

CHAPTER 1

Reproduction in Organisms

Chapter Analysis with respect to Last 3 Years' Board Exams

List of Topics	2016		2017		2018
	Delhi	All India	Delhi	All India	Delhi/All India
Reproduction, a characteristic feature of all organisms for continuation of species					
Asexual reproduction Modes of reproduction-Asexual and sexual reproduction		1Q (1 mark)	1Q (1 mark)		1Q (3 marks)
Modes-Binary fission, sporulation, budding, gemmule, fragmentation	1Q (2 marks)	1Q (2 marks)			
Vegetative propagation in plants			1Q (3 marks)		

On the basis of above analysis, it can be said that from exam point of view Different types of plants, Types of Fertilization and application of the Sexual Reproduction and Asexual Reproduction are most important concepts of the chapter.

[Topic 1] Asexual Reproduction

Summary

Reproduction and its basic features

Reproduction can be defined as the production of offspring by a sexual or asexual process. Formation of reproductive bodies or units can be done by,

- Replication of DNA
- Development of reproductive bodies into offsprings
- Cell division

Types of Reproduction

Production of offsprings by a single parent is known as asexual reproduction. The offsprings produced are identical to one another and also to their parent. This type of reproduction is usually found in unicellular organisms and also in simple plants and animals.

Methods of Asexual reproduction

- **Fission**- In this type of asexual reproduction, the cell divides into two or more individuals. For example - Monerans and Protists.

Fission can be divided into two types:

- Binary fission: It is a division of parent cell into two individuals. For example: Amoeba.
- Multiple fission: It is a division of parent cell into multiple individuals. For example: Plasmodium.
- **Budding**- In this type of asexual reproduction, a daughter individual is formed from a small projection (bud) arising on the parent body. It can be found in Yeasts, Hydra and Sponges.

Other reproductive structures

- Zoospores (motile spores): Found in some algae, fungi and protists.
- Conidia (non-motile spores): Penicillium
- Gemmules (internal buds of sponges): sponges

Vegetative propagation

In certain plants, vegetative propagules arise from the nodes of modified stems. When the nodes come in contact with damp soil or water, they produce roots and new plants. For example: Eyes in potato, Rhizomes of banana and ginger, Bulbil.

Sexual reproduction

In sexual reproduction, formation of male and female gametes is achieved, either by the same individual or by different individuals of the opposite sex. It results

in offsprings that are not exactly identical to their parents or amongst themselves.

Juvenile phase: The period of rapid growth to attain maturity for sexual reproduction. In plants, it is known as the vegetative phase.

Reproductive phase: It is the phase of life cycle wherein the growth of the individuals is slowed down but it attains the maturity to reproduce. Annual and biennial plants show visible vegetative, reproductive and senescent phases but it is quite difficult to identify these phases in perennial plants.

Oestrus cycle: The females of placental mammals exhibit cyclic changes in the activities of ovaries and hormones, during reproductive phase. These cyclic changes are known as Oestrus cycle.

Senescence: Also known as 'Old age' in plants. It is the last phase of their life span and end of reproductive phase. In this phase, metabolism slows down, finally leading to death.

Events in Sexual reproduction

- **Pre-fertilization Events**- The events prior to the fusion of gametes.

Gametogenesis- Process of gamete formation for both male and female

- Homogametes/Isogametes: Gametes cannot be classified into male or female. Fusion of such gametes is known as Isogamy.
- Heterogametes: Male and female gametes can be easily differentiated. Female gamete is known as ovum or egg and the male gamete is known as antherozoid or sperm.

Sexuality in organism

- Heterothallic/dioecious: Plants that have only one sex organ.
- Homothallic/monoecious: Plants that have both male and female sex organs.
- Unisexual: Animals that have only one type of reproductive system. For example: cockroach.
- Bisexual: Animals that have both male and female reproductive system. Example: earthworms or leech. Fungi maybe bisexual (homothallic) or unisexual (heterothallic).

Cell division

Diploid parental body produces haploid gametes by the process of meiosis. It can be observed in angiosperms, gymnosperms and animals.

Haploid parental body produces haploid gametes by mitosis. It can be observed in Algae, Fungi, Monera.

Gamete transfer: For fertilization, male gametes need a medium to transport towards female. A large number of male gametes are produced to compensate the loss of male gametes during their movement toward the female gametes.

In plants like bryophytes and algae, the medium for the transfer of gametes is water.

- **Fertilization Events-** Fusion of gametes to form a diploid zygote.

The female gamete develops into a new organism without fertilization in honeybees, turkey, some lizards. This is called parthenogenesis.

There are two types of Fertilization (Syngamy):

- **External fertilization-** In this, the fertilization occurs outside the body of the organism. For example- Aquatic organisms like amphibians, algae. The offsprings produced from this type of fertilization are extremely vulnerable to predators threatening their survival.
- **Internal fertilization-** In this the fertilization occurs inside the body of the organism. For example- angiosperms, gymnosperms and bryophytes. The number of eggs is very low while the sperms are produced in large quantity.
- **Post-fertilization Events-** The events that take place after the formation of zygote.
- **Zygote:** Every sexually reproducing organism begins its life as a zygote. Zygote is formed after fertilization. The development of zygote depends on the life cycle of the organism and nature of environment. Organisms having diplontic life cycle, zygote divides by the process of mitosis whereas organisms having haplontic life cycle, zygote divides by the process of meiosis to produce haploid spores.
- **Embryogenesis-** The process of development of zygote into an embryo.

Cell division increases the number of cells in the embryo. Cell division (mitosis) and cell differentiation occurs in zygote.

Animals that lay eggs and the zygote development takes place inside the egg are known as Viviparous. For example- Reptiles and birds

Animals that give birth to the young ones are known as Oviparous. The zygote is developed inside the body of the female.

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 1

1 Mark Questions

1. How many chromosomes do drones of honey bees possess? Name the type of cell division involved in the production of sperms by them. [ALL INDIA 2015]
2. Name the type of cell division that takes place in the zygote of an organism exhibiting haplontic life cycle? [DELHI 2011]
3. A male honeybee has 16 chromosomes whereas its female has 32 chromosomes. Give one reason. [ALL INDIA 2016]
4. State the fate of a pair of autosomes during gamete formation. [DELHI 2017]
5. Name the phase all organisms have to pass through before they can reproduce sexually. [ALL INDIA 2011]
6. Name the type of cell division that takes place in the zygote of an organism exhibiting haplontic life cycle? [ALL INDIA 2011]
7. Mention the unique flowering phenomenon exhibited by *Strobilanthes kunthiana*? [ALL INDIA 2012]
8. Name an organism where cell division in itself is a mode of reproduction. [ALL INDIA 2013]

2 Marks Questions

9. The cell divisions involved in gamete formation is not of the same type in different organisms. Justify. [ALL INDIA 2011]
10. Why do algae and fungi shift to sexual mode of reproduction just before the adverse conditions? [DELHI 2014]
11. Explain the significance of meiosis in a diploid organism. [DELHI 2016]
12. A single pea plant in your kitchen garden produces pods with viable seeds, but the individual papaya plant does not. Explain. [ALL INDIA 2016]

3 Marks Questions

13. (a) List the three stages the annuals and biennial angiosperms have to pass through during their life cycle.
(b) List and describe any two vegetative propagules in flowering plants. [DELHI 2017]
14. Differentiate between parthenocarpy and Parthenogenesis. Give one example of each. [DELHI 2018]

Solutions

- Drones are male honey bees. They are haploid and contains 16 chromosomes. Sperms produced by drones is through mitosis cell division. [1]
- Meiosis is the cell division that takes place in the zygote of an organism which forms haploid spores which grow into haploid individuals. [1]
- Male honey bees are called drones and have 16 chromosomes because they develop from unfertilized eggs, hence they are haploid. Females develop from fertilized eggs and are diploid having 32 chromosomes. [1]
- During gametogenesis or gamete formation, the pair of autosomes get separated from each other and one set of a pair moves to each gamete. Hence each gamete receives one set of chromosomes. Gamete has one set of chromosomes and is haploid. [1]
- All organisms have to pass through juvenile phase before they can reproduce sexually. It is also known as vegetative phase in plants. [1]
- Meiosis is the cell division that takes place in the zygote of an organism which include production of haploid spores. [1]
- Strobilanthus kunthiana* is known for flowering once in 12 years. This plant is found in the states like Kerala, Karnataka and Tamil Nadu. [1]
- Amoeba is the name of organism where cell division in itself is a mode of reproduction. [1]
- Yes, cell divisions involved in gamete formation is not of the same type in different organisms. For example, in organism like monera, algae and fungi, gametes are haploid and are produced by mitotic division whereas in humans, pteridophytes and angiosperms, the parent body is diploid and produces haploid gametes with the help of meiotic division. [2]
- Sexual reproduction is helpful in bringing new variation in the organisms that is not possible using asexual reproduction. Hence, the variation produced by sexual reproduction could induce useful variation that may help the algae and fungi to cope up with adverse conditions. [2]
- In diploid organisms, there are two types of cells somatic and germ cells. Germ cells are specialised cells called meiocytes which undergo meiosis to form gametes. Gametes are universally haploid. During meiosis only one set of chromosomes gets incorporated into each gamete. Diploid status is restored after fertilization, forming zygote. [2]
- Pea plant is monoecious, and produces bisexual flowers (Both male and female flowers) on the same plant. It produces viable seeds after self-pollination and fertilization. Whereas papaya plant is dioecious, produces unisexual flowers (male and female flowers) which develop on the different plants. Each plant is either male or female. In absence of opposite reproductive partner a single papaya plant cannot produce viable seeds. [2]
- The three phases through which the annuals and biennial angiosperms pass during their life cycle are: Vegetative or Juvenile phase, reproductive phase and senescent phase.[1]
 - In flowering plants, the vegetative propagules are the structures through which vegetative propagation takes place. Examples of these structures are runner, rhizome, sucker, tuber, offset, and bulb. These structures give rise to new offspring. These structures are called vegetative propagules. The formation of these structures does not involve two parents. Rhizome is a modified stem which contains node, from the nodes, it give rise to new plants. For example ginger, turmeric. Tuber is also modified stem, contains buds (eyes) which gives rise to new plant. For example potato. [1]



Fig.: Rhizome

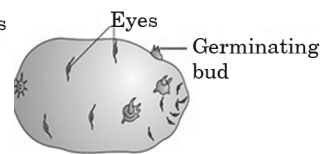


Fig.: Tuber

- In most plants, female gametes need to be fertilized by male gamete to produce fruits. However, some plants can produce fruits without fertilization or before fertilization. The process is called parthenocarpy. During this process, the unfertilized ovule develops into fruits. These fruits do not contain seeds (seedless). For examples papaya, banana, guava. [1½]
Parthenogenesis is a type of asexual reproduction common in some invertebrates and lower plants. In parthenogenesis, the unfertilized ovum develops into an individual (virgin birth) without fertilization. Organisms produced by parthenogenesis are haploid. Therefore, it can be considered as a method of asexual reproduction. It is seen in organism like rotifers, honeybees and even some lizards. [1½]

CHAPTER 2

Sexual Reproduction in Flowering Plants

Chapter Analysis with respect to Last 3 Years' Board Exams

List of Topics	2016		2017		2018
	Delhi	All India	Delhi	All India	Delhi/All India
Flower structure		1Q (3 marks)			
Development of male and female gametophytes					
Pollination-types, agencies and examples, Outbreeding devices	1Q (3 marks)			1Q (2 marks)	
Pollen-Pistil interaction; Double fertilization; Post fertilization events- Development of endosperm and embryo		1Q (5 marks)	1Q (3 marks)	1Q (3 marks), 1Q (5 marks)	1Q (5 marks)
Development of seed and formation of fruit; Special modes-apomixis, parthenocarpy, polyembryony			1Q(5 marks)		
Significance of seed and fruit formation					

On the basis of above analysis, it can be said that from exam point of view the concepts Structure of Mature Pollen Grain, Embryo Sac, Double Fertilization and Specialized Phenomena are most important concepts.

[Topic 1] Flowers and its parts

Summary

Structure of Flower

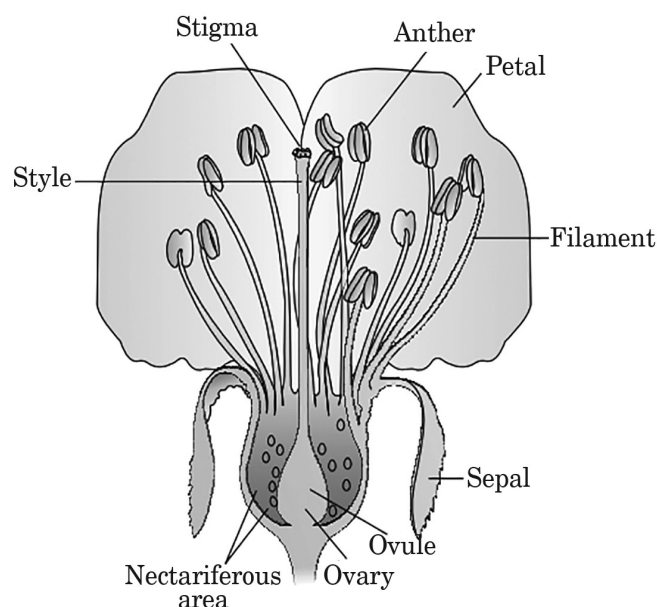


Fig.: Structure of Flower

Flower is the reproductive structure in plants. This is where male and female gametes fuse.

Structures and Events of pre-fertilization

The male reproductive system in a flower is called androecium that contains whorl of stamens and a female reproductive part known as gynoecium consisting pistil.

- **Stamen:** It is the organ of the flower that produces pollen.

It consists of three main parts namely: filament which is a lean and long stalk and has a bilobed extension known as an anther.

There are four microsporangia located at the four sided structure of anther, two in each lobe. The

further development of microsporangia takes place and converts into pollen sacks. Microsporogenesis can be defined as the process in which microspores are formed from the mother cell. They are divided by the process of meiosis.

Pollen grain: The pollen grains represent the male gametophytes.

The presence of sporopollenin ensures the pollen grains are well preserved as fossils. Generative cell and the vegetative cell are the two cells present in a matured pollen grain.

- **Pistil:** The gynoecium represents the female reproductive part of the flower. Gynoecium consisting of single pistil is known as monocarpellary and of multiple pistils is known as multicarpellary.

Gynoecium consists of pistils and each pistil has three part, the stigma, style and the ovary. From the placenta, megasporangia arises which are also called as ovules. An ovary may have one ovule such as in paddy or mango or it may have several ovules such as in water melons.

The stigma lands on pollen grains. Beneath the stigma is a lean part known as style. The bottom bulged part is ovary.

Megasporangium (Ovule)

The female gametophyte is situated inside the nucleus. The megaspore is responsible for formation of a single embryo. The process in which megaspores are formed from the mother cell is coined as megasporogenesis.

Female gametophyte

Monosporic development is the method of embryo sac formation from a single megaspore. In general an angiosperm embryo sac at maturity, though it is 8 nucleate is 7 celled.

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 1

1 Mark Questions

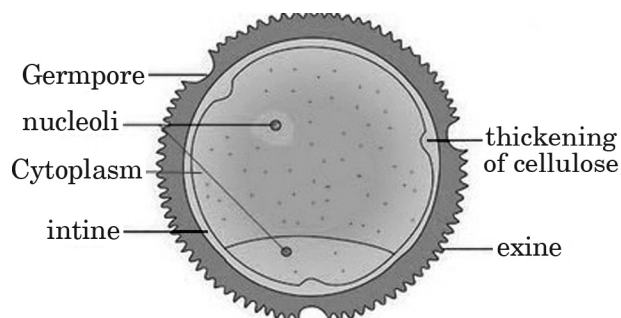
1. An anther with malfunctioning tapetum often fails to produce viable male gametophytes. Give any one reason. [DELHI 2013]
2. Name the part of the flower which the tassels of the corn-cob represent. [ALL INDIA 2014]

2 Marks Questions

3. Why do moss plants produce very large number of male gametes? Provide one reason. What are these gametes called? [ALL INDIA 2015]

3 Marks Questions

4. Draw a diagram of a male gametophyte of an angiosperm. Label any four parts. Why is sporopollenin considered the most resistant organic material? [DELHI 2011]



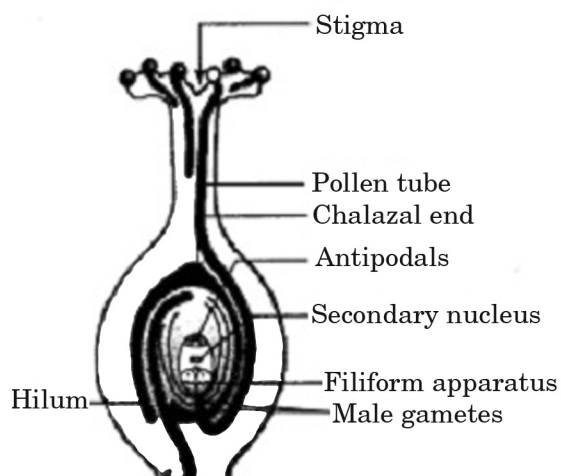
5 Marks Questions

5. (a) Draw a L.S. of a pistil showing pollen tube entering the embryo-sac in an angiosperm and label any six parts other than stigma, style and ovary.
(b) Write the changes a fertilized ovule undergoes within the ovary in an angiosperm plant. [ALL INDIA 2013]

Solutions

1. The main function of the tapetum include nourishment of viable male gametes. Hence, malfunctioning tapetum often fails to produce viable male gametophytes. [1]
2. Style and stigma that are female reproductive parts of a flower which represents the tassels of the corn-cob. [1]

3. Moss such as Sphagnum are bryophytes. For fertilization water is an essential requirement. Mosses produce flagellated male gametes which swim across the water to reach the female gamete. In this process, a majority of male gametes fail to reach the female gametes. Therefore, large number of male gametes are produced by mosses to ensure fertilization. The male gametes of mosses are antherozoids in antheridium. [1+1]
4. Sporopollenin that made outer layer of pollen which is exine considered as most resistant organic material because Sporopollenin is highly resistant to temperature, acid, alkali or enzymatic action. [3]
5. (a)



[2]

Fig.: L.S. of a pistil showing pollen tube entering the embryo-sac in an angiosperm

- (i) Seed is formed from the fertilized ovule. A seed develop seed coat. This is the outermost covering of the seed and provides protection to the seed from adverse environmental conditions. The outer layer of seed coat is known as testa and inner layer of seed is called as tegma. Seed coat also contain germ pore that aid in the entry of oxygen and water that is required during seed germination.
- (ii) Embryo is formed from fertilised egg (zygote).
- (iii) Antipodal cells degenerate.
- (iv) Synergid cells degenerate.
- (v) Central triploid cell form the endosperm.
- (vi) Chalaza and micropyle remain but nucellus is gets consumed. [3]

[Topic 2] Pollination

Summary

- Pollination is the transfer of pollen grains from anther to stigma of a pistil.
- Pollination can be conducted through abiotic agents like wind and water and biotic agent like animals.
- We can prevent self-pollination by various practices like, In some species pollen release and stigma receptivity cannot take place simultaneously. In some species anther and stigma are at different positions, third device is incompatible and another way to prevent self pollination and encourage cross pollination is production of unisexual flowers.

There are three types of pollination, on the basis of source of pollen:

- Autogamy: When the pollination is attained within the same flower and pollen grains transfer from the anther to the stigma of the same flower.
- Geitonogamy: When pollen grains transfer from the anther to the stigma of a different flower of same plant.

- Xenogamy: When the pollen grains transfer from anther to the stigma of another plant.

Pistil- Pollen Interaction

- Emasculation is the process carried out in bisexual flowers by removing their anthers using a pair of forceps before the anther bursts open.
- A bag of convenient size, usually made up of butter paper is used to cover the flowers that are emasculated to prevent contamination of that flowers stigma with unwanted pollen is called bagging.

Double-Fertilisation

- When two types of fusions happen inside the embryo sac the first being triple fusion and the other syngamy this event is called double fertilization. After triple fusion, the central cell becomes the primary endosperm cell and is developed into endosperm. The zygote is developed into an embryo.

species growing in New Delhi? Provide explanations to your answer.

- (b) Draw the diagram of a pistil where pollination has successfully occurred. Label the parts involved in reaching the male gametes to its desired destination.

[ALL INDIA 2017]

5. Why are beehives kept in crop field during flowering period? Name any two crop fields where this is practiced. [ALL INDIA 2014]

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 2

▣ 2 Marks Questions

1. State one advantage and one disadvantage of cleistogamy. [DELHI 2012]

▣ 3 Marks Questions

2. Double fertilization is reported in plants of both, castor and groundnut. However, the mature seeds of groundnut are non-albuminous and castor are albuminous. Explain the post fertilization events that are responsible for it. [DELHI 2015]

3. (a) Name the organic material exine of the pollen grain is made up of. How is this material advantageous to pollen grain?
 (b) Still it is observed that it does not form a continuous layer around the pollen grain. Give reason.
 (c) How are 'pollen banks' useful?

[ALL INDIA 2016]

4. (a) Can a plant flowering in Mumbai be pollinated by pollen grains of the same

▣ 5 Marks Questions

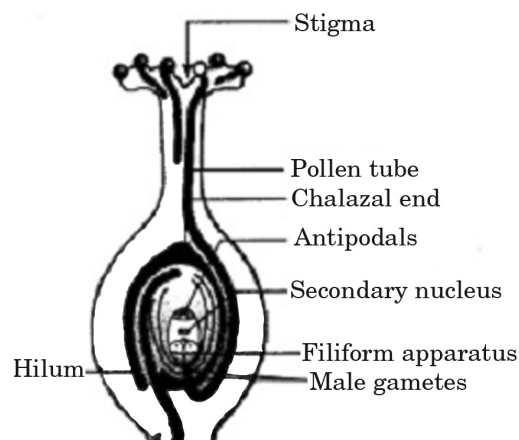
6. (a) Why is Fertilization in an angiosperm referred to as double fertilization? Mention the ploidy of the cells involved.
 (b) Draw a neat labelled sketch of L.S. of an endospermous monocot seed. [DELHI 2012]
7. A flower of tomato plant following the process of sexual reproduction produces 240 viable seeds. Answer the following questions giving reasons:
 (a) What is the minimum number of pollen grains that must have been involved in the pollination of its pistil?
 (b) What would have been the minimum number of ovules present in the ovary?
 (c) How many megaspore mother cells were involved?

- (d) What is the minimum number of microspore mother cells involved in the above case?
 (e) How many male gametes were involved in this case? [DELHI 2015]

Solutions

- Cleistogamy is the phenomenon of self-pollination and takes place in unopened flower. The advantage of cleistogamy is that it produces seed even in the absence of pollination. The disadvantage is that it produces flowers are exactly similar to the parent and hence have no variation. [2]
- Double fertilisation occurs in both castor and groundnut but their mature seeds are different as far as endosperm is concerned. One of the male gamete fuses with polar nuclei to form primary endosperm nucleus. It divides mitotically without cytokinesis to initiate the formation of endosperm. As a result of repeated nuclear division, free nuclear endosperm is formed. Then, cell wall formation occurs around each nucleus to become cellular endosperm. In groundnut, endosperm may be completely utilised by the developing embryo before the maturation of seeds. Such seeds are called non-albuminous or non-endospermic seeds. But in castor seed, a portion of endosperm remains in the seed and is used up during seed germination. Such seeds are called albuminous or endospermic seed. [1+1+1]
- (a) The exine is made of sporopollenin. It is one of the most resistant organic material. It can withstand high temperature, strong acids and alkalis. It cannot be degraded by any of the known enzymes. Hence, sporopollenin protects pollen grain from any kind of damage. [1]
 (b) Exine layer is not a continuous layer around pollen grain. Continuity of the layer is broken by a pore called germ pore through which pollen tube emerges. [1]
 (c) Pollen grains at a large can be stored for years in liquid nitrogen at (-196°C). So, after this treatment they are stored in pollen banks. Such stored pollen grains can be used in plant breeding programs. [1]
- (a) Yes, such type of pollination can be achieved by artificial means or artificial hybridisation. But there should not be any self-incompatibility. In such type of pollination pollen grain of one flower from one city is introduced artificially on the stigma of another flower of another city. [2]

- (b) Diagram of a pistil after pollination [1]



- Beehives are kept in crop field during flowering period as they help in the pollination of the crop that increases the yield of that crop. Bees while collecting nectar from the flower help in the transfer of pollen. For example, apple and watermelon. [3]
- (a) Fertilization in an angiosperm referred to as double fertilization because out of two sperm nuclei, one is fertilized with egg nucleus to form an embryo and the other one fuse with polar nuclei to form endosperm [2]

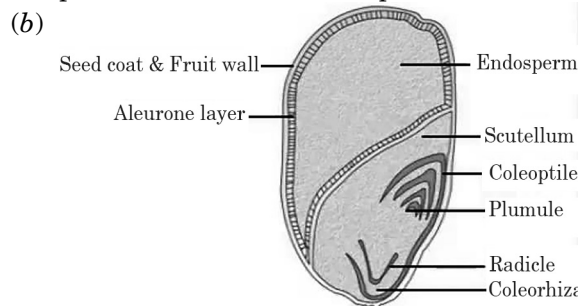


Fig: L.S. of Endospermous monocot seed. [3]

- (a) The minimum number of pollen grains are 240. One of the male gametes fuses with the egg cell to form the zygote that eventually give rise to seeds. Therefore, in order to form in 240 seeds, number of pollen grains are required is 240. [1]
 (b) The number of ovules involved in this process would be 240, as the number of viable seeds are 240. After fertilisation, the ovary becomes fruit and the ovules becomes seeds. Therefore, the number of ovules are corresponding to the number of seeds developed. [1]
 (c) During the process of gametogenesis, 240 megaspore mother cells are involved because out of four (tetrad) megaspores formed after meiosis, only one megaspore is functional and it develops further and the rest three megaspores get degenerated. [1]

- (d) Minimum 60 microspore mother cells are involved in producing 240 pollen grains. Each microspore mother cell divides by meiosis to give rise to 4 microspores or pollen grains. Since 1 microspore mother cell would produce 4 microspores, therefore, to obtain 240 pollen grains 60 microspore mother cells are required. [1]

- (e) The number of male gametes involved in seed formation would be 240 as one of the male gametes fuses with egg nuclei to form zygote, which will further give rise to the seed. [1]

[Topic 3] Post-fertilisation: Structure and Events

Post-fertilisation events is a collective term given to transformation of ovary into fruits, ovules into seeds and the development of embryo and endosperm that starts after the double fertilisation process.

Endosperm

Before the development of the embryo, endosperms develop. The cells of the endosperm tissue contain banked food materials and are also used to provide nutrition to the developing embryo. It is either to be entirely eaten up by the developing embryo (e.g., pea, groundnut, beans) before the seed matures or it may exist in the mature seed. For example- coconut.

The Embryo

- At the micropylar end of embryo sac the embryo development begins, this is where zygote is situated. Embryogeny refers to the early stage of embryo development which is common in both dicotyledonous and monocotyledonous embryo.

Seed

- The mature may be of two types either non-albuminous or ex- albuminous. The non albuminous seeds have no residual endosperm as it is consumed during embryonic development where as in albuminous seeds a part of endosperm is retained as it is not completely used up during embryonic development.

Apomixis and Polyembryony

- Some species of Asteraceae and grasses and few other flowering plants have evolved a special mechanism to produce seeds without fertilization and this is called 'Apomixis'.
- The event of presence of more than one embryo in a seed is referred to as polyembryony.

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 3

▣ 1 Mark Questions

- Normally one embryo develops in one seed but when an orange seed is squeezed many embryos of different shapes and sizes are seen. Mention how it has happened. [DELHI 2011]
- Why banana is considered a good example of parthenocarpy? [DELHI 2012]

▣ 2 Marks Questions

- Differentiate between albuminous and non-albuminous seeds, giving one example of each. [DELHI 2011]
- Geitonogamous flowering plants are genetically autogamous but functionally cross-pollinated. Justify. [DELHI 2013]
- In angiosperms, zygote is diploid while primary endosperm cell is triploid. Explain. [ALL INDIA 2013]
- A mature embryo-sac in a flowering plant may possess 7-cells, but 8-nuclei. Explain with the help of a diagram only. [DELHI 2017]
- A pollen grain in angiosperm at the time of dehiscence from an anther could be 2-celled or 3-celled. Explain. How are the cells placed within the pollen grain when shed at a 2-celled stage? [ALL INDIA 2017]

▣ 3 Marks Questions

- State what is apomixis? Comment on its significance. How can it be commercially used? [ALL INDIA 2015]

9. Explain the function of each of the following:
 (a) Coleorhizae
 (b) Umbilical cord
 (c) Germ pores **[DELHI 2012]**
10. (a) Describe the endosperm development in coconut.
 (b) Why is tender coconut considered a healthy source of nutrition?
 (c) How are pea seeds different from castor seeds with respect to endosperm?
[ALL INDIA 2013]
11. Explain any three advantages the seeds offer to angiosperms. **[DELHI 2014]**
12. Why angiosperm anthers are called ditheous? Describe the structure of its microsporangium. **[ALL INDIA 2014]**
13. How does the megaspore mother cell develop into 7-celled, 8 nucleate embryo sac in an angiosperm? Draw a labelled diagram of a mature embryo sac. **[ALL INDIA 2011]**
17. (a) Explain the different ways apomictic seeds can develop, Give an example of each.
 (b) Mention one advantage of apomictic seeds to farmers.
 (c) Draw a labelled mature stage of a dicotyledonous embryo. **[ALL INDIA 2014]**
18. (a) Plan an experiment and prepare a flow chart of the steps that you would follow to ensure that the seeds are formed only from the desired sets of pollen grains. Name the type of experiment that you carried out.
 (b) Write the importance of such experiments. **[ALL INDIA 2015]**
19. (a) Explain the post-pollination events leading to seed production in angiosperms.
 (b) List the different types of pollination depending upon the source of pollen grain. **[DELHI 2016]**
20. (a) As a senior biology student you have been asked to demonstrate to the students of secondary level in your school, the procedure(s) that shall ensure cross pollination in a hermaphrodite flower. List the different steps that you would suggest and provide reasons for each one of them.
 (b) Draw a diagram of a section of a megasporangium of an angiosperm and label funiculus, micropyle, embryosac and nucellus. **[ALL INDIA 2016]**

▣ 5 Marks Questions

14. Give reason why:
 (i) Most zygote in angiosperms divide only after certain amount of endosperm is formed.
 (ii) Groundnut seed are ex-albuminous and castor seed are albuminous.
 (iii) Micropyle remains as a small pore in the seed coat of a seed.
 (iv) Integuments of an ovule harden and the water content is highly reduced, as the seed matures.
 (v) Apple and cashew are not called as true fruits. **[ALL INDIA 2012]**
15. Draw a diagrammatic sectional view of a mature anatropous ovule and following parts in it:
 (i) that develops into seed coat.
 (ii) that develops into an embryo after fertilization.
 (iii) that develops into an endosperm in an albuminous seed
 (iv) through which the pollen tube gains its entry into the embryo sac.
 (v) that attach the ovule to the placenta
 Describe the characteristics feature of wind pollinated flowers. **[DELHI 2013]**
16. (a) Coconut palm is monoecious, while date palm is dioecious. Why are they so called?
 (b) Draw a labelled diagram of sectional view of a mature embryo sac of an angiosperm. **[DELHI 2014]**
21. Read the following statement and answer the questions that follow:
 "A guava fruit has 200 viable seeds."
 (a) What are viable seeds?
 (b) Write the total number of:
 (i) Pollen grains
 (ii) Gametes in producing 200 viable guava seeds.
 (c) Prepare flow-chart to depict the post-pollination events leading to viable-seed production in a flowering plant. **[DELHI 2017]**
22. (a) When a seed of an orange is squeezed, many embryos, instead of one are observed. Explain how it is possible.
 (b) Are these embryos genetically similar or different? Comment. **[ALL INDIA 2017]**
23. (a) Describe any two devices in a flowering plant which prevent both autogamy and geitonogamy.
 (b) Explain the events up to double fertilization after the pollen tube enters one of the synergids in an ovule of an angiosperm. **[DELHI 2018]**

Solutions

- Presence of more than one embryo is called as polyembryony, is the phenomenon responsible for embryos of different shapes and sizes are seen in oranges. This occur due to formation of two or more embryo from the nucellar cells surrounding the embryo. These cells divide and protrude into the embryo. Then they develop as seeds. [1]
- Banana is considered a good example of parthenocarpy because it produces seedless fruit in the absence of successful fertilization by application of hormones [1]
- Seed is formed as a result of sexual reproduction in angiospermic plants. Seed contain three important parts: seed coat, cotyledons and embryo axis. Mature seed can be classified into albuminous and non-albuminous seed on the basis of reserve food. [1]
 - Albuminous seed: they store or retain their some part of endosperm during the period of embryo development. Example is sunflower [½]
 - Non-albuminous seed: they consume entire endosperm during the period of embryo development. Example is pea. [½]
- The pollination where pollen grain is transferred from one flower anther to stigma of another flower in the same plant is known as geitonogamy. As, in this type of plants, gametes are coming from the same parent it is known as autogamous but at the same time since, pollen grain is transferred from one flower anther to stigma of the another flower which require the pollinating agent is known as cross-pollination. [1+1]
- Zygote is formed by the fusion of haploid male gamete and haploid female gamete by the process of syngamy. [1]

Male gamete (n) + Egg (n) → Zygote (2n)

Primary endosperm is formed by the fusion of secondary nucleus which is diploid and male gamete which is haploid. Hence, endosperm is triploid

Secondary nucleus (2n) + Male gamete (n) → Primary endosperm (3n) [1]
- Diagram of mature embryo-sac in a flowering plant may possess 7-cells, but 8-nuclei. 7 cells are: 3 antipodal cells (3 nuclei), 1 central cell (2 nuclei), 1 egg cell (1 nucleus) and 2 synergids (2 nuclei). [1]

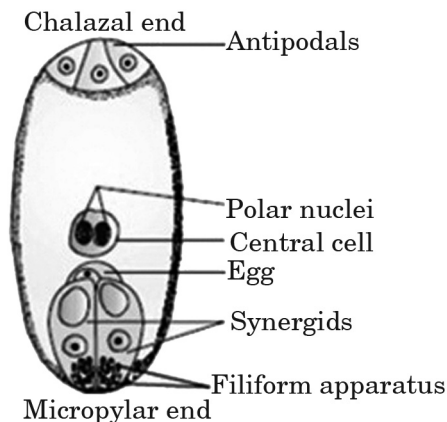


Fig.: Mature embryo-sac [1]

- In most of the angiosperms, pollen grains released at 2-celled stage. Pollen grain contains a small generative and a large vegetative cell. At 3-celled stage pollen grains contains one vegetative cell and two male gametes. [1]

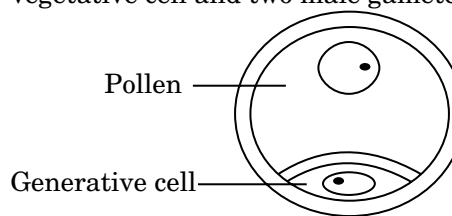


Fig.: Schematic diagram of a pollen grain with two cells [1]

- Apomixis is a process by which new individuals are formed without involving the process of meiosis and syngamy (fertilization) due to non-formation of gametes. Apomixis can be seen in certain plants like grasses, citrus plants, conifers like pine etc. Significance of Apomixis: Apomixis is an alternative process by which hybrid varieties can be raised from hybrid seeds. If the Hybrid seeds are sown they segregate their characteristics in progeny plants. Therefore, Hybrid seeds have to be produced every year as these cannot be collected from hybrid plants. By making hybrid seeds as apomicts, rapid multiplication of genetically uniform individuals can be achieved without risk of segregation by apomixis. [2]

Commercial applications of apomixis are:

 - By apomixis, hybrid seeds can be produced, which will provide higher and better yield.
 - It prevents the loss of specific characteristics in the hybrid plants.
 - Apomixis is a cost-effective method of producing seeds. [1]
- (a) Coleorhiza is a sheath like structure in the seed of plants that provide protective covering enclosing radicle and root cap. [1]

(b) The functions of umbilical cord are:

- (i) Deliver oxygen to the foetus
- (ii) Delivers nutrients to foetus
- (iii) Withdrawing of CO₂ & waste. [1]
- (c) Germ pores is the region through which the pollen tube enters the ovary. [1]
- 10. (a) Coconut endosperm formation is of nuclear type which involve the nuclear division of primary endosperm without the formation of cell wall. [1]
- (b) Tender coconut considered a healthy source of nutrition as its endosperm is rich in nutrients like proteins, minerals, vitamins. [1]
- (c) Pea is a non-albuminous seed as they consume entire endosperm during the period of embryo development where castor seed is an albuminous seed as it retains some part of endosperm during the period of embryo development. [1]
- 11. Three advantages that the seeds offer to angiosperms are:
 - (a) Seeds provide protection of the embryo from adverse environmental conditions. [1]
 - (b) Seed provide nourishment to the embryo. [1]
 - (c) Dispersal of seed helps them to have better adaptive strategies. [1]
- 12. Angiosperm anthers are called dithecous because it is bilobed with each lobe having two theca. Structure of its microsporangium include four layers:
 - (i) Epidermis: Provide protection
 - (ii) Endothecium: Provide protection
 - (iii) Middle layer: Provide protection [1]
 - (d) Tapetum : Nourishes the pollen grain

At the young stage of anther, it consist of sporogenous tissue present in the center of each microsporangium.

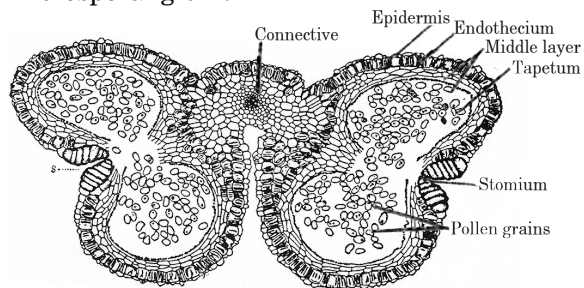


Fig.: Microsporangium

- 13. Mitosis in the megaspore mother cell leads to formation two nuclei which move to two opposite poles. After that, further mitotic divisions lead to the formation of 4 nuclei and 8 nuclei embryo sac in an angiosperm. This division is unique because nuclear division is not followed by cell

wall formation. Out of the eight nuclei, six are covered by cell wall while remaining two nuclei are placed above the egg apparatus in the central cell. Among the six cells, three cells are placed at micropylar end, in which two are called as synergids and one is egg cell. Remaining three cells are placed at chalazal end and are known as antipodals. In this way, megaspore mother cell develop into 7-celled, 8 nucleate embryo sac in an angiosperm. [2]

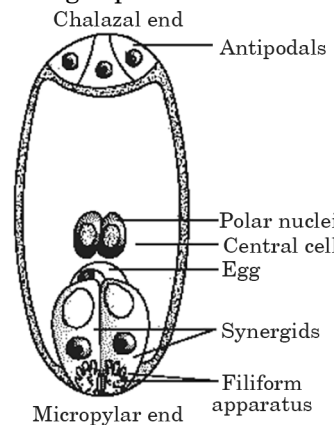


Fig.: Mature embryo sac [1]

- 14. (i) Most zygote in angiosperms divide only after certain amount of endosperm is formed to get nourishment from the endosperm for the developing embryo. [1]
- (ii) Groundnut is a non-albuminous seed as they consume entire endosperm during the period of embryo development whereas castor seed is an albuminous seed as it retain their some part of endosperm during the period of embryo development [1]
- (iii) Micropyle remains as a small pore in the seed coat of a seed because it provide the entry for water and oxygen which is required for the germination. [1]
- (iv) Integuments of an ovule protect the embryo from the harsh environmental conditions and help the seed to remain viable. [1]
- (v) Apple and cashew are not called as true fruits because their fruit is not formed from ovary but it develop from thalamus. [1]

15.

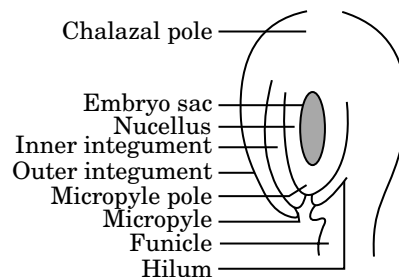
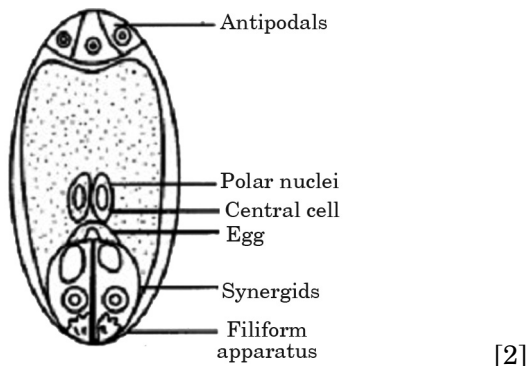


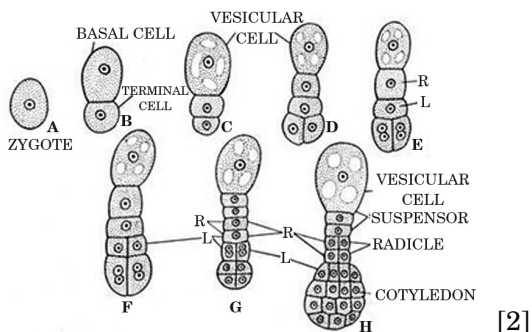
Fig.: Mature anatropous ovule [3]

Fig: sectional view of a mature anatropous ovule
The characteristics feature of wind pollinated flowers are

- (a) Large number of pollen grain production
(b) Pollen are smooth and light [2]
16. (a) Coconut palm is monoecious due to the presence of male and female flowers on the same plant. [2]
Date palm is dioecious due to the presence of either male flower or female flower exclusively on one plant. [1]
(b)



- Fig.:** sectional view of a mature embryo sac [2]
17. (a) Different ways apomictic seeds can develop are:
(i) Diploid embryo is formed without the process of fertilization. Example is banana. [1]
(ii) Some nucellar cells surrounding the embryo sac, enter into the embryo sac, divide in a continuous manner and lead to the formation of embryo. Example is mango. [1]
(b) Farmers can use the hybrid seeds for the next season that reduce the seed cost. [1]
(c)



- Fig.:** Mature stage of a dicotyledonous embryo [2]
18. (a) The name of the experiment or technique to obtain seeds from a desired set of pollen grains is 'Artificial Hybridization'. In this technique, only desired pollen grains are used to pollinate the stigma of a desired plant. The specific stigma is kept protected from the contact of unwanted pollen.

This Flow chart of the steps of the experiment:

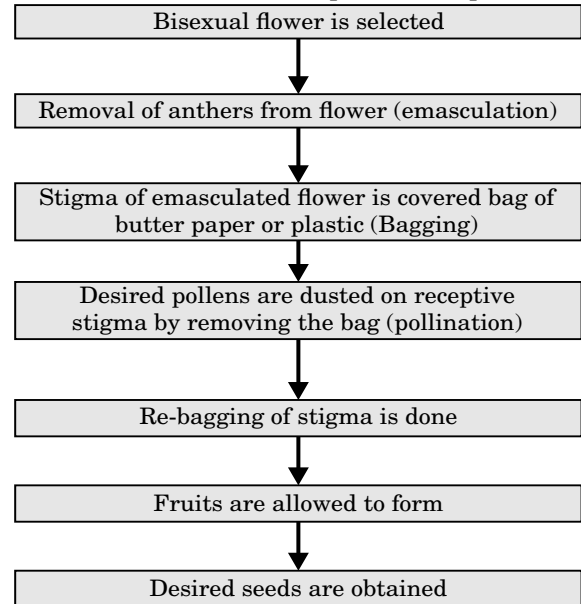


Fig.: Artificial hybridization [1½]

- (b) Importance of artificial hybridization are:
(i) Creation of new genetic recombination with better qualities.
(ii) Incorporation of a large number of desirable characters into a single variety. [2]
19. (a) After the pollination, pollen grains are transferred to the stigma. As a result of pollen-pistil interaction, germination of pollen grains occur. Pollen tubes arise from pollen grains. Pollen tubes carrying two male gametes enters into the embryo sac for double fertilization. One male gamete fuses with the egg cell (syngamy), while the other fuses with two polar nuclei to form primary endosperm nucleus (PEN). The fertilised egg develops into zygote, which eventually develops into an embryo while the PEN develops to form endosperm. After double fertilisation, the ovule matures into a seed while the ovary matures into a fruit. [2]
(b) Different types of pollination depending upon the source of pollen grain are: [1]
Autogamy: A type of pollination in which transfer of pollen grains from the anther to the stigma of the same flower. For examples as in Pansy, Oxalis.
Geitonogamy: Transfer of pollen grain from anther of one flower to the stigma of another flower of the same plant. [1]
Xenogamy: A pollination in which transfer of pollen grains from anther to the stigma of a different plant In xenogamy, genetically different types of pollen grains are introduced to the stigma. [1]

20. Cross-pollination in a hermaphrodite or bisexual flower can be achieved by:

Emasculation: by removing anthers of one of the flowers. [1]

Bagging: The emasculated flower is covered by a bag to prevent contamination of its stigma by unwanted pollen grains. [1]

Rebagging: When the stigma of the bagged flower becomes receptive, the pollen grains collected from the other flower are dusted on the stigma and allow the fruit to develop after pollination and fertilisation by covering the stigma with a bag. [1]

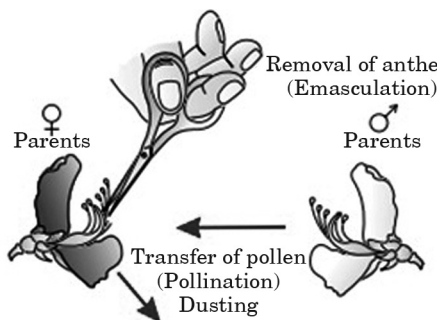


Fig.: A diagram of a section of a megasporangium of an angiospermic plant.

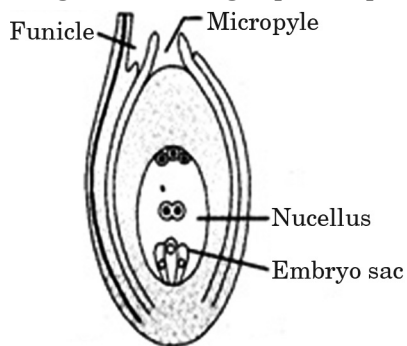


Fig.: Megasporangium [1]

21. (a) Seeds that remain alive and can give rise to new plant or have the capacity to germinate into a new plant are called viable seeds [1]
- (b) (i) Number of pollen grains required is 200. [1]
- (ii) Number of gametes required is 600 gametes (400 male gametes and 200 female gametes). [1]
- (c) A flow-chart showing the post-pollination events leading to viable-seed production in a flowering plant: [1]

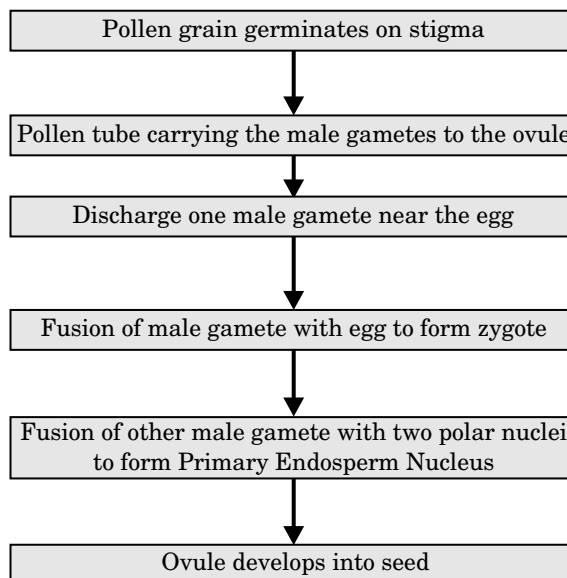


Fig.: Post pollination event in a flowering plant

22. (a) When a seed of an orange is squeezed, instead one, many embryos are observed in it. This happens due to the phenomenon called polyembryony. Polyembryony may arise due to the development of embryos from synergids or from antipodal cells. Some embryos can also be develops from sporophytic cells of ovule such as nucellus or integument. [3]
- (b) The embryos develop as a result of polyembryony are genetically similar. The embryos developing from gametophytic tissues such as synergids and antipodal cells are similar to each other, but not to their parents. Similarly the embryos that are formed from sporophytic tissues are usually similar to each other as well as their parents. [2]
23. (a) A type of pollination in which there is transfer of pollen grains from anther to the stigma of same flower is called autogamy and in geitonogamy there is transfer of pollen grains from anther to the stigma of another flower of same plant. Two devices that prevent both autogamy and geitonogamy are: [1]
- (i) Self-incompatibility is a genetic mechanism which prevents self-pollen from fertilising the ovules by inhibiting pollen germination or pollen tube growth in the pistil. [½]
- (ii) Dioecious plants: Male and female flowers are present on different plants, that is each plant is either male or female. [½]

- (b) The events seen after the pollen tube enters one of the synergids in an ovule are as follows:
- (i) Pollen tube, after reaching the ovary, enters the ovule through the micropyle and thus enters one of the synergids through filiform apparatus.
 - (ii) After entering into synergid, the pollen tube releases the two male gametes into the cytoplasm of the synergids.
 - (iii) One of the male gametes move towards the egg cell and fuses (fertilization) with it results in formation of the zygote.
 - (iv) The other male gamete move towards the two polar nuclei located in the central cell and fuses to form triploid primary endosperm nucleus (PEN). This involves fusion of three haploid nuclei & hence termed as triple fusion.
 - (v) Two types of fusions, fertilization (syngamy) and triple fusion takes place in an embryo sac and hence the phenomenon is termed as double fertilisation.
 - (vi) After fertilisation, PEN becomes the primary endosperm cell and develops into endosperm while zygote develops into an embryo. [2]

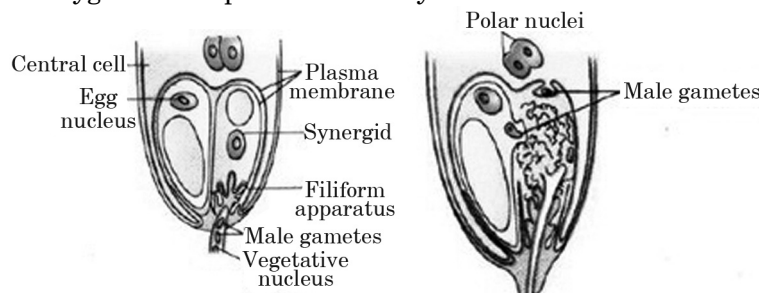


Fig.: Double fertilization

[1]



Smart Notes

A series of horizontal lines for writing notes, consisting of 20 evenly spaced lines.

CHAPTER 3

Human Reproduction

Chapter Analysis with respect to Last 3 Years' Board Exams

List of Topics	2016		2017		2018
	Delhi	All India	Delhi	All India	Delhi/All India
Male and female reproductive systems					
Microscopic anatomy of testis and ovary					
Gametogenesis-spermatogenesis & oogenesis, Menstrual cycle		1Q (1 mark)			
Fertilisation embryo development up to blastocyst formation, implantation	1Q (1 mark)				
Pregnancy and placenta formation (Elementary idea), Parturition (Elementary idea), Lactation (Elementary idea)			1Q (5 marks)	1Q (4 marks), 1Q (5 marks)	1Q (3 marks)

On the basis of above analysis, it can be said that from exam point of view Parturition, The Fertilization Events, Hormones, Male and Female Reproductive System, Menstrual Cycle and contraceptive methods are most important concepts of the chapter.

[Topic 1] Reproductive Systems

Summary

Male Reproductive System

The male reproductive system is classified into the following categories:

- Testes
 - Testes are the sex organ whose primary role is to produce testosterone and sperms.
 - Testes are found inside of scrotum in the upper thigh area.
 - The shape of testes is oval.
 - Testes are found outside of the body in a sack because it needs 2 to 3 degrees less temperature for its optimal functioning.
 - There are two testes both having around 500 testicular lobules.
 - Every single lobule is stacked with connective tissue having around 2 semiferous tubules which are yellow in color.
 - These semiferous tubules are queued along with spermatogenic cells are also termed as sertoli cells.
 - These sertoli cells are responsible for optimal growth of spermatogenic cells and hence the term coined for it, is nurse cells.
- Accessory Ducts
 - The four major constituent part of duct systems are:
 - testis
 - epididymis
 - vas deferens
 - vasa efferentia
 - The tubules semiferous in nature open in vasa efferentia via testes.
 - Vasa efferentia is lead into opening of Epididymis.
 - Now a duct is being attached to urethra as an exit path.
 - Now the urethra originates at urinary bladder and ends in urethral meatus which is an opening end of penis.
- External Genetelia
 - Penis is the only major part of the external organ.
 - Penis is made up of special tissue.
 - This special tissue helps in erection of the penis which is needed for insemination.
 - The terminal end of penis comprises of foreskin.
- Accessory Glands
 - It comprises of several glands such as Cowper's gland, prostate gland etc.
 - Seminal plasma is the resulted secretion of these glands.
 - This seminal plasma is very calcium and fructose rich.
 - Cowper's gland acts as lubricating agent for penis as their secretion is rich in mucus.

Female Reproductive System

The female reproductive system is classified into the following categories:

- Ovaries
 - Ovaries are the sex organ whose primary role is to produce estrogen and ova.
 - Ovaries are found in the lower abdomen.
 - The size of each ovary is around 3cm in length.
 - A ligament is used to link ovary to pelvic wall.
 - Graafian follicles are the constituent cell of ovary.
- Accessory Ducts

The three major constituent part of duct systems are:

Two oviducts: The oviducts are comprised of the following parts-

- Ampulla
- Isthmus
- Infundibulum
- Uterine Part

Uterus:

- Uterus is basically the womb. It called so because the shape of the womb is uterus in shape.
- Uterus opens up in vagina by cervix.
- Uterus is responsible for the growth of the baby after fertilization.

Vagina: It is a tube shaped canal which connects the outer body with the uterus. It is used for accommodating male external organ i.e. penis which results into fertilization of an egg and the other use is to deliver a baby while child birth.

- External Genetelia:
 - Vagina is the major part of the external organ in females. It also constitutes of the following parts:
 - Clitoris
 - Hymen
 - Labia Minora
 - Mons pubis

- Mons pubis is the fatty tissue. It acts as a cushion and is overlapped by pubic hair and skin.
- The opening of vagina is Labia minora. It is basically two folds which are very fleshy.
- Above the urethra opening there is a tiny structure like a finger. This part is called as clitoris.
- Mammary Glands
- In the chest region there is a pair of mammary gland.
- This gland also contains a vital component known as Glandular tissue that helps to carry milk to the nipples.
- Every single tissue has around 20 lobes which is actually a cell cluster also called as alveoli.
- In alveoli cavities we can find the stored milk which can be secreted.
- The alveoli opens up into mammary duct.
- These ducts combined together are connected to a lactiferous duct using which the milk is secreted out.

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 1

1 Mark Questions

1. Where is acrosome present in humans? Write its function. **[DELHI 2012]**
2. Write the location and function of the sertoli cells in humans. **[ALL INDIA 2012]**

2 Marks Questions

3. Give reasons for the following
 - (a) The human testes are located outside the abdominal cavity.
 - (b) Some organisms like honey-bees are called parthenogenetic animals. **[DELHI 2012]**
4. When and where do chorionic villi appear in humans? State their function. **[DELHI 2013]**
5. Why are the human testes located outside the abdominal cavity? Name the pouch in which they are present. **[ALL INDIA 2014]**

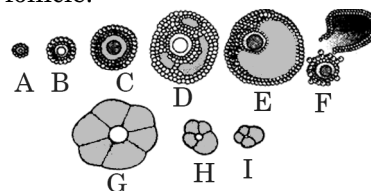
3 Marks Questions

6. Draw a labelled diagrammatic sectional view of a human seminiferous tubule. **[DELHI 2017]**
7. Write the function of each one of the following:
 - (a) Fimbriae
 - (b) Coleptile
 - (c) Oxytocin **[ALL INDIA 2012]**

8. Draw a labelled diagram of the human female reproductive system. **[ALL INDIA 2011]**

5 Marks Questions

9. (a) Draw a labelled diagram of the human female reproductive system.
- (b) Enumerate the events in the ovary of a human female during:
 - (i) Follicular phase
 - (ii) Luteal phase of menstrual cycle **[DELHI 2011]**
10. (a) Write the specific location and the functions of the following cells in human males:
 - (i) Leydig cells
 - (ii) Sertoli cells
 - (iii) Primary spermatocyte
- (b) Explain the role of any two accessory glands in human male reproductive system. **[DELHI 2011]**
11. (a) Identify the figure that illustrates corpus luteum and name the pituitary hormone that influences its formation.
- (b) Specify the endocrine function of corpus luteum. How does it influence the uterus? Why is it essential?
- (c) What is the difference between “d” and “e”?
- (d) Draw a neat labelled sketch of Graafian follicle.



[DELHI 2012]

12. (a) Draw a diagrammatic sectional view of the female reproductive system of human and label the parts:
 - (i) Where the secondary oocytes develop
 - (ii) Which helps in collection of ovum after ovulation
 - (iii) Where fertilization occurs
 - (iv) Where implantation of embryo occurs.
- (b) Explain the role of the pituitary and the ovarian hormones in menstrual cycle in human females. **[DELHI 2013]**
13. (a) Draw a diagrammatic sectional view of a human seminiferous tubule, and label Sertoli cells, primary spermatocyte, spermatogonium and spermatozoa in it.
- (b) Explain the hormonal regulation of the process of spermatogenesis in humans.

[ALL INDIA 2013]

Solutions

1. Acrosome is a cap like structure present in the head of sperm. It facilitates the entry of sperm nucleus in the human ovum by breaking the zona pellucida. [1]
2. Sertoli cells are present in the membrane of seminiferous tubule and its function is to provide nourishment to the male gamete. [1]
3. (a) The human testes are located in the scrotum which is outside the abdominal cavity because it need slower temperature for developing male gametes than the normal body temperature. [1]
(b) As, male honey bee are formed without the process of fertilization they are called as parthenogenetic animals. [1]
4. Chorionic villi appear in humans develop from trophoblast layer that develop into zygote after its implantation. Chorionic villi helps in the formation of placenta which is the interface between maternal and fetal blood during the period of pregnancy. [2]
5. The human testes located outside the abdominal cavity because it needs a little lower temperature than the normal body temperature. Scrotum is the pouch in which they are present. [2]
6. Sectional view of a human seminiferous tubule:

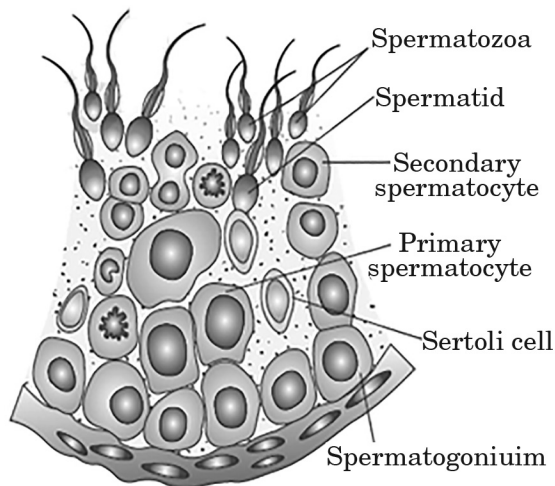
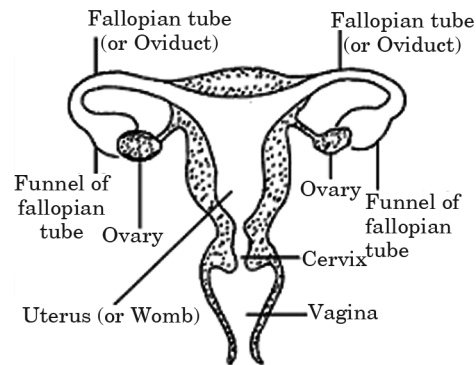


Fig.: Sectional view of a human seminiferous tubule. [3]

7. (a) Fimbriae are present in the fallopian tubes of human female They pick up the eggs from the ovaries and move it into the fall opium tube. [1]
(b) Coleoptile provides protection of emerging shoot in monocotyledons. [1]
(c) Oxytocin helps in milk ejection during lactation period and in parturition. [1]

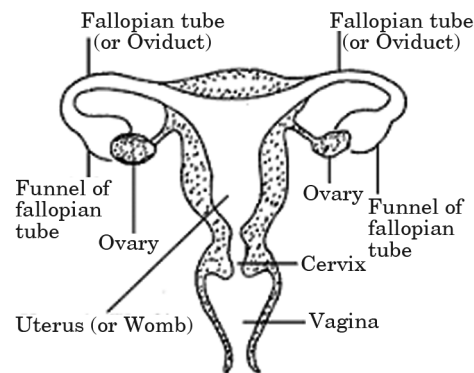
8.



[3]

Fig.: Labelled diagram of the human female reproductive system

9. (a)



[2]

Fig.: Labelled diagram of the human female reproductive system

(b) (i) During Follicular phase, Follicle stimulating hormone aids in the growth of primary ovarian follicles and maturation of primary oocyte in the follicle. Graafian follicle cells secrete estrogen that lead to the thickening of uterine endometrium and make it more vascular and grandular. This phase has the duration of 10 to 14 days and results in the ovulation. [2]

(ii) In this phase, after ovulation, ruptured graafian follicle develops into corpus luteum. It secretes progesterone which further makes the uterus more vascular and glandular in anticipation of a fertilised ovum. If fertilisation occurs and zygote arrives in the uterus, progesterone supports pregnancy. Otherwise the levels decline and luteal phase ends in menstrual cycle. [1]

10. (a) (i) Leydig cells are located in the seminiferous tubule of human male and its function is to secrete testosterone under the effect of LH from the pituitary gland. [1]

- (ii) Sertoli cells are present in the membrane of seminiferous tubule and its function is to provide nourishment to the male gamete under the effect of FSH from pituitary gland. [1]
- (iii) Primary spermatocytes are present in the inner lining of seminiferous tubule and undergo meiosis to form sperms. [1]
- (b) The accessory glands of the male reproductive system are the seminal vesicles, prostate gland, and the bulbourethral glands. Prostate gland helps in the secretion of semen and seminal vesicles helps in providing nourishment to the sperm. [2]
- 11. (a) Figure (g) is representing corpus luteum and LH hormone that influences its formation. [1]
- (b) Secretion of progesterone is the endocrine function of corpus luteum which is necessary for the maintenance of uterus endometrium. This endometrium is required for the implantation of the fertilized ovum. [1]
- (c) D is showing developing secondary follicle and E is showing developing tertiary follicle [1]
- (d)

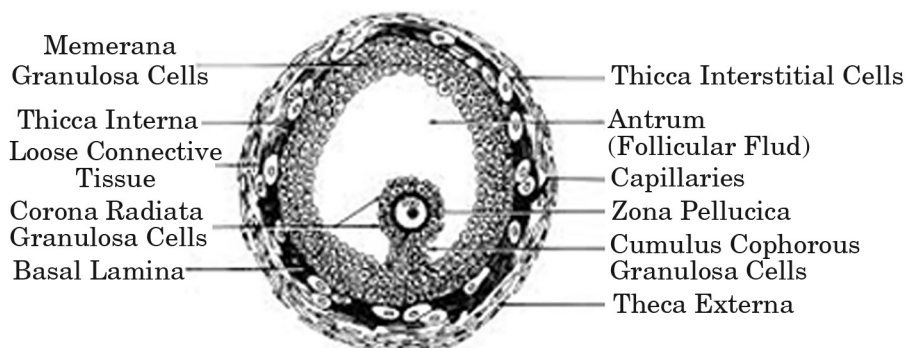


Fig.: Graafian follicle

[2]

12. (a)

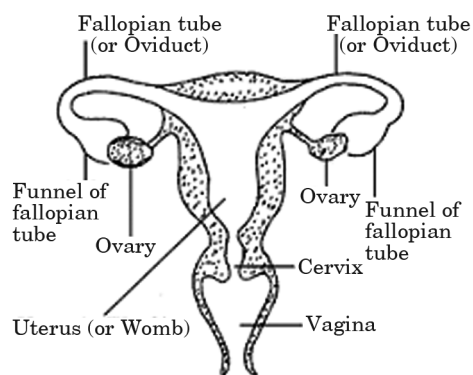


Fig.: Female reproductive system [2]

- (b) Soon after the menstrual phase, pituitary secretes two hormones LH and FSH. During the follicular phase, their secretion increases and enhances the development of follicles. The follicles start secreting estrogen hormone. On the 13th and 14th day of the menstruation cycle, LH and FSH secretion reaches its maximum value. This eventually results in ovulation due to the secretion of LH. During the luteal phase, the graafian follicle changes to the corpus luteum, which secretes progesterone that helps in the implantation (if fertilisation of the ovum occurs) by maintaining the endometrium. [3]

13. (a)

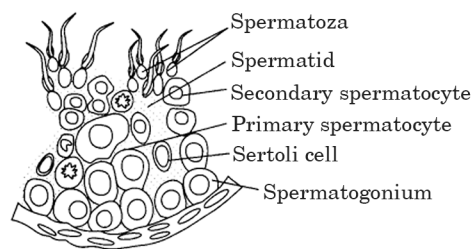


Fig.: Diagrammatic sectional view of a human seminiferous tubule [3]

- (b) Hormonal regulation of the process of spermatogenesis in humans are:
 - (i) Hypothalamus secretes gonadotropin-releasing hormone during puberty.
 - (ii) Further, gonadotropin-releasing hormone stimulates the anterior pituitary to secrete LH and FSH.
 - (iii) LH stimulates the secretion of androgens from the Leydig cells. Androgens stimulate the process of spermatogenesis.
 - (iv) Follicle-stimulating hormone stimulates the secretion of factors responsible for spermiogenesis (sperm maturation) from the Sertoli cells. [1+1]

[Topic 2] Gametogenesis

Gametogenesis

- The process in which the sex cells are produced is being coined as gametogenesis.
- Gametogenesis is classified in following components:

Spermatogenesis

Oogenesis

Spermatogenesis

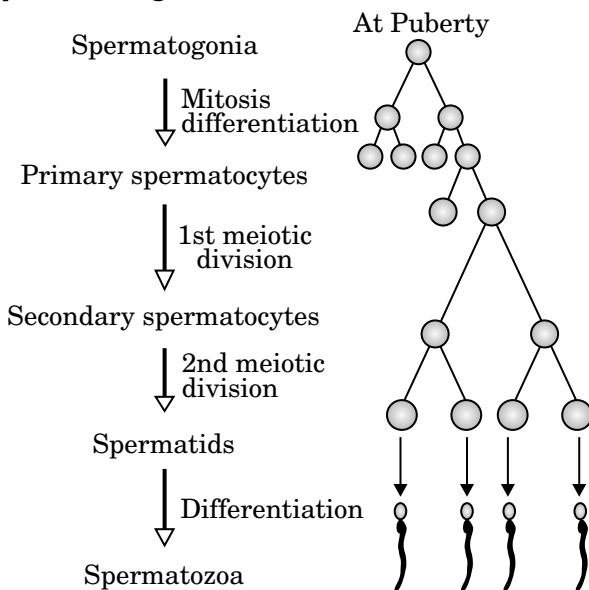


Fig.: Spermatogenesis mechanism

- The process which results in formation of sperms is called as spermatogenesis.
- It comprises of two stages:
Spermatids formation: In this process the mother sperm cell results in formation of spermatids.
Spermiogenesis: The spermatids formed in the above step results into formation of sperms.
- Meiosis-I is undergone by spermatocyte to produce secondary spermatocytes.
- Now Meiosis-II is undergone by spermatocyte to produce haploid spermatids.
- Now using the process of spermiogenesis, the spermatids produced in the above step transforms into spermatozoa.

Structure of Sperm

- The length of a sperm is around 0.06 mm.
- The plasma encloses the sperm.
- The four basic parts of sperms are:
 - (a) Head: The shape of the head is oval and the constituent part is acrosome and nucleus.

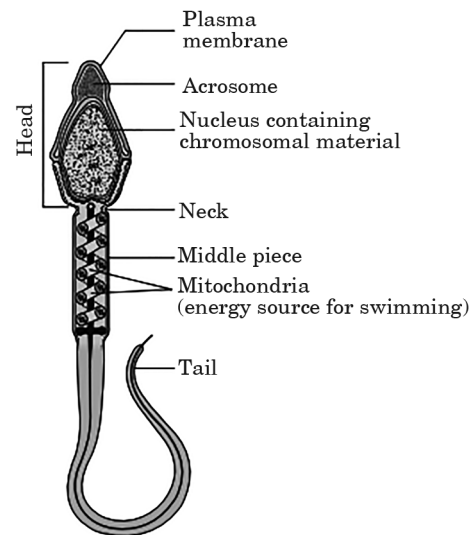


Fig.: Structure & various parts of Sperm

- (b) Neck: Distal and proximal centrioles is the basic part of neck. Neck is followed by the head.
- (c) Middle Part: The power house or mitochondria and cytoplasm comprises to make the middle part.
- (d) Tail: It is a filament that is axial in nature. Tail is used for the movement by sperms. Accessory ducts are used to transport sperms.

• Oogenesis

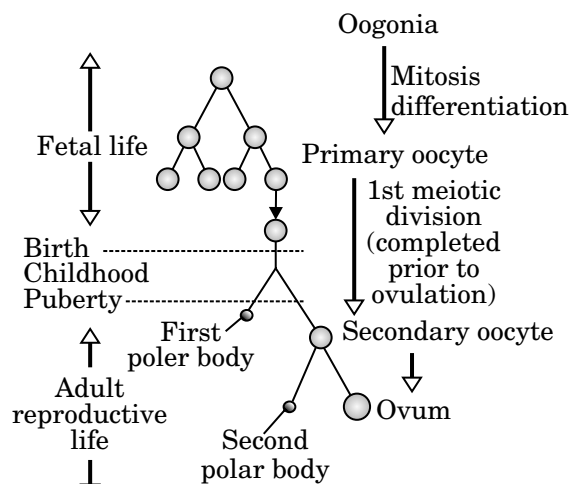


Fig.: Oogenesis mechanism

- The process which results in formation of ovum is termed as oogenesis.
- A Graafian follicle is the site where the above process takes place.
- During the onset of embryo stage, oogenesis process initiates.

- During this process multiple of egg cells are produced in each ovary.
- Prophase I meiosis is undergone by these egg cells obtained in the above step and the result into several multiplied cells.
- The granulosa cells surround the egg cell to result into an primary follicle.
- As the ovary reaches the age of puberty, only around 70,000 primary follicles are left out which again are surrounded by granulosa cells to form secondary follicles.
- This process continues to form tertiary follicles.
- Unequal meiosis division is undergone by the egg cells inside the tertiary follicle and this results in to secondary egg cells and body.
- Now this polar body obtained in the above step either withers or survives by dividing itself.
- Now this secondary egg cell is released outside when it is being punctured by Graafian follicle.
- This releasing process is also termed as ovulation.

Structure of Ovum

- The shape is oval or it can be spherical.
- The radius of an ovum is around 0.1mm.
- It has got several membranes which are as follows:

Zona pellucid	Corona Radiata
Vitelline membrane	Plasma Membrane

Menstrual Cycle

- Human females undergo a reproductive cycle every month, this reproductive cycle is being termed as menstrual cycle.
- This cycle usually an onset at the age of 10 years and this onset process is being termed as menarche.
- This above cycle takes around 28 days.
- In each cycle a release of ovum takes place and is termed as menstrual flow. This flow occurs in between of a cycle and goes on for around three to five days.
- This cycle only takes place when the egg is not being fertilized yet. If this cycle does not takes place, that means an onset of pregnancy.
- The menstrual flow begins when the lining of the uterus breaks itself as a result of the egg not getting fertilized.
- The next phase that is being followed by the menstrual cycle is follicular. In this phase all the follicles become mature and results into Graafian follicles.
- During this phase the secretion of estrogen also increases as a result of increased levels of gonadotropins.
- These gonadotropins attain their highest level on around 13th day of the cycle.

- This ongoing secretion due to such high increased level of gonadotropins is the sole reason which results in to the puncturing of the uterus lining.
- Now a third phase occurs after follicular is luteal phase. In this after the ovulation, the Graafian follicle results in to corpus luteum.
- There is no menstrual cycle taking place at the time of pregnancy.

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 2

1 Mark Questions

1. Name the embryonic stage that gets implanted in the uterine wall of a human female.

[ALL INDIA 2011]

3 Marks Questions

2. Draw a diagram of a mature human sperm. Label any three parts and write their functions.

[DELHI 2018]

3. Draw a diagram of the microscopic structure of human sperm. Label the following parts in it and write their functions.

(a) Acrosome

(b) Nucleus

(c) Middle piece

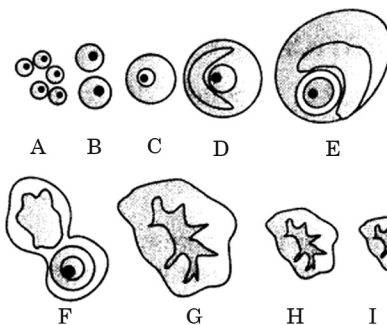
[DELHI 2013]

4. Explain the steps in the formation of an ovum from an oogonium in humans.

[ALL INDIA 2013]

5 Marks Questions

5. The following is the illustrations of the sequence of ovarian events (a-i) in a human female.



- (i) Identify the figure that illustrates ovulation and mention the stage of oogenesis it represents.
- (ii) Name the ovarian hormone and the pituitary hormone that have caused the above mentioned event.
- (iii) Explain the changes that occur in the uterus simultaneously in anticipation.

- (iv) Write the difference between “c” and “h”.
- (v) Draw a labelled sketch of the structure of human ovum prior to fertilization. [ALL INDIA 2012]
6. (a) How is oogenesis markedly different from spermatogenesis with respect to the growth till puberty in humans?
- (b) Draw a sectional view of human ovary and label the different follicular stages, ovum and corpus luteum? [DELHI 2014]
7. (a) Where does fertilization occur in humans? Explain the events that occur during this process.
- (b) A couple where both husband and wife are producing functional gametes, but the wife is still unable to conceive, is seeking medical aid. Describe any one method that you can suggest to this couple to become happy parents. [ALL INDIA 2014]
8. (a) Briefly explain the events of fertilization and implantation in an adult human female.
- (b) Comment on the role of placenta as an endocrine gland. [DELHI 2016]

Solutions

- The embryonic stage that gets implanted in the uterine wall of a human female is blastocyst. [1]
-

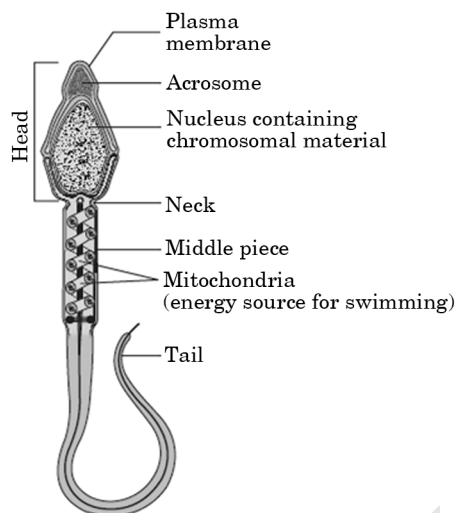
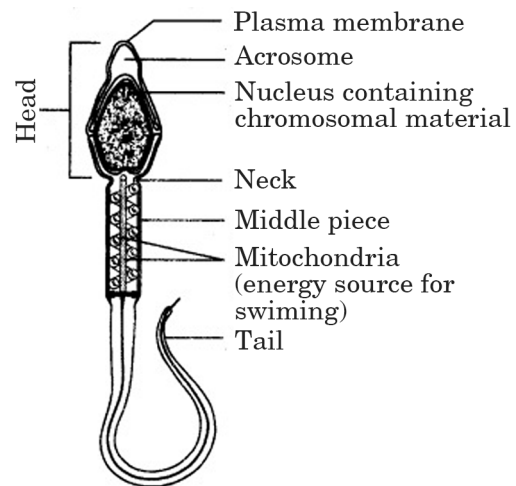


Fig.: Diagram of the microscopic structure of human sperm [2]

- I. Acrosome:** It is a cap like structure, filled with hydrolytic enzymes that help fertilisation of the ovum.
- II. Middle piece:** Possesses numerous mitochondria, which produces energy for the movement of tail.
- III. Tail:** helps in sperm motility, essential for fertilisation. [1]

3.



[3]

Fig.: Diagram of the microscopic structure of human sperm

- Three steps: (a) Multiplication phase (b) Growth phase (c) Maturation phase
 - (a) Multiplication phase:** In this step, ovum mother cell divides repeatedly by mitosis to form many diploid oogonia. [1]
 - (b) Growth phase:** This is the longest phase. Oogonia grow in size and develop into primary oocyte. In this step, egg size increases multiple times. [1]
 - (c) Maturation phase:** In this stage, primary oocyte grows in size and enters in the meiosis I division to form the secondary oocyte and polar body. Secondary oocyte is big in size, whereas polar body is small in size. [1]
- (i) Figure F illustrates ovulation and it represents oogenesis ovulatory stage. [1]**
 - (ii) Oestrogen is the ovarian hormone and the pituitary hormone is Leutinizing Hormone [1]**
 - (iii) Uterus endometrium get thickened and receives more blood supply for implantation of the fertilized egg. [2]**
 - (iv) “C” is representing secondary follicle and “h” is representing corpus luteum which is degenerate. [1]**
- (a) Spermatogenesis:** It takes place in the human males and start from the puberty till complete life cycle. Four haploid spermatids are developed from single spermatogonium after second meiotic division. Spermatogenesis takes place in testis and releases mature sperm. [1] Oogenesis takes places in human female and starts before the birth during embryonic development and ends at menopause.

A single oogonium, after second meiotic division result in the formation of one ovum and two non-functional polar bodies. Oogenesis is followed by ovulation in fallopian tubes when sperm enters to fertilise the ovum. [2]

(b)

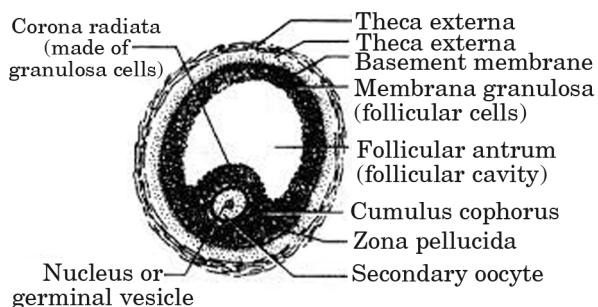


Fig.: Sectional view of human ovary [2]

7. (a) Fertilization occur in humans in the fallopian tubes that connect ovary to the uterus.

The events that occur during this process are:

- (i) The sperm crosses the outermost layer of egg known as corona radiata.
- (ii) Then, sperm breaks the wall of zona pellucida.
- (iii) The membrane of egg and sperm fuses.
- (iv) The female egg mature into mature ovum.
- (v) The sperm tail and mitochondria degenerate that result in the formation of male pronucleus.
- (vi) The male and female pronuclei fuse to form a new nucleus that is combination of egg and sperm.
- (vii) Semen is ejaculated deep within the cavity in vagina to allow passage of sperms. [3]

(b) Couples can take the help of IVF, GIFT, ZIFT. In vitro fertilization (IVF) that include

fertilization outside of the body. It is the most common type of ART. It is preferred in the situation where few sperms are produced by male and blockage in female fallopian tubes. In this situation, drug is given to female that aid in the production of multiple eggs. Once, the eggs mature, they are removed from female ovary and placed in a dish along with men's sperm for fertilization. After few days, that is 3-5 days, embryo is implanted in uterus of the female. [2]

8. (a) Fusion of sperm and ova is called fertilization. It takes place in the fallopian tube of the human female. In the process, one sperm comes in contact with the zona pellucida layer of ovum and induces changes to block entry of additional sperms. The entry of sperm induces completion of meiosis II leading to the formation of anootid and second polar body. The haploid nucleus of the sperm and that of the ovum fuse to form a diploid zygote. Implantation is the process of the attachment of the fertilized egg (the blastocyst) to the lining of the uterus to grow and develop. It is an entirely natural process that happens a week after ovulation and is an early stage of pregnancy. The trophoblast layer of the blastocyst attaches to the endometrium of the uterus. The uterine cells divide rapidly and cover the blastocyst which becomes embedded in the endometrium to complete implantation. [3]

(b) Placenta acts as an endocrine tissue and produces hormones such as human chorionic gonadotropin (hCG), human placental lactogen (hPL), estrogens, and progestogens. The hormones hCG, hPL and relaxin are produced in women only during pregnancy. [2]

[Topic 3] Fertilization, Pregnancy and Embryonic development

Fertilization

- The process in which male and female gamete fuse together is termed as fertilization.
- The male gametes are sperms and the female gametes is ova. The sperms are being released in the vagina with the help of penis.

- As soon as the sperms enter the vagina, they swim towards the uterus. Then a fusion takes place at the oviduct on ampullaryisthmic junction.
- Now the sperms and ova fuse together to form zygote and hence leads to pregnancy.
- For the formation of zygote the ova and sperms have to travel together.

- Now the sperms are ample, so when a sperm makes a contact with the zona pellucid, there are some changes being done to the membrane which results in no extra sperms entering in.

Implantation

- The process in which the zygote just after fertilization moves and reaches the uterus is called as implantation.
- Reaching the uterus, the zygote forms blastomeres i.e. daughter cells in group of powers of 2 (2,4,8,16,32).
- Morula is an embryo that has eight to sixteen blastomeres. This morula obtained keeps on getting divided to form blastocyst which is a group of so many cells together.
- Throphblast is the outer layer in which the blastomeres are being arranged.
- The inner cells now gets differentiated in to the following germ layers:
 - Inner endoderm
 - Middle mesoderm
 - Outer ectoderm
- Conclusively in the process of implantation the blastocyst discussed above settles in uterus at endometrium.

Pregnancy and Embryo Development

- After the implantation of zygote in uterus, the female is said to be having pregnancy.
- The chorionic villi which is a finger like projection starts developing on the throphblast.
- This is also being surrounded by maternal blood and tissue. Placenta is also being developed in this stage.
- Placenta acts as a point of link in between the mother's body and the developing fetus which provides the required nutrition for the growth.

Parturition

- Parturition is defined as a process in which a female delivers a baby after 9 months of gestation period.
- Neuroendocrine is the main principle on which parturition is based.
- When it is the time to deliver a child, the foetus and placenta sends a few signals in the form of uterine contractions.
- As a result oxytocin hormone is released, uterine wall starts to contract which results in the baby coming out of the baby.
- As the baby comes out, the placenta and the umbilical chord is being taken off the body.

Lactation

- After the baby is being delivered, the mammary glands starts producing milk. This process as a whole is called as lactation.
- During the first few days after the onset of milk production, we find the milk to be yellow and is termed as colostrums.
- Several antibodies in order to develop the immune system is the essential part of the colostrums.
- This helps in providing the appropriate nutrition to the newly born child.

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 3

▣ 2 Marks Questions

1. (a) Where do the signals for parturition originate from in human?
(b) Why is it important to feed the new born babies on colostrum? [DELHI 2012]
2. (a) State the difference between meiocyte and gamete with respect to chromosome number.
(b) Why is a whiptail lizard referred to as parthenogenetic? [ALL INDIA 2012]

▣ 3 Marks Questions

3. Describe the process of parturition in humans. [DELHI 2015]
4. Medically it is advised to all young mothers that breastfeeding is the best for their new-born babies. Do you agree? Give reasons in support of your answer. [DELHI 2018]

▣ 4 Marks Questions

5. It is commonly observed that parents feel embarrassed to discuss freely with their adolescent children about sexuality and reproduction. The result of this parental inhibition is that the children go astray sometimes.
 - (a) Explain the reasons that you feel are behind such embarrassment amongst some parents to freely discuss such issues with their growing children.
 - (b) By taking one example of a local plant and animal, how would you help these parents to overcome such inhibitions about reproduction and sexuality? [ALL INDIA 2017]

5 Marks Questions

6. During the reproductive cycle of a human female, when, where and how does a placenta develop? What is function of placenta during pregnancy and embryo development? **[DELHI 2015]**
7. Describe the role of pituitary and ovarian hormones during the menstrual cycle in a human female. **[ALL INDIA 2015]**
8. (a) Explain the menstrual phase in a human female. State the levels of ovarian and pituitary hormones during this phase.
(b) Why is follicular phase in the menstrual cycle also referred as proliferative phase? Explain.
(c) Explain the events that occur in a Graafian follicle at the time of ovulation and thereafter.
(d) Draw a Graafian follicle and label antrum and secondary oocyte. Explain. **[ALL INDIA 2016].**
9. (a) Arrange the following hormones in sequence of their secretion in a pregnant woman.
(b) Mention their source and the function they perform:
hcG ; LH ; FSH ; Relaxin **[DELHI 2017]**
10. (a) Explain the following phases in the menstrual cycle of a human female:
(i) Menstrual phase
(ii) Follicular phase
(iii) Luteal phase
(b) A proper understanding of menstrual cycle can help immensely in family planning. Do you agree with the statement? Provide reasons for your answer. **[ALL INDIA 2017]**

Solutions

1. (a) The signals of parturition originates from fully developed foetus and placenta and is called foetal ejection reflex. [1]
(b) It is very important to feed the new born babies with colostrum because it consists of ample antibodies like IgA essential to protect the infant against infections. [1]
2. (a) Difference include in the chromosome number. Gamete have single set of chromosome (n) and meiocyte are diploid ($2n$). [1]
(b) As, new whiptail lizard individual can develop from an unfertilized egg it is known as parthenogenetic. [1]
3. Parturition is a process of childbirth in which there is expulsion of the fully developed foetus from mother's uterus at the end of the gestation period. A fully developed foetus triggers release of oxytocin from maternal pituitary. Oxytocin causes stronger uterine contractions. This stimulates further release of oxytocin from maternal pituitary. Parturition involves forceful muscular contraction of uterine wall called labour. The entire process of parturition is stimulated by complex neuroendocrine mechanism. The process of parturition involves cortisol, estrogen and oxytocin. [2]
There are three stages of parturition
(i) 1st stage: Dilation of cervix
(ii) 2nd Stage: Delivery of baby
(iii) 3rd stage: Delivery of placenta and umbilical cord. [1]
4. Yes, I agree with the fact that breast milk is the best for new-born babies. Mammary glands of the young mother start producing milk at the end of pregnancy. The milk produced during the initial few days is called colostrum which contains several antibodies. It helps in developing resistance for new-born baby. It helps the baby fight with viruses and bacteria. Thus breast milk is packed with disease-fighting antibodies that protect your baby from microbial infections Breast milk also naturally contains many of the vitamins and minerals that a new-born requires. Breast milk is easily digested therefore, no constipation, diarrhoea and upset stomach. [3]
5. (a) The parents in our society feel embarrassed to discuss sexuality and reproduction related issues with their adolescent children due to the following reasons:
(i) The parents feel that discussing sexuality and reproduction will have a negative impact on children.
(ii) Talking about sex-related issues are considered as taboo in our society, so people feel uncomfortable to discuss these issues.
(iii) Illiteracy, conservative mind set and social barrier are the other reasons.[2]
(b) To overcome inhibitions about reproduction and sexuality, parents can explain about sexuality and reproduction with one or two examples of plants or animals. In papaya, palm plants, male and female reproductive structures are present on the different plant like humans. Similarly in animals such as earthworm both male and female organs are present in one individual. [2]
6. Placenta is a tissue connection between foetus and endometrium layer of uterus of mother. It supports the foetus during its development.

The foetus is connected to the placenta by a long, flexible tube called umbilical cord. After fertilisation, the zygote divides and leads to the formation of blastocyst. The blastocyst comes into contact with the endometrium. The outer layer of blastocyst, trophoblast secrete lytic enzymes which encroach into the endometrial lining. This give rise to finger-like projections called chorionic villi. This forms the foetal part of placenta. These villi extend into the maternal part of placenta called- Decidua. The villi are immersed into the blood sinuses found in decidua region which is divided into three distinct regions. These regions are decidua basalis, decidua capsularis and decidua parietalis. [2]

The functions of placenta are:

1. The placenta facilitates the supply of oxygen and nutrients to the embryo and also removes carbon dioxide and excretory or waste materials produced by the embryo. [1]
2. Placenta also acts as an endocrine tissue as it secretes several hormones like human chorionic gonadotropin (hCG), human placental lactogen (hPL), estrogens, progesterone, etc., that are essential for maintaining maternal physiological conditions appropriate for continued development of foetus. [1]

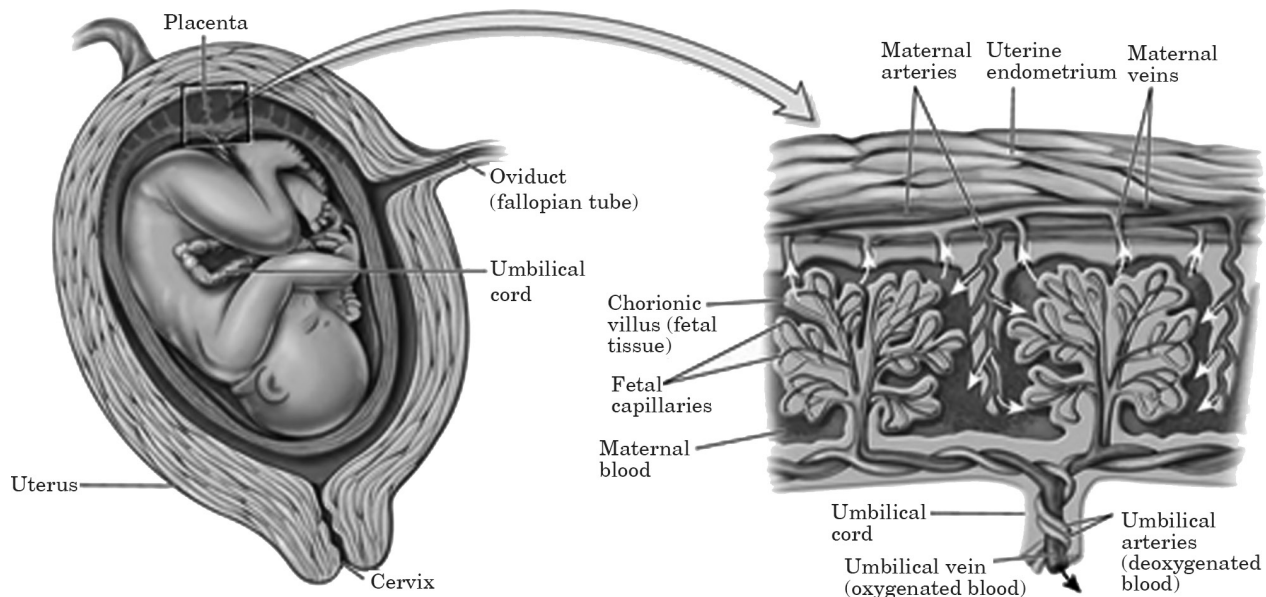


Fig.: (a) Location of the placenta in the uterus (b) Details view of the placenta [1]

7. At the start of the menstrual cycle, the hypothalamus signals (by GnRH) the pituitary gland to produce the follicle-stimulating hormone (FSH), which in turn signals the ovaries to begin forming and maturing eggs. On the maturation of follicles, the level of estrogen in the body rises, indicating that an egg is ready. This first half of the menstrual cycle is called the follicular phase. When high estrogen levels signal an egg is ready, the pituitary gland then produces a luteinizing hormone (LH), triggering the ovary to release the mature egg by the process of ovulation. The day ovulation happens is the first day of the second half of the cycle, the luteal phase. During the luteal phase of the menstrual cycle the ovaries (the corpus luteum) begin to increase the levels of progesterone in the body. Progesterone, secreted by ovary regulates and maintains the inner lining of the uterus both during menstrual cycle and gestation. Progesterone is a hormone that

prepares the lining of the uterus for pregnancy. If the egg is fertilized and implanted, the body continues to produce progesterone and if not, then progesterone levels fall, and that month's menstrual period begins. [3]

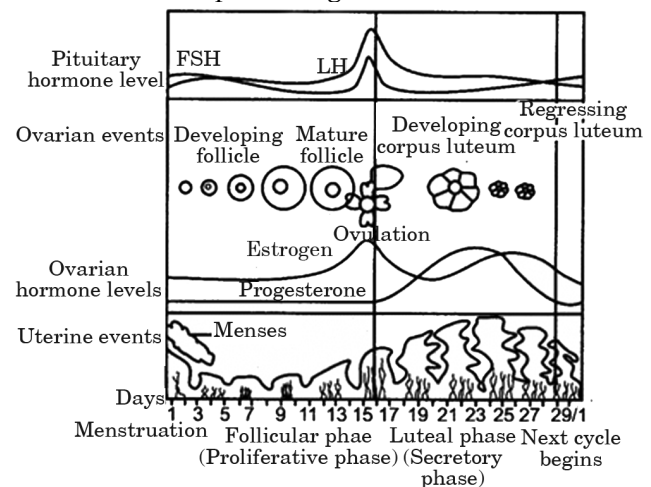


Fig.: Menstrual cycle & hormones level [2]

8. (a) If fertilisation fails to occur menstrual phase starts. The endometrium (the lining of the uterus) breaks and its blood vessels form the liquid that comes out through the vagina, and is called menstrual flow. It lasts for 3 to 5 days. During menstrual phase, the levels of hormones secreted by corpus luteum and hormones secreted by pituitary gland are low. [1]

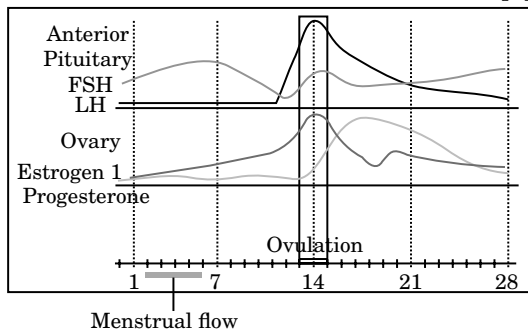


Fig.: Level of pituitary and ovarian hormones [1]

- (b) The follicular phase begins just after menstrual phase. In this phase the primary follicles mature into the Graafian follicle under the influence of follicle stimulating hormone (FSH) and Luteinising hormone (LH). As the follicles and the endometrium proliferate during the follicular phase, it is also known as the proliferative phase. [1]
- (c) The LH and FSH are at their peak in the middle of the cycle (14th day) this causes the rupturing of the Graafian follicle to release the ovum (secondary oocyte) and the remaining parts of the Graafian follicle changed to the corpus luteum. [1]
- (d) Structure of a Graafian follicle: [1]
9. (a) The correct sequence of hormones is FSH – LH – hCG – Relaxin. [1]
- (b) Sources and functions of the hormones:

Hormones	Source	Function
FSH	Anterior lobe of Pituitary	Stimulates the growth of ovarian follicles and maturation of primary oocyte
LH	Anterior lobe of pituitary	Induces ovulation and maintains corpus luteum

hCG	Chorionic cells of placenta	Maintains the corpus luteum and stimulates it to secrete progesterone.
Relaxin.	Ovary	Helps during child birth by relaxing the pelvic muscles as well as muscles of the cervix.

[1+1+1+1]

10. (a) (i) Menstrual phase: This phase is characterised by bleeding. Bleeding occurs due to breakdown of the soft tissue of endometrial lining of the uterus. The unfertilised egg and soft tissues are discharged in the bleeding. It lasts for 3 to 5 days. [1]
- (ii) Follicular phase: it is also known as proliferative Phase. In this phase the primary follicles in the ovary grow and mature to become Graafian follicle. The secretion of gonadotropins (LH and FSH) increases gradually during the follicular phase. It lasts for about 10 to 14 days. [1]
- (iii) Luteal phase: In this phase the ruptured follicle changes into corpus luteum in the ovary and it begins to secrete hormone progesterone. If ovum is not fertilised, the corpus luteum undergoes degeneration and this causes disintegration of endometrium leading to menstruation. It lasts 15 days to 28 days. [1]
- (b) Yes, a proper understanding of menstrual cycle can help greatly in family planning. It is obvious from the menstrual cycle is that in between 10th to 17th day of the cycle, the chances of fertilisation is high. If copulation is done during this period, it increases the chances of pregnancy Also abstaining from copulation during this period, pregnancy can be avoided. [2]

CHAPTER 4

Reproductive Health

Chapter Analysis with respect to Last 3 Years' Board Exams

List of Topics	2016		2017		2018
	Delhi	All India	Delhi	All India	Delhi/All India
Need for reproductive health and prevention of sexually transmitted diseases (STD)					
Birth control – Need and Methods, Contraception and Medical Termination of Pregnancy (MTP), Amniocentesis		1Q (3 marks), 1Q (4 marks)	1Q (2 marks)		
Infertility and assisted reproductive technologies - IVF, ZIFT, GIFT	1Q (4 marks)				

On the basis of above analysis, it can be said that from exam point of view the concepts of Birth Control Measures, Practical Relevance of Reproductive system, Child Healthcare Programs and Infertility are the most important concepts of the chapter.

[Topic 1] Reproductive Health-Problems and Strategies

Summary

Reproductive Health: The physical, emotional, behavioral and social well-being of reproduction is referred as reproductive health. To accomplish the social goal of total reproductive health, India has initiated 'family planning' programs in 1951.

- In present time, 'Reproductive and Child Health Care (RCH) programmers' are being operated as improved programs which cover wide reproduction-related areas.
- The primary steps to achieve the goal of reproductive health is counselling the people and aware them about adolescence, reproductive organs, changes associated with adolescence, safe and hygienic sexual practices, STDs (sexually transmitted disease) as AIDS etc.
- Some of the other facets of RCH programs are to provide care and medical facilities for the problems related to pregnancy, menstrual irregularities, delivery, STDs, birth control, post-natal child and maternal management, etc.

Population explosion and Birth control

- Reduction of maternal and infant mortality rates, assistance to infertile couples, early identification and cure of STDs, etc. indicate that reproductive health is improved in our country.
- A volatile population growth has been promoted by better living conditions and improved health facilities. That is why the intense propagation of contraceptive methods became necessary. Some natural as well as traditional, IUDs, pills, injectable, implants, surgical, barrier contraceptive options are available nowadays. These methods are useful to delay or avoid the pregnancy.
- In **natural methods** the chances of meeting the ovum and sperms are avoided by taking care of the period of menstrual cycle. In this method, the sexual intercourse from day 10 to 17 of the menstrual cycle is avoided as this is called the fertile period and this method is called Periodic abstinence. Withdrawal or coitus interrupts and lactational amenorrhoea are the other natural methods.

- **Withdrawal or coitus interrupts:** Method in which the male partner removes the penis before ejaculating inside the women's vagina to avoid insemination.
- **Barrier** method helps to prevent the physical meeting of ovum and sperm. Condoms, diaphragms, cervical caps and vaults are the examples of barriers.
- **IUDs (Intra Uterine Devices)** are the devices which are inserted in the uterus of female through vagina which helps to prevent unwanted pregnancy.
- **Pills** are taken orally in order to prevent pregnancy. These are the small doses of progestogens or progestogen-estrogen combinations.
- **Sterilization** is a surgical method to prevent any more pregnancies. It is a terminal method which blocks gamete transport. In males, it is **Vasectomy** and in females it is **Tubectomy**.

Medical Termination of Pregnancy: Our country has legalized the medical termination of pregnancy (MTP). Casual relationships, rapes can cause unwanted pregnancy. To get rid of such types of pregnancy, MTP is performed. It is also performed in some cases where the need to discontinue the pregnancy is necessary as it could be harmful or fatal to either the mother, or the foetus or both.

Sexually Transmitted Diseases and Infertility

Sexually transmitted diseases or STDs are transferred through the sexual interactions. These are also called as **VD (Venereal Diseases)** or **RTI (Reproductive Tract Infections)**. Some complications of STDs are still birth, infertility, Pelvic Inflammatory diseases (PIDs). In order to cure these diseases in a better way, their early detection is necessary. Some precautions can be adopted to avoid STDs like use of condoms during sexual intercourse and avoiding it with multiple or unknown partners.

Some of the common STDs are syphilis, gonorrhoea, chlamydia, genital herpes, genital warts, hepatitis-B, trichomoniasis and HIV which leads to AIDS. Few principles to be free from such infections:

- Use of condoms during coitus.
- Avoiding sex with unknown partners/multiple partners.

- Visiting a qualified doctor for early detection of the disease and to get full treatment, if diagnosed with one.

Infertility: Infertility is the inability to conceive even when the sexual interaction is unprotected. Physical diseases, psychological reasons, drugs etc can be responsible for infertility. In present time, there are some methods and techniques available to help the couples who are dealing with infertility. These certain techniques are called assisted reproductive technologies (ART).

In vitro fertilization (IVF): In one of such methods, embryo is transferred into the female genital tract and is known as In vitro fertilization (IVF) and this program is called the 'Test Tube Baby' program.

ZIFT (Zygote intra fallopian transfer): Another method is ZIFT (Zygote intra fallopian transfer) in which a donor provides the ovum and it is then transferred into the fallopian tube of the female who cannot produce it but can give suitable environment for the fertilization and development process.

Intra cytoplasmic sperm injection (ICSI): is another technique to help the couples who are unable to produce a child because of infertility. In this technique an embryo is formed in the laboratory in which a sperm is directly injected into the ovum.

Artificial insemination (AI): Intra cytoplasmic sperm injection could be corrected by this technique, the semen is collected from either the husband or a healthy donor and is artificially introduced either into the vagina or into the uterus of the female also known as IUI (intra-uterine insemination).

There are many methods to help the couples dealing with infertility but they are not reachable to every class as not everyone can adopt these methods because of financial or some emotional and religious facts. So another method is adoption which is legal in our country now.

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 1

▣ 2 Marks Questions

1. After a brief medical examination a healthy couple came to know that both of them are unable to produce functional gametes and should look for an 'ART' (Assisted Reproductive Technique). Name the 'ART' and the procedure

involved that you can suggest to them to help them bear a child. [DELHI 2015]

2. Why is CuT considered a good contraceptive device to space children? [DELHI 2011]
3. Describe the Lactational Amenorrhoea method of birth control. [ALL INDIA 2011]
4. Our government has intentionally imposed strict conditions for M.T.P. in our country. Justify giving a reason. [DELHI 2017]

▣ 3 Marks Questions

5. (a) Mention the problems that are taken care of by Reproduction and Child Health Care programme.
(b) What is amniocentesis and why there is a statutory ban on it? [ALL INDIA 2016].
6. Suggest and explain any three Assisted Reproductive Technologies (ART) to an infertile couple? [ALL INDIA 2013].

▣ 4 Marks Questions

7. Your school has been selected by the Department of Education to organize and host an interschool seminar on "Reproductive Health – Problems and Practices". However, many parents are reluctant to permit their wards to attend it. Their argument is that the topic is "too embarrassing." Put forth four arguments with appropriate reasons and explanation to justify the topic to be very essential and timely. [ALL INDIA 2015].
8. Reproductive and Child Healthcare (RCH) programmes are currently in operation. One of the major tasks of these programmes is to create awareness amongst people about the wide range of reproduction related aspects. As this is important and essential for building a reproductively healthy society.
(a) "Providing sex education in schools is one of the ways to meet this goal." Give four points in support of your opinion regarding this statement.
(b) List any two 'indicators' that indicate a reproductively healthy society. [DELHI 2016]
9. A large number of married couples the world over are childless. It is shocking to know that in India the female partner is often blamed for the couple being childless
(a) Why in your opinion the female partner is often blamed for such situations in India? Mention any two values that can promote to check this social evil.

- (b) State any two reasons responsible for the cause of infertility.
- (c) Suggest a technique that can help the couple to have a child where the problem is with male partner. [ALL INDIA 2016]

5 Marks Questions

10. A pregnant human female was advised to undergo M.T.P. It was diagnosed by her doctor that the foetus she is carrying has developed from a zygote formed by an XX egg fertilized by Y carrying sperm. Why she was advised to undergo M.T.P? [ALL INDIA 2011]

Solutions

- Assisted reproductive technology (ART) is fertility treatment technique. One such technique is called ZIFT (Zygote intra fallopian transfer). In this technique, the sperm and ovum are collected from the donor male and the donor female respectively. The sperm and the ovum are fused in the laboratory and allowed zygote to develop till the 8-blastomere stage, then is transferred to the fallopian tube of the mother for further development. GIFT (gamete intra fallopian transfer) is another such technique. [2]
- CuT or copper T is an intrauterine device. CuT is inserted into the uterus through vagina by expert doctors. The copper ion released by this device decreases the motility and fertilizing capacity of sperms. At the same time, it increases the phagocytosis of the sperms. Hence, in this way, CuT is considered a good contraceptive device to space children. [2]
- Lactational Amenorrhea is characterized by absence of menstruation during intense lactation. It is a method of birth control because:
 - In this period, ovulation and other physiological processes ovulation are stopped. [1]
 - The period where child is fed by the mother, there is no chance of conception. [1]
- M.T.P. stand for Medical Termination of Pregnancy. It also called induced abortion. Our government has intentionally strict conditions for M.T.P. to prevent female foeticide. By imposing such regulations on MTP, sex ratio may be maintained and also avoid any danger for (young) mother (and foetus) [1]
- Reproduction and child health care programme addresses problems such as uncontrolled population growth, problems of sex abuse, sex related crimes and sexually transmitted diseases (STDs). [1½]
 - Amniocentesis is a process of diagnosis of chromosomal abnormalities and foetal infections by analysing a small amount of amniotic fluid. But this process is misused for detecting gender of the foetus. Therefore, there is a statutory ban on amniocentesis to avoid female foeticides. [1½]
- Three Assisted Reproductive Technologies (ART) to an infertile couple are:
 - In vitro fertilization (IVF) that include fertilization outside of the female body. It is the most common type of ART. It is preferred in the situation where few sperms are produced by male or if there is a blockage in female fallopian tubes. In this situation, drug is given to female that aid in the production of multiple eggs. Once, the eggs are mature, they are removed from female ovary and placed in a dish along with men's sperm for fertilization. After few days, that is 3- 5 days, embryo at 8-blastomere stage is implanted in uterus of the female. [1]
 - ZIFT or Zygote intrafallopian transfer or tubal embryo transfer is the fertilization outside of the female body. It is similar to the IVF except the embryo is implanted in fallopian tubes of the female. [1]
 - GIFT or Gamete intrafallopian transfer include transferring of egg and sperm into fallopian tubes of the female. Hence, fertilization takes place inside female body. [1]
- Reproductive health is very important aspect of human life. It is very important for one must attend seminar on 'Reproductive Health Problems and Practices' as it deals with the problems and strategies of reproductive health. In the seminar, following topics about reproductive health that should be discussed with the students:
 - Lack of proper knowledge or too little understanding about the safe reproductive process may lead to unwanted pregnancies. Therefore, it is necessary to create awareness among youth to know about reproductive process. [1]
 - Make adolescents aware about one's sexuality at a proper age that may help them to know about the different changes happening in their body; thereby, leading to a better mental and physical state of health. [1]

- III. Counselling and creating awareness about reproductive health also helps to curb the problems of infertility, birth control, mortality, etc. [1]
- IV. It prevents sex abuse and sex related crime. People should think and take up necessary steps to prevent sex abuse and build up a reproductively healthy society. [1]
8. (a) Reproductive and Child Healthcare (RCH) programmes Provides education on sex and reproduction related issue. It is one of the best ways to lay the foundation of reproductively healthy society. Sex education may help in achieving goal by. [½]
- I. This type of program give proper information to adolescents and preventing them from believing in myths about sex-related aspects. [½]
- II. Creates awareness about sexually transmitted diseases (STDs) such as syphilis, gonorrhoea and ways to prevent them. [½]
- III. Provides proper information about reproductive organs and various adolescents and related changes. [½]
- IV. Proper information about safe and hygienic sexual practices. [½]
- (b) Two indicators of a reproductively healthy society may be:
- (i) When there will be no discrimination between male and female child by their parents. I would be the biggest indicator of reproductively healthy society. [½]
- (ii) If there is decrease in IMR (Infant Mortality Rate) and MMR (Maternal Mortality Rate). [½]
- (iii) Less evidence of occurrence of sexually transmitted diseases. [½]
9. (a) Due to improper knowledge on reproduction related issues, lack of moral values and also due to the orthodox male dominant nature of society in India. Female partner is blamed. For not being able to produce babies. As a biology student awareness can be created that Abnormality can be in any of the partners in the couple. Only proper diagnosis of both the partners can help in detecting the reason for infertility. Awareness can be created to bring about respect towards both the partners in case of such a problem and to find a remedy from medical experts rather than consulting baba and ojhas. Awareness can be created not to believe in superstitions. [2]
- (b) The reasons for infertility may be abnormality in reproductive system, congenital (by birth) and may be due to immunity. [1]
- (c) Intra cytoplasmic sperm injection (ICSI) or artificial insemination (AI) can help the couple to have a child in case the problem is with the male partner. [1]
10. MTP is medical terminal of pregnancy. Another name of MTP is abortion. It is medical procedure of getting rid of unwanted pregnancy. As in this case, pregnant human female have XX egg chromosome that is going to be fertilized with Y chromosome of male will result in the formation of foetus having XXY chromosome. This is the situation, where foetus is carrying an abnormal sex chromosome from the egg. This condition is known as trisomy condition. In this condition, foetus is having extra X chromosome and result in the occurrence of a disorder in foetus such as Klinefelter's syndrome and hence, female was advised to terminate the pregnancy. [5]

CHAPTER 5

Principles of Inheritance and Variation

Chapter Analysis with respect to Last 3 Years' Board Exams

List of Topics	2016		2017		2018
	Delhi	All India	Delhi	All India	Delhi/All India
Mendelian Inheritance, Deviations from Mendelism-Incomplete dominance, Co-dominance	1Q (1 mark)		1Q (5 marks)	1Q (1 mark), 1Q (5 marks)	
Multiple alleles and Inheritance of blood groups, Pleiotropy					
Elementary idea of polygenic inheritance, Chromosome theory of inheritance, Chromosomes and genes					
Sex determination - in humans, birds, honey bee, Linkage and crossing over	1Q (3 marks)				1Q (3 marks)
Sex linked inheritance - Haemophilia, Colour blindness, Mendelian disorder in humans – Thalassemia, chromosomal disorders in humans, Down's syndrome, Turner's and Klinefelter's syndromes.					

On the basis of above analysis, it can be clearly inferred that from exam point of view the concepts Law of Independent Assortment, Genetics, Application of Crosses, Human Genetically Disorders, Monohybrid & Dihybrid types and Sex determination are most important concepts of the chapter.

[Topic 1] Mendel's Laws of Inheritance

Summary

- **Genetics:** The inheritance and the variation of characters from parents to progeny are dealt in the branch of biology known as Genetics.
- **Inheritance:** The process of passing the characters from parents to offspring is called the inheritance which is the basis of heredity.
- **Variation:** The degree of difference of offspring from its parents is called the variation.

Mendel's Laws of Inheritance

Mendel performed experiments on garden pea for 7 years in order to study the inheritance and gave the inheritance laws in living organisms. According to Mendel, the 'factors' (presently known as genes) are always found in pairs (called alleles) and they are responsible for regulating the characters. A definite pattern is followed in different generations by the expression of the characters in the progeny.

- **Principles or Laws of Inheritance:** It comprises two laws as follows:
 - **Law of Dominance:**
 - Discrete units called **factors** control the characters.
 - Factors occur in pairs.
 - One member of the pair dominates the other member in a dissimilar pair of factors.
 - Dominative member is called dominants while the other called recessive.
 - **Law of Segregation:** The alleles or factors of a pair segregate from each other such that a gamete receives only one of the two factors.

A parent which produces all similar gametes is called a homozygous parent while the one producing two kinds of gametes each having one allele with equal proportion is called heterozygous.

All the characters do not show true dominance. Some of the characters show incomplete dominance while the others may show co-dominance. Dominance is dependent on the gene product, particular phenotype chosen to examine and the production of the particular phenotype.

Inheritance of one gene:

Mendel proposed that the units of inheritance are called factors (known as genes now) and they carry the required information in order to express a particular attribute. The genes which code for a pair of contrasting attributes are called alleles.

- **Monohybrid Cross:**

- Monohybrid cross is a cross involving two plants differing in one pair of contrasting characters.
- A tall and a dwarf pea plant were crossed to study the inheritance of one gene
- **Steps in making a cross in pea**
 - Two pea plants with contrasting characters were selected.
 - Emasculation: Anthers on one plant were removed in order to avoid self-pollination. This is called female parent.
 - Pollination: It involves collecting pollen grains from male and transferring it to female parent.
 - The pollen grains were collected and offspring was produced.
 - Some factors were inherited from parent to offspring which were called as genes.
 - The production of gametes by the parents, the formation of the zygotes, the F_1 and F_2 plants is understood from a diagram called Punnett Square.
 - Following is the representation for monozygous cross

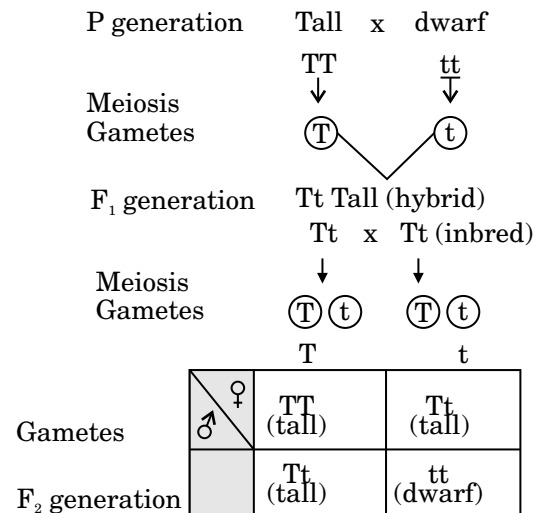


Fig.: Monozygous cross

- Gametes T and t are produced in equal production when F_1 is self-pollinated.
- Monozygous Genotypic ratio is
Homozygous Tall : Heterozygous Tall : Homozygous Dwarf = 1 : 2 : 1
- Monozygous Phenotypic ratio is Tall : Dwarf = 3 : 1

Non Mendelian Inheritance

- **Incomplete Dominance:**

- It refers to the inheritance in which heterozygous offspring shows intermediate character between

to parental characteristics. Example: Flower color in snapdragon and *Mirabilis Jalapa*.

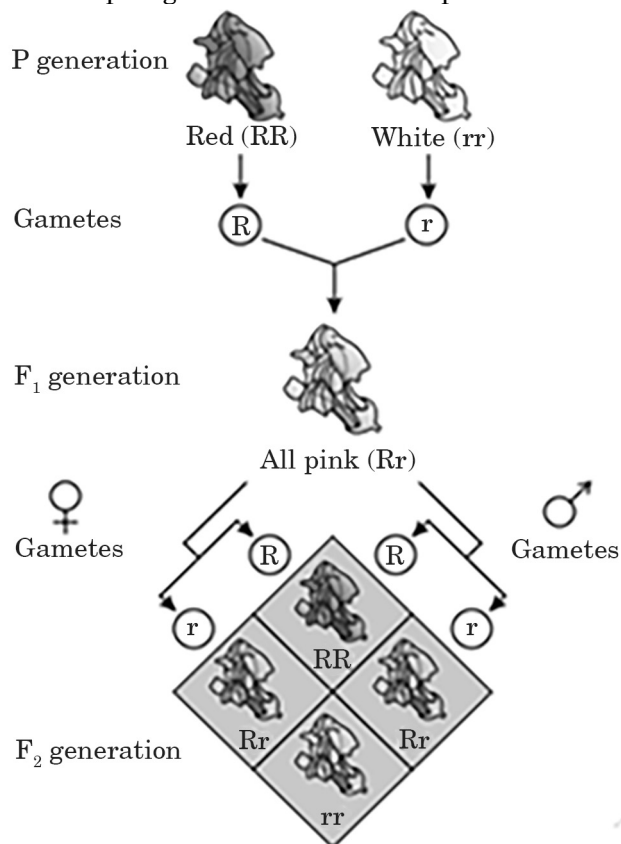


Fig.: Non Mendelian inheritance

- Genotypic Ratio = RR : Rr : rr = 1 : 2 : 1
- Phenotypic Ratio = Red : Pink : White = 1 : 2 : 1
- **Co Dominance:**
- It is the dominance in which both the alleles of a gene are expressed independently and equally in a hybrid that is both the alleles are dominant. Example: ABO blood group in humans.
- A gene I has three alleles I^A , I^B (the dominant alleles) and i (recessive allele)
- Antigen A and B are produced by I^A , I^B respectively and no antigen is produced by the recessive allele.

Allele from parent 1	Allele from parent 2	Genotype of offspring	Blood group of offspring
I^A	I^A	$I^A I^A$	A
I^A	I^B	$I^A I^B$	AB
I^A	i	$I^A i$	A
I^B	I^A	$I^A I^B$	AB
I^B	I^B	$I^B I^B$	B
I^B	i	$I^B i$	B
i	i	ii	O

Inheritance of two genes

- **Dihybrid Cross:**

- It refers to a cross between two parents who have two pairs of contrasting characters.
- Dihybrid cross between round pea plant with yellow seeds and wrinkled shaped pea plant with green seeds was studied by Mendel.
- The Punnett square is shown below:

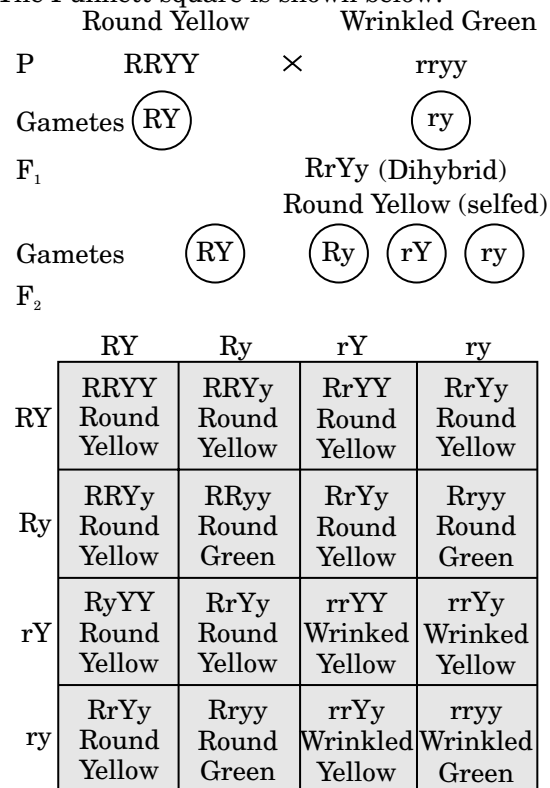


Fig.: Dihybrid cross (Punnett square)

- Dihybrid Phenotypic ratio is
Round yellow: Round green : Wrinkled yellow :
Wrinkled green = 9 : 3 : 3 : 1
- Dihybrid genotypic ratio is
RRYY : RRYy : RrYY : RrYy : RRyy : Rryy :
rrYY : rrYy : rryy = 1:2:1:2:4:2:1:2:1

After this study, the Law of Independent Assortment was given which says that the factors are independently assorted and they combine in all permutations and combinations.

- **Chromosomes:** Chromosomes are the structures found in the nucleus. They double and divide just before each cell division. They also occur in pairs.
- **Chromosomal Theory of Inheritance:** Both gene and chromosome are found in pair. The two alleles of a gene pair are located on the same locus on homologous chromosomes. According to the argument of Sutton and Boveri that the pairing and segregation of a pair of chromosomes would

lead to the separation of a pair of genes or factors they carried. The knowledge of chromosomal segregation was united with mendelian principles by Sutton and named as the chromosomal theory of inheritance.

Pleiotropy

- A single gene exhibiting multiple phenotypic expression is called as pleiotropic gene.
- Dominance depends on the production of a particular prototype and the gene product.

Example: Gene in pea plant which controls the wrinkled texture and roundness of the seeds influences the phenotype expression of the grain size of starch.

• Linkage and Recombination:

The physical association of genes on a chromosome is termed as linkage and the generation of non-parental gene combinations is termed as recombination. The genes are tightly linked when they are located on the same chromosome and show very low recombination.

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 1

▣ 1 Mark Questions

1. Name the event during cell division cycle that results in the gain or loss of chromosome. [DELHI 2011]
2. Mention the contribution of genetic maps in human genome project. [ALL INDIA 2011]
3. A garden pea plant produced axial white flowers. Another of the same species produced terminal violet flowers. Identify the dominant traits. [DELHI 2012]
4. A garden pea plant (A) produced yellow inflated pod, and another plant (B) of the same species produced constricted green pods. Identify the dominant traits. [ALL INDIA 2012]
5. Mention any two contrasting traits with respect to seeds in pea plant that were studied by Mendel. [ALL INDIA 2014]
6. State a difference between a gene and an allele. [DELHI 2016]
7. Name the type of cross that would help to find the genotype of a pea plant bearing violet flowers. [ALL INDIA 2017]

▣ 2 Marks Questions

8. Differentiate between male and female heterogamety. [DELHI 2015]
9. In a cross between two tall pea plants some of the offsprings produced were dwarf. Show with the help of Punnett square. How this is possible. [DELHI 2013]
10. A cross between a red flower bearing plant and a white flower bearing plant of *Antirrhinum* produced all plants having pink flowers. Work out a cross to explain how this is possible. [ALL INDIA 2013]
11. A cross was carried out between two pea plants showing the contrasting traits of height of the plant. The result of the cross showed 50% of parental characters.
 - (i) Work out the cross with the help of a Punnett square.
 - (ii) Name the type of the cross carried out. [DELHI 2014]
12. How does the gene 'I' control ABO blood groups in humans? Write the effect the gene has on the structure of red blood cells. [DELHI 2014]
13. In Snapdragon, a cross between true-breeding red flowered (RR) plants and true breeding white flowered (rr) plants showed a progeny of plants with all pink flowers.
 - (a) The appearance of pink flowers is not known as blending. Why?
 - (b) What is this phenomenon known as? [ALL INDIA 2014]
14. With the help of one example, explain the phenomena of co-dominance and multiple allelism in human population. [ALL INDIA 2014]
15. Write the scientific name of the fruit-fly. Why did Morgan prefer to work with fruit-flies for his experiments? State any three reasons. [ALL INDIA 2014]
16. Linkage and crossing-over of genes are alternatives of each other. Justify with the help of an example. [ALL INDIA 2014]

▣ 3 Marks Questions

17. How are dominance, co-dominance and incomplete dominance patterns of inheritance different from each other? [DELHI 2011]
18.
 - (a) Why is human ABO blood group gene considered a good example of multiple alleles?
 - (b) Work out a cross upto F₁ generation only, between a mother with blood group A (homozygous) and the father with blood group B (homozygous). Explain the pattern of inheritance exhibited. [DELHI 2013]

19. Mendel published his work on inheritance of characters in 1865, but it remained unrecognized till 1900. Give three reasons for the delay in accepting his work. **[DELHI 2014]**
20. Women are often blamed for producing female children. Consequently, they are ill-treated and Criticized. How will you address this issue scientifically if you were to conduct an awareness programme to highlight the values involved? **[DELHI 2014]**
21. Why is pedigree analysis done in the study of human genetics? State the conclusions that can be drawn from it. **[ALL INDIA 2014]**
22. A teacher wants his/her students to find the genotype of pea plants bearing purple coloured flowers in their school garden. Name and explain the cross that will make it possible. **[DELHI 2015]**
23. During a monohybrid cross involving a tall pea plant with a dwarf pea plant, the offspring populations were tall and dwarf in equal ratio. Work out a cross to show how it is possible. **[ALL INDIA 2015]**
24. Give an example of an autosomal recessive trait in humans. Explain its pattern of inheritance with the help of a cross. **[DELHI 2016]**

5 Marks Questions

25. Explain the genetic basis of blood grouping in human population. **[DELHI 2015]**
26. (a) Why are thalassemia and haemophilia categorized as Mendelian disorders? Write the symptoms of these diseases. Explain their pattern of inheritance in humans.
(b) Write the genotypes of the normal parents producing a haemophilic son. **[ALL INDIA 2015]**
27. State and explain the “law of independent assortment” in a typical Mendelian dihybrid cross. **[DELHI 2017]**
28. (a) Write the scientific name of the organism Thomas Hunt Morgan and his colleagues worked with for their experiments. Explain the correlation between linkage and recombination with respect to genes as studied by them.
(b) How did Sturtevant explain gene mapping while working with Morgan? **[ALL INDIA 2017]**
29. Describe the mechanism of pattern of inheritance of ABO blood groups in humans. **[ALL INDIA 2011]**

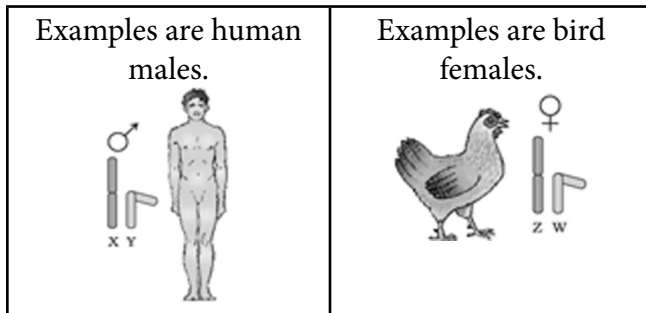
30. (a) Explain a monohybrid cross taking seed coat colour as a trait in *Pisum sativum*. Work out the cross upto F₂ generation.
(b) State the laws of inheritance that can be derived from such a cross.
(c) How is the phenotypic ratio of F₂ generation different in a dihybrid cross? **[DELHI 2012]**
31. What is the inheritance pattern observed in the size of the starch grains and seed shape of *Pisum sativum*? Workout the monohybrid cross showing the above traits. How does this pattern of inheritance deviate from that of Mendelian law of dominance? **[ALL INDIA 2012]**
32. (a) Explain the phenomena of multiple allelism and co-dominance taking ABO blood group as an example.
(b) What is the phenotype of the following:
(i) I^Ai (ii) ii **[DELHI 2012]**



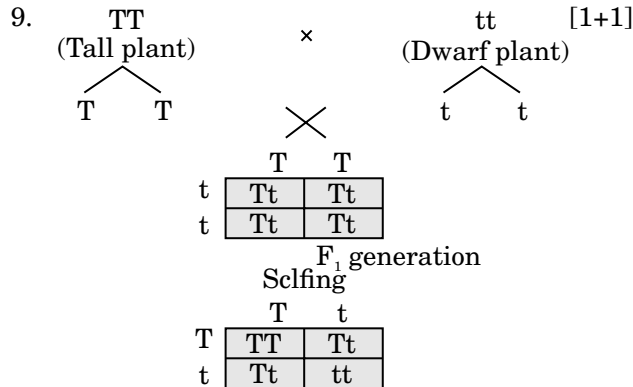
Solutions

1. Aneuploidy is the event during cell division cycle that results in the gain or loss of chromosome.[1]
2. Genetic maps are used in sequencing the whole genome of an organism, to find out the location of a gene on a chromosome. [1]
3. The Dominant Characters are axial and violet flower. [1]
4. Dominant trait is green inflated pod of the garden pea plant (A) [1]
5. Two contrasting traits with respect to seeds in pea plant are: seed colour in which yellow is dominant over green and second is shape of the seed where round seed is dominant over wrinkled seed. [1]
6. Alternate form of the same gene is called an allele. For example T is a gene which determines length of a plant. An allele of T is t hence, t is an allele of T or vice-versa. [1]
7. To find genotype of a pea plant bearing violet flower, test cross technique is used. [1]
- 8.

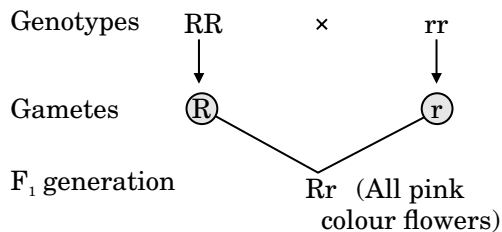
Male heterogamety	Female heterogamety
It is condition in which males produce two different types of gametes- gamete with X-chromosome and gametes with Y-chromosome.	It is condition in which females of some organisms produce two different types of gametes- gamete with Z-chromosome and gametes with W-chromosome.



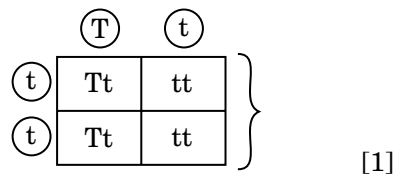
[½x4=2]



10. It is an example of incomplete determinant. [2]
 Parents Red flower White flower



11. (i) Tt × tt .

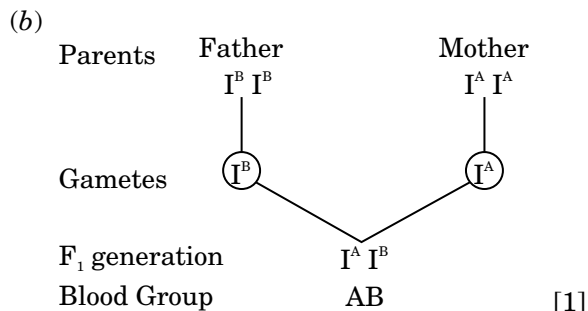


- (ii) Test cross is carried out in this question [1]
12. In human gene 'I' controls ABO blood group. Gene 'I' consist of three alleles :i, I^A, I^B, in which I^A, I^B are dominant over i. At the same time, I^A, I^B are co-dominant implying that both are expressed in the presence of each other. If the genotype of the person is I^AI^B, then the blood group of the offspring will be AB, whereas if the genotype of the person is I^A, I^A, then the blood group of the off spring will be A, If the genotype of the person is I^B, I^B then the blood group of the off spring will be B, If the genotype of the person is ii, then the blood group of the off spring will be O. Human gene 'I' controls the structure of red blood cells is this way: allele i does not code for any sugar of the plasma membrane of the red

blood cells whereas I^A, I^B code for sugar A and sugar B of the plasma membrane respectively.

[1+1]

13. (a) The appearance of pink flowers is not known as blending because pink it is not the mixture of red and white color but because of the fact that dominant allele is not completely dominant over the recessive trait. [1]
- (b) This phenomenon known as incomplete dominance. [1]
14. The best example of both to explain the phenomena of co-dominance and multiple allelism in human population is ABO blood group. In human gene 'I' control ABO blood groups in humans. Gene 'I' consist of three allele :i, I^A, I^B, (example of multiple allelism), in which I^A, I^B are dominant over i. At the same time, I^A, I^B are co-dominant means both expressed in the presence of each other(example of co-dominance). [1+1]
15. The scientific name of the fruit-fly is *Drosophila melanogaster*. Three reasons Morgan prefer to work with fruit-flies for his experiments are:
- Fruitfly have short life cycle of two weeks
 - Easy to grow in laboratory.
 - Single mating produce multiple progeny. [1+1]
16. Linkage is the phenomenon where two or more genes are so close to each other that they are inherited together whereas crossing over is the phenomenon where two or more genes get separated from each other during meiosis – I by exchange of chromosomal material. In *Drosophila*, yellow bodied white eyed female was crossed with brown bodies red eyed male, F₂ generation does not have Mendel 9:3:3:1 ratio as eye color and body color genes are closely present on the X chromosome and inherited together due to linkage. [1+1]
17. In dominance, one trait is completely dominant over other trait which is recessive trait whereas in co-dominance, both the traits are dominant no one is recessive trait. Incomplete dominance is the condition where trait is not completely dominant over the other trait. [3]
18. (a) In human gene 'I' control ABO blood groups. Gene 'I' consist of three allele :i, I^A, I^B, in which I^A, I^B are dominant over i. That is why human ABO blood group is an example of multiple alleles. [1]



As, I^A , I^B are both dominant over i . This pattern of inheritance is called as co-dominance. [1]

19. Three reasons for the delay in accepting his work are:

- (i) Mendel's concept of "gene" as discrete units were not accepted by the scientist of that time. [1]
- (ii) Lack of communication of Mendel's work to other part of the World. [1]
- (iii) As, Mendel explained all the biological inheritance pattern and concept with the help of Maths, this thing was not accepted by the scientist of that time. [1]

20. Women are not responsible for producing female children. Both girl and boy child should be equally important for the family. Women have 22 pairs of autosomes and one pair of sex chromosome. Human female have one pair of X chromosome. Human males have 22 pairs of autosomes and one pair of sex chromosome. Human male have one X chromosome and one Y chromosome. The sex of an individual is determined by the type of chromosome present in the child. If the children is carrying XX, then the child is female whereas if the children is carrying XY, then the child is male. As, Y chromosome is always given by male gamete, hence, Women should not be blamed for producing female children. [3]

21. Pedigree analysis done in the study of human genetics because it provides a method through which one can study the inheritance of a specific trait. Since central crosses are not possible in humans. So only way to find out the inheritance pattern is by studying existing families. As, some diseases are inherited from the parents, pedigree analysis is very important to find out such disease inheritance pattern. [1½]

- (i) It is used to find sex linked disorder. [½]
- (ii) It is used to find whether the trait is dominant or recessive. [½]
- (iii) It is used to find Mendelian pattern of inheritance. [½]

22. The cross which will help find the genotype of given pea plants is the Test cross. In this case purple flower (P) is dominant and

white (w) is recessive trait. In a test cross, the unknown dominant genotype is crossed with recessive parent. Test cross determines whether the dominant character is inherited from homozygous dominant genotype (PP) or heterozygous genotype (Pw). [½]

1. When an F_1 hybrid is crossed with its homozygous recessive parent. (Pw X ww).

	P	w
w	Pw	ww
w	Pw	ww

[1]

If the progeny obtained consist of 50% purple and 50% white means the purple flower is heterozygous.

2. Dominant purple is crossed with recessive white flower. (PP X ww).

	P	P
w	Pw	Pw
w	Pw	Pw

[1]

If all flower (100%) obtained are purple, it means the purple flower Plant is homozygous for dominant allele.

23. Pea plants with similar alleles are homozygotes. For tall plant (TT) and for dwarf plant (tt). Pea plant with dissimilar alleles are heterozygote (Tt) tall plant. The given condition is possible only when a heterozygous pea plant is crossed with dwarf pea plant. This cross can be represented as follows: [1]

	T	t
t	Tt	tt
t	Tt	tt

[1]

Tall plants (Tt) = 2 and Dwarf pea plants = 2. Hence tall and dwarf plant in equal ratio. [1]

24. Sickle cell anaemia is an autosomal recessive trait disease than can be transmitted from parents to the offspring when both the partners are carrier

for the gene. The disease is controlled by a single pair of allele which are Hb^A and Hb^S . Out of three possible genotypes only homozygous individuals ($Hb^S Hb^S$) show the diseased phenotype while heterozygous ($Hb^A Hb^S$) individuals are carrier of the disease. [2]

	Hb^A	Hb^B
Female gametes	Hb^A	Hb^B
Hb^A	$Hb^A Hb^A$ Normal	$Hb^A Hb^B$ Carrier
Hb^B	$Hb^A Hb^B$ Carrier	$Hb^B Hb^B$ Affected

[1]

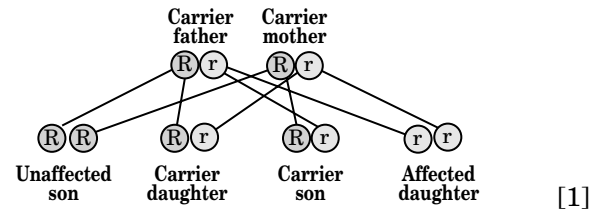
25. The genetic basis of blood grouping in human is done by codominance in which two genes expressed together for a particular character in F1 hybrid progeny. There is no blending of characters. In humans blood is ABO type. Blood groups are determined by gene called 'I'. It has three alleles, namely I^A , I^B and i . I^A and I^B are dominant alleles and i is recessive allele. Then the possible phenotypes are: A, B, AB, and O. [2]
Table Showing the Genetic Basis of Blood Grouping in Human Population:

Blood group	Antigen(s) present on the red blood cells	Anti-body(s) in the serum	Genotype (s)
A	A antigen	Anti-B	$I^A I^A$ or $I^A i$
B	B antigen	Anti-A	$I^B I^B$ or $I^B i$
AB	A antigen and B antigen	None	$I^A I^B$
O	None	Anti-A and Anti-B	ii

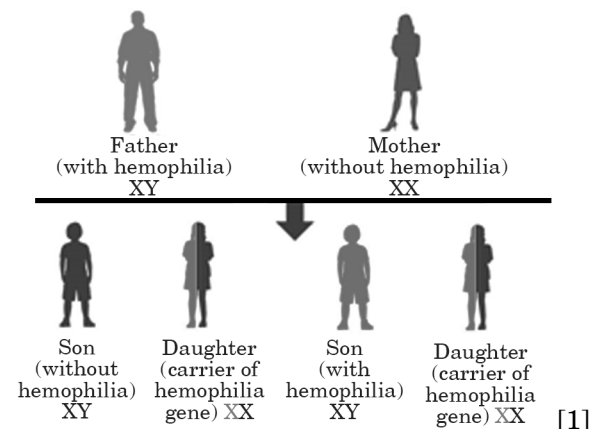
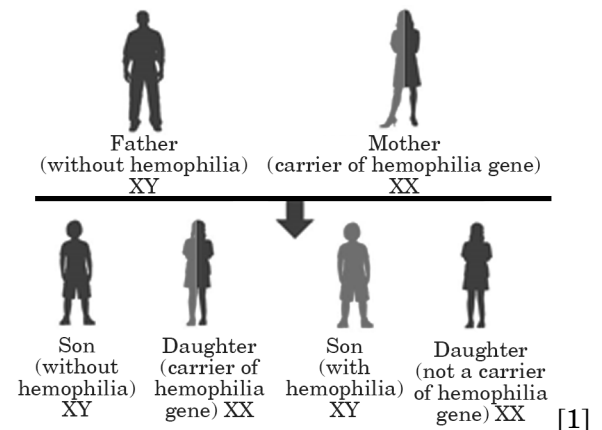
[1+1+1]

26. (a) Thalassaemia and haemophilia are Mendelian disorders which is caused by alteration or mutation in the single gene. Their transmission to the offspring follows the principle of inheritance. Thalassaemia is an autosomal linked recessive blood disorder characterised by defect in α or β chain of haemoglobin resulting in abnormal haemoglobin molecule. Symptoms of thalassaemia are anaemia, jaundice, cardiac enlargement and skeletal deformities. Haemophilia is a sex-linked recessive disorder and the recessive gene present on X-chromosome. Symptoms include symptoms includes increased clotting time, non stop bleeding, non-stop bleeding on a minor cut or injury. [1]

Inheritance pattern of thalassaemia: It is an autosomal, recessively inherited blood disorder. It can be transmitted to the offspring when both parents are heterozygous.



Inheritance pattern of haemophilia: This is a sex-linked recessive disease. Gene is present on the X-chromosome. It shows criss-cross inheritance. The carrier female transmit the disease to sons. The haemophilic father transmits the haemophilic gene to daughter. But the possibility of a female becoming a haemophilic is extremely rare.



- (b) The genotype of the parents producing a haemophilic son should be a carrier mother ($X^h X$) and normal father (XY) for haemophilic gene. [1]

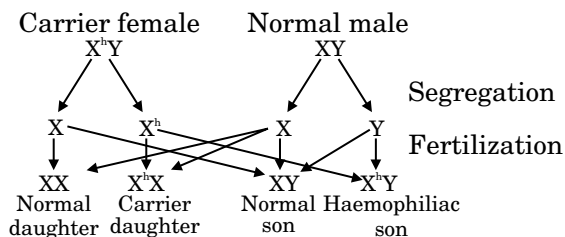
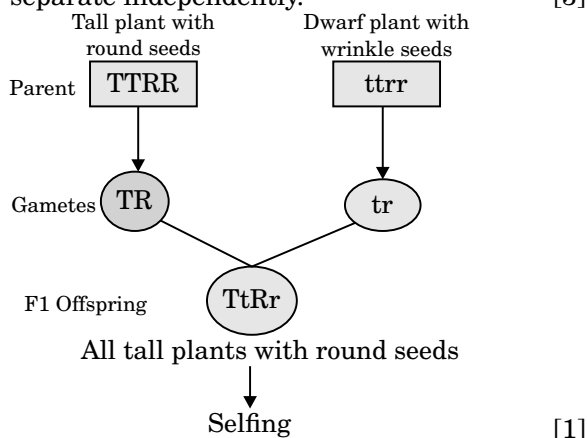


Fig.: Haemophilic son of normal parents

27. Mendel's law of independent assortment states that allele pairs separate independently during the gamete formation. This means that traits are transmitted to offspring independently of one another. Alleles do not mix or blend. A typical dihybrid cross between tall plant with round seeds (TTRR) and dwarf plant with wrinkled seeds (ttrr). Tall plant with round seeds is dominant over dwarf plant with wrinkle seeds. In F2 generation four types of phenotypes are formed. Tall plant with round seeds, tall plants with wrinkled seeds, dwarf plants with round seeds and dwarf plants with wrinkled seeds in the ratio 9:3:3:1 respectively. Appearance of tall plants with wrinkled seeds and dwarf plants with round seeds proves that allele pairs separate independently. [3]



		Male gametes			
Female gametes		TR	Tr	tR	tr
TR	TTRR Talk round	TTRr Talk round	TtRr Talk round	TtRr Talk round	
Tr	TTRr Talk round	TTrr Talk wrinkled	TtRr Talk round	Ttrr Talk wrinkled	
tR	TtRR Talk round	TtRr Talk round	ttRR Dwarf round	ttRr Dwarf round	
tr	TtRr Talk round	Ttrr Talk wrinkled	ttRr Dwarf round	ttrr Dwarf wrinkled	

Phenotypes plants:
Tall round : Tall wrinkle : Dwarf Round : Dwarf wrinkle
9 : 3 : 3 : 1

28. (a) Thomas Hunt Morgan and his colleagues worked on *Drosophila*, a fruit fly. The scientific name is *Drosophila melanogaster*. Morgan did several experiments on *Drosophila* to study the sex-linked genes. In one such experiment, he crossed yellow-bodied, white-eyed flies with brown-bodied, red-eyed ones. The resultant F2 ratio he got was the deviation from the typical Mendelian dihybrid ratio of 9:3:3:1. From the result Morgan suggested that this was due to the phenomenon called linkage. He found that the genes for both characters were present on the X- chromosome. When two genes are present close to each other on the same chromosome, then they tend to get inherited together. The chances of formation of new recombination are very less. Morgan named this phenomenon 'linkage'. Thus, it can be stated that higher the linkage between two genes, lesser are the chances of recombination [3]
- (b) Alfred Sturtevant was the student of Morgan. He studied The frequency of recombination between gene pairs on the same chromosome and used it as a measurement of the distance between genes and 'mapped' their position on the chromosome. Today genetic maps are extensively used as a starting point in the sequencing of whole genomes. [2]
29. In human gene 'I' control ABO blood groups in humans. Gene 'I' consists of three allele :i, I^AI^B, in which I^A and I^B are dominant over i. At the same time, I^A, I^B are co-dominant means both expressed in the presence of each other. If the genotype of the person is I^AI^B, then the blood group of the off spring will be AB, If the genotype of the person is I^AI^A, then the blood group of the off spring will be A, If the genotype of the person is I^BI^B then the blood group of the off spring will be B, If the genotype of the person is ii, then the blood group of the off spring will be O. [5]

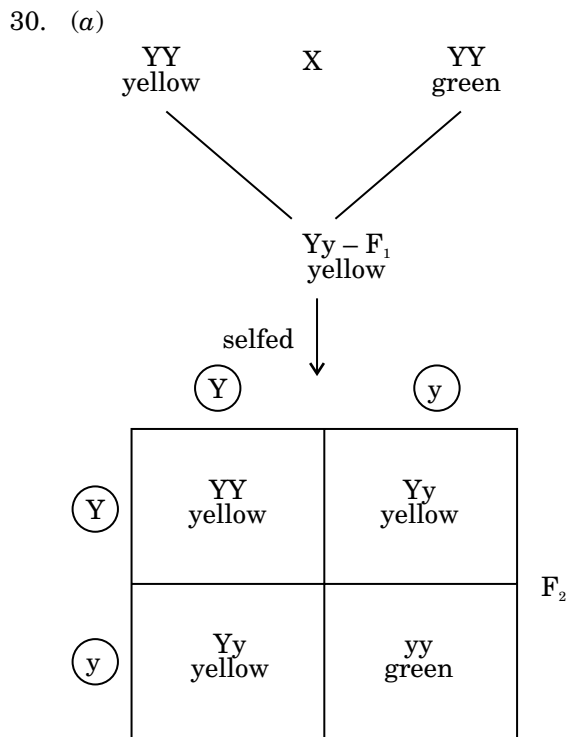


Fig.: Monohybrid cross [3]

- (b) Law of dominance and law of segregation can be derived from such a cross. [1]
- (c) Phenotypic ratio of monohybrid cross is 3 : 1. Dihybrid cross the phenotypic ratio is 9 : 3 : 3 : 1. [1]

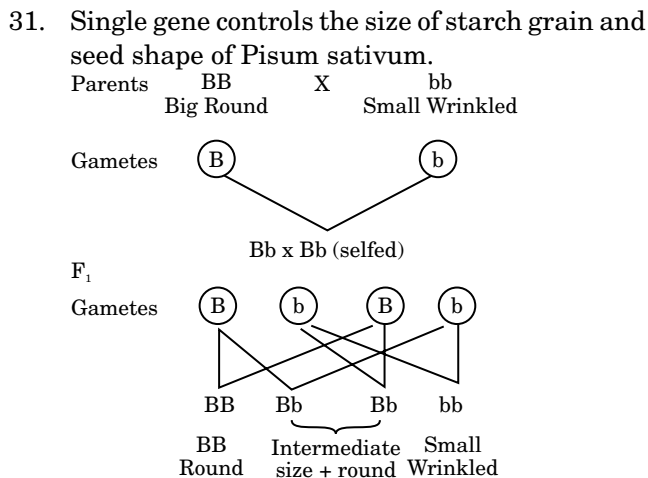


Fig.: Monohybrid cross between *Pisum sativum* starch grains [3]
In this monohybrid cross, we can see trait of seed size is not following Mendel law as Bb is coding for intermediate trait. As, the cross is not following Mendel's law of dominance, where one trait is completely dominant over the recessive trait. [2]

32. (a) In human gene 'I' control ABO blood groups in humans. Gene 'I' consist of three allele :i, I^A, I^B, in which I^A, I^B are dominant over i.[2]
- (b) (i) As, I^A is dominant over i, the blood of this person would be A [2]
- (ii) As, ii is present, this individual will have O blood group. [3]

[Topic 2] Sex-Determination and Genetic Disorders

Summary

Sex Determination

The genes which were linked to sexes named as sex-linked genes. It was found out that both the sexes have a set of common chromosomes and a set of different chromosomes. The different chromosomes were called the sex chromosomes and the other set as autosomes. In many insects mammals (including man) XY type of sex determination is observed in which both the sexes carry same number of chromosomes.

Sex Determination in Humans

- There are total 23 pairs of chromosomes in humans and 22 of them are exactly same and known as autosomes. In females, a pair of X chromosomes is present while XY in male. Two types of gametes or sperms are produced by male during spermatogenesis.

- 50% of them carry X chromosome while the other 50% carry Y chromosome. In female, only one kind of gamete or ovum carrying X chromosome only is produced.
- If the sperm which carry X chromosome fertilizes the egg, then the sex of the baby is female while if the one carrying Y chromosome fertilizes the egg, the sex of the baby is male.

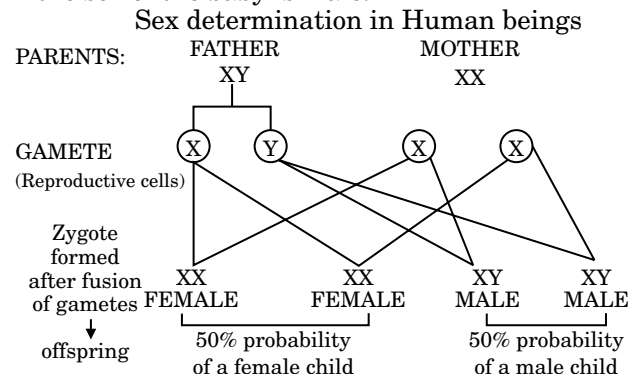


Fig.: Sex determination in human beings

Sex Determination in honey-bee (Haplodiploid sex-determination system)

- The males possess half the number of chromosomes than that of a female. The females are diploid having 32 chromosomes and males are haploid having 16 chromosomes.
- The sex determination in a honey bee is based on the number of sets an individual gets.
- A female is developed when there is a union of a sperm and an egg.
- A male is formed by parthenogenesis from an unfertilized egg.

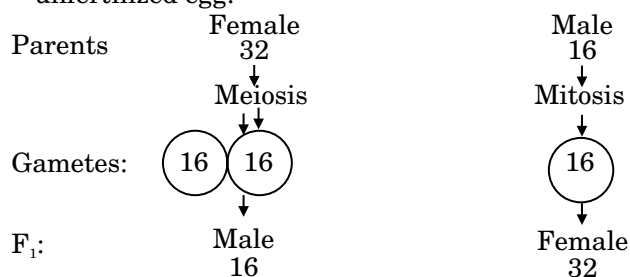


Fig.: Haplodiploid sex determination system

Mutation: A change in the genetic material is known as mutation. The result of this phenomenon is that it alters the DNA sequence and thus the change in the genotype and phenotype of an organism. If the mutation is due to the change in single base pair of DNA, then it is called the point mutation.

Genetic Disorders: Genetic disorders may be grouped into Mendelian disorders and Chromosomal disorders.

- **Pedigree Analysis:** The attribute analysis in a several of generations of a family is known as pedigree analysis. In this analysis, family tree over generations represents the inheritance of particular trait. It is useful in tracing the inheritance of a particular trait, disease and abnormality.
- **Mendelian Disorders:** Alteration in a single gene is responsible for Mendelian disorders. Through the Mendelian principles of inheritance, these are transmitted into generations. Their nature may be either dominant or recessive. Color blindness and phenylketonuria are the examples of Mendelian disorders. It also includes haemophilia (sex linked recessive disease), sickle cell anemia (an autosome linked recessive trait) and phenylketonuria (an inborn error of metabolism inherited as autosomal recessive trait).
- **Haemophilia:** In this, a single protein that is a part of the cascade of proteins involved in the clotting of blood is affected which results in nonstop bleeding in case of a simple cut.

- **Sickle-cell anaemia:** It is a recessive trait that can be transmitted from parents to the offspring when both the partners are carrier for the gene
- **Phenylketonuria:** In this, the affected individual lacks an enzyme responsible for converting amino acid phenylalanine into tyrosine.
- **Thalassemia:** It is an autosome linked recessive blood disease inherited by the offspring when both the parents are unaffected carrier for the gene. The defect is due to deletion or mutation. Abnormal haemoglobin is formed which results into anaemia.
- **Color blindness:** The defect is due to mutation in certain genes present in the X chromosome. It is a sex-linked recessive disorder which is due to defect in either red or green cone of eye resulting in failure to discriminate between red and green color.
- **Chromosomal Disorders:** The absence or excess of one or more than one chromosomes or their abnormal arrangement is the cause of this disorder. They are transmitted as the affected individual is sterile. Their nature is always dominant. The loss or gain of chromosome due to the failure of segregation of chromatids during cell division is known as aneuploidy. Two sets of chromosome called polyploidy are led due to the failure of cytokinesis.

Down's syndrome, Klinefelter's syndrome and Turner's syndrome are examples of chromosomal disorders.

- **Down syndrome:** The retardation in mental development is the result of Down's syndrome. The presence of additional copy of the chromosome number 21 is the cause of it.
- **Klinefelter's syndrome:** The reason of Klinefelter's syndrome is the presence of an additional copy of X-chromosome. Persons affected from it are sterile.
- **Turner's syndrome:** The person's having Turner's syndrome lack secondary sexual characters. The absence of one of the X chromosome is the cause of Turner's syndrome.

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 2

▣ 1 Mark Questions

1. Indiscriminate diagnostic practices using X-rays etc., should be avoided. Give one reason.

[DELHI 2015]

2 Marks Questions

2. Write the types of sex-determination mechanisms the following crosses show? Give an example of each
- (i) Female XX with Male XO
(ii) Female ZW with Male ZZ [DELHI 2014]

3 Marks Questions

3. Why are human females rarely haemophilic? Explain. How do haemophilic patients suffer? [ALL INDIA 2013]
4. A colour blind child is born to a normal couple. Work out a cross to show how it is possible. Mention the sex of this child. [DELHI 2014]
5. Explain the mechanism of 'sex determination' in birds. How does it differ from that of human beings? [DELHI 2018]

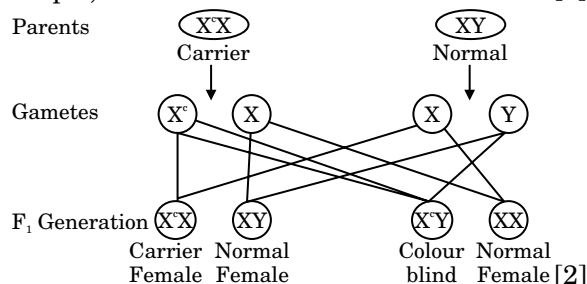
5 Marks Questions

6. A child suffering from Thalassaemia is born to be a normal couple. But the mother is being blamed by the family for delivering a sick baby.
- (a) What is Thalassaemia?
(b) How would you counsel the family not to blame the mother for delivering a child suffering from this disease? Explain.
(c) List the values your counselling can propagate in the families. [DELHI 2013]
7. (a) Explain the mechanism of sex-determination in humans.
(b) Differentiate between male heterogamety and female heterogamety with the help of an example of each. [ALL INDIA 2013]
8. Why is haemophilia generally observed in human males? Explain the conditions under which a human female can be haemophilic. [ALL INDIA 2011]

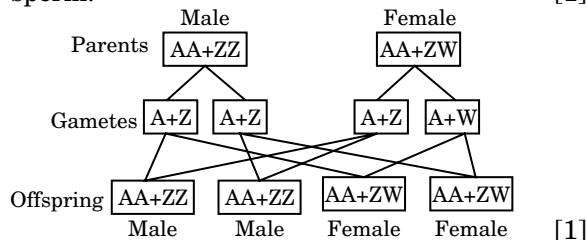
Solutions

1. X-rays are electromagnetic radiations that may cause mutation. The mutations can alter the genetic make-up of an organisation. Therefore, indiscriminate use of X-rays should be avoided. [1]
2. (i) Female XX with Male XO: this is the sex determination found in grasshopper and known as heterogamety as females have two pairs of X chromosome and male have only one X chromosome. [1]
- (ii) Female ZW with Male ZZ: this is the sex determination found in birds and known as heterogamety as female have one Z chromosome and one W chromosome and male have two pairs of Z chromosome. [1]

3. Female as have two X chromosomes, so it is very unlikely that mutation takes place in both the alleles on both X chromosome. i.e., this is controlled by repressive genes. Hence it has to be homozygous for its expression. Hence, human females rarely haemophilic. The individuals suffering from this disorder face the problem of blood clotting and coagulation. [3]
4. Color blindness is a sex linked disorder. The gene for this disease is present on X chromosome. Hence, if a colour blind child is born to a normal couple, then the mother should be a carrier. [1]



5. The sex chromosomes in birds are denoted as Z and W. In birds, males are homogametic having a pair of ZZ chromosomes besides autosomes (AA). Whereas female birds are heterogametic. One Z chromosome and one W chromosome besides autosomes. Therefore, in case of birds, the sex is determined by the egg and not by the sperm. [1]



In humans, sex are determined by XX and XY chromosomes. Males are heterogametic having X and Y sex chromosomes and females are homogametic having XX sex chromosomes. Therefore, sex in humans is determined by sperm unlike as in birds. [1]

6. (a) Thalassaemia occurs due to the gene deletion responsible for the formation of alpha and beta chain of hemoglobin. It is an autosomal recessive disorder. [2]
- (b) The mother is blamed for delivering a child suffering from this disease, should not be so blamed because as Thalassaemia is a autosomal recessive disorder, and the gene responsible for the formation of alpha nad beta chain of hemoglobin is not present on the sex chromosome. [2]

- (c) Values propagated are awareness, respect towards women and deeper understanding of Biology. [1]
7. (a) Women have 22 pairs of autosomes and one pair of sex chromosome. Human female have one pair of X chromosome. Human males have 22 pairs of autosomes and one pair of sex chromosome. Human males have one X chromosome and one Y chromosome. The sex of an individual is determined by the type of chromosome present in the child. If the child is carrying XX, then the child is female whereas if the child is carrying XY, then the child is male. As, Y chromosome is always given by male gamete. [3]
- (b) There are two types of sex determining mechanisms, i.e., XO type and XY type. In both mechanism, males produce two gametes, (a) either with or without X-chromosome or (b) some gametes with X-chromosome and some with Y-chromosome. Such types of sex determination is called as male heterogamety. In other mechanism, of sex determination the total number of chromosome is same in both males and females. But two different types of gametes in terms of the sex chromosomes, are produced by females, i.e., female heterogamety (ZW). In these organisms the females have one Z and one W chromosome, whereas males have a pair of Z-chromosomes besides the autosomes. [2]
8. Haemophilia is a defect of the blood that prevent it from the clotting. The affected person bleed excessively at the time of injury. Haemophilia is generally observed in human males because it is a sex linked recessive disorder as it is caused due to the presence of recessive gene on X chromosome. Man has one X chromosome. The gene responsible for causing haemophilia, being located on X chromosome, produces this defect because there is no homologue of this gene on the Y chromosome to check its expression. Women have 2 X chromosome. Hence, for human females to be haemophilic, it is required that both X chromosomes have a gene for haemophilia. [5]

CHAPTER 6

Molecular Basis of Inheritance

Chapter Analysis with respect to Last 3 Years' Board Exams

List of Topics	2016		2017		2018
	Delhi	All India	Delhi	All India	Delhi/All India
Search for genetic material and DNA as genetic material		1Q (5 marks),			
Structure of DNA and RNA; DNA packaging, DNA replication	1Q (2 marks), 1Q (3 marks)	1Q (2 marks), 1Q (5 marks),	1Q (2 marks)	1Q (5 marks)	1Q (1 marks)
Central dogma, Transcription, genetic code, translation	1Q (3 marks)		1Q (2 marks)		1Q (2 marks)
Gene expression and regulation - Lac Operon	1Q (3 marks)			1Q (5 marks)	
Genome and human ganeome project, DNA fingerprinting				1Q (5 marks)	1Q (3 marks)

On the basis of above analysis, it can he said that from exam point of view the concepts DNA Fingerprinting, Genetic Code, Human Genome Project , Transcription, Recombinant DNA Technology are most important concepts of the chapter.

[Topic 1] The DNA & RNA World

Summary

There are two types of nucleic acids found in living organisms, DNA (Deoxyribonucleic acid) and RNA (Ribonucleic acid). They are the building blocks of genetic material. Apart from some viruses, whose RNA is the genetic material; mostly DNA is the genetic material in all the organisms. RNA functions as a messenger.

DNA

Deoxyribonucleic acid also called as DNA is a long polymer of deoxyribonucleotides. The number of nucleotides define the length of DNA.

• Structure of Polynucleotide Chain:

- Polymers of nucleotides are called as Polynucleotides. DNA and RNA are polynucleotides.
- Nucleotide comprises of – a nitrogenous base, a pentose sugar (ribose in RNA, and deoxyribose in DNA) and a phosphate group.
- Types of nitrogenous bases are- Purines and pyrimidines.
- Purine comprises of Adenine (A) and Guanine (G). Cytosine (C), Thymine (T) and Uracil (U) comprise Pyrimidine.
- N- glycosidic linkage links pentose sugar to a nitrogenous base to form a nucleoside.
- Nucleosides in RNA-Adenosine, Guanosine, Cytidine and Uridine. Nucleosides in DNA-Deoxyadenosine, Deoxyguanosine, Deoxycytidine and Deoxythymidine.
- Nucleoside along with phosphate group, which gets attached at 5'-OH, forms corresponding Nucleotide.
- 3'-5' Phosphodiester bond links two nucleotides and forms dinucleotide. Similarly other nucleotides can be joined to form polynucleotide chain.

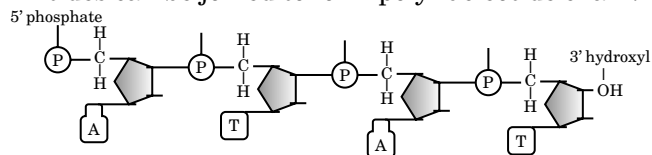


Fig.: 5' phosphate

• Structure of DNA:

- DNA was identified in 1869 by Friedrich Meischer who called it "Nuclein".
- On the basis of X-ray diffraction data given by Maurice Wilkins and Rosalind Franklin, the

structure of DNA given by James Watson and Francis Crick. In the model two polynucleotide chains are coiled together in a right-handed fashion. The model is known as Double Helix model.

- Links of sugar and phosphate together acts like a backbone.
- Hydrogen bonds between Adenine (A) and Thymine (T) & Guanine (G) and Cytosine (C) keeps the two strands together.
- A and T are linked by two hydrogen bonds ($A = T$) whereas G and C are linked by three hydrogen bonds ($G \equiv C$).
- One chain has polarity of $5' \rightarrow 3'$ and the other chain has polarity of $3' \rightarrow 5'$ which means the two chains have anti-parallel polarity.

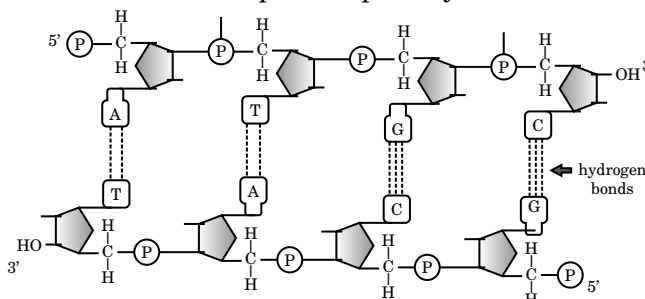


Fig.: Double stranded polynucleotide chain

- There are approximately 10 base pairs in each turn and the pitch of the helix is 3.4 nm. So, the distance between a base pair is approximately 0.34 nm.
- The ratio of Adenine-Thymine & Guanine-Cytosine is constant for a given species.
- **Packaging of DNA Helix:**
- As DNA is negatively charged, so it is held in region called 'nucleoid' with some proteins which are positively charged, in prokaryotes, like E. coli.
- In eukaryotes, the positively charged protein is basic in nature and is called as Histones. It is rich in amino acid residues, lysines and arginines. They both carry positive charge in their side chains.
- Histone octamer is a complex formed when histones organize to form a unit of eight molecules.
- The structure formed when a negatively charged DNA is wrapped around histone octamer is called nucleosome.

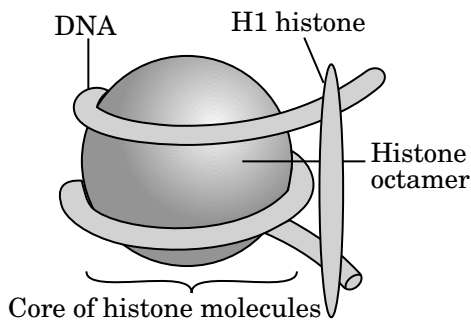


Fig.: Nucleosome

• **Nucleosome:**

- A nucleosome comprises of generally 200 bp.
- It constitutes the repeating unit to form a structure called Chromatin.
- Chromatins are packaged to form chromatin fibers which are further coiled and condensed to form chromosome at metaphase.
- Types of chromatins in nucleus- Euchromatin and Heterochromatin.

Euchromatins are transcriptionally active part of chromatin which are loosely packed. Whereas, heterochromatin is inactive part of chromatin and are densely packed.

The Search for Genetic Material

• **Transforming principle:**

- In 1928, Frederick Griffith used *Streptococcus pneumoniae* and mice for his experiment.
- *Streptococcus pneumoniae* bacteria were allowed to grow on a culture plate. Some of them produced rough colonies (R) while others produced smooth shiny colonies (S). This is because the S strain bacteria has a polysaccharide mucous coating whereas R strain does not have the coating.
- When S strain was injected into mice, it died. Whereas when R strain was injected in mice, it survived.
- When heat killed S-strain was injected into mice, it survived. However, when heat killed S-strain along with R- strain was injected into mice, it died.
- The conclusion made from this experiment was that, that some transforming principle' got transferred to R-strain from the heat-killed S strain. This might have enabled synthesise of smooth polysaccharide coat in the R strain and made them virulent. This must be due to the transfer of the genetic material.

• **Biochemical Characterization of transforming principle:**

- The biochemical nature of 'transforming principle' in Griffith's experiment was given by Colin MacLeod, Maclyn McCarty and Oswald Avery.
- They used suitable enzymes to purify the

biochemicals, such as proteins, DNA, RNA etc. from the heat killed S cells.

- The discovery made from their experiment involved that:

- Proteins and RNA were digested using proteases and RNases, but this did not affect transformation. They inferred that transforming substance was not a protein or RNA.
- DNA was digested with help of DNases and this inhibited transformation. From this they concluded that DNA was the reason behind transformation of R-cells to S-cells.

- Hence, DNA was considered the 'transforming principle'.

• **The Hershey-Chase Experiment:**

- Experiment done by Alfred Hershey and Martha Chase in 1952 with bacteriophages, also proved that DNA is the genetic material.
- Some viruses were allowed to grow on a medium that contained radioactive phosphorus (P-32) and some others on medium that contained radioactive sulphur (S-35).
- E. coli bacteria were infected which radioactive phages, after which the cells were agitated gently and then the culture was centrifuged to separate virus particles from bacteria.

- It was found that:

- Bacteria infected with viruses that had radioactive DNA were radioactive, showing that DNA was the genetic material that passed from the virus to the bacteria.
 - Bacteria infected with viruses that had radioactive proteins were not radioactive.
- They concluded that DNA is the genetic material.

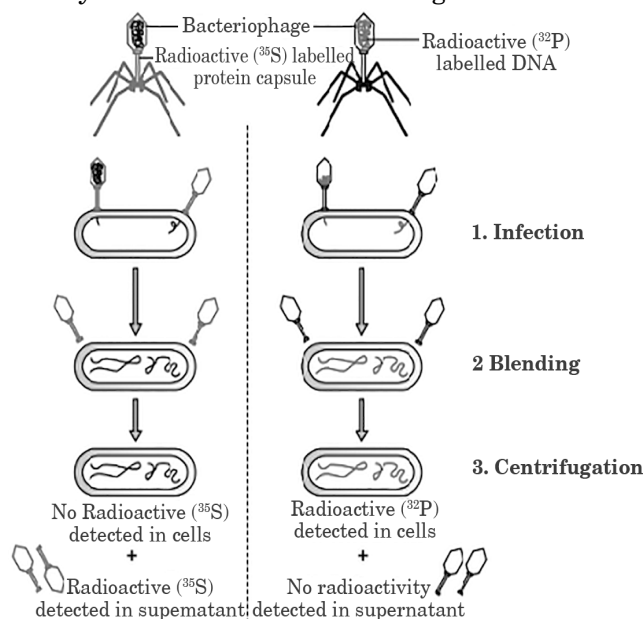


Fig.: The Hershey-Chase Experiment

- **Properties of Genetic Material:**

A molecule needs to possess following characteristics to be a genetic material-

- The molecule should be stable, structurally as well as chemically.
- There should be scope of slow changes which result in mutation which is essential for evolution.
- It should be able to replicate itself and create its replica by the process of Replication.
- It should possess the property to express itself as 'Mendelian Characters'.

- **DNA v/s RNA**

DNA	RNA
Chemically less reactive.	Chemically more reactive.
Structurally more stable.	Structurally less stable.
Less prone to mutation.	Prone to mutation.
Better for storage of genetic material.	Not good for storage due to instability.
Not suitable for transmission of genetic material.	Better for transmission of genetic material.
Depends on RNA for protein synthesis.	Can directly code for protein synthesis.
Double stranded.	Single stranded.

RNA

RNA or ribonucleic acid is a single stranded structure which is folded back upon itself forming helices. Nitrogenous bases of RNA are same as DNA except that it has uracil in place of thymine. It acts as genetic material for various viruses. RNA was the genetic material in early life forms after which it went into chemical modifications and evolved into DNA.

DNA Replication

It is the process of copying of DNA from the parent DNA. Watson and Crick proposed semi-conservative model of DNA replication. The model suggests the separation of two strands would and synthesis the new complementary strands by acting as a template. Once the replication is completed, each DNA molecule is left with one newly synthesized and one parental strand each. This scheme was termed as semi-conservative DNA replication.

- **The Experimental Proof:**

- In 1958, Matthew Meselson and Franklin Stahl performed an experiment to show that DNA replicates semi conservatively.
- *E. Coli* was grown in medium containing $^{15}\text{NH}_4\text{Cl}$

which resulted in ^{15}N being incorporated into newly synthesized DNA and made it heavier. Then the cells were transferred into a medium with $^{14}\text{NH}_4\text{Cl}$, which also got incorporated in both strands of DNA which made it lighter.

- The samples were studied at different time intervals. After 20 minutes when ^{15}N had transferred to ^{14}N , the sample was isolated and centrifuged. Its density came out to be intermediate between ^{14}N DNA and ^{15}N DNA.
- In the next generation, i.e. after 40 minutes, the DNA extract was composed of equal amount of hybrid DNA and of 'light' DNA.

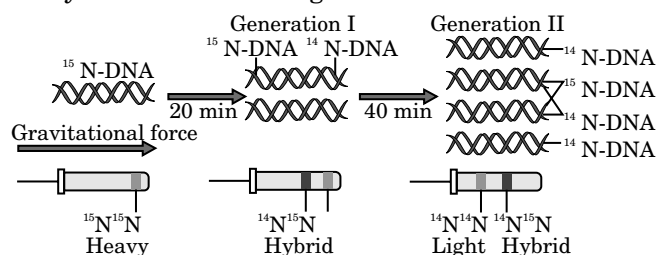


Fig.: Separation of DNA by Centrifugation

- **The Machinery and the Enzymes for replication:**

- DNA replication begins at a point called origin. In this process both the strands unwind and *Helicase* enzyme break hydrogen bond between both the strands. The structure formed by breaking of bond and unwinding of strand is called as 'replication fork'.
- The process of DNA replication can be done only in $5' \rightarrow 3'$ direction. In presence of enzyme *primase*, a small RNA primer is synthesized and then in presence of *DNA Polymerase* nucleotides join with one another to primer strand and result in polynucleotide chain.
- The replication is continuous on strand in which the template had polarity of $3' \rightarrow 5'$ whereas it is discontinuous over $5' \rightarrow 3'$. *DNA ligase* helps in joining the discontinuous fragments.

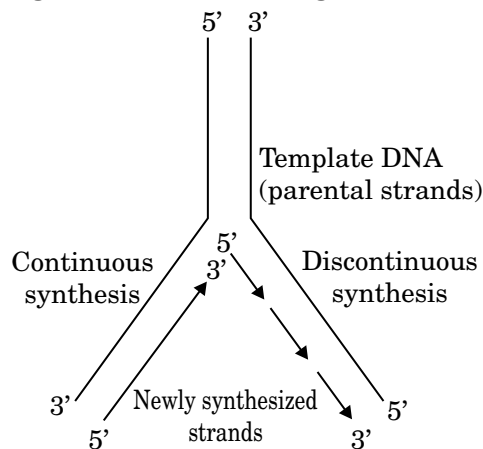


Fig.: Replicating Fork

Transcription

Transcription refers to the process of duplicating the genetic data from one strand of the DNA into RNA. Here also, the principle of complementarity governs the process of transcription, except the adenosine now forms base pair with uracil instead of thymine.

• Transcription Unit:

There are three main regions in a transcription unit in DNA, which are as follows:

- In a transcription unit, the promoter and terminator are found along with structural gene.
- The promoter is said to be located towards 5' –end (upstream) of the structural gene (the reference is made with respect to the polarity of coding strand).
- A DNA sequence helps in providing the binding site for RNA polymerase, and the template and coding strands are defined by the presence of a promoter.
- The explanation of coding and template strands can be switched by changing the position with terminator.
- The terminator defines the end of the process of transcription.

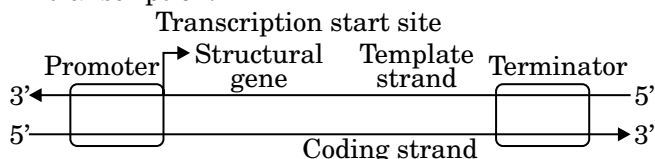


Fig.: Schematic structure of a transcription unit

• Gene and the Transcription Unit:

- A gene is considered as the functional unit of inheritance. Genes can also be called as DNA sequence coding for tRNA or rRNA molecules.
- Segment of DNA which codes for a polypeptide is called as cistron. There are two types of the structural gene in a transcription unit:
 - Monocistronic: It is found in eukaryotes, where the coding sequence or exons are split and are interrupted by introns, the intervening sequence
 - Polycistronic: It is found in bacteria or prokaryotes, where there's no split genes.

• Types of RNA:

- Bacteria have three types of RNAs: mRNA, tRNA and rRNA also known as messenger, transfer and ribosomal RNAs respectively.
- They are required for synthesizing a protein in a cell.
- The mRNA provides the template, tRNA brings amino acids and reads the genetic code, and rRNAs play structural and catalytic role during translation.

• Process of transcription:

- The first phase is initiation where RNA polymerase holds on to promoter and starts transcription.

- RNA polymerase follows the rule of complementarity where it uses nucleoside triphosphates as substrate and it is then polymerized into a template.
- It also helps helix to open up and keep on elongating.
- Enzyme is bound to a small part of RNA. Now the polymerase reaches the terminator region.
- The last phase is termination of transcription where the nascent RNA lowers down.

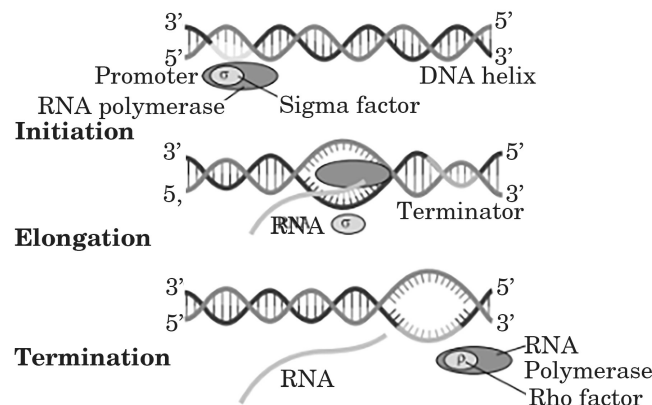


Fig.: Process of Transcription in Bacteria

• Complexities in Eukaryotes:

- There exist non-functional exons and introns in the primary transcripts. Now, the exons are arranged in a set order and the introns are removed and this process is known as splicing. hnRNA goes through a process known as capping where an unusual nucleotide is added to 5' end of hnRNA. It goes through another process called tailing in which adenylate residues (200-300) are added at 3'- end.
- There exist three RNA polymerases in the nucleus. The RNA polymerase I, II and III transcribes rRNAs, precursor of mRNA and tRNA, 5S rRNA, and snRNAs, respectively.

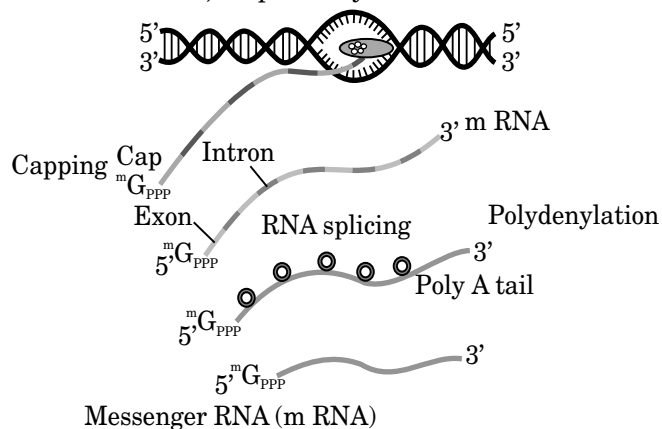


Fig.: Process of transcription in Eukaryotes

- (a) Is this representation indicating a normal human or a sufferer from certain genetic disease? Give reason in support of your answer.
- (b) What difference would be noticed in the phenotype of the normal and the sufferer related to this gene?
- (c) Who are likely to suffer more from the defect related to the gene represented - the males, the females or both males and females equally? And why?
25. Write the full form of VNTR. How is VNTR different from “probe”? **[DELHI 2015]**

5 Marks Questions

26. Describe Frederick Griffith's experiment on *Streptococcus pneumoniae*. Discuss the conclusion he arrived at. **[DELHI 2012]**
27. (a) Write the conclusion drawn by Griffith at the end of his experiment with *Streptococcus pneumoniae*.
- (b) How did O. Avery, C. MacLeod and M. McCarty prove that DNA was the genetic material? Explain **[ALL INDIA 2013]**
28. (a) Explain the process of DNA replication with the help of schematic diagram.
- (b) In which phase of the cell cycle DNA replication occur in Eukaryotes. What would not happen if cell division is not followed after DNA replication? **[DELHI 2014]**
29. (a) Describe the various steps of Griffith's experiment that led to the conclusion of the 'Transforming Principle'.
- (b) How did the chemical nature of the 'Transforming Principle' get established? **[DELHI 2014]**
30. Describe how the lac operon operates, both in the presence and absence of an inducer in *E. coli*. **[DELHI 2014]**
31. How did Hershey and Chase established that DNA is transferred from virus to bacteria? **[DELHI 2015]**
32. How do m-RNA, t-RNA and ribosomes help in the process of translation? **[ALL INDIA 2015]**
33. (a) How are the following formed and involved in DNA packaging in a nucleus of a cell?
- Histone octamer
 - Nucleosome
 - Chromatin
- (b) Differentiate between Euchromatin and Heterochromatin. **[DELHI 2016]**
34. Explain the role of lactose as an inducer in a lac operon. **[DELHI 2016]**

35. Describe Meselson and Stahl's experiment that was carried in 1958 on *E. coli*. Write the conclusion they arrived at after the experiment. **[ALL INDIA 2016]**
36. (a) Describe the process of transcription in bacteria.
- (b) Explain the processing the hnRNA needs to undergo before becoming functional mRNA in eukaryotes. **[ALL INDIA 2016]**
37. (a) Describe the structure and function of a t-RNA molecule. Why is it referred to as an adapter molecule?
- (b) Explain the process of splicing of hn-RNA in a eukaryotic cell. **[ALL INDIA 2017]**
38. Write the different components of a lac-operon in *E. coli*. Explain its expression while in an 'open' state. **[ALL INDIA 2017]**



Solutions

- The region of a chromatin which is active for transcription is euchromatin. [1]
- Retroviruses have RNA as genetic material. Virus attacks the macrophage cells of the host body where the RNA of the virus reverse transcribes to form viral DNA with the help of the reverse transcriptase enzyme. [1]
- Deoxyribonucleoside triphosphates serve dual purposes. they act as substrate. They provide energy for polymerisation reaction. [1]
- AUG code for methionine that is the starting codon for protein synthesis from RNA whereas UGA is the termination codon for protein synthesis. [1]
- The enzyme is DNA polymerase which is DNA dependent. The property unique is that it catalyses the polymerisation in one direction which is 5'→3'. Hence, this leads to the replication of DNA in leading strand as continuous and lagging strand is discontinuous. [1]
- Transposon have the ability to jump from one location to another in a genome that helps in gene silencing. [1]
- As, histones mainly consist of positively charged amino acids like lysine, arginine, hence in this way histones acquire positive charge. [2]
- (a)

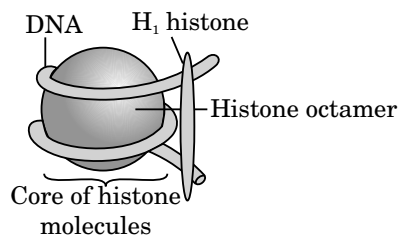


Fig.: Labelled diagram of a nucleosome [1]

(b) As, histones mainly consist of positively charged amino acids like lysine, arginine, hence in this way histones acquire positive charge. [1]

9. [2]

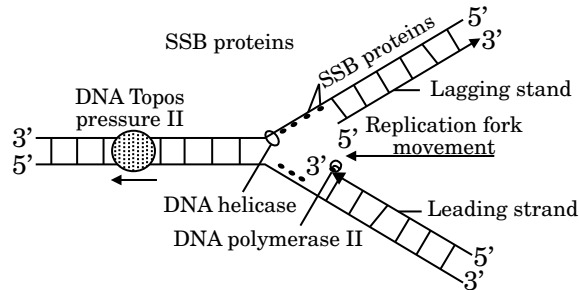


Fig.: Neat labelled sketch of a replicating fork of DNA

10. (i) George Gamow is the name of the scientist who suggested that the genetic code should be made of a combination of the three nucleotides. [1]

(ii) According to him, if the codons consist of three amino acids, then only they would be able to code for 20 amino acids. [1]

11. Role of DNA ligase during DNA replication:

(i) The enzyme DNA ligase joins or seals discontinuous DNA fragments. [1]

(ii) DNA ligase adds on nucleotide in the usual 5' to 3' direction along the DNA strand. [1]

12. Stop codon: the codon which does not code for any amino acid, examples are UAA, UAG and UGA. These codons terminate the synthesis of polypeptide chain. Unambiguous codon: one codon codes for only one amino acid. Degenerative codon: some amino acids are coded by more than one codon. [1]

Universal codon – the same genetic code codes for same amino acid across all living organisms whether it is humans or bacteria. [1]

13. The negatively charged DNA is wrapped around positively charged histone octamer to form a structure called nucleosome. A typical nucleosome consist of 200 bp of DNA helix. It consist four type of proteins which occurs in pairs: H₂A, H₂B, H₃ and H₄ [1]

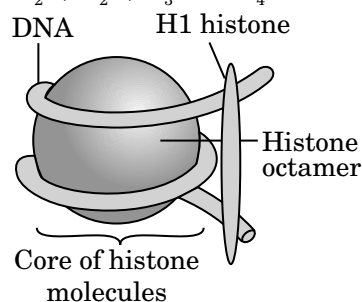


Fig.: Nucleosome

[1]

14. (a) Unambiguous and Universal
Unambiguous: The code is specific. It means one codon codes for only one amino acid.

Universal: The code which codes a particular amino acid is same in all organisms. [1]

(b) Degenerate and Initiator:

Degenerate: when an amino acid is coded by more than one codon, it is said to be degenerate.

Initiator: AUG is an initiator codon which codes for the amino acid methionine. This initiates the translation process. [1]

15. In prokaryotes, such as, E. coli, though they do not have a defined nucleus, the DNA is not scattered throughout the cell. The nucleus is called incipient nucleus in which DNA (being negatively charged) is held with some proteins (that have positive charges) in a region termed as 'nucleoid'. The DNA in nucleoid is organised in large loops held by proteins. [2]

16. (a) According to Chargaff rule, Amount of Adenine (A) = Amount of Thymine (T) and Amount of Cytosine (C) = Amount of Guanine (G).

Given is 240 of nucleotides are adenine, it means therefore, same amount of thymine.

Total 1000 nucleotides are present

So $1000 - (A + T) = \text{amount of } C + G$

$1000 - (240 + 240) = C + G$

$C + G = 620$. It means $C = 310$ and $G = 310$

Therefore, amount of pyrimidine in DNA = $T + C$, $240 + 310 = 550$ [1½]

(b) Diagrammatic sketch of a portion of DNA segment:

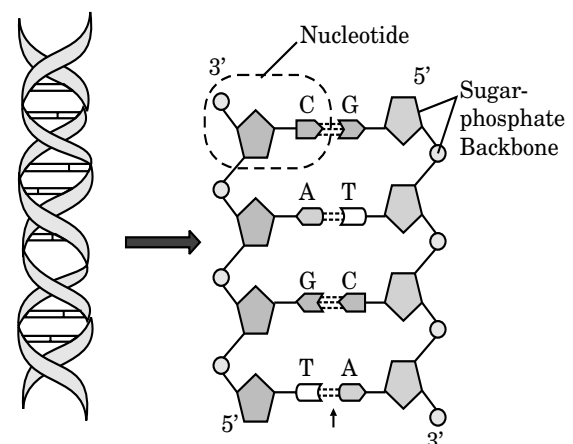


Fig.: DNA double helix **Fig.:** Antiparallel DNA

[1½]

17. DNA fingerprinting is the modern scientific method used for the identification of kinship.

DNA Fingerprinting process can be carried out in following steps:

- I. Blood sample from taken from the dead passengers, then DNA is extracted from blood cells.
 - II. With the help of restriction enzymes DNA is cut into fragments.
 - III. The DNA fragments are separated into bands during electrophoresis in agarose gel.
 - IV. By southern blotting technique the DNA band pattern in the gel is transferred to a nylon membrane.
 - V. The radioactive DNA probe is prepared.
 - VI. The DNA probe binds to specific DNA sequences on the membrane.
 - VII. Excess DNA probe is washed and the radioactive probe is bound to the DNA pattern on the membrane.
 - VIII. X-ray film is placed next to the membrane to detect the radioactive pattern and the X-ray film is developed to make visible the pattern of bands which is known as a DNA fingerprint. [2+1]
18. After the replication of DNA if newly formed DNA molecule consists of one parental and one newly synthesised strand. This type of replication is called semiconservative DNA replication. This has been proved experimentally by Meselson and Stahl in 1958:
- (I) They grew *E. coli* in a medium containing $^{15}\text{NH}_4\text{Cl}$. After sometime N^{15} , the heavy isotope of nitrogen was incorporated into newly synthesised DNA and other nitrogenous compounds. This heavy DNA molecule could be distinguished from the normal DNA by centrifugation in a cesium chloride (CsCl) density gradient [1]
 - (II) Then they transferred the cells into a medium with normal $^{14}\text{NH}_4\text{Cl}$ and took samples at various definite time intervals as the cells multiplied, and extracted the DNA that remained as Double-stranded helices. The various samples were separated independently on CsCl gradients to measure the densities of DNA [1]

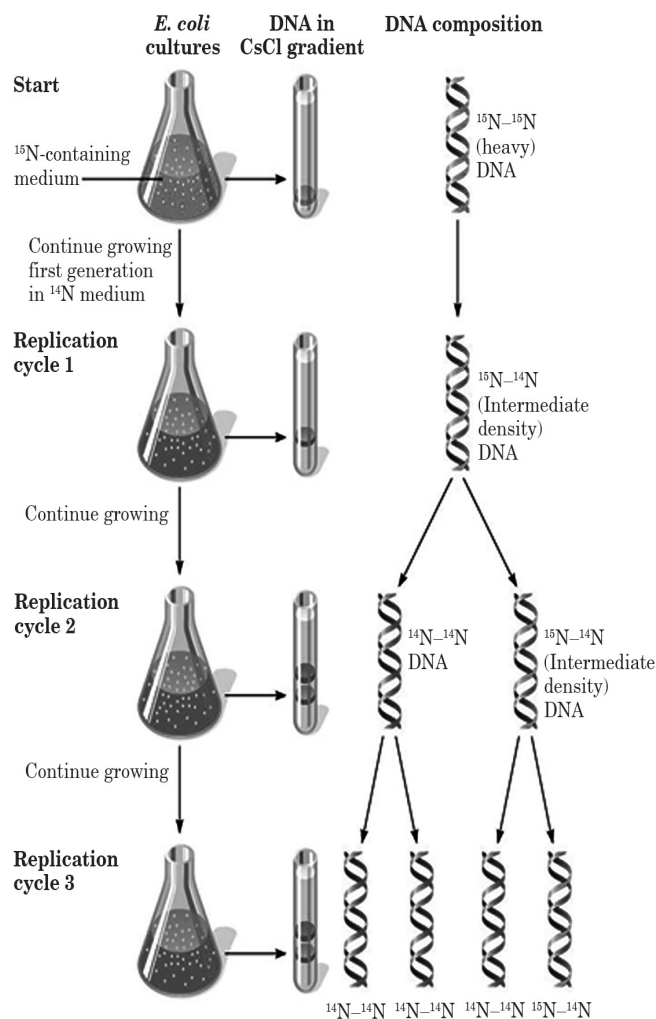


Fig.: Meselson and Stahl's experiment. [1]

19. (i) The base sequence of its complementary strand is ATCGTACTA [1]
 - (ii) Base pairs are held together by hydrogen bond [1]
 - (iii) Chargaff framed the rule of complementarity rules, in which G is bonded with C by triple hydrogen bonds and T is bonded with A by two hydrogen bonds. [1]
20. (i) RNA polymerase II catalyses the transcription of heteronuclear RNA. [1]
 - (ii) Heteronuclear RNA consists of intron sequence which is the non-coding part and that needs to be removed, hence it undergoes changes like capping, tailing, splicing that occur in the nucleus. [2]
21. Unambiguous means one codon will code for one amino acid. Universal stands for same codon will code for same amino acid in all the organism from bacteria to human. Degenerate stand for one amino acid can be coded by more than one codon. [3]

22. The salient features of double helix structure of DNA are:
- Double helix structure of DNA consist of two polynucleotide chain whose backbone consists of sugar and phosphate. [½]
 - The one polynucleotide chain runs in 5' to 3' direction and other in 3' to 5'. This property is known as antiparallel. [1]
 - The two strands of DNA are joined by hydrogen bonds. Chargaff framed the rule of complementarity C always comes with C and form a tripple bond. A always comes with T and form a double bond. [1]
 - The two polynucleotide chain are coiled in a right handed manner. Distance between two base pair is 3.4\AA . [½]
23. Lac operon in *E. coli* consist of three structural genes: z, y, a. Lactose act as inducer, binds with repressor gene and hence operator site become free to bind with RNA polymerase and start the activation and transcription of structural genes. [3]
24. (a) This representation indicating a normal human, as glutamic Acid in the sixth position is not substituted by Valine. [1]
- The sufferer's RBCs get elongated and sickle shaped as compared to the normal biconcave RBCs [1]
 - Both males and females are likely to suffer from the disease equally, as the diseases is not a sex linked trait. [1]
25. VNTR is "variable number of tandem repeats". VNTR is a small stretch of DNA that consist of repeated nucleotide bases. The length of repeated sequences vary among chromosome and individual. Probe is a small stretch of DNA used to find any gene in genome. VNTR is used in forensic science to find out the criminals and to confirm parent of their child. [3]
26. Fredrick Griffith conducted the experiment in 1928 on *Streptococcus pneumoniae*. He observed, that two strains of bacteria: smooth type(S-type) and other is rough (R-type). R bacteria were non-virulent (not capable of causing disease), whereas S bacteria are virulent (capable of causing disease). The R type bacteria had rough appearance and S type had smooth appearance due to a polysaccharide, or sugar-based, coat produced by the bacteria. The R bacteria were non-virulent, meaning that they did not cause sickness when injected into a mouse. Mice injected with live S bacteria developed pneumonia and died. Griffith further injected some mice with heat-killed S bacteria and some with harmless R bacteria pooled with harmless heat-killed S bacteria. [2½]
- Conclusion: Heat-killed S bacteria is not able to develop pneumonia in mice whereas harmless R bacteria pooled with harmless heat-killed S bacteria when injected together led to the development of pneumonia in mice. Harmless R-strain bacteria pooled with harmless heat-killed S bacteria when injected together must have taken up something and Griffith called it a "transforming principle" that permitted bacteria to transform into smooth-coated bacteria and become virulent. Hence, the bacteria is able to pass its genetic material to another bacteria by a process known as transformation. [2½]
27. (a) Harmless R-strain bacteria pooled with harmless heat-killed S bacteria when injected together must have taken up something and Griffith called it a "transforming principle" that permitted bacteria to transform into smooth-coated bacteria and become virulent. Hence, the bacteria is able to pass its genetic material to another bacteria by a process known as transformation. Hence, the name of the experiment is "transformation experiment". [2½]
- Oswald Avery, Colin MacLeod, and Maclyn McCarty in the year 1944, from America, tried to find out the molecular nature of Griffith's "transforming material". They started their experiment with large cultures of heat-killed S cells. Further, through a series of biochemical events, they are able to find the nature of Griffith's "transforming material". They concluded that DNA might be the "transforming material". [2½]
28. (a) DNA replication is the process through which DNA replicates and make a copy of it. The main enzyme involved in DNA replication is DNA polymerase. Energy required for DNA is provided by dNTPs. DNA replication involve three process: initiation, elongation and termination. The initiation of replication occurs at specific region called origin of replication. DNA polymerase help in the DNA synthesis. During the initiation of replication, the parent strands of DNA open , forming a Y shaped structure called as replication fork. The enzyme is DNA polymerase which is DNA dependent. The property unique is that it catalyses the polymerisation in one direction which is 5'→3'. Hence, this lead to the DNA replication in leading strand

as continuous and lagging strand as discontinuous. The discontinuous strands are joined by an enzyme called DNA ligase. [2]

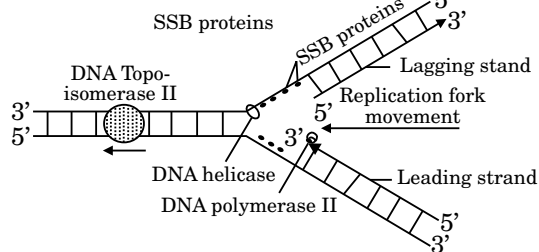


Fig.: DNA replication [½]

- (b) In S phase of the cell cycle, DNA replication occurs in Eukaryotes. If cell division is not followed by DNA replication, then replicated chromosome will not get distributed in daughter nuclei. This will result in the accumulation of replicated chromosome or DNA that eventually increase the nucleus cell volume and cause expansion. [2½]
29. (a) Fredrick Griffith conducted the experiment in 1928 on *Streptococcus pneumoniae*. He observed, two strains of bacteria: smooth type(S-type) and other is rough (R-type). The R bacteria were non-virulent (not capable of causing disease), whereas S bacteria were virulent (capable of causing disease). R type bacteria appearance is rough and smooth appearance of S strain was due to a polysaccharide, or sugar-based coat produced by the bacteria. The R bacteria were non-virulent, meaning that they did not cause sickness when injected into a mouse whereas Mice injected with live S bacteria developed pneumonia and died. Griffith further injected some mice with heat-killed S bacteria and some with Non-virulent R bacteria pooled them with Non-virulent heat-killed S bacteria. Heat-killed S bacteria was not able to develop pneumonia in mice whereas Non-virulent R bacteria pooled with Non-virulent heat-killed S bacteria when injected together led to the development of pneumonia in mice. Non-virulent R-strain bacteria pooled with Non-virulent heat-killed S bacteria when injected together must have taken up something and Griffith called it a “transforming principle” that permitted mice to transform into smooth-coated bacteria and become virulent. Hence, the bacteria is able to pass its genetic material to another bacteria by a process known as transformation. [3]
- (b) Oswald Avery, Colin MacLeod, and Maclyn McCarty in the year 1944, from America, tried to find out the molecular nature of Griffith’s “transforming material”. They concluded that DNA might be the “transforming material”. Alfred Hershey and Martha Chase in the year 1952, finally confirmed that DNA is the genetic material. [2]
30. Lac operon in *E. coli* consists of four parts: structural gene, promoter gene, operator gene and regulator gene. These genes become functional and are turned on and off as per the requirement. The lac operon consist of three structural genes z, y, a that code for enzyme beta galactosidase, permease and transacetylase respectively. These genes are expressed in the presence of lactose. The promoter is the site at which RNA polymerase binds to start the transcription of the structural gene. The operator is the site at which protein repressor binds. In the absence of regulator protein, RNA polymerase is prevented from attaching through promoter. The repressor binds to the operator in the absence of lactose. When a lactose is added, it binds to the repressor to form a complex which is unable to bind the operator. The RNA polymerase binds to the promoter and hence, operator is switched on. This initiates the transcription of three structural gene that result in the formation of polynucleotide chain. These three enzymes metabolise lactose into glucose and galactose. [5]
31. Alfred Hershey & Martha Chase in 1952 conducted transduction experiments to prove that DNA is the genetic material. They conducted experiments on bacteriophage and allowed it to infect two separate bacterial colonies. One bacterial colony has radioactive phosphorus P^{32} and the other bacterial colony with radioactive sulphur S^{35} . When bacteriophage infected these two colonies, radioactive sulphur (S^{35}) got incorporated in the capsid proteins of bacteriophage, While radioactive phosphorus (P^{32}) became a component of phage DNA. The two types of bacteriophage were then introduced to infect two different bacterial colonies of *E. coli*. The two bacterial cultures were centrifuged separately. The phage capsid gets separated from the bacteria. The bacterial cells were present at the bottom of centrifuge tube as pellets. Hershey and Chase observed that in the experiment using S^{35} the supernatant capsid showed radioactivity but the bacterial

cells does not show radioactivity whereas in the experiment using P^{32} , the supernatant does not show radioactivity. Thus, it was concluded that the DNA, which is able to enter the bacteria, is the genetic material. The protein part has no such function. [3½]

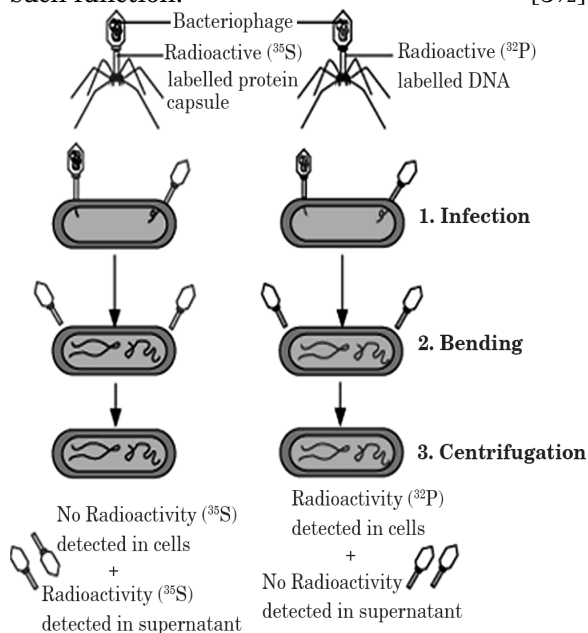


Fig.: Alfred-Martha experiment [1½]

32. Role of m-RNA, t-RNA and ribosomes in protein synthesis:

- I. mRNA: The messenger RNA or mRNA synthesised on the DNA template in the nucleoplasm. It carries genetic information from DNA and moves into the cytoplasm and takes part in its translation by bringing amino acids in a specific sequence during the synthesis of a polypeptide chain. The same mRNA can be reused many times. [1]
- II. t-RNA: The transfer RNA or tRNA has particular function during protein synthesis. As its name suggests, it transfers a specific amino acid to mRNA over a particular codon corresponding to their anticodons. Each t-RNA has an area for coming in contact with ribosome and the enzyme amino acyl tRNA synthetase. [1]
- III. Ribosomes: Ribosomes are cell organelles present abundantly in the cell cytoplasm. It is the site of protein synthesis. Each ribosome has two subunits— smaller and larger subunits. The larger subunit has a groove. Through groove the newly formed polypeptide comes out. The groove also protects the polypeptide from cellular enzymes. The smaller subunit fits like a cap over the larger one and leaves a tunnel for

m-RNA. The smaller subunit has a point for recognising m-RNA and binding area for initiation factors. [2]

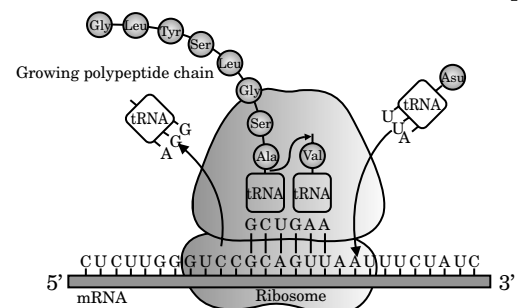


Fig.: Translation [1]

33. (a) (i) They are organised to form histone octamer. [1]
- (ii) Negatively charged DNA is wrapped around positively charged histone octamer to give rise to a nucleosome. [1]
- (iii) Nucleosomes constitute repeating unit of a structure in the nucleus called chromatin. It is thread-like stained (coloured) bodies. [1]

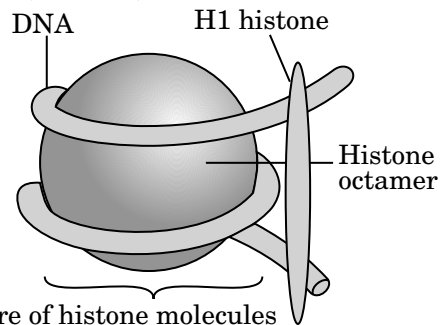


Fig.: Nucleosome [1]

(b) Difference between Euchromatin and Heterochromatin: [1]

Euchromatin	Heterochromatin
A region of loosely packed, light stained chromatin.	A region of densely packed, dark stained chromatin.
Transcriptionally active chromatin	Transcriptionally inactive chromatin

34. Lactose is the substrate for the enzyme beta galactosidase and it regulates switching ON and OFF of the operon. In the presence of an inducer such as lactose, the repressor is inactivated by interaction with the inducer. This allows RNA polymerase access to the promoter and transcription proceeds. [3]

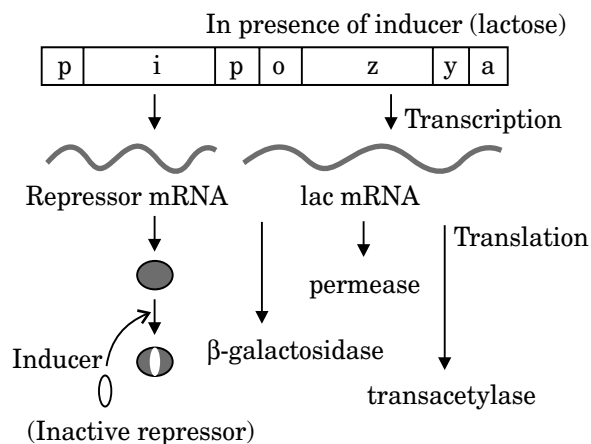


Fig.: Lac-Operon [2]

35. The steps of the Meselson and Stahl's experiment:

- (i) They grew *E. coli* for many generations in $^{15}\text{NH}_4\text{Cl}$ to get the heavy isotope ^{15}N as the nitrogen source. [½]
- (ii) They incorporated ^{15}N into the DNA. [½]

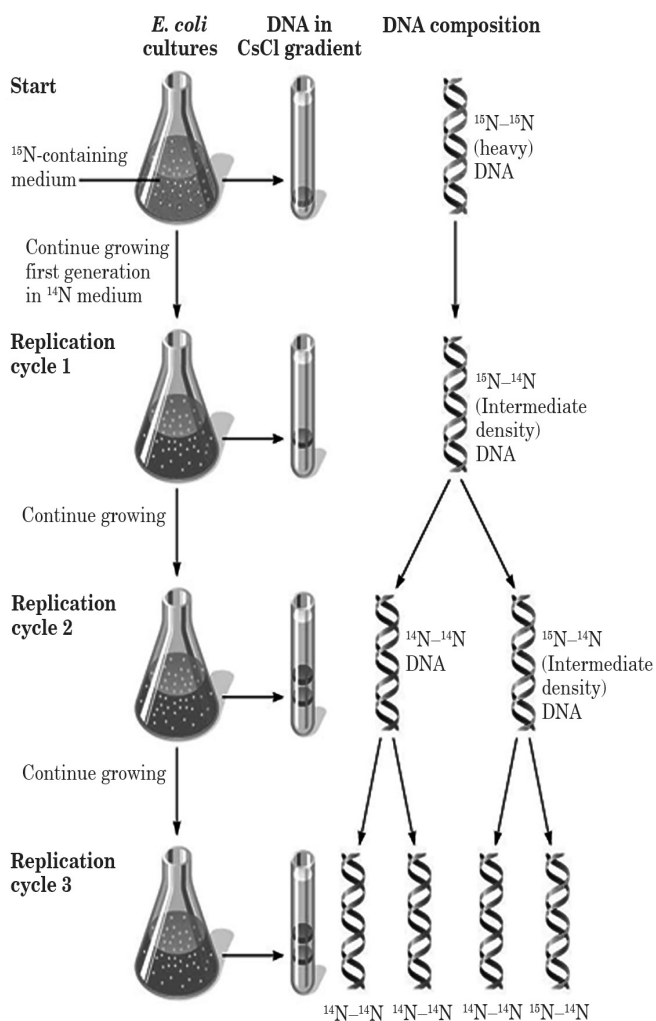


Fig.: Meselson and Stahl's experiment [1]

- (iii) This heavy ^{15}N DNA was separated from the normal DNA by density gradient centrifugation using caesium chloride as the gradient. [½]
- (iv) The cells were then transferred into a medium of $^{14}\text{NH}_4\text{Cl}$ with ^{14}N as the nitrogen source. [½]
- (v) Samples were taken from this medium of $^{14}\text{NH}_4\text{Cl}$ and the DNA was extracted. [½]

Observation:

DNA extracted from the culture after one generation (20 minutes is the generation time of *E. coli*) showed intermediate hybrid density. The DNA extracted after two generations (40 minutes) showed light DNA and hybrid DNA. [1½]

Conclusion:

It can be concluded that the newly synthesised DNA contains one strand of its parent and one is new. Thus, replication was semi-conservative. [½]

36. (a) Transcription has three steps—initiation, elongation and termination.

Initiation: RNA polymerase binds with sigma factor (σ) and attaches to the promoter site at 5' end to initiate the process of transcription.

Elongation: When RNA polymerase moves from promoter to the terminator site it causes the polymerisation of nucleotides resulting in the formation of RNA in the 5'-3' direction.

Termination: When RNA polymerase reaches to the terminator site it binds to ρ factor and the transcribed RNA falls off along with RNA polymerase. [1]

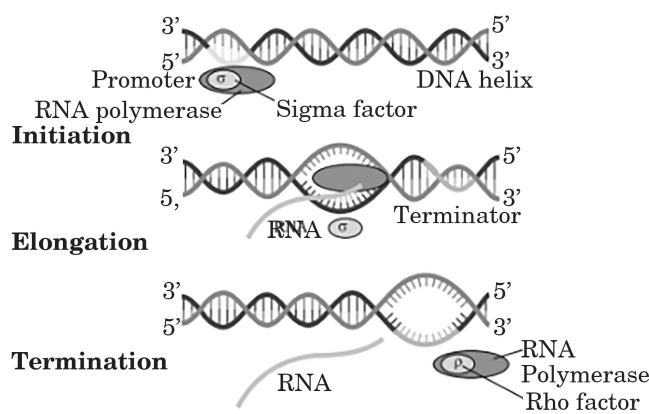


Fig.: The process of transcription in bacteria

[1½]

- (b) The hnRNA before becoming functional mRNA in eukaryotes, it undergoes splicing. During splicing introns are removed and exons are joined in a specific order. The hnRNA undergoes additional processing in two ways:

Capping: addition of methyl guanosine triphosphate to the 5' end of hnRNA.

Tailing: Poly adenylate residues are added to the 3' end of hnRNA. The fully processed hnRNA is the functional mRNA which is transported out of the nucleus. [1½]

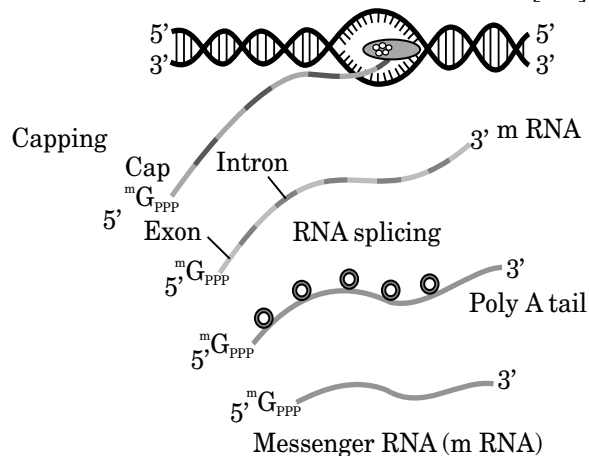


Fig.: Splicing of hnRNA [1]

37. (a) The structure of tRNA is a cloverleaf-like. It consists of five arms or loops. The five loops are anticodon loop, Amino acid acceptor, T-loop, D-loop and Variable loop. [1½]
38. Lac operon consists of one regulatory gene (*i*), a promoter (*p*), an operator (*o*), and three structural genes *z*, *y* and *a*. The operon can be switched on or switched off. Lactose acts as inducer thus absence of lactose switches off the operon. Regulator gene (*i*) produces repressor protein. Repressor protein binds to the operator gene (*o*) region of the operon which prevents RNA polymerase from transcribing the structural gene and operon is switched off. Gene regulation is the process of controlling which genes in a cell's DNA will make a functional product such as a protein. Thus making of functional protein is called expression of gene. [3]

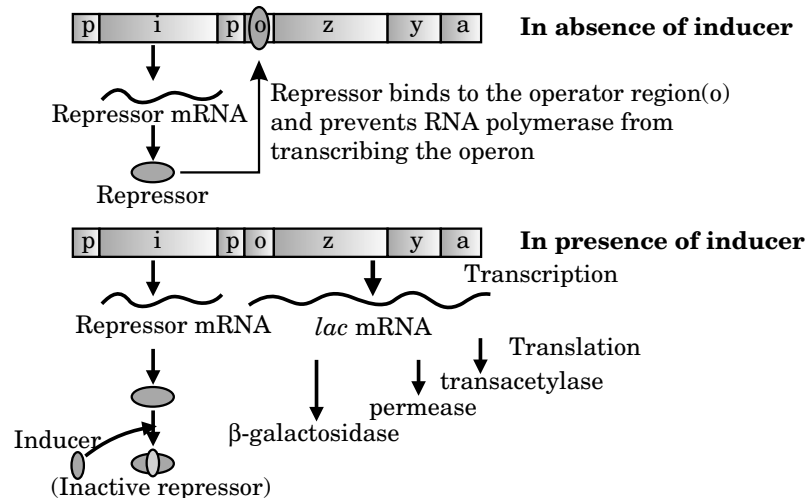


Fig.: Expression of gene & Lac operon [2]

The main function of tRNA is to pick up an amino acid from the cytoplasm of the cell and bring it to the mRNA template at a specific position for polymerisation. tRNA is called an adapter molecule because it attaches itself to the ribosome-mRNA complex which facilitates the incorporation of the correct amino acid to the growing polypeptide chain by its specific anticodon to the mRNA codon.

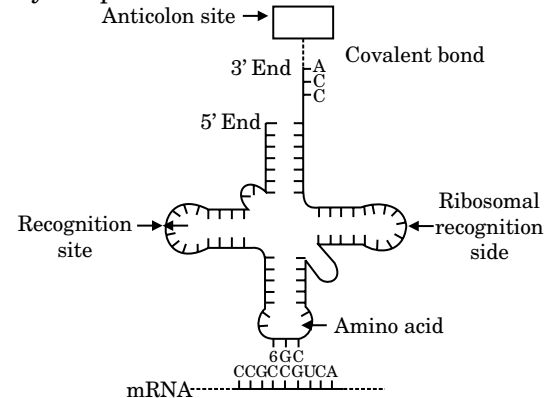


Fig.: Structure of t-RNA [1]

- (b) A non-functional primary transcript formed in eukaryotes. It consists of both the coding region (exon) and non-coding region (intron) in RNA and are called heterogeneous RNA or hn-RNA. hn-RNA undergoes a process by which the introns are removed and exons are joined to form functional m-RNA through the process called splicing. [2½]

[Topic 2] Genetic Code, Human Genome Project & DNA Fingerprinting

Genetic Code

Genetic code is the sequence of nucleotides in mRNA that contains information for protein synthesis.

• **Salient features of Genetic Code:**

- The genetic code is a triplet code.
- One amino acid has only one codon code, hence, it is specific and undebatable.
- The code is almost universal and non-overlapping.
- Sometimes more than one codon is used to code amino acids and so the code is dissipated.
- No punctuation is used between adjacently placed codons.
- Exceptions to this rule have been found in mitochondrial codons, and in some protozoans

	Second position				
First position	U	C	A	G	Third position
U	UUU Phe	UCU Ser	UAU Tyr	UGU Cys	U
	UUC Phe	UCC Ser	UAC Tyr	UGC Cys	C
	UUA Leu	UCA Ser	UAA Stop	UGA Stop	A
	UUG Leu	UCG Ser	UAG Stop	UGG Trp	G
C	CUU Leu	CCU Pro	CAU His	CGU Arg	U
	CUC Leu	CCC Pro	CAC His	CGC Arg	C
	CUA Leu	CCA Pro	CAA Gin	CGA Arg	A
	CUG Leu	CCG Pro	CAG Gin	CGG Arg	G
A	AUU Ile	ACU Thr	AAU Asn	AGU Ser	U
	AUC Ile	ACC Thr	AAC Asn	AGC Ser	C
	AUA Ile	ACA Thr	AAA Lys	AGA Arg	A
	AUG Met	ACG Thr	AAG Lys	AGG Arg	G
G	GUU Val	GCU Ala	GAU Asp	GGU Gly	U
	GUC Val	GCC Ala	GAC Asp	GGC Gly	C
	GUA Val	GCA Ala	GAA Glu	GGA Gly	A
	GUG Val	GCG Ala	GAG Glu	GGG Gly	G

Fig.: The Codons for Various Amino Acids

• **Mutations and Genetic Code:**

- Studying mutation explains the relationships between DNA and genes.
- Deletion or rearrangement in DNA segment results in loss or gain of a gene and so its function.
- Example of point mutation includes, change of single base pair in the gene for beta globin chain, results in the change of amino acid residue glutamate to valine which results into a diseased condition called as sickle cell anaemia.
- If a base or two are inserted or deleted, it changes the reading frame from the point of insertion or deletion.

• **tRNA- The Adapter Molecule:**

- Amino acids have no structural specialties to read the code uniquely. On one hand they read the code and on other hand would bind to specific amino acids.
- An anticodon loop is present in tRNA which has bases that are complementary to the code and amino acids are binded together by tRNA with the help of amino acid acceptor end. There are specific tRNAs for each amino acid.
- There is a specific initiator tRNA that helps in initiation. There are no tRNAs present for stop codons.

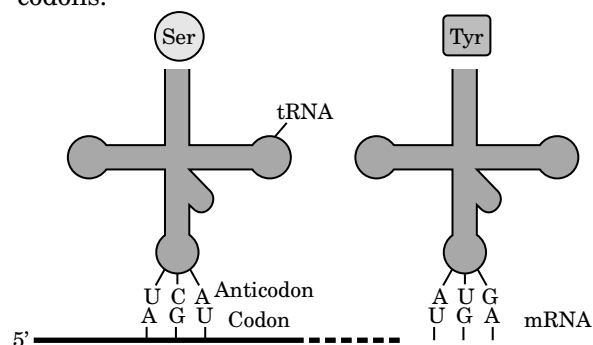


Fig.: tRNA – the adapter molecule

• **Translation:**

- Polymerisation of amino acids to form a polypeptide is referred as translation.
- In the first phase which is called as charging of tRNA, as energy is required from ATP for formation of peptide bond, so amino acids are activated in the presence of ATP and linked to their cognate tRNA in presence of *aminoacyl tRNA synthetase*. This step is also called as aminoacylation of tRNA.
- In the next step called as initiation, the ribosome binds to the mRNA at the start codon (AUG) that is recognized by initiator tRNA.
- In the third phase of elongation, complexes which are formed by linkage of amino acids to tRNA, bind to appropriate codon in mRNA by forming complimentary base pairs with the tRNA anticodon.
- At the end, in last phase, the process of translation is terminated and complete polypeptide is released from the ribosome.

• **Regulation of Gene Expression:**

- Polypeptide is formed as a result of gene expression. In eukaryotes, the regulation could be exerted at:
 - Transcriptional level (formation of primary transcript)

- Processing level (regulation of splicing)
- Transport of mRNA from nucleus to the cytoplasm
- Translational level.

- **Lac Operon:**

- A polycistronic structural gene is controlled with the help of a common promoter and regulatory genes. In bacteria, this kind of an arrangement is quite common and is known as an operon. For example: val operon, trp operon, lac operon, etc.
- It is the operon which controls metabolism of lactose. Lactose is used as an inducer as it regulates switching on and off of the operon.

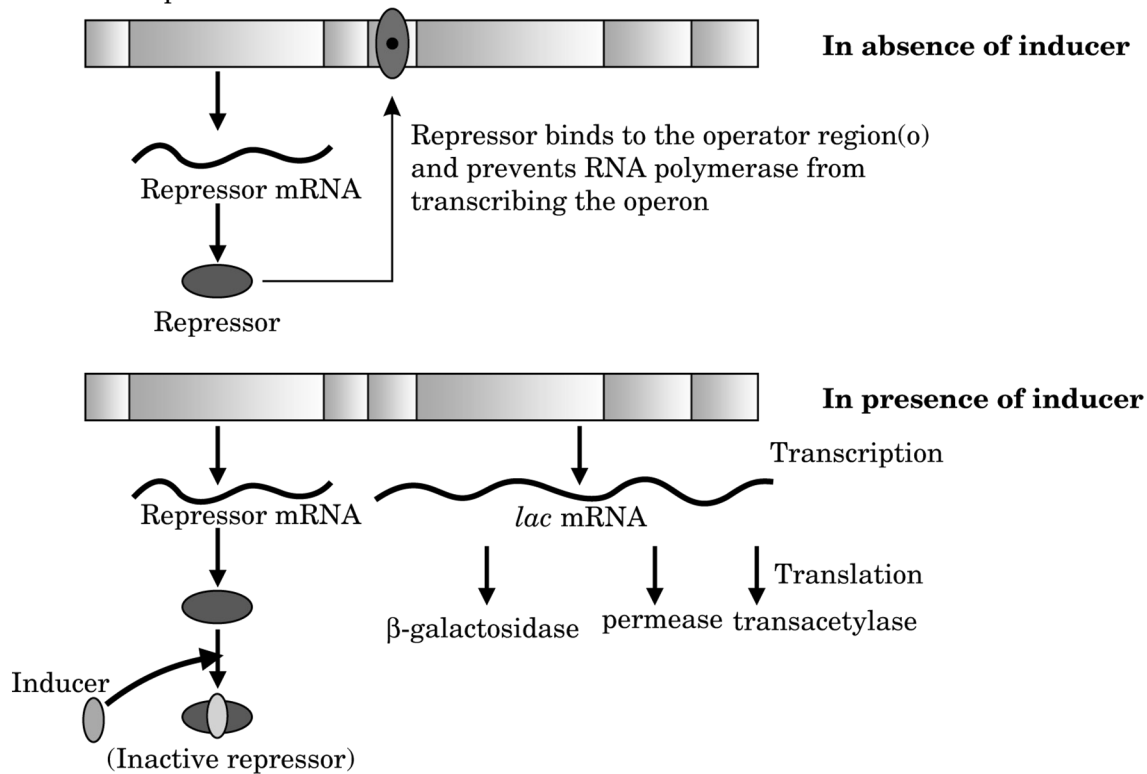


Fig.: The *lac* Operon

Human Genome Project

Genome is referred to as the complete DNA, found in the haploid set of chromosomes of an organism. Human Genome project (HGP) was the first effort in identifying the sequence of nucleotides and mapping of all genes in human genome.

- **Goals of HGP:**

- To determine the sequences of the 3 billion chemical base pairs that comprise of human DNA.
- To identify all the genes present in human DNA.
- To improve data analysis tools.
- To have a storage facility to safely keep this information in databases.
- To transfer related technologies to other sectors, such as industries.
- To deal with ethical, legal and social issues that may arise due to this project.

- **Methodologies:**

- One of the two methods focuses on recognizing all the genes that expressed as RNA.
- The second method takes the blind outlook of aligning the genome, containing all the coding and non-coding sequence, and are assigned different regions later in the sequence.

DNA Fingerprinting

DNA fingerprinting is a way to identify the similarities and differences in specific region of DNA sequence known as repetitive DNA, as in these sequences, a small stretch of DNA is repeated many times.

- **Basis of DNA fingerprinting:**

- Polymorphism in DNA sequence is the basis of genetic mapping of human genome as well as of DNA fingerprinting. Polymorphism (variation at genetic level) arises due to mutations.

- **Steps of DNA fingerprinting:**

- Firstly, isolate the DNA.
- Then, DNA is digested by restriction endonuclease.
- Then, DNA fragments are separated by electrophoresis.
- After this, separated DNA fragments are transferred to synthetic membranes, such as nitrocellulose or nylon, also referred as blotting.
- Then DNA fragments are hybridized using labelled VNTR probe.
- Finally, hybridized NA fragments are detected by auto radiography.

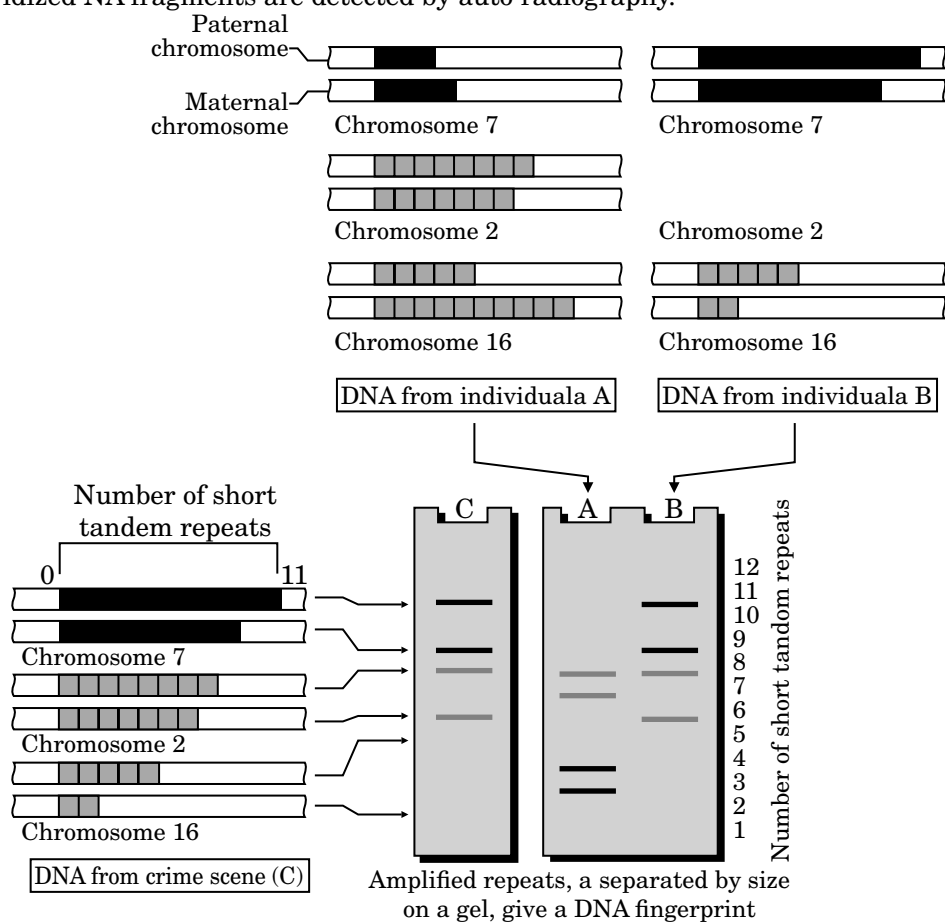


Fig.: Schematic representation of DNA Fingerprinting

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 2

3 Marks Questions

1. Explain the significance of satellite DNA in DNA finger printing technique. [ALL INDIA 2015]

2. (a) What do 'Y' and 'B' stand for in 'YAC' and 'BAC' used in Human Genome Project (HGP). Mention their role in the project.
 (b) Write the percentage of the total human genome that codes for proteins and the percentage of discovered genes whose functions are known as observed during HGP.
 (c) Expand 'SNPs' identified by scientists in HGP. [ALL INDIA 2016]

3. (a) List the two methodologies which were involved in human genome project. Mention how they were used.
(b) Expand 'YAC' and mention what it was used for. [ALL INDIA 2017]
4. (a) Expand VNTR and describe its role in DNA fingerprinting.
(b) List any two applications of DNA fingerprinting technique. [DELHI 2018]
5. It is established that RNA is the first genetic material. Explain giving three reasons. [DELHI 2012]
6. (a) Name the enzyme responsible for the transcription of tRNA and the amino acid, the initiator tRNA gets linked with.
(b) Explain the role of initiator tRNA in initiation of protein synthesis. [ALL INDIA 2012]
7. Describe the structure of a RNA polynucleotide chain having four different types of nucleotides. [DELHI 2013]



Solutions

1. Satellite DNA are small non-coding sequences of bases. It is inheritable and may be separated from main DNA during density gradient centrifugation. Satellite DNA shows variable morphology which forms the basis of DNA fingerprinting. The short nucleotide repeats in the DNA varies in number from person to person and nucleotide repeats are specific in each individual. These are called 'variable number tandem repeats' or mini-satellites. Individuals inherit these repeats from their parents which are used as genetic markers in a personal identity test [3]
2. (a) In Human Genome Project (HGP), 'YAC' Y stands for Yeast and in 'BAC' B stands for bacteria. These are used as vector for cloning foreign DNA. [1]
(b) The percentage of total human genome that codes for proteins is less than 2%. The percentage of discovered genes whose functions are known is more than 50% [1]
(c) 'SNPs' stands for Single Nucleotide Polymorphism in HGP. [1]
3. (a) Two methodologies of HGP:
 - (1) Expressed Sequence Tags (EST's): This method focusses on identifying all the genes that are expressed as RNA. [1]
 - (2) Sequence Annotation: It is an approach of simply sequencing the whole set of genome that contains all the coding and non-coding sequences, and later assigning different regions in the sequence with functions. [1]
- (b) 'YAC' stands for Yeast Artificial Chromosome: It is used as a cloning vector for cloning DNA fragments in suitable host so that DNA sequencing can be done. [1]
4. (a) VNTR stands for Variable Number of Tandem Repeats. The VNTR is a satellite DNA called mini-satellite. A small DNA sequence is arranged tandemly in many copy numbers. The copy number in an individual is different. The numbers of repeat show very high degree of polymorphism. The size of VNTR range from 0.1 to 20 kb. Consequently, after hybridisation with VNTR probe, the autoradiogram gives many bands of differing sizes. These bands give a characteristic pattern for an individual DNA. Except identical twins, the band of characteristic patterns are different in different individuals. The sensitivity of the technique has been increased by use of polymerase chain reaction (PCR). Consequently, DNA from a single cell is enough to perform DNA fingerprinting analysis. [1+1]
(b) In addition to application in forensic science, it has much wider application in determining population and in genetic diversities. [1]
5. Three reasons to prove that RNA is the first genetic material are:
 1. RNA is capable of storing genetic information and self-replication [1]
 2. RNA is capable of catalysing chemical reaction. [1]
 3. It can directly code for the synthesis of proteins. [1]
6. (a) RNA polymerase III is responsible for the transcription of tRNA and methionine is the amino acid, the initiator tRNA gets linked with. [1½]
(b) Initiator tRNA reaches the small sub unit of ribosome having anticodon UAC that recognize the codon AUG on mRNA. The bases make the complementary base pairings. This starts the protein synthesis initiation. [1½]
7. RNA consist of single chain of nucleotides and is a polymer of ribonucleotides. The four bases present in the RNA are : adenine (A), cytosine (C), guanine (G), uracil (U). Ribonucleotides are link by 3'-5' phosphodiester bonds to form polyribonucleotide chain. Normally, polyribonucleotide chain consist of 700-1200 ribonucleotides. [3]

CHAPTER 7

Evolution

Chapter Analysis with respect to Last 3 Years' Board Exams

List of Topics	2016		2017		2018
	Delhi	All India	Delhi	All India	Delhi/All India
Origin of life, Biological evolution and evidences for biological evolution (Paleontological, comparative anatomy, embryology and molecular evidence)	1Q (1 mark)				
Darwin's contribution, Modern Synthetic theory of Evolution	1Q (1 mark)		1Q (1 mark)	1Q (1 mark)	1Q (3 marks)
Mechanism of evolution - Variation (Mutation and Recombination) and Natural Selection with examples, types of natural selection		1Q (2 marks)	1Q (2 marks)		
Gene flow and genetic drift					
Hardy - Weinberg's principle, Adaptive Radiation, Human evolution		1Q (2 marks)	1Q (3 marks)	1Q (3 marks)	1Q (2 marks)

On the basis of above analysis, it can be said that from exam point of view the concepts Hardy-Weinberg's Principle, Darwin's Theory of Natural Selection and on Analogous and homologous structures are most important concepts of the chapter.

[Topic 1] Origin of Life on Earth and Various Related Exidences

Summary

Theories of origin of life: Many theories have been given by various scientists to explain the phenomenon of origin of life. Some of these proposed theories are as follows:

- Biogenesis
- Theory of sudden creation from inorganic material.
- Theory of special creation.
- Naturalistic theory
- Theory of spontaneous generation or Abiogenesis.
- Cosmozoic theory

Modern Theory by Oparin

- The main idea of the theory - "life could have originated from non-living organic molecules."
- In 1936, Oparin presented his ideas in his book "The origin of life".
- He proposed that, the origin of the Earth was about 4,500 million years ago. There was a reduced atmosphere which is also called as primitive atmosphere which had presence of nitrogen, hydrogen, ammonia, methane, carbon mono-oxide and water, when the earth was cooling down. Ultraviolet rays and electric discharges by lightening acted as the source of energy. Folded earth crust was formed during this process. For centuries, rains poured over the earth and got deposited in deep places of the earth crust.

Stanley Miller, an American biologist, performed an experiment known as Miller's experiment. He synthesized the basic compounds which are essential for life in the laboratory, on a small scale.

He made a specially designed flask which was containing hydrogen, ammonia and methane in the proportion of 2 : 1 : 2 respectively at 0°C. This proportion is the same as the proportion of gases that were present in the environment of primitive earth. A smaller flask, filled with water was connected to the flask that was containing the gases, with the help of glass tubes. Two tungsten electrodes were fitted and a current of 60,000 volts was passed through the gases to recreate the lightning storms that were there at the time of origin of life. This process was continued for seven days. On the last day when the vapours condensed, a red color substance was found

in the tubes. On the analysis, it was found that the red substance was containing glycine, amino acids, and nitrogenous bases. The substances are found in the nucleus of a cell.

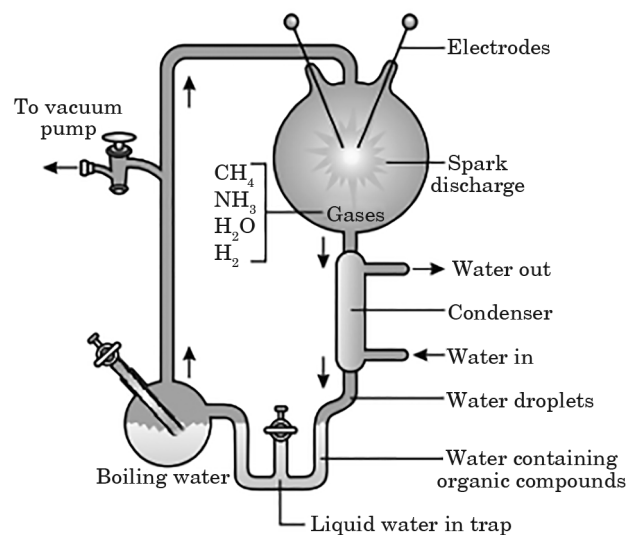


Fig.: Miller's experiment

Evolution of life forms

During a sea voyage, some observations were made. Charles Darwin concluded them all and proposed that current living forms have some similarities among themselves and also with life forms prevailing millions of years back. Quite a lot of them do not exist anymore. The geological history of earth matches up quite closely with the biological history of earth. Earlier it was a common conclusion that earth is very old, around thousands but in actual it is billions of years old.

Evidences for evolution

- **Divergent evolution:** Because of different needs, along different directions the same structures been developed.
- **Convergent evolution:** Different structures developed along same direction due to adaptation to perform similar functions.

Adaptive Radiation

In a given geographical area, evolution of different species from a point and diverging to different areas of geography. A number of marsupials, each different from the other evolved from an ancestral stock, but all within the Australian island continent

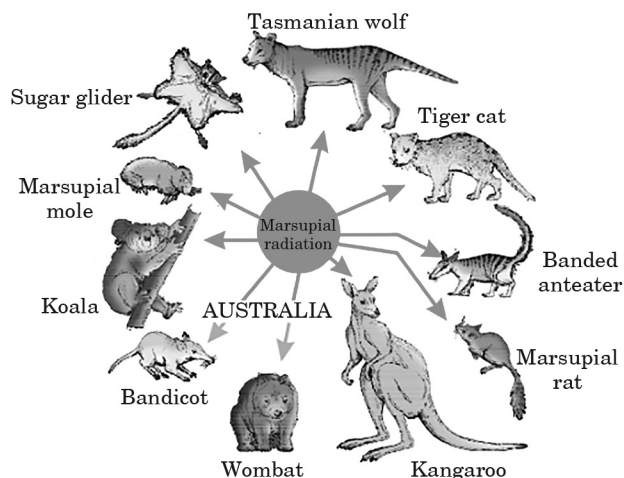


Fig.: Adaptive Radiation

PREVIOUS YEARS' EXAMINATION QUESTIONS

TOPIC 1

1 Mark Questions

- Comment on the similarity between the wing of a cockroach and the wing of a bird. What do you infer from the above, with reference to evolution? **[DELHI 2012]**
- Write the similarity between the wing of a butterfly and the wing of a bat. What do you infer from the above with reference to evolution? **[ALL INDIA 2012]**
- Identify the examples of convergent evolution from the following:
 - Flippers of penguins and dolphins
 - Eyes of octopus and mammals
 - Vertebrate brains **[DELHI 2013]**
- State a reason for the increased population of dark coloured moths coinciding with the loss of lichens (on tree barks) during industrialization period in England. **[DELHI 2015]**
- According to de-Vries what is saltation? **[DELHI 2016]**
- What role does an individual organism play as per Darwin's theory of natural selection? **[DELHI 2017]**
- State two postulates of Oparin and Haldane with reference to origin of life. **[ALL INDIA 2017]**

2 Marks Questions

- List the two main propositions of Oparin and Haldane. **[ALL INDIA 2013]**

- Select the homologous structures from the combinations given below:
 - Forelimbs of whales and bats
 - Tuber of potato and sweet potato
 - Eyes of octopus and mammals
 - Thorns of Bougainvillea and tendrils of Cucurbita
 - State the kind of evolution they represent. **[ALL INDIA 2015]**
- Mention the evolutionary significance of the following organisms:
 - Shrews
 - Lobefins
 - Homo habilis
 - Homo erectus **[DELHI 2017]**

3 Marks Questions

- Branching descent and natural selection are the two key concepts of Darwinian Theory of evolution. Explain each concept with the help of suitable example. **[ALL INDIA 2011]**
- How does industrial melanism support Darwin's theory of Natural Selection? Explain. **[DELHI 2012]**
- State the theory of Biogenesis. How does the Miller's experiment support this theory? **[ALL INDIA 2012]**
- With the help of two suitable examples explain the effect of anthropogenic actions on organic evolution. **[DELHI 2013]**
- Explain the increase in the numbers of melanic (dark winged) moths in the urban areas of post industrialisation period in England. **[ALL INDIA 2013]**
- Since the origin of life on Earth, there were five episodes of mass extinction of species.
 - How is the 'Sixth Extinction', presently in progress, different from the previous episodes?
 - Who is mainly responsible for the 'Sixth Extinction'?
 - List any four points that can help to overcome this disaster. **[ALL INDIA 2014]**
- Explain adaptive radiation with the help of a suitable example. **[DELHI 2015]**
- Describe the experiment that helped Louis Pasteur to dismiss the theory of spontaneous generation of life. **[DELHI 2016]**
- Differentiate between homology and analogy. Give one example of each. **[ALL INDIA 2016]**

20. (a) Differentiate between analogous and homologous structures.
 (b) Select and write analogous structures from the list given below:
 (i) Wings of butterfly and birds
 (ii) Vertebrate hearts
 (iii) Tendrils of bougainvillea and cucurbita
 (iv) Tubers of sweet potato and potato

[DELHI 2018]

▣ 5 Marks Questions

21. (a) Explain Darwinian Theory of evolution with the help of one suitable example. State the two key concepts of the theory.
 (b) Mention any three characteristics of Neanderthal man that lived in near east and central Asia.

[DELHI 2014]



Solutions

- The wing of a cockroach and the wing of a bird are the examples of analogous organs which means they have different structure but their function is same. Hence, we can say that they have originated from different ancestor as a part of convergent evolution. Wings of both bird and cockroach are used for flying. [1]
- The wing of a butterfly and the wing of a bird are the examples of analogous organs means they have different structure but their function is same. Hence, we can say that they have originate from a different ancestor as a part of convergent evolution. Wings of both are used for flying. [1]
- The examples of convergent evolution are Flippers of penguins and dolphins and Eyes of octopus and mammals as both pairs of structure perform the similar function but evolved independently in various animals. [1]
- During industrial revolution, large amount of smoke resulted in large scale soot which deposited on tree trunks. Deposition of soot causes the tree trunks to become darker turning them black. Hence, the number of dark moths increased as they were not easily visible to their predators while the white-winged were easily picked up by the predators. Thus, light coloured moth fail to survive and dark ones were selected by natural selection. [1]
- According to de-Vries, 'mutation caused speciation'. He called this as saltation. It means saltation is single step, large mutation. [1]
- An individual organism may produce new species due to variations by random mating or artificial selection. [1]
- Two postulates of Oparin and Haldane with reference to origin of life are given below:
 (a) First life originated from pre-existing, non-living organic molecules (RNA, protein). [½]
 (b) Formation of life was preceded by chemical evolution. [½]
- Oparin-Haldane theory of origin of life
 (1) First life originated was anaerobic, as at that point, free O₂ was absent [1]
 (2) The primitive atmosphere was reducing as oxygen was absent. [1]
- (a) Homologous structures are those which are similar in origin but dissimilar in function. Examples of homologous structures are (i) Forelimbs of whales and bats, (iv) Thorns of Bougainvillea and tendrils of Cucurbita. [1]
 (b) The homologous structures represent divergent evolution. [1]
- (a) Shrews: The first small sized viviparous mammals evolved on the earth. [½]
 (b) Lobefins: These were amphibians considered to be extinct 65 million years ago. Lobefins evolved into the first amphibian which lived in water and on land. They are considered ancestors of modern frog. [½]
 (c) Homo habilis. It was evolved from Australopithecus. Its brain capacity was 650-800cc and were likely non- meat eaters. The teeth and bipedal locomotion are the features. [½]
 (d) Homo erectus. It evolved from Homo habilis primitive type of speech have developed. It started using fire. It had larger brain size i.e 900cc. They were probably meat eaters. [½]
- Natural selection is a process by which the organism having better traits to survive are selected by nature as compared to those organism which are less adapted. Example, different microbes react differently to the antibiotics. [2]
 Branching descent is the formation of new species from a single common descendant. Example is Darwin finches. [1]
- The effects of Industrial melanism in the support the Darwin's theory. In 1850s before industrialisation, the population of white winged moth on trees were larger than dark winged. But after industrialisation, in 1920 population of darker winged moth increased and white winged moth decreased. It was due to the fact that predators were able to identify moth against a contrasting background. Hence, moths those which are able to camouflage with the plants, and surroundings were able to survive. [3]

13. Theory of Biogenesis state that life have originated from pre-existing life. It was given by Louis Pasteur. Diverse organic compounds were formed from in-organic compounds. [1]
In 1953, Miller and Urey conducted an experiment to prove theory of Biogenesis. They created primitive earth conditions like high temperature, reducing atmosphere, gases like methane, ammonia and then stimulated electric discharge in closed flask having the gases that were present in the primitive atmosphere. They observed the formation of amino acids. Hence, Miller and Urey support the theory of Biogenesis. [2]
14. Two suitable examples explain the effect of anthropogenic actions on organic evolution are:
(a) In 1850s before industrialisation population of white winged moth on trees were larger than dark winged. But after industrialisation in 1920 population of darker winged moth increased and white winged moth decreased. It was due to the fact that predators were able to identify moth against a contrasting background. Hence, moths which were able to camouflage with the plants, and surroundings were able to survive. [2]
(b) Use of herbicides and insecticides in agriculture, increased the selection of the plants which are resistant to herbicides and insecticides. [1]
15. In 1850s before industrialisation population of white winged moth on trees were larger than dark winged. But after industrialisation in 1920 population of darker winged moth increased and white winged moth decreased. It was due to the fact that predators were able to identify moths against a contrasting background. Hence, moths which were able to camouflage with the plants, and surroundings were able to survive. [3]
16. (i) ‘Sixth Extinction’, presently in progress, different from the previous episodes in the (a) rates of extinction is very fast as compare to previous one (b) Sixth Extinction is occurring because of human activities, not involving any natural calamity. [1]
(ii) Various human activities like deforestation, global warming are responsible for the ‘Sixth Extinction’ [1]
(iii) Conservation of plants and animals, conservation of natural resources and preventing habitat loss, decreased the rate of deforestation are four points that can help to overcome this disaster. [1]

17. Adaptive radiation is a process of evolution of different species in a given geographical area starting from a point and radiating to other geographical areas. One of the example of adaptive radiation is Australian marsupials. In Australian island, a number of marsupials have evolved from an ancestral stock. When more than one adaptive radiation appeared to have occurred in an isolated geographical area (representing different habitats). This is called convergent evolution. [1+1]

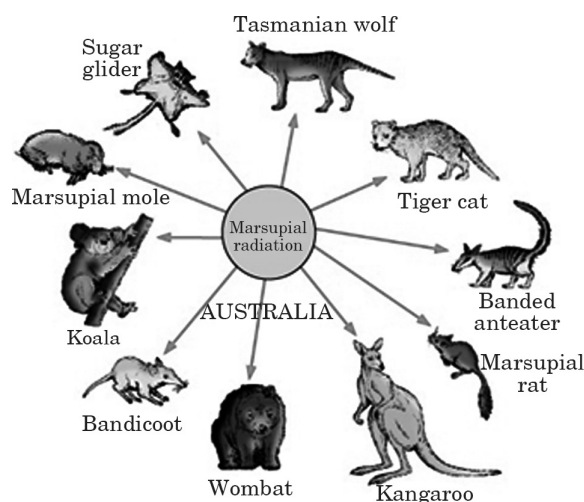


Fig.: Adaptive Radiation [1]

18. Louis Pasteur did an experimentation very carefully to demonstrate that life comes only from pre-existing life. He took two pre-sterilised flasks with killed yeast. One flask was sealed while the other was kept open in air. Differential growth of life was observed in the flasks-life was found only in the open flask’. It proved that life comes from pre-existing life (theory of biogenesis). [3]
- 19.

Homology	Analogy
It is the study of organs which are similar in origin and dissimilar in function.	It is the study of organs which are dissimilar in origin and similar in function.
Example are wings of birds and forelimbs of humans.	Example are wings of birds and wings of insects.
It supports divergent evolution.	It supports convergent evolution.

[1+1+1]

20. (a) Difference between analogous and homologous structures:

Analogous structures	Homologous structures
Structures or organs which are dissimilar in origin and similar in function.	Structures or organs which are similar in origin and dissimilar in function.
Example are wings of birds and wings of insects.	Example are wings of birds and forelimbs of humans.
It supports convergent evolution.	It supports divergent evolution.

[1+1]

- (b) The analogous organ are:
- Wings of butterfly and birds
 - Tubers of sweet potato and potato. [1]

21. (a) Darwinian Theory of evolution was given by Charles Darwin. His theory of evolution is called as Theory of Natural selection. He Explain "Natural selection" as a principle that helps in creating variations and inheritance of those variations in future progeny. Resulting in creation of new species. Famous example is: In 1850s before industrialisation population of white winged moth on trees were larger than dark winged. As these moths were able to the camouflage with background. But after industrialisation in 1920 population of darker winged moth increased and white winged moth decreased. It was due to the fact that predators able to identify moth against a contrasting background. Hence, those moths which are able to camouflage with the plants, and surroundings were able to survive. [3]

- (b) Three characteristics of Neanderthal man are:
- Brain size of 1400 cc
 - They used Hides to protect their bodies
 - They buried their dead [2]

[Topic 2] Biological Evolution, Its Mechanism and Evolution of Man

Evolution by natural selection, in a true sense would have started when cellular forms of life with differences in metabolic capability originated on earth.

Lamarck, proposed that the evolution of various life forms happened but was driven by the use or disuse of the organs.

Darwinian Theory of natural selection, given by Charles Robert Darwin said that only the fittest species can survive the changing environmental and physical conditions. The two important concepts of Darwinian's Theory of Evolution: Branching descent and natural selection.

Mechanism of Evolution

Mutations are random and directionless while Darwinian variations are small and directional. Evolution for Darwin was gradual while deVries believed mutation caused speciation and hence called it saltation (single step large mutation).

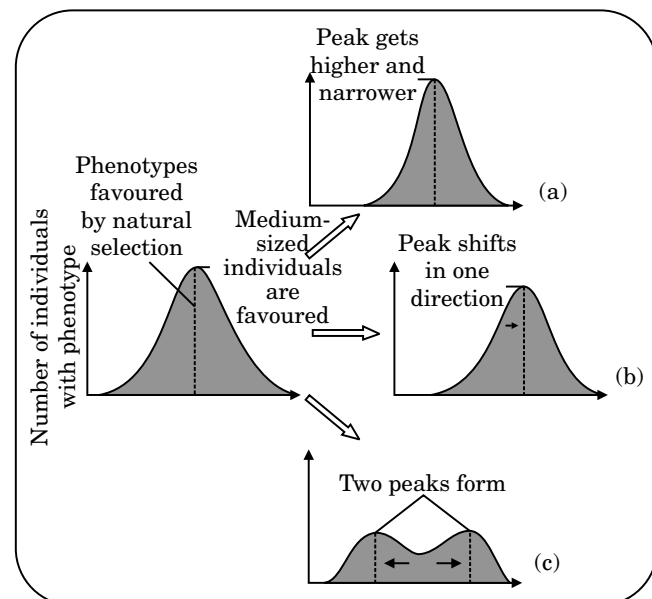


Fig.: Hardy weinberg principle

Hardy-Weinberg principle

The principle states that within a population, allele frequencies are stable and persistent from generation to generation.

In a population, total genes along with their alleles always remain a constant and this is referred to as genetic equilibrium. The total sum of every allelic frequency is 1.

Origin and Evolution of Man

- Primates called Dryopithecus (ape-like) and Ramapithecus (man-like) existed around 15 million years ago. They use to walk like chimpanzees and gorillas and were also hairy.
- According to few fossils found in Ethiopia and Tanzania, around three to four million years ago, man-like primates existed in eastern parts of Africa.
- Around two million years ago, the first human-like creatures were traced back and were called Homo habilis. They assumingly did not eat meat.
- Homo erectus, who is supposed to have a large brain, probably ate meat.
- Then came the age of Homo sapiens found first in Africa and they moved across continents and evolved into distinct races.
- Around 18,000 years ago, pre-historic cave art developed. Agriculture came into existence about 10,000 years back. After that the human settlement started.

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 2

1 Mark Questions

1. Name the common ancestor of the great apes and man. [ALL INDIA 2011]
2. Write the probable differences in eating habits of Homo habilis and Homo erectus. [ALL INDIA 2016]
3. Write the names of the following:
 - (a) A 15 mya primate that was ape-like
 - (b) A 2 mya primate that lived in east African grasslands [DELHI 2018]

2 Marks Questions

4. With the help of an algebraic equation, how did Hardy-Weinberg explain that in a given population the frequency of occurrence of alleles of a gene is supposed to remain the same through generations? [DELHI 2018]

3 Marks Questions

5. $p^2 + 2pq + q^2 = 1$. Explain this algebraic equation on the basis of Hardy Weinberg's principle. [DELHI 2017]

6. Write the characteristics of Ramapithecus, Dryopithecus and Neanderthal man. [ALL INDIA 2017]
7. What does the following equation represent? Explain. [ALL INDIA 2015]

$$P^2 + 2pq + q^2 = 1$$

5 Marks Questions

8. (a) Name the primates that lived about 15 million years ago. List their characteristics feature.
 - (i) Where was the first-man like animal found?
 - (ii) Write the order in which Neanderthals, Homo habilis and Homo erectus appeared on earth. State the brain capacity of each one of them.
 - (iii) When did modern Homo sapiens appear on this planet? [DELHI 2011]



Solutions

1. Dryopithecus was the common ancestor of the great apes and man. [1]
2. Eating habits of Homo habilis and Homo erectus were different. Homo habilis did not eat meat while Homo erectus were likely to be meat eating. [1]
3. (a) Dryopithecus [½]
(b) Australopithecines [½]
4. In a given population, the frequency of occurrence of alleles of a gene can be found out. According to Hardy-Weinberg's principle the allele frequencies in a population are stable and is constant over generations. The total genes and their alleles in a population remains a constant. Then this is called genetic equilibrium. Sum total of all the allelic frequencies is 1. [1]
It means $p^2 + 2pq + q^2 = 1$.
This is a binomial expansion of $(p+q)^2$. When frequency of each trait is measured, if it differs from expected values, then the difference (direction) indicates the extent of evolutionary change. Disturbance in genetic equilibrium, or Hardy-Weinberg equilibrium, i.e., change of frequency of alleles in a population would then be interpreted as resulting in evolution. [1]
5. Hardy-Weinberg principle states that allele frequency in a population is stable and remain constant from generation to generation. The gene pool remains constant and known as genetic equilibrium.
 $p^2 + 2pq + q^2 = 1$

p^2 represents frequency of homozygous dominant genotype

$2pq$ represents frequency of heterozygous genotype

q^2 represents frequency of homozygous recessive genotype

Sum total of all frequency is 1

Over several generations if the gene frequencies remains constant, it indicates that, no evolution has taken place. Change in gene frequencies would indicate that evolution is in progress. [3]

6. The characteristics of Ramapithecus, Dryopithecus and Neanderthal man:
 Ramapithecus was primate which were was more man-like walked erect on their feet. They had small canines and large molars. [2]
 Dryopithecus was primate, more ape-like. He had arms and legs equal. Muzzles and canine large
 Neanderthal was primate with erect posture, sloping forehead and flat cranium. [1]
7. According to Hardy—Weinberg law, the given equation represents the gene frequency of the total population. Suppose a gene has two alleles A and a, then p is the frequency of occurrence of dominant allele A and q is the frequency of

occurrence of recessive allele a in the parental generation. [1]

Then according to the equation,

P^2 = Frequency of occurrence of individuals with homozygous dominant alleles (AA) [1]

$2pq$ = Frequency of occurrence of individuals with heterozygous alleles (Aa)

q^2 = Frequency of occurrence of individuals with homozygous recessive alleles (aa)

1 is the sum of all frequencies. [1]

8. (a) Dryopithecus and Ramapithecus are the primates that lived about 15 million years ago. These primates were hairy and walk look like chimpanzees. Ramapithecus were more similar to man whereas Dryopithecus were more similar to ape. [2]
- (b) (i) The first man like animal was found in Africa. [1]
- (ii) Order according to the evolution on the earth include Homo habilis having brain capacity of 650-680 cc, Homo erectus having brain capacity of 900 cc and Neanderthal having brain capacity of 1400 cc. [1]
- (iii) Modern Homo sapiens appear on this planet around 75000 year ago. [1]

Human Health and Diseases

Chapter Analysis with respect to Last 3 Years' Board Exams

List of Topics	2016		2017		2018
	Delhi	All India	Delhi	All India	Delhi/All India
Pathogens					
Parasites causing human diseases (Malaria, Filariasis, Ascariasis, Typhoid, Pneumonia, common cold, amoebiasis, ring worm)		1Q (3 marks)		1Q (3 marks)	1Q (2 marks)
Basic concepts of immunology - vaccines	1Q (3 marks)	1Q (3 marks)		1Q (2 marks)	1Q (1 mark)
Cancer, HIV and AIDs; Adolescence, drug and alcohol abuse				1Q (3 marks)	1Q (2 marks)

On the basis of above analysis, it can be said that from exam point of view the concepts Immune Responses, blood Transfusion, Social Issue, Human Diseases, Symptoms and Preventive measures, Immunity and Drugs are most important concepts of the chapter.

[Topic 1] Health, Common Diseases in Human and Immunity

Summary

Health and Disease

• Introduction:

- Health is a state of complete physical, mental, social and well-being. Human health can be affected by lifestyle, genetic disorders and infections. Good health is maintained by regular exercise, balanced diet and personal hygiene.
- When functioning of one or more organs or systems of the body is affected, that state is called disease. Diseases are grouped as infectious and non-infectious.
- The diseases caused by gene mutation, chromosomal aberrations or environmental factors are congenital as they are present in the body from birth.
- The diseases which are developed after birth are acquired diseases which can further be of two types: Communicable and non-communicable diseases.
- The diseases which are infectious and caused by bacteria, fungi, protozoa, etc. are communicable while the diseases which do not spread and remain confined to people like deficiency diseases, allergies, cancer and degenerative diseases are non-communicable diseases.

Common Diseases in Humans

Infectious diseases can be divided into five types: Bacterial, Viral, Protozoan, Fungal and Helminthic.

• Bacterial Diseases:

➤ Typhoid:

It is caused by bacterium *Salmonella typhi* and the symptoms include stomach pain, high fever, weakness, headache etc.

➤ Pneumonia:

It is caused by bacterium *Streptococcus pneumoniae* and *Haemophilus influenzae* and the symptoms include fever, cough, chills, headache, etc.

➤ Dysentery:

It is caused by bacterium *Shigella bacillus* and the symptoms include abdominal cramps, diarrhea, stomach-ache, etc.

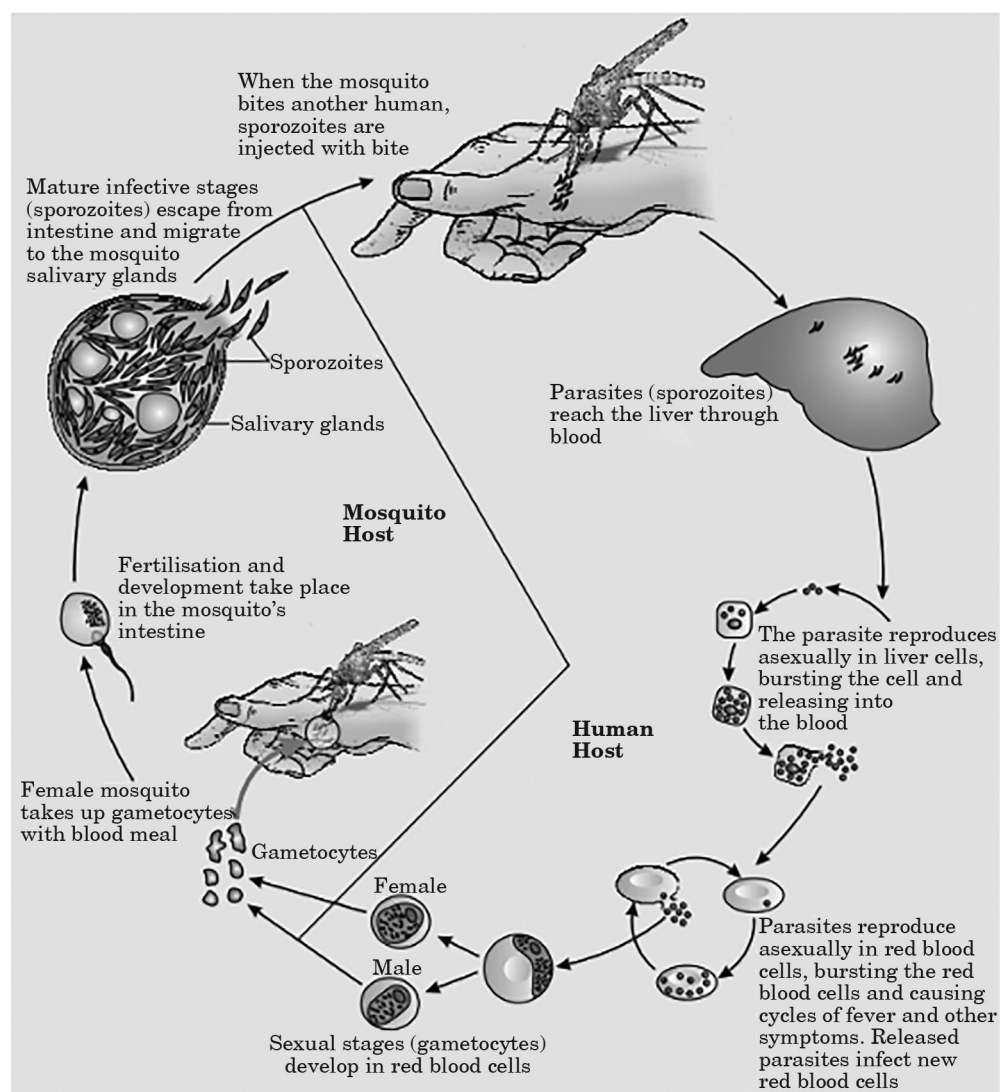


Fig.: Stages in Lifecycle of *Plasmodium*

- **Viral Disease:**
 - **Common cold:** It occurs due to rhino viruses. It is characterized by sore throat, cough, headache, nasal congestion, etc. It can be caused by transmission through contaminated objects.
- **Protozoan Diseases:**
 - **Malaria:** Plasmodium is a protozoan which causes malaria. Plasmodium has four different species: *P. Vivax*, *P. ovale*, *P. malariae*, *P. falciparum*. The malignant, malaria caused by *P. falciparum* is the most serious one and can be fatal. Symptoms of malaria include, high fever, sweating, headache,, nausea, fatigue, etc.
- **Fungal Disease:**
 - **Ringworm:** It is a type of fungal disease which is caused by fungi *Epidermophyton*, *Microsporium*, and *Trichophyton*. It occurs from use of comb, clothes, etc. of infected person or from soil. It grows in region like skin folds, in between toes by heat and moisture. Appearance of scaly, dry lesions on skin, scalp and nails, intense itching are some of its symptoms.
- **Helminthic Diseases:**
 - **Ascariasis:** Intestinal endoparasite called *Ascaris* or common round worm is the main cause of Ascariasis. The eggs of parasite are excreted along with the faeces of infected person contaminate soil, water, plants, etc. which reaches to human beings and cause infection. Fever, internal bleeding, anemia are some of its symptoms.
 - **Filariasis/Elephantiasis:** It is caused by filarial worms (*Wuchereria malayi*, *Wuchereria bancrofti*). The organs in which worm lives gets severely inflamed. Genital organs and limbs are deformed which are affected by it.
- **Prevention and Control of Diseases:**
 - Maintaining personal hygiene by keeping the body clean, consuming clean drinking water, food, etc.
 - Maintaining public hygiene by disposing of wastes and excreta properly, cleaning and disinfecting water reservoirs and keeping a check on breeding places of vectors.

Immunity

It is the immune system which can prevent us from these diseases. Entry of pathogens can be blocked by various defenses present in our body. There are some antimicrobial substances present in saliva, tears, mucous membranes, skin helps to protect us from the pathogens which might enter into our body. Antibodies and specified lymphocytes are produced to work against specific antigens. Immunity is basically of two types: **Innate** and **Acquired**

- **Innate immunity:**
 - It is present in an individual since birth and remains throughout life and it is a non-specific defense system. The barriers could be of four types:
 - Physiological barrier: Microbial growth in the body is prevented by physiological barrier like tears from eyes, acid in stomach, saliva in mouth, etc.
 - Cytokine barrier: Virus infected cells which secrete protein called interferon protect non infected cells from further viral infection.
 - Physical barrier: They prevent microorganisms to enter different parts of the body like gastrointestinal tracts, skin, etc.
 - Cellular barrier: These destroy microbes. Example: Some natural killer cells in the blood, polymorpho-nuclear leukocytes, etc.
- **Acquired immunity:**
 - It is acquired in the body of an individual after birth and can be short lived.
 - If same pathogen is exposed several times then immune response would be quick as our immune system have a good memory.
 - These responses are produced by B-lymphocytes (produce antibodies) and T-lymphocytes (help B-cells to produce antibodies).
 - Structure of antibody: Antibody is represented as H₂L₂ as each antibody molecule has 4 peptide chains out of which two are small, called light chains and 2 are longer called heavy chains.
 - There are two types of acquired immunity response – humoral immune response and cell-mediated immunity.

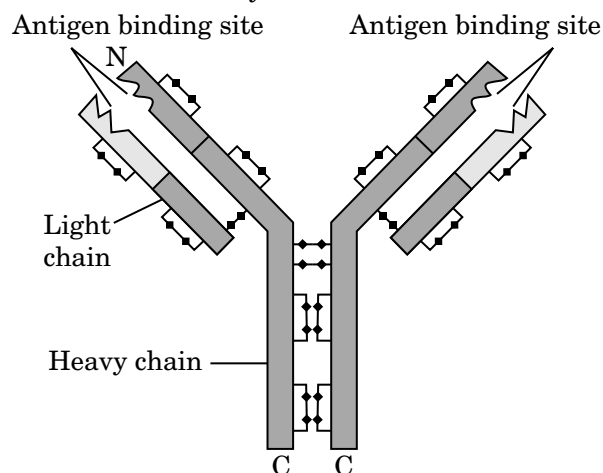


Fig.: Structure of an Antibody Molecule

- **Active and Passive immunity:**
 - Antibodies are produced in the host body as it is exposed to antigens present in the form of living or dead microbes. This type of immunity is called active immunity.

➤ In some cases, antibodies are prepared and just provided to the body to protect against foreign agents. This type of immunity is called passive immunity.

• **Immunization:**

➤ Active Immunization: When a vaccine is introduced in body, the antibodies which are produced against the antigens neutralize the pathogenic agents during infection.

➤ Passive Immunization: It is pre-formed antibodies or antitoxin, introduced in body as injections for quick immune response.

• **Allergy:**

➤ An amplified response to some antigens called allergens present in the environment is called allergy. Some of the allergens are mites in animal dander, dust, pollens, etc.

➤ Histamine and serotonin are some of the chemicals which are released from mast cells due to which causes allergy.

➤ Running nose, sneezing, difficulty in breathing are some of the symptoms of allergy.

➤ Anti-histamine, steroids and adrenaline are used to quickly reduce the symptoms of allergy.

• **Auto Immunity:**

➤ Higher vertebrates can differentiate foreign organisms and foreign molecules.

➤ Body attacks self cells due to genetic and some other unknown reasons which is called auto-immune disease causing damage to the body.

➤ One of the example of auto-immune disease is Rheumatoid arthritis.

• **Immune System in Human Body:**

➤ Immune system plays a vital role in identifying foreign antigens, remembering them and responding them. It is crucial in allergic reactions, organ transplantation and auto immune diseases. Immune system in human body comprises of lymphoid organ, tissues, cells and soluble molecules like antibodies.

➤ Lymphoid Organs: The organs where lymphocytes originate, mature and proliferate. They are of two types- primary lymphoid organs and secondary lymphoid organs.

➤ Bone marrow and thymus come under primary lymphoid organs, whereas spleen, tonsils, lymph nodes and MALT are examples of secondary lymphoid organs.

• **AIDS:**

➤ A sexually transmitted disease called AIDS (Acquired Immune Deficiency Syndrome) kill number of people worldwide.

➤ A retrovirus which has RNA genome, Human Immunodeficiency Virus (HIV) is the reason for AIDS.

➤ Its infection can be spread by various ways like infected blood, sexual intercourse, contaminated needles, etc.

➤ There are various symptoms of AIDS like mononucleosis-like symptoms (high fever, chills, itchy rash, swollen lymph glands, etc.), weakness and weight loss.

➤ AIDS can be treated by antiretroviral drugs and it is only partially effective. It can prolong the life of the patient but cannot prevent death.

➤ AIDS is diagnosed by ELISA test (Enzyme-linked immune-sorbent assay)

➤ Prevention involves- controlling drug abuse, advocating safe sex, educating people about AIDS, etc.

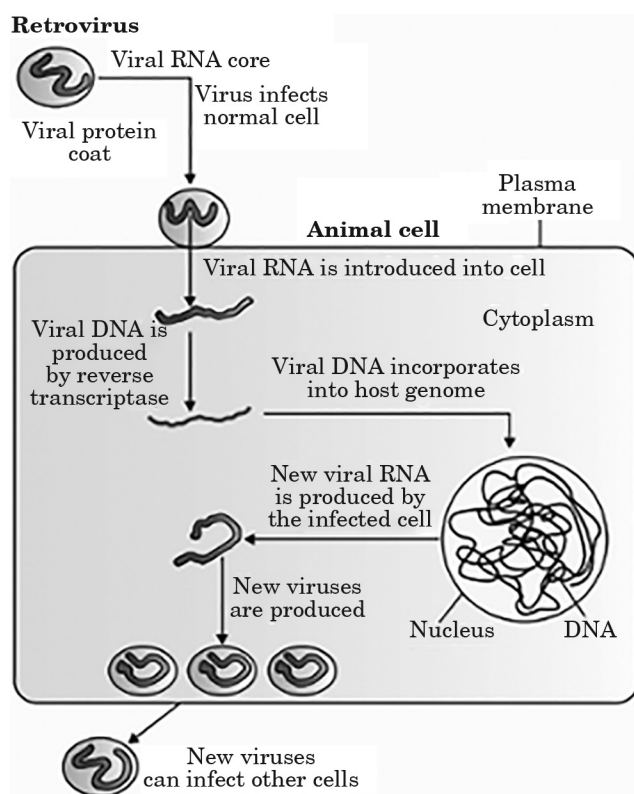


Fig.: Replication of Retrovirus

• **Cancer:**

➤ It is the proliferation or uncontrolled growth of cells. These cells divide uncontrollably and are not affected by growth factors or property of growth inhibition.

➤ A large mass of cells is formed by repeated division called tumors. The cancer cells move from one part to other part of the body by body fluids.

➤ There are two types of tumors- benign tumor which is confined to its place of origin and is less harmful and other is malignant tumor which keeps spreading to nearby tissues and is fatal.

- Agents which cause transformation of normal cells into cancerous cells are called carcinogens. They can be physical agents, chemical or biological.
- Cancer can be detected by various methods like:
 - Computed Tomography where a 3-D image is generated using X-rays.
 - It can be detected by histopathological studies and biopsy of the tissue.
 - Non-ionizing radiation and strong magnetic field is used for resonance imaging. It detects physiological and pathological changes in living tissue.
 - Different tests can be conducted like bone marrow and blood test for increased cell counts.
 - Cancer in internal organs can be detected using radiography by X-rays.
- Cancer can be treated by various methods:
 - Chemotherapy is done to kill cancer cells but the drugs used cause some side effects as well.
 - Surgery can be done for Tumors to avoid further spread of cells.
 - Immune system can be activated by some immunotherapy response modifiers.

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 1

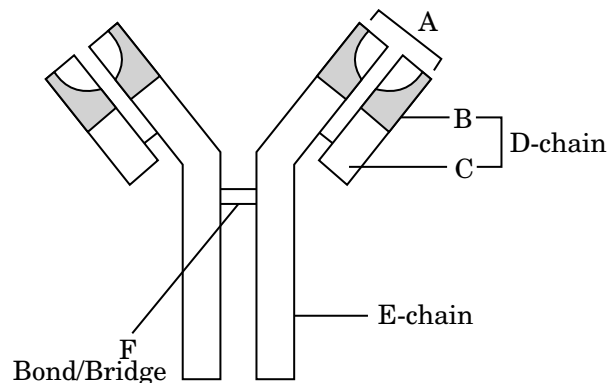
▣ 1 Mark Questions

1. State two different roles of spleen in the human body. **[DELHI 2012]**
2. Name any two types of cells which act as 'Cellular barriers' to provide Innate Immunity in humans. **[DELHI 2014]**
3. Why is secondary immune response more intense than the primary immune response in humans? **[ALL INDIA 2014]**
4. How do cytokine barriers provide innate immunity in humans? **[ALL INDIA 2018]**
5. Name two diseases whose spread can be controlled by the eradication of *Aedes* mosquitoes. **[DELHI 2018]**

▣ 2 Marks Questions

6. Name the two types of immune systems in a human body. Why are cell mediated and humoral immunities so called? **[DELHI 2011]**
7. Write the scientific names of the causal organisms of elephantiasis and ringworm in humans. Mention the body parts affected by them. **[DELHI 2011]**

8. Identify A, D, E and F in the diagram of an antibody molecule given below: **[DELHI 2011]**



9. Differentiate between benign and malignant tumours. **[ALL INDIA 2011]**
10. Name the two special types of lymphocytes in humans. How do they differ in their roles in immune response? **[DELHI 2012]**
11. Name the bacterium that causes typhoid. Mention two diagnostic symptoms. How is this disease transmitted to others? **[DELHI 2012]**
12. (a) Highlight the role of thymus as a lymphoid organ.
(b) Name the cells that are released from the above mentioned gland. Mention how they help in immunity. **[ALL INDIA 2012]**
13. (a) Name the protozoan parasite that causes amoebic dysentery in humans.
(b) Mention the diagnostic symptoms of the disease.
(c) How is the disease transmitted to others? **[ALL INDIA 2012]**
14. Write the events that take place when a vaccine for any disease is introduced into the human body. **[ALL INDIA 2013]**
15. Why is a person with cuts and bruises following an accident administered tetanus antitoxin? Give reasons. **[ALL INDIA 2013]**
16. List the symptoms of Ascariasis. How does a healthy person acquire this infection? **[ALL INDIA 2014]**
17. Mention one application for each of the following:
 - (a) Passive immunization
 - (b) Antihistamine
 - (c) Colostrum
 - (d) Cytokinin-barrier **[ALL INDIA 2017]**

▣ 3 Marks Questions

18. (i) Write the scientific names of the two species of filarial worms causing filariasis.
(ii) How do they affect the body of infected person?
(iii) How does the disease spread? **[ALL INDIA 2011]**

19. Trace the life-cycle of malarial parasite in the human body when bitten by an infected female Anopheles. [DELHI 2012]
20. Community Service department of your school plans a visit to a slum area near the school with an objective to educate the slum dwellers with respect to health and hygiene.
- (a) Why is there a need to organize such visits?
(b) Write the steps you will highlight, as a member of this department, in your Interaction with them to enable them to lead a healthy life. [ALL INDIA 2014]
21. A team of students are preparing to participate in the interschool sports meet. During a practice session you find some vials with labels of certain cannabinoids.
- (a) Will you report to the authorities? Why?
(b) Name a plant from which such chemicals are obtained.
(c) Write the effect of these chemicals on human body. [DELHI 2015]
22. A heavily bleeding and bruised road accident victim was brought to a nursing home. The doctor immediately gave him an injection to protect him against a deadly disease.
- (a) Write what the doctor injected into the patient's body.
(b) How do you think this injection would protect the patient against the disease?
(c) Name the disease against which this injection was given and the kind of immunity it provides. [ALL INDIA 2015]
23. During a school trip to 'Rohtang Pass', one of your classmate suddenly developed 'altitude sickness'. But, she recovered after sometime.
- (a) Mention one symptom to diagnose the sickness.
(b) What caused the sickness?
(c) How could she recover by herself after sometime? [DELHI 2016]
24. (a) It is generally observed that the children who had suffered from chicken-pox in their childhood may not contract the same disease in their adulthood.' Explain giving reasons the basis of such an immunity in an individual. Name this kind of immunity.
(b) What are interferons? Mention their role. [ALL INDIA 2016]
25. (a) What precaution(s) would you recommend to a patient requiring repeated blood transfusion?

- (b) If the advice is not followed by the patient, there is an apprehension that the patient might contract a disease that would destroy the immune system of his/her body. Explain with the help of schematic diagram only how the immune system would get affected and destroyed. [ALL INDIA 2016]
26. Name a human disease, its causal organism, symptoms (any three) and vector, spread by intake of water and food contaminated by human faecal matter. [ALL INDIA 2017]

5 Marks Questions

27. Describe the asexual and sexual phases of life cycle of Plasmodium that causes malaria in humans. [DELHI 2013]

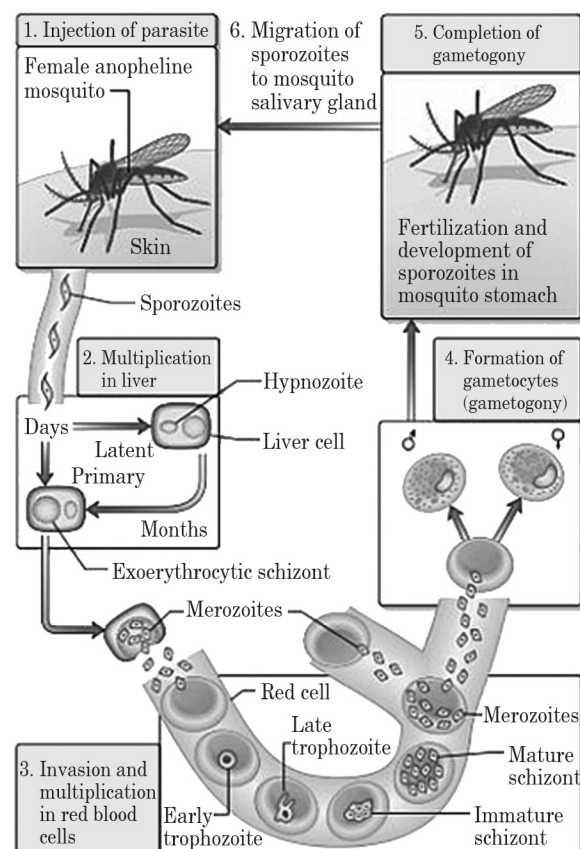


Fig.: Plasmodium life cycle

28. A person in your colony has recently been diagnosed with AIDS. People/residents in the colony want him to leave the colony for the fear of spread of AIDS.
- (a) Write your view on the situation, giving reasons.
(b) List the possible preventive measures that you would suggest to the residents of your locality in a meeting organised by you so that they understand the situation.

- (c) Write the symptoms and the causative agent of AIDS [ALL INDIA 2013]
29. (a) Cancer is one of the most dreaded diseases of humans. Explain 'Contact inhibition' and 'Metastasis' with respect to the disease.
- (b) Name the group of genes which have been identified in normal cells that could lead to cancer and how they do so?
- (c) Name any two techniques which are useful to detect cancers of internal organs.
- (d) Why are cancer patients often given -interferon as part of the treatment? [DELHI 2014]
10. T cell and B cells are the two special types of lymphocytes in humans. B cells are a part of humoral immune response and respond to antigen by producing antibodies. T cell is a part of cell mediated immunity and respond to antigen by helping B cells to produce antibodies. [2]
11. Salmonella typhi is the bacterium that causes typhoid. Stomach pain and headache are two diagnostic symptoms. This disease is transmitted through contaminated food or water. [2]
12. (a) Thymus is an important gland involved in the maturation of lymphocytes and T cells.
- (b) T cells are produced from thymus gland. T cells help the B cells in producing antibodies and are a part of cell mediated immunity. [1+1]
13. (a) Entamoeba histolytica is the parasite that lives in small intestine, and causes amoebic dysentery in humans. [1]
- (b) Diagnostic symptoms of the disease include stool with blood and abdominal pain and cramps. [½]
- (c) The disease is transmitted through contaminated food and drinking water. [½]
14. Vaccine stimulates the production of antibody and memory cells because it acts as a weak antigen when the first time vaccine is given for specific antigen. When this pathogen enters the second time (during an infection) in the body then memory cells generated in prior vaccination, elicits a rapid and massive response against the pathogen. [2]
15. Tetanus antitoxin contains antibody against pathogen it binds and inactivates pathogen. This is an example of passive immunity. [2]
16. Blockage of intestine passage, muscular pain, anaemia, internal bleeding are the symptoms of Ascariasis. A healthy person acquire this infection by the foods contaminated with the eggs of parasite. [2]
17. (a) Passive immunisation is a process of acquiring immunity. It is achieved by introducing ready made antibodies into the body. It provides quick immune response to the body. [½]
- (b) Antihistamines are the chemicals which are given against allergic reactions. [½]
- (c) Colostrum is the yellow fluid comes out from the mother's breast just after the child birth. It contains antibodies which provide passive immunity to the new born. [½]

Solutions

- Two different roles of spleen in the human body are filtering of the blood and recycling of old blood cells. [1]
- Natural killer cells and leukocytes are two types of cells which act as 'Cellular barriers' to provide Innate Immunity in humans. [1]
- In secondary immune response, memory cells get activated and come in action when the second time the person is exposed to same antigen, therefore, the secondary immune response is more intense than the primary immune response in humans. [1]
- Innate immunity is an important component of the host defense against infection. Innate immunity is initiated within hours of infection and provides a rapid defence by secreting proteins called interferons which protect non-infected cells from further viral infection. [1]
- Dengue and Chikungunya can be controlled by the eradication of Aedes mosquito. [1]
- Cell mediated and humoral immunity are two types of immune systems in a human body. Humoral immunity involve the B lymphocytes which produced the antibodies and cell mediated immunity involve the T lymphocytes. [2]
- Scientific names of the causal organisms of elephantiasis is Wuchereia bancrofti and scientific names of the causal organisms of ringworm is Trichophyton. Body parts affected in elephantiasis is lower limb lymphatic vessels and body parts affected by ringworm is skin. [2]
- A is representing antigen binding site, D is representing light chain, E is representing heavy chain, F is representing disulphide bonds. [2]
- Benign tumours is located at a single place and cannot spread from one part of the body to another whereas malignant tumours involve the movement of cancer cells from one part of the body to another. [2]

- (d) Cytokinin-barrier is a glycoprotein which protects non-infected cells from further viral infection. [½]
18. (i) The scientific names of the two species of filarial worms causing filariasis are *Wuchereria bancrofti* and *Wuchereria malayi*. [1]
- (ii) Both the worms attack the lymphatic vessels of lower limb. This result in the swelling of lower limbs and result in the disease called as elephantiasis. [1]
- (iii) The disease spread is spread through female mosquito bite. [1]
19. *P. falciparum* enter into the human body in the form of a sporozoite through a bite from a female *Anopheles* mosquito and enters the blood stream followed by liver cells. There they reproduce asexually by dividing into schizonts that consist of many merozoites. [1]
- In the mosquito gut they undergo sexual reproduction, the microgamete nucleus divides three times and fertilizes a macrogamete forming a zygote. The zygote, after fertilization, changes into - ookinete. The ookinete, then, enter the mosquito midgut wall, where it encysts into a formation called oocyst. [2]
20. (a) There a need to organize such visits to create the awareness in the people about the need of hygiene to prevent many diseases that are spread through contaminated food and water. [1]
- (b) The steps I will highlight, as a member of this department are:
- (i) Will teach them about the importance of healthy life.
- (ii) Will teach them about deadly diseases and the vaccination of these diseases.
- (iii) Will teach them about the proper disposal of garbage. [1+1]
21. (a) Of course I will tell the authority about the presence of vials. As cannabinoids is a type of drug. Intake of this drug is illegal practice. [1]
- (b) It is obtained from the inflorescences of the plant *Cannabis sativa* plant. [1]
- (c) Cannabinoids effects on cardiovascular system of the body. [1]
22. (a) The patient was injected with antiserum containing preformed antibodies against the organism that may cause infection or toxin produced by it. [1]
- (b) The preformed antibody injected, act on the pathogen immediately to provide protection. [1]
- (c) The injection was given to prevent tetanus caused by *Clostridium tetani*, which usually exists in environment as spores and may again access to the body through wound. The injection containing antiserum provides quick response by giving passive immunity. [1]
23. (a) The symptoms may appear as nausea, fatigue and heart palpitation. [1]
- (b) The sickness was due to low atmospheric pressure which prevails at high altitude. At the high altitude, the body does not get sufficient oxygen due to low atmospheric pressure. [1]
- (c) The body of the girl student compensates low oxygen availability by increasing number of red blood cells (RBC) production. The binding affinity of haemoglobin decreases. Hence, breathing rate increases and the body gets acclimatised. [1]
24. (a) The children who have suffered from chickenpox in their childhood may not suffer from the disease again due to acquired active immunity. The first infection of chicken pox produces a primary response of low intensity against chicken pox virus. On subsequent encounters with the same pathogen, a secondary response occurs of high intensity. This is attributed to the fact that our body has memory of the pathogen from the first encounter which had resulted in the production of antibodies against the pathogen. Hence, no contract with disease. [2½]
- (b) Interferons are proteins secreted by virus-infected cells. These interferons protect the non-infected cells from getting infected by inhibiting viral replication. When an interferon is given to cancer patient it activates immune system and may destroy tumour. [1½]
25. (a) The patients who require regular blood transfusion should take following precautions: I. Every time use of new sterilised needle for blood transfusion. II. Transfused blood must be tested for HIV and it should be HIV free. [1]
- (b) In case contaminated blood is infected, HIV virus may enter and cause AIDS. [1]

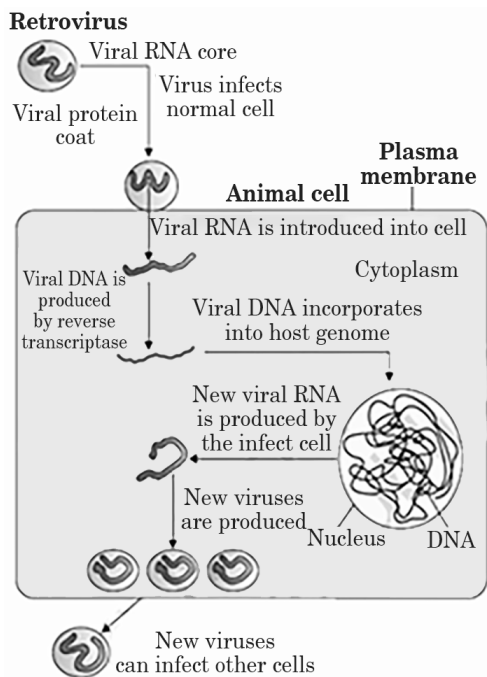


Fig.: Schematic diagram showing how immune system get affected and destroyed [1]

26.

Disease	Causal organism	Symptoms	Vector
Amoebiasis (Amoebic dysentery)	<i>Entamoeba-histolytica</i> , is a protozoan parasite in the large intestine of human which causes	Symptoms of include constipation, abdominal pain and cramps, stools with excess mucous and blood clots.	Houseflies act as mechanical carriers and serve to transmit the parasite from faeces of infected person to food

[3]

27. *P. falciparum* go into the human in the form of a sporozoite through a bite from a female anopheles mosquito and enters the bloodstream followed by liver cells. There they reproduce asexually by dividing into schizonts that consist of many merozoites.

- In the mosquito gut they form sexual reproduction, the microgamete nucleus divides three times and fertilizes a macrogamete forming a zygote. The zygote, after fertilization, changed into - ookinete. The ookinete, then, enter the mosquito midgut wall, where it encysts into a formation called oocyst. [5]
28. (a) AIDS does not spread by shaking hand and use of common utensil so there is no need of fear to live with AIDS patient. [1]
- (b) Taking care of the blood during transfusion, use of only disposable needles and syringes in hospitals and clinics, free distribution of condoms, controlling drug abuse, advocating safe sex are some preventive measures that you would suggest to the residents of your locality in a meeting organised by you so that they understand the situation [2]
- (c) AIDS is caused by the Human Immuno deficiency Virus (HIV), which is a type of retrovirus. Symptoms of AIDS include fever, sore throat, weight loss, fever and recurrent infections. [2]
29. (a) Cancer is one of the most dreaded disease of humans. This is because it is associated with the phenomenon called as “metastatis” in which group of infected cells have a tendency to move from one location to another. Hence, the disease spread very fast and individuals die. [2]
- (b) Oncogenes and proto-oncogenes are the group of genes that have been identified in normal cells. These genes when become active under certain conditions, would lead to oncogenic transformation of the cells. [1]
- (c) Techniques such as radiography, CT (Computed Tomography) and MRI (Magnetic Resonance Imaging) are useful to detect cancers of internal organs. [1]
- (d) Cancer patients are often given alpha-interferons as part of their treatment because it activates a patient’s immune system and helps in destroying the tumour. [1]

[Topic 2] Adolescence and Drug/Alcohol Abuse

Drugs and Alcohol

Use of drugs and alcohol cause harmful effects on the body. Some commonly abused drugs are opioids, coca alkaloids and cannabinoids.

- **Opioids:**

- These drugs bind to the opioid receptors present in the central nervous system.
- Heroin which is chemically called diacetylmorphine is obtained from acetylation of morphine. It is a depressant which slows down body functions.

- **Cannabinoids:**
 - These interact with receptors present in the brain called cannabinoid receptors.
 - These are taken by oral ingestion or inhalation which affects cardiovascular system of the body.
 - Natural cannabinoids are obtained from plant *Cannabis sativa*.
- **Cocaine:**
 - It is obtained from the plant *Erythroxylum coca*. It has a stimulating action on the central nervous system.
 - It interferes with transportation of neurotransmitter dopamine.
- **Alcohol:**
 - Alcoholic drink is further divided into beverages and spirits. Wine, beer, etc. which have alcohol content between 5-15% come under beverages and whisky, brandy, etc. which have alcohol content more than 50% are types of spirits.
 - Alcohol has various effects on human body. It hampers speech, thinking ability, movement, blurred vision, loss of body balance, vomiting, nausea etc. It causes cirrhosis and fatty liver.

Adolescence and Drug/Alcohol Abuse

- **Adolescence:**
 - It is a phase in which child attains maturity for effective participation in society.
 - This phase links childhood and adulthood, which makes it crucial and vulnerable stage of life.
- **Causes of Drug or Alcohol Use in Adolescence Period:**
 - Curiosity, excitement, need for adventure are main causes of beginning drug or alcohol use by adolescents.

Addiction and Dependence

- **Addiction:**

It is a psychological attachment to effects such as euphoria and temporary feeling of well being associated with drugs and alcohol.
- **Dependence:**

The body's tendency to show a characteristic and unpleasant withdrawal syndrome because of regular dose of drugs or alcohol is dependence. It may lead to depression.

Effects of Drugs and Alcohol Abuse

- Showing reckless behavior, vandalism and violence are some adverse effects of drugs and alcohol abuse
- The chronic use of drugs and alcohol damages nervous system and liver this is termed as cirrhosis.

- Depression, fatigue, rebellious and aggressive behavior, withdrawal and isolation are some of the effects of alcohol and drugs.

Prevention and Control

- Measures like education and counseling, seeking help from parents and peers, avoid undue peer pressure, etc can be taken for prevention and control of drugs and alcohol abuse.

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 2

▣ 1 Mark Questions

1. How does smoking tobacco in human lead to the oxygen deficiency in their body?
[ALL INDIA 2012]
2. Why sharing of injection needles between two individuals is not recommended?
[DELHI 2013]
3. When does a human body elicit an anamnestic response?
[ALL INDIA 2013]

▣ 2 Marks Questions

4. Name the plant source of the drug popularly called "smack" How does it affect the body of the abuser?
[ALL INDIA 2012]
5. (a) Name the source plant of heroin drug. How is it obtained from the plant?
(b) Write the effects of heroin on the human body.
[DELHI 2018]

▣ 3 Marks Questions

6. (a) Why is there a fear amongst the guardians that their adolescent wards may get trapped in drug/alcohol abuse?
(b) Explain 'addiction' and 'dependence' in respect of drug/alcohol abuse in youth.
[ALL INDIA 2017]

Solutions

1. Smoking tobacco produces blood carbon monoxide content and decreases the oxygen binding capacity of the blood. It causes Oxygen deficiency in their body. [1]
2. Sharing of injection needles between two individuals is not recommended because it can spread disease and infection from unfit person to healthy person. [1]

3. An anamnestic response also known as secondary immune response. Human body elicit an anamnestic response when it gets exposed to same antigen second time. [1]
4. *Papaver somniferum* is the source of the drug popularly called "smack". It affects the respiratory and circulatory depressant and slows down body functions. [2]
5. (a) Heroin commonly called smack is chemically diacetyl morphine which is a white, odourless, bitter crystalline compound. This is obtained by acetylation of morphine, which is extracted from the latex of poppy plant *Papaver somniferum*. [1]
(b) Heroin is a depressant and slows down body functions. [1]
6. (a) Reasons for fear amongst the guardians of their adolescents for trapping habits of alcohol or drug abuse:
 - (i) Influence of Peer pressure.
 - (ii) Out of curiosity, excitement and experiment.
 - (iii) To escape from stress, frustration and depression.
 - (iv) To overcome hardships of life.
 - (v) No supportive family members. [2](b) Addiction: The psychological attachment to some effects such as euphoria and a feeling of temporary well-being associated with drugs and alcohol. Dependence: The tendency of the body that shows withdrawal symptoms when doses of drug or alcohol is suddenly discontinued. [1]

Strategies for Enhancement in Food Production

Chapter Analysis with respect to Last 3 Years' Board Exams

List of Topics	2016		2017		2018
	Delhi	All India	Delhi	All India	Delhi/All India
Improvement in food production : Plant breeding, tissue culture, single cell protein, Biofortification	1Q (2 marks), 1Q (3 marks)	1Q (3 marks), 1Q (2 marks)	1Q (2 marks),	1Q (3 marks)	1Q (2 marks)
Apiculture and Animal husbandry	1Q (1 mark)		1Q (3 marks)		1Q (3 marks)

On the basis of above analysis, it can be said that from exam point of view the concepts Bio-control Agents, Bioactive Molecules, Disease Resistance and Plant/Animal Breeding Techniques are most important concepts of the chapter.

[Topic 1] Animal husbandry

Summary

It is the agricultural practice of breeding and raising livestock like buffaloes, cows, pigs, goats, etc.

Management of farms and farm animals

- **Dairy farm management:**

- It deals with the processes and systems that increase yield and improve quality of milk.
- For better yield from cattle:
 - The cattle needs to be well fed, well housed get adequate water and remain disease free
 - Special emphasis should be given to quality and quantity of fodder.
 - Cleanliness and hygiene of cattle should be the main priority while milking and then while storing and transporting the milk.

- **Poultry farm management:**

- Poultry is the class of domesticated fowl used for food or for their eggs.
- Aspects of poultry farm management:
 - The breed that is selected should be disease free and suitable for breeding and it also includes proper feed and water for domesticated birds, hygienic and health care of birds, proper and safe farm conditions.

Animal Breeding

It aims at increasing the yield of animals and improving the desirable qualities of the produce.

- **Inbreeding:**

- When mating is between animals of the same breed for 4 to 6 generations is called as inbreeding.
- Superior males and females of breed are mated in pairs to get superior progeny.
- Superior female is the cow or buffalo that produces more milk and superior male is the bull that helps in producing superior progenies.
- Inbreeding helps in increasing homozygosity to evolve a pure line animal. It also plays a role in accumulating superior genes and discarding less desirable genes.
- However, it also results in inbreeding depression, where the progeny may reduce productivity and fertility.

- **Outbreeding:**

- When breeding is between different breeds of animals or breeding of unrelated animals or different species altogether.
- Types of outbreeding:
 - Out-crossing: Mating of animals within the same breed, but having no common ancestors on either side of their pedigree up to 4-6 generations. It helps in overcoming inbreeding depression.
 - Cross-breeding: In this, superior males of one breed is crossed with superior females of another breed.
 - Interspecific hybridization: In this method the male and female animals of two different species are crossed. The progeny attains desirable characters from both the parents.
 - Controlled Breeding Experiments: It is carried out using artificial insemination. In this method the semen is collected from the male that is chosen as a parent and injected into the reproductive tract of the selected female by the breeder.

- **Bee keeping:**

- It is also called apiculture. It deals with the maintenance of hives of honeybees for the production of honey and bee wax.
- Honey and bee wax both have industrial purpose. Honey is used in various medicines and for consumption as it is high in nutritional value. Bee wax is used in preparing cosmetics, polishes, etc.
- Bees also help in pollination of various flowering plants and crops.

- **Fisheries:**

- This industry deals with the catching, processing or selling of fish, shellfish or other aquatic animals.
- In coastal area it is major source of employment and income, as it is the only source of livelihood for many.

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 1

▣ 1 Mark Questions

1. Suggest the breeding method most suitable for animals that are below average in milk productivity. [DELHI 2016]

2. Write the name of the following:
 - (a) The most common species of bees suitable for apiculture
 - (b) An improved breed of chicken [DELHI 2012]
3. Write the importance of MOET. [DELHI 2013]

▣ 2 Marks Questions

4. State the disadvantage of inbreeding among cattle. How it can be overcome? [DELHI 2014]

▣ 3 Marks Questions

5. Enlist the steps involved in inbreeding of cattle. Suggest two disadvantages of this practice. [DELHI 2015]
6. Enumerate any six essentials of good, effective Dairy Farm Management Practices. [ALL INDIA 2015]
7. (a) Write the two limitations of traditional breeding technique that led to promotion of micro propagation.
(b) Mention two advantages of micro propagation.
(c) Give two examples where it is commercially adopted. [ALL INDIA 2016]
8. (a) What is inbreeding depression?
(b) Explain the importance of "selection" during inbreeding in cattle. [DELHI 2017]
9. Explain out-breeding, out-crossing and cross-breeding practices in animal husbandry. [DELHI 2018]
10. What is inbreeding depression and how is it caused in organisms? Write any two advantages of inbreeding. [DELHI 2011]
11. (a) What is the programme called that is involved in improving success rate of production of desired hybrid and herd size of cattle?
(b) Explain the method used for carrying this programme for cows. [DELHI 2012]
12. Differentiate between the inbreeding and out breeding in cattle. State one advantage and one disadvantage for each of them. [DELHI 2013]

▣ 5 Marks Questions

13. (a) State the objective of animal breeding.
(b) List the importance and limitations of inbreeding. How can the limitations be overcome?
(c) Give an example of a new breed each of cattle and poultry. [ALL INDIA 2014]



Solutions

1. To improve productivity in animals any one of the following methods can be followed: Outbreeding, outcrossing, cross-breeding, artificial insemination, hybridisation, etc. [1]
2. (a) *Apis indica* is the most common species of bees suitable for apiculture [½]
(b) Leghorn is an improved breed of chicken [½]
3. Multiple Ovulation and Embryo Transfer (MOET) is an advanced method of cattle breeding which increases the cattle size in a short time including added benefits like production of lean meat (less lipid and more protein content) and high milk yielding breeds of females. [1]
4. Inbreeding among cattle result in inbreeding depression. It can be overcome by outbreeding. [2]
5. Inbreeding is the process of the mating of more closely related individuals within the same breed for 4-6 generations. [½]
The steps involved in breeding of cattle:
 - (a) Selection of superior males and superior females of the same breed. [½]
 - (b) Allowed them to mate. [½]
 - (c) Evaluation of the progeny obtained from them after mating. [½]
 - (d) Superior males and females among them are identified for further mating. [½]
 - (e) A superior female in the case of cattle gives more milk and superior male can gives superior progeny as compared to those of other males. [½]
 Continued inbreeding reduces fertility and even productivity.
6. The essentials of good and effective dairy farm management practices are:
 - (i) Selection of good and healthy breed of dairy farm animals. [½]
 - (ii) Cattle shed should have adequate ventilation, suitable inside temperature, sufficient light, water, air and well-drained drains and sufficient accommodation space. [½]
 - (iii) Each animal should be given proper and balanced feed. [½]
 - (iv) Hygiene and proper cleanliness should be included in the housing of animals. [½]
 - (v) Animals should be vaccinated regularly in order to protect them from diseases. [½]
 - (vi) Regular visits by a veterinary doctor is must. [½]

7. (a) Two limitations of traditional breeding which led to the promotion of micropropagation:
- (i) Productivity of Hybrids is much lower as compared to tissue culture.
 - (ii) Hybrid character get segregate in future generations. Cost of producing Hybrids is very high. I uncertainty of desired combination. [1]
- (b) Two advantages of micropropagation:
- (i) This process can produce larger number of plants in very short time.
 - (ii) Produces disease free plants. [1]
- (c) Micropropagation technology is commercially adopted for:
Tomato and banana plants. [1]
8. (a) When inbreeding is carried for long time it usually reduces fertility, and even productivity or yield. The continued inbreeding is called inbreeding depression. [1½]
- (b) "Selection" during inbreeding in cattle helps in accumulation of superior genes and discard undesirable genes. Hence, it increases homozygosity and pure lines. It helps to restore fertility and helps to increase yield. [1½]
9. Out-breeding, out-crossing and cross-breeding are breeding practices for animals. These practices are carried out to increase the yield. **Out-breeding** is the Breeding of unrelated animals of the same breed but not having common ancestors for 4-6 generations (outcrossing) or of different breeds (cross-breeding) or even different species (interspecific hybridisation). [1]
- Out-crossing** is a type of out-breeding in which mating of animals, within the same breed but having no common ancestors on either side of their pedigree up to 4-6 generations and the resulting offspring is called outcross. It is the best breeding method for animals. [1]
- Cross-breeding** is also a type of out-breeding in which the mating of superior males of one breed is done with the superior female of another breed is called cross- breeding. This is done to combine the desirable qualities of two breeds into a single individual. [1]
10. Continued inbreeding specially close inbreeding, usually reduces productivity and fertility as recessive genes get exposed. Two advantages of inbreeding are superiority is maintained among generation and true breeding trait is obtained. [3]

11. (a) The programme is called by name Multiple Ovulation Embryo Transfer Technology (MOET). [1]
- (b) In this method a cow is administered hormones to induce follicular maturation and super ovulation --instead of one egg which they normally yield per cycle they produce 6-8 eggs. The animal is either mated with an elite bull or artificially inseminated, and the fertilised eggs at 8-32 cell stages, are recovered non surgically and transferred to surrogate mothers. [2]

12.

Inbreeding in cattle	Outbreeding in cattle
Mating of closely related individual	Mating of unrelated individual
Mating is between the same breed for 4-6 generations.	Mating is between the same breed which are not bred at least for the past 4-6 generations. It is even done between different species

[1]

Advantage of inbreeding: it is used for developing pure lines.

Advantage of outbreeding: it is used for producing organism with desirable traits. [1]

Disadvantage of inbreeding: it result in inbreeding depression

Disadvantage of outbreeding: the organism are produces are not very fertile. [1]

13. (a) Objectives of animal breeding are (i) production of animals having high yield of biological products (ii) improved varieties of animal and disease resistance(iii) Elimination of harmful traits [2]
- (b) Advantage of inbreeding: it is used for developing pure lines. Disadvantage of inbreeding: it results in inbreeding depression. It can be overcome by out breeding. [2]
- (c) Jersey is the new breed each of cattle and Leghorn is new breed each of poultry [1]

[Topic 2] Plant Breeding

Plant Breeding

It is the purposeful manipulation of plant species in order to create desired plant types that are better suited for cultivation, give better yields and are disease resistant.

- **Steps of Plant Breeding:**
Breeding a new genetic variety of crop involves following steps:
 - Collection of variability
 - Evaluation and selection of parents
 - Cross hybridization among the selected parents
 - Selection and testing of superior recombinants
 - Testing, release and commercialization of new cultivars
- **Wheat and Rice:**
 - Due to development of semi-dwarf varieties of wheat and rice, their production increased enormously during 1960 to 2000.
 - This variety of wheat was developed by Nobel Laureate Norman E. Borlaug
- **Sugarcane:**
 - *Saccharum barberi* that grew in north India was crossed with *Saccharum officinarum* of south India as it had higher sugar content and thicker stem.
 - Hybrid had desirable traits of both species; it had high sugar content with thick stems and had ability to grow in north India.
- **Millet:**
 - Breeding hybrid varieties of maize, jowar and bajra has helped in developing high yielding varieties which are resistant to water stress.

Plant Breeding for Disease Resistance

Food production can be enhanced if the hybrid of plant is bred and developed in such a way that it is resistant to diseases. This will reduce the dependence on fungicides and bactericides.

- **Methods of breeding for disease resistance:**
 - Breeding can be carried out by – conventional breeding techniques or by mutation breeding.
 - A conventional breeding technique involves hybridization and selection. This method has restriction that limited number of disease resistance genes is available.
 - Mutation breeding is the process of artificially inducing mutations through use of chemicals or

radiations and selecting and using the plants that have the desirable character as a source in breeding.

Crop	Variety	Resistance to diseases
Wheat	<i>Himgiri</i>	Leaf and stripe rust, hill bunt
Brassica	<i>Pusa swarnim (Karan rai)</i>	White rust
Cauliflower	<i>Pusa Shubhra, Pusa Snowball K-1</i>	Black rot and Curl blight black rot
Cowpea	<i>Pusa Komal</i>	Bacterial blight
Chilli	<i>Pusa Sadabahar</i>	Chilly mosaic virus, Tobacco mosaic virus and Leaf curl

- **Plant Breeding for Developing Resistance to Insect Pests:**
 - Insect and pest infestation destroy crops on a very large scale. So various morphological, biochemical or physiological characteristics can help plant to become insect resistant.
 - For example, hairy leaves in several plants, solid stems, etc. are some of the characteristics to keep the plant insect resistant.

Crop	Variety	Insect Pests
Brassica (rapeseed mustard)	<i>Pusa Gaurav</i>	Aphids
Flat bean	<i>Pusa Sem 2, Pusa Sem 3</i>	Jassids, aphids and fruit borer
Okra (Bhindi)	<i>Pusa Sawani, Pusa A-4</i>	Shoot and Fruit borer

- **Plant Breeding for Improved Food Quality**
 - As large number of people can't afford enough vegetables, fruits, meat, etc. So, breeding crops that are better in quality and high in nutritional value is necessary.
 - Bio fortification: It is the practice of breeding crops with higher levels of vitamins and minerals, or higher protein and healthier fats to improve public health.
 - The main objectives of improving nutritional quality involves improving:

- Protein content and its quality.
- Micronutrients and mineral content.
- Vitamin content
- Oil content and its quality.

Single Cell Protein

- SCP or Single Cell Protein is one of the alternate sources of proteins for animal and human nutrition.
- *Spirulina* is easy to cultivate as it can grow on materials like straw, molasses, etc. It is rich in all nutrients. It also reduces environmental pollution.

Tissue Culture

- It is the technique of regenerating a plant from any part of plant in steril condition under special nutrient media.
- Totipotency is the capacity to generate a whole plant from any cell/explant.
- The nutritional medium should provide a carbon source, inorganic salts, vitamins, amino acids and growth regulators.
- The process of producing thousands of plants through tissue culture is called micropropagation.
- Somaclones: The plants produced by the micropropagation will be genetically identical to the original plant from which they are grown.
- When the plant is infected its meristem can be removed and can be grown in vitro to obtain a virus-free plant.
- The process of fusing the isolated protoplasts from two different varieties of plants each of which is having desirable characters to get a hybrid protoplasts, which can be further grown to form a new plant is called somatic hybridization and the hybrid is called somatic hybrid.

PREVIOUS YEARS' EXAMINATION QUESTIONS TOPIC 2

1 Mark Questions

1. State the importance of bio fortification. [ALL INDIA 2011]
2. Name the following:
 - (a) The semi-dwarf variety of wheat which is high-yielding and disease-resistant
 - (b) Any one inter-specific hybrid mammal. [ALL INDIA 2012]
3. Name any two diseases the 'Himgiri' variety of wheat is resistant to. [ALL INDIA 2013]

4. What are 'true breeding lines' that are used to study inheritance pattern of traits in plants?

[DELHI 2014]

2 Marks Questions

5. How has mutation breeding helped in improving the production of mung bean crop?

[DELHI 2015]

6. (a) Why are the plants raised through micropropagation are termed as somaclones?
(b) Mention two advantages of this technique.

[ALL INDIA 2015]

7. Identify 'A', 'B', 'C' and 'D' in the given table.

Crop	Variety	Resistance to disease
A	Himgiri	Leaf rust
Cauliflower	Pusa Subhra	B
Brassica	Pusa Swarnim	C
Cowpea	D	Bacterial blight

[DELHI 2016]

8. Suggest four important steps to produce a disease resistant plant through conventional plant breeding technology. [ALL INDIA 2016]
9. In an agricultural field there is a prevalence of the following organisms and crop diseases which are affecting the crop yield badly:

- (a) White rust
- (b) Leaf and stripe rust
- (c) Black rot
- (d) Jassids

Recommend the varieties of crops the farmers should grow to get rid of the existing problem and thus improve the crop yield.

[DELHI 2017]

10. You have obtained a high yielding variety of tomato. Name and explain the procedure that ensures retention of the desired characteristics repeatedly in large populations of future generation of the tomato crop. [DELHI 2018]

3 Marks Questions

11. Plant breeding technique has helped sugar industry in North India. Explain how? [DELHI 2016]
12. (a) Write the desirable characters a farmer looks for in his sugarcane crop.
(b) How did plant breeding techniques help north Indian farmers to develop cane with desired characters? [ALL INDIA 2017]

13. How can crop varieties be made disease resistant to overcome food crisis in India? Explain. Name one disease resistant variety in India of:
 (a) Wheat to leaf and stripe rust
 (b) Brassica to white rust [DELHI 2011]
14. Scientists have succeeded in recovering healthy sugarcane plants from a diseased one.
 (a) Name the part of the plant used as explant by the scientist.
 (b) Describe the procedure the Scientist followed to recover the healthy plants.
 (c) Name this technology for crop improvement. [ALL INDIA 2011]
15. (a) Name the tropical sugar cane variety grown in South India. How has it helped in improving the sugar cane quality grown in North India?
 (b) Identify a, b, c in the following table

No.	Crop	Variety	Insect pests
1.	Brassica	Pusa Gaurav	(a)
2.	Flat bean	Pusa Sem 2 Pusa Sem 3	(b)
3.	(c)	Pusa Sawani Pusa A-4	Shoot and fruit borer

[DELHI 2014]

16. Make a list of any three outbreeding devices that flowering plants have developed and explain how they help to encourage cross-pollination.
 [ALL INDIA 2014]

5 Marks Questions

17. (a) What is plant breeding? List the two steps the classical plant breeding involves.
 (b) How has the mutation breeding helped in improving crop varieties? Give one example.
 (c) How has the breeding programme helped in improving the public nutritional health? State two examples in support of your answer. [DELHI 2013]
18. (a) Name the technology that has helped the scientists to propagate on large scale the desired crops in short duration. List the steps carried out to propagate the crops by the said technique.
 (b) How are somatic hybrids obtained? [DELHI 2014]
19. With advancements in genetics, molecular biology and tissue culture, new traits have been incorporated into crop plants. Explain the main steps in breeding a new genetic variety of a crop. [ALL INDIA 2014]



Solutions

- Bio fortification is done in order to increase the nutritional quality of crop. For example, crop is enriched with vitamins, protein and other minerals. [1]
- (a) Sonalika and Kalyan sona are semi-dwarf variety of wheat which is high-yielding and disease-resistant. [½]
 (b) Mule is an inter-specific hybrid mammal. [½]
- Leaf and Stripe rust and Hill bunt are two diseases the 'Himgiri' variety of wheat is resistant to. [1]
- 'True breeding lines' are those plants that are produced from self-fertilization. These plants are homozygous for a trait. [1]
- It is possible to induce mutations artificially by using chemicals or radiations to create a new character or trait which is not found in the parental type and by using the plants, that have the desirable character as a source in breeding. This process is called mutation breeding. In mung bean, resistance to yellow mosaic virus and powdery mildew were induced by mutations. [2]
- (a) The method of producing plants through tissue culture is called micropropagation. The plants produced through micropropagation are genetically identical to the original plant from which they are produced hence, they are called somaclones. [1]
 (b) Advantages of micropropagation:
 - A large number of plants can be produced from a single plant in a short span of time and in a limited space.
 - Virus-free healthy plants can be produced from the shoot apical meristem. [1]

[½x4=2]

Crop	Variety	Resistance to disease
A (Wheat)	Himgiri	Leaf rust
Cauliflower	Pusa Subhra	B (Black rot and Curl blight black rot)
Brassica	Pusa Swarnim	C (white rust)
Cow pea	D (Pusa Komal)	Bacterial blight

8. Important steps, to produce a disease resistant plant, through conventional plant breeding technology are:
 (a) Selection of plant with desired characters.

- (b) Cross breeding among the selected parents
 (c) Selection and evaluation of raised hybrids.
 (d) Testing of superior recombinant. [$\frac{1}{2} \times 4 = 2$]
9. Normal varieties of crops, shows poor growth, as they are prone to pathogen infestation. To get rid of the problems, the farmers should grow improved, diseases resistant varieties for higher yield. Farmers should grow the following varieties to improve the crop yield.
 (a) Pusa Swarnim or Karan rai
 (b) Himgiri
 (c) Pusa Shubhra or Pusa Snowball K-1
 (d) Pusa Sem 2 or Pusa Sem 3 [2]
10. Tissue culture technique helps in retention of the desired characteristics repeatedly in large populations of future generations for tomato crop. In this technique plant cells, tissues or organs are allowed to grow in nutrient media under controlled environmental conditions. These are meristematic tissues and are totipotent. These plants parts give rise to new plants. Tissue culture is used to produce large number of genetically similar plants in a short duration of time. [2]
11. *Saccharum barberi* was originally grown in North India, but had poor sugar content and yield. Sugar cane grown in South India, *Saccharum officinarum* had thicker stems and higher sugar content. But *Saccharum officinarum* did not grow well in North India. The two species *Saccharum barberi* from North and *Saccharum officinarum* from South India were crossed to get desirable qualities of high yield, thick stems, high sugar and ability to grow in North India. [3]
12. (a) Desirable characters for sugarcane crop are thick stem with long internodes, high sugar content and disease resistance. [1]
 (b) *Saccharum barberi* was originally grown in North India, but had poor sugar content and yield. Sugar cane grown in South India, *Saccharum officinarum* had thicker stems and higher sugar content. But *Saccharum officinarum* did not grow well in North India. The two species *Saccharum barberi* and *Saccharum officinarum* from South India were crossed to get desirable qualities of high yield, thick stems, high sugar and ability to grow in North India. [2]
13. Crop varieties can be made disease resistant by plant breeding method. In this method, traits of plants are changed in order to produce the desired characteristics like greater nutritional content and disease resistance. Breeding consist of selecting the plants with desired characteristics in a given field, cross pollinate the desired plants, allow them to grow fully to produce seeds and use the seeds to grow further progeny and select the plants with desired traits in that generation.
 (a) Himgiri
 (b) Pusa Swarnim [3]
14. (a) The stem of *Saccharum barberi* and *Saccharum officinarum* is used as explant by the scientist. [1]
 (b) Firstly, explant is grown in aseptic conditions in a nutrient medium that lead to the formation of undifferentiated mass. Then this mass is transferred to hormone containing medium. [1]
 (c) Tissue culture is the technology for crop improvement [1]
15. (a) *Saccharum officinarum* which is having more sugar and thicker stem is tropical sugar cane variety grown in South India. *Saccharum barberi* is grown in North India. The two varieties are bred, in order to produce a variety with more sugar content and thick stem which can grow in North India. [2]
 (b) In this table, a is aphids, b is jassids and fruit borer, c is okra [1]
16. Three outbreeding devices that flowering plants have developed are:
 (a) Not allowing the maturation of pollen and stigma at the same time. Sometimes, pollen is allowed to mature first and sometimes stigma is mature. This helps in cross-pollination. [1]
 (b) In some plants, anthers are placed in such a position that pollen cannot come in contact with stigma of the flower. [1]
 (c) Growing plants which have cross pollination mechanism. [1]
17. (a) In Plant breeding, traits of plants are changed in order to produce the desired characteristics like greater nutritional content and disease resistant. In this method, breeding consist of selecting the best plants in a given field, cross pollinate the desired plants, allow them to grow fully to produce seeds and use the seeds to grow further progeny and select the plants with desired traits in that generation. Two steps are: hybridisation and selection [2]
 (b) Mutation breeding involve the introduction of desirable mutations in the selected plants. Then these plants are used as source plants.

- This is known as mutation breeding. This method has been applied in Mung bean to provide the resistance against mosaic virus. [2]
- (c) Breeding programmes have helped in improving the public nutritional health by development of high nutrient carrying traits. Two examples are iron and calcium enriched spinach, protein enriched beans – garden peas. [1]
18. (a) Tissue culture is the technology that has helped the scientists to propagate on large scale the desired crops in short duration. The steps carried out to propagate the crops by the said technique are: [1]
- (i) Explant (part of plant) is grown in sterile conditions in nutrient media to develop complete plants.
- (ii) Nutrient media is rich in carbon sources, vitamins, amino acid and hormones.
- (iii) This lead to the propagation of plants in a short period of time.
- (iv) Somaclones are the plants produced by tissue culture as they are genetically similar to their parents. [2]
- (b) Somatichybrids are obtained by cellular hybridization in which somatic part of the plants are hybridized. For example, protoplast of potato and tomato are produced to form pomato. [2]
19. The main steps in breeding a new genetic variety of a crop are
- (a) Collection of variability [1]
- (b) Evaluation and selection of germplasm of plants [1]
- (c) Cross hybridization of selected plants [1]
- (d) Selection and testing of superior recombinants. [1]
- (e) Commercialization of new variety [1]

CHAPTER 10

Microbes in Human Welfare

Chapter Analysis with respect to Last 3 Years' Board Exams

List of Topics	2016		2017		2018
	Delhi	All India	Delhi	All India	Delhi/All India
In household food processing, industrial production					1Q(2 marks)
Sewage treatment	1Q (1 mark)	1Q (2 marks)	1Q (3 marks)	1Q (3 marks)	
Energy generation and as biocontrol agents and biofertilizers		1Q (2 marks), 1Q (3 marks),	1Q (2 marks)		1Q (3 marks)
Antibiotics; production and judicious use	1Q (3 marks)			1Q (2 marks)	

On the basis of above analysis, it can be said that from exam point of view Sewage Treatment and Bio Control agents are most important concepts of the chapter.

[Topic 1] Microbes in Household Products, Industrial Products and in Sewage Treatment

Summary

- Microbes are diverse in nature; they include protozoa, bacteria, fungi, viruses, viroids and prions.
- Not all microbes are harmful, many microbes are useful to human in various ways.
- **Microbes in Household Products:**
 - *Lactobacillus* and other LAB (lactic acid bacteria) help in formation of curd by producing acids during their growth that coagulates and partially digests milk proteins. LAB also keeps a check on disease causing microbes in our stomach.
 - Various food items require microbes for their preparation. Dough of idli and dosa are prepared by bacteria. The fermentation of the dough used in making bread is done by using baker's yeast (*Saccharomyces cerevisiae*). Microbes are used in cheese to provide characteristic texture, flavor and taste.
- **Microbes in Industrial Products:**
 - Alcoholic beverages are prepared by the process of fermentation using same yeast *Saccharomyces cerevisiae* which is used for bread making. Different drinks are obtained depending on the raw material used and whether or not distillation is required.
 - Antibiotics are produced by microbes which kill or retard the growth of disease-causing microbes.
 - Microbes are used in commercial production of acetic acids, citric acids, enzymes like lipase, pectinases and streptokinase.
- **Microbes in Sewage Treatment:**
 - First the sewage undergoes primary treatment which involves filtration and sedimentation. During sequential filtration, floating debris is removed. Then grit is removed by sedimentation.
 - The effluent from the primary settling tank then undergoes secondary treatment, where it is passed through large aeration tanks where air is pumped and constantly agitated. This activity results in strong growth of essential aerobic microbes into flocs, which are masses of bacteria along with fungal filaments that form mesh like structures. As this floc consumes major part of organic matter, so the biochemical oxygen demand, BOD reduces significantly.

- The effluent is then transferred to a settling tank where the bacterial flocs are allowed to sediment, this sediment is called an activated sludge. A part of it is pumped back in tank to act as inoculum and rest is pumped into anaerobic sludge digesters. Here, other bacteria digest the sludge and produce a mixture of gases which form biogas.

PREVIOUS YEARS' EXAMINATION QUESTIONS

TOPIC 1

▣ 1 Mark Questions

1. Write the scientific name of the microbe used for fermenting malted cereals and fruit juices.
[DELHI 2011]
2. Name the enzyme produced by *Streptococcus bacterium*. Explain its importance in medical science.
[ALL INDIA 2011]

▣ 2 Marks Questions

3. List the events that reduce the Biological Oxygen Demand (BOD) of a primary effluent during sewage treatment.
[DELHI 2016]
4. Mention a product of Human welfare obtained with the help of each one of the following microbes:
 - (a) LAB
 - (b) *Saccharomyces cerevisiae*
 - (c) *Propionibacterium sharmanii*
 - (d) *Aspergillus niger*
[DELHI 2015]
5. Explain the different steps involved during primary treatment phase of sewage.
[ALL INDIA 2015]
6. Name the microbes that help production of the following products commercially:
 - (a) Statin
 - (b) Citric acid
 - (c) Penicillin
 - (d) Butyric acid.
[ALL INDIA 2017]
7. How does the application of the fungal genus, *Glomus*, to the agricultural farm increase the farm output?
[DELHI 2017]
8. Name the bacterium responsible for the large holes seen in "Swiss Cheese". What are these holes due to?
[ALL INDIA 2013]

9. List the events that reduce the Biological Oxygen Demand (BOD) of a primary effluent during sewage treatment. [ALL INDIA 2016]
10. Mention a product of Human welfare obtained with the help of each one of the following microbes:
 - (a) LAB
 - (b) *Saccharomyces cerevisiae*
 - (c) *Propionibacterium sharmanii*
 - (d) *Aspergillus niger* [ALL INDIA 2015]

3 Marks Questions

11. Given below is a list of six micro-organisms. State their usefulness to humans.
 - (a) Nucleopolyhedro virus
 - (b) *Saccharomyces cerevisiae*
 - (c) *Monascus purpureus*
 - (d) *Trichoderma polysporum*
 - (e) *Penicillium notatum*
 - (f) *Propionibacterium sharmanii*

[DELHI 2016]
12. Choose any three microbes, from the following which are suited for organic farming which is in great demand these days for various reasons. Mention one application of each one chosen. Mycorrhiza; *Monascus*; *Anabaena*; *Rhizobium*; *Methenobacterium*; *Trichoderma*. [DELHI 2015]
13. Describe how do 'flocs' and 'activated sludge' help in Sewage Treatment [DELHI 2017]
14. Secondary treatment of the sewage is also called Biological treatment. Justify this statement and explain the process. [ALL INDIA 2017]
15. (a) Why are the fruit juices bought from market clearer as compared to those made at home?
 (b) Name the bioactive molecules produced by *Trichodermapolysporum* and *Monascus purpureus*. [DELHI 2013]

2. Streptokinase is the enzyme produced by *Streptococcus* bacterium. This enzyme used as a clot buster for the people suffering from myocardial infarctions. [1]
3. Effluent from the primary settling tank passed into aeration tank where it is constantly agitated mechanically and air is pumped into it. This allows vigorous growth of useful aerobic microbes into flocs. These microbes consume the major part of the organic matter in the effluent and significantly reduces the BOD (biochemical oxygen demand) of the effluent. [2]
4. Product of microbes for human welfare:
 - (a) LAB stands for lactic acid bacteria or *Lactobacillus*. It is gram positive bacteria which is used in curd production or making curd at our home. [½]
 - (b) *Saccharomyces cerevisiae* is used in bread making or brewing industry or for production of ethanol (ethyl alcohol). [½]
 - (c) *Propionibacterium sharmanii* produces large holes in Swiss cheese by releasing large amount of CO₂. [½]
 - (d) *Aspergillus niger* is used in industries for production of citric acid. [½]
5. The primary phase of sewage treatment involves physical removal of particles through filtration and sedimentation. The floating debris is removed by sequential filtration. Then the filtered sewage is passed into the grit chamber where the coarse solid materials like soil and pebbles settle by gravity. After this, the sewage is allowed to pass into a sedimentation tank where the suspended materials settle and form the primary sludge whereas suspended effluents float in the effluent. The effluent from the primary setting tank is taken for secondary treatment. [2]

6.

Product	Microbes
Statin	<i>Monascus purpureus</i>
Citric acid	<i>Aspergillus niger</i>
Penicillin	<i>Penicillium notatum</i>
Butyric acid	<i>Clostridium butylicum</i>

[2]

7. Many members of genus of fungus *Glomus* form symbiotic association with plants to form mycorrhiza. The fungal symbiont in these associations absorbs phosphorus from soil and passed it to the plants in addition to the other benefits like resistance to root-borne pathogens, tolerance to salinity and drought. Thus *Glomus* plays important role in the crop yield. [2]

Solutions

1. A yeast, whose scientific name is *Saccharomyces cerevisiae* is used for fermenting malted cereals and fruit juices. [½]

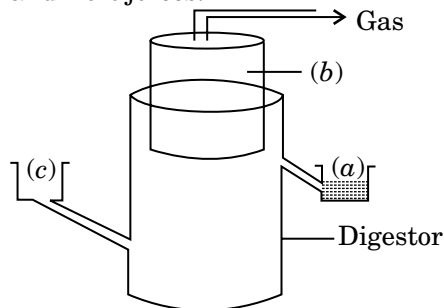


Fig.: Fermenter

[½]

8. The large holes in Swiss cheese' are due to bacterium propionibacterium sharmanii carbon-dioxide production. [2]
9. Effluent from the primary settling tank passed into aeration tank where it is constantly agitated mechanically and air is pumped into it. This allows vigorous growth of useful aerobic microbes into flocs. These microbes consume the major part of the organic matter in the effluent and significantly reduces the BOD (biochemical oxygen demand) of the effluent. [2]
10. Product of microbes for human welfare:
 - (a) LAB is stands for lactic acid bacteria or lactobacillus. It is gram positive bacteria which is used in curd production or curd making at our home. [½]
 - (b) Saccharomyces cerevisiae is used in bread making or brewing industry or for production of ethanol (ethyl alcohol). [½]
 - (c) Propionibacterium sharmanii produces large holes in Swiss cheese by releasing large amount of CO₂. [½]
 - (d) Aspergillus nigeris used in industries for production of citric acid. [½]
11.
 - (a) Nucleopolyhedro virus is used as bio control agents for Integrated Pest Management. [½]
 - (b) Saccharomyces cerevisiae is used in bread making or brewing industry or for production of ethanol (ethyl alcohol). [½]
 - (c) Monascus purpureus is a cholesterol lowering agent [½]
 - (d) Trichoderma polysporum produces Cyclosporin A which is an immunosuppressive agent. [½]
 - (e) Penicillium motatum produces antibiotic penicillin. [½]
 - (f) Propioni bacterium sharmanii produces large holes in Swiss cheese by releasing large amount of CO₂. [½]
12. The three microbes chosen that are suited for organic farming.
 - (a) Anabaena is a cyanobacteria which can fix atmospheric nitrogen. In paddy fields, cyanobacteria serve as an important bio fertiliser. It also add organic matter to the soil and increase its fertility. [1]
 - (b) Rhizobium is a symbiotic bacteria which lives in the root nodules of leguminous plants such as peas, beans. It fixes atmospheric nitrogen. [1]
 - (c) Mycorrhiza is a symbiotic association between fungus and roots of higher plants. Fungal symbiont like Glomus in these associations absorbs phosphorus from soil and passes it to the plant. [1]
13. Sewage effluent is pumped into an aeration tank that contains sludge (consisting of bacteria and algae). In aeration tank, bacteria multiply rapidly and form masses along with fungal filaments to form aggregates called flocs. These flocs sediment at the bottom of tank and is called activated sludge. A part of activated sludge is pumped back into the aeration tank to serve as the inoculum, while the remaining major part of the sludge is pumped into anaerobic sludge digesters for anaerobic microbial decomposition and production of biogas. The bacteria are able to decompose most of the organic matter while algae provide oxygen to these decomposers. The bacteria commonly used in sewage treatment are: Coliform, Clostridium, Pseudomonas, Micrococcus etc. But this water still carries large amounts of nitrates, phosphates, etc. Before this water is allowed to pass into water bodies, it undergoes tertiary treatment. [3]
14. Secondary treatment is also called biological treatment because it uses organisms and detritus feeders. The process includes the following steps:
 - (a) The primary effluent is carried to aeration tanks and the liquid is mechanically agitated continuously with pumping of air.
 - (b) A large number of aerobic heterotrophic microbes such as bacteria, fungi, yeasts and protozoa grow in the aeration tank and form flocs.
 - (c) The microbes digest organic matter and convert it to microbial biomass and release minerals. This reduces the biochemical oxygen demand (BOD).
 - (d) As the BOD of the waste matter is reduced to 10 to 15% of raw sewage, it passes into the settling tank where the bacterial flocs are allowed to undergo sedimentation.
 - (e) The settled material is called activated sludge.
 - (f) The activated sludge is collected and subjected to anaerobic digestion in a separate tank. This tank has oxygen-free atmosphere where anaerobic microbes start digesting the bacteria and fungi in the sludge.
 - (g) Anaerobic microorganisms digest the organic matter into soluble substances and gaseous products such as methane, carbon dioxide and hydrogen sulphide. Methane is highly inflammable and can be used as biogas.

- (h) Finally, the treated sewage effluent is subjected to chemical treatment for disinfection before releasing it into natural water bodies such as rivers and streams. [3]
15. (a) The fruit juices bought from market clearer as compared to those made at home because they are clarified by the pectinase and proteases enzymes. [1½]
- (b) Cyclosporine A which is an immunosuppressive agent is bioactive molecules produced by *Trichoderma polysporum* and Statins are produced by *Monascus purpureus*. [1½]

[Topic 2] Microbes in Production of Biogas, as Bio-control Agents and Bio-fertilizers

- **The role of Microbes in Production of Biogas:**

- Biogas constitutes of methane primarily along with other mixture of gases. It is used as a fuel and is produced by the actions of microbes. Bacteria commonly found in anaerobic sludge and rumen of cattle are methanogens, which produce large amount of methane along with carbon dioxide and hydrogen.
- Biogas plant consists of a concrete tank, a floating cover and an outlet. Slurry and bio-waste is put in concrete tank. Floating cover rises when gas is produced in the tank due to microbial activity and the outlet helps to supply biogas to nearby houses through a pipe.

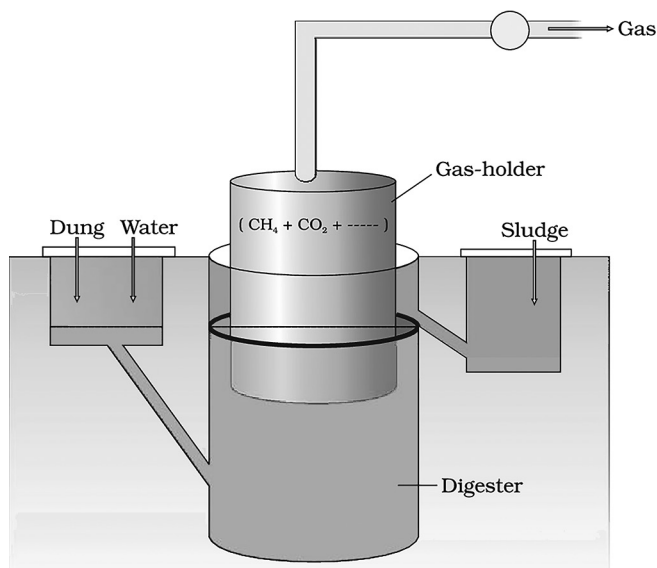


Fig.: A typical biogas plant

- **Microbes as Bio control Agents:**

- Plant diseases and pests can be controlled by the use of biological methods and this is referred as bio control. Organic farmers do not eradicate insects which are pests to their farms, instead

they are kept at manageable level within a living and vibrant ecosystem.

- The use of bio-control measures will reduce our dependence on pesticides and other toxic chemicals. To control butterfly caterpillars the bacteria named Bt. or *Bacillus thuringiensis* is used.

- **The role of Microbes in Bio-fertilizers:**

- Bio fertilizers are nothing but the organisms that enhance the quality of nutrient in the soil. The microbes acting as bio-fertilizers are bacteria, fungi and cyanobacteria.
- *Rhizobium* found in nodules on the roots of leguminous plants fix atmospheric nitrogen into organic form for the plant to utilize as a nutrient.
- The symbiotic association between fungi and plants is known as Mycorrhiza. Phosphorus is absorbed from soil by fungal symbiont and passed on to plant as nutrient.
- Cyanobacteria are used in paddy fields as bio fertilizers.

PREVIOUS YEARS' EXAMINATION QUESTIONS

TOPIC 2

▣ 1 Mark Questions

1. Mention the role of cyanobacteria as a bio fertiliser. [ALL INDIA 2012]

▣ 2 Marks Questions

2. Name a genus of baculovirus. Why are they considered good bio-control agents?

[ALL INDIA 2016]

3. Your advice is sought to improve the nitrogen content of the soil to be used for cultivation of a non-leguminous terrestrial crop.
 - (a) Recommend two microbes that can enrich the soil with nitrogen.
 - (b) Why do leguminous crops not require such enrichment of the soil? **[DELHI 2018]**
4. Why is Rhizobium categorized as a 'symbiotic bacterium'? How does it act as a bio fertilizer? **[ALL INDIA 2012]**
5. Your advice is sought to improve the nitrogen content of the soil to be used for cultivation of a non-leguminous terrestrial crop.
 - (a) Recommend two microbes that can enrich the soil with nitrogen.
 - (b) Why do leguminous crops not require such enrichment of the soil? **[DELHI 2018]**

▣ 3 Marks Questions

6. What are methanogens? How do they help to generate biogas? **[ALL INDIA 2015].**
7. (a) How do organic farmers control pests? Give two examples.
(b) State the difference in their approach from that of conventional pest control methods. **[ALL INDIA 2016]**
8. (a) Organic farmers prefer biological control of diseases and pests to the use of chemicals for the same purpose. Justify.
(b) Give an example of a bacterium, a fungus and an insect that are used as biocontrol agents. **[DELHI 2018]**

▣ 5 Marks Questions

9. Describe how biogas is generated from activated sludge. List the components of biogas. **[ALL INDIA 2013]**

🔑 Solutions

1. Cyanobacteria fix atmospheric nitrogen into ammonia and other usable forms of nitrogen that plant can use to make amino acids and proteins and hence increase the fertility. [1]
2. Nucleopolyhedro virus is a genus of baculovirus. It is effective and efficient bio-control agent because it is species-specific, narrow spectrum insecticidal agent. It does not show any negative impacts on plants, mammals, birds or even non-target insects. [2]

3. (a) Azospirillum and Azotobacter are free-living bacteria in the soil. They can fix atmospheric nitrogen thus enriching the nitrogen content of the soil. [1]
(b) Leguminous plants contain root nodules in which Rhizobium bacteria are present. Rhizobium bacteria can fix atmospheric nitrogen in the usable form which can be used by plants. This is why leguminous crops do not require fertilisers as nitrogen source. [1]
4. Rhizobium is a gram negative bacteria live in the roots of legume plants. This bacteria live in the nodules in root of leguminous plants and convert atmospheric nitrogen into ammonia and other usable forms of nitrogen that plants can use to make amino acids. [2]
5. (a) Azospirillum and Azotobacter are free-living bacteria in the soil. They can fix atmospheric nitrogen thus enriching the nitrogen content of the soil. [1]
(b) Leguminous plants contain root nodules in which Rhizobium bacteria are present. Rhizobium bacteria can fix atmospheric nitrogen in the usable form which can be used by plants. This is why leguminous crops do not require nitrogen from fertilisers. [1]
6. Certain bacteria which grow anaerobically on cellulosic material and produce large amount of methane along with CO₂ and H₂. These bacteria are collectively called methanogens. Example is bacterium is Methano bacterium. The methanogenic bacteria digest the organic mass to produce marsh gas during the secondary treatment of sewage. Marsh gas is a mixture of gases containing methane, hydrogen sulphide and carbon dioxide which form biogas. [3]
7. (a) Organic farmers control pests either by natural predation or by using biological control. Examples: Owls are used to kill rats in the crop field, lady bird used to kill aphids. Bt Cotton plants are introduced with the Bt toxin gene of the bacterium Bacillus thuringiensis. This gene provides the cotton crops resistance against the bollworms. [1½]

(b) Differences between organic pest control and conventional pest control methods:

Conventional Pest Control	Organic farming based pest control
Chemical insecticides and pesticides are used to control pest	Natural or biological pest control
It is harmful to crops also	It does not harm crops
Causes environmental pollution	It does not have impact on environment

[1½]

8. (a) Chemical methods used to control diseases and pests are not safe as often chemicals (pesticides) kills both useful and harmful life forms without any discrimination. Eradication of the insects that are often described as pests is not only possible, but also undesirable. Without them the beneficial predatory and parasitic insects

which depend upon them as food or hosts would not be able to survive. [1½]

(b) Insects = Ladybird and Dragonflies. They are useful to get rid of aphids and mosquitoes, respectively

Bacteria = *Bacillus thuringiensis*. It is used to control butterfly caterpillars.

Fungus, *Trichoderma* free-living in very common in the root ecosystems. They are effective biocontrol agents of several plant pathogens [1½]

9. Biogas produced by anaerobic fermentation of waste biomass in the following steps:

(a) Complex monomers like proteins, lipids, cellulose and hemi-cellulose are degraded by facultative microbes to form simple monomers. [2]

(b) After that, monomers are changed into organic acid under partially aerobic condition. [1]

(c) In the last stage, acid is converted into methane by methanogen. [1]

Methane, carbon-dioxide and hydrogen sulphide are the components of biogas. [1]

Biotechnology: Principles and Processes

Chapter Analysis with respect to Last 3 Years' Board Exams

List of Topics	2016		2017		2018
	Delhi	All India	Delhi	All India	Delhi/All India
Genetic engineering (Recombinant DNA technology)	1Q (1 mark), 1Q (3 marks)	1Q (3 marks)	1Q (3 marks)	1Q (3 marks), 1Q (3 marks)	1Q (3 marks), 1Q (3 marks)

On the basis of above analysis, it can be said that from exam point of view the concepts Steps Insertion Inactivation, Cloning, r-DNA Technology Tools and Methodology and PCR are most important concepts of the chapter.

[Topic 1] Principles of biotechnology and tools of recombination DNA Technology

Summary

Introduction

Biotechnology deals with large scale production of products and processes that are useful to humans that makes use of live organisms, cells or enzymes. Karl Ereky coined the term 'biotechnology' in 1919.

Biotechnology helps in:

- Correcting a defecting gene
- Microbe-interceded process (making curd, bread, wine, etc.)
- Preparation of a DNA vaccine
- Synthesis and using of a gene
- *In vitro* fertilisation (test tube baby program)

Principles of Biotechnology

• Genetic engineering:

This type of engineering uses different techniques that alter the chemistry of genetic material (DNA and RNA) which introduce these into host organisms and thus change the phenotype of the host organism.

• Maintenance of sterile ambience:

It refers to a traditional hybridization technique leading to multiplication of undesirable genes along with desired genes to enable growth leading to creation of DNA.

The techniques of genetic engineering involve creating recombinant DNA, using gene cloning and gene transfer, overcome this limitation and allows us to isolate and introduce only one or a set of desirable genes without introduction of undesirable genes into the target organism.

A recombinant piece of DNA cannot multiply itself in the progeny cells of an organism as the alien piece of DNA becomes a part of chromosomes having the inability to replicate. So, it inherits and multiplies along with the host DNA as it gets integrated into the recipient genome. This process of making multiple copies of template DNA can also be termed as **cloning**.

Steps of genetically modifying an organism

- Recognise the DNA with desirable genes.
- Introduce those recognised DNA into the host medium.

- Maintain the recognised DNA in the host medium and then transfer DNA to its progeny.

Tools of recombinant DNA Technology

• Restriction enzyme

- They are also known as restriction endonuclease which cleaves DNA into fragments at recognition sites. The sequence in which the DNA is cut is known as recognition sequence.
- The first restriction endonuclease is Hind II, isolated by Wilcox, Kelley and Smith in 1968 from, *Haemophilis influenzae* bacterium.
- It always cut DNA molecules at a particular point by recognizing a specific sequence of six base pairs which is called as Recognition sequence.
- There are two kinds of restriction enzymes: exonucleases (removes nucleotides from the ends of DNA) and endonucleases (makes cuts at specific positions within DNA).

Action of Restriction enzyme

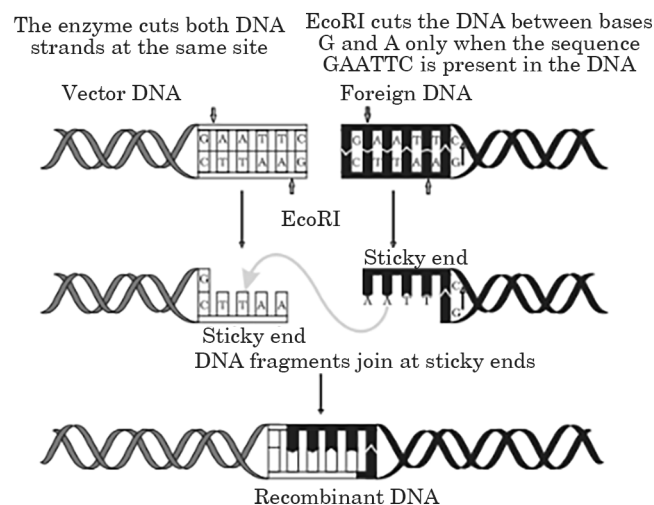


Fig.: Steps in formation of recombinant DNA by action of restriction endonuclease enzyme - EcoRI

- Diagrammatic representation of recombinant DNA technology is shown below.
- Separation and isolation of DNA fragments:
 - The DNA fragments are formed by the cutting of DNA by restriction endonucleases and are separated by a technique called as gel electrophoresis.

- DNA fragments are negatively charged molecules which are separated by forcing them to move towards the anode under an electric field through a medium/matrix.
- Agarose is the most commonly used matrix which is a natural polymer extracted from sea weeds.

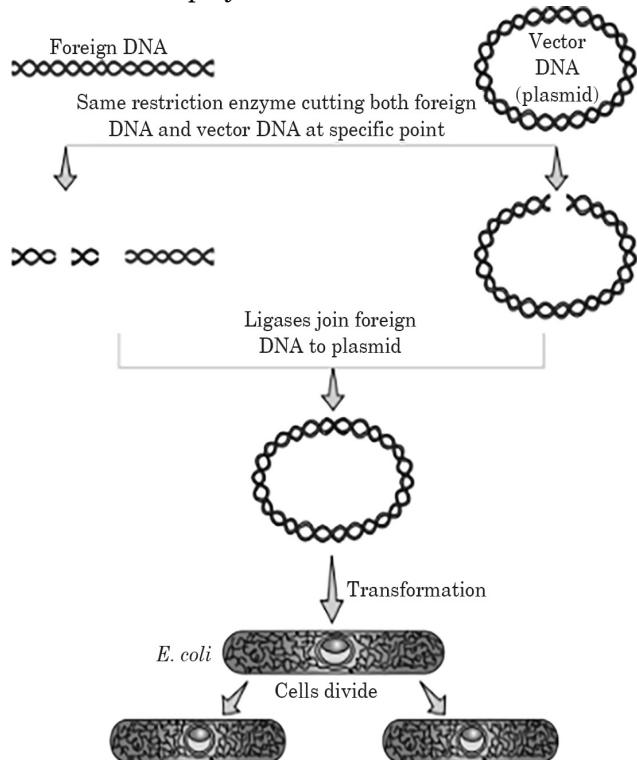


Fig.: Recombinant DNA Technology

- **Cloning vectors:**
 - DNA molecules which carry a foreign DNA segment and can replicate inside the host cells are called as cloning vectors. Example: Plasmids and bacteriophages.
- The cloning of a DNA requires following features:
- **Origin of replication (Ori):** A DNA sequence from where replication begins is known as Origin of replication (Ori).
 - **Selectable marker:** It helps in recognising and removing transformants and selectively allowing the growth of transformants. The procedure in which a DNA is introduced in a host is known as Transformation.
 - **Cloning sites:** Vector needs to have recognition sites for linking alien DNA.
 - **Vectors for cloning genes in plants and animals:** Genes of some pathogens can be changed into useful vectors for delivering genes to plants and animals.
- **Competent host:**
 - To force bacteria to take up the plasmid, first the bacterial cell should be made competent to take up DNA and for that they are treated with a

specific concentration of a divalent cation, which improves the efficiency with which DNA enters the bacterium through pores in its cell wall.

- Alien DNA can be introduced into host cells in some other following ways:
 - **Micro-injection:** This is the process of directly injecting recombinant DNA into the nucleus of an animal cell.
 - **Biolistics method:** The process of bombardment of cells with high velocity micro-particles of gold or tungsten coated with DNA. It is a suitable method for the plants.
 - **Disarmed pathogens vectors:** Cells transfer the recombinant DNA into the host after getting infected by disarmed pathogens vectors.

PREVIOUS YEARS' EXAMINATION QUESTIONS

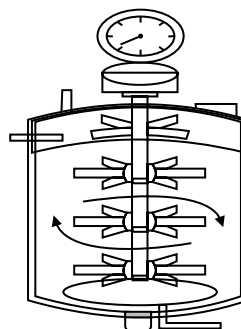
TOPIC 1

1 Mark Questions

1. Retroviruses have no DNA. However, the DNA of the infected host cell does possess viral DNA. How is it possible? [ALL INDIA 2015]
2. Suggest a technique to a researcher who needs to separate fragments of DNA. [DELHI 2016]
3. How can bacterial DNA be released from the bacterial cell for biotechnology experiments? [DELHI 2011]
4. Mention the type of host cells suitable for the gene guns to introduce an alien DNA. [DELHI 2014]
5. Why is it not possible for an alien DNA to become part of a chromosome anywhere along its length and replicate normally? [ALL INDIA 2014]

2 Marks Questions

6. List the key tools used in recombinant DNA technology. [DELHI 2011]
7. Name the type of bioreactor shown. Write the purpose for which it is used. [ALL INDIA 2011]



8. Explain the work carried out by Cohen and Boyer that contributed immensely in biotechnology. **[ALL INDIA 2012]**
9. Name two commonly used bioreactors. State the importance of using a bioreactor. **[DELHI 2013]**
10. (a) Mention the difference in the mode of action of exonuclease and endonuclease.
(b) How does the restriction endonuclease function? **[DELHI 2013]**
11. Explain with the help of a suitable example the naming of a restriction endonuclease? **[DELHI 2014]**
12. How are 'sticky ends' formed on a DNA strand? Why are they so called? **[DELHI 2014]**
13. How does a restriction nuclease function? Explain. **[ALL INDIA 2014]**

3 Marks Questions

14. Draw a labelled sketch of sparged-stirred-tank bioreactor. Write its application. **[DELHI 2015]**
15. Rearrange the following in the correct sequence to accomplish an important biological reaction:
 - (a) In vitro synthesis of copies of DNA of interest
 - (b) Chemically synthesized oligonucleotides
 - (c) Enzyme DNA-polymerase
 - (d) Complementary region of DNA
 - (e) Genomic DNA template
 - (f) Nucleotides provided
 - (g) Primers
 - (h) Thermostable DNA-polymerase (from *Thermus aquaticus*)
 - (i) Denaturation of ds-DNA **[ALL INDIA 2015]**
16. Suggest and describe a technique to obtain multiple copies of a gene of interest in vitro. **[DELHI 2016]**
17. Explain enzyme-replacement therapy to treat adenosine deaminase deficiency. Mention two disadvantages of this procedure. **[ALL INDIA 2016]**
18. Explain the role(s) of the following in Biotechnology:
 - (a) Restriction endonuclease
 - (b) Gel – electrophoresis
 - (c) Selectable markers in pBR322. **[DELHI 2017]**
19. (a) How has the development of bioreactor helped in biotechnology?
(b) Name the most commonly used bioreactor and describe its working. **[DELHI 2018]**
20. Draw a schematic sketch of pBR322 plasmid and label the following in it: **[ALL INDIA 2012]**
 - (a) Any two restriction site
 - (b) Ori and rop gene
 - (c) An antibiotic resistant gene
21. Name and describe the technique that helps in separating the DNA fragments formed by the use of restriction endonuclease. **[ALL INDIA 2014]**
22. (i) Describe the characteristics of a cloning vector must possess.
(ii) Why DNA cannot pass through the cell membrane? Explain. How a bacterial cell is made 'competent' to take up the recombinant DNA from the medium. **[ALL INDIA 2011]**

Solutions

1. The genetic material of retrovirus is the RNA. It enters the cell of the host, where the virus undergoes reverse transcription to use its RNA genome to form viral DNA in presence of reverse transcriptase enzyme. This viral DNA then incorporates into the host cell DNA, directing the infected cells to produce more copies of viruses. In this way, the infected cell possesses viral DNA. **[1]**
2. Gel-electrophoresis. **[1]**
3. Bacteria DNA are released from the bacterial cell for biotechnology experiments with enzyme lysozyme that break the cell wall of bacteria. **[1]**
4. Undifferentiated plant cell are the type of host cells suitable for the gene guns to introduce an alien DNA because plant cells consist of cell wall that can be easily broken by gold and tungsten coated with DNA. **[1]**
5. It not possible for an alien DNA to become part of a chromosome any where along its length and replicate normally because replication of DNA start at specific place in a DNA called as ORI (origin of replication). **[1]**
6. The key tools used in recombinant DNA technology are:
 - (i) Cloning vectors **[½]**
 - (ii) restriction endonuclease enzyme **[½]**
 - (iii) competent host **[½]**
 - (iv) DNA ligase, cellulose, chitinase enzymes **[½]**
7. The given bioreactor is the simple stirred tank bioreactor. It is used for the production of recombinant proteins at a large scale using microbial plants/animals/human cells. It is cylindrical or with a curved base to facilitate mixings of reactor contents and use available oxygen. **[2]**
8. Stanley Cohen and Herbert Boyer conducted one of the first recombinant DNA technology experiments in the year 1972. Both were first to give the DNA cloning method. Cohen was the first to extract plasmid from the bacterial cell and

transfer it into another cell and Boyer found that when DNA is cut with restriction enzymes they form sticky ends which can be ligated easily. Hence, techniques of both produced the first recombinant DNA. [2]

9. Simple stirred tank bioreactor and sparged stirred tank bioreactor are two commonly used bioreactors. Bioreactors are used for the production of recombinant proteins in a large scale. [2]
10. (a) Exonuclease cut the DNA at free ends whereas endonuclease cut within DNA segment [1]
(b) Restriction endonuclease play an important role in DNA recombinant technology in cutting the required DNA segment at specific site in DNA called as palindromic sequences. [1]
11. In restriction enzyme naming, Ist letter represents the genus of the organism from which the enzyme is derived. IInd and IIIrd letters represent the species and strain of the organism. In, EcoRI, E stands for the genus "Escherichia" and "co" for coli species and R for "RY13" strain. I stand for order of restriction enzyme identification from the bacterium. [2]
12. Sticky ends are produced by restriction enzymes. They are formed when restriction enzymes cut the DNA at specific palindromic sites and result in the generation of overhanging stretches called 'sticky ends' on each strand. These are called sticky ends because they form hydrogen bonds with their complementary cut counterparts. [2]
13. Restriction endonuclease play an important role in DNA recombinant technology in cutting the required DNA segment at specific sites called as palindromic sequences. Hence, they play an important role in taking out the gene of interest from the organism and cutting the vector DNA at specific site, so that gene of interest can be inserted in vector. [2]
14. A labelled sketch of sparged-stirred-tank bioreactor:

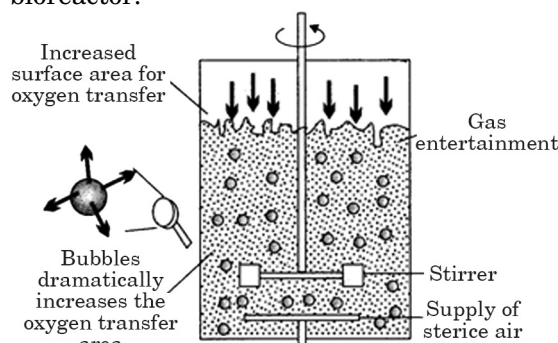


Fig.: Sparged-stirred-tank bioreactor [1]

Applications:

- (a) Culture can be processed on the large scale.
- (b) It provides optimum conditions producing the desired products, example it is used to produce large quantity of proteins, alcohols. [1+1]
15. The correct sequence of the steps involved in PCR (Polymerase chain reaction) are:
 - (i) Denaturation of ds-DNA
 - (d) Complementary region of DNA
 - (c) Enzyme DNA polymerase
 - (b) Chemically synthesized oligonucleotides
 - (g) Primers
 - (h) Thermostable DNA-polymerase (*from Thermus acquticus*)
 - (f) Nucleotides Provided
 - (a) In vitro synthesis of region of DNA of interest [3]
16. Polymerase chain reaction (PCR) is the technique to obtain multiple copies of a gene. It involves the following steps. Multiple copies of the gene of interest is synthesised in vitro by the following steps:
 - (a) Denaturing: The double-stranded template DNA is heated to separate it into two strands. [1]
 - (b) Annealing: The temperature is lowered to enable the DNA primers to attach to the template DNA.
 - (c) Extending: The temperature is increased and the new strand of DNA is made by the Taq polymerase enzyme. [1]
 These steps are repeated 20-40 times, doubling the number of DNA copies each time.

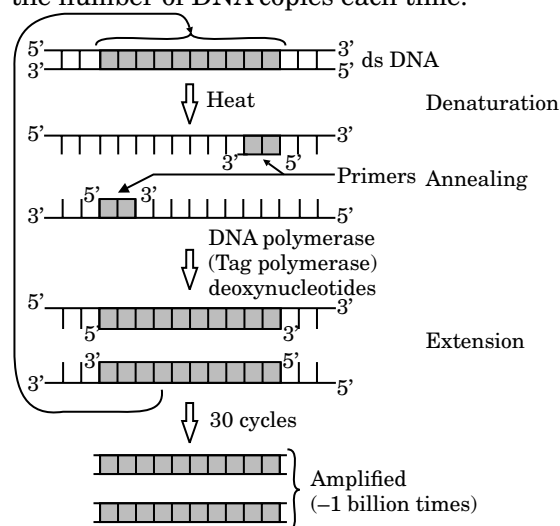


Fig.: Polymerase Chain Reaction [1]

17. Adenosine deaminase (ADA) deficiency is a genetic disorder. In this disorder the gene coding for the enzyme ADA gets deleted

leading to deficiency of ADA which can be treated by enzyme replacement therapy. In this treatment, patients are regularly injected with the functional adenosine deaminase enzyme. [2]

Disadvantages:

Therapy does not cure disease completely. It is very expensive therapy as repeated infusion of enzyme is required. [1]

18. (a) Restriction endonuclease is an enzyme which cuts DNA at specific position or specific nucleotide or palindromic nucleotide sequence. [1]
- (b) Gel-electrophoresis separates DNA fragments based on size under the influence of electric field. [1]
- (c) Selectable markers in pBR322 helps in identifying and eliminating non-transformants from transformants. [1]
19. (a) Appreciable quantities of products are not obtained by small volume cultures. To process culture of large volumes such as 100 to 1000 litres, the development of such bioreactors, are needed. Thus, bioreactors can be thought of as vessels in which raw materials are biologically converted into specific products using microbial, plant, animal or human cells. A bioreactor provides the optimal conditions for achieving the desired products. [1½]
- (b) Stirring type bioreactors are commonly used. A stirred - tank reactors is usually cylindrical or with a curved base to facilitate the mixing of the reactor contents. The stirrer facilitates even mixing and oxygen availability throughout the bioreactor. The bioreactor has an agitator system, an oxygen delivery system and a foam control

system, a temperature control system. Also, pH control system and sampling ports so that small volumes of the culture can be withdrawn periodically. [1½]

20. [3]

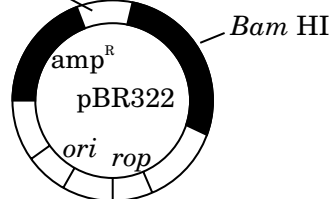


Fig.: Schematic sketch of pBR 322 plasmid

21. Gel electrophoresis is the technique that helps in separating the DNA fragments formed by the use of restriction endonuclease. In this process, DNA samples are loaded into wells at one end of a gel, and an electric current is applied to pull them through the gel. DNA fragments are negatively charged, so they move towards the positive electrode. As, the DNA fragments are of different sizes, the smaller DNA molecule move faster and heavier DNA molecule move slower. DNA fragments are seen as a band, in gel electrophoresis, because they are mixed with dye so that they become visible. [3]
22. (i) Cloning vector should have origin of replication, selectable marker, genes encoding for antibiotic resistance, recognition site for the restriction enzyme to recognise cloning sites. [1½]
- (ii) DNA is a hydrophilic molecule and hence, cannot pass through the cell membrane. Bacterial cell is made competent by treating with specific concentration of calcium ion /divalent ions, incubating them on ice, providing heat shock for a short period and placing it back on ice once again. [1½]

[Topic 2] Process of Recombinant DNA Technology

Introduction

Recombinant DNA technology involves many steps in a defined sequence which are –

Isolation of DNA, fragmentation of DNA by restriction endonucleases, isolation of a desired DNA fragment, ligation of the DNA fragment into a vector, transferring the recombinant DNA into the host, culturing the host cells in a medium at large scale and extraction of the desired product.

Isolation of the Genetic Material (DNA)

- In order to get the DNA free from other macromolecules, there is a need of treating bacterial cell/plant or animal tissue with enzyme.
- Enzymes namely lysozyme is used to treat bacteria, cellulasetotreatplantcells, chitinasetotreatfungus.
- Thecellwhenbroken, releasesDNAalongwithother macro-molecules like proteins, lipids, RNA etc.
- The RNA is removed on treatment with ribonuclease and proteins are removed by treatment with protease.

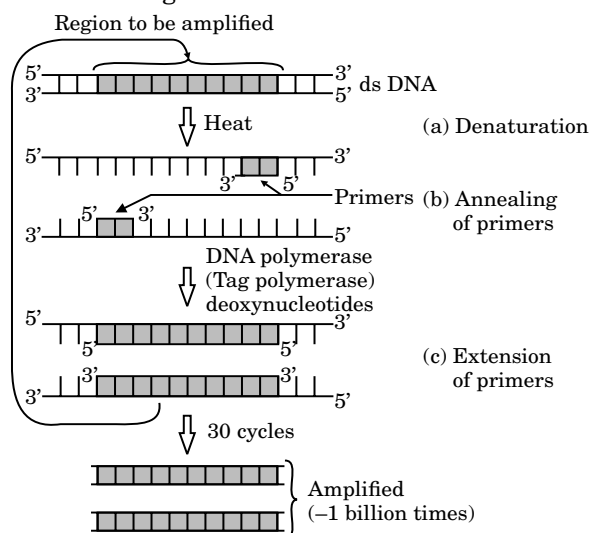
- The purified DNA precipitates after chilled ethanol is added and can be collected as fine threads in the suspension.

Cutting of DNA at specific locations

- At the optimal conditions, incubating purified DNA perform restriction enzyme digestions with the restriction enzyme.
- To check the progression of a restriction enzyme digestion, the technique adopted is agarose gel electrophoresis. As DNA is a negatively charged molecule, it moves towards the positive electrode.
- The source and the vector DNA are cut with specific restriction enzyme and then the cut out 'gene of interest' from the source DNA and the cut vector are mixed and ligase is added which forms recombinant DNA.

Amplification of Gene of interest using PCR

- Polymerase Chain Reaction (PCR) is a chemical reaction in which the multiple copies of the gene synthesizes in vitro with two set of primers and the enzyme DNA polymerase.
- The segment of DNA is amplified around 1 billion times if the process of replication is repeated several times.
- Source DNA and vector DNA are cut with some endonuclease of double stranded DNA when are then ligated by mixing the gene of interest vector DNA in presence of the enzyme DNA ligase to form recombinant DNA and the amplified fragment can be used to ligate with a vector for further cloning.



Insertion of Recombinant DNA into the host cell/organism

- There exist many methods to introduce the ligated DNA into recipient cells.

- The DNA present in the surrounding is taken by recipient cells.
- If a recombinant DNA bearing ampicillin resistant gene is transferred into E.coli cells, the host cell become ampicillin-resistant cells.
- But the untransformed recipient cell will die if the transformed cells are spread on agar plates containing ampicillin and only transformants will grow. The gene which is resistance to ampicillin in this case is called a selectable marker.

Obtaining the foreign gene product

- Recombinant protein is the protein encoding gene which is expressed in a heterologous host.
- After the cloning of genes, the production of which can be done on a large scale, the fresh medium is obtained by separation technique and is added such that the cell maintain physiologically active phase and then produces a larger biomass leading to higher yields.

- Bioreactors:
 - Bioreactor is a device used for biological conversion of raw materials into specific products like human cells, animal cells or microbial plants.
 - Large volumes of cultures may be processed.
 - The main components of a bioreactor are an oxygen delivery system, a foam control system and an agitator system.
 - Desired conditions for the production of the product are provided like pH, vitamins, salts and temperature.
 - Stirring type of bioreactors are mainly used which are usually cylindrical.
 - A bioreactor is shown below:

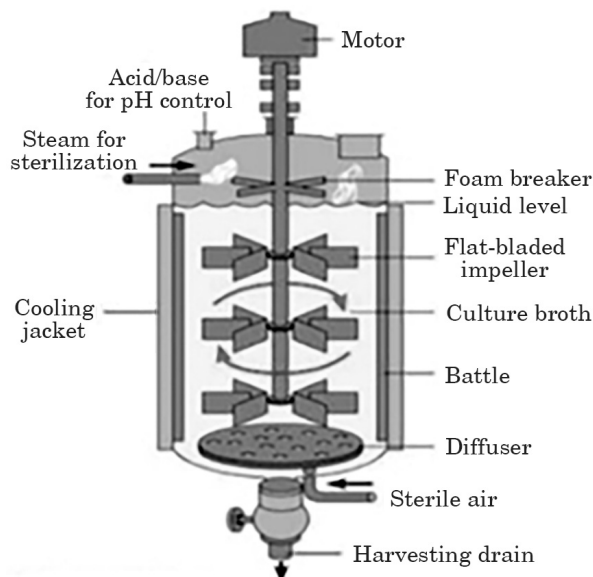


Fig.: Bioreactor

- In a recombinant protein, protein encoding gene is expressed in a heterologous host.

Downstream processing

Two main processes are referred as downstream processing which are separation and purification.

- Suitable preservations have to formulate the product.
- In case of drugs, formulation has to undergo thorough clinical trials and the process of quality control varies for every product.

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 2

▣ 1 Mark Questions

1. Why is the enzyme cellulase needed for isolating genetic material from plant cells and not from the animal cells? **[DELHI 2013]**
2. Name the enzymes that are used for the isolation of DNA from bacterial and fungal cells for recombinant DNA technology. **[ALL INDIA 2014]**

▣ 2 Marks Questions

3. (a) A recombinant vector with a gene of interest inserted within the gene of α - galactosidase enzyme, is introduced into a bacterium. Explain the method that would help in selection of recombinant colonies from non-recombinant ones.
(b) Why is this method or selection referred to as "insertional inactivation"? **[DELHI 2012]**
4. Explain the following and mention one application of each:
(i) PCR (ii) ELISA **[DELHI 2013]**
5. Name the source of the DNA polymerase used in PCR technique. Mention why it is used. **[ALL INDIA 2013]**
6. Write any four ways used to introduce a desired DNA segment into a bacterial cell in recombinant technology experiments. **[ALL INDIA 2013]**

▣ 3 Marks Questions

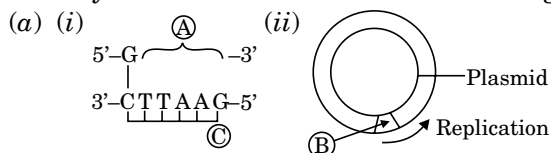
7. (a) Explain the significance of 'palindromic nucleotide sequence' in the formation of recombinant DNA.
(b) Write the use of restriction endonuclease in the above process. **[ALL INDIA 2017]**
8. Describe the roles of heat, primers and the bacterium *Thermus aquaticus* in the process of PCR. **[ALL INDIA 2017]**

9. Explain the roles of the following with the help of an example each in recombinant DNA technology:

(a) Restriction Enzymes

(b) Plasmids **[DELHI 2018]**

10. Identify A and B illustration in the following:



(b) Write the term given to A and B and why?

(c) Expand PCR. Mention its importance in biotechnology. **[DELHI 2011]**

11. How is the amplification of a gene sample of interest carried out using Polymerase Chain Reaction (PCR)? **[DELHI 2012]**

▣ 5 Marks Questions

12. If a desirable gene is identified in an organism for some experiments. Explain the following:
(i) cutting the desired gene at specific location.
(ii) synthesis of the multiple copies of that gene **[ALL INDIA 2011]**

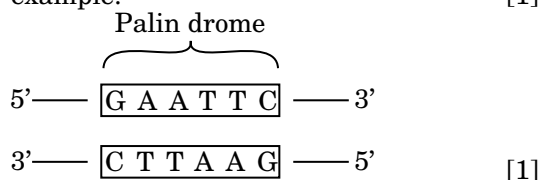


Solutions

1. Animal cells do not have cellulose cell wall, whereas plant cells have. Hence, the enzyme cellulase is needed for isolating genetic material from plant cells and not from the animal cells. **[1]**
2. For bacteria cell, enzyme lysozyme is used and for fungal cells, enzyme chitinase are used for the isolation of DNA for recombinant DNA technology. **[1]**
3. (a) Alternative selectable markers have been developed which differentiate recombinant from non-recombinant on the basis of their ability to produce colour in the presence of a chromogenic substrate. **[1]**
(b) The method is referred as Insertional inactivation because a recombinant DNA is inserted within the coding sequence of an enzyme α -galactosidase which results in the inactivation of the enzyme. **[1]**
4. (i) PCR: polymerase chain reaction. It is used for the amplification of DNA for cloning purpose. **[1]**
(ii) ELISA: Enzyme linked Immuno sorbent assay. It is used for the measurement of antibodies in the blood. **[1]**
5. *Thermus aquaticus* produces a DNA polymerase and is used in PCR technique because it is heat stable DNA polymerase. **[2]**

6. (i) Chemical method – Poration by divalent cation such as calcium [½]
 (ii) Micro injection [½]
 (iii) Biolistic or gene gun [½]
 (iv) Disarmed pathogen vectors [½]

7. (a) The palindromic sequences is the sequence of base pairs which read the same on both the DNA strands, wherein orientation of reading is remains the same. Every endonuclease inspects the entire DNA sequence for palindromic recognition sequence. For example: [1]



- (b) The restriction endonuclease binds to the DNA when it finds the palindrome. It cuts the opposite strands of DNA, but between the same bases on both the strands and forms Sticky Ends. The sticky ends make easy the action of enzyme DNA ligase and helps in the formation of recombination DNA. [1]

8. The role of heat, primers and the bacterium *Thermus aquaticus* in the process of PCR:

Heat: It denatures PCR. The ds DNA is heated at the temperature 95°C, both the strands separate.

Primers: Primers are the small oligonucleotides of varying length of about 10-18 nucleotides that are complementary to a region of template DNA and helps in the extension of new chain. [2]

Thermus aquaticus: A specialized thermostable enzyme Taq DNA polymerase is isolated from the bacterium *Thermus aquaticus* which can tolerate high temperatures and synthesizes new strand. [1]

9. (a) Restriction enzymes: A class of nucleases which breaks nucleic acids at specific recognition site by cleaving their phosphodiester bonds. They are used to cut the donor DNA to isolate the desired gene. The desired gene has sticky ends which can be easily ligated to cloning vector cut by same restriction enzymes having complementary sticky ends to form recombinant DNA. For example, EcoRI which is obtained from *E. coli* bacteria “R” strain which cuts DNA at specific palindromic Recognition site. [1½]
 (b) Plasmids: plasmids are extra chromosomal circular, self –replicating double stranded DNA of bacteria. Plasmids are used as

cloning vectors in genetic engineering by cutting and ligating the desired genes into it and transforming into host cell for amplification to obtain the desired products. An example of artificial modified plasmids are pBR322. [1½]

10. (a) the part “a” is showing sticky ends that are produced when restriction endonuclease cut the DNA at palindromic sites and the other part is foreign DNA. [1]
 (b) The term given to A and B is palindromic sequence as sequence of characters (nucleotides) which reads the same backward as forward [1]
 (c) PCR means polymerase chain reaction. It is used for the amplification of DNA for cloning purpose. [1]
11. Amplification of a gene sample of interest carried out using Polymerase Chain Reaction with the help of three steps:
 (i) Denaturation of DNA that involves the separation of DNA strands at high temperature. [1]
 (ii) Annealing involves the attachment of primers to the separated DNA [1]
 (iii) Extension involves the polymerization of nucleotide chain by the enzyme Taq polymerase. [1]
12. (i) Restriction endonuclease play an important role in DNA recombinant technology in cutting the required DNA segment at specific site in DNA called as palindromic sequences. Sticky ends are produced by restriction enzymes. They are formed when restriction enzymes cut the DNA at specific palindromic sites and result in the generation of overhanging stretches called ‘sticky ends’ on each strand. These are called sticky ends because they form hydrogen bonds with their complementary cut counterparts. Hence, restriction enzymes play an important role in taking out the gene of interest from the organism and cutting the vector DNA at specific site, so that gene of interest can be inserted in the vector. [3]
 (ii) Amplification of a gene sample of interest is carried out using Polymerase Chain Reaction with the help of three steps: (i) Denaturation of DNA that involves the separation of DNA strands at high temperature. (ii) Annealing involves the attachment of primers to the separated DNA (iii) Extension involves the polymerization of nucleotide chain by the enzyme Taq polymerase. [2]

Biotechnology and Its Applications

Chapter Analysis with respect to Last 3 Years' Board Exams

List of Topics	2016		2017		2018
	Delhi	All India	Delhi	All India	Delhi/All India
Human insulin and vaccine production, gene therapy				1Q (3 marks)	1Q (1 mark)
Genetically modified organisms-Bt crops	1Q (3 marks), 1Q (3 marks),	1Q (3 marks)	1Q (3 marks)	1Q (1 mark)	1Q (3 marks),
Transgenic Animals, biosafety issues, biopiracy and patents		1Q (3 marks), 1Q (1 mark)	1Q (3 marks), 1Q (1 mark)		

On the basis of above analysis, it can be said that from exam point of view Transgenic Animals, Mechanism of Bt toxin, Bio-piracy, Insulin Production, Bioreactors and Pest resistant plants are most important concepts of the chapter.

[Topic 1] Biotechnological Applications in Agriculture and Medicine

Summary Biotechnology

Biotechnology is the science which is responsible for the manufacturing of different pharmaceuticals. These pharmaceutical products are produced from genetically modified fungi, animals, plants, microbes etc.

- **Applications of biotechnology:**

- Therapeutics
- Genetically modified crops for agriculture
- Diagnostics
- Bio remediation
- Energy production
- Waste treatment

- **Biotechnology Research Areas:**

- Creating the optimal conditions which are required for a catalyst to work through engineering.
- The purification of protein or organic compounds by downstream processing technologies.
- Providing the top suitable catalyst as an improved organism such as microbes.

Biotechnological Applications in Agriculture

- Helped in increasing the production of food using the following:
 - Organic Agriculture
 - Genetically engineered crop based production
 - Agro-chemical based agriculture
- The Green Revolution increased the production of food by three folds.
- **Genetically Modified Organisms (GMO):**
Genetically Modified Organisms are the flora and fauna whose genes are being modified to enhance them to be more productive according to the human needs.
 - Advantages of GMO in Plants:
 - The crop becomes more tolerant towards the physical climatic conditions i.e. weather, salinity etc.
 - The post-harvest losses are reduced enhancing more profit.
 - The nutrition value of the food also increases.
 - It increases the efficiency of the plant on the basic level which avoids early exhaustions.

- **Pest Resistant Plants:**

- These plants cut the use of chemical pesticides by a huge amount and enable us to not use insecticides. Some of the examples of such plants are as follows:

- **Bt (*Bacillus thuringiensis*) Cotton:**

- The *Bacillus thuringiensis* produces a few strains which kill insects such as worms, flies and mosquitoes.
- The *Bacillus thuringiensis* produces an insecticidal protein while growing. This does not affect the bacillus as it is present in its inactive protoxin form.
- When an insect eats the plant, the inactive toxin converts into an active toxin.
- This toxin results in binding of midgut surface to epithelial cells to create pores.
- This whole process causes the cell to swell and as a result die.
- The toxin is coded by a gene which is known as *cry*.

- **Nematode Resistance in Tobacco Plants**

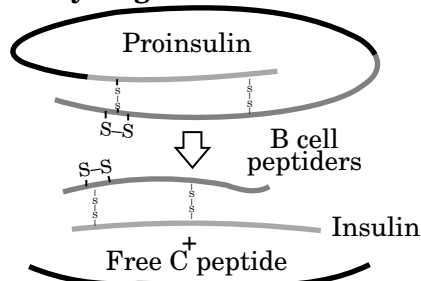
- *Meloidogyne incognitia* is a nematode which generally attacks the roots of the Tobacco plant causing a very less tobacco yield.
- RNA interference is used to prevent this nematode attack.
- The eukaryotic organisms use RNAi for their defence.
- This prevents mRNA translation because of complementary dsRNA molecule.
- The source of complementary RNA is from an infection by RNA virus.
- Nematode specific genes are introduced into the host plant by *Agrobacterium* vectors.
- Both sense and anti-sense bacteria are produced in the host cell.
- These two complementary RNA initiates RNAi which silences the nematode. As a result the parasites are not able to survive this environment.

Biotechnological Applications in Medicine

The biotechnology is used for a mass production of pharmaceutical products and drugs using recombinant technology. Now a days there are thirty recombinant therapeutics officially throughout the

globe among which twelve are being marketed in India.

- **Genetically Engineered Insulin**



- The diabetes in adults can be managed by taking insulin at regular intervals of time.
- At the present moment we can produce insulin for humans synthetically.
- The pancreas of different animals have insulins present in them.
- Insulin consists of two polypeptide chains (Chain A and Chain B), which are connected by disulphide bridge.
- In all the mammals the insulin is always produced in pre-hormone i.e. hormone which is in a stage of growth before it converts in to a fully grown hormone.
- These pre-hormones have C-peptide which is extracted at the time of maturation.

- **Gene Therapy**

- It is a method using which a defect in a gene can be corrected.
- In this method, the genes are inserted in to the cells externally in order to treat a hereditary disease.
- It replaces the non functional gene causing the problem.
- In the process patient blood's lymphocytes are cultured in culture.
- The lymphocytes are introduced by a functional ADA cDNA.
- This process is repeated unless all the cells are not immortal.
- A permanent cure can be a result if ADA gene is introduced at early embryonic stage.

- **Molecular Diagnosis**

- Using the conventional methods makes it is very difficult to make a diagnosis at an early stage.
- Hence for early diagnosis tests like PCR, ELISA, recombinant DNA technology etc are done.
- The presence of a pathogen is usually noted when the pathogen results in to the first symptom. At this time the density of pathogens is very high.
- Using PCR the density of the pathogens is increased by amplification of nucleic acid.

- PCR is vastly used to identify HIV or Cancer pathogens.
- Antigen and antibody interactions is the principle on which ELISA works.
- Infection produced by a pathogen can be detected by the presence of antigen or antibodies which are made to counter pathogens.

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 1

▣ 1 Mark Questions

1. Why do children cured by enzyme-replacement therapy adenosine deaminase deficiency need periodic treatment? [DELHI 2015]
2. What are Cry genes? In which organism are they present? [ALL INDIA 2017]
3. Mention the chemical change that proinsulin undergoes, to be able to act as mature insulin. [DELHI 2018]
4. State the role of transposons in silencing of mRNA in eukaryotic cells. [ALL INDIA 2013]
5. State the role of C peptide in human insulin. [ALL INDIA 2014]

▣ 2 Marks Questions

6. Explain how a hereditary disease can be corrected. Give an example of first successful attempt made towards correction of such diseases. [DELHI 2011]
7. Biotechnologist refer to *Agrobacterium tumifaciens* as a natural genetic engineer of plants. Give reason to support the statement. [ALL INDIA 2011]
8. How is 'Rosie' considered different from a normal cow? Explain. [ALL INDIA 2011]
9. (a) Mention the cause and the body system affected by ADA deficiency in humans.
(b) Name the vector used for transferring ADA DNA into the recipient cells in humans. Name the recipient cells. [DELHI 2012]
10. (a) State the role of ligase in Biotechnology
(b) What happen when *Meloidegyne incognita* consumes cell with RNAi gene? [ALL INDIA 2012]
11. Write the function of adenosine deaminase enzyme. State the cause of ADA deficiency in humans. Mention a possible permanent cure for an ADA deficiency patient. [DELHI 2013]

12. Why is proinsulin so called? How is insulin different from it? **[ALL INDIA 2013]**
13. State how *Agrobacterium tumefaciens* has been made a useful cloning vector to transfer DNA to plant cells. **[DELHI 2014]**

▶ 3 Marks Questions

14. Recombinant DNA-technology is of great importance in the field of medicine. With the help of a flow chart, show how this technology has been used in preparing genetically engineered human insulin. **[DELHI 2015]**
15. Describe any three potential applications of genetically modified plants. **[ALL INDIA 2015]**
16. How did an American Company, Eli Lilly use the knowledge of r-DNA technology to produce human insulin? **[ALL INDIA 2015]**
17. How has RNAi technique helped to prevent the infestation of roots in tobacco plants by a nematode *Meloidogyne incognita*? **[DELHI 2016]**
18. What is a GMO? List any five possible advantages of a GMO to a farmer. **[DELHI 2016]**
19. (a) Name the selectable markers in the cloning vector pBR322? Mention the role they play
(b) Why is the coding sequence of an enzyme β -galactosidase a preferred selectable marker in comparison to the ones named above? **[ALL INDIA 2016]**
(b) The coding sequence of an enzyme β -galactosidase, a preferred selectable marker because of simpler and easy process. In the presence of chromogenic substrate, the recombinants are colourless and non-recombinants are blue in colour.
20. (a) Why must a cell be made 'competent' in biotechnology experiments? How does calcium ion help in doing so?
(b) State the role of 'biolistic gun' in biotechnology experiments. **[ALL INDIA 2016]**
21. Write the steps you would suggest to be undertaken to obtain a foreign-gene-product. **[DELHI 2017]**
22. Why do lepidopterans die when they feed on Bt cotton plant? Explain how it happens. **[DELHI 2017]**
23. Explain the various steps involved in the production of artificial insulin. **[ALL INDIA 2017]**
24. How has the use of *Agrobacterium* as vectors helped in controlling *Meloidogyne incognita* infestation in tobacco plants? Explain in correct sequence. **[DELHI 2018]**

25. (a) Tobacco plants are damaged severely when infested with *Meloidogyne incognita*. Name and explain the strategy that is adopted to stop this infestation.
(b) Name the vector used for introducing the nematode specific gene in tobacco plant. **[DELHI 2012]**
26. Name the genes responsible for making Bt cotton plants resistant to bollworms attack. How do such plants attain resistance against bollworm attack. Explain. **[ALL INDIA 2012]**
27. In a maternity clinic, for some reasons the authorities are not able to hand over the two new-borns to their respective real parents. Name and describe the technique that you would suggest to sort out the matter. **[ALL INDIA 2013]**
28. Name the pest that destroys the cotton bolls. Explain the role of *Bacillus thuringiensis* in protecting the cotton crop against the pest to increase the yield. **[ALL INDIA 2013]**
29. How did the process of RNA interference help to control the nematode from infecting roots of tobacco plants? Explain. **[ALL INDIA 2014]**

Solutions

- The enzyme-replacement therapy for adenosine deaminase (ADA) deficiency is not a completely curative method because lymphocytes have a definite life cycle and it needs periodic transfusion of genetically engineered lymphocytes into the patient. [1]
- Cry genes are present in bacterium *Bacillus thuringiensis*. Cry genes code for a toxin which is poisonous to some insects. [1]
- The proinsulin is cleaved and the C-peptide chain removed to form mature insulin leaving only A-chain and B-chain joined by disulphide bond. [1]
- Transposon are the jumping DNA sequences that can move from one location to another in the genome. Hence, when they jump, at a point where they can bind with transcribing DNA to RNA and prevent it from translation. [1]
- Removal of C peptide makes the active form of insulin from non- active form which is pro-insulin. [1]
- Hereditary disease can be corrected now- a-days with gene therapy. In this method, disease causing gene is replaced with new normal gene which does not cause the disease. It involve gene corrections in embryo stage, if discovered through amniocentesis and juvenile stage. [1]

First successful attempt was made on a 4-year old girl. She was suffering from Adenosine deaminase deficiency. This enzyme is important for immune system. The enzyme can be infused inside by injection or by bone marrow transplantation for correction of the disease.[1]

7. *Agrobacterium tumefaciens* a gram negative bacteria and known as natural genetic engineer of plants. The name is given to it because it integrates its plasmid DNA known as T DNA into plant genome without any vector. It can be used to incorporate genes for plant defense, or against stress. Therefore it is a natural genetic engineer of plants. [2]
8. 'Rosie' is a transgenic cow developed by scientist in the year 1997. Its milk is better than other cows because it is enriched with alpha - lactalbumin. This milk is nutritionally more balanced for human babies than natural cow's milk. [2]
9. (a) ADA deficiency in humans is caused due to the missing ADA gene in diseased person, wherein Adenosine deaminase enzyme is not produced. Its deficiency in humans affect the immune system. [1]
(b) The vector used for transferring ADA is a retrovirus. Recipient cells are lymphocytes. [1]
10. (a) DNA ligase act as a "glue" to join the two DNA strands by forming phosphodiester bond. [1]
(b) When *Meloidogyne incognita* consumes cell with RNAi gene, then it will die because introduced RNAi will form sense and anti-sense RNA (dsRNA) that are complementary to each other will be complementary to mRNA. Hence, the situation lead to the process of gene silencing by RNAi. [1]
11. Adenosine deaminase enzyme plays an important role in the immune system of human. ADA deficiency in humans is caused due to the lack of gene responsible for the production of ADA enzyme. This condition, is cured by gene replacement therapy, where the gene of Adenosine deaminase enzyme is introduced in then human lymphocytes with the help of retrovirus. [2]
12. Proinsulin is like a pro-enzyme having extra stretch of C-peptide which makes it inactive. So it needs to be processed to become fully mature and functional hormone like insulin, insulin is mature hormone which contains only A and B peptide. [2]

13. *Agrobacterium tumefaciens* a gram negative bacteria and known as natural genetic engineer of plants. The name is given to it because it integrates its plasmid DNA known as T DNA into plant genome without any vector. This property is used by biotechnologist to transfer desired gene in the plants with the help of its T-DNA. [2]

14. Preparation of Human Insulin Using Recombinant DNA Technology:

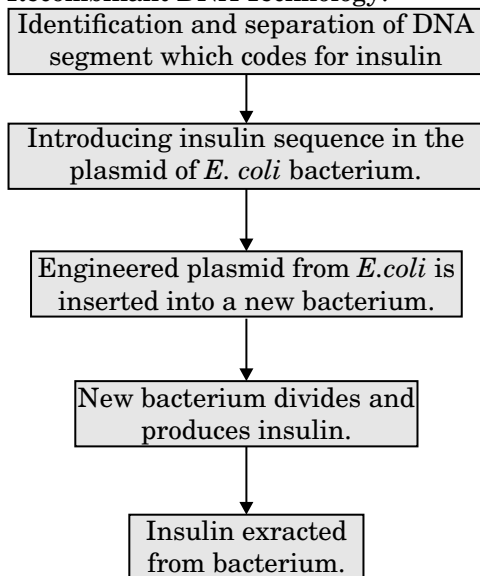


Fig.: Human Insulin preparation using recombinant DNA technology [$\frac{1}{2} \times 4 + 1 = 3$]

15. (a) Genetically modified plants are more tolerant to abiotic stresses such as cold, drought, salt and heat. [1]
(b) Genetically modified plants increase the efficiency of mineral usage and prevent early exhaustion of soil fertility. [1]
(c) GM plants do not dependent much on chemical pesticides. [$\frac{1}{2}$]
(d) They have enhanced the nutritional value of food such as vitamin A-enriched rice. [$\frac{1}{2}$]
16. The structure of insulin consist of two short polypeptide chains- chain A and chain B that are linked together by disulphide bridges. In mammals including humans, insulin is synthesised as a pro-hormone. It needs to be processed before it becomes a fully mature and functional hormone. It contains an extra stretch called C-peptide. C-peptide is removed during maturation into insulin. The rDNA technique is used for assembling insulin into the mature form. [1]
In 1983, Eli Lilly, an American company, prepared two DNA sequences corresponding to A and B chains and it introduced into *E. coli* to produce A and B chains separately. These chains

were extracted and combined to form disulphide bonds to form human insulin. [1]

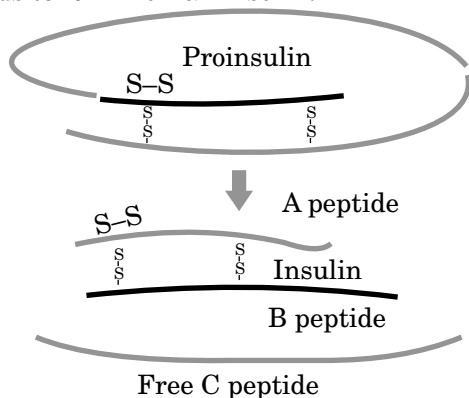


Fig.: Maturation of pro-insulin into insulin [1]

17. RNA Interference (RNAi) is process which silences a gene. It blocks the expression of genes in the parasite when it enters the host's body. RNAi is a method adopted to prevent infestation of roots of tobacco plants by a nematode *Meloidogyne incognitia*. In RNAi, a complementary RNA binds to mRNA to form a dsRNA that cannot translate. Therefore, its expression is blocked (Silenced). In this process, nematode-specific genes (DNA) are introduced in the host plant. This introduced DNA forms both sense and anti-sense RNA. These two strands, being complementary to each other, bend and form ds RNA, leading to RNA interference. mRNA of nematode is thus silenced and the parasite cannot survive in the transgenic host. Thus, tobacco plants can be protected from nematode attack. [3]
18. Genetically Modified Organisms (GMOs) are those plants, bacteria, fungi or animals whose genes have been altered by manipulation. [1]
Advantages:
- They have high tolerance factors cold, drought, salt, heat, etc.
 - Less dependent on chemical pesticides.
 - Minimum post-harvest losses.
 - Increased efficiency of mineral usage by plants.
 - increased nutritional value. [2]
19. (a) Ampicillin resistance gene (ampR) and tetR/ tetracycline resistance gene (tetR) are the selectable markers in the cloning vector pBR322. They help in identifying and eliminating non-transformed cells and distinguish recombinant cells from non-recombinant cells. [1½]
- (b) The coding sequence of an enzyme β -galactosidase, a preferred selectable marker because of simpler and easy process.
- In the presence of chromogenic substrate, the recombinants are colourless and non-recombinants are blue in colour. [1½]
20. (a) In most biotechnology experiments the cells are made competent so that it can take up the DNA from the external medium. The bacterial cells are treated with divalent cations such as calcium to increase the efficiency of DNA entering the cell through pores in the cell wall. [1½]
- (b) Biolistic gun or gene gun is used to introduce alien DNA into host cells especially in plants. In this method, the host cells are bombarded with high-velocity microparticles of gold or tungsten coated DNA molecules. [1½]
21. The steps to obtain a foreign-gene product are stated below:
- Identification of DNA having desirable genes. [½]
 - Identified DNA is inserted into suitable host to form recombinant DNA (*rDNA*). [½]
 - In the host the introduced DNA is cloned.
 - Transfer of the DNA (gene transfer) to its progeny. [½]
 - Selection of the recombinants from non-recombinants. [½]
 - Gene of interest is expressed by culturing recombinant cells. [½]
 - Production of desired gene product on large scale by cell culture in bioreactors. [½]
22. Bt cotton are genetically modified plants have a *Bacillus thuringiensis* gene called cry gene. This gene, encodes for Bt toxin protein crystals having insecticidal properties. The toxin is effective for lepidopteran such as cotton boll worm. Bt toxin exists as inactive protoxins. When an insect ingests the inactive toxin, it gets converted into an active form of toxin due to the alkaline pH of the gut (stomach) which solubilise the crystals. The activated toxin binds to the surface of mid gut epithelial cells and make pores that cause cell swelling and cell lysis (breakdown) and eventually cause death of the insect. [3]
23. Insulin consist of two short polypeptide chains- chain A and chain B that are linked together by disulphide bridges. In mammals including humans, insulin is synthesised as a pro-hormone. It needs to be processed before it becomes a fully mature and functional hormone. It contains an extra stretch called C-peptide. C-peptide is removed during maturation into functional insulin. The two DNA sequences

corresponding to A and B chains are introduced into *E. coli* to produce A and B chains separately. These chains are extracted and combined by creating disulphide bonds to form human insulin. [3]

24. A nematode *Meloidegryne incognitia* infects the roots of tobacco plants and causes a great reduction in yield. An effective strategy was adopted to prevent this infestation which was based on the process of RNA interference (RNAi). Using *Agrobacterium* vectors, nematode-specific genes were introduced into the host plants. The introduction of DNA was such that it produced both sense and anti-sense RNA in the host cells. These two RNA's being complementary to each other formed a double stranded (dsRNA) that initiated RNAi and it silenced specific mRNA of the nematode. As a result the parasite could not survive in a transgenic host expressing specific interfering RNA. The transgenic plant therefore gets itself protected from the parasite. [3]
25. (a) When *Meloidegryne incognitia* consumes cell with RNAi gene, then it will die because introduced RNAi will form sense and anti-sense RNA that are complementary to each other and form double stranded RNA. Hence, the situation lead to silencing of mRNA due to RNAi. [1½]
- (b) *Agrobacterium tumefaciens*: *Agrobacterium tumefaciens* a gram negative bacteria and known as natural genetic engineer of plants. The name is given to it because it integrates its plasmid DNA known as T DNA into plant genome without any vector. This property is used by biotechnologist to transfer desired gene in the plants with the help of its T-DNA. [1½]
26. The gene encoding cry protein is called "cry gene". This Cry protein isolated and transferred into several crops. For example, the proteins encoded by the genes cryIAC and cryIIAB control the cotton bollworms, that of cryIAB controls corn borer. Some strains of *Bacillus thuringiensis* produce proteins that kill certain insects such as, coleopterans and dipterans. *B. thuringiensis* forms protein crystals which contain a toxic insecticidal protein. [3]
27. DNA Fingerprinting or DNA test is the technique that I would suggest to sort out the matter. It consist of isolation of DNA, digestion of DNA by restriction endonucleases, separation of DNA fragments by electrophoresis, transferring (blotting) of separated DNA fragments to synthetic membranes, such as nitrocellulose or nylon, hybridisation using labelled VNTR probe, and detection of hybridised DNA fragments by autoradiography. Half of the bands obtained on autoradiogram of child will resemble father and other half to mother. [3]
28. The gene encoding cry protein is called "cry gene". This Cry protein isolated and transferred into several crops. For example, the proteins encoded by the genes cryIAC and cryIIAB control the cotton bollworms, that of cryIAB controls corn borer. Some strains of *Bacillus thuringiensis* produce proteins that kill certain insects such as, coleopterans and dipterans. [1½]
- B. thuringiensis* forms protein crystals which contains a toxic insecticidal protein. The Bt toxin protein exist as inactive protoxins but once an insect ingest the inactive toxin, it is converted into an active form of toxin due to the alkaline pH of the gut which solubilises the crystals. The activated toxin binds to the midgut epithelial cells, causes cell lysis and lead to the death of the insect. [1½]
29. RNAi is a gene silencing process. RNA interference help to control the nematode from infecting roots of tobacco plants. When *Meloidegryne incognitia* consumes cell with RNAi gene, then it will die because introduced RNAi will form sense and anti-sense RNA that are complementary to each other and form double stranded RNA. Hence, the situation lead to the silencing of mRNA due to RNAi. [3]

[Topic 2] Transgenic Animals and Bioethical Issues

- **Transgenic Animals:** There are some animals in which an extra gene is expressed and possessed by DNA manipulation. Such animals are called transgenic animals. There are many animals of this type like rabbits, sheep, rats, cows, fish, etc. but most of them are mice.

These modifications lead to some benefits which are explained below:

- **Normal physiology and development:** These modifications in animals help us to understand about the regulation of genes and their effect of normal functioning of body.

- Study of disease: These modifications also help to understand their contribution for diseases. It helps us to investigate about the new treatments for various diseases like cancer, Alzheimer's, rheumatoid arthritis and cystic fibrosis.
- Biological products: Some products are used to treat certain diseases but are expensive therefore some transgenic animals are used to create those products. Some diseases which are treated by such products are phenylketonuria (PKU), emphysema, etc.
- Vaccine safety: Some of the vaccines are tested for safety on transgenic mice before being used by humans. If it is found reliable, mice are replaced by monkeys.
- Chemical safety testing: Transgenic animals are used to test toxicity of drugs. These animals are more sensitive to toxic substances. These animals are exposed to toxic substances and the effects are studied.
- **Ethical Issues:** There are some ethical standards to be followed so that the morality of human activities is evaluated. These are necessary because genetic modifications of organisms can have unpredictable results.
- GEAC (Genetic Engineering Approval Committee) is an organization set up by the Indian Government to determine the validity and safety of introducing genetic modification organisms for public services.
- Some companies are using products and technologies that have already been identified and used by some farmers and indigenous people.
- Rice is an example which is an important food grain and its varieties are produced in India. There are some varieties which were already derived by Indian farmers and the companies are using their patent rights.
- Biopiracy is used for the companies and organizations when they do not authorize from the concerned countries and people along with compensatory payment.
- Traditional knowledge of some developing and under developed countries is exploited for developing modern applications.
- Some laws are developed by some developed and developing countries to avoid unauthorized exploitation of traditional knowledge and bio-resources.

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 2

▣ 1 Mark Questions

1. What is Biopiracy? [ALL INDIA 2016]
[DELHI 2017]

▣ 2 Marks Questions

2. How have transgenic animals proved to be beneficial in:
 - (a) Production of biological products
 - (b) Chemical safety testing
 [ALL INDIA 2014]

▣ 3 Marks Questions

3. (a) Why are transgenic animals so called?
(b) Explain the role of transgenic animals in
 - (i) vaccine safety
 - (ii) Biological products with the help of an example of each. [DELHI 2013]

Solutions

1. Biopiracy is the practice of using bio-resources by multinational companies and other organisations without proper permission from the countries

- and people concerned and without giving monetary benefits. [1]
2. (a) Transgenic animals are used for the production of biological products like milk, which is much cheaper than other methods. For example, Rosie' is a transgenic cow developed by scientist in the year 1997. Its milk is better than other cows' because it is enriched with alpha – lactalbumin, for human babies. [1]
(b) Transgenic animals are modified in such a way that they become sensitive to toxic substance more easily, so the scientist can use them for toxicity testing. [1]
 3. (a) Transgenic animals so called because their DNA is manipulated by scientist to produce biological products and other uses. [1]
(b) (i) vaccine safety: Transgenic mice are used to check the safety of polio virus. [1]
(ii) Biological products: Rosie' is a transgenic cow developed by scientist in the year 1997. Its milk is better than other cows' milk for human babies because it is enriched with alpha - lactalbumin. [1+1]

CHAPTER 13

Organisms and Populations

Chapter Analysis with respect to Last 3 Years' Board Exams

List of Topics	2016		2017		2018
	Delhi	All India	Delhi	All India	Delhi/All India
Habitat and niche, Population and ecological adaptations					
Population interactions- mutualism, competition, predation, parasitism					
Population attributes growth, birth rate and death rate, age distribution	1Q (5 marks)	1Q (5 marks)	1Q (5 marks)		1Q (5 marks)

On the basis of above analysis, it can be said that from exam point of view the concepts Human Population, Abiotic factors and Growth Curve are most important concepts of the chapter.

[Topic 1] Organisms and Their Environment

Summary

Ecology is a branch of biology, which gives us holistic perspective to biology. It is the study of relationships of living organisms with their environments abiotic and biotic components.

Organism and its environment

Physiological ecology is important as it explains how organisms adapt to their environment for survival and reproduction. Major abiotic or physical factors that affect the adaptation of the organisms are temperature, water, soil and light.

Major Abiotic Factors

- **Light:**
 - Species of small plants like herbs and shrubs that grow in forests can photosynthesize optimally under very low light conditions.
 - Some plants depend on sunlight to meet their photoperiodic requirement for flowering.
 - Animals need light for timing their foraging, migratory and reproductive activities.
 - Some plants present at the bottom of the ocean does not get sunlight so some of the color components are not available to them.
- **Temperature:**
 - The average temperature decreases continuously as we move from plains to hilly areas and from the equator towards the poles.
 - In some unique habitats like thermal springs, deep sea hydrothermal vents the average temperature exceed 100°C
 - Some factors like kinetics of enzymes, physiological functions, basal metabolism of the organism are affected by the temperature.
 - The geographical distribution of different species is determined by the levels of thermal tolerance of the species. Some species are called eurythermal which can survive in wide range of temperatures while species called stenothermal can survive only in narrow range of temperatures.
- **Soil**
 - The nature and properties of soil depend on the climate, weathering process, transportation of soil and the development of soil.
 - Vegetation in an area is determined by the mineral composition, topography, pH of the soil.

- Water holding capacity of the soil is determined by the soil composition, grain size and aggregation.

- **Water**

- The amount of water available in a particular area determines the distribution and productivity of plants.
- Salt concentration in water varies for different areas like less than 5 in inland waters, 30 – 35 in the sea and more than 100 in hypersaline lagoons.
- Some aquatic organisms can grow in wide range of salt water, such aquatic organisms are called euryhaline and other can tolerate salinities in a narrow range, called stenohaline.

Responses to Abiotic Factors

- **Homeostasis:**

A process of maintaining the constancy of its internal environment by the organism besides experiencing different external environmental conditions.

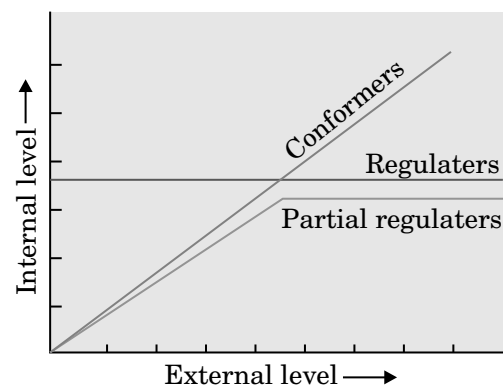


Fig.: Diagrammatic representation of organismic response

The various possibilities by which various organisms deal with the external environmental conditions are **regulate, conform, migrate and suspend.**

- **Regulate**

- Constant body temperature, constant osmotic concentrations are the physiological means by which some organisms maintain homeostasis.
- Success of mammals is largely due to their ability to maintain a constant body temperature and thrive whether they live in poles or in the arid deserts.
- Humans maintain a constant body temperature of 37°C
- In summers sweat cool due to evaporation and brings down the body temperature.
- In winters we shiver which produces heat and raises body temperature.

- **Conform**

- A constant internal environment cannot be maintained by plants and animals.
- With change in water osmotic concentration, body temperature of aquatic animals also changes.
- The animals and plants whose body temperature changes with ambient temperature are called conformers.
- Thermoregulation is expensive energetically for many organisms that includes small birds like shrews and humming birds, because of which such organisms are conformers.

- **Migrate**

- Some organisms move to favorable or more hospitable areas temporarily and return back once the stressful period is over in their own area this is called migration.
- Many Siberian birds migrate from Siberia to Rajasthan in winters.

- **Suspend**

- To help bacteria, fungi and lower plants to survive in unfavorable conditions various kinds of thick walled spores are formed that generate on availability of suitable environment.
- Some organisms escape time to avoid stress like bears goes into hibernation in winters and fishes and snails go into aestivation to avoid summer.
- Under unfavorable conditions many zooplankton species in lakes enter diapause, a stage of suspended development.

Adaptation

- It is any attribute of the organism (morphological, physiological, and behavioral) that enables the organism to survive and reproduce in its habitat. For example people living in higher altitudes have higher Red Blood Cell count because the oxygen level in higher altitudes is low because of which body produces more Red Blood Cells to allow increased level of transportation of gases.
- **Allen's rule:** According to Allen's rule, the limbs, ears and other appendages of the animals living in cold climates tend to be shorter than the animals of the same species living in warm climates to prevent loss of heat.
- Some dessert plants perform their photosynthetic function by stems as the leaves are reduced to spines. Some aquatic animals survive in hot springs while others may survive in Antarctic waters where the temperature is very less. These plants and animals adapt according to the conditions.

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 1

▣ 1 Mark Questions

1. Give an example of an organism that enters 'diapause' and why. [DELHI 2014]
2. State Gause's Competitive Exclusion Principle. [ALL INDIA 2014]
3. Name the type of association that the genus *Glomus* exhibits with higher plants. [ALL INDIA 2014]

▣ 2 Marks Questions

4. Explain brood parasitism with the help of an example. [DELHI 2012]
5. Why do clown fish and sea anemone pair up? What is this relationship called? [ALL INDIA 2012]
6. Some organisms suspend their metabolic activities to survive in unfavourable conditions. Explain with the help of any four examples. [ALL INDIA 2012]
7. Explain the significant role of the genus *Nucleopolyhedro virus* in an ecological sensitive area. [ALL INDIA 2014]
8. Describe the mutual relationship between fig tree and wasp and comment on the phenomenon that operates in their relationship. [ALL INDIA 2014]
9. Many fresh water animals cannot survive in marine environment. Explain. [DELHI 2015]
10. What is mutualism? Mention any two examples where the organisms involved are commercially exploited in agriculture. [ALL INDIA 2015]
11. Many fresh water animals cannot survive in marine environment. Explain. [DELHI 2015]

▣ 3 Marks Questions

12. Water is very essential for life. Write any three features both for plants and animals which enable them to survive in water scarce environment. [ALL INDIA 2011]
13. How do organisms cope with stressful environmental conditions which are localized or of short duration? [ALL INDIA 2011]
14. Explain the mutualism with the help of any two examples. How is different from commensalism? [DELHI 2013]

▶ 5 Marks Questions

15. Name the type of interaction in each of the following examples:
- Ascaris worms living in the intestine of human
 - Wasp pollinating fig inflorescence
 - Clown fish living among the tentacles of sea anemone
 - Mycorrhizae living on the roots of higher plants
 - Orchid growing on a branch of a mango tree
 - Disappearance of smaller barnacles when *Balanus* dominated in the coast of Scotland.

[DELHI 2011]

🔑 Solutions

- Zooplankton is an example of an organism that enters 'diapause' due to adverse environmental conditions. [1]
- Gause's Competitive Exclusion Principle was given by Georgy Gause. According to this law, two species that compete for the same resources cannot stably coexist indefinitely. They competitively inferior one will get eliminated soon. [1]
- Glomus* shows mutualism where it makes the symbiotic relationship with plant roots by forming mycorrhiza. [1]
- Brood Parasitism is a type of parasitism in which the parasitic bird lays its egg in the nest of its host and lets the host incubate them. The best example is between the koel and the crow. Koel is the brood parasite that lays its eggs in the nests of crows and other birds. [2]
- Clown fish gets protection from its predators by moving around hiding in the stinging tentacles of the sea anemone whereas the other one is neither helped nor harmed by the interaction. This relationship is called commensalism. [2]
- Four examples are:
 - Frogs hibernate in cold season in winters.
 - The kangaroo has the ability to concentrate its urine and can live from birth to death without drinking water.
 - Zooplanktons undergo a state of suspended development called diapause during unfavourable conditions.
 - Bears also undergo hibernation in cold weather. [$\frac{1}{2} \times 4 = 2$]
- Nucleopolyhedrovirus is a type of virus that plays a significant role in an ecologically sensitive area. These viruses are perfect examples of species-specific narrow spectrum insecticidal applications. [2]
- Fig tree and wasp show the phenomenon of co-evolution. It means evolution of fig tree and wasp takes place together. The female wasp uses the flower to lay the eggs whereas the wasp pollinates the flower. [2]
- In a marine environment, water is more concentrated than in a fresh water environment. The bodies of many fresh water animals are not adapted to living in the marine environment. Freshwater fishes lose their body water through osmosis because of the higher concentration of salt in the surrounding water (hypertonic environment), which makes their survival in marine water difficult. [2]
- Interrelationship between two organisms in which both organisms get benefit with respect to food and shelter. Two examples:
 - Lichen is a mutualistic relationship between fungi and algae. The fungus provides shelter and nutrients from the environment and the alga makes food for the partner by photosynthesis. [1]
 - Nitrogen fixing bacteria, *Rhizobium*, live in the root nodules of legumes where the bacterium derives nutrition from the roots of the plant and benefits the plants by fixing atmospheric nitrogen in a usable form for the plants. [1]
- In a marine environment, water is more concentrated than in a fresh water environment. The bodies of many fresh water animals are not adapted to the marine environment. Freshwater fishes lose their body water through osmosis because of the higher concentration of salt in the surrounding water (hypertonic environment), which makes their survival difficult. [2]
- Three features, both for plants and animals, which enable them to survive in a water scarce environment are:
 - Some plants have a CAM cycle and animals are nocturnal to save water. [1]

- (b) Few plants' leaves are converted into spines and animals have dry scaly skin to save the water. [1]
 - (c) Plants have sunken conditions whereas animals undergo aestivation to save the water during summers. [1]
13. Plants undergo dormancy during unfavourable conditions and germinate when favourable conditions appear. The seeds and some vegetative structures are used to germinate when favourable conditions appear. Similarly, animals undergo hibernation and migrate to some other places when stressful environmental conditions occur. The zooplankton enter the diapause when adverse conditions come. [3]
 14. Fig tree and wasp show the phenomenon of mutualism. For example, Fig tree and wasp. Another example is between oxpeckers and zebra. Oxpeckers land on zebras and eat ticks and other parasites that live on their skin. The oxpeckers get food and the beasts get pests eliminated. In mutualism, both the organisms in relationship are benefitted from each other where in commensalism, only one partner is benefitted and other is neither benefitted nor harmed. [3]
 15. (i) Ascaris worms living in the intestine of human show parasitism [1]
 - (ii) Wasp pollinating fig inflorescence shows mutualism [1]
 - (iii) Clown fish living among the tentacles of sea anemones shows commensalism [1]
 - (iv) Mycorrhizae living on the roots of higher plants shows mutualism [1]
 - (v) Orchid growing on a branch of a mango tree shows commensalism
 - (vi) Disappearance of smaller barnacles when Balanus dominated in the coast of Scotland shows competition [1]

[Topic 2] Population

- **Population**

- When a group dwells in a well defined geographic area, share or compete for similar resources and interbreed, this represents a population.
- A population has different attributes that an individual organism does not possess like birth rates, death rates and sex ratio.
- The growth status of the population can be reflected by the shapes of the pyramids.

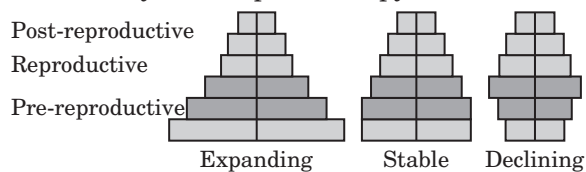


Fig.: Representation of age pyramids for human population

- **Population density:** Also known as population size, is the measurement of population per unit area or unit volume.
- **Population Growth:** The size of a population is not always constant, it varies with factors like food availability, adverse weather, predation pressure these factors provide insight into whether the population is declining or flourishing, these variations in size of population is called population growth. The population fluctuations take place due to four basic processes.

- Natality- Number of births during a given period
- Mortality- Number of deaths in a given period
- Immigration- Number of individuals of the same species that have come into the habitat from some other place.
- Emigration- Number of individuals of the same species that left the habitat and shifted to a new place.

- **Growth models**

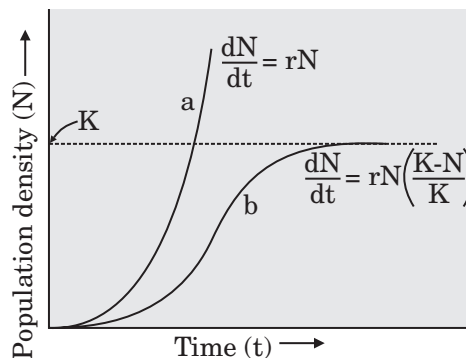


Fig.: Population growth curve

- **Exponential growth:** When the resources are unlimited population has exponential growth. If in a population of size N the birth rates are represented as b and death rates as d then the increase or decrease in N in a unit time period t will be

$$\frac{dN}{dT} = (b - d) \times N$$

$$\text{Let } (b - d) = r \text{ then, } \frac{dN}{dT} = rN$$

- **Logistic Growth:** When the resources are limited exponential growth is not possible, leading to competition between individuals for limited resources and only the fittest will survive and reproduce.

Verhulst-Pearl Logistic growth is given by

$$\frac{dN}{dt} = rN \left(\frac{K - N}{K} \right)$$

- **Life History Variation: Population Interactions**

- The various species of a habitat depend on each other for their survival. There is always a minimal requirement for any species to have one or more species on which it can feed. The populations interact with each other to survive in this ecology. Various population interactions can be understood by this table,

Species A	Species B	Name of Interaction
		Mutualism
		Competition
		Predation
		Parasitism
	0	Commensalism
	0	Amensalism

'+' for beneficial interaction

'-' for detrimental interaction

'0' for neutral interaction

- **Types of Interactions**

- **Mutualism:** This interaction benefits both the interacting species such as the plant-animal relationship. Plants offer pollen and nectar for pollinators and juicy and nutritious fruits for seed dispersers, for e.g. relationship between female wasp and fig species.
- **Competition:** It occurs when closely related species compete for same resource but sometimes totally unrelated species also compete for same resource. For example flamingoes and resident fishes compete for common food, i.e. zooplanktons in some shallow South American lakes. In this process, fitness of one species is lower in presence of the other. Gause's 'Competitive Exclusion Principle' states that two closely related species competing for the same resource cannot coexist indefinitely and the inferior one is eliminated.

- **Predation:** When one species is benefited harming the second species as it preys on it. For example for plants herbivores are predators. Predators maintain the species diversity in a community. If the predator makes the prey extinct then there are possibilities of predator becoming extinct as well.
- **Parasitism:** It is similar to predation where one species is benefited and the second species gets detrimented. The parasite obtains food and shelter from the host. For example lice on humans and ticks on dogs. Parasites have a complex life cycle as parasitisation of primary host is facilitated by one or two intermediate hosts. Ectoparasites are those parasites which feed on the external surface of host organism while endoparasites live inside the host body. An example of parasitism in birds is Brood parasitism where parasitic bird lay its eggs in the nest of the host.
- **Commensalism:** In this interaction one species is benefited while the other is neither harmed nor benefited. For example an orchid growing on a mango branch.
- **Amensalism:** In this interaction one species is detrimented/inhibited or destroyed while the other species is unaffected. For example bread mold penicillium and black walnut trees.

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 2

▣ 3 Marks Questions

- (a) Write the importance of measuring the size of a population in a habitat or an ecosystem
(b) Explain with the help of an example how the percentage cover is a more meaningful measure of population size than mere numbers. **[ALL INDIA 2013]**

▣ 5 Marks Questions

- (a) List the different attributes that a population has and not an individual organism.
(b) What is population density? Explain any three different ways the population density can be measured, with the help of an example each. **[ALL INDIA 2015]**
- (a) Represent diagrammatically three kinds of age-pyramids for human populations.
(b) How does an age pyramid for human population at given point of time helps the policymakers in planning for future. **[DELHI 2016]**

4. (a) Name the two growth models that represents population growth and draw the respective growth curves they represent.
- (b) State the basis for the difference in the shape of these curves.
- (c) Which one of the curves represent the human population growth at present? Do you think such a curve is sustainable? Give reason in support of your answer.

[ALL INDIA 2016]

5. (a) What is an age-pyramid?
- (b) Name three representative kinds of age-pyramids for human population and list the characteristics for each one of them.

[DELHI 2017]

6. (a) Following are the responses of different animals to various a biotic factors. Describe each one with the help of an example.
 - (i) Regulate
 - (ii) Conform
 - (iii) Migrate
 - (iv) Suspend
- (b) If 8 individuals in a population of 80 butterflies die in a week, calculate the death rate of population of butterflies during that period.

[DELHI 2018]

Solutions

1. (a) Measuring the size of a population in a habitat helps us to have knowledge of the relative abundance of that particular species and the effect of the species on the available resources of habitat. [1]
 - (b) Percentage cover is more meaningful measure of population size than mere numbers because the relative abundance of a species is not only determined by number of individuals but by both i.e. the relative abundance in number and relative abundance in biomass. For example, In unit area the number of a grass species individuals or relative abundance in number is high but not in relative abundance of biomass. [2]
 2. (a) Population density, population growth, natality, mortality, sex ratio are the different attributes of a population but these are not the attributes of an individual organism.[1]
 - (b) Population density: it is the number of individuals per unit area at a given time.[1]
- There several ways to measure population density. These are:
- (a) By counting all the individuals in a region if individuals in a population is small. For example, counting Siberian cranes at Bharatpur wetlands. [1]

- (b) By using percent cover or biomass in huge populations. For example, dense laboratory culture of bacteria in a Petri dish can be measured only by biomass. [1]
- (c) By using relative density. For example, the number of fish caught per trap is used to measure its total population density in a lake. [1]
3. (a) A population at any given time is composed of individuals of different ages. Graphical representation of age distribution in a population is called an age pyramid. The age pyramids in human population show age distribution of males and females in a combined diagram. The shape of the pyramids reflects the growth status of the population - whether it is growing or stable or declining. [3]

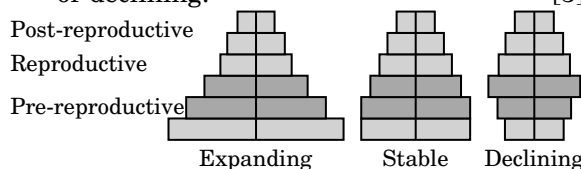


Fig.: Age Pyramids of human population

- (b) An age pyramid for human population at given point of time helps the policymakers in planning for various social issues such as health services, education, infrastructure, finance management. [2]
4. (a) There are two types of growth models which represents population growth are exponential growth and logistic growth. Exponential growth curve:

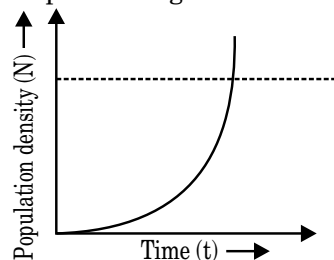


Fig.: Exponential Growth [1]

Logistic growth curve:

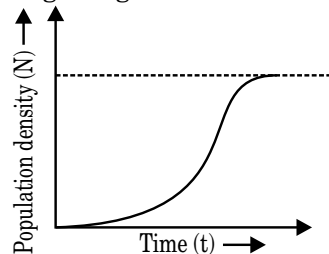


Fig.: Logistic Growth [1]

- (c) In exponential growth model the resources and space are unlimited, the population

tends to grow in an exponential pattern. In logistic growth model the resources and space are limited which leads to competition between individuals. In this type of growth, there is an initial lag phase followed by log phase and then in steady state. [1]

- (c) The present human population follows the logistic growth curve because the human population growing rapidly than the resources. Such a growth pattern is not sustainable because the resources would not be able to meet the demand of increasing population. For sustainable growth it is important to use our resources judiciously. [1]
5. (a) A population at any given time is composed of individuals of different ages. Graphical representation of age distribution in a population is called an age-pyramid. [1]
- (b) The three kinds of age – pyramids are expanding, stable and declining. The characteristics of age pyramids are given below: [1]
- (i) Expanding: pre-reproductive population is greater than reproductive or post-reproductive population. Maximum number of individuals are added in pre-reproductive population and the least number is in post reproductive phase. [1]
- (ii) Stable: Pre-reproductive and reproductive population are almost the same. Its pyramid maintains balanced number of individuals in reproductive and pre-reproductive phase. Less number of individuals are present in post reproductive phase. [1]
- (iii) Declining: Pre-reproductive population is less than reproductive population. Less number of individuals are present in pre-reproductive phase than reproduction phase. [1]

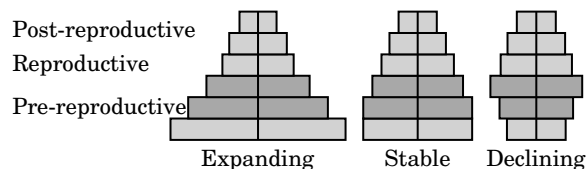


Fig.: Age Pyramids of human population [1]

6. (a) (i) Regulate: some animals able to regulate constant body temperature, constant osmotic concentration, etc. by thermoregulation and osmoregulation. Examples are all birds and mammals. [1]
- (ii) Conform: Most of the animals and almost all plants cannot maintain a constant internal environment. Their body temperature changes with the change in external temperature. Examples are fish, frog, and lizards. [1]
- (iii) Migrate: The organism can move away temporarily. This movement of animals from the stressful habitat to a more favourable habitat and returning back to original place when stressful period is over is migration. Example, Siberian cranes. [1]
- (iv) Suspend: Some animals unable to migrate to other place during stressful conditions of their habitats. To avoid the stress, they escape in time. Examples, bears go into hibernation during winter. [1]
- (b) Number of deaths per 1000 individuals is the death rate.

Death rate of butter flies

$$= \frac{\text{Number of butterflies died}}{\text{Total number of butterflies in a population}}$$

$$\frac{8}{80} = 0.1 \text{ butterflies per week} \quad [1]$$

CHAPTER 14

Ecosystem

Chapter Analysis with respect to Last 3 Years' Board Exams

List of Topics	2016		2017		2018
	Delhi	All India	Delhi	All India	Delhi/All India
Patterns, components; productivity and decomposition				1Q (2 marks)	
Energy flow, pyramids of number, biomass, energy, nutrient cycles (carbon and phosphorous)	1Q (3 marks)				1Q (5 marks)
Ecological succession; ecological services - carbon fixation, pollination, seed dispersal, oxygen release			1Q (5 marks)	1Q (5 marks)	

On the basis of above analysis, it can be said that from exam point of view both the concepts Structure and Function of Ecosystem, Nutrient Cycling and Ecological Pyramids are most important concepts of the chapter.

[Topic 1] Ecosystem–Structure & Function, Productivity & decomposition

Summary

Introduction

The most basic part of nature where the living interact in between themselves and with the surrounding environment

Types of Ecosystems

- **Terrestrial:**
 - Forest, grassland and desert are some examples of terrestrial ecosystems.
- **Aquatic:**
 - Pond, lake, wetland, river and estuary are some examples of aquatic ecosystems.
- **Man-made ecosystems:**
 - Crop fields and an aquarium may also be considered as man-made ecosystems.

Structure and Function

- An Ecosystem has two components:
 - Biotic components: These are consumers, producers and decomposers
 - Abiotic components: These are inorganic materials- air, water and soil
- Every ecosystem has characteristic physical structure derived from interaction of abiotic and biotic components.
- Stratification is vertical distribution of different species occupying different levels. These levels are called STRATA.
- The components of an ecosystem work as a unit by considering the following aspects:
 - Productivity
 - Decomposition
 - Energy flow
 - Nutrient cycling

Productivity

For ecosystems to sustain and function a basic input of solar energy is needed. The rate at which the biomass is produced is termed as productivity.

- **Primary productivity**
 - During the process of photosynthesis, the amount of biomass produced per unit area by different plants is coined as primary productivity.
 - The primary productivity can be illustrated in energy kcal m^{-2} or weight g^{-2} .

- Primary productivity can be divided into NPP (net primary productivity) and GPP (gross primary productivity).

- NPP of an ecosystems the remaining biomass after respiration (R) and GPP is the rate at which the biomass is produced under the process of photosynthesis.

$$\text{GPP} - \text{R} = \text{NPP}$$

The available biomass for heterotrophs to consume is NPP.

- **Secondary productivity:**

- The rate at which the new organic matter is formed is coined as secondary productivity.

Decomposition

The process in which complex organic compounds disintegrate to form inorganic simple compounds is termed as decomposition. The simple disintegrated compounds can be water, carbon gases etc. Detritus is formed from dead remains of animals and dead plants remains like bark, leaves, and flowers.

- **Steps are involved in decomposition**

- **Fragmentation:** Detritivores break down detritus into smaller particles which increases the surface area of detritus particles for microbial action. This process is called fragmentation.

- **Leaching:** The process in which inorganic nutrients goes into the ground and is stored in form of precipitation which cannot be accessed is called Leaching.

- **Catabolism:** The process in which detritus disintegrates into simple inorganic compounds with the help of fungal or bacterial enzymes is called Catabolism.

- **Humification:** This process results in accumulated humus. Humus is an amorphous substance which is black in colour. The decomposition of humus is also very slow.

- **Mineralization:** Mineralization is a process in which the humus produced decomposes to give inorganic simple compounds.

- **Factors affecting Rate of Decomposition:**

- **Chemical composition of detritus:** Decomposition rate is slower if detritus is rich in lignin and chitin, and it is quicker if detritus is rich in nitrogen and sugar.

- **Climatic conditions:** Warm and moist environment favours decomposition.

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 1

1 Mark Questions

- Write the difference between net primary productivity and gross productivity. **[ALL INDIA 2011]**
- Write the equation that helps in deriving the net primary productivity of an ecosystem. **[DELHI 2013]**
- State what 'standing crop' of a trophic level represents. **[ALL INDIA 2013]**
- How is 'stratification' represented in a forest ecosystem? **[DELHI 2014]**

2 Marks Questions

- How are productivity, gross productivity, net primary productivity and secondary productivity interrelated? **[DELHI 2015]**

3 Marks Questions

- Describe the inter-relationship between productivity, gross primary productivity and net productivity. **[ALL INDIA 2017]**

5 Marks Questions

- Describe the advantages of keeping the ecosystems healthy. **[DELHI 2015]**

Solutions

- Gross productivity involve the rate of production of organic matter during the process of photosynthesis. Net primary productivity is the difference between gross productivity and respiratory loss.
Where NPP is Net primary productivity, GPP is Gross primary productivity and R is respiratory loss. **[1]**
- Where NPP is Net primary productivity, GPP is Gross primary productivity and R is respiratory loss.
$$\boxed{GPP - R = NPP}$$
 [1]
- 'Standing crop' of a trophic level represents mass of living material present at a particular time. Measured as mass of living organisms or the number in unit area. **[1]**
- 'Stratification' represented in a forest ecosystem by trees occupying top layer followed by shrubs

second layer and lastly herbs and grasses forming bottom layer. **[1]**

- Productivity is the rate of biomass production per unit area over a period of time by the plants through photosynthesis. It is expressed as $(\text{kcal m}^{-2}) \text{ yr}^{-1}$ or $\text{g/m}^2/\text{yr}$ or $\text{g m}^{-2} \text{ y}^{-1}$. The inter-relationship between productivity, gross primary productivity and net productivity is depicted below: **[1]**

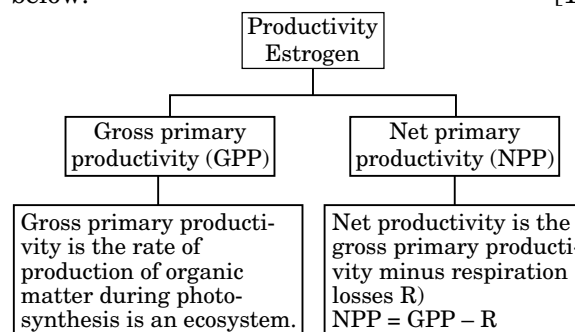


Fig.: Productivity & its types **[1]**

- Productivity is the rate of biomass production per unit area over a period of time by the plants through photosynthesis. It is expressed as $(\text{kcal m}^{-2}) \text{ yr}^{-1}$ or $\text{g/m}^2/\text{yr}$ or $\text{g m}^{-2} \text{ y}^{-1}$. The inter-relationship between productivity, gross primary productivity and net productivity is depicted below: **[1½]**

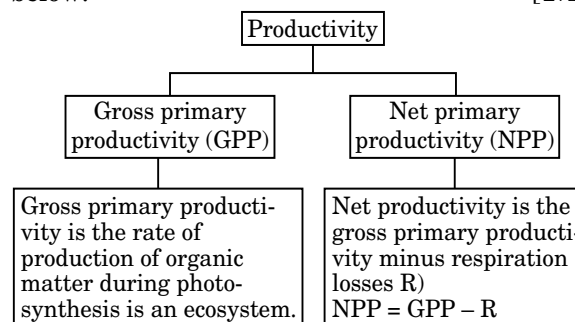


Fig.: Productivity & its types **[1½]**

- There are many advantages of keeping the ecosystems healthy. The various benefits that humans can obtain from the ecosystem are collectively called ecosystem service. Ecosystem services can be categorised into following types: **[1]**
 - Provisioning services: Fruits, vegetables, trees, fish, live stock are directly available to us by an ecosystem. The other benefits in this category are timber, oils, medicines, etc. **[1]**
 - Regulating services: The components of ecosystem can regulate atmospheric temperature, decomposition, flood control, etc. **[1]**

- (iii) Cultural services: It contributes towards the development and advancement of people, e.g. recreational facilities, etc. [1]
- (iv) Supporting services: Allow the earth to sustain basic life forms, e.g., photosynthesis, water cycle, etc. [1]

Besides these benefits the evolution in the gene pool of species through number of generation has produced substances that offer us significant health & other benefits. Thus, by maintaining ecosystem, our future remains secured.

[Topic 2] Energy Flow & Ecological Succession

Summary

Energy Flow

Energy flow is unidirectional. First, plants capture solar energy and then, food is transferred from the producers to consumers and then to decomposers. Organisms of different trophic levels in nature are connected to each other for food or energy relationship forming a food chain. To synthesize the molecules, ecosystem need a constant supply of energy.

- **Producers:**

- The green plants in the ecosystem which produces food are called producers.
- All living animals are dependent on the producers for their food; directly or indirectly.
- The solar energy trapped by the plants is either passed on to consumer or the organism dies.
- The detritus food chain starts when an organism dies.

- **Consumers:**

- The animals that depend on producers directly or indirectly for their food.
- They include:
 - Primary Consumers: These are herbivores that feed on producers. Example: birds, insects etc.
 - Secondary Consumers: They feed on herbivore. Example: fox, man etc.
 - Tertiary Consumers: They feed on primary carnivores.

- **Grazing Food Chain (GFC):**

- An example of grazing food chain (GFC) can be:

(Producer) → (Herbivore) → (Carnivore)

Grass → Deer → Lion

(Producer) → $\left(\begin{array}{c} \text{Primary} \\ \text{Consumer} \end{array} \right)$ → $\left(\begin{array}{c} \text{Secondary} \\ \text{Consumer} \end{array} \right)$

- **Detritus Food Chain (DFC):**

- This chain begins as soon as an organism die.
- This is made up of saprotrophs. For example: bacteria and fungi.

- These saprotrophs secrete enzymes that breakdown the dead and waste materials into simpler materials.
- Some animal are omnivores as well. For example: cockroaches, crow etc.
- These interconnections of food chains make a food web.
- The organisms have specific place in their ecosystem which is known as their trophic level.
- With every successive trophic level, the amount of energy decreases. Only 10% of energy is transferred to each trophic level from the previous one.

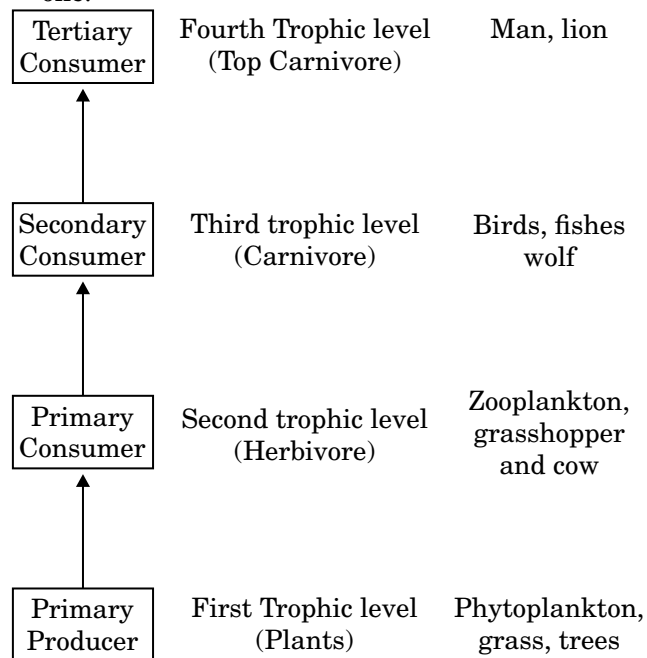


Fig.: Diagrammatic Representation of Trophic Levels in an Ecosystem

Ecological Pyramids

Expressing the relationship between organisms graphically in terms of biomass, energy or number results in ecological pyramids, where the base represents producers and the apex represents top level consumer.

Pyramid of Number:

- It demonstrates the relationship between organisms on the basis of their number.

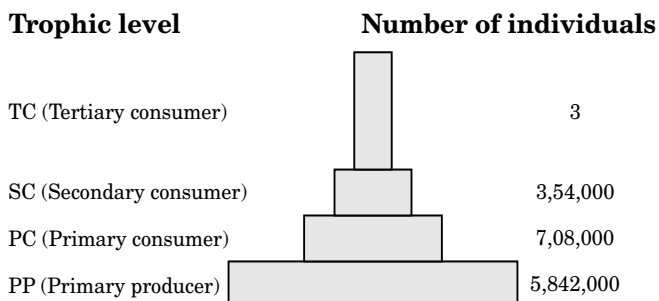


Fig.: Pyramid of Number

Pyramid of Biomass:

- Sharp decrease in biomass at higher trophic levels can be seen in pyramid of biomass in grassland ecosystem.

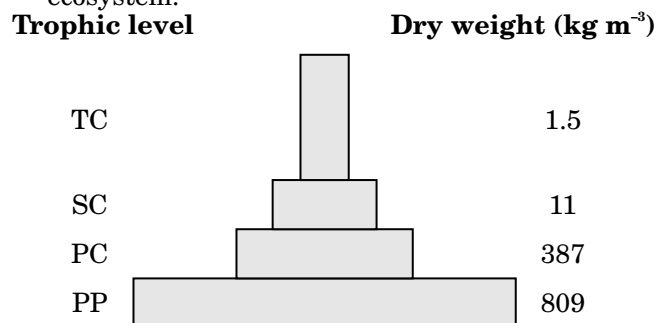


Fig.: Pyramid of Biomass (Grassland Ecosystem)

- Inverted pyramid of biomass is seen in aquatic ecosystem, where small standing crop of phytoplankton supports large crop of zooplankton.

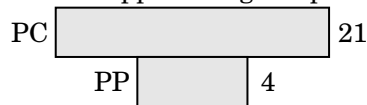
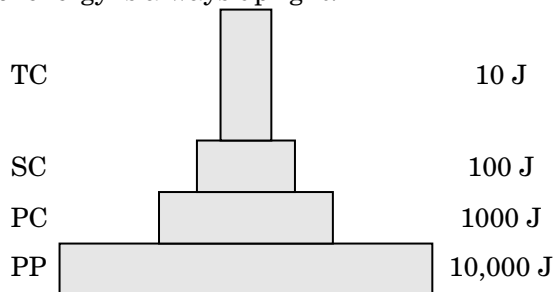


Fig.: Pyramid of Biomass (Aquatic Ecosystem)

Pyramid of Energy:

- Only 1% of energy in sunlight is converted by primary producers.
- When energy flows from one trophic level to next, some amount of energy is always lost. So, pyramid of energy is always upright.



1,000,000 J of Sunlight
Fig.: Pyramid of Energy

Limitations of Ecological Pyramids:

- It does not consider same species belonging to two or more trophic levels.
- It does not work for a food web.
- It does not accommodate saprophytes, though they play crucial role in ecosystem.

Ecological Succession

The biotic community is dynamic and undergoes changes with the passage of time. These changes are sequentially ordered and constitute ecological succession. Succession begins with invasion of a bare lifeless area by pioneers which later pave way for successors and ultimately a stable climax community is formed. The climax community remains stable as long as the environment remains unchanged.

Types of Succession:

- **Primary Succession:** It occurs in areas where no living form ever existed, like bare rock or newly cooled lava, etc.
- **Secondary Succession:** It occurs where living form once existed but not any longer, like abandoned lands or burned forests, etc.

Succession of Plants:

- Based on nature of habitat of plant, succession of plant is of two types: hydrarch succession and xerarch succession.
- **Hydrarch succession:** It occurs in wetter areas and the series progresses from too wet condition (hydric) to medium water (mesic) conditions.
- **Xerarch succession:** It occurs in dry places and series progresses from too dry (xeric) to medium water (mesic) conditions.
- Pioneer species are the first species that invade a bare area to begin an ecosystem.

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 2

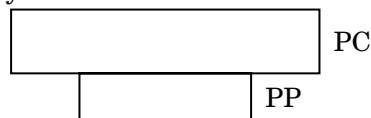
1 Mark Questions

1. Write what do phytophagous insects feed on.

[ALL INDIA 2012]

2 Marks Questions

2. Identify the type of the given ecological pyramid and give one example each of pyramid of number and pyramid of biomass in such cases.

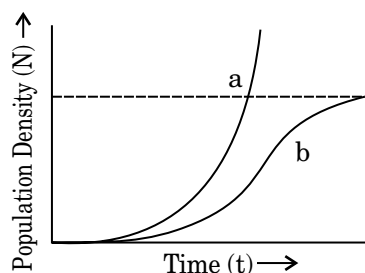


[ALL INDIA 2014]

3. Why the pyramid of energy is always upright? Explain. [DELHI 2013]
4. Construct an age pyramid which reflects a stable growth status of human population. [DELHI 2014]
5. Apart from being part of the food chain, predators play other important roles. Mention any two such roles supported by examples. [DELHI 2014]
6. Construct an age pyramid which reflects an expanding growth status of human population. [DELHI 2014]

3 Marks Questions

7. Differentiate between two different types of pyramids of biomass with the help of one example of each. [ALL INDIA 2013]
8. Study the graph given and answer the questions that follow:



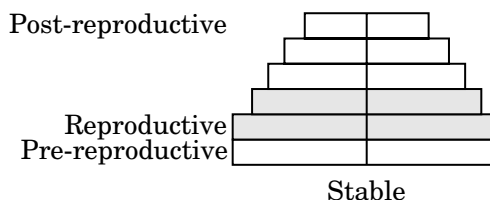
- (i) Write the status of food and space in the curves (a) and (b)
- (ii) In the absence of predators, which one of the two curves would appropriately depict the prey population?
- (iii) Time has been shown on X axis and there is a parallel dotted line above it. Give the significance of this dotted line. [DELHI 2014]
9. (i) What is primary productivity? Why it is vary in different types of ecosystem?
- (ii) State the relation between gross and net primary productivity. [DELHI 2014]
10. "In a food-chain, a trophic level represents a functional level, not a species." Explain. [DELHI 2016]

5 Marks Questions

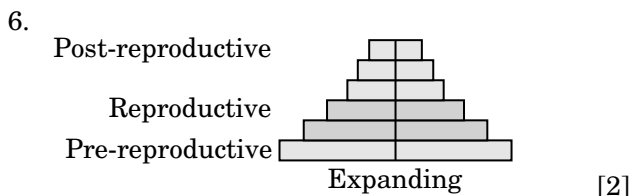
11. Explain how does:
- a primary succession start on a bare rock and reach a climax community?
 - the algal bloom eventually choke the water body in an industrial area?
- [ALL INDIA 2012]
12. It is often said that the pyramid of energy is always upright. On the other hand, the pyramid of biomass can be both upright and inverted." Explain with the help if examples and sketches. [ALL INDIA 2015]
13. Discuss the role of healthy ecosystem services as a pre-requisite for a wide range of economic, environmental and aesthetic goods and services. [DELHI 2017]
14. (a) What is an ecological pyramid? Compare the pyramids of energy, biomass and numbers.
- (b) Write any two limitations of ecological pyramids. [ALL INDIA 2017]
15. (a) What is a trophic level in an ecosystem? What is 'standing crop' with reference to it?
- (b) Explain the role of the 'first trophic level' in an ecosystem.
- (c) How is the detritus food chain connected with the grazing food chain in a natural ecosystem? [DELHI 2018]

Solutions

- Phytophagous insect feed on plants, and plant products like leave and sap [1]
- This is an inverted ecological pyramid. Example of pyramid of number is forest ecosystem and example of pyramid of biomass in lakes. [2]
- This is because When energy flows from one trophic level to the next trophic level, some energy is always lost as heat. (10% law) [2]
- [2]



5. Predators are able to maintain the population of the prey. Hence, in this way intra species regulation occur. Other role is they are the indicators of ecological disturbances. [2]



7. Pyramid of biomass are of both types upright and inverted. Upright pyramid of biomass is present in forest and grassland ecosystems while inverted pyramid of biomass is present in lake and ocean ecosystem as the biomass in next trophic level is higher than previous trophic level. [3]

8. (i) When the resources are unlimited, then the graph is exponential whereas when the resources are limited, then the graph is sigmoid. [1]

(ii) Curve (a), depicts prey population in the absence of predators. [1]

(iii) Parallel dotted line represent the carrying capacity of a population. [1]

9. (i) Primary productivity is the rate at which solar energy is converted by the plant closing photosynthesis or (Rate of production of biomass by plants). It varies in different types of ecosystem because it depends on factors like quality of sunlight, availability of water and nutrients, temperature of given place. [2]

(ii) $NPP = GPP - R$ [1]

10. Position of a species in any trophic level is determined by the function they perform based on their mode of nutrition in a particular food chain. A given species may occupy more than one trophic level in the same ecosystem at a given time. If the function of the mode of nutrition of species changes, its position shall change in the trophic levels. The same species can be at the primary level of consumer in one food chain and at the secondary consumer level in another food chain in the same ecosystem at a given time.

11. (a) Lichens are the example of primary succession on a bare rock. They secrete acids that result in the formation of soil by weathering of rocks. In this soil, bryophytes are able to grow because they can grow on less amount of soil. Further, new bigger plants start growing on that soil and in the end, the climax community, i.e., forest is present. [2]

(b) Algal bloom means “excessive growth of algae”. This bloom produces some harmful toxin when these algae die, they affect

fishes and other life in water bodies. This bloom also gives a distinct colour to the water bodies. This bloom severely decreases the water quality and consume all oxygen depleting it completely for fish, and other aquatic organisms. [3]

12. The pyramid of energy is always upright because base of the pyramid is occupied by producers which make food and contains maximum energy. There is a gradual decrease in energy at successive trophic levels as we move up. This happens due to the 10% law of energy transfer. According to the law, only 10% of the total energy is transferred from one trophic level to another. The energy is the highest at the producer level, and it gradually decreases on moving from herbivores (primary consumer) to carnivores (secondary or tertiary consumer). [1]

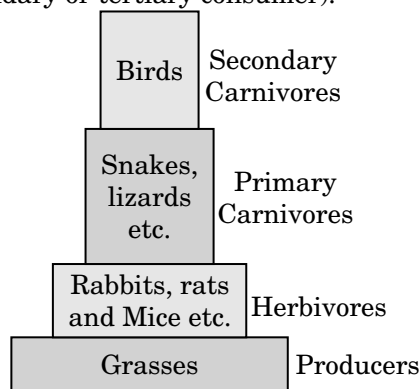


Fig.: Upright pyramid [1]

Pyramid of biomass can be upright or inverted. It depends on the type of ecosystem. Examples: In a grassland or forest ecosystem, there is a gradual decrease in biomass of organisms as we move from producers to top carnivores. Hence, the pyramid of bio mass is upright. [1]

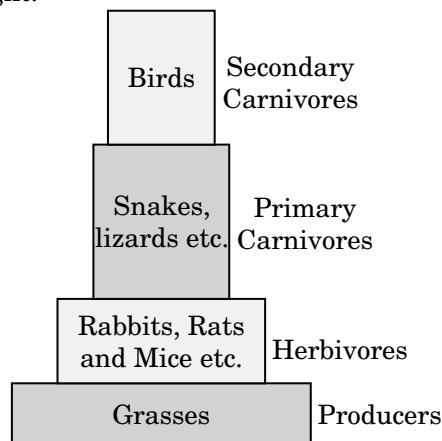


Fig.: Upright pyramid [1]

In a pond ecosystem, the pyramid is inverted as there is a gradual increase in biomass of

organisms as we move from producers to top carnivores. The producers are the smallest organisms while the carnivores are larger in size.

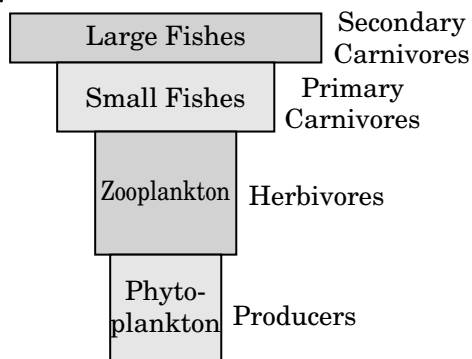


Fig.: Inverted pyramid [1]

13. The various benefits that humans can obtain from the ecosystem are collectively called ecosystem services. Ecosystem services are the products of ecosystem processes.

Forests are the major source of ecosystem services. It indirectly provides economic values in the following ways: [1]

1. Environmental Values:

- (i) Trees purify air by fixing CO_2 into organic molecules through photosynthesis. All the organisms at other trophic levels, i.e. consumers depend upon food produced by the plants or trees.
- (ii) Trees release oxygen as a by-product in the process of photosynthesis, improves the air quality and supports life on earth.
- (iii) Plants protect the soil erosion from the agents like wind and water. The soil remains spongy and fertile. There are no landslides and no floods. [2]

2. Economic Value:

- (i) Ecosystem services provide certain economical important products. These include timber, paper, rubber, wax, medicines, cosmetics, resins, etc.
- (ii) Ecosystem also provides other benefits such as aid in pollination. Bees and other insects of natural ecosystem visit nearby farmlands to pollinate crops. It maintains biodiversity.

3. Aesthetic values: Natural ecosystems add spiritual, cultural and recreational values to the human life. [2]

14. (a) Based on the source of nutrition or food, organisms occupy a specific place in the

food chain that is known as their trophic level. There is food or energy relationship between organisms at different trophic levels. The graphical representation of the relationship between organisms at different trophic levels is called ecological pyramid. [1]

The base of each pyramid represents the producers or the first trophic level while the apex represents tertiary or top level consumer. There are three ecological pyramids namely (i) pyramid of number; (ii) pyramid of biomass and (iii) pyramid of energy. [1]

(i) Pyramid of number: it is the number of individuals that occupy a particular trophic level in a given area at a given time. Example, in grassland ecosystem pyramid of number is upright because number of organisms decrease at successive trophic levels.

(ii) Pyramid of Biomass: Biomass or organic matter of living beings present per unit area in different trophic levels. It can be upright or inverted.

(iii) Pyramid of energy: it is a representation of transfer of energy between organisms of different trophic levels. The pyramid of energy is always upright. [1]

(b) Limitations of ecological pyramids:

(i) It does not take into account the same species which belongs to two or more trophic levels.

(ii) It does not accommodate a food web.

(iii) Saprophytes are not given any place in ecological pyramids, though they play a vital role in the ecosystem [2]

15. (a) Based on the source of nutrition or food, organisms occupy a specific place in the food chain that is known as their trophic level. There is food or energy relationship between organisms at different trophic levels. The first trophic level is occupied by producer and successive trophic levels by different consumers. Each trophic level has a certain mass of living material at a given time in a specific location is called Standing crop. It is measured as the mass of living organisms (biomass) or the number in a unit area. [2]

- (b) The 'first trophic level' is always occupied by producers in any ecosystem. They are autotrophs as they synthesise food using sunlight, carbon dioxide and water. All other organisms depend on producers for food or energy directly or indirectly. [1]
- (c) In the grazing food chain, energy is derived from the Sun during photosynthesis by producers. Energy is stored in the producers

in form of food which is transferred to the consumers when they eat them. The detritus food chain consists of decomposers which are heterotrophic organisms, mainly fungi and bacteria. They meet their energy and nutrient requirements by degrading dead organisms of grazing food chain or any other food chain. Therefore, detritus food chain is also connected to the grazing food chain for energy. [2]

[Topic 3] Nutrient Cycling & Ecosystem Services

Nutrient Cycling

Nutrients are mandatory for living organisms in any ecosystem to survive and grow. The continuous movement of nutrients through the various components of an ecosystem is called nutrient cycling or bio-geochemical cycles.

- **Types of nutrient cycling:**
 - Gaseous – the reservoir for the gaseous type of cycle is atmosphere or hydrosphere.
 - Sedimentary- the reservoir for the sedimentary type of cycle is earth's crust.
- **Carbon Cycle:**
 - 49% of dry weight of an organism is constituted by carbon. Reservoirs of carbon include- oceans, fossil fuels, etc. A large amount of carbon returns to atmosphere due to respiration, decomposition of waste material and dead organic matter also contribute carbon dioxide in atmosphere.

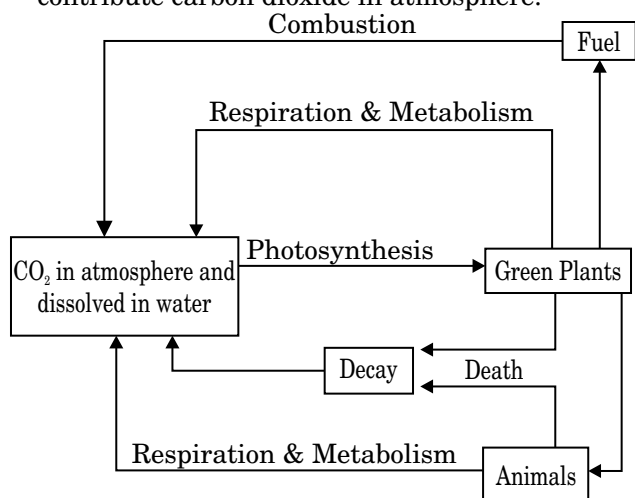


Fig.: Basic Carbon Cycle Flow Diagram

- **Phosphorus Cycle:**
 - Rocks which contain phosphorus as phosphates are the natural reservoirs of phosphorus. Animals obtain this element from plants as plant roots absorb phosphates dissolved in soil solution.

Ecosystem Services

Benefits that organisms generally humans get from the environment and ecosystem come under ecosystem services.

For example:

- Purification of air and water by forests.
- Generating fertile soil.
- Maintaining biodiversity, etc.

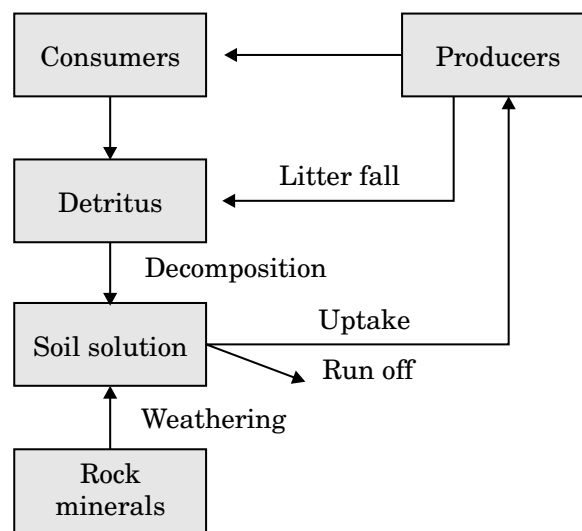


Fig.: Phosphorus Cycle

PREVIOUS YEARS' EXAMINATION QUESTIONS TOPIC 3

1 Mark Questions

1. Explain the carbon cycle with the help of a simplified model. [ALL INDIA 2014]

3 Mark Questions

2. State the function of a reservoir in a nutrient cycle. Explain the simplified model of carbon cycle in nature. [ALL INDIA 2014]

5 Mark Questions

3. Explain the carbon cycle with the help of a simplified model. [ALL INDIA 2012]

Solutions

1. 49% of dry weight of an organism is constituted by carbon. Reservoirs of carbon include- oceans, fossil fuels, etc. A large amount of carbon returns to atmosphere due to respiration, decomposition of waste material and dead organic matter also contribute carbon dioxide in atmosphere.

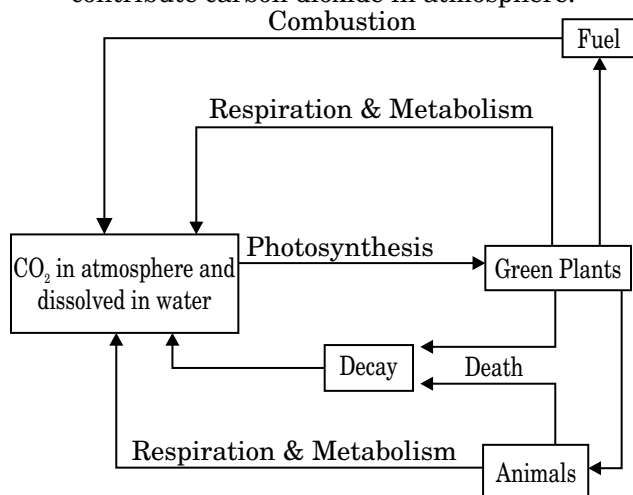


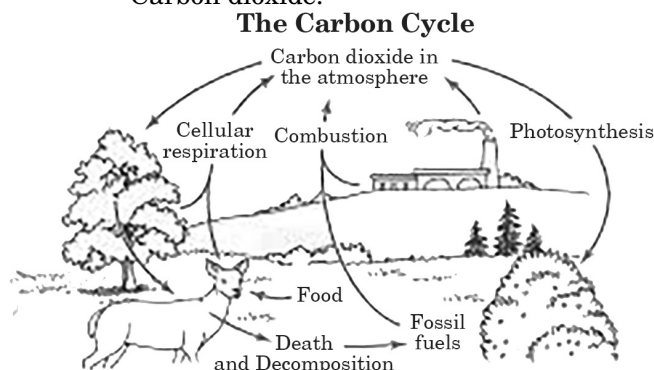
Fig.: Basic Carbon Cycle

2. The function of a reservoir in a nutrient cycle is to fill the gap that occurs due to any imbalance in rate of influx and efflux of the mineral or gas in a nutrient cycle.

Carbon cycle includes:

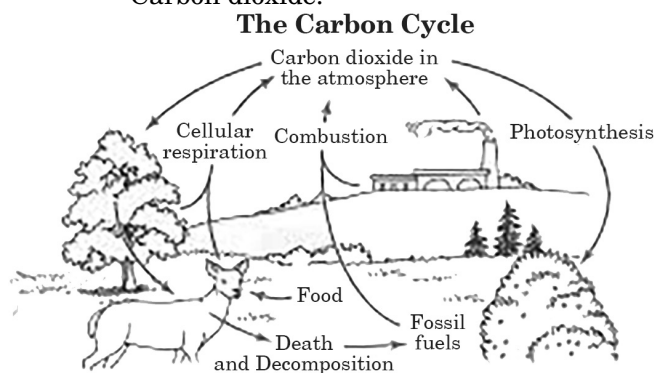
- (a) 49 percent of Plants content is carbon dioxide and 70% of it is dissolved in water.
 (b) This carbon-dioxide is used by plants to prepare the food by photosynthesis in the presence of light.

- (c) This carbon-dioxide is returned back to the environment by the respiration of animal, combustion, volcanic eruptions, decay of plants and animals.
 (d) Decay of plants and animals is also acted by decomposers which leads to the formation of Carbon dioxide.



3. Carbon cycle includes:

- (a) 49 percent of Plants' content is carbon dioxide and 70% of it is dissolved in water.
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CHAPTER 15

Biodiversity and Its Conservation

Chapter Analysis with respect to Last 3 Years' Board Exams

The analysis given here gives you an analytical picture of this chapter and will help you to identify the concepts of the chapter that, are to be focused more from exam point of view.

List of Topics	2016		2017		2018
	Delhi	All India	Delhi	All India	Delhi/All India
Concept of biodiversity; patterns of biodiversity					
Importance of biodiversity; loss of biodiversity; biodiversity conservation;	1Q (2 marks)		1Q (3 marks)		1Q (5 marks)
Hotspots, endangered organisms, extinction, Red Data Book	1Q (5 marks)	1Q (2 marks)	1Q (3 marks)	1Q (2 marks)	
Biosphere reserves, national parks, sanctuaries and Ramsar sites					

From last 3 years question papers, it can be inferred that Types of Biodiversity, Importance of Biodiversity, Conservation of Biodiversity are most important concepts.

[Topic 1] Biodiversity

Summary

Biologist Edward Wilson popularized the term Biodiversity to explain the combined diversity in every aspect of biological organization. It refers to the summation of diversity that exists in any respective level of biological organization. The most important among them are:

- **Genetic diversity:** One species would possibly show high diversity at the genetic level over its spatial arrangement vary. The medicinal plant *Rauwolfia vomitoria* shows a genetic variation. It grows in numerous mountain range ranges may well be in terms of the efficiency and concentration of the active chemical (reserpine) that the plant produces. There are over fifty thousand genetically different strains of rice, and 1,000 types of mango in India.
- **Species diversity:** It is the variation at the species level. For instance, the Western Ghats and Eastern Ghats differ in amphibian species diversity.
- **Ecological diversity:** This refers to the diversity at ecosystem level. India, as an example, with its deserts, rain forests, mangroves, coral reefs, wetlands, estuaries, and alpine meadows incorporates a bigger system diversity than a Scandinavian country like Serbia.

Number of species on Earth and in India

- Biodiversity and its conservation is currently the most important environmental problem with international concern as increasing number of folks round the world begin to grasp the vital importance of diversity for our survival and well-being on this planet.
- More than seventy per cent of all the species recorded are animals, whereas plants (including alga, fungi, bryophytes, gymnosperms and angiosperms) comprise no over twenty two per cent of the entire. Among animals, insects are the foremost species rich taxon, creating up over seventy per cent of the entire. That means, out of each ten animals on this planet, seven are insects.
- India constitutes 2.4 per cent of the world's total land area and also shares 8.1 per cent of the global species diversity. That makes India as one of the 12 mega diversity countries of the world. Nearly 45,000 species of plants and twice as many of animals have been recorded from India.

Patterns of Biodiversity

- **Latitudinal gradient:** The diversity of plants and animals isn't uniform throughout the planet however shows a rather uneven distribution. For several clusters of animals or plants, there are attention-grabbing patterns in diversity, the foremost well- famed being the angular distance gradient in diversity.
- **Species-Area relationships:** The increase in explored area will increase with the richness of the species within vicinity.

Importance of Species Diversity

An excessive amount of variation shouldn't be showed by a stable community in productivity from year to year; it should be either resistant or resilient to occasional disturbances (natural or man-made), and it should even be immune to invasions by alien species. Plots with additional species show less year-to-year variation in total biomass. Multiplied diversity contributes to higher productivity.

Loss of Biodiversity

- **Habitat loss and fragmentation:** The accelerated rates of species extinctions that the planet is facing currently are mostly because of human activities. Degradation of the many habitats by pollution threatens the survival of the many species. When massive habitats are shrunk into little fragments because of varied human activities, mammals and birds requiring massive territories and bound animals with migratory habits are badly affected, resulting in population declines.
- **Over-exploitation:** Many species extinctions within the last five hundred years (Steller's sea cow, passenger pigeon) were because of exploitation by humans. Presently several marine fish populations throughout the world are over harvested, endangering the continued existence of some commercially necessary species.
- **Alien species invasion:** When alien species are introduced accidentally or deliberately for any purpose, a number of them become invasive, and cause decline or extinction of native species.
- **Co- extinctions:** Whenever there is an extinction of any species, the animal and plant species linked to it become extinct. For example- mutualism in coevolved plant-pollinator, where the latter becomes extinct with the extinction of the first one or vice-versa.

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 1

1 Mark Questions

- Name the biodiversity represented by the following;
 - 50,000 different strains of rice in India
 - Estuaries and alpine meadows in India.

[DELHI 2013]
- Name the type of biodiversity represented by the following:
 - 1000 varieties of mangoes in India.
 - Variations in terms of potency and concentration of reserpine in *Rauwolfia vomitoria* growing in different regions of Himalayas.

[ALL INDIA 2013]

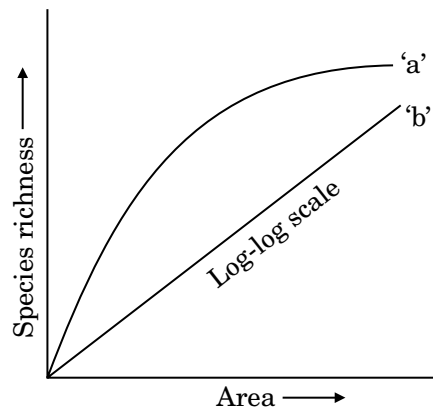
2 Marks Questions

- Justify with the help of an example where a deliberate attempt by humans has led to the extinction of a particular species. [DELHI 2011]
- State the use of Biodiversity in modern agriculture. [ALL INDIA 2011]
- The above graph shows Species–Area relationship. Write the equation of the curve 'a' and explain. [ALL INDIA 2011]
- Explain why very small animals are rarely found in polar region. [DELHI 2013]
- Where would you expect more species biodiversity in tropics or in Polar Regions? Give reasons in support of your answer. [ALL INDIA 2013]
- Mention the kind of biodiversity of more than a thousand varieties of mangoes in India represent. How is it possible? [DELHI 2016]
- Why sacred groves are highly protected? [ALL INDIA 2016]
- Suggest two practices giving one example of each that help protect rare or threatened species. [ALL INDIA 2017]

3 Marks Questions

- Many plant and animal species are on the verge of their extinction because of loss of forest land by indiscriminate use by the humans. As a biology student what method would you suggest along with its advantages that can protect such threatened species from getting extinct? [DELHI 2015]
- Name and describe any three causes of biodiversity losses. [DELHI 2017]

- Alien species are highly invasive and are a threat to indigenous species. Substantiate this statement with any three examples. [DELHI 2012]
- The following graph shows the species - area relationship. Answer the following questions as directed.



- Name the naturalist who studied the kind of relationship shown in the graph. Write the observations made by him.
- Write the situations as discovered by the ecologists when the value of 'Z' (Slope of the line) lies between.
 - 0.1 and 0.2
 - 0.6 and 1.2
 What does 'Z' stand for?
- When would the slope of the line 'b' become steeper? [ALL INDIA 2014]

5 Marks Questions

- "India has greater ecosystem diversity than Norway." Do you agree with the statement? Give reasons in support of your answer.
 - Write the difference between genetic biodiversity and species biodiversity that exists at all the levels of biological organisation [DELHI 2018]

Solutions

- Genetic Diversity [½]
 - Ecological diversity [½]
- Genetic Diversity [½]
 - Genetic Diversity [½]
- Humans are "selfish" means that they exploit other organisms for food and shelter. Many species extinctions in the last 500 years like Steller's sea cow, passenger pigeon were due to over-exploitation by humans. [2]

4. The use of Biodiversity in modern agriculture are:

- (i) Biodiversity helps in reducing the use of harmful chemicals in agriculture. [1]
- (ii) Biodiversity helps in improving the varieties of plants, specially disease resistant plants. [1]

5.

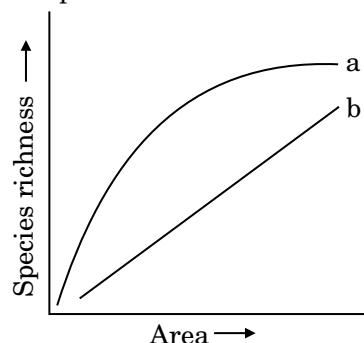


Fig.: Species area relationship [1]

Equation for the curve a is:

$$\log S = \log C + Z \log A$$

Where S is showing species richness, Z is representing regression coefficient, A is area and C is Y-intercept.

This graph is representing:

- (i) Richness of species is increasing within a region but only upto a limit.
 - (ii) Straight line is representing species richness in logarithmic values. [1]
6. Small animals due to their small size have large surface area as compare to their volume. Hence, they tend to loose heat very fast in cold temperature. Hence, very small animals are rarely found in polar regions. [2]
7. High species or biodiversity lies in tropical areas because
- (i) Tropical areas favours speciation.
 - (ii) Seasonal variation is less than polar areas.
 - (iii) High availability of sunlight helps in growth of more plant species. [2]
8. The type of diversity is the genetic diversity. Single species of mango show high diversity at genetic level over its distributional range. India has more than 1,000 varieties of mango. [2]
9. Sacred groves are highly protected forest tracts by certain communities due to religious and cultural traditions. Sacred groves help in the protection of many rare, threatened, and endemic species of plants and animals found in an area. [2]
10. Practices that help to protect rare threatened species are (a) In situ (on-site) and (b) Ex situ (off site) conservations. In situ conservation involves protection of species in their natural

habitat. Biosphere reserves, national parks, wildlife sanctuaries, sacred groves, etc, involves this type of conservation. Ex situ conservation involves placing of threatened animals and plants in special care units for their protection. Zoological parks, botanical gardens and wildlife safari parks serve this purpose. [2]

11. Methods to protect the species which are on the verge of extinction.

(a) **Ex situ conservation:** The threatened species of plants and animals which are at the verge of extinction should be safely taken out of their habitats and are kept in special settings such as zoological parks, botanical gardens and wildlife parks. These special settings protect the threatened species, help maintain their number and prevent them from becoming extinct. [1½]

(b) **Cryopreservation** of the gametes of endangered species allow *in-vitro* fertilization to produce offspring. The use of tissue culture for propagation of the organism and the use of seed banks in case of plants. These methods allow us to preserve the genes of the endangered species and can be used to increase the number of endangered species by keeping the gamete or seeds viable and fertile for a long period of time and use it when required. [1½]

We can stop indiscriminate cutting of trees thus save the habitat of the species and protect them from extinction.

12. The main cause of the loss of biodiversity is due to human intervention. The three threats to biodiversity are discussed below:

(a) **Over exploitation:** Over exploitation of natural resources leads to loss of biodiversity. For example marine fish populations around the world are over exploited and endangering existence of commercially important species. [1]

(b) **Alien species invasions:** When any foreign species is deliberately introduced for a purpose, some of them turn invasive and decline indigenous species. Example Parthenium and African cat fish pose threat to indigenous cat fishes of our rivers. [1]

(c) **Co-extinctions:** When a species becomes extinct the plant or animal species associated with it also become extinct. For example when a host species becomes extinct parasite residing on it also becomes extinct. [1]

13. Yes, when Alien species are introduced, they are highly invasive and are a threat to indigenous species. For example,
- (i) Extinction of 200 species approximately by the introduction of Cichlid fish in Lake Victoria. [1]
 - (ii) Environmental damage of the native species by the introduction of carrot, Lantana, water hyacinth. [1]
 - (iii) Catfish extinction due to introduction of African catfish *Clarias gariepinus*. [1]
14. (a) Alexander von Humboldt studied the kind of relationship shown in the graph. He observed that species richness increases with explored area but upto certain extent. [1]
- (b) (i) 0.1 and 0.2 Z value is representing area is small to normal
 - (ii) 0.6 and 1.2 Z value is representing area is very large.
- Z is representing slope of the graph which is regression coefficient. [1]
- (c) When area is very large, then the slope of the line 'b' become steeper. [1]
15. (a) India has greater ecosystem diversity than Norway because India lies in the tropical and sub-tropical zones, whereas Norway lies near the Arctic region. India receives greater amounts of sunlight hence, more Indian climate is more predictable and stable. Photosynthesis as compared to Norway. Besides India has greater geographical, topological and climatic diversity compared to Norway, leading to greater biodiversity. [3]
- (b) **Genetic biodiversity:** Refers to number of genes and their alleles present in the organisms. It is the trait of the individual species.
- Species biodiversity:** Number of types of species occurring in an area. It is the trait of the community. [2]

[Topic 2] Conservation of Biodiversity

- The barely utilitarian contentions for securing decent variety are self-evident; people infer multitudinous direct monetary benefits from nature sustenance (oats, beats, organic products), kindling, fiber, development material, mechanical item (tannins, greases, colors, gums, scents) and result of therapeutic significance.
- The broadly utilitarian argument says that diversity plays a significant role in several ecosystem services that nature gives. For the existence of humanity diversity is required because it provides oxygen and fruits and seeds created by pollination. There are alternative intangible benefits –we have a tendency to derive from nature–the aesthetic pleasures of walking through thick woods, looking at spring flowers fully bloom or rousing to a bulbul's song within the morning.
- The ethical argument for protecting diversity relates to what we have a tendency to owe to ample plant, animal and bug species with whom we share this planet. We've an ethical duty to worry for their well-being and gift our biological heritage in sensible order to future generations.

Reasons to conserve Biodiversity

- **In situ conservation:** Conservation and protection of whole ecosystem in order to protect the biodiversity at all levels. The species are protected in their natural environment so the complete ecosystem is protected. For example- To save the tiger, save the entire forest.

There are more species that can become extinct in near future than the conservation resources available to conserve and protect them. Many conservationists have identified species rich zones known as 'biodiversity hotspots'. In India, Western Ghats and Eastern Himalayas come under this category out of total 34 in the world.

Few traditional tribes of Jaintia and Khasi hills in Meghalaya have rituals in which they leave aside tracts of forests, given total protection and are known as 'sacred groves'.

- **Ex situ conservation:** In this type of conservation, the species that are endangered are shifted from their natural habitat to some artificial arrangements like botanical gardens, parks and wildlife sanctuaries. Strategies embody

protecting maintenance of vulnerable species in zoological parks and biological science gardens, in vitro fertilisation, tissue culture propagation and cryopreservation of gametes.

PREVIOUS YEARS' EXAMINATION QUESTIONS

TOPIC 2

▣ 2 Marks Questions

1. Write the importance of cryopreservation in conservation of biodiversity. **[DELHI 2011]**
2. Differentiate between in situ and ex situ approaches of conservation of biodiversity. **[ALL INDIA 2011]**
3. List any four techniques where the principle of ex-situ conservation of biodiversity has been employed. **[ALL INDIA 2015]**

▣ 3 Marks Questions

4. 'in-situ' conservation can help in protection of endangered/threatened species. Justify the statement. **[DELHI 2017]**

▣ 5 Marks Questions

5. (a) Taking one example each of habitat loss and fragmentation, explain how are the two responsible for biodiversity loss.
(b) Explain two different ways of biodiversity conservation. **[DELHI 2012]**
6. (a) Why should we conserve biodiversity? How can we do it?
(b) Explain the importance of biodiversity hotspots and sacred groves. **[DELHI 2016]**

Solutions

1. Cryopreservation is a technique of preserving viable and fertile gametes under freezing temperature for long period of time in order to produce new offsprings from these gametes in the future. This technique helps in the preservation of many species of plants and animals. **[1]**
2. Ex situ means "off-site conservation" whereas in situ means "onsite". Ex-situ is the method of conservation of plant or animal species outside its natural habitat whereas "in-situ" is the method of conservation of plant or animal species in its natural habitat. **[2]**

3. Ex situ conservation of biodiversity is the providing protection in man-made surroundings. The four techniques where principle of ex situ conservation of biodiversity has been employed are:**[1]**
 - (i) Tissue culture
 - (ii) Cryopreservation
 - (iii) Botanical gardens
 - (iv) Zoological parks **[1]**
4. *In situ* conservation is the method of protecting a species in their natural habitats. It helps in the conservation of threatened, endangered species through:
 - (a) Biodiversity hotspots are the regions having high levels of species richness and these species confined to that region are not found anywhere. Three hotspots which cover India's biodiversity regions are Western Ghats and Sri Lanka, Indo-Burma and Himalaya. These hotspots can reduce the on going mass extinctions by almost 30%. **[1]**
 - (b) Protected areas are ecologically unique and biodiversity rich regions. These are legally protected as biosphere reserves, national parks and sanctuaries. In India there are 14 biosphere reserves, 90 national parks and 448 wildlife sanctuaries. **[1]**
 - (c) Sacred groves are highly protected forest tracts maintained by certain communities due to religious and cultural traditions. Sacred groves help in the protection of many rare, threatened, and endemic species of plants and animals found in that area. Some of the sacred groves in India are: Western Ghat regions of Karnataka and Maharashtra, Khasi and Jaintia Hills in Meghalaya. Aravalli Hills of Rajasthan. Sarguja, Chanda and Bastar areas of Madhya Pradesh. **[1]**
5. (a) Habitat loss and fragmentation are responsible for biodiversity loss because it lead to the destruction of the habitat of the organism. One Example of habitat loss can be of animals that live on trees or plants at the time of deforestation, eg., road building in Amazon rainforest. Habitat fragmentations are caused by natural processes such as flood and volcanic activity. For example geographical distribution of single species that divide into two species. **[2½]**
 - (b) Two different ways of biodiversity conservations are in-situ and ex-situ

conservation. Ex situ means “off-site conservation” whereas in situ means “in situ conservation”. Ex-situ is the method of conservation of plant or animal species outside its natural habitat whereas “in-situ” is the method of conservation of plant or animal species in its natural habitat. [2½]

6. (a) There are many benefits by conserving biodiversity.

Narrowly utilitarian: We get economic benefits from nature such as cereals, pulses, fruits. We get firewood, fibre, construction materials, and industrial products such as tannins, lubricants, dyes, resins, perfumes and products of medicinal importance. [1]

Broadly utilitarian: about 20% of total oxygen from Amazon forests. Conservation of biodiversity provides aesthetic pleasures.

[½]

Ethical benefits: Millions of species of plants, animals, microbes share this planet and we should realise that every species has an intrinsic value. Therefore, we have a moral duty to care for their well-being and pass on our biological legacy to future generations. Conservation of biodiversity can be done through - In situ conservation through biosphere reserves, national parks, sanctuaries and sacred groves or by Ex situ conservation through zoological parks, botanical gardens, cryopreservation, seed banks and tissue culture. [1]

- (b) Hot spots are the regions with high level of species richness and high degree of endemism. Sacred groves are the tracts of forest containing tree wild life. They are maintained by some religious communications, and give total protection to rare and threatened plants. [2½]

CHAPTER 16

Environmental Issues

Chapter Analysis with respect to Last 3 Years' Board Exams

The analysis given here gives you an analytical picture of this chapter and will help you to identify the concepts of the chapter that, are to be focused more from exam point of view.

List of Topics	2016		2017		2018
	Delhi	All India	Delhi	All India	Delhi/All India
Air pollution and its control	1Q (2 marks)	1Q (1 mark)	1Q (4 marks)	1Q (1 mark)	1Q (4 marks)
Water pollution and its control	1Q (1 mark)				1Q (2 marks)
Agrochemicals and their effects					
Solid waste management, radioactive waste management					
Greenhouse effect and climate change, ozone layer depletion, deforestation, special case studies		1Q (2 marks)			

On the basis of above analysis, it can be said that from exam point of view Electrostatics Precipitators, Aquatic Food chain, CNG, CFC, Algal Bloom, Waste water treatment and pollution are most important concepts of the chapter.

[Topic 1] Pollution, Solid and Radioactive wastes

Summary

Introduction

- Because of an explosion in the human population, the demand for food, water, home, electricity, roads, automobiles has been increased which leads to the pollution of air, water, and soil.
- Major issues relating to environmental pollution and depletion of valuable natural resources are different in local levels than that of regional or global levels.
- Any undesirable or harmful change in physical, chemical or biological characteristics of air, land, water or soil is known as pollution.
- The substances responsible for the pollution are called pollutants. The government of India has passed the Environmental (protection) Act, 1986 to protect and improve the quality of our environment (air, water, and soil).
- According to the Central Pollution Control Board (CPCB), the particulate which causes the greatest harm to human health is of size 2.5 micrometers or less in diameter (PM 2.5)

Air Pollution

- **Causes of Air Pollution:**
 - Utilization of leaded petrol.
 - Pollutants released from automobiles
 - Particulate and gaseous air pollutants released by thermal power plants and other industries.
- **Harmful effects of air pollution:**
 - It causes respiratory problems, irritation, inflammation and damage to lungs and premature deaths.
 - Injuries to all living organisms are caused by air pollutants.
 - The growth and yield of crops gets affected by air pollution and results in premature death of plants.
- **Controls of air pollution:**
 - Catalyst converters should be used (having Platinum-Palladium and Rhodium as the catalysts)
 - Pollutants must be separated out before releasing harmful gases into the atmosphere.
 - Vehicles having a catalytic converter should use unleaded petrol.
 - CNG is a better fuel than petrol or diesel because it burns more efficiently and very little of it is left unburnt.

Electrostatic Precipitator

- It is the most commonly used electrical device to remove particulate matter

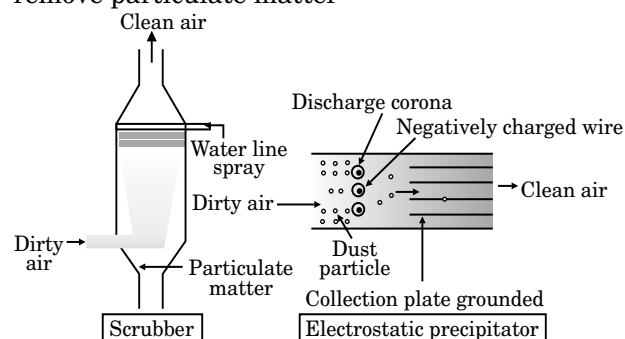


Fig.: Electro Static Precipitator (ESP)

- Electrode wires which are maintained at several thousand volts produce a corona which releases electrons.
- The dust particles get negatively charged as the electrons that are release get attached to them. These dust particles get attracted by grounded charged plates.
- The scrubber can remove gases like SO_2
- Over 99 percent particulate matter present in the exhaust from a thermal power point can be removed by this.

Noise Pollution:

- The undesired high level of sound is noise pollution. In 1987, the Air (Prevention and Control of Pollution) Act (1981) was amended to include noise as an air pollutant.
- **Causes:**
 - Loudspeaker, detonations, industries, led planes and rockets, music instruments, crackers, etc. are the causes of noise pollution.
- **Effects:**
 - Physiological and psychological and disorders are caused by it.
 - Exposure to relatively higher or lower noise may damage hearing ability of humans.
- **Ways of control:**
 - Sound-absorbent material should be used in industries.
 - Delimit the timings and sound level of the crackers and loudspeakers.
 - There should be horn-free zone around hospitals and schools.
- **Laws in India to control vehicular pollution:**
 - Auto fuel policy
 - Euro II norms

➤ The Bharat Stage II

Water pollution

- Human activities have polluted the lakes, ponds, stream, rivers, and oceans which is known as water pollution.
 - Water (Prevention and Control of Pollution) Act, 1974 has been passed by the Government of India to safeguard the water resources.
 - **Domestic Sewage and Industrial Effluents:**
- Prevention of disposal of all kinds of waste in the water. Domestic sewage is the most common source of pollution of water bodies which reduces dissolved oxygen but increases biochemical oxygen demand of receiving water. It is rich in nutrients, especially, nitrogen and phosphorus, which cause eutrophication and nuisance algal blooms. The effect of sewage discharge on characteristics of a river are shown below.

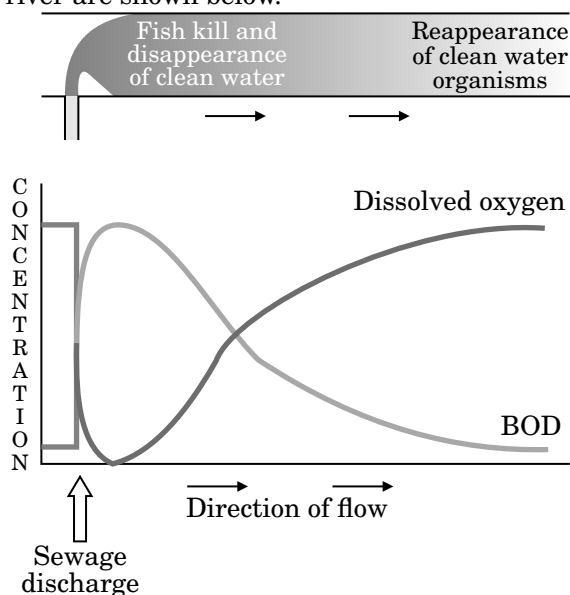


Fig.: Effect of sewage discharge on characteristics of a river

- Industrial waste waters are often rich in toxic chemicals, especially heavy metals and organic compounds. Industrial waste waters harm living organisms.

Using dry composting toilets, human excreta can be handled and this is called a sustainable system. This composite method allows human excreta to be recycled into a resource, which works as natural fertilizer.

• **Algal Bloom:**

- Increase in amount of nutrients in water bodies result in excessive growth of algae, due to which quality of water degrades. Some of them are harmful to animals and humans.

• **Eutrophication:**

- It refers to the natural aging of a lake by nutrient enrichment of the water.

- Streams draining into the lake introduce nutrients like N_2 , P_2 due to which the aquatic organisms grow.

- The phenomenon where the pollutants (effluents from the industries) and homes accelerate the ageing process is called cultural or accelerated eutrophication.

• **Bio-magnification:**

- It means the increase in concentration of the toxicant at successive trophic levels.

Water (DDT:0.03ppm) → Zooplankton (0.04ppm)
 → Small fish (0.5 ppm) → Large fish (2 ppm)
 → Birds (5 ppm)

This causes decline in bird population.

Solid Wastes

- Anything that goes in the trash is called solid waste.
- The wastes from homes, stores, offices, hospitals (like plastics, metals, glass etc.) are collected and disposed by the municipality are called Municipal solid wastes.
- In a sanitary landfill, the wastes are dumped in a trench after compaction.
- Bio-degradable, recyclable and non-biodegradable are the three types of solid waste.
- **Radioactive wastes:** Nuclear wastes emit radiation which causes mutation at a very high rate and creates various disorders such as cancer.
- **Plastic waste:** These are non-biodegradable wastes. Kabadi-wallas and rag-pickers help to separate material for recycling.
- **E-wastes:** The electronic good that cannot be repaired are called electronic waste (e-waste). Recycling is the only solution to get rid of these wastes.
- **Agrochemicals:** The use of inorganic fertilizers and pesticides has increased manifold for enhancing crop production.

Pesticides, herbicides, fungicides, etc., are being increasingly used. These incidentally, are also toxic to non-target organisms which form the important components of the soil ecosystem.

- **Organic Farming:** In this, the waste products from one process are cycled in as nutrients for other processes.

Crop waste is used in creating compost, which can be used as a natural fertilizer or can be used to generate natural gas for satisfying the energy needs of the farm.

PREVIOUS YEARS'

EXAMINATION QUESTIONS

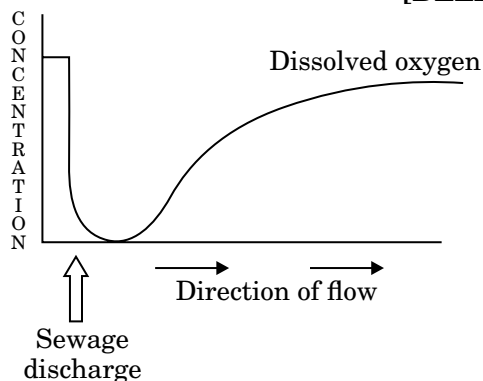
TOPIC 1

1 Mark Questions

- Write the unit used for measuring ozone thickness. [DELHI 2011]
- How do algal blooms affect the life in water bodies? [ALL INDIA 2011]
- Why is the use of unleaded petrol recommended for motor vehicles equipped with catalytic converters? [ALL INDIA 2013]
- State the cause of accelerated Eutrophication. [DELHI 2014]
- Write the name of the organism that is referred to as the 'Terror of Bengal'. [DELHI 2014]
- List two advantages of the use of unleaded petrol in automobiles as fuel. [ALL INDIA 2015]
- Excessive nutrients in a fresh water body cause fish mortality. Give two reasons. [DELHI 2016]
- Mention two advantages for preferring CNG over diesel as an automobile fuel. [ALL INDIA 2016]
- An electrostatic precipitator in a thermal power plant is not able to generate high voltage of several thousands. Write the ecological implication because of it. [ALL INDIA 2017]

2 Marks Questions

- How did a citizen group called Friends of Arcata Marsh, Arcata, California, USA, help to improve water quality of the marshland using integrated waste water Treatment? Explain in four steps. [DELHI 2018]
- Study the graph given below. Explain how oxygen concentration is affected in the river when sewage is discharged into it. [DELHI 2011]



- How did Ahmed Khan, plastic sacks manufacturer from Bangalore, solve the ever increasing problem of accumulating plastic waste? [DELHI 2012]
- Name any two sources of e-wastes and write two different ways for their disposal. [DELHI 2013]

3 Marks Questions

- Name the two different categories of microbes naturally occurring in sewage water. Explain their role in cleaning sewage water into usable water. [ALL INDIA 2011]
- By the end of 2002 the public transport of Delhi switched over to a new fuel. Name the fuel. Why is this fuel considered better? Explain. [ALL INDIA 2011]
- How does algal bloom destroy the quality of a fresh water body? Explain. [DELHI 2013]
- "Determination of Biological Oxygen Demand (BOD) can help in suggesting the quality of a water body." Explain. [DELHI 2015]
- With the help of a flow chart, show the phenomenon of bio magnification of DDT in an aquatic food chain. [ALL INDIA 2015]
- (a) Name any two places where it is essential to install electrostatic precipitators. Why it is required to do so?
(b) Mention one limitation of the electrostatic precipitator. [DELHI 2016]

4 Marks Questions

- Since October 02, 2014 "Swachh Bharat Abhiyan" has been launched in our country
(a) Write your views on this initiative giving justification.
(b) As a biologist name two problems that you may face while implementing the programme in your locality.
(c) Suggest two remedial methods to overcome these problems. [DELHI 2015]
- Public all over India is very much concerned about the deteriorating air quality in large parts of North India. Alarmed by this situation the Resident's Welfare Association of your locality organized an awareness programme entitled "Bury not burn". They invited you, to participate.
(a) How would you justify your arguments that promote burying and discourage burning? (Give two reasons)
(b) With the help of flow charts, one for each practice depict the chain of events that follow. [DELHI 2017]

22. Looking at the deteriorating air quality because of air pollution in many cities of the country, the citizens are very much worried and concerned about their health. The doctors have declared health emergency in the cities where the air quality is very severely poor.
- Mention any two major causes of air pollution.
 - Write the two harmful effects of air pollution to plants and humans.
 - As a captain of your school Eco-club, suggest any two programmes you would plan to organise in the school so as to bring awareness among the students on how to check air pollution in and round the school.
- [DELHI 2018]**

▣ 5 Marks Questions

23. (a) What is El Niño effect? Explain how it accounts for biodiversity loss.
- (b) Explain any three measures that you as an individual would take, to reduce environmental pollution. **[DELHI 2011]**

Solutions

- “Dobson” is the unit used for measuring ozone thickness. One Dobson unit is equivalent to 0.01 mm thickness. [1]
- Algal bloom means “excessive growth of algae”. This overgrowth of algae depletes water bodies of oxygen. It affects fishes and other life in water bodies and they die. [1]
- Lead corrodes the catalytic rods of Palladium, Rhodium, Platinum which decrease the efficiency of catalytic converter, of motor vehicles. Hence, the use of unleaded petrol is recommended for motor vehicles equipped with catalytic converters [1]
- Eutrophication means Nutrient enrichment in water body that results in the excessive growth of microbial life. Causes of the accelerated Eutrophication are: disposal of nutrient rich sewage in water body and Algal bloom in the water bodies. [1]
- Eichhornia crassipes*/Water Hyacinth which is an exotic shrub is referred to as the ‘Terror of Bengal’ because it strongly competes with native species of Bengal and destroys the native species [1]
- Two advantages of using unleaded petrol as fuel in automobiles:
 - Use of unleaded petrol does not release lead compounds from exhaust fumes into the atmosphere from vehicles. [½]
 - It helps in preventing health issues like anaemia, loss of appetite, damage to erythrocytes and damage to nervous system. [½]
- The presence of large amounts of nutrients in the water bodies results in excessive algal growth called algal bloom. Excess algal growth deteriorates the quality of water by producing toxins, reduces dissolved oxygen and it leads to fish mortality. [1]
- The two advantages of CNG over diesel are:
 - CNG burns more efficiently leaving very little residue. [½]
 - It is cost effective and cannot be adulterated. [½]
- Non-generation of a high voltage in a thermal power plant by the electrostatic precipitator is unable to remove particulate matter present in the exhaust of thermal power plants. This causes air pollution as dust particles are released into the air. [1]
- Wastewater including sewage can be treated in an integrated manner, by using a mix of **artificial** and **natural** processes. (a) In the first step, a conventional sedimentation, filtering and chlorine treatments are given which **removes physical impurities**. (b) In the second step, an innovative approach was taken and the biologists developed a series of six connected marshes over 60 hectares of marshland. (c) In the third step, appropriate plants, algae, fungi and bacteria were grown that area to neutralise, absorb and assimilate the pollutants. (d) Finally the water flows through the marshes, it gets **purified naturally**. [2]
- The figure shows that there is a decrease in the oxygen concentration of water when sewage water is discharged into the fresh water. But, as the flow of water increases, the amount of oxygen increases slowly. [2]
- Ahmed Khan in collaboration with Engineering College and the Bangalore City Corporation proved that the blend of Bitumen and plastic waste, when used to lay roads, enhanced the bitumen’s water repellent properties and helped to increase road life by a factor of three. So using Khan’s technique many roads were laid in Bangalore. [2]
- Electronic goods and damaged computers are two sources of e-wastes. Two different ways for their disposal are: [1]
 - BURYING IN THE LAND [½]
 - INCINERATION [½]

14. **Fungi and bacteria are the** two different categories of microbes naturally occurring in sewage water. Role of these microbes in cleaning sewage water into usable water are:
- The primary effluent is delivered into a large aeration tanks which is agitated constantly.
 - This agitation facilitates the growth of fungi and bacteria.
 - This **growth of fungi and bacteria decreases the biological oxygen demand**.
 - This effluent is delivered into settling tanks where bacteria flocks are allowed to sediment and known as activated sludge.
 - Small part of activated sludge is disposed at anaerobic sludge reactors that result in the formation of methane, hydrogen sulphide and carbon-dioxide.
 - This effluent is discharged into natural water bodies.
Thus Fungi and bacteria helps in the digestion of organic material present in the Sewage. [½x6=3]
15. Compressed natural gas (CNG) is the new fuel that has been added to the Delhi in the year 2002. It is considered better than any other fuel because it produces very less amount of unburnt particles and thus it is a clean fuel. CNG burnt very efficiently leading to the production of few unburnt particles. At the same time, it is cheap too. [3]
16. Algal bloom means “excessive growth of algae”. This bloom consumes the dissolved oxygen. This bloom also give a distinct color to the water bodies. This bloom severely decreases the water quality and causes death of fish, and other aquatic organisms. [3]
17. Biological Oxygen Demand (BOD) is the amount of the oxygen required to consume all the organic matter present in one Liter of water oxidising bacteria. The BOD test measures the rate of uptake of oxygen by micro-organisms in a sample of water. Therefore, indirectly, BOD is a measure of the organic matter present in the water. If the BOD in a water body is more, it means the water body is more polluted. So, by measuring BOD of water body, its water quality can be determined. [3]
18. Successive increase in concentration of toxic chemicals at each trophic level in a food chain is called **biomagnification**. We can understand **with this example**, when the crop field is sprayed with dichlorodiphenyltrichloroethane (DDT), it is carried into water bodies and gets

dissolved in water. It gets into the zooplankton and concentration of DDT goes on increasing at each trophic level in a food chain—from small fish to large fish and birds. [2]

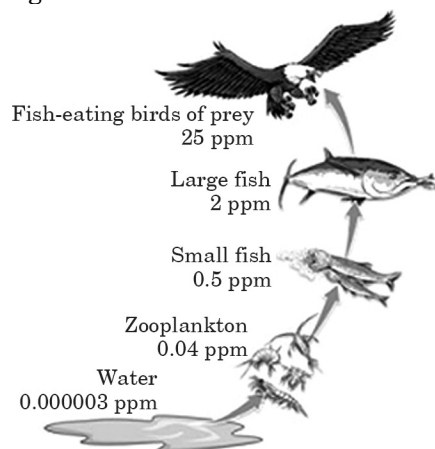


Fig.: Bio-magnification in a food [1]

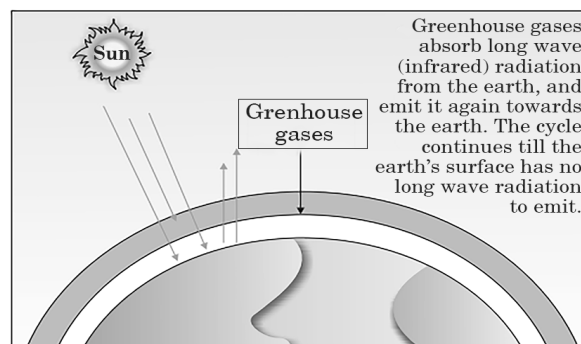
19. (a) Two places where it is essential to install electrostatic precipitators are
- In the thermal power plants
 - In the industries that release other particulate matter. Electrostatic precipitators are installed to remove particulate matter. [2]
- (b) Electrostatic precipitators does not remove very small particulate matter which measures less than 2.5 micrometres. Electrostatic precipitators cannot work without electricity. These are some of the limitations of electrostatic precipitators. [1]
20. “Swachh Bharat Abhiyan” is an initiative started on 2nd October, 2014. It is very good cleanliness drive. Unmanaged waste is the biggest evil that hinders the development and progress of a country. An unclean surrounding will lead to a lot of problems, such as decreased quality of air and water. Unclean surrounding causing health issues along with polluted air and water. [1]
- (b) Two problems faced while implementing the programme in my locality are as follows:
- Poor drainage system and improper sanitation.
 - Handling of non-biodegradable wastes. [1]
- (c) Remedies to overcome the problems:
- To overcome sanitation problems, we should make people aware regarding the benefits of proper sanitation and encourage the local people to make proper toilets. Covering of open drains by crowd funding. [1]

- (ii) There should be separate bins for non-biodegradable wastes so that they can be disposed and recycled accordingly. [1]
21. (a) Arguments in favour of burying and against burning:
- (i) Burying the waste does not have any harmful effect. Buried waste are decomposed by bacteria and fungi into simple inorganic nutrients. [1]
- (ii) Waste on burning, releases smoke and pollutants such as CO_2 , NO_2 , SO_2 , etc., in the atmosphere. These pollutants disturbs air quality of the atmosphere causing health issues. [1]
- (b) The solid wastes are classified into two categories:
Biodegradable and non-biodegradable waste. Biodegradable waste are those which can be degraded by the microbes, e.g., plants parts, kitchen waste etc. Non-biodegradable waste are those which cannot degraded by the microbes and can remain as it is for very long periods, e.g. plastics, aluminium cans pesticides. [1]
Flow charts depicting effects of burying and burning are:
- (i) Burying of biodegradable wastes (Agricultural waste, kitchen waste, plant parts) → in pit or in landfill → decomposition by bacteria and fungi → compost → Crop field → Plants → Recycled.
- (ii) Burning of waste → air pollution → global warming → respiratory diseases [1]
22. (a) Two major causes of air pollution are:
- (i) Burning of fossil fuels such as petroleum products and coal.
- (ii) Generation of dust which remain as suspended particulate matter produced by the construction activity. [1]
- (b) Harmful effects of air pollution.
- (i) In plants: It reduces vegetative growth which results into reduced crop yield. It also results into premature death of plants.
- (ii) It affects respiratory system of humans and of animals, affects vision. [1]
- (c) Two suggested programmes:
- (i) Organise a workshop for students, teachers and parents to create awareness regarding the harmful effects of air pollution. Arrange discussion on health issues related to air pollution. [1]
- (ii) Organise a pollution-free week in the school where teachers and students will promote use of bicycle to reduce pollution. [1]
23. (a) El Nino effect is a odd climate changes that is observed in the Pacific Ocean that affect the weather severely. The cycle starts when warm water in Pacific Ocean move towards coast of South America. This effect result in the melting of ice in Antarctica and global warming. Hence, the change in environmental conditions leads to the effect the organism life living in those areas. [3]
- (b) Three measures that I as an individual would take, to reduce environmental pollution are:
- (i) Planting more trees.
- (ii) Use of energy efficient electrical appliances.
- (iii) Saving the water bodies by not dumping the waste into it. [2]

[Topic 2] Greenhouse Effect, Ozone Depletion and Deforestation

Greenhouse effect and global warming:

- This is a natural phenomenon responsible for the heating of the Earth's surface and atmosphere. It allows the light to come in but restricts heat to go out. Earth's surface re-emit the heat as infrared radiation but a part of these radiations is absorbed by the atmospheric gases like CO_2 , CH_4 , etc. These gases cause the greenhouse effect.



- Global warming is caused by the increasing level of the greenhouse effect. Earth's temperature has been increased by 0.6°C during the last three decades. Some of its effects are melting of polar ice caps, Himalayan snowcaps etc.
- Over many years, there will be a rise in sea level that will submerge many coastal areas.
- It can be controlled by reducing deforestation and planting more trees and reducing usage of fossil fuels.

Ozone depletion in the stratosphere

- "Good" Ozone acts as shield absorbing UV-rays from the sun, which cause mutation and is found in stratosphere.
- The "bad" ozone is formed in the troposphere.
- The balance in production and degradation of ozone in the stratosphere is disturbed due to Chlorofluorocarbons (CFCs) which move upward and reach the stratosphere. UV rays act on them releasing Cl atoms. In the presence of Cl (catalyst), ozone degrades molecular oxygen causing ozone depletion which has formed ozone hole over the Antarctic region.
- The thickness of the ozone in a column of air from the ground to the top of the atmosphere is measured in terms of Dobson units (DU).
- UV-B damages DNA and causes damage to skin cells, aging of skin and various types of skin cancers. Cornea of the eye absorbs UV-B radiation, and a high dose of UV-B causes inflammation of cornea, called snow-blindness cataract, etc.
- The Montreal Protocol was signed in 1987 to control the emission of ozone-depleting substances.

Degradation by improper resource utilization and maintenance

- **Soil erosion and desertification:**
 - Over-cultivation, deforestation, grazing and poor irrigation practices done by human are responsible for soil erosion. When large barren patches extend and meet over time, a desert is created
- **Waterlogging and Soil Salinity:**
 - Without proper drainage of water, the irrigation process leads to waterlogging which damages the agriculture. Water logging also draws salt to the surface of the soil.

Deforestation:

- Conversion of forest area to a non-forested area leads to deforestation and one of its hazardous effects is that concentration of CO₂ is enhanced because the tree is lost with deforestation who can hold a lot of carbon.
- Deforestation cause soil erosion and disturbance in hydrologic cycle.

- It can be controlled by reforestation which is restoring the forest that once existed in the past. It can speed up by planting more and more trees.
- **Participation by people for conserving the forests**
 - Chipko Movement:
 - It was started in 1974 by the local women in Garhwal, Himalayas.
 - In order to protect the trees from the axe of the contractors, the women used to hug the trees.
 - Bishnoi Movement:
 - The king of Jodhpur in Rajasthan instructed his minister to arrange wood for constructing a new palace in 1731. The minister and workers went to a forest near a village where the Bishnois lived, to cut down trees.
 - A Bishnoi woman Amrita Devi showed immense bravery by hugging a tree and daring king's men to cut her first before cutting the tree.
 - Her three daughters and hundreds of other Bishnois followed her, and lost their lives saving trees.
 - The Amrita Devi Bishnoi Wildlife Protection Award has been introduced by the Government of India for individuals or communities from rural areas that show dedication in protecting the wildlife.

PREVIOUS YEARS'

EXAMINATION QUESTIONS

TOPIC 2

▣ 2 Marks Questions

1. Explain the relationship between CFC's and Ozone in the stratosphere. [ALL INDIA 2016]
2. List four benefits to human life by eliminating the use of CFCs. [ALL INDIA 2017]

▣ 3 Marks Questions

3. How have human activities caused desertification? Explain. [DELHI 2013]

▣ 5 Marks Questions

4. (a) What depletes ozone in the stratosphere? How does this affect human life?
(b) Explain bio magnification or DDT in an aquatic food chain. How does it affect the bird population? [DELHI 2012]

Solutions

1. The chlorofluorocarbons (CFCs) are non-biodegradable chemicals which are used as a coolant in refrigerators and in air conditioners. In the stratosphere ultraviolet (UV) rays act on CFC's to release chlorine (Cl) atom from the CFC's. Cl atoms react with ozone to release O_2 and a chain reaction consuming the ozone molecules and producing free radicals and diatomic oxygen. This results in ozone layer depletion. [2]
2. (a) Elimination of the use of CFCs can prevent damaging and ageing of skin [½]
 (b) Prevention of ozone layer depletion and prevention of global warming. [½]
 (c) Reduction in greenhouse effect. [½]
 (d) Reduction in odd climatic changes or El Nino effect. [½]
3. Desertification is the removal of the top layer of the soil which is very fertile. Human activities like deforestation, unrestricted grazing, poor irrigation practices and over-cultivation causes desertification. These activities result in the formation of large barren patches which eventually convert into desert. [3]
4. (a) **Chlorofluorocarbons (CFC)** depletes ozone in the stratosphere. CFC present in atmosphere reaches the stratosphere which is present above the atmosphere. Cl-chlorine free radically acts as a catalyst in the process of ozone depletion. This release of CFC affect the health of human life by causing respiratory distress because it depletes Ozone layer which blocks Harmful UV radiations in the local environment. [3]
 (b) **Bio-magnification** refers to the increase in the concentration of toxic waste at each successive trophic level. This causes the thinning of egg shells of birds, thus decline in the bird population. [1]
 Amount of water in DDT (0.003 ppm) → small fish (0.5 ppm) → large fish (2 ppm) → fish eating birds (5 ppm) [1]

CBSE

Sample Question Paper 1

Biology

Class XII

Time : 3 hrs

Maximum Marks : 70

General Instructions

- (i) The question paper has 27 questions in all. All questions are compulsory.
- (ii) Marks are indicated against each question.
- (iii) Questions from serial number 1 to 5 are Very Short Answer type Questions. Each question carries one mark.
- (iv) Questions from serial number 6 to 12 are 2 marks questions. Answers of these questions should not exceed 30 words each.
- (v) Questions from serial number 13 to 24 are 3 marks questions. Answers of these questions should not exceed 60 words each.
- (vi) Questions from serial number 25 to 27 are 5 marks questions. Answers of these questions should not exceed 100 words each.
- (vii) There is no overall choice. However, internal choice has been provided in some questions. You have to attempt only one of the alternatives in all such-questions.

SECTION A

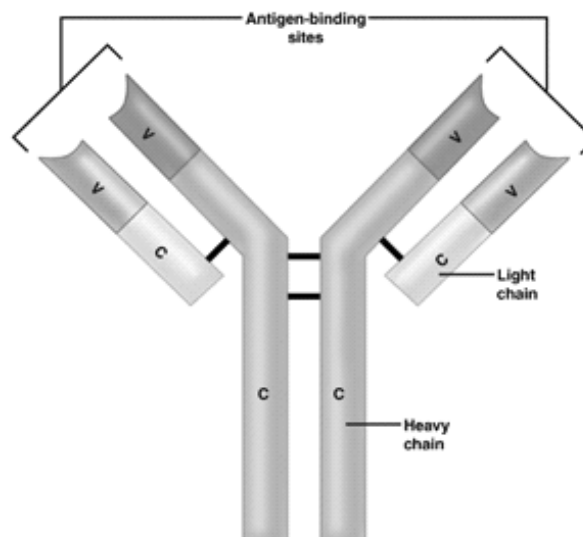
(1 × 5 = 5)

1. What is perisperm in black pepper?
2. Write down two special features of climax community.
3. State the role of Sertoli cells in Spermiation.
4. After a successful in-vitro fertilisation, the fertilised egg begins to divide. What is this technique named? At which stage are the cells, when they are transferred to the female uterus?
5. State a difference between a gene and an allele.

SECTION B

(2 × 7 = 14)

6. Write the difference between two types of autogamous flowers with examples.
7. Differentiate between male and female heterogamety in humans.
8. Mention a product of human welfare obtained with the help of each one of the following microbes:
 - (a) *Clostridium butylicum*
 - (b) *Saccharomyces cerevisiae*
 - (c) *Propionibacterium sharmanii*
 - (d) *Streptococcus*
9. Draw the structure of Antibody molecule and label its parts



10. What is the function of restriction enzymes in recombinant DNA technology? State giving an example.
11. Discuss the role the enzyme DNA ligase plays during DNA replication.
12. Name the causative organism of the disease malaria. List one symptom of the disease, one vector, and the species which causes malignant malaria.

OR

Differentiate between two types of tumors.

SECTION C

(3 × 12 = 36)

13. Describe the role of oxytocin in foetal ejection reflex.
14. Give an example of a sex linked recessive trait in humans and the affected offsprings. Explain its pattern of inheritance with the help of a cross.
15. Which experiments disapprove the theory of spontaneous generation? Explain with diagram.
16. Suggest and describe a technique to obtain multiple copies of a gene of interest in vitro
17. Name the causative organism for Typhoid, disease symptoms and the diagnostic test.
18. What are the ecosystem services provided free of cost and what shall be the estimated costs?
19. List advantages of GMOs to a farmer.
20. How has RNAi technique helped to prevent the infestation of roots in tobacco plants by a nematode *Meloidogyne incognitia*.

OR

Prior to a sports event blood and urine samples of sportspersons are collected for drug tests.

- (a) Why is this test conducted?
 - (b) Name the drugs the authorities usually look for?
 - (c) Write the generic names of two plants from which these drugs are obtained?
21. Name the three types of IUDs.

22. Given below is a list of six micro-organisms. State their usefulness to humans. (3)

- (a) Nucleopolyhedrovirus
- (b) *Saccharomyces cerevisiae*
- (c) *Monascus purpureus*
- (d) *Trichoderma polysporum*
- (e) *Penicillium notatum*
- (f) *Propionibacterium sharmanii*

23. What is passive immunity? How does mother's milk provide passive immunity? State another example of passive immunity.

24. Write the function of each one of the following:

- (a) Contact inhibition
- (b) Interferons
- (c) Placenta

OR

How are the following formed and involved in DNA packaging in a nucleus of a cell?

- (i) Histone octamer
- (ii) Nucleosome
- (iii) Chromatin

SECTION D

(5 × 3 = 15)

25. Draw a schematic sketch of pBR 322 plasmid and label the following in it:

- (i) antibiotic resistant gene-Ampicillin
- (ii) antibiotic resistant gene-Tetracyclin
- (iii) Origin of replication
- (iv) Any two restriction sites in Tetracyclin
- (v) Any two restriction sites outside Tetracyclin gene

OR

Explain the role of lactose as an inducer in a lac operon with a diagram.

26. (a) Why should we conserve biodiversity? How can we do it?
(b) Explain the importance of biodiversity hot-spots and sacred groves.

OR

- (a) There are three kinds of age-pyramids for human populations. Represent them diagrammatically.
(b) Name the two sedimentary cycles working in nature.
27. Explain the post-pollination events leading to seed production in angiosperms.

OR

Diagrammatically represent the events of menstrual cycle showing pituitary hormone levels, ovarian events, ovarian hormones, uterine events, menstruation phase and luteal phase, developing graafian follicle, mature Graafian follicle, Developing corpus luteum and mature corpus luteum.

CBSE

Sample Question Paper 2

Biology

Class XII

Time : 3 hrs

Maximum Marks : 70

General Instructions

- (i) The question paper has 27 questions in all. All questions are compulsory.
- (ii) Marks are indicated against each question.
- (iii) Questions from serial number 1 to 5 are Very Short Answer type Questions. Each question carries one mark.
- (iv) Questions from serial number 6 to 12 are 2 marks questions. Answers of these questions should not exceed 30 words each.
- (v) Questions from serial number 13 to 24 are 3 marks questions. Answers of these questions should not exceed 60 words each.
- (vi) Questions from serial number 25 to 27 are 5 marks questions. Answers of these questions should not exceed 100 words each.
- (vii) There is no overall choice. However, internal choice has been provided in some questions. You have to attempt only one of the alternatives in all such-questions.

SECTION A**(1 × 5 = 5)**

1. Apomixis is a method of asexual reproduction. Justify the statement.
2. What are the different components of semen?
3. Name the term used for molecular scissors giving one example.
4. State an example of evolution as a stochastic process in current times.
5. What is the importance of ART?

SECTION B**(2 × 7 = 14)**

6. Name the enzyme needed for isolation of bacterial DNA. Why is it not necessary to use it in the isolation of plant DNA?
7. Progeny formed from sexual reproduction have better chances of survival. Why?
8. If a person is born with a hereditary disease how can it be cured? Give an example.
9. Mention a product of human welfare obtained with the help of each one of the following microbes.
 - a. Trichoderma
 - b. Methanobacterium
 - c. Aspergillus niger
 - d. Oscillatoria
10. Many fresh water animals cannot survive in marine environment. Explain?
11. Double fertilization is reported in plants of both castor and ground nut. How are the mature seeds of groundnut and castor? Explain the post fertilization events responsible for it?
12. Rupture of Graafian follicle and thereby the release of ovum (ovulation) is controlled by hormones. Mention two hormonal changes which bring about ovulation.

OR

If a new habitat is just being colonised, how does immigration contribute to population growth than birth rates. Justify giving the mathematical formula.

SECTION C**(3 × 12 = 36)**

13. Seeds are the basis of agriculture. Justify in the light of water dependency and dormancy.

14. A teacher wants students to find out the genotype of pea plant with tall trait in the school garden. Name and explain the cross that will make it possible.
15. During the reproductive cycle of a human female:
 - a. Name the tissue which forms placenta.
 - b. What is the function of placenta?
 - c. What are the hormones secreted by placenta?
16. How are Numbat and ant-eater connected? Use concepts of evolution and two examples pairs to justify your answer.
17. Enlist the steps involved in inbreeding. How is it disadvantageous?
18. Explain with an example of symbiotic fungi on how their mutual association helps fungal and plant partners.
19. (a) Point out the key difference between primary and secondary sewage treatment?
(b) Microbes can be used to decrease the use of chemical fertilizers and pesticides. Explain with examples how it can be accomplished.
20. (a) A DNA segment has 200 nucleotides. Out of this 30 of them are guanine. How many pyrimidine bases does the segment possess?
(b) Make a diagrammatic sketch of DNA to support your answer.
21. Insulin is a hormone which is needed by diabetics for treatment. With the advent of biotechnology, the recombinant insulin can be made. Write down the steps to make recombinant insulin.
22. (a) Name the simplest and most common bioreactor in use.
(b) How has the advent of bioreactor influenced biotechnology?
23. Explain with evidences how the evolution of man and cheetah was from a common predecessor.

Name the predecessor of current form of crocodile and dinosaur.
24. Giving an example of polygenic inheritance, how blood grouping can be used to study it?

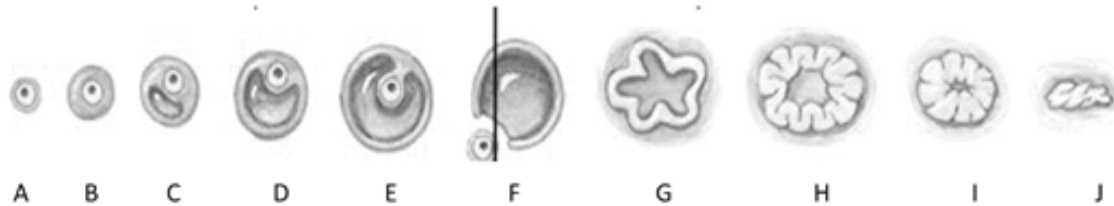
Make a cross and justify your answer.

Why does human skin colour pattern show much variation as compared to monkeys'?

SECTION D

(5 × 3 = 15)

25. Out of the following figures shown below, which one of the following represents



- a. Ovulation
- b. Mature Graafian Follicle
- c. degenerating corpus luteum
- d. ovum stage which releases high estrogen
- e. ovum stage which releases high progesterone

OR

Explain the process of spermatogenesis with diagrams and labelling.

26. You went to a hill station in summers and started wheezing. You had runny nose and sneezing. But when you changed the place, you became normal.

- a. Define what it the type of body response?
- b. What are the substances called?
- c. What type of antibodies are produced?
- d. Point out what is the chemical released in your body which cause it?
- e. Name one drug which can be used to treat it.

27. Give an example of plasmid vector labelling it as

- a. Antibiotic resistance
- b. Replicative apparatus
- c. Cloning site

How does presence of two antibacterial genes help in identifying transformants from non-transformants and recombinants from non-recombinants?

OR

How is the phenomenon of accelerated eutrophication different from eutrophication? Take thermal power plant as an example, how does it cause accelerated eutrophication.

