his/her offspring. Mendel's Law of Independent Assortment states the inheritance of one pair of factors (genes) is independent of the inheritance of the other pair.

##### 4. What do mean by discrete inheritance and Mendel's laws? [MODEL QUESTION]

Answer:

At its most fundamental level, inheritance in organisms occurs by passing discrete heritable units, called genes, from parents to offspring. This property was first observed by Gregor Mendel, who studied the segregation of heritable traits in pea plants. In his experiments studying the trait for flower color, Mendel observed that the flowers of each pea plant were either purple or white—but never an intermediate between the two colors. These different, discrete versions of the same gene are called alleles.

In the case of the pea, which is a diploid species, each individual plant has two copies of each gene, one copy inherited from each parent. Many species, including humans, have this pattern of inheritance. Diploid organisms with two copies of the same allele of a given gene are called homozygous at that gene locus, while organisms with two different alleles of a given gene are called heterozygous.

The set of alleles for a given organism is called its genotype, while the observable traits of the organism are called its phenotype. When organisms are heterozygous at a gene, often one allele is called dominant as its qualities dominate the phenotype of the organism, while the other allele is called recessive as its qualities recede and are not observed. Some alleles do not have complete dominance and instead have incomplete dominance by expressing an intermediate phenotype, or codominance by expressing both alleles at once.

When a pair of organisms reproduce sexually, their offspring randomly inherit one of the two alleles from each parent. These observations of discrete inheritance and the

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segregation of alleles are collectively known as Mendel's first law or the Law of Segregation.

##### 5. What are the different Mendel's Laws?

#### [MODEL QUESTION]

Answer:

An analysis of genetic crosses depends upon an understanding of Mendel's two laws:

- The Principle of Segregation (First Law): The two members of a gene pair (alleles) segregate (separate) from each other in the formation of gametes. Half the gametes carry one allele, and the other half carry the other allele.

- The Principle of Independent Assortment (Second Law): Genes for different traits assort independently of one another in the formation of gametes.

In practice, the manifestation of Mendel's laws is seen by characteristic ratios of phenotypic classes, such as 3:1 and 9:3:3:1. Further, the Mendelian principles just stated include the simple assumption that one allele is dominant to the other allele.

In the time since Mendel's original experiments, we have come to learn that there are extensions to Mendelian principles, including the fact that some alleles are incompletely dominant, that some genes are sex-linked, and that some pairs of genes do not assort independently because they are physically linked on a chromosome.

##### 6. What is gene and its function?

#### [MODEL QUESTION]

Answer:

Genes are a set of instructions that determine what the organism is like, its appearance, how it survives, and how it behaves in its environment. Genes are made of a substance called deoxyribonucleic acid, or DNA. They give instructions for a living being to make molecules called proteins.

Genes are actually unit of heredity which is transferred from parents to the offsprings. Genes are found in the chromosomes, this chromosomes are found in the nucleus of a cell. Function of genes are to give specific character to the off-springs from their parents, like eye color, no. of limbs, haircolor, etc.

##### 7. What is allele?

#### [MODEL QUESTION]

Answer:

An allele is a variant form of a gene. Some genes have a variety of different forms, which are located at the same position, or genetic locus, on a chromosome. Humans are called diploid organisms because they have two alleles at each genetic locus, with one allele inherited from each parent. Each pair of alleles represents the genotype of a specific gene. Genotypes are described as homozygous if there are two identical alleles at a particular locus and as heterozygous if the two alleles differ. Alleles contribute to the organism's phenotype, which is the outward appearance of the organism.

Some alleles are dominant or recessive. When an organism is heterozygous at a specific locus and carries one dominant and one recessive allele, the organism will express the dominant phenotype. Alleles can also refer to minor DNA sequence variations between alleles that do not necessarily influence the gene's phenotype.

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**8. What is gene mapping used for?**

**Answer:**  
Genetic maps are a necessary tool for mapping of disease genes or trait loci, a method also commonly known as linkage mapping. Integrating genetic mapping and disease gene mapping with next-generation sequencing has proven to be a powerful strategy in genetic research.

[MODEL QUESTION]

**9. How do researchers create a genetic map?**

**Answer:**  
To produce a genetic map, researchers collect blood or tissue samples from members of families in which a certain disease or trait is prevalent. Using various laboratory techniques, the scientists isolate DNA from these samples and examine it for unique patterns that are seen only in family members who have the disease or trait. These characteristic patterns in the chemical bases that make up DNA are referred to as markers.

[MODEL QUESTION]

DNA markers don't, by themselves, identify the gene responsible for the disease or trait; but they can tell researchers roughly where the gene is on the chromosome. This is why: when eggs or sperm develop, the paired chromosomes that make up a person's genome exchange stretches of DNA. Think of it as a shuffling process, called recombination. The single chromosome in a reproductive cell contains some stretches of DNA inherited from the person's mother and some from his or her father. If a particular gene is close to a DNA marker, the gene and marker will likely stay together during the recombination process, and they will likely be passed on together from parent to child. If each family member with a particular disease or trait also inherits a particular DNA marker, it is very likely that the gene responsible for the disease lies near that marker.

The more DNA markers there are on a genetic map, the more likely it is that at least one marker will be located close to a disease gene—and the easier it will be for researchers to zero in on that gene. One of the first major achievements of the HGP was to develop dense maps of markers spaced evenly across the entire human genome.

**10. What is Gene Interactions?**

[MODEL QUESTION]

**Answer:****Meaning of Gene Interactions:**

When expression of one gene depends on the presence or absence of another gene in an individual, it is known as **gene interaction**. The interaction of genes at different loci that affect the same character is called epistasis.

**Gene interaction** is the influence of allelic or non-allelic genes on normal phenotypic expression of the trait. In other words, cases where two genes of the same allelic pair or genes of two or more different allelic pairs influence one another is called **gene interaction**.

[MODEL QUESTION]

**11. What is Complementary Gene Interaction?**

**Answer:**  
The Complementary Gene Interaction is the production by two interacting genes of effects distinct from those produced by either one separately.

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[MODEL QUESTION]

**12. Give example of supplementary Gene.**

**Answer:**  
They are two non allelic genes which not only are able to produce their own effects independently when present in the dominant state but can also interact to form a new trait. Comb types in poultry is an example of collaborative supplementary genes, P and R.

[MODEL QUESTION]

**13. Define "polygene" or "multiple gene inheritance". Give example.**

[MODEL QUESTION]

**Answer:**  
A "polygene" or "multiple gene inheritance" is a member of a group of non-epistatic genes that interact additively to influence a phenotypic trait. The term "monozygous" is usually used to refer to a hypothetical gene as it is often difficult to characterise the effect of an individual gene from the effects of other genes and the environment on a particular phenotype. Advances in statistical methodology and high throughput sequencing are, however, allowing researchers to locate candidate genes for the trait. In the case that such a gene is identified, it is referred to as a quantitative trait locus (QTL). These genes are generally pleiotropic as well. The genes that contribute to type 2 diabetes are thought to be mostly polygenes. In July 2016, scientists reported identifying a set of 355 genes from the last universal common ancestor (LUCA) of all organisms living on Earth.

Traits with polygenic determinism correspond to the classical quantitative characters, as opposed to the qualitative characters with monogenic or oligogenic determinism. In essence instead of two options, such as freckles or no freckles, there are many variations. Like the color of skin, hair, or even eyes.

Examples of polygenic inheritance in nature can be found in many places: in human height, skin color, and hair color; in animal size, longevity, or disease resistance; and in plants with grain color, length of maize, or flower size. All of these traits are influenced by multiple genes and considered polygenic.

**14. Why is body size controlled by more than one gene?** [MODEL QUESTION]**Answer:**

The sizes of all of these body parts are, in turn, determined by numerous genes. Human skin, hair, and eye color are also polygenic traits because they are influenced by more than one allele at different loci. The result is the perception of continuous gradation in the expression of these traits.

**15. What is Epistasis?****Answer:**

Epistasis is the phenomenon where the effect of one gene (locus) is dependent on the presence of one or more 'modifier genes', i.e. the genetic background. Originally the term meant that the phenotypic effect of one gene is masked by a different gene (locus). Thus, epistatic mutations have different effects in combination than individually. It was originally a concept from genetics but is now used in biochemistry, computational biology and evolutionary biology. It arises due to interactions, either between genes, or within them, leading to non-linear effects. Epistasis has a large influence on the shape of evolutionary landscapes, which leads to profound consequences for evolution and evolvability of phenotypic traits.

**[MODEL QUESTION]****16. Define CELL CYCLE.****Answer:**

Cell division is a very important process in all living organisms. During the division of a cell, DNA replication and cell growth also take place. All these processes, i.e., cell division, DNA replication, and cell growth, hence, have to take place in a coordinated way to ensure correct division and formation of progeny cells containing intact genomes. The sequence of events by which a cell duplicates its genome, synthesises the other constituents of the cell and eventually divides into two daughter cells is termed cell cycle. Although cell growth (in terms of cytoplasmic increase) is a continuous process, DNA synthesis occurs only during one specific stage in the cell cycle. The replicated chromosomes (DNA) are then distributed to daughter nuclei by a complex series of events during cell division. These events are themselves under genetic control.

**17. Describe the different Phases of Cell Cycle.****[MODEL QUESTION]****Answer:**

A typical eukaryotic cell cycle is illustrated by human cells in culture. These cells divide once in approximately every 24 hours. However, this duration of cell cycle can vary from organism to organism and also from cell type to cell type. Yeast for example, can progress through the cell cycle in only about 90 minutes. The cell cycle is divided into two basic phases:

- Interphase
- M Phase (Mitosis phase)

**18. Describe the InterPhase of cell cycle.****[MODEL QUESTION]****Answer:**

The interphase is divided into three further phases:

- G<sub>1</sub> phase (Gap 1)
- S phase (Synthesis) I
- G<sub>2</sub> phase (Gap 2)

G<sub>1</sub> phase corresponds to the interval between mitosis and initiation of DNA replication. During G<sub>1</sub> phase the cell is metabolically active and continuously grows but does not

replicate its DNA. S or synthesis phase marks the period during which DNA synthesis or replication takes place. During this time the amount of DNA per cell doubles. If the initial amount of DNA is denoted as 2C then it increases to 4C. However, there is no increase in the chromosome number; if the cell had diploid or 2n number of chromosomes at G<sub>1</sub>, even after S phase the number of chromosomes remains the same, i.e., 2n. In animal cells, during the S phase, DNA replication begins in the nucleus, and the centriole duplicates in the cytoplasm. During the G<sub>2</sub> phase, proteins are synthesised in preparation for mitosis while cell growth continues.

Some cells in the adult animals do not appear to exhibit division (e.g., heart cells) and many other cells divide only occasionally, as needed to replace cells that have been lost because of injury or cell death. These cells that do not divide further exit G<sub>1</sub> phase to enter an inactive stage called quiescent stage (G<sub>0</sub>) of the cell cycle. Cells in this stage remain metabolically active but no longer proliferate unless called on to do so depending on the requirement of the organism.

In animals, mitotic cell division is only seen in the diploid somatic cells. Against this, the plants can show mitotic divisions in both haploid and diploid cells. From your recollection of examples of alternation of generations in plants identify plant species and stages at which mitosis is seen in haploid cells.

**19. Describe M PHASE in detail.****[MODEL QUESTION]****Answer:**

This is the most dramatic period of the cell cycle, involving a major reorganisation of virtually all components of the cell. Since the number of chromosomes in the parent and progeny cells is the same, it is also called as equational division. Though for convenience mitosis has been divided into four stages of nuclear division, it is very essential to understand that cell division is a progressive process and very clear-cut lines cannot be drawn between various stages. Mitosis is divided into the following four stages:

- Prophase
- Metaphase
- Anaphase
- Telophase

**Prophase**

Prophase which is the first stage of mitosis follows the S and G<sub>2</sub> phases of interphase. In the S and G<sub>2</sub> phases the new DNA molecules formed are not distinct but intertwined. Prophase is marked by the initiation of condensation of chromosomal material. The chromosomal material becomes untangled during the process of chromatin condensation. The centriole, which had undergone duplication during S phase of interphase, now begins to move towards opposite poles of the cell. The completion of prophase can thus be marked by the following characteristic events:

- Chromosomal material condenses to form compact mitotic chromosomes. Chromosomes are seen to be composed of two chromatids attached together at the centromere.

- Initiation of the assembly of mitotic spindle, the microtubules, the proteinaceous components of the cell cytoplasm help in the process.
- Cells at the end of prophase, when viewed under the microscope, do not show Golgi complexes, endoplasmic reticulum, nucleolus and the nuclear envelope.

**Metaphase**

The complete disintegration of the nuclear envelope marks the start of the second phase of mitosis, hence the chromosomes are spread through the cytoplasm of the cell. By this stage, condensation of chromosomes is completed and they can be observed clearly under the microscope. This is the stage at which morphology of chromosomes is most easily studied. At this stage, metaphase chromosome is made up of two sister chromatids, which are held together by the centromere. Small disc-shaped structures at the surface of spindle fibres (formed by the spindle fibres) to the chromosomes that are moved into position at the centre of the cell. Hence, the metaphase is characterised by all the chromosomes coming to lie at the equator with one chromatid of each chromosome connected by its kinetochore to spindle fibres from one pole and its sister chromatid connected by its kinetochore to spindle fibres from the opposite pole. The plane of alignment of the chromosomes at metaphase is referred to as the metaphase plate. The key features of metaphase are:

- Spindle fibres attach to kinetochores of chromosomes.
- Chromosomes are moved to spindle equator and get aligned along metaphase plate through spindle fibres to both poles.

**Anaphase**

At the onset of anaphase, each chromosome arranged at the metaphase plate is split simultaneously and the two daughter chromatids, now referred to as chromosomes of the future daughter nuclei, begin their migration towards the two opposite poles. As each chromosome moves away from the equatorial plate, the centromere of each chromosome is towards the pole and hence at the leading edge, with the arms of the chromosome trailing behind. Thus, anaphase stage is characterised by the following key events:

- Centromeres split and chromatids separate.
- Chromatids move to opposite poles.

**Telophase**

At the beginning of the final stage of mitosis, i.e., telophase, the chromosomes that have reached their respective poles decondense and lose their individuality. The individual chromosomes can no longer be seen and chromatin material tends to collect in a mass in the two poles (Figure 10.2 d). This is the stage which shows the following key events:

- Chromosomes cluster at opposite spindle poles and their identity is lost as discrete elements.
- Nuclear envelope assembles around the chromosome clusters.
- Nucleolus, Golgi complex and ER reform.

**20. Define Cytokinesis.**

Answer:

Mitosis accomplishes not only the segregation of duplicated chromosomes into daughter nuclei (karyokinesis), but the cell itself is divided into two daughter cells by a separate process called cytokinesis at the end of which cell division is complete. In an animal cell, this is achieved by the appearance of a furrow in the plasma membrane. The furrow gradually deepens and ultimately joins in the centre dividing the cell cytoplasm into two. Plant cells however, are enclosed by a relatively inextensible cell wall, therefore they undergo cytokinesis by a different mechanism. In plant cells, wall formation starts in the centre of the cell and grows outward to meet the existing lateral walls. The formation of the new cell wall begins with the formation of a simple precursor, called the cell-plate that represents the middle lamella between the walls of two adjacent cells. At the time of cytoplasmic division, organelles like mitochondria and plastids get distributed between the two daughter cells. In some organisms karyokinesis is not followed by cytokinesis as a result of which multinucleate condition arises leading to the formation of syncytium.

**BIOLOGY****[MODEL QUESTION]****21. What is Significance of Mitosis?**

Answer:

Mitosis or the equational division is usually restricted to the diploid cells only. However, in some lower plants and in some social insects haploid cells also divide by mitosis. It is very essential to understand the significance of this division in the life of an organism. Are you aware of some examples where you have studied about haploid and diploid insects? Mitosis usually results in the production of diploid daughter cells with identical genetic complement. The growth of multicellular organisms is due to mitosis. Cell growth results in disturbing the ratio between the nucleus and the cytoplasm. It therefore becomes essential for the cell to divide to restore the nucleo-cytoplasmic ratio. A very significant contribution of mitosis is cell repair. The cells of the upper layer of the epidermis, cells of the lining of the gut, and blood cells are being constantly replaced. Mitotic divisions in the meristematic tissues – the apical and the lateral cambium, result in a continuous growth of plants throughout their life.

**[MODEL QUESTION]****22. What is MEIOSIS?**

Answer:

The production of offspring by sexual reproduction includes the fusion of two gametes, each with a complete haploid set of chromosomes. Gametes are formed from specialised diploid cells. This specialised kind of cell division that reduces the chromosome number by half results in the production of haploid daughter cells. This kind of division is called meiosis. Meiosis ensures the production of haploid phase in the life cycle of sexually reproducing organisms whereas fertilisation restores the diploid phase. We come across meiosis during gametogenesis in plants and animals. This leads to the formation of haploid gametes. The key features of meiosis are as follows:

- Meiosis involves two sequential cycles of nuclear and cell division called meiosis I and meiosis II but only a single cycle of DNA replication.

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- Meiosis I is initiated after the parental chromosomes have replicated to produce identical sister chromatids at the S phase.
- Meiosis involves pairing of homologous chromosomes and recombination between them.
- Four haploid cells are formed at the end of meiosis II.

**23. Mention the significance of meiosis.**

**Answer:**  
Meiosis is the mechanism by which conservation of specific chromosome number of each species is achieved across generations in sexually reproducing organisms, even though the process, per se, paradoxically, results in reduction of chromosome number by half. It also increases the genetic variability in the population of organisms from one generation to the next. Variations are very important for the process of evolution.

**[MODEL QUESTION]**

**24. What is Gene mapping?**

**Answer:**  
Gene mapping is the sequential allocation of loci to a relative position on a chromosome. Genetic maps are species-specific and comprised of genomic markers and/or genes and the genetic distance between each marker.

**[MODEL QUESTION]**

**25. What are the differences between Mitosis versus Meiosis?**

**[MODEL QUESTION]**

**Answer:**

Mitosis	Meiosis
Involves one cell division?	Involves two successive cell divisions
Results in two daughter cells	Results in four daughter cells
Results in diploid? daughter cells? (chromosome?)	Results in haploid? daughter cells (chromosome number is halved from the parent cell)
Number remains the same as parent cell	
Daughter cells are genetically identical	Daughter cells are genetically different
Occurs in all organisms except viruses	Occurs only in animals, plants and fungi
Creates all body cells (somatic?) apart from the germ cells? (eggs and sperm)	Creates germ cells (eggs and sperm) only
Prophase is much shorter	Prophase I takes much longer
No recombination/crossing over occurs in prophase.	Involves recombination/crossing over of chromosomes in prophase I
In metaphase individual chromosomes (pairs of chromatids) line up along the equator.	In metaphase I pairs of chromosomes line up along the equator.
During anaphase the sister chromatids are separated to opposite poles.	During anaphase I the sister chromatids move together to the same pole. During anaphase II the sister chromatids are separated to opposite poles.

**26. What are the Similarities of Mitosis versus meiosis?**

**[MODEL QUESTION]**

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**BIOLOGY**

**Answer:**

- Mitosis
- Diploid parent cell
- Consists of interphase, prophase, metaphase, anaphase and telophase
- In metaphase individual chromosomes (pairs of chromatids) line up along the equator.
- During anaphase the sister chromatids are separated to opposite poles.
- Ends with cytokinesis.
- Meiosis
- Diploid parent cell
- Consists of interphase, prophase, metaphase, anaphase and telophase (but twice!)
- In metaphase II individual chromosomes (pairs of chromatids) line up along the equator.
- During anaphase II the sister chromatids are separated to opposite poles.
- Ends with cytokinesis.

**27. What is Recessiveness in genetics?**

**[MODEL QUESTION]**

**Answer:**

Recessiveness, in genetics, is the failure of one of a pair of genes (alleles) present in an individual to express itself in an observable manner because of the greater influence, or dominance, of its opposite-acting partner. Both alleles affect the same inherited characteristic, but the presence of the recessive gene cannot be determined by observation of the organism; i.e., although present in the organism's genotype, the recessive trait is not evident in its phenotype. The term recessive is applied both to the organism having the alleles of a gene pair in the recessive condition and to the allele whose effect can be masked by another allele of the same gene.

**28. What is Dominance in genetics?**

**[MODEL QUESTION]**

**Answer:**

Dominance, in genetics, is the phenomenon of one variant (allele) of a gene on a chromosome masking or overriding the effect of a different variant of the same gene on the other copy of the chromosome. The first variant is termed dominant and the second recessive. This state of having two different variants of the same gene on each chromosome is originally caused by a mutation in one of the genes, either new (*de novo*) or inherited. The terms autosomal dominant or autosomal recessive are used to describe gene variants on non-sex chromosomes (autosomes) and their associated traits, while those on sex chromosomes (allosomes) are termed X-linked dominant, X-linked recessive or Y-linked, and these show a very different inheritance and presentation pattern to autosomal traits which depends on the sex of the individual. Additionally, there are other forms of dominance such as incomplete dominance, in which a gene variant has a partial effect compared to when it is present on both chromosomes, and co-dominance, in which different variants on each chromosome both show their associated traits.

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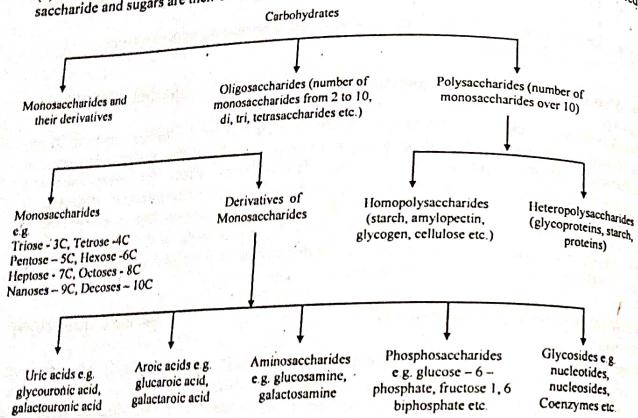
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## BIOMOLECULES

### Chapter at a Glance

**Carbohydrates:**

- (1) e.g. sugars, glycogen (animal starch), plant starch and cellulose.
- (2) **Source of carbohydrate:** Mainly photosynthesis. It exists only in 1% but constitutes 80% of the dry weight of plants.
- (3) **Composition:** It consists of carbon, hydrogen and oxygen in the ratio  $C_nH_2N$ . It is also called saccharide and sugars are their basic components.


**(4) Properties of monosaccharide**

- (a) Monosaccharides are colourless, sweet tasting, solids.
- (b) Due to asymmetric carbon, they exist in different isomeric forms. They can rotate polarized light hence they are dextrorotatory and leavortatory.
- (c) D-glucose after reduction gives rise to a mixture of polyhydroxy alcohol, sorbitol or mannitol.
- (d) The sugars with a free aldehyde or ketone group reduce  $Cu^{+2}$  to  $Cu^{+}$  (cupric to cuprous)
- (e) Sugars show oxidation, esterification and fermentation.
- (f) The aldehyde or ketone group of a simple sugar can join an alcoholic group of another organic compound bond C-O-C the process involves loss of water and is called condensation ( $H-O-H$ ) or  $H+OH \rightarrow H_2O$ .

**Lipids**

- (1) Term lipid was coined by Bloor.
- (2) These are esters of fatty acids and alcohol.
- (3) They are hydrophobic insoluble in water but soluble in benzene, ether and chloroform.
- (4) Lipids are classified into three groups:-
  - (a) Simple lipids: These are the esters of fatty acids and glycerol. Again they are typed as-  
(a) Fats and Oils: (Natural lipids or true fats). These are triglycerides of fatty acid and glycerol. Fats which are liquid at room temperature are called oils. Oils with polyunsaturated fatty acids are called polyunsaturated e.g. sunflower oil, lower blood cholesterol.
  - (b) Fatty acids: Obtained by hydrolysis of fats. Formic acid is simplest fatty acid ( $HCOOH$ ). These are of 2 types:-
    - (i) Saturated fatty acids: The fatty acids which do not have double bond in between carbon atoms e.g. butyric acid, palmitic acid, hexanoic acid, etc. They have high melting points, solid at room temperature and increase blood cholesterol.
    - (ii) Unsaturated fatty acids: The fatty acids which have double bonds in carbon atoms. e.g. 8 hexadecanoic acid, 9 octadecanoic acid etc. They have lower melting points mostly found in plant fats, liquid at room temperature and lower the blood cholesterol.
  - (c) Waxes: These are simple lipids composed of one molecule of long chain fatty acid and long chain monohydric alcohol. Waxes have high melting point, insoluble in water, resistant to atmospheric oxidation, chemically inert and not digested by enzymes. They reduce rate of transpiration by making plant tissue water proof and work as excellent lubricant.
- (B) Compound lipids: They contain some additional element. Group with fatty acid and alcohol on the basis of group they may be of following types:
  - (a) Phospholipids: These contain phosphoric acid. It helps in transport, metabolism, blood clotting and permeability of cell membrane. It is a bipolar molecule i.e. phosphate containing end is hydrophilic whereas fatty acid molecules represent hydrophobic (non-polar tail).
  - (b) Glycolipids: These contain nitrogen and carbohydrate beside fatty acids. Generally found in white matter of nervous system. e.g. sesocine frenocin.
  - (c) Chromolipids: It includes pigmented lipids e.g. carotene.
  - (d) Aminolipids: Also known as sulpholipids. It contains sulphur and amino acids with fatty acid and glycerol. Cutin and suberin are also compound lipids resistant to water and also provide mechanical support in plants.
- (iii) Derived lipids: These are obtained by hydrolysis of simple and compound lipids.
- (5) Functions of lipids
  - (a) Oxidation of lipids yields comparatively more energy in the cell than protein and carbohydrates. 1 gm of lipids accounts for 39.1 KJ.
  - (b) The oil seeds such as groundnut, mustard, coconut store fats to provide nourishment to embryo during germination.
  - (c) They function as structural constituent i.e. all the membrane systems of the cell are made up of lipoproteins.
  - (d) Amphiphatic lipids are emulsifier.
  - (e) It works as heat insulator.
  - (f) Used in synthesis of hormones.
  - (g) Fats provide solubility to vitamins A, D, E, and K.

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### Amino Acids

- (1) Amino acids are normal components of cell proteins (called amino acid).
- (2) They are 20 in number specified in genetic code and universal in viruses, prokaryotes and eukaryotes.
- (3) **Structure and Composition :** Amino acids are basic units of protein and made up of C, H, O, N and sometimes S. Amino acids are organic acids with a carboxyl group ( $\text{--COOH}$ ) and one amino group ( $\text{--NH}_2$ ) on the  $\alpha$ -carbon atom. Carboxyl group attributes acidic properties and amino group gives basic ones. In solution, they serve as buffers and help to maintain pH. General formula is  $\text{R}-\text{CH}(\text{NH}_2)\text{COOH}$ .
- (4) **Classification**

### Based on R-group of amino acids

- (a) **Simple amino acids:** These have no functional group in the side chain. e.g. glycine, alanine, leucine, valine etc.
- (b) **Hydroxy amino acids:** They have alcohol group in side chain. e.g. threonine, serine, etc.
- (c) **Sulphur containing amino acids:** They have sulphur atom in side chain. e.g. methionine, cysteine.
- (d) **Basic amino acids:** They have basic group ( $\text{--NH}_2$ ) in side chain. e.g. lysine, arginine.
- (e) **Acidic amino acids:** They have carboxyl group in side chain. e.g. aspartic acid, glutamic acid.
- (f) **Acid amide amino acids:** These are the derivatives of acidic amino acids. In this group, one of the carboxyl group has been converted to amide ( $\text{--CONH}_2$ ). e.g. asparagine, glutamine.
- (g) **Heterocyclic amino acids:** These are the amino acids in which the side chain includes a ring involving at least one atom other than carbon. e.g. tryptophan, histidine.
- (h) **Aromatic amino acids:** They have aromatic group (benzene ring) in the side chain. e.g. phenylalanine, tyrosine, etc.

