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B.SC. IV SEM

EVOLUTIONARY & DEVELOPMENTAL BIOLOGY

- 400+ MCQs
- Brief and Intensive Notes

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Course Code: B050601T

Course Title: Evolutionary and Developmental Biology

Syllabus

UNIT I Theories of Evolution

- Origin of Life
- Historical review of evolutionary concept: Lamarckism, Darwinism (Natural, Sexual and Artificial selection)
- Modern synthetic theory of evolution
- Patterns of evolution (Divergence, Convergence, Parallel, Coevolution)

UNIT II Population Genetics

- Microevolution and Macroevolution: allele frequencies, genotype frequencies, Hardy-Weinberg equilibrium and conditions for its maintenance
- Forces of evolution: mutation, selection, genetic drift

UNIT III Direct Evidences of Evolution

Types of fossils, Incompleteness of fossil record, Dating of fossils, Phylogeny of horse

UNIT IV Species Concept and Extinction

- Biological species concept (Advantages and Limitations); Modes of speciation (Allopatric, Sympatric)
- Mass extinction (Causes, Names of five major Extinctions

UNIT V Gamete Fertilization and Early Development

- Gametogenesis, Fertilization
- Cleavage pattern
- Amphibian Gastrulation and fate maps

UNIT VI Developmental Genes

- Genes and development

- Molecular basis of development in drosophila

UNIT VII Early Vertebrate Development

- Early development of vertebrates (fish, birds & mammals)
- Metamorphosis, regeneration and stem cells
- Environmental regulation of development

UNIT VIII Late Developmental Processes

- The dynamics of organ development: Development of eye,
- Metamorphosis: the hormonal reactivation of development in amphibians
- Regeneration: salamander limbs, Hydra
- Aging: the biology of senescence

UNIT I

Theories of Evolution

UNIT-I

- Origin of Life
- Historical review of evolutionary concept: Lamarckism, Darwinism (Natural, Sexual and Artificial selection)
- Modern synthetic theory of evolution
- Patterns of evolution (Divergence, Convergence, Parallel, Coevolution)

- The Earth was lifeless & inhospitable to living organisms when formed about **4.6 billion years ago.** Later on, about after one billion years, it became hospitable to prokaryotic organisms i.e. Ancestors of all present living things. For centuries, no. of theories have been given to explain origin of life.
- Divided into 2 categories-

1. Old Theories
2. Modern Theories

1. OLD THEORIES-

1.THEORIES OF SPECIAL CREATION-

- Proposed by **Hebrew et.al**. & supported by **Father Suarez**
- According to this theory, life was created by supernatural power
- According to Bible, the world was created within 6 days by God
- 1st day- Heaven & the Earth, 2nd day- separation of sky from water, 3rd day- dry land & Plants, 4th day- Sun, Moon & Stars, 5th day – Birds & Fishes, 6th day – land animals & human beings
- 1st man – Adam & 1st woman – Eve
- According to Hindu mythology, the world was created by God Brahma (God of creation). The first man was Manu & the first woman was Shradha. The theory of special creation is based on religious faith & lacks scientific evidences

2. THEORY OF CATASTROPHISM-

- Advocated by **Georges Cuvier & Orbigney**

- ❖ According to this, there have been many creations & each creation is preceded by a Catastrophe due to geological disturbances
- ❖ Each catastrophe completely destroyed the life

3. THEORY OF ETERNITY OF LIFE / STEADY-STATE THEORY-

- ❖ Given **by Richter, Arrhenius, Helmholtz, Preyer**
- ❖ They believed that life is immortal & life has ever been in existence as at present. It will continue to be so for ever, changing only in form. It neither had a beginning nor will have an end

4. Cosmozoic / panspermia/ Interplanetary theory-

- ❖ put forward by **Richter (1865**) & supported by **Arrhenius (1908)**
- ❖ According to this, life had reached the Earth from outer space in form of resistant spores of simple organisms in Meteorites. The spores grew in the soil & evolved into the various existing forms

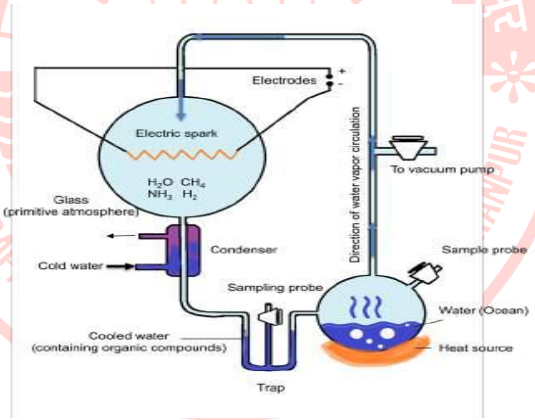
5. THEORY OF SPONTANEOUS GENERATION (ABIOGENESIS)

