जीव विज्ञान

BIOLOGY

कक्षा/Class: XII

2024-25

विद्यार्थी सहायक सामग्री

Student Support Material

तत् त्वं पूषन् अपावृणु
केन्द्रीय विद्यालय संगठन

केन्द्रीय विद्यालय संगठन

Kendriya Vidyalaya Sangathan

संदेश

विद्यालयी शिक्षा में शैक्षिक उत्कृष्टता प्राप्त करना केन्द्रीय विद्यालय संगठन की सर्वोच्च वरीयता है। हमारे विद्यार्थी, शिक्षक एवं शैक्षिक नेतृत्व कर्ता निरंतर उन्नति हेतु प्रयासरत रहते हैं। राष्ट्रीय शिक्षा नीति 2020 के संदर्भ में योग्यता आधारित अधिगम एवं मूल्यांकन संबन्धित उद्देश्यों को प्राप्त करना तथा सीबीएसई के दिशा निर्देशों का पालन, वर्तमान में इस प्रयास को और भी चुनौतीपूर्ण बनाता है।

केन्द्रीय विद्यालय संगठन के पांचों आंचलिक शिक्षा एवं प्रशिक्षण संस्थान द्वारा संकलित यह 'विद्यार्थी सहायक सामाग्री' इसी दिशा में एक आवश्यक कदम है । यह सहायक सामग्री कक्षा 9 से 12 के विद्यार्थियों के लिए सभी महत्वपूर्ण विषयों पर तैयार की गयी है । केन्द्रीय विद्यालय संगठन की 'विद्यार्थी सहायक सामग्री' अपनी गुणवत्ता एवं परीक्षा संबंधी सामाग्री-संकलन की विशेषज्ञता के लिए जानी जाती है और अन्य शिक्षण संस्थान भी इसका उपयोग परीक्षा संबंधी पठन सामग्री की तरह करते रहे हैं । शुभ-आशा एवं विश्वास है कि यह सहायक सामग्री विद्यार्थियों की सहयोगी बनकर सतत मार्गदर्शन करते हुए उन्हें सफलता के लक्ष्य तक पहुंचाएगी ।

शुभाकांक्षा सहित ।

निधि पांडे
आयुक्त, केन्द्रीय विद्यालय संगठन

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CLASS XII BIOLOGY

INDEX

CLASS XII
(2024-25)
(THEORY)

Time: 03 Hours **Max. Marks: 70**

Unit	Title	Marks
VI	Reproduction	**16**
VII	Genetics and Evolution	**20**
VIII	Biology and Human Welfare	**12**
IX	Biotechnology and its Applications	**12**
X	Ecology and Environment	**10**
	Total	**70**

UNIT-VI REPRODUCTION

Chapter-2: Sexual Reproduction in Flowering Plants

Flower structure; development of male and female gametophytes; pollination - types, agencies and examples; out breeding devices; pollen-pistil interaction; double fertilization; post fertilization events - development of endosperm and embryo, development of seed and formation of fruit; special modes- apomixis, parthenocarpy, polyembryony; Significance of seed dispersal and fruit formation.

Chapter-3: Human Reproduction

Male and female reproductive systems; microscopic anatomy of testis and ovary; gametogenesis -spermatogenesis and oogenesis; menstrual cycle; fertilization, embryo development up to blastocyst formation, implantation; pregnancy and placenta formation (elementary idea); parturition (elementary idea); lactation (elementary idea).

Chapter-4: Reproductive Health

Need for reproductive health and prevention of Sexually Transmitted Diseases (STDs); birth control - need and methods, contraception and medical termination of pregnancy (MTP); amniocentesis; infertility and assisted reproductive technologies - IVF, ZIFT, GIFT (elementary idea for general awareness).

UNIT-VII GENETICS AND EVOLUTION

Chapter-5: Heredity and variation: Mendelian inheritance; deviations from Mendelism – incomplete dominance, co-

dominance, multiple alleles and inheritance of blood groups, pleiotropy; elementary idea of polygenic inheritance; chromosome theory of inheritance; chromosomes and genes; Sex determination - in humans, birds and honey bee; linkage and crossing over; sex linked inheritance - haemophilia, color blindness; Mendelian disorders in humans - thalassemia; chromosomal disorders in humans; Down's syndrome, Turner's and Klinefelter's syndromes.

Chapter-6: Molecular Basis of Inheritance

Search for genetic material and DNA as genetic material; Structure of DNA and RNA; DNA packaging; DNA replication; Central Dogma; transcription, genetic code, translation; gene expression and regulation - lac operon; Genome, Human and rice genome projects; DNA fingerprinting.

Chapter-7: Evolution

Origin of life; biological evolution and evidences for biological evolution (paleontology, comparative anatomy, embryology and molecular evidences); Darwin's contribution, modern synthetic theory of evolution; mechanism of evolution - variation (mutation and recombination) and natural selection with examples, types of natural selection; Gene flow and genetic drift; Hardy- Weinberg's principle; adaptive radiation; human evolution.

UNIT-VIII: BIOLOGY AND HUMAN WELFARE

Chapter-8: Human Health and Diseases

Pathogens; parasites causing human diseases (malaria, dengue, chikungunya, filariasis, ascariasis, typhoid, pneumonia, common cold, amoebiasis, ring worm) and their control; Basic concepts of immunology - vaccines; cancer, HIV and AIDS; Adolescence –drug and alcohol abuse.

Chapter-10: Microbes in Human Welfare

Microbes in food processing, industrial production, sewage treatment, energy generation and microbes as bio-control agents and biofertilizers. Antibiotics; production and judicious use.

UNIT-IX BIOTECHNOLOGY AND ITS APPLICATIONS

Chapter-11: Biotechnology - Principles and Processes

Genetic Engineering (Recombinant DNA Technology).

Chapter-12: Biotechnology and its Applications

Application of biotechnology in health and agriculture: Human insulin and vaccine production, stem cell technology, gene therapy; genetically modified organisms - Bt crops; transgenic animals; biosafety issues, biopiracy and patents.

UNIT-X ECOLOGY AND ENVIRONMENT

Chapter-13: Organisms and Populations

Population interactions - mutualism, competition, predation, parasitism; population attributes - growth, birth rate and death rate, age distribution. (Topics excluded: Organism and its Environment, Major Abiotic Factors, Responses to Abiotic Factors, Adaptations)

Chapter-14: Ecosystem

Ecosystems: Patterns, components; productivity and decomposition; energy flow; pyramids ofnumber, biomass, energy (Topics excluded: Ecological Succession and Nutrient Cycles)

Chapter-15: Biodiversity and its Conservation

Biodiversity-Concept, patterns, importance; loss of biodiversity; biodiversity conservation; hotspots, endangered organisms, extinction, Red Data Book, Sacred Groves, biosphere reserves, national parks, wildlife, sanctuaries and Ramsar sites.

Prescribed Books:

1. Biology, Class-XII, Published by NCERT
2. Other related books and manuals brought out by NCERT (consider multimedia also)
3. Biology Supplementary Material (Revised). Available on CBSE website.
4. **Question Paper Design (Theory) 2024-25**

Class XII Biology (044)

Competencies	
Demonstrate Knowledge and Understanding	50%

Application of Knowledge / Concepts	30%
Analyse, Evaluate and Create	20%
	100

Note:

- Typology of questions: VSA including MCQs, Assertion – Reasoning

  type questions; SA; LA-I; LA-II; Source-based/ Case-based/Passage-based/ Integrated assessment questions.

- An internal choice of approximately 33% would be provided.

Suggestive verbs for various competencies

- **Demonstrate, Knowledge and Understanding**

  State, name, list, identify, define, suggest, describe, outline, summarize, etc.

- **Application of Knowledge/Concepts**

  Calculate, illustrate, show, adapt, explain, distinguish, etc.

- **Analyze, Evaluate and Create**

  Interpret, analyze, compare, contrast, examine, evaluate, discuss, construct,etc.

UNIT VI

Reproduction

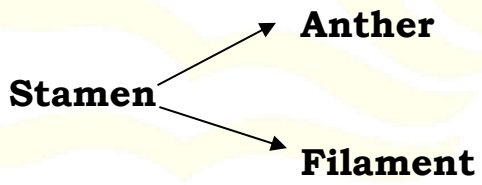
Chapter 2
Sexual Reproduction in flowering Plants

Chapter 3
Human Reproduction

Chapter 4
Reproductive Health

CHAPTER-2 REPRODUCTION IN FLOWERING PLANTS

STAMEN, MICROSPORANGIUM AND POLLEN GRAIN-



In majority of Angiosperms anther- bilobed and dithecous

MICROSPORANGIUM

Each anther contains four microsporangia. Microsporangia further develops into pollen sacs.

Microsporangium is surrounded by four walls-

1.Epidermis- protects and help in dehiscence of anther.
2. Endothecium- protects and help in dehiscence of anther.
3. Middle layers (2 in number)- protects and help in dehiscence of anther.
4. Tapetum- nourishes the developing pollen grain.

Young anther contains compactly arranged homogenous cells called sporogenous tissue.

MICROSPOROGENESIS

Meiotic division occurs in Sporogenous tissue to form microspore tetrads.

When the anther matures and dehydrates, the microspore dissociates from each other and develop into pollen grains.

The pollen grains represent the male gametophytes.

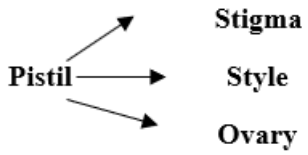
STRUCTURE OF POLLEN GRAIN

Pollen grains possess two layered Wall,

1. **Exine** - Made of sporopollenin- most resistant organic material known, withstand in high temperature, strong acid and alkali.
2. **Intine**- -Thin and continuous layer made of cellulose and pectin.

Mature pollen grain consists of a vegetative cell and generative cell.

PISTIL, MEGASPORANGIUM (OVULE) AND EMBRYO SAC



The gynoecium is the female reproductive part of the flower.
Single pistil – monocarpellary
More than one pistil - multicarpellary.
Fused pistil – syncarpous Free pistil –apocarpous.

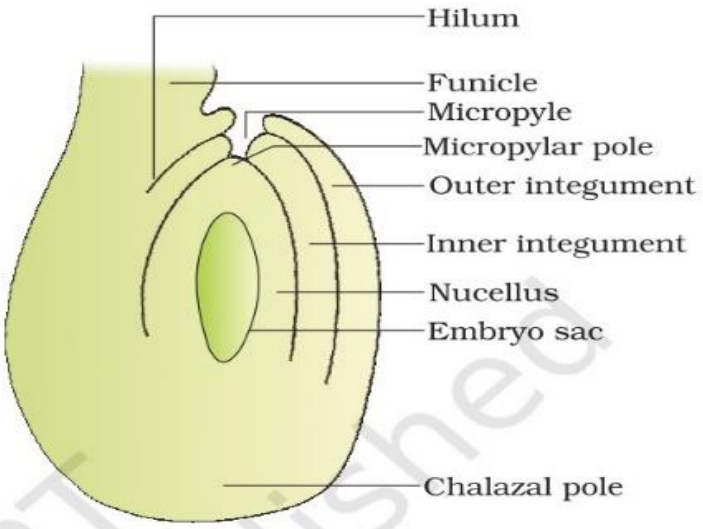
MEGASPORANGIUM (OVULE)

Inside ovary ovarian cavity **(**locule) is present. The placenta is located inside the ovarian cavity. Ovules (Megasporangium) arises from placenta.

Plant	Number of ovules in an ovary
Wheat	one
Paddy	one
Mango	one
Papaya	many
Water melon	many
Orchids	many

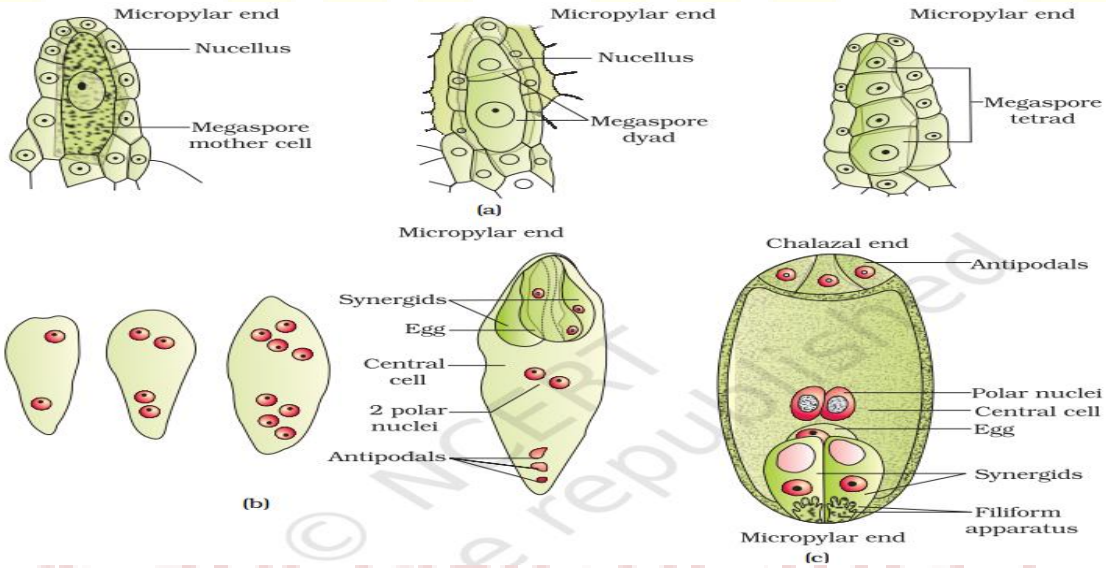
Stalk of ovule- **Funicle**
Region where ovule fuses with funicle- **Hilum**
Protective envelope of Ovule-**Integuments**
Nucellus a mass of cells is covered by integuments except at an

opening called **Micropyle**. Opposite end of micropyle is called **Chalazal end.**Nucellus have abundant reserve food materials.



MEGASPOROGENESIS

Process of formation of megaspores from megaspore mother cells is called megasporogenesis**.**



FEMALE GAMETOPHYTE (EMBRYO SAC):

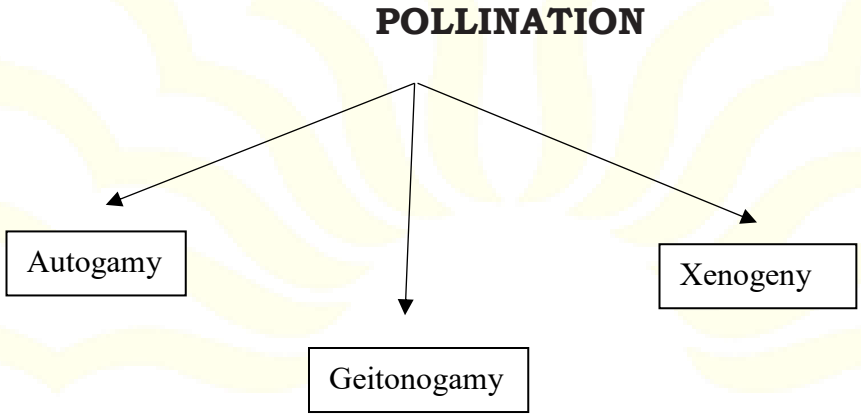
Monosporic development- When only one functional megaspore develops into the female gametophyte (embryo sac) while other three degenerate.

Nucleus of functional megaspore divides mitotically to form 2 nuclei which move to opposite poles forming 2- nucleate embryo sacs. Two

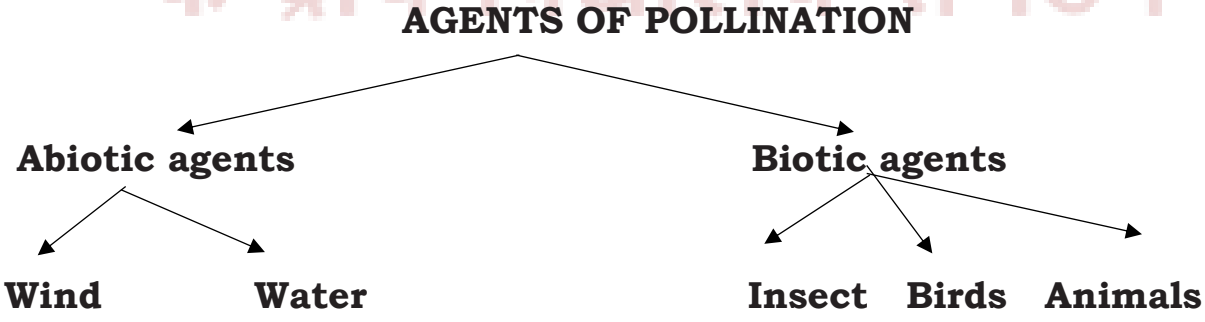
more mitotic nuclear division results in 4-nucleate and later 8-nucleate stages of embryo sac.
A mature embryo sac is seven celled eight nucleate, It consists of an egg apparatus having two synergids and one egg cell.
Synergids have special cellular thickenings called filiform apparatus, which play an important role in
guiding the pollen tubes into the synergid.
Three cells present at the chalazal end are called the antipodals. The large central cell contains two polar nuclei.

POLLINATION:

The transfer of pollen grains from anther to stigma of a pistil is called pollination.



Autogamy- Transfer of pollen grains from the anther to the stigma of the same flower.
Geitonogamy -Transfer of pollen grains from the anther to the stigma of another flower of the same plant.
Xenogamy- Transfer of pollen grains from the anther to the stigma of a different plant.



Adaptation of Wind Pollinated Flowers

•Pollen grains are light, non-sticky/ dry, sometimes winged.
•Well exposed anther.
•Large feathery stigma.
•Flowers arranged as inflorescence.
•Single ovules.

Adaptation of Water Pollinated Flowers

•Seen in submerged flowers like Vallisneria and Hydrilla and Zostera.
•In Vallisneria male flowers released on water surface and female flowers reaches the surface for pollination.
•In sea grasses, pollen grains are long ribbon like and carried passively to submerged female flowers.
•Mucilage coated pollen grains.

Adaptation in Insect Pollinated Flowers

•Large
•Brightly coloured and showy.
•If flowers are small, grouped into inflorescence.
•Highly fragrant
•Produce nectar
•Sticky pollen and stigmatic surface
•Provide rewards to animal pollinator such as nectar, food (pollen) or provide safe place for laying eggs.

OUTBREEDING DEVICES:

Continued self-pollination results in Inbreeding Depression

Methods to promote cross pollination & avoid self-pollination

1.Pollen release and stigma receptivity are not synchronised.
2.Stigma and anther – placed at different positions in a flower
3. Self-incompatibility
4. Production of unisexual flowers

POLLEN-PISTIL INTERACTION:

Pistil recognises the pollen, as right type (compatible) or of the wrong type (incompatible).If it is of the right type pollination is allowed if wrong, then rejects it.

ARTIFICIAL HYBRIDISATION:

It helps in crossing of plants for desired characters.

EMASCULATION- Removal of anthers from the flower bud before the anther dehisces.

BAGGING- Emasculated flowers covered to avoid contamination. When Emasculated flower get mature it is dusted with desired pollens & rebadged.

DOUBLE FERTILISATION:

SYNGAMY: Fusion of one male gamete and egg leads to formation of zygote.

TRIPLE FUSION: The other male gamete fuses with the two polar nuclei and results in the formation of Primary endosperm nucleus (PEN).

Since two types of fusions, syngamy and triple fusion takes place the phenomenon is termed as double fertilisation.

Primary Endosperm Cell (PEC) ⟶ Endosperm

Zygote ⟶ Embryo.

POST-FERTILISATION: STRUCTURES AND EVENTS

ENDOSPERM- Endosperm provides nutrition to the developing embryo.

Two types of endosperm development:

(i) Free nuclear type

(ii) Cellular type

Coconut water- free-nuclear endosperm

White kernel- cellular endosperm.

Non-Albuminous or Non-Endospermic seeds- endosperm completely utilised- before maturation of seeds. E.g., pea

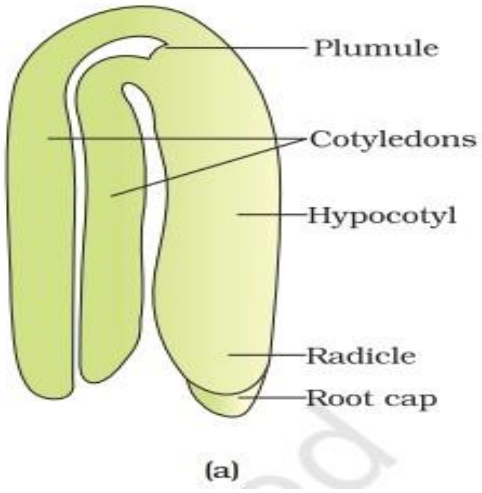
Albuminous or Endospermic seeds- a portion of endosperm remain in mature seeds. E.g.: castor

EMBRYO-

Development of embryo is called embryogeny.

a. DICOTYLEDONS EMBRYO

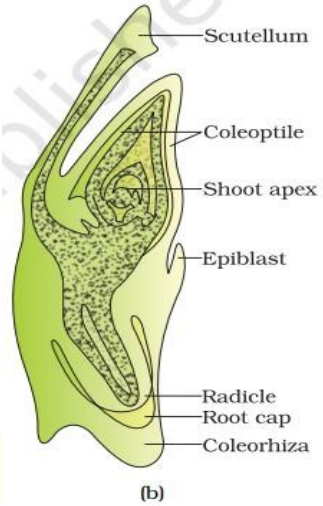
Dicotyledonous embryo possesses two cotyledons. In dicotyledons plants the zygote gives rise to the pre-embryo and subsequently to the globular, heart-shaped and mature embryo.



embryonal axis consists of epicotyl, plumes, hypocotyl and radicle. The root tip is covered with a root cap.

b. MONOCOTYLEDON- EMBRYO

Monocotyledons embryos possess only one cotyledon.
The cotyledon is called scutellum that is situated towards one side (lateral) of the embryonal axis. Embryonal axis consists of radicle root cap is covered with the coleorhiza epicotyl and a few leaf primordia enclosed in coleoptile.



SEEDS

Non-albuminous seeds - No residual endosperm e.g. pea, groundnut.
Albuminous Seeds-Retain a part of endosperm e.g., wheat, maize, barley, castor.
Perisperm- This residual, persistent nucellus is perisperm.

FRUITS

TRUE FRUIT

When fruits develop from ovary

FALSE FRUITS

When thalamus or other part also forms fruit.

PARTHENOCARPIC FRUIT

Fruit develops without fertilisation

APOMIXIS – Asexual reproduction mimics sexual reproduction
Apomictic seeds are formed when-
• Diploid cell develops into embryo without fertilisation
• Cells of nucellus (2n) surrounding embryo sac- protrude into embryo sac- develop into embryos. Eg. Citrus and mango

POLYEMBRYONY- Presence of more than one embryo in a seed Eg. Citrus

QUESTIONS AND ANSWER

VERY SHORT ANSWER (2 marks)

1. 

   Observe the diagram carefully name the process and explain why it is required.

   Ans. Emasculation. The removal of anthers is required for crop breeding programmes so that the pollination can be done with the desired pollen only.

2. A microsporangium has 200 microspore mother cells. How many male gametes will be produced by it?

   Ans. no of pollen grains produced by the 200 mmc

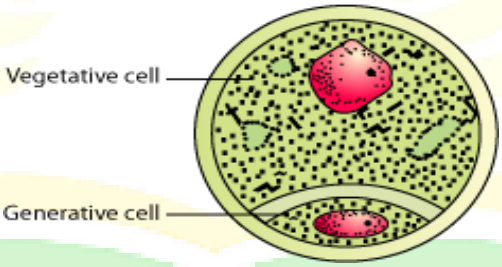
   200x 4= 800 pollen grains

   Each pollen grain carries two male gametes

   800x 2=1600 male gametes

3. Draw the diagram of male gametophyte.

   Ans.



4. How flowers prevent self-pollination? Explain with the help of any two strategies develop by them.

   Ans. Two strategies evolved lay flowers to prevent self-pollination

   i) Pollen release & stigma receptivity – not synchronised

   (ii) Stigma and anther – placed at different positions

   (iii) Self-incompatibility

   (iv) Production of unisexual flowers (any two)

5. A single pea plant in your kitchen garden produces pods with viable seeds, but the individual papaya plant does not. Explain.

Ans. Pea- flowers of pea plants are bisexual, monoecious / self-pollinated (to produce pods with viable seeds)

SHORT ANSWER (3 marks)

1. 

You can see the honeybee visiting flower in the given picture. Is its visit important for the flower? Give any three characteristics of the flower whom it is visiting.

Ans. Yes, honeybee's visit helps in the pollination of the flower. This is an insect pollinated flower with following characteristic features.

- Large
- Brightly coloured.
- If flowers are small, grouped into inflorescence.
- High fragrance
- Produce nectar
- Sticky pollen and stigmatic surface
- Provide rewards to animal pollinator such as nectar, food (pollen) or provide safe place for laying eggs.

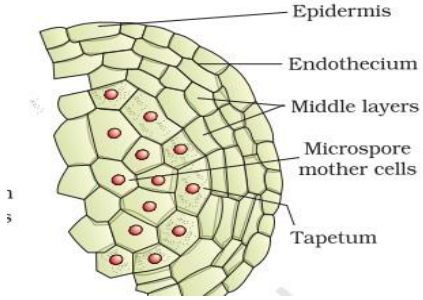
2. Write one differences and one similarity between autogamy and geitonogamy with one example of each.

Ans.

Autogamy	Geitonogamy
1. It is transfer of pollen grains from anther to stigma of the same flower	1. It is transfer of pollen grains from the anther to the stigma of another flower of same plant.
2. e.g., pea, rice, wheat, etc.	2. e.g., Cucurbita.

Genetically both are similar.

3. Draw a well labelled diagram of T.S of anther. Give the importance of tapetum.



Ans. The innermost wall layer is the tapetum. It nourishes the developing pollen grains.

LONG ANSWER (5 marks)

1.Seema was observing T.S of ovary of *Hibiscus*. Her teacher told her that this ovule has an embryo sac which contains eight nucleus and seven cells. Can you help her to explain this process?

Ans.

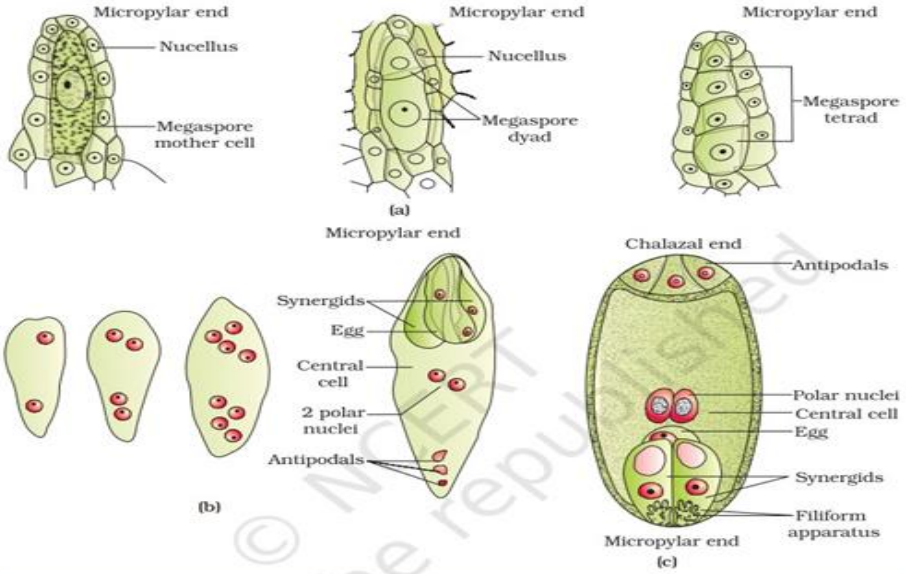


Figure 2.8 (a) Parts of the ovule showing a large megaspore mother cell, a dyad and a tetrad of megaspores; (b) 2, 4, and 8-nucleate stages of embryo sac and a mature embryo sac; (c) A diagrammatic representation of the mature embryo sac.

2.Describe the stages in embryo development in a dicot plant with the help of diagram.

Ans. The embryo develops at the micropylar end where the zygote is located. The zygote starts developing only after certain amount of endosperm is formed to assure nutrition to the embryo. The zygote divides mitotically to form various stages including pro- embryo, globular, heart shaped and finally the mature embryo.

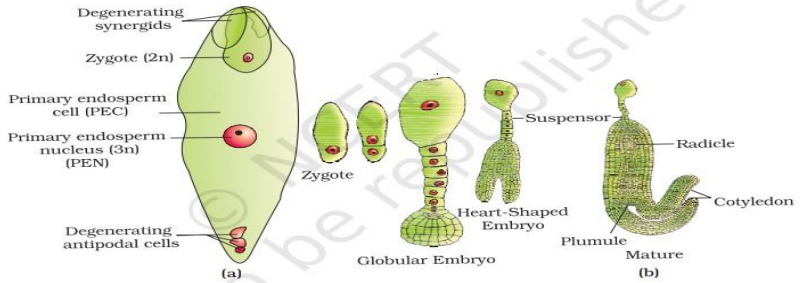


Figure 2.13 (a) Fertilised embryo sac showing zygote and Primary Endosperm Nucleus (PEN); (b) Stages in embryo development in a dicot [shown in reduced size as compared to (a)]

3.Is there any difference between apomixes and parthenocarpy? Explain the benefits of each.

Ans. Yes, parthenocarpy is different from apomixes. In parthenocarpy, the fruit is produced without the fertilization. It is used for the production of fruits without seeds such as banana and grapes for commercial purposes. Apomixes is the process in which the seeds are produced without fertilization. In this, the megaspore mother cell does not undergo meiosis. It is used for the commercial production of hybrid varieties and in the production of virus-free varieties.

MCQ

1. The flowers having large often-feathery stigma to easily trap air-borne pollen grains are found in
   a. Wind pollinated flowers
   b. Water pollinated flowers
   c. Insect pollinated flowers
   d. Bird pollinated flowers
   Ans. Wind pollinated flowers
2. Before fertilization, nuclei of a particular cell fuse and form a diploid nucleus. The cell is----------.
   (a) Antipodal cell
   (b) Central cell
   (c) Egg cell
   (d) Synergid cell
   Ans. Central cell
3. How many meiotic divisions would be required for a plant that undergoes monosporic development to give rise to 200 functional eggs?
   A.50
   B.200
   C.800
   D.400
   Ans. 200
4. Exine of pollen is made up of
   (a) Pectocellulose
   (b) Lignocellulose
   (c) Sporopollenin
   (d) Pollen kit
   Ans. Sporopollenin

5. Filiform apparatus occurs in
   (a) Synergids
   (b) Antipodals
   (c) Egg nucleus
   (d) Secondary nucleus
   Ans. Synergids

CASE BASED QUESTIONS

Pollen viability is the capability of pollen to get mature and then fertilize and after fertilization, it's the ability to develop into seed and fruit. Male gametophytes are pollen grains. They're made within microsporangia in anthers and discharged when the anther dehisces.

1. Write the factors Pollen viability is dependent upon.
   Ans. Temperature & humidity
2. Mention any two families whose pollens are viable for months.
   Ans. Rosaceae, Leguminosae and Solanaceae.
3. How pollen grains are stored for longer period?
   Ans. Pollen grains are stored in liquid nitrogen (-196^{0}C).
4. Storage of pollen grains for longer periods is of any importance yes or no. Give reason in support of your answer.
   Ans. Yes, stored pollen grains can be used in future in pollen banks for crop breeding programmes.

ASSERTION AND REASON

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false, but R is true.

1. Assertion (A): Entomophiles plants produce less pollen when compared to anemophilous plants.

Reason (R): The wastage of pollen is reduced to the minimum in entomophilous plants because of the directional pollination.
Ans. b

2. Assertion: In monosporic type of embryo development megaspore is situated towards the micropylar end and remains functional.
   Reason: In monosporic development the embryo sac develops from a single functional megaspore.

Ans. d

3. Assertion: 7-celled, 8 nucleate embryo sac is developed from monosporic development.
   Reason: Out of four megaspores only one remains functional and will give rise to embryo sac

Ans. a

4. Assertion: antipodal cells and egg cell are haploid in nature
   Reason: Both are formed from functional megaspore through meiotic division

Ans. a

5. Assertion: Cotyledon of the maize embryo is known as scutellum
   Reason: Scutellum is situated towards one side of embryonal axis

Ans. b

CHAPTER-3

HUMAN REPRODUCTION

MALE REPRODUCTIVE SYSTEM

- Male reproductive system consists of a pair of testes along with accessory ducts, glands and the external genitalia.
- Testes are situated outside the abdominal cavity within a pouch called scrotum which maintains 2^0 to 2.5^0 c lower temperature.
- The male sex accessory ducts include rete testis, vasa efferentia, epididymis and vas deferens
- The male accessory glands include paired seminal vesicles, a prostate and paired bulbourethral glands.
- Secretions of these glands form seminal plasma which is rich in fructose, calcium and certain enzymes. The secretions of bulbourethral glands also help in the lubrication of the penis.

THE FEMALE REPRODUCTIVE SYSTEM

- The female reproductive system consists of a pair of ovaries along with a pair of oviducts, uterus, cervix, vagina and the external genitalia.

- Ovaries are the primary female sex organs that produce the female gamete (ovum) and several steroid hormones (ovarian hormones).
- The oviducts (fallopian tubes), uterus and vagina constitute the female accessory ducts.
- The uterus opens into vagina through a narrow cervix. The cavity of the cervix is called cervical canal which along with vagina forms the birth canal.

GAMETOGENESIS

Spermatogenesis

- The process of formation of sperms from spermatogonia is called spermatogenesis.

Spermatogonia(2n)

↓

Primary spermatocytes(2n)

↓

Secondary spermatocytes(n)

↓

Spermatids(n)

↓

Spermatozoa(n)

Oogenesis

- The process of formation of egg from oogonia is called oogenesis

Oogonia(2n)

↓

Primary oocyte (2n)

↓

Secondary oocyte (n)

↓

egg (n)

MENSTRUAL CYCLE- In human females, menstruation is repeated at an average interval of about 28/29 days, and the cycle of events starting from one menstruation till the next one is called the menstrual cycle.

1. Menstrual Phase: Occurrence of menstrual flow which lasts for 3-5 days due to breakdown of endometrial lining of the uterus.
2. Follicular Phase: Due to increase in FSH & LH follicular development & estrogen production took place.
3. Ovulation/Ovulatory Phase: Rapid secretion of LH leads to ovulation due to rupture of Graffian follicle.
4. Luteal Phase: production of progesterone from corpus luteum for maintenance of endometrium.

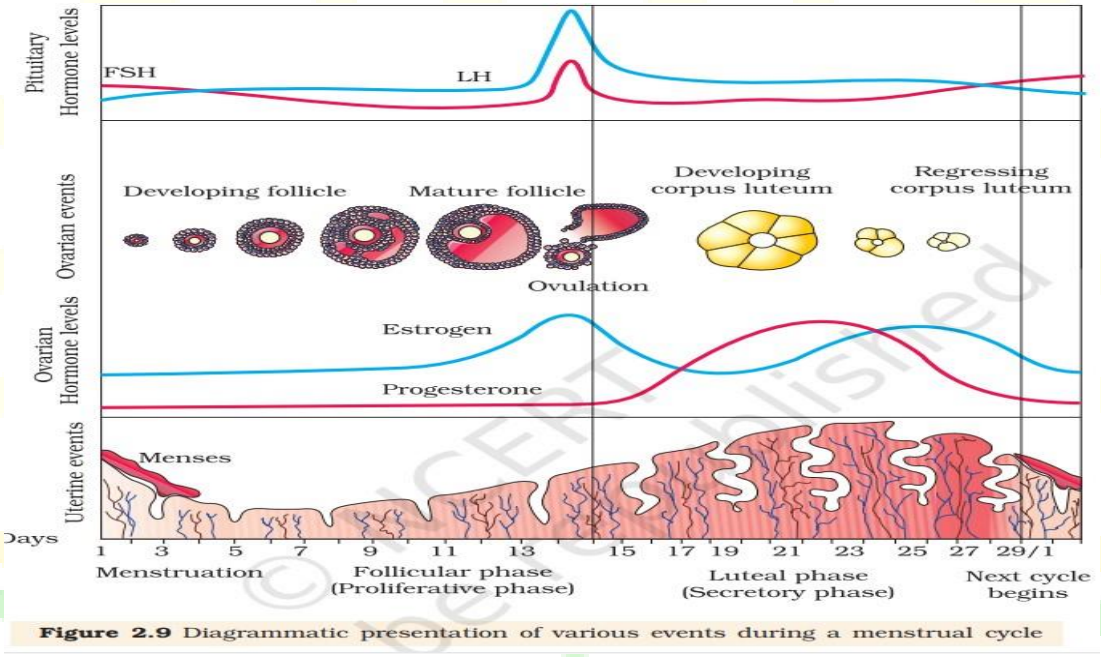


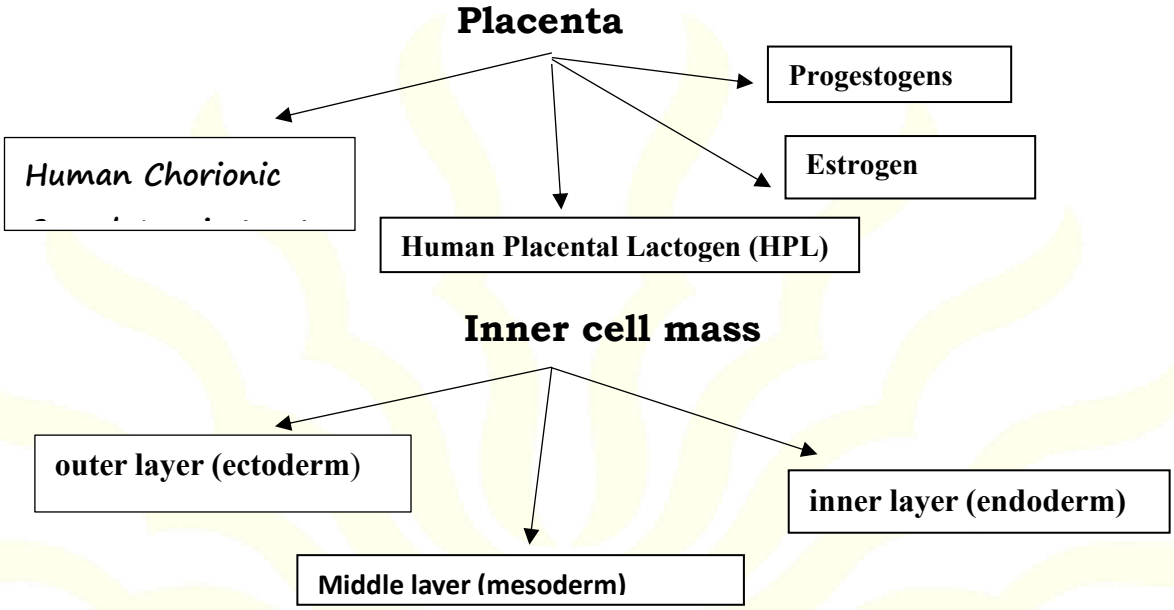
Figure 2.9 Diagrammatic presentation of various events during a menstrual cycle

FERTILISATION AND IMPLANTATION

- The process of fusion of a sperm with an ovum is called fertilisation.
- Cleavage occurs in zygote results in formation of 2, 4, 8, 16 daughter cells called blastomeres.
- At 8 to 16 stage morulae get implanted in uterus & develops into blastocyst.
- The blastomeres in the blastocyst are arranged into an outer layer called trophoblast and an inner group of cells attached to trophoblast called the inner cell mass.
- When blastocyst embedded into the uterus implantation took place.

PREGNANCY AND EMBRYONIC DEVELOPMENT

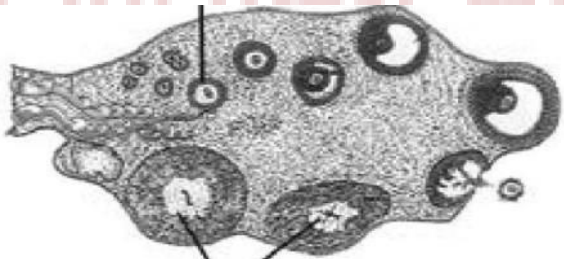
- The chorionic villi and uterine tissue become interdigitated each other and form placenta.
- The placenta is connected to the embryo through an umbilical cord.
- The transport of substances to and from the embryo took place through umbical cord.



PARTURITION AND LACTATION

- **Parturition**-the process of delivery of fully developed foetus is called parturition.
- Signals for parturition originate from the fully developed foetus
- Placenta inducing mild uterine contractions called **Foetal ejection reflex.**
- It triggers the release of oxytocin from maternal pituitary.
- Lactation occurs through mammary glands first mother's milk is called colostrum rich in antibodies.

CASE BASED QUESTION



i) Identify the structure and mention its function.
ii) Give the hormones formed by this structure.

iii) Write the role played by these hormones.

Or

Name the structures which form these hormones.

MCQ

1. The membranous cover of the ovum at ovulation is:
   a. Corona radiata
   b. Zona radiata
   c. Zona pellucida
   d. Chorion
   Ans. a, corona radiata
2. Which of the following hormones is secreted by human ovary?
   a. hCG
   b. FSH
   c. Progesterone
   d. LH
   Ans. b, FSH
3. Ovulation is induced a hormone called ----
   a. LH
   b. FSH
   c. hCG
   d. hPL
   Ans. a, LH
4. The spermatogonia undergo division to produce sperms by the process of spermatogenesis. Choose the correct one with reference to above.
   a. Spermatogonia have 46 chromosomes and always undergo meiotic cell division
   b. Primary spermatocytes divide by mitotic cell division
   c. Secondary spermatocytes have 23 chromosomes and undergo second meiotic division
   d. Spermatozoa are transformed into spermatids
   Ans. c, Secondary spermatocytes have 23 chromosomes and undergo second meiotic division
5. Name the gland which helps in lubrication of penis.
   a. Prostate
   b. Bulbourethral gland
   c. Seminal vesicle
   d. Leydig cells

   Ans. b, Bulbourethral gland

ASSERTION REASON

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false, but R is true.

1. Assertion: Myometrium is middle thick layer of smooth muscles
Reason: Myometrium undergoes strong contraction during delivery of baby
Ans. a

2. Assertion: LH acts on Leydig cells and stimulates them to secrete androgens.
Reason: Androgens stimulates spermatogenesis
Ans. b

3. Assertion: The signals for parturition originate from the fully developed foetus and the placenta
Reason: Oxytocin acts on the uterine muscle and causes stronger uterine Contractions
Ans. b

SHORT ANSWER (2 Marks)

1.Draw a diagram of T.S. of the part of seminiferous tubule of testis of an adult male and label any four parts in it.

Ans.

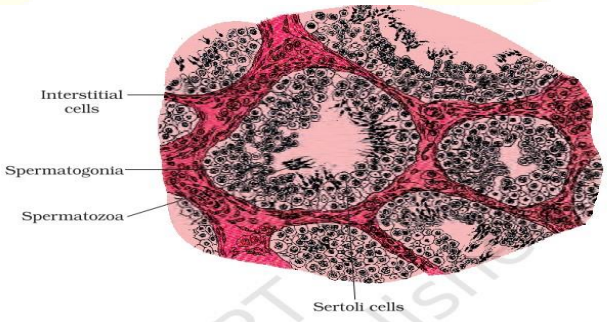


Figure 2.2 Diagrammatic sectional view of seminiferous tubule

2.What is the difference between a primary oocyte and a secondary oocyte?

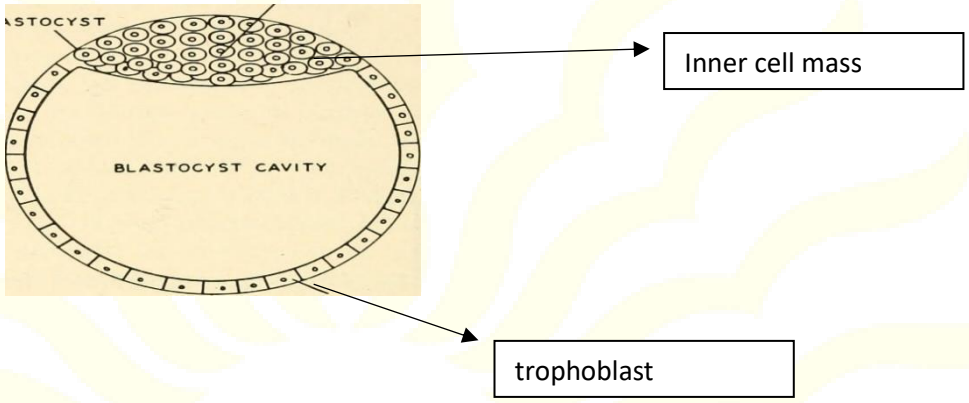
Ans.

primary oocyte	secondary oocyte
1. Primary oocyte is a diploid cell	1.secondary oocyte is a haploid cell
2.Oogonia undergoes mitosis and forms primary oocyte	2. primary oocyte undergoes meiosis I and forms secondary oocyte

3.Name the stage of human embryo at which it gets implanted. Explain the process of implantation

Ans. Blastocyst stage.
The trophoblast layer gets attached to the endometrium & the inner cell mass gets differentiated as the embryo. After attachment. the uterine cells divide rapidly and covers the blastocyst. As a result, the blastocyst become embedded in the endometrium of the uterus & known as implantation.

4.Draw a labelled diagram of the embryonic stage that gets implanted in the human uterus. Ans.



5.How does zona pellucida prevent entry of more than one sperm?

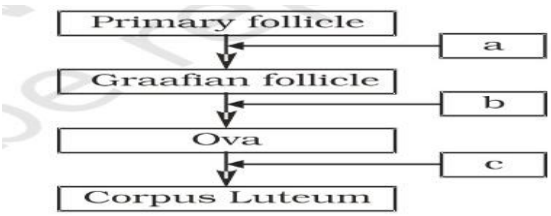
Ans. During fertilisation, a sperm comes in contact with the zona pellucida layer of the ovum and induces changes in the membrane that block the entry of additional sperms.

6.What is colostrum? Why is it recommended.

Ans. The milk produced during the initial few days of lactation is called colostrum which contains several antibodies absolutely essential to develop resistance for the new-born babies.

SHORT ANSWER (3 Marks)

1.Given below is a flow chart showing ovarian changes during menstrual cycle. Fill in the spaces giving the name of the hormones responsible for the events shown.



Ans. a- FSH & LH. b- LH & c- LH

2.a) In which part of the human female reproductive system do the following events take place.

I. Release of 1st polar body
II. Release of 2nd polar body
III. Fertilization
IV. Implantation

b) From where do the signals for parturition originate and what does maternal pituitary release for stimulating uterine contractions for childbirth.

Ans. a) I) Ovary II) In the isthmus- ampullary junction of fallopian tube III) Isthmus- ampullary junction of fallopian tube. IV) In the uterus

b) Fully developed foetus and placenta, oxytocin

3.The figure given below shows 3 sperms A, B and C.

a) Which one of the three sperms will gain entry into the ovum?

b) Describe the associated changes induced by it on P and Q.

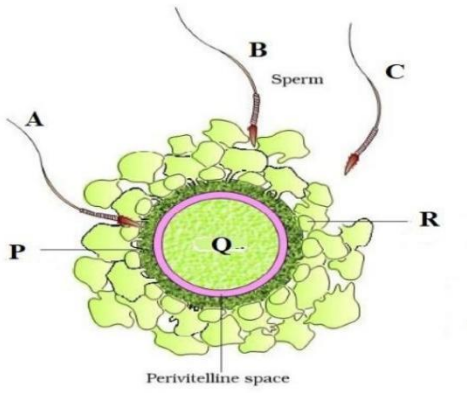


Figure Ovum surrounded by few sperms

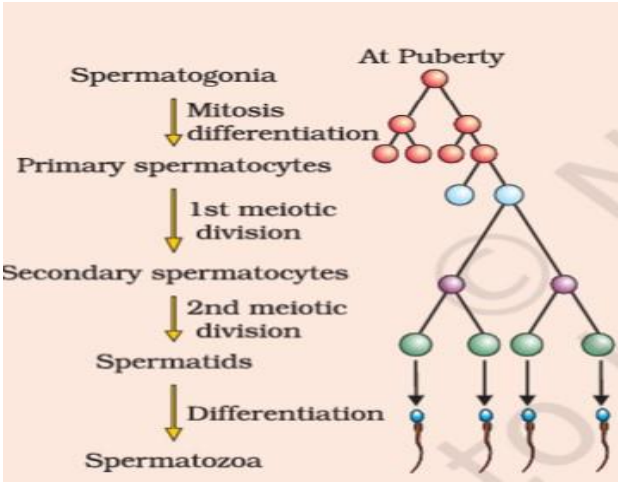
Ans.) Sperm A

b) In the figure given, Sperm 'A 'has come in contact with the zona pellucida layer (P) of the ovum (Q), it will induce changes in the membrane that will block the entry of additional sperms (B and c). Thus, it ensures that only one sperm can fertilise the ovum.

The secretions of the acrosome of sperm A will help it to enter into the cytoplasm of the ovum (Q) through the zona pellucid (P) and the plasma membrane, this will induce the completion of the meiotic division of the secondary oocyte (Q). The second meiotic division in Q being unequal will result in the formation of a second polar body and a haploid ovum. Then, the haploid nucleus of the sperm 'A' and that of the ovum (Q) will fuse together to form a diploid zygote.

LONG ANSWER (5 Marks)

1. a) Give a schematic representation of Spermatogenesis in humans.



b) At which stage of life does gametogenesis begin in human male and female respectively?

c) Name the organs where gametogenesis gets completed in human male and female respectively.

Ans a)

b) Spermatogenesis – puberty
Oogenesis - embryonic development stage

c) Males – Testes (Seminiferous tubule)
Female – Fallopian tube (Oviduct)

2.a) Explain the menstrual phase in a human female. State the levels of ovarian and pituitary hormones during this phase.

b) Why is follicular phase in the menstrual cycle also referred as proliferative phase? Explain.

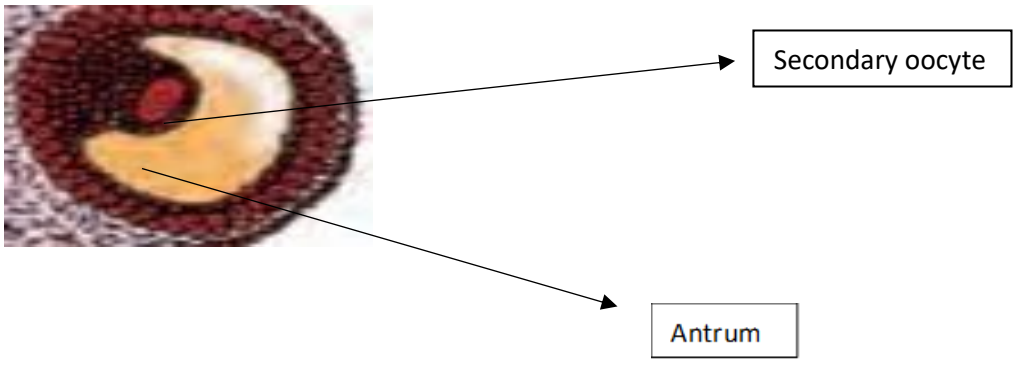
c) Explain the events that occur in a Graafian follicle at the time of ovulation and thereafter.

d) Draw a Graafian follicle and label antrum and secondary oocyte.

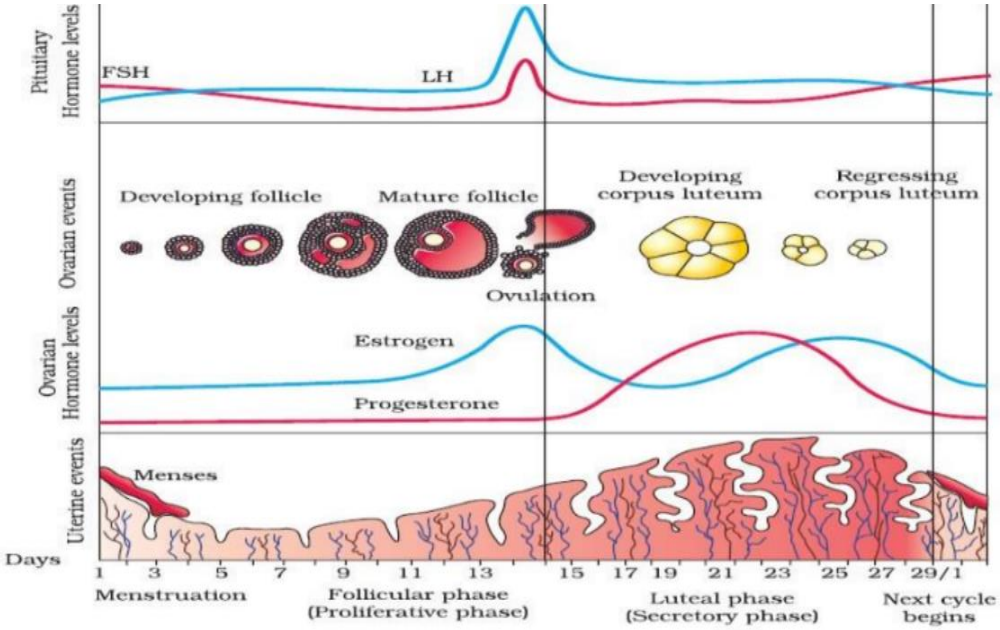
Ans. a) Menstrual phase occurs when released ovum not fertilised, breakdown of endometrial lining (of the uterus) and its blood vessel form the liquid that comes out through the vagina, lasts for 3 to 5 days Level of ovarian and pituitary hormones fall graphically represented

b) Primary follicle grows into Graafian follicle under the influence of & FSH, regeneration of endometrium (under the influence of estrogen)

c) Graafian follicle ruptures to release the ovum (secondary oocyte), remaining parts of the Graafian follicle transform into corpus luteum.



2. Observe the following diagram and answer the questions given below.



a) Why is follicular phase also known as proliferative phase?
b) What happens to corpus luteum if pregnancy does not occur?
c) What ovarian changes take place during luteal phase?
d) At what time of Menstrual cycle LH surge occurs?
e) What are the uterine changes that occur during menstrual phase?

Ans. a) The follicular phase in the menstrual cycle is also called proliferative phase because during this phase, the endometrium of uterus regenerates and becomes thick through proliferation. Simultaneously, the primary follicles in the ovary grow to become a fully mature Graafian follicle.

b) It will stop secreting progesterone and will degenerate.

c)In the luteal phase, the corpus luteum forms on the ovary and secretes many hormones, most significantly progesterone, which makes the endometrium of the uterus ready for implantation of an embryo

d)On the 14th day, LH levels reach its peak. This induces rupture of the Graafian follicle and release of the ovum (ovulation)

e) If a pregnancy doesn't happen, the uterine lining sheds during a Menstrual period.

CHAPTER-4
REPRODUCTIVE HEALTH

REPRODUCTIVE HEALTH- PROBLEMS AND STRATEGIES

Problems

1. Over Population
2. Early Marriage
3. Health of Mothers
4. Deformities
5. Maternal Mortality Rate (MMR) & Infant Mortality Rate (IMR)
6. Sexually Transmitted Diseases (STD's)
7. Career

Strategies-

1. family planning and RCH (Reproductive and Child Healthcare) programmes
2. Awareness about Reproduction
3. Sex Education
4. Knowledge of STDs
5. Birth control Devices and care of mother and child
6. Prevention of Sex Abuse and Sex Related Crimes
7. Information About Reproduction Related Problems
8. Medical Facilities
9. Amniocentesis

IDEAL CONTRACEPTIVE

- Easy to use
- Easily available
- Effective
- No have side effects
- Reversible
- No interfere with the sexual drive, desire or act of the individual

METHODS OF CONTRACEPTION

1. Natural or Traditional
2. Barrier Methods
3. Intra-uterine devices (IUDs)
4. Oral contraceptives
5. Injectable and implants
6. Surgical Methods

Natural Methods or Traditional methods

Works on the principle of avoiding the chances of sperm and egg meeting

- Periodic Abstinence

- Withdrawal or Coitus interruptus
- Lactational amenorrhea

Barrier Methods

In this method sperms and ovum are physically prevented from meeting with the help of barriers.

- Condoms
- Diaphragms, Cervical Caps and Vaults

Intra-Uterine Devices (IUDs)

These devices are inserted into the uterus by doctors or expert nurses through the vagina.

- Non-medicated IUDs like Lippes Loops increase phagocytosis of sperms
- Copper releasing IUDs like Copper-T, Copper-7, Multiload 375 decrease motility of sperms
- Hormone releasing IUDs like Progestasert, LNG-20 makes the uterus unsuitable for implantation. They also make the cervix hostile to sperms.

Oral Contraceptives

- Oral contraceptives are progestogens or progesterone-oestrogen combinations.
- They are used by females for a period of 21 days starting within the first five days of the menstrual cycle. After a gap of 7 days (during which menstruation occurs)
- Saheli are once a week non-steroidal pills with lesser side effects.
- Oral contraceptives inhibit ovulation and implantation by altering the quality of cervical mucus.

Injectable and implants

- Progesterone alone or in combination with estrogen can be used by females as injections or implants under the skin.

Surgical Methods

- Vasectomy: Vas deferens is tied up or removed through a small incision in the scrotum
- Tubectomy: A small part of the fallopian tube is tied up or removed through a small incision in the abdomen or the vagina.

MEDICAL TERMINATION OF PREGNANCY (MTP)

- Voluntary termination of pregnancy before full term is called medical termination of pregnancy (MTP) or induced abortion.
- Unwanted pregnancies can be terminated by this.

- MTPs can also be done when pregnancy could be harmful or even fatal either to the mother or to the foetus or both.

SEXUALLY TRANSMITTED DISEASES (STDS)

Diseases or infections of the reproductive tract which are transmitted through sexual activities and intercourse are called sexually transmitted diseases (STD) or venereal diseases (VD) or reproductive tract infections (RTI).

- Gonorrhoea- Bacteria
- Syphilis - Bacteria
- Chlamydiosis-Bacteria
- Genital herpes- Virus
- Genital warts- Virus
- Trichomoniasis- Protozoa
- Hepatitis-B- Virus
- AIDS – Virus

Steps to prevent STDs

- Avoid sex with unknown/multiple partners
- Always use condoms during coitus
- If in doubt, go to a qualified doctor for early detection and treatment for diseases.

INFERTILITY

- Infertility is the inability to produce children in spite of unprotected sexual co-habitation.
- Reasons could be physical, congenital, diseases, drugs, immunological or even psychological.

ASSISTED REPRODUCTIVE TECHNOLOGY (ART)

These are the applications of Reproductive Technologies to solve infertility problems. Some important techniques are as follows

In vitro fertilization:

- Fertilization outside the body in the laboratory.
- Condition created in laboratory similar to the body.

Embryo transfer:

- Popularly known as **test tube baby** programme.
- Ova from the wife/donor and sperm from the husband/donor are collected and induced to form zygote under simulated conditions in the laboratory.

ZIFT- Zygote intra fallopian transfer

- The zygote or early embryos (with up to 8 blastomeres) could be transferred into the fallopian tube.

IUT- Intra Uterine transfer

- Embryos with more than 8 blastomeres can be transferred directly into the uterus.

Gamete intra fallopian transfer- GIFT

- Transfer of ovum collected from the donor into the fallopian tube of another female who cannot produce it.
- Such female can provide suitable environment for fertilization and development.

Intra cytoplasmic sperm injection (ICSI):

- The sperm is directly injected into the ovum.

Artificial insemination (AI)

- Semen is collected either from the husband or donor is artificially introduced into vagina or into the uterus (**IUI-intra uterine insemination**) of the female.

CASE BASED QUESTION

A couple just married do not want a child and focus on their respective careers. They want to use a contraception method for 3- 4 years. The female partner has an allergy with physical barriers. She doesn't want to use oral contraceptives.

1. Suggest a contraceptive method which suits their requirement.
2. Mention different types of such devices available.

   or

   Write two examples of each type.
3. Is there any method to avoid pregnancy after unprotected coitus in emergency? Yes, or no, Justify your answer.

1. Couple should go for IUDs. These devices are inserted by doctors or expert nurses in the uterus through vagina.
2. Non-medicated IUDs, Copper releasing IUDs and Hormone releasing IUDs

   or

   Non-medicated IUDs eg. Lippes's loop
   Copper releasing IUDs eg. CuT, Cu7, Multiload 375
   Hormone releasing IUDs eg. Progestasert, LNG-20
3. Yes, Administration of progestogens or progestogen-estrogen combinations or IUDs within 72 hours of coitus have been found to be very effective as emergency contraceptives.

ASSERTION & REASON

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false, but R is true.

1.Assertion: Vasectomy blocks gamete transport and thereby prevent conception.
Reason: In vasectomy, a small part of the vas deferens is removed or tied up.
Ans. a

2.Assertion: In India there is statutory ban on amniocentesis.
Reason: Amniocentesis is used for sex-determination & resulting in increased female foeticide.
Ans. a

3.Assertion: Infections transmitted through sexual intercourse are called Sexually Transmitted Diseases.
Reason: AIDS is a Sexually Transmitted Disease
Ans. b

MCQ

1. The birth control device not common among women is
   (a) Diaphragm
   (b) Oral pill
   (c) Condom
   (d) Copper – T
   Ans. C
2. The method of directly injecting a sperm into ovum in Assisted Reproductive Technology is called
   (a) GIFT
   (b) ZIFT
   (c) ICSI
   (d) ET
   Ans. C
3. Non reversible technique of contraception.
   (a) Diaphragm
   (b) Condom

(c) IUDs
(d) Tubectomy
Ans. d

4. Intensely lactating mothers don't generally conceive due to the
(a) suppression of gonadotropins
(b) hyper secretion of gonadotropins
(c) suppression of gametic transport
(d) suppression of fertilisation
Ans. a

5. The most important component of oral contraceptive pill is
(a) Progesterone
(b) FSH
(c) LH
(d) Thyroxine
Ans. a

SHORT ANSWER (2 Marks)

1.STDs can be considered as self-invited diseases. Comment
Ans. STDs can be considered as self-invited diseases because the can be avoided by following simple practices
(i) Avoid sex with unknown partners/multiple partners.
(ii) Always use condoms during coitus.
(iii) In case of doubt, one should go to a qualified doctor for early detection and get complete treatment if diagnosed with disease.

2.What is the significance of progesterone-estrogen combination as a contraceptive measure?
Ans. They inhibit ovulation and implantation as well as alter the quality of cervical mucus to prevent/ retard entry of sperms.

3. Lactational amenorrhea is a contraceptive method. List two advantages.
- Ans. During lactational amenorrhea no ovulation and therefore no chances of conception.
- Side effects are almost nil.

4.Write any four characteristics of ideal contraceptives.
Ans. User friendly, easily available, effective, reversible with no side effects, noninterfering.

5.Defines and illustrates the processes of tubectomy and vasectomy

Ans. Tubectomy and Vasectomy are the surgical methods to prevent any more pregnancies. Sterilisation procedure in the male is called

'vasectomy' and that in the female, 'tubectomy'. In vasectomy, a small part of the vas deferens is removed or tied up through a small incision on the scrotum whereas in tubectomy, a small part of the fallopian tube is removed or tied up through a small incision in the abdomen or through vagina.

SHORT ANSWER (3 Marks)

1.Mention any three ways by which awareness about significance of reproductively healthy society be developed.
Ans: i. Awareness of problem due to population explosion, social evil like sex abuse etc.
ii. Legal checking of female foeticides by banning amniocentesis
iii. Educating people about birth control and other sex related aspects.
iv. Providing facility for reproductive help
v. Creating awareness among people by introduction of sex education in school. (any three)
2.Describes the different kinds of natural contraceptive methods.
Ans. **Periodic abstinence** -The Coitus is avoided from day 10 to 17 (fertile period) of the menstrual cycle. & conception could be prevented.
Withdrawal or coitus interruptus – In this method the male partner withdraws his penis from the vagina just before ejaculation so as to avoid insemination.
Lactational amenorrhea (absence of menstruation)- In this method due to intense lactation following parturition. Chances of conception are almost nil. However, this method has been reported to be effective only upto a maximum period of six months following parturition.
3.List the advantages of using 'Saheli' as a contraceptive.
Ans. Nonsteroidal
Once a week
High contraceptive value
Less side effects

LONG ANSWER (5 Marks)

1.What is infertility? Describe the different assisted reproductive technologies which can help an infertile couple.
Ans. Infertility is the condition when a couple is unable to produce children in spite of unprotected sexual co-habitation.
In vitro fertilization:
Fertilization outside the body in the laboratory.

Embryo transfer:
Ova from the wife/donor and sperm from the husband/donor are collected and induced to form zygote under simulated conditions in the laboratory.

ZIFT- Zygote intra fallopian transfer The zygote or early embryos (with upto 8 blastomeres) could be transferred into the fallopian tube.

IUT- Intra Uterine transfer
Embryos with more than 8 blastomeres can be transferred directly into the uterus.

Gamete intra fallopian transfer- GIFT
Transfer of ovum collected from the donor into the fallopian tube of another female who cannot produce it.

Intra cytoplasmic sperm injection (ICSI):
The sperm is directly injected into the ovum.

Artificial insemination (AI)
Semen is collected either from the husband or donor is artificially introduced into vagina or into the uterus (**IUI-intra uterine insemination**) of the female.

2.Defines MTP. Explain the Indian laws about Medical Termination of Pregnancy (MTP).

Ans. Intentional or voluntary termination of pregnancy before full term is called medical termination of pregnancy (MTP). MTPs are considered relatively safe during the first trimester, i.e., upto 12 weeks of pregnancy. Second trimester abortions are much riskier.

The Medical Termination of Pregnancy (Amendment) Act, 2017 was enacted by the government of India with the intension of reducing the incidence of illegal abortion and consequent maternal mortality and morbidity.

According to this Act, a pregnancy may be terminated on certain considered grounds within the first 12 weeks of pregnancy on the opinion of one registered medical practitioner.

If the pregnancy has lasted more than 12 weeks, but fewer than 24 weeks, opinion two registered medical practitioners must require ground exist. The grounds for such termination of pregnancies are:

(i) The continuation of the pregnancy would involve a risk to the life of the pregnant woman or of grave injury physical or mental health;

or (ii There is a substantial risk that of the child were born, it would suffer from such physical or mental abnormalities as to be seriously handicapped.

3. i) Write the properties of an ideal contraceptive.

ii) How are non-medicated IUDs different from hormone releasing IUDs? Give examples.

Ans. i.) User friendly, no side effect, easily available, no interference with sexual desire, reversible and cost effective (any four)
ii) non-medicated IUDs - Lippes's loop, Copper releasing IUDS (CuT, Multiload 375), these increase phagocytosis of sperms within the uterus and release copper ions which suppress sperm motility and fertilizing capacity of sperm. Hormone-releasing IUDs – Progestasert, LNG-20 -These make the uterus unsuitable for implantation and the cervix hostile to sperm.

UNIT VII

GENETICS AND EVOLUTION

Chapter 5
Principles of Inheritance and Variation

Chapter 6
Molecular Basis of Inheritance

Chapter 7
Evolution

CHAPTER-5

PRINCIPLES OF INHERITANCES AND VARIATION

SHORT NOTE / CHAPTER AT A GLANCE FOR QUICK REVIEW

KEY WORDS

1. Genetics:-The branch of biology which deals with the study of heredity and variation in characters.
2. Inheritance:- Transmission of characters from one generation to the next.
3. Heredity:- The process of inheritance of characters from parents to the offspring.
4. Variation:- Appearance of new characters in offspring. It is the difference between parents and offspring.
5. Character:- A heritable feature among the parents & offspring. E.g. Stem height.
6. Trait: Observable features or variants of a character. E.g.- Tall, dwarf etc.
7. Allele: A pair of genes located on the same locus of homologous chromosomes which control the same character. (traits may be same or different)

OR Alternative forms of the same gene. E.g.- T (tall) and t (dwarf) are two alleles of a gene for the character stem height.

8. Homozygous: The condition in which the two alleles of the same gene are similar.

OR If an organism produces only one kind of gametes.

Also known as pure line (True breeding). Eg- TT, tt, YY, yy etc.

9.Heterozygous: The condition in which the two alleles of the same gene are not similar. OR If an organism produces more than one kind of gametes Eg- Tt, Yy etc.

10.Dominant trait(allele): The trait/allele which is expressed in heterozygous condition. It is denoted in capital letter. Eg- Tt is a tall plant. So Tall(T) is the dominant trait.

11.Recessive trait(allele): The trait/allele which is suppressed in heterozygous condition. It is only expressed in homozygous recessive

condition when both the alleles are tt. It is denoted in small letter. Eg- tt is a dwarf plant. So, dwarf(t) is the recessive trait.
12.Phenotype: Physical expression of a character. Eg-Tall
13.Genotype: Genetic constitution of a character. Eg-Tall-TT or Tt

MENDEL'S EXPERIMENT

-During 8000-1000 B.C. Humans knew that one of the causes of variation is due to sexual reproduction.