### Nucleotides:

- (1) Structurally a nucleotide can be regarded as a phosphoester of a nucleoside.
- (2) A combination of nitrogenous base and a sugar is called nucleoside and combination of a base, a sugar and phosphate group is known as nucleotide.

Types of nitrogen base	Nucleoside	Nucleotide
Adenine	Adenosine	Adenylic acid
Guanine	Guanosine	Guanylic acid
Cytosine	Cytidine	Cytidilic acid
Thymine	Thymidine	Thymidylic acid
Uracil	Uridine	Uridylic acid

### (3) Functions of nucleotides:

- Following are the major functions of nucleotides.
- (a) **Formation of nucleic acids:** Different nucleotides polymerize together to form DNA and RNA.
  - (b) **Formation of energy carrier:** They help in formation of ATP, AMP, ADP, GDP, GTP, TDP, TTP, UDP, etc. which on breaking release energy.
  - (c) **Formation of Coenzymes:** Coenzymes like NAD, NADP, FMN, FAD, CoA, etc are formed. Coenzymes are non-proteinaceous substance necessary for the activity of the enzymes.

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### Nucleic Acid

- (1) **Definition:** Nucleic acids are the polymers of nucleotide made up of carbon, hydrogen, oxygen, nitrogen and phosphorus and which controls the basic functions of the cell.
- (2) These were first reported by Friedrich Miescher (1871) from the nucleus of pus cell.
- (3) Altmann called it first time as nucleic acid.
- (4) They are found in nucleus. They help in transfer of genetic information.
- (5) **Types of nucleic acids :** On the basis of nucleotides i.e. sugars, phosphates and nitrogenous bases, nucleic acids are of two types which are further subdivided. These are DNA (Deoxyribonucleic acid) and RNA (Ribonucleic acid).

#### (A) DNA (Deoxyribonucleic acids)

- (i) **Types of DNA:** It may be linear or circular in eukaryotes and prokaryotes respectively.
- (ii) **Palindromic DNA:** The DNA helical bears nucleotide in a serial arrangement but opposite in two strands.

-T-T-A-A-C-G-T-T-A-A....

-A-A-T-T-G-C-A-A-T-T....

- (b) **Repetitive DNA:** This type of arrangement is found near centromere of chromosome and is inert in RNA synthesis. The sequence of nitrogenous bases is repeated several times.

- (c) **Satellite DNA:** It may have base pairs up to 11 – 60bp and are repetitive in nature. They are used in DNA matching or finger printing (Jefferey). In eukaryotes, DNA is deuterorotatory and sugars have pyranose configuration.

- (B) **RNA or Ribonucleic acid:** RNA is second type of nucleic acid which is found in nucleus as well as in cytoplasm i.e. mitochondria, plastids, ribosomes etc. They carry the genetic information in some viruses. They are widely distributed in the cell.

### Multiple Choice Type Questions

1. Which of the following is a nitrogenous base? [MODEL QUESTION]

- a) Arginine      b) Lysine      c) Adenine      d) Cysteine

Answer: (c)

2. Genomic DNA is..... Resulting in the production of .....

[MODEL QUESTION]

- a) Transcribed mRNA      b) Translated, t-RNA  
c) Transcribed, DNA      d) Translated, protein

Answer: (a)

3. Some of the enzymes, which are associated in converting fats into carbohydrates, are present in [MODEL QUESTION]

- a) Liposomes      b) Golgi bodies      c) Microsomes      d) Glyoxysomes

Answer: (d)

4. Largest physical and chemical molecules are [MODEL QUESTION]

- a) Carbohydrates      b) Lipids  
c) Proteins      d) Nucleic acids

Answer: (c)

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5. No cell could live without  
a) Phytochrome b) Enzyme c) Chloroplasts d) Protein [MODEL QUESTION]  
Answer: (d)
6. Which of the following is the characteristics of plants  
a) Glucose and cellulose b) Pyruvic acid and glucose c) Cellulose and starch d) Starch and pyruvic acid [MODEL QUESTION]  
Answer: (c)
7. Starch and cellulose are the compounds made of many units of  
a) Simple sugar b) Fatty acid c) Glycerol d) Amino acid [MODEL QUESTION]  
Answer: (a)
8. Oval shaped and eccentric starch particles are found in  
a) Wheat b) Maize c) Potato d) Rice [MODEL QUESTION]  
Answer: (c)
9. What are the most diverse molecules in the cell  
a) Lipids b) Proteins c) Carbohydrates d) Mineral salts [MODEL QUESTION]  
Answer: (b)
10. The form in which sugar is present in sugarcane  
a) Maltose b) Sucrose c) Fructose d) Glucose [MODEL QUESTION]  
Answer: (d)
11. Peptide bond is formed between two amino acids through  
a) Addition of water b) Loss of water c) Decarboxylation d) Deamination [MODEL QUESTION]  
Answer: (d)
12. A basic amino acid is  
a) Leucine b) Methionine c) Aspartic acid d) Lysine [MODEL QUESTION]  
Answer: (b)
13. Most abundant organic compound on earth is  
a) Cellulose b) Protein c) Lipids d) Steroids [MODEL QUESTION]  
Answer: (c)
14. Most common monosaccharides found in nucleus are  
a) Trioses b) Tetroses c) Pentoses d) Hexoses [MODEL QUESTION]  
Answer: (b)

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15. Hydrolysis of nucleic acid yields  
a) Only sugar b) Nitrogenous base only c) All of these [MODEL QUESTION]  
Answer: (c)
16. Nucleic acids were discovered by  
a) Watson and Crick b) Khorana c) Wilkins d) Miescher [MODEL QUESTION]  
Answer: (c)
17. A nucleoside differs from a nucleotide in not having  
a) Phosphate b) Sugar c) Phosphate and sugar d) Nitrogen base [MODEL QUESTION]  
Answer: (b)
18. DNA was first discovered by  
a) Beadle and Tatum b) Watson and Crick c) Friedrich Miescher d) Kornberg [MODEL QUESTION]  
Answer: (b)
19. Which one of the following is a base analogue  
a) Nitrous acid b) Colchicine c) 5 - bromouracil d) Caffeine [MODEL QUESTION]  
Answer: (c)
20. Isolation and purification of specific DNA segment from a living organism was achieved by  
a) Crick b) Nirenberg c) Beckwith and his colleagues d) Boorman [MODEL QUESTION]  
Answer: (b)
21. Cyclic adenosine monophosphate was discovered by  
a) Bakhor et al b) E.W. Sutherland c) Boorman d) Welsmann [MODEL QUESTION]  
Answer: (b)
22. Clover leaf model of tRNA has  
a) Acceptor arm and C arm b) Anticodon arm c) D arm d) All the above [MODEL QUESTION]  
Answer: (d)
23. Micrococca nuclease enzyme  
a) Cuts the DNA from a specific site b) Joins the DNA segment c) Cuts the DNA at the junction between nucleosome d) Binds the DNA with histone [MODEL QUESTION]  
Answer: (c)

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24. The mean diameter of DNA double helix is  
 a)  $20\text{ \AA}$  b)  $3.4\text{ \AA}$  c)  $4.5\text{ \AA}$  d)  $10\text{ \AA}$   
 Answer: (a)

25. If an isolated strain of DNA is kept at  $82-90^\circ\text{C}$ , then  
 a) It changes into RNA  
 b) It divides into one million pieces  
 c) No effect  
 d) It uncoils into helixes  
 Answer: (d)

26. The length of a helix of DNA is  
 a)  $10\text{ \AA}$  b)  $20\text{ \AA}$  c)  $30\text{ \AA}$  d)  $34\text{ \AA}$   
 Answer: (d)

27. Which site of a t-RNA molecule hydrogen bonds to a m-RNA molecule  
 a) Codon b) Anticodon  
 c) 5' end of the t-RNA molecule d) 3' end of the t-RNA molecule  
 Answer: (b)

28. How many types of ribonucleic acids are known  
 a) One type b) Two types c) Three types d) Four types  
 Answer: (c)

29. The element absent in RNA is  
 a) Nitrogen b) Sulphur c) Oxygen d) Hydrogen  
 Answer: (b)

30. Who was awarded Nobel Prize for synthesis of RNA in 1959  
 a) S. Ochoa b) A. Kornberg c) H. Khorana d) Nirenberg  
 Answer: (a)

31. Breakthrough of the year 2002  
 a) cDNA b) 16 SrRNA c) rDNA d) miRNA  
 Answer: (d)

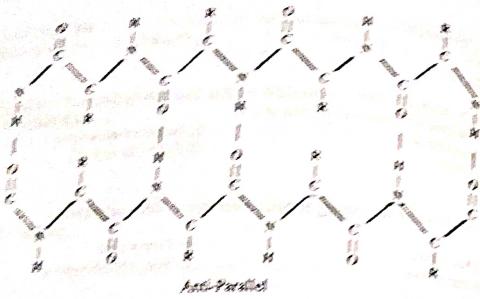
32. Uridine monophosphate is found in  
 a) Centrosome b) Lysosome c) Cell wall d) RNA  
 Answer: (d)

33. Franklin and Wilkins showed that DNA  
 a) Contains four bases b) Is a helix  
 c) Has equal amount of adenine and thymine  
 d) Is made up of nucleotides  
 Answer: (b)

[MODEL QUESTION]

**BIOLOGY**

[MODEL QUESTION]

**CBSE PUBLICATIONS**

2. Explain the structure and properties of starch.

**Answer:**

The basic chemical formula of the starch molecule is  $(C_{6}H_{10}O_5)_n$ . Starch is a carbohydrate comprising glucose monomers joined in  $\alpha 1,4$  linkages. The simplest form of starch is the linear polymer amylose; amylopectin is the branched form.

The functional properties of starch granules include swelling power, starch solubility, gelatinization, retrogradation, synthesis, and rheological behaviour, which are generally determined by the multiple characteristics of starch structure. Starch is the main constituent of chestnut fruit.

3. Write short notes on the following:

- Structure of t-RNA
- TATA box

**Answers:**

a) Structure of t-RNA:

The t-RNA molecule has a distinctive folded structure with three hairpin loops that form the shape of a three-leaved clover. One of these hairpin loops contains a sequence called the anticodon, which can recognize and decode an mRNA codon. Each t-RNA has its corresponding amino acid attached to its end.

b) TATA box:

A TATA box is a DNA sequence that indicates where a genetic sequence can be read and decoded. It is a type of promoter sequence, which specifies to other molecules where transcription begins. Transcription is a process that produces an RNA molecule from a DNA sequence.

4. Define polysaccharides. Classify them and explain their importance. Describe the structure and functions of Mucopolysaccharides.

[MODEL QUESTION]

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[MODEL QUESTIONS]

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**Answer:**  
Polysaccharides are long chains of carbohydrate molecules, specifically polymeric carbohydrates composed of monosaccharide units bound together by glycosidic linkages. This carbohydrate can react with water (hydrolysis) using amylase enzymes as catalyst, which produces constituent sugars (monosaccharides, or oligosaccharides). They range in structure from linear to highly branched. Examples include storage polysaccharides such as starch and glycogen, and structural polysaccharides such as cellulose and chitin.

**The structure and functions of Mucopolysaccharides:**

Mucopolysaccharides are long linear polysaccharides consisting of repeating disaccharide (double sugar) units. Except for keratan, the repeating unit consists of an amino sugar, along with a uronic sugar or galactose.

Mucopolysaccharides or Glycosaminoglycans are highly polar and attract water and are therefore useful to the body as a lubricant or as a shock absorber. They can covalently connect to proteins in order to form proteoglycans.

5. What are the molecules of life?

[MODEL QUESTION]

**Answer:**

All life on Earth is built from four different types of molecules. These four types of molecules are often referred to as the molecules of life. The four molecules of life are proteins, carbohydrates, lipids and nucleic acids. Each of the four groups is vital for every single organism on Earth. Without any of these four molecules, a cell and organism would not be able to live. All of the four molecules of life are important either structurally or functionally for cells and, in most cases, they are important in both ways.

6. What are the four molecules of life?

[MODEL QUESTION]

**Answer:**

All organisms need four types of organic molecules: nucleic acids, proteins, carbohydrates and lipids; life cannot exist if any of these molecules are missing.

- Nucleic Acids. The nucleic acids are DNA and RNA, or deoxyribonucleic acid and ribonucleic acid, respectively. ...
- Proteins. ...
- Carbohydrates. ...
- Lipids

7. Are molecules living things?

[MODEL QUESTION]

**Answer:**

But as well as carbon, living organisms also contain a lot of hydrogen, oxygen, nitrogen, sulfur, and phosphorous. Those atoms combine together to form complex molecules of various types: proteins, carbohydrates, lipids, and nucleic acids

8. What was the first molecule of life?

[MODEL QUESTION]

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**Answer:**  
The widely accepted view among scientists is that RNA, found in all living cells, would have likely represented the first molecules of life, hypothesizing an "RNA-first" view of the origin of living systems from non-living molecules.

**9. Why is carbon so basic to life?**

**Answer:**  
The reason is carbon's ability to form stable bonds with many elements, including itself. This property allows carbon to form a huge variety of very large and complex molecules. In fact, there are nearly 10 million carbon-based compounds in living things!

**[MODEL QUESTION]****10. What is macromolecule?**

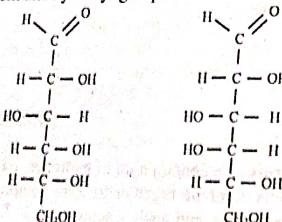
**Answer:**  
A macromolecule is a very large molecule, such as protein, commonly created by the polymerization of smaller subunits (monomers). They are typically composed of thousands of atoms or more. The most common macromolecules in biochemistry are biopolymers (nucleic acids, proteins, carbohydrates and lipids) and large non-polymeric molecules (such as lipids and macrocycles). Synthetic macromolecules include common plastics and synthetic fibers as well as experimental materials such as carbon nanotubes.

**11. Give the Definition of Carbohydrates.****[MODEL QUESTION]**

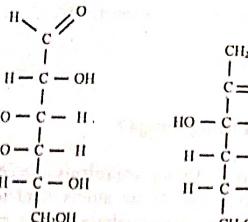
**Answer:**  
Carbohydrates are made up of carbon, hydrogen, and oxygen. They can also be defined as Polyhydroxy Aldehydes or Ketones.

**12. Describe the Carbohydrate Structure.****[MODEL QUESTION]**

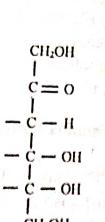
**Answer:**  
Generally, word saccharides are used for carbohydrates. Saccharides includes starch, sugars, cellulose etc. Formaldehyde is considered as simplest carbohydrate. They have general formula  $(CH_2O)_n$ , where n is three or more. They have aldehyde or ketone with hydrogen atom and hydroxyl group.



Glucose



Galactose



Fructose

Fig: Structure of Carbohydrates

**13. Classify the Monosaccharides on the Basis of Number of Carbons Present.**  
**[MODEL QUESTION]**

**Answer:**  
If number of carbon atoms present is 6, then it is known as Hexose Sugar. For Example: Glucose.

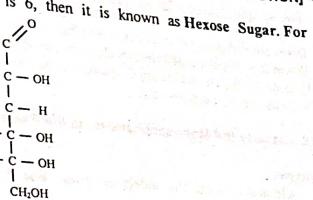


Fig: Structure of Glucose or Hexose Sugar

If number of carbon atoms present is 5, then it is known as Pentose Sugar. For Example: Ribose.

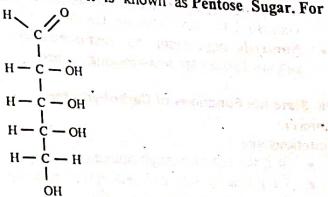


Fig: Structure of Ribose

If number of carbon atoms present is 3, then it is known as Triose Sugar. For Example: Glyceraldehyde.

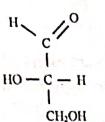


Fig: Structure of Glyceraldehyde

**14. What are the different classes of Carbohydrates?****[MODEL QUESTION]**

**Answer:**

**Classification of Carbohydrates / Types of Carbohydrates**

- Classification on the basis of number of units of sugar  
Saccharides can be monosaccharides, disaccharides,

oligosaccharides and polysaccharides. The simplest saccharide or unit of saccharides are known as Monosaccharides, such as Glucose. When two monosaccharides are joined by glycosidic bond, they form Disaccharides, such as Sucrose. Sucrose is composed of Glucose and Fructose. When 2 to 10 units of monosaccharides are joined, they form Oligosaccharides, such as Raffinose. When more than 10 monosaccharides are joined, they form Polysaccharides. Such as starch, cellulose etc.

#### 15. Classify the Monosaccharides on the Basis of Functional Group Present.

[MODEL QUESTION]

**Answer:**

- Aldoses contain the aldehyde group. For Example: Glucose, Galactose, Ribose, Glyceraldehyde, etc.
- Ketoses contain the ketone group. For Example: Fructose
- Reducing sugars contain a hemiacetal or hemiketal group. For Example: Glucose, Galactose, Fructose, Maltose, Lactose
- Non-reducing contain no hemiacetal groups. For Example: Sucrose and all polysaccharides are non-reducing sugars.

#### 16. State the Functions of Carbohydrates.

[MODEL QUESTION]

**Answer:**

**Functions are-**

- It is the most common source of energy.
- Cellulose is present in cell wall of plants that provides and rigidity to it.
- Lactose sugar is found in milk.
- Chitin is also another sugar found in exoskeleton of insects.
- It is a dietary fiber.

#### 17. What is Lipids?

[MODEL QUESTION]

**Answer:**

Term lipid was coined by Bloor. These are esters of fatty acids and alcohol. They are hydrophobic insoluble in water but soluble in benzene, ether and chloroform.

#### 18. What are the different types of Lipid?

[MODEL QUESTION]

**Answer:**

Lipids are classified into three groups:

- (i) **Simple lipids:** These are the esters of fatty acids and glycerol. Again they are typed as:
  - (a) **Fats and Oils:** (Natural lipids or true fats). These triglycerides of fatty acid and glycerol. Fats which are liquid at room temperature are called oils. Oils with polyunsaturated fatty acids are called polyunsaturated e.g. sunflower oil, lower blood cholesterol.
  - (b) **Fatty acids:** Obtained by hydrolysis of fats. Formic acid is simplest fatty acid ( $\text{HCOOH}$ ). These are of 2 types:

**BIOLOGY**  
Saturated fatty acids: The fatty acids which do not have double bond in between carbon atoms.e.g. butyric acid, palmitic acid, hexanoic acid, etc. They have high melting points, solid at room temperature and increase blood cholesterol.

Unsaturated fatty acids: The fatty acids which have double bonds in carbon atoms. e.g. 8 hexadecanoic acid, 9 octadecanoic acid etc. They have lower melting points mostly found in plant fats, liquid at room temperature and lower the blood cholesterol.

(c) **Waxes:** These are simple lipids composed of one molecule of long chain fatty acid and long chain monohydric alcohol. Waxes have high melting point, insoluble in water, resistant to atmospheric oxidation, chemically inert and not digested by enzymes. They reduce rate of transpiration by making plant tissue water proof and work as excellent lubricant.

**Types of waxes**

- **Plant wax :** Forms coating.
- **Bee's wax :** It is secretion of abdominal glands of worker honeybee. It consists of palmitic acid and myricyl alcohol.
- **Lanolin or Wool fat :** It is secreted by cutaneous glands, also obtained from wool of sheeps. It consists of palmitic acid, oleic or stearic acid and cholesterol.
- **Sebum :** It is secretion of sebaceous gland of skin.
- **Paraffin wax :** Obtained from petroleum.

(ii) **Compound lipids:** They contain some additional or element. Group with fatty acid and alcohol on the basis of group they may be of following types:

a) **Phospholipids:** These contain phosphoric acid. It helps in transport, metabolism, blood clotting and permeability of cell membrane. It is a bipolar molecule i.e. phosphate containing end is hydrophilic whereas fatty acid molecules represent hydrophobic (non-polar tail). Phospholipids again comprises.

**Lecithin:** These are yellowish grey solids, soluble in ether and alcohol but insoluble in acetone. On hydrolysis they yield glycerol, fatty acid, phosphoric acid and choline. Lecithins are broken down by enzyme lecithinase to lyssolecithin. The enzyme is found in venom of bee and cobra.

**Cephalins:** Found in animal tissue and soyabean oil. Cephalin contains choline or serine sometimes and stearic acid, oleic acid, linoleic and arachidonic acid.

- b) **Glycolipids:** These contain nitrogen and carbohydrate beside fatty acids. Generally found in white matter of nervous system. e.g. sesocine frenocin.
- c) **Chromolipids:** It includes pigmented lipids e.g. carotene.
- d) **Aminolipids:** Also known as sulpholipids. It contains sulphur and amino acids with fatty acid and glycerol. Cutin and suberin are also compound lipids resistant to water and also provide mechanical support in plants.

- (iii) **Derived lipids:** These are obtained by hydrolysis of simple and compound lipids. Derived lipids include following components:
- Sterols:** Lipids without straight chains are called sterols. They are composed of fused hydrocarbon rings and a long hydrocarbon side chain. Best known sterol is cholesterol, present in high concentration in nervous tissue and in bile. Cholesterol is also the precursor of hormones like progesterone, testosterone, estradiol and cortisol and vitamin D. Diosgenin is obtained from yam plant (*Dioscorea*) used in making anti-infertility pills.
  - Digitatin:** It is prepared from leaves of Foxglove (*Digitalis lantana*) is a heart stimulant.
  - Ergosterol:** Present in food, found in ergot and yeast. It is precursor of another form of vitamin D, ergocalciferol ( $D_2$ ).
  - Coprosterol:** It is found in faeces. It is formed as a result of the reduction by bacteria in intestine from the double bond of cholesterol between C<sub>5</sub> and C<sub>6</sub>.
  - Tarpons:** It is essential oil and present mostly in oils of camphor, eucalyptus, lemon and mint. Phytol is a terpenoid alcohol present in Vitamin A, K, E and in pigments like chlorophyll carotenoid. Other forms are licopene, gibberellins and natural rubber.
  - Prostaglandin:** It is hormone like compound derived from arachidonic acid. Mostly present in secretion of seminal vesicles in males and menstrual cycle fluid in females.
  - Blubber:** A very thick layer of subcutaneous fat in whale.

#### 19. What are the Functions of lipids?

[MODEL QUESTION]

- Answer:
- Oxidation of lipids yields comparatively more energy in the cell than protein and carbohydrates. 1gm of lipids account for 39.1 KJ.
  - The oil seeds such as groundnut, mustard, coconut store fats to provide nourishment to embryo during germination.
  - They function as structural constituent i.e. all the membrane system of the cell are made up of lipoproteins.
  - Amphipathic lipids are emulsifier.
  - It works as heat insulator.
  - Used in synthesis of hormones.
  - Fats provide solubility to vitamins A, D, E, and K.

#### 20. What is Amino Acid?

[MODEL QUESTION]

Answer:

Amino acids are normal components of cell proteins (called amino acid). They are 20 in number specified in genetic code and universal in viruses, prokaryotes and eukaryotes. Otherwise amino acids may be termed rare amino acids, which take part in protein synthesis e.g. hydroxyproline and non-protein amino acids do not take part in protein synthesis e.g. Ornithine, citrulline, gamma-aminobutyric acid (GABA) a neurotransmitter, etc.

#### 21. Describe the Structure and Composition of amino acid. [MODEL QUESTION]

BIOLOGY  
Answer:  
Amino acids are basic units of protein and made up of C, H, O, N and sometimes S. Amino acids are organic acids with a carboxyl group (-COOH) and one amino group (-NH<sub>2</sub>) on the α-carbon atom. Carboxyl group attributes acidic properties and amino group gives basic ones. In solution, they serve as buffers and help to maintain pH. General formula is R-CH(NH<sub>2</sub>)COOH.

Amino acids are amphoteric or bipolar ions or Zwitter ions. Amino acids link with each other by peptide bond and long chains are called polypeptide chains.

#### 22. What are the different Classes of amino acid?

[MODEL QUESTION]

Answer:

Classification

Based on R-group of amino acids:

- Simple amino acids:** These have no functional group in the side chain. e.g. glycine, alanine, leucine, valine etc.
- Hydroxy amino acids:** They have alcohol group in side chain. e.g. threonine, serine, etc.
- Sulphur containing amino acids:** They have sulphur atom in side chain. e.g. methionine, cysteine.
- Basic amino acids:** They have basic group (-NH<sub>2</sub>) in side chain. e.g. lysine, arginine.
- Acidic amino acids:** They have carboxyl group in side chain. e.g. aspartic acid, glutamic acid.
- Acid amide amino acids:** These are the derivatives of acidic amino acids. In this group, one of the carboxyl group has been converted to amide (-CONH<sub>2</sub>). e.g. asparagine, glutamine.
- Heterocyclic amino acids:** These are the amino acids in which the side chain includes a ring involving at least one atom other than carbon. e.g. tryptophan, histidine.
- Aromatic amino acids:** They have aromatic group (benzene ring) in the side chain. e.g. phenylalanine, tyrosine, etc.

**On the basis of requirements:** On the basis of the synthesis amino acids in body and their requirement, they are categorized as:

- Essential amino acids:** These are not synthesized in body hence to be provided in diet e.g. valine, leucine, isoleucine, threonine, lysine, etc.
- Semi-essential amino acids:** Synthesized partially in the body but not at the rate to meet the requirement of individual. e.g., arginine and histidine.
- Non-essential amino acids:** These amino acids are derived from carbon skeleton of lipids and carbohydrate metabolism. In humans there are 12 non-essential amino acids e.g. alanine, aspartic acid, cysteine, glutamic acid etc. Proline and hydroxyproline have, NH (imino group) instead of NH<sub>2</sub> hence are called imino acids. Tyrosine can be converted into hormone thyroxine and adrenaline and skin pigment melanin. Glycine is necessary for production of heme. Tryptophan is the precursor of vitamin niacinamide etc.

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and auxins. If amino group is removed from amino acid it can form glucose and if  $\text{COOH}$  group is removed, it forms amines e.g. histamine.

#### **23. What are the Functions of Amino Acid?**

**Answer:**

##### **Functions of Amino Acids**

- Amino acids are building blocks of proteins and enzymes.
- By glycogenolysis, they form glucose.
- Hormones like adrenaline and thyroxine are formed with the help of tyrosine.
- Antibiotics often contain non-protein amino acids.
- They are precursors of many substances.

#### **24. What are the Significance of nucleic acids?**

**Answer:**

Deoxyribonucleic acids and ribonucleic acids are the key centres which control all the metabolic activities of cell and in turn the whole organism.

(1) If there occurs any deficiency in the DNA amount, nucleus loses its capacity to support adenosine triphosphate (ATP) synthesis.

(2) Nucleus also becomes inefficient to incorporate amino acids into proteins.

(3) Besides, DNA is the main genetic material constituting genes and chromosomes which carry hereditary information from generation to generation. DNA helps in the RNA synthesis in the cell. If the loops of amphibian oocytic chromosome (lamp brush) are exposed to actinomycin (which has the property to fuse with DNA and thereby causing decrease in DNA amount), RNA synthesis is inhibited.