- ❖ According to this, the life originated from non-living things in a spontaneous manner. Given by **Plato, Aristotle, Thales** etc. It was believed that water of Nile River could give rise to frogs, toads, snakes, mice & even Crocodiles when warmed by Sun
- ❖ Aristotle proposed that insects developed from morning dew & rotting manure & tapeworms, frogs from wet excreta of animals & Crabs, salamanders from wet Earth & Slime
- ❖ **Von Helmont** observed the production of mice from his dirty shirt & wheat grains after keeping them in dark for 3 weeks
- ❖ **William Harvey** also believed that lower animals (worms & Insects) might arise spontaneously

6. THEORY OF BIOGENESIS-

- ❖ Rejected the theory of spontaneous generation. According to this, life originated from pre existing life. Theory of Abiogenesis was Challenged by **Lazzaro Spallanzani & Francisco Redi**
- ❖ **Oparin-Haldane theory of origin of life** was put forward by A.I. Oparin, a Russian biochemist and J.B.S. Haldane, an English biologist.

- According to this theory, life originated on earth spontaneously from non-living matter, first inorganic compounds and then organic compounds were formed in accordance with ever changing environmental conditions.
- **Oparin-Haldane theory** is also called **chemical theory or naturalistic theory.**
- Haldane gave the term hot dilute soup or prebiotic soup for broth of chemicals formed in oceans of the early earth from which living cells are believed to have appeared.
- The Oparin-Haldane theory was experimentally supported by Stanley Miller (1953) a student of Harold Urey.
- In Stanley Miller's experiment, electric discharge was created in a closed flask containing mixture of four gases- CH4, H2, NH3 and water vapour at 800°C temperature. The mixture was passed through a condenser and gases were circulated for about one week resulting in the formation of amino acids, such as alanine, glycine and aspartic acid.



- The synthesis of carbohydrates, fats, amino acids and other complex organic molecules from simple organic molecules probably occurred in sea in primeval atmosphere.
- Electric discharge, ATP, solar energy, lightning might have provided the source of energy.
- Biological evolution is defined as the process through which the characteristics of organisms change over successive generation by means of genetic variation and natural selection.

- Oparin gave the term **coacervates** for non-living structures, from which first living cells were formed. Coacervates are surrounded by a thin film of water, lack a definite membrane but are able to grow and divide in a favourable environment.
- **Proteinoids** are protein like structures formed by dehydration synthesis of amino acid. Sydney Fox demonstrated that microspheres could be formed from proteinoids placed in boiling water.
- The first living organism which originated from organic molecules in oxygen free atmosphere (reducing atmosphere) were **anaerobes**.
- They were capable of anaerobic respiration and lived in the absence of oxygen. They depended on the existing organic molecules for their nutrition and thus they were **heterotrophs**.
- Some of these prokaryotic heterotrophs might have evolved into autotrophs when the supply of existing organic molecules was exhausted.
- The eukaryotes developed from primitive prokaryotic cells about 1.5 billion years ago. There are two theories regarding origin of eukaryotes.
- According to symbiotic theory, some anaerobic predator host cells engulfed primitive aerobic bacteria but did not digest them. These aerobic bacteria became symbionts. Such predator host cells evolved into first prokaryotic cells.
- According to origin by invagination theory, cell organelles of eukaryotic cells might have originated by invagination of surface membrane of primitive prokaryotic cells.
- Primitive eukaryotes led to the evolution of protists, plants, fungi and animals. Life was present on earth about **3.9 billion** years ago.

LAMARCKISM 'OR' THEORY OF INHERITANCE OF ACQUIRED CHARACTERS

- 1st theory of Evolution, proposed by Jean Baptiste de Lamarck in 1801 & in 1809 in his book " **Philosphie Zoologique".**
- According to this, the organisms undergo changes for adapting themselves to environment & the characters thus acquired are passed on to the next generation.
- Lamarck's theory is also k/a "**Theory of inheritance of acquired characters".**

- According to this theory, the ecological conditions in which an organism lives cause it to have certain needs.