-Gregor Johann Mendel, for the first time conducted hybridisation experiments to show the pattern of inheritance of characters in living beings.

-Mendel's Experimental Material-

He conducted experiments on garden pea plant (*Pisum sativum*) for seven years (1856-1863) and proposed the laws of inheritances.

Why had he selected garden pea for his experiment?

He selected garden pea plant as a sample for experiment because of:
(a) Easy availability on a large scale.
(b) Many varieties are available with distinct characteristics.
(c) They are self-pollinated and can be cross-pollinated easily in case self-pollination does not occur.
(d) They do not require much care for their growth.
(e) They have short life span and many generations can be observed within a short period of time.

Characters and traits observed by Mendel-

i. Mendel selected 7characters in the pea plant with 14 traits(two contrasting traits in each characters) which are called true-breeding lines
ii. A breeding line which has undergone continuous self-pollination shows stable trait inheritance and expression for several generations.
iii. These Seven characters with their contrasting traits are as follows:

SN	CHARACTERS	TRAITS	
		DOMINANT	RECESSIVE
1	Stem height	Tall	Dwarf
2	Flower colour	Violet	White
3	Flower position	Axial	Terminal
4	Pod Colour	Green	Yellow
5	Pod shape	Round	Wrinkled
6	Seed colour	Yellow	Green
7	Seed shape	Inflated/Full	Constricted

INHERITANCE OF ONE GENE/MONOHYBRID CROSS:-

(i)A cross involving 2 plants differing in one character(or a pair of contrasting traits). E.g. Mendel crossed tall and dwarf pea plants to study the inheritance of one gene.

(ii) Mendel hybridised plants with alternate forms of a single character (monohybrid cross). The seeds produced by these crosses were grown to develop into plants of Filial$_1$ progeny or F_1-generation.

(iii) He then self-pollinated the tall F_1 plants to produce plants of F_2-generation.

(iv) In F_1 generation, Mendel found that all pea plants were tall and none were dwarf.

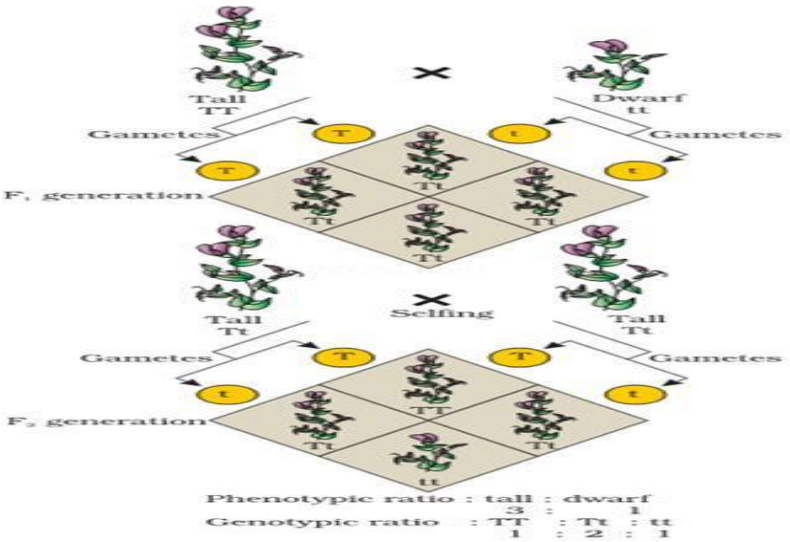
(v) In F_2-generation, he found that some of the off springs were dwarf, i.e. the traits which were not seen in F_1-generation were expressed in F_2-generation.

(vi) These contrasting traits (tall/dwarf) did not show any mixing either in F_1 or in F_2-generation.

(vii) Similar results were obtained with the other traits that he studied. Only one of the parental traits was expressed in F_1-generation, while at F_2-generation stage, both the traits were expressed in the ratio of 3:1.

Monohybrid phenotypic ratio:- 3 Tall: 1 Dwarf = 3:1

Monohybrid genotypic ratio:- 1 Homozygous tall (TT) :2 Heterozygous tall (Tt) : 1 Homozygous dwarf (tt) = 1:2:1



APPLICATION OF BINOMIAL THEOREM IN MENDEL'S EXPERIMENT

¼ th of the random fertilization leads to TT (¼ TT).

½ (2/4) of the random fertilization leads to Tt (½ Tt).

¼ th of the random fertilization leads to tt (¼ tt).

In parent generation probability of T = ½ and t = ½

Binomial expression = $(a + b)^2$ = (a + b)(a + b)

Hence $(½ T + ½ t)^2$ = (½ T + ½ t) (½ T + ½ t)

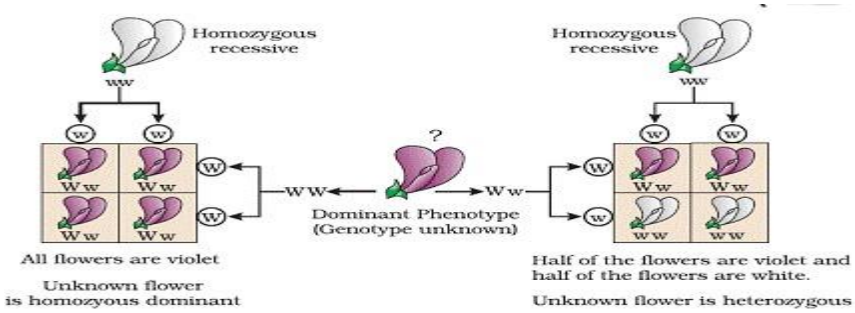
= ¼ TT + ¼ Tt + ¼ Tt + ¼ tt

= ¼ TT + ½ Tt + ¼ tt

=1:2:1

Testcross: Crossing of an organism with dominant phenotype to a recessive individual.

Eg.



Hence monohybrid test cross ratio= 1:1

Test cross is done to find the genotype of an unknown organism.

MENDEL.S LAWS OF INHERITANCES

1. First Law (Law of Dominance)

i.Characters are controlled by discrete units called factors.

ii.Factors occur in pairs.

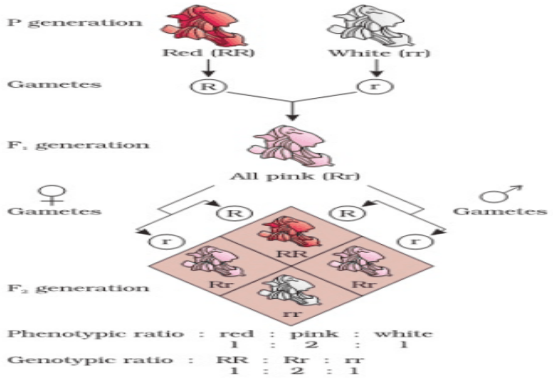
iii.In a dissimilar pair of factors, one member of the pair dominates (dominant) the other (recessive).

2. Second Law (Law of Segregation)

"During gamete formation, the factors (alleles) of a character pair present in parents segregate from each other such that a gamete receives only one of the 2 factors".

NON-MENDELIAN INHERITANCES

1.INCOMPLETE DOMINANCE



Incomplete dominance is a phenomenon in which the F1 hybrid does not resemble either of the parents and shows characters intermediate/in between of the parental characters. In this process, the phenotypic ratio of F_2-generation deviates from the Mendel's monohybrid ratio.

Example, inheritance of flower colour in the dog flower (snapdragon or *Antirrhinum* sp) and four O' clock plant (*Mirabilis jalapa*).

In a cross between a plant with red flower (RR) and another plant with white flower(rr), the F_1 (Rr) was pink (in figure). When F_1 was self-pollinated, the F_2 resulted in the ratio 1: 2: 1

2.CO-DOMINANCE

In co-dominance, the F 1 progeny resembles both the parents.

Example: ABO blood groups in human beings

ABO blood groups are controlled by gene I . Gene I has three alleles, I^A , I^B and i

A person possesses any two of the three alleles.

I^A and I^B dominate over i . But with each other, I^A and I^B are co-dominant.

I^A and I^B contain A and B types of sugar polymer, while i does not contain any sugar.

Table Showing the Genetic Basis of Blood Groups in Human Population

Allele from Parent 1	Allele from Parent 2	Genotype of offspring	Blood types of offspring
I^A	I^A	I^AI^A	A
I^A	I^B	I^AI^B	AB
I^A	i	I^Ai	A
I^B	I^A	I^AI^B	AB
I^B	I^B	I^BI^B	B
I^B	i	I^Bi	B
i	i	ii	O

3.MULTIPLE ALLELISM

It is the presence of more than two alleles of a gene to govern same character. E.g. ABO blood grouping (3 alleles: I^A, I^B & i). In an individual, only two alleles are present. Multiple alleles can be found only in a population.

INHERITANCE OF TWO GENES /DIHYBRID CROSS:-

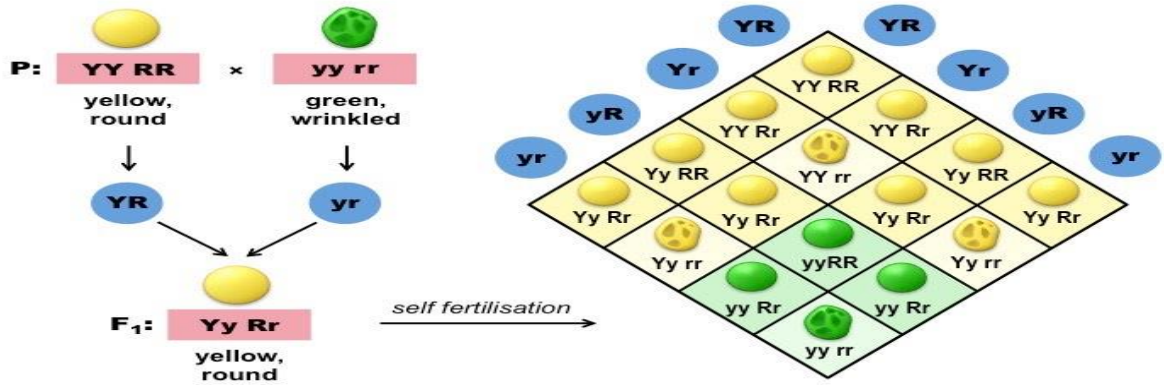
-It is a cross between two parents differing in 2 characters(or 2 pairs of contrasting traits).

E.g. Cross b/w pea plant with homozygous round shaped & yellow-coloured seeds (RRYY) and wrinkled shaped & green coloured seeds (rryy).

-On observing the F2, Mendel found that yellow and green colour segregated in a 3:1 ratio. Round & wrinkled seed shape also segregated in a 3:1 ratio.

-Dihybrid Phenotypic ratio: 9 Round yellow: 3 Round green: 3 Wrinkled yellow: 1 Wrinkled green = 9:3:3:1.

Dihybrid genotypic ratio: 1:1:2: 2:4:2: 2:1:1



CALCULATING THE PHENOTYPIC AND GENOTYPIC RATIOS

If you know the phonotypic ratio and genotypic ratio of monohybrid cross then you can calculate the phenotypic and genotypic ratios of dihybrid, trihybrid, tetra hybrid (etc.) crosses. For Eg-

Phenotypic Ratio of Monohybrid cross is- 3:1

Phenotypic Ratio of Dihybrid (2) cross wiil be- $(3:1)^2 = (3:1)(3:1) = 9:3:3:1$

Phenotypic Ratio of Trihybrid (3) cross will be- $(3:1)^3 = (3:1)(3:1)(3:1)$

Phenotypic Ratio of Tetra hybrid(4) cross will be- $(3:1)^4 = (3:1)(3:1)(3:1)(3:1)$ and so on...

Genotypic Ratio of Monohybrid cross is- 1:2:1

Genotypic Ratio of Dihybrid (2) cross will be- $(1:2:1)^2 = (1:2:1)(1:2:1) = 1:2:1:2:4:2:1:2:1$

Genotypic Ratio of Trihybrid (3) cross will be- $(1:2:1)^3 = (1:2:1)(1:2:1)(1:2:1)$

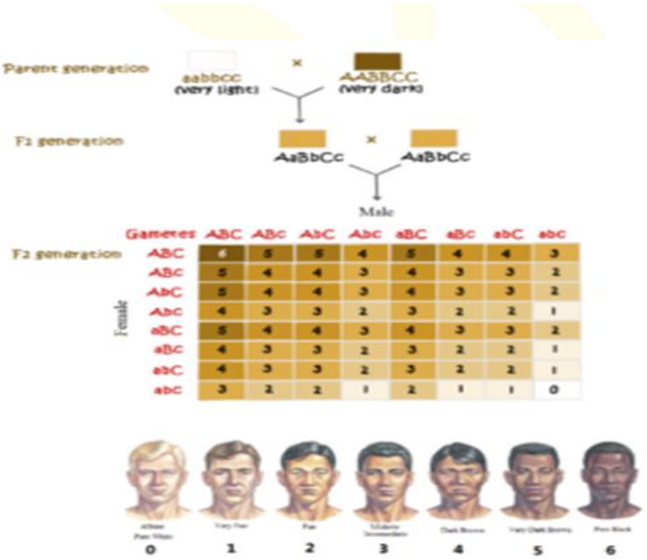
Genotypic Ratio of Tetra hybrid (4) cross will be-
$(1:2:1)^4$=(1:2:1)(1:2:1)(1:2:1)(1:2:1)& so on.

3. Third Law (Law of Independent Assortment)

Law of independent assortment (third law) It is based on inheritance of two genes, i.e. dihybrid cross which states that when two pairs of contrasting traits are combined in a hybrid, segregation of one pair of characters is independent of the other pair of characters. These factors randomly rearrange in the offsprings producing both parental and new combination of characters.

POLYGENIC INHERITANCE/QUANTITATIVE INHERITANCE

-Polygenic inheritance was given by Galton in 1833.



-In this inheritance pattern, traits are controlled by more than two genes. These traits are called polygenic traits.

-The phenotype shows participation of each allele and is also influenced by the environment and is called quantitative inheritance as the character/phenotype can be quantified.

-For example, human skin colour which is caused by a pigment melanin. The quantity of melanin is due to three pairs of polygenes (A, B and C). If it is black or very dark (AA BB CC) and white or very light (aa bb cc) individuals marry each other, the offspring shows intermediate colour often called mulatto (Aa Bb Cc). A total of eight allele combinations is possible in the gametes forming 27 distinct genotypes.

PLEIOTROPY

-It is the phenomenon in which a single gene exhibits multiple phenotypic expressions.

-A single pleiotropic gene may produce more than one effect. For example-Phenylketonuria, a disorder caused by mutation in the

gene coding the enzyme phenylalanine hydroxylase. The affected individuals show hair and skin pigmentation and mental problems.

REDISCOVERY OF MENDEL'S WORK

Mendel's work remained unrecognized for several years because of the following reasons.

1.Communication and publicity were not easy at that time as it is now

2.His concept of factors (genes) as discrete units that did not blend with each other was not accepted by his contemporaries in the light of variations occurring continuously in nature.

3.Mendel's approach to explain biological phenomenon with the help of mathematics was totally new and unacceptable to many biologists at that time.

4.Mendel couldn't provide any physical proof for the existence of factors and what they were made of.

In 1990, three scientists Hugo DeVries, Correns and Von Tschermak in dependently rediscovered Mendel's work.

CHROMOSOMAL THEORY OF INHERITANCE

It was proposed independently by Walter Sutton and Theodore Boveri in 1902. They united the knowledge of chromosomal segregation with Mendelian principles and called it chromosomal theory of inheritance. The main points are as follow:

(i) Gametes (sperm and egg) transmit hereditary characters from one generation to another.

(ii) Nucleus is the site of hereditary characters.

(iii) Chromosomes as well as genes are found in pairs.

(iv) The two alleles of a gene pair are located on homologous sites on the homologous chromosomes.

(v) The sperm and egg having haploid sets of chromosomes fuse to regain the diploid state.

(vi) Homologous chromosomes synapse during meiosis and get separated to pass into different cells and is the basis of segregation and independent assortment during meiosis.

Experimental verification of the chromosomal theory of inheritance was done by Thomas Hunt Morgan and his colleagues.

Morgan selected fruit fly, *Drosophila melanogaster* for his experiments

because:

(a) They could be grown on simple artificial medium in the laboratory.

(b) Their life cycle is only about two weeks.

(c) A single mating could produce a large number of flies.

(d) There was a clear differentiation of the sexes, i.e. male (smaller) and female (bigger).

(e) It has many types of hereditary variation that can be easily seen through low power microscopes.

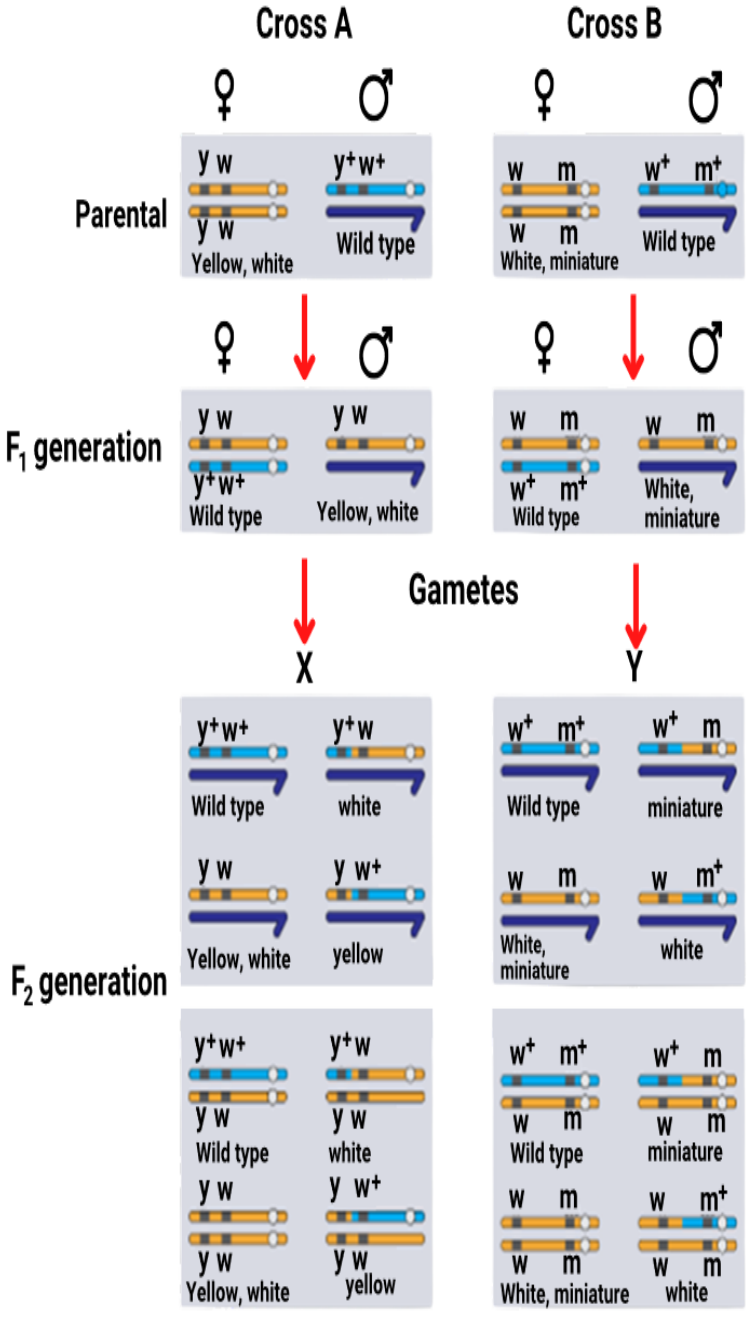
LINKAGE AND RECOMBINATION

(a) The physical association of two genes on a chromosome is called linkage.

Recombination explains the generation of non-parental gene combinations.

To explain the phenomena of linkage and recombination, Morgan carried out several dihybrid crosses in Drosophila to study genes that were sex-linked, i.e. the genes are located on X-chromosome. He observed that two genes did not segregate independently of each other.

He observed that the proportion of parental gene combinations were much higher than the non-parental type, when two genes in a dihybrid cross were situated on the same chromosome. Morgan concluded this as



a physical association or linkage.
(e) Morgan and his group also found that even when genes were grouped on the same chromosome, some genes were very tightly linked (very low recombination), while others were loosely linked (higher recombination).
(f) Recombination of linked genes is by crossing over (exchange of corresponding parts between the chromatids of homologous chromosomes). Linkage results of two dihybrid crosses conducted by Morgan. Cross 'A' shows crossing between genes y and w. Cross 'B1 shows crossing between genes w and m. Here, dominant wild type alleles are represented with (+) sign.
(g) Alfred Sturtevant (Morgan's student) used the frequency of recombination between gene pairs on the same chromosome as a measure of the distance between genes and 'mapped' their position on the chromosome.

SEX DETERMINATION

The chromosomes that are involved in sex determination are called sex chromosomes (allosomes). They include X & Y chromosomes. Autosomes are chromosomes other than sex chromosomes. Number of autosomes is same in males and females. Henking (1891) studied spermatogenesis in some insects and observed that 50 % of sperm received a nuclear structure after spermatogenesis, and other 50 % sperm did not receive it. Henking called this structure as the X body (now it is called as X-chromosome).

Male heterogamety – XO and XY types of sex determination are exam ples of male heterogamety.

1. XO type of sex determination

a. In XO type, some gametes have X chromosomes, while some gametes are withoutchromosomes. Other than autosomes, atleast one X chromosome is present in all insects.
b. Some sperms contain X chromosomes, while some do not.
c.Eggs fertilized by sperms having X chromosomes become female So, f emales have two X chromosomes.
d.Eggs fertilized by sperms not having X chromosomes become males. So, males have only one X chromosome.
example of organisms with XO type of sex determination –Insects

2. XY type of sex determination

a. In XY type, some gametes have X chromosomes, while other gametes have Y chromosomes.
b. Males have X chromosome and its counterpart Y chromosome. Hence, males are XY.
c. Females have a pair of X chromosomes. Hence, females are XX.
example of organisms with XY type of sex determination –Human and Drosophila

Female heterogamety –

1.ZW type of sex determination

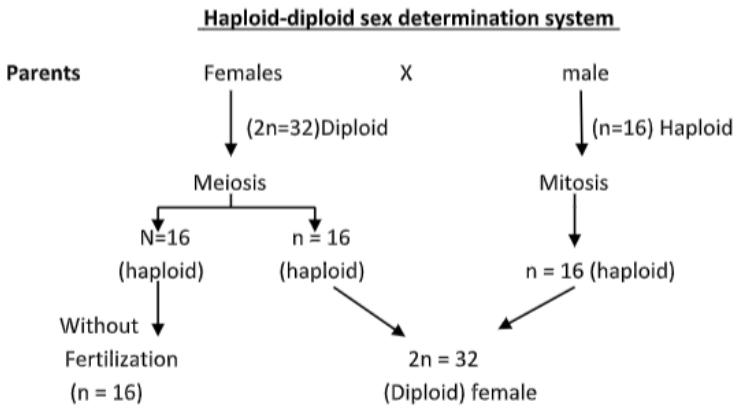
In ZW type, the female has one Z and one W chromosome, while the male has a pair of Z chromosomes. Eg- Certain butterflies, some moths, fishes, reptiles and birds

2.ZO type of sex determination

In ZO type, the female has only one Z chromosome, while the male has a pair of Z chromosomes. Some female gametes have Z chromosomes, while other female gametes are without Z chromosomes. Eg- Certain butterflies and moths.

Sex determination in honey bee (Haplo-Diploidy)

Haplo-diploidy is based on the number of sets of chromosomes an individual receives. Fertilized egg develops into a female (queen or worker). An unfertilized egg develops into a male (drone) parthenogenetically.



Therefore, the females are diploid (32 chromosomes) and males are haploid (16 chromosomes). This is called as haplo-diploid sex determination system. In this system, the males produce sperms by mitosis. They do not have father and thus cannot have sons, but have a grandfather and can have grandsons.

MUTATION

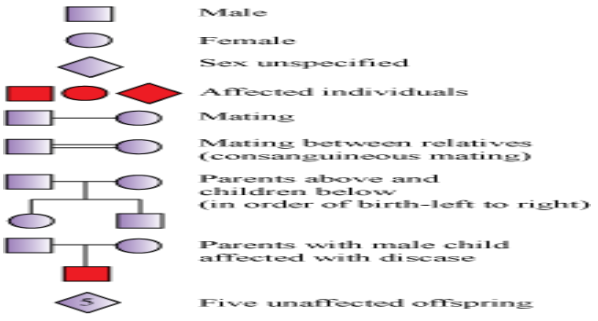
A sudden, heritable, permanent and irreversible change in DNA sequences resulting in changes in the genotype and the phenotype of an organism is called mutation.

Mutation is 2 types: 1. Gene (Point) Mutation, 2. Chromosomal Mutation/Aberration

1.Gene Mutation: Mutation within a gene. It may be:
a. Deletion-A part of gene is deleted
b. Duplication-A part of gene is deleted and joined on the sister chromatid
c. Insertion-One or more pair of nucleotides are inserted within the gene.
d. Substitution-One or more pairs of nucleotides are replaced by the same number of nucleotide pairs. It may be transition or transversion.
i. Transition- If purine is replaced by purine and pyrimidine is replaced by pyrimidine.
ii. Transversion- If purine is replaced by pyrimidine and vice versa
Point mutation: The mutation due to change (substitution) in a single base pair of DNA. E.g. sickle cell anemia.
Frame-shift mutation: It is the deletion or insertion of base pairs resulting in the shifting of DNA sequences.
2.Chromosomal Aberration- Mutation among the genes(a part of a chromosome or DNA segment)
1.Loss (deletion) or gain (insertion/ duplication) of DNA segment cause Chromosomal abnormalities (aberrations).
2.When there is a change in chromosomal number that leads to
a. Aneuploidy-Gain or loss of one or two chromosomes. This may be
i.Nullisomy- 2n – 2 ii. Monosomy-2n – 1
iii. Trisomy- 2n + 1 iv. Tetrasomy-2n + 2
b. Polyploidy-Gain of one or more sets of chromosomes. It may be
i. Triploidy- 2n + n
ii. Tetraploidy- 2n + 2n
Chromosomal aberrations are seen in cancer cells. The agents which induce mutation are called mutagens. They include
-Physical mutagens: UV radiation, α, β, γ rays, X-ray etc.
-Chemical mutagens: Mustard gas, phenol, formalin etc.
-Biological mutagens: Oncogenic viruses

PEDIGREE ANALYSIS

Analysis of genetic traits in several generations of a family is called pedigree analysis. The representation or chart showing family history is called family tree



(pedigree). In human genetics, pedigree study is utilized to trace the inheritance of a specific trait, abnormality or disease.

GENETIC DISORDER

The disorders which are causeddue to change in genes or chromosomes and that are herited from parents to offsprings. It is of 2 types: Mendelian disorders & Chromosomal disorders.

1. Mendelian Disorders

1.It is caused by mutation in a single gene. E.g. Hemophilia, Colour blindness, Sickle-cell anemia, Phenylketonuria, Thalassemia, Cystic fibrosis etc.

2.The pattern of inheritance of Mendelian disorders can be traced in a family by the pedigree analysis.

3.Mendelian disorders may be dominant or recessive and they inherit from one generation to the next by following the Mendelian inheritance pattern.

4.Pedigree analysis helps to understand whether the trait is dominant or recessive.

Haemophilia (Royal disease):

It is a sex linked (X-linked) recessive disease. In this, a protein involved in the blood clotting is affected. A simple cut results in non-stop bleeding. The disease is controlled by 2 alleles, H & h. H is normal allele and h is responsible for haemophilia.

X^HX^H -Normal female

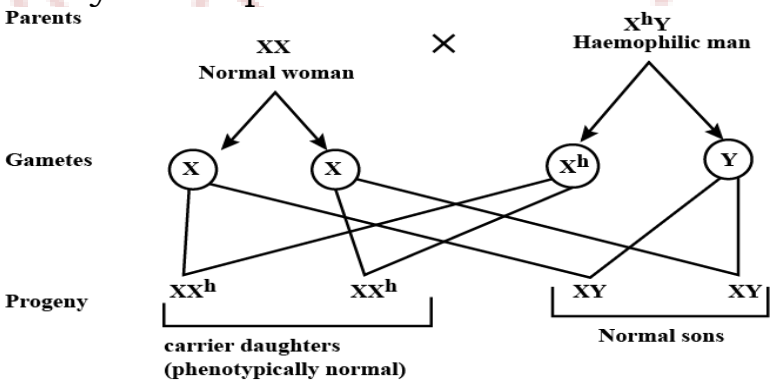
X^HX^h -Heterozygous female (carrier). She may transmit the disease to sons.

X^hX^h -Hemophilic female

X^HY -Normal male

X^hY -Hemophilic male

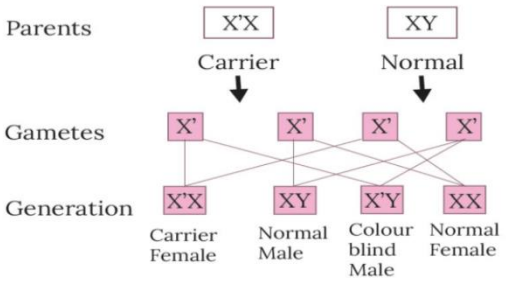
In females, haemophilia is very rare because it happens only when mother is at least carrier and father haemophilic (unviable in the later stage of life). Queen Victoria was a carrier of hemophilia. So her family pedigree shows many haemophilic descendants.



The pattern of inheritance is called crisscross mechanism as the allele passes from father to daughter and from mother to son.

Colour blindness:

1.It is a sex-linked (X-linked) recessive disorder due to defect in either red or green cone cells of eye.



2.It results in failure to discriminate between red and green colour.

3.It is due to mutation in some genes in X chromosome.

4.It occurs in 8% of males and only about 0.4% of females. This is because the genes are X-linked.

5.Normal allele is dominant (C). Recessive allele (c) causes colour blindness. The son of a heterozygous woman (carrier, X^CX^c) has a 50% chance of being colour blind. A daughter will be colour blind only when her mother is at least a carrier and her father is colour blind (X^cY).

Phenylketonuria:

1.It is an inborn error of metabolism and inherited as autosomal recessive trait.

2.It is due to mutation of a gene that codes for the enzyme phenyl alanine hydroxylase.

3.This enzyme converts an amino acid phenylalanine into tyrosine.

4.The affected individual lacks this enzyme. As a result, phenylalanine accumulates and converts into phenyl pyruvic acid and other derivatives.

5.They accumulate in brain resulting in mental retardation. These are also excreted through urine because of poor absorption by kidney.

Thalassemia:

1.An autosome-linked recessive blood disease.

2.It is transmitted from unaffected carrier (heterozygous) parents to offspring.

3.It is due to a mutation which results in reduced synthesis of α or β globin chains of haemoglobin. It forms abnormal haemoglobin and causes anaemia.

Based on the chain affected, thalassemia is 2 types:

a.α Thalassemia: Here, production of α globin chain is affected. It is controlled by two closely linked genes HBA1 & HBA2 on chromosome 16 of each parent. Mutation or deletion of one or more of the four genes

causes the disease. The more genes affected; the less α globin molecules produced.

b. β Thalassemia: Here, production of β globin chain is affected. It is controlled by a single gene HBB on chromosome 11 of each parent. Mutation of one or both the genes causes the disease.

Thalassemia is a quantitative problem (synthesize very less globin molecules). Sickle-cell anaemia is a qualitative problem (synthesize incorrectly functioning globin).

2. Chromosomal disorders

They are caused due to absence or excess or abnormal arrangement of one or more chromosomes. They are caused due to 2 types of mutations:

1.Aneuploidy: The gain or loss of chromosomes due to failure of segregation of chromatids during cell division (non-disjunction of homologous chromosomes).

2.Polyploidy (Euploidy): It is an increase in a whole set of chromosomes due to failure of cytokinesis after telophase stage of cell division. This is very rare in human but often seen in plants.

Examples for chromosomal disorders

Down's syndrome:

It is the presence of an additional copy of chromosome number 21 (trisomy of 21). Genetic constitution: 45 A + XX or 45 A + XY (i.e. 47 chromosomes). First described by Langdon Down in 1866.

Features:

1.They are short statured with small round head.

2. Furrowed tongue and partially open mouth.

3. Palm is broad with characteristic palm crease.

4. Retarded physical, psychomotor & mental development.

Klinefelter's Syndrome:

It is the presence of an additional copy of X-chromosome in male (trisomy).

Genetic constitution: 44 A + XXY (i.e. 47 chromosomes).

Features:

1.Overall masculine development. However, the feminine development is also expressed. E.g. Development of breast (Gynecomastia).

2.Such individuals are sterile.

Turner's syndrome:

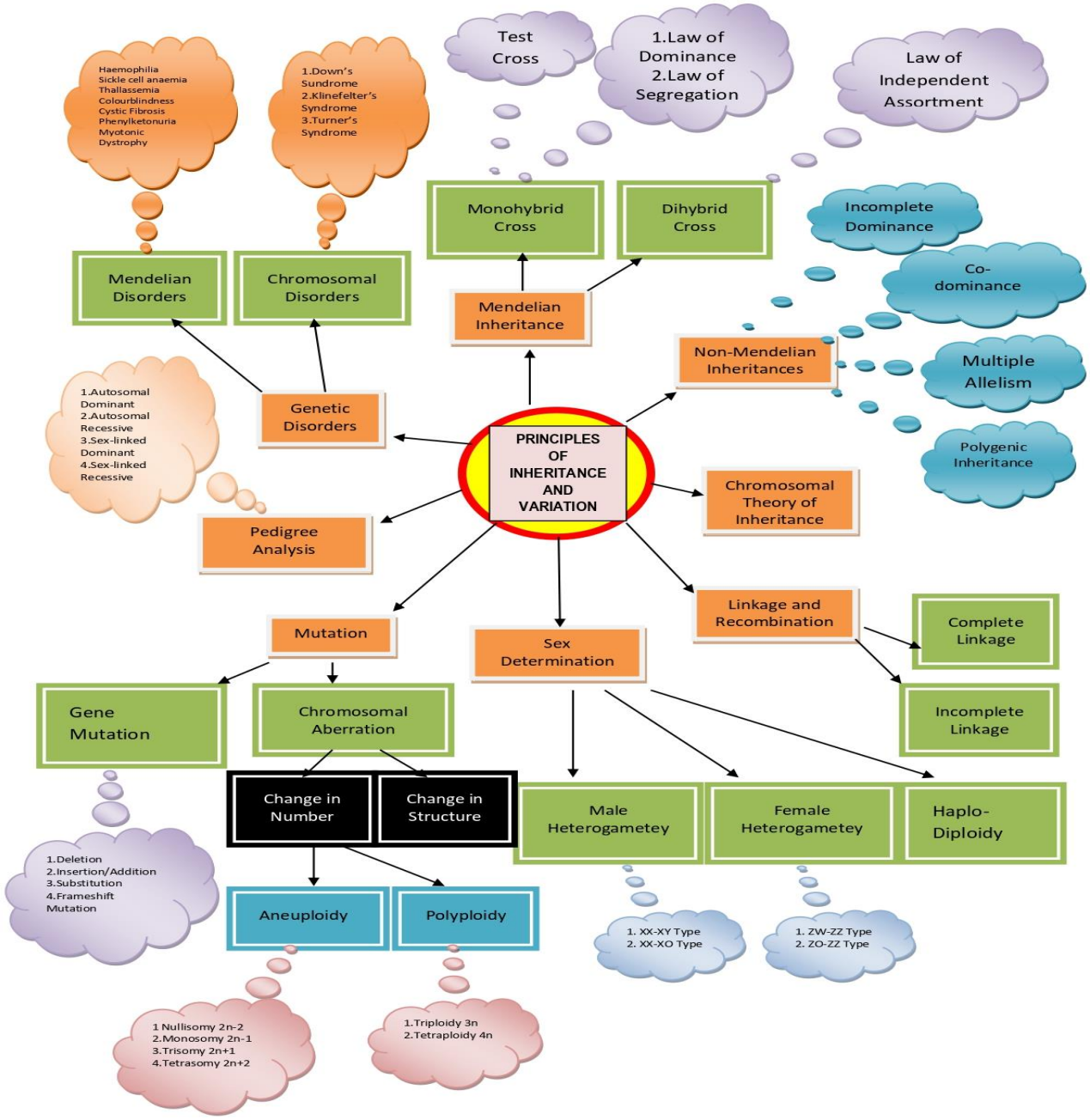
This is the absence of one X chromosome in females. Genetic constitution: 44 A + X0 (i.e. 45 chromosomes).

Features:

1.Sterile, Ovaries are rudimentary.

2.Lack of other secondary sexual characters.

MIND/CONCEPT MAP



QUESTION BANK

MULTIPLE CHOICE QUESTIONS

1.As per Mendelian inheritance pattern identify the correct matching.

Conditions	Alleles/Genotypes
1.Dominant allele	i.TT or tt
2.Recessive allele	ii. T
3.Homozygous	iii. Tt
4.Heterozygous	iv. t

a) 1-ii, 2-iv, 3-i, 4-iii
b) 1-i, 2-ii, 3-iv, 4-iii
c) 1-ii, 2-iii, 3-i, 4-iv
d) 1-i, 2-ii, 3-iv, 4-iii

2.The genotype of a diploid organism is AaBBCcDd. The types of gametes it will form is
a) 3
b) 6
c) 8
d) 9

3.In Mendel's dihybrid cross (RRYY x rryy) the percentage of individuals which are homozygous for both the characters are
a)25%
b)50%
c)75%
d)100%

4.In Mendel's dihybrid cross (RRYY x rryy) the percentage of individuals which are heterozygous for one character are
a)25%
b)50%
c)75%
d)100%

5.An allele is said to be dominant when
a) it expresses its phenotype in homozygous condition
b) it expresses its phenotype in heterozygous condition
c) it express desirable phenotype
d) Both (b) and (c)

6.A heterozygous tall plant with yellow seed is crossed with a similar genotype, what percentage of plants should possess TtYy genotype?
a) 6.25%
b) 12.5%
c) 25%
d) 75%

7.The law of Mendel that is disproved by Linkage of Morgan
a)Law of paired factors
b)Law of dominance
c)Law of segregation
d)Law of independent assortment
8.Mendel studied 7 characters of the pea plant in his experiments. All the genes controlling these seven pea characters are located in chromosome numbers
a) 1, 2, 6, 7
b) 1, 4, 5, 7
c) 1, 3, 4, 7
d) 1, 3, 5, 7
9.The genotypic ratio is 1:2:1 in
a) Test cross only
b) Incomplete dominance only
c) both a) and b)
d) neither a) nor b)
10.The inheritance pattern of human ABO blood grouping is an example of
a) dominance, incomplete-dominance and co-dominance
b) dominance, co-dominance and multiple allelism
c) incomplete dominance, co-dominance and multiple allelism
d) dominance, incomplete dominance, co-dominance and multiple allelism
11.A pair of couple with blood group A and B have four children with all the 4 different types of blood groups. The possible genotypes of parents will be
a) I^AI^A& I^BI^B
b) I^AI^A& I^Bi
c) I^Ai& I^BI^B
d) I^Ai& I^Bi
12.Drosophila with XXY genotypes are females but human beings with such genotypes are abnormal males (Klinefelter's syndrome). This means
a) The Y chromosome is male determining in humans
b) The Y chromosome has no role in sex determination
c) The Y chromosome is female determining in Drosophila
d) In Drosophila, the Y chromosome is essential for sex determination
13.If A and B genes are linked, the genotype of progeny in a cross between AB/ab and ab/ab?
a) AABB and aabb

b) AAbb and aabb
c)AaBb and aabb
d) AaBb and AaBb
14.Identify the correct matching

Diseases	Conditions
1.Sickle Cell Anaemia 2.Haemophilia 3.Down's Syndrome 4.Myotonic dystrophy	i.non-disjunction of 21st chromosome ii.autosomal dominant iii.X-linked recessive iv.point mutation

a)1-iv, 2-ii, 3-i, 4-iii
b)1-i, 2-ii, 3-iv, 4-iii
c)1-iv, 2-iii, 3-i, 4-ii
d)1-i, 2-ii, 3-iv, 4-iii
15.A trisomy condition is represented by
a) 3n
b) 3n+2
c) 2n+3
d) 2n+1
16.In XO type of sex determination
a) Females produce two different types of gametes
b) Males produce two different types of gametes
c) Females have only one X chromosome
d) Males produce single type of gametes
17.In pea plant the number of haploid chromosomes is 7. The number of chromosomes in its monosomic condition will be
a) 6
b) 7
c) 13
d) 14
18.A haemophilic boy child has both his parents normal. Then find the most appropriate statement applicable for him.
a) his maternal grandfather is haemophilic
b) his paternal grandfather is haemophilic
c) his maternal grandfather is normal
d) his paternal grandfather is normal
19. A normal man whose father was haemophilic marries a woman whose father was also haemophilic. They have their first child as daughter. What is the chance of this girl child to be haemophilic
a) 0%
b) 25%

c) 50%
d) 100%
20.The cause of aneuploidy in human being is due to
a) the non-disjunction of homologous chromosomes during spermatogenesis.
b) the non-disjunction of homologous chromosomes during oogenesis.
c) the non-disjunction of homologous chromosomes either during spermatogenesis or oogenesis.
d) addition of extra chromosome during embryogenesis
21.Red-green colour blindness in humans is governed by a sex-linked recessive gene. A normal woman whose father was colour blind marries a colour-blind man. What is the chance of their daughters and sons are expected to be colour blind?
a) 0% & 100% respectively
b) 25% & 75% respectively
c) 50% & 50% respectively
d) 100% & 0% respectively
22.There are three genes in a chromosome named X, Y & Z. The recombination percentage between X & Y is 15%, between Y & Z is 44% and X & Z is 29%. The correct sequence of the genes is-
a) X Y Z
b) Y X Z
c) X Z Y
d) Y Z X
23.Which one of the following cannot be explained based on Mendel's Law of Dominance?
a) Alleles do not show any blending and both the characters recover as such in F2 generation.
b) The discrete unit controlling a particular character is called a factor
c) Factors occur in pairs
d) Out of one pair of factors one is dominant, and the other recessive
24.An organism has 50 pairs of chromosomes. The number of linkage group in this organism is
a) 25
b) 50
c) 75
d) 100
25.Select the incorrect statement with relation to Phenylketonuria patient.
a) it is an autosomal recessive disorder
b) the phenylalanine is converted into tyrosine

c) the phenylalanine is converted into phenyl-pyruvic acid
d) it is an example of pleiotropy

26.The inheritance pattern of human skin colour is an example of
a) Polygenic inheritance
b) Co-dominance
c) Incomplete dominance
d) chromosomal mutation

27.Select the correct statement with respect to a dihybrid cross
a) Genes of the same chromosome which are far apart show high parental combinations
b) Genes of the same chromosome which are very near show fewer parental combinations
c) Frequency of recombination is directly proportional to the strength of linkage
d) Frequency of recombination is inversely proportional to the strength of linkage

28.The analysis of a trait in a several of generations of a family can be done by
a) study of test cross
b) analysis of punnet square of a dihybrid cross
c) pedigree analysis
d) analysis of frequency of recombination

29.Female honeybees are developed
a) the fertilisation of male and female haploid gametes
b) parthenogenetically
c) directly from haploid female gametes
d) directly from haploid male gametes

30.Sickle cell anaemia is caused due to
a) deletion of a single nucleotide pair in the gene coding for beta globin chain
b) duplication of a single nucleotide pair in the gene coding for beta globin chain
c) substitution in a single nucleotide pair in the gene coding for beta globin chain
d) insertion of a single nucleotide pair in the gene coding for beta globin chain

ANSWER KEY

Q.NO.	CORRECT OPTION	Q.NO.	CORRECT OPTION	Q.NO.	CORRECT OPTION
1	a	11	d	21	c
2	c	12	a	22	b
3	a	13	c	23	a
4	b	14	c	24	b
5	d	15	d	25	b
6	c	16	d	26	a
7	d	17	c	27	d
8	b	18	a	28	c
9	c	19	a	29	a
10	b	20	c	30	c

ASSERTION-REASON TYPE QUESTIONS

Directions: In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as:
(A) If both Assertion and Reason are true and Reason is the correct explanation of Assertion.
(B) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
(C) If Assertion is true but Reason is false.
(D) If both Assertion and Reason are false.

1.A-In honey bees, female is diploid and male is haploid.
R-Gametes are formed by meiosis in female and by mitosis in male.
2.A-Mendel had chosen garden pea plant for his hybridisation experiment.
R-Garden pea are easy to grow and many generations can be obtained within a short period of time.
3.A- *Drosophila melanogaster* is widely used in genetic research.
R- *Drosophila melanogaster* is a readily available insect.

ANSWER KEY

1.B, 2.A, 3.C

SA TYPES QUESTIONS

1. During a monohybrid cross involving a tall pea plant with a dwarf pea plant, the offspring populations were tall and dwarf in equal ratio. Work out a cross to show how it is possible.
2. The map distance in certain organisms between gene A and B is 6 units, B and C is 2 units and between C and D is 10 units which one of

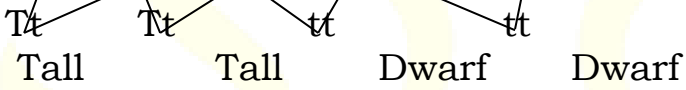
these gene pairs will show more recombination frequency? Give reasons in support of your answer.

3.A pair of couple has four children with four different types of blood groups i.e. A, B, AB and O. Decide the blood groups of the couple and the genotypes.

ANSWER KEY

1. Tall Dwarf

Tt **X** tt



Tall Tall Dwarf Dwarf

So Tall : Dwarf = 1:1

2. _____

A 6u B 2u C 10u D

Since the recombination frequency is directly proportional to the map distance, CD pair will show more recombination frequency.

3. Since the children have blood groups A, B AB and O, their genotypes will be

A – I^AI^A or I^Ai

B – I^BI^B or I^Bi

AB – I^AI^B

O - ii

This is only possible if their parents have all the three alleles i.e. I^A, I^B and i. So, the blood groups of parents will be heterozygous A(I^Ai) and B(I^Bi). Do the cross by your own to verify.

CASE BASED QUESTION/CBQ

Aneuploidy is a condition which is caused due to non-disjunction (failure of segregation) of homologous chromosomes during meiosis. It leads to the formation of a new cell with an abnormal number of chromosomes. Consequently, the individual may develop a trisomy or monosomal syndrome. Non-disjunction can occur in both Meiosis I and Meiosis II of the cellular division. It is also the main cause of many genetic disorders. Although it results in the majority of cases from errors in maternal meiosis-II, both paternal and maternal meiosis-I do influence it.

Q1. Which of the following conclusions can be true regarding aneuploidy?

i. It is the presence of an extra chromosome in a diploid cell.

ii. An aneuploid cell differs from other cells only in size.
iii. It can be less number of chromosomes in a diploid cell.
iv. Aneuploidy always affects female individuals.

A. i only
B. both i and iii
C. both ii and iii
D. i, iii and iv

Q2. Considering the different phases of meiosis, select the correct statements from the following.

i. Errors in meiosis I is the only cause of aneuploidy
ii. Aneuploidy always affects sex chromosomes.
iii. Most of the aneuploidy results from errors in cell division involved in egg formation.
iv. Non-disjunction in meiosis I can lead to more abnormal cells than disjunction in meiosis II.

A. i only
B. both i and iii
C. both iii and iv
D. i, iii and iv

Q3: The type of genetic disorders mainly caused by chromosomal non-disjunction is

A. Chromosomal disorders
B. Mendelian disorders
C. Incomplete dominance
D. All the above

Q4: Assertion: All types of genetic disorders are caused by chromosomal non-disjunction.
Reason: Chromosomal non-disjunction always affects female individuals.

A. Both assertion and reason are correct and the reason is the correct explanation of assertion
B. Both assertion and reason are correct but the reason is not the correct explanation of the assertion
C. Assertion is correct but the reason is incorrect
D. Both assertion and reason are incorrect

Answer Key

1.B, 2.C, 3.A, 4.D

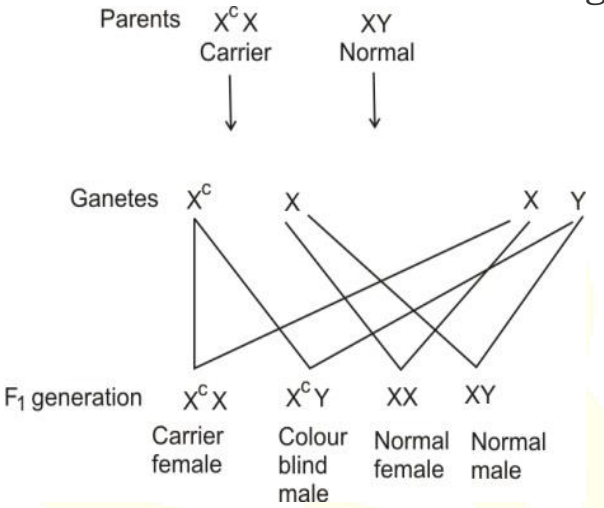
LA TYPE QUESTION

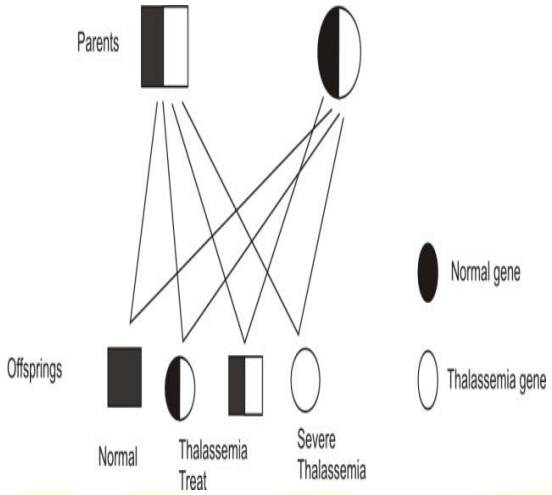
Q1. A normal couple has a colour blind child, where as a child suffering from thalassemia is born to normal parents. Compare the

pattern of inheritance of these two traits in the said case. State the reasons how is it possible.

ANSWER KEY

Colour blindness is a sex-linked recessive disorder, males are affected more than females because the gene is located on x chromosomes.





Colour blindness is a defect in which a person cannot distinguish between red, green or both the colours from other colours.

Thalassemia is an autosomal recessive disorder. It is transmitted to the offspring when both the parents are heterogeneous or carriers of the disease.

CHAPTER-6

MOLECULAR BASIS OF INHERITANCE

SHORT NOTE / CHAPTER AT A GLANCE FOR QUICK REVIEW

KEY WORDS

1. DNA: Deoxyribo Nucleic Acid
2. RNA: Ribo Nucleic Acid
3. Gene: A functional segment of DNA which is the unit of heredity.
4. Polymer: A complex chemical molecule which is made of same/similar units (called monomers)
5. Purine Bases: Having two heterocyclic ring structure. Eg- Adenine & Guanine
6. Pyrimidine bases: Having a single heterocyclic ring structure. Eg- Cytosine, Thymine & Uracil.
7. Genetic Material: The chemical molecule which can carry the information/characters from one generation to the next.

8. Replication: Copying of DNA/Synthesis of a DNA from a parental DNA molecule
9. Transcription: Synthesis of RNA from DNA
10. Translation: Synthesis of a polypeptide/protein molecule as per the information encoded in an mRNA molecule.
11. Mutation: A sudden, permanent, irreversible and heritable change in our genetic material.
12. Cistron: A segment of DNA coding for a polypeptide.
13. Exons: The coding/expressed sequences of cistron
14. Introns: The segments/sequences in the cistron which don't appear in a mature or processed RNA.
15. Genetic Code: The relation between the sequence of nucleotides in the mRNA and the sequence of amino acids in a polypeptide chain.
16. UTR: Untranslated regions of mRNA at both the ends i.e. before the start codon (5' end) and after the stop codon (3' end).
17. Operon: A set/series/arrangement of genes/nucleotide sequences which work together in a coordinated way for a metabolic pathway.
18. HGP: Human Genome Project
19. BAC: Bacterial Artificial Chromosomes.
20. YAC: Yeast Artificial Chromosomes.
21. SNPs: 'Single Nucleotide Polymorphism' which are the locations in a DNA molecule with single base differences.
22. Repetitive DNA: The sequences in DNA with a small stretch of nucleotide sequences repeated many times.
23. Satellite DNA: During density gradient centrifugation of DNA molecules, the bulk DNA forms the major peak and the sequences which form minor/small peaks are called satellite DNA.
24. DNA Polymorphism: If the frequency of variation of a character (or trait) at the genetic level of a given population of a particular species due to mutation is greater than 0.01, then it is called DNA polymorphism.
25. VNTR: Variable Number Tandem Repeat is a location in a genome where a short nucleotide sequence is organized as a tandem repeat (one after the other).

The DNA

1. DNA & RNA are polynucleotide chains(polymer of nucleotides) made of monomers called nucleotides.
2. DNA consists of two polynucleotide chains which are joined together by weak hydrogen bonds. Hence DNA is double stranded.
3. Both the chains are aligned anti-parallel to each other.

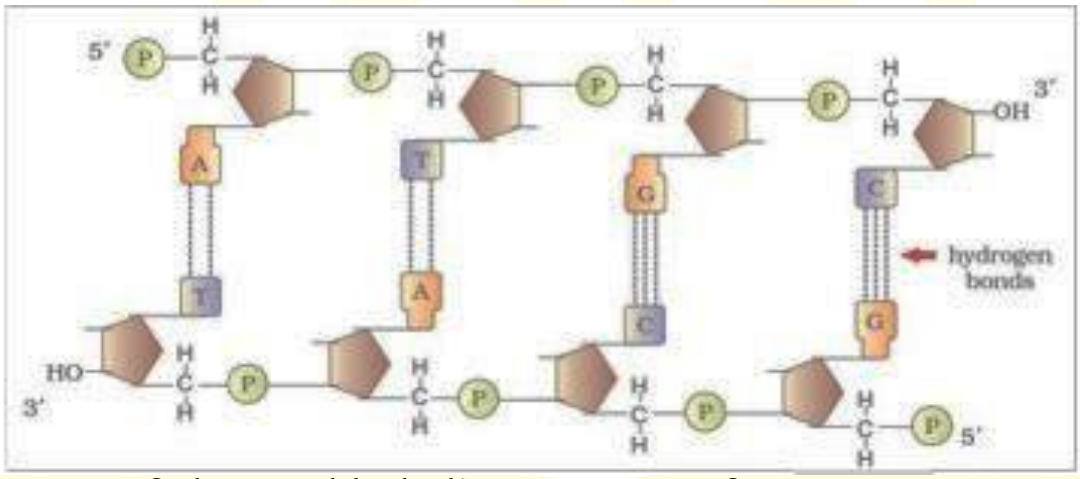
4. Nucleotide= A nitrogen base + A pentose sugar (ribose in RNA & deoxyribose in DNA) + a phosphate group.
5. Nucleoside= A nitrogen base + pentose sugar.
6. Nitrogen bases are of 2 types:

a) Purines: Adenine (A) and Guanine (G).
b) Pyrimidines: Cytosine (C), Thymine (T) & Uracil (U).
c) Base Pairings: A=T (2 hydrogen bonds), C≡G (3 hydrogen bonds).

Types of Bonding: 1. Between sugar & nitrogenous base = N-glycosidic bond
2.Between sugar & phosphate group = Phosphoester bond
3.Between two consecutive nucleotides = Phosphodiester bond

Erwin Chargaff's rule:

1. In a DNA, the proportion of A is equal to T and the proportion of G is equal to C.
2. [A] + [G] = [T] + [C] or [A] + [G] / [T] + [C] =1



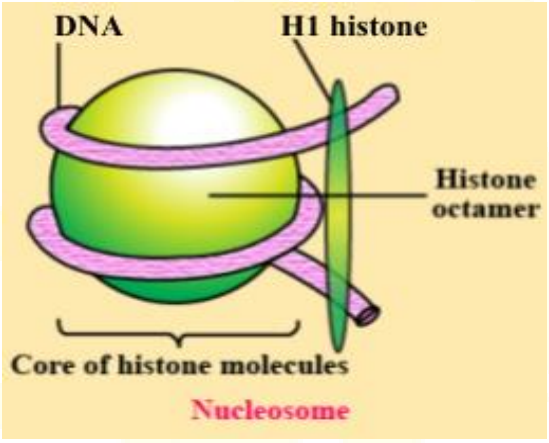
Salient Features of the Double-helix structure of DNA

1. It is made of two polynucleotide chains, where the backbone is constituted by sugar-phosphate, and the bases project inside.
2. The two chains have anti-parallel polarity. It means, if one chain has the polarity 5'→3', the other has 3'→5'.
3. The bases in two strands are paired through hydrogen bond (H-bonds) forming base pairs (bp). Adenine forms two hydrogen bonds with Thymine from opposite strand and vice-versa. Similarly, Guanine is bonded with Cytosine with three H-bonds. As a result, always a purine comes opposite to a pyrimidine. This generates approximately uniform distance between the two strands of the helix.
4. The two chains are coiled in a right-handed fashion. The pitch of the helix is 3.4 nm and there are roughly 10 bp in each turn. Consequently, the distance between a bp in a helix is approximately 0.34 nm.

5. The plane of one base pair stack over the other in double helix. This, in addition to H-bonds, confers stability of the helical structure.

Packaging of DNA Helix

1. DNA is negatively charged which is wrapped around histone octamer having positive charge to form nucleosome.
2. Histones are positively charged as they are rich in the basic amino acid residues lysines and arginines which carry positive charges in their side chains.
3. Nucleosomes condense to form chromatin (seen as 'beads-on-string' under electron microscope).



4. Higher level packaging of chromatin needs non-histone chromosomal (NHC) proteins to form condensed structure called chromosome.
5. Chromatins have generally 2 regions:
6. Euchromatin: Loosely packed, stains light and transcriptionally active region.
7. Heterochromatin: Densely packed, stains dark and transcriptionally inactive region.

THE SEARCH FOR GENETIC MATERIAL

1. Griffith's Transforming Principle experiment

S-strain — Inject into mice —> Mice die
R-strain —> Inject into mice —> Mice live
S-strain (Heat killed) —> Inject into mice —> Mice live
S-strain (Heat killed) + R-strain (live) —> Inject into mice —> Mice die
Conclusion: Some 'transforming principle' transferred from heat killed S-strain had enabled the R strain to become virulent.

2. Biochemical characterization of transforming principle

- By Oswald Avery, Colin MacLeod & Maclyn McCarty (1933-1944).
- They purified biochemicals from heat killed S cells using suitable enzymes.

R-Strain + Carbohydrates of S-Strain -----→ No transformation
R-Strain + Proteins of S-Strain -----→ No transformation
R-Strain + DNA of S-Strain -----→ Transformation of R-Strain into S-Strain
R-Strain + DNA of S-Strain + DNase -----→ No transformation

Digestion of DNA with DNase inhibited transformation. It proves that DNA caused transformation.

3. The Genetic material is DNA(Hershey-Chase Experiment)

- This experiment was the unequivocal proof that DNA is the genetic material
- Bacteriophage having DNA labelled with radioactive phosphorus (^{32}P) infected with E. coli.
- Bacteriophage having protein capsule labelled with radioactive sulphur (^{35}S) infected with *E. coli*.
- The viral coats were removed from the bacteria by agitating them in a blender.
- Centrifugation to separate virus particles from bacterial cells.
- Bacteria infected with viruses having radioactive DNA were radioactive. i.e., DNA passed from virus to bacteria.
- Bacteria infected with viruses having radioactive Proteins were not radioactive. i.e., proteins did not enter the bacteria from the viruses.

-This proves that DNA is the genetic material.

Properties of Genetic Material (DNA versus RNA)

A molecule that can act as a genetic material must fulfil the following criteria:

(i) It should be able to generate its replica (Replication).

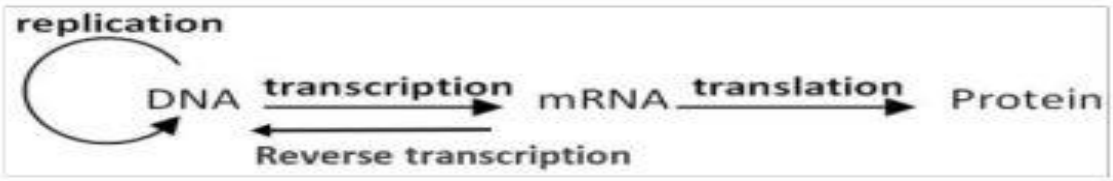
(ii) It should be stable chemically and structurally.

(iii) It should provide the scope for slow changes (mutation) that are required for evolution.

(iv) It should be able to express itself in the form of 'Mendelian Characters'.

Central Dogma of Molecular Biology

It is proposed by Francis Crick.



DNA

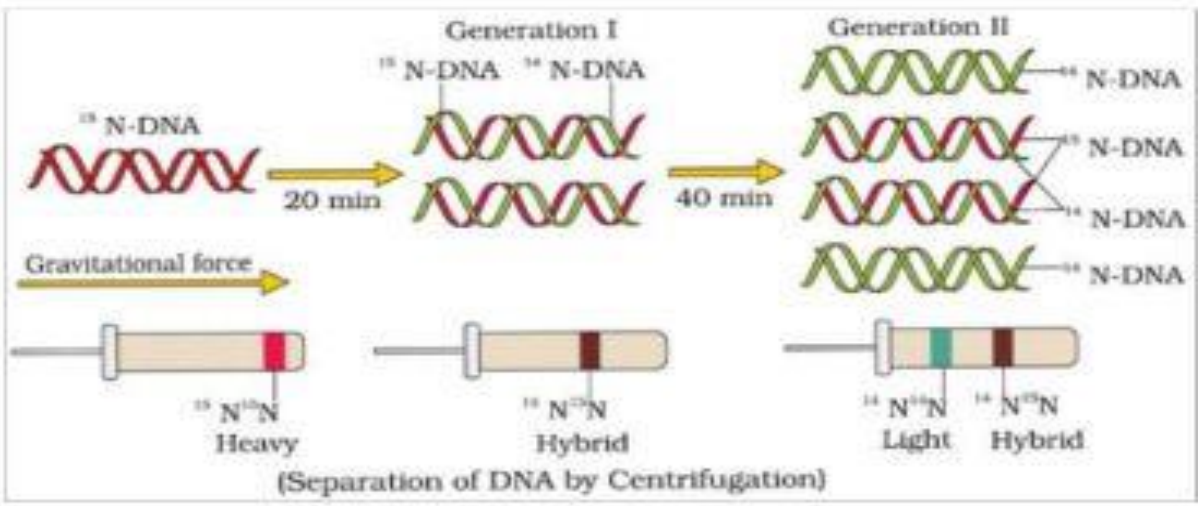
REPLICATION

-Replication is the copying/synthesis of a new DNA from a parental DNA.

-Watson & Crick proposed Semi-conservative model of replication.

EXPERIMENTAL PROOF OF SEMI-CONSERVATIVE MODE OF DNA REPLICATION

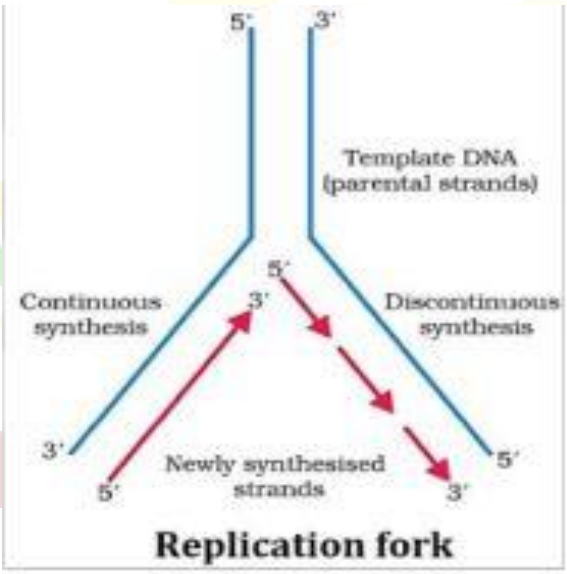
Meselson & Stahl's Experiment (1958)



-They grew *E. coli* in a medium containing $^{15}NH_4C1$ medium (^{15}N is the heavy isotope) in which ^{15}N was incorporated into newly synthesized DNA.
-Heavy DNA (^{15}N) could be distinguished from normal DNA (^{14}N) by centrifugation in a Caesium chloride density gradient.
-E. coli cells from ^{15}N medium were transferred to ^{14}N medium.
-In generation I, density of DNA was intermediate between ^{15}N DNA &^{14}N DNA. i.e., one strand is old (^{15}N) and one strand is new (^{14}N).
-In generation II, the extracted DNA was composed of equal amounts of this hybrid DNA and of light DNA.

Process of Replication

DNA replication starts at a point called origin of replication.
DNA replicates in the 5'—>3' direction.
Deoxyribonucleoside triphosphates serve dual purpose i.e. act as substrate and source of energy.
Two strands unwind and separate to form replication fork.
In presence of the enzyme DNA dependent DNA polymerase, deoxyribonucleotides join to form new strand in 5'→3' direction.



Old DNA strand with polarity 3'→5' undergoes Continuous synthesis. Hence the new strand will be in 5'→ 3'(leading strand)
Other strand with polarity 5'→3' undergoes discontinuous synthesis forming Okazaki fragments. They join to form a new strand by the

enzyme DNA ligase. Hence the new strand will be in 3'→ 5'(lagging strand)

Transcription

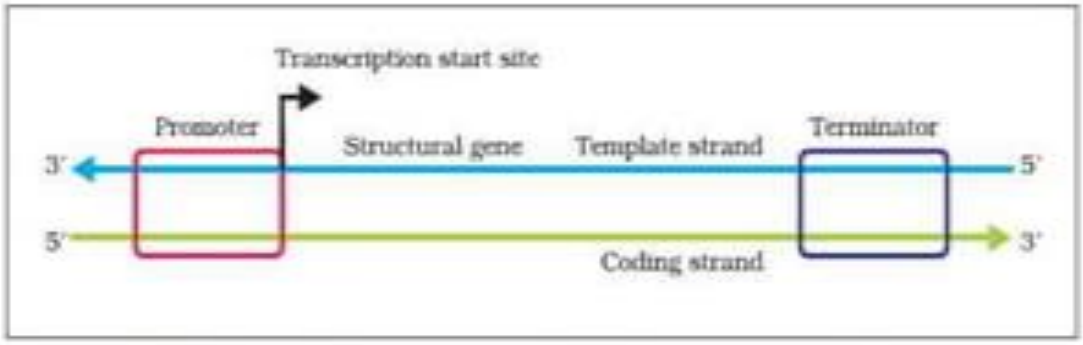
Copying of genetic information from one strand of the DNA into RNA is called transcription.

In transcription, both strands of DNA are not copied because:

1.they would code for two different proteins from the same DNA fragment which would complicate the genetic information transfer machinery.

2.Two RNA molecules if produced would form double stranded RNA.

Transcription Unit



A transcription unit mainly consists of three regions:

1. A promoter: located towards 5' end (upstream). Binding site for RNA polymerase.
2. Structural gene: Flanked by promoter and terminator.
3. A terminator: located towards 3' end (downstream). Defines the end of transcription.

Template strand: on which RNA is transcribed in 5'→3' direction. Promotor is located towards the 3' end of the template strand.