(4) Recently, McConnell and Cameron (1968) have produced the evidence that RNA amount increases the intelligence and learning capacity of men.

#### **25. What do mean by Denaturation of DNA.**

**Answer:**

DNA exists in double stranded form. When two DNA strands separate from each other, DNA is said to be denatured. Heating or alkaline pH denatures the DNA. The temperature at which DNA double strands can be separated is known as Melting Temperature. Breakage of G-C base pairs needs high temperature as compared to breakage of A-T base pairs due to triple bond in G-C base pairs. But if denaturing agents are removed, the DNA will regain its structure and it is said to be renatured.

Boiled eggs become hard because egg proteins and DNA gets denatured. A classic example of denaturing in proteins comes from egg whites, which are typically largely egg albumins in water. Fresh from the eggs, egg whites are transparent and liquid. Cooking the thermally unstable whites turns them opaque, forming an interconnected solid mass. Quantification of DNA content is performed using Absorption at 260nm.

### [MODEL QUESTION]

### BIOLOGY

#### **[MODEL QUESTION]**

#### **26. Define of Nucleic Acid.**

**Answer:**

Nucleic acids are large, organic molecules present in living cells. DNA and RNA are nucleic acids. They are the polymers of nucleotides. There are three chemically distinct components in a nucleotide. These are as follows- Phosphate group, sugar known as Deoxyribose or Ribose and nitrogenous bases. There are two types of nitrogenous bases - Purines and Pyrimidines. Purines includes adenine and guanine whereas pyrimidines include thymine and cytosine. DNA contains all 4 bases, that is, adenine, guanine, thymine and cytosine. But in RNA, thymine is replaced by uracil.

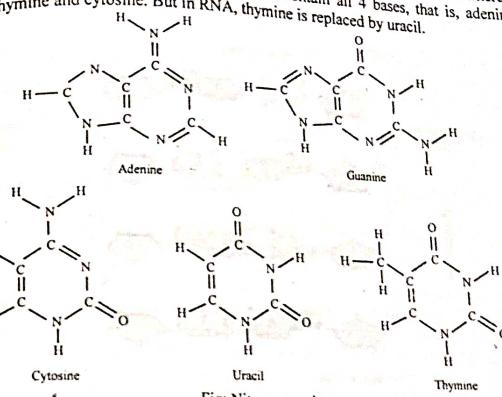


Fig: Nitrogenous bases

DNA contains deoxyribose sugar whereas RNA contains ribose sugar.

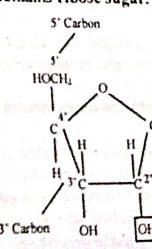
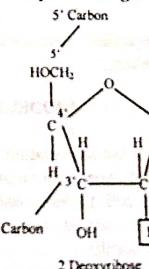


Fig: Structure Deoxyribose and Ribose Sugar

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**BIO-80**

27. Describe the Structure of the DNA.

**Answer:**

DNA is a double helix formed by twisting of two polynucleotide chains around each other. Watson and Crick proposed the DNA structure using X-ray diffraction studies. The two strands are antiparallel to each other. The bases are stacked inside the helix. The two helices are bonded together via hydrogen bond. Adenine forms two hydrogen bonds with thymine and cytosine forms three hydrogen bonds with guanine.

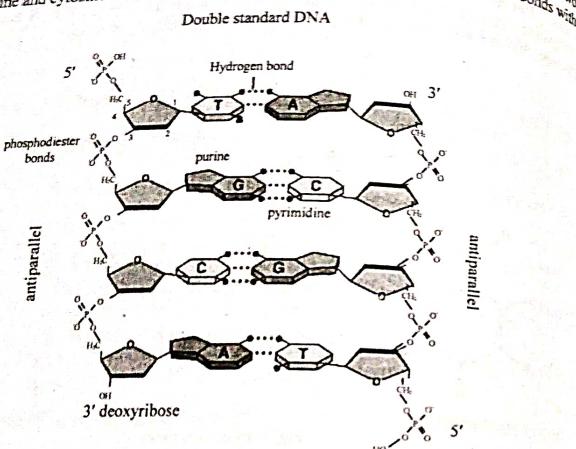


Fig: Hydrogen Bonding in DNA

DNA is negatively charged due to the presence of phosphate groups. This negative charge is stabilized by basic proteins known as histone proteins.

28. How nucleic acids are important for life?

**Answer:**

All the hereditary (genetic) information of the cell (i.e., all the information necessary to reproduce and maintain a new organism) is stored in coded form in molecules of DNA. DNA is replicated and distributed to daughter cells during cell division, and in this way all the hereditary information accumulated over billions of years of evolution is passed from cell to cell and from one generation of an organism to another.

With the aid of RNA, this information is expressed as specific patterns of protein synthesis. These nucleic acids are of two types: (i) deoxyribonucleic acid (DNA) and (ii) ribonucleic acid (RNA). DNA is the major store of genetic information. This information

**[MODEL QUESTION]**

**BIOLOGY**  
is transmitted by transcription into RNA molecules, proteins are then synthesized in a process involving translation of the RNA.

DNA → transcription RNA → translation Protein

In higher cells DNA is localized mainly in the nucleus as part of the chromosomes. A small amount of DNA is present in the cytoplasm and contained within mitochondria and chloroplasts. RNA is found both in the nucleus, where it is synthesized, and in the cytoplasm, where the synthesis of proteins takes place.

Nucleic acids consist of a sugar (pentose), nitrogenous bases (purines and pyrimidines), and phosphoric acid. A nucleic acid molecule is a linear polymer in which nucleotides are linked together by means of phosphodiester 'bridges' or bonds. These bonds link the 3' carbon in the pentose of one nucleotide to the 5' carbon in the pentose of the adjacent nucleotide. Thus the backbone of a nucleic acid consists of alternating phosphates and pentoses. The nitrogenous bases are attached to the sugars of this backbone.

Nucleic acids are basophilic, i.e., stain readily with basic dyes. After a mild hydrolysis the nucleic acids are decomposed into nucleotides.

29. Describe the structure of DNA in details.

**[MODEL QUESTION]**

**Answer:** It forms about 9% part of nucleus as found by spectrophotometric analysis. Chemically it consists of mainly three components: phosphoric acid, sugar, and bases.

**1. Phosphoric acid:**

It may occur also as phosphate and forms the backbone of DNA molecule along with sugar molecule. It links the nucleotides by joining the deoxyribose (pentose sugar) of two adjacent nucleotides with an ester-phosphate bond. These bonds connect carbon 3' in one nucleotide with carbon 5' in next. This acid is a channel for the chemical energy used by the molecule.

**2. Pentoses:**

These are of two types: ribose in RNA and deoxyribose in DNA. DNA has one oxygen atom less than that of RNA. The pentose sugar in nucleic acids is always ribose-, in RNA it is D-ribose and in DNA, it is deoxyribose. It is always the OH on C-1 carbon which is the point of attachment of the base.

This linked to the 1-nitrogen atom in case of pyrimidines and to 9-nitrogen atom in purines. Both deoxyribose and ribose (pentose sugars of nucleic acids) have a pentagonal ring with five carbons, among which two (i.e., 3' and 5') are attached to phosphoric acid and three (1') to the base.

**3. Bases:**

These may be of two types:

(a) Purines and (b) Pyrimidines.

**(a) Purines:**

These are characterised by the presence of two fused benzene rings. They may be adenine (A) and guanine (G). RNA contains uracil (U) instead of thymine. The combination of base plus a pentose, minus the phosphate, forms a nucleoside. For example, adenine is a

purine base; adenine (adenine + ribose) is the corresponding nucleoside, i.e., deoxyadenosine and deoxyguanosine.

#### (b) Pyrimidines:

These are characterized by the occurrence of single benzene ring. They are thymine (T) and cytosine (C).

#### Nucleotides:

Nucleotides are phosphate esters of nucleosides, purine or pyrimidine bases linked to sugars. In the nucleotides, the 3'-nitrogen of the pyrimidine bases or the 9-N of the purine bases is attached to the 1-carbon atom of the sugar, and the phosphoric acid residue is attached to the 5'-carbon atom of the sugar.

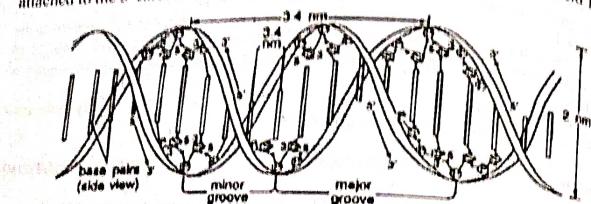


Fig: Double-helical model of DNA

Thus nucleotides of purines are deoxyribonucleic acid and deoxyriboguanine acid, and of pyrimidines are deoxyribothymidine acid and deoxyribocytidine acid.

#### 30. What are the different types of RNA?

[MODEL QUESTION]

**Answer:**

The ribonucleic acids are of three types:

#### 1. Messenger RNA:

This ribonucleic acid is of nuclear origin and conveys genetic information from DNA in the nucleus to the ribosomes in the cytoplasm, where amino acids become grouped to form proteins.

#### 2. Transfer or adapter RNA:

It is another important type of ribonucleic acid which is present in the cytoplasm, helping there in protein synthesis. It has been recently found that t-RNA originates from nucleus near the nucleolar region.

#### 3. Ribosomal RNA:

This ribonucleic acid is the major component of cytoplasmic particles called ribosomes. Ribosomal RNA comprises up to 80% of the cellular RNA of *Escherichia coli*. It is the site of amino acids union.

#### 31. Describe the Importance of Nucleic Acids/Functions of Nucleic Acids.

[MODEL QUESTION]

**Answer:** Deoxyribonucleic acids and ribonucleic acids are the key components which control almost all the metabolic activities in an organism.

- DNA is necessary for transferring genes from parents to offspring.
- DNA stores all the information of a cell.
- Loss of DNA content is associated with lots of diseases.
- DNA samples are used to identify the suspect or father of an unidentified child.
- DNA sequence helps in studying relationship between the two organisms such as which organism originates from which ancestor.
- Without DNA, no protein synthesis will occur.
- RNA is essential for protein synthesis.
- RNA and DNA helps to understand the diseases and to find the cure of genetic diseases.

#### 32. Describe the Structure of the RNA.

[MODEL QUESTION]

**Answer:**

RNA exists as single stranded structure. In RNA, thymine is replaced by uracil. There are 3 major classes of RNA found:

- **Messenger RNA** is a sequence of nucleotides that codes for proteins. In messenger RNA, nucleotides are arranged in the form of codons.
- **Transfer RNA** is used during protein synthesis. It is found in the cytoplasm.
- **Ribosomal RNA** is also found in cytoplasm and is the most abundant RNA found in cells.

#### 33. Describe the Structure of RNA.

[MODEL QUESTION]

**Answer:**

RNA is a long-chain molecule built up of repeating nucleotide units linked by 3' to 5' phosphate diester bonds. Sugar component of RNA is ribose and three out of four bases, adenine, guanine and cytosine are the same as in DNA, and the fourth base is uracil in place of thymine of DNA. Uracil has one methyl group less.

#### Nucleotides:

RNA nucleotides are formed from pentose sugar ribose, phosphoric acid and either adenine, guanine, cytosine or uracil (U). Nucleotides are regarded as phosphorylated derivatives of nucleosides. Nucleosides are combinations of a nitrogenous base and a pentose sugar without an attached phosphate group.

A nucleotide unit consists of a molecule of sugar, a base and a phosphoric acid. A single nucleic acid contains a large number of nucleotide units consisting of high molecular weight (about 8,000,000).

Nucleotides are the monomeric units of the nucleic acid macromolecule. The nucleotides result from the covalent bonding of a phosphate and a heterocyclic base to the pentose. Within the nucleotide, the combination of a base with the pentose forms a nucleoside.

For example, adenine is a purine base; adenosine (adenine + ribose) is the corresponding nucleoside, and adenosine monophosphate (AMP), adenosine diphosphate (ADP) and

adenosine triphosphate (ATP) are nucleotides. Nucleotides, thus constitute the building blocks of nucleic acids and they are also used to store and transfer chemical energy.

**Polynucleotide:**

Nucleotides are joined together to form a polynucleotide chain by a covalent linkage between the phosphoric acid residue of one nucleotide and 3' carbon of the sugar on the next nucleotide. This linkage is often called a 3', 5' phosphodiester bond, because the phosphate is esterified to two OH groups, one attached to the 3' carbon and one attached to the 5' carbon.

The backbone of a polynucleotide chain thus consists of alternating sugar and phosphate units.

The sequence of nucleotides in DNA and RNA is the key to their genetic functions, just as the sequence of amino acids determines the biological activity of a particular protein. Even though both DNA and RNA are usually composed of only four different nucleotides, the number of possible sequences of nucleotides is enormous in a large polymer.

RNA usually exists as a single-stranded polynucleotide chain and have no regular helical configuration. The linear chain is thought to be folded in many ways, with certain nucleotides pairing off and forming short double-stranded regions.

**34. Describe the double helix model of DNA.****[MODEL QUESTION]****Answer:**

On the basis of X-ray diffraction data of Wilkins and Franklin, Watson and Crick (1953) proposed a model for DNA structure. It is composed of two right-handed helical polynucleotide chains that form a double helix around the same central axis. The two strands are antiparallel, meaning that their 3', 5' phosphodiester links run in opposite directions. The bases are stacked inside the helix in a plane perpendicular to the helical axis.

The two strands are held together by hydrogen bonds present between pairs of bases. Since there is a fixed distance between two pentose sugars in the opposite strands, only certain base pairs can fit into the structure.

As shown in figure 5 two hydrogen bonds are formed between A and T, three are formed between C and G, therefore a CG pair is more stable than AT pair. In addition to hydrogen bonds, hydrophobic interactions established between the stacked bases are important in maintaining the double helical structure.

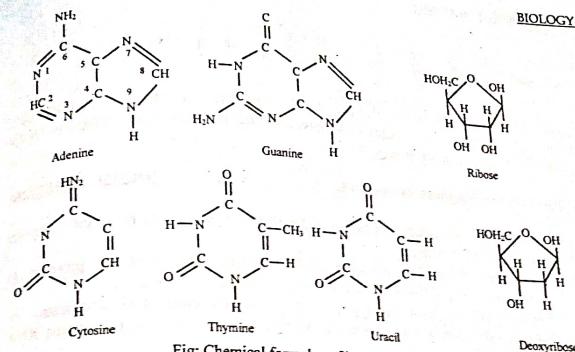


Fig: Chemical formulae of bases and sugars

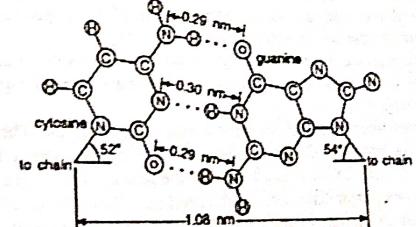
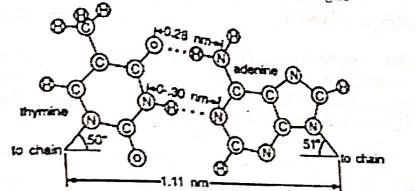
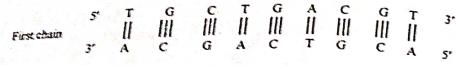


Fig: Two base pairs in DNA. Complementary bases are T=A and C=G linked with hydrogen bonds

The axial sequence of bases along one polynucleotide chain may vary considerably, but on the other chain the sequence must be complementary, as given below —



Because of this property, order of bases on one chain, the other chain is complementary. During duplication the two chains dissociate and each one serves as a template for the synthesis of a new complementary chain.

### 35. Describe the Structure of the RNA.

**Answer:**

RNA exists as single stranded structure. In RNA, thymine is replaced by uracil. There are 3 major classes of RNA found:

- Messenger RNA is a sequence of nucleotides that codes for proteins. In messenger RNA, nucleotides are arranged in the form of codons.
- Transfer RNA is used during protein synthesis. It is found in the cytoplasm.
- Ribosomal RNA is also found in cytoplasm and is the most abundant RNA found in cells.

### 36. Describe the Structure of RNA.

**Answer:**

RNA is a long-chain molecule built up of repeating nucleotide units linked by 3' to 5' phosphate diester bonds. Sugar component of RNA is ribose and three out of four bases, adenine, guanine and cytosine are the same as in DNA, and the fourth base is uracil in place of thymine of DNA. Uracil has one methyl group less.

#### Nucleotides:

RNA nucleotides are formed from pentose sugar ribose, phosphoric acid and either derivatives of nucleosides. Nucleosides are combinations of a nitrogenous base and a pentose sugar without an attached phosphate group.

A nucleotide unit consists of a molecule of sugar, a base and a phosphoric acid. A single nucleic acid contains a large number of nucleotide units consisting of high molecular weight (about 8,000,000).

Nucleotides are the monomeric units of the nucleic acid macromolecule. The nucleotides result from the covalent bonding of a phosphate and a heterocyclic base to the pentose. Within the nucleotide, the combination of a base with the pentose forms a nucleoside. For example, adenine is a purine base; adenosine (adenine + ribose) is the corresponding nucleoside, and adenosine monophosphate (AMP), adenosine diphosphate (ADP) and adenosine triphosphate (ATP) are nucleotides. Nucleotides, thus constitute the building blocks of nucleic acids and they are also used to store and transfer chemical energy.

**Polynucleotide:**  
Nucleotides are joined together to form a polynucleotide chain by a covalent linkage between the phosphoric acid residue of one nucleotide and 3' carbon of the sugar on the

#### [MODEL QUESTIONS]

#### [MODEL QUESTIONS]

#### BIOLOGY

next nucleotide. This linkage is often called a 3', 5' phosphodiester bond, because the phosphate is esterified to two OH groups, one attached to the 3' carbon and one attached to the 5' carbon.

The backbone of a polynucleotide chain thus consists of alternating sugar and phosphate units.

The sequence of nucleotides in DNA and RNA is the key to their genetic functions, just as the sequence of amino acids determines the biological activity of a particular protein. Even though both DNA and RNA are usually composed of only four different nucleotides, the number of possible sequences of nucleotides is enormous in a large polymer.

DNA usually exists as a single-stranded polynucleotide chain and have no regular helical configuration. The linear chain is thought to be folded in many ways, with certain nucleotides pairing off and forming short double-stranded regions.

### 37. Describe the Molecular arrangement of components in nucleic acids.

#### [MODEL QUESTIONS]

**Answer:**

In deoxyribonucleic acid (DNA), nucleotides are arranged in the form of helices or chains spirally coiling around each other. According to Watson and Crick (1962), DNA consists of two helices coiled about each other. The chain of each helix is made of sugar and phosphate group.

These two helices are interconnected by the bases through hydrogen bonds. Generally one purine becomes attached with one pyrimidine to form base connection between the chain. Thus, adenine along with thymine, and cytosine along with guanine becomes connected with the sugar molecule of chain alternately.

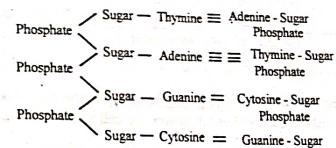


Fig: Molecular arrangement of components in DNA

The direction of one helix is opposite to the other. In DNA one helix serves as a template for the formation of complementary helix, i.e., adenine in one helix forms the thymine in new helix and similarly cytosine effects the formation of guanine in new helix.

In ribonucleic acid (RNA), the nucleotides are not arranged in double helical model but for the most part RNA exists as a single strand. Sometimes it may form also smaller helices in some parts due to folding and convolutions. These secondary helical structures in RNA are regular according to recent research. In the formation of helix, bases become hydrogen-bonded like DNA except uracil substitutes thymine.

**ENZYMES****Chapter at a Glance**

- Enzymes (Gk. en = in; zyme = yeast) are proteinaceous substances which are capable of catalysing chemical reactions of biological origins without themselves undergoing any change.
- Enzymes are biocatalysts.
- An enzyme may be defined as "a protein that enhances the rate of biochemical reactions but does not affect the nature of final product."
- Maximum enzymes (70%) in the cell are found in mitochondrion. The study of the composition and function of the enzyme is known as enzymology.

**Classification of Enzymes**

Group of Enzyme	Reaction Catalysed	Examples
1. Oxidoreductases	Transfer of hydrogen and oxygen atoms or electrons from one substrate to another	Dehydrogenases oxidases
2. Transferases	Transfer of a specific group (a phosphate or methyl etc.) from one substrate to another	Transaminase Kinases
3. Hydrolases	Hydrolysis of a substrate	Estrases Digestive enzymes
4. Isomerases	Change of the molecular form of the substrate	Phospho hexo isomerase, Fumarase
5. Lyases	Nonhydrolytic removal of a group or addition of a group to a substrate	Decarboxylases Aldolases
6. Ligases (Synthetases)	Joining of two molecules by the formation of new bonds	Citric acid synthetase

Inorganic part of enzyme acts as prosthetic group in few enzymes they are called activator. These activators are generally metals. Hence these enzymes are called "Metallo enzyme" such as

S. No.	Activators	Enzymes
1	Iron (Fe)	Acotinase, Catalase and Cytochrome oxidase
2	Zinc (Zn)	Dehydrogenase, Carbonic anhydrase
3	Copper (Cu)	Triosinase, Ascorbic acid oxidase
4	Magnesium (Mg)	Kinase, Phosphatase

S. No.	Activators	Enzymes
5	Manganese (Mn)	Peptidase, Decarboxylase
6	Molybdenum (Mo)	Nitrate reductase
7	Nickel (Ni)	Urease
8	Boron	Enolase

**Mode of Action of Enzymes**

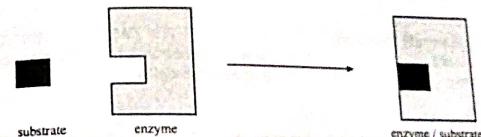
There are two views regarding the mode of enzyme action:

- Lock and key hypothesis
- Induced fit hypothesis

(1) **Lock and key hypothesis:** The hypothesis was put forward by Emil Fischer (1894). According to this hypothesis the enzyme and its substrate have a complementary shape. The specific substrate molecules are bound to a specific site of the enzyme molecule.

(2) **Induced fit hypothesis:** This hypothesis was proposed by Daniel, E. Koshland (1959). According to this view, the active sites of an enzyme are not rigid. When the substrate binds to enzyme, it may induce a change in shape of the enzyme molecule in such a way that it is fit for the substrate-enzyme interaction. The change in shape of the enzyme molecules can put strain on the substrate. This stress may help bonds to break, thus promoting the reaction.

"Lock and Key" model of substrate binding (Fischer)



"Induced Fit" model of substrate binding (Koshland)

**Multiple Choice Type Questions**

[MODEL QUESTION]

1. "Lysosomes" were discovered by

- Haekel
- De Duve
- De Vries
- Purkinje

Answer: (b)

POPULAR PUBLICATIONS

2. The "marker" enzyme of lysosome is  
a) Lysozyme (muramidase)  
b) Acid protease  
c) Acid phosphatase  
d) Beta-galactosidase

Answer: (c)

[MODEL QUESTION]

3. Which of the following statements is incorrect with reference to lysosomes  
a) They are filled acid hydrolase and other enzymes  
b) They are monomorphic and uniform in structure and function  
c) They may be autophagic  
d) They can digest proteins, nucleic acids, lipids and polysaccharides

Answer: (b)

**BIOLOGY**  
**Short & Long Answer Type Questions**  
1. Define enzyme inhibition. Explain in detail the different types of inhibitions with suitable examples. Explain the factors affecting enzyme activity.

[MODEL QUESTION]

Answer:  
An enzyme inhibitor is a molecule that binds to an enzyme and decreases its activity. By binding to enzymes' active sites, inhibitors reduce the compatibility of substrate and enzyme and this leads to the inhibition of Enzyme-Substrate complexes' formation, preventing the catalysis of reactions and decreasing (at times to zero) the amount of product produced by a reaction. It can be said that as the concentration of enzyme inhibitors increases, the rate of enzyme activity decreases, and thus, the amount of product produced is inversely proportional to the concentration of inhibitor molecules. Since blocking an enzyme's activity can kill a pathogen or correct a metabolic imbalance, many drugs are enzyme inhibitors. They are also used in pesticides. Not all molecules that bind to enzymes are inhibitors; *enzyme activators* bind to enzymes and increase their enzymatic activity, while enzyme substrates bind and are converted to products in the normal catalytic cycle of the enzyme.

Reversible inhibitors attach to enzymes with non-covalent interactions such as hydrogen bonds, hydrophobic interactions and ionic bonds. Multiple weak bonds between the inhibitor and the active site combine to produce strong and specific binding. In contrast to substrates and irreversible inhibitors, reversible inhibitors generally do not undergo chemical reactions when bound to the enzyme and can be easily removed by dilution or dialysis.

There are four kinds of reversible enzyme inhibitors. They are classified according to the effect of varying the concentration of the enzyme's substrate on the inhibitor.

- In **competitive inhibition**, the substrate and inhibitor cannot bind to the enzyme at the same time, as shown in the figure on the right. This usually results from the inhibitor having an affinity for the active site of an enzyme where the substrate also binds; the substrate and inhibitor compete for access to the enzyme's active site. This type of inhibition can be overcome by sufficiently high concentrations of substrate ( $V_{max}$  remains constant), i.e., by out-competing the inhibitor. However, the apparent  $K_m$  will increase as it takes a higher concentration of the substrate to reach the  $K_m$  point, or half the  $V_{max}$ . Competitive inhibitors are often similar in structure to the real substrate (see examples below).
- In **uncompetitive inhibition**, the inhibitor binds only to the substrate-enzyme complex. This type of inhibition causes  $V_{max}$  to decrease (maximum velocity decreases as a result of removing activated complex) and  $K_m$  to decrease (due to better binding efficiency as a result of Le Chatelier's principle and the effective elimination of the ES complex thus decreasing the  $K_m$  which indicates a higher binding affinity).
- In **non-competitive inhibition**, the binding of the inhibitor to the enzyme reduces its activity but does not affect the binding of substrate. As a result, the extent of inhibition depends only on the concentration of the inhibitor.  $V_{max}$  will decrease due

4. Which of the following organ has single membrane  
a) Nucleus      b) Cell wall      c) Mitochondria      d) Spherosomes

Answer: (b)

[MODEL QUESTION]

5. Lysosomes are rich in  
a) Polyribosome  
b) Lipoproteins  
c) DNA ligase  
d) Hydrolytic enzymes

Answer: (b)

6. Lysosomes are generally found in

- a) Animal cells only  
b) Animal cell and in some plant cells  
c) Plant cells only  
d) Bacterial cells

Answer: (b)

7. Which of the function is performed by lysosome  
a) Breakdown of cell substances  
b) Photosynthesis  
c) Breakdown of water  
d) Synthesis of protein

Answer: (a)

8. At which pH enzymes of Lysosomes are usually active  
a) pH 5      b) pH 7      c) pH 8      d) In any pH

Answer: (a)

9. The organelles whose major function is storage of hydrolytic enzymes are  
a) Centrioles      b) Chromoplasts      c) Lysosomes      d) Chloroplasts

Answer: (c)

10. A lysosome in which intracellular organelles is getting digested is called  
a) Primary lysosome  
b) Secondary lysosome  
c) Autophagosome  
d) None of these

Answer: (c)

- to the inability for the reaction to proceed as efficiently, but  $K_m$  will remain the same as the actual binding of the substrate, by definition, will still function properly.
- Mixed Inhibition:** the inhibitor can bind to the enzyme at the same time as the enzyme's substrate. However, the binding of the inhibitor affects the binding of the substrate, and vice versa. This type of inhibition can be reduced, but not overcome by increasing concentrations of substrate. Although it is possible for mixed-type inhibitors to bind in the active site, this type of inhibition generally results from an allosteric effect where the inhibitor binds to a different site on an enzyme. Inhibitor binding to this allosteric site changes the conformation (i.e., tertiary structure or three-dimensional shape) of the enzyme so that the affinity of the substrate for the active site is reduced.
- Irreversible inhibitors usually covalently modify an enzyme, and inhibition can therefore not be reversed. Irreversible inhibitors often contain reactive functional groups such as nitrogen mustards, aldehydes, haloalkanes, alkenes, Michael acceptors, phenyl sulfonates, or fluorophosphonates. These nucleophilic groups react with amino acid side chains to form covalent adducts. The residues modified are those with side chains containing nucleophiles such as hydroxyl or sulphydryl groups; these include the amino acids serine (as in DFP, right), cysteine, threonine, or tyrosine.