  New needs produce a new movement in the body that brings about modifications of existing organs & formation of new organs, also k/a **Doctrine of Desires or Appetency**.
- These needs are met by modification of old organs or by production of new rudimentary organs.
- When these rudimentary structures are used continuously, they increase in size & functional capacity & by disuse they may be degenerated & become lost.
- The character changes brought out by the environment during the life of an individual become hereditary & hence can be transmitted to the next generation.
- After several generations, they give rise to a new species.
  - **New Needs:** Variation in environment, conditions and the over-all circumstance which affect the existence of organism, needs adaptation in organism to survive. As a result, organism has to put special efforts to fulfil its new needs for adaptation. In few cases, it just needs change in habit or behavior of the organism. New habit includes fresh or extensive use of certain organs or structure of the body or disuse of others.
  - **Acquisition of Characters:** There are 3 ways to acquire the characters required to adopt into changed conditions:
  - **Innate Tendency:** There is innate tendency in each organism to acquire greater complexicity and perfection to perform functions. In this process of achieving perfection, organism is better and better adapted to the changed environment.
  - **Use or disuse of organs:** Use and disuse of organ affect their structure, shape and efficiency of functioning. More usage of a particular organ brings additional strength, size and more efficient. In contrast, disuse or under usage of organ gradually makes them weaker and smaller and finally they may disappear as well. Thus, differential usage of organ allowed the additional character in the body during the life span of an organism.
  - **Environmental factors:** Variation in environmental factors such as temperature, light, humidity, wind, enemies affects the living things and brings changes in life

style and habits. The combined effect of use and disuse of organ and influence of environmental factors, results into the change in the body of organism and these characters are known as **"acquired characters"**.

- **Inheritance of Acquired Characters:** The characters acquired by one generation are transmitted to the new generation and subsequently newer characters are added in next generation to acquire perfection.
- This, Lamarck proposed that evolution is a slow process where characters are acquired over the course of time in various generations.

NEO LAMARCKISM-

- Certain experiments show the influence of the environment on the germ cells & heredity.

- The revival of Lamarckism in a modified form k/a **Neo- Lamarckism.**
- There are evidences to support the inheritance of acquired characters. For examples, effect of radiation and chamicals on germ cells and resulting change in the phenotype of the cell.
- The evidence for the inheritance of acquired character revived the Lamarck theory as neo- lamarckism. The modified neo-lamarckism has following postulates:
- Germ cells are not always immune from the effect of environment. Germ cells may be affected directly by environment without any effect on the somatic cells.
- Germ cells may carried acquired character to the next generation. Even considering these points, Lamarckism could not be able to provide satisfactory mechanism for evolution.

- The supporters of Neo- Lamarckians are- **McDougall, Naegali, Gadow, Spencer, Cope, Richards, Lawrence**

DARWINISM

- Charles Darwin was an English naturalist & he got an opportunity to travel on H.M.S. Beagle in 1931. During voyage, he read Principles of Geology by Charles Lyell given by **Henslow.**
- **H.M.S. Beagle** sailed to the Galapagos Islands where he observed great variations among the organisms that lived on these Islands.

- Darwin took idea of his theory of natural selection from the Finches found on Galapagos Island.
- He was much impressed with **Thomas Malthus's essay** on the principal of population showing that human population increase geometrically, the food supply only grows arithmetically.
- **A.R. Wallace**, another English Naturalist, also travelled widely, & studied the flora & fauna of South America & South East Asia.
- He expressed his ideas similar to Darwin, in an essay Entitled "**On the tendency of varieties to depart indefinitely from the original types".**
- He sent his essay to Darwin & after receiving his essay Darwin developed a clear idea about organic evolution.
- In 1859, Wallace's paper & a summary of Darwin theory was published in Journal of the proceedings of Linnean Society.
- Finally, in 1859, Darwin published his observations in form of a book "origin of species by natural selection".
- The theory of natural selection is based on following points
- **Rapid Multiplication:** Every organism has enormous ability to reproduce to continuance of the species. All animals and plant tend to multiply in geometrical progression. For example, an organism will be double in Ist year, four times by 2nd yr and 8 times in a third year and so on.
- **Limited natural resources:** In spite the enormous capacity of an organism to reproduce, the number of individual species remain constant. It is due to increase in population in animal or plant requires more space and food.
- **Struggle for existence:** Due to shortage of food, water and space, there is severe competition among the off spring for existence. Every individual has few basic requirements, such as food, space, water, mate to reproduce and protection from enemies. In order to achieve basic needs, organisms compete with each other and it is known as struggle for existence.
- **Variation:** Each and every individual varies in several aspects to other individual. Even the off springs produced by parents also differ in many aspects. The two

individuals can be different from each other in their behavior, color, size, strength etc.