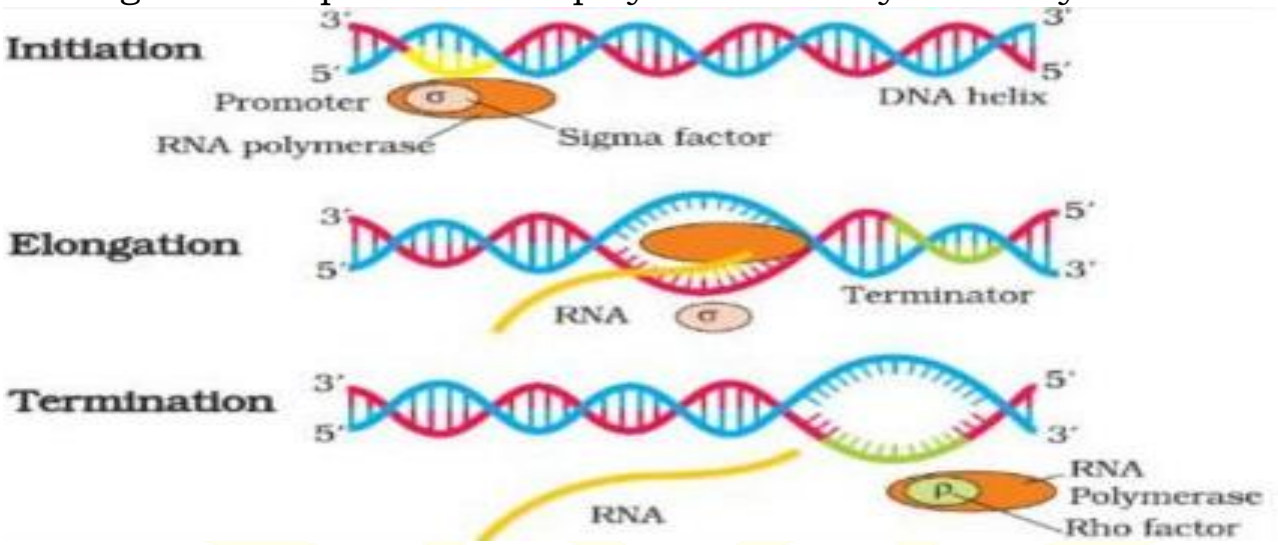
Coding strand: The promotor is located towards the 5' end of the coding strand

Transcription unit and gene:

1. Genes are the functional segment of DNA.
2. The segment of DNA coding for a polypeptide is called cistron.
3. Structural gene in a transcription unit may be monocistronic or polycistronic.
4. Monocistronic structural genes: Codes for one polypeptide only. Seen in eukaryotes. It contains exons and introns. Hence called split genes. The coding/expressed sequences are called exons while the non-expressed sequences are called introns.
5. Polycistronic structural genes: Codes for more than one Polypeptides. Seen in prokaryotes.

Transcription in prokaryotes:

A single DNA dependent RNA polymerase catalyses the synthesis of all



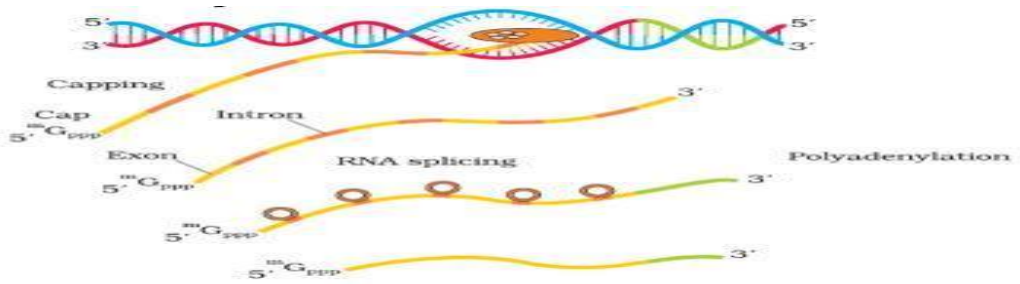
the RNAs i.e mRNA, tRNA and rRNA

1. **Initiation**: RNA polymerase binds to the promoter site along with the initiation factor (sigma factor) which initiates RNA synthesis.
2. **Elongation**: RNA chain is synthesized in 5'-3' direction. Activated ribonucleoside triphosphates are added following the rule of base complementarity.
3. **Termination**: Once the RNA polymerase reaches the terminator, a termination factor (ρ factor) binds to the RNA polymerase and terminates the transcription.

Transcription in eukaryotes:

There are 2 additional complexities:

1. Three different RNA polymerases are required
   RNA polymerase I transcribes 28 S, 18 S and 5.8 S rRNA
   RNA polymerase II transcribes hnRNA(precursor mRNA
   RNA polymerase III transcribes 5S rRNA and tRNA
2. Primary transcripts (hnRNA) contain exons & introns. Hence it undergoes the following processes and become mature mRNA:
   -Splicing: Introns are removed and exons are joined
   -Capping: Methyl guanosine triphosphate (cap) is added to the 5' end of hnRNA. -Tailing (Polyadenylation): Adenylate residues (200-300) are added to 3 '-end.



Genetic Code

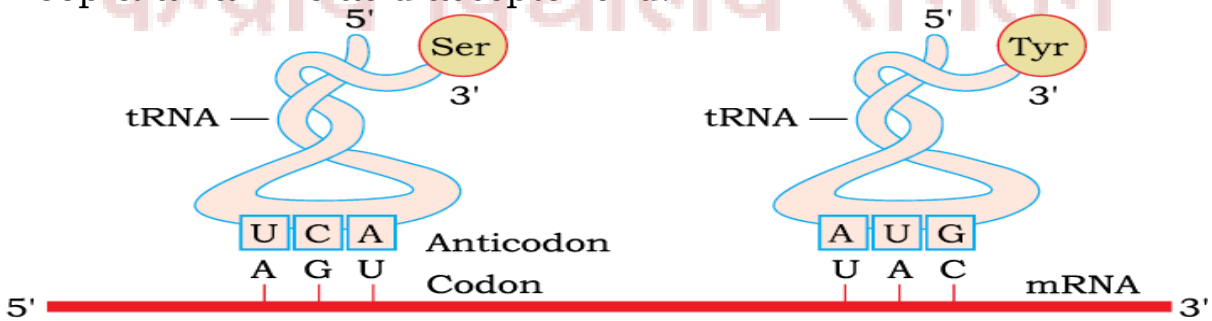
-The relation between the sequence of nucleotides in the mRNA and the sequence of amino acids in a polypeptide chain.
-George Gamow suggested that the genetic code is triplet.
-Har Govind Khurana synthesised an RNA molecule with known nucleotides.
-Marshal Nirenberg synthesised proteins in a cell free system.
-Severo Ochoa discovered enzyme polynucleotide phosphorylase for enzymatic synthesis of RNA.

Salient features of genetic code:

1. The codons are triplet. 61 codons code for amino acids. UAA, UAG & UGA are stop codons (Termination codons). So total 64 codons.
2. Genetic code is universal.
3. One codon codes for only one amino acid. Hence it is unambiguous and specific.
4. Some amino acids are coded by more than one codon. So the code is degenerate.
5. No punctuations between adjacent codons.
6. AUG has dual functions: Codes for Methionine and it is the initiator codon.

Types of RNA:

1. mRNA (messenger RNA): Provide template for translation (protein synthesis).
2. rRNA (ribosomal RNA): catalytic role during translation.
3. tRNA (transfer RNA): Adapter molecule. Brings amino acids for protein synthesis and reads the genetic code. It has an Anticodon loop & an amino acid acceptor end.



Translation (Protein Synthesis)

1. **Charging (aminoacylation) of tRNA**: Amino acids are activated (amino acid + ATP) + tRNA.
2. **Initiation**: Smaller sub-unit of the ribosome binds to mRNA at the start codon (AUG). Then the initiator tRNA (with methionine) binds with the first codon. The larger subunit of the ribosome recognized by the initiator tRNA binds to form a complete initiation complex.
3. **Elongation**: Second aminoacyl tRNA binds to ribosome. Its anticodon binds to second codon. A peptide bond is formed between first and second amino acids. The ribosome proceeds from codon to codon along the mRNA and amino acids are added one by one to form a polypeptide chain.
4. **Termination**: Once the ribosome reaches to the stop codon, the release factor binds to the stop codon, terminate the process of translation and the polypeptide chain is released.

UTR- mRNA has sequences that are not translated (untranslated regions or UTR). They are required for efficient translation.

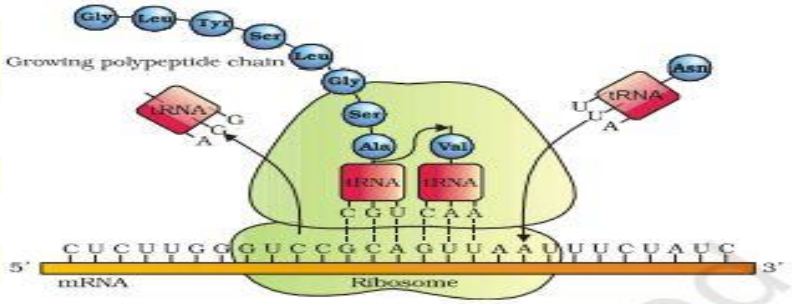


Figure 6.13 Translation

Regulation of Gene Expression

In eukaryotes, gene expression can be regulated at several levels such as:

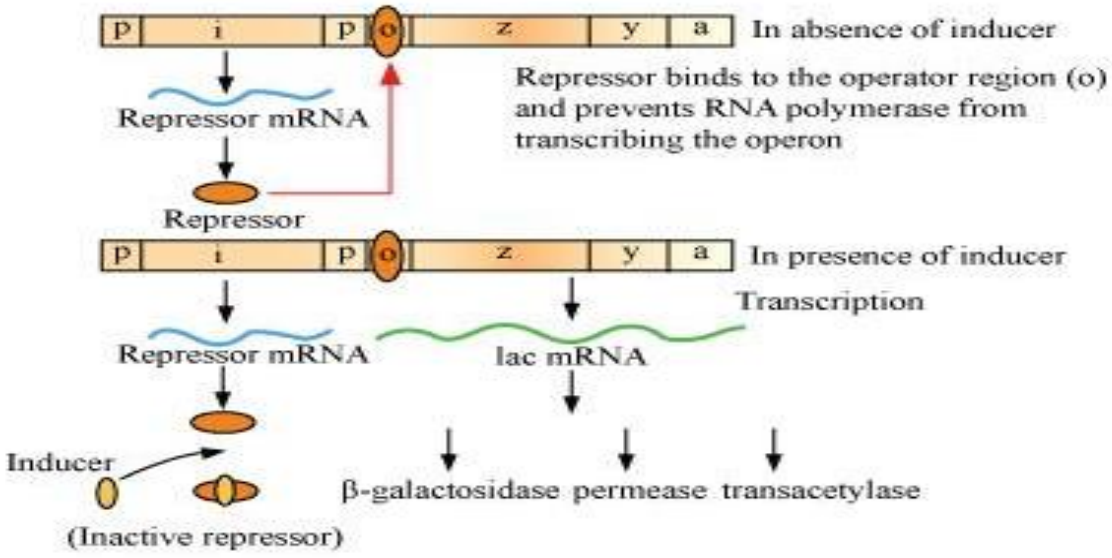
1. transcriptional level (formation of primary transcripts),
2. processing level (regulation of splicing),
3. transport of mRNA from nucleus to cytoplasm
4. translational level.

But in prokaryotes, gene expression is regulated at transcriptional level only. One of the example is Lac Operon (*Lactose Operon*).

Lac Operon:

- Proposed by 'Jacob' and 'Monod'
- A polycistronic structural gene is regulated by a common promoter and regulatory gens.
- In *E. coli* lac operon consists of

1. A regulatory or inhibitor (i gene) Codes for repressor protein.
2. three structural genes:
    i. z gene: Codes for β-galactosidase. It hydrolyses lactose to galactose and glucose.
    ii. y gene: Codes for permease. It increases permeability of the cell to lactose.
    iii. a gene: Codes for a transacetylase.



Human Genome Project

First mega project for sequencing of nucleotides and mapping of all genes in human genome.

Goals of HGP

1. Identify all the genes in DNA.
2. Sequencing of 3 billion base pairs of human DNA.
3. Store this information in databases.
4. Improve tools for data analysis.
5. Transfer related technologies to other sectors.
6. Address the ELSI.

Methodologies of HGP: 2 approaches.

1. Expressed Sequence Tags (ESTs): Focused on identifying all the genes that are expressed as RNA.
2. Sequence Annotation: Sequencing whole genome.

Procedure of sequencing:

1. Isolation of DNA
2. Fragmentation of whole DNA into small fragments.
3. Separation of fragments

4. Attachment with vectors like BAC and YAC and transferring to the host.
5. Fragments are sequenced by using Automated DNA Sequencer developed by Sanger.
6. Arrangement of sequences with the help of overlapping fragments.
7. The sequences are annotated and assigned to individual chromosomes.

Salient features of Human Genome

1. Contains 3164.7 million bases & 30,000 genes.
2. 99.9% nucleotide bases are same in all people.
3. Chromosome I has most genes (2968) and Y has the fewest (231).
4. Major portion of genome is made of Repeated (repetitive) sequences.
5. 1.4 million locations have single-base DNA differences. They are called SNPs (Single nucleotide polymorphism or `snips').

Rice Genome Project

-Rice genomes consist of 12 chromosomes and sizes of 380 to 430 Mb.

-A rice plant has more genes than a human being. i.e. about 45000 to 63000 genes.

What was the Rice Genome Project?

-In September 1997, during a workshop conducted in connection with the International Symposium on Plant Molecular Biology in Singapore, the International Rice Genome Sequencing Project (IRGSP) was launched.

-Scientists from Japan, the United States, European Union, China, Korea etc. participated in the symposium.

- The IRGSP predicted to complete the project in ten years at a cost of around 200 million dollars.

Objectives of Rice Genome Project

The objectives of the rice genome project are as follows:

1. Discover the function of every gene in the rice genome by the year 2020,
2. To find the functional diversity of alleles
3. Use the findings of functional genomics research to rice genetic improvement

Salient Features of Rice Genome Project

1. Rice has a genome size of 389 mb. 370.7 mb has been sequenced, 18.1 mb unsequenced.
2. Sequenced segment represents 99% of euchromatin and 95% of rice genome.

3. A total of 37,544 rice genes have been discovered.
4. Repetitive DNA constitute about 50% of the genome
5. 2859 genes unique to rice and other cereals.

Applications of Rice Genome Project

1. Improve efficiency of rice breeding.
2. Improve the nutritional quality of rice.
3. Rice mutants in large numbers and types have been created intentionally. It aids in the enhancement of molecular products.
4. Rice genomics is an open-access journal dedicated to rice genome research.
5. Understanding plant evolution.

DNA Fingerprinting (DNA Profiling)

-Technique to identify similarities & differences of the DNA fragments of 2 individuals. -It is developed by Dr. Alec Jeffreys.

Basis of DNA fingerprinting

-DNA carries non-coding repetitive sequences called variable number tandem repeats (VNTR). VNTR is specific in each person.

Steps (Southern Blotting Technique)

1. Isolation of DNA.
2. Digestion of DNA by restriction endonucleases.
3. Separation of DNA fragments by gel electrophoresis.
4. Transferring (blotting) DNA fragments to nitrocellulose or nylon membrane.
5. Hybridization by radioactive VNTR probe.
6. Detection of hybridized DNA by autoradiography.

Application of DNA fingerprinting:

1. Forensic tool to solve paternity, rape, murder etc.
2. For the diagnosis of genetic diseases.
3. To determine phylogenetic status of animals.

QUESTION BANK

MULTIPLE CHOICE TYPE

1.In a DNA strand the nucleotides are linked together by
(a) glycosidic bonds
(b) phosphodiester bonds
(c) peptide bonds
(d) hydrogen bonds.

2. The net electric charge on DNA and histones is
(a) both positive
(b) both negative

(c) negative and positive, respectively
(d) zero.

3.The first genetic material could be
(a) protein
(b) carbohydrates
(c) DNA
(d) RNA.

4.The human chromosome with the highest and least number of genes in them are respectively
(a) chromosome 21 and Y
(b) chromosome 1 and X
(c) chromosome 1 and Y
(d) chromosome X and Y.

5.Who amongst the following scientist had no contribution in the development of the double helix model for the structure of DNA?
(a) Rosalind Franklin
(b) Maurice Wilkins
(c) Erwin Chargaff
(d) Meselson and Stahl

6.Which of the following steps in transcription is catalysed by RNA polymerase?
(a) Initiation
(b) Elongation
(c) Termination
(d) All of the above

7.If a double stranded DNA has 20% of cytosine, what will be the percentage of adenine in it?
(a) 20%
(b) 40%
(c) 30%
(d) 60%

8.If the sequence of bases in one strand of DNA is ATGCATGCA, what would be the sequence of bases on complementary strand?
(a) ATGCATGCA
(b) AUGCAUGCA

(c) TACGTACGT
(d) UACGUACGU

9.Synthesis of DNA from RNA is explained by
(a) central dogma reverse
(b) reverse transcription
(c) feminism
(d) all of these.

10.The structure in chromatin seen as 'beads-on string' when viewed under electron microscope are called
(a) nucleotides
(b) nucleosides
(c) histone octamer
(d) nucleosomes.

11.Select the incorrectly matched pair.
(a) Initiation codons – AUG
(b) Stop codons – UAA, UAG, UGA
(c) Methionine – AUG
(d) Anticodons – mRNA

12.Amino acid acceptor end of tRNA lies at
(a) 5' end
(b) 3' end
(c) T VC loop
(d) DHU loop.

13.During translation, activated amino acids get linked to tRNA. This process is commonly called as
(a) charging of tRNA
(b) discharging of tRNA
(c) aminoacylation of tRNA
(d) both (a) and (c)

14.To prove that DNA is the genetic material, which radioactive isotopes were used by Hershey and Chase (1952) in experiments?
(a) ^{33}S and ^{15}N
(b) ^{32}P and ^{35}S
(c) ^{32}P and ^{15}N
(d) ^{14}N and ^{15}N

15.If the sequence of bases in coding strand of DNA is ATTCGATG, then the sequence of bases in mRNA will be
(a) TAAGCTAC
(b) UAAGCUAC
(c) ATTCGATG
(d) AUUCGAUG.

16.If the sequence of bases in DNA is GCTTAGGCAA then the sequence of bases in its transcript will be
(a) GCTTAGGCAA
(b) CGAATCCGTT
(c) CGAAUCCGUU
(d) AACGGAUUCG.

17.In eukaryotes, the process of processing of primary transcript involves
(a) removal of introns
(b) capping at 5'end
(c) tailing (polyadenylation) at 3' end
(d) all of these.

18.Which was the last human chromosome to be completely sequenced?
(a) Chromosome 1
(b) Chromosome 23
(c) Chromosome Y
(d) Chromosome X

19.The RNA polymerase holoenzyme transcribes
(a) the promoter, structural gene and the terminator region.
(b) the promoter and the terminator region
(c) the structural gene and the terminator region
(d) the structural gene only.

20.In *E. coli*, the lac operon gets switched on when
(a) lactose is present and it binds to the repressor
(b) repressor binds to operator
(c) RNA polymerase binds to the operator
(d) lactose is present and it binds to RNA polymerase.

21.Which out of the following statements is incorrect?
(a) Genetic code is ambiguous.
(b) Genetic code is degenerate.
(c) Genetic code is universal.
(d) Genetic code is non-overlapping.

22.The mutations that involve addition, deletion or substitution of a single base pair in a gene are referred to as
(a) point mutations
(b) lethal mutations
(c) silent mutations
(d) retrogressive mutations.

23.Select the correct match of enzyme with its related function.
(a) DNA polymerase – Synthesis of DNA strands
(b) Helicase – Unwinding of DNA helix
(c) Ligase – Joins together short DNA segments
(d) All of these

24.DNA replication takes place at _____ phase of the cell Cyle.
(a) G_1
(b) S
(c) G_2
(d) M

25.In a mRNA molecule, untranslated regions (UTRs) are present at
(a) 5' – end (before start codon)
(b) 3' – end (after stop codon)
(c) both (a) and (b)
(d) 5'- end only.

26.UTRs are the untranslated regions present on
(a) rRNA
(b) hnRNA
(c) mRNA
(d) tRNA.

27.Which of the following statements is correct regarding ribosomes?
(a) in most of the cells, DNA molecule are stored there.
(b) Complete polypeptide is released from there.

(c) mRNAs are produced there.
(d) DNA replication takes place there.

28.The sequence of structural genes in lac operon is
(a) Lac a, Lac y, Lac z
(b) Lac a, Lac z, Lac y
(c) Lac y, Lac a, Lac z
(d) Lac z, Lac y, Lac a

29.Human genome consists of approximately
(a) 3×10^9 bp
(b) 6×10^9 bp
(c) 20,000 – 25,000 bp
(d) 2.2×10^4 bp.

30.Chemically, RNA is (i) reactive and (ii) stable as compared to DNA.
(a) (i) equally, (ii) equally
(b) (i) less, (ii) more
(c) (i) more, (ii) less
(d) (i) more, (ii) equally

ANSWER KEY

Q.NO.	CORRECT OPTION	Q.NO.	CORRECT OPTION	Q.NO.	CORRECT OPTION
1	b	11	d	21	a
2	c	12	b	22	a
3	d	13	d	23	d
4	c	14	b	24	b
5	d	15	d	25	c
6	d	16	c	26	c
7	c	17	d	27	b
8	c	18	a	28	d
9	b	19	d	29	a
10	d	20	a	30	c

CASE BASED/SOURCE BASED QUESTIONS

Q1.

The Human Genome Project is an international research project whose primary mission is to decipher the chemical sequence of the

complete human genetic material, identify all 50000 -1lakh genes contained within the genome and provide research tools to analyze all this genetic information. This ambitious project based on the fact that the isolation and analysis of genetic material contained in the DNA can provide scientists with powerful new approaches to understanding the development of disease and to creating new strategies for their prevention and treatment. These disorders include the four thousand are so Mendelian diseases that result from mutations from a single gene.

1. What is meant by Genome?
2. What are the goals of HGP? (Any two)
3. What are the assumptions on which the HGP is based on?

Q2.

4. Name the term used for mutation in a single gene.

DNA replicates through the semiconservative method. It is proved by scientists Matthew Meselson and Franklin Stahl. Meselson and Stahl conducted an experiment to prove that DNA replication is semi conservative. They grew bacterium E. coli in a medium containing nitrogen salt (15NH4Cl) labelled with heavy isotope of nitrogen ^{15}N. ^{15}N was incorporated into both the strands of DNA and such a DNA was heavier than the DNA obtained from E. coli grown on a medium containing ^{14}N. Then they transferred the E. coli cells on to a medium containing ^{14}N. After one generation, when one bacterial cell has multiplied into two, they isolated the DNA and evaluated its density. Its density was intermediate between that of the heavier ^{15}N-DNA and the lighter ^{14}N-DNA. This is because during replication, new DNA molecule with one ^{15}N-old strand and a complementary ^{14}N-new strand was formed (semi-conservative replication) and so its density is intermediate between the two.

1.In Meselson and Stahl experiment, ^{15}N can only be differentiated on the basis of

(a) Radioactivity (b) Filtration
(c) Physical observation (d) Density gradient

2. *E. coli* completes DNA replication in approximately

(a) 15 minutes (b) 20 minutes
(c) 18 minutes (d) 40 minutes

3. Which Chemical essential for density gradient centrifugation-

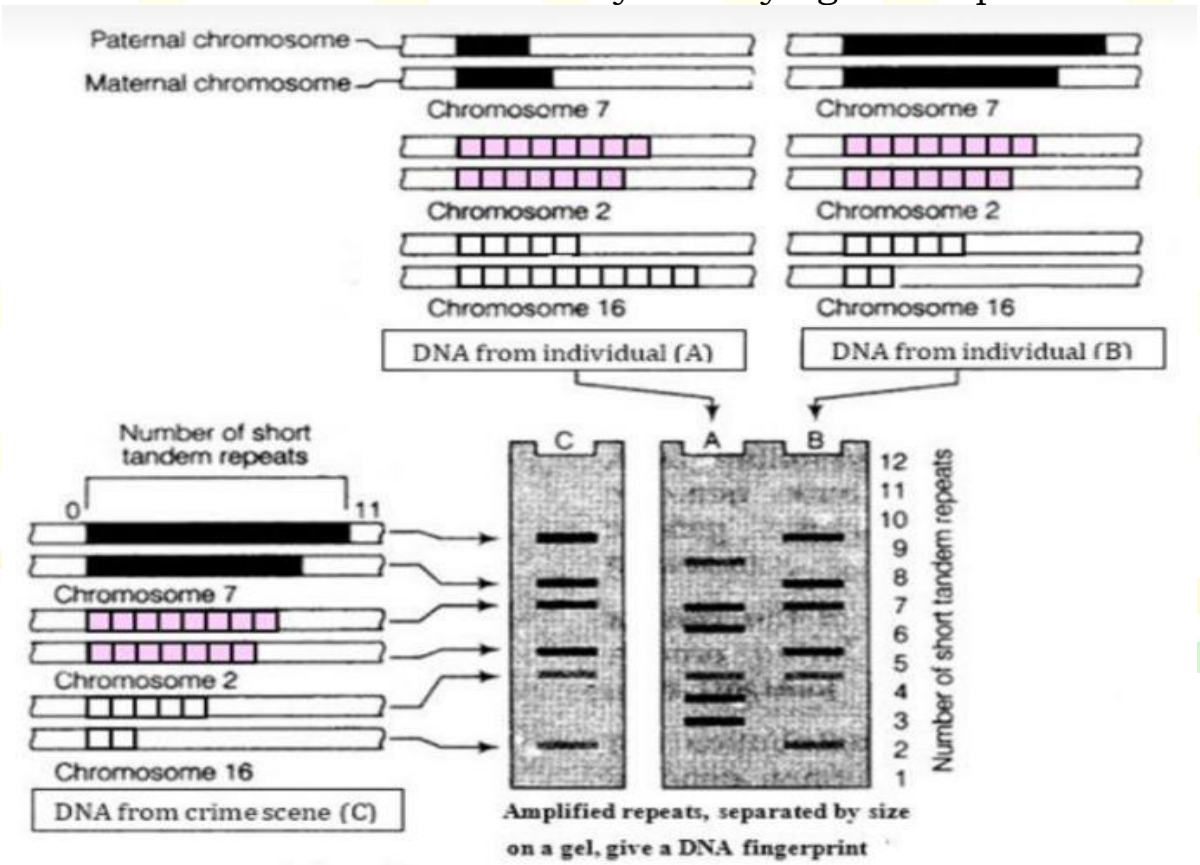
(a) $CsCl_2$ (b) Cs_2Cl_2
(c) Cs_2Cl (d) CsCl

4. If Meselson and Stahl's experiment is continued for four generations in bacteria, the ratio of N15/N15: N15/N14: N14/N14 containing DNA in the third generation would be:

a. 0:2:2
b. 1:4:0
c. 0:1:3
d. 0:2:6

Q3.

Two blood samples of suspects 'A' and 'B' were sent to the Forensic Department along with sample 'C' from the crime scene. The Forensic Department was assigned the responsibility of running the samples and matching the samples of the suspects with that of the sample from the scene of the crime and thereby identifying the culprit.



1. In genetic fingerprinting, the 'probe' refers to –
   a. A radioactively labelled double stranded RNA molecule.
   b. A radioactively labelled double stranded DNA molecule.
   c. A radioactively labelled single stranded DNA molecule.
   d. A radioactively labelled single stranded RNA molecule.
2. What does 'minisatellite' and 'microsatellite' mean in relation to DNA fingerprinting?

Q3: How does polymorphism arise in a population?

Q4: State the steps involved in DNA Fingerprinting in a sequential manner.

Q4.

The genes in a cell are expressed to perform a particular function or a set of functions. For example, if an enzyme called beta-galactosidase is synthesized by E. coli, it is used to catalyse the hydrolysis of a disaccharide, lactose into galactose and glucose; the bacteria used them as a source of energy. Hence, if the bacteria do not have lactose around them to be utilized for energy source, they would no longer require the synthesis of the enzyme beta- galactosidase. The development and differentiation of embryo into adult organism are also a result of the coordinated regulation of expression of several sets of genes.

1. Which one is not a part of transcription unit in DNA?
   a. The inducer
   b. promoter
   c. terminator
   d. structural gene
2. The correct option regarding the lac operon in E.coli from the following is:
   a. lac operon is switched on in the absence of lactose
   b. lac repressor binds to the lac promoter
   c. beta- galactosidase is the only enzyme produced in large quantities when lac operon is turned on
   d. lac operon messenger RNA is a polycistronic mRNA
3. In a cell, as per the operon concept governs, the regulator gene governs the chemical reactions by-
   a. inhibiting the substrate in the reaction.
   b. mRNA transcription inhibited
   c. enzyme-reaction inactivation
   d. none of the above
4. In E. coli when does the lac operon gets switched on?

ANSWER KEY
CASE BASED/SOURCE BASED QUESTIONS

Q1.

1.Complete set of genes of genetic material present in a cell.

2.(i)To identify all the genes in human DNA (ii)To store the information in Database, (Any two correct)

3.DNA sequencing and Genetic engineering.

4.Point mutation.

Q2.

1. d
2. b
3. d
4. d

Q3.

1. c
2. Minisatellite: the repeating unit consists of 10-100 base pairs.
   Microsatellite: the repeating unit consists of 2-6 base pairs.
3. Polymorphism (variation at the genetic level) arises due to mutations.
4. Steps of DNA Fingerprinting:
   i. DNA isolation
   ii. DNA digestion with restriction enzymes.
   iii. DNA fragment separation by electrophoresis.
   iv. Blotting
   v. Hybridization
   vi. DNA visualization under UV light.

Q4.

1. a
2. d
3. b
4. In the presence of lactose

LA TYPE QUESTIONS

Q1. The Human Genome Project was an international scientific research project with the goal of determining the base pairs that make up human DNA, and of identifying, mapping and sequencing all of the genes of the human genome from both a physical and a functional standpoint. It started in 1990 and was completed in 2003.The methods involved two major approaches which paved the pathway to understand human biology, to treat and diagnose a disease and prevent thousands of disorders.

(a) What are the two major approaches involved in the 'Human Genome Project'?

(b) Identify one of the above methods which took the blind approach and what was the blind approach?

(c) Name the commonly used two vectors in the HGP?

(d) 'The scientists involved in the above project identified about 1.4 million peculiar locations in the human genome'. Name these locations and state any one revolutionary significance.

(e) Apart from working on the principle of automated DNA sequencers, Frederick Sanger was also credited for another significant development. What was that development?

Q2. Lac operon contains genes involved in lactose metabolism. It is one of the classic examples of gene regulation in prokaryotes which very well explains that it is the metabolic, physiological or environmental conditions that regulate the gene expression. Lac operon also illustrates the concept of polycistronic genes, which is a key feature of prokaryotic genes.

(a) A curious student based on the above information started working in the lab using culture plates to study the concept of Lac Operon. In one culture plate he provided lactose medium for the *E. coli bacteria*. Explain the observation of the student through a labelled diagram.

(b) In the other culture plate, he grew *E. coli* without lactose. Do you think the operon worked in this situation? Substantiate your answer by giving a suitable explanation.

Why is Lactose termed as inducer?

Q3.

(a) DNA replication occur in small replication forks and not in its entire length. Give reasons.

(b) DNA replication is continuous and discontinuous in a replication fork. Justify and explain both.

(c) During which phase of cell cycle does replication occur?

(d) The discontinuously synthesised fragments are joined by an enzyme. Name the enzyme.

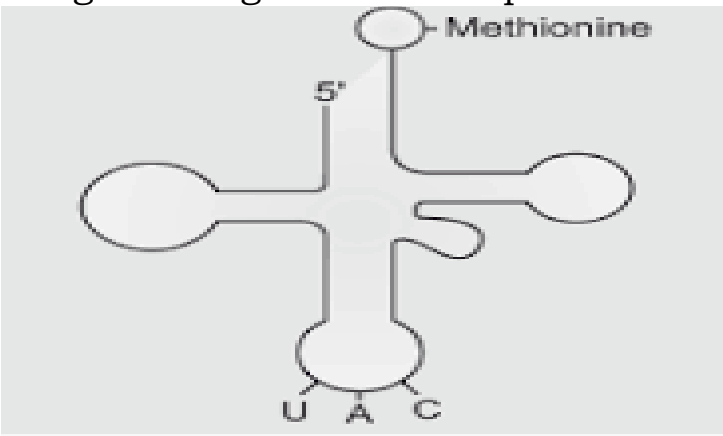
Q4. How did Alfred Hershey and Martha Chase arrive at the conclusion that DNA is
the genetic material?

Q5. In a series of experiments with Streptococcus and mice F. Griffith concluded that R-strain bacteria had been transformed. Explain.

Q6. (a) State the 'Central dogma' as proposed by Francis Crick. Are there any exceptions to it? Support your answer with a reason and an example.

(b) Explain how the biochemical characterisation (nature) of 'Transforming Principle' was determined, which was not defined from Griffith's experiments.

Q7. The following is the figure of an adapter molecule.



(a) Name the scientist who postulated the presence of an adapter molecule in protein synthesis. What was it known as before the genetic code was postulated?
(b) Mention its role in protein synthesis.
(c) Explain the first step of protein synthesis in which this molecule is involved.

Q8. Observe the segment of mRNA given below.

(a) Explain and illustrate the steps involved to make fully processed hnRNA?
(b) Gene encoding RNA Polymerase I and III have been affected by mutation in a cell. Explain its impact on the synthesis of polypeptide, stating reasons.

Q9. Study the schematic representation of the genes involved in the lac operon given below and answer the questions that follow:

(a) The active site of enzyme permease present in the cell membrane of a bacterium has been blocked by an inhibitor,

how will it affect the lac operon?

(b) The protein produced by the i gene has become abnormal due to unknown reasons. Explain its impact on lactose metabolism stating the reason.

(c) If the nutrient medium for the bacteria contains only galactose, will operon be expressed? Justify your answer.

Q10. (a)Identify giving reasons the salient features of their record by studying the following nucleotide sequences of mRNA stand and the polypeptide translated from it

5' AUG UUU UCU UUC UUU UCC UAG 3'

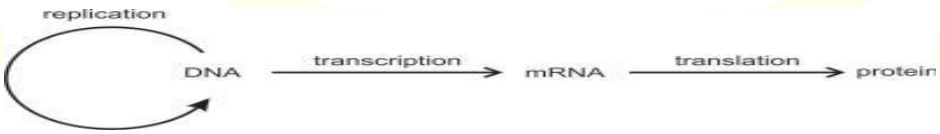
Met-Phe-Ser-Phe-Phe-Ser

(b). Calculate the length of DNA of bacteriophage lambda that has 48502 base pairs?

MARKING SCHEME

Q.N	PROBABLE ANSWERS	MARKS
1	(a)Expressed Sequence Tags/Sequence Annotation (b)Sequence Annotation – This blind approach involved sequencing the whole genome (coding and non-coding) and later assigning functions to the different regions. (c)BAC(bacterial artificial chromosome and YAC (Yeast Artificial Chromosome (d)SNPs/for tracing human history and also helps in finding chromosomal locations for disease associated sequences. (e)For determination of amino acid sequences in proteins.	1 X 5
2	Figno.6.14 (a) Lac operon diagram in presence of inducer (b) No, because in the absence of inducer lactose, the regulatory gene, I produces a repressor protein that binds to the operator site and prevents transcription of structural genes so operon gets switched off. It regulates switching off and on of the operon	½ X 6 1 1

3	(a) DNA being very long, requires high energy for opening along its entire length (b) DNA dependent DNA polymerase catalyse polymerisation only in one direction, i.e. 5' to 3', Correct explanation (c) S phase (d) DNA ligase.	2 1+1 ½ ½
4.	Hershey and Chase conducted their experiment on bacteriophage and proved that DNA is the genetic material. (i) They grew some bacteriophage virus on a medium that contained radioactive phosphorus (**P^{32}**) and some in another medium with radioactive Sulphur (**S^{35}**) respectively. (ii) Viruses grown in the presence of radioactive phosphorus (**P^{32}**) contained radioactive DNA. (iii) Similar viruses grown in presence of radioactive Sulphur (**S^{35}**) contained radioactive protein. (iv) Both the radioactive viruses were allowed to infect E. coli separately. (v) Soon after infection the bacterial cells were gently agitated in a blender to remove viral coats from the bacteria. (vi) The culture was also centrifuged to separate the viral particle from the bacterial cell. (vii) It was observed that only radioactive (**P^{32}**) was found associated with the bacterial cell and (**S^{35}**) was only in the surrounding medium and not in the bacterial cell. (viii) The result clearly indicates that only DNA and not protein coat entered the bacterial cell and this proves that DNA is the genetic material that is passed from virus to bacteria and not protein. OR Fig 6.5 NCERT page no. 102	5

5.	F. Griffith (1928), conducted an experiment with Streptococcus pneumoniae (bacterium causing pneumonia). He observed two strains of this bacterium, one forming a smooth shiny colony (S-type) with capsule, while other forming rough colonies (R-type) without capsule. When live S-type cells were injected into the mice, mice died due to pneumonia. When live R-type cells were injected into the mice, mice survived. When heat killed S-type cells were injected into the mice, mice survived and there were no symptoms of pneumonia. When heat killed S-type cells were mixed with live R-type cells and injected into the mice, the mice died due to unexpected symptoms of pneumonia. He concluded that heat killed S-type bacteria caused a transformation of the R type bacteria into S-type bacteria.	5
6	a.  Yes , in some viruses flow of information is in reverse direction / reverse transcription = ½ + ½ e.g. Any Retrovirus / HIV = ½ (b) Protein and DNA and RNA were purified from heat killed S strain / smooth *Streptococcus / Diplococcus pneumoniae* = ½ Protein + Protease transformation occurred (R cell to S type) = ½ RNA + RNAase transformation occurred (R cell to S type) = ½ DNA + DNAase transformation inhibited = ½ Hence DNA alone is the transforming material = ½, independent of the other pair of characters = 1	2+3

7	(a) Francis crick, soluble RNA/ (sRNA) (½ + ½) (b) On one hand it reads the code, on the other hand binds to specific amino acids. (1) + (1) (c) Charging of tRNA/ Aminoacylation of tRNA, activation of amino acids in the presence of ATP and linking them to their cognate tRNA. (1)+(1)	5
8	(a) The hnRNA undergoes processes called capping and tailing followed by splicing. In capping, an unusual nucleotide is added to the 5-end of hnRNA methyl guanosine triphosphate. In tailing, adenylate residues (about 200–300) are added at 3¢-end in a template independent manner. Now the hnRNA undergoes a process where the introns are removed and exons are joined to form mRNA called splicing. (½x 6 =3 marks) (b) The process of translation will not happen, thu polypeptide synthesis is stopped/ hampered. (1 Mark) The reason for the above is: RNA polymerase I transcribes rRNAs which is the cellular factory for protein synthesis. (½ Mark) RNA polymerase III helps in transcription of tRNA which is the adaptor molecule/ that transfers amino acids to the site of protein synthesis. (½ Mark)	
9	(a) When the active site of enzyme permease present in the cell membrane of a bacterium has been blocked by an inhibitor, the lactose is not transported into the cell (1 Mark). As lactose is the inducer, the lac operon will not be switched on. (1Mark) (b) Since the repressor protein synthesized by the i gene is abnormal, it will not bind to the operator region of th operon (1Mark), resulting in a continuous state of	

	transcription process. (1 Mark) (c) No (½ Mark), because galactose is not an inducer/ it is a product of lactose metabolism (½ Mark)	
10	(a). (i) The codon is a triplet. e.g., AUG, UUU, etc, are triplets (ii) One codon codes for only one amino acid, hence it is unambiguous and specific. e.g., UUU codes for serine, AUG for methionine, etc. (iii) One amino acid can be coded by more than one codon. Hence degenerate. (iv) AUG has dual function as it codes for methionine and it also acts as initiator codon. AUG is seen at the beginning of the polypeptide chain. (v) (iv) UAG does not code for any amino acid hence is called stop codon and leads to end of translation. No amino acid is coded by UAG in the polypeptide chain given. Any Four (b). Distance between two consecutive base pairs = 0.34×10^{-9} m The length of DNA in bacteriophage lambda = $48502 \times 0.34 \times 10^{-9}$ m $= 16.49 \times 10^{-6}$ m	4 + 1

CHAPTER-7 EVOLUTION

SHORT NOTE / CHAPTER AT A GLANCE FOR QUICK REVIEW

KEY WORDS

Evolution- It is the study of history of life forms on earth.

Big Bang- A huge explosion in cosmic material which gave rise to the universe.

Fossils- Remains of hard parts of life forms of past found in rocks.

Homologous organs- Organs in different organisms which share similarities in structural plan but perform different functions.
Analogous organs- Organs in different organisms which perform similar functions but not anatomically similar in structures.
Divergent Evolution- Development of the same structures in different animals of the same group along different directions due to adaptations to different needs.
Convergent Evolution- Different structures evolving for the same function and hence having similarity.
Adaptive radiation- The process of evolution of different species in a given geographical area starting from a point and literally radiating to other areas of geography is called adaptive radiation.
Natural selection- Natural selection is a process in which heritable variations enabling better survival are enabled to reproduce and leave greater number of progeny.
Speciation- Process of formation of new species from a pre-existing species.
Saltation- Single step large mutation that may cause speciation.

EVOLUTION

-Derived from Latin word *'evolvere'* means to unfold or unroll.
-It is the history of life on earth.

ORIGIN OF LIFE

1.Creation of Universe (Big Bang Theory)-

-Universe is about 20 billion years old
-Origin of universe was by a single huge explosion unimaginable in physical term.

2.Origin of solar system and earth-

-Earth was about 4.5 billion years old.
-Water vapour, methane, ammonia and carbon dioxide covered the earth surface
-UV rays broke up water into hydrogen and oxygen.
-Life originated about 4 bya.

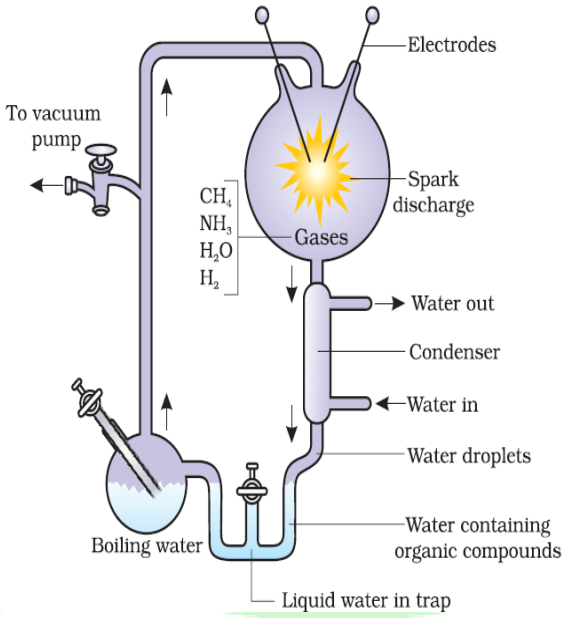
3.Theories of Origin of Life-

a. Theory of special creation- Life was created by some supernatural power, the god.
b. Theory of panspermia- Theory of panspermia/cosmozoic theory, given by early Greek thinkers states that the spores or panspermia came from outer space and developed into living forms.
c. Theory of Spontaneous generation / Abiogenesis- Theory of spontaneous generation states that life originated from decaying and rotting matter like straw, mud, etc

-Louis Pasteur rejected the theory of spontaneous generation and demonstrated that life came from pre-existing life.
- In his experiment, he kept killed yeast cells in pre-sterilised flask and another flask open into air. The life did not evolve in the former but new living organisms evolved in the second flask.
d. Theory of chemical evolution or Oparin-Haldane theory- It states that life originated from pre-existing non-living organic molecules and formation of life was preceded by chemical evolution. The conditions on the earth that favoured chemical evolution were very high temperature, volcanic storms and reducing atmosphere that contained CH_4, NH_3, water vapour, etc.

Experimental Proof for Chemical Evolution of Life-

Miller's experiment provided experimental evidence for chemical evolution.



- The experiment was carried out by SL Miller and HC Urey in 1953.

- He took a closed flask containing CH4, H2, NH3 and water vapour at 800°C and created electric discharge. These conditions were like those in primitive atmosphere.

- After a week, formation of amino acids was observed. Complex molecules like sugars, nitrogen bases, pigments and fats were seen in the flask by other scientists.

- Analysis of the meteorite also revealed the presence of similar compounds.

- Chemical evolution of life was more or less accepted.

EVIDENCES OF ORGANIC EVOLUTION

1.Evidence from Palaeontology- Palaeontology is the study of fossils. Rocks form sediments and a cross-section of earth's crust indicates the arrangement of sediments one over the other during the long history of earth.

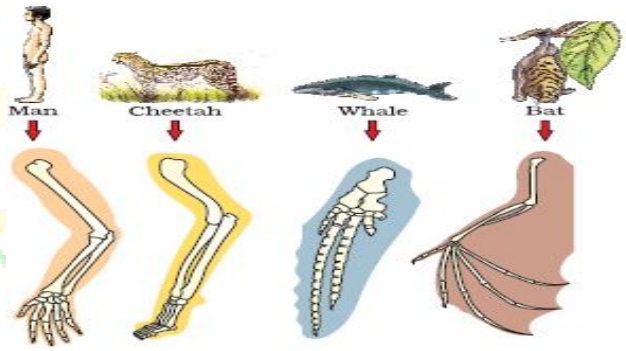
- Different aged rock sediments contain fossils of different life forms, who died during the formation of the sediment.

- Some organisms appear like modern organisms. They represent extinct organisms like dinosaurs.

- A study of fossils in different sedimentary layers indicates the geological period in which they existed.

- The study showed that life forms varied over time and certain life forms are restricted to certain geological time-scale Hence, new forms of life have evolved at different times in the history of earth.

2.Evidence from morphology and comparative anatomy- It shows the similarities and differences among the organisms of today and those that existed years ago. The evidences come from comparative study of external and internal structure.



A. Homologous organs-

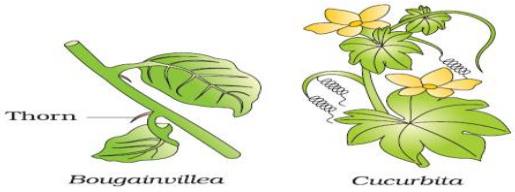
-The organs with same structural design and origin but different functions are called homologous organs

-Homology in organ indicates common ancestry.

-Homology is based on divergent evolution. The same structure developed along different directions due to adaptations to different needs. The condition is called divergent evolution.

-Examples are forelimbs of some animals like whales, bats and cheetah have similar anatomical structure, such as humerus, radius, ulna, carpals, metacarpals and phalanges. Other examples of homology are vertebrate hearts or brains.

In plants also, thorns and tendrils of Bougainvillea and Cucurbita represent homology.



B. Analogous organs-

-Organs which are anatomically different but functionally similar are called analogous organs. For example, wings of butterfly and birds.

-Analogy refers to a situation exactly opposite to homology.

-Analogous organs are a result of convergent evolution. It is the evolution in which different structures evolve for same function and hence, have similarity.

-Other examples of analogy are eyes of Octopus and mammals; flippers of penguins and dolphins. In plants, sweet potato (root modification) and potato (stem modification).

3.Evidence from embryology-

-Study of comparative embryology shows common patterns of development.

-The principles of embryonic development were given by Von Baer.

-Ernst Haeckel propounded the **theory of recapitulation or Biogenetic law** which states that an individual organism in its development (ontogeny) tends to repeat the stages passed through by its ancestors (phylogeny), i.e. **ontogeny recapitulates phylogeny**.

4.Evidence from biochemistry-

-Similarities in proteins and genes performing a given function among diverse organisms give clues to common ancestry. -These biochemical similarities point to the same shared ancestry as structural similarities among diverse organisms.

5.Evidences from Natural selection-

Before industrialisation in England: - During 1850s, moths were observed in the tree trunks in which white winged moths were more than dark winged moths.

After industrialisation: - During 1920s, there were more dark winged moths in the same area.

-This was due to the light lichens on the tree trunk where white winged moths couldn't be identified by the predators. But after industrialisation the tree trunk becomes dark where dark winged moths survived better.

-This showed the population that can better-adapt, survive and increase population size.

Evolution by Anthropogenic action: - The followings are the examples of evolution by anthropogenic action

1. Industrial melanism
2. Herbicides and Pesticide resistant varieties of crops
3. Microbes resistant towards antibiotics and drugs

Adaptive radiation-

Adaptive radiation is an evolutionary process in which an ancestral stock gives rise to new species adapted to new habitats and new ways of life. Examples are Darwin's finches. These were small black birds, which Darwin observed in Galapagos Island.

1. He observed many varieties of finches in the same island.
2. All varieties of finches had evolved from original seed-eating finches.
3. There was alternation in beaks enabling some to become insectivorous and some vegetarian.

Australian Marsupials: A number of marsupials, different from each other evolved from an ancestral stock, all within the Australian island continent.

Lamarck's theory

1. Innate tendency.
2. Use and disuse of organs.
3. Effects of environment.
4. Inheritance of acquired characters

Lamarck gave the example of Giraffes who, to forage leaves on tall trees had to adapt by elongation of their necks and they passed on this acquired character of elongated neck to succeeding generations. Giraffe, slowly over the years came to acquire long necks.

Darwin's theory of evolution

-He was influenced by Population theory by Malthus.
-Alfred Wallace a naturalist who worked in Malay Archipelago came to similar conclusion like that of Darwin.
-Darwin's theory is also known as Theory of Natural Selection which is based on the following factors:

1. Rapid multiplication
2. Limited environmental resources such as food and space
3. Struggle for existence
4. Survival of the fittest
5. Variation
6. Inheritance of useful variations
7. Speciation

Two key concepts are

a) Branching descent
b) Natural selection

Mechanism of evolution:

-Evolution for Darwin was gradual and was due to variations which were small & directional.
-Hugo de Vries based on his work on 'evening primrose' proposed mutation theory of evolution.
-Mutations that are random and directionless.
-Speciation is due to saltation **(single step large mutation)**

Hardy- Weinberg Principle:

-Hardy- Weinberg principle is also called genetic equilibrium. Allele frequency remains constant from generation to generation.
-The gene pool (total genes and their alleles in a population) remains a constant and is stable, this is called genetic equilibrium.
-Sum total of all allelic frequencies is 1
-Consider two alleles of a gene as A and a
-Individual frequencies can be named as p, q.
-In diploids, the frequency of AA is p2, aa is q2 and of Aa is 2pq.
-Hence, the formula is $p^2 + 2pq + q^2$. = 1which is a binomial expansion of $(p+q)^2$ which can be applied to any population to find out the gene frequency.
-Disturbance in genetic equilibrium, or Hardy- Weinberg equilibrium, i.e., change of frequency of alleles in a population would be interpreted as resulting in evolution.
-Factors affecting Hardy- Weinberg principle is

1. Gene Migration
2. Genetic drift
3. Natural selection
4. Mutation
5. Recombination

1.Gene migration– The transfer of section of population to another place resulting in a change in gene frequencies in both old and new population is called gene migration. Frequent gene migration is called gene flow.

2.Genetic drift- The random change in gene frequency occurs by chance is called genetic drift. Sometimes, the change in allelic frequency is so different in the new population, that they become a different species and the original drifted population becomes **founder**s. Hence the effect is called founder effect.

3.Mutation: The spontaneous change in the genetic makeup of an individual is called mutation.

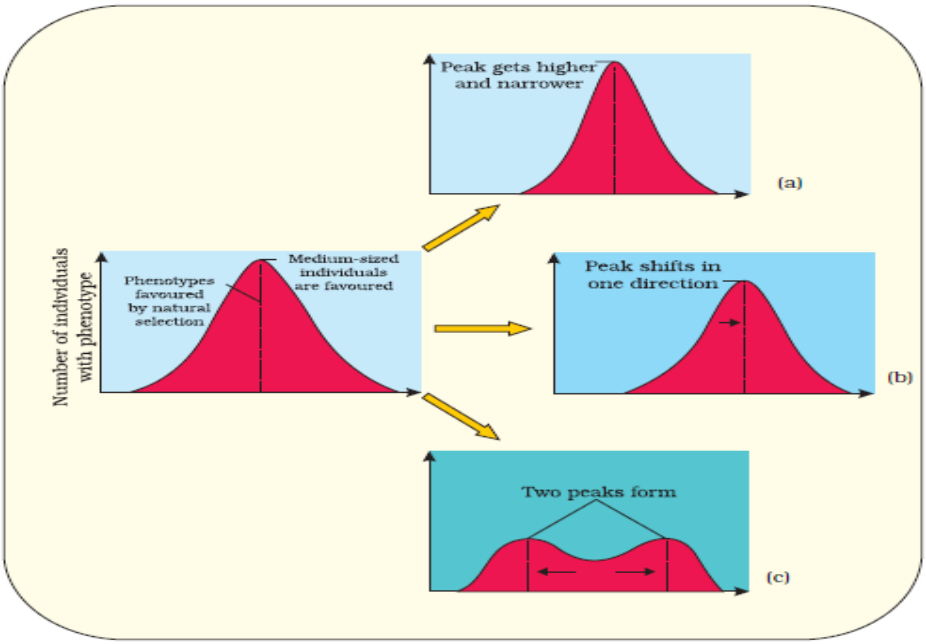
4.Genetic recombination: Exchange of genes between non sister chromatids of homologous chromosomes during gametogenesis is called genetic recombination. Variation due to recombination during gametogenesis, or due to gene flow or genetic drift results in changed frequency of genes and alleles in future generation.

5.Natural selection The process by which better adapted individuals with useful variations are selected by nature and leave greater number of progenies is called natural selection. Natural selection can lead to

a. Stabilizing selection – Individuals at both the individuals contribute relatively fewer offspring to the next generation than those closer to average phenotype. It reduces the variation but does not change mean value.

b. Directional selection - individuals at either of the extreme phenotype contribute more offsprings to the next generation, more individuals acquire value other than the mean character value.

c. Disruptive selection – individuals at both extremes of the distribution contribute more offspring's, more individuals acquire peripheral character value at both ends of the distribution curve.



7.8 Diagrammatic representation of the operation of natural selection on different traits : (a) Stabilising (b) Directional and (c) Disruptive

A Brief Account of Evolution :-

1. About 2000 million years ago (mya) the first cellular forms of life appeared on earth.
2. Some of these cells had the ability to release O_2.
3. Slowly single-celled organisms became multi-cellular life forms.

4.By the time of 500 mya, invertebrates were formed and active.

5.Jawless fish probably evolved around 350 mya.

6.Sea weeds and few plants existed probably around 320 mya.

7.We are told that the first organisms that invaded land were plants.
8.Fish with stout and strong fins could move on land and go back to water. This was about 350 mya.

9.In 1938, a fish caught in South Africa happened to be a Coelacanth which was thought to be extinct. These animals called lobefins evolved into the first amphibians that lived on both land and water. These were ancestors of modern-day frogs and salamanders.
10.The amphibians evolved into reptiles.

11.In the next 200 million years or so, reptiles dominated on earth. Some of these land reptiles went back into water to evolve into fishlike reptiles probably 200 mya (e.g. Ichthyosaurs).

12.The land reptiles were the dinosaurs. Tyrannosaurus rex was about 20 feet in height and had dagger-like teeth.

13 About 65 mya, the dinosaurs suddenly disappeared from the earth. The cause might be climatic changes or most of them evolved into birds. The truth may live in between.
9. The first mammals were like shrews.

YEARS	EVOLUTION OF LIFE FORMS
65 mya	Dinosaurs disappeared and First mammals evolved
200 mya	Reptiles, fish like reptiles(Ichthyosaurs)
320 mya	Sea weeds and few plants
350 mya	Jawless fishes, Fish with stout and strong fins could move on land and go back to water
500 mya	Invertebrates
---	Slowly single-celled organisms became multi-cellular life forms.
2000 mya	First cellular life forms, some released O_2

Human Evolution

Human Phylogeny

NAME	AGE	BRAIN CAPACITY IN CC	FEATURES
Homo sapiens (Modern man)	75,000-10,000	1200-1600	Omnivorous, modern man
Homo neanderthalensis (Neanderthal man)	1,00,000-34,000 yrs	1400	Lived near east and central Asia, used hides to protect their body and buried their dead.
Homo erectus	1.5 mya Pleistocene	900	Ate meat,
Homo habilis	2 mya Pliocene era	650-800	First human like, did not eat meat
Australopithecines	2 mya Pliocene era	450	Hunted with stones but ate fruits
Ramapithecus (earliest hominid fossil)	15 mya Miocene era	---	Small canines, large molars, seed and nut eaters
Dryopithecus africanus (earliest fossil apes)	25-15 mya Miocene era	---	Large canines, arm and leg size equal, fruit and leaf eaters

QUESTION BANK

MULTIPLE CHOICE TYPE

1. The theory of spontaneous generation stated that
(a) life arose from living forms only
(b) life can arise from both living and non-living
(c) life can arise from non-living things only
(d) life arises spontaneously, neither from living nor from the non-living.

2. Animal husbandry and plant breeding programmes are the examples of
(a) reverse evolution

(b) artificial selection
(c) mutation
(d) natural selection.

3. The bones of forelimbs of whale, bat, cheetah and man are similar in structure, because
(a) one organism has given rise to another
(b) they share a common ancestor
(c) they perform the same function.
(d) they have biochemical similarities.

4. Analogous organs arise due to
(a) divergent evolution
(b) artificial selection
(c) genetic drift
(d) convergent evolution.

5. $(p+q)^2 = p^2 + 2pq + q^2 = 1$ represents an equation used in
(a) population genetics
(b) Mendelian genetics
(c) biometrics
(d) molecular genetics.

6. Appearance of antibiotic-resistant bacteria is an example of
(a) adaptive radiation
(b) transduction
(c) pre-existing variation in the population
(d) divergent evolution.

7. Which type of selection is industrial melanism observed in moth, *Biston betularia*?
(a) Stabilising
(b) Directional
(c) Disruptive
(d) Artificial

8. Variations during mutations of meiotic recombination are
(a) random and directionless
(b) random and directional
(c) random and small
(d) random small and directional

9. Who proposed that the first form of the could have come from pre-existing non-living organic molecules?
(a) S.L. Miller
(b) Oparin and Haldane
(c) Charles Darwin
(d) Alfred Wallace

10. The correct sequence for the manufacture of the compounds on the primitive earth is
(a) NH3, CH4, protein and carbohydrate
(b) protein, carbohydrate, water and nucleic acid
(c) NH3, CH4, carbohydrate and nucleic acid
(d) NH3, carbohydrate, protein and nucleic acid.

11. The first life originated
(a) on land
(b) in air
(c) in water
(d) all of these.

12. Presence of gills in the tadpole of frog indicated that
(a) fishes were amphibious in the past
(b) fishes evolved from frog-like ancestors
(c) frogs will have gills in future
(d) frogs evolved from gilled ancestors.
13. The extinct stone ancestor, who ate only fruits and hunted with stone weapons was
(a) Ramapithecus
(b) Australopithecus
(c) Dryopithecus
(d) Homo erectus

14. The ship used by Charles Darwin during the sea voyages was
(a) HMS Beagle
(b) HSM Beagle
(c) HMS Eagle
(d) HSM Eagle.

15. Fitness according to Darwin refers to
(a) number of species in a community

(b) useful variation in population
(c) strength of an individual
(d) reproductive fitness of an organism.

16. The preserved fossil remains of Archaeopteryx show that
(a) it was a flying reptile from the Permian period
(b) reptiles gave rise to birds during Jurassic period
(c) it was a flying reptile in the Triassic period
(d) reptiles gave rise to birds during Permian period.

17. Which of the following statements is True ?
(a) Wings to birds and insects are homologous organs.
(b) Human hands and bird's wings are analogous organs.
(c) Human hands and bat's wings are analogous organs.
(d) Flipper of penguin and dolphin are analogous organs.

18. Phenomenon of 'industrial melanism' demonstrates
(a) geographical isolation
(b) reproductive isolation
(c) natural selection
(d) induced mutation.

19. Which one of the following phenomena supports Darwin's concept of natural selection in organic evolution?
(a) Development of transgenic animals
(b) Production of "Dolly', the sheep by cloning
(c) Prevalence of pesticide resistant insects
(d) Development of organs from 'stem cells' for organ transplantation.

20. By the statement 'survival of the fittest', Darwin meant that
(a) the strongest of all species survives
(b) the most intelligent of the species survives
(c) the cleverest of the species survives
(d) the species most adaptable to changes survives.

21. Which of the following are the two key concepts of Darwinian theory of evolution?
(a) Genetic drift and mutation
(b) Adaptive radiation and homology
(c) Mutation and natural selection

(d) Branching descent and natural selection

22. Which one of the following scientist's names are correctly matched with the theory put forth by him?
(a) de Vries – Theory of natural selection
(b) Darwin – Theory of pangenesis
(c) Weismann – Theory of continuity of germplasm
(d) Pasteur – Theory of inheritance of acquired characters

23. Single step large mutation leading to speciation is also called
(a) founder effect
(b) saltation
(c) branching descent
(d) natural selection

24. The Hardy-Weinberg principle cannot operate if
(a) a population does not migrate for a longtime to a new habitat.
(b) frequent mutations occur in the population
(c) the population has no chance of interaction with other populations
(d) free interbreeding occurs among all members of the population.

25. Genetic drift operates only in
(a) larger populations
(b) Mendelian populations
(c) island populations
(d) smaller populations.

26. Which of the following is most important for speciation?
(a) Seasonal isolation
(b) Reproductive isolation
(c) Behavioural isolation
(d) Tropical isolation

27. The factors involved in the formation of new species are
(a) Isolation and competition
(b) gene flow and competition
(c) competition and mutation
(d) isolation and variation.

28. Stabilising selection favours
(a) both extreme forms of a trait

(b) intermediate forms of a trait
(c) environmental differences
(d) one extreme form over the other extreme form and over intermediate forms of a trait.

29. The extinct human who lived 1,00,000 to 40,000 years ago, in East and Central Asia, used hides to protect their bodies and had brain capacity of 1400 c.c. were
(a) Homo habilis
(b) Neanderthal man
(c) Cro-Magnon man
(d) Ramapithecus.

30. Which of the following statements is correct regarding evolution of mankind?
(a) Homo erectus is preceded by Homo habilis.
(b) Neanderthal man and Cro-Magnon man were living at the same time.
(c) Australopithecus was living in Australia.
(d) None of these

ANSWER KEY

Q.NO.	CORRECT OPTION	Q.NO.	CORRECT OPTION	Q.NO.	CORRECT OPTION
1	c	11	c	21	d
2	d	12	d	22	c
3	b	13	b	23	b
4	d	14	a	24	b
5	a	15	d	25	d
6	c	16	b	26	b
7	b	17	d	27	d
8	a	18	c	28	b
9	b	19	c	29	b
10	d	20	d	30	a

ASSERTION AND REASON TYPE QUESTIONS

1.ASSERTION-The first living organisms were heterotrophs.
REASON-They were surrounded by preformed organic molecules which they used as food.
2.ASSERTION-Analogous organs serve the same function and look alike, but have different structure and origin

REASON- Analogous organs explain about divergent evolution.

3.ASSERTION-Artificial selection is highly beneficial for humans.

REASON-Artificial selection is carried out by man

ANSWER KEY

1.A 2.C 3.B

SHORT ANSWER TYPE QUESTIONS:

1. State the significance of study of fossils in evolution.

2. Why analogous structures are considered a result of convergent evolution?

3. Differentiate between homology and analogy. Give one example of each.

4. What role does an individual organism play as per Darwin`s theory of natural selection?

5. State and explain three anthropogenic activities on organic evolution.

ANSWER KEY

1.

- Fossils are the preserved remnants of animals, flora, and different organisms which are present million years ago. Fossils vary in age from 10,000 to 3.48 billion years old. Fossils range in size from microscopic, like single celled microorganisms, to gigantic, like dinosaurs and trees.
- Fossils can provide us information about how pre- historic plants and animals produced their food, reproduced and their features. It gives proof for how or why the fossil organism became extinct. Fossils permit researchers to match layers of rock in different locations by age based on how same the fossils in every rock layer are.
- Using information pieced collectively from fossil proof, scientists can reconstruct body varieties of animals that do not exist today and put together to explain the evolutionary relation between organisms.

2.-Analogous structures are anatomically different but perform similar functions and hence are a result of convergent evolution.

-It occurs when two groups of largely unrelated organisms are exposed to very similar environments and develop similar adaptations to survive.

-For example, the ability to fly has evolved in both bats and insects, and they both have wings, which are adaptations to flight. However, the wings of bats and insects have evolved from very different original structures.

3.

HOMOLOGY	ANALOGY
-Homologous organs: The organs which perform different functions in different species but have similar basic structure and similar embryonic origin are called homologous organs. E.g., limbs of human being, frog, bird and lizard. -Homology: Similar in characteristics resulting from shared ancestry. -Homologous features arise from adaptive behaviour, to adapt to different environmental conditions and modes of life.	-Analogous Organs: The organs which are quite different in fundamental structure and embryonic origin but perform same function and may superficially look alike are called analogous organs. For e.g., wings of bird, bat, insects are used for flying but the internal structure is different. -Analogy: The organisms showing analogy do not share common ancestors. -Analogous feature arise when two unrelated species adapt themselves to similar climate and environmental condition.

4.

-As per Darwin's theory of natural selection, an individual organism in a population is responsible for passing on the variations and favourable mutations to the next generation by taking part in a successful event of sexual reproduction.

-These variations and the mutations have been selected for survival by the changing environment as they have conferred fitness to the individuals they are present in.

5.

Effect of anthropogenic actions on organic evolution:

-Industrial melanism: It was due to smoke and soot coming out of man-made industries which caused a shift from white-winged moths on trees to dark winged or melanised moths. Prior to industrialisation white coloured lichens covered the bark of trees which was favourable for white-winged moths.

-Use of herbicides and pesticides has resulted in the selection of resistant varieties in very short time scale.

-The development of microbes resistant to antibiotics in a period of months is due to anthropogenic actions.

CASE BASED QUESTIONS

In a given population one can find out the frequency of occurrence of alleles of a gene or a locus. This frequency is supposed to remain fixed and even remain the same through generations. Hardy-Weinberg principle stated it using algebraic equations. This principle says that allele frequencies in a population are stable and is constant from generation to generation. The gene pool (total genes and their alleles in a population) remains a constant. This is called genetic equilibrium. Sum total of all the allelic frequencies is 1. Individual frequencies, for example, can be named p, q, etc. In a diploid, p and q represent the frequency of allele A and allele a. The frequency of AA individuals in a population is simply p^2. This is simply stated in another ways, i.e., the probability that an allele A with a frequency of p appear on both the chromosomes of a diploid individual is simply the product of the probabilities, i.e., p^2. Similarly of aa is q^2, of Aa 2pq. Hence,

$p^2+2pq+q^2=1$. This is a binomial expansion of $(p+q)^2$.

1. **A gene locus has two alleles A and a. If the frequency of dominant allele A is 0.4, then the frequency of homozygous dominant, heterozygous and homozygous recessive individuals in the population is**

(a) 0.16(AA); 0.48(Aa); 0.36(aa)
(b) 0.16(AA); 0.24(Aa); 0.36(aa)
(c) 0.16(AA); 0.36(Aa); 0.48(aa)
(d) 0.36(AA); 0.48(Aa); 0.16(aa)

2. **What does p^2 in the below mentioned Hardy-Weinberg equation indicate?**

$(p+q)^2 = p^2 + 2pq + q^2$

(a) individuals that are heterozygous dominant
(b) individuals having a lethal allele
(c) individuals that are homozygous dominant
(d) individuals that are homozygous recessive

3. **A sampled "a" population has 16% of homozygous recessive genotype (aa). Then the frequency of allele "a" is**

(a) 0%
(b) 16%
(c) 20%
(d) 40%

4. **This condition is essential for a population to be in the Hardy-Weinberg equilibrium**

(a) random mating

(b) no mutations
(c) large population
(d) all of these

ANSWER KEY

1.a 2.c 3.d 4.d

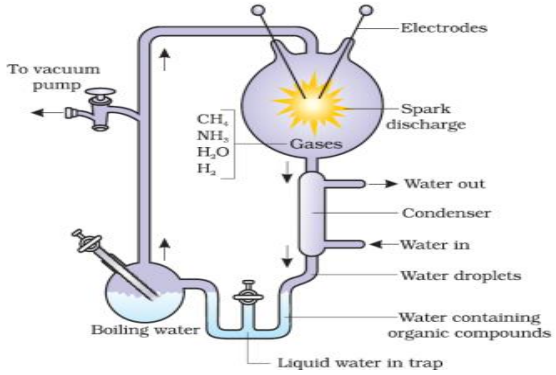
LONG ANSWER TYPE QUESTIONS:

1. Describe the experiment set up by Miller and Urey. What is the significance of their findings.
2. i. List any four evidences of evolution.
   ii. How did Darwin explain adaptive radiation? Give another example exhibiting adaptive radiation.
3. $p^2 + 2pq + q^2 = 1$. Explain this algebraic equation on the basis of Hardy-Weinberg`s principle.
4. Explain the interpretation of Charles Darwin when he observed a variety of small back birds on Galapagos Island.

ANSWER KEY

1.

- The experiment was carried out by SL Miller and HC Urey in 1953.
- He took a closed flask containing CH4, H2, NH3 and water vapour at 800°C and created electric discharge. These conditions were like those in primitive atmosphere.
- After a week, formation of amino acids was observed. Complex molecules like sugars, nitrogen bases, pigments and fats were seen in the flask by other scientists.
- Analysis of the meteorite also revealed the presence of similar compounds.
- They verified Oparin and Haldane theory of chemical evolution experimentally. It states that life originated from pre-existing non-living organic molecules and formation of life was preceded by chemical evolution. The conditions on the earth that favoured chemical evolution were very high temperature, volcanic storms and reducing atmosphere that contained CH4,NH3, water vapour, etc.