**Factors affecting enzyme activity**

Enzyme activity can be affected by a variety of factors, such as temperature, pH, and concentration. Enzymes work best within specific temperature and pH ranges, and sub-optimal conditions can cause an enzyme to lose its ability to bind to a substrate.

- Temperature:** Raising temperature generally speeds up a reaction, and lowering temperature slows down a reaction. However, extreme high temperatures can cause an enzyme to lose its shape (denature) and stop working.
- pH:** Each enzyme has an optimum pH range. Changing the pH outside of this range will slow enzyme activity. Extreme pH values can cause enzymes to denature.
- Enzyme concentration:** Increasing enzyme concentration will speed up the reaction, as long as there is substrate available to bind to. Once all of the substrate is bound, the reaction will no longer speed up, since there will be nothing for additional enzymes to bind to.
- Substrate concentration:** Increasing substrate concentration also increases the rate of reaction to a certain point. Once all of the enzymes have bound, any substrate increase will have no effect on the rate of reaction, as the available enzymes will be saturated and working at their maximum rate.

**[MODEL QUESTION]****2. What Is Enzyme?****Answer:**

Almost all enzymes are proteins. There are some nucleic acids that behave like enzymes. These are called ribozymes. One can depict an enzyme by a line diagram. An enzyme like any protein has a primary structure, i.e., amino acid sequence of the protein. An enzyme like any protein has the secondary and the tertiary structure. In the tertiary

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structure it will be noticed that the backbone of the protein chain folds upon itself, the chain criss-crosses itself and hence, many crevices or pockets are made. One such pocket is the 'active site'. An active site of an enzyme is a crevice or pocket into which the substrate fits. Thus enzymes, through their active site, catalyse reactions at a high rate.

**3. How enzyme is different from inorganic catalysts?****[MODEL QUESTION]**

Enzyme catalysts differ from inorganic catalysts in many ways, but one major difference needs mention. Inorganic catalysts work efficiently at high temperatures and high pressures, while enzymes get damaged at high temperatures (say above 40°C). However, enzymes isolated from organisms who normally live under extremely high temperatures (e.g., hot vents and sulphur springs), are stable and retain their catalytic power even at high temperatures (upto 80°-90°C).

**4. What are the Biological Importance of Enzyme?****[MODEL QUESTION]****Answer:**

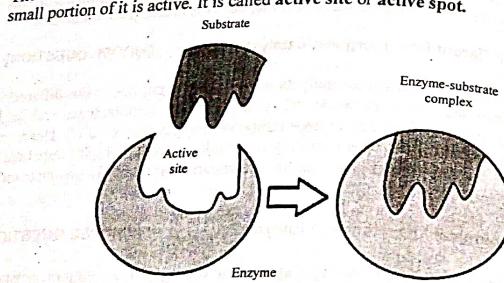
- Thousands of chemical reactions are taking place in the body of a living organism, all of them are mediated by enzymes.
- Enzymes are specialized catalysts that operate at biological temperatures.
- enzyme mediated reactions do not require harsh treatment.
- They are pH specific so that reactions requiring different pH operate in different parts of the body.
- As they operate under favourable conditions, enzymes force the organisms to live under favourable environment.
- Enzymes are highly regulated. Their formation is controlled by separate genes. Activation and repression of genes allow certain enzymes to be functional or nonfunctional in cells.

**5. Describe the Chemical Nature Of Enzymes?****[MODEL QUESTION]****Answer:**

- All enzymes are globular proteins (Sumner, 1926) with the exception of recently discovered RNA enzymes. Some enzymes may additionally contain a nonprotein group. Accordingly there are two types of enzymes, simple and conjugate.
- Simple Enzyme** It is an enzyme which is wholly made up of protein. Active site is formed by specific grouping of its own amino acids. Additional substance or group is absent, e.g., pepsin, trypsin, urease.
- Conjugate Enzyme** It is an enzyme which is formed of two parts- a protein part called apoenzyme (e.g., flavoprotein) and a nonprotein part named cofactor. The complete conjugate enzyme, consisting of an apoenzyme and a cofactor, is called holoenzyme. Active site is formed jointly by apoenzyme and cofactor.

**6. What do you understand by Active Site or Active Spot?** [MODEL QUESTION]

**Answer:**  
The whole of enzyme molecule is not active in catalyzing a chemical reaction. Only a small portion of it is active. It is called active site or active spot.



- An enzyme may have one to several active sites.
- An active site or spot is an area of the enzyme which is capable of attracting and holding particular substrate molecules by its specific charge, size and shape so as to allow the chemical change. It fails to recognize other molecules.

**7. What are the different classes of Enzymes?**

[MODEL QUESTION]

**Answer:**  
In older times enzymes were classified into two broad categories.

(i) **Hydrolyzing:**

Catalyzing hydrolysis of large molecules into smaller ones, e.g., carbohydrates or amylases, proteases, lipases, esterases, phosphorylases, amidases. Digestive enzymes are hydrolyzing in nature. They are often grouped into three types- proteolytic, amylolytic and lipolytic.

(ii) **Desmolyzing:**

Catalyzing reactions other than hydrolysis, e.g., aldolases, dehydrogenases, oxidases, peroxidases, catalase, carboxylases, etc.

The modern system of enzyme classification was introduced by International Union of Biochemistry (IUB) in 1961. It groups enzymes into the following six categories:

(a) **Oxidoreductases**

- They take part in oxidation and reduction reactions or transfer of electrons.
- Oxidoreductases are of three types- oxidases, dehydrogenases and reductases, e.g.,
- Cytochrome oxidase (oxidizes cytochrome), succinate dehydrogenase, nitrate reductase.

(b) **Transferases**  
They transfer a group from one molecule to another e.g., glutamate-pyruvate transaminase (transfers amino group from glutamate to pyruvate during synthesis of alanine). The chemical group transfer does not occur in free state.

(c) **Hydrolases**  
They catalyse hydrolysis of bonds like ester, ether, peptide, glycosidic, C-C, C-halide, P-N, etc. which are formed by dehydration condensation. Hydrolases break up large molecules into smaller ones with the help of hydrogen and hydroxyl groups of water group, e.g., amylase (hydrolysis of starch), sucrose, lactase.

(d) **Lyases**  
The enzymes cause cleavage, removal of groups without hydrolysis, addition of groups to double bonds or removal of a group producing double, e.g., histidine decarboxylase (breaks histidine to glyceraldehydes phosphate).

(e) **Isomerases**

The enzymes cause rearrangement of molecular structure to effect isomeric changes. They are of three types, isomerases (aldose to ketose group or vice-versa like glucose 6-phosphate to fructose 6-phosphate), epimerases (change in position of one constituent or carbon group like xylulose phosphate to ribulose phosphate) and mutases (shifting the position of side group like glucose-6-phosphate to glucose-1-phosphate).

(f) **Ligases (synthetases)**

The enzymes catalyse bonding of two chemicals with the help of energy obtained from ATP resulting in formation of such bonds as C-O, C-S, C-N and P-O, e.g., pyruvate carboxylase. It combines pyruvic acid with CO<sub>2</sub> to produce oxaloacetic acid.

**8. Describe the Characteristics (Properties) of Enzymes.** [MODEL QUESTION]

**Answer:**

**Properties of Enzymes are:**

- 1) **Protein nature:** Enzymes are generally globular proteins. They may have additional inorganic or organic substances for their activity.
- 2) **Molecular weight:** Being proteinaceous, the enzymes are giant molecules with a molecular weight of 6000 (bacterial ferredoxin) to 4,600,000 (pyruvate dehydrogenase complex).
- 3) **Colloidal nature:** They are hydrophilic and form hydrosol in the free state.
- 4) **Chemical Reaction:** Enzymes do not start a chemical reaction but increase the rate of chemical reaction. They do not change the equilibrium but bring about equilibrium very soon.
- 5) **Efficiency:** The number of substrate molecules changed per minute by a molecule or enzyme is called turn over number ( $k^{cat}$ ): The higher the turn-over number, the more efficient an enzyme is.
- 6) **Unchanged Form:** Enzymes are in no way transformed or used up in the chemical reaction but come out unchanged at the end of reaction.

- 7) **Reversibility:** Theoretically, all enzyme controlled reactions are reversible. Reversibility is, however, dependent upon energy requirements, availability of reactants, concentration of end products and pH.
- 8) **Enzyme specificity:** Enzymes are highly specific in their action. For example, enzyme maltase acts on sugar maltose but not on lactose or sucrose. Different enzymes may act on the same substrate but give rise to different products. For example, raffinose gives rise to melibiose and fructose in the presence of enzyme an enzyme may act on different substrates, e.g., sucrose can act on both sucrose and raffinose producing different end products.
- 9) **Heat Sensitivity:** All enzymes are heat sensitive or thermolabile. Most enzymes operate optimally between  $25^{\circ}\text{C}$ – $35^{\circ}\text{C}$ .
- 10) **Protein poisons:** Being made of proteins, enzymes are inactivated or denatured by all those substances and forces which destroy energy radiations.
- 11) **pH:** Each enzyme functions at a particular pH, e.g., pepsin ( $2\text{pH}$ ), sucrose ( $4.5\text{pH}$ ), salivary amylase ( $6.8\text{pH}$ ), trypsin ( $8.5\text{pH}$ ). A change in pH makes the enzymes ineffective.
- 13) **Enzyme-substrate Complex:** The active sites of enzymes have a specific conformation for attracting and holding substrate. It usually possess a crevice or pocket where the substrate fits in a complementary fashion.

9. Mention the factors which are influencing the enzyme activities?

[MODEL QUESTION]

**Answer:**

#### Factors Influencing Enzyme Activity

- (1) **Temperature:** An enzyme is active within a narrow range of temperature. The temperature generally corresponds to the body temperature of warm blooded animals, e.g.,  $37^{\circ}\text{C}$  in human beings. Enzyme activity decreases above and below this temperature. Enzyme become inactive below **minimum temperature** and beyond **maximum temperature**.
- (2) **Optimum pH:** Every enzyme has an optimum pH when it is most effective. A rise or fall in pH reduces enzyme activity by changing the degree of ionization of its side chains. A change in pH may also start reverse reaction.
- (3) **Enzyme concentration:** The rate of a biochemical reaction rises with the increase in enzyme concentration upto a point called limiting or saturation point.
- (4) **Product concentration:** If the products are allowed to remain in the area of the Reversible reaction can also start.
- (5) **Activators:** They increase activity of enzymes (e.g., chloride for salivary amylase), function as cofactors (e.g.,  $\text{K}^+$ ,  $\text{Mn}^{2+}$ ) and convert proenzymes to enzyme state.
- (6) **Protein poisons:** Cyanides, azides, iodoacetate, and salts of heavy metals destroy tertiary structure of enzymes by either combining with cofactor or a group of apoenzyme (-SH group, -COOH).
- (7) **Radiation Energy:** High energy radiations break hydrogen bonds, ionic bonds, and other weak linkages to destroy enzyme structure.

(8) **Substrate Concentration:** Increase in substrate concentration increases the rate of reaction. The enhanced rate is due to two factors:

- (a) occupation of more and more active sites by the substrate molecules;
- (b) higher number of collisions between substrate molecules. The rise in velocity is quite high in the beginning but it decreases progressively with the increase in substrate concentration.

**Michaelis-Menten Constant** ( $K_m$ ) is a mathematical derivation or constant which indicates the chemical reaction catalysed by an enzyme attains half its maximum velocity.

10. What do you mean by Activation Energy?

[MODEL QUESTION]

**Answer:** Most of the chemical reactions do not start automatically because the reactant molecules have an **energy barrier** to become reactive. The energy barrier may be on account of:

- (A) Mutual repulsion due to presence of electrons over their surfaces.
- (B) Salvation or holding of reactants in solution form by hydrogen bonds.
- (C) Reaction sites of the reactive molecules being small, precise collisions do not occur. Therefore, an external supply of energy is needed for the start of the chemical reaction. It is called **activation energy**. Activation energy of the system and brings about forceful collisions between the reactants. The requirements of activation energy is quite high.

## INFORMATION TRANSFER

### Chapter at a Glance

- DNA was first extracted from nuclei in 1870
  - a) named 'nuclein' after their source.
- Chemical analysis – determined that DNA was a weak acid rich in phosphorous.
- Its name provides a lot of information about DNA: – deoxyribose nucleic acid: – it contains a sugar moiety (deoxyribose), – it is weakly acidic, – and is found in the nucleus.
- Because of its: – nuclear localization – subsequent identification as a component of chromosomes – it was implicated as a carrier of genetic information. Are genes composed of DNA or protein?
- Chromosomes are also known to contain protein – so early on it was a challenge to demonstrate that DNA was indeed the molecule that contained the genetic information., DNA – Only four different subunits make up DNA – Chromosomes contain less DNA than protein by weight
- Protein – 20 different subunits – greater potential variety of combinations – Chromosomes contain more protein than DNA by weight
- Classical experimental data confirmed DNA as the genetic material.

### Multiple Choice Type Questions

1. A codon contains how many nucleotides?  
 a) 4      b) 1      c) 2      d) 3      [MODEL QUESTION]

Answer: (d)

2. The initiation codon is  
 a) UAA      b) UGA      c) AUG      d) UAG      [MODEL QUESTION]

Answer: (c)

3. A piece of double stranded DNA has 30% A, what will be the % of G?  
 a) 30%      b) 40%      c) 20%      d) 70%      [MODEL QUESTION]

Answer: (c)

4. Who were the first to suggest that one strand of DNA might act as a template for the synthesis of its complementary strand?  
 a) Meselson and Stahl      b) Watson and Crick      c) Walter Flemming      d) Rosalind Franklin and Maurice Wilkins      [MODEL QUESTION]

Answer: (b)

5. Semiconservative nature of replication of eukaryotic chromosome was first demonstrated by \_\_\_\_\_ [MODEL QUESTION]  
 a) Walter Flemming on root tip cells of Vicia faba  
 b) J. Herbert Taylor, Philip Wood and Walter Hughes on root tip cells of Vicia faba  
 c) Walter Flemming on root tip cells of Phaseolus vulgaris  
 d) J. Herbert Taylor, Philip Wood and Walter Hughes on root tip cells of Phaseolus vulgaris

Answer: (b)

6. Watson and Crick's suggestion of the complementary strand synthesis taking one of the parent strand as template was proposed in \_\_\_\_\_ [MODEL QUESTION]  
 a) 1869      b) 1909      c) 1953      d) 1952

Answer: (c)

7. Which of the following statements is true with respect to the DNA double helix?  
 a) Composed of two or more polynucleotide chains      b) The base pairs have opposite polarity      c) Covalent bond exists in base pairing      d) T is transcribed as U      [MODEL QUESTION]

Answer: (b)

8. Who, in which year showed firm enzymological proof that DNA alone functions as the template for the synthesis of new DNA strands? [MODEL QUESTION]  
 a) Watson and Crick in 1953  
 b) Avery, MacCarty and MacLeod in 1944  
 c) Meselson and Stahl in 1958  
 d) Hershey and Chase in 1952

Answer: (c)

9. Replication of DNA ends are carried out by polymerase. [MODEL QUESTION]  
 a) True      b) False      c) Both      d) none

Answer: (b)

10. Which of the following regarding the basic mechanism of gene expression is correct? [MODEL QUESTION]  
 a) DNA → tRNA → protein  
 b) RNA → cDNA → mRNA → protein  
 c) RNA → DNA → mRNA → protein  
 d) DNA → protein

Answer: (b)

11. Which of the following does not take part in gene expression? [MODEL QUESTION]  
 a) Replication      b) Transcription      c) RNA processing      d) Translation

Answer: (a)

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12. Multiple copies of RNA could be formed at the same time.  
a) True      b) False      c) Both      d) none [MODEL QUESTION]  
Answer: (a)
13. Amino acids prior to their incorporation into polypeptide must be attached to a special adaptor molecule. Who proved this and when?  
a) Francis H. Crick in 1955      b) Paul C. Zamecnik and Mahlon B. Hoagland in 1957  
c) James Watson and Francis H. Crick in 1953      d) Linus Pauling in 1950 [MODEL QUESTION]
- Answer: (b)

#### Short & Long Answer Type Questions

1. Write a note on the different types of DNA replication. [MODEL QUESTION]  
Answer:

There were three models for how organisms might replicate their DNA: semi-conservative, conservative, and dispersive.

**Semi-conservative replication:** In this model, the two strands of DNA unwind from each other, and each acts as a template for synthesis of a new, complementary strand. This results in two DNA molecules with one original strand and one new strand.

**Conservative replication:** In this model, DNA replication results in one molecule that consists of both original DNA strands (identical to the original DNA molecule) and another molecule that consists of two new strands (with exactly the same sequences as the original molecule).

**Dispersive replication:** In the dispersive model, DNA replication results in two DNA molecules that are mixtures, or "hybrids," of parental and daughter DNA. In this model, each individual strand is a patchwork of original and new DNA.

2. Elaborately explain the process of DNA replication i.e. initiation, elongation and termination process (with diagram). [MODEL QUESTION]

Answer:

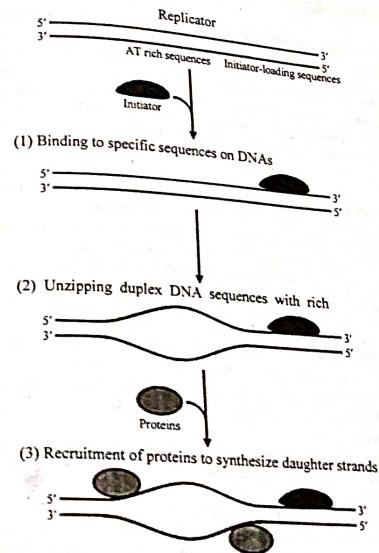
DNA replication is the process by which DNA makes a copy of itself during cell division. DNA replication, like all biological polymerization processes, proceeds in the enzymatically catalyzed and coordinated steps: initiation, elongation and termination.

##### Initiation

For a cell to divide, it must first replicate its DNA. DNA replication is an all-or-none process; once replication begins, it proceeds to completion. Once replication is complete, it does not occur again in the same cell cycle. This is made possible by the division of initiation of the pre-replication complex.

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##### Elongation

DNA polymerase has 5'-3' activity. All known DNA replication systems require a free 3' hydroxyl group before synthesis can be initiated (note: the DNA template is read in 3' to 5' direction whereas a new strand is synthesized in the 5' to 3' direction—this is often confused). Four distinct mechanisms for DNA synthesis are recognized:

1. All cellular life forms and many DNA viruses, phages and plasmids use a primase to synthesize a short RNA primer with a free 3' OH group which is subsequently elongated by a DNA polymerase.
2. The retroelements (including retroviruses) employ a transfer RNA that primes DNA replication by providing a free 3' OH that is used for elongation by the reverse transcriptase.
3. In the adenoviruses and the q29 family of bacteriophages, the 3' OH group is provided by the side chain of an amino acid of the genome attached protein (the terminal protein) to which nucleotides are added by the DNA polymerase to form a new strand.

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4. In the single stranded DNA viruses—a group that includes the Gemini viruses, the parvoviruses and others—and also the circoviruses and plasmids that use the rolling circle replication (RCR) mechanism, the RCR endonuclease creates a nick in the genome strand (single stranded viruses) or one of the DNA strands (plasmids). The 5' end of the nicked strand is transferred to a primase residue on the nuclease and the free 3' OH group is then used by the DNA polymerase to synthesize the new strand.

### Termination:

Eukaryotes initiate DNA replication at multiple points in the chromosome, so replicative forks meet and terminate at many points in the chromosome. Because eukaryotes have linear chromosomes, DNA replication is unable to reach the very end of the chromosomes. Due to this problem, DNA is lost in each replication cycle from the ends of the chromosome. Telomeres are regions of repetitive DNA close to the ends and help prevent loss of genes due to this shortening. Shortening of the telomeres is a normal process in somatic cells. This shortens the telomeres of the daughter DNA chromosome. As a result, cells can only divide a certain number of times before the DNA loss prevents passing DNA to the next generation. Telomerase extends the repetitive sequences of the telomere region to prevent degradation. Telomerase can become mistakenly active in somatic cells, sometimes leading to cancer formation. Increased telomerase activity is one of the hallmarks of cancer.

Termination requires that the progress of the DNA replication fork must stop or be blocked. Termination at a specific locus, when it occurs, involves the interaction between two components:

- (1) a termination site sequence in the DNA, and
- (2) a protein which binds to this sequence to physically stop DNA replication. In various bacterial species, this is named the DNA replication terminus site-binding protein, or T<sub>r</sub> protein.

### 3. What is the Structure of the DNA?

#### [MODEL QUESTION]

**Answer:**  
The double helical structure of DNA was cracked by Watson and Crick based on the X-ray crystallography results. DNA is a double helical structure. Each strand of a DNA helix is composed of repeating units of nucleotides. Nucleotide consists of 3 components: deoxyribose or desoxyribose sugar, nitrogenous base (purines or pyrimidines) and phosphate. DNA is negatively charged due to the presence of negatively charged phosphate groups. These negatively charged phosphate groups are stabilized by basic proteins known as histone.

### 4. Explain how DNA acts as a Genetic Material.

#### [MODEL QUESTION]

**Answer:**  
Griffith performed an experiment known as transforming experiment. He used two strains of Pneumococcus. These two different strains were used to infect the mice. The two

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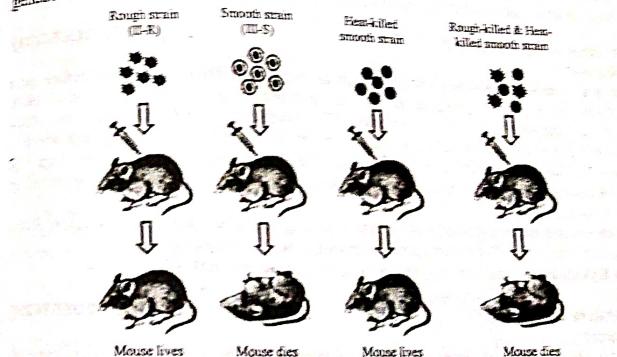
strains used were type III-S (smooth), that contains outer capsule made up of polysaccharide and type II-R (rough) strain do not contain capsule. The capsule protects the bacteria from the host immune system.

The Griffith experiment is explained below:

- Rough strain of Pneumococcus is injected in mouse. The mouse is alive.
- Smooth strain of Pneumococcus is injected in mouse. The mouse dies.
- When heat killed smooth strain of Pneumococcus is injected into mouse, the mouse is alive.
- In the last set of experiment, rough strain and heat killed smooth strain is injected into mouse. The mouse dies.

This proves that there is some transforming substance present in heat killed S strain that is converting or transforming the rough strain into virulent strain that is responsible for the death of the mouse. This transforming substance is DNA.

Later on, Avery, MacLeod McCarty and Hershey and Chase confirms that DNA is a genetic material.



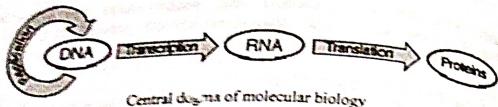
### 5. What is Central Dogma of Molecular Biology?

#### [MODEL QUESTION]

**Answer:**  
It is an explanation about how the flow of genetic information occurs in a biological system. This explains how DNA replicates and then gets converted into messenger RNA (mRNA) via transcription. Then this mRNA is translated to form proteins.

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Central dogma of molecular biology

**6. What is DNA Replication?****Answer:**

DNA Replication is a process of producing two identical copies of DNA from a single DNA molecule. It is a process of biological inheritance. DNA is a double helix in which two strands are complementary to each other. These two strands of a helix separate at the time of replication to form two new DNA molecules. Out of the two strands of DNA formed, one is identical to one of the strand and another strand is complementary to the parent strand. This form of replication is known as semi-conservative replication. Before the cell enters the mitosis, the DNA is replicated in S phase of interphase. Before DNA polymerase is the most important enzyme involved in DNA replication.

**7. What is Transcription?****Answer:**

It is a process of formation of RNA such as messenger RNA from DNA before gene expression or protein synthesis occurs. During transcription, one of the strand of DNA acts as template for mRNA formation. The synthesis of mRNA occurs via RNA polymerase enzyme. Transcription usually occurs for a particular DNA segment which is required further for gene expression. Other than the messenger RNA, other forms of RNA such as ribosomal RNA, micro RNA, small nuclear RNA can also be transcribed in the similar manner.

Some viruses have a property of reverse transcription. They are able to convert RNA template into DNA. The enzyme used is known as reverse transcriptase.

For Example: Human immunodeficiency virus that causes "AIDS".

**[MODEL QUESTION]****8. What is Translation?****[MODEL QUESTION]****Answer:**

This is the process of gene expression or protein synthesis that occurs in cytosol. Ribosomes are the cell organelles that are involved in protein synthesis. The messenger RNA formed by the process of transcription is decoded by ribosomes to form a polypeptide made up of amino acids. Messenger RNA is composed of polymer of nucleotides or codon. Each codon consists of 3 nucleotides that will code for a single amino acid. There are some important components that are involved in protein synthesis: ribosomes, messenger RNA and transfer RNA (tRNA).

Transfer RNA is involved in physically linking mRNA and the amino acid sequence of proteins.

**BIOLOGY  
MACROMOLECULAR ANALYSIS****Chapter at a Glance****Proteins**

(1) The word protein was coined by Berzelius in 1838 and was used by G. J. Mulder first time 1840.

(2) 15% of protoplasm is made up of protein. Average proteins contain 16% nitrogen, 50–55% carbon, oxygen 20–24%, hydrogen 7% and sulphur 0.3 – 0.5%. Iron, phosphorous, copper, calcium, and iodine are also present in small quantity.

(3) Structure of proteins: It is due to different rearrangement of amino acids. When carboxyl group of one amino acid binds with amino group ( $-NH_2$ ) of another amino acid the bond is called peptide bond. A peptide may be dipeptide, tripeptide and polypeptide. The simplest protein is Insulin. According to Sanger (1953) insulin consists of 51 amino acids. A protein can have up to four level of conformation.

(i) Primary structure: The primary structure is the covalent connections of a protein. It refers to linear sequence, number and nature of amino acids bonded together with peptide bonds only. e.g. ribonuclease, insulin, haemoglobin, etc.

(ii) Secondary structure: The folding of a linear polypeptide chain into specific coiled structure ( $\alpha$  - helix) is called secondary structure and if it is with intermolecular hydrogen bonds the structure is known as  $\beta$  - pleated sheet.  $\alpha$  - helical structure is found in protein of fur, keratin of hair claws, and feathers.  $\beta$  - pleated structure is found in silk fibres.

(iii) Tertiary structure: The arrangement and interconnection of proteins into specific loops and bends is called tertiary structure of proteins. It is stabilized by hydrogen bond, ionic bond, hydrophobic bond and disulphide bonds. It is found in myoglobin (globular proteins).