- **Natural Selection:** Due to variation among different individual, they struggle towards their existence with different potentials. The variation in an individual may allow him to survive and complete its life cycle comfortable. Whereas, if the variations are unfavorable, the individual will struggle against every odds and as a result it may not be able to complete the life cycle.
- **Inheritance of useful variations:** The individual survived due to unique variation, mate and produces their off spring to complete their life-cycle. As a result, they transfer the useful variations to the next generations and allow the individual to multiply.
- **Formation of new Species:** As a result of struggle and natural selection, only the individual fits to the environmental conditions will survive and complete its life-cycle. As a result, the number of these individual will increase over the course of time compared to the less favorable organism.
- **Sexual selection** is a mode of natural selection in which members of one biological sex choose mates of the other sex to mate with (intersexual selection), and compete with members of the same sex for access to members of the opposite sex (intrasexual selection).
- These two forms of selection mean that some individuals have greater reproductive success than others within a population, for example because they are more attractive or prefer more attractive partners to produce offspring.
- Successful males benefit from frequent mating and monopolizing access to one or more fertile females. Females can maximize the return on the energy they invest in reproduction by selecting and mating with the best males.
- **Artificial selection** is an evolutionary process in which humans consciously select for or against particular features in organisms – for example, by choosing which individuals to save seeds from or breed from one generation to the next. People have been artificially selecting plants and animals for thousands of years.

- The “Neo Darwinism” or “Modern Synthetic Theory” or “Modern Theory of evolution” is based on important work done by a number of workers like, R.S. Fisher, J. B. S. Haldane, Sewall Wright, Mayr and G. L. Stebbins in the last few decades.
- This greatest drawback of Darwin's Theory, i.e. the ignorance about the process of heredity of variations has now been removed by applying "Principles of Mendelism" to "Population Dynamics", i.e. known as "Population Genetics
- As a result of this, "Neodarwinism" has gradually emerged out as the mathematically based "Modern Synthetic Theory of Evolution", so designated by Huxley (1942).
- Dobzhansky's (1937) book, "Genetics and the Origin of Species", provided the initial basis of this theory.
- Muller (1949), Fisher (1958), Wright (1968), Mayr (1963,70), Stebbins (1966-76), etc. further provided the help significantly in its formulation.
- The Neo Darwinism or **Modern Synthetic Theory** emphasizes the role of:
- (i) population genetics
- (ii) Sources of variations in evolution.
- (ii) What are the sources of Variations?
- Variations are raw material for evolution.
- Natural selection can act on genetic variations, only when it is expressed in phenotype.
- These variations are due to;
- 1. **Mutation**: Alteration in the chemistry of gene (DNA) is able to change its phenotypic effect is called point mutation or gene mutation. Chromosomal mutation such as deletion, duplication, inversion, and translocation also result in variation.
- 2. **Gene Recombination**: Recombination i.e. new genotype from already existing genes was little known at the time of Darwin. Recombination is the important factor that increases the variability of individual genotypes in a population.

- 3. **Heredity**: The transmission of characteristics or variations from parent to offspring is an important mechanism of evolution. As a result, the off springs are able to benefit from the advantageous characteristics of their parents
- 4. **Natural Selection**: Natural selection brings about evolutionary change by guiding different populations into different adaptive channels.
- 5. **Isolation**: Isolation of organisms of a species into several populations or groups is supposed to be one of the most significant factors responsible for evolution.
- Isolation is a segregation of separation of populations by some barriers which prevent interbreeding between related organisms.
- The reproductive isolation between the populations due to certain barriers leads to the formation of new species.
- 6. **Origin of new Species**:
- The populations of a species present in different environments and are separated by geographical and physiological barriers, accumulate different genetic differences due to mutations, recombination, hybridization, genetic drift and natural selection.
- The first three factors namely Mutation, Gene Recombination and Heredity are responsible for providing genetic variability.
- While the last two factors namely Natural Selection and Isolation are responsible for giving a direction to the evolutionary process.
- Besides these five basic factors outlined above, Migration of individuals from one to the other populations, Hybridization between members of closely related species and Genetic drift