2.

i. –Evidences from palaeontology

- Evidences from morphology and comparative anatomy

-Evidences from embryology

-Evidences from biochemistry

ii. -Adaptive radiation is the evolutionary process by which many species originate from one species in an area and radiate to different species.

-The phenomenon of adaptive radiation was first observed by Darwin when he travelled to a place called Galapagos Island. There he observed that there were finches with different types of beaks. So, he concluded that all of these inches radiated on the same island from a single ancestor Finch. All of these finches developed beaks according to the kind of food available to them. Hence, they evolved from the conventional seed-eating finches to vegetarian and insectivorous finches. They later came to be known as Darwin's finches.

-Another example of adaptive radiation is evolution of Australian Marsupials.

3.

The equation $p^2 + 2pq + q^2 = 1$ is a binomial expression of $(p + q)^2 + 1$.

$p^2 + 2pq + q^2 = 1$ mathematically represents Hardy-Weinberg's principle used to calculate the genetic variation of a population at equilibrium.

It states that the allele frequencies in a population are stable and remain constant from one generation to another.

p represents the allele A frequency

q represents the allele a frequency

p^2 represents the frequency of AA individuals in a population

q^2 represents the frequency aa individuals

2pq represents the frequency of Aa individuals

The Sum of all the allelic frequencies is 1

If the values of p and q are known, the frequencies of the three genotypes can be determined using the Hardy-Weinberg equation.

Therefore, p represents the allele A frequency.

-Disturbance in genetic equilibrium, or Hardy- Weinberg equilibrium, i.e., change of frequency of alleles in a population would be interpreted as resulting in evolution.

-Factors affecting Hardy- Weinberg principle is

1. Gene Migration

2. Genetic drift
3. Natural selection
4. Mutation
5. Recombination

4.

-Charles Darwin went on a voyage to Galapagos islands for 5 years in his ship H.M.S beagle.

-There he observed a variety of birds with different beaks which are known as Darwin's finches.

-While studying these birds he gave his theory of natural selection.

-According to his theory, there is a rapid multiplication of species in the environment. But due to limited food and space, there is always an interspecific or intraspecific struggle for existence.

-Therefore, only those individuals which are fit to survive in the existing environment are selected by nature. These organisms reproduce while others die.

-This variation which exists in the surviving individuals are passed to next generation and ultimately lead to evolution.

UNIT VIII

BIOLOGY IN HUMAN WELFARE

Chapter 8
Human Health and Disease

Chapter 10
Microbes in Human Welfare

CHAPTER - 8

HUMAN HEALTH AND DISEASE

1. **Health** does not simply mean 'absence of disease' or 'physical fitness'. It could be defined as a state of complete physical, mental and social well-being.

2. Improper functioning of one or more organs or systems of the body is adversely affected, gives rise to various signs and symptoms i.e. we have disease.
3. Diseases which can easily transmit from one person to other by any means are called infectious or **communicable diseases**.
4. Diseases which cannot be transmitted from one person to another are called non-infectious or **non-communicable diseases**.
5. Disease causing organisms are said to be **pathogen**.

(A) Some common Human Diseases

TYPHOID:

1. Pathogen: ***Salmonella typhi*** (bacterium).
2. Organs affected: small intestine, migrate to other organs through blood.
3. Method of transmission: contamination of food and water.
4. Symptoms:
   - Sustained high fever (39^{o}C to 40^{o}C).
   - Weakness, stomach pain, constipation, headache and loss of appetite.
   - Intestinal perforation and death may occur.

   Test: Typhoid fever could be confirmed by Widal test.

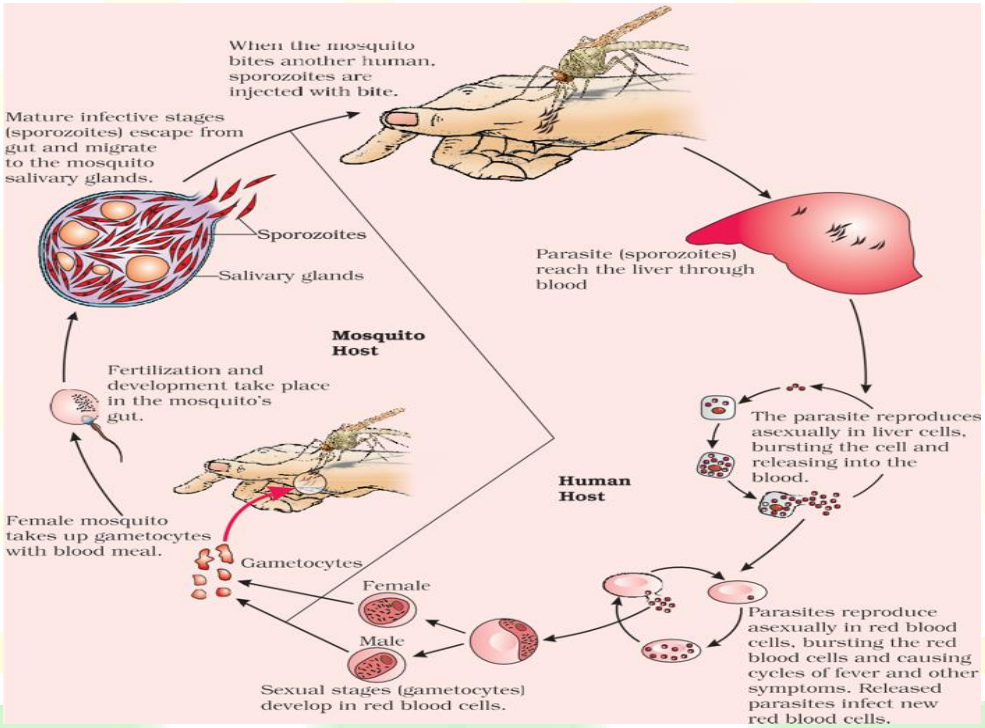
PNEUMONIA:

1. Pathogen: ***Streptococcus pneumonia*** and ***Haemophilus influenzae***.
2. Organs affected: Alveoli of lungs, alveoli get filled with fluid.
3. Method of transmission:
   - Inhaling the droplets/aerosols released by infected person.
   - Sharing glasses and other utensils.
4. Symptoms:
   - Fever, chills, cough and headache.
   - In severe cases the lips and finger nails turn gray to bluish colour.

COMMON COLD:

1. Pathogen: **Rhino viruses**.
2. Organs affected: nose and respiratory passage
3. Method of transmission:
   - Direct inhalation of droplets from infected person.
   - Through contaminated objects like pen, books, cups, computer key board.
4. Symptoms:
   - Nasal congestion and discharge, sore throat, hoarseness, cough.

Life Cycle of Malaria Parasite



MALARIA:

1. Pathogen: Plasmodium (*P. vivax, P. malariae, P. ovale, P. falciparum*).
2. Malignant malaria: caused by ***P. falciparum*** is most fatal.
3. Organs affected: liver, RBC.
4. Method of transmission: by biting of **female anopheles' mosquito** (vector).
5. Symptoms: high fever and chill, fever occurs on every alternate day, vomiting.
   - **Life cycle of plasmodium** starts with inoculation of sporozoites (infective stage) through the bite of infected female Anopheles mosquitoes.

• The parasite initially multiplied within the liver cells and then attack the red blood cells (RBCs) resulting in their rupture.

• There is release of a toxic substance called **hemozoin** from the ruptured RBCs which responsible for the chill and high fever.

• From the infected human the parasite enters into the body of Anopheles mosquito during biting and sucking blood.

• Further development takes place in the body of Anopheles mosquitoes.

• The female mosquito takes up gametocytes with the blood meal.

• Formation of gametes and fertilization takes place in the intestine of mosquito.

• The zygote develops further and forms thousands of sporozoites which migrated into the salivary gland of mosquito.

• When the mosquito bites another human, sporozoites are injected.

• The malarial parasite requires two hosts – human and Anopheles, to complete their life cycle.

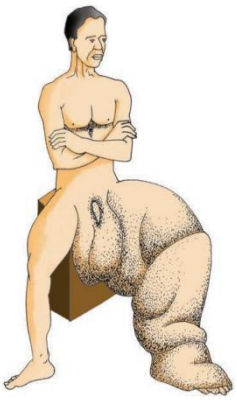
AMOEBIASIS (Amoebic dysentery):

1. Pathogen: ***Entamoeba histolytica*** a protozoan parasite.
2. Organs affected: large intestine of man.
3. Method of transmission:
   • House fly acts as mechanical carrier.
   • Contamination water and food with faecal matter.
4. Symptoms:
   • Constipation, abdominal pain and cramps.
   • Stools with excess mucous and blood clots.

ASCARIASIS:

1. Pathogen: ***Ascaris lumbricoids*** (nematode).
2. Organs affected: intestine of man.
3. Method of transmission: Contaminated water, vegetables, fruits.
4. Symptoms:
   • Internal bleeding, muscular pain, fever, anaemia.
   • Blockage of the intestinal passage.

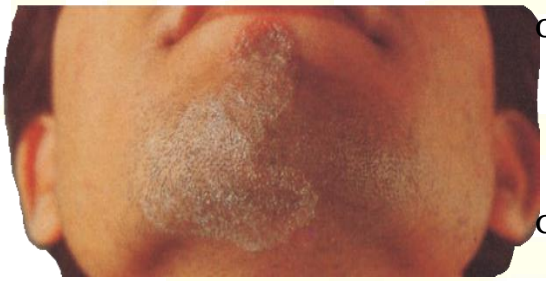
FILARIASIS (ELEPHANTIASIS):



1. Pathogen: *Wuchereria* (***W.bancrofti*** and ***W. Malayi***) is nematode parasite.
2. Organs affected: lymphatic vessels of the lower limbs, genital organs.
3. Methods of transmission: biting of infected female Culex mosquito.
4. Symptoms:
   - Chronic inflammation of the organs where they live for many years.
   - Abnormal swelling of lower limb, scrotum, penis.
   - Hence the disease named as elephantiasis or Filariasis.

RING WORMS:

1. Pathogen: ***Microsporum***, ***Trichophyton*** and ***Epidermophyton*** (fungi).
2. Organs affected: Skin, nails, folds of skin, groin.



3. Method of transmission:
   - Acquired from the soil.
   - Using towel, clothes or even comb of infected individuals.
4. Symptoms:
   - Appearance of dry, scaly lesions in skin nails and scalp.
   - Lesion accompanied with intense itching.
   - Heat and moisture help these fungi to grow.

(B) PREVENTION AND CONTROL OF INFECTIOUS DISEASES:

- Maintenance of personal and public hygiene is very important for prevention and control of many infectious diseases.
- Consumption of clean drinking water, food vegetable fruits.
- Keeping the body cleans.
- Proper disposal of waste and excreta
- Periodic cleaning and disinfection of water reservoirs, pools, cesspools.
- Standard practices of hygiene in public catering.
- In case of air-borne diseases, close contact with the infected persons or their belongings should be avoided.

For vector borne diseases:

- To control or eliminating the vectors and the breeding places.
- Avoiding stagnation of water in and around residential areas.
- Regular cleaning of household coolers.
- Use of mosquito nets.
- Introducing fishes like ***Gambusia*** in pond that feeds on mosquito larvae.
- Spraying of insecticides in ditches, drainage area and swamps.
- Window and doors must be fitted with wire mesh.
- All these precautions are use full for vector borne disease like dengue and Chikungunya, malaria and filarial etc.

(C) IMMUNIZATION:

• By massive immunization there is complete eradication of disease like smallpox.

• Diseases like polio, diphtheria, pneumonia, and tetanus have been controlled in large extent.

IMMUNITY:

• The overall ability of the host to fight the disease-causing organism by immune system is called **immunity**.

• There are two types of immunity:

- **Innate Immunity**.
- **Acquired Immunity**.

1.Innate (non-specific) immunity:

• called inborn immunity. This is called the **first line of defence**.

• It consists of various barriers that prevent entry of foreign agents into the body.

• Different **types of barriers** are as follows:

Physical barriers	Skin, Mucus coating of the epithelium lining	It prevents entry of the micro-organisms
Physiological barriers	Acid in the stomach, saliva in the mouth, tears from eyes	prevent microbial growth
Cellular barriers	WBC, polymorpho-nuclear leukocytes (PMNL-neutrophils)	Phagocytose and destroy microbes.
Cytokine barriers	Virus-infected cells secrete proteins called interferons	Protect non-infected cells from further viral infection

2. Acquired (specific) immunity:

- It is characterised by memory.

a) **Primary response**- When or body encounters a pathogen for the first time produces low intensity response.

b) **Secondary response**- Subsequent encounter with the same pathogen elicits a highly intensified secondary or **anamnestic response**.

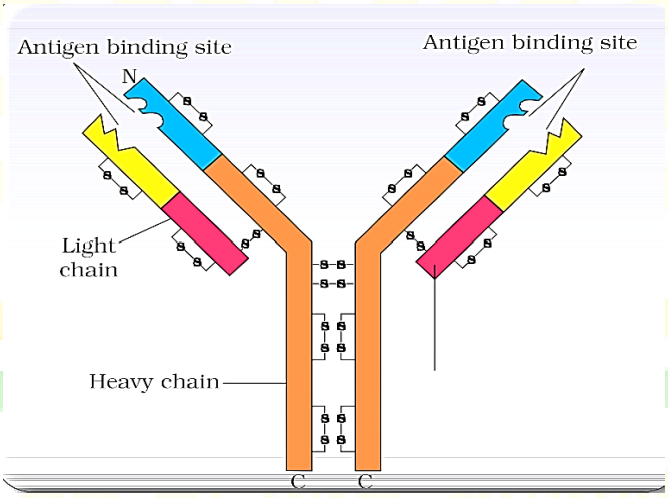
The primary and secondary immune responses are carried out with the help of two special types of lymphocytes present in our blood - (i) B-lymphocytes and (ii) T - lymphocytes.

B lymphocyte - they produce Antibodies (immunoglobin) in response to pathogens

T lymphocyte - help B cells produce antibodies.

ANTIBODY

- **H_2L_2** structure – Antibodies are composed of four peptide chains, two small (light chains) and two longer (heavy chains).



- Types of antibodies - IgA, IgM, IgE, IgG.

Humoral immune response- Antibody mediated response.

Cell-mediated immune response or cell-mediated immunity (**CMI**)- lymphocytes mediated response.

• Immune response by T-cells is by activation of cytotoxic killer cells which detects and destroys the foreign cells and also cancerous cells called cell mediated immune response.

• Rejection of organs transplants are due to T-lymphocytes.

• Tissue matching, blood group matching are essential for organ transplantation.
• Even after tissue typing immune-suppressants is required before and after transplantation.

VACCINATION AND IMMUNIZATION:

• The principle of immunization or vaccination is based on the property of 'memory, of the immune system.

Active Immunity – In this, antibodies are produced in the host cell after infection with antigens. Active immunity is slow and takes time to give its full effective response
Passive Immunity - When ready-made antibodies are directly given to protect the body against foreign agents. e.g. baby receives a mother's antibodies through the placenta or breast milk.

• In vaccination, a preparation of antigenic protein of pathogen or inactivated/weakened pathogen (vaccine) is introduced into the body.
• The antibodies produced in the body against vaccine (antigen) would neutralize the pathogenic agents during actual infection.
• The vaccines also generate memory B and T-cells that recognize the pathogen quickly on subsequent exposure.

Passive immunization:

• Preformed antibody or antitoxin injection for specific antigen.
• Injection of antivenin for snake bites to counter the snake venom.

Vaccine production:

• Recombinant DNA technology has allowed the production of antigenic polypeptide of pathogen in bacteria and yeast.
• Vaccine produced by this approach allows large scale production of antigen for immunization. E.g.- hepatitis-B produced from yeast.

(D) ALLERGIES:

1) The exaggerated response of the immune system to certain antigens present in the environment is called allergy.
2) The substance to which such immune response is produced is allergen.
3) IgE is produced during allergic reactions.
4) Common allergens are dust, pollen, animal dander etc.
5) Common symptoms are sneezing, watery eyes, running nose etc.
6) Allergy is due to release of histamine and serotonin from the mast cells.
7) Drugs like anti-histamine, adrenalin and steroid quickly reduce symptoms of allergy.

AUTO IMMUNITY:

1) Memory based acquired immunity able to distinguish foreign molecules or cells (pathogen) from self-cells.
2) Sometimes due to genetic and other unknown reasons the body attacks self-cells. This results in damage to the body cells and is called auto-immune disease. E.g. Rheumatoid arthritis, Multiple sclerosis.
3) The immune system of our body consists of:
   - Lymphoid organs
   - Lymphoid tissues
   - T and B-cells.
   - Antibodies.

• **Primary lymphoid organs:** bone marrow and thymus where production and maturation of lymphocytes take place.

• **Secondary lymphoid organs:** spleen, tonsil, lymph node, Payer's patches of small intestine and appendix where proliferation and differentiation of lymphocyte take place.

• **Bone marrow** is the main lymphoid organ where all blood cell including lymphocytes are produced.

• **Thymus** is a bilobed organ located near the heart, beneath the breastbone.

a) B-lymphocytes are produced and matured in bone marrow.
b) T-lymphocytes are produced in bone marrow but matured in thymus.

• **Spleen:**

a) Is a large bean shaped organ mainly contain lymphocytes and phagocytes.
b) Acts as a filter of the blood by trapping blood-borne micro-organisms.
c) Spleen is also serves as the large reservoir of erythrocytes.

• **Lymph node**:

a) Small solid structure located at different points along the lymphatic system.
b) Traps the micro-organisms or other foreign antigens.
c) Antigen trapped into the lymph node responsible for activation and differentiation of lymphocytes and cause immune response.

• **Mucosal Associated Lymphoid Tissues (MALT):**

a) Located within the lining of major tract (respiratory, digestive and urogenital tracts)
b) It constitutes 50% of lymphoid tissues.

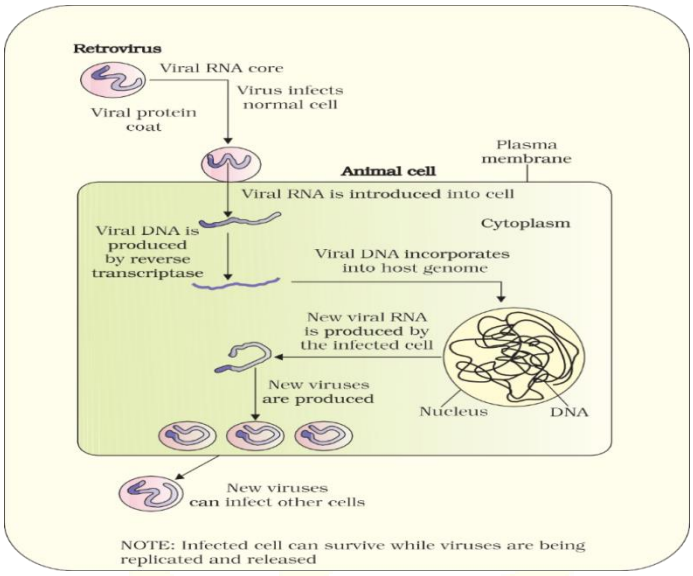
(D) Acquired Immuno- Deficiency Syndrome (AIDS):

a) Deficiency of immune system that acquired during life time and not congenital disease.

b) Syndrome means a group of symptoms.

c) AIDS was first reported in 1981. It is caused by HIV (Human Immuno-deficiency Virus).

d) HIV is retrovirus, having RNA as the genetic material.



Method of transmission:

- Sexual contact with infected persons.
- Transfusion of contaminated blood and blood products.
- Sharing infected needles for intravenous drug.
- From infected mother to the foetus through placenta.

Life cycle of HIV:

- After getting into the body the HIV enters into macrophages or T-helper cells.
- The viral RNA genome replicated to form viral DNA with the enzyme called ***reverse transcriptase***.
- The viral DNA gets incorporated into the host cell's DNA by an enzyme called ***integrase*** and directs the infected cells to produce virus particle.
- The macrophage continues to produce virus and acts as HIV factory.
- Virus released from macrophage attack **T-helper cells**.
- There is progressive reduction in the number of T-helper cells.
- Due to reduction of T-helper cells the person starts suffering from infections of other virus, fungi and even parasites like ***Toxoplasma***.
- The patient becomes immune-deficient and more prone to other disease.

Diagnosis of AIDS:

- ELISA (Enzyme Linked Immuno Sorbent Assay) is used to diagnose the infection of HIV.

Prevention of AIDS:

• AIDS has no cure; prevention is the best option.	• Free distribution of condoms.
• Safe blood for transfusion	• Prevention of drug abuse
• Use of disposable needles	• Advocating safe sex.

(E) CANCER:

a) Uncontrolled cell division leads to production of mass of cell called cancer.
b) Cancerous cell lost the property of contact inhibition.
c) Cancerous cell just continues to divide giving rise to masses of cell called tumours.

d) Benign tumours:

- Normally **remain confined** to their original location
- Do not spread to other location.
- Cause **little damage**.

e) Malignant tumours:

- Mass of proliferating cells called **neoplastic** or tumor cells.
- These cells grow very rapidly.
- Invade and damage surrounding tissues.
- These cells actively divide and grow; they also starve the normal cells.
- Cancerous cells escape from the site of origin and moves to distant place by blood, wherever they get lodged make the normal cell cancerous. This property is called **metastasis**.

Causes of cancer:

a) Normal cells transformed into cancerous neoplastic cells by physical, chemical and biological agents. These agents are called carcinogen.
b) Physical agents: ionizing radiation like X-rays, gamma rays non-ionizing radiations like UV-rays.
c) Chemical agents: Tobacco smoke, sodium azaide, Methyl ethane sulphonate.
d) Biological agents:

- Cancer causing viruses called oncogenic viruses have a gene called viral oncogenes, induce transformation of neoplastic cells.
- Cellular oncogenes (C-oncogene) or proto-oncogenes in normal cells when activated lead to oncogenic transformation of the normal cells.

Cancer detection and diagnosis:

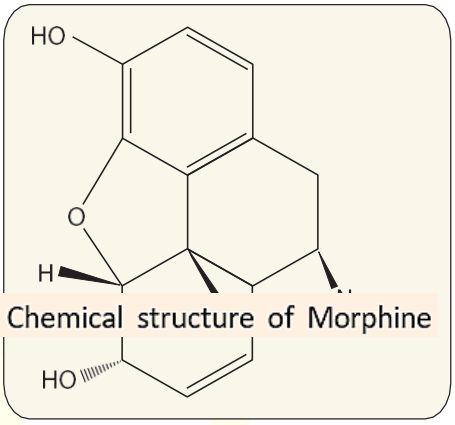
- Biopsy and histopathological study of the tissues.
- Radiography like X-rays, CT (computerized tomography).
- MRI (magnetic resonance Imaging).
- Presence of antibodies against cancer-specific antigen.

Treatment of cancer:

• Surgery, Radiation therapy, Immunotherapy, Chemotherapy, Cryosurgery, Laser therapy and administration of *a-interferone* a response modifier used to detect the cancer.

(F) DRUGS AND ALCOHOL ABUSE:

1.Opioid:



Chemical structure of Morphine

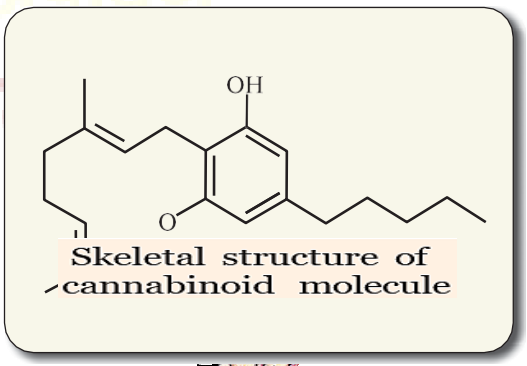
- The drugs which bind to specific opioid receptor present in central nervous system and gastrointestinal tract.
- Heroin commonly called smack, chemically **diacetylmorphine**.
- It is white, odourless, bitter crystalline compound.
- Obtained by acetylation of **morphine**.
- Extracted from latex of poppy plant ***Papaver somniferum***.
- Generally taken by snorting and injection.
- Heroin is depressant and slows down body function.

2.Cannabinoids:

- Group of chemicals that interact with the cannabinoid receptors of brain.
- Obtained from inflorescence of ***Cannabis sativa***.
- Flower top, leaves and resin of cannabis plant are used in various combinations to produce marijuana, hashish, charas and Ganja.
- Generally taken by inhalation and oral ingestion
- Effects on cardiovascular system of the body.

2.Cocaine:

- Coca alkaloid or cocaine is obtained from coca plant ***Erythroxylon coca***.
- It interferes with transport of neurotransmitter **dopamine**.
- Cocaine is commonly called as coke or crack is usually snorted.



Skeletal structure of cannabinoid molecule

- Potent stimulating effect on central nervous system.

• Produces sense of euphoria and increased energy.
• Excessive dosage causes hallucination.
• Other plants with hallucinogenic properties are:

➢ ***Atropa belladonna***
➢ Datura

Datura plant

• Cannabinoids are also being abused by some sportspersons.

Medicinal use of drugs:

a) Barbiturates, amphetamines, benzodiazepines, Lysergic-acid Diethylamide (LSD) used as medicines to help patients cope with mental illnesses, depression and insomnia.
b) Morphine is a very effective sedative and painkiller used for surgery patient
c) Plant product with hallucinogenic property have used as folk-medicine, religious ceremonies and rituals.

TOBACCO:

• It is smoked, chewed or used as a snuff.
• Tobacco contains nicotine an **alkaloid**.
• Nicotine stimulates Adrenal glands to raise blood pressure and increased heart rates.
• Smoking tobacco is associated with cancer of lung, urinary bladder, and throat, bronchitis, emphysema, coronary heart disease, gastric ulcer etc.
• Smoking increased Carbon monoxide content of blood which reduces oxygen carrying capacity of haemoglobin.
• Tobacco chewing is associated with cancer of oral cavity.

Adolescence and Drug/Alcohol Abuse:

a) The period between 12-18 years of age may think of an adolescent period.
b) Adolescent is a bridge linking childhood and adulthood.
c) Curiosity, need for adventure and excitement, and experimentation, are the common cause of drug/alcohol abuse.

Addiction and dependence:

a) Addiction is a psychological attachment to certain effects such as euphoria and a temporary feeling of well-being associated with drugs and alcohol.
b) With repeated use of drugs, the tolerance level of the receptors present in our body increases. Consequently, the receptors respond only to higher doses of drugs or alcohol leading to greater intake and addiction.

c) Use of drugs even once, can be a fore runner to addiction.

• Dependence is the tendency of the body to manifest a characteristic and unpleasant **withdrawal syndrome** if regular dose of drugs/alcohol is abruptly discontinued.

• Withdrawal syndrome characterized by anxiety, shakiness, nausea and sweating.

Effects of Drug / Alcohol Abuse:

a) Immediate effects are reckless behaviour, vandalism and violence.
b) Excessive doses of drugs may lead to coma and death due to respiratory failure, heart failure or cerebral haemorrhage.
c) Warning sign of drug and alcohol abuse among youth include:

- Drop in academic performance,
- Unexplained absence from school/college.
- Lack of interest in personal hygiene
- Withdrawal, isolation, depression fatigue, aggressive and rebellious behaviour.
- Deterioting relationship with family and friends.
- Change in eating and sleeping habits.
- Fluctuation in weight and appetite.

d) Intravenous drug user more prone to acquire infections like AIDS and hepatitis.
e) The chronic use of drugs and alcohol damages nervous system and cause of liver cirrhosis.
f) Use of drug and alcohol during pregnancy affect the foetus.

Prevention and control:

- Avoid undue peer pressure.
- Education and counselling.
- Seeking help from parents and peers.
- Looking for danger signs.
- Seeking professional and medical help.

QUESTIONAIRE

Multiple Choice Questions (MCQ's):

Q 1. Antibodies produced against allergens are –
a) IgA b) IgE c) IgG d) IgM
Ans. B

Q 2. Immature lymphocytes become antigen sensitive in -
a) Spleen b) Thymus c) Lymph node d) Tonsil
Ans. B

Q 3. The plant that does not cause hallucination is –
a) *Atropa belladonna* b) *Erythroxylon coca*
c) *Papaver somniferum* d) *Datura sp.*
Ans. C

Q 4. Cellular barrier that provides non-specific innate immunity does not include –
a) Erythrocyte b) Neutrophil
c) Macrophages d) Monocyte
Ans. A

Q 5. Fertilization between gametocytes occur in –
a) gut of mosquito b) liver of human
c) salivary gland of mosquito d) erythrocyte of human
Ans. A

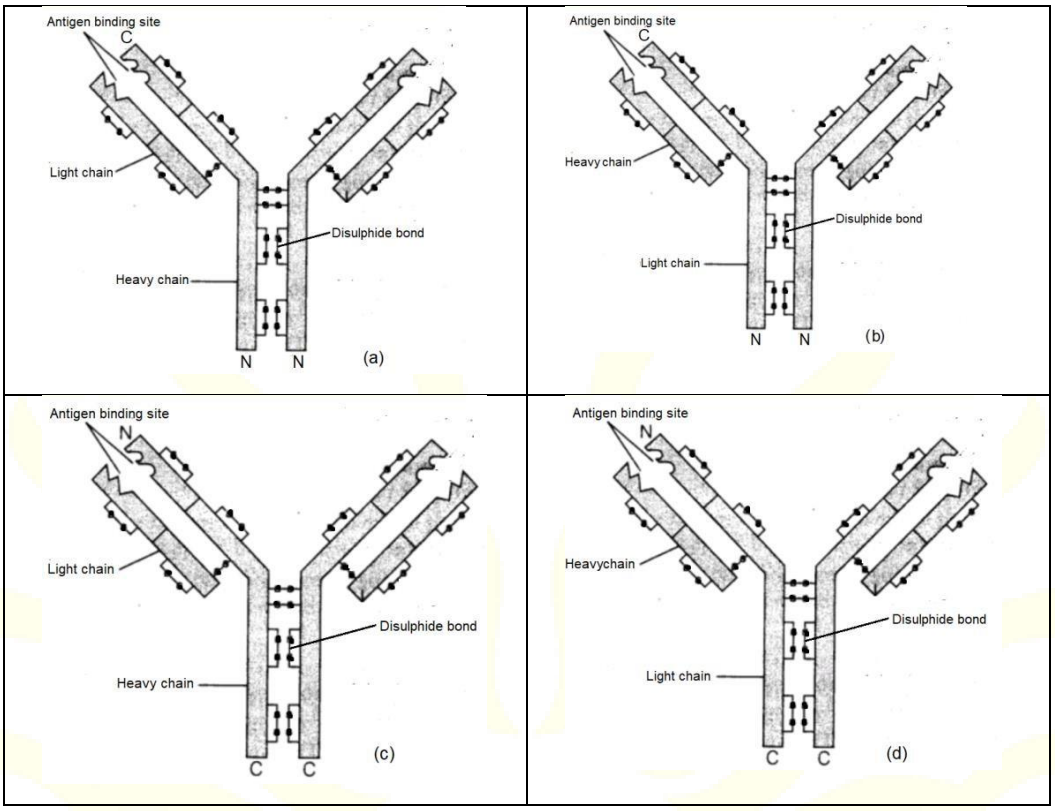
Q 6. Ringworm is caused by –
a) *Ascaris* b) *Wuchereria* c) *Microsporum* d) *Entamoeba*
Ans. C

Q 7. The disease that does not spread through contaminated food and water is –
a) Ascariasis b) Typhoid c) Amoebiasis d) Filariasis
Ans. D

Q 8. The percentage of lymphoid tissue in our body comprising of MALT is –
a) 5% b) 15% c) 25% d) 50%
Ans. d

Q 9. Which one of the following is a physical barrier?
a) Tear from eyes
b) Acid in stomach
c) Mucus coating on respiratory tract epithelium
d) Saliva in mouth
Ans. c

Q 10. Which one of the following is a correct depiction of antibody molecule?



Ans. c

ASSERTION AND REASON BASED QUESTIONS

In the following questions a statement of Assertion (A) is followed by a statement of Reason(R) mark the correct choice as:

a. Both A and R are true and R is the correct explanation of A.
b. Both A and R are true but R is NOT the correct explanation of A.
c. A is true but R is false.
d. A is false but R is true.

Q 1. Assertion: Thymus is a primary lymphoid organ.
Reason: Immature lymphocyte differentiates into antigen sensitive lymphocyte in thymus.

Ans. a

Q 2. Assertion: People become addicted to drugs with repeated use.
Reason: With repeated use of drugs, the tolerance level of the receptors in our body increases.

Ans. a

Q 3. Assertion: Colostrum provides passive immunity to foetus during gestation.

Reason: colostrum is rich in antibodies like IgA.

Ans. d

Q 4. Assertion: cases of allergy is more common in children living in cities than in villages.

Reason: modern lifestyle has lowered immunity in urban children.

Ans. a

Q 5. Assertion: Malignant tumour is more dangerous than benign tumour.

Reason : Malignant tumour undergoes metagenesis.

Ans. c

Q 6. Assertion: Anamnestic response is less intense than primary response to a pathogen.

Reason: First exposure to pathogen generates memory B and T cell that recognises the same pathogen more quickly on subsequent exposure.

Ans. d

Short Answer (SA) type Questions (2 Marks)

Q 1. Give any two molecular diagnosis techniques used to diagnose disease.

Ans: Widal test for typhoid Biopsy- Cancer

Q 2. Malignant malaria is caused by which pathogen?

Ans: Plasmodium falciparum

Q 3. Interferons are secreted by which type of cell. What is the chemical nature of interferon?

Ans: interferon is secreted by virus infected cell. Interferons are protein.

Q 4. Name the infective stage of malaria parasite in human. In which organ of mosquito that is situated?

Ans: Sporozoite. Situated in mosquito salivary gland

Q 5. Malaria parasite requires two hosts to complete its life cycle. Identify the host where following events takes place-

(i) Asexual reproduction and gametocyte formation (ii) Fertilization (fusion of gametocyte)

Ans: (i) Human (ii) Mosquito

Q 6. Name any four types of immunoglobin present in human immune system.

Ans: IgA, IgM, IgE, IgG

Q 7. Provide two means of passive immunity through which foetus and newly born baby get protected from infection.

Ans: The yellowish fluid colostrum secreted by mother during the initial days of lactation. The foetus also receives some antibodies from their mother, through the placenta during pregnancy.

Q 8. Identify the type of immunoglobins in the followings- (i) in colostrum (ii) released during allergic response

Ans: (I) Ig A (II) Ig E

Q 9. Why it is not possible to treat autoimmune diseases. Give one example of such disease.

Ans: there is no treatment of such diseases because immune system of body attacks self-cells. Example- Rheumatoid arthritis

Q 10. Mention any two drugs that are used treat mental illnesses like depression and insomnia.

Ans: Barbiturates, Amphetamines

Short Answer (SA) type Questions (3 Marks)

Q 1. Give detailed account on factors which affects disease.

Ans: (i) genetic disorders – deficiencies with which a child is born and deficiencies/defects which the child inherits from parents from birth.

(ii) Infections

(iii) Life style including food and water we take

Q 2. Explain disease and its type with two examples of each.

Ans: Complete physical, mental and social well-being is known as health. Infectious disease – cancer, arthritis.

Non-infectious disease- flu, tuberculosis

Q 3. Primary immune response is of slow intensity than secondary immune response. Justify the statement.

Ans: When our body pathogen for the first time it produces primary response which is of low intensity. Subsequent encounter with the same pathogen shows quick and highly intensified secondary or anamnestic response. This is because in primary response antibodies are formed which have property of memory.

Q 4. (i) Draw the structure of immunoglobin.

(ii) Why immunoglobins are called as H_2L_2 molecules.

Ans: (i) Correct Diagram

(ii) Because it contains two heavy chains (H_2) and two light chains (L_2) of polypeptide.

Q 5. (i) What is allergy?

(ii) Name two factors which are responsible for allergy in out body.

(iii) List any two medicines advised by doctors to reduce the effect of allergy.

Ans: (i) he exaggerated response of the immune system to certain antigens present in the environment is called allergy

(ii) Histamine and serotonin

(iii) Anti-histamine, adrenalin

Q 6. Which cell is known as factory of HIV and why?

Ans: Macrophages are called as HIV factory. After entering into the e host body, HIV moves into macrophages where its RNA replicates to form viral DNA. This viral DNA gets incorporated into the host cells' DNA and directs the infected cells to produce more viruses. Hence macrophages continue to produce viruses and act as HIV factories.

Q 7. What are the different diagnosis techniques to detect cancer in a patient?

Ans: CT scan, MRI, Biopsy, Blood and bone marrow tests are done for increased cell counts in case of leukaemia, X ray, Monoclonal antibodies test.

Q 8. (i) Name two recent incidences of wide-spread diseases caused by *Aedes* mosquitoes.

(ii) Mention the name of two pathogens which are responsible ringworm disease.

(iii) Which pathogen infects alveoli (of the lungs) that result in severe breathing problem?

Ans: (i) Dengue and Chikungunya

(ii) *Microsporum, Trichophyton*

(iii) *Streptococcus pneumoniae* or *Haemophilus influenzae.*

Q 9. Differentiate between two different types of tumours? Which one is lethal and why?

Ans: (i) Benign tumour - tumour remain confined to place of origin or affected organ. Rate of growth of tumour is low.

(ii) Malignant tumour- it invades surrounding tissue & spread throughout the body. Rate of growth of tumour is rapid.

Malignancy is lethal as it spreads all over body through the process of metastasis.

Q 10. A person undergoes ELISA testing and tested positive-

(i) ELISA is widely conducted to diagnose which disease.

(ii) Write the causative agent of that disease.

(iii) Which organization in India educates people about that disease?

Ans:

(i) AIDS (ii) HIV (iii) NACO (National AIDS Control Organisation)

CASE BASED QUESTION – (4 marks)

Read the following and answer the questions given below:

All children between 9 months and 15 years were given a dose of Measles – Rubella (MR) Vaccine in their schools across West Bengal as a part of a campaign to eradicate Measles and control Rubella. The vaccination campaign was held from 9th January 2023 to 11th February 2023 in all schools across West Bengal. This was an additional dose of MR vaccine irrespective of previous vaccination. The same MR vaccine administered to children during routine immunisation will be used during the campaign. One new auto AD (auto disabled) syringe will be used for each child. More than 32.4 crore children had already been vaccinated with MR vaccine in 24 states of India.

a) What is a vaccine?
b) Why was this campaign organised?
c) Name another disease against which a similar is being carried out in India.
d) Why AD syringe was being used?

Ans.-a) A preparation of inactive or weakened pathogen or antigen.

b).to eradicate measles and control Rubella

c) Polio

d) to prevent contamination and spread of any other pathogen through it.

Long Answer (LA) type Questions (5 Marks)

Q 1. Describe different mechanism by which innate immunity protect the human body since birth.

Ans: Physical barriers - Skin prevents entry of the micro-organisms. Mucus coating of the epithelium lining (respiratory, gastrointestinal &urogenital tracts also help in trapping microbes entering our body) Physiological barriers- Acid (stomach), saliva (mouth), tears (eyes) prevent microbial growth.

Cellular barriers- Leukocytes (WBC) like polymorpho-nuclear leukocytes (PMNL-neutrophils), monocytes and natural killer in the blood, macrophages in tissues can phagocytose and destroy microbes

Cytokine barriers- Virus-infected cells secrete proteins called interferons which protect non-infected cells from further viral infection.

Q 2. "*A disease has symptoms of high fever with chill. The causative agents depend on red blood cells of human body for their life cycle*". Based on the statement answer the following questions-

Why do patients suffer from high fever with chill?

Name the disease and its causative agent.

Represent the life cycle of the pathogen diagrammatically.

Ans.- (i) due to release of chemical hemozoin from ruptured RBC,

(ii) Malaria, Plasmodium (*P. vivax, P. Malariae and P. falciparum*).

(iii) Life cycle of Plasmodium: Correct diagram.

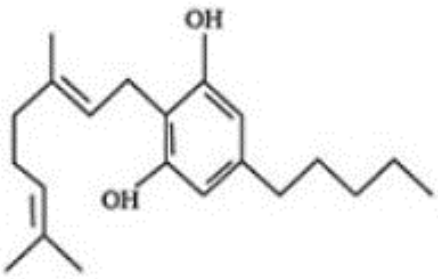
Q 3. How addiction and dependence differ to each other? What are consequences of withdrawal syndrome?

Ans.- Addiction is a psychological attachment to certain effects –such as euphoria and a temporary feeling of well-being – associated with drugs and alcohol.

Dependence is the tendency of the body to manifest a characteristic and unpleasant withdrawal syndrome if regular dose of drugs/alcohol is abruptly discontinued.

Withdrawal syndrome occurs if regular dose of drugs/alcoholic abruptly discontinued. This is characterised by anxiety, shakiness, nausea and sweating, which may be relieved when use is resumed again. In some cases, withdrawal symptoms can be severe and even life threatening and the person may need medical supervision.

Q 4. By observing the diagram answer the flowing questions-



(i) Mention the group of drugs this structure represents.

(ii) How these drugs are taken by drug abusers?

(iii) Name the source of plant from which these are isolated.

(iv) Which part of human body is affected by this drug?

(v) Provide any two common names for this drug.

Ans.- (i) Cannabinoids (ii) Oral Ingestion or inhalation (iii) Cannabis sativa (iv) Cardiovascular system

(v) Charas, ganja

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CHAPTER – 10 MICROBES IN HUMAN WELFARE

1) Microbes are diverse – protozoa, bacteria, fungi and microscopic plants viruses, viroids and also prions (proteinaceous infectious agents).
2) Microbes like bacteria and fungi can be grown in nutrient media to form colonies and can be seen in naked eyes.
3) Some microbes' causes diseases and some are useful for human being.

MICROBES IN HOUSEHOLD PRODUCTS:

1) Lactic acid Bacteria (**LAB**) grow in milk and convert it to curd.
2) LAB produces acids that coagulate and partially digest milk proteins.
3) A small amount of curd added to fresh milk as inoculums or starter.
4) LAB improves nutritional quality of milk by increasing **vitamin B_{12}**
5) LAB plays very important role in checking disease causing microbes.
6) Dough, used to make dosa and idli is also **fermented** by bacteria.
7) The puffed-up appearance of dough is due to the production of CO_2.
8) Baker's yeast (***Saccharomyces cerevisiae***) is used to making bread.
9) '**Toddy**' a traditional drink is made by fermentation of sap from palms.
10) Large holes in '**Swiss cheese**' are due to production of large amount of CO_2 by a bacterium named ***Propionibacterium sharmanii***.
11) The '**Roquefort cheese**' is ripened by specific fungi, which gives specific flavour.

Figure 8.4 Fermentors

Figure 8.5 Fermentation Plant

MICROBES IN INDUSTRIAL PRODUCTS:

1) Microbes are used in industry to synthesize a number of products
2) Beverages and antibiotics are some examples.
3) Microbes are grown in very large vessels called fomenters.

Fermented Beverages:

1) Yeasts are used for production of beverages like wine, beer, whisky, brandy or rum.

2) ***Saccharomyces cerevisiae*** commonly called 'brewer's yeast used for fermenting malted cereals and fruit juices to produce ethanol.
3) The type of raw material used for fermentation and the processing; different types of alcoholic drinks are produced.
4) Wine and beer are produced without distillation.
5) Whisky, brandy and rum are produced by distillation of the fermented broth.

Antibiotics:

1) Antibiotics are the chemical substances which are produced by some microbes and can kill or retard the growth of other microbes.
2) The first antibiotic discovered is the penicillin, from a mould (fungus) ***Penicillium notatum***.
    1) Antibiotics have greatly improved our capacity to treat deadly diseases such as plague, whooping cough, diphtheria and leprosy.

Chemicals, Enzymes and other Bioactive Molecules:

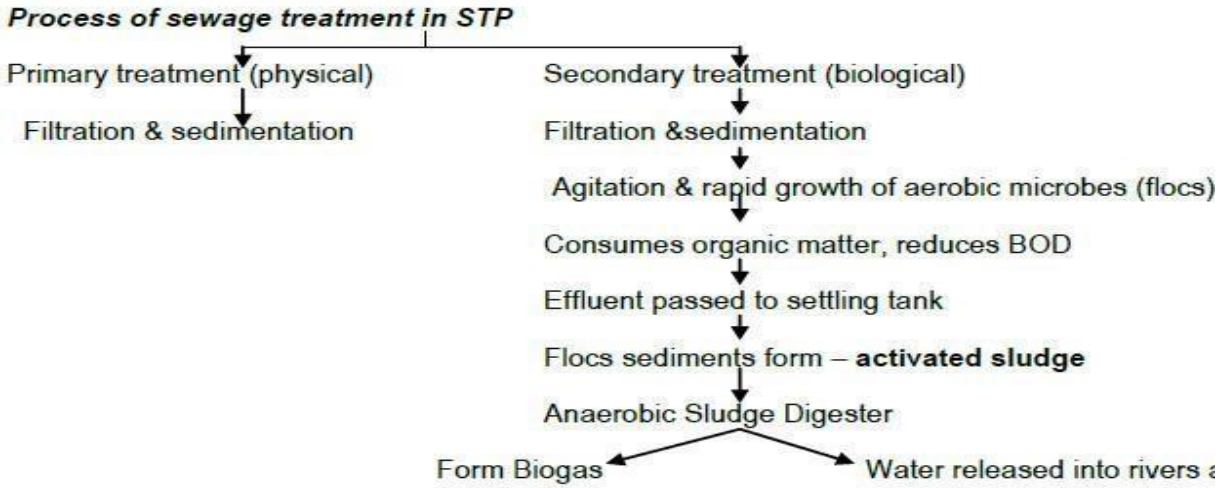
s.no	**Microbes**	**Product**
1.	*Aspergillus niger* (a fungus)	Citric acid
2.	*Acetobacter aceti (a bacterium)*	Acetic acid
3.	*Clostridium butylicum* (a bacterium)	Butyric acid
4.	*Lactobacillus* (a bacterium)	Lactic acid
5.	*Saccharomyces cerevisiae* (Yeast)	Ethanol

s.no	**Microbial product**	**Commercial use**
1.	Lipases (*bacillus and pseudomonas*)	Useful in removing oily stains from the cloth in laundry.
2.	*Lactobacillus* (LAB) Lactic Acid Bacteria	Clarifying fruit pulp in bottled juices

S.NO	**Source organism**	**Bioactive molecule**	**Medicinal use**
1.	*Streptococcus sp.*(bacterium)	Streptokinase	Used as a clot buster. Removing clots from the blood vessels of patients who have undergone myocardial infarction
2,	*Trichoderma polysporum* (fungus)	Cyclosporin-A	Immunosuppressive agent in organ-transplant patients
3.	*Monascus purpureus* (Yeast)	Statins	Blood-cholesterol lowering agents. It acts by competitively inhibiting the enzyme responsible for synthesis of cholesterol

MICROBES IN SEWAGE TREATMENT:

1) The waste water generated in cities and town containing human excreta. This water (municipal water) is called **sewage**.



2) Before disposal to the natural body sewage is treated in **Sewage Treatment Plants** (STPs) to make it less polluting.
3) Treatment is done by heterotrophic microbes naturally present in sewage.

This treatment is carried out in two stages:

1) **Primary Treatment** (Physical treatment): In the primary settling tank
   - Removal of floating debris by filtration.
   - Removal of soil & pebbles by sedimentation.
   - All solids that settle form the primary sludge and supernatant form the primary effluent. The effluent is taken for secondary treatment.

SEWAGE TREATMENT PLANT

Source-https://saiglobalnaturecare.com/stp/

2) **Secondary treatment** (Biological treatment):
   - Primary effluent passed into a large aeration tank & constantly agitated.
   - This allows vigorous growth of aerobic microbes like chlorella, fungi, bacteria and protozoans into flocs. **Flocs** are masses of bacteria associated with the fungal filaments These microbes consume major part of the organic matter.
   - This reduces the BOD (**Biochemical Oxygen Demand**) of the effluent.
   - The effluent is then passed into a settling tank where bacterial flocs are allowed to sediment. This sediment is called "**Activated Sludge**".
   - The small part of activated sludge is pumped back into aeration tank to serve as inoculum. And remaining part into large tank (Anaerobic sludge digesters). Some anaerobic bacteria digest the

bacteria and fungi in the sludge by producing gases: CH_4, H_2S, and CO_2 (Bio gases). Finally, this treated sewage is allowed for chemical treatment for disinfection and thrown into natural water bodies.

BOD: Represent the amount of dissolved O_2 required for the complete oxidation of all the organic matter present in one liter of H_2O by bacteria at 20^0C.

Higher BOD indicates water is highly polluted. Lower value of BOD means water is less polluted.

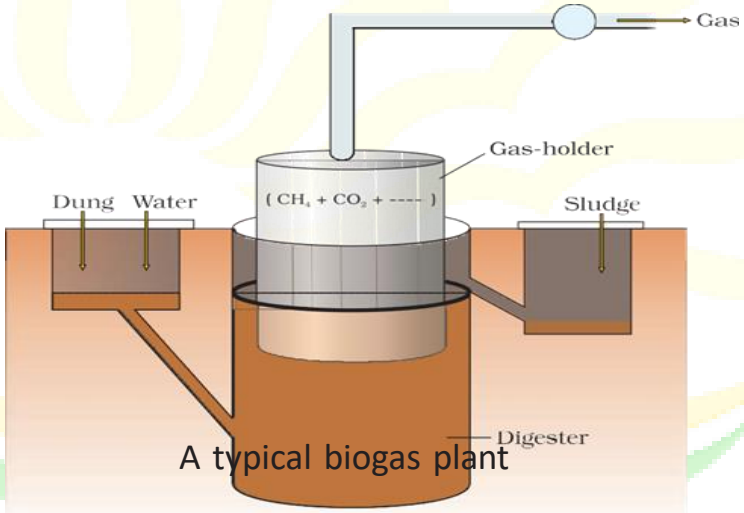
MICROBES IN PRODUCTION OF BIOGAS:

Methane gas is the main gas of Bio gas. Used for cooking & lighting. Methanogens grow anaerobically on cellulosic material and produce methane gas.

Biogas plant:

1. A concrete tank: 10-15 feet deep collects biowaste & slurry of dung.
2. Floating cover: placed over slurry.
3. An outlet: is connected to a pipe to supply Biogas.

IARI and KVIC developed the technology of Biogas production in India.



A typical biogas plant

MICROBES AS BIOCONTROL AGENTS:

Biocontrol: Biological methods for controlling plant diseases and pests that relies on natural predation rather than introducing chemicals.

Bacillus thuringiensis (***Bt.***)

1) It is available in sachets as dried spores mixed with water and sprayed on plants as Brassica, Cotton & fruit trees, where leaves are eaten by insect larvae. In the gut of larvae, toxin is released & larvae get killed.
2) ***Baculoviruses*** (genus **Nucleopolyhedrovirus**): They are pathogens on insects and other arthropods that damage crops. They are species-specific, as such have narrow spectrum insecticidal application on insects & pathogens. Desirable in **IPM** programme to conserve beneficial insects.

MICROBES AS BIOFERTILIZERS:

Microbes that enrich the nutrient quality of the soil: Bacteria, fungi, cyanobacteria are used as Biofertilizer to promote Organic farming and check overuse of chemical fertilisers.

Rhizobium bacteria and ***Cyanobacteria*** have property of N_2 fixation.

1.Free living bacteria such as ***Azospirillum*** & ***Azotobacter*** enrich N_2 content of the soil.

*2.**Mycorrhiza***: is symbiotic association of fungi e.g., Glomus with roots of higher plants. Fungus absorbs phosphorus from soil and pass it to plant, give resistance to pathogens, tolerance to salinity & drought.

3.Cyanobacteria: ***Anabaena, Nostoc, Oscillatoria*** fix N_2.

QUESTIONAIRE

Multiple Choice Questions (MCQ's):

Q 1. In bioremediation, which microorganisms are commonly used to clean up the oil spills?

(a) *Pseudomonas* (b) *Rhizobium*
(c) *Bacillus subtilis* (d)*Saccharomyces cerevisiae*

Ans.- (a)

Q 2. What is the purpose of using bacteria in the process of sewage treatment?

(a) Decomposition of organic matter
(b) Production of methane gas
(c) Synthesis of antibiotics
(d) Generation of electricity

Ans.- (a)

Q 3. What is the primary function of mycorrhizal fungi in the context of plant growth?

(a) Nitrogen fixation. (b)Phosphorus absorption
(c) Photosynthesis (d) Carbon dioxide fixation **Ans.- (b)**

Q 4. Identify the significance of A*zotobacter* in agriculture –

(a) Pest control (b) Nitrogen fixation
(c) Soil aeration (d) Antibiotic production

Ans.- (b)

Q 5. A nitrogen fixing microbe associated with the fern *Azolla* in rice fields is-

(a) *Frankia* (b) *Rhizobium* (c) *Spirulina* (d) *Anabaena*

Ans.- (d)

Q 6. The vitamin whose content increases following the conversion of milk into curd by LAB is

(a) Vitamin A (b) Vitamin D (c) Vitamin B_{12} (d) Vitamin E

Ans.- (c)

Q 7. Methanogenic bacteria are not found more number in

(a) Rumen of cattle (b) Gobar gas plant

(c) bottom of water-logged paddy field (d) activated sludge

Ans.- (d)

Q 8. The primary treatment of wastewater involves the removal of

(a)Dissolved impurities (b) stable particles

(c) toxic substances (d) harmful bacteria

Ans.- (b)

Q 9. BOD of wastewater is estimated by measuring the amount of

(a) total organic matter (b) biodegradable organic matter

(c) oxygen evolution (d) oxygen consumption

Ans.- (d)

Q.10.Which one of the following is not a nitrogen-fixing organism?

(a) *Anabaena* (b) *Nostoc*

(c) *Azotobacter* (d) *Pseudomonas*

Ans.- (d)

ASSERTION AND REASON BASED QUESTIONS

In the following questions a statement of Assertion (A) is followed by a statement of Reason(R) mark the correct choice as:

a. Both A and R are true and R is the correct explanation of A.

b. Both A and R are true but R is NOT the correct explanation of A.

c. A is true but R is false.

d. A is false but R is true.

Q 1. Assertion: Microbes play a crucial role in the production of antibiotics.

Reasoning: Antibiotics are chemicals produced by microorganisms that inhibit the growth of or kill other microorganisms.

Ans.- b)

Q 2. Assertion: Biocontrol agents based on microbes are considered environmentally friendly alternatives to chemical pesticides.

Reasoning: Microbial biocontrol agents are specific in their action and do not pose long-term environmental risks.

Ans.- a)

Q 3. Assertion: Fermentation by microbes is used in the production of alcoholic beverages.

Reasoning: During fermentation, microbes convert sugars into water and carbon dioxide.

Ans.- c)

Q 4. Assertion: Microbes are used in bioremediation to clean up oil spills.

Reasoning: Certain bacteria have the ability to degrade hydrocarbons present in crude oil.

Ans.- a)

Q 5. Assertion: Microbes are not used in the production of recombinant proteins like insulin.

Reasoning: Genetic engineering techniques allow the insertion of human genes into microbial cells to produce desired proteins.

Ans.- d)

Short Answer (SA) type Questions (2 Marks)

Q 1. How does a small amount of curd added to fresh milk convert it into curd? Mention a nutritional quality that get added to the curd.

Ans.-

A large number of lactic acid bacteria are found in small amount of curd which multiply and convert the milk into curd by producing the lactic acid. The nutritional quality improves by increasing Vitamin B12.

Q 2. Why is secondary treatment of water in sewage treatment plant called biological treatment?

Ans.-

In this treatment Organic wastes of sewage water are decomposed by certain microorganisms in presence of water.

Q 3. An antibiotic called Wonder Drug was used to treat the wounded soldiers of America during World War-II. Name the drug and the scientist who discovered it.

Ans.- Penicillin, Alexander Fleming.

Q 4. You have observed that fruit juice in bottles bought from the market is clearer as compared to those made at home. Give reason.

Ans.-

Bottle juices are clarified by the use of pectinase and proteases.

Q 5. Alexander Fleming discovered Penicillin, but its full potential as an effective antibiotic was established by other scientists. Name the two scientists.

Ans.- Ernest Chain and Howard Florey.

Q 6. Name the plant whose sap is used in making Toddy. Mention the process involved in it.
Ans.-Palm tree, by fermentation.
Q 7. What is the medicinal use of cyclosporin?
Ans.-Cyclosporin A is used as an immunosuppressive drug during organ transplantation.
Q 8. Name the pests that lady bird & dragon flies help to get rid of respectively?
Ans.- Lady bird beetle is useful to get rid off aphids & dragon – flies control mosquitoes.
Q 9. Give an example to prove that microbes release gases during metabolism?
Ans.-The best example of microbes release gases during metabolism are the puffed dough & bread.
Q 10. What are interferons?
Ans.-Proteins released by cells in response to viral infection which they help to combat are called interferons.

Short Answer (SA) type Questions (3 Marks)

Q 1. Explain how Biogas is produced from activated sludge? Name the microbe involved in the production of this cooking fuel and mention the chemical composition of it.
Ans.- The anaerobic digestion of activated sludge results in production of Biogas; Microbe- Methanogens/ *methanobacterium*; Chemical composition- Methane, carbon dioxide, Hydrogen etc.
Q 2. Explain why aerobic degradation of Sewage water is more important than anaerobic degradation for the treatment of large volumes of wastewaters rich in organic matter?
Ans.- Aerobic degradation is more important as naturally occurring aerobic and facultative microbes (bacteria, fungi, Protozoa and others) in the waste water can rapidly oxidise soluble organic and nitrogenous compounds. Mechanical addition of oxygen makes the process faster and most of the pathogenic content of the effluent is removed
Q 3. Yeast is an important ingredient for making soft and spongy breads. Illustrate the process involved and the cause of sponginess of bread.
Ans.- The process involved is fermentation during which lots of CO_2 is produced that causes the sponginess of bread.
Q 4. Illustrate the application of the fungi to the agricultural field and how it increases the farm output?
Ans.- Fungi form symbiotic association with the roots of higher plants called mycorrhiza, eg., Glomus. The fungal hyphae absorb phosphorus

from soil and pass it to the plant. Mycorrhiza shows the following benefits:

(a) Resistance to root-borne pathogens.
(b) Tolerance to salinity and drought.
(c) Overall increase in plant growth and development.

Due to increased availability of phosphorus, there is an increase in farm output.

Q 5. Expand BOD. Mention its significance in sewage treatment plant.

Ans.- BOD refers to the amount of the oxygen that would be consumed if all the organic matter in one liter of water were oxidized by bacteria. The sewage water is treated till the BOD is reduced. The greater the BOD of waste water, more is its polluted.

Q 6. Alexander Fleming observed that in presence of Penicillium notatum a particular species "A" can't grow. Give the reason and also identify "A".

Ans.- "A" is Staphylococci bacteria.

'A' is unable to grow because chemical Penicillin (now called as antibiotic) is released by Penicillium notatum

Q 7. Give two examples each of distilled and non-distilled beverages.

Ans.- Wine and beer (without distillation), whisky, brandy (distillation) of the fermented broth.

Q 8. Name the type of association that genus Glomus exhibits with the higher plant. How it is beneficial for plants?

Ans.- Mycorrhiza

The fungal mycelium absorbs phosphorus from soil and passes it to the plant. Such plants also show resistance to root-borne pathogens, tolerance to salinity and drought.

Q 9. From which organism we can obtain clot buster. Write its use.

Ans.- clot buster is obtained from Streptococcus. It is used for removing clots from the blood vessels of patients who have undergone myocardial infarction.

Q 10. How Flocs are formed during sewage treatment. Mention its application.

Ans.- Flocs are mesh like structure containing aerobic bacterial and fungal mycelium.

These are forms in aerobic tank when organic matter is abundant.

CASE BASED QUESTION – (4 marks)

Read the following and answer the questions given below:

Q 1. Biological control is a great hope for reducing the overutilization of pesticides in agricultural soils. It often involves microorganisms or molecules produced by microorganisms that will be able to interact

with either a plant or pathogens of this plant to reduce the growth of the pathogen and limit its negative impact on the host plant. When new biocontrol products are developed, strains were mostly selected based on their ability to inhibit a pathogen of interest under in vitro conditions via antagonistic effects. Biological control is an alternative source to manage the plant disease. Biological control is an extremely supportive approach for disease management, and it is exceptionally valuable to make an eco-friendly environment.

1. An organic farmer controls pest in agriculture by

a) Chemical fertilizers b) Natural predation
c) Morphological method d) Physiological method

Ans.- b) Natural predation.

2.Dragonflies are used to get rid of which pests?

a) Bumble bees b) Mosquitoes c) Earthworms d) Honey bees

Ans.- b) Mosquitoes

3. What are biocontrol agents for controlling butterfly caterpillars?

a) *Bacillus thuringiensis* b) *Lactobacillus*
c) *Acetobacter aceti* d) *Treponema pallidum*

Ans- a) Bacillus thuringiensis.

4. How is Bacillus thuringiensis available to be sprayed on plants?

a) In the form liquid spray b) In the form of crystals
c) In the form of dried spores d) In the form of wet spores

Ans.- c) In the form of dried spores.

5. *Baculoviruses* are not the excellent candidates for which kind of applications?

a) Species-specific applications
b) Narrow spectrum applications
c) Insecticidal applications
d) Broad-spectrum applications

Ans.- d) Broad-spectrum applications.

Q 2. Some microbes have an expanding application in Food industry. These microorganisms can ferment carbohydrates to produce chemicals, and are currently widely used in the food fermentation industry. They are used to improve the flavour of fermented foods, increase the nutritive value of foods, reduce harmful substances, increases shelf life, and so on. They can also be used as probiotics to promote health in the body.

1. State the full form of LAB.

Ans.- Lactic Acid Bacteria.

2. Lactic acid bacteria can be found in which type of food?

Ans.- In curd and yogurt

3. Give an outline of curd formation.

Ans.- Curd is formed by adding a small amount of curd to warm milk, which acts as a starter(inoculum). Microbes (LAB) present in the starter multiply at suitable temperature and convert milk into curd.

4. What happens to the milk protein during formation of the curd?

Ans.- Acids released by LAB during the growth coagulate and partially digest milk protein, casein thus increases the digestibility of milk protein.

Long Answer (LA) type Questions (5 Marks)

Q 1. Explain the process of secondary sewage treatment.

Ans.- The primary effluent is passed into large aeration tanks where it is constantly agitated mechanically and air is pumped into it.

•This allows vigorous growth of useful aerobic microbes as flocs. These microbes consume the organic matter in the effluent. This significantly reduces the BOD.

•Once the BOD of sewage reduced significantly, the effluent is then passed into a settling tank where the bacterial 'flocs' are allowed to sediment. This sediment is called activated sludge.

•The major part of the sludge is pumped into anaerobic sludge digesters. Here anaerobic bacteria produce biogas (methane, hydrogen sulphide and carbon dioxide).

•The effluent from the secondary treatment plant is generally released into natural water bodies like rivers and streams.

Q 2. (i) Draw a typical biogas plant.
(ii) Describe how biogas is obtained from the activated sludge?

Ans.- (i) Suitable Diagram.
(ii)Biogas formation from activated sludge:

•Major portion of activated sludge is pumped into anaerobic sludge digesters. Here, anaerobic bacteria digest the organic material of the sludge.

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UNIT IX

BIOTECHNOLOGY

Chapter 11
Biotechnology: Principles and Processes

Chapter 12
Biotechnology and Its Applications

CHAPTER-11
BIOTECHNOLOGY: PRINCIPLES AND PROCESSES

Introduction to Biotechnology

Definition: Biotechnology involves using living organisms or their enzymes to create products beneficial to humans.

Examples: Curd, bread, wine (traditional), and modern techniques such as genetically modified organisms, DNA vaccines, gene therapy.

Principles of Biotechnology

Core Techniques:

1.Genetic Engineering: Altering the genetic material (DNA/RNA) to change the organism's phenotype.

2.SterileTechniques: Maintaining contamination-free environments to grow desired microbes or eukaryotic cells for product manufacture (antibiotics, vaccines, enzymes).

Tools of Recombinant DNA Technology

Restriction Enzymes:

- Discovered in 1963; enzymes that cut DNA at specific sequences.
- Types: Exonucleases (remove nucleotides from ends) and Endonucleases (cut DNA at specific positions within).
    - Example: EcoRI from E. coli recognizes and cuts at GAATTC sequences.

Cloning Vectors:

- **Plasmids and Bacteriophages**: Capable of replicating independently within bacterial cells.

Features:

1. **Origin of Replication (ori)**: Initiates replication, controls copy number.
2. **Selectable Markers**: Identify transformed cells, e.g., antibiotic resistance genes.

3. **Cloning Sites**: Restriction sites for inserting foreign DNA.
4. **Vectors for Plants and Animals**: Agrobacterium tumefaciens (Ti plasmid) for plants, retroviruses for animals.

Competent Host:

- **Making Cells Competent**: Treating with calcium ions and heat shock to enable DNA uptake.
- **Micro-injection**: Direct injection of DNA into the nucleus.
- **Biolistics/Gene Gun**: Bombarding cells with DNA-coated particles.
- **Disarmed Pathogen Vectors**: Using viruses/bacteria to transfer DNA.

Processes of Recombinant DNA Technology

- **Isolation of Genetic Material (DNA)**:
  - Breaking cells open to release DNA using enzymes like lysozyme (bacteria), cellulase (plants), chitinase (fungi).
  - Removing RNA and proteins to purify DNA.
- **Cutting of DNA at Specific Locations**:
  - Using restriction enzymes to cut DNA at specific sites.
  - Visualizing DNA fragments using agarose gel electrophoresis.
- **Amplification of Gene of Interest using PCR**:
  - **Polymerase Chain Reaction (PCR)**: In vitro synthesis of multiple DNA copies using primers and DNA polymerase.
  - **Steps**: Denaturation, primer annealing, and extension.
- **Insertion of Recombinant DNA into Host Cells**:
  - Introducing ligated DNA into host cells to transform them, e.g., E. coli with antibiotic resistance genes.
  - Selecting transformed cells using selective media.
- **Obtaining the Foreign Gene Product**:
  - Cloning genes into vectors and transferring into host cells for expression.
  - Producing recombinant proteins in large scale using bioreactors.
- **Downstream Processing**:
  - Purification and formulation of the product after biosynthesis.
  - Clinical trials and quality control testing.

Principles of Biotechnology

1. **Genetic Engineering**:

- Techniques to modify the genetic material (DNA/RNA) of an organism.
- Allows for the insertion of specific genes, enabling the expression of desirable traits without introducing unwanted genes.

2. **Sterile Techniques**:
   - Essential for growing desired microbes/eukaryotic cells without contamination.
   - Used in the production of biotechnological products such as antibiotics, vaccines, and enzymes.

Tools of Recombinant DNA Technology

Restriction Enzymes

Definition:

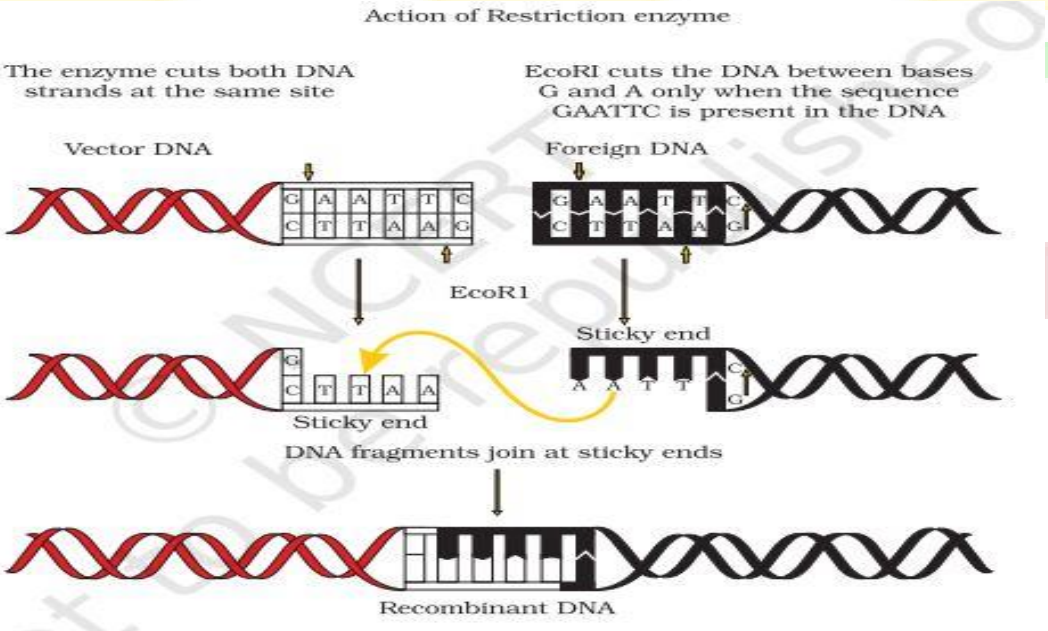
- Restriction enzymes, also known as restriction endonucleases, are enzymes that cut DNA at specific recognition sequences.