(iv) Quaternary structure: It is shown by protein containing more than one peptide chain. The protein consists of identical units. It is known as homologous quaternary structure e.g. lactic dehydrogenase. If the units are dissimilar, it is called as heterogeneous quaternary structure e.g. hemoglobin which consists of two  $\alpha$  - chains and two  $\beta$  - chains.

**Multiple Choice Type Questions****[MODEL QUESTION]****1. Proteins consist of**

- a) Carbon, hydrogen, chlorine, sulphur
- b) Carbon, hydrogen, oxygen, nitrogen
- c) Carbon, manganese, phosphorus, nitrogen
- d) Carbon, iodine, oxygen and inorganic phosphate

**Answer: (b)****[MODEL QUESTION]****2. Which of the following is conjugated protein**

- a) Chromoproteins
- b) Phosphoprotein
- c) Glycoprotein
- d) All of the above

**Answer: (d)**

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3.  $\alpha$ -helical model of protein was discovered by  
 a) Pauling and Correy  
 b) Watson  
 c) Morgan  
 d) Berzelius

Answer: (a)

4. Aleurone grains are  
 a) Enzymes  
 b) Carbohydrates  
 c) Protein  
 d) Fat

Answer: (c)

5. High content of lysine is present in  
 a) Wheat  
 b) Apple

Answer: (a)

6. Which of the following is polymerized to form proteins  
 a) Protein  
 b) Carbohydrates  
 c) Amino acid  
 d) Muramic acid

Answer: (c)

7. Basic structure of protein was given by  
 a) Stanley  
 b) Nicholson

Answer: (a)

8. Weight of protein is  
 a) > 12000  
 b) < 6000

Answer: (a)

9. Which of the following is the simplest amino acid  
 a) Tyrosine  
 b) Asparagine  
 c) Glycine  
 d) Alanine

Answer: (c)

**Short & Long Answer Type Questions****1. What is Protein?**

## [MODEL QUESTION]

Answer:  
 The word protein was coined by Berzelius in 1838 and was used by G. J. Mulder first time 1840.

15% of protoplasm is made up of protein.

Average proteins contain 16% nitrogen, 50–55% carbon, oxygen 20–24%, hydrogen 7% and sulphur 0.3 – 0.5%. Iron, phosphorous, copper, calcium, and iodine are also present in small quantity.

**2. Describe the Structure of Proteins.**

## [MODEL QUESTION]

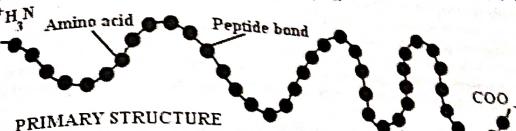
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## [MODEL QUESTION]

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**Answer:**  
 It is due to different rearrangement of amino acids. When carboxyl group ( $-COOH$ ) of one amino acid bonded with amino group ( $-NH_2$ ) of another amino acid the bond is called peptide bond. A peptide may be dipeptide, tripeptide and polypeptide. The simplest protein is Insulin. According to Sanger (1953) insulin consists of 51 amino acids. A protein can have up to four level of conformation.

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**SECONDARY STRUCTURE****Alpha-Helix**

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**3. What are the different classes of Proteins?**

## [MODEL QUESTION]

Answer:

**Classification of Proteins**

Proteins are classified on the basis of their shape, constitution and function.

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### On the basis of shape

(i) **Fibrous protein:** Insoluble in water. Animal protein resistant to proteolytic enzyme is spirally coiled thread like structure form fibres, e.g. collagen (in connective tissue), actin and myosin, keratin in hairs, claws, feathers, etc.

(ii) **Globular proteins:** Soluble in water. Polypeptides coiled about themselves to form oval or spherical molecules e.g. albumin insulin hormones like ACTH, oxytocin, etc.

### On the basis of constituents

(i) **Simple proteins:** The proteins which are made up of amino acids only, e.g. albumins,

globulins, prolamins, glutelins, histones, etc.

(ii) **Conjugated proteins:** These are complex proteins combined with characteristic non-amino acid substance called as prosthetic group. These are of following types:

(a) **Nucleoproteins:** Combination of protein and nucleic acids, found in chromosomes and ribosomes, e.g. deoxyribonucleoproteins, ribonucleoproteins, etc.

(b) **Mucoproteins:** These are combined with large amount (more than 4%) of carbohydrates e.g. mucin.

(c) **Glycoproteins:** In this, carbohydrate content is less (about 2 - 3%) e.g. immunoglobulins or antibiotics.

(d) **Chromoproteins:** These are compounds of protein and coloured pigments, e.g. haemoglobin, cytochrome, etc.

(e) **Lipoproteins:** These are water soluble proteins and contain lipids, e.g. cholesterol and serum lipoproteins.

(f) **Metalloproteins:** These are metal binding proteins, AB<sub>1</sub>-globin known as transferring is capable of combining with iron, zinc and copper e.g. chlorophyll.

(g) **Phosphoprotein:** They composed of protein and phosphate e.g. casein (milk) and vitellin (egg).

(iii) **Derived proteins:** When proteins are hydrolysed by acids, alkalies or enzymes, the degradation products obtained from them are called derived proteins. On the basis of progressive cleavage, derived proteins are classified as primary proteoses, secondary proteoses, peptones, polypeptides, amino acids, etc.

### On the basis of nature of molecules

(i) **Acidic proteins:** They exist as anion and include acidic amino acids, e.g. blood groups.

(ii) **Basic proteins:** They exist as cations and rich in basic amino acids e.g. lysine, arginine etc.

### 4. What do you understand by hierarchy of Proteins? [MODEL QUESTION]

**Answer:**

The implications of this hierarchy are that:

- each level of the hierarchy is 'held together' by characteristic interactions and forces

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## BIOLOGY

higher levels of structure in the hierarchy are composed of the structural entities (also called elements) of the lower levels. However, subsequent work has revealed that this four-level hierarchy of protein structure is a bit too simple and the three dimensional structure of proteins can now be conveniently described by a six level structural hierarchy, which includes:

- primary structure
- secondary structure
- supersecondary structure
- domain structure
- tertiary structure
- quaternary structure,

Quaternary Structure	Two or more polypeptides each polypeptide a subunit	Associations of tertiary structure
More compact structures		
Tertiary Structure	Multidomain (mosaic) or single domain	Associations of domain structure
Domain Structure folds or Modules	All alpha, all beta, $\alpha/\beta$ , $\alpha + \beta$	Units of tertiary structure
Super secondary Structure	$\alpha-\alpha$ , $\beta-\beta$ , greek key helix-loop-helix	Associates of secondary structure
Secondary Structure	$\alpha$ -helix $\beta$ -sheet $\beta$ -turns loop	Units of secondary structure
Primary Structure	-P-R-K-F-E-V-G-O-N-W-K-M-N-G-D-K-K-	Linear Sequence of amino acids

The definitions of primary, secondary, tertiary, and quaternary structure are as above and the definitions of the other levels of structure are:

**Supersecondary structure** is the next level up from secondary structure and involves the association of secondary structures. Also known as structural motifs.

**Domains** are larger associations of two or more secondary structures, two or more supersecondary elements, or mixtures of two or more secondary and supersecondary structures. They can also be known as 'folds', and 'modules'. As we will see later in Protein Tertiary Structure domains are independently folding units of tertiary structure and contain between 35 and 200 amino acids. Note that some other authors may present slightly different definitions of the terms above and we will look at some definitions later in Protein Tertiary Structure.

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**5. What are the Function of Proteins?****Answer:**

- (i) Proteins occur as food reserves as glutelin, globulin casein in milk.
- (ii) Proteins are coagulated in solutions, alkaline to the isoelectric pH by positive ions such as  $Zn^{2+}$ ,  $Cd^{2+}$ ,  $Hg^{2+}$  etc. Casein - pH 4.6, cyt. C - 9.8, serum globulin 5.4, pepsin 2.7, lysozyme 11.0 etc.
- (iii) Proteins are the most diverse molecule on the earth.
- (iv) Proteins work as hormone as insulin and glucagon.
- (v) Antibiotics as gramicidin, tyrocidin and penicillin are peptides.
- (vi) They are structural component of cell.
- (vii) They are biological buffers.
- (viii) Monellin is the sweetest substance obtained from African berry (2000 time sweeter than sucrose).
- (ix) Proteins help in defence, movement activity of muscles, visual pigments receptor molecules, etc.
- (x) Natural silk is a polyamide and artificial silk is a polysaccharide. Nitrogen is the basic constituent.

**6. What do you understand by Motif?****[MODEL QUESTION]****Answer:**

A motif can be either a structural or a sequence motif:

- A structural motif is the arrangement of atoms in 3-D space to produce a particular structural pattern eg: alpha helix, beta sheet.
- A sequence motif is a particular pattern in the sequence of amino acids or nucleotides.

A structural or sequence motif may or may not have a particular function associated with it.

**7. Describe the structure ad functions of primary Proteins.****[MODEL QUESTION]****Answer:**

The primary structure of a protein is the level of protein structure which refers to the specific sequence of amino acids. When two amino acids are in such a position that the carboxyl groups of each amino acid are adjacent to each other, they can be combined by undergoing a dehydration reaction which results in the formation of a peptide bond. Amino acids in a polypeptide (protein) are linked by peptide bonds that begin with the N-terminal with a free amino group and ends at C-terminal with a free carboxyl group. The peptide bond is planar and cannot rotate freely due to a partial double bond character. While there is a restricted rotation about peptide bond, there are two free rotations on (N-C) bond and (C-C) bond, which are called torsion angles, or more specifically the phi and psi angles. The freedoms of rotation of these two bonds are also limited due to steric hindrance. Genes carry the information to make polypeptides with a defined amino acid sequence. An average polypeptide is about 300 amino acids in length, and some genes encode polypeptides that are a few thousand amino acids long. It's important to know the primary structure of the protein because the primary structure encodes motifs that are of

**[MODEL QUESTION]****BIOLOGY**

functional importance in their biological function; structure and function are correlated at all levels of biological organization.

**8. Describe the structure and functions of secondary Proteins.****[MODEL QUESTION]****Answer:**

The amino acid sequence of a polypeptide, together with the laws of chemistry and physics, cause a polypeptide to fold into a more compact structure. Amino acids can rotate around bonds within a protein. This is the reason proteins are flexible and can fold into a variety of shapes. Folding can be irregular or certain regions can have a repeating folding pattern. The coils and folds that result from the hydrogen bonds between the repeating segments of the polypeptide backbone are called secondary structures<sup>[1]</sup>. Although the individual hydrogen bonds are weak, they are able to support a specific shape for that part of the protein due to the fact that they are repeated many times over a long part of the chain<sup>[1]</sup>. Secondary structures of a protein are proposed by Pauling and Corey. Its structures are formed by amino acids that are located within short distances of each other. Because of the planar nature of the peptide bonds, only certain types of secondary structure exist. The three important secondary structures are  $\alpha$ -helix,  $\beta$ -sheets, and  $\beta$ -turns. Also, the beta sheets can be parallel, antiparallel, or mixed. Antiparallel beta sheets are more stable because the hydrogen bonds are at a ninety degree angles. The  $\alpha$ -helix is a coiled structure stabilized by intrachain hydrogen bonds.

**Characteristics of the Secondary Structures:**

**1.  $\alpha$ -helix:** In an  $\alpha$ -helix, the polypeptide backbone forms a repeating helical structure that is stabilized by hydrogen bonds between a carbonyl oxygen and an amine hydrogen. These hydrogen bonds occur at regular intervals of one hydrogen bond every fourth amino acid and cause the polypeptide backbone to form a helix. The most common helical structure is a right-handed helix with its hydrogen bonds parallel to its axis. The hydrogen bonds are formed between carbonyl oxygen and amine hydrogen groups of four amino acid residues away. Each amino acid advances the helix, along its axis, by 1.5 Å. Each turn of the helix is composed of 3.6 amino acids; therefore the pitch of the helix is 5.4 Å. There is an average of ten amino acid residues per helix with its side chains orientated outside of the helix. Different amino acids have different propensities for forming  $\alpha$ -helix, however proline is a helix breaker because proline does not have a free amino group. Amino acids that prefer to adopt helical conformations in proteins include methionine, alanine, leucine, glutamate and lysine (malek).

**2.  $\beta$ -sheet:**  $\beta$ -sheets are stabilized by hydrogen bonding between peptide strands. In a  $\beta$ -sheet, regions of the polypeptide backbone come to lie parallel to each other and are connected by hydrogen bonds. The hydrogen bonds are formed between the carbonyl oxygen and the amine hydrogen of amino acid in adjacent strands in a polypeptide, which means that the hydrogen bonds are inter-strand.  $\beta$ -sheet regions are more extended than an  $\alpha$ -helix, and the distance between adjacent amino acids is 3.5 Å. Hydrogen bonding in  $\beta$ -parallel strand can occur as parallel, anti-parallel, or a mixture. Amino acid residues in  $\beta$ -parallel

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**configuration** units in the same orientation. Pleated sheets makes up the core of many globular proteins and also are dominant in some fibrous proteins such as a spiders web. The large amino acids such as tryptophan, tyrosine and phenylalanine, and beta branched amino acids like isoleucine, valine, and threonine prefer to adopt  $\beta$ -turning conformations. This orientation is energetically less favorable because of its strained non-parallel hydrogen bonds. Tryptophan, tyrosine, and phenylalanine are hydrophobic while the other amino acids are hydrophilic.

**3.  $\beta$ -turn:** Poly-peptide chains can change direction by making reverse turns and loops turn. These loop regions have irregular lengths and shapes and are usually found on the surface of the protein. The turn is stabilized by hydrogen bond between the backbone carbonyl oxygen and amide hydrogen. The CO group of the residue, in many reverse turns, which is bonded to the NH group of residue i + 3. The interaction stabilizes alpha turns in direction of the polypeptide chain. Unlike the alpha-helices and  $\beta$ -strands, loops do not have regular periodic structures. However, they are usually rigid and well defined. Since they loops lie on the surface of the proteins, they are able to participate in interactions between proteins and other molecules. Ramachandran plot is a plot that shows the available torsion angles of whose proteins can be found. However, in the plot if there are many dots that locate all over the places, it means that there exists a loop.

**Q. Describe the structure and functions of Tertiary & Quaternary Proteins.** [MODEL QUESTION]

### Answer:

**Tertiary:** As the secondary structure becomes established due to the primary structure, a polypeptide folds and refolds upon itself to assume a complex three-dimensional shape called the protein tertiary structure. Tertiary structure is the overall shape of a polypeptide. Tertiary structure results from the interactions between the side chains (R groups) of the various amino acids. This three-dimensional structure is due to intramolecular interactions between the side groups along the polypeptide chain. It domain typically contains 300 - 400 amino acids, and it adopts a stable tertiary structure when it is isolated from their parent protein. As a polypeptide folds into its functional shape, amino acids that have hydrophobic side chains tend to end up clustered at the core of the protein so that they are out of contact with water. Covalent bonds called disulfide bridges can also affect the shape of a protein. Disulfide Bridges form where two amino acids containing sulfhydryl groups on their side chains are brought close together by how the protein is folding. For some proteins, such as ribonuclease, the tertiary structure is the final structure of a functional protein. Other proteins are composed of two or more polypeptides and adopt a quaternary structure.

**Quaternary:** While all proteins contain primary, secondary and tertiary structures, quaternary structures are observed for proteins composed of two or more polypeptide chains. Proteins that have quaternary structures contain more than one polypeptide and each adopts a tertiary structure and then assemble with each other via intermolecular

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## BIOLOGY

interactions. The quaternary structure of a protein is the overall structure that is the result of the addition of these polypeptide subunits. The individual polypeptides are called protein subunits, which means different polypeptides folded separately. Subunits may be identical polypeptides or they may be different. When proteins consist of more than one polypeptide chain, they are said to have quaternary structure and are also known as multimeric proteins, meaning proteins consisting of many parts. Quaternary structures can also be defined as when more than one protein come together to create either a dimer, trimer, tetramer, etc. HeteroViduit. Haemoglobin is an example of a quaternary structure that is composed of two alpha subunits and two beta subunits.

**10. State the factors which influence the structure the Proteins.**

[MODEL QUESTION]

### Answer:

Several factors determine the way that polypeptides adopt their secondary, tertiary and quaternary structures. The amino acid sequences of polypeptides are the defining features that distinguish the structure of one protein from another. As polypeptides are synthesized in a cell, they fold into secondary and tertiary structures, which assemble into quaternary structures for most proteins. As mentioned, the laws of chemistry and physics, together with amino acid sequence, govern this process. Five factors are critical for protein folding and stability:

**1. Hydrogen bonds:** Hydrogen bonds are formed between a hydrogen bond donor and hydrogen bond acceptor. For amino acids, hydrogen bonding would occur between the backbone of the amine group and the oxygen of the carbonyl group.

**2. Ionic bonds:** Electrostatic interactions occur between two oppositely charged molecules. Ionic interactions are weaker in water than in vacuum, this is due to a different dielectric constant faced in water between opposing charges within the protein's structure.

**3. Hydrophobic effect:** The hydrophobic interaction originates from the tendency of non-polar molecules to minimize their interactions with water. When non-polar molecules interact with water, these molecules tend to cluster together in the center to form a micelle.

**4. Van der waals forces:** Van der waals forces exist between non-polar molecules at close range. Of the three van der waals interactions, interactions between permanent dipoles is the strongest, dipole-induced dipole interactions are weaker than permanent dipole and the London dispersion forces are the weakest. While van der waals forces between individual atoms are weak, the sum of van der waals forces resulting from interactions between many atoms in large macromolecules can be substantial. The strength of van der waals interactions varies with the distance between the atoms and is maximal at the van der waals contact distance.

**5. Disulfide bridges:** A disulfide bond can be formed between two cysteines through oxidation. These are also the strongest covalent bonds within a protein's tertiary structure.

**11. What is Protein denaturation? What are the Conditions for that?**

[MODEL QUESTION]

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**Answer:**

**Protein denaturation:** is the loss of native conformations of tertiary structure. Denaturing proteins experience either the destruction or disruption of internal tertiary or secondary structure. Denaturation however, does not break the peptide bond between adjacent amino acids, thus not affecting the primary structure of the protein. Denaturation however, will interfere the normal alpha-helix and beta sheets in a protein which ultimately distort its 3D shape.

Denaturation causes the disruption of hydrogen bonding between close proximity amino acids, thus interfering a protein's secondary and tertiary structure. In tertiary structure there are four types of bonding interactions between "side chains" including: hydrogen bonding, ionic bridges, disulfide bonds, and hydrophobic intermolecular interactions. In other words, there are several different conditions to denature the conformation of a protein.

**Conditions that denature proteins:**

1. Extreme pH ( $\text{pH} < 4$  or  $\text{pH} > 9$ ): alters H-bonding
2. Heat (temp  $> 70^\circ\text{C}$ ): thermal effect, disrupts weak forces of non-covalent bonds
3. Detergents or organic solvents : disrupts hydrophobic interaction
4. Chaotropic agents (high concentrations) : e.g., urea and guanidinium chloride

**12. What is DEAD box proteins?****[MODEL QUESTION]****Answer:**

DEAD box proteins consist of RNA helicases, they are involved in RNA metabolism processes, and they are conserved in nine domains found in bacteria and viruses to humans. They are 350 amino acids in length. DEAD box proteins are involved in pre-mRNA processing, splicesosome formation, and rearranging of ribonucleoprotein (RNP) complexes. DEAD box proteins are required in the pre-mRNA splicing and the in vivo splicing process. During the pre-mRNA processing, the DEAD box proteins unwind to provide energy to rearrange the five snRNPs (U1, U2, U4, U5, and U6) required in pre-mRNA splicing. In the in vivo splicing, three DEAD box proteins, Sub2, Prp28, and Prp5, are needed. Prp5 helps rearrange the conformation of U2, which allows the U2 sequence bind to the branch point sequence. Prp28 helps the recognition of the 5' splicing location.

The first DEAD box protein, the EIF4A translation initiation factor, are dependent on RNA ATPase activity. This protein helps unwind the secondary structure, which stops the scanning.

**13. Why all enzymes are proteins, but not all proteins are enzymes?****[MODEL QUESTION]****Answer:**

Proteins is the larger set of molecules to which enzymes belong as subsets.

**Explanation:**

- Proteins are biological macromolecules that are diverse in shape size and function.

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- Enzymes are molecules that facilitate reactions in a living cell without undergoing too much change i.e. these are biological catalysts.
- The ability of proteins to undergo shape changes and reversibly so, make them most suited to function as enzymes among other things.
- Other biological macromolecules like sugars and fats are less suited for such a function. Some RNA molecules serve as enzymes too. And for the same reason, too,

**14. How do proteins act as enzymes?****[MODEL QUESTION]****Answer:**

Cells rely on thousands of different enzymes to catalyze metabolic reactions. Enzymes are proteins, and they make a biochemical reaction more likely to proceed by lowering the activation energy of the reaction, thereby making these reactions proceed thousands or even millions of times faster than they would without a catalyst. Enzymes are highly specific to their substrates. They bind these substrates at complementary areas on their surfaces, providing a snug fit that many scientists compare to a lock and key. Enzymes work by binding one or more substrates, bringing them together so that a reaction can take place, and releasing them once the reaction is complete. In particular, when substrate binding occurs, enzymes undergo a conformational shift that orients or strains the substrates so that they are more reactive.

**15. What is Transporter proteins?****[MODEL QUESTION]****Answer:**

Transporter proteins constitute a significant fraction of membrane-bound proteins. They are typically expressed in all organs involved in the uptake, distribution, and elimination of drugs, including the gastrointestinal tract, the blood-brain barrier, the liver, and the kidneys. The sequence of many transporters is known.

**16. Why the Transport Proteins are called as The Doors to the Cell?****[MODEL QUESTION]****Answer:**

Our cells are constantly shipping and receiving different types of molecules, similar to how a post office handles various letters and packages.

Each cell has a plasma membrane, or a filter, that helps regulate materials moving in and out of the cell. Each plasma membrane has different transport proteins embedded within it, which are used to help with this process. Each transport protein only allows a certain molecule to enter or exit the cell.

Think of these transport proteins as specialized doors of the post office. Each type of parcel - each letter, each package, and so on - may only enter the post office through a specific doorway designated for it. Letters enter through the letter door, packages enter through the package door, and Speed post mail comes through the Speed post door.

**17. What Is Passive and Active Cellular Transport?****[MODEL QUESTION]**

**Answer:**

There are two main kinds of cellular transport: passive transport and active transport. When passive transport occurs, molecules are moving from a concentrated area to a less concentrated area. This doesn't require any energy; the pressure in the concentrated area will naturally push molecules to the area of lower pressure. The opposite of this process, active transport, moves molecules from a less concentrated area to a more concentrated area. This requires an input of energy in the form of ATP, adenosine triphosphate.

Let's go back to the post office. Imagine there are 100 postal workers inside the post office and 20 workers outside. That'd be 100 molecules inside the cell and 20 outside. When workers from inside leave and go outside of the post office, they are moving from an area with more workers (a higher concentration) to an area with less workers (lower concentration). There's a lot more room outside, so leaving the crowded post office requires very little energy. This is exactly how passive transport works. On the other hand, if some of the workers on the outside decide to go into the post office, they would be moving from an area with less workers (lower concentration) to an area with more workers (higher concentration). They would need to exert energy to crawl themselves back into the crowded building. That's why active transport requires energy from the cell.

**18. What is receptor proteins?****Answer:**

Receptor proteins are located within the cell surface membrane, nucleus membrane or other cellular organelle membrane. They can bind to corresponding ligands to initiate cellular signaling pathways. For cell surface receptors, such as receptor tyrosine kinases, interleukin receptors and receptors of growth factors, they are usually subdivided into three domains, extracellular domain, transmembrane domain and intracellular domain. Receptor proteins form the largest family of biological targets.

Examples of receptor proteins/receptors include:

Guanine nucleotide-binding protein-coupled receptors (GPCRs) (metabotropic).

**[MODEL QUESTION]**

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**METABOLISM**

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**Chapter at a Glance**

The laws of thermodynamics are important unifying principles of biology. These principles govern the chemical processes (metabolism) in all biological organisms. The First Law of Thermodynamics, also known as the law of conservation of energy, states that energy can neither be created nor destroyed. It may change from one form to another, but the energy in a closed system remains constant. The Second Law of Thermodynamics states that when energy is transferred, there will be less energy available at the end of the transfer process than at the beginning. Due to entropy, which is the measure of disorder in a closed system, all of the available energy will not be useful to the organism. Entropy increases as energy is transferred. In addition to the laws of thermodynamics, the cell theory, gene theory, evolution, and homeostasis form the basic principles that are the foundation for the study of life.

