

## [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 *Strobilanthus 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]

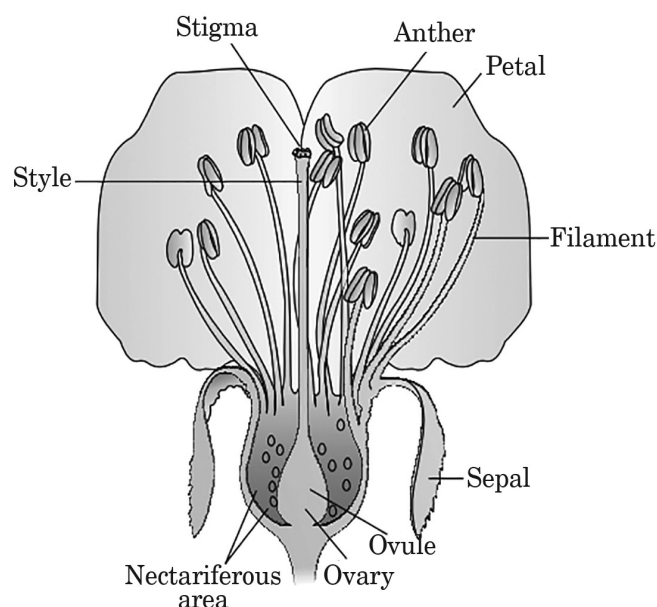
#### 3 Marks Questions

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]

## [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.

## [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) 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]

## [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]**

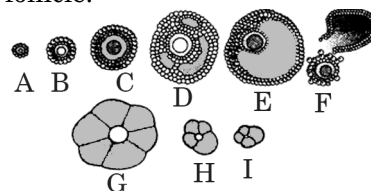
#### ▣ 3 Marks Questions

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]**

## [Topic 2] Gametogenesis

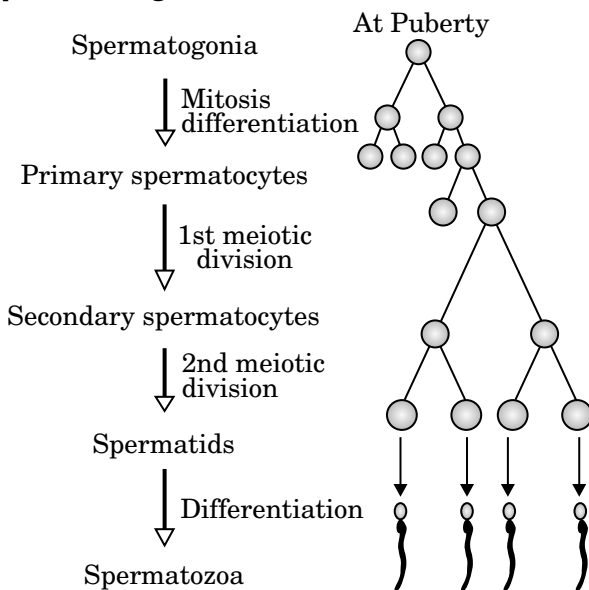
### Gametogenesis

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

Spermatogenesis

Oogenesis

### Spermatogenesis

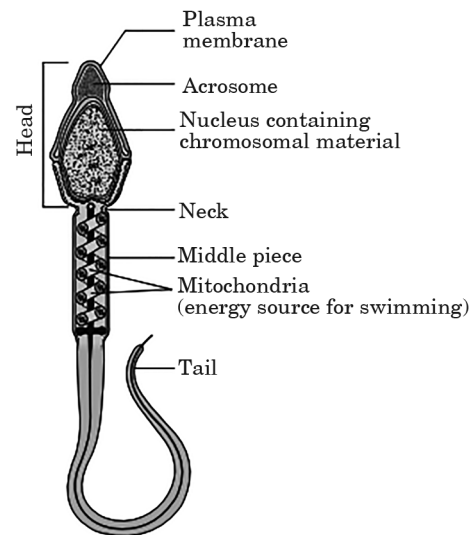


**Fig.:** Spermatogenesis mechanism

- 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

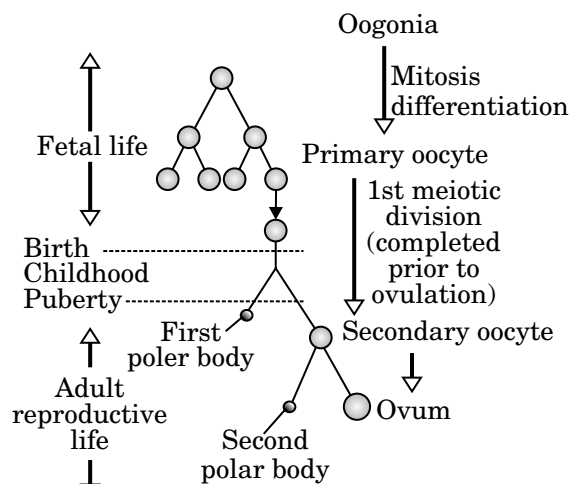
- The length of a sperm is around 0.06 mm.
- The plasma encloses the sperm.
- The four basic parts of sperms are:
  - Head: The shape of the head is oval and the constituent part is acrosome and nucleus.



**Fig.:** Structure & various parts of Sperm

- Neck: Distal and proximal centrioles is the basic part of neck. Neck is followed by the head.
- Middle Part: The power house or mitochondria and cytoplasm comprises to make the middle part.
- 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

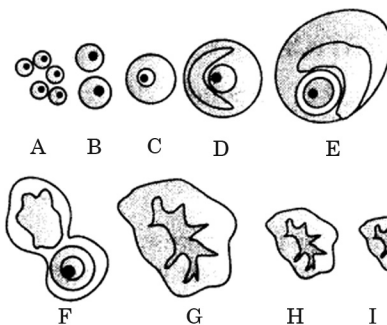
[DELHI 2013]

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

[ALL INDIA 2013]

#### 5 Marks Questions

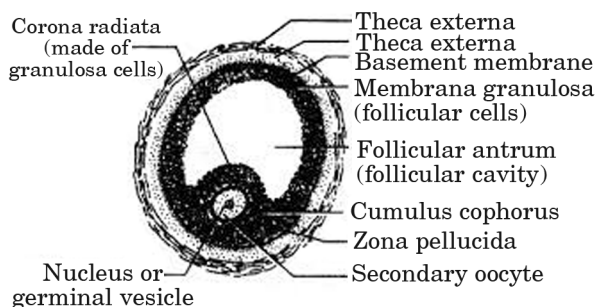
5. The following is the illustrations of the sequence of ovarian events (a-i) in a human female.



- (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.

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]

# [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.

## [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.

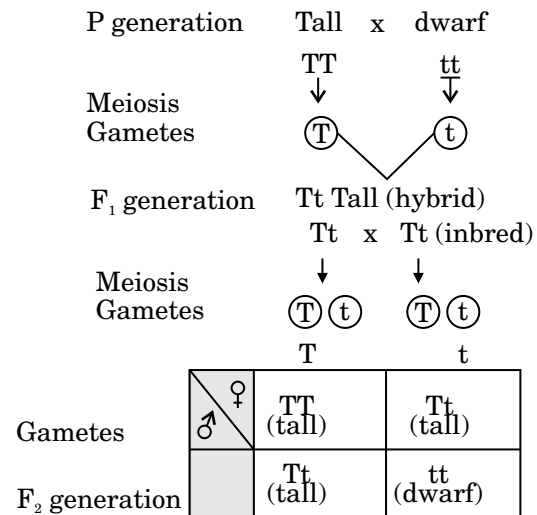
All the characters do not show true dominance. Some of the characters show incomplete dominance while the others may show co-dominance. Dominance is dependent on the gene product, particular phenotype chosen to examine and the production of the particular phenotype.