History:

- Discovered in 1963 by Werner Arber, Hamilton O. Smith, and Daniel Nathans.
- Initially observed in bacteria, where they serve as a defense mechanism against invading viral DNA.

Types of Restriction Enzymes:

1. **Exonucleases**: Remove nucleotides from the ends of DNA molecules.
2. **Endonucleases**: Cut DNA at specific positions within the molecule.

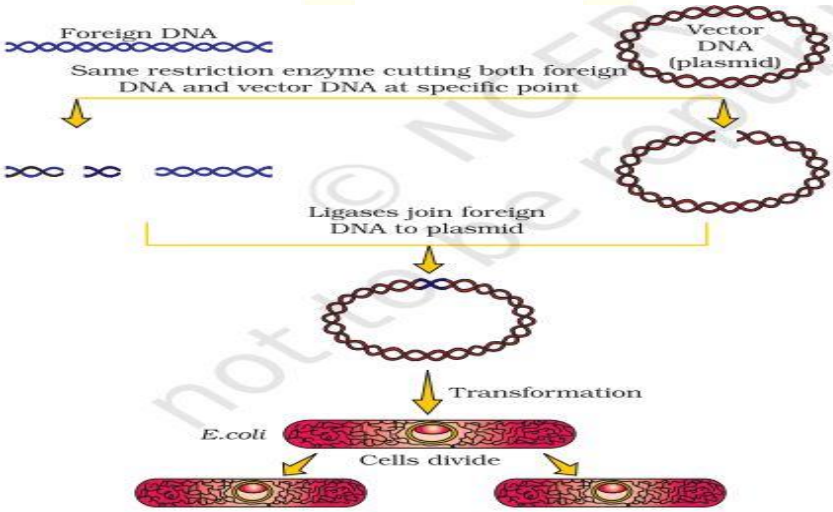


Key Features:

Recognition Sites: Specific sequences of 4-8 base pairs where the enzyme cuts. Often palindromic.

Types of Cuts:

- **Sticky Ends**: Staggered cuts with overhanging single-stranded ends. These ends can form hydrogen bonds with complementary sequences.
- **Blunt Ends**: Straight cuts across both DNA strands, resulting in no overhangs.



Examples:

- **EcoRI**: Recognizes and cuts at the sequence GAATTC, producing sticky ends.
- **HindIII**: Recognizes and cuts at the sequence AAGCTT, producing sticky ends.
- **SmaI**: Recognizes and cuts at the sequence CCCGGG, producing blunt ends.

Applications:

- **Gene Cloning**: Creating recombinant DNA by cutting and pasting DNA from different sources.
- **Genome Mapping**: Identifying and mapping the locations of genes within a genome.
- **Gene Therapy**: Inserting therapeutic genes into patient DNA to treat genetic disorders.

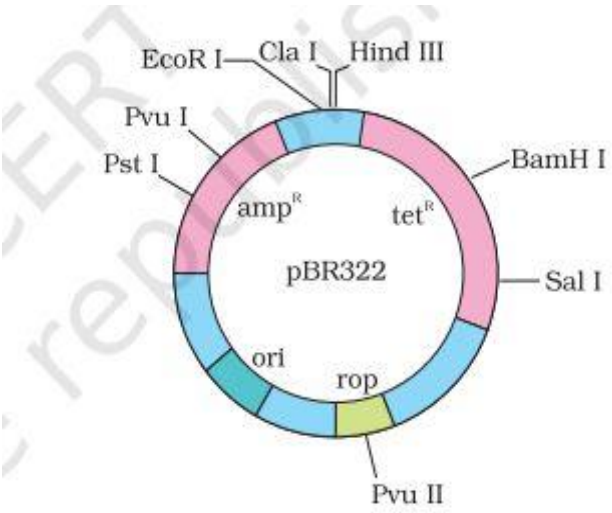
Cloning Vectors

Definition:

- Cloning vectors are DNA molecules that can carry foreign DNA into a host cell and replicate within it.

Types of Cloning Vectors:

1. **Plasmids**: Small, circular DNA molecules found in bacteria that replicate independently of the bacterial chromosome.
2. **Bacteriophages**: Viruses that infect bacteria, used to introduce foreign DNA into bacterial cells.
3. **Cosmides**: Hybrid vectors that combine features of plasmids and bacteriophages, used for cloning large DNA fragments.



4. **Artificial Chromosomes**: Large capacity vectors such as bacterial artificial chromosomes (BACs) and yeast artificial chromosomes (YACs) for cloning very large DNA fragments.

Key Features:

1. **Origin of Replication (ori)**: Sequence required to initiate replication of the vector within the host cell. Controls copy number.
2. **Selectable Markers**: Genes that allow for the identification of cells that have taken up the vector. Common markers include antibiotic resistance genes.
3. **Multiple Cloning Sites (MCS)**: Short DNA sequences containing multiple unique restriction enzyme sites, allowing for easy insertion of foreign DNA.
4. **Reporter Genes**: Genes that encode easily detectable proteins, such as GFP (green fluorescent protein), used to monitor the expression of the inserted gene.

Examples:

- **pBR322**: A widely used plasmid vector with ampicillin and tetracycline resistance genes.
- **pUC19**: A plasmid vector with a high copy number and a lacZ gene for blue/white screening.
- **λ Phage**: A bacteriophage vector used for cloning DNA fragments up to 23 kb.

Process of Cloning with Vectors:

1. **Preparation of Vector and Insert**:
    - Cut the vector and the foreign DNA with the same restriction enzyme to create compatible ends.

2. **Ligation**:
    - Mix the vector and insert DNA fragments with DNA ligase to join them together.
3. **Transformation**:
    - Introduce the recombinant DNA into a host cell (e.g., E. coli) by methods such as heat shock or electroporation.
4. **Selection**:
    - Grow the transformed cells on selective media containing antibiotics to identify cells that have taken up the vector.
5. **Screening**:
    - Use techniques such as blue/white screening, PCR, or restriction analysis to confirm the presence of the insert in the vector.

Applications:

- **Gene Cloning**: Producing multiple copies of a gene for research or therapeutic use.
- **Protein Expression**: Producing recombinant proteins in host cells for industrial or medical use.
- **Genetic Engineering**: Creating genetically modified organisms (GMOs) for agriculture, medicine, and research.

Advantages of Different Vectors:

- **Plasmids**: Easy to manipulate, high copy number, suitable for cloning small DNA fragments.
- **Bacteriophages**: Can package larger DNA fragments, efficient infection of bacterial cells.
- **Cosmides**: Combine the advantages of plasmids and bacteriophages, suitable for larger DNA fragments.
- **Artificial Chromosomes**: Capable of carrying very large DNA fragments, useful for genome mapping and studying large genes

Competent Host:

- **Making Cells Competent**: Treating with calcium ions and heat shock to enable DNA uptake.
- **Micro-injection**: Direct injection of DNA into the nucleus.
- **Biolistics/Gene Gun**: Bombarding cells with DNA-coated particles.
- **Disarmed Pathogen Vectors**: Using viruses/bacteria to transfer DNA.

11.3 Processes of Recombinant DNA Technology

1. **Isolation of Genetic Material (DNA)**:
    - Breaking cells open to release DNA using enzymes like lysozyme (bacteria), cellulase (plants), chitinase (fungi).

- Removing RNA and proteins to purify DNA.

2. **Cutting of DNA at Specific Locations**:
   - Using restriction enzymes to cut DNA at specific sites.
   - Visualizing DNA fragments using agarose gel electrophoresis.

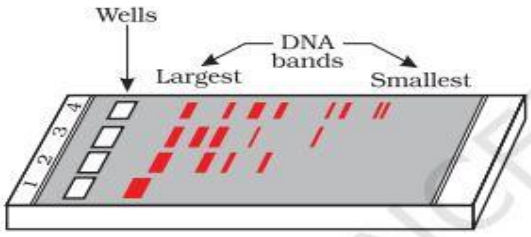
- Gel electrophoresis is a technique used to separate DNA fragments based on their size and charge.

Principle:

- DNA fragments are negatively charged due to their phosphate backbone. When an electric field is applied, these fragments migrate towards the positive electrode (anode) through a gel matrix.

Components:

1. **Gel Matrix**:
   - Typically made of agarose for DNA separation.
   - Acts as a sieve, allowing smaller fragments to move faster than larger ones.
2. **Electrophoresis Unit**:
   - Consists of a gel casting tray, comb, electrophoresis tank, and power supply.



Steps of Gel Electrophoresis:

1. **Preparation of the Gel:**
   - **Agarose Gel Preparation**:
     - Agarose is dissolved in a buffer solution (e.g., TAE or TBE) by heating.
     - The molten agarose is poured into a casting tray with a comb inserted to create wells.
     - The gel is allowed to solidify at room temperature.
2. **Preparation of DNA Samples:**
   - DNA samples are mixed with a loading dye that contains a tracking dye and a dense compound like glycerol or sucrose.

- The tracking dye helps monitor the progress of electrophoresis.

3. **Loading the Gel:**
   - The solidified gel is placed in the electrophoresis tank and covered with a running buffer.
   - DNA samples and a DNA ladder (molecular weight marker) are loaded into the wells using a micropipette.
4. **Running the Gel:**
   - The electrophoresis unit is connected to a power supply.
   - An electric current is applied, causing DNA fragments to migrate through the gel towards the positive electrode.
   - Smaller DNA fragments move faster and travel further than larger ones.
5. **Staining and Visualization:**
   - After electrophoresis, the gel is stained with a DNA-specific dye such as ethidium bromide or SYBR Green.
   - The stained DNA fragments are visualized under UV light.
   - Ethidium bromide intercalates between DNA bases and fluoresces under UV light, revealing the position of the DNA bands.

3. **Amplification of Gene of Interest using PCR**:
   - **Polymerase Chain Reaction (PCR)**: In vitro synthesis of multiple DNA copies using primers and DNA polymerase.

Definition:

Polymerase Chain Reaction (PCR) is a technique used to amplify specific segments of DNA, generating thousands to millions of copies of a particular DNA sequence.

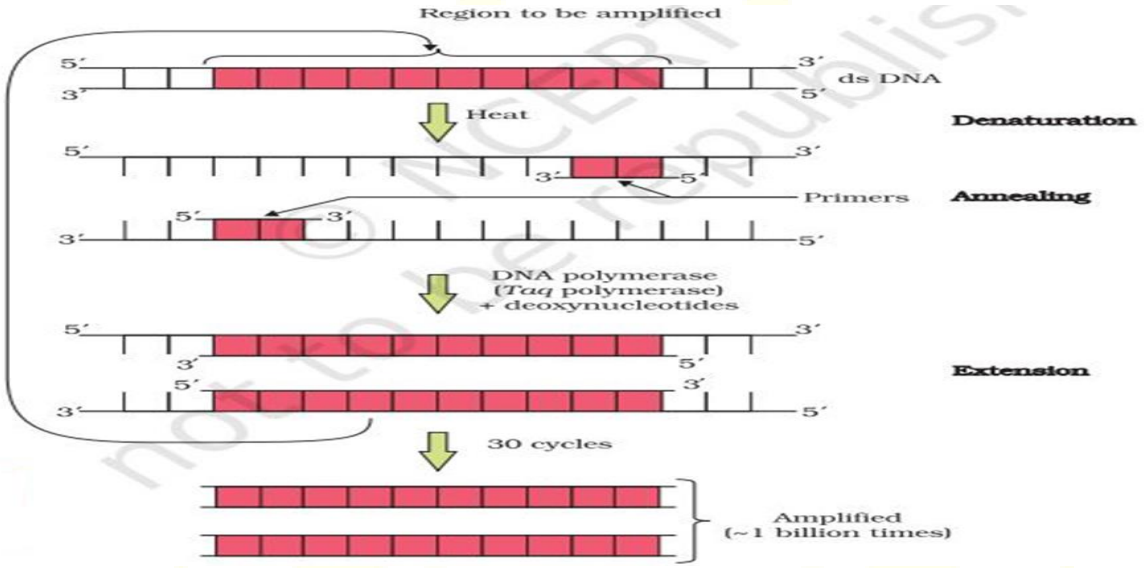
Principle:

PCR relies on the principle of DNA replication. It uses a DNA template, primers, DNA polymerase, and nucleotides to replicate the target DNA sequence through thermal cycling.

Components:

1. **DNA Template**: The DNA segment that needs to be amplified.
2. **Primers**: Short single-stranded DNA sequences that are complementary to the target DNA's flanking regions. Two primers are used: forward and reverse.

3. **DNA Polymerase**: An enzyme that synthesizes new DNA strands. Taq polymerase, derived from the thermophilic bacterium *Thermus aquaticus*, is commonly used because it is heat-stable.
4. **Deoxynucleotide Triphosphates (dNTPs)**: The building blocks (A, T, C, G) used by DNA polymerase to synthesize the new DNA strands.
5. **Buffer Solution**: Provides the necessary ionic environment and maintains the pH for the activity of DNA polymerase.



Steps of PCR: PCR consists of three main steps repeated for 20-40 cycles:

1. **Denaturation**:
   - The double-stranded DNA template is heated to 94-98°C for 20-30 seconds.
   - This high temperature breaks the hydrogen bonds between the DNA strands, resulting in two single-stranded DNA molecules.
2. **Annealing**:
   - The reaction temperature is lowered to 50-65°C for 20-40 seconds.
   - This allows the primers to bind (anneal) to their complementary sequences on the single-stranded DNA template.
3. **Extension (Elongation)**:
   - The temperature is raised to 72°C for 30-60 seconds.
   - Taq polymerase synthesizes a new DNA strand complementary to the DNA template by adding dNTPs to the annealed primer.

Cycle Repetition:

- The three steps (denaturation, annealing, and extension) are repeated for 20-40 cycles.

- Each cycle doubles the amount of target DNA, leading to an exponential increase in the DNA quantity.

Final Extension:

- A final extension step is often carried out at 72°C for 5-10 minutes to ensure that any remaining single-stranded DNA is fully extended.

Applications of PCR:

1. **Molecular Diagnostics**:
   - Detecting and identifying pathogens in clinical samples.
   - Genetic testing for inherited diseases and conditions.
2. **Forensic Science**:
   - DNA fingerprinting for identifying individuals.
   - Analysing genetic material from crime scenes.
3. **Research**:
   - Cloning genes for further study.
   - Analysing gene expression patterns.
4. **Agriculture**:
   - Identifying genetically modified organisms (GMOs).
   - Breeding programs for crop improvement.

Advantages of PCR:

- **Sensitivity**: Can amplify minute quantities of DNA.
- **Specificity**: Targets specific DNA sequences using primers.
- **Speed**: Rapid process with results in a few hours.
- **Versatility**: Applicable to a wide range of DNA samples.

4. **Insertion of Recombinant DNA into Host Cells**:
   - Introducing ligated DNA into host cells to transform them, e.g., E. coli with antibiotic resistance genes.
   - Selecting transformed cells using selective media.
5. **Obtaining the Foreign Gene Product**:
   - Cloning genes into vectors and transferring into host cells for expression.
   - Producing recombinant proteins in large scale using bioreactors.

Definition:

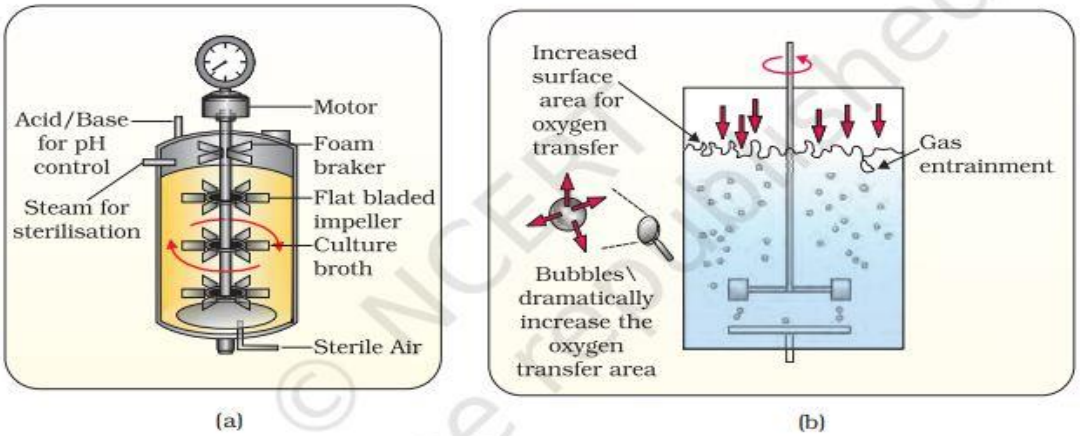
- Bioreactors are vessels in which raw materials are biologically converted into specific products by microbes, plant and animal cells, or enzymes.

Purpose:

- They provide a controlled environment for the optimal growth of microorganisms or cells to produce desired products like proteins, enzymes, vaccines, and other bioactive compounds.

Types of Bioreactors:

1. **Stirred Tank Bioreactor:**
   - Most commonly used type.
   - Consists of a cylindrical vessel with a motor-driven central shaft, equipped with impellers to mix the contents.
   - Ensures uniform distribution of nutrients and oxygen.
   - Provides a controlled environment for the cells.
2. **Sparged Stirred-Tank Bioreactor:**
   - Similar to the stirred tank bioreactor but with spargers to introduce air at the bottom.
   - Ensures efficient oxygen transfer and mixing.



Components of a Bioreactor:

1. **Vessel:**
   - Usually made of stainless steel to withstand pressure and maintain sterility.
   - Equipped with ports for adding nutrients, inoculating cells, and withdrawing samples.
2. **Agitator System:**
   - Consists of impellers attached to a central shaft.
   - Ensures proper mixing of the culture to maintain uniform conditions.
3. **Aeration System:**
   - Uses spargers or diffusers to introduce air or oxygen into the culture medium.
   - Essential for aerobic cultures to provide sufficient oxygen.
4. **Control Systems:**
   - Monitors and regulates parameters like temperature, pH, dissolved oxygen, and agitation speed.

- Sensors and automated controllers ensure optimal growth conditions.

5. **Sampling Ports:**
   - Allow periodic sampling of the culture without contaminating the bioreactor.
6. **Heating/Cooling System:**
   - Maintains optimal temperature for cell growth and product formation.
   - Often includes a jacket around the vessel or internal coils.
7. **Foam Control:**
   - Uses antifoam agents or mechanical foam breakers to control foam formation, which can interfere with aeration and mixing.

Operation of Bioreactors:

1. **Inoculation:**
   - Introduction of microorganisms or cells into the bioreactor under sterile conditions.
2. **Cultivation:**
   - Maintaining optimal conditions for cell growth and product formation.
   - Continuous monitoring and adjustment of parameters.
3. **Harvesting:**
   - Collecting the desired product from the culture medium.
   - Involves separation processes like filtration, centrifugation, or chromatography.

Advantages of Using Bioreactors:

1. **Controlled Environment:**
   - Precise control over growth conditions, leading to higher yields and product quality.
2. **Scalability:**
   - Can be scaled up from laboratory to industrial production.
3. **Efficiency:**
   - Enhanced mixing and aeration improve nutrient and oxygen availability.
4. **Sterility:**
   - Designed to maintain sterile conditions, preventing contamination.

Applications of Bioreactors:

1. **Pharmaceutical Industry:**
   - Production of antibiotics, vaccines, hormones, and therapeutic proteins.
2. **Food and Beverage Industry:**
   - Fermentation processes for products like yogurt, cheese, beer, and wine.
3. **Environmental Biotechnology:**
   - Treatment of wastewater and bioremediation.
4. **Agriculture:**
   - Production of biofertilizers and biopesticides.
5. **Research:**
   - Studying cellular processes and developing new biotechnological applications.
6. **Downstream Processing**:
   - Purification and formulation of the product after biosynthesis.
   - Clinical trials and quality control testing.

Question Bank for "Biotechnology: Principles and Processes"

Long-Answer Type Questions

1. Explain the principle and steps involved in recombinant DNA technology.
2. Describe the role of restriction enzymes in genetic engineering.
3. Discuss the various types of cloning vectors used in genetic engineering.
4. Explain the process of gel electrophoresis and its applications in biotechnology.
5. Describe the Polymerase Chain Reaction (PCR) and its significance in biotechnology.
6. Discuss the process of transformation in bacteria and the methods used to achieve it.
7. Explain the process of selecting recombinant colonies using blue-white screening.
8. Describe the different types of bioreactors and their applications in industrial biotechnology.
9. Explain the steps involved in the isolation of genetic material (DNA) from a bacterial cell.
10. Discuss the ethical, legal, and social implications of biotechnology.
11. Explain the importance of downstream processing in the production of biotechnological products.

12. Describe the use of Agrobacterium tumefaciens in plant genetic engineering.
13. Discuss the applications of recombinant DNA technology in medicine.
14. Explain the process of gene cloning and its applications.
15. Describe the role of bioreactors in large-scale production of biotechnology products.

Short-Answer Type Questions

1. What is recombinant DNA technology?
2. Name two types of restriction enzymes and their functions.
3. What are plasmids and why are they used as cloning vectors?
4. Explain the principle of gel electrophoresis.
5. What is the role of Taq polymerase in PCR?
6. How is DNA visualized after gel electrophoresis?
7. What are the steps involved in the PCR cycle?
8. Define transformation in the context of genetic engineering.
9. What is blue-white screening and how is it used in biotechnology?
10. List two types of bioreactors and their uses.
11. What is the purpose of using a selectable marker in cloning vectors?
12. Explain the significance of the origin of replication (ori) in a plasmid.
13. How does Agrobacterium tumefaciens transfer genes to plant cells?
14. What are the applications of recombinant DNA technology in agriculture?
15. Describe the role of antibiotic resistance genes in the selection of transformants.

Very Short Answer Type Questions

1. Define genetic engineering.
2. What is a restriction enzyme?
3. Name a commonly used cloning vector.
4. What is the purpose of gel electrophoresis?
5. What does PCR stand for?
6. Name one method of introducing DNA into bacterial cells.
7. What is the function of a selectable marker?
8. Define the term 'bioreactor'.
9. What is the role of DNA ligase in genetic engineering?
10. Name a bacterium commonly used in plant genetic engineering.
11. What is the significance of the term 'transformation' in biotechnology?

12. Name the enzyme used to synthesize DNA in PCR.
13. What is the function of the lacZ gene in blue-white screening?
14. Define plasmid.
15. What is meant by 'downstream processing'?

Multiple Choice Questions

1. Which of the following is a restriction enzyme?
    - a) DNA polymerase
    - b) RNA polymerase
    - c) EcoRI
    - d) Ligase
2. The process of transferring DNA into bacterial cells is called:
    - a) Transcription
    - b) Translation
    - c) Transformation
    - d) Translocation
3. Which enzyme is used to join DNA fragments?
    - a) DNA polymerase
    - b) DNA ligase
    - c) RNA polymerase
    - d) Restriction enzyme
4. What does PCR stand for?
    - a) Protein Chain Reaction
    - b) Polymerase Chain Reaction
    - c) Plasmid Chain Reaction
    - d) Polypeptide Chain Reaction
5. Which of the following is a commonly used vector in genetic engineering?
    - a) RNA
    - b) Plasmid
    - c) Ribosome
    - d) Golgi apparatus
6. In gel electrophoresis, DNA fragments are separated based on:
    - a) Size
    - b) Charge
    - c) Shape
    - d) Colour
7. Taq polymerase is obtained from:
    - a) *Escherichia coli*
    - b) *Saccharomyces cerevisiae*
    - c) *Thermus aquaticus*

- d) *Bacillus subtilis*

8. The term 'recombinant DNA' refers to:
   - a) RNA molecules joined together
   - b) DNA molecules from two different sources
   - c) DNA and RNA combined
   - d) Proteins synthesized from DNA
9. Which of the following is used as a selectable marker in cloning vectors?
   - a) Antibiotic resistance gene
   - b) LacZ gene
   - c) Ori site
   - d) None of the above
10. The technique used to amplify DNA is:
   - a) Southern blotting
   - b) Northern blotting
   - c) PCR
   - d) Gel electrophoresis
11. What is the role of the origin of replication in a plasmid?
   - a) Initiates DNA replication
   - b) Terminates DNA replication
   - c) Degrades DNA
   - d) Modifies DNA
12. Which of the following is an example of a bioreactor?
   - a) Test tube
   - b) Petri dish
   - c) Fermenter
   - d) Microscope
13. The enzyme used to cut DNA at specific sites is:
   - a) DNA ligase
   - b) RNA polymerase
   - c) Restriction enzyme
   - d) DNA polymerase
14. Which of the following is used to visualize DNA fragments after gel electrophoresis?
   - a) Ethidium bromide
   - b) Coomassie blue
   - c) Silver stain
   - d) Bromophenol blue
15. The process of inserting foreign DNA into a host cell is known as:
   - a) Transcription
   - b) Translation

- c) Transformation
- d) Translocation

Competency-Based Questions

1. Design an experiment to study the effectiveness of different restriction enzymes in cutting a specific DNA sequence.
2. Propose a method to verify the success of a gene cloning experiment using gel electrophoresis.
3. Explain how you would use PCR to detect a genetic mutation in a patient's DNA sample.
4. Describe the steps you would take to produce a recombinant protein using bacterial cells.
5. Outline a procedure to compare the efficiency of two different transformation methods in bacteria.

Case-Study Based Questions

1. A biotech company wants to produce human insulin using recombinant DNA technology. Describe the steps involved and the considerations for scaling up production.
2. In a research project, a team discovers a novel antibiotic resistance gene. How would they clone and express this gene in *E. coli*?
3. A student needs to purify a protein expressed in *E. coli*. Describe the downstream processing steps they should follow.
4. A researcher is developing a GMO crop resistant to a particular pest. Explain the process and potential regulatory and ethical issues involved.
5. A laboratory is tasked with diagnosing a genetic disorder using PCR. Describe the steps they would take and how they would interpret the results.

Answers Scheme

Long-Answer Type Questions - Answers

1. **Explain the principle and steps involved in recombinant DNA technology.**
   - Recombinant DNA technology involves combining DNA from two different sources to create a new genetic combination. The steps include:

1. **Isolation of DNA**: Extracting DNA from the donor organism.
2. **Cutting DNA at specific sites**: Using restriction enzymes to cut the DNA at specific sequences.

3. **Insertion of DNA into a vector**: Ligating the DNA fragments into a vector using DNA ligase.
4. **Introduction into a host cell**: Transforming the host cell with the recombinant DNA.
5. **Selection of recombinant cells**: Identifying and isolating cells that have taken up the recombinant DNA.
6. **Cloning and expression**: Cloning the recombinant cells to produce the desired product.

2. **Describe the role of restriction enzymes in genetic engineering.**
    - Restriction enzymes are molecular scissors that cut DNA at specific recognition sequences. They create sticky or blunt ends that allow the insertion of foreign DNA into vectors. This precise cutting and pasting of DNA fragments are fundamental to creating recombinant DNA molecules.

3. **Discuss the various types of cloning vectors used in genetic engineering.**
    - Cloning vectors are DNA molecules that carry foreign DNA into host cells. Types include:

1. **Plasmids**: Small circular DNA used in bacterial transformation.
2. **Bacteriophages**: Viruses that infect bacteria, used for larger DNA fragments.
3. **Cosmids**: Hybrid vectors combining features of plasmids and phages.
4. **Yeast Artificial Chromosomes (YACs)**: Used for cloning very large DNA fragments in yeast.
5. **Bacterial Artificial Chromosomes (BACs)**: Similar to YACs but used in bacteria.

4. **Explain the process of gel electrophoresis and its applications in biotechnology.**
    - Gel electrophoresis separates DNA fragments based on size. DNA is loaded into wells of an agarose gel and an electric current is applied. DNA fragments migrate towards the positive electrode, with smaller fragments moving faster. Applications include DNA fingerprinting, assessing PCR products, and analysing restriction enzyme digests.

5. **Describe the Polymerase Chain Reaction (PCR) and its significance in biotechnology.**
    - PCR amplifies specific DNA sequences exponentially. The process involves repeated cycles of denaturation (94-98°C), annealing (50-65°C), and extension (72°C) using Taq

polymerase. PCR is significant for cloning, genetic analysis, pathogen detection, and forensic identification.

6. **Discuss the process of transformation in bacteria and the methods used to achieve it.**
    - Transformation is the process of introducing foreign DNA into bacterial cells. Methods include:

1. **Chemical transformation**: Using calcium chloride and heat shock to make cells competent.

Electroporation: Using an electric field to create pores in the bacterial cell membrane, allowing DNA to enter.

7. **Explain the process of selecting recombinant colonies using blue-white screening.**
    - Blue-white screening involves using a plasmid vector with the lacZ gene, which encodes β-galactosidase. The plasmid also contains a multiple cloning site within the lacZ gene. When foreign DNA is inserted, it disrupts the lacZ gene, preventing β-galactosidase production. Transformed cells are grown on media containing X-gal. Colonies with non-recombinant plasmids (intact lacZ) produce β-galactosidase and turn blue. Colonies with recombinant plasmids (disrupted lacZ) remain white.
    -

8. **Describe the different types of bioreactors and their applications in industrial biotechnology.**
    - Bioreactors are vessels for growing organisms under controlled conditions. Types include:

1. **Stirred Tank Bioreactor**: Used for large-scale cell cultures and fermentation.
2. **Air-Lift Bioreactor**: Utilizes air to circulate cells and medium, suitable for shear-sensitive cultures.
3. **Packed Bed Bioreactor**: Cells are immobilized on a solid support, used for immobilized cell cultures.
4. **Fluidized Bed Bioreactor**: Support particles are suspended by the upward flow of medium, used for high-density cultures.
5. **Photobioreactor**: Used for photosynthetic organisms, equipped with light sources.

9. **Explain the steps involved in the isolation of genetic material (DNA) from a bacterial cell.**
    - The steps include:

1. **Cell Lysis**: Breaking the cell wall/membrane using enzymes (lysozyme for bacteria) or detergents.
2. **Removal of Proteins**: Adding proteases or phenol to denature and remove proteins.
3. **Purification**: Using ethanol or isopropanol to precipitate the DNA.
4. **Resuspension**: Dissolving the DNA in a suitable buffer (e.g., TE buffer).

10. **Discuss the ethical, legal, and social implications of biotechnology.**

Ethical concerns include the safety of genetically modified organisms (GMOs), potential environmental impacts, and the ethical treatment of genetically engineered animals. Legal issues involve patenting biotechnological inventions, regulations on GMO use, and intellectual property rights. Social implications include access to biotechnological advances, public perception, and the potential for bioterrorism.

11. **Explain the importance of downstream processing in the production of biotechnological products.**

Downstream processing involves the purification and formulation of biotechnological products. It ensures product purity, quality, and stability. Steps include cell separation, product isolation, purification, and formulation. It is crucial for producing pharmaceuticals, enzymes, and other high-value products.

12. **Describe the use of Agrobacterium tumefaciens in plant genetic engineering.**

Agrobacterium tumefaciens naturally transfers a portion of its Ti plasmid (T-DNA) into plant cells, causing crown gall disease. Scientists exploit this mechanism to introduce desired genes into plants. The Ti plasmid is modified to carry the gene of interest, and the bacterium infects plant cells, transferring the T-DNA into the plant genome.

13. **Discuss the applications of recombinant DNA technology in medicine.**

Applications include:

1. **Gene Therapy**: Treating genetic disorders by correcting defective genes.

2. **Production of Insulin**: Producing human insulin in bacteria for diabetes treatment.
3. **Vaccine Development**: Creating recombinant vaccines for diseases like hepatitis B.
4. **Monoclonal Antibodies**: Producing antibodies for targeted cancer therapy.

14. **Explain the process of gene cloning and its applications.**
    - Gene cloning involves:

1. **Isolation of the gene of interest**: Extracting the specific DNA sequence.
2. **Insertion into a cloning vector**: Using restriction enzymes and DNA ligase.
3. **Transformation into host cells**: Introducing the recombinant vector into cells.
4. **Selection and screening**: Identifying cells with the recombinant DNA.

Applications include studying gene function, producing recombinant proteins, and developing genetically modified organisms.

15. **Describe the role of bioreactors in large-scale production of biotechnology products.**

Bioreactors provide a controlled environment for growing cells or microorganisms on a large scale. They ensure optimal conditions for cell growth and product formation, improving yield and efficiency. Bioreactors are essential for producing pharmaceuticals, enzymes, biofuels, and other biotechnological products.

Short-Answer Type Questions - Answers

1. **What is recombinant DNA technology?**

A technology that combines DNA from two different sources to create a new genetic combination.

2. **Name two types of restriction enzymes and their functions.**
    - **EcoRI**: Cuts DNA at GAATTC sequences, creating sticky ends.
    - **HindIII**: Cuts DNA at AAGCTT sequences, creating sticky ends.
3. **What are plasmids and why are they used as cloning vectors?**

Plasmids are small, circular DNA molecules that replicate independently in bacterial cells. They are used as cloning vectors because they can carry foreign DNA and replicate within the host.

4. **Explain the principle of gel electrophoresis.**

Gel electrophoresis separates DNA fragments based on size using an electric field. DNA moves through a gel matrix towards the positive electrode, with smaller fragments moving faster.

5. **What is the role of Taq polymerase in PCR?**

Taq polymerase is a heat-stable enzyme that synthesizes new DNA strands during PCR.

6. **How is DNA visualized after gel electrophoresis?**

DNA is visualized by staining the gel with a DNA-specific dye like ethidium bromide, which fluoresces under UV light.

7. **What are the steps involved in the PCR cycle?**

The PCR cycle includes denaturation (94-98°C), annealing (50-65°C), and extension (72°C).

8. **Define transformation in the context of genetic engineering.**

Transformation is the process of introducing foreign DNA into bacterial cells.

9. **What is blue-white screening and how is it used in biotechnology?**

Blue-white screening identifies recombinant colonies using a plasmid vector with the lacZ gene. Recombinant colonies disrupt lacZ and remain white, while non-recombinant colonies turn blue.

10. **List two types of bioreactors and their uses.**

Stirred Tank Bioreactor: Used for large-scale cell cultures and fermentation.

Photobioreactor: Used for growing photosynthetic organisms like algae.

11. **What is the purpose of using a selectable marker in cloning vectors?**

Selectable markers identify and select cells that have taken up the cloning vector.

12. **Explain the significance of the origin of replication (ori) in a plasmid.**

The ori initiates DNA replication, allowing the plasmid to replicate within the host cell.

13. **How does Agrobacterium tumefaciens transfer genes to plant cells?**

Agrobacterium tumefaciens transfers genes to plant cells via its Ti plasmid, which integrates into the plant genome.

14. **What are the applications of recombinant DNA technology in agriculture?**

Applications include developing genetically modified crops with improved traits like pest resistance, herbicide tolerance, and enhanced nutritional content.

15. **Describe the role of antibiotic resistance genes in the selection of transformants.**

Antibiotic resistance genes allow for the selection of transformants by providing resistance to specific antibiotics, enabling only transformed cells to grow on selective media.

Very Short Answer Type Questions - Answers

1. **Define genetic engineering.**
    - Genetic engineering is the manipulation of an organism's genes using biotechnology.
2. **What is a restriction enzyme?**
    - A restriction enzyme is an enzyme that cuts DNA at specific recognition sequences.
3. **Name a commonly used cloning vector.**
    - Plasmid.
4. **What is the purpose of gel electrophoresis?**
    - To separate DNA fragments based on size.
5. **What does PCR stand for?**
    - Polymerase Chain Reaction.

6. **Name one method of introducing DNA into bacterial cells.**
    - Transformation.
7. **What is the function of a selectable marker?**
    - To identify and select cells that have taken up the cloning vector.
8. **Define the term 'bioreactor'.**
    - A bioreactor is a vessel in which biological processes are carried out under controlled conditions.
9. **What is the role of DNA ligase in genetic engineering?**
    - DNA ligase joins DNA fragments by forming phosphodiester bonds.
10. **Name a bacteria commonly used in plant genetic engineering.**
    - Agrobacterium tumefaciens.
11. **What is the significance of the term 'transformation' in biotechnology?**
    - Transformation refers to the process of introducing foreign DNA into cells.
12. **Name the enzyme used to synthesize DNA in PCR.**
    - Taq polymerase.
13. **What is the function of the lacZ gene in blue-white screening?**
    - The lacZ gene encodes β-galactosidase, which hydrolyses X-gal, producing a blue colour in non-recombinant colonies.
14. **Define plasmid.**
    - A plasmid is a small, circular DNA molecule that replicates independently in bacterial cells.
15. **What is meant by 'downstream processing'?**
    - Downstream processing involves the purification and formulation of biotechnological products after they are synthesized in the bioreactor.

Multiple Choice Questions - Answers

1. Which of the following is a restriction enzyme?
    - c) EcoRI
2. The process of transferring DNA into bacterial cells is called:
    - c) Transformation
3. Which enzyme is used to join DNA fragments?
    - b) DNA ligase
4. What does PCR stand for?
    - b) Polymerase Chain Reaction
5. Which of the following is a commonly used vector in genetic engineering?

- b) Plasmid

6. In gel electrophoresis, DNA fragments are separated based on:
   - a) Size
7. Taq polymerase is obtained from:
   - c) *Thermus aquaticus*
8. The term 'recombinant DNA' refers to:
   - b) DNA molecules from two different sources
9. Which of the following is used as a selectable marker in cloning vectors?
   - a) Antibiotic resistance gene
10. The technique used to amplify DNA is:
   - c) PCR
11. What is the role of the origin of replication in a plasmid?
   - a) Initiates DNA replication
12. Which of the following is an example of a bioreactor?
   - c) Fermenter
13. The enzyme used to cut DNA at specific sites is:
   - c) Restriction enzyme
14. Which of the following is used to visualize DNA fragments after gel electrophoresis?
   - a) Ethidium bromide
15. The process of inserting foreign DNA into a host cell is known as:
   - c) Transformation

Competency-Based Questions - Answers

1. **Design an experiment to study the effectiveness of different restriction enzymes in cutting a specific DNA sequence.**

Objective: To evaluate the cutting efficiency of different restriction enzymes on a specific DNA sequence.

Materials: DNA sample, restriction enzymes (e.g., EcoRI, Hind III, Bam HI), agarose gel, electrophoresis apparatus, DNA ladder, loading dye, UV transilluminator, and ethidium bromide.

Procedure:

1. **Preparation**: Extract and purify the DNA sample.
2. **Digestion**: Set up multiple reaction mixtures, each containing the DNA sample and a different restriction enzyme.

3. **Incubation**: Incubate the reactions at the optimal temperature for each enzyme for 1-2 hours.
4. **Gel Electrophoresis**: Load the digested samples into an agarose gel and run electrophoresis.
5. **Visualization**: Stain the gel with ethidium bromide and visualize the DNA fragments under UV light.
6. **Analysis**: Compare the fragment patterns to determine which enzyme cuts the DNA most efficiently.

Conclusion: The restriction enzyme producing the most distinct and expected fragment pattern is considered the most effective.

2. **Propose a method to verify the success of a gene cloning experiment using gel electrophoresis.**

Objective: To confirm the presence of the inserted gene in the cloning vector.

Materials: Recombinant plasmid DNA, restriction enzymes, agarose gel, electrophoresis apparatus, DNA ladder, loading dye, UV transilluminator, and ethidium bromide.

Procedure:

1. **Preparation**: Isolate plasmid DNA from transformed bacterial colonies.
2. **Digestion**: Perform restriction digestion of the plasmid DNA with enzymes that flank the inserted gene.
3. **Gel Electrophoresis**: Load the digested samples into an agarose gel and run electrophoresis.
4. **Visualization**: Stain the gel with ethidium bromide and visualize the DNA fragments under UV light.
5. **Analysis**: Compare the fragment sizes with the expected sizes based on the known sequences of the vector and the inserted gene.

Conclusion: Successful cloning is confirmed if the fragment sizes match the expected pattern.

3. **Explain how you would use PCR to detect a genetic mutation in a patient's DNA sample.**

Objective: To identify the presence of a specific genetic mutation using PCR.

Materials: Patient's DNA sample, PCR primers specific to the mutation site, Taq polymerase, dNTPs, PCR buffer, thermocycler, agarose gel, electrophoresis apparatus, DNA ladder, loading dye, UV transilluminator, and ethidium bromide.

Procedure:

1. **DNA Extraction**: Extract DNA from the patient's blood or tissue sample.
2. **PCR Setup**: Prepare the PCR reaction mixture with the patient's DNA, primers, Taq polymerase, dNTPs, and buffer.
3. **PCR Amplification**: Run the PCR in a thermocycler with appropriate cycling conditions.
4. **Gel Electrophoresis**: Load the PCR product into an agarose gel and run electrophoresis.
5. **Visualization**: Stain the gel with ethidium bromide and visualize the PCR products under UV light.
6. **Analysis**: Compare the PCR product sizes with the expected sizes for the normal and mutant alleles.

Conclusion: The presence of a mutation is indicated if the PCR product corresponds to the size of the mutant allele.

4. **Describe the steps you would take to produce a recombinant protein using bacterial cells.**

Objective: To express and purify a recombinant protein in *E. coli*.

Materials: Gene of interest, cloning vector, competent *E. coli* cells, growth medium, IPTG (inducer), antibiotic, centrifuge, lysis buffer, affinity chromatography column.

Procedure:

1. **Cloning**: Insert the gene of interest into a suitable expression vector.
2. **Transformation**: Introduce the recombinant vector into competent *E. coli* cells via heat shock or electroporation.
3. **Selection**: Plate the transformed cells on antibiotic-containing media to select for transformants.

4. **Expression**: Inoculate a culture with a single colony and grow to the desired density. Induce protein expression with IPTG.
5. **Harvesting**: Collect the cells by centrifugation.
6. **Lysis**: Lyse the cells using a lysis buffer to release the recombinant protein.
7. **Purification**: Purify the protein using affinity chromatography.

Conclusion: Analyse the purified protein using SDS-PAGE to confirm expression and purity.

5. **Outline a procedure to compare the efficiency of two different transformation methods in bacteria.**

Objective: To compare the efficiency of chemical transformation and electroporation.

Materials: Competent *E. coli* cells, plasmid DNA, calcium chloride solution, electroporation apparatus, recovery medium, antibiotic plates, incubator.

Procedure:

1. **Chemical Transformation**:
    - Treat competent cells with calcium chloride.
    - Mix with plasmid DNA and incubate on ice.
    - Heat shock the cells and recover in LB medium.
    - Plate on antibiotic-containing media.
2. **Electroporation**:
    - Mix competent cells with plasmid DNA.
    - Transfer the mixture to an electroporation cuvette.
    - Apply an electric pulse using the electroporator.
    - Recover the cells in LB medium and plate on antibiotic-containing media.
3. **Incubation**: Incubate the plates overnight at 37°C.
4. **Analysis**: Count the number of colonies on each plate.

Conclusion: Compare the colony counts to determine which method yields more transformants.

Case-Study Based Questions - Answers

1. **A biotech company wants to produce human insulin using recombinant DNA technology. Describe the steps involved and the considerations for scaling up production.**
    - **Steps**:

1. **Gene Isolation**: Isolate the gene encoding human insulin.
2. **Cloning**: Insert the insulin gene into a plasmid vector.
3. **Transformation**: Introduce the recombinant plasmid into *E. coli* cells.
4. **Selection**: Select transformed cells using antibiotic resistance markers.
5. **Expression**: Induce the expression of insulin in the transformed cells.
6. **Purification**: Harvest and lyse the cells, then purify insulin using chromatography.
7. **Formulation**: Formulate the purified insulin for medical use.

    - **Scaling Up Considerations**:

1. **Bioreactor Selection**: Choose a suitable bioreactor for large-scale production.
2. **Optimization**: Optimize growth conditions and induction parameters.
3. **Quality Control**: Implement rigorous quality control to ensure product consistency and safety.
4. **Regulatory Compliance**: Ensure compliance with regulatory standards for pharmaceutical production.
5. **Cost Efficiency**: Optimize processes to reduce production costs while maintaining product quality.

2. **In a research project, a team discovers a novel antibiotic resistance gene. How would they clone and express this gene in *E. coli*?**
    - **Steps**:

1. **Gene Isolation**: Isolate the novel antibiotic resistance gene from the source organism.
2. **Cloning**: Insert the gene into a suitable plasmid vector with an origin of replication and a selectable marker.
3. **Transformation**: Transform competent *E. coli* cells with the recombinant plasmid using heat shock or electroporation.
4. **Selection**: Plate the transformed cells on media containing the antibiotic to select for cells expressing the resistance gene.

5. **Expression**: Grow the selected colonies in liquid media with the antibiotic to ensure stable expression.

Confirmation: Confirm the presence and expression of the gene by PCR, restriction digestion, and sequencing.

Applications: Use the cloned gene to study antibiotic resistance mechanisms, develop new antibiotics, or create genetically modified bacteria for biotechnological applications.

3. **A student needs to purify a protein expressed in *E. coli*. Describe the downstream processing steps they should follow.**
    - **Steps**:

1. **Cell Harvesting**: Grow the *E. coli* culture expressing the protein of interest and harvest the cells by centrifugation.
2. **Cell Lysis**: Lyse the cells using a lysis buffer containing lysozyme, detergents, and/or sonication to release the protein.
3. **Clarification**: Centrifuge the lysate to remove cell debris, retaining the supernatant containing the soluble protein.
4. **Initial Purification**: Perform affinity chromatography using a column with a resin that specifically binds the target protein (e.g., His-tagged proteins using nickel affinity columns).
5. **Wash and Elution**: Wash the column to remove non-specifically bound proteins, then elute the target protein with an appropriate elution buffer.
6. **Concentration**: Concentrate the eluted protein using ultrafiltration or other concentration methods.
7. **Further Purification**: Use additional chromatography techniques (e.g., ion exchange, size exclusion) if higher purity is required.
8. **Dialysis**: Dialyze the purified protein against a suitable buffer to remove salts and other small molecules.
9. **Quality Control**: Analyse the purity and integrity of the protein using SDS-PAGE and western blotting.

Applications: Use the purified protein for structural studies, functional assays, or as a therapeutic agent.

4. **A researcher is developing a GMO crop resistant to a particular pest. Explain the process and potential regulatory and ethical issues involved.**

Process:

1. **Gene Identification**: Identify a gene that confers resistance to the target pest (e.g., Bt toxin gene from *Bacillus thuringiensis*).
2. **Cloning**: Clone the resistance gene into a suitable plant transformation vector.
3. **Transformation**: Introduce the recombinant vector into plant cells using Agrobacterium-mediated transformation or biolistics.
4. **Selection and Regeneration**: Select transformed cells on media containing a selectable marker and regenerate whole plants from these cells.
5. **Screening**: Screen the regenerated plants for the presence and expression of the resistance gene using molecular techniques (PCR, Southern blotting).
6. **Field Testing**: Conduct field trials to evaluate the performance of the GMO crop under natural conditions.

Regulatory Issues:

7. **Safety Assessment**: Conduct safety assessments to evaluate potential risks to human health and the environment.
8. **Regulatory Approval**: Obtain approval from relevant regulatory authorities (e.g., FDA, USDA, EPA in the USA) before commercial release.
9. **Labelling**: Ensure proper labelling of GMO products as required by regulations.

Ethical Issues:

10. **Environmental Impact**: Assess the potential impact on non-target organisms and biodiversity.
11. **Gene Flow**: Consider the risk of gene flow to wild relatives or non-GMO crops.
12. **Public Perception**: Address public concerns and engage in transparent communication about the benefits and risks of GMO crops.
13. **Intellectual Property**: Consider the implications of patenting GMO crops and access to technology for farmers.

5. **A laboratory is tasked with diagnosing a genetic disorder using PCR. Describe the steps they would take and how they would interpret the results.**
    - **Steps**:

1. **Sample Collection**: Collect a sample of the patient's blood or tissue.
2. **DNA Extraction**: Extract DNA from the collected sample using a DNA extraction kit.
3. **Primer Design**: Design primers specific to the region of the gene where the mutation is known to occur.
4. **PCR Setup**: Prepare the PCR reaction mixture with the extracted DNA, primers, Taq polymerase, dNTPs, and buffer.
5. **PCR Amplification**: Run the PCR in a thermocycler with appropriate cycling conditions (denaturation, annealing, extension).
6. **Gel Electrophoresis**: Load the PCR product onto an agarose gel and run electrophoresis.
7. **Visualization**: Stain the gel with ethidium bromide and visualize the bands under UV light.

Interpretation:

8. **Band Pattern**: Compare the band pattern of the patient's sample with a control sample. The presence or absence of specific bands can indicate whether the patient has the mutation.
9. **Size of PCR Product**: If the mutation causes a change in the size of the PCR product, this can be detected by comparing the sizes of the bands.
10. **Sequencing**: If necessary, sequence the PCR product to confirm the presence of the mutation.
    - **Conclusion**: Based on the PCR results, determine whether the patient has the genetic disorder.

CHAPTER-12
BIOTECHNOLOGY AND ITS APPLICATIONS

Biotechnology deals with the industrial-scale production of biopharmaceuticals and biologicals using genetically modified organisms. Its applications are vast and include areas like therapeutics, diagnostics, genetically modified crops for agriculture, processed food, bioremediation, waste treatment, and energy production. The critical research areas in biotechnology are:

1. **Improved Catalysts**: Using enhanced organisms or pure enzymes.
2. **Optimal Conditions**: Engineering the best environment for catalysts to act.

3. **Downstream Processing**: Technologies to purify proteins or organic compounds.

Biotechnological Applications in Agriculture

1. **Increasing Food Production**:
   - **Agro-Chemical Based Agriculture**: Use of fertilizers and pesticides.
   - **Organic Agriculture**: Natural farming methods.
   - **Genetically Engineered Crop-Based Agriculture**: Use of genetically modified organisms (GMOs).
2. **Green Revolution**:
   - Increased food supply but not enough to feed the growing population.
   - Use of improved crop varieties and better management practices.
   - Traditional breeding techniques were slow, leading to the development of tissue culture.
3. **Tissue Culture**:
   - Whole plants can be regenerated from explants (any part of a plant grown in a test tube under sterile conditions).
   - **Totipotency**: The ability to generate a whole plant from any cell/explant.
   - **Micropropagation**: Producing thousands of plants in a short time, all genetically identical (somaclones).
   - Recovery of healthy plants from diseased ones using virus-free meristems (apical and axillary).
4. **Protoplast Fusion and Somatic Hybridization**:
   - Isolation of protoplasts (naked cells without cell walls) from different plant varieties.
   - Fusion of protoplasts to create hybrid plants combining desirable characteristics.
5. **Genetically Modified Organisms (GMOs)**:
   - Plants, bacteria, fungi, and animals whose genes have been altered through genetic engineering.
   - Benefits of GM crops:
     - Tolerance to abiotic stresses (cold, drought, salt, heat).
     - Reduced reliance on chemical pesticides.
     - Decreased post-harvest losses.
     - Improved nutrient efficiency and soil fertility.
     - Enhanced nutritional value of food (e.g., golden rice enriched with Vitamin A).
   - GM crops provide alternative resources to industries in the form of starches, fuels, and pharmaceuticals.

Pest Resistant Plants

Pest-resistant plants are genetically engineered to withstand attacks from insects and other pests, reducing the need for chemical pesticides and improving crop yields. One of the primary methods of achieving pest resistance is through the incorporation of genes from the bacterium *Bacillus thuringiensis* (Bt), which produces toxins that are harmful to specific insects.

Bt Toxin

1. **Source**:

Bacillus thuringiensis (Bt) is a soil bacterium that produces crystal proteins (Cry proteins) during sporulation.

2. **Mechanism of Action**:

Bt toxins exist as inactive protoxins. When ingested by insect larvae, the alkaline pH of the insect gut activates the protoxins, converting them into active toxins.

The active toxins bind to specific receptors on the gut epithelial cells of the insect, creating pores in the cell membranes.

These pores disrupt the osmotic balance, causing cell swelling and lysis, which ultimately leads to the death of the insect.

3. **Development of Bt Crops**:

Scientists have isolated specific Bt toxin genes (e.g., cryIAc, cryIIAb) and incorporated them into the genomes of various crop plants.

The choice of Bt gene depends on the target pest and the crop. For example, cryIAc and cryIIAb control cotton bollworms, while cryIAb controls corn borer.

Examples of Bt Crops

1. **Bt Cotton**:

Bt cotton contains Bt genes that produce toxins against lepidopteran pests like tobacco budworm and armyworm.

The introduction of Bt cotton has significantly reduced the need for chemical insecticides in cotton farming.

2. **Bt Corn**:

Bt corn is engineered to express Bt toxins that target corn borers, reducing crop losses and increasing yields.

3. **Other Bt Crops**:

Bt rice, Bt tomato, Bt potato, and Bt soybean have been developed to resist various insect pests.

RNA Interference (RNAi) for Pest Resistance

1. **RNA Interference (RNAi)**:

RNAi is a biological process in which RNA molecules inhibit gene expression by neutralizing targeted mRNA molecules.

This method is used to develop pest-resistant plants by silencing specific genes essential for pest survival.

2. **Mechanism**:

Double-stranded RNA (dsRNA) corresponding to a target gene in the pest is introduced into the plant.

When the pest feeds on the plant, the dsRNA is ingested and processed into small interfering RNAs (siRNAs) by the pest's cellular machinery.

These siRNAs bind to the complementary mRNA in the pest, leading to its degradation and preventing the production of essential proteins.

3. **Application**:

RNAi has been used to protect tobacco plants from root-knot nematode (*Meloidogyne incognita*).

Using Agrobacterium vectors, nematode-specific genes are introduced into the host plant, producing both sense and antisense RNA that form dsRNA.

The dsRNA triggers RNAi, silencing the specific mRNA of the nematode and preventing infestation.

Advantages of Pest-Resistant Plants

1. **Reduced Use of Chemical Pesticides**:
    - Pest-resistant plants significantly reduce the need for chemical pesticides, leading to lower production costs and reduced environmental pollution.
2. **Sustainable Agriculture**:
    - By reducing reliance on chemical pesticides, pest-resistant plants contribute to more sustainable agricultural practices.
3. **Increased Crop Yields**:
    - Protecting crops from pests helps in achieving higher yields, which is crucial for meeting the food demands of a growing population.
4. **Environmental and Health Benefits**:
    - Reduced pesticide use lowers the risk of pesticide residues in food and the environment, benefiting both human health and biodiversity.

Challenges and Concerns

1. **Resistance Development**:
    - Pests may develop resistance to Bt toxins or RNAi over time, potentially reducing the effectiveness of pest-resistant crops.
2. **Non-Target Effects**:
    - There is a possibility that Bt toxins or RNAi could affect non-target organisms, including beneficial insects and soil microbes.
3. **Regulatory and Ethical Issues**:
    - The development and deployment of genetically modified pest-resistant crops involve regulatory hurdles and raise ethical concerns regarding the manipulation of natural organisms.
4. **Public Perception**:
    - Public acceptance of genetically modified crops varies, and there may be resistance to adopting these technologies in certain regions.

Conclusion

Pest-resistant plants, particularly those developed using Bt toxins and RNA interference, offer a promising solution for reducing pesticide use, enhancing crop yields, and promoting sustainable agriculture. However, it is essential to monitor and manage the potential challenges

and ethical concerns associated with their use to ensure long-term effectiveness and safety.

- **Bt Toxin**: Produced by *Bacillus thuringiensis* (Bt), used to create insect-resistant crops like Bt cotton, Bt corn, rice, tomato, potato, and soybean.
- **RNA Interference (RNAi)**: Used to protect plants from nematodes by silencing specific genes.

Biotechnological Applications in Medicine

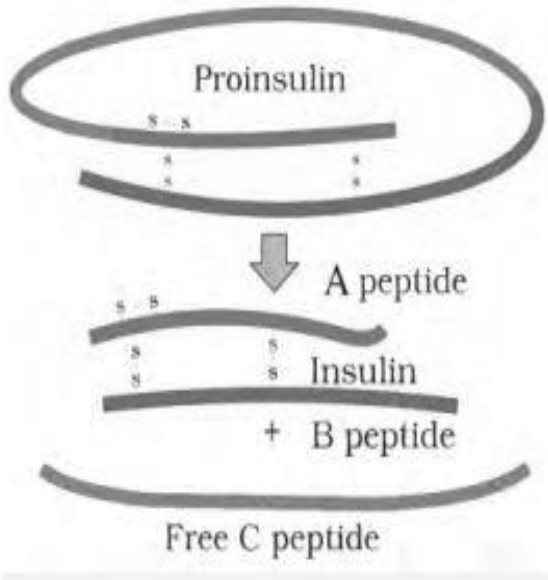
1. **Recombinant Therapeutics**:
   - Mass production of safe and effective therapeutic drugs using recombinant DNA technology.
   - Recombinant therapeutics do not induce unwanted immunological responses.
   - Examples include insulin, growth hormones, and interferons.

2. **Genetically Engineered Insulin**

Insulin is a hormone produced by the pancreas that regulates blood sugar levels. In individuals with diabetes, the body either does not produce enough insulin (Type 1 diabetes) or cannot effectively use the insulin it produces (Type 2 diabetes). Traditionally, insulin for medical use was extracted from the pancreas of slaughtered cattle and pigs. However, this animal-derived insulin could cause allergic reactions in some patients. The advent of recombinant DNA technology has enabled the production of human insulin in bacteria, providing a more effective and safer alternative.

Structure of Insulin

- **Insulin** consists of two short polypeptide chains: Chain A and Chain B.
- These chains are linked together by disulfide bridges.
- In mammals, including humans, insulin is initially synthesized as a pro-hormone called proinsulin.
- Proinsulin contains an extra stretch called the C peptide, which is removed during



maturation to form functional insulin.

Challenges in Insulin Production

- The primary challenge in producing insulin using recombinant DNA technology was assembling the insulin chains into a mature form.
- Human insulin needs to be identical to the natural molecule to avoid immunological responses.

Production of Genetically Engineered Insulin

1. **Gene Cloning**:
    - The genes encoding the A and B chains of human insulin were identified and cloned.
    - These genes were inserted into plasmids, which are circular DNA molecules used as vectors to introduce foreign genes into host cells.
2. **Transformation**:
    - The recombinant plasmids carrying the insulin genes were introduced into *Escherichia coli* (E. coli) bacteria through a process called transformation.
    - E. coli cells took up the recombinant plasmids and began to produce the insulin chains.
3. **Expression**:
    - In the 1980s, Eli Lilly, an American pharmaceutical company, developed a method to produce human insulin in bacteria.
    - The company prepared two separate DNA sequences corresponding to the A and B chains of human insulin and inserted them into different plasmids.
    - These plasmids were then introduced into separate cultures of *E. coli*, leading to the production of the individual A and B chains.
4. **Purification and Assembly**:
    - The A and B chains were produced separately and then extracted from the bacterial cultures.
    - The extracted chains were purified to remove any bacterial contaminants.
    - Finally, the A and B chains were combined and chemically bonded through disulfide bridges to form functional human insulin.
5. **Advantages of Recombinant Insulin**:

- **Identical to Human Insulin**: The structure of recombinant insulin is identical to natural human insulin, reducing the risk of allergic reactions.
- **Consistent Supply**: Recombinant technology allows for a consistent and scalable supply of insulin.
- **Reduced Risk of Contamination**: Unlike animal-derived insulin, recombinant insulin is free from potential contaminants and pathogens associated with animal tissues.

Benefits of Genetically Engineered Insulin

1. **Enhanced Safety**:
   - Recombinant insulin does not induce unwanted immunological responses as it is identical to the insulin produced by the human body.
2. **Increased Availability**:
   - The ability to produce large quantities of insulin using bacterial cultures ensures a steady and reliable supply to meet global demand.
3. **Reduced Allergic Reactions**:
   - Human insulin produced through recombinant DNA technology is less likely to cause allergic reactions compared to insulin extracted from animal sources.
4. **Cost-Effectiveness**:
   - The large-scale production of recombinant insulin in bacterial cultures is more cost-effective than extracting insulin from animal pancreases.

- Before the development of genetically engineered insulin, diabetic patients relied on insulin extracted from the pancreas of slaughtered cattle and pigs.
- The first successful production of recombinant human insulin was achieved by Eli Lilly in 1983.
- This breakthrough marked a significant advancement in biotechnology and medical treatment for diabetes.

- The production and use of genetically engineered insulin are subject to strict regulatory oversight to ensure safety and efficacy.
- Ethical considerations include ensuring patient access to affordable insulin and addressing any concerns related to genetic engineering.

Genetically engineered insulin represents a major milestone in biotechnology, offering a safe, effective, and scalable solution for managing diabetes. The use of recombinant DNA technology to produce human insulin has revolutionized diabetes treatment, improving the quality of life for millions of patients worldwide. By overcoming the challenges associated with animal-derived insulin, recombinant insulin provides a consistent and reliable source of this essential hormone

2. **Gene Therapy**:

Gene therapy is a collection of methods that allows the correction of a gene defect diagnosed in a child or embryo. It involves the delivery of a normal gene into the individual's cells and tissues to take over the function of and compensate for the non-functional gene.

Types of Gene Therapy

1. **Somatic Gene Therapy**:
    - Targets somatic (body) cells.
    - Genetic changes are not passed on to the next generation.
    - Used to treat the patient with the genetic disorder.
2. **Germline Gene Therapy**:
    - Targets germ cells (sperm or eggs).
    - Genetic changes are heritable and passed on to future generations.
    - Currently not practiced in humans due to ethical and technical issues.

Techniques and Vectors Used in Gene Therapy

- **Retroviruses**: Integrate their genetic material into the host cell's DNA, ensuring long-term expression.
- **Adenoviruses**: Deliver DNA to the nucleus of host cells but do not integrate into the host genome, leading to transient expression.
- **Adeno-Associated Viruses (AAV)**: Cause less immune response and have been used in clinical trials.

First Successful Gene Therapy: ADA Deficiency

1. **Adenosine Deaminase (ADA) Deficiency**:
    - ADA is crucial for the immune system to function.
    - The disorder is caused by the deletion of the gene for ADA.
2. **Treatment Options**:

- **Bone Marrow Transplantation**: Can cure some children but has limitations.
- **Enzyme Replacement Therapy**: Functional ADA is given to the patient by injection but is not a permanent cure.

3. **Gene Therapy Procedure**:
   - **Step 1**: Lymphocytes are extracted from the patient's blood and grown in culture.
   - **Step 2**: A functional ADA cDNA is introduced into these lymphocytes using a retroviral vector.
   - **Step 3**: The genetically modified lymphocytes are returned to the patient's bloodstream.
   - **Outcome**: The patient requires periodic infusions of these genetically engineered lymphocytes. Introducing the gene into early embryonic cells could potentially offer a permanent cure.

3. **Molecular Diagnosis**:For effective treatment of a disease, early diagnosis and understanding its pathophysiology is crucial. Molecular diagnosis uses techniques that identify diseases by detecting specific genes or gene products. These techniques are more sensitive and specific than traditional methods.

Techniques of Molecular Diagnosis

1. **Recombinant DNA Technology**
   - Involves the manipulation of DNA to identify genetic mutations or the presence of pathogens.
   - Allows for the detection of specific DNA sequences associated with diseases.
2. **Polymerase Chain Reaction (PCR)**
   - PCR is a powerful technique to amplify a specific segment of DNA.
   - It can detect very low amounts of DNA in a sample, making it useful for early diagnosis.
   - **Application**:
     - Used to detect the presence of HIV in suspected AIDS patients.
     - Helps in identifying genetic mutations in cancer patients.
     - Can detect pathogens in various infectious diseases.
   - **Procedure**:
     - A small DNA sample is mixed with primers, nucleotides, and DNA polymerase.

        - The mixture is subjected to repeated cycles of heating and cooling to denature the DNA, anneal primers, and extend new DNA strands.
        - The result is the exponential amplification of the target DNA sequence.

3. **Enzyme-Linked Immunosorbent Assay (ELISA)**
    - Based on the principle of antigen-antibody interaction.
    - Used to detect the presence of antigens (proteins, glycoproteins) or antibodies in a sample.
    - **Application**:
        - Used to diagnose infections by detecting antibodies against pathogens like viruses and bacteria.
        - Can be used to monitor the immune response to infections and vaccines.
    - **Procedure**:
        - The sample is added to a plate coated with a specific antigen or antibody.
        - If the target antigen or antibody is present in the sample, it will bind to the coating.
        - A secondary antibody conjugated to an enzyme is added, which binds to the target.
        - A substrate for the enzyme is added, leading to a colour change that indicates the presence of the target antigen or antibody.
4. **Autoradiography and DNA Probes**
    - A single-stranded DNA or RNA, tagged with a radioactive molecule (probe), is used to detect its complementary DNA.
    - **Procedure**:
        - The probe hybridizes to its complementary DNA in a sample.
        - The sample is then subjected to autoradiography.
        - The presence of the probe is visualized as bands on a photographic film, indicating the presence of the target DNA sequence.
    - **Application**:
        - Used to identify specific genes or mutations.
        - Helps in the diagnosis of genetic disorders and infections.

Advantages of Molecular Diagnosis

1. **Early Detection**:
    - Molecular techniques can detect diseases at a very early stage, even before symptoms appear.
    - Early diagnosis allows for timely treatment and better management of diseases.
2. **High Sensitivity and Specificity**:
    - These techniques can detect low levels of pathogens or genetic mutations with high accuracy.
    - They reduce the chances of false positives and false negatives.
3. **Wide Range of Applications**:
    - Molecular diagnosis is applicable to various fields, including infectious diseases, genetic disorders, cancer, and monitoring immune responses.
    - Molecular diagnosis has revolutionized the field of medical diagnostics by providing highly sensitive, specific, and early detection methods. Techniques like recombinant DNA technology, PCR, ELISA, and DNA probes have become indispensable tools in the diagnosis and management of diseases, enabling more effective treatment and improved patient outcomes

Transgenic Animals

Transgenic animals are those that have had their DNA manipulated to possess and express an extra (foreign) gene. This technology is used to understand gene function, study diseases, and produce valuable biological products.

Reasons for Creating Transgenic Animals

1. **Study of Gene Regulation and Development**:
    - Transgenic animals are used to study how genes are regulated and how they affect normal physiology and development.
    - For example, insulin-like growth factor studies involve introducing genes from other species that alter the formation of this factor and studying the resulting biological effects.
2. **Modelling Human Diseases**:
    - Transgenic animals are designed to serve as models for human diseases, allowing researchers to study the development and progression of these diseases.
    - Examples include models for cancer, cystic fibrosis, rheumatoid arthritis, and Alzheimer's disease.

3. **Production of Biological Products**:
    - Transgenic animals can be engineered to produce valuable biological products such as pharmaceuticals.
    - For instance, the human protein alpha-1-antitrypsin used to treat emphysema is produced in transgenic animals.
    - In 1997, the first transgenic cow, Rosie, produced human protein-enriched milk, which was more balanced nutritionally for human babies than natural cow milk.
4. **Testing Vaccine Safety**:
    - Transgenic animals, particularly mice, are developed to test the safety of vaccines before they are used in humans.
    - Transgenic mice have been used to test the safety of the polio vaccine, potentially replacing the use of monkeys in these tests.
5. **Chemical Safety Testing**:
    - Also known as toxicity or safety testing, transgenic animals are made to carry genes that make them more sensitive to toxic substances than non-transgenic animals.
    - These animals are exposed to toxic substances, and the effects are studied to obtain results more quickly.

Examples and Applications

1. **Transgenic Mice**:
    - Over 95% of all transgenic animals are mice.
    - They are widely used in the study of human diseases, gene function, and the effects of genetic modifications.
2. **Transgenic Cows**:
    - Example: Rosie, the transgenic cow, produced milk containing human alpha-lactalbumin.
3. **Transgenic Sheep and Pigs**:
    - These animals are used for studying gene function and producing human proteins for pharmaceutical use.

Transgenic animals play a crucial role in advancing our understanding of gene function, disease mechanisms, and the production of biological products. While they offer significant benefits in research and medicine, ethical and regulatory considerations are essential to ensure their responsible use. The study of transgenic animals continues to provide valuable insights and innovations in biotechnology and medicine.

Ethical Issues

The manipulation of living organisms by humans, particularly through genetic engineering, raises several ethical issues. These concerns revolve around the morality, safety, and potential consequences of such activities on living organisms and the environment.