**Multiple Choice Type Questions**

1. Which of the following are products of the light reactions of photosynthesis that are utilized in the Calvin cycle? [MODEL QUESTION]

- a) H<sub>2</sub>O and O<sub>2</sub>
- b) ADP, Pi and NADP+
- c) Electrons and H+
- d) ATP and NADPH

Answer: (d)

2. Catalysts:

- a) increase the activation energy
- b) are used up in reactions
- c) provide an alternative reaction pathway
- d) slow down chemical reactions

Answer: (c)

3. Which of the following is not a feature of collision theory? [MODEL QUESTION]

- a) the rate of chemical reactions increases with increasing temperatures
- b) the reaction is faster in dilute solute solutions than in concentrated
- c) at high temperatures molecules have more energy than at low temperatures
- d) the more molecules present, the faster the reaction

Answer: (b)

4. Examples of anabolic reactions include:

- a) the breakdown of lipids
- b) the breakdown of carbohydrates
- c) hydrolysis reactions
- d) the build up of proteins

Answer: (d)

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5. The conversion of glucose to carbon dioxide and water is an example of  
 a) a catabolic reaction [MODEL QUESTION]  
 b) a condensation reaction  
 c) an esterification reaction  
 Answer: (a)

6. In an exergonic reaction:  
 a) energy is absorbed from the surroundings [MODEL QUESTION]  
 b) bonds being formed are the same strength as bonds being broken  
 c) bonds being formed are stronger than bonds being broken  
 d) energy is released to the surroundings  
 Answer: (d)

7. In an endergonic reaction:  
 a) bonds being formed are stronger than bonds being broken [MODEL QUESTION]  
 b) energy is absorbed from the surroundings  
 c) bonds being formed are the same strength as bonds being broken  
 d) energy is released to the surroundings  
 Answer: (c)

8. If left hand side of chemical equation is  $ADP + \text{water}$  then right hand side of that chemical equation is equal to  
 a)  $AMP + P_i + \text{energy}$  [MODEL QUESTION]  
 b)  $ATP + M_i + \text{energy}$   
 c)  $BMP + B_i + \text{energy}$   
 d)  $TDA + T_i + \text{energy}$   
 Answer: (a)

9. Major source of energy to perform cellular functions such as exocytosis, endocytosis, movement and transmission of nerve impulses is

- a) ATP      b) BTP      c) PTA      d) APT [MODEL QUESTION]  
 Answer: (a)

10. Biologist who discovered ATP is  
 a) Daniel Oliver  
 b) Daniel Koshland  
 c) Karl Lohmann  
 d) Emil August  
 Answer: (c)

11. Nobel Prize winner biologist who proposed ATP as major energy-transfer molecule in cells is  
 a) Fritz Lipmann  
 b) Emil August  
 c) Daniel Koshland  
 d) Karl Lohmann [MODEL QUESTION]  
 Answer: (a)

12. Nobel Prize winner Fritz Lipmann who proposed ATP as major energy-transfer molecule in cells in  
 a) 1949      b) 1935      c) 1941      d) 1929 [MODEL QUESTION]  
 Answer: (c)

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b) a condensation reaction [MODEL QUESTION]  
 c) an anabolic reaction

13. Glycolytic pathway regulation involves  
 a) allosteric stimulation by ADP  
 b) allosteric inhibition by ATP  
 c) feedback, or product, inhibition by ATP  
 d) all of the above

Answer: (d)

14. During catabolism, only about 40% of the energy available from oxidizing glucose is used to synthesize ATP. Remaining 60% [MODEL QUESTION]  
 a) is lost as heat  
 b) is used to reduce NADP  
 c) remains in the products of metabolism  
 d) is stored as fat

Answer: (a)

15. Why does the glycolytic pathway continue in the direction of glucose catabolism?  
 a) There are essentially three irreversible reactions that act as the driving force for the pathway [MODEL QUESTION]  
 b) High levels of ATP keep the pathway going in a forward direction  
 c) The enzymes of glycolysis only function in one direction  
 d) Glycolysis occurs in either direction

Answer: (a)

16. The released energy obtained by oxidation of glucose is stored as  
 a) a concentration gradient across a membrane [MODEL QUESTION]  
 b) ADP      c) ATP      d) NAD<sup>+</sup>

Answer: (c)

17. Kinase is an enzyme that  
 a) removes phosphate groups of substrates  
 b) uses ATP to add a phosphate group to the substrate  
 c) uses NADH to change the oxidation state of the substrate  
 d) removes water from a double bond

Answer: (b)

18. Krebs has been awarded Nobel Prize in 1953 for explaining  
 a) Energy forming process in the cell [MODEL QUESTION]  
 b) ATP metabolism  
 c) Respiration chain  
 d) Oxidation of cytoplasm

Answer: (a)

19. The product formed by maleic dehydrogenase is  
 a) Maleic acid      b) Fumaric acid [MODEL QUESTION]  
 c) Oxaloacetic acid      d) Succinic acid

Answer: (c)

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BIOLOGY

[MODEL QUESTION]

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20. In presence of TPP and carboxylase, pyruvic acid is transformed into [MODEL QUESTION]
- a) Acetaldehyde and CO<sub>2</sub>
  - b) Ethyl alcohol and CO<sub>2</sub>
  - c) Citric acid and CO<sub>2</sub>
  - d) None of the above
- Answer: (a)
21. TCA cycle is a [MODEL QUESTION]
- a) Direct oxidation pathway
  - b) Indirect oxidation pathway
  - c) Both [a] and [b]
  - d) None of the above
- Answer: (b)
22. Hydrogen of malate is accepted by [MODEL QUESTION]
- a) FAD
  - b) FMN
  - c) NAD
  - d) CoQ
- Answer: (c)
23. Which of the coenzyme is used in acetylation reaction [MODEL QUESTION]
- a) CoA
  - b) FAD
  - c) FMN
  - d) None of the above
- Answer: (a)
24. Ferredoxin is a [MODEL QUESTION]
- a) Protein
  - b) Fat
  - c) Phenol
  - d) None of the above
- Answer: (a)
25. Which intermediate compound is involved in the synthesis of amino acids [MODEL QUESTION]
- a) Malic acid
  - b) Citric acid
  - c)  $\alpha$ -ketoglutaric acid
  - d) Isocitric acid
- Answer: (c)

Short & Long Answer Type Questions

1. State the importance of first Law of Thermodynamics in Biological Systems. [MODEL QUESTION]

Answer:

All biological organisms require energy to survive. In a closed system, such as the universe, this energy is not consumed but transformed from one form to another. Cells, for example, perform a number of important processes. These processes require energy. In photosynthesis, the energy is supplied by the sun. Light energy is absorbed by cells in plant leaves and converted to chemical energy. The chemical energy is stored in the form of glucose, which is used to form complex carbohydrates necessary to build plant mass. The energy stored in glucose can also be released through cellular respiration. This process allows plant and animal organisms to access the energy stored in carbohydrates, lipids, and other macromolecules through the production of ATP. This energy is needed to perform cell functions such as DNA replication, mitosis, meiosis, cell movement, endocytosis, exocytosis, and apoptosis.

2. State the importance second law of Thermodynamics in Biological Systems. [BIOLOGY MODEL QUESTION]

Answer:

As with other biological processes, the transfer of energy is not 100 percent efficient. In photosynthesis, for example, not all of the light energy is absorbed by the plant. Some energy is reflected and some is lost as heat. The loss of energy to the surrounding environment results in an increase of disorder or entropy. Unlike plants and other photosynthetic organisms, animals cannot generate energy directly from the sunlight. They must consume plants or other animal organisms for energy. The higher up an organism is on the food chain, the less available energy it receives from its food sources. Much of this energy is lost during metabolic processes performed by producers and primary consumers that are eaten. Therefore, much less energy is available for organisms at higher trophic levels. (Trophic levels are groups that help ecologists understand the specific role of all living things in the ecosystem.) The lower the available energy, the less number of organisms can be supported. This is why there are more producers than consumers in an ecosystem.

Living systems require constant energy input to maintain their highly ordered state. Cells, for example, are highly ordered and have low entropy. In the process of maintaining this order, some energy is lost to the surroundings or transformed. So while cells are ordered, the processes performed to maintain that order result in an increase in entropy in the cell's/organism's surroundings. The transfer of energy causes entropy in the universe to increase.

3. What is exothermic and endothermic reaction? [MODEL QUESTION]

Answer:

An exothermic process releases heat, causing the temperature of the immediate surroundings to rise. An endothermic process absorbs heat and cools the surroundings. Many chemical reactions release energy in the form of heat, light, or sound. These are exothermic reactions. Exothermic reactions may occur spontaneously and result in higher randomness or entropy ( $\Delta S > 0$ ) of the system. They are denoted by a negative heat flow (heat is lost to the surroundings) and decrease in enthalpy ( $\Delta H < 0$ ). In the lab, exothermic reactions produce heat or may even be explosive.

There are other chemical reactions that must absorb energy in order to proceed. These are endothermic reactions. Endothermic reactions cannot occur spontaneously. Work must be done in order to get these reactions to occur. When endothermic reactions absorb energy, a temperature drop is measured during the reaction. Endothermic reactions are characterized by positive heat flow (into the reaction) and an increase in enthalpy ( $+ \Delta H$ ).

4. What is exergonic and endergonic reaction? [MODEL QUESTION]

Answer:

When a chemical reaction takes place energy is either taken in or released. This depends on the relative strengths of bonds being broken and bonds being formed.

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In an exergonic reaction, energy is released to the surroundings. The bonds being formed are stronger than the bonds being broken.  
 In an endergonic reaction, energy is absorbed from the surroundings. The bonds being formed are weaker than the bonds being broken.

**5. What is metabolism and metabolites?**

**[MODEL QUESTION]**

**Answer:**  
 Countless chemical reactions take place in cells and are responsible for all the actions of organisms. Together, these reactions make up an organism's metabolism. The chemicals taking part in these reactions are called metabolites.

In all reactions:

- chemical bonds in the reacting molecules are broken; this takes in energy
- new chemical bonds form to make the products; this gives out energy

When a chemical reaction takes place energy is either taken in or released. This depends on the relative strengths of bonds being broken and bonds being formed.

**6. What are the differences between Exothermic reaction and Exergonic reaction?**

**[MODEL QUESTION]**

**Answer:**

1. Exothermic reaction
  - a. Energy released is just called energy
  - b. Energy of reactants is greater than that of products
  - c. Energy of the reaction system decreases relative to that of the surrounding, i.e. the surrounding becomes hotter.
2. Exergonic reaction
  - a. Energy released, has a special name called Gibbs energy or Gibbs free energy
  - b. Energy reactants is greater than that of the products
  - c. It has nothing to do with how hot or cold reactants become. Has a more chemical meaning - it relates to the spontaneity of the reaction; thus it always means that a reaction is feasible, i.e. reaction will always happen.

**7. Can endothermic reaction also be an exergonic reaction? [MODEL QUESTION]**

**Answer:**

An exergonic reaction is always accompanied by a decrease in free energy of the system. That means,  $\Delta G$  is always negative. Most of such reactions are exothermic; that is,  $\Delta H$  (change in enthalpy) is also negative.

Changes in free energy ( $G$ ), enthalpy ( $H$ ) and entropy ( $S$ ) are related by the equation:  $\Delta G = \Delta H - T \cdot \Delta S$ .

So, even if  $\Delta H$  is positive (endothermic),  $\Delta G$  can be negative, provided  $\Delta S$  is also positive with large value for  $T$  (temperature). In other words, decrease in free energy is still possible even if there is absorption of heat. So, an endothermic reaction can also be an exergonic reaction under certain conditions.

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**8. State the Relationship between free Energy and Equilibrium Constant. [MODEL QUESTION]**

**Answer:**

The free energy change of the reaction in any state,  $\Delta G$  (when equilibrium has not been attained) is related to the standard free energy change of the reaction,  $\Delta G^\circ$  (which is equal to the difference in free energies of formation of the products and reactants both in their standard states) according to the equation.

$$\Delta G = \Delta G^\circ + RT \ln Q$$

Where  $Q$  is the reaction quotient

When equilibrium is attained, there is no further free energy change i.e.  $\Delta G = 0$  and  $Q$  becomes equal to equilibrium constant. Hence the above equation becomes,

$$\Delta G^\circ = -RT \ln K_{(eq)}$$

$$\text{or, } \Delta G^\circ = -2.303RT \log K_{(eq)}$$

**9. What is the Spontaneity of Chemical reaction?**

**[MODEL QUESTION]**

**Answer:**

In general, the spontaneity of a process only determines whether or not a process can occur and makes no indication as to whether or not the process will occur. In other words, spontaneity is a necessary, but not sufficient, condition for a process to actually occur. Furthermore, spontaneity makes no implication as to the speed at which a spontaneous may occur.

As an example, the conversion of a diamond into graphite is a spontaneous process at room temperature and pressure. Despite being spontaneous, this process does not occur since the energy to break the strong carbon-carbon bonds is larger than the release in free energy.

**10. How to determine spontaneity of a chemical reaction Using free energy?**

**[MODEL QUESTION]**

**Answer:**

For a process that occurs at constant temperature and pressure, spontaneity can be determined using the change in Gibbs free energy, which is given by:  
 Where the sign of  $\Delta G$  depends on the signs of the changes in enthalpy ( $\Delta H$ ) and entropy ( $\Delta S$ ). The sign of  $\Delta G$  will change from positive to negative (or vice versa)

$$\text{Where } T = \frac{\Delta H}{\Delta S}$$

In cases where  $\Delta G$  is:

- negative, the process is spontaneous and may proceed in the forward direction as written.
- positive, the process is non-spontaneous as written, but it may proceed spontaneously in the reverse direction.
- zero, the process is at equilibrium, with no net change taking place over time.

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This set of rules can be used to determine four distinct cases by examining the signs of the  $\Delta S$  and  $\Delta H$ .

- When  $\Delta S > 0$  and  $\Delta H < 0$ , the process is always spontaneous as written.
- When  $\Delta S < 0$  and  $\Delta H > 0$ , the process is never spontaneous, but the reverse process is always spontaneous.
- When  $\Delta S > 0$  and  $\Delta H > 0$ , the process will be spontaneous at high temperatures and non-spontaneous at low temperatures.
- When  $\Delta S < 0$  and  $\Delta H < 0$ , the process will be spontaneous at low temperatures and non-spontaneous at high temperatures.

For the latter two cases, the temperature at which the spontaneity changes will be determined by the relative magnitudes of  $\Delta S$  and  $\Delta H$ .

#### 11. What is ATP- Adenosine Triphosphate?

##### [MODEL QUESTION]

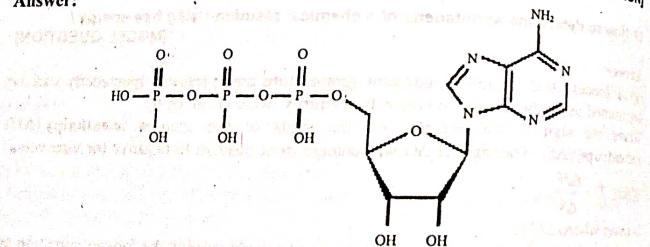
**Answer:**  
ATP - Adenosine triphosphate is called the energy currency of the cell. It is the organic compound composed of the phosphate groups, adenine, and the sugar ribose. These molecules provide energy for various biochemical processes in the body. Therefore, it is called "Energy Currency of the Cell". These ATP molecules are synthesized by Mitochondria, therefore it is called powerhouse of the cell. The ATP molecule was discovered in the year 1929 by German chemist Karl Lohmann. Later in the year 1948, Scottish biochemist Alexander Todd was the first person to synthesized the ATP molecule.

ATP - the energy-carrying molecules are found in the cells of all living things. These organic molecules function by capturing the chemical energy obtained from the digested food molecules and are later released for different cellular processes.

#### 12. Describe the structure of Structure of ATP molecule.

##### [MODEL QUESTION]

**Answer:**



ATP - Adenosine triphosphate is a nucleotide, which is mainly composed of the molecule adenine and three phosphate groups. It is soluble in water and has a high energy content, which is primarily due to the presence of two phosphoanhydride bonds connected to the three phosphate groups.

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The triphosphate tail of ATP is the actual power source which the cell taps. The available energy is contained in the bonds between the phosphates and is released when they are broken or split into molecules. This occurs through the addition of a water molecule (hydrolysis). Usually, only the outer phosphate group is removed from ATP to yield energy; when this occurs, ATP - Adenosine triphosphate is converted into ADP - adenosine diphosphate, it is the form of the nucleotide having only two phosphates.

- The pentose sugar molecule i.e. ribose sugar.
- Nitrogen base- Adenine, attached to the first carbon of this sugar molecule.
- The three phosphate groups which are attached in a chain to the 5th carbon of the pentose sugar. The phosphoryl groups, starting with the group closest to the phosphates play an important role in the activity of ATP.

#### 13. How is energy produced by the ATP molecules?

##### [MODEL QUESTION]

**Answer:**  
The three phosphate groups present in this ATP molecule are called high energy bonds as they are involved in the liberation of a huge amount of energy when they are broken. This molecule provides energy for various life processes without which life cannot exist. It is used by various enzymes and structural proteins in cellular processes like biosynthetic reactions, cell divisions, etc. This "energy currency of the cell" is produced during cellular respiration where a digested simple molecule of food is utilized. Once after the energy is produced by the ATP molecules, they are stored in its bonds which are later utilized by the cells by breaking the bonds whenever required.

#### 14. What are the Functions of ATP?

##### [MODEL QUESTION]

**Answer:**  
The ATP is used for various cellular functions, including transportation of different molecules across cell membranes. Other functions of ATP include supplying the energy required for the muscle contraction, for the blood circulation, and various body movements. A significant role of ATP apart from energy production includes: Synthesizing the multi-thousands of types of macromolecules that the cell requires to exist. ATP molecule is also used as a switch to control chemical reactions and to send messages.

#### 15. What is the Importance of ATP Molecule in Metabolism?

##### [MODEL QUESTION]

**Answer:**

- These ATP molecules can be recycled after every reaction.
- ATP molecule provides energy for both the exergonic and endergonic processes.
- ATP serves as an extracellular signalling molecule and acts as a neurotransmitter in both central and peripheral nervous systems.
- It is the only energy, which can be directly used for different metabolic process. Other forms of chemical energy need to be converted into ATP before they can be used.

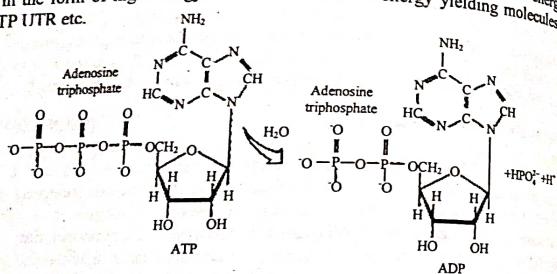
5. It plays an important role in the Metabolism – A life-sustaining chemical reactions including cellular division, fermentation, photosynthesis, photophosphorylation, aerobic respiration, protein synthesis, exocytosis, endocytosis and motility.

**16. Why ATP is called energy currency of the cell?**

**Answer:**  
All activities inside a living cell need energy which is available in the form of ATP as the immediate source. Hence, ATP is described as "The Energy Currency of the cell". When energy in form of ATP is used, the ATP is converted to ADP and again when more energy is available by further breakdown of glucose, the ADP is reconverted to ATP and so it goes on. One mole of glucose on complete oxidation yields 38 molecules of ATP. Thus, ATP provides energy whenever, wherever and however it is needed.

**17. Explain the term 'energy currency'? Which substance acts as energy currency in plants and animals?**

**Answer:**  
The term energy currency refers to that molecule which provides energy for cellular activities, whenever required. ATP is termed as energy currency because the energy is present in the form of high energy bonds of ATP other energy yielding molecules are GTP, CTP UTR etc.

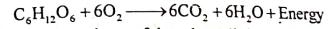


The conversion of ATP to ADP yields about 7.3 kcal/mol of energy. This is the energy source in a variety of biological processes occurring in both plants and animals. Justification for the term 'energy currency' for ATP can be given as (i) Store small packets of energy as soon as it is available thus, minimising its wastage. (ii) Can make energy available to a distant location in cell away from where the site it is produced. (iii) Can carry out heavy work/activity by continuously supplying large amount of energy through its accumulation at one place.

**[MODEL QUESTION]**

**18. Do plants breathe?**

**Answer:**  
Plants require O<sub>2</sub> for respiration to occur and they also give out CO<sub>2</sub>. Hence, plants have systems in place that ensure the availability of O<sub>2</sub>. Plants, unlike animals, have no specialised organs for gaseous exchange but they have stomata and lenticels for this purpose. There are several reasons why plants can get along without respiratory organs. First, each plant part takes care of its own gas-exchange needs. There is very little transport of gases from one plant part to another. Second, plants do not present great demands for gas exchange. Roots, stems and leaves respire at rates far lower than animals do. Only during photosynthesis are large volumes of gases exchanged and, each leaf is well adapted to take care of its own needs during these periods. When cells photosynthesise, availability of O<sub>2</sub> is not a problem in these cells since O<sub>2</sub> is released within the cell. Third, the distance that gases must diffuse even in large, bulky plants is not great. Each living cell in a plant is located quite close to the surface of the plant. 'This is true for leaves', you may ask, 'but what about thick, woody stems and roots?' In stems, the 'living' cells are organised in thin layers inside and beneath the bark. They also have openings called lenticels. The cells in the interior are dead and provide only mechanical support. Thus, most cells of a plant have at least a part of their surface in contact with air. This is also facilitated by the loose packing of parenchyma cells in leaves, stems and roots, which provide an interconnected network of air spaces. The complete combustion of glucose, which produces CO<sub>2</sub> and H<sub>2</sub>O as end products, yields energy most of which is given out as heat.



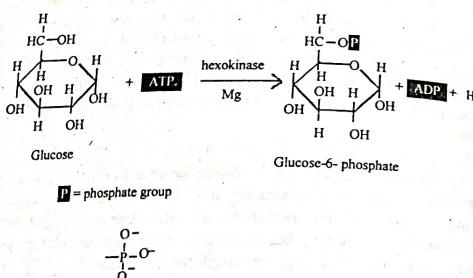
If this energy is to be useful to the cell, it should be able to utilise it to synthesise other molecules that the cell requires. The strategy that the plant cell uses is to catabolise the glucose molecule in such a way that not all the liberated energy goes out as heat. The key is to oxidise glucose not in one step but in several small steps enabling some steps to be just large enough such that the energy released can be coupled to ATP synthesis. How this is done is, essentially, the story of respiration. During the process of respiration, oxygen is utilised, and carbon dioxide, water and energy are released as products. The combustion reaction requires oxygen. But some cells live where oxygen may or may not be available. Can you think of such situations (and organisms) where O<sub>2</sub> is not available? There are sufficient reasons to believe that the first cells on this planet lived in an atmosphere that lacked oxygen. Even among present-day living organisms, we know of several that are adapted to anaerobic conditions. Some of these organisms are facultative anaerobes, while in others the requirement for anaerobic condition is obligate. In any case, all living organisms retain the enzymatic machinery to partially oxidise glucose without the help of oxygen. This breakdown of glucose to pyruvic acid is called glycolysis.

**19. What is glycolysis? Describe the different stages of glycolysis.**

**[MODEL QUESTION]**

**Answer:**  
 The term glycolysis has originated from the Greek words, glycos for sugar, and lysis for splitting. The scheme of glycolysis was given by Gustav Embden, Otto Meyerhof, and J. Parnas, and is often referred to as the EMP pathway. In anaerobic organisms, it is the only process in respiration. Glycolysis occurs in the cytoplasm of the cell and is present in all living organisms. In this process, glucose undergoes partial oxidation to form two molecules of pyruvic acid. In plants, this glucose is derived from sucrose, which is the end product of photosynthesis, or from storage carbohydrates. Sucrose is converted into glucose and fructose by the enzyme, invertase, and these two monosaccharides readily enter the glycolytic pathway. Glucose and fructose are phosphorylated to give rise to glucose-6-phosphate by the activity of the enzyme hexokinase. This phosphorylation of glucose then isomerizes to produce fructose-6-phosphate. This phosphorylation of glucose and fructose are same. In glycolysis, a chain of ten reactions under the control of different enzymes, takes place to produce pyruvate from glucose.

**Step 1: Hexokinase**



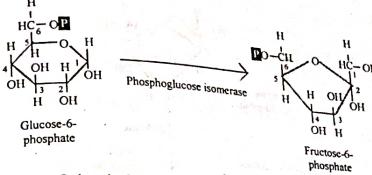
The first step in glycolysis is the conversion of D-glucose into glucose-6-phosphate. The enzyme that catalyzes this reaction is hexokinase.

**Details:**

Here, the glucose ring is phosphorylated. Phosphorylation is the process of adding a phosphate group to a molecule derived from ATP. As a result, at this point in glycolysis, 1 molecule of ATP has been consumed.

The reaction occurs with the help of the enzyme hexokinase, an enzyme that catalyzes the phosphorylation of many six-membered glucose-like ring structures. Atomic magnesium ( $\text{Mg}$ ) is also involved to help shield the negative charges from the phosphate groups on the ATP molecule. The result of this phosphorylation is a molecule called glucose-6-phosphate (G6P), thusly called because the 6' carbon of the glucose acquires the phosphate group.

**Step 2: Phosphoglucomutase**



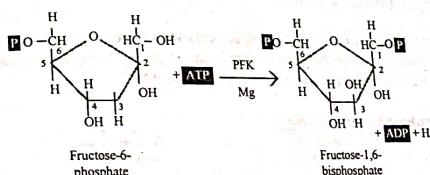
The second reaction of glycolysis is the rearrangement of glucose 6-phosphate (G6P) into fructose 6-phosphate (F6P) by glucose phosphate isomerase (Phosphoglucomutase).

**Details:**

The second step of glycolysis involves the conversion of glucose-6-phosphate to fructose-6-phosphate (F6P). This reaction occurs with the help of the enzyme phosphoglucomutase (PM). As the name of the enzyme suggests, this reaction involves an isomerization reaction.

The reaction involves the rearrangement of the carbon-oxygen bond to transform the six-membered ring into a five-membered ring. To rearrange, the ring opens and then closes in such a way that the first carbon becomes now external to the ring.

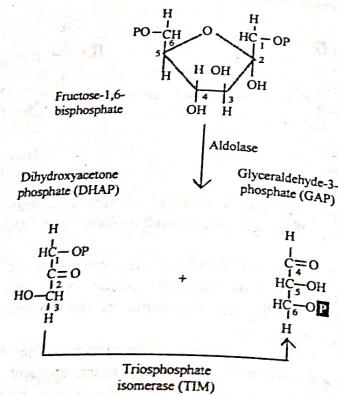
**Step 3: Phosphofructokinase**



Phosphofructokinase, with magnesium as a cofactor, changes fructose 6-phosphate into fructose 1,6-bisphosphate.

**Details:**

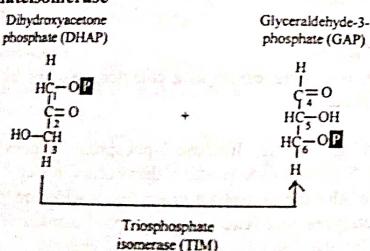
In the third step of glycolysis, fructose-6-phosphate is converted to fructose-1,6-bisphosphate (FBP). Similar to the reaction that occurs in step 1 of glycolysis, a second molecule of ATP provides the phosphate group that is added on to the F6P molecule. The enzyme that catalyzes this reaction is phosphofructokinase (PFK). As in step 1, a magnesium atom is involved to help shield negative charges.

**Step 4: Aldolase**

The enzyme Aldolase splits fructose 1, 6-bisphosphate into two sugars that are isomers of each other. These two sugars are dihydroxyacetonephosphate (DHAP) and glyceraldehyde 3-phosphate (GAP).

**Details:**

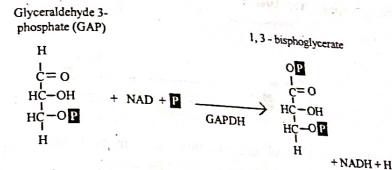
This step utilizes the enzyme aldolase, which catalyzes the cleavage of FBP to yield two 3-carbon molecules. One of these molecules is called glyceraldehyde-3-phosphate (GAP) and the other is called dihydroxyacetone phosphate (DHAP).

**Step 5: Triosephosphateisomerase**

The enzyme triosephosphateisomerase rapidly inter- converts the molecules dihydroxyacetone phosphate (DHAP) and glyceraldehyde 3-phosphate (GAP). Glyceraldehyde phosphate is removed / used in next step of Glycolysis.

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**Details:**  
GAP is the only molecule that continues in the glycolytic pathway. As a result, all of the DHAP molecules produced are further acted on by the enzyme Triosephosphateisomerase (TIM), which reorganizes the DHAP into GAP so it can continue in glycolysis. At this point in the glycolytic pathway, we have two 3-carbon molecules, but have not yet fully converted glucose into pyruvate.

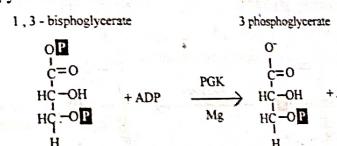
**Step 6: Glyceraldehyde-3-phosphate Dehydrogenase**

Glyceraldehyde-3-phosphate dehydrogenase (GAPDH) dehydrogenates and adds an inorganic phosphate to glyceraldehyde 3-phosphate, producing 1,3-bisphosphoglycerate.

**Details:**

In this step, two main events take place: 1) glyceraldehyde-3-phosphate is oxidized by the coenzyme nicotinamide adenine dinucleotide (NAD); 2) the molecule is phosphorylated by the addition of a free phosphate group. The enzyme that catalyzes this reaction is glyceraldehyde-3-phosphate dehydrogenase (GAPDH).

The enzyme GAPDH contains appropriate structures and holds the molecule in a conformation such that it allows the NAD molecule to pull a hydrogen off the GAP, converting the NAD to NADH. The phosphate group then attacks the GAP molecule and releases it from the enzyme to yield 1,3bisphoglycerate, NADH, and a hydrogen atom.

**Step 7: Phosphoglycerate Kinase**

Phosphoglycerate kinase transfers a phosphate group from 1,3-bisphosphoglycerate to ADP to form ATP and 3-phosphoglycerate.