#### 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

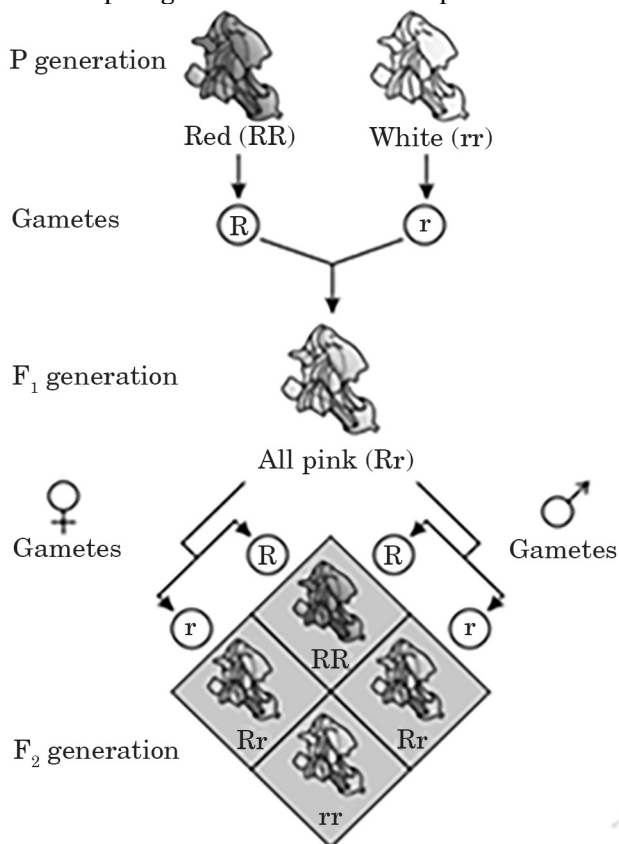
- Gametes T and t are produced in equal production when  $F_1$  is self-pollinated.
- Monozygous Genotypic ratio is  
Homozygous Tall : Heterozygous Tall : Homozygous Dwarf = 1 : 2 : 1
- Monozygous Phenotypic ratio is Tall : Dwarf = 3 : 1

### 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

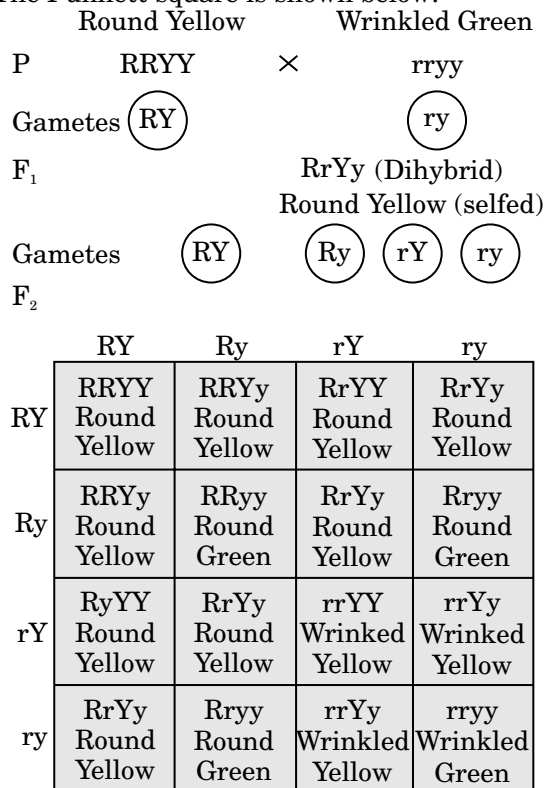
- Genotypic Ratio =  $RR : Rr : rr = 1 : 2 : 1$
- Phenotypic Ratio = Red : Pink : White =  $1 : 2 : 1$
- **Co Dominance:**
- It is the dominance in which both the alleles of a gene are expressed independently and equally in a hybrid that is both the alleles are dominant. Example: ABO blood group in humans.
- 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  
 $RRYY : RRYy : RrYY : RrYy : RRyy : Rryy :$   
 $rrYY : rrYy : rrYy : rryy = 1:2:1:2:4:2:1:2:1$

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]

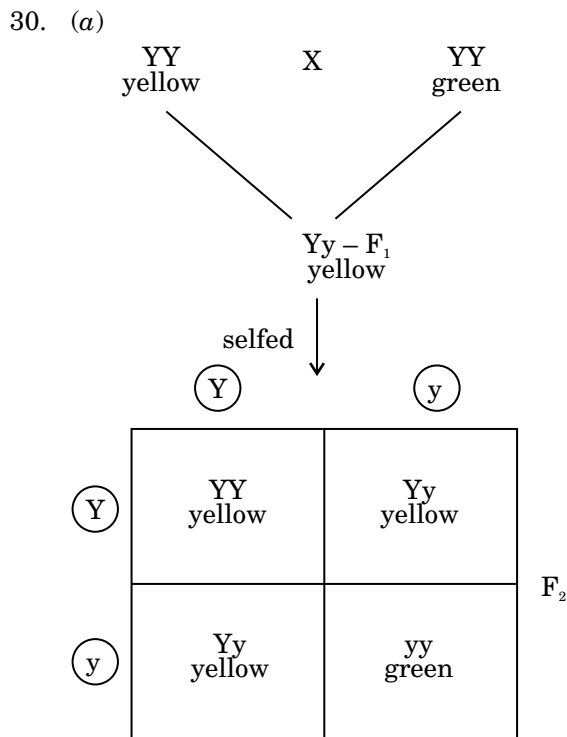
#### ▣ 2 Marks Questions

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]

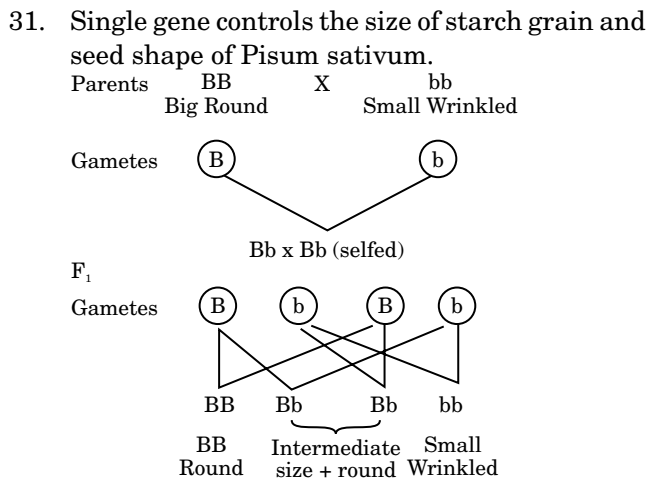
#### ▣ 3 Marks Questions

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 F<sub>1</sub> 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]





- 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<sup>A</sup>, I<sup>B</sup>, in which I<sup>A</sup>, I<sup>B</sup> are dominant over i.[2]
- (b) (i) As, I<sup>A</sup> is dominant over i, the blood of this person would be A
- (ii) As, ii is present, this individual will have O blood group. [3]

## [Topic 2] Sex-Determination and Genetic Disorders

### Summary

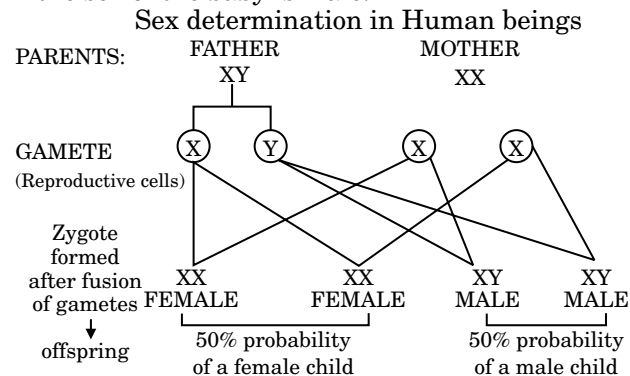
#### Sex Determination

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.