Key Ethical Issues in Biotechnology

1. **Safety of Genetically Modified Organisms (GMOs)**
    - The release of GMOs into the environment could have unpredictable and potentially harmful effects on ecosystems.
    - There is concern about the long-term impact of GMOs on biodiversity and natural species.
    - The safety of GMOs for human consumption and their potential health impacts are also major ethical considerations.
2. **Impact on Biodiversity**
    - Genetic modification can lead to the creation of new species or alter existing ones in ways that could disrupt natural ecosystems.
    - There is a risk that GMOs could outcompete natural species, leading to a loss of biodiversity.
3. **Gene Therapy and Human Genetics**
    - The use of gene therapy to correct genetic defects raises ethical questions about genetic manipulation in humans.
    - There are concerns about the potential for eugenics, where genetic modifications could be used to create 'designer babies' with enhanced traits.
    - The long-term effects and potential risks of gene therapy on future generations need careful consideration.
4. **Animal Welfare**
    - The creation and use of transgenic animals for research and biotechnology purposes raise concerns about the welfare and ethical treatment of these animals.
    - There is a need to ensure that transgenic animals are not subjected to unnecessary suffering and are treated humanely.
5. **Patenting and Biopiracy**
    - The patenting of genetically modified organisms, genes, and biological products raises ethical issues about ownership and access.
    - There is growing concern about biopiracy, where companies patent genetic resources and traditional knowledge from

developing countries without proper authorization or compensation.
    - This can lead to the exploitation of biodiversity and traditional knowledge, depriving local communities of their rights and benefits
6. **Regulation and Oversight**
    - Effective regulation is essential to ensure that genetic engineering and biotechnology practices are safe, ethical, and responsible.
    - Regulatory bodies like the Genetic Engineering Approval Committee (GEAC) in India oversee the validity of GM research and the safety of introducing GMOs for public services.
7. **Public Perception and Acceptance**
    - The public's perception of GMOs and genetic engineering plays a crucial role in the acceptance and adoption of these technologies.
    - There is a need for transparency, public engagement, and education to address concerns and build trust in biotechnological advancements.

Biopiracy and Intellectual Property Rights

1. **Biopiracy**
    - Biopiracy refers to the unauthorized use of biological resources by multinational companies and organizations without proper compensation to the countries and people concerned.
    - It involves the exploitation of genetic resources and traditional knowledge from biodiversity-rich developing countries.
2. **Case of Basmati Rice**
    - An example of biopiracy is the case of Basmati rice, where an American company was granted a patent on Basmati rice lines and grains, derived from Indian farmer's varieties.
    - This patent allowed the company to sell Basmati rice in the US and abroad, potentially restricting the rights of Indian farmers and traditional practices.
3. **Protecting Traditional Knowledge**
    - There is a need to develop laws and frameworks to protect traditional knowledge and ensure fair compensation and benefit-sharing.

- The Indian Parliament has taken steps to address these issues through amendments to the Indian Patents Bill, which considers patent terms, emergency provisions, and research and development initiatives.

The ethical issues in biotechnology, particularly concerning genetic engineering, require careful consideration and regulation. It is essential to balance the potential benefits of these technologies with their impact on living organisms, ecosystems, and human society. By addressing these ethical concerns, we can ensure the responsible and equitable use of biotechnology for the betterment of all.

Question Bank from "Biotechnology and Its Applications"

Long-Answer Type Questions (15 Questions)

1. Explain the process of creating genetically modified organisms (GMOs) and their applications in agriculture.
2. Discuss the role of biotechnology in the production of insulin for diabetic patients.
3. Describe the steps involved in the production of Bt cotton and its impact on pest management.
4. Explain the process of gene therapy with a focus on the treatment of ADA deficiency.
5. Discuss the ethical issues related to the use of transgenic animals in research and biotechnology.
6. Describe the various techniques used for molecular diagnosis and their applications.
7. Explain the production and use of transgenic animals in studying human diseases.
8. Discuss the significance of biopiracy and the measures taken to prevent it.
9. Explain the role of RNA interference (RNAi) in developing pest-resistant plants.
10. Describe the process of producing genetically engineered insulin using recombinant DNA technology.
11. Discuss the impact of genetically modified crops on food security and the environment.
12. Explain the use of recombinant DNA technology in the production of vaccines.
13. Discuss the potential benefits and risks associated with gene therapy.

14. Describe the process of molecular diagnosis using PCR and ELISA.
15. Explain the role of transgenic animals in the production of biological products.

Short-Answer Type Questions (15 Questions)

1. What are genetically modified organisms (GMOs)?
2. Name two applications of biotechnology in agriculture.
3. What is Bt cotton?
4. Describe the principle of gene therapy.
5. What is the significance of ADA deficiency in gene therapy?
6. Define transgenic animals.
7. What is biopiracy?
8. Explain RNA interference (RNAi).
9. What is the role of recombinant DNA technology in insulin production?
10. How do GM crops benefit food security?
11. What is the use of recombinant DNA technology in vaccine production?
12. List two potential risks of gene therapy.
13. What is PCR?
14. Describe the use of ELISA in molecular diagnosis.
15. Name two biological products produced using transgenic animals.

Very Short Answer Type Questions (15 Questions)

1. Define biotechnology.
2. What does GMO stand for?
3. Name one pest-resistant crop.
4. What is gene therapy?
5. What does ADA stand for?
6. Give an example of a transgenic animal.
7. What is meant by biopiracy?
8. Define RNA interference.
9. What is recombinant DNA?
10. Name one application of GM crops.
11. What is a vaccine?
12. What is PCR used for?
13. Define ELISA.
14. Name one benefit of gene therapy.
15. What is the purpose of using transgenic animals in biotechnology?

Multiple Choice Questions (15 Questions)

1. What does GMO stand for?
    - a) Genetically Modified Organism
    - b) General Medical Organization
    - c) Genetic Mutation Order
    - d) Global Medical Operation
2. Which bacterium is used to produce Bt toxin?
    - a) *Escherichia coli*
    - b) *Bacillus thuringiensis*
    - c) *Agrobacterium tumefaciens*
    - d) *Pseudomonas fluorescens*
3. What is the main purpose of gene therapy?
    - a) To enhance physical abilities
    - b) To correct defective genes
    - c) To produce food crops
    - d) To create transgenic animals
4. Which of the following is a transgenic animal?
    - a) Dolly the sheep
    - b) Rosie the cow
    - c) Both a and b
    - d) None of the above
5. What is biopiracy?
    - a) Unauthorized use of biological resources
    - b) Legal patenting of genes
    - c) Sharing of genetic information
    - d) Conservation of biodiversity
6. RNAi technology is used to:
    - a) Enhance growth rate
    - b) Silence specific genes
    - c) Increase yield
    - d) Produce insulin
7. Which enzyme is crucial for PCR?
    - a) DNA polymerase
    - b) RNA ligase
    - c) Restriction endonuclease
    - d) Taq polymerase
8. ELISA is based on:
    - a) DNA hybridization
    - b) Antigen-antibody interaction
    - c) RNA interference

- d) Protein synthesis

9. The first gene therapy was used to treat:
   - a) Cystic fibrosis
   - b) Adenosine deaminase deficiency
   - c) Hemophilia
   - d) Sickle cell anemia
10. Which organism is commonly used in the production of human insulin?
   - a) *Bacillus thuringiensis*
   - b) *Escherichia coli*
   - c) *Saccharomyces cerevisiae*
   - d) *Pseudomonas putida*
11. Transgenic plants are produced by introducing genes using:
   - a) Bacterial transformation
   - b) Viral infection
   - c) Gene gun
   - d) All of the above
12. Which of the following is a method of molecular diagnosis?
   - a) ELISA
   - b) PCR
   - c) Both a and b
   - d) None of the above
13. What is the role of cry genes in Bt crops?
   - a) Provide resistance to herbicides
   - b) Provide resistance to pests
   - c) Enhance growth rate
   - d) Improve nutritional value
14. Gene therapy aims to:
   - a) Cure genetic disorders
   - b) Modify physical appearance
   - c) Increase muscle strength
   - d) All of the above
15. Transgenic animals are used to:
   - a) Study diseases
   - b) Produce biological products
   - c) Test vaccine safety
   - d) All of the above

Competency-Based Questions

1. Design an experiment to evaluate the effectiveness of Bt cotton in pest resistance.

2. Propose a method to produce insulin using recombinant DNA technology.
3. Explain how RNA interference (RNAi) can be used to develop pest-resistant crops.
4. Describe the process and considerations for creating a transgenic animal model to study a human disease.
5. Outline the steps and safety measures for conducting gene therapy to treat ADA deficiency.

Case-Study Based Questions

1. A biotech company wants to develop a pest-resistant crop using RNA interference (RNAi). Describe the process and potential benefits.
2. A researcher is using transgenic mice to study Alzheimer's disease. Explain the steps involved in creating the transgenic mice and how they are used in research.
3. A patient with ADA deficiency is considered for gene therapy. Outline the procedure and expected outcomes of the treatment.
4. A pharmaceutical company is producing human insulin using recombinant DNA technology. Describe the production process and its advantages over traditional methods.
5. A farmer is considering planting Bt cotton. Discuss the benefits and potential risks associated with growing Bt cotton.

Answers Scheme

Long-Answer Type Questions - Answers

1. **Explain the process of creating genetically modified organisms (GMOs) and their applications in agriculture.**
    - GMOs are created by inserting specific genes into the DNA of an organism to introduce new traits. The process involves:
    - **Gene Identification**: Identify the gene responsible for the desired trait.
    - **Gene Cloning**: Isolate and clone the gene into a vector.
    - **Gene Insertion**: Introduce the vector into the host organism.
    - **Selection**: Select successfully modified organisms using markers.
    - **Expression**: Ensure the gene is expressed in the host.
    - Applications in agriculture include pest-resistant crops (e.g., Bt cotton), herbicide-tolerant crops (e.g., Roundup Ready soybeans), and crops with improved nutritional profiles (e.g., Golden Rice).
2. **Discuss the role of biotechnology in the production of insulin for diabetic patients.**

- Biotechnology has enabled the production of human insulin using recombinant DNA technology. The process involves:
- **Gene Cloning**: Cloning the insulin gene into a plasmid vector.
- **Transformation**: Introducing the plasmid into *E. coli* bacteria.
- **Expression**: Culturing the bacteria to produce insulin.
- **Purification**: Extracting and purifying the insulin from bacterial cultures.
- This recombinant insulin is identical to human insulin, reducing the risk of allergic reactions and providing a steady supply for diabetic patients.

3. **Describe the steps involved in the production of Bt cotton and its impact on pest management.**
   - Bt cotton is produced by inserting genes from *Bacillus thuringiensis* (Bt) into cotton plants:
- **Gene Identification**: Identify Bt toxin genes (e.g., cryIAc).
- **Gene Cloning**: Clone the genes into a vector.
- **Transformation**: Introduce the vector into cotton cells using Agrobacterium or a gene gun.
- **Selection**: Select transformed cells and regenerate plants.
- Bt cotton produces toxins that kill specific insect pests, reducing the need for chemical pesticides and decreasing crop losses.

4. **Explain the process of gene therapy with a focus on the treatment of ADA deficiency.**
   - Gene therapy aims to treat genetic disorders by introducing functional genes. For ADA deficiency:
- **Isolation of Lymphocytes**: Extract lymphocytes from the patient's blood.
- **Gene Introduction**: Introduce a functional ADA gene using a retroviral vector.
- **Culturing**: Grow the genetically modified lymphocytes in culture.
- **Reintroduction**: Infuse the modified lymphocytes back into the patient.
- This process restores ADA enzyme activity, improving immune function.

5. **Discuss the ethical issues related to the use of transgenic animals in research and biotechnology.**
   - Ethical issues include:
- **Animal Welfare**: Concerns about the welfare and humane treatment of transgenic animals.
- **Environmental Impact**: Potential risks of releasing transgenic animals into the environment.

- **Regulation**: Need for strict regulatory oversight to ensure ethical practices.
- **Public Perception**: Addressing public concerns and building trust in biotechnology.

6. **Describe the various techniques used for molecular diagnosis and their applications.**

Polymerase Chain Reaction (PCR): Amplifies specific DNA sequences, enabling the detection of pathogens and genetic mutations. Used in diagnosing infectious diseases, cancer, and genetic disorders.

Enzyme-Linked Immunosorbent Assay (ELISA): Detects antigens or antibodies in a sample, commonly used for HIV testing, pregnancy tests, and diagnosing various infections.

DNA Probes and Autoradiography: Uses labelled DNA probes to detect complementary DNA sequences in samples. Applied in identifying genetic mutations and pathogens.

Applications: Early diagnosis, monitoring disease progression, and guiding treatment decisions.

7. **Explain the production and use of transgenic animals in studying human diseases.**

Transgenic animals are created by introducing foreign genes into their genome. This process involves:

8. **Gene Identification**: Identify and isolate the gene of interest.
9. **Gene Insertion**: Insert the gene into a fertilized egg or embryonic stem cells.
10. **Embryo Transfer**: Implant the modified embryo into a surrogate mother.

Use in Disease Study:
Disease Models: Transgenic mice with human genes for diseases like Alzheimer's, cancer, and cystic fibrosis.
Biological Products: Transgenic animals producing human proteins for therapeutic use.
Vaccine Testing: Transgenic animals for testing vaccine safety and efficacy.

11. **Discuss the significance of biopiracy and the measures taken to prevent it.**
- **Biopiracy**: The unauthorized use of biological resources and traditional knowledge from developing countries by multinational companies.
- **Significance**:
  - **Loss of Biodiversity**: Exploitation of genetic resources without fair compensation.
  - **Economic Impact**: Deprives local communities and countries of potential revenue.
- **Measures**:
  - **Legal Frameworks**: National and international laws to protect biodiversity and traditional knowledge.
  - **Benefit-Sharing**: Agreements ensuring fair compensation for the use of genetic resources.
  - **Patents**: Protecting genetic resources and traditional knowledge through intellectual property rights.

12. **Explain the role of RNA interference (RNAi) in developing pest-resistant plants.**
- **RNAi Mechanism**:
  - **Double-Stranded RNA (dsRNA)**: Introduced into the plant, corresponding to a specific pest gene.
  - **Gene Silencing**: dsRNA is processed into small interfering RNAs (siRNAs), which bind to the target mRNA, preventing its translation.
- **Application**:
  - **Pest Resistance**: Plants produce dsRNA targeting pest genes, rendering the pests unable to survive or reproduce.
  - **Example**: RNAi used to develop nematode-resistant crops like tobacco and soybean.

13. **Describe the process of producing genetically engineered insulin using recombinant DNA technology.**
- **Gene Cloning**: Clone the human insulin gene into a plasmid vector.
- **Transformation**: Introduce the plasmid into *Escherichia coli* (E. coli) bacteria.
- **Expression**: Grow the bacteria to express the insulin gene.
- **Purification**: Extract and purify the insulin from the bacterial cultures.
- **Benefits**: Provides a consistent and safe supply of insulin identical to human insulin, reducing allergic reactions and dependence on animal sources.

14. **Discuss the impact of genetically modified crops on food security and the environment.**

- **Food Security**:
  - **Increased Yields**: GM crops with higher yields and pest resistance contribute to food security.
  - **Nutritional Enhancement**: Biofortified crops like Golden Rice improve nutritional value.
- **Environmental Impact**:
  - **Reduced Pesticide Use**: Pest-resistant GM crops decrease the need for chemical pesticides.
  - **Biodiversity Concerns**: Potential risks of gene flow to wild species and loss of biodiversity.
  - **Sustainability**: GM crops can contribute to sustainable agriculture by reducing environmental footprint.

15. **Explain the use of recombinant DNA technology in the production of vaccines.**

- **Recombinant Vaccines**:
  - **Gene Cloning**: Clone the gene encoding the antigen of interest into a plasmid vector.
  - **Expression in Host Cells**: Introduce the plasmid into suitable host cells (bacteria, yeast) to produce the antigen.
  - **Purification**: Extract and purify the antigen for vaccine formulation.
- **Advantages**:
  - **Safety**: Recombinant vaccines do not contain live pathogens, reducing the risk of infection.
  - **Efficacy**: Induce a strong immune response with fewer side effects.
  - **Examples**: Hepatitis B vaccine, HPV vaccine.

16. **Discuss the potential benefits and risks associated with gene therapy.**

- **Benefits**:
  - **Cure Genetic Disorders**: Potential to correct genetic defects and cure inherited diseases.
  - **Targeted Treatment**: Precise targeting of specific genes for effective treatment.
  - **Long-Term Effects**: Potential for long-lasting effects with a single treatment.
- **Risks**:
  - **Immune Response**: Risk of immune reactions to viral vectors.

- **Insertional Mutagenesis**: Potential for gene insertion to disrupt normal genes, leading to cancer.
- **Ethical Concerns**: Issues related to germline modification and genetic enhancement.

17. **Describe the process of molecular diagnosis using PCR and ELISA.**

- **Polymerase Chain Reaction (PCR)**:
  - **Amplification**: PCR amplifies specific DNA sequences to detectable levels.
  - **Procedure**: Cycles of denaturation, annealing, and extension using Taq polymerase.
  - **Applications**: Detects pathogens, genetic mutations, and forensic analysis.
- **Enzyme-Linked Immunosorbent Assay (ELISA)**:
  - **Principle**: Based on antigen-antibody interaction.
  - **Procedure**: Sample added to wells coated with antigen or antibody, followed by a secondary antibody conjugated to an enzyme. A substrate is added, producing a detectable signal.
  - **Applications**: Diagnoses infections (HIV, hepatitis), monitors immune responses.

18. **Explain the role of transgenic animals in the production of biological products.**

- **Production of Pharmaceuticals**:
  - **Human Proteins**: Transgenic animals produce human proteins like insulin, growth hormone, and clotting factors.
  - **Example**: Transgenic goats producing antithrombin, a protein used to prevent blood clots.
- **Advantages**:
  - **High Yield**: Large-scale production of biological products.
  - **Cost-Effective**: Lower production costs compared to traditional methods.
  - **Safety**: Reduced risk of contamination from human pathogens.

Short-Answer Type Questions - Answers

1. **What are genetically modified organisms (GMOs)?**
   - Organisms whose genetic material has been altered using genetic engineering techniques to introduce new traits.
2. **Name two applications of biotechnology in agriculture.**
   - Pest-resistant crops (e.g., Bt cotton) and herbicide-tolerant crops (e.g., Roundup Ready soybeans).
3. **What is Bt cotton?**

- Cotton genetically engineered to produce Bt toxin, which provides resistance against specific insect pests.

4. **Describe the principle of gene therapy.**
   - Gene therapy involves introducing functional genes into a patient's cells to correct genetic defects and treat diseases.
5. **What is the significance of ADA deficiency in gene therapy?**
   - ADA deficiency is a genetic disorder that can be treated with gene therapy by introducing a functional ADA gene into the patient's cells.
6. **Define transgenic animals.**
   - Animals that have had foreign genes introduced into their genome through genetic engineering.
7. **What is biopiracy?**
   - The unauthorized use of biological resources and traditional knowledge from developing countries by multinational companies.
8. **Explain RNA interference (RNAi).**
   - RNAi is a biological process where double-stranded RNA (dsRNA) induces the degradation of specific mRNA, effectively silencing the target gene.
9. **What is the role of recombinant DNA technology in insulin production?**
   - Recombinant DNA technology allows the production of human insulin in bacteria, providing a consistent and safe supply for diabetic patients.
10. **How do GM crops benefit food security?**
    - GM crops can increase yields, improve nutritional content, and reduce losses due to pests and diseases, contributing to food security.
11. **What is the use of recombinant DNA technology in vaccine production?**
    - Recombinant DNA technology is used to produce antigens for vaccines, ensuring safety and efficacy.
12. **List two potential risks of gene therapy.**
    - Immune response to viral vectors and the risk of insertional mutagenesis.
13. **What is PCR?**
    - PCR (Polymerase Chain Reaction) is a technique used to amplify specific DNA sequences for detection and analysis.
14. **Describe the use of ELISA in molecular diagnosis.**

- ELISA detects antigens or antibodies in a sample, commonly used for diagnosing infections and monitoring immune responses.

15. **Name two biological products produced using transgenic animals.**
    - Human insulin and antithrombin.

Very Short Answer Type Questions – Answers

1. **Define biotechnology.**
    - The use of living organisms or their products to modify human health and the environment.
2. **What does GMO stand for?**
    - Genetically Modified Organism.
3. **Name one pest-resistant crop.**
    - Bt cotton.
4. **What is gene therapy?**
    - Gene therapy is a technique that involves the insertion of normal genes into cells to correct genetic disorders.
5. **What does ADA stand for?**
    - Adenosine Deaminase.
6. **Give an example of a transgenic animal.**
    - Rosie the cow, which produced human protein-enriched milk.
7. **What is meant by biopiracy?**
    - Biopiracy refers to the unauthorized exploitation of biological resources and traditional knowledge without proper compensation.
8. **Define RNA interference.**
    - RNA interference (RNAi) is a biological process where RNA molecules inhibit gene expression by neutralizing targeted mRNA molecules.
9. **What is recombinant DNA?**
    - Recombinant DNA is DNA that has been formed artificially by combining constituents from different organisms.
10. **Name one application of GM crops.**
    - Increased pest resistance in crops such as Bt cotton.
11. **What is a vaccine?**
    - A vaccine is a biological preparation that provides active acquired immunity to a particular infectious disease.
12. **What is PCR used for?**

- PCR (Polymerase Chain Reaction) is used to amplify specific DNA sequences for detection and analysis.

13. **Define ELISA.**
    - ELISA (Enzyme-Linked Immunosorbent Assay) is a test that uses antibodies and color change to identify the presence of a substance.
14. **Name one benefit of gene therapy.**
    - The potential to cure genetic disorders by correcting defective genes.
15. **What is the purpose of using transgenic animals in biotechnology?**
    - Transgenic animals are used for research, to study diseases, and to produce valuable biological products such as pharmaceuticals.

Multiple Choice Questions - Answers

1. What does GMO stand for?
    - a) Genetically Modified Organism
2. Which bacterium is used to produce Bt toxin?
    - b) *Bacillus thuringiensis*
3. What is the main purpose of gene therapy?
    - b) To correct defective genes
4. Which of the following is a transgenic animal?
    - c) Both a and b
5. What is biopiracy?
    - a) Unauthorized use of biological resources
6. RNAi technology is used to:
    - b) Silence specific genes
7. Which enzyme is crucial for PCR?
    - d) Taq polymerase
8. ELISA is based on:
    - b) Antigen-antibody interaction
9. The first gene therapy was used to treat:
    - b) Adenosine deaminase deficiency
10. Which organism is commonly used in the production of human insulin?
    - b) *Escherichia coli*
11. Transgenic plants are produced by introducing genes using:
    - d) All of the above
12. Which of the following is a method of molecular diagnosis?
    - c) Both a and b

13. What is the role of cry genes in Bt crops?
    - b) Provide resistance to pests
14. Gene therapy aims to:
    - a) Cure genetic disorders
15. Transgenic animals are used to:
    - d) All of the above

Competency-Based Questions - Answers

1. **Design an experiment to evaluate the effectiveness of Bt cotton in pest resistance.**

Objective: To assess the effectiveness of Bt cotton in resisting pest attacks compared to non-Bt cotton.

Materials: Bt cotton seeds, non-Bt cotton seeds, pest insects (e.g., bollworms), planting soil, water, fertilizers, and insect observation equipment.

Procedure:

1. **Plant Growth**: Plant Bt cotton and non-Bt cotton seeds in separate, but identical, conditions.
2. **Pest Exposure**: Introduce an equal number of pest insects to both sets of plants after they have grown sufficiently.
3. **Observation**: Monitor the plants over a specified period, recording the number of pests, the extent of damage, and the growth rate of the plants.
4. **Data Collection**: Collect data on pest damage and plant health.
5. **Analysis**: Compare the data between Bt and non-Bt cotton plants to evaluate the effectiveness of Bt cotton in resisting pests.

Conclusion: Determine the relative effectiveness of Bt cotton in pest resistance based on the observed data.

2. **Propose a method to produce insulin using recombinant DNA technology.**
    - **Objective**: To produce human insulin using recombinant DNA technology.
    - **Materials**: Human insulin gene, plasmid vector, restriction enzymes, ligase enzyme, *E. coli* bacteria, growth medium, antibiotics, centrifuge, and purification equipment.
    - **Procedure**:

1. **Gene Isolation**: Isolate the gene coding for human insulin.
2. **Vector Preparation**: Cut the plasmid vector and the insulin gene with the same restriction enzymes.

3. **Ligation**: Ligate the insulin gene into the plasmid vector using DNA ligase.
4. **Transformation**: Introduce the recombinant plasmid into *E. coli* bacteria through transformation.
5. **Selection**: Plate the bacteria on antibiotic-containing media to select for transformed cells.
6. **Expression**: Grow the transformed bacteria in a suitable medium to express the insulin gene.
7. **Purification**: Harvest the bacteria, lyse the cells, and purify the insulin protein from the bacterial lysate.
   - **Conclusion**: Analyse the purified insulin for activity and compare it to standard human insulin.

3. **Explain how RNA interference (RNAi) can be used to develop pest-resistant crops.**
   - **Objective**: To understand the process of using RNA interference to create pest-resistant crops.
   - **Mechanism**:

1. **Gene Identification**: Identify a gene essential for pest survival.
2. **dsRNA Synthesis**: Synthesize double-stranded RNA (dsRNA) corresponding to the identified gene.
3. **Gene Insertion**: Insert the dsRNA gene into the plant genome using Agrobacterium-mediated transformation or a gene gun.
4. **Expression**: The plant expresses the dsRNA, which is processed into small interfering RNAs (siRNAs) in the plant cells.
5. **Pest Ingestion**: When pests feed on the plant, they ingest the siRNAs.
6. **Gene Silencing**: The siRNAs in the pest cells degrade the target mRNA, silencing the gene and leading to pest death or reduced fitness.
7. **Conclusion**: RNAi can effectively reduce pest populations and damage to crops by silencing essential pest genes.

4. **Describe the process and considerations for creating a transgenic animal model to study a human disease.**
   - **Objective**: To create a transgenic animal model for studying a specific human disease.
   - **Materials**: Disease-related human gene, plasmid vector, fertilized animal eggs or embryonic stem cells, microinjection equipment, surrogate animals, and screening tools.
   - **Procedure**:

1. **Gene Cloning**: Clone the human disease-related gene into a plasmid vector.
2. **Microinjection**: Inject the plasmid vector into fertilized eggs or embryonic stem cells of the animal.

3. **Embryo Transfer**: Implant the genetically modified embryos into a surrogate mother.
4. **Breeding**: Allow the surrogate mother to give birth to offspring and breed them to establish a transgenic line.
5. **Screening**: Screen the offspring for the presence and expression of the human gene.
6. **Phenotypic Analysis**: Study the transgenic animals to observe disease development and progression.
    - **Considerations**:
        - **Ethical Approval**: Obtain ethical approval for creating and using transgenic animals.
        - **Animal Welfare**: Ensure humane treatment and minimize suffering.
        - **Environmental Impact**: Prevent accidental release into the environment.
    - **Conclusion**: Use the transgenic animal model to gain insights into the disease mechanism and potential treatments.
    5. **Outline the steps and safety measures for conducting gene therapy to treat ADA deficiency.**
    - **Objective**: To treat ADA deficiency using gene therapy.
    - **Materials**: ADA gene, viral vector (e.g., retrovirus), patient's lymphocytes, culture medium, and medical facilities.
    - **Procedure**:

1. **Lymphocyte Isolation**: Extract lymphocytes from the patient's blood.
2. **Gene Insertion**: Introduce the ADA gene into the viral vector.
3. **Transduction**: Use the viral vector to deliver the ADA gene into the isolated lymphocytes.
4. **Culturing**: Grow the transduced lymphocytes in culture to expand their numbers.
5. **Infusion**: Infuse the genetically modified lymphocytes back into the patient.
    - **Safety Measures**:

- **Sterile Techniques**: Use sterile techniques to prevent contamination.
- **Vector Safety**: Ensure the viral vector is replication-deficient and safe for use in humans.
- **Monitoring**: Monitor the patient for adverse reactions and immune responses.

- **Regulatory Compliance**: Adhere to regulatory guidelines and obtain necessary approvals.
- **Conclusion**: Gene therapy can restore ADA enzyme activity, improving immune function in patients with ADA deficiency.

Case-Study Based Questions - Answers

1. **A biotech company wants to develop a pest-resistant crop using RNA interference (RNAi). Describe the process and potential benefits.**
   - **Process**:

1. **Gene Identification**: Identify a target gene essential for pest survival or reproduction.
2. **dsRNA Synthesis**: Synthesize double-stranded RNA (dsRNA) corresponding to the target gene.
3. **Gene Insertion**: Insert the dsRNA gene into the plant genome using Agrobacterium-mediated transformation or a gene gun.
4. **Expression**: The plant expresses the dsRNA, which is processed into small interfering RNAs (siRNAs) within the plant cells.
5. **Pest Ingestion**: When pests feed on the plant, they ingest the siRNAs.
6. **Gene Silencing**: The siRNAs degrade the target mRNA in the pest cells, silencing the gene and causing pest death or reduced fitness.

Benefits:

- **Reduced Pesticide Use**: Decreases reliance on chemical pesticides, reducing environmental impact and production costs.
- **Enhanced Crop Yield**: Protects crops from pest damage, increasing yield and productivity.
- **Sustainability**: Promotes sustainable agriculture practices by reducing chemical inputs and preserving beneficial insect populations.

2. **A researcher is using transgenic mice to study Alzheimer's disease. Explain the steps involved in creating the transgenic mice and how they are used in research.**
   - **Steps**:

1. **Gene Identification**: Identify the human gene associated with Alzheimer's disease, such as the APP (amyloid precursor protein) gene.
2. **Gene Cloning**: Clone the gene into a plasmid vector suitable for mammalian expression.

3. **Microinjection**: Inject the plasmid vector containing the gene into fertilized mouse eggs or embryonic stem cells.
4. **Embryo Transfer**: Implant the genetically modified embryos into a surrogate mother.
5. **Breeding**: Allow the surrogate mother to give birth to offspring and breed them to establish a transgenic mouse line.
6. **Screening**: Screen the offspring for the presence and expression of the human gene using PCR and protein assays.
    - **Research Use**:

    - **Disease Model**: Transgenic mice exhibit Alzheimer's-like symptoms, such as amyloid plaque formation and cognitive decline, allowing researchers to study disease progression.
    - **Drug Testing**: These mice are used to test potential therapeutic drugs for efficacy and safety before clinical trials in humans.
    - **Pathophysiology Studies**: Researchers can study the underlying mechanisms of Alzheimer's disease in transgenic mice to identify new therapeutic targets and understand disease pathology.

3. **A patient with ADA deficiency is considered for gene therapy. Outline the procedure and expected outcomes of the treatment.**
    - **Procedure**:

1. **Lymphocyte Isolation**: Extract lymphocytes from the patient's blood.
2. **Gene Insertion**: Introduce the functional ADA gene into a viral vector, such as a retrovirus.
3. **Transduction**: Use the viral vector to deliver the ADA gene into the isolated lymphocytes.
4. **Culturing**: Grow the genetically modified lymphocytes in culture to expand their numbers.
5. **Infusion**: Infuse the modified lymphocytes back into the patient's bloodstream.
6. **Monitoring**: Regularly monitor the patient for immune responses and ADA enzyme activity.
    - **Expected Outcomes**:

    - **Enzyme Activity**: Restoration of ADA enzyme activity in the patient's immune cells.
    - **Immune Function**: Improved immune function, reducing the risk of infections and improving the patient's overall health.

- **Quality of Life**: Enhanced quality of life and potentially reduced need for enzyme replacement therapy.
- **Long-Term Monitoring**: Continued monitoring to assess the long-term effectiveness of the therapy and detect any adverse effects.

4. **A pharmaceutical company is producing human insulin using recombinant DNA technology. Describe the production process and its advantages over traditional methods.**
    - **Production Process**:

1. **Gene Cloning**: Clone the human insulin gene into a plasmid vector.
2. **Transformation**: Introduce the plasmid into *Escherichia coli* (E. coli) bacteria.
3. **Expression**: Culture the transformed bacteria to express the insulin gene.
4. **Purification**: Harvest and purify the insulin protein from the bacterial cultures using chromatography and other purification techniques.
5. **Quality Control**: Perform quality control tests to ensure the insulin is biologically active and free from contaminants.
    - **Advantages**:

- **Safety**: Recombinant insulin is identical to human insulin, reducing the risk of allergic reactions and immune responses compared to animal-derived insulin.
- **Consistency**: Provides a consistent and scalable supply of insulin, ensuring availability for diabetic patients worldwide.
- **Cost-Effectiveness**: Lower production costs and higher yield compared to traditional extraction methods from animal pancreases.
- **Ethical Considerations**: Avoids ethical issues related to the use of animal tissues.

5. **A farmer is considering planting Bt cotton. Discuss the benefits and potential risks associated with growing Bt cotton.**
    - **Benefits**:

- **Pest Resistance**: Bt cotton produces Bt toxin, which is effective against pests such as bollworms, reducing crop damage and loss.
- **Reduced Pesticide Use**: Decreases the need for chemical pesticides, lowering production costs and reducing environmental impact.

- **Increased Yield**: Higher crop yields due to reduced pest damage and healthier plants.
- **Sustainability**: Promotes sustainable agricultural practices by reducing chemical inputs and protecting beneficial insect populations.
  - **Potential Risks**:
- **Resistance Development**: Pests may develop resistance to Bt toxin over time, reducing its effectiveness and requiring additional pest management strategies.
- **Non-Target Effects**: Potential impact on non-target organisms, including beneficial insects and soil microbes, which could disrupt ecosystem balance.
- **Gene Flow**: Risk of gene flow from Bt cotton to wild relatives or non-GM crops, potentially affecting biodiversity and leading to regulatory challenges.
- **Regulatory and Ethical Concerns**: Need for proper regulatory oversight and consideration of ethical implications related to the use of genetically modified crops.

UNIT- X

ECOLOGY

CHAPTER 13- ORGANISMS AND POPULATIONS

KEYPOINTS

Ecology - The branch of science in which we study the relationships od biotic components with their abiotic components.

*It consists of four levels of biological organisation, i.e., organisms, populations, communities and biomes.
*The place where an organism lives is called as its habitat.

Populations – Groups of individuals of the same species which can interbreed and living in a given place at a specific time. Ex. Cormorants in a wetland, rats in abandoned dwelling etc.

*Individuals of any population remain in competition for their basic needs.

Population Attributes –

*__Birth Rates__ (b): Number of births = Natality (B)
b = B/N; N = Population density
*__Death Rates__ (d): Number of deaths = Mortality (D)
d = D/N
*__Sex Ratio__: Male: Female ratio
*__Age Pyramid__ – Plotting of the percent individuals of a given age or an age group.
* The shape of the pyramids is helpful in finding the growth status of the population.

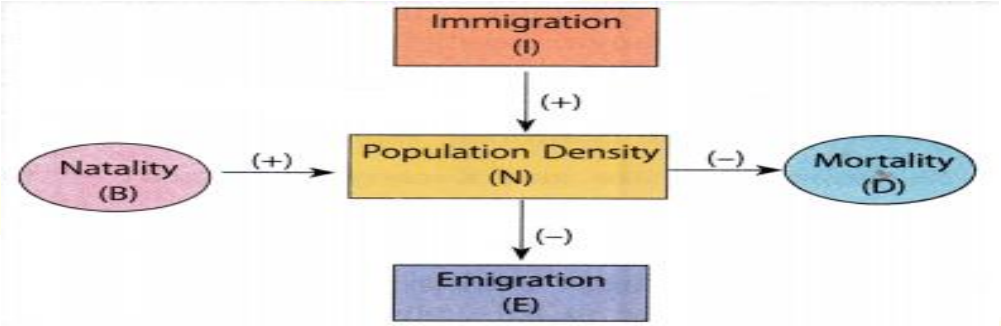
***Expanding:** Maximum number of pre-reproductive individuals. It is not ideal for a population

***Stable**: Number of pre-reproductive and reproductive individuals is almost same. Post reproductive individuals are fewer. It is ideal for a population.

*__Declining__: Number of post reproductive individuals are high. It is not ideal for a population.

Population Density – The total number if individuals present in a given area at a specific time.

*The density of a population in a given period changes due to four basic processes, namely (i) Natality (ii) Mortality (iii) Immigration (iv) Emigration.



*Natality and immigration always contribute to an increase in the size and density of a population.

Mortality and emigration always contribute to a decrease the population.

So, the equation for population growth is:

$N_{t+1} = N_t + [(B + I) - (D + E)]$

Where, N_t = population density at time t,

B = birth rate,

I = immigration,

D = death rate,

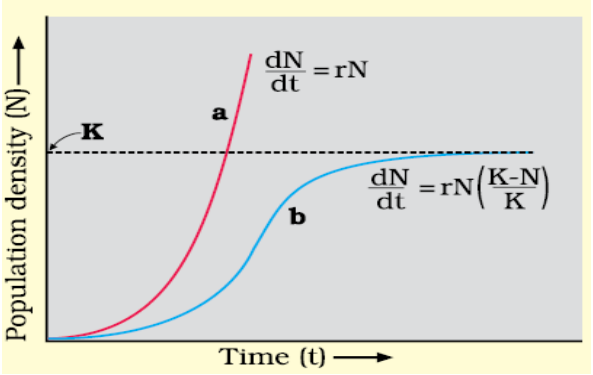
E = emigration.

If **B + I is more** than D + E, the population density **increases**.

If **B + I is less** than D + E, the population density **decreases**.

Examples: The tiger census in our national parks and tiger reserves is often based on pug marks and faecal pellets.

Growth models - Populations have characteristic patterns of growth with time called as growth models.



. (i) **Exponential growth/ Geometric growth (a)** : Unlimited availability of resources results in the exponential growth. Ex. Bacteria grown in the lab

dN/dt = (b-d) x N
Let (b – d) = r,
then dN / dt = rN

*It results in J shaped curve and the integral form can be represented by

$$N_t = N_0 e^{rt}$$

where Nt = population density after time t
N_0 = population density at time 0 (beginning)
r = intrinsic rate of natural increase
e = the base of natural logarithm (2.71828)

(ii) **Logistic growth/ Verhulst-Pearl Logistic Growth (b) :** Limited resources availability of resources results in the logistic growth. Ex. Yeast, a microscopic fungus used to make bread and alcoholic beverages, can produce a classic S-shaped curve when grown in a test tube.

(dN/dt = rN((K-N)/K)

Where N = Population density at time t.
r = Intrinsic rate of natural increase
K = Carrying capacity. (determined by intraspecific competition if the resource is limited)

- **Logistic growth model is more realistic in nature because no population can sustain exponential growth indefinitely, as there will be completion for the basic needs among organisms.**
- **POPULATION INTERACTIONS** - Living organism cannot live in isolation and they do interact in various ways to form biological communities.

***Interspecific interactions** - Interactions of individuals or populations between two different species.

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

- Such interactions are of the following types:

***Mutualism** - Beneficial to both organisms involved. Ex. Lichen, Mycorrhiza, fig and wasp, moth and Yucca plant.
***Parasitism** - Beneficial to one organism and or detrimental to the other organism. Ex. Cuscuta growing on green plants, hookworm in the intestine (endo-parasite), lice on head (ecto-parasite).

Few special adaptations evolved by the parasites:

-Loss of unnecessary sense organs.
-Presence of hooks or adhesive organs and suckers.
-Loss of digestive system.
-High reproductive capacity.

Brood parasitism - a phenomenon in which one bird species lays its eggs in the nest of another bird species and the foreign eggs are hatched as well as chicks are fed by the host bird.
***Predation -** Beneficial to one organism and or detrimental to the other organism. Ex. Lion eating a deer, a snake eating a frog.
Predators play the following important roles in an ecosystem:

-They act as a channel for energy transfer to highest trophic levels.
-They keep the population (herbivores) under control, which otherwise can reach very high population density and disturb the balance of the ecosystem.
-Species diversity in a community is maintained by reducing the intensity of competition among the prey species.

Prey Defence Mechanisms:

-Camouflage (cryptic colouration) observed in certain insect species and frogs is to avoid detection by their predators.
-The Monarch butterfly species accumulates a chemical by feeding on a poisonous weed (Calotropis) during its caterpillar stage.

***Commensalism** - Beneficial to one and neutral (neither beneficial nor harmful) to the other. Ex. Barnacles growing on the whale are benefited to move to where food is available, the cattle egrets always forage near to the grazing cattle,
Sexual deceit by Mediterranean orchid -The Mediterranean Orchid, Orphreys employs sexual deceit for pollinating its flowers. The male

bee pseudo copulates with the floral petal perceiving it as a female bee and pollinates the flower.

***Competition** - Detrimental to both. Ex. In certain shallow lakes of South America, the visiting flamingos and the native fishes compete for the same zooplanktons as their food, when goats were introduced in the Galapagos Island the population of Abingdon tortoise in Galapagos Island became extinct within a decade. This happened as the goats had greater browsing efficiency than the tortoise.

Connell's elegant field experiments

-It showed that on the rocky sea coasts of Scotland, the larger and competitively superior barnacle Balanus dominates the intertidal area, and excludes the smaller barnacle Chathamalus from that zone.

Gause's Competitive Exclusion Principle - For Limited Resources

-When two closely related species are competing for the same resources cannot exist together for long if the resources for which there is struggle are limited.

-The competitively inferior species will be eliminated if the resources are limiting.

Competing species evolve mechanisms that promote co-existence, rather than exclusion.

Resource partitioning

- Mac Arthur had demonstrated that five closely related species of warblers co-existed on the same tree and avoided competition by their behavioural differences in their foraging activities.

***Ammensalism- D**etrimental to one and neutral to the other. Ex. The antibiotic secreted by a fungus kills many other bacteria in its vicinity but the fungus remains unaffected.

ASSERTION AND REASONS QUESTIONS

(a) Both, A and R, are true and R is the correct explanation of A

(b) Both, A and R, are true but R is not the correct explanation of A

(c) If A is true but R is false

(d) If A is false but R is true

1. **Assertion (A)**: Increased biodiversity in an ecosystem promotes stability.

Reason (R): A diverse ecosystem has more producers and consumers, leading to a more complex food web.

2. **Assertion (A):** Resource partitioning allows competing species to coexist in the same habitat.
   Reason (R): Resource partitioning increases competition between species by allowing them to utilize different resources or use the same resource at different times.

3. **Assertion (A):** Populations in a closed system with limited resources will exhibit an exponential growth curve.
   Reason (R): In an exponential growth curve, each individual reproduces at exponentially.

4. **Assertion (A):** A decrease in infant mortality rate (IMR) can lead to an increase in population growth.
   Reason (R): A lower IMR means more individuals survive to reproductive age, contributing to a larger population.

5. **Assertion (A):** In commensalism, one organism is benefitted and other is unaffected
   Reason (R): Cattle egret bird and cattle is an example of commensalism

1 MARK QUESTIONS

1. A group of organisms of the same species living in a defined area at a particular time is called a:
   a) Community
   b) Ecosystem
   c) Population
   d) Habitat

2. The maximum number of individuals of a species that can be supported by an environment is known as:
   a) Exponential growth
   b) Carrying capacity
   c) Logistic growth
   d) Age pyramid

3. The interaction between a barnacles and whales is an example of:
   a) Mutualism

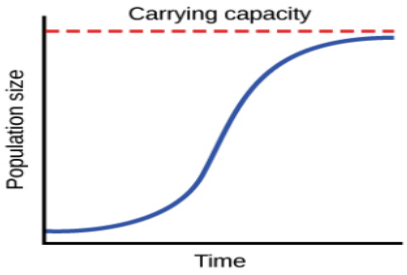
b) Commensalism
c) Predation
d) Competition

4. In an age pyramid, a broad base indicates a:
a) Stable population
b) Declining population
c) Growing population
d) None of the above

5. According to Darwin the fitness of a species is determined by
a) Low r value
b High r value
c) Low K value
d) High K value

6. A _____ coevolves itself along with the host to derive the benefits from it
a) Parasite
b) Host
c) Decomposer
d) Producer

7.



Identify the graph.
a) Exponential growth
b) Logistic growth
c) Stable population
d) Declining population

8. Mutualism is found between:
a) Colourful flowers and pollinators
b) Moth and Yucca Plant
c) Fig and Wasp
d) All of the above

9.

_____ in the above picture is a mechanism exhibited by the chameleon to hide itself in the surrounding from the prey.

a) Mimicry
b) Ammensalism
c) Sexual deceit
d) Competition

10. Between which of the following sexual deceit is observed?

a) Wasp and fig
b) Fungi and roots of higher plants
c) Ophrys and bee
d) Cuckoo and crow

11. Population interaction where neither is helped, it's called:

a) Mutualism
b) Commensalism
c) Parasitism
d) Competition

12. Which animal became extinct due to invasion of goats on the Galapagos Island?

a) Mediterranean Ophrys
b) Pisaster
c) Abingdon tortoise
d) Chathamalus

13. An invasive species harm the native ecosystem is called as

a) Endemic species
b) Keystone species
c) Exotic species
d) Endangered species

14. Select the statement which explains best about mutualism.

a) One organism is benefitted.
b) One is harmed and the other one remains un affected.
c) Both get benefitted.
d) One is benefitted and the other remains unaffected.

15. Name the scientist who observed that the resource partitioning in the 5 species of

a) Mac Arthur
b) G.F Gause
c) J.H Connell
d) None of the above

2 MARKS QUESTIONS

1. Match the columns

1. Mutualism	a) One organism benefit, the other is unaffected.
2. Commensalism	b) Both organisms are benefitted.
3. Predation	c) Two organisms compete for the same resources.
4. Competition	d) One organism hunts and kills another for food.

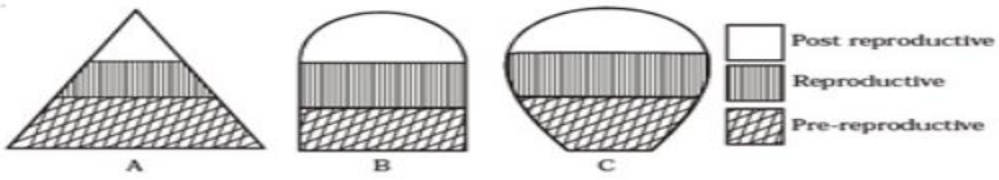
2. State Gause's competitive exclusion principle with one example.
3. A biologist studied the population of horses in a farm and found that the average natality was 350, average mortality 320, immigration 40 and emigration 20. So, what will the net increase in the population?
4. Explain the difference between birth rate and death rate in a population. How do these factors influence population growth?
5. Certain birds, like egrets, are often seen following grazing animals. Explain how this behaviour represents commensalism. How does this benefit the egret?

3 MARKS QUESTIONS

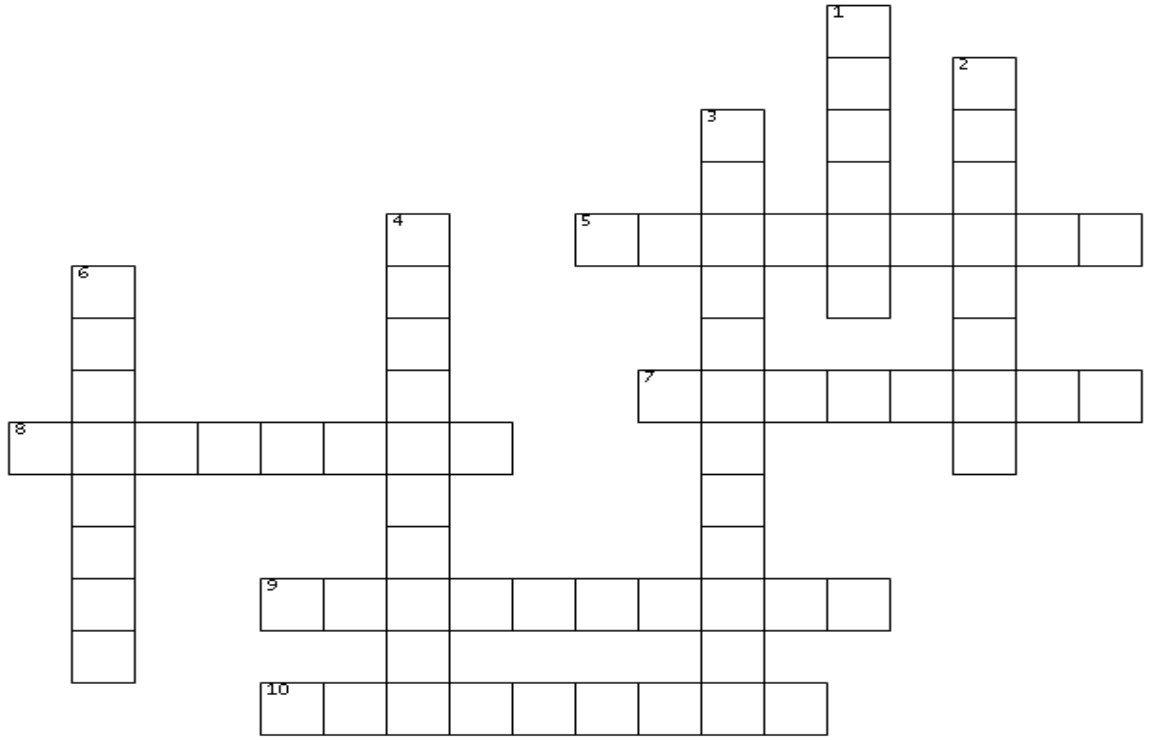
1. (a) Define the term "carrying capacity" in the context of population growth.
   (b) How does the concept of carrying capacity influence the logistic growth model?
   (c) Give one example of a factor that can affect the carrying capacity of an environment for a specific population.
2. Predators play the following important roles in an ecosystem. Justify the statement.
3. Explain with an example what is the meaning of brood parasitism?
4. How do factors like competition, predation, and resource availability regulate population size?
5. Explain three important characteristics of population.

5 MARKS QUESTIONS

1. Identify the age pyramids of different populations and write briefly about their population status.



2.Answer the following crossword puzzle

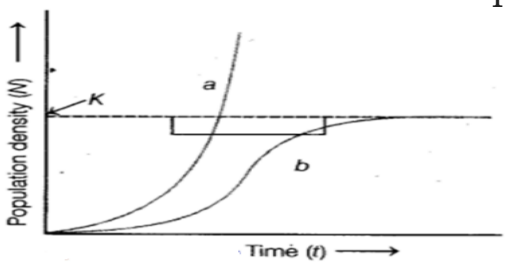


ACROSS
5. Relation between the fig and wasp
7. _____ capacity is the maximum population size
8. Refers to number of births in a population in a given time
9. The number of individuals in a given place at a given time
10. Factors like food and space that limit growth

DOWN
1. This rat has the "r" value of 0.015
2. Growth model exhibited under limited resource.
3. Parasite living outside the host
4. Plant producing highly poisonous cardiac glycosides
6. An important predator of American Pacific Ocean

2. Briefly describe any 5 different types of population interactions with an example for each.

3.Study the graph given below and answer the questions that follows



(i) The curve W is described by the following equation:
$dN/dt = rN (K-N)/K$
What does 'K' stand for in this equation? Mention its significance.
(ii) Which one of the two curves is considered a more realistic one for most of the animal populations?
(iii) Which curve would depict the population of a species of deer if there are no predators in the habitat? Why is it so?

CASE BASED QUESTIONS (4 Marks)

1. Read the following and answer any four questions from (i) to iv) given below:
   While scuba diving in a coral reef of Australia, you observed a small fish swimming in and around the sea. The small fish appear to be benefiting from this interaction in some way.

i) Name the population interaction observed between the small fish and the sea anemone? Define it.
ii) How the sea anemone benefitted the small fish?
iii) Identify the small fish being mentioned above.
iv) Give another example showing the same time of population interaction.

2. Read the following and answer any four questions from (i) to iv) given below:
   If in a population of size 'N', the birth rate is represented as 'b' and the death rate as 'd', the increase or decrease in 'N' during a unit time period 't' will be
   $dN/dt = (b - d) \times N$
   The equation given above can also be represented as
   $dN/dt = r \times N$, where $r = (b - d)$.

   i) What does 'r' represent in the above?
   ii) Write anyone significance of calculating 'r' for any population.
   iii) In a pond there are 100 frogs. 20 more were born in a year. Calculate the birth rate of this population.
   (iv) Name this growth curve.

ANSWERS

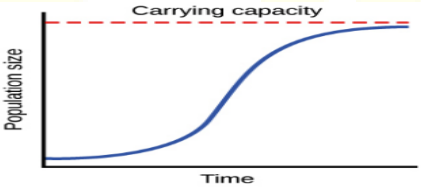
ASSERTION AND REASON QUESTIONS

1. (a) Both, A and R, are true and R is the correct explanation of A
2. (c) If A is true but R is false
3. (d) If A is false but R is true

4. (a) Both, A and R, are true and R is the correct explanation of A
5. (b) Both, A and R, are true but R is not the correct explanation of A

1 MARKS QUESTIONS

1. A group of organisms of the same species living in a defined area at a particular time is called a:
   c) Population
2. The maximum number of individuals of a species that can be supported by an environment is known as:
   b) Carrying capacity
3. The interaction between a barnacles and whales is an example of:
   b) Commensalism
4. In an age pyramid, a broad base indicates a:
   b) Declining population
5. According to Darwin the fitness of a species is determined by
   b High r value
6. A _____ coevolves itself along with the host to derive the benefits from it
   a) Parasite
7



.

Identify the following graph given above.
   b) Logistic growth
8. Mutualism is found between:
   d) All of the above
9.

_____ in the above picture is a mechanism exhibited by the chameleon to hide itself in the surrounding from the prey.
   a) Mimicry
10. Between which of the following sexual deceit is observed?
   c) Ophrys and bee
11. Population interaction where neither is helped, it's called:

d) Competition

12. Which animal became extinct due to invasion of goats on the Galapagos Island?

c) Abingdon tortoise

13. An invasive species harm the native ecosystem is called as

c) Exotic species

14. Select the statement which explains best about mutualism.

c) Both get benefitted.

15. Name the scientist who observed that the resource partitioning in the 5 species of

a) Mac Arthur

2 MARKS QUESTIONS

1. Match the columns

1. Mutualism	b) Both organisms are benefitted.
2. Commensalism	a) One organism benefit, the other is unaffected.
3. Predation	d) One organism hunts and kills another for food
4. Competition	c) Two organisms compete for the same resources.

2. Gause's competitive exclusion principle states that two competing species for same resource cannot coexist, if all other ecological factors are constant. Ex. When goats were introduced in the Galapagos Island the population of Abingdon tortoise in Galapagos Island became extinct within a decade.

3. B = 350, I = 40

D = 320, E = 20

Increase in Population size

$\mathbf{N_{t+1} = N_t + [(B + I) - (D + E)]}$

= [350 + 40 - (320 + 20)]

= 50

4.

Birth rate	Death Rate
The number of new individuals born in a population per unit time (usually per year).	The number of individuals in a population that die per unit time (usually per year).
A high birth rate leads to population growth.	A high death rate reduces population growth.

5. The egret's association with grazing animals is an example of commensalism. As the animal's graze, they disturb insects hidden in the grass. The egret benefits by easily catching the insects jumping out by the grazing animals. The grazing animal is neither harmed nor helped by the egret's presence.

3 MARKS QUESTIONS

1.(a) Carrying capacity is the maximum population size that a particular environment can sustain for a prolonged period.

(b) The logistic growth model incorporates carrying capacity. As the population approaches the carrying capacity, the resources become limited, slowing down the population growth and eventually reaching a stationary phase.

(c) Examples of factors affecting carrying capacity include: food availability, shelter availability.

2. Predators play the following important roles in an ecosystem:
-They act as a channel for energy transfer to highest trophic levels.
-They keep the population (herbivores) under control, which otherwise can reach very high population density and disturb the balance of the ecosystem.
-Species diversity in a community is maintained by reducing the intensity of competition among the prey species.

3. Brood parasitism is a reproductive strategy seen in some animals, where one species (the parasite) lays its eggs in the nest of another species (the host). The host bird then unknowingly incubates and raises the parasitic young as its own. Ex. Cuckoos are known for laying their eggs in the nests of crows and other birds.

4. Competition, predation, and resource availability regulate population size in an ecosystem in the following way-
Competition:

Intraspecific competition: This occurs when individuals within the same species compete for limited resources like food, water, space etc. As a population grows, competition intensifies which may decrease the population.

Predation: Predators naturally limit the prey population.

More prey means more food for predators, allowing their population to expand.
With more predators hunting the prey, its population will decline.
Resource Availability:
Resources like food, water, and shelter are essential for survival and reproduction. When resources are limited, it can lead to increase in competition among species leading to the survival of the fittest.

5 MARKS QUESTIONS

1. Figure A – The base of the pyramid-shaped age pyramid is wide in comparison to the reproductive and post-reproductive phases of the population. It indicates that the population would increase quickly.
Figure B – This inverted bell-shaped structure denotes that both the reproductive and pre-reproductive phases are the same, indicating stability in the population.
Figure C – This urn-shaped structure denotes clearly that both the reproductive and the pre-productive phases are less than the post-productive phases of the particular population, it indicates that it has more older people. Hence decline in the population.
2. Answer.

ACROSS	DOWN
5. Mutualism	1. Norway
7. Carrying	2. Exponential.
8. Natality	3. Ectoparasite
9. Population	4. Calotropis
10. Resources	6. Pisaster

Any 5
Predation - Beneficial to one organism and or detrimental to the other organism. Ex. Lion eating a deer.
Mutualism - Beneficial to both organisms involved. Ex. Lichen.
Parasitism - Beneficial to one organism and or detrimental to the other organism. Ex. Cuscuta growing on green plants
Commensalism - Beneficial to one and neutral (neither beneficial nor harmful) to the other. Ex. Barnacles growing on the whale are

benefited to move to where food is available, the cattle egrets always forage near to the grazing cattle.
Competition - Detrimental to both. Ex. In certain shallow lakes of South America, the visiting flamingos and the native fishes compete for the same zooplanktons as their food.
Ammensalism - Detrimental to one and neutral to the other. Ex. The antibiotic secreted by a fungus kills many other bacteria in its vicinity but the fungus remains unaffected.

3.(i) 'K' stands for 'carrying factor'. The carrying capacity signifies the limit of habitat, i.e. limited resources in a given habitat to support growth up to a certain level beyond which no further growth can take place.
(ii) The curve 'V' is considered a more realistic one for most of the animal populations. It is because in the curve 'b', the sources of food and space are limited and it supports the growth curve of animal populations.
(iii) The curve 'b' would depict the population of a species of deer, if there are no predators in the habitat then the prey population will increase. There will be increase in competition for the limited food and shelter resources within the prey population.

CASE BASED QUESTION (4 Marks)

1.
i) Commensalism - Beneficial to one and neutral (neither beneficial nor harmful) to the other.
ii) The sea anemone provides protection with its stinging tentacles to the small fish from its predators.
iii) Clown fish
iv) Ex. Barnacles growing on the whale are benefited to move to where food is available
2.
i) 'r ' represents the 'intrinsic rate of natural increase'.
ii) It is an important parameter for assessing the impacts of any biotic and abiotic factor on population growth.
iii) The birth rate is 20/100 or 0.5/frog/year.
iv) Exponential growth curve

CHAPTER 14- ECOSYSTEM

KEYPOINTS

Ecosystem- It is the functional unit of nature where biotic component interacts among themselves and also with the abiotic component.

Categories of Ecosystem

*Terrestrial ecosystem- Ex. Forest, grassland, desert.
*Aquatic ecosystem- Ex. Pond, lake, wetland, river and estuary.
*Man made ecosystem- Crop field and aquarium.

Components of Ecosystem

*Biotic components- Living components. Ex. Plants and animals
*Abiotic components- Non-living components. Ex. Soil, water and air.

Ecosystem – Structure and Function

* Interaction of biotic and abiotic components result in a physical structure.
*Stratification- Vertical distribution of different species occupying different levels is called as stratification. Ex. Trees occupy the top vertical strata followed by shrubs and thereafter by herbs and grasses.

Ecosystem Components Function as a Unit-

*Productivity- The rate of biomass production is called as productivity.

Primary production: Amount of biomass or organic matter produced per unit area over a time period by plants during photosynthesis.

Expressed in terms of weight (gm^{-2}) or energy (K cal m^{-2}).
Rate of biomass production is productivity, expressed as $gm^{-2}\ yr^{-1}$ or (K cal m^{-2}) yr^{-1}.
It can be divided into:

(i) **Gross primary productivity (GPP):** Rate of production of organic matter during photosynthesis.

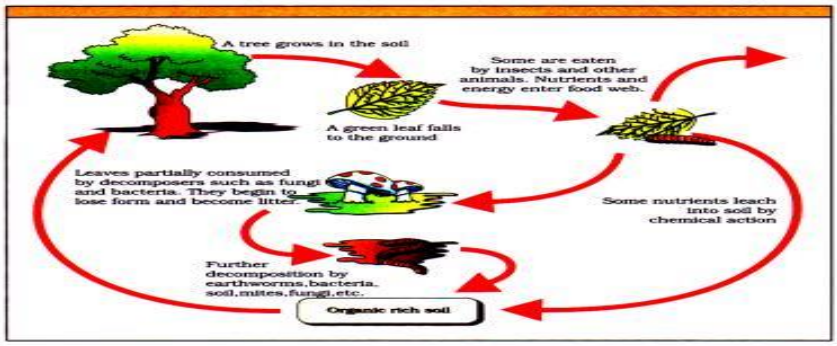
(ii) **Net primary productivity (NPP):** Available biomass for the consumption to heterotrophs (herbivores and decomposers). NPP = GPP - R (where R is respiration loss)

Primary productivity depends on a plant species inhabiting a particular area.
*Depends on environmental factors, availability of nutrients and photosynthetic capacity of plants.
*Thus, varies in different types of ecosystems:
*Annual net primary productivity of whole biosphere is approximately = 170 billion tons (dry wt.) of organic matter.
*Productivity of oceans (70% of surface) = 55 billion tons, rest is on land.

Secondary productivity: Rate of formation of new organic matter by consumers.

Decomposition- Breakdown of complex organic matter into inorganic substances like carbon dioxide, water and nutrients.

Detritus- Dead plant remains and dead remains of animals.



Diagrammatic representation of decomposition cycle in a terrestrial ecosystem.

Steps of Decomposition- Fragmentation, leaching, catabolism, humification and mineralization.

Fragmentation	Detritivores (e.g., earthworms) break down detritus into smaller particles. This process is called fragmentation.
Leaching	Water-soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts.
Catabolism	Bacterial and fungal enzymes degrade detritus into simpler inorganic substances.
Humification	Accumulation of a dark coloured amorphous substance called humus.
Mineralization	Degradation- of humus microbes and release of inorganic nutrients in the soil.

Factors affecting rate of Decomposition

***Chemical composition**- The decomposition rate will be slow when detritus is rich in lignin and chitin and the rate increases when detritus is rich in nitrogen and water-soluble substances like sugars. ***Climatic conditions**- Warm and moist environment favour decomposition and low temperatures and anaerobiosis inhibit decomposition

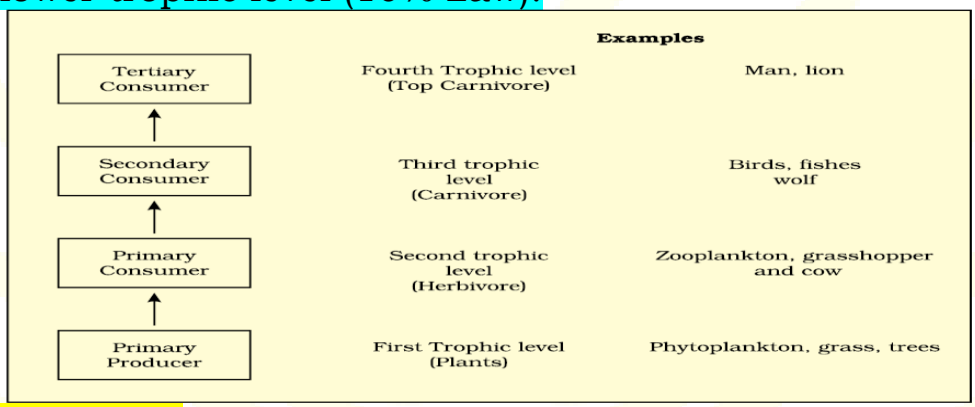
Energy Flow

*All living organisms are dependent on their food on producers, directly or indirectly.

*There is a unidirectional flow of energy from the sun to producers and then to consumers.
*Photosynthetically active radiation (PAR) is responsible for the synthesis of food by plants.
*Transfer of energy follows the 10 percent law that is only 10 percent of the energy is transferred to each trophic level from the lower trophic level

Trophic Levels in an Ecosystem

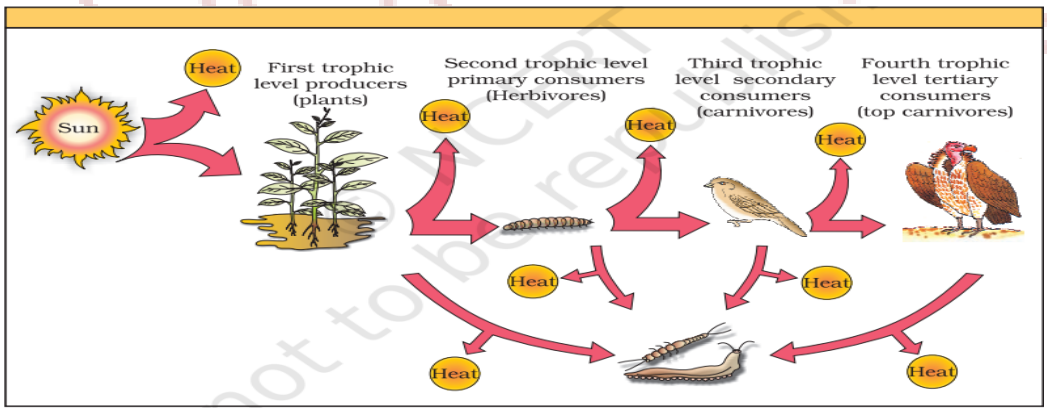
Amount of energy decreases at successive trophic levels.
Only 10% of the energy is transferred to each trophic level from the lower trophic level (10% Law).



Food Chain –

* Consumers obtain their food from autotrophs (plants).
* Food chain is the flow of energy from one trophic level to another trophic level.
* Trophic level: Based on the source of their nutrition or food, organisms occupy a specific place in the food chain that is known as the trophic level. E.g. producer, herbivore, primary carnivore, secondary carnivore

Grass (Producer) → Goat (Primary Consumer) → Man (Secondary Consumer)



- **Food chains are of two types-**
  ***Grazing Food Chain (GFC) and Detritus Food Chain (DFC)**

GFC	Energy flows from producers to consumers.
DFC	Begins with dead organic matter. It is made up of saprotrophs/ decomposers (heterotrophic organisms like fungi and bacteria)

Standing Crop	*Each trophic level has a certain mass of living material at a particular time. *Measured as the mass or living organisms (Biomass) or the number in a unit area. *Measurement of biomass in terms of dry weight is more accurate.
Standing State	*Organisms need a constant supply of nutrients to grow, reproduce and regulate various body functions. *The amount of nutrients such as carbon, nitrogen, phosphorus, calcium etc., present in the soil at any given time. *It varies in different kinds of ecosystems and also one seasonal basis.

Food Web -The natural interconnection of the food chain forms the food web.

***Significance of Food Web:**

(1) Food webs permit alternative foods.

(2) They ensure a better chance of survival of an organism, in case any of its food sources happens to be scarce

(3) More complex food web means a more stable ecosystem

Ecological Pyramids

*Pyramid is the graphical representation of an ecological parameter (number, biomass, energy) sequence-wise in various trophic levels of a food chain with producers at the base and herbivores in the middle and carnivores at the top tiers.

*It can be upright, inverted, or spindle-shaped. Three common ecological pyramids are –

Pyramids of number	*Represent the number of individuals per unit area at various trophic levels with a producer at the base. *It is generally upright. *A pyramid of numbers in the case of a big tree is generally inverted because the number of insects feeding on that tree generally exceeds in number.
Pyramids of biomass	*Represent the biomass in various trophic levels. *The pyramid of mass is upright except in the aquatic food chain involving short lived plankton. *A pyramid of biomass in the sea is generally inverted.
Pyramids of energy	*Gives graphic representation of the amount of energy trapped by different trophic levels per unit area. *It is always upright, and can never be inverted, because when energy flows from a particular trophic level to the next trophic level, some energy is always lost as heat at each step. Eg. in feeding, digestion, assimilation and respiration.