**Details:**

In this step, 1,3bisphoglycerate is converted to 3-phosphoglycerate by the enzyme phosphoglycerate kinase (PGK). This reaction involves the loss of a phosphate group from the starting material. The phosphate is transferred to a molecule of ADP that yields our first molecule of ATP. Since we actually have two molecules of 1,3bisphoglycerate

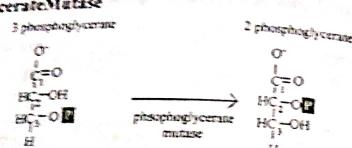
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(because there were two 3-carbon products from stage 1 of glycolysis), we actually synthesize two molecules of ATP at this step. With this synthesis of ATP, we have cancelled the first two molecules of ATP that we used, leaving us with a net of 0 ATP molecules up to this stage of glycolysis. Again, we see that an atom of magnesium is involved to shield the negative charge on the phosphate groups of the ATP molecule.

#### Step 8: Phosphoglycerate Mutase



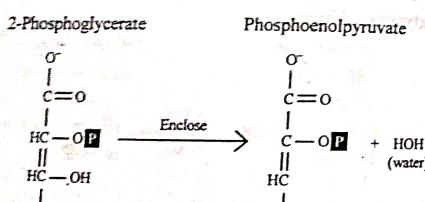
The enzyme phosphoglyceromutase relocates the P from 3-phosphoglycerate from the 3rd carbon to the 2nd carbon to form 2-phosphoglycerate.

#### Details:

This step involves a simple rearrangement of the position of the phosphate group on the 3-phosphoglycerate molecule, making it 2-phosphoglycerate. The molecule responsible for catalyzing this reaction is called phosphoglycerate mutase (PGM). A *mutase* is an enzyme that catalyzes the transfer of a functional group from one position on a molecule to another.

The reaction mechanism proceeds by first adding an additional phosphate group to the 3-position of the 3-phosphoglycerate. The enzyme then removes the phosphate from the 3-position leaving just the 2' phosphate, and thus yielding 2-phosphoglycerate. In this way, the enzyme is also restored to its original, phosphorylated state.

#### Step 9: Enolase



The enzyme enolase removes a molecule of water from 2-phosphoglycerate to form phosphoenolpyruvate (PEP).

#### Details:

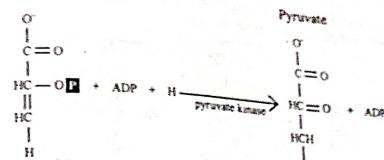
This step involves the conversion of 2-phosphoglycerate to phosphoenolpyruvate (PEP). The reaction is catalyzed by the enzyme enolase. Enolase works by removing a water

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group, or dehydrating the 2-phosphoglycerate. The specificity of the enzyme pocket allows for the reaction to occur through a series of steps too complicated to cover here.

#### Step 10: Pyruvate Kinase

##### Phosphoenolpyruvate



The enzyme pyruvate kinase transfers a P from phosphoenolpyruvate (PEP) to ADP to form pyruvic acid and ATP. Result in step 10.

#### Details:

The final step of glycolysis converts phosphoenolpyruvate into pyruvate with the help of the enzyme pyruvate kinase. As the enzyme's name suggests, this reaction involves the transfer of a phosphate group. The phosphate group attached to the 2' carbon of the PEP is transferred to a molecule of ADP, yielding ATP. Again, since there are two molecules of PEP, here we actually generate 2 ATP molecules.

Steps 1 and 3 = -2ATP

Steps 7 and 10 = +4ATP

Net "visible" ATP produced = 2.

Immediately upon finishing glycolysis, the cell must continue respiration in either an aerobic or anaerobic direction; this choice is made based on the circumstances of the particular cell. A cell that can perform aerobic respiration and which finds itself in the presence of oxygen will continue on to the aerobic citric acid cycle in the mitochondria. If a cell able to perform aerobic respiration is in a situation where there is no oxygen (such as muscles under extreme exertion), it will move into a type of anaerobic respiration called homolactic fermentation. Some cells such as yeast are unable to carry out aerobic respiration and will automatically move into a type of anaerobic respiration called alcoholic fermentation.

#### 20. What is Citric Acid Cycle?

#### [MODEL QUESTION]

#### Answer:

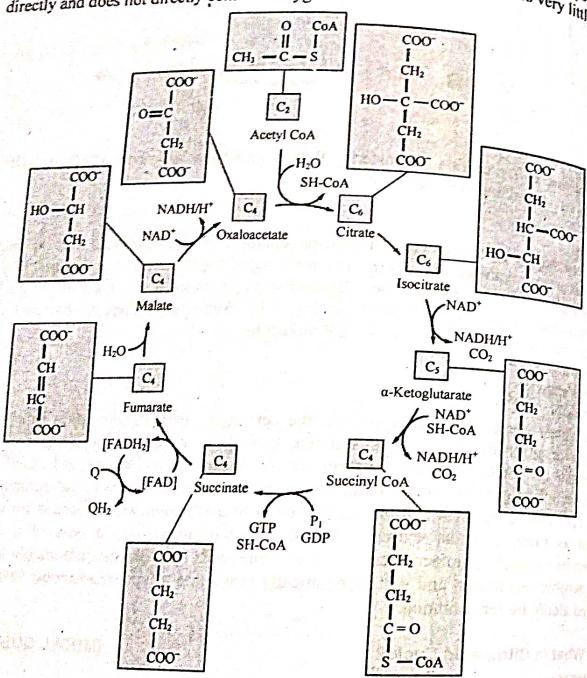
Tricarboxylic Acid Cycle or Citric Acid Cycle or Krebs Cycle

Like the conversion of pyruvate to acetyl CoA, the citric acid cycle takes place in the matrix of the mitochondria. Almost all of the enzymes of the citric acid cycle are soluble, with the single exception of the enzyme succinate dehydrogenase, which is embedded in the inner membrane of the mitochondrion. Unlike glycolysis, the citric acid cycle is a closed loop: the last part of the pathway regenerates the compound used in the first step. The eight steps of the cycle are a series of redox, dehydration, hydration, and

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decarboxylation reactions that produce two carbon dioxide molecules, one GTP/ATP, and reduced forms of NADH and FADH<sub>2</sub>. This is considered an aerobic pathway because the NADH and FADH<sub>2</sub> produced must transfer their electrons to the next pathway in the system, which will use oxygen. If this transfer does not occur, the oxidation steps of the citric acid cycle also do not occur. Note that the citric acid cycle produces very little ATP directly and does not directly consume oxygen.



### 21. Define Citric Acid Cycle. Explain all the steps of Citric Acid Cycle. [MODEL QUESTION]

**Answer:**

The citric acid cycle: In the citric acid cycle, the acetyl group from acetyl CoA is attached to a four-carbon oxaloacetate molecule to form a six-carbon citrate molecule. Through a series of steps, citrate is oxidized, releasing two carbon dioxide molecules for each acetyl group fed into the cycle. In the process, three NAD<sup>+</sup> molecules are reduced to NADH,

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one FAD molecule is reduced to FADH<sub>2</sub>, and one ATP or GTP (depending on the cell type) is produced (by substrate-level phosphorylation). Because the final product of the citric acid cycle is also the first reactant, the cycle runs continuously in the presence of sufficient reactants.

#### Steps in the Citric Acid Cycle

**Step 1:** The first step is a condensation step, combining the two-carbon acetyl group (from acetyl CoA) with a four-carbon oxaloacetate molecule to form a six-carbon eventually combine with another acetyl group. This step is irreversible because it is highly exergonic. The rate of this reaction is controlled by negative feedback because it is amount of ATP available. If ATP levels increase, the rate of this reaction decreases. If ATP is in short supply, the rate increases.

**Step 2:** Citrate loses one water molecule and gains another as citrate is converted into its isomer, isocitrate.

**Steps 3 and 4:** In step three, isocitrate is oxidized, producing a five-carbon molecule, α-ketoglutarate, together with a molecule of CO<sub>2</sub> and two electrons, which reduce NAD<sup>+</sup> to NADH. This step is also regulated by negative feedback from ATP and NADH and by a positive effect of ADP. Steps three and four are both oxidation and decarboxylation steps, which release electrons that reduce NAD<sup>+</sup> to NADH and release carboxyl groups that form CO<sub>2</sub> molecules. α-Ketoglutarate is the product of step three, and a succinyl group is the product of step four. CoA binds the succinyl group to form succinyl CoA. The enzyme that catalyzes step four is regulated by feedback inhibition of ATP, succinyl CoA, and NADH.

**Step 5:** A phosphate group is substituted for coenzyme A, and a high-energy bond is formed. This energy is used in substrate-level phosphorylation (during the conversion of the succinyl group to succinate) to form either guanine triphosphate (GTP) or ATP. There are two forms of the enzyme, called isoenzymes, for this step, depending upon the type of animal tissue in which they are found. One form is found in tissues that use large amounts of ATP, such as heart and skeletal muscle. This form produces ATP. The second form of the enzyme is found in tissues that have a high number of anabolic pathways, such as liver. This form produces GTP. GTP is energetically equivalent to ATP; however, its use is more restricted. In particular, protein synthesis primarily uses GTP.

**Step 6:** Step six is a dehydration process that converts succinate into fumarate. Two hydrogen atoms are transferred to FAD, producing FADH<sub>2</sub>. The energy contained in the electrons of these atoms is insufficient to reduce NAD<sup>+</sup> but adequate to reduce FAD. Unlike NADH, this carrier remains attached to the enzyme and transfers the electrons to the electron transport chain directly. This process is made possible by the localization of the enzyme catalyzing this step inside the inner membrane of the mitochondrion.

**Step 7:** Water is added to fumarate during step seven, and malate is produced. The last step in the citric acid cycle regenerates oxaloacetate by oxidizing malate. Another molecule of NADH is produced.

**22. What are the Products of the Citric Acid Cycle?****Answer:**

Two carbon atoms come into the citric acid cycle from each acetyl group, representing four out of the six carbons of one glucose molecule. Two carbon dioxide molecules are released on each turn of the cycle; however, these do not necessarily contain the most recently-added carbon atoms. The two acetyl carbon atoms will eventually be released on later turns of the cycle; thus, all six carbon atoms from the original glucose molecule are eventually incorporated into carbon dioxide. Each turn of the cycle forms three NADH molecules and one FADH<sub>2</sub> molecule. These carriers will connect with the last portion of aerobic respiration to produce ATP molecules. One GTP or ATP is also made in each cycle. Several of the intermediate compounds in the citric acid cycle can be used in synthesizing non-essential amino acids; therefore, the cycle is amphibolic (both catabolic and anabolic).

**Breakdown of Pyruvate**

After glycolysis, pyruvate is converted into acetyl CoA in order to enter the citric acid cycle.

**23. Define Photosynthesis.****[MODEL QUESTION]****Answer:**

"Photosynthesis is a process used by plants in which energy from sunlight is used to convert carbon dioxide and water into molecules needed for growth. These molecules include sugars, enzymes and chlorophyll. Light energy is absorbed by the green chemical chlorophyll."

All animals and human beings are dependent on plants for food and these plants synthesize the food via physio-chemical process called Photosynthesis. This process is important because:

- It is the primary source of food.
- It results in the release of oxygen in atmosphere.

**24. Where Photosynthesis does takes place?****[MODEL QUESTION]****Answer:**

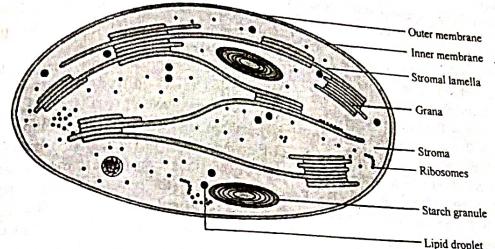
Photosynthesis includes series of chemical reactions which are carried out in chloroplast, i.e. the specialized structures found on cells of plants. In these series of reaction, water and carbon dioxide are converted into glucose and in this reaction energy from sunlight is used. Because, it is an endothermic reaction, the entire process requires input of energy. Photosynthesis is also classified as oxidation-reduction reaction as it includes loss of electrons by water and gain of electrons by carbon dioxide.

The process of photosynthesis takes place in Mesophyll Cells and the carbon dioxide required by the process enters the process via stomata, i.e. the small holes present on the outer layer of leaves. The water required for the process is transported via roots through the vascular tissues.

The chloroplast contains membranous system (shown in image below) consisting of the stroma lamellae, grana and the fluid stroma. The membrane system traps the light energy

**[MODEL QUESTION]**

and helps in synthesizing ATP and NADPH. Following diagram shows the electron micrograph of a section of chloroplast:

**25. What are the Types of Photosynthetic Reactions?****[MODEL QUESTION]****Answer:**

Photosynthetic Reactions are of two types, i.e.

- Light Dependent Reaction – In these reactions, the energy from sunlight is absorbed by chlorophyll and transformed into chemical energy in the form of ATP and NADPH (electron carrier molecule).
- Light Independent Reaction – This reaction is also referred as Calvin Cycle. In this reaction, the energized electron from light dependent reactions provides energy to form carbohydrates from CO<sub>2</sub> molecules.

**26. Define Biosynthetic Phase.****[MODEL QUESTION]****Answer:**

Biosynthetic Phase is the process by which carbon dioxide is reduced to carbohydrates and the process is termed as carbon fixation; it makes use of the ATP and NADPH produced in the light phase. This process occurs in the stroma of chloroplasts with the help of series of enzyme-catalysed reactions.

**27. How ATP and NADPH are used in Biosynthetic Phase?****[MODEL QUESTION]****Answer:**

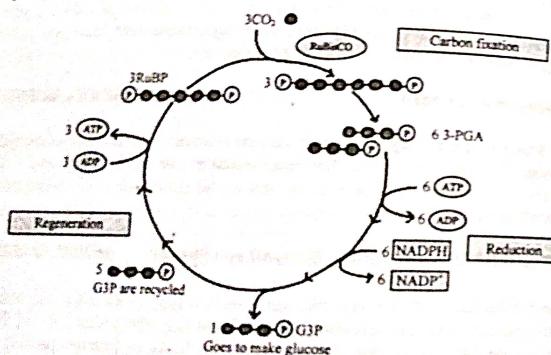
We are aware of the fact that CO<sub>2</sub> is combined with H<sub>2</sub>O to produce sugar. Scientist were very eager to find out how this reaction proceeded and just after Second World War, the use of radioisotope <sup>14</sup>C led to the discovery that the first CO<sub>2</sub> fixation product was 3-<sup>14</sup>C Organic Acid. Melvin Calvin contributed in answering this and therefore, the complete biosynthetic pathway is named as Calvin Cycle. The first identified product was PGA, i.e. 3-Phosphoglyceric Acid.

**29. Describe the Calvin Cycle.****Answer:**

In Calvin Cycle, Carbon atoms from  $\text{CO}_2$  are fixed and are used to form three-Carbon Sugar. This process is dependent on ATP and NADPH formed from light reactions. The light reaction is carried out in thylakoid membrane while the Calvin Cycle takes place in stroma. The Calvin cycle can be described in three stages:

- **Carboxylation** – It is the fixation of  $\text{CO}_2$  in stable organic intermediate. It is an important stage in Calvin Cycle where  $\text{CO}_2$  is utilized for carboxylation. It is catalyzed by RuBP in the presence of enzyme RuBP carboxylase. It results in the formation of 2 molecules of 3-PGA. RuBP carboxylase also helps in oxygenation activity and is therefore also referred as RuBP carboxylase – oxygenase (RuBisCO).
- **Reduction** – This stage includes series of reactions that result in the formation of glucose. This step utilizes 2 molecules of ATP (for phosphorylation) and two molecules of NADPH (for reduction per  $\text{CO}_2$  molecule). The fixation of 6 molecules of  $\text{CO}_2$  and 6 turns of cycle result in the removal of 1 molecule of glucose from pathway.
- **Regeneration** – This stage includes regeneration of  $\text{CO}_2$  acceptor molecule and requires 1 ATP for phosphorylation to form RuBP.

Following diagram represents the entire Calvin cycle, as discussed above in detail. The cycle starts with carboxylation, followed by reduction and then, finally regeneration. The last stage includes regeneration of  $\text{CO}_2$  acceptor molecule and requires 1 ATP for phosphorylation to form RuBP:

**29. What are the reactions involved in Calvin Cycle?****Answer:****Reactions in Calvin Cycle**

With reference to the above diagram, the reactions are divided in three different stages:

- **Carbon Fixation** – A  $\text{CO}_2$  molecule combines with 5 C acceptor molecule and RuBP. This step makes 6 Carbon compound that splits into 2 molecules of 3

**[MODEL QUESTION]****[MODEL QUESTIONS]**

**BIOLOGY**  
Carbon compound and 3PGA. The reaction is catalyzed by RuBP carboxylase or oxygenase.

- Reduction – At the second stage, ATP and NADPH are converted to 3 PGA molecules into molecules of a three carbon sugar and G3P (glyceraldehyde-3-phosphate).
- Regeneration – At the final stage, 3GP molecules go to make glucose while other may be recycled to regenerate RuBP acceptor. The process of regeneration requires ATP along with complex network of reactions.

For exiting cycle, three  $\text{CO}_2$  molecules enter the cycle for exiting 3GP molecule. This provides three new atoms of fixed carbon. Entering of 3  $\text{CO}_2$  molecules, results in regeneration of 3 molecules of RuBP acceptor.

**30. Define Photorespiration.****[MODEL QUESTION]**

**Answer:**  
Photorespiration is a biochemical process in plants in which, especially under conditions of water stress, oxygen inhibits the Calvin cycle, the carbon fixation portion of photosynthesis.

Photorespiration results in light dependent uptake of  $\text{O}_2$  and release of  $\text{CO}_2$  and is associated with metabolism and synthesis of small molecule named glycolate. This process simultaneously takes place in green plants along with photosynthesis. Its end result decreases the net amount of  $\text{CO}_2$  and both photosynthesis and photorespiration works opposite to each other.

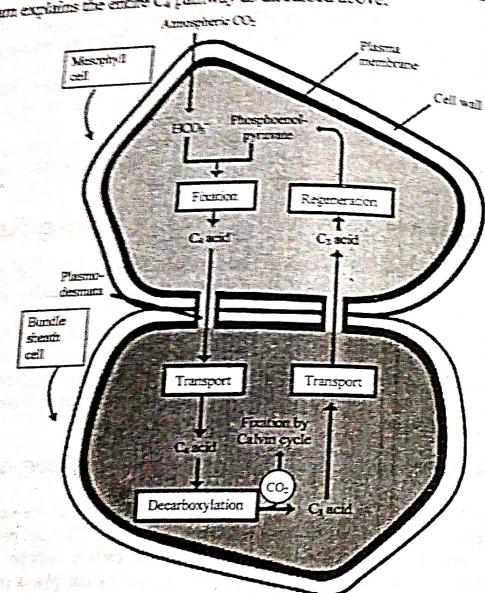
**31. Describe The C<sub>4</sub> Pathway.****[MODEL QUESTION]****Answer:**

Plants that carry out C<sub>4</sub> pathways comprise of specific enzymes that are located in two different cell types, i.e. Mesophyll Cells and Bundle – Sheath Cells. This pathway is the method that is used by plants to convert atmospheric carbon dioxide in chemical compound containing four carbons. This pathway is used by the plants in subtropical areas such as Sugar Cane, Maize, Millet, Papyrus and Sorghum. These plants are special and have several type of leaf anatomy, i.e. they can tolerate higher temperature and also show response to high light intensity.

This pathway is cyclic in nature. The primary  $\text{CO}_2$  acceptor is 3-Carbon Molecule PEP (phosphoenol pyruvate) and is present in mesophyll cells. PEPcase or PEP carboxylase is the enzyme that is responsible for this fixation. It is important to note that the mesophyll cells do not have RuBisCO enzyme and C<sub>4</sub> acid OAA is formed within cells.

After this, 4 - carbon compounds like aspartic acid or malic acid are formed in mesophyll cells which are then transported to bundle sheath cells, where C<sub>4</sub> acids are broken down to release Carbon Dioxide ( $\text{CO}_2$ ) and three carbon molecules. These 3 Carbon molecules are transported back to mesophyll cells where it gets converted in PEP, thereby completing the cycle. The  $\text{CO}_2$  released enters in bundle sheath cells and thereby the Calvin pathway. These bundle sheath cells have surplus of an enzyme called RuBisCO

(Ribulose-Bisphosphate Carboxylase – Oxygenase) and is deficient in PEPcase. Following diagram explains the entire C<sub>4</sub> pathway as discussed above:



### 32. What happens in the energy payoff phase of glycolysis? [MODEL QUESTION]

**Answer:**

The energy payoff phase of glycolysis consists of five additional steps and results in the formation of four ATP, two NADH<sup>+</sup>H<sup>+</sup>, and two pyruvate molecules. Substrate level phosphorylation is the process by which ATP is produced from the transfer of a phosphate group from a substrate molecule in a metabolic pathway.

### 33. What are the influencing factors of Photosynthesis? [MODEL QUESTION]

**Answer:**

#### Factors affecting Photosynthesis

There are several factors that affect the rate of photosynthesis. These factors are both internal and external factors:

1. Temperature – When carbon dioxide, light and other factors are not limiting, photosynthesis rate increases with the rise in temperature. The most preferred range of temperature is 6° C – 37° C. High temperature results in inactivation of enzymes and thereby affects enzymatically controlled dark reactions.
2. Carbon Dioxide Concentration – It is the major limiting factor and its concentration to 0.05% causes increase in fixation rate of CO<sub>2</sub>. Added to this, C<sub>3</sub> and C<sub>4</sub> plants differently respond to the concentration of carbon dioxide. The fact that C<sub>3</sub> plants respond to higher CO<sub>2</sub> concentration by showing increased rate of photosynthesis leading to higher productivity has been used for some greenhouse crops like bell pepper and tomatoes. Such plants are allowed to grow in CO<sub>2</sub> enriched environment that leads to higher yields.
3. Light – The light varies as per quality, duration and intensity and has significant impact on the rate of photosynthesis. For instance, there is a linear relationship between incident light and CO<sub>2</sub> fixation at low light intensities. Added to this, increase in the incident light beyond point causes breakdown of chlorophyll and decrease in photosynthesis.
4. Oxygen – Oxygen inhibits photosynthesis in C<sub>3</sub> plants but C<sub>4</sub> plants show little effect. This is so because C<sub>4</sub> plants carry out photorespiration and high oxygen stimulates it. The rate of photosynthesis increases with the reduction of concentration of oxygen.
5. Water – It is an essential raw material for the assimilation of carbon. Less than one percent of absorbed water is utilized in photosynthesis. The decrease of water content in soil decreases the rate of photosynthesis as well. This is so because it results in dehydration of protoplasm and also results in stomatal closure. Added to this, it impairs enzymatic efficiency, affects its colloidal state, inhibits respiration, etc.
6. Mineral elements – These are also essential for the growth of plants and it includes Cu, Cl, Mg, Fe, P and these are closely related with the process of photosynthesis.
7. Air pollutants – Metallic and gaseous pollutants reduce photosynthesis. The pollutants include SO<sub>2</sub>, oxidants, ozone and hydrogen fluorides.
8. Chemical compounds – Although, chemical compounds are present in very less quantity but even the small quantity depresses the rate of photosynthesis. On contrary, increase in the presence of chemical compound results in dying of cells. Thus, there are several factors that affect the rate of photosynthesis. Other factors include content of chlorophyll, protoplasmic factor, accumulation of carbohydrates, etc.

### 34. What are the Energy-yielding and energy-consuming reactions? [MODEL QUESTION]

**Answer:**

The work of biological growth depends on the transfer of energy from catabolic (yielding) to anabolic (consuming) reactions. Classically, the two reactions have been depicted to be connected by ATP, in the sense that the energy released by, for example,

the glycolytic breakdown of sugars is conserved in the form of ATP, which then provides the energy necessary for the biosynthesis of cell material. It is now clear that most organisms, including anaerobes, can conserve energy, in the form of a transmembrane electrochemical gradient of protons, or protonmotive force. However, the protonmotive force drives few biosynthetic processes directly, and the transfer of energy from the protonmotive force to ATP via a membrane-bound reversible ATPase is a vital link between catabolic and anabolic reactions.

## 35. What are energy yields?

[MODEL QUESTION]

**Answer:**  
The net energy yield refers to the amount of energy that is gained from harvesting an energy source. This yield is the total amount of energy gained from harvesting the source after deducting the amount of energy that was spent to harvest it.

## 36. What is the relationship between free energy and metabolism?

[MODEL QUESTION]

**Answer:**  
Free energy is energy that is available to do cellular work. Free energy ( $S$ ) and free energy ( $G$ ) are related inversely.  $G = H - TS$ , where  $G = \text{free energy}$ ,  $H = \text{enthalpy of the system}$ ,  $T$  is the absolute temperature expressed in degrees Kelvin, and  $S$  is entropy. Free energy decreases during an exergonic reaction.

## 37. What is metabolic energy?

[MODEL QUESTION]

**Answer:**  
Energy metabolism is the process of generating energy (ATP) from nutrients. Metabolism comprises a series of interconnected pathways that can function in the presence or absence of oxygen. Aerobic metabolism converts one glucose molecule into 30-32 ATP molecules.

## 38. What type of energy are high net energy yield?

[MODEL QUESTION]

**Answer:**  
Net energy is the amount of high-quality usable energy available from a resource after the amount of energy needed to make it available is subtracted.

## 39. How energy is extracted from glucose?

[MODEL QUESTION]

**Answer:**  
Through the process of cellular respiration, the energy in food is converted into energy that can be used by the body's cells. During cellular respiration, glucose and oxygen are converted into carbon dioxide and water, and the energy is transferred to ATP.

## 40. What forms of energy are released during the energy yielding phase of glycolysis?

**Answer:**  
Glycolysis produces 2 ATP, 2 NADH, and 2 pyruvate molecules. Glycolysis, or the aerobic catabolic breakdown of glucose, produces energy in the form of ATP, NADH, and pyruvate, which itself enters the citric acid cycle to produce more energy.

## 41. What do you understand by energy charge in biological systems?

**Answer:**  
The energy charge is an index used to measure the energy status of biological cells. ATP or Mg-ATP is the principal molecule for storing and transferring energy in the cell; it is used for biosynthetic pathways, maintenance of trans-membrane gradients, movement, cell division, etc. More than 90% of the ATP is produced by phosphorylation of ADP by the ATP synthase. ATP can also be produced by "substrate level phosphorylation" reactions (ADP phosphorylation by (1, 3)-bisphosphoglycerate, phosphoenolpyruvate, phosphocreatine), by the succinate-CoA ligase and phosphoenolpyruvatecarboxykinase, and by adenylate kinase, an enzyme that maintains the three adenine nucleotides in equilibrium (ATP → AMP → 2ADP).

The energy charge is related to ATP, ADP and AMP concentrations. It was first defined by Atkinson and Walton who found that it was necessary to take into account the concentration of all three nucleotides, rather than just ATP and ADP, to account for the energy status in metabolism. Since the adenylate kinase maintains two ADP molecules in equilibrium with one ATP (2ADP → ATP + AMP), Atkinson defined the adenylate energy charge as:

$$\text{Energy Charge} = \frac{[\text{ATP}] + \frac{1}{2}[\text{ADP}]}{[\text{ATP}] + [\text{AMP}] + [\text{ADP}][\text{ATP}]}$$

The energy charge of most cells varies between 0.7 and 0.95; oscillations in this range are quite frequent. Daniel Atkinson showed that when the energy charge increases from 0.6 to 1.0, the citrate lyase and phosphoribosyl pyrophosphate synthetase, two enzymes controlling anabolic (ATP-demanding) pathways are activated, while the phosphofructokinase and the pyruvate dehydrogenase, two enzymes controlling amphibolic pathways (supplying ATP as well as important biosynthetic intermediates) are inhibited. He concluded that control of these pathways has evolved to maintain the energy charge within rather narrow limits - in other words, that the energy charge, like the pH of a cell, must be buffered at all times. We now know that most if not all anabolic and catabolic pathways are indeed controlled, directly and indirectly, by the energy charge. In addition to direct regulation of several enzymes by adenyl nucleotides, an AMP-activated protein kinase known as AMP-K phosphorylates and thereby regulates key enzymes when the energy charge decreases. This results in switching of anabolic pathways while switching on catabolic pathways when AMP increases.