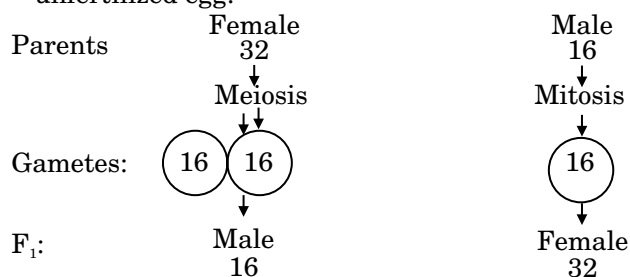
- 50% of them carry X chromosome while the other 50% carry Y chromosome. In female, only one kind of gamete or ovum carrying X chromosome only is produced.
- If the sperm which carry X chromosome fertilizes the egg, then the sex of the baby is female while if the one carrying Y chromosome fertilizes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

## [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.

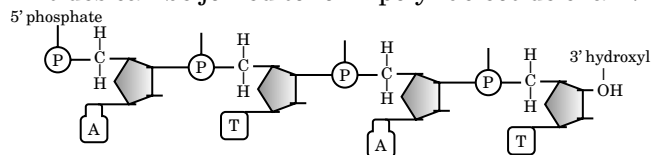


Fig.: 5' phosphate

#### • 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.

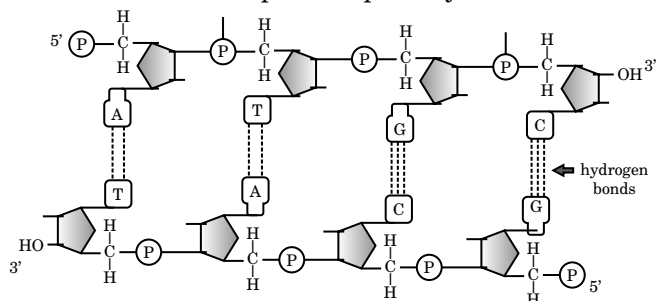


Fig.: Double stranded polynucleotide chain

- 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.

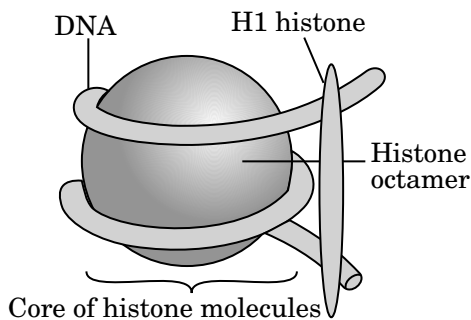


Fig.: Nucleosome

• **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.

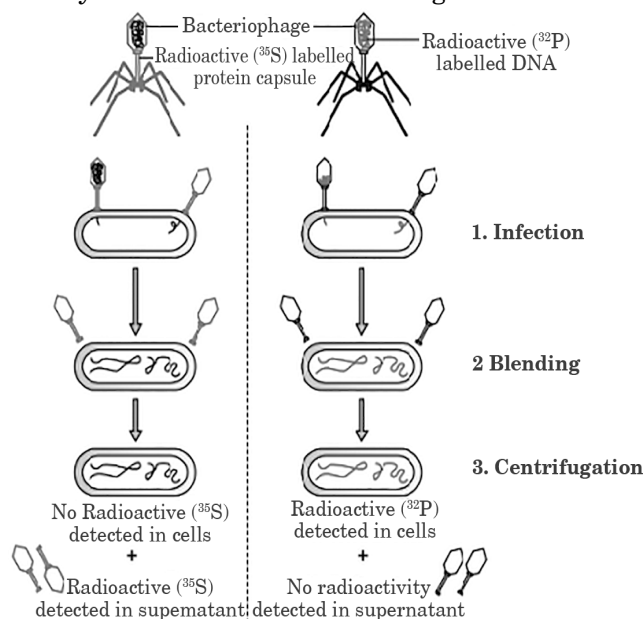


Fig.: The Hershey-Chase Experiment

- **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

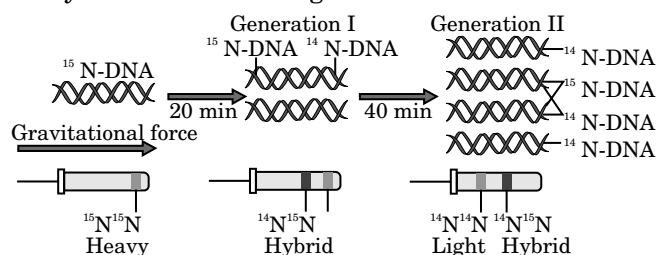
It is the process of copying of DNA from the parent DNA. Watson and Crick proposed semi-conservative model of DNA replication. The model suggests the separation of two strands would and synthesis the new complementary strands by acting as a template. Once the replication is completed, each DNA molecule 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  $^{15}\text{N}$  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.

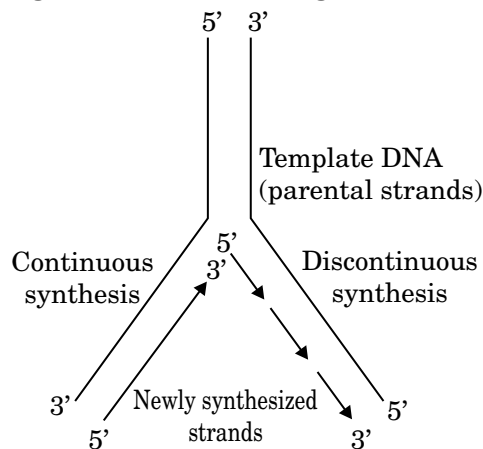
- The samples were studied at different time intervals. After 20 minutes when  $^{15}\text{N}$  had transferred to  $^{14}\text{N}$ , the sample was isolated and centrifuged. Its density came out to be intermediate between  $^{14}\text{N}$  DNA and  $^{15}\text{N}$  DNA.
- In the next generation, i.e. 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.

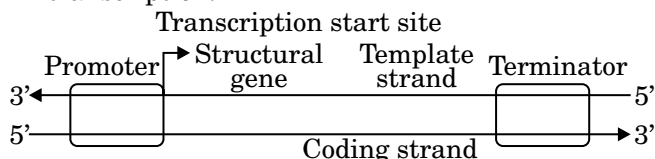


Fig.: Schematic structure of a transcription unit

### • 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.

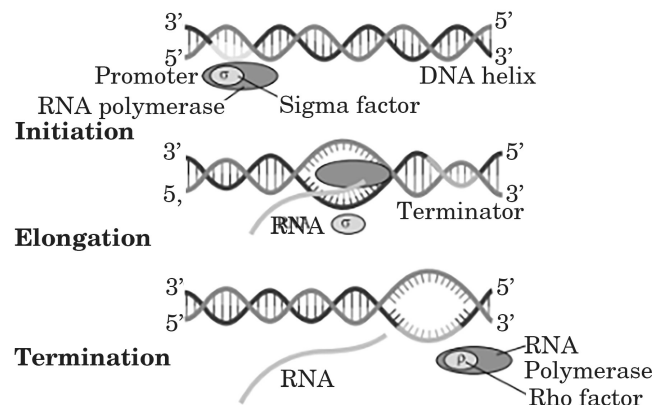


Fig.: Process of Transcription in Bacteria

### • 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.

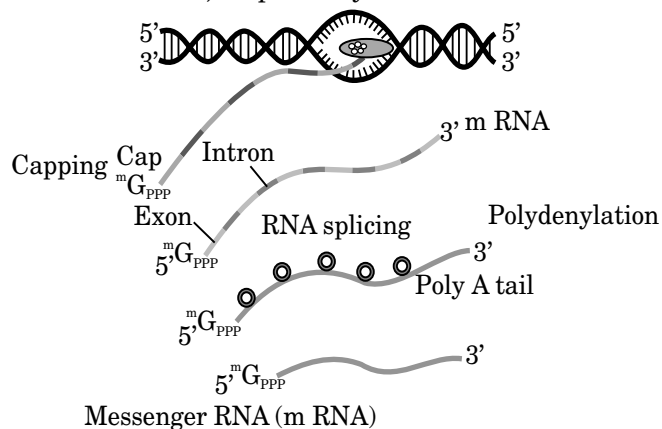


Fig.: Process of transcription in Eukaryotes

# [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.

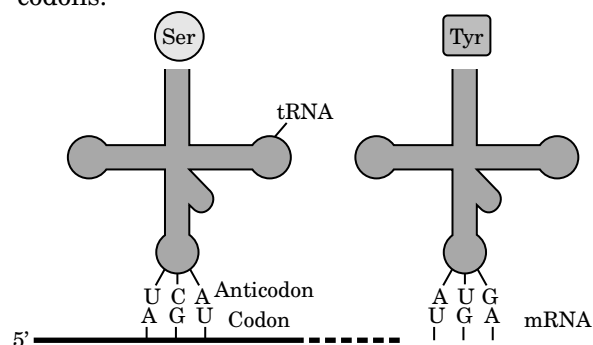


Fig.: tRNA – the adapter molecule

• **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.