Pyramids of number

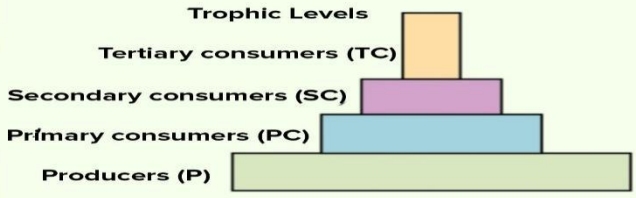


Fig: Pyramid of number in a grassland ecosystem

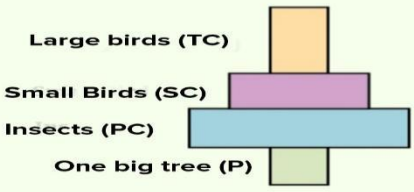
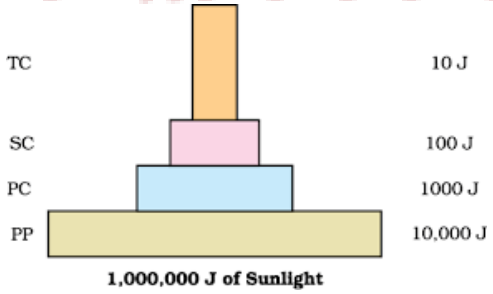
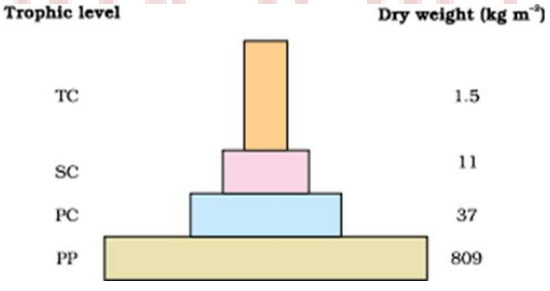


Fig: Pyramid of number on a tree ecosystem

Pyramids of energy



Pyramids of biomass



Limitations of Ecological Pyramids

*It does not take into account the same species belonging to two or more trophic levels.

*It assumes a simple food chain that never exists in nature. It does not accommodate a food web. *Saprophytes are not given any place in ecological pyramids even though they play a vital role in the ecosystem.

ASSERTION AND REASONS QUESTIONS

(a) Both, A and R, are true and R is the correct explanation of A
(b) Both, A and R, are true but R is not the correct explanation of A
(c) If A is true but R is false
(d) If A is false but R is true

1. **Assertion (A):** Pyramid of energy is always upright.
   Reason (R): Energy cannot be created nor can be destroyed but gets transformed from one trophic level to another.
2. **Assertion (A):** Detritivores and decomposers are functionally similar in an ecosystem.
   Reason (R): Both break down dead organic matter into simpler forms.
3. **Assertion (A):** Decomposition is a slower process in colder climates.
   Reason (R): The activity of decomposers is increased at lower temperatures.
4. **Assertion (A):** In a pond ecosystem, the fish population is not limited by the available zooplankton.
   Reason (R): Zooplankton is the primary food source for many fish species.
5. **Assertion (A):** Introduced species can disrupt the balance of an ecosystem.
   Reason (R): Introduced species may not have natural predators in the new environment.

1 MARK QUESTIONS

1. The primary source of energy in most ecosystems is:
a) Chemical energy from decomposers.
b) Solar energy.
c) Thermal energy from the Earth's core.
d) Wind energy.
2. Which trophic level in an ecosystem represents the first trophic level?
a) Herbivores
b) Carnivores

c) Producers
d) Decomposers

3. Which of the following statements is true about a food web in an ecosystem?
a) It represents a single linear feeding relationship.
b) It shows the interconnectedness of multiple food chains.
c) It only includes primary consumers.
d) It depicts the flow of minerals but not energy.

4. Which trophic level in an ecosystem represents the primary producers?
a) Herbivores
b) Carnivores
c) Producers
d) Decomposers

5. The breaking of detritus into smaller particles by detritivores is called as _____.
a) Leaching
b) Fragmentation
c) Catabolism
d) Humification

6. What is the percentage of photosynthetically active radiation (PAR) in the incident solar radiation?
a) 100%
b) 50%
c) 1-5%
d) 2-10%

7. The detritus food chain begins with?
a) Decomposers
b) Producers
c) Primary Consumers
d) Secondary Consumers
8. What does in the equation GPP – R = NPP, R represents:
a) Respiration losses
b) Retardation factors
c) Environmental factors
d) Radiant energy

9. Which of the statement is not correct?
a) Pyramids of number and biomass may be either upright or inverted
b) Pyramid of biomass in sea is generally inverted as biomass of fish far exceeds that of phytoplankton
c) Food chains are generally short with few trophic levels as only 10% of the energy is transferred to higher trophic level from lower one
d) Pyramid of energy is mostly upright but sometimes it may be) inverted

10. What is the formula to calculate Net primary productivity (NPP) in an ecosystem?
a) GPP – R = NPP
b) GPP + R = NPP
c) GPP – NPP = R
d) R – NPP = GPP

11. Write the name of the missing trophic level in the given food chain.
Plants (Producer) → Rabbit (?) → Snake (Secondary Consumer) → Eagle (Tertiary Consumer).

12. Steps of decomposition are-
Fragmentation → ? → Catabolism → Humification → Mineralization
13. The primary productivity is expressed in terms of
a) Joule m^{-2}
b) Gm^{-2}
c) Kcal m-2
d) Both b and c

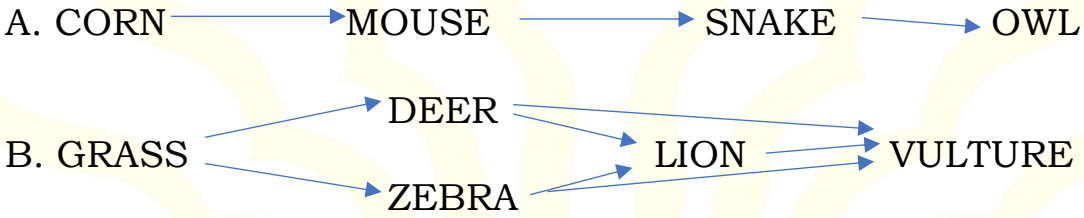
14.Calculate the energy of the secondary consumer in the given food chain below, if the producer has 10000 J of energy?

a) 100 J
b) 1000 J
c) 10 J
d) 1 J

15. The 10% energy transfer law of food chain was given by
a) Tansley
b) Stanley
c) Weismann
d) Lindemann

2 MARKS QUESTIONS

1. What will happen to a food chain if a predator population is significantly reduced?
2. Identify the diagrams A and B. Give any two differences between them.



3. Match the columns.

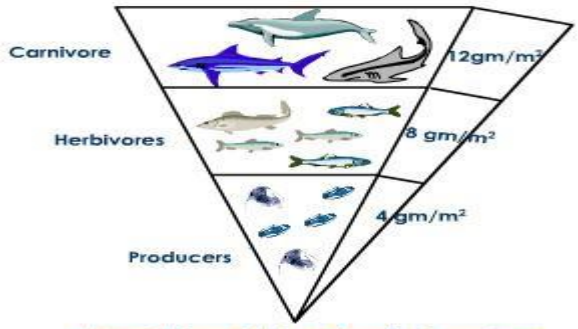
1.Pyramids of energy	a) Energy flows from producers to consumers.
2.Standing state	b) Ultimate source of energy on the earth
3. GFC	c) Organisms need a constant supply of nutrients to grow, reproduce and regulate various body functions
4.Solar energy	d) It is always upright.

4. What are the limitations of ecological pyramids?
5. Decomposition depends on the environmental factors. Justify the statement

3 MARKS QUESTIONS

1. Scientists are studying the impact of climate change on a specific grassland ecosystem. They are concerned about the potential decline of decomposers. Explain how this could affect the different types of ecological pyramids?

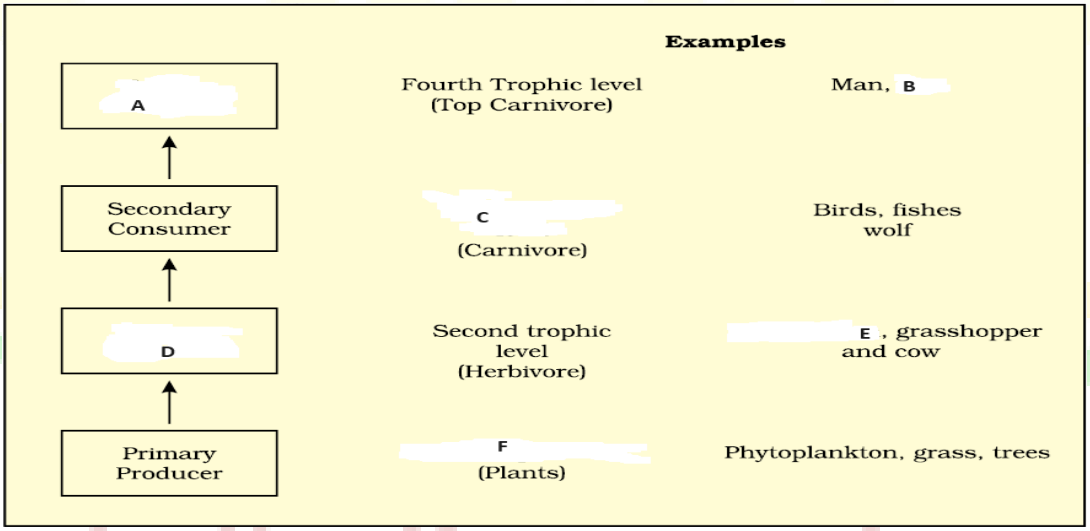
2. The diagram below shows a simplified ecological pyramid of biomass for a pond ecosystem. Analyse the pyramid and answer the following questions.



Inverted Pyramid in an Aquatic Ecosystem

a. What trophic level does each section of the pyramid represent? (1 mark)
b. Explain why the pyramid is inverted? (1 mark)
c. Identify one limitation of using ecological pyramids to understand this ecosystem. (1 mark)

3. Observe and label A, B, C, D, E, F and G.



4. a) In a food chain, the trophic levels are limited. Why?
b) Draw a three trophic levels food chain.

5. Differentiate between the following

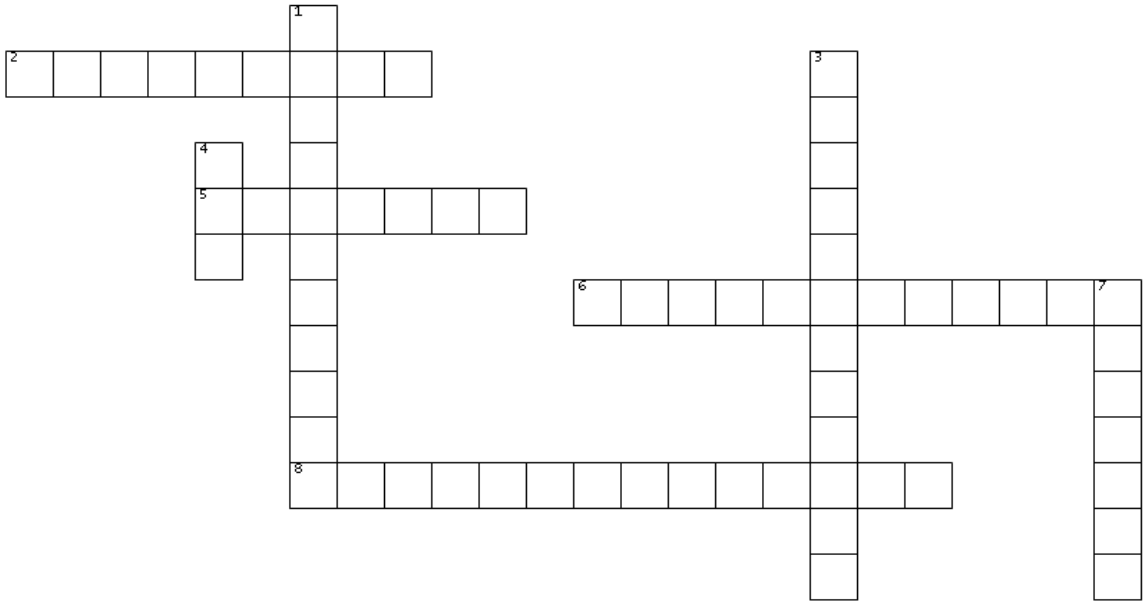
a) **Gross primary productivity (GPP) and Net primary productivity (NPP)**

b) Standing crop and standing state

c) Ecological pyramid of energy and biomass

5 MARKS QUESTIONS

1. Give an account of energy flow in an ecosystem.
2. a) Solve the puzzle.

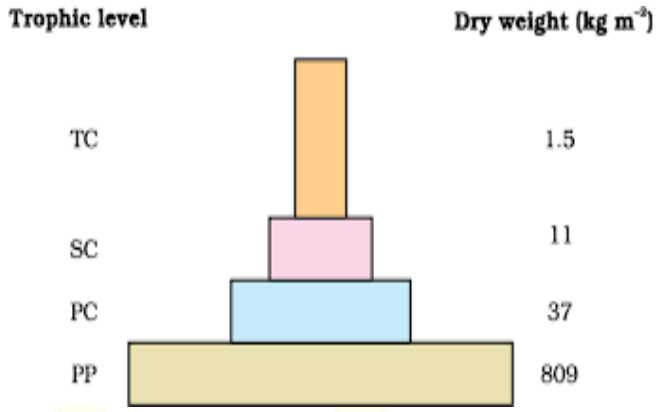


ACROSS
2. The flow of energy from one trophic level to another trophic level.
5. Intricate network of food chains.
6. Each trophic level has a certain mass of living material at a particular time called as _____.
8. Vertical distribution of different species occupying different levels.

DOWN
1. They depend on organic dead and decayed matter for their nutrient requirement.
3. Accumulation of a dark coloured amorphous substance called humus.
4. Begins with dead organic matter. It is made up of saprotrophs/ decomposers
7. It is the graphical representation of an ecological parameter (number, biomass, energy).

b) What are the components of an ecosystem?
3. Define decomposition and describe the process and products of it.

4. The diagram below represents a pyramid of biomass in a grassland ecosystem.



a) Based on the pyramid, which trophic level has the greatest total biomass? (1 mark)
b) Explain why the pyramid of biomass typically takes this shape in most ecosystems. (2marks)
c) Can you identify any limitations of using a pyramid of biomass to understand an ecosystem? (1 mark)
d) Sketch a possible pyramid of numbers for the same grassland ecosystem. (1 mark)

5. Describe the inter-relationship between productivity, gross primary productivity and net productivity.

CASE BASED QUESTIONS (4 Marks)

1. Read the following and answer any four questions from (i) to (iii) given below:

   You are a wildlife biologist studying a deer population in a forest ecosystem. Standing crop data shows a decrease in deer biomass over the past few years.

i) Explain how this could impact other trophic levels in the ecosystem. (2marks)
ii) In which terms the measurement of biomass is more accurate? (1mark)
iii) Which organisms constitute the first trophic level in the forest ecosystem? (1mark)

2. Read the following and answer any four questions from (i) to (ii) given below:

The fallen parts of plants such as leaves, flowers, etc., faecal matter of animals, dead remains of animals, etc. are ultimately broken down into simpler inorganic nutrients, carbon dioxide and water.
1. Fragmentation, 2. Leaching, 3. Catabolism are some important steps in the process; they occur simultaneously.

i) What term is given to the group of organisms that carry out the steps 1 and 3, respectively and give an example for each. (2marks)
ii) Name the other two steps involved in the process. (2marks)

ANSWERS

ASSERTION AND REASON QUESTIONS

6.(b) Both, A and R, are true but R is not the correct explanation of A
7.(a) Both, A and R, are true and R is the correct explanation of A
8.(c) If A is true but R is false
9.(d) If A is false but R is true
10. (a) Both, A and R, are true and R is the correct explanation of A

1 MARK QUESTIONS

1. The primary source of energy in most ecosystems is:
b) Solar energy.
2. **Which trophic level in an ecosystem represents the primary producers?**
c) Producers
3. **Which of the following statements is true about a food web in an ecosystem?**
b) It shows the interconnectedness of multiple food chains.
4. **Which trophic level in an ecosystem represents the primary producers?**
c) Producers
5. The breaking of detritus into smaller particles by detritivores is called as _____.
b) Fragmentation
6. What is the percentage of photosynthetically active radiation (PAR) in the incident solar radiation?
b) 50%
7. The detritus food chain begins with?
a) Decomposers
8. What does in the equation GPP – R = NPP, R represents:
a) Respiration losses

9. Which of the statement is not correct?
d) Pyramid of energy is mostly upright but sometimes it may be inverted
10. What is the formula to calculate Net primary productivity (NPP) in an ecosystem?
a) GPP – R = NPP
11. Write the name of the missing trophic level in the given food chain.
Plants (Producer) → Rabbit (Primary Consumer) → Snake (Secondary Consumer) → Eagle (Tertiary Consumer)
12. Steps of decomposition are-
Fragmentation → Leaching → Catabolism → Humification → Mineralization
13. The primary productivity is expressed in terms of
d) Both b and c
14. Calculate the energy of the secondary consumer in the given food chain below, if the producer has 10000 J of energy?
a) 100 J
15. The 10% energy transfer law of food chain was given by
d) Lindemann

2 MARKS QUESTIONS

1. If a predator population drops, the population of their prey (herbivores) will likely increase. This can lead to overgrazing of plants, disrupting the balance of the ecosystem and impacting other species that rely on those plants for food or habitat.
2. A – Food chain
B – Food web

Food Chain	Food Web
Linear sequence of organisms where one organism eats the one below it in the chain	A complex network of interconnected food chains.
It is less stable. Disruption at any one trophic level can affect the entire food chain.	It is more stable. If one trophic is affected, others can compensate.

3.

1.Pyramids of energy	d) It is always upright.
2.Standing state	c) Organisms need a constant supply of nutrients to grow, reproduce and regulate various body functions.
3. GFC	a) Energy flows from producers to consumers.
4.Solar energy	b) Ultimate source of energy on the earth.

4. **Limitations of Ecological Pyramids**

*It does not take into account the same species belonging to two or more trophic levels.

*It assumes a simple food chain that never exists in nature. It does not accommodate a food web.

5. Decomposition depends on the environmental factors -

***Chemical composition**- The decomposition rate will be slow when detritus is rich in lignin and chitin and the rate increases when detritus is rich in nitrogen and water-soluble substances like sugars.

***Climatic conditions**- Warm and moist environment favour decomposition and low temperatures and anaerobiosis inhibit decomposition

3 MARKS QUESTIONS

1. Decomposer decline would impact the different types of ecological pyramids by-

***Nutrient Cycling:** Decomposers break down dead organic matter and return nutrients back to the soil. Their decline would slow down nutrient recycling, potentially affecting producer over a long time.

***Energy Flow Bottleneck:** Decomposers are not included in most ecological pyramids, but they represent a crucial step in energy flow. A decline in decomposers could lead to a buildup of dead organic matter, effectively trapping nutrients and energy unavailable for other organisms.

***Long-term Effects:** The decline of decomposers might not be immediately reflected in the pyramid, but it could have significant long-term consequences for ecosystem health and energy flow.

2.

a) Bottom section (widest): Producers (phytoplankton)
Middle section: Primary consumers (zooplankton)
Top section (narrowest): Secondary consumers (large fish)

b) In a water body, the producers are tiny phytoplankton that grow and reproduce rapidly. Thus, the pyramid of biomass has a small base, providing support to consumer biomass which have large weight. Hence, it forms an inverted shape.

c)Limitation: This ecological pyramid only represents a single food chain within the pond ecosystem. In reality, there's a complex food web with multiple feeding interactions.

3. A- Tertiary Consumer

B- Lion
C- Third Trophic level
D- Primary Consumer
E- Zooplankton
F- First Trophic level
4.
a) According to 10 % law proposed by Lindemann, as we move up in the food chain the energy keeps on reducing by 10% from one trophic level to another. A time comes, when the energy available is negligible to sustain another trophic level.
b) Grass → Deer → Lion
5.

a) GPP	**NPP**
Rate of production of organic matter during photosynthesis	Available biomass for the consumption to heterotrophs
b) Standing Crop	**Standing State**
Each trophic level has a certain mass of living material at a particular time.	The amount of nutrients such as carbon, nitrogen, phosphorus, calcium etc., present in the soil at any given time.
c) Ecological pyramid of energy	**Ecological pyramid of biomass**
It is always upright, and can never be inverted, because when energy flows from a particular trophic level to the next trophic level, some energy is always lost as heat at each step	Represent the biomass in various trophic levels. The pyramid of mass is upright except in the aquatic food chain involving short lived plankton.

5 MARKS QUESTIONS

1. *Photosynthesis fixes carbon from the abiotic environment and incorporates into the biological compounds of producers
*Food chain transfers the fixed carbon to different trophic levels. Plants absorb 2% of sun energy for photosynthesis.
*With each trophic level, only 10% energy is transferred and 90% is lost as heat in respiration.
*The longer the food chains, the lesser is the energy transfer efficiency.

*To increase the energy transfer efficiency, food chains must be smaller and consumers should directly feed on producers.

2. a)

ACROSS

2. Food chain
5. Food web
6. Standing crop
8. Stratification

DOWN

1. Saprotrophs
3.Humification
4. DFC
7. Pyramid

b) Biotic components- They are the living components of the ecosystem. Eg. Human, Plants.

Abiotic components- They are the non-living components of the ecosystem. Eg. Soil, Water.

3. Decomposition is the process that involves the breakdown of complex organic matter or biomass from the body of dead plants and animals with the help of decomposers into inorganic raw materials such as carbon dioxide, water, and other nutrients.

The various processes involved in decomposition are as follows:

Fragmentation	Detritivores (e.g., earthworms) break down detritus into smaller particles. This process is called fragmentation.
Leaching	Water-soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts.
Catabolism	Bacterial and fungal enzymes degrade detritus into simpler inorganic substances.
Humification	Accumulation of a dark coloured amorphous substance called humus.
Mineralization	Degradation- of humus microbes and release of inorganic nutrients in the soil.

4.a) **Producers (Plants)** have the greatest total biomass in this pyramid.

b) The pyramid of biomass is basically upright because of energy flow through the ecosystem. At each trophic level, there is a transfer of energy from one organism to the next. Organisms use some of the energy for their own life processes, and this energy is lost as heat. As a result, there is less total biomass at each higher trophic level compared to the one below. Thus, follows the **10% Law of Energy Transfer**.

c) One limitation of using a pyramid of biomass is that it can be determined only after the death of the organisms.

d)

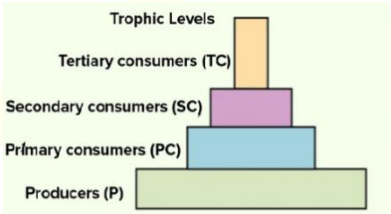


Fig: Pyramid of number in a grassland ecosystem

5. The rate of biomass production is called productivity. It is expressed in terms of g^{-2} yr^{-1} or (kcal m^{-2}) yr^{-1}.

Productivity of an ecosystem can be categorised as primary and secondary productivity.

Primary Productivity (PP) is the amount of biomass or organic matter produced per unit area over a time period by plants during photosynthesis.

It can be divided into

Gross Primary Productivity (GPP.) It is the rate of production of organic matter during photosynthesis. A considerable amount of GPP is utilised by plants in respiration.

Net Primary Productivity (NPP) It is the amount of energy left in the producers after utilisation of some energy for respiration.

Inter-relationship between GPP and NPP:

Gross primary productivity minus the respiration losses is net primary productivity.

It is actually the available mass for consumption by heterotrophs.

GPP – R = NPP where, R = Respiration losses.

CASE BASED QUESTIONS (4 Marks)

1. i) A decrease in deer biomass (standing crop of herbivores) could have cascading effects on other trophic levels:

Impact on Producers (Plants): With fewer deer to graze, plant populations might increase due to reduced herbivores. This could lead to competition for resources among plant species.

Impact on Predators: Deer are a food source for predators. A decline in deer biomass could lead to a decrease in predator populations due to limited prey availability.

ii) The measurement of biomass is more accurate in terms of dry weight.

iii) Producers- Green plants

3. i) Decomposers.

Fragmentation – Eg. Earthworm

Catabolism- Eg. Bacterial and fungal enzymes

ii)

Humification	Accumulation of a dark coloured amorphous substance called humus.
Mineralization	Degradation- of humus microbes and release of inorganic nutrients in the soil.

CHAPTER 15

BIODIVERSITY AND CONSERVATION

KEYPOINTS

BIODIVERSITY - Immense diversity (or heterogeneity) exists not only at the species level but at all levels of biological organisation ranging from macromolecules within cells to biomes.

*The term Biodiversity was popularised by the socio-biologist Edward Wilson.

***Genetic Diversity** - A single species might show high diversity at genetic level over its distributional range. E.g., Genetic variation shown by Rauwolfia vomitoria in different Himalayan ranges in potency and concentration of reserpine. India has more than 50,000 genetically different strains of rice and 1,000 varieties of mango.

***Species Diversity** - Diversity at the species level. E.g., Western ghats have a greater amphibian species diversity than Eastern ghats.

***Ecological Diversity**- Diversity at the ecosystem level. E.g., India with its deserts, rain forests, mangroves and alpine meadows has a greater ecosystem diversity than a Scandinavian Country like Norway.

SPECIES ON EARTH AND INDIA

*According to IUCN (2004), the total number of plant and animal species described so far is slightly more than **1.5 million**.

*A conservative and scientifically sound estimate made by Robert May places the global species diversity at about **7 million**.

Interesting Aspects of Earth's Biodiversity

(a) More than **70%** of all species recorded are animals while plants (including algae, fungi, bryophytes, gymnosperms and angiosperms) comprise no more than **22%** of the total.

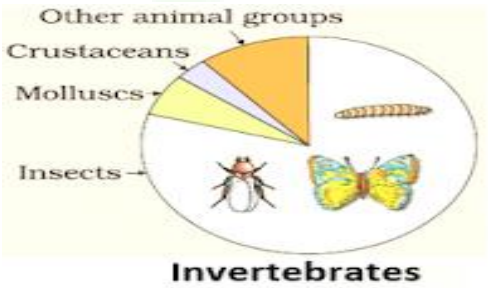
(b) Among animals, insects make more than **70%** of total, i.e., out of every **10** animals on this planet**, 7** are insects.

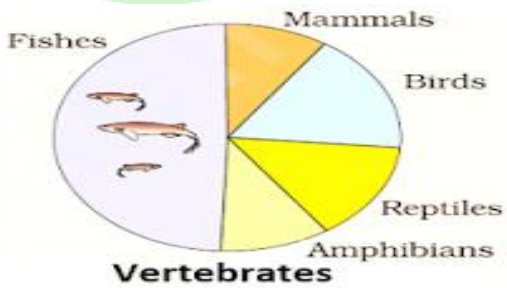
(c) Number of fungi species are more than fishes, amphibians, reptiles and mammals combined.

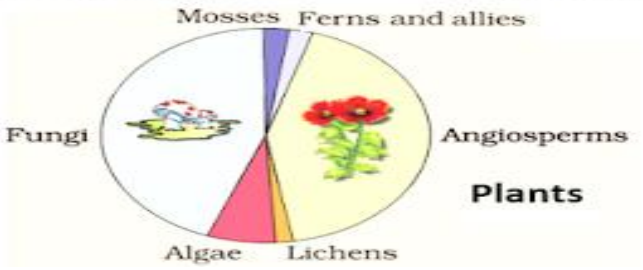
*Although, India has only **2.4%** of world's land area, its share of the global species diversity is an impressive 8.1 percent.

*India is 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.

*If we accept May's global estimates, only **22** percent of the total species have been recorded so far, then, India has more than **1,00,000** plant species and **3,00,000** animal species yet to be discovered.







PATTERNS OF BIODIVERSITY

A. LATITUDINAL GRADIENT

*Species diversity decreases as we move from equator towards the poles.

*Tropics (23.5° N to 23.5°S) harbour more species than temperate or polar areas.

Eg.,	Colombia	Newyork	Greenland	India
	Near Equator	41°N temperate	71°N poles	Tropics
	1,400 bird species	105 bird species	56 bird species	1,200 bird species

Amazon Rainforest in South America has the greatest biodiversity on Earth

- 40,000 species of plants
- 3,000 of fishes
- 1,300 of birds
- 427 of mammals.
- 427 of amphibians
- 378 of reptiles
- More than 1,25,000 invertebrates

Ecologists and Evolutionary biologists have proposed various hypotheses to explain greater biological diversity at the tropics

(a) Unlike temperate regions subjected to frequent glaciations in the past, tropical latitudes remained undisturbed, having long evolutionary time for species diversification

(b) Constant, less seasonal tropical environments promote niche specialisation and lead to greater species diversity

(c) More solar energy in tropics contributes to higher productivity and might contribute indirectly to greater diversity

B. SPECIES-AREA RELATIONSHIPS (by German naturalist Alexander Von Humboldt)

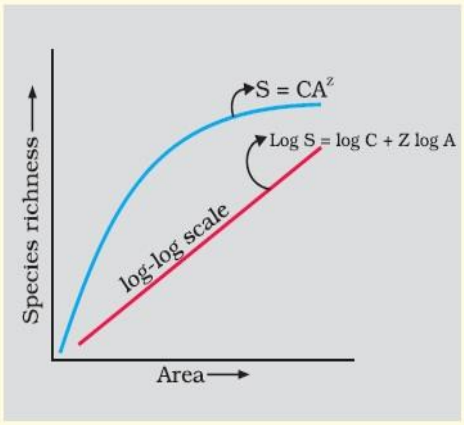


Figure Showing species area relationship. Note that on log scale the relationship becomes linear

*Species richness within a region increased with increasing explored area, but only upto a limit.

*The relation between species richness and area for a wide variety of taxa (angiosperms, birds, bats, freshwater fishes) is a rectangular hyperbola. On a logarithmic scale, it is a straight line, described by the equation.

$$\log S = \log C + Z \log A$$

where S = species richness, A=Area; Z = Slope of the line (regression coefficient), C = Y intercept.

*The value of Z lies in the range of **0.1 to 0.2** regardless of region or taxa

*Slope of the line is much steeper in very large areas like the entire continents, Eg. For frugivorous birds and mammals in tropical forests the, slope is **1.15.**

IMPORTANCE OF SPECIES DIVERSITY TO THE ECOSYSTEM

* Communities with more species, tend to be more stable than those with less species.

*A stable community must be resistant or resilient to occasional disturbances (natural or man-made) and it must also be resistant to invasions by alien species.

***David Tilman's long-term ecosystem experiments** using outdoor plots show that plots with more species showed less year-to-year variation in total biomass and increased diversity contributed to higher productivity.

*The **'rivet popper hypotheses'** of Stanford ecologist Paul Ehrlich, puts the importance of a species in proper perspective.

AIRPLANE	ECOSYSTEM
Rivets	Species
Rivet on the wings	Key species

i) Popping a rivet (causing a species to become extinct) may not affect flight safety (proper functioning of ecosystem) initially, but if more rivets are removed, the plane will become dangerously weak.

ii) Loss of rivets on the wings (Key species, that drive major ecosystem functions) will be serious. So, each species is important for the ecosystem.

LOSS OF BIODIVERSITY

*The colonisation of tropical pacific islands by humans led to extinction of more than **2,000** species of native birds. The IUCN red list (**2004**) documents extinction of 784 species (including **338** vertebrates, **359** invertebrates and **87** plants) in the last **500** yrs.

*The last 20 years alone witnessed disappearance of **27 species**.

*Amphibians appear more vulnerable to extinction. **15,500** species world-wide are facing threat of extinction.

*There were five episodes of mass extinction of species in the past, before humans appeared.

*The Sixth Extinction presently in progress is 100 to 1000 times faster than pre-human times and our activities are responsible for the faster rates.

Loss of biodiversity in a region may lead to:
(a) Decline in plant production.
(b) Lowered resistance to environmental perturbations like drought.
(c) Increased variability in plant productivity water uses and pest and disease cycles.

Recent Extinctions
1. Dodo - Mauritius
2. Quagga - Africa
3. Thylacine - Australia
4. Steller's sea cow - Russia
5. Three sub-species of tiger - Bali, Javan & Caspian

Species Facing Threat of Extinction in World
12% Birds
23% Mammals
32% Amphibians
31% Gymnosperms

CAUSES OF BIODIVERSITY LOSSES: THE EVIL QUARTET-FOUR MAJOR CAUSES

1. Habitat Loss and Fragmentation (Most Important Cause)
*Tropical rain forests once covered more than **14%** of earth's land, now it is just **6%**. Amazon rain forest (lungs of the planet), being cut for soyabeans cultivation and grasslands for raising beef cattle.
*Mammals and birds requiring large territories and animals with migratory habits are badly affected, leading to population declines.

2. Over-Exploitation

*When need turns to greed, there is overexploitation. In the last 500 years Steller's Sea Cow, passenger pigeon became extinct due to over-exploitation.
*Marine fish populations are over harvested, endangering commercially Important species.

3. Alien Species invasions.

*Nile perch introduced in Lake Victoria in East Africa led to the extinction of 200 species of Cichlid fish in the lake. Carrot grass (***Parthenium***), Lantana and water hyacinth (***Eichhornia***) are invasive weeds. African catfish ***Clarias gariepinus*** are posing threat to indigenous cat fishes.

4. Co-Extinctions (Obligatory Associations)

*When a host species becomes extinct, its parasites meet the same fate.
*Co- evolved plant-pollinator mutualism is another example.

Why should we conserve biodiversity?

Narrowly Utilitarian Arguments

*Humans derive countless direct economic benefits from nature — food, firewood, fibre, construction material, industrial products and medicinal products.
*More than **25%** drugs are derived from **25,000** species of plants.
*Nations endowed with rich biodiversity can reap enormous benefits by 'bioprospecting' — exploring molecular, genetic and species level diversity for products of economic importance.

Broadly Utilitarian Arguments

*Biodiversity plays a major role in many ecosystem services that nature provides.
*Amazon rain forest produce approx. **20%** of total oxygen of Earth's atmosphere by photosynthesis.
*Pollination by bees, bumble-bees, birds and bats.

Ethical Arguments

*Philosophically or spiritually, we have to understand that each species has a intrinsic value.
*We have a moral duty to care for their well-being.
*We need to pass on our biological legacy in good order to future generations.

HOW DO WE CONSERVE BIODIVERSITY?

In-situ Conservation

*When we conserve and protect whole ecosystem, i.e., saving the entire forest to save the tiger, it is called in-situ (on-site) conservation.

*Organisms facing a very high risk of extinction in the wild in near future and needs urgent measures to save it from extinction, then ex-situ (offsite) conservation is desirable.

***Biodiversity Hot Spots:** Regions with very high levels of species richness and high degree of endemism (species confined to a particular region & not found anywhere else).

Total number are **25** (initially) +**9** (added later) = **34**;

Three of these—Western ghats and Sri Lanka, Indo-Burma & Himalaya— cover our country's regions.

They (all 34) cover less than 2% of Earth's land area and their strict protection could reduce the ongoing mass extinctions by **30%.**

*__14__ biosphere reserves, **90** National Parks and **448** wild life sanctuaries provide legal protection in India.

*Sacred groves in Khasi and Jaintia Hills of Meghalaya, Aravali Hills (Rajasthan), Western Ghats, Sarguja, Chanda and Bastar regions (Madhya Pradesh) are the last refuges of rare and threatened plants.

Ex-situ Conservation

*Zoological Parks, Botanical gardens and wild-life Safari parks.

*Many animals have become extinct in the wild but are maintained in zoological parks.

*Cryopreservation to protect and preserve gametes of threatened species in viable and fertile condition. • Plants can be propagated using tissue culture methods.

*Seeds of different genetic strains of commercially important plants can be kept for long periods in seed banks.

Convention on Biological diversity (The Earth Summit)

*Held in Rio de Janeiro (1992) for biodiversity conservation and sustainable utilisation of benefits.

*World Summit on sustainable development (WSSD) held in 2002 in Johannesburg, South Africa, 190 countries pledged for significant reduction in current rate of biodiversity loss at global, regional and local levels by 2010

RAMSAR SITE

Ramsar Sites are wetland sites designed of international importance under the Ramsar Convention.
These wetlands are protected under strict guidelines of the Ramsar Convention on Wetlands.

The main objectives of the Ramsar Convention are:

* To ensure the wise use of all their wetlands. The wise use of wetlands means; maintaining the ecological character of a wetland.
* To designate appropriate wetlands for the list of Wetlands of International Importance (the "Ramsar List") and guarantee their effective management.
* To cooperate worldwide on transboundary wetlands, shared wetland systems and shared species.

India currently has 80 sites designated as Ramsar sites.

ASSERTION AND REASONS QUESTIONS

(a) Both, A and R, are true and R is the correct explanation of A
(b) Both, A and R, are true but R is not the correct explanation of A
(c) If A is true but R is false
(d) If A is false but R is true

1. **Assertion (A):** Genetic diversity within a species increases its adaptability.
   Reason (R): More genetic variations allow for a wider range of responses to environmental changes.
2. **Assertion (A):** Protected areas do not play any role in biodiversity conservation.
   Reason (R): These areas restrict human activities that harm wildlife.
3. **Assertion (A):** Deforestation is a major threat to biodiversity.
   Reason (R): Forests provide habitat for a wide variety of species.

4. **Assertion (A):** The Earth Summit was the first international conference to address environmental issues.
   Reason (R): There were environmental concerns before 1992, but no major international discussions.
5. **Assertion (A):** Habitat loss and fragmentation is the leading cause of increase of species.
   Reason (R): When habitats are destroyed or broken up, species lose access to resources and mates.

1 MARK QUESTIONS

1. The term biodiversity refers to the
a) Abundance of a single species in an area
b) Variety of life at all levels
c) Number of ecosystems on Earth
d) Rate of extinction of species

2. Which of the following is NOT a major threat to biodiversity?
a) Habitat destruction
b) Climate change
c) Overexploitation of resources
d) Introduction of invasive species

3. The permanent disappearance of a species is called:
a) Adaptation
b) Extinction
c) Evolution
d) Endemism

4. Which of these is an example of in-situ conservation?
a) National parks
b) Botanical gardens (Ex-situ conservation)
c) Zoos (Ex-situ conservation)
d) Seed banks (Ex-situ conservation)

5. Hotspots of biodiversity are characterized by:
a) High species richness and endemism
b) Low species diversity
c) Mainly introduced species
d) Primarily aquatic ecosystems

6. Which type of ecological pyramid would be obtained with the given data?
Secondary consumer: 220 g
Primary consumer: 120 g
Primary producer: 20 g

a) Upright pyramid of numbers
b) Upright pyramid of biomass
c) Pyramid of energy
d) Inverted pyramid of biomass

7. Which one of the following is a primary consumer in the maize field ecosystem?
a) Phytoplankton
b) Grasshopper
c) Tiger
d) Hyena

8. Which ecosystem has the maximum biomass?
a) Pond ecosystem
b) Lake ecosystem
c) Forest ecosystem
d) Grassland ecosystem

9. The successful conservation of biodiversity requires:
a) A focus on individual species only.
b) A combined effort from governments, individuals, and organizations.
c) Prioritizing economic development over conservation.
d) Ignoring the needs of local communities.

10. Identify the extinct animal.

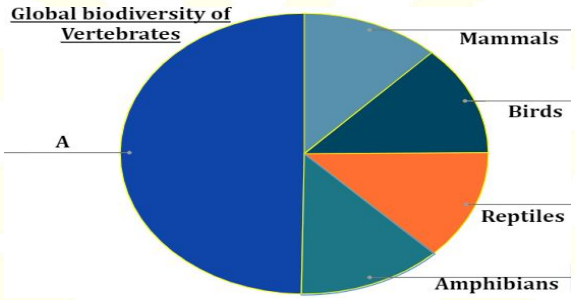
a) Dodo - Mauritius
b) Quagga - Africa
c) Thylacine - Australia
d) Steller's sea cow - Russia

11. Who proposed the 'rivet popper hypotheses"?

a) David Tilman
b) Alexander Von Humboldt
c) Paul Erhlich
d) Alexander Fleming

12. _____ is one of the most prevalent hotspots of biodiversity in India.
a) Himalayas
b) Western Ghats
c) Ganges
d) None of the above.

13. **In the global biodiversity pie chart of vertebrates given below, 'A' is covered by**



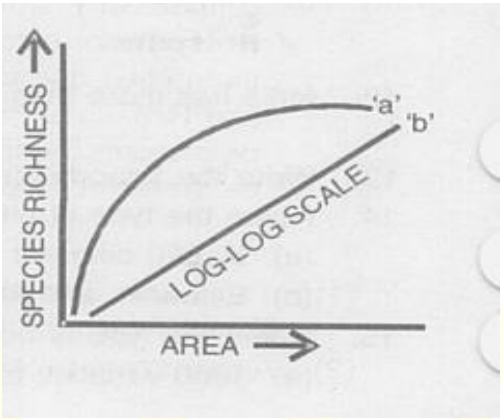
a) Insects
b) Fishes
c) Angiosperms
d) None of the above

14. **On a logarithmic scale, the relationship is a straight line described by the equation**
a) log S = log C + Z log A
b) log S = log A + Z log C
c) log C = log S + Z log A
d) log Z = log S + C log A

15. Which one of the following is not an example of Alien species invasion?
a) Pisum Sativum
b) Parthenium
c) Eichhornia crassipes
d) Latana camara

2 MARKS QUESTIONS

1. The graph shows species area relationship. Answer the following; Name the naturalist who studied two kinds of relationship shown in the graph. Write the observation made by him.



2. **State two ways through which humans are benefitted from biodiversity.**

3. Name the type of biodiversity represented by the following and give another example of it.
   (i) 50000 different strains of rice in India,
   (ii) Estuaries and alpine meadows in India

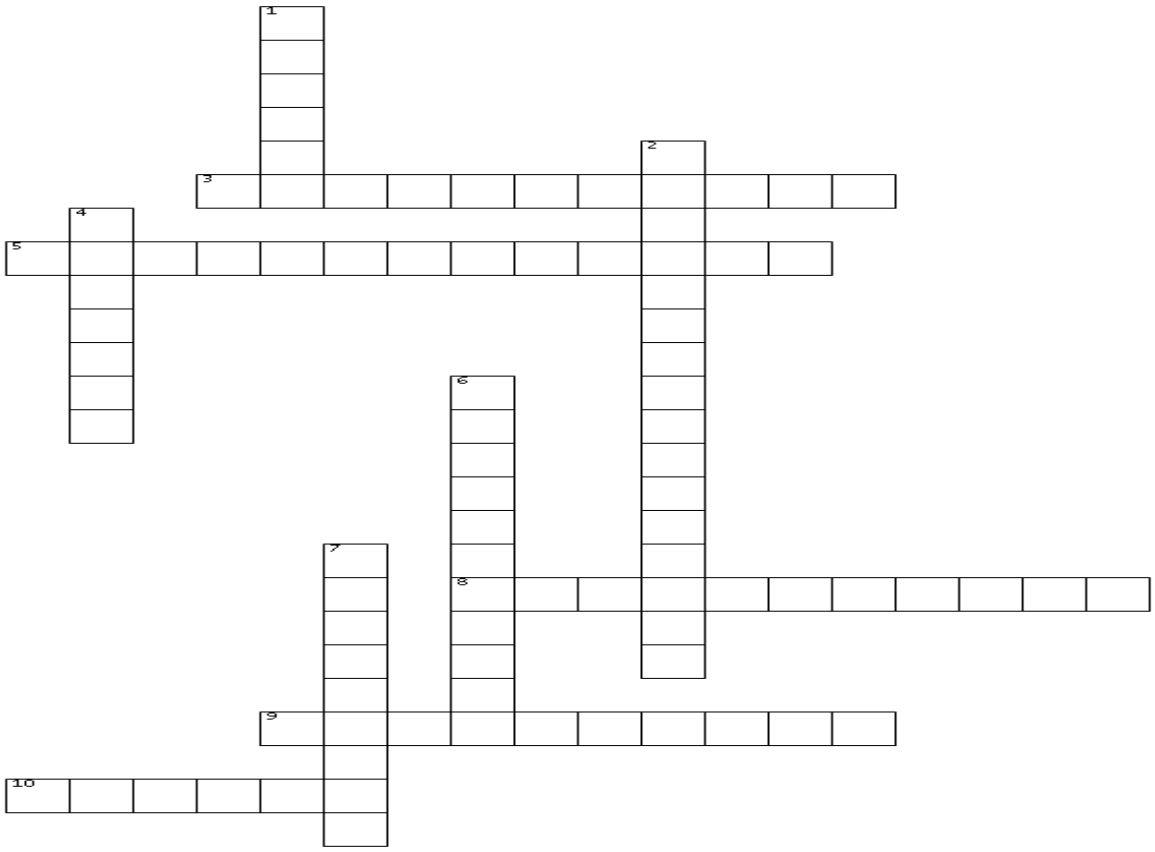
4. Eichhornia crassipes is an alien hydrophyte introduced in India. Mention the problem posed by this plant.
5. Differentiate between in-situ and Ex- situ conservation.

3 MARKS QUESTIONS

1. State the objectives of Ramsar Site.
2. We should conserve our biodiversity. Justify the statement.
3. Why a greater biodiversity is found in the Tropics compared to the other parts of the world?
4. Name the scientist who proposed 'rivet popper hypotheses. What does the hypotheses signify?
5. **Define sacred groves. What is their role in the conservation of biodiversity?**

5 MARKS QUESTIONS

1. Solve the puzzle



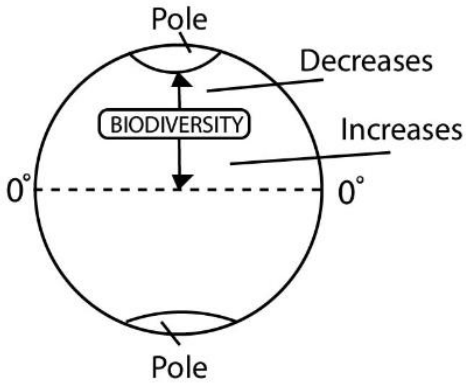
ACROSS

3. Birds feeding on fruit are known as _____
5. Extinction of one species leads to the extinction of another species.
8. Who stated that plots with more species showed less year-to-year variation in total biomass and increased diversity contributed to higher productivity?
9. Diversity at the ecosystem level.
10. This rain forest (lungs of the planet), being cut for soyabeans cultivation and grasslands for raising beef cattle.

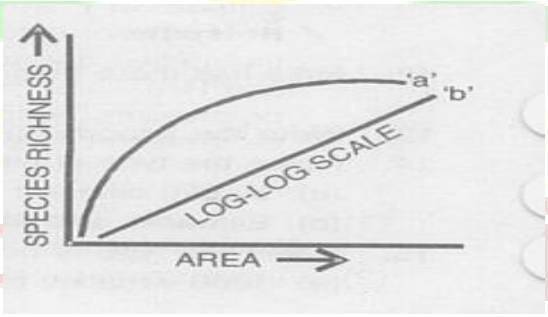
DOWN
1. The wetlands are protected under strict guidelines of _____ Convention.
2. Technique to protect and preserve gametes of threatened species in viable and fertile condition.

4. Regions with very high levels of species richness and high degree of endemism.
6. Species diversity decreases as we move from equator towards the poles is called as a _____ gradient
7. An extinct animal of Australia
2. Mention the major causes for loss of biodiversity?
3. Describe at least two approaches each for ex-situ conservation and in-situ conservation as a strategy for biodiversity conservation.

4.



a) Study the diagram of the earth given below. Give the name of the pattern of biodiversity therein. Suggest any two reasons for this type of occurrence.
b) Out of the three views given on why to conserve biodiversity, which one do you think is the best and why?
5. The following graph shows the species-area relationship. Answer the following questions as directed.



(i) Name the naturalist who studied the kind of relationship shown in the graph. Write the observations made by him.
(ii) Write the situations as discovered by the ecologists when the value of Z (slope of the line) lies between.
(a) 0.1 and 0.2
(b) 0.6 and 1.2

What does Z stand for?
(iii) When would the slope of the line B become steeper?

CASE BASED QUESTIONS (4 Marks)

1. Read the following and answer any four questions from (i) to iv) given below:

You are a park ranger working in a national park known for its diverse bird population. Recently, there has been an increase in invasive plant species that threaten the native bird habitats.
i) Identify the negative impacts of invasive species on biodiversity.
ii) Apply your knowledge of conservation methods to tackle the problem of the plant species invasion in the area.
ii) How will you come to know that the conservation methods used by you as answered above has been successful?
iv) Give any other reason of biodiversity loss.

2. Read the following and answer any four questions from (i) to (iv) given below:

Non-native or alien species are often introduced in advertently for their economic and other uses. They often become invasive and drive away-the local species. Exotic species have proved harmful to both aquatic and terrestrial ecosystems. For example, water hyacinth (Eichhornia crassipes) was introduced in Indian waters to reduce pollution. It was clogged water bodies including wetlands at many places resulting in death of several aquatic plants and animals.

(i) Island water ecosystem is the most vulnerable due to

(a) small size	(b) small number of species	(c) increases reproductive capacity	(d) both (a) and (b).

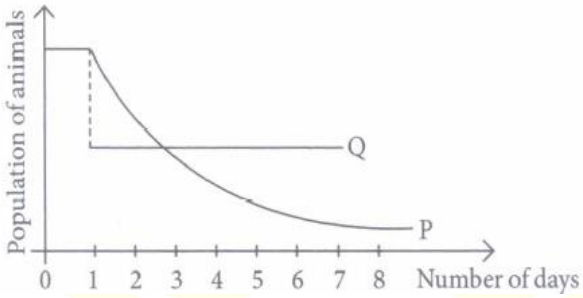
(ii) Which of the following is not an alien species?

(a) Lantana camara	(b) Periplaneta americana	(c) Nile Perch	(d) Yucca moth

(iii) **Assertion:** Eichhornia crassipes drains off oxygen from water and can be seen growing in standing water.
Reason: Eichhornia crassipes is an indigenous species of India.

(a) Both assertion and reason are true and reason is the correct explanation of assertion.
(b) Both assertion and reason are true but reason is not the correct explanation of assertion.
(c) Assertion is true but reason is false.
(d) Both assertion and reason are false.

(iv) The population of species P in a certain community was constant until a population species Q from a distant land was subsequently introduced into that community. The interaction between the two populations is reflected in the graph below.



What could be the possible reason for the decrease in the population of species P over a number of days?

(a) Species Q is a predator of species P.
(b) Species Q.is a prey species which wiped out the population of species P.
(c) Species P and Q compete for space but feeds on different food.
(d) None of these

ANSWERS

ASSERTION AND REASONS QUESTIONS

1. (a) Both, A and R, are true and R is the correct explanation of A
2. (d) If A is false but R is true

3. (a) Both, A and R, are true and R is the correct explanation of A
4. (c) If A is true but R is false
5. (d) If A is false but R is true

1 MARK QUESTIONS

1. The term biodiversity refers to the
c) Variety of life at all levels

2. Which of the following is NOT a major threat to biodiversity?
b) Climate change

3. The permanent disappearance of a species is called:
b) Extinction

4. Which of these is an example of in-situ conservation?
a) National parks

5. Hotspots of biodiversity are characterized by:
a) High species richness and endemism

6. Which type of ecological pyramid would be obtained with the given data?
d) Inverted pyramid of biomass

7. Which one of the following is a primary consumer in the maize field ecosystem?
a) Phytoplankton

8. Which ecosystem has the maximum biomass?
c) Forest ecosystem.

9. The successful conservation of biodiversity requires:
b) A combined effort from governments, individuals, and organizations.

10. Identify the extinct animal.
d) Steller's sea cow - Russia

11. Who proposed the 'rivet popper hypotheses"?
c) Paul Ehrlich

12. _____ is one of the most prevalent hotspots of biodiversity in India.
b) Western Ghats

13. **In the global biodiversity pie chart of vertebrates given below, 'A' is covered by**
b) Fishes

14. **On a logarithmic scale, the relationship is a straight line described by the equation**
a) log S = log C + Z log A

15. Which one of the following is not an example of Alien species invasion?
a) Pisum sativum

2 MARKS QUESTIONS

1. Alexander Von Humboldt observed the species area relationship. He observed that when the area explored increases, the species richness increases but till a certain limit. That is represented by the rectangular hyperbola which represents the equation $S = CA^z$ where S is the species richness, A is the area, C is a constant and Z is the regression constant.
   The straight line represents the logarithmic form of the same equation which is logS = logC + ZlogA.

2. We derive economic benefits from the diversity of entities, such as:
   *Food, fibre, firewood, medicinal products from plants
   *Pure oxygen, flood and soil erosion control, natural pollinators
   *Recycling of wastes by microbes
   *Nutrient restoration

3. Genetic Diversity - E.g., Genetic variation shown by Rauwolfia vomitoria in different Himalayan ranges in potency and concentration of reserpine.
   Ecological Diversity- Diversity at the ecosystem level. E.g., India with its deserts, rain forests, mangroves etc.

4. Water hyacinth (Eichhornia) introduced in India is threatening the existing aquatic life in ponds and lakes, etc., as it propagates very fast and clogs the stagnant waterbodies very fast, thus, the native species are threatened.

5.

In-situ Conservation	Ex-situ Conservation
Conservation of flora and fauna in their natural habitat	Conservation of flora and fauna in an artificial habitat
This is an on-site conservation.	This is an off-site conservation.
It is not suitable in case of rapid decline in the number of a species, due to any factor.	It is best suited in case of rapid decline in the number of a species, due to any factor.
Example – National parks, wildlife sanctuaries, Biosphere reserves.	Example – Zoos, Cryopreservation DNA banks, Aquariums, botanical gardens.

3 MARKS QUESTIONS

1. The main objectives of the Ramsar Convention are:
   * To ensure the wise use of all their wetlands. The wise use of wetlands means; maintaining the ecological character of a wetland.
   * To designate appropriate wetlands for the list of Wetlands of International Importance (the "Ramsar List") and guarantee their effective management.
   * To cooperate worldwide on transboundary wetlands, shared wetland systems and shared species.

2. We should conserve our biodiversity
   Narrowly Utilitarian Arguments
   *Humans derive countless direct economic benefits from nature.
   *Nations endowed with rich biodiversity can provide enormous benefits by 'bioprospecting'.
   Broadly Utilitarian Arguments
   *Biodiversity plays a major role in many ecosystem services that nature provides.

*Amazon rain forest produce approx. 20% of total oxygen of Earth's atmosphere by photosynthesis.
Ethical Arguments
*Philosophically or spiritually, we have to understand that each species has an intrinsic value.
*We have a moral duty to care for their well-being.

3. A greater biodiversity is found in the tropics-
*Unlike temperate regions subjected to frequent glaciations in the past, tropical latitudes remained undisturbed, having long evolutionary time for species diversification
*Constant, less seasonal tropical environments promote niche specialisation and lead to greater species diversity
*More solar energy in tropics contributes to higher productivity and might contribute indirectly to greater diversity

4.

The **'rivet popper hypotheses'** was given by Stanford ecologist Paul Ehrlich, puts the importance of a species in proper perspective.

AIRPLANE	**ECOSYSTEM**
Rivets	Species
Rivet on the wings	Key species

i) Popping a rivet (causing a species to become extinct) may not affect flight safety (proper functioning of ecosystem) initially, but if more rivets are removed, the plane will become dangerously weak.

ii) Loss of rivets on the wings (Key species, that drive major ecosystem functions) will be serious. So, each species is important for the ecosystem.

5. They are sacred tracts which are of utmost importance to local communities. They are devoted to ancestral spirits and local deities and are guarded by local communities through taboos and social traditions which include ecological and spiritual values. They are rich in Biodiversity nurturing rare plant and animal species and are found in Aravalli hills, Meghalaya, western Ghats etc.

5 MARKS QUESTIONS

1. ACROSS
3. Frugivorous
5. Coextinctions.
8. David Tilman.
9. Ecological.
10. Amazon

DOWN
1. Ramsar
2. Cryopreservation
4. Hotspot
6. Latitudinal
7. Thylacine

2. The four major causes that are responsible for loss of biodiversity are: -
i) Habitat loss and fragmentation of crops or conversion into grassland for raising beef cattle Eg. Amazon rain forest. Total loss of habitat deprives many plants and animals of their home and they face extinction.
ii) Overexploitation: - when nature is over-exploited by man for natural resources, many species become extinct. Passenger pigeon.
iii) Invasion of alien species: - The alien species become invasive and compete with native species and cause the extinction of indigenous species. Eg. *Lantana camara.*
iv) Co-extinction: - Co-extinction is a phenomenon in which when a species becomes extinct, the plant and animal species associated with it in an obligatory manner become extinct.

3. As a strategy for biodiversity conservation the two approaches for in-situ and ex-situ conservation is as follows:
In situ conservation:
(i) Identification and maximum protection should be provided to 'hot spots.'
(ii) Legal protection to ecologically rich areas.
(iii) Biosphere reserves, national parks, and sanctuaries.
(iv) Sacred groves.

Ex-situ Conservation :
(i) Creation of zoological parks, botanical gardens, a wildlife sanctuary.
(ii) Cryopreservation
(iii) Seed bank.

4. a) The pattern of biodiversity shown in the given diagram of the earth is Latitudinal gradients. The two reasons behind the occurrence of Latitudinal gradients are:
(i) More solar energy available in the tropics results in more productivity.
(ii) Tropical environments are less seasonal, so they are more predictable.
b) **Ethical Arguments because** Philosophically or spiritually, we have to understand that each species has a intrinsic value. We have a moral duty to care for their well-being. We need to pass on our biological legacy in good order to future generations.
5. (i) Alexander von Humboldt studied the relationship shown in above graph. He observed that the species richness in an area increased with an increase in exploring area, up to a certain limit only.
(ii) (a) Ecologists have observed that when the value of Z lies between 0.1-0.2 then the Species are considered for a small or average area.
(b) When the value of Z lies between 0.6-1.2, the area considered is very large. Z represents the slope of the line, i.e. regression coefficient.
(iii) The slope of the line B will become steeper when very large areas such as continents are considered for species area relationship.

CASE BASED QUESTION (4 Marks)

1.
i) Competition for resources like food and habitat.
ii) Manual removal of invasive plants, introducing biological control agents.
iii) The population of the birds will rise again due to the controlled population of the invasive plant.
iv) **Co-Extinctions -** When a host species becomes extinct, its parasites meet the same fate. Co- evolved plant- pollinator mutualism is another example. **OR ANY OTHER**
2.

i) (d) both (a) and (b).
ii) (d) Yucca moth
iii) (c) Assertion is true but reason is false.
iv) (a) Species Q is a predator of species P.

NAME OF UNIT	VSA 1 MARK	SA 2 MARKS	LA 3 MARKS	CASE/PARAGRAPH BASED 4 MARKS	VLA 5 MARKS	WEIGHTAGE
REPRODUCTION	2(1)=2	2(2)=4	2(3)=6	1(4)=4	-	16
GENETICS AND EVOLUTION	3(1)=3	2(2)=4	3(3)=9	1(4)=4	-	20
BIOLOGY AND HUMAN WELFARE	4(1)=4	-	1(3)=3	-	1(5)=5	12
BIOTECHNOLOGY AND ITS APPLICATIONS	4(1)=4	-	1(3)=3	-	1(5)=5	12
ECOLOGY AND ENVIRONMENT	3(1)=3	1(2)=2		-	1(5)=5	10
	16	10	21	8	15	70

SAMPLE QUESTION PAPER(SOLVED)-1

Blue

Print

SAMPLE QUESTION PAPER-1

CLASS XII

BIOLOGY (044)

Maximum Marks: 70 **Time: 3 hours**

General Instructions:

(i) All questions are compulsory.

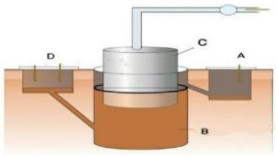
(ii) The question paper has five sections and 33 questions. All questions are compulsory.

(iii) Section–A has 16 questions of 1 mark each; Section–B has 5 questions of 2 marks each; Section– C has 7 questions of 3 marks each; Section– D has 2 case-based questions of 4 marks each; and Section–E has 3 questions of 5 marks each.

(iv) There is no overall choice. However, internal choices have been provided in some questions. A student has to attempt only one of the alternatives in such questions.

Wherever necessary, neat and properly labeled diagrams should be drawn.

<table>
<tr><td colspan="2">SECTION-A</td><td></td></tr>
<tr><td>Q.NO</td><td>QUESTION</td><td>MARKS</td></tr>
<tr><td>1.</td><td>Match the following list of microbes and their importance:
<table>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>A</td><td>Sacchromyces</td><td>1</td><td>Production of immunosuppressive agents</td></tr>
<tr><td>B</td><td>Monascus purpureus</td><td>2</td><td>Ripening of Swiss cheese</td></tr>
<tr><td>C</td><td>Trichoderma polysporum</td><td>3</td><td>Commercial production of ethanol</td></tr>
<tr><td>D</td><td>Propionibacterium sharmanii</td><td>4</td><td>Production of blood cholesterol-lowering agent</td></tr>
</table>
Which of the following is the correct option?
<table>
<tr><td></td><td>A</td><td>B</td><td>C</td><td>D</td></tr>
<tr><td>a</td><td>2</td><td>4</td><td>1</td><td>3</td></tr>
<tr><td>b</td><td>4</td><td>3</td><td>1</td><td>2</td></tr>
<tr><td>c</td><td>2</td><td>1</td><td>4</td><td>3</td></tr>
<tr><td>d</td><td>3</td><td>4</td><td>1</td><td>2</td></tr>
</table></td><td>1</td></tr>
</table>

2.	Match the column I with column II and choose the correct option. Column I — Column II a. Sporogenous tissue — 1. Pollen grain b. Nucellus — 2. Microsporangium c. Male gametophyte — 3. Embryo sac d. Female gametophyte — 4. Megasporangium (a) a-3, b-1,c-4, d-2 (b) a-2, b-4,c-3, d-1 (c) a-4, b-2,c-1, d-3 (d) a-2, b-4,c-1, d-3	1
3.	In the F2 generation of a Mendelian dihybrid cross the number of phenotypes and genotypes are (a) phenotypes – 4; genotypes – 16 (b) phenotypes – 9; genotypes – 4 (c) phenotypes – 4; genotypes – 8 (d) phenotypes – 4; genotypes – 9	1
4.	DNA is a polymer of nucleotides which are linked to each other by 3′→ 5′ phosphodiester bond. To prevent polymerisation of nucleotides, which of the following modifications would you choose? (a) Replace purine with pyrimidines (b) Remove/replace 3′ OH group in deoxyribose (c) Remove/replace 2′ OH group with some other group in deoxyribose (d) Both 'b' and 'c'	1
5.	Genotypic ratio of 1:2:1 is obtained in a cross between (a) AB X AB (b) Ab X Ab (c) Ab X ab (d) ab X ab	1
6.	Read the following statements about male reproductive system and choose the incorrect statements from the given options. (I) It is located in the pelvis region. (II) The testes are situated outside the abdominal cavity within a pouch called scrotum. (III) Each testis has about 350 testicular tubules. (IV) Penis, the male external genitalia is made up of special tissues to facilitate insemination. (a) I and III (b) III and IV (c) I and IV (d) Only III	1
7.	Select the correct option among the following  (a) A – slurry, B – Digester, C – Gas Holder,D - Sludge (b) A – sludge, C – Gas mixture, B – Slurry,D – Water + Dung (c) A – sludge, B – Digester, C – Gas Holder, D – Slurry	1

(d)A – slurry, C – Gas mixture, B – Sludge,D – Water + Dung

8. Match the items in Column-I and Column- II and choose the correct answer. 1

	Column I		Column II
a	Ladybird	1	Methanobacterium
b	Mycorrhiza	2	Trichoderma
c	Biological control	3	Aphids
d	Biogas	4	Glomus

Which of the following is the correct option?