### POPULAR PUBLICATIONS

Life depends on an adequate energy charge. If ATP synthesis is momentarily insufficient to maintain an adequate energy charge, AMP can be converted by two different pathways to hypoxanthine and ribose-5P, followed by irreversible oxidation of hypoxanthine to uric acid. This helps to buffer the adenylate energy charge by decreasing the total {ATP+ADP+AMP} concentration.

### BIOLOGY

## MICROBIOLOGY

### Chapter at a Glance

**Microbiology** is the study of microorganisms, those being unicellular (single cell), multicellular (cell colony), or acellular (lacking cells). Microbiology encompasses numerous sub-disciplines including virology, parasitology, mycology and bacteriology. Eukaryotic microorganisms possess membrane-bound cell organelles and include fungi and protists, whereas prokaryotic organisms—all of which are microorganisms—are conventionally classified as lacking membrane-bound organelles and include Bacteria and Archaea. Microbiologists traditionally relied on culture, staining, and microscopy. However, less than 1% of the microorganisms present in common environments can be cultured in isolation using current means. Microbiologists often rely on molecular biology tools such as DNA sequence based identification, for example 16S rRNA gene sequence used for bacteria identification. Viruses have been variably classified as organisms, as they have been considered either as very simple microorganisms or very complex molecules. Prions, never considered as microorganisms, have been investigated by virologists, however, as the clinical effects traced to them were originally presumed due to chronic viral infections, and virologists tool search—discovering "infectious proteins".

The existence of microorganisms was predicted many centuries before they were first observed, for example by the Jains in India and by Marcus Terentius Varro in ancient Rome. The first recorded microscope observation was of the fruiting bodies of moulds, by Robert Hooke in 1666, but the Jesuit priest Athanasius Kircher was likely the first to see microbes, which he mentioned observing in milk and putrid material in 1658. Antonie van Leeuwenhoek is considered a father of microbiology as he observed and experimented with microscopic organisms in 1676, using simple microscopes of his own design. Scientific microbiology developed in the 19th century through the work of Louis Pasteur and in medical microbiology Robert Koch.

### Multiple Choice Type Questions

1. The identification of bacteria by serologic tests is based on the presence of specific antigens. Which of the following bacterial components is least likely to contain useful antigens? [MODEL QUESTION]

a) Capsule      b) Cell wall      c) Flagella      d) Ribosomes

Answer: (d)

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### POPULAR PUBLICATIONS

2. Each of the following statements concerning the Gram stain is correct except [MODEL QUESTION]
- a) Escherichia coli stains pink because it has a thin peptidoglycan layer
  - b) Streptococcus pyogenes stains blue because it has a thick peptidoglycan layer
  - c) Mycoplasma pneumoniae is not visible in the Gram's stain because it does not have a cell wall
  - d) Mycobacterium tuberculosis stains blue because it has a thick lipid layer

Answer: (d)

3. An outbreak of sepsis caused by Staphylococcus aureus has occurred in the newborn nursery. You are called upon to investigate. According to your knowledge of the normal flora, what is the most likely source of the organism?

- a) Nose      b) Colon      c) Hand      d) Throat [MODEL QUESTION]

Answer: (d)

4. Each of the following organisms is an important cause of urinary tract infections except: [MODEL QUESTION]
- a) Klebsiella pneumoniae
  - b) Escherichia coli
  - c) Bacteriodes fragilis
  - d) Proteus mirabilis

Answer: (d)

5. A 30 year old woman has non-bloody diarrhea for the past 14 hours. Which one of the following organisms is least likely to cause this illness? [MODEL QUESTION]

- a) Streptococcus pyogenes      b) Clostridium difficile  
c) Shigelladysenteriae      d) Salmonella enteritidis

Answer: (d)

6. Each of the following agents is a recognized cause of diarrhea except [MODEL QUESTION]

- a) Clostridium perfringens      b) Vibrio cholera  
c) Enterococcus faecalis      d) Escherichia coli

Answer: (d)

7. Each of the following statements about the classification of streptococci is correct except [BIOLOGY] [MODEL QUESTION]
- a) Pneumococci (Streptococcus pneumoniae) are alpha-hemolytic and can be serotyped on the basis of their polysaccharide capsule
  - b) Enterococci are group D streptococci and can be classified by their ability to grow 6.5% sodium chloride
  - c) Viridans streptococci are identified by Lancefield grouping, which is based on the C carbohydrate in the cell wall
  - d) Although pneumococci and the viridans streptococci are alpha-hemolytic, they can be differentiated by the bile solubility test and their susceptibility to optochin

Answer: (d)

8. Which of the following bacteria has the lowest 50% infective dose (ID<sub>50</sub>)? [MODEL QUESTION]
- a) Campylobacter jejuni
  - b) Salmonella typhi
  - c) Vibrio cholera
  - d) Shigellasonnei

Answer: (d)

9. Which of the following disease is best diagnosed by serologic means? [MODEL QUESTION]
- a) Pulmonary tuberculosis
  - b) Gonorrhea
  - c) Actinomycosis
  - d) Q Fever

Answer: (d)

10. The coagulase test is used to differentiate [MODEL QUESTION]
- a) Staphylococcus epidermidis from Neisseria meningitidis
  - b) Staphylococcus aureus from Staphylococcus epidermidis
  - c) Streptococcus pyogenes from Staphylococcus aureus
  - d) Streptococcus pyogenes from Enterococcus faecalis

Answer: (d)

### Short & Long Answer Type Questions

1. Write short note on Types of termination in bacterial transcription. [MODEL QUESTION]

Answer:

Termination in bacteria. There are two major termination strategies found in bacteria: Rho-dependent and Rho-independent. In Rho-dependent termination, the RNA contains a binding site for a protein called Rho factor. Rho factor binds to this sequence and starts "climbing" up the transcript towards RNA polymerase.

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## POPULAR PUBLICATIONS

2. What is in a single celled organism?

Answer:

A unicellular organism, also known as a single-celled organism, is an organism that consists of only one cell, unlike a multicellular organism that consists of more than one cell.

3. What was the first single celled organism?

Answer:

The first living things on Earth, single-celled micro-organisms or microbes lacking a cell nucleus or cell membrane known as prokaryotes, seem to have first appeared on Earth almost four billion years ago, just a few hundred million years after the formation of the Earth itself.

4. What are 3 examples of unicellular organisms?

Answer:

Examples of unicellular organisms:

Bacteria (E.coli, Nitrospirae, Streptobacillus, Planctomycetes, etc), Diatoms (photosynthetic algae), Brewer's Yeast, Amoeba, Paramecium, Euglena, Phytoplankton, Slime molds, etc. A unicellular organism is one where a single cell is the individual and has a complete set of its species DNA.

5. What is the largest single celled organism?

Answer: Biologists used the world's largest single-celled organism, an aquatic alga called Caulerpa taxifolia, to study the nature of structure and form in plants. It is a single cell that can grow to a length of six to twelve inches.

6. What are characteristics of unicellular organisms?

Answer:

Some living organisms are unicellular which means that they only consist of one cell. This means that this single cell will be able to show all the characteristics of a living organism. Euglena has chloroplasts which is typical of a plant. Typical animal features include flagellum (for movement), lack of cell wall.

7. Which single celled organism has Pseudopodia?

[MODEL QUESTION]

Answer:

An amoeba, sometimes written as "ameba", is a term generally used to describe a single celled eukaryotic organism that has no definite shape and that moves by means of pseudopodia. Pseudopodia or pseudopods are temporary projections of the cell and the word literally means "false feet".

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[MODEL QUESTION]

## BIOLOGY

& What are the similarities and differences between unicellular and multi cellular organism?

Answer:

**Similarities:**

- One important distinction here is whether we're talking about prokaryotes, i.e. organisms without a complex cell structure, and/or eukaryotes, organisms that have nuclei and other structures. This would significantly affect the comparison.
- However, generally speaking, we can say that unicellular and multicellular organisms are alike in that they exhibit all the functions of life, such as a metabolism and reproduction, they contain DNA and RNA, they can exhibit a wide range of lifestyles, and they are essential to almost every ecosystem that we currently know of.

**Differences:**

- Unicellular organisms can reproduce faster and in greater numbers. Some of them are also capable of actually sharing DNA between living individuals, which is impossible for more complex life without technological intervention.
- Multicellular organisms are almost always larger.
- Unicellular organisms are more commonly found in extreme environments; the archaea, the third domain of life, counts among its members a number of "extremophiles" - single-celled organisms that thrive in environments of extreme heat, acidity, salinity, etc.
- Multicellular organisms typically experience severe stress or death if a certain number of cells die or are separated from the group; unicellular organisms have no comparable problem.
- Multicellular organisms require more food and living space and typically occupy a higher link in the food web.
- Multicellular organisms may be better equipped to survive a harmful DNA mutation due to redundancy in other cells, but they are also at risk of cancer and other related diseases that have no comparison in the unicellular organism.

9. What is the bacterial species concept?

[MODEL QUESTION]

Answer:

The emerging phylo-phenetic bacterial species concept posits that a bacterial species is a monophyletic and genetically coherent cluster of individual organisms that show a high degree of overall similarity with respect to many independent characteristics, and is diagnosable by a discriminative phenotypic property."

10. What is strain?

[MODEL QUESTION]

Answer:

A strain is a genetic variant or subtype of a microorganism, that is to say a virus or bacterium or fungus. For example, a "flu strain" is a certain biological form of the influenza or "flu" virus. Properly speaking, Bacteria, Archaea and viruses do not have species, because they do not have eukaryote-type sexual reproduction. Bacteria do exchange DNA, but they may exchange it between different kinds of bacteria, illustrating

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their considerable difference from eukaryotes. Strains are therefore an absolutely essential part of bacterial identification.

**11. What is type strain?**

**Answer:**  
Type strain is the strain, which was used when the species was described for the first time and which was selected by the author as the type strain. A strain designation including superscript T (e.g. B78<sup>T</sup>) shows the the strain is a type strain.

**12. What do you mean by strain of bacteria?**

**Answer:**  
In microbiology or virology, a strain is a genetic variant or subtype of a micro-organism (e.g., virus or bacterium or fungus). For example, Escherichia coli is a well studied bacterium and encompasses an enormous population of bacteria that exhibit a very high degree of both genetic and phenotypic diversity.

**13. How many E. coli strains are there?**

**Answer:**  
Microbiologics offers over 45 different strains of E. coli including O157:H7, O104:H4 and the Big 6 Shiga toxin-producing strains. Visit our website to find the right strain and format for your lab.

**14. What are the four types of infection?**

**Answer:**  
Types of infection include bacterial, fungal, viral, protozoan, parasitic, and prion disease. What are the five signs of an infection?

If you notice any of the following signs, see your doctor as soon as possible for infected wound treatment.

- Feelings of Malaise. Malaise is a common non-specific sign of a localized systemic infection.
- Running a Fever
- Fluid Drainage
- Continual or Increased Pain
- Redness and Swelling
- Hot Incision Site.

**15. Describe the classification of Microorganisms? Give their identification features.**

**[MODEL QUESTION]**

**Answer:**  
Microorganisms or microbes are microscopic organisms that exist as unicellular, multicellular, or cell clusters. Microorganisms are widespread in nature and are beneficial to life, but some can cause serious harm. They can be divided into six major types: bacteria, archaea, fungi, protozoa, algae, and viruses.

**Bacteria**

Bacteria are unicellular organisms. The cells are described as prokaryotic because they lack a nucleus. They exist in four major shapes: bacillus (rod shape), coccus (spherical shape), spirilla (spiral shape), and vibrio (curved shape). Most bacteria have a peptidoglycan cell wall; they divide by binary fission; and they may possess flagella for motility. The difference in their cell wall structure is a major feature used in classifying these organisms.

According to the way their cell wall structure stains, bacteria can be classified as either Gram-positive or Gram-negative when using the Gram staining. Bacteria can be further divided based on their response to gaseous oxygen into the following groups: aerobic (living in the presence of oxygen), anaerobic (living without oxygen), and facultative anaerobes (can live in both environments).

According to the way they obtain energy, bacteria are classified as heterotrophs or autotrophs. Autotrophs make their own food by using the energy of sunlight or chemical reactions, in which case they are called chemoautotrophs. Heterotrophs obtain their energy by consuming other organisms. Bacteria that use decaying life forms as a source of energy are called saprophytes.

**Archaea**

Archaea or Archaeabacteria differ from true bacteria in their cell wall structure and lack peptidoglycans. They are prokaryotic cells with adaptability to extreme environmental conditions. Based on their habitat, all Archaeans can be divided into the following groups: methanogens (methane-producing organisms), halophiles (archaea that live in salty environments), thermophiles (archaea that live at extremely hot temperatures), and psychrophiles (cold-temperature Archaeans). Archaeans use different energy sources like hydrogen gas, carbon dioxide, and sulphur. Some of them use sunlight to make energy, but not the same way plants do. They absorb sunlight using their membrane pigment, bacteriorhodopsin. This reacts with light, leading to the formation of the energy molecule adenosine triphosphate (ATP).

**Fungi**

Fungi (mushroom, molds, and yeasts) are eukaryotic cells (with a true nucleus). Most fungi are multicellular and their cell wall is composed of chitin. They obtain nutrients by absorbing organic material from their environment (decomposers), through symbiotic relationships with plants (symbionts), or harmful relationships with a host (parasites). They form characteristic filamentous tubes called hyphae that help absorb material. The collection of hyphae is called mycelium. Fungi reproduce by releasing spores.

**Protozoa**

Protozoa are unicellular aerobic eukaryotes. They have a nucleus, complex organelles, and obtain nourishment by absorption or ingestion through specialized structures. They make up the largest group of organisms in the world in terms of numbers, biomass, and diversity. Their cell walls are made up of cellulose. Protozoa have been traditionally divided based on their mode of locomotion: flagellates produce their own food and use

their whip-like structure to propel forward, ciliates have tiny hair that beat to produce movement, amoeboids have false feet or pseudopodia used for feeding and locomotion, and sporozoans are non-motile. They also have different means of nutrition, which groups them as autotrophs or heterotrophs.

**Algae**  
Algae, also called cyanobacteria or blue-green algae, are unicellular or multicellular eukaryotes that obtain nourishment by photosynthesis. They live in water, damp soil, and rocks and produce oxygen and carbohydrates used by other organisms. It is believed that cyanobacteria are the origins of green land plants.

**Viruses**  
Viruses are non-cellular entities that consist of a nucleic acid core (DNA or RNA) surrounded by a protein coat. Although viruses are classified as microorganisms, they are not considered living organisms. Viruses cannot reproduce outside a host cell and cannot metabolize on their own. Viruses often infect prokaryotic and eukaryotic cells causing diseases.

#### Multicellular Animal Parasites

A group of eukaryotic organisms consisting of the flatworms and roundworms, which are collectively referred to as the helminths. Although they are not microorganisms by definition, since they are large enough to be easily seen with the naked eye, they live a part of their life cycle in microscopic form. Since the parasitic helminths are of clinical importance, they are often discussed along with the other groups of microbes.

#### 16. What is Microscopy?

[MODEL QUESTION]

**Answer:**

Microscopy is the technical field of using microscopes to view objects and areas of objects that cannot be seen with the naked eye (objects that are not within the resolution range of the normal eye). There are three well-known branches of microscopy: optical, electron, and scanning probe microscopy, along with the emerging field of X-ray microscopy.

#### 17. What is Optical microscopy?

[MODEL QUESTION]

**Answer:**

Optical or light microscopy involves passing visible light transmitted through or reflected from the sample through a single lens or multiple lenses to allow a magnified view of the sample. The resulting image can be detected directly by the eye, imaged on a photographic plate, or captured digitally. The single lens with its attachments, or the system of lenses and imaging equipment, along with the appropriate lighting equipment, sample stage, and support, makes up the basic light microscope. The most recent development is the digital microscope, which uses a CCD camera to focus on the exhibit of interest. The image is shown on a computer screen, so eye-pieces are unnecessary.

[MODEL QUESTION]

#### 18. What is Electron microscopy?

**Answer:**  
Until the invention of sub-diffraction microscopy, the wavelength of the light limited the resolution of traditional microscopy to around 0.2 micrometers. In order to gain higher resolution, the use of an electron beam with a far smaller wavelength is used in electron microscopes.

- Transmission electron microscopy (TEM) is quite similar to the compound light microscope, by sending an electron beam through a very thin slice of the specimen. The resolution limit in 2005 was around 0.05 nanometer and has not increased appreciably since that time.
- Scanning electron microscopy (SEM) visualizes details on the surfaces of specimens and gives a very nice 3D view. It gives results much like those of the stereo light microscope. The best resolution for SEM in 2011 was 0.4 nanometer. Electron microscopes equipped for X-ray spectroscopy can provide qualitative and quantitative elemental analysis. This type of electron microscope, also known as analytical electron microscope, can be a very powerful characterization tool for investigation of nanomaterials.

#### 19. What is Scanning probe microscopy?

[MODEL QUESTION]

**Answer:**

This is a sub-diffraction technique. Examples of scanning probe microscopes are the atomic force microscope (AFM), the Scanning tunneling microscope, the photonic force microscope and the recurrence tracking microscope. All such methods use the physical contact of a solid probe tip to scan the surface of an object, which is supposed to be almost flat.

#### 20. What are the different types of Optical Microscope?

[MODEL QUESTION]

**Answer:**

- The optical microscope, often referred to as the light microscope, is a type of microscope that uses visible light and a system of lenses to magnify images of small subjects.
- There are two basic types of optical microscopes:
  1. Simple microscopes
  2. Compound microscopes.

#### 21. Describe simple microscope?

[MODEL QUESTION]

**Answer:**

- A simple microscope is one which uses a single lens for magnification, such as a magnifying glass while a compound microscope uses several lenses to enhance the magnification of an object.
- A simple microscope uses a lens to enlarge an object through angular magnification alone, giving the viewer an erect enlarged virtual image.

### POPULAR PUBLICATIONS

- The use of a single convex lens or groups of lenses is found in simple microscopes and microscopes.
- A simple microscope is actually a convex lens of small focal length, which is used for seeing the magnified images of small objects.

22. Give the principle of simple microscope.

**Answer:**

A simple microscope works on the principle that when a tiny object is placed within its near distance from the eye held close to the lens.

### Magnification of Simple Microscope

The magnifying power of a simple microscope is given by:

$$M = \frac{1}{D} + \frac{F}{D}$$

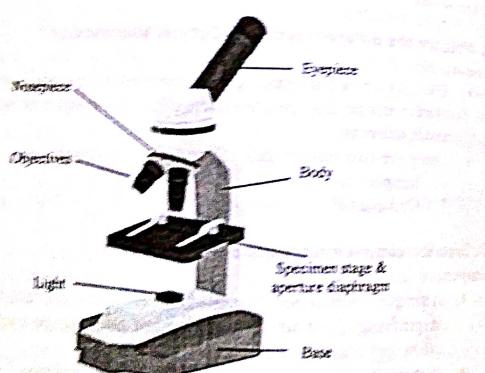
Where,  $D$  = near distance of distinct vision

$F$  = focal length of the convex lens

- The focal length of the convex lens should be small because smaller the focal length of the lens, greater will be its magnifying power.
- The maximum magnification of a simple microscope is about 10, which means that the object will appear 10 times larger by using the simple microscope of maximum magnification.

23. Draw a simple microscope.

**Answer:**



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### [MODEL QUESTION]

24. What is Microbial ecology?

**Answer:**

Microbial ecology (or environmental microbiology) is the ecology of microorganisms: their relationship with one another and with their environment. It concerns the three major domains of life—Eukaryota, Archaea, and Bacteria—as well as viruses.

Microorganisms, by their omnipresence, impact the entire biosphere. Microbial life plays a primary role in regulating biogeochemical systems in virtually all of our planet's environments, including some of the most extreme, from frozen environments and acidic lakes, to hydrothermal vents at the bottom of deepest oceans, and some of the most familiar, such as the human small intestine. As a consequence of the quantitative magnitude of microbial life (calculated as  $5.0 \times 10^{31}$  cells; eight orders of magnitude greater than the number of stars in the observable universe) microbes, by virtue of their biomass alone, constitute a significant carbon sink. Aside from carbon fixation, microorganisms' key collective metabolic processes (including nitrogen fixation, methane metabolism, and sulfur metabolism) control global biogeochemical cycling. The immensity of microorganisms' production is such that, even in the total absence of eukaryotic life, these processes would likely continue unchanged.

### ECOLOGY

#### [MODEL QUESTION]

25. What is Symbiosis?

**Answer:**

Microbes, especially bacteria, often engage in symbiotic relationships (either positive or negative) with other microorganisms or larger organisms. Although physically small, symbiotic relationships amongst microbes are significant in eukaryotic processes and their evolution. The types of symbiotic relationship that microbes participate include mutualism, commensalism, parasitism, and amensalism, and these relationships affect the ecosystem in many ways.

### [MODEL QUESTION]

#### Mutualism

Mutualism in microbial ecology is a relationship between microbial species and between microbial species and humans that allow for both sides to benefit. One such example would be *Syntrophy*, also known as cross-feeding, which is clearly shown in *Methanobacterium omelianskii*. Although initially thought of as one microbial species, this system is actually two species - an S organism and *Methabacterium bryantii*. The S organism provides the bacterium with the H<sub>2</sub>, which the bacterium needs in order to grow and produce methane. The reaction used by the S organism for the production of H<sub>2</sub> is endergonic (and so thermodynamically unfavored) however, when coupled to the reaction used by *Methabacterium bryantii* in its production of methane, the overall reaction becomes exergonic. Thus the two organisms are in a mutualistic relationship which allows them to grow and thrive in an environment, deadly for either species alone. Lichen is an example of a symbiotic organism.

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## POPULAR PUBLICATIONS

### Amensalism

Amensalism (also commonly known as antagonism) is a type of symbiotic relationship where one species/organism is harmed while the other remains unaffected. One example of such a relationship that takes place in microbial ecology is between the microbial species *Lactobacillus casei* and *Pseudomonas taetrolens*. When co-existing in an environment, *Pseudomonas taetrolens* shows inhibited growth and decreased production of lactobionic acid (its main product) most likely due to the byproducts created by *Lactobacillus casei* during its production of lactic acid. However, *Lactobacillus casei* shows no difference in its behavior, and such this relationship can be defined as amensalism.

### 26. What is Microbial resource management?

#### Answer:

Biotechnology may be used alongside microbial ecology to address a number of environmental and economic challenges. For example, molecular techniques such as community fingerprinting can be used to track changes in microbial communities over time or assess their biodiversity. Managing the carbon cycle to sequester carbon dioxide and prevent excess methanogenesis is important in mitigating global warming, and the prospects of bioenergy are being expanded by the development of microbial fuel cells. Microbial resource management advocates a more progressive attitude towards disease, whereby biological control agents are favoured over attempts at eradication. Fluxes in microbial communities has to be better characterized for this field's potential to be realised. In addition, there are also clinical implications, as marine microbial symbioses are a valuable source of existing and novel antimicrobial agents, and thus offer another line of inquiry in the evolutionary arms race of antibiotic resistance, a pressing concern for researchers.

### 27. How microbes interact with human beings?

#### Answer:

Microbes exist in all areas, including homes, offices, commercial centers, and hospitals. In 2016, the journal *Microbiome* published a collection of various works studying the microbial ecology of the built environment. A 2006 study of pathogenic bacteria in hospitals found that their ability to survive varied by the type, with some surviving for only a few days while others survived for months. The lifespan of microbes in the home varies similarly. Generally bacteria and viruses require a wet environment with a humidity of over 10 percent. *E. coli* can survive for a few hours to a day. Bacteria which form spores can survive longer, with *Staphylococcus aureus* surviving potentially for weeks or, in the case of *Bacillus anthracis*, years. In the home, pets can be carriers of bacteria; for example, reptiles are commonly carriers of salmonella.

*S. aureus* is particularly common, and asymptotically colonizes about 30% of the human population; attempts to decolonize carriers have met with limited success and generally involve mupirocin nasally and chlorhexidine washing, potentially along with vancomycin and cotrimoxazole to address intestinal and urinary tract infections.

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#### [MODEL QUESTION]

### 28. What is Antimicrobials?

#### Answer:

Some metals, particularly copper and silver, have antimicrobial properties. Using antimicrobial copper-alloy touch surfaces is a technique which has begun to be used in the 21<sup>st</sup> century to prevent transmission of bacteria. Silver nanoparticles have also begun to be incorporated into building surfaces and fabrics, although concerns have been raised about the potential side-effects of the tiny particles on human health.

#### BIOLOGY

#### [MODEL QUESTION]

### 29. What is Sterilization?

#### Answer:

Sterilization refers to any process that eliminates, removes, kills, or deactivates all forms of life (in particular referring to microorganisms such as fungi, bacteria, viruses, spores, unicellular eukaryotic organisms such as Plasmodium, etc.) and other biological agents like prions present in a specific surface, object or fluid, for example food or biological culture media. Sterilization can be achieved through various means, including heat, chemicals, irradiation, high pressure, and filtration. Sterilization is distinct from disinfection, sanitization, and pasteurization, in that those methods reduces rather than eliminate all forms of life and biological agents present. After sterilization, an object is referred to as being sterile or aseptic.

#### [MODEL QUESTION]

### 30. What is growth medium?

#### Answer:

A growth medium or culture medium is a solid, liquid or semi-solid designed to support the growth of microorganisms or cells or small plants like the moss *Physcomitrella patens*. Different types of media are used for growing different types of cells.

The two major types of growth media are those used for cell culture, which use specific cell types derived from plants or animals, and microbiological culture, which are used for growing microorganisms, such as bacteria or fungi. The most common growth media for microorganisms are nutrient broths and agar plates; specialized media are sometimes required for microorganism and cell culture growth. Some organisms, termed fastidious organisms, require specialized environments due to complex nutritional requirements. Viruses, for example, are obligate intracellular parasites and require a growth medium containing living cells.

#### [MODEL QUESTION]

### 31. What are the types of growth medium?

#### Answer:

The main types are

- Cultural media
- Minimal media
- Selective media
- Differential media
- Transport media
- Indicator media

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### POPULAR PUBLICATIONS

Q2. What is the composition of growth media?

**Answer:** The most common growth media for microorganisms are nutrient broths (liquid medium) or LB medium (lysogeny broth). Liquid media are often mixed well and poured via a sterile media dispenser into Petri dishes to solidify. These agar plates provide a solid medium on which microbes may be cultured.

### [MODEL QUESTIONS]

## ENVIRONMENTAL SCIENCE

### Fundamentals of Environment

2

### Ecology

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### Air Pollution & Control

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### Water Pollution & Control

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### Land Pollution & Control

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### Noise Pollution & Control

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### Environmental Management

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### NOTE:

MAKAUT course structure and syllabus of 4<sup>th</sup> semester has been changed from 2020. Basic Environmental Engineering & Elementary Biology has been redesigned and restructured as ENVIRONMENTAL SCIENCE in present curriculum. Taking special care of this matter we are providing the relevant MAKAUT university solutions, so that students can get an idea about university questions patterns.