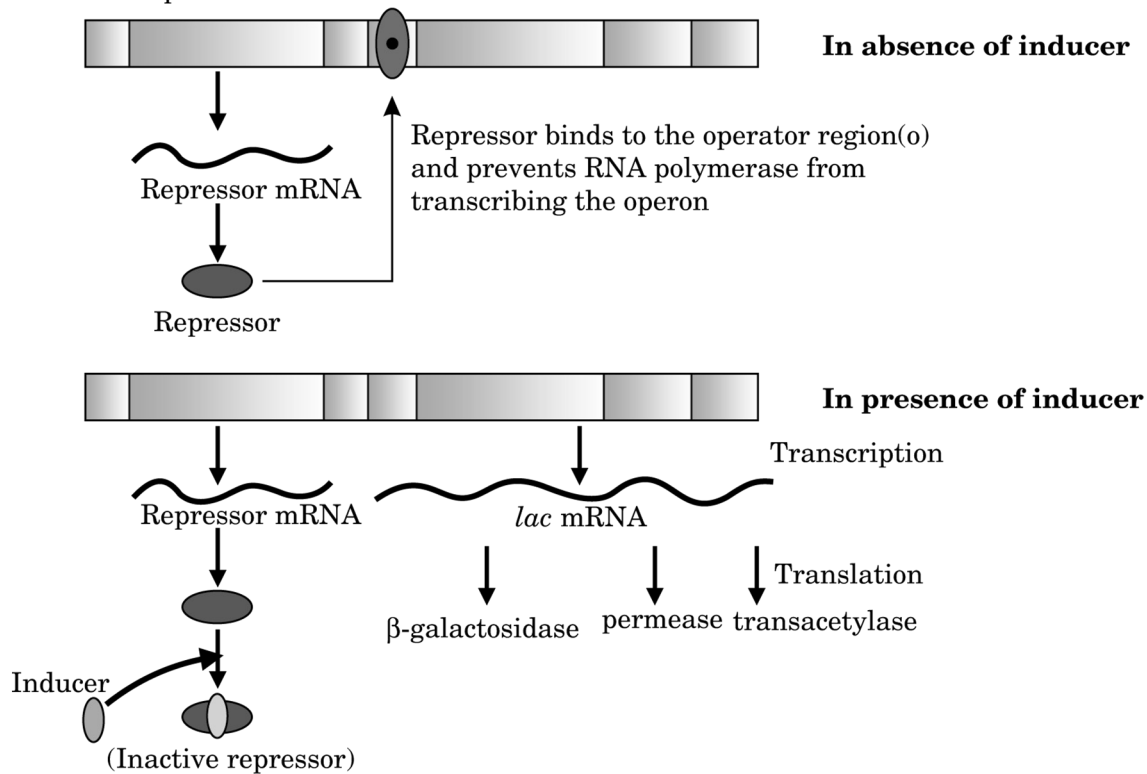
• **Regulation of Gene Expression:**

- 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

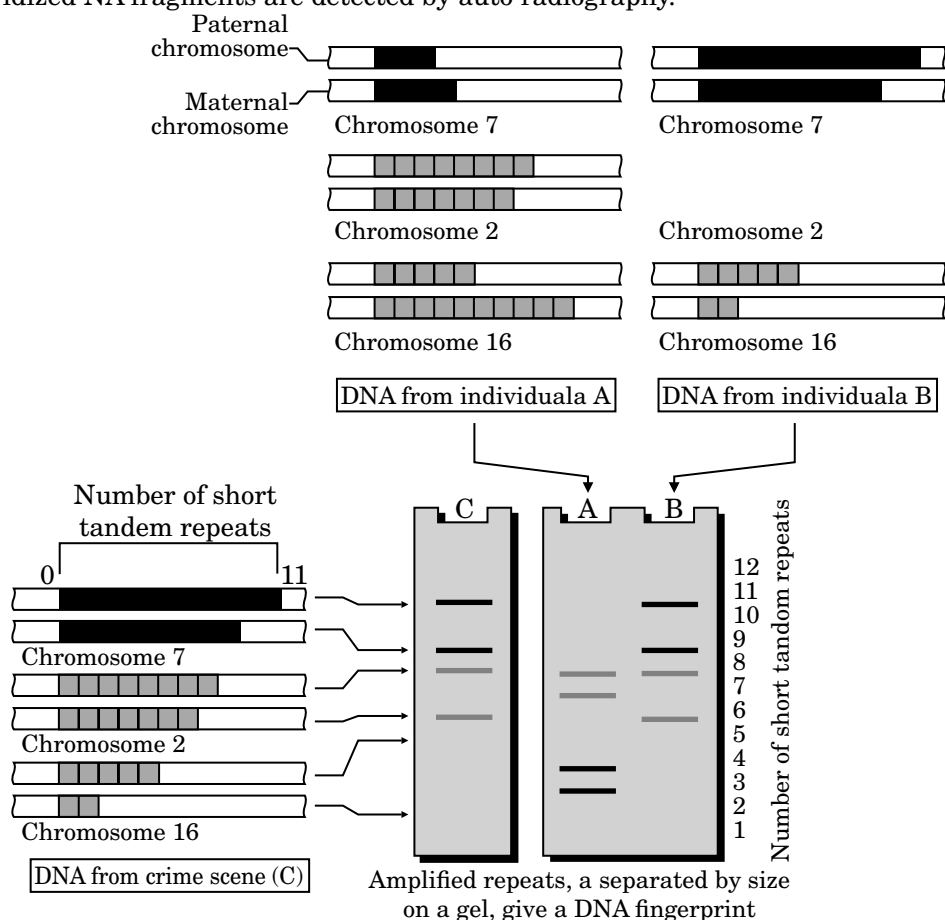
DNA fingerprinting is a way to identify the similarities and differences in specific region of DNA sequence known as repetitive DNA, as in these sequences, a small stretch of DNA is repeated many times.

- **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]

## [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

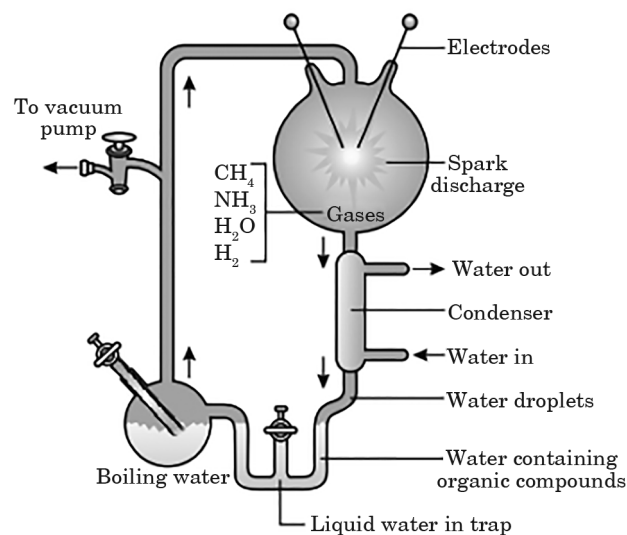
### Modern Theory by Oparin

- 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

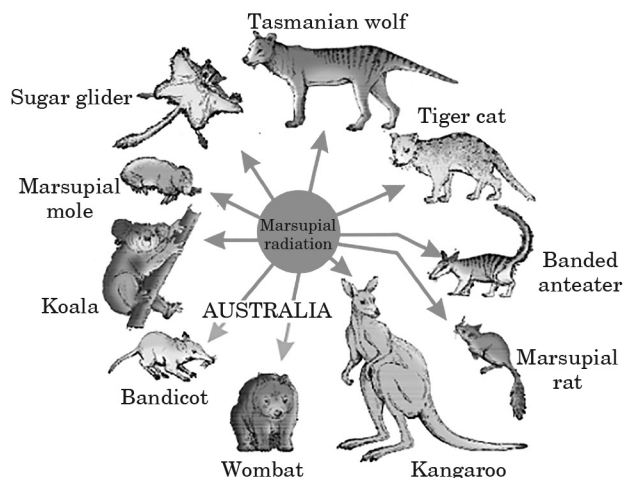
During a sea voyage, some observations were made. Charles Darwin concluded them all and proposed that current living forms have some similarities among themselves and also with life forms prevailing millions of years back. Quite a lot of them do not exist anymore. The geological history of earth matches 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) 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

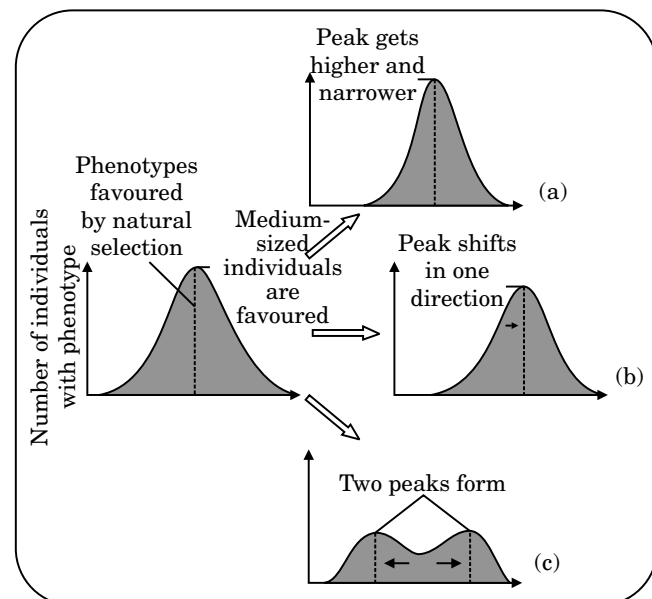
Evolution by natural selection, in a true sense would have started when cellular forms of life with differences in metabolic capability originated on earth.

**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.  
 $p^2 + 2pq + q^2 = 1$

# [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.

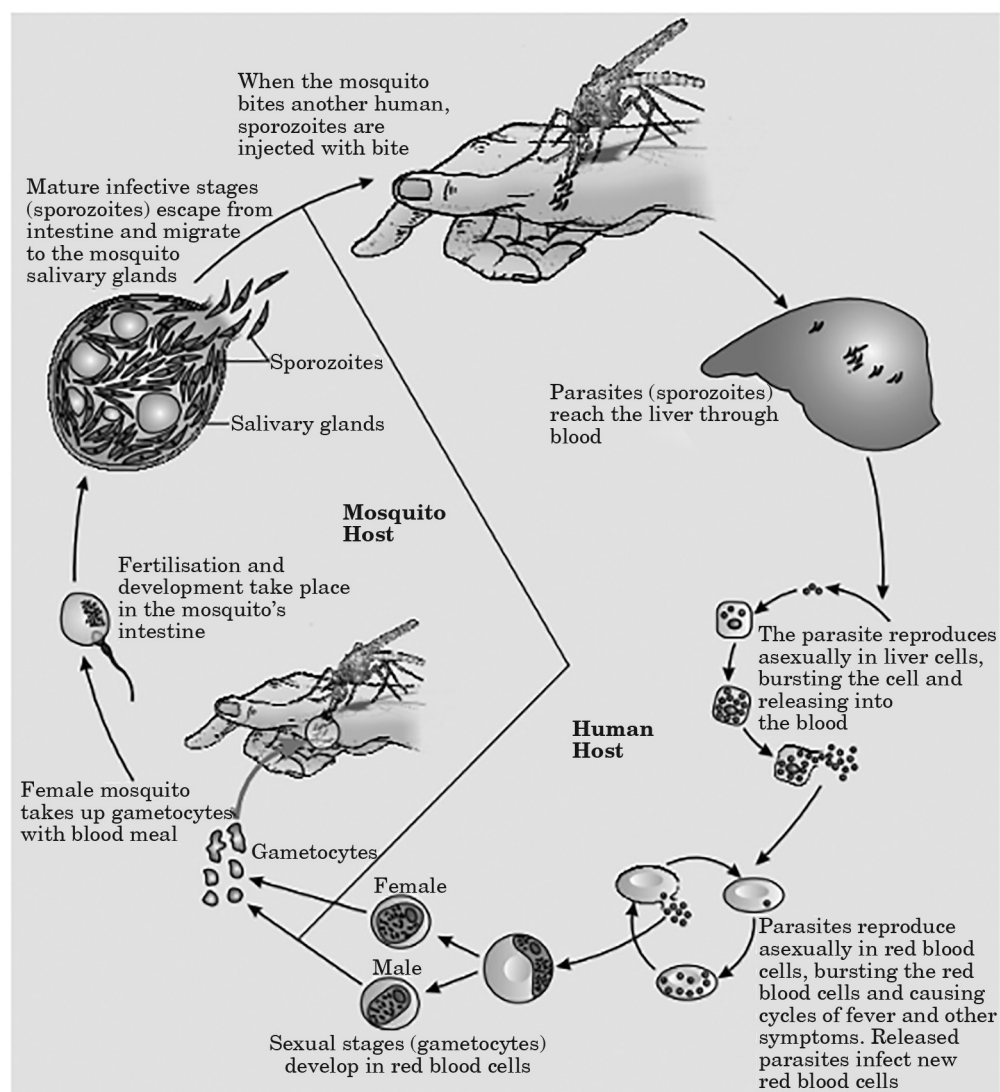


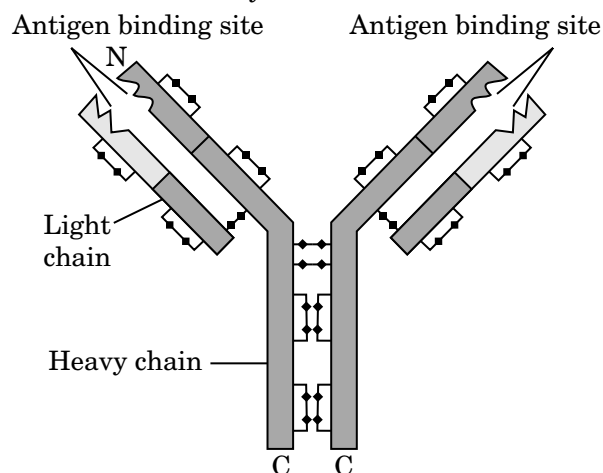
Fig.: Stages in Lifecycle of *Plasmodium*

- **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 H<sub>2</sub>L<sub>2</sub> 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.

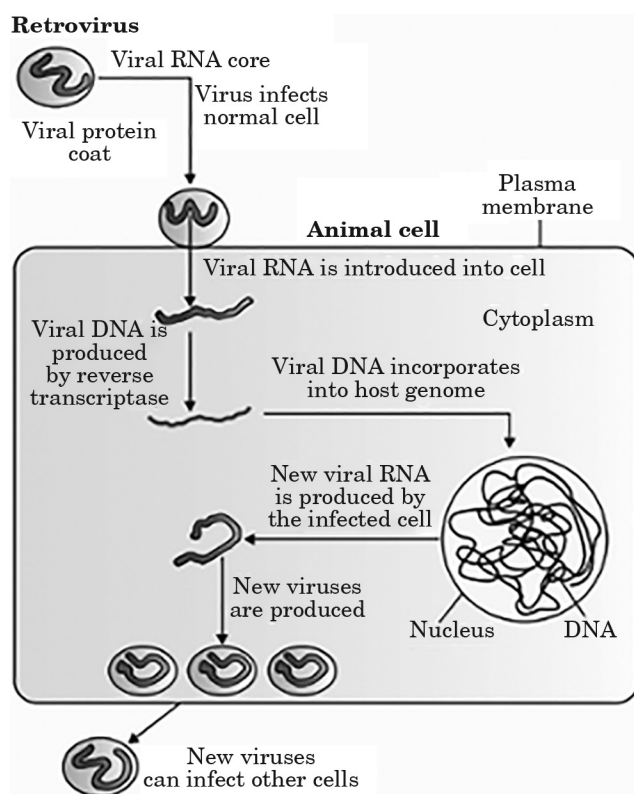
➤ Its infection can be spread by various ways like infected blood, sexual intercourse, contaminated needles, etc.

➤ 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

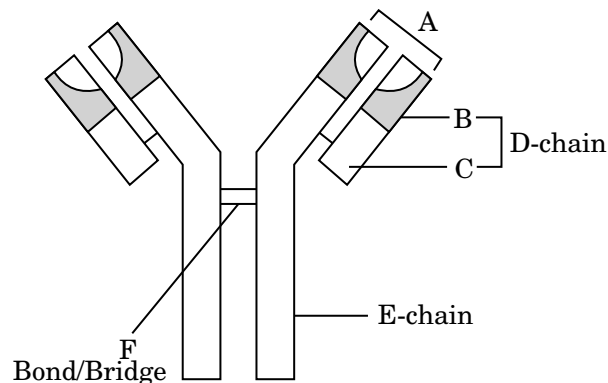
#### ▣ 1 Mark Questions

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]

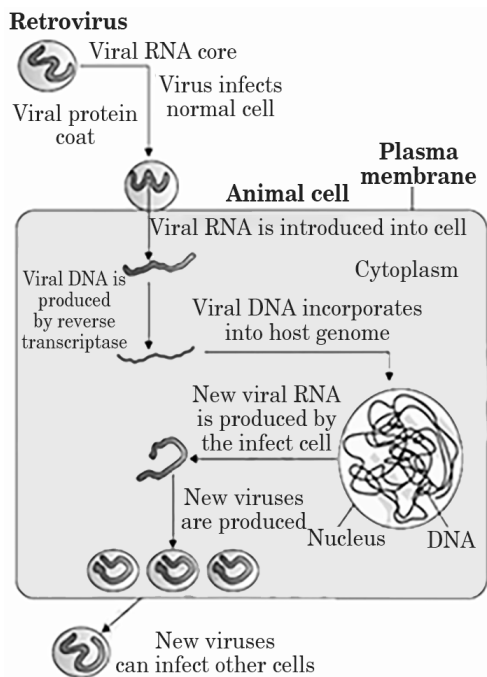
#### ▣ 2 Marks Questions

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]



**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]

## [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.

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## 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]

# [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]

## [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.

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## 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]

- (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.

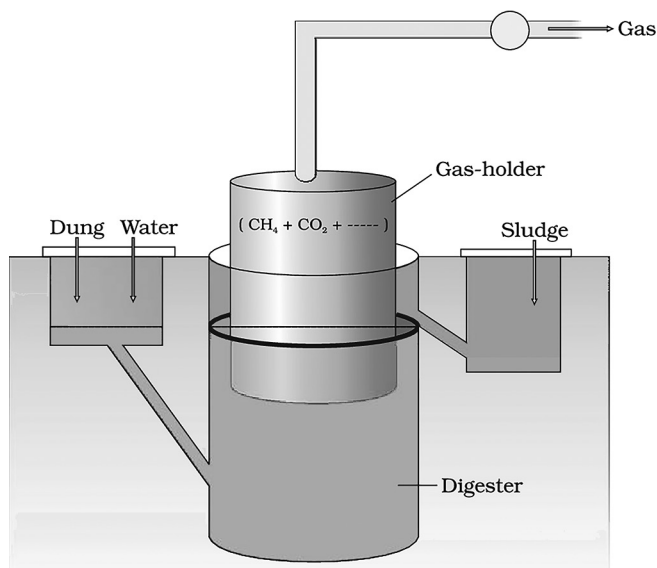


Fig.: A typical biogas plant

### • 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]



# [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.

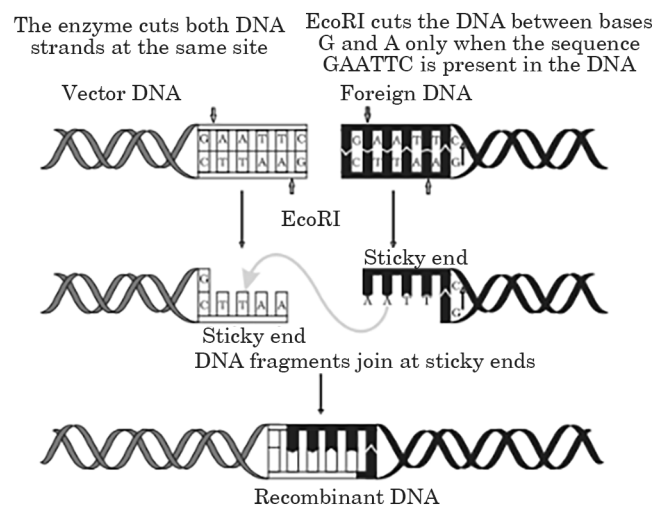
- Maintain the recognised DNA in the host medium and then transfer DNA to its progeny.

## 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.

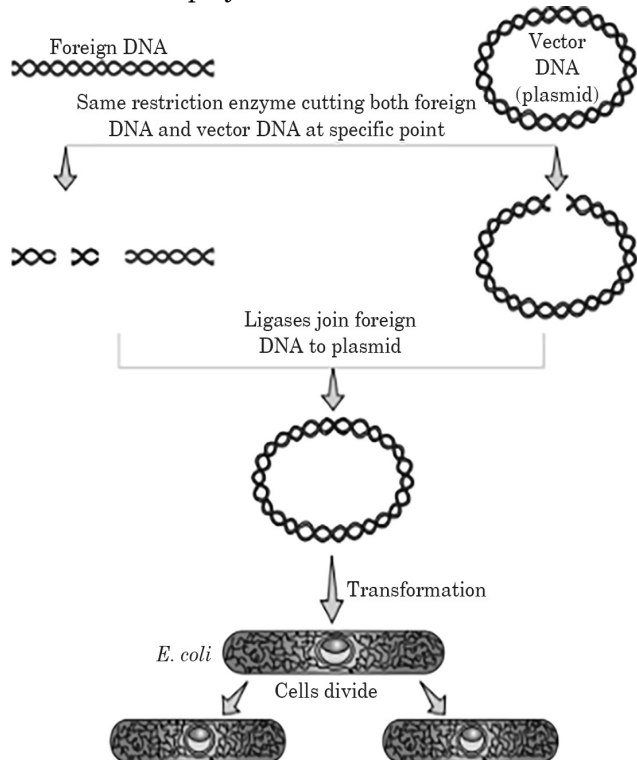


Fig.: Recombinant DNA Technology

- **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

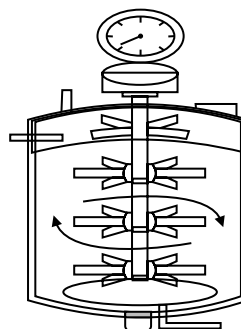
### TOPIC 1

#### 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]



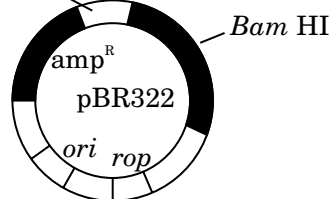
leading to deficiency of ADA which can be treated by enzyme replacement therapy. In this treatment, patients are regularly injected with the functional adenosine deaminase enzyme. [2]  
Disadvantages:

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. Eco RI [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.

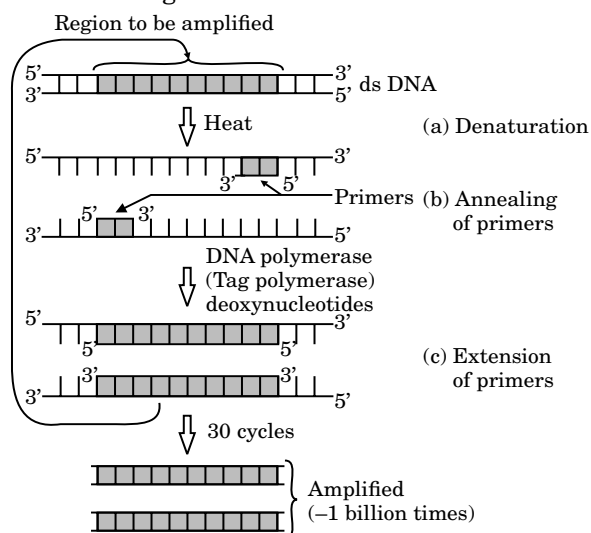
- The purified DNA precipitates after chilled ethanol is added and can be collected as fine threads in the suspension.

### 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:

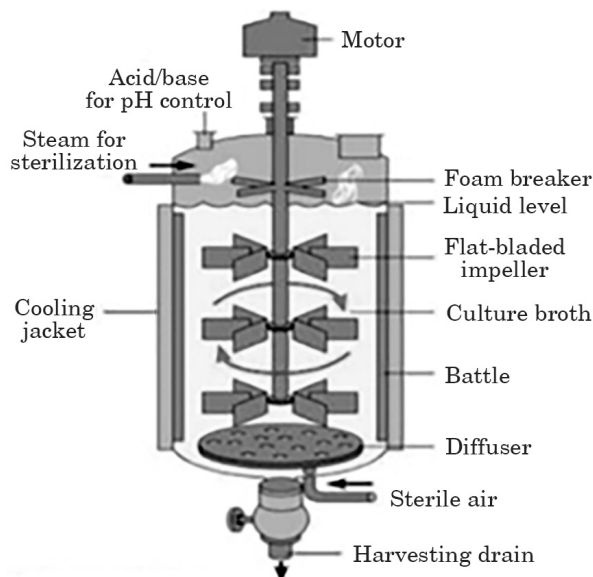


Fig.: Bioreactor

- 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  $\alpha$ -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

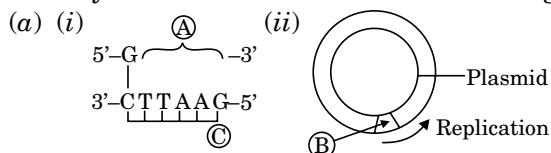
7. (a) Explain the significance of 'palindromic nucleotide sequence' in the formation of recombinant DNA.  
(b) Write the use of restriction endonuclease in the above process. **[ALL INDIA 2017]**
8. Describe the roles of heat, primers and the bacterium *Thermus aquaticus* in the process of PCR. **[ALL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

# [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**

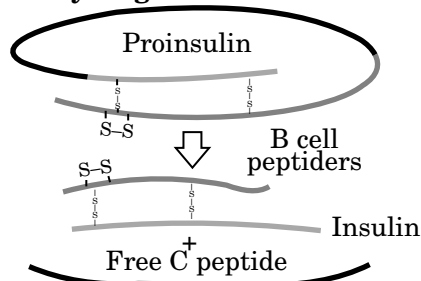
- *Meloidogyne incognita* is a nematode which generally attacks the roots of the Tobacco plant causing a very less tobacco yield.
- RNA interference is used to prevent this nematode attack.
- The eukaryotic organisms use RNAi for their defence.
- This prevents mRNA translation because of complementary 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]

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]

## [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.

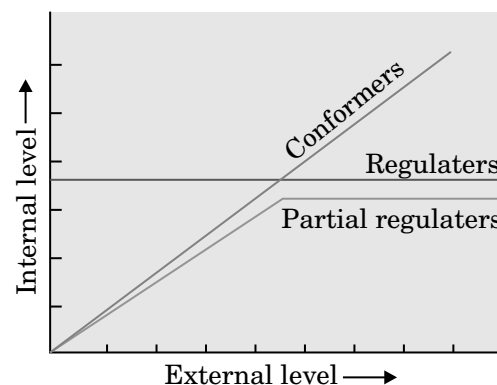
- **Water**

- 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

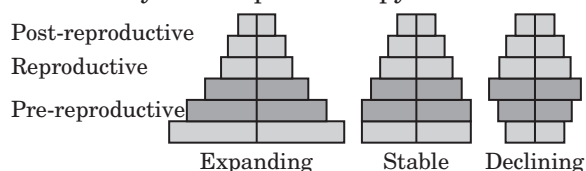
12. Water is very essential for life. Write any three features both for plants and animals which enable them to survive in water scarce environment. [ALL INDIA 2011]
13. How do organisms cope with stressful environmental conditions which are localized or of short duration? [ALL INDIA 2011]
14. Explain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

- (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.

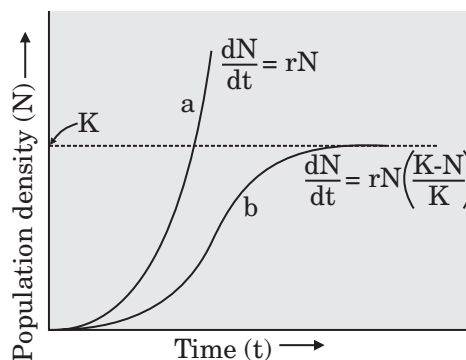


**Fig.:** Representation of age pyramids for human population

- **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

1. (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

2. (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]**
3. (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]**

# [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  $\text{kcal m}^{-2}$  or weight  $\text{g}^{-2}$ .

- 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.

- (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)

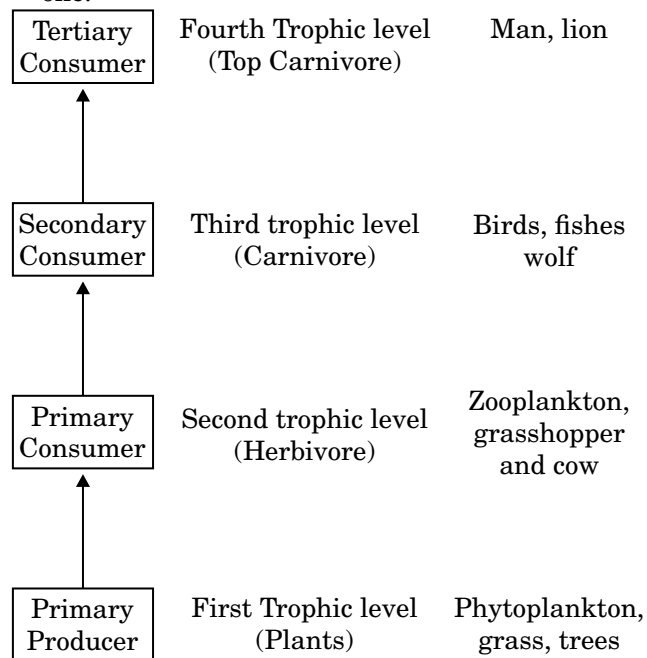
Grass → Deer → Lion

(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

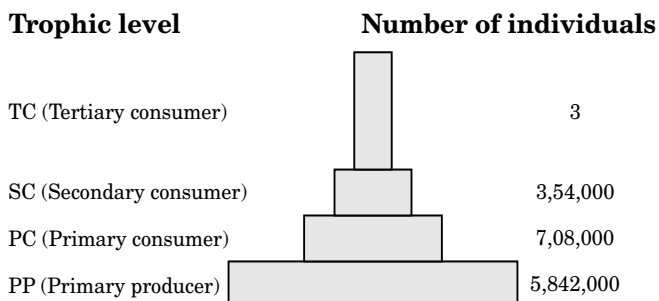
### Ecological Pyramids

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:**

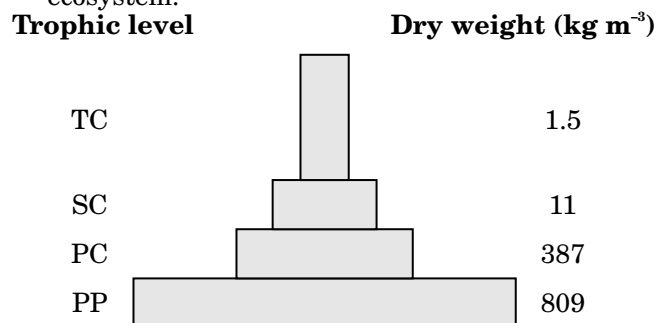
- It demonstrates the relationship between organisms on the basis of their number.



**Fig.:** Pyramid of Number

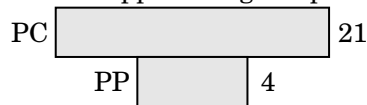
**Pyramid of Biomass:**

- Sharp decrease in biomass at higher trophic levels can be seen in pyramid of biomass in grassland ecosystem.



**Fig.:** Pyramid of Biomass (Grassland Ecosystem)

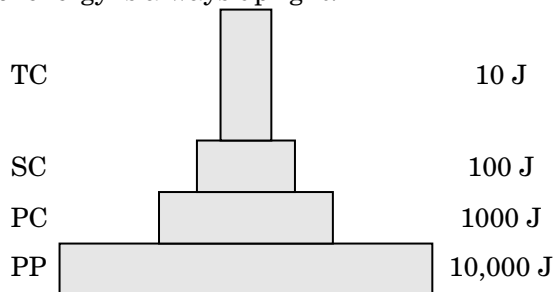
- Inverted pyramid of biomass is seen in aquatic ecosystem, where small standing crop of phytoplankton supports large crop of zooplankton.



**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]



- (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.

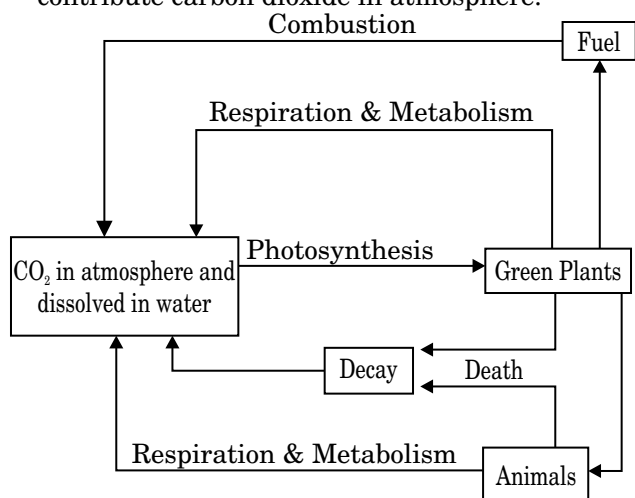


Fig.: Basic Carbon Cycle Flow Diagram

- **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.

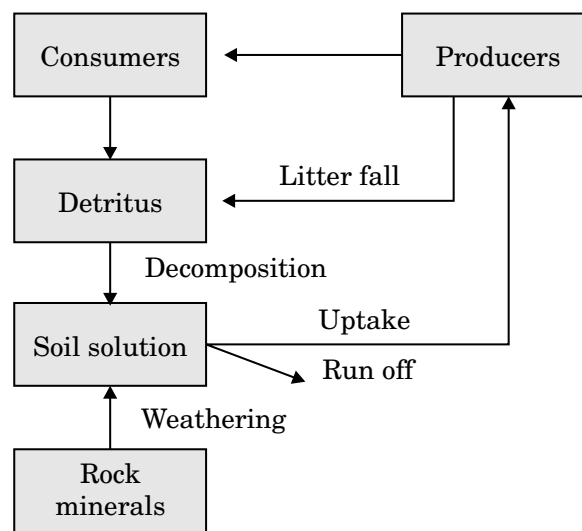


Fig.: Phosphorus Cycle

## PREVIOUS YEARS' EXAMINATION QUESTIONS TOPIC 3

### 1 Mark Questions

1. Explain the carbon cycle with the help of a simplified model. [ALL INDIA 2014]

## [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.

13. Yes, when Alien species are introduced, they are highly invasive and are a threat to indigenous species. For example,
- Extinction of 200 species approximately by the introduction of Cichlid fish in Lake Victoria. [1]
  - Environmental damage of the native species by the introduction of carrot, Lantana, water hyacinth. [1]
  - 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]
- 0.1 and 0.2 Z value is representing area is small to normal
    - 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]
  - 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

# [Topic 1] Pollution, Solid and Radioactive wastes

## Summary

### Introduction

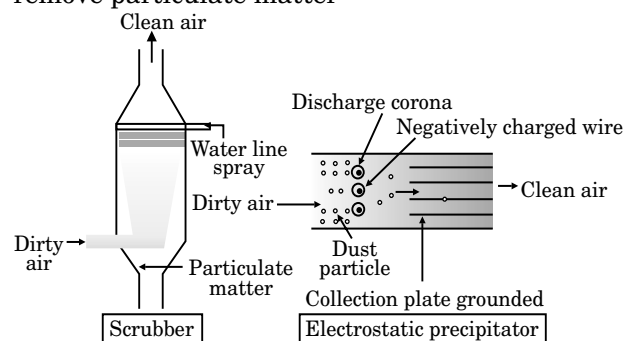
- Because of an explosion in the human population, the demand for food, water, home, electricity, roads, automobiles has been increased which leads to the pollution of air, water, and soil.
- Major issues relating to environmental pollution and depletion of valuable natural resources are different in 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 released get attached to them. These dust particles get attracted by grounded charged plates.
- The scrubber can remove gases like  $\text{SO}_2$
- Over 99 percent particulate matter present in the exhaust from a thermal power point can be removed by this.

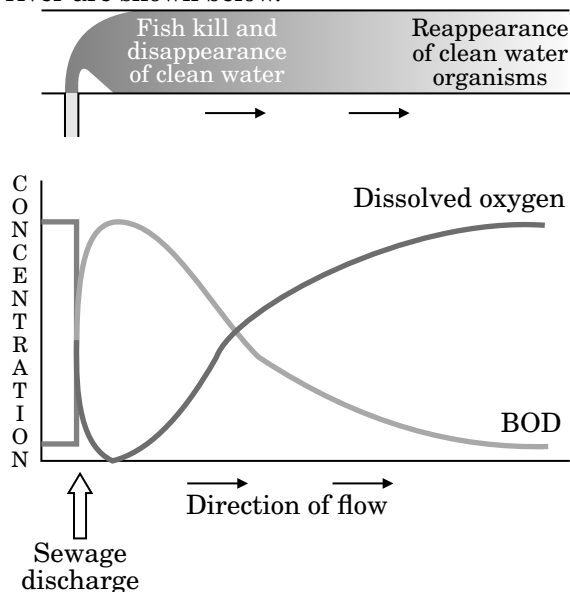
### Noise Pollution:

- 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.

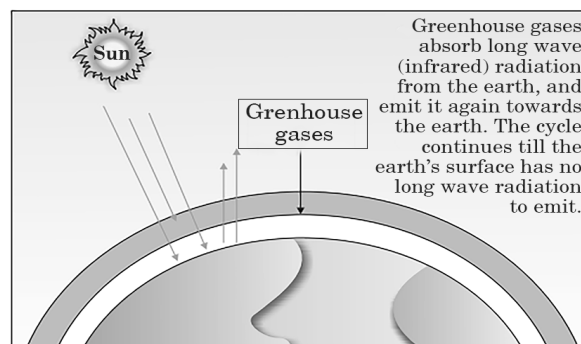
Crop waste is used in creating compost, which can be used as a natural fertilizer or can be used to generate natural gas for satisfying the energy needs of the farm.

- (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  $\text{CO}_2$ ,  $\text{NO}_2$ ,  $\text{SO}_2$ , etc., in the atmosphere. These pollutants disturb 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 be 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 Niño 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-emits the heat as infrared radiation but a part of these radiations is absorbed by the atmospheric gases like  $\text{CO}_2$ ,  $\text{CH}_4$ , 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 CO<sub>2</sub> 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]