	A	B	C	D
a	1	4	3	2
B	3	4	2	1
C	4	1	2	3
D	3	2	1	4

9. An antibody cvonsists of 1

a. Two small light chains and two long heavy chains
b. Two long light chains and two small heavy chains
c. One small light chains and two long heavy chains
d. Two small light chains and one long heavy chains

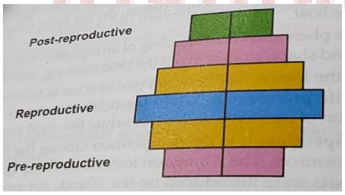
10. BOD stands for- 1

a) Biosynthesis of diphenol
b) Biochemical of demand
c) Biological oxygen degree
d) Biochemical oxygen demand

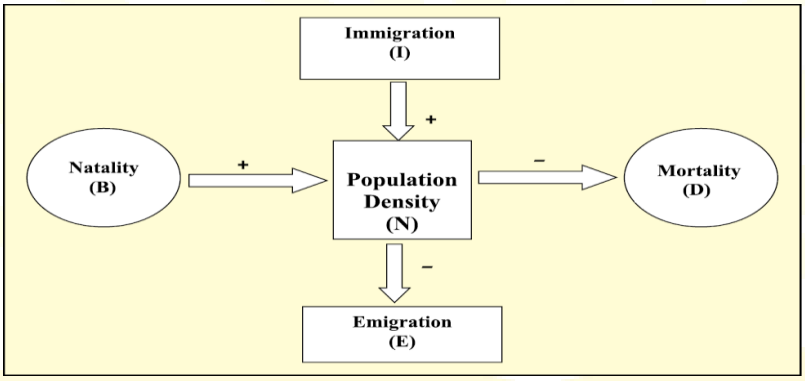
11. 1

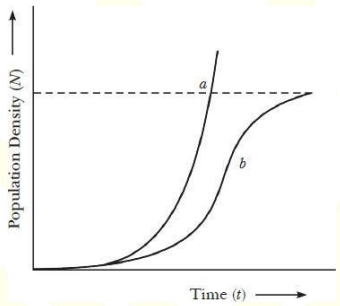
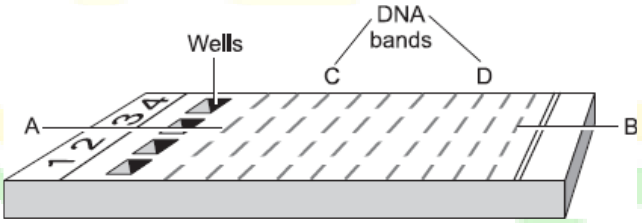
The figure shows DNA separated out, removed by :
(a) spooning (b) spooling (c) spilling (d) speeling

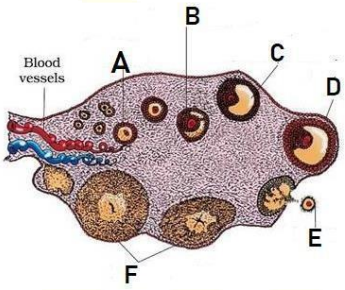
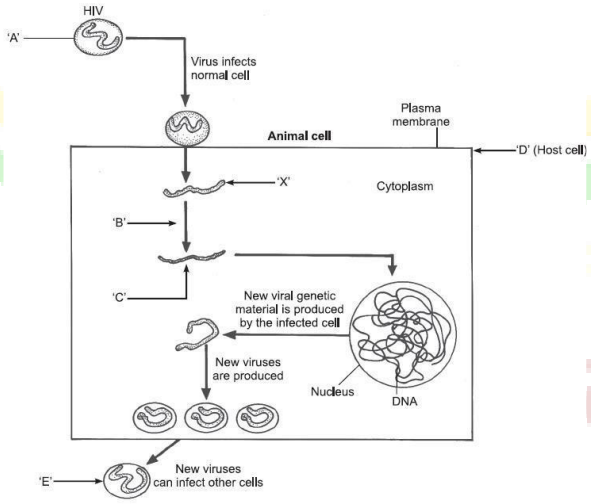
12. The status of the human population reflected in the human age pyramid given below is : 1

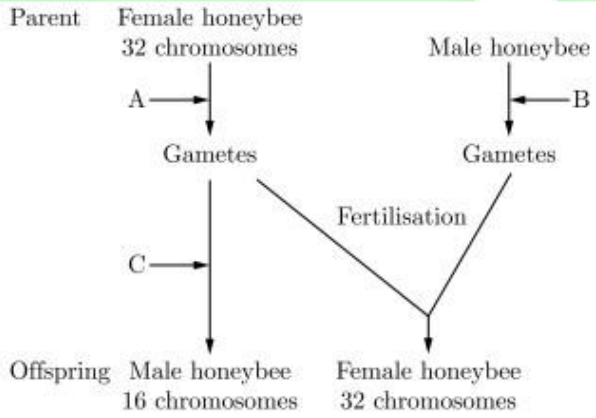


(a)Declining population
(b)Stable population
(c) Expanding population
(d)Extinct population

	Question No. 13 to 16 consist of two statements – Assertion (A) and Reason (R). Answer these questions selecting the appropriate option given below: a) Both A and R are true and R is the correct explanation of A. b) Both A and R are true and R is not the correct explanation of A. c) A is true but R is false. d) A is False but R is true.	
13.	**Assertion:** Pneumonia is caused by the infection of *Streptococcus pneumoniae*. **Reason:** *Streptococcus pneumoniae* bacteria infect respiratory passage.	1
14.	**Assertion**- Vector should have many recognition sites for commonly used restriction enzymes. **Reason**- Lot of recognition sites generate several fragments, which make gene cloning easy.	1
15.	Given below is a population density flowchart. Study the figure below and comment upon the appropriateness of the Assertion and the Reason.  Assertion -The density of a population in a given habitat during a given period, fluctuates due to changes in four basic processes. Reason - So if N is the population density at given time t, then density its density at time t+1 is- Nt+1=Nt+[(B+1)+(D+E)]	1
16.	**Assertion** - Tropical latitudes have greater biological diversity than temperate latitudes. **Reason**- Tropical rain forests remain relatively undisturbed for millions of years**.**	1
	SECTION-B	
17.	**(*a*) How does a Chromosomal disorder differ from a Mendelian disorder?** **(b) Name any two chromosomal aberration associated disorders.** **List the characteristics of the disorders mentioned above that help in their diagnosis.**	1+1

18.	**(*a*) Name the scientist who called *t*RNA an adaptor molecule.** **(b)Draw a clover leaf structure of *t*RNA showing the following:** **(i) Tyrosine attached to its amino acid site.** **(ii) Anticodon for this amino acid in its correct site (codon for tyrosine is UCA).** **(c) What does the actual structure of *t*RNA look like?**	½+½+½+½
19.	**Cleistogamous flowers produce assured seed set even in the absence of pollinators. How?**	2
20	**Study the graph given below and answer the questions that follow:** **(a) Write the status of food and space in the curves (a) and (b).** **(b) In the absence of predators, which one of the two curves would appropriately depict the prey population?**  	1+1
21.	Expand ICSI. Under what conditions will the doctor advice it?	1+1
	SECTION-C	
22.	**Why is it essential to have a 'selectable marker' in a cloning vector?** **Study the diagram given below and answer the questions that follow:**  **(a) Why have DNA fragments in band 'D' moved farther away in comparison to those in band 'C'?** **(b) Identify the anode end in the diagram.** **(c) How are these DNA fragments visualized**?	1+1+1
23.	**a) Identify the given figure.** b) Name the initial cell from which this structure has developed. c) Draw the next mature stage and label the parts. 	1+1+1
24.	**(a) Write the conclusion drawn by Griffith at the end of his experiment with Streptococcus pneumoniae.** **(b) How did O. Avery, C MacLeod and M. McCarty prove that DNA was the genetic material? Explain.**	1.5+1.5=3

25.	**(a) A true breeding homozygous pea plant with green pods and axial flowers as dominant characters, is crossed with a recessive homozygous pea plant with yellow pods and terminal flowers. Work out the cross up to F2 generation giving the phenotypic ratios of F1 and F2 generation respectively.** **(b) State the Mendelian principle which can be derived from such a cross and not from monohybrid cross.**	2+1
26.	Observe the diagrammatic section view of ovary and answer the questions  (a) Write correct labelling of A, B, C and D are: (b) Which part represent corpus luteum.	2+1
27.	(a) Why is the collection of white winged moths and dark winged moths made in England between 1850 – 1920 considered a good example of natural selection ? (b) ‘‘Evolution is based on chance events in nature and chance mutations in organ isms.’’ Justify the statement.	1.5+1.5=3
28.	Study the diagram –  Study the diagram showing replication of HIV in humans and answer the following questions accordingly: (a) Write the chemical nature of the coat ‘A’. (b) Name the enzyme ‘B’ acting on ‘X’ to produce molecule ‘C’. Name ‘C’. (c) Mention the name of the host cell ‘D’ the HIV attacks first when it enters	1+1+1

	into the human body.	
	SECTION-D	
29.	Intrauterine devices are most widely accepted methods of contraception. This are used by female and are inserted by doctors are nurses in the uterus through vagina. However this devices are not recommended for those who eventually intend to conceive. **1. How does copper -t prevent contraception** a) Cu ions make uterus Unsuitable for implantation b) Cu ions make cervix hostile to the sperms c) Cu ions suppress sperm motility d) Cu ions inhibit ovulation **2. Which of the following iodine make uterus unsuitable for implantation** a) LNG 20 b) Multiload 375 c) Cu7 d) lippes loop **3. Identify the correct statement for IUDs** a. The slowly released synthetic progesterone in the body b. The increase phagocytosis of sperms within the uterus c. They block entry of sperms through the cervix d. Both (b) and (c) **4. Selected the correct matched pair** (a) Hormone releasing IUD - LNG 20 (b) Non-medicated IUD - Progestasert (c) Copper releasing IUD - Lippes loop (d) None of these.	1+1+1+1
30.	'The cytological observations made in a number of insects led to the development of the concept of genetic/ chromosomal basis of sex determination mechanism. Honeybee is an interesting example to study the mechanism of sex-determination. Study the schematic cross between the male and the female honeybees given below and answer the questions that follow:  (a) Identify the cell divisions 'A' and 'B' that lead to gamete formation in female and male honeybees respectively. (b) Name the process 'C' that leads to the development of male	1+1+1+1

<table>
<tr><td></td><td>honeybee (drone).
(c) Identify the type of sex determination in this case.
(d)If the no. of chromosome in male honeybee is 48 and female honeybee is 32 than find no. of chromosome in their progeny which is form by fusion of gamets.</td><td></td></tr>
<tr><td colspan="3">SECTION-E</td></tr>
<tr><td>31.</td><td>Answer the following question with respect to recombinant DNA technology:
a) Why is plasmid considered to be an important tool in rDNA technology? From
where can plasmids be isolated? (Any two sources)
b) Explain the role of 'ori' and 'selectable marker' in a cloning vector.
c) "r-DNA technology cannot proceed without restriction endonuclease." Justify.
OR
a) Name the source from which insulin was extracted earlier. Why is this insulin no more in use by diabetic people?
b) Explain the process of synthesis of insulin by Eli Lilly Company. Name the technique used by the company.
c) How is the insulin produced by human body different from the insulin produced by the above mentioned company?</td><td>2+2=1
=5</td></tr>
<tr><td>32.</td><td>a) State how ex-situ conservation helps in protecting biodiversity. Name four types of ex-situ methods .
b)Explain the importance of sacred groves.
OR
Refer the table given below and answer the following questions.
Table : Types of Interaction
<table><tr><th>SPECIES A</th><th>SPECIES B</th><th>INTERACTION</th></tr><tr><td>+</td><td>+</td><td>P</td></tr><tr><td>-</td><td>-</td><td>Q</td></tr><tr><td>+</td><td>-</td><td>R</td></tr><tr><td>+</td><td>-</td><td>S</td></tr><tr><td>+</td><td>0</td><td>T</td></tr><tr><td>-</td><td>0</td><td>U</td></tr></table>(a) Identify P, Q, R, S, T and U.
(b) (i) An orchid growing as an epiphyte on a mango branch is an example of which interaction?
(ii) Name the type of interaction seen between wasp and fig tree.
(c) Give one example of interaction ‘P’.</td><td>4+1

½*6=3
½*2=1
1</td></tr>
<tr><td>33.</td><td>(a) Choose any three microbes, from the following which are suited for organic farming, which is in great demand these days for various reasons. Mention one application of each one chosen. Mycorrhiza; Monascus; Anabaena; Rhizobium; Methanobacterium; Trichoderma.</td><td>3+2
=
5M</td></tr>
</table>

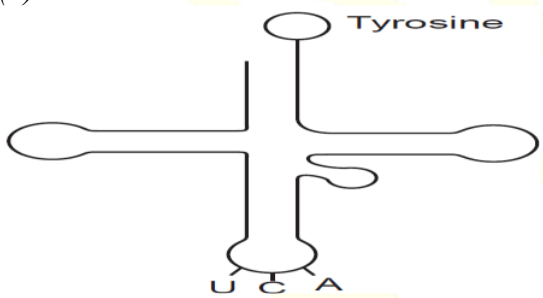
	(b) Explain the function of "anaerobic sludge digester" in a sewage treatment plant. **OR** (a) Patients who have undergone myocardial infarction are given clot buster. Mention the clot buster administered and its microbial source. (b) A person recuperating from illness is advised to have curd regularly. Why? (c) Bottled fruit juices bought from the market are clearer as compared to those made at home. Give reason.	**2+** **2+** **1=** **5M**

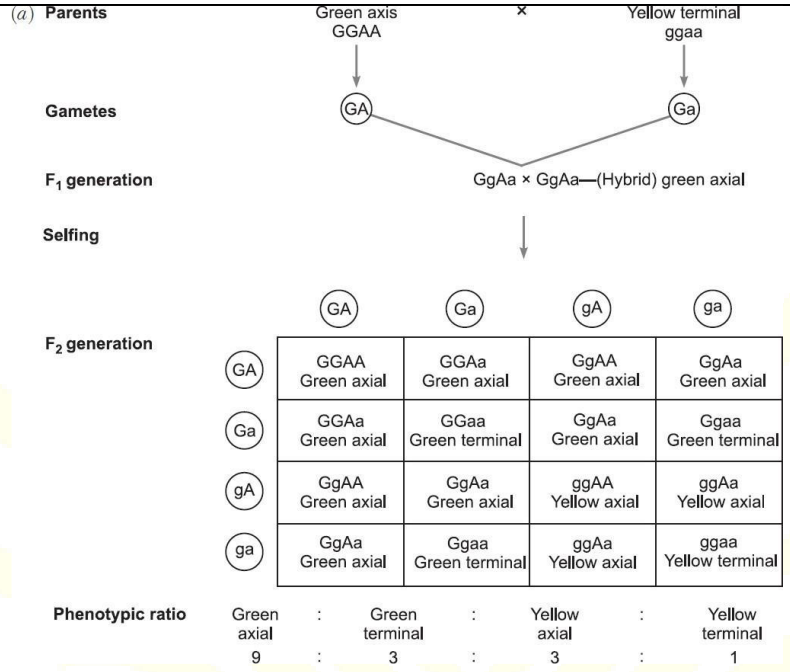
SAMPLE PAPER-1 MARKING SCHEME

SUBJECT: BIOLOGY **CLASS: XI**

TIME: 3 Hours **M. M: 70**

Q.NO	ANSWER	MARKS
1	A 3, B 4, C 1, D 2 — d	1
2	(d) a-2, b-4,c-1, d-3	1
3	(d) phenotypes – 4; genotypes – 9	1
4	(b) Remove/replace 3′ OH group in deoxyribose	1
5	(c) **Ab X ab**	1
6	(d) Only III	1
7	(c) A – sludge, B – Digester, C – Gas Holder, D – Slurry	1
8	A 3, B 4, C 2, D 1 — b	1
9	(a) Two small light chains and two long heavy chains	1
10	(d) Biochemical oxygen demand	1
11	(b) spooling	1
12	(a)Declining population	1
13	(c) Ais truebut Ris false.	1
14	(c) Ais truebut Ris false.	1
15	(c) Ais truebut Ris false.	1
16	(a) Both Aand Raretrue and Ris thecorrect explanationofA	1
17	(a)	1+1

	(i) **S. No.** / **Mendelian Disorder** / **Chromosomal Disorder** (i) This disorder is mainly due to alteration or mutation in the single gene. / This disorder is caused due to absence or excess or abnormal arrangement of one or more chromosomes. (ii) This follows Mendel's principles of inheritance. / This does not follow Mendel's principles of inheritance. (iii) This may be recessive or dominant in nature / This is always dominant in nature. (iv) For example, haemophilia, sickle-cell anaemia. / For example, Turner's syndrome. (b) Two chromosomal aberration-associated disorders are Down's syndrome and Klinefelter's syndrome. **(i) Down's syndrome:** The individuals have overall masculine development but theyexpress feminine development like development of breast, i.e., gynaecomastia. They are sterile. (ii) **Klinefelter's syndrome:** The females are sterile as ovaries are rudimentary. Other secondary sexual characters are also lacking.	
18	*(a)* Francis Crick (b)  (*c*) The actual structure of *t*RNA looks like inverted L.	½+½ +½+ ½
19	Clestogamous flower is closed flower so only there is chance of self pollination (autogamy) which result in sure seed set.	2
20	(a) a-unlimited food and space b-limited food and space (b) Curve a	1+1
21	**Intra cytoplasmicsperm injection** (ICSI) It is another specialised procedure to form an embryo in the laboratory in which a sperm is directly injected into the ovum	1+1
22	(a) DNA fragments in band 'D' are smaller in size than fragments in band 'C'. Therefore, they moved faster and farther away. (b) The anode end is 'B'. (c) The separated DNA fragments can be visualised by staining the DNA with ethidium bromide followed by exposure to UV radiation.	1+1 +1
23	a) Globular Embryo (b) Zygot (c) Draw & label	1+1 +1
24	**(*a*)** At the end of his experiments Griffith concluded that transformation of R strain by the heat-killed S strain indicated the presence of a transforming principle or genetic material. This transforming principle made the R strain virulent. **(*b*)** They purified biochemicals (proteins, DNA, RNA, etc.) from the heat-killed S cells. They discovered that DNA alone from S bacteria caused R bacteria to become transformed. They also discovered that protein-digesting enzymes (proteases) and RNA-	1.5+ 1.5= 3

	digesting enzymes (RNases) did not affect transformation, so the transforming substance was not a protein or RNA. Digestion with DNase did inhibit transformation, suggesting that the DNA caused the transformation. They concluded that DNA is the hereditary material.	
25	 **(b)** From the above cross law of independent assortment can be derived which states that when two pairs of traits are combined in a hybrid, segregation of one pair of character is independent of the other pair of characters.	2+1
26	(a) Oogonia, primary follicle,secondary follicle, graffian (b) F	2+1
27	a) During Pre-industrialisation white-winged moths survived due to white coloured lichens on trees, During post-industrialisation white-winged moths did not survive due to predation / predators could spot the moth against contrasting back ground, then the dark-winged or melanised moths survived, this showed that in a mixed population of white and dark winged moths those who can adapt better will survive b) excess use of herbicides /pesticides and antibiotics has resulted in selection of resistant varieties that developed due to chance mutation (in much lesser time scale)	1.5+ 1.5= 3
28	(*a*) Coat 'A' is made up of protein. (b) The enzyme 'B' is reverse transcriptase, 'C' is viral DNA. (c) The host cell 'D' is macrophage.	1+1 +1
29	*(1) c (2) a (3) b (4) a*	1+1 +1+ 1
30	(a) 'A' Meiosis and 'B'- Mitosis (b) 'C'- Parthenogenesis- ovum develops into an individual without fertilisation. (c) Haplo-Diploid type of sex determination (d) 64	1+1 +1+ 1
31	a) Plasmids are autonomously replicating circular extra-chromosomal DNA which carry a foreign DNA segment into the host cell. Plasmids can be isolated	2+2 +1

	from bacteria, yeast and plants. b) ori controls the copy numbers of the linked DNA. Selectable marker helps select the host cells which contain the vector (transformants) and eliminate the non-transformants. c) The restriction enzymes are called molecular scissors and are responsible for cutting DNA. If the desired DNA and the plasmid DNA are not cut at specific sites, they cannot be linked to form recombinant DNA . **OR** a) Earlier, insulin was extracted from pancreas of slaughtered cattle and pig. This insulin is not in use as some patients developed allergic reaction to this foreign protein. b) Eli Lilly used the following procedure for insulin synthesis using r-DNA technology: i) Two DNA sequences corresponding to A and B chains of insulin were prepared. ii) These sequences were then introduced in plasmids of E. coli. iii) The two insulin chains are produced separately. iv) The two chains are extracted and combined by creating disulphide bonds to form the assembled mature molecule of insulin. c) The pro-hormone produced in the human body has an extra stretch of Cpeptide	
32	Chapter-15 correct explanation **OR** (a) P — Mutualism Q — Competition R — Predation S — Parasitism T — Commensalism U —Amensalism (b) (i) Commensalism (Q) (ii) Mutualism (c) Nitrogen — fixing bacteria (Rhizobium) living in root nodules of legumes represent mutualism (P).	4+1 ½*6 =3 ½*2 =1 1
33	**(a)** Mycorrhiza: Fungal symbiont Absorbs phosphorus from soil. Anabaena: Fix atmospheric nitrogen and adds organic matter to the soil. Rhizobium: Fix atmospheric nitrogen (in leguminous plants). Methanobacterium: They digest cellulosic material and their product/spent slurry can be Used as a fertiliser. Trichoderma: Biocontrol agent for several plant pathogens. (Any three) **(b)** Anaerobic sludge digester has anaerobic bacteria that digests the aerobic bacteria and fungi present in the sludge. During the digestion these bacteria produce mixture of gases such as methane, H2S and CO2 (biogas). OR **a.** *Streptokinase* is the clot buster and its microbial source is Streptococcus. **b.** Curd contains Lactic Acid Bacteria, which play beneficial role in checking disease-causing microbes. It is also a source of vitamin B12. **c.** Bottled fruit juices are clarified by pectinases and proteases which makes them clearer.	**3+2 = 5M** **2+ 2+ 1= 5M**

NAME OF UNIT	VSA 1 MARK	SA 2 MARKS	LA 3 MARKS	CASE/PARAGRAPH BASED 4 MARKS	VLA 5 MARKS	WEIGHTAGE
REPRODUCTION	3(1)=3	1(2)=2	2(3)=6	-	1(5)=5	16
GENETICS AND EVOLUTION	8(1)=8	1(2)=2	2(3)=6	1(4)=4	-	20
BIOLOGY AND HUMAN WELFARE	2(1)=2	1(2)=2	1(3)=3	-	1(5)=5	12
BIOTECHNOLOGY AND ITS APPLICATIONS	2(1)=2	1(2)=2	1(3)=3	-	1(5)=5	12
ECOLOGY AND ENVIRONMENT	1(1)=1	1(2)=2	1(3)=3	1(4)=4	-	10
	16	10	21	8	15	70

XII BIOLOGY –SAMPLE PAPER-2

Class XII SET-2
Biology (Subject Code-044)

Maximum Marks: 70 Time: 3 hours

General Instructions:

(i) All questions are compulsory.

(ii) The question paper has five sections and 33 questions. All questions are compulsory.

(iii) Section–A has 16 questions of 1 mark each; Section–B has 5 questions of 2 marks each; Section– C has 7 questions of 3 marks each; Section– D has 2 case-based questions of 4 marks each; and Section–E has 3 questions of 5 marks each.

(iv) There is no overall choice. However, internal choices have been provided in some questions. A student has to attempt only one of the alternatives in such questions.

(v) Wherever necessary, neat and properly labeled diagrams should be drawn.

SNo.	Questions	marks
1	Aquatic plants like water hyacinth and water lily are pollinated by (a) Bird (b) insects and wind (c) water (d) none of the above	1

2	A wide range of contraceptive methods are presently available which are grouped into various categories. Match list I with list II : LIST I — LIST II A. Vasectomy — i) oral method B. Coitus interruptus — ii) barrier method C. Cervical caps — iii) surgical method D. Saheli — iv) natural method Choose the correct answer from the options given below: a) A :iv B: ii C: i D: iii b) A : iii B: i C: iv D:ii c) A : iii B: iv C: ii D:i d) A : ii B: iii C: i D:iv	1
3	The ploidy of spermatogonia, primary spermatocyte, secondary spermatocyte and spermatid is (a) 2n, 2n, 2n, n (b) n, 2n, 2n, n (c) n, 2n, n, n (d) 2n, 2n, n, n	1
4	Colour-blindness is a sex linked recessive trait in humans. A man with normal colour vision marries a woman who is colourblind. What would be the possible genotype of the parents, the son and the daughter of this couple. Mother Father Daughter Son	1
5	A polycistronic structural gene is regulated by a common promoter and regulator gene in bacteria and is commonly termed as (a) Codon (b) Operon (c) Genetic code (d) None of these	1
6	The most accepted line of descent in human evolution is (a) *Australopithecus → Ramapithecus → Homo sapiens → Homo habilis* (b) *Homo erectus → Homo habilis → Homo sapiens* (c) *Ramapithecus → Homo habilis → Homo erectus → Homo sapiens* (d) *Australopithecus → Ramapithecus → Homo erectus → Homo habilis → Homo sapiens*	1
7	In sea urchin DNA, which is double stranded, 17% of the bases were shown to be cytosine. The percentages of the other three bases expected to be present in this DNA are : (a) G 34%, A 24.5%, T 24.5% (b) G 17%, A 16.5%, T 32.5% (c) G 17%, A 33%, T 33% (d) G 8.5%, A 50%, T 24.5%	1
8	Match the terms in Column I with their description in Column II and choose the correct option:	1

	Father	Mother	Son	Daughter
A	X^CY	XX	XY	X^CX
B	X^CY	X^CX	X^CY	X^CX
C	XY	X^CX	XY	X^CX
D	XY	X^CX^C	X^CY	X^CX

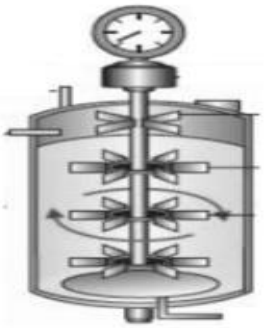
Column I	Column II
(a) Dominance	(i) Many genes govern a single character
(b) Codominance	(ii) In a heterozygous organism only one allele expresses itself.
(b) Codominance	(iii) In a heterozygous organisms both alleles express

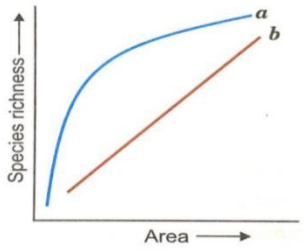
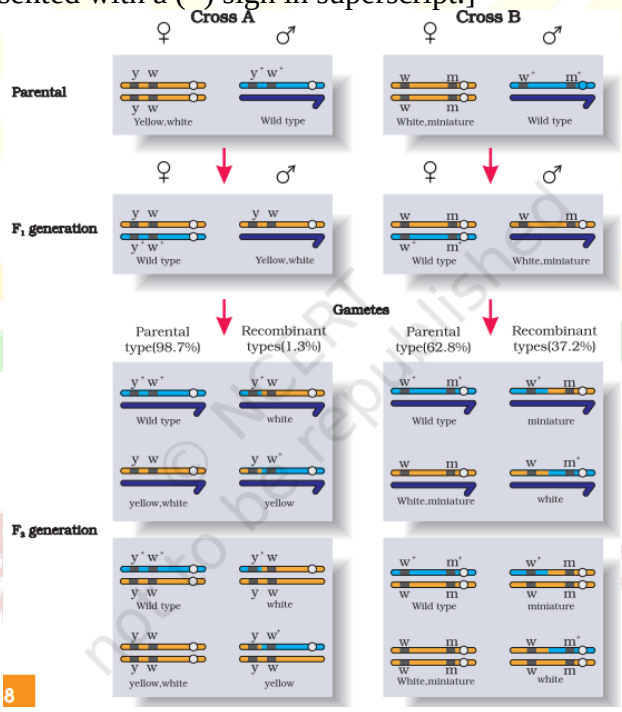
		themselves fully.
	(d) Polygenic inheritance	(iv) A single gene influences many characters.

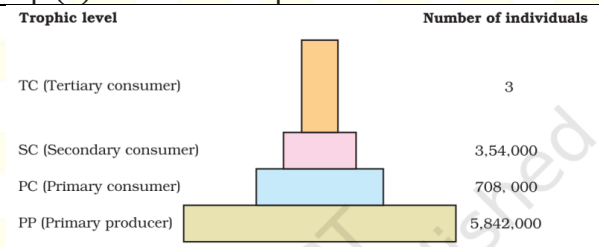
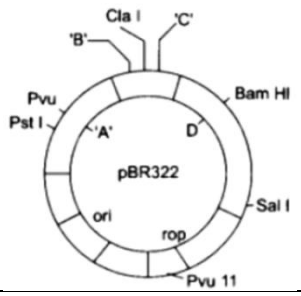
Options:

	(a)	(b)	(c)	(d)
(a)	ii	i	iv	iii
(b)	ii	iii	iv	i
(c)	iv	I	ii	iii
(d)	iv	iii	i	ii

9	'Swiss cheese' bears large holes due to the production of CO2 by which microbe? (a) *Lactobacillus* (b) *Saccharomyces cerevisiae* (c) *Propionibacterium shermanii* (d) *Aspergillus niger*	1
10	Select the correct order of processing of PCR: a) Extension, primer annealing, denaturation b) Primer annealing, denaturation, extension c) Denaturation, primer annealing, extension d) Denaturation, extension, primer annealing	1
11	Occasionally, a single gene may express more than one effect. The phenomenon is called (a) Multiple allelism (b) Polymorphism (c) Pleiotropy (d) Polygeny.	1
12	Important attributes belonging to a population but not to an individual are : (i) Birth rate and death rate (ii) Male and female (iii) Birth and death (iv) Sex-ratio Select the correct option from the given options: (a) (ii) only (b) (i) only (c) (ii) and (iii) (d) (i) and (iv)	1
	Question No. 13 to 16 consist of two statements – Assertion (A) and Reason (R). Answer These questions selecting the appropriate option given below: A. Both A and R are true and R is the correct explanation of A. B. Both A and R are true and R is not the correct explanation of A. C. A is true but R is false. D. A is False but R is true.	
13	Assertion: Cystic fibrosis is Mendelian disorder . Reason: Tuners syndrome is chromosomal disorder	1
14	Assertion (A) : The genes on a chromosome are physically linked.	1

<table>
<tr><td></td><td>Reason (R) : The number of linkage groups in an organism is equal to their haploid number of chromosomes.</td><td></td></tr>
<tr><td>15</td><td>Assertion: Greater is BOD of waste water, more is its polluting potential.
Reason: BOD is a measure of organic matter present in water.</td><td>1</td></tr>
<tr><td>16</td><td>Assertion: Transgenic animals are made that carry genes which makes them more sensitive to toxic substances than non transgenic animals.
Reason: Toxicity testing in such animals will allow us to obtain result in less time.</td><td>1</td></tr>
<tr><td>17</td><td>Write the function of each of the following :
(i) Middle piece in human sperm
(ii) Luteinising hormone in human male</td><td>1+1</td></tr>
<tr><td>18</td><td>A smooth seeded & red – flowered pea plant (SsRr) is crossed with smooth seeded & white flowered pea plant (Ssrr). Determine the phenotypic & genotypic ratio in F1 progeny?</td><td>1+1</td></tr>
<tr><td>19</td><td>Identify (i) to (vi) in the following table.
<table>
<tr><th>Name of disease</th><th>Causal organism</th><th>Symptom</th><th>Mode of transmission</th></tr>
<tr><td>Common cold</td><td>Rhinovirus</td><td>i</td><td>ii</td></tr>
<tr><td>Chikungunya</td><td>iii</td><td>iv</td><td>Through female Aedes mosquito</td></tr>
</table></td><td>½*4=2</td></tr>
<tr><td>20</td><td>Name the type of bioreactor shown below. Write the purpose for which it is used.
  </td><td>1+1</td></tr>
<tr><td>21</td><td>(a) What is ‘r’ in the population equation given : dN/dt = rN
(b) How does the increase and decrease in the value of r affect the population size.</td><td>1+1</td></tr>
<tr><td>22</td><td>Draw a labeled diagram of the embryonic stage that gets implanted in the human uterus. State the functions of the two parts labeled.</td><td>2+1</td></tr>
<tr><td>23</td><td>(i) Suggest any two methods of ARTs which can be used for males with low sperm count.
(ii) Describe any one method of Assisted Reproductive Technology where both husband and wife are producing functional gametes but wife is still unable to conceive.</td><td>1.5+1.5</td></tr>
<tr><td>24</td><td>Draw a longitudinal section of the pistil from a flowering plant, where pollination has occurred.
Label the following:
(a) Stigma showing germinating pollen grains. (b) Style
(c) Pollen tube reaching the micropyle of the ovule.
(d) Embryo sac (e) Components of the egg apparatus.</td><td>½*6=3</td></tr>
<tr><td>25</td><td>State Hardy-Weinberg principle and list four factors that affect it.</td><td>1+2</td></tr>
<tr><td>26</td><td>Trace the stages of life cycle of the parasite from the point of entry into human body till</td><td>3</td></tr>
</table>

	the time another mosquito bites this person.	
27	EcoRI is used to cut a segment of foreign DNA and that of a vector DNA to form a recombinant DNA. Show with the help of schematic diagrams only. OR DNA being hydrophilic cannot pass through the cell membrane of a host cell. Explain how does recombinant DNA get introduced into the host cell to transform the later.	3
28	The given graph alongside shows species-area relationship. Write the equation of the curve 'a' and explain.  	1+2
29	During a study on the inheritance of two genes, the teacher asked students to perform an experiment. The students crossed white-eyed, yellow-bodied female Drosophila with a red-eyed, brown-bodied male Drosophila (i.e., wild). They observed that progenies in the F2 generation had 1.3 percent recombinants and 98.7 percent parental type combinations. The experimental cross with results is shown in the given figure.[Note: Dominant wild-type alleles are represented with a (+) sign in superscript.]  (i) By conducting the given experiment, the teacher can conclude that A. Genes for eye color and body color are linked B. Genes for eye color and body color show complete linkage C. Linked genes remain together and are inherited (a) A and B only	1+1+ 1+1

	(b) B only (c) A and C only (d) A, Band C (ii) Teacher asked to conduct an experiment on Drosophila because (a) the male and female flies are easily distinguishable (b) it completes its life cycle in about two weeks (c) a single mating could produce a large number of progeny flies (d) all of these. (iii) Genes white-eyed and yellow-bodied located very close to one another on the same chromosome tend to be transmitted together and are called (a) allelomorphs (b) linked genes (c) identical genes (d) recessive genes (iv) Which of the following will not result in variations among siblings? (a) Independent assortment of genes (b) Crossing over (c) Linkage (d) Mutation OR Percentage of recombination and distance between the genes shows (a) a direct relationship (b) an inverse relationship (c) a parallel relationship (d) no relationship	
30	 (i) Identify the type of pyramid. (ii) Study the pyramid and depict it for grassland ecosystem. **OR** Study the pyramid and depict it for sea ecosystem. (iii) What would be the shape of pyramid of biomass in the above case and why? (iv) Draw a pyramid of energy for above ecosystems.	1+1+ 1+1
31	A) Draw a labeled diagram of the embryonic stage that gets implanted in the human uterus. State the functions of the two parts labeled. (B) What is the function of acrosome and middle piece in human sperm. **OR** A)Write the properties of an ideal contraceptive. B) How are non-medicated IUDs different from hormone releasing IUDs? Give examples.	3+2 2+3
32	Observe the diagram of E. coli vector shown below: i) Identify the selectable markers A' and ' D' in the diagram of E coli vector shown below. ii) Give the function of 'ori' other than it's function as 'origin of replication' iii) Give the role of 'rop'. iv) How is the coding sequence of Alpha- galactosidase considered a better marker than the ones identified by you in 	1+1+ 1+2

	the above diagram. Explain. **OR** i) How is the mature insulin different from pro-insulin secreted by pancreas in human? ii) Explain how was human functional insulin produced by rDNA technology? iii) Why is the functional insulin produced by rDNA technology considered better than the ones used earlier by the diabetic patient?	1+2+2
33	(i) If a patient is advised anti-retroviral drug, name the possible infection he/ she is likely to be suffering from. Name the causative organism. (b) How do vaccines prevent subsequent microbial infection by the same pathogen? (c) How does a cancerous cell differ from a normal cell? **OR** (a) Describe how does the application of the fungi to the agricultural farm increases the farm output? (b)Why is Rhizobium categorized as a 'symbiotic bacterium'? How does it act as a biofertilizer?	2+1+2 2+3

Sl. No.	**Unit**	**SECTION A (1 Mark)**	**SECTION B (2 Marks)**	**SECTION C (3 Marks)**	**SECTION D (4 Marks) *CSB**	**SECTION E (5 Marks)**	**Marks**
1.	Reproduction	2(1)	2(2)	2(3)	1(1x4)*CSB		16
2.	Genetics and evolution	3(1)	3(2)	2(3)		1(5)	20
3.	Biology and human Welfare	4(1)		1(3)		1(5)	12
4.	Biotechnology and its applications	4(1)	-	1(3)		1(5)	12
5.	Ecology and environment	3(1)		1(3)	1(1x4)*CSB		10
	TOTAL =	16(1)	5(2)	7(3)	2(4)	3(5)	33(70)

SAMPLE PAPER-3

Subject: Biology **Class - XII**

Blue Print

SAMPLE PAPER-3

CLASS- XII

Biology(044)

Time : 3 hrs. Maximum Marks: 70

General Instructions:

(i) All questions are compulsory.

(ii) The question paper has five sections and 33 questions. All questions are compulsory.

(iii) Section–A has 16 questions of 1 mark each; Section–B has 5 questions of 2 marks each; Section– C has 7 questions of 3 marks each; Section– D has 2 case-based questions of 4 marks each; and Section–E has 3 questions of 5 marks each.

(iv) There is no overall choice. However, internal choices have been provided in some questions. A student has to attempt only one of the alternatives in such questions.

(v) Wherever necessary, neat and properly labeled diagrams should be drawn.

SECTION – A

1. In albuminous seeds, food is stored in _____ and in non albuminous seeds, it is stored in _____.
   (a) endosperm, cotyledons (b) cotyledons, endosperm
   (c) nucellus, cotyledons (d) endosperm, radicle
2. Which one of the following events is correctly matched with the time period in a normal menstrual cycle ?
   (a) Release of egg : 5th day
   (b) Endometrium regenerates : 5 – 10 days
   (c) Endometrium secretes nutrients for implantation: 11 – 18 days
   (d) Rise in progesterone level : 1 – 15 days
3. **Rajesh and Mahesh have defective haemoglobin due to genetic disorders. Rajesh has too few globin molecules while Mahesh has incorrectly functioning globin molecules. Identify the disorder they are suffering from.**

	Rajesh	**Mahesh**
(a)	**Sickle cell anaemia-an autosome linked recessive trait**	**Thalassemia-an autosome linked dominant trait**
(b)	**Thalassemia- an autosome linked recessive blood disorder**	**Sickle cell anaemia-an autosome linked recessive trait**
(c)	**Sickle cell anaemia-an autosome linked recessive trait**	**Thalassemia- an autosome linked recessive blood disorder**
(d)	**Thalassemia- an autosome linked recessive blood disorder**	**Sickle cell anaemia-an autosome linked dominant trait**

4. **Taylor conducted the experiments to prove semi-conservative mode of chromosome replication on-?**
   (a). *Vicia faba* (b). *Vinca rosea* (c). *E.coli* (d). *Drosophila*
5. In higher vertebrates, the immune system can distinguish between its own cells and foreign cells. If this property is lost due to genetic abnormalities, and it attacks its own cells, then it leads to
   (a). Activated immunity (b). Graft rejection
   (c). Autoimmune disease (d). None of the above
6. Which of the following is not a casual organism for ringworm?
   (a). *Microsporum* (b). *Trichophyton*

(c). *Epidermophyton* (d). *Macrosporum*

7. **The free-living fungus Trichoderma can be used for**
   (a) Killing insects **(b) Biological control of plant diseases**
   (c) Controlling butterfly caterpillars **(d) Producing antibiotics**

8. Given below is a sample of a portion of DNA strand giving the base sequence on the opposite strands. What is so special shown in it?

   5′_____GAATTC_____3′

   3′_____CTTAAG_____5′

   (*a*) Replication completed (*b*) Deletion mutation

   (*c*) Start codon at the 5′ level (*d*) Palindromic sequence of base pairs

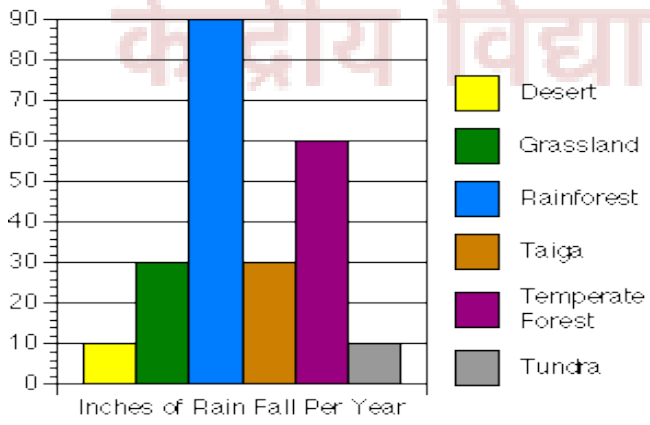
9. **GEAC stands for**
   (a) Genome Engineering Action Committee
   (b) Ground Environment Action Committee
   (c) Genetic Engineering Approval Committee.
   (d) Genetic and Environment Approval Committee

10. Identify the **incorrectly** matched pair:

(a)	Humulin	First therapeutic rDNA product approved for human use
(b)	RNAi	Silencing of mRNA with the help of dsRNA
(c)	Rosie	Transgenic sheep producing alpha 1antitrypsin
(d)	Golden rice	Vitamin A enriched rice variety

1. **Amensalism is an association between two species where**
   (a) One species is harmed and other is benefitted
   (b) One species is harmed and other is unaffected
   (c) One species is benefitted and other is unaffected
   (d) Both the species are harmed.

12. Identify the biome that is not correctly matched with the physical parameters (mean annual temp/precipitation) given in corresponding Column II and Column III:



	Biomes	Temp. (oC)	Rainfall (cm)
(a)	Tropical forest	20 to 25	130-430
(b)	Arctic and Alpine	-12 to 2	10-125
(c)	Coniferous forest	-5 to 5	100-200
(d)	Temperate Forest	8 to22	50-225

In the following questions (13 to 16) a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choice.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statements but reason is wrong statement.

(d) Assertion is wrong statements but reason is correct statement.

13. **Assertion :**Excessive use of herbicides and pesticides has no effect on resistant varieties of microbes.

Reason : Pathogenic bacteria are appearing in very short period of time because of chemical resistance.

14. **Assertion :**Baculoviruses control growth of many insects and arthropods.

Reason : Lady bird and *Trichoderma* are used as biocontrol agents.

15. **Assertion** – *E.coli* having *pBR322* with DNA insert at *Bam*H1 site cannot grow in medium containing tetracycline.

Reason- Recognition site for *Bam*H1 is present in tet^r region of *pBR322*.

16. **Assertion :**Nile Perch introduced into Lake Victoria in east Africa lead to extinction of many species of Cichlid fish.

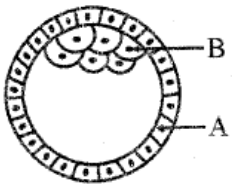
Reason : When alien species are introduced in a region, they become invasive and cause extinction of indigenous species.

SECTION B

17. Differentiate between Spermiogenesis and spermiation.

OR

Study the figure given below and answer the questions that follows.



(i) Name the stage of human embryo the figure represents.

(ii) Identify A and B.

18. Identify the given diagram. What it contains and is used for?

19. Study the figures given below and answer the question.

Identify in which of the crosses is the strength of linkage between the genes higher. Give reasons in support of your answer.

20. Study the diagrammatic representation of S.L. Miller's experiment given below and answer the questions that follow:

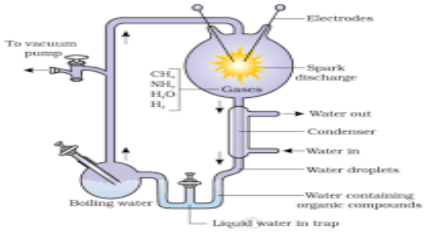


Fig: The apparatus set up by Miller and Urey to simulate conditions in the atmosphere of the primitive earth

(a) How did S.L. Miller create the conditions which existed before the origin of any life on Earth.

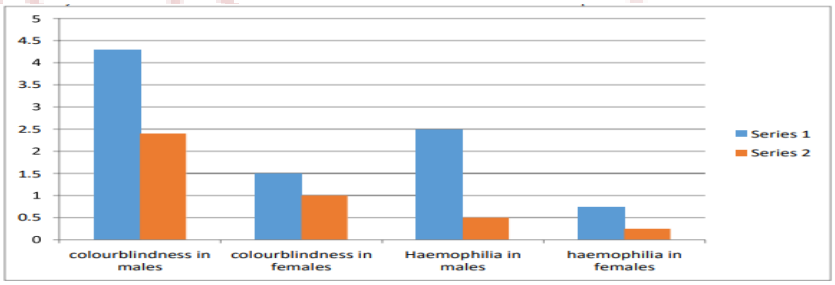
(b) Mention the kind of evolution his experiment supports.

21. Differentiate between the genetic codes given below:

(a) Unambiguous and Universal (b) Degenerate and Initiator

OR

The chances of colour blindness about 8 % in males and only about 0.4 % in females. Another sex linked recessive disease, which shows its transmission from unaffected carrier female to some of the male progeny has been widely studied. In this disease a single protein that is a part of the cascade of proteins involved in the clotting of the blood is affected. Due to this in an affected individual a simple cut will result in nonstop bleeding.



Note :- in each group bar 1 represent the individuals of less than 12 years of age. And bar 2 represent the individuals of more than 12 years of age.

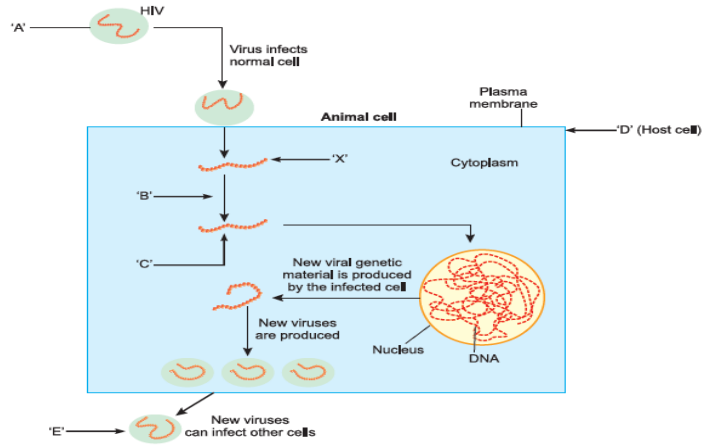
GRAPH : DEPICTS THE VIABILITY OF INDIVIDUALS WITH X LINKED MENDELIAN DISORDERS

(*a*) State the cause and symptoms of colour-blindness in humans.

(*b*) Statistical data has shown that 8% of the human males are colour-blind whereas only 0.4% of females are colour-blind. Explain giving reasons how is it so.

SECTION C

22. Study the diagram showing replication of HIV in humans and answer the following questions accordingly:



(*i*) What type of virus causes AIDS? Name its genetic material.

(*ii*) Name the enzyme 'B' acting on 'X' to produce molecule 'C'. Name 'C'.

(*iii*) Name the type of cells the AIDS virus enters into after getting in the human body.

23. Write the specific location and the functions of the following cells in human males:
(i) Leydig cells (ii) Sertoli cells (iii) Primary spermatocyte.

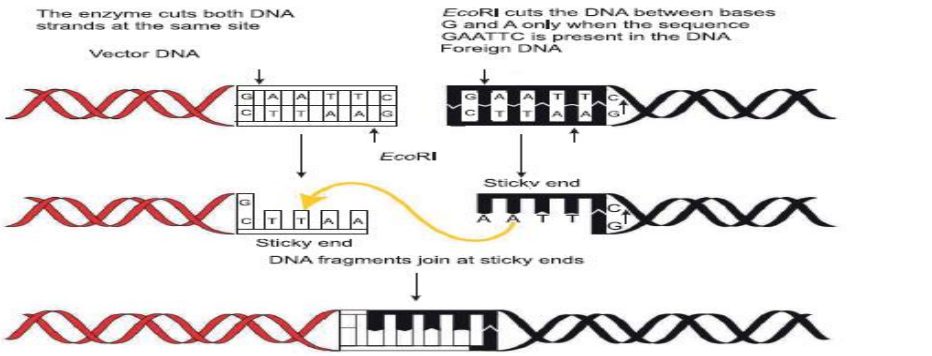
24. It is said that "Males in Honey bees neither have fathers nor sons but have grandfathers and grandsons". Explain this statement with suitable cross.

25. Study the diagram given below and answer the questions that follow:

(*i*) What is *Eco*RI?

(*ii*) How is the action of exonuclease different from that of endonuclease?

(*iii*) How are 'sticky ends' formed on a DNA strand? Why are they so called?



26. List the different anthropogenic actions, and explain how have they led to evolution.

27. 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.

OR

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?

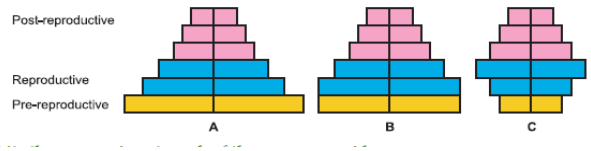
(b) State any two reasons responsible for the cause of infertility.

(c)Suggest a technique that can help the couple to have a child where the problem is with the male partner.

28. Draw a pyramid of biomass and pyramid of energy in sea. Give your comment on the type of pyramids drawn.

SECTION D

Q. 29 Study the three different age pyramids for human population given below and answer the questions that follow:



(*i*) Write the names given to each of these age pyramids.

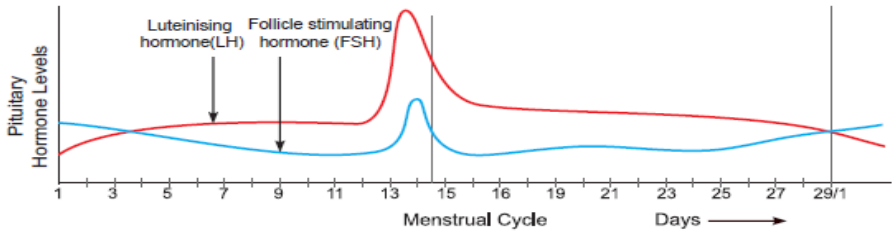
(*ii*) What would be the growth rate pattern when the resources are unlimited?

(*iii*) Mention the one which is ideal for human population and why.

OR

(iii) Define Birth rate and death rate.

30. Study the graph given below and answer the questions that follow:



(*i*) What is the importance of LH surge?

(*ii*) Identify the ovarian phases during the menstrual cycle.

(a) 5th day to 12th day of the cycle. (b) 14th day of the cycle.

(*iii*) Menstrual cycles are absent during pregnancy. Why?

OR

(iii). What will happen when egg is not fertilized?

SECTION E

31. The following table shows certain diseases, their causative organisms and symptoms. Fill the gaps.

S. No.	Name of the Disease	Causative organism	Symptoms
(i)	Typhoid	**A**	High fever, weakness, headache, stomach pain, Constipation.
(ii)	Pneumonia	*Streptococcus pneumonia*	**B**
(iii) .	**C**	*Rhino viruses*	Nasal congestion and discharge, sorethroat, cough, headache
(iv)	Filariasis	***D***	Inflammation in lower limbs.
(v)	E	*Antamoeba histolitica*	Stool with blood and mucus, constipation, Abdominal pain

OR

Fill the gaps of column B on the basis of information provided in column A

S.no.	Column A	Column B
(i)	stage of malarial parasite that enters into human body	A
(ii)	Asexual cycle of of malarial parasite takes place in	B
(iii)	Chemical that causes chill and fever	C
(iv)	malarial parasite that causes most malignant malaria	D
(v)	Fertilisation of gametes of malarial parasite takes place in	E

32. Answer the following questions.

(a) What is biopiracy?

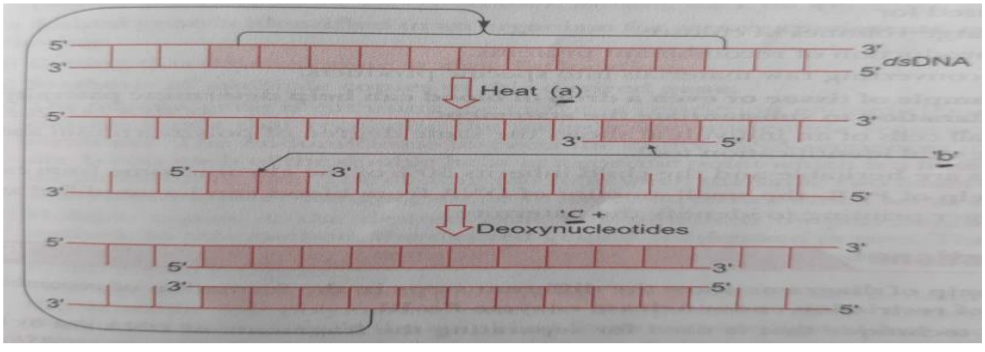
(b) What is patent?

(c)Discuss the controversies in India regarding Patent and Biopiracy taking example of Turmeric and Basmati rice.

(d) State the initiative taken by the Indian Parliament towards it.

OR

A schematic representation of polymerase chain reaction (PCR) upto the extension stage is given below. Answer the questions that follow.



(a) Name the process ‘a’.
(b) Identify ‘b’.
(c) Identify ‘c’
(d) What is the importance of ‘c’ in PCR?
(e) Write the uses of PCR in biotechnology.

Q.33 How did Alfred Hershey and Martha Chase arrive at the conclusion that DNA is the genetic material?

OR

In a series of experiments with Streptococcus and mice F. Griffith concluded that R-strain bacteria had been transformed. Explain.

SAMPLE PAPER 04- CLASS XII

NAME OF UNIT	MCQ (1 MARK)	AR type (1 MARK)	SA(2 MARKS)	SA(3 MARKS)	CASE/COMPETENCY BASED (4 MARKS)	LA (5 MARKS)	WEIGHTAGE
REPRODUCTION	2 (2)	1(1)	1(2)	2(6)	-	1 (5)	16
GENETICS AND EVOLUTION	3 (3)	1(1)	2(4)	1(3)	1 (4)	1 (5)	20
BIOLOGY AND HUMAN WELFARE	2(2)	1(1)	-		1 (4)	1 (5)	12
BIOTECHNOLOGY AND ITS APPLICATIONS	2 (2)	-	2(4)	2(6)	-	-	12
ECOLOGY AND ENVIRONMENT	3 (3)	1(1)	-	2(6)	-	-	10
TOTAL	12 (12)	4(4)	5 (10)	7 (21)	2 (8)	3 (15)	33 (70)

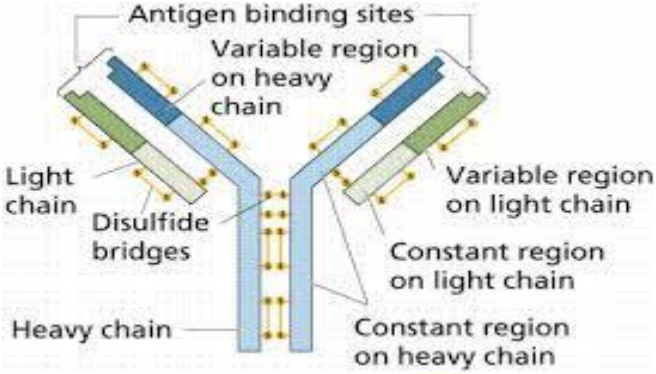
SAMPLE PAPER-4

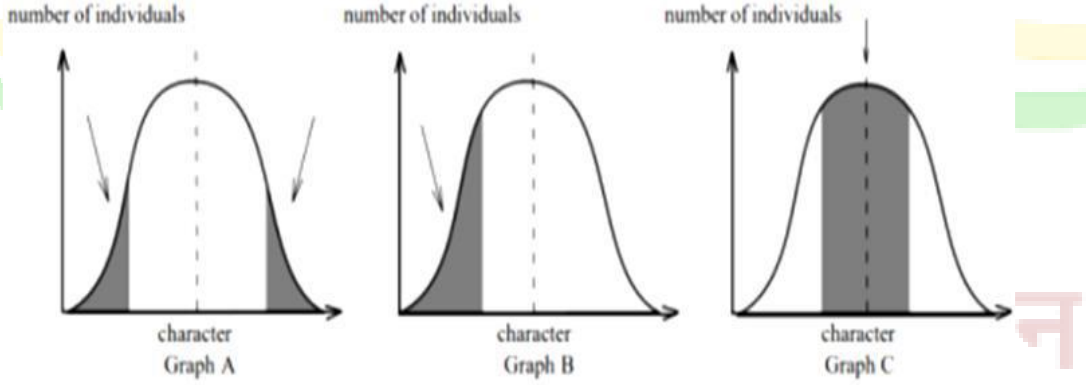
CLASS: XII
BIOLOGY

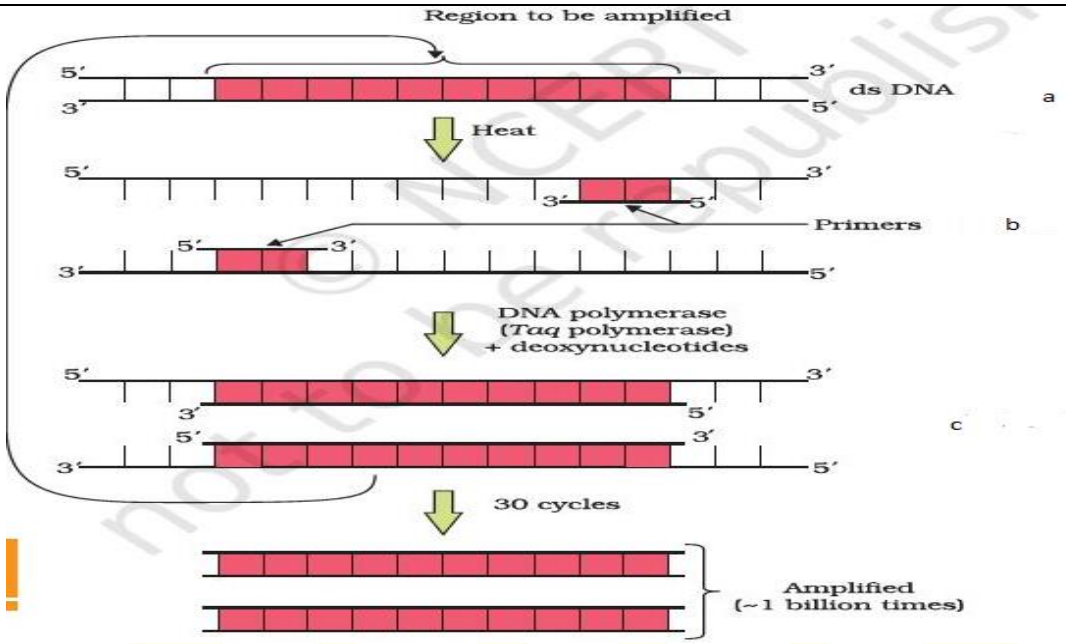
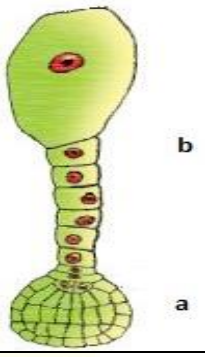
MAXIMUM MARKS: 70 **TIME ALLOWED: 3 HRS**

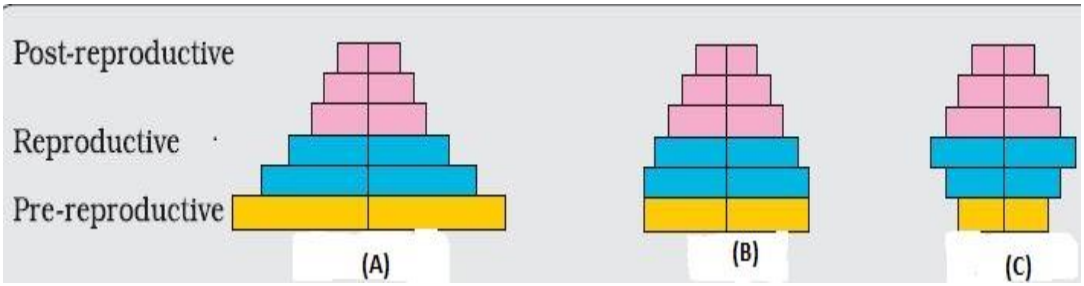
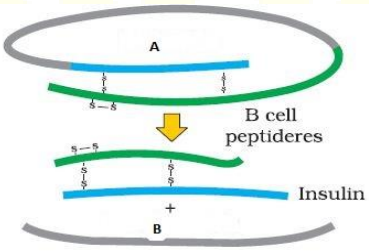
General Instructions:
(i) All questions are compulsory.
(ii) The question paper has five sections and 33 questions. All questions are compulsory.
(iii) Section–A has 16 questions of 1 mark each; Section–B has 5 questions of 2 marks each; Section– C has 7 questions of 3 marks each; Section– D has 2 case-based questions of 4 marks each; and Section–E has 3 questions of 5 marks each.
(iv) There is no overall choice. However, internal choices have been provided in some questions. A student must attempt only one of the alternatives in such questions.
(v) Wherever necessary, neat, and properly labelled diagrams should be drawn.

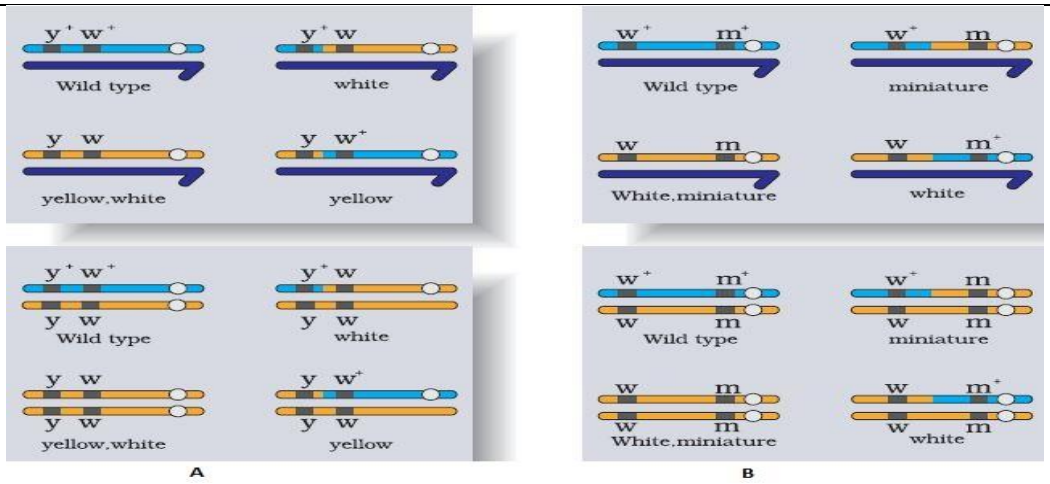
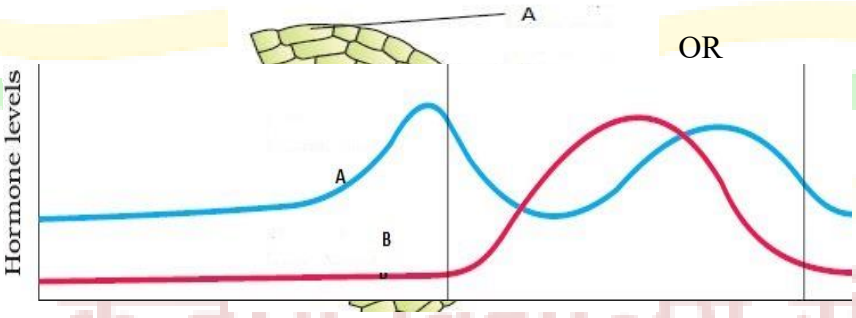
SECTION: A		
Q NO.	**QUESTIONS**	**MARKS**
1	Which of the following statement confirm the law of dominance (a) Alleles do not show any blending and both characters recovered as such in F2 generation (b) It is the conclusion of a dihybrid cross (c) 3:1 ratio in F2 generation (d) Alleles of a pair segregate from each other such that gamete receives only one of the two factors	**1**
2	Evolutionary convergence is development of a (a) common set of functions in groups of different ancestry (b) dissimilar set of functions in closely related groups (c) common set of structures in closely related groups (d) dissimilar set of functions in unrelated groups.	**1**
3	An infertile couple was advised to undergo in vitro fertilisation by the doctor. Out of the options given below, select the correct stage for transfer to the fallopian tube for successful results? (a) Zygote only (b) Zygote or early embryo upto 8 blastomeres (c) Embryos with more than 8 blastomeres (d) Blastocyst Stage	**1**
4	Match column I with column II and select the correct option from the given codes. **Column I** **Column II** A. Sigma factor (i) 5'– 3' B. Capping (ii) Initiation C. Tailing (iii) Termination D. Coding strand (iv) 5' end (v) 3' end (a) A-(iii), B-(v), C-(iv), D-(ii) (b) A-(ii), B-(iv), C-(v), D-(i) (c) A-(ii), B- (iv), C-(v), D-(iii) (d) A-(iii), B-(v), C-(iv), D-(i)	**1**
5	Match column I with column II and select the correct option from the codes given below. **Column I** **Column II** A. Hyaluronidase (i) Acrosomal reaction B. Corpus luteum (ii) Embryonic development C. Gastrulation (iii) Progesterone D. Colostrum (iv) Mammary gland (a) A-(iii), B-(ii), C-(iv), D-(i) (b) A-(i), B-(iii), C-(ii), D-(iv) (c) A-(iii), B-(ii), C-(i), D-(iv) (d) A-(i), B-(ii), C-(iii), D-(iv)	**1**
6	Match column I with column II and select the correct option from the given codes. **Column I** **Column II** A. Methanogens (i) BOD B. Fermentors (ii) Methane rich fuel gas C. Organic waste in water (iii) Production of methane D. Biogas (iv) Large vessels for growing microbes (a) A-(ii), B-(iv), C-(iii), D-(i) (b) A-(iv), B-(iii), C-(ii), D-(i) (c) A-(ii), B-(i), C-(iv), D-(iii) (d) A-(iii), B-(iv), C-(i), D-(ii)	**1**
7	Observe the following diagram-	**1**

	 i)Each antibody molecule has four disulphide chains. ii) an antibody is represented as H2L2. iii) antibodies are found in the blood iv) Different types of antibodies are produced outside our body. Identify the correct pair from the options given below- a) i&ii b) iii & iv c) ii &iii d) i& iv	
8	The main reason why antibiotics could not always treat the bacteria-mediated diseases is (a) insensitivity of the individual following prolonged exposure to antibiotics (b) inactivation of antibiotics by bacterial enzymes (c) decreased efficiency of immune system (d) the development of mutant bacterial strains resistant to antibiotics	**1**
9	C-peptide of human insulin is (a) removed during maturation of pro-insulin to insulin (b) responsible for the formation of disulphide bridge (c) a part of mature insulin molecule (d) responsible for its biological activity	**1**
10	An urn shaped population age pyramid represents (a) growing population (b) static population (c) declining population (d) extinct population	**1**
11	Select the option that correctly identifies A, B and C in the given table. **Organism** **Trophic level** **Food chain** Eagle A Grazing Earthworm Primary consumer B Frog C Grazing (a) A-Top carnivore, B-Detritus, C-Secondary consumer (b) A-Top carnivore, B-Detritus, C-Primary consumer (c) A-Secondary consumer, B-Grazing, C-Secondary consumer (d) A-Scavanger, B-Grazing, C-Producer	**1**
12	Which of the following is an example of ex situ conservation? (a) Sacred Groves (b) National Park (c) Biosphere Reserve (d) Seed Bank	**1**
	Question No. 13 to 16 consist of two statements – Assertion (A) and Reason (R). Answer these questions selecting the appropriate option given below: **a) Both A and R are true, and R is the correct explanation of A.** **b) Both A and R are true, and R is not the correct explanation of A.** **c) A is true but R is false.** **d) A is false but R is true.**	

13	**Assertion:** The middle piece of sperm is called as power house of the sperm. **Reason:** The numerous mitochondria coiling around axial filament produce energy for the movement of the tail.	**1**
14	**Assertion**: Human Genome Project was a mega project launched to find out the complete DNA sequence of human genome. **Reason**: It was possible only with the help of genetic engineering techniques to isolate and clone any piece of DNA and fast techniques for determining DNA sequences	**1**
15	**Assertion**: Wine and beer are produced by distillation of the fermented broth. **Reason**: Different types of alcoholic drinks are obtained only by fermentation, always followed by the distillation process**.**	**1**
16	**Assertion**: A stable community shows much variation in productivity from year to year. **Reason**: It is not resistant to occasional disturbances.	**1**
	SECTION: B	
17	State the agent(s) which helps in pollinating the following plants. Explain the adaptations in these plants to ensure pollination: (a) Corn (b) Water hyacinth	**2**
18	Disease X is a chromosomal disorder occur due to autosomal aneuploidy. The children with this syndrome suffer from severe mental retardation, short statured with small round head, furrowed tongue and partially open mouth. Palm is broad with characteristic palm crease. (a) Name the disease 'X' and state main cause of autosomal aneuploidy in it. (b) What will be the genotype in males suffering from this disease?	**2**
19	The graphs below show three types of natural selection. The shaded areas marked with arrows show the individuals in the population which are not selected. The dotted vertical lines show the statistical means  a) What names are given to the types of selection shown in graphs A, B and C. b) After the selection has operated for several generations in the above populations, graphically illustrate the probable results indicated in Graph B.	**2**
20	A schematic representation of polymerase chain reaction (PCR) upto the extension stage is given below. Answer the questions that follow:	**2**

	 (i) Identify a,'b'& c. (ii) Mention the importance of "b" in PCR	
21	Expand GEAC. State its main objectives	**2**
	SECTION:C	
22	(a) What are the early symptoms of STDs(any2) (b) List any four complications that may arise due to STDs if not treated early.	**3**
23	(a) Identify the structure. (b) Label a and b. **(c)** What will be the fate of both.? 	**3**
24	The DNA packaging in eukaryotes is carried out with the help of lysine and arginine rich basic proteins called histamine. The unit of compaction is nucleosome. (a) What would happen if histones were to be mutated and made rich in aspartic and glutamic acid in place of basic amino acids such as lysine and arginine? (b) What is the role of non-histone chromosomal proteins in DNA packaging? **OR** (a)A DNA segment has a total of 1000 nucleotides, out of which 240 are adenine containing nucleotides. How many pyrimidines bases this DNA segment possesses? (b)which rule governs to solve the above problem.	**3**
25	Alien species are highly invasive and are a threat to indigenous species. Substantiate this statement with any three examples. **OR** What are the two types of desirable approaches to conserve biodiversity? Explain with examples bringing out the difference between the two types.	**3**

26	 (a) What is an age pyramid? (b) Identify -A, B and C. (c) How does analysis of age pyramids can provide inputs for long term planning strategies?	**3**
27	(a)Which organism in biotechnology is described as natural genetic engineer? (b) Why is it called so? (c) How this property is used in the preparation of Transgenic plant?	**3**
28	Observe the above diagram and answer the following questions- (a) Identify A and B. (b) How insulin is different from Humulin? Which technology is used in the preparation of Humulin by Eli Lily company? 	**3**
	SECTION:D	
29	Manish went to his hometown located in the countryside along with his parents during his summer vacations. His grandparents' house is surrounded by farmland from all sides. Lots of crops were growing nearby and Manish was very excited to visit the crop fields. He seeked permission from his mother to play in the farmland along with his friends and then went to play in the fields. On returning home he had running nose, watering eyes and continuous sneezing which was very frequent. The symptoms worsened with time. Based on the above information answer the following questions: (a) What could be the possible reason for Manish's condition? (b) How can allergy be diagnosed in a person? (c) Name the type of allergy that Manish developed. (d) Find out the reasons for developing allergic reactions?	**4**

30	 Observe the above F_2 generation Results of two dihybrid crosses conducted by Morgan and answer the following questions- (i)What do the above crosses 'A' and 'B' illustrate? (ii) What does (+) sign in superscript represent? (iii)How is the strength of linkage between **y** and **w** is different than **w** and **m**. (iv)What is the strength of linkage with increase in age?	**4**
	SECTION: E	
31	Read the graph given above and correlate the uterine events that take place according to the hormonal levels on (i)Identify 'A' and 'B'. (ii) Specify the source of the hormone marked in the diagram. (iii) Give reason why A peaks before B. (iv) Compare the role of A and B. (v) Under which condition will the level of B continue to remain high on the 28th day?  OR (a) Identify the diagram and labelA, B& C. (b) Mention the function of B& C. (c) What is the ploidy of A,B&C? (d) How many pollen grains will be released from 100 microspore mother cell?	**5**
32	Answer the following question regarding Griffith experiment (a) Name the bacteria with which the experiment was done. (b) What do you mean by the R-Strain and S-Strain?	**5**

	(c) Did the mice developed the disease when he injected the heat killed S Strain to the mice? (d) Among the two strains which one is Virulent?? (e) What was the finding of his experiment? OR (a) Explain the process of amino acylation of tRNA. Mention its role in translation. (b) At what site in the ribosome will the tRNA bind? Name the enzyme responsible for this binding? (c) How do ribosomes in the cells act as factories for protein synthesis?	
33	(a) Describe how does the application of the fungi to the agricultural farm increases the farm output? (b)Why is Rhizobium categorized as a 'symbiotic bacterium'? How does it act as a biofertilizer? OR Name the infective stage of *Plasmodium* that is introduced into the human body when a mosquito bites him/her. b) Trace the stages of life cycle of the parasite from the point of entry into human body till the time another mosquito bites this person.	**5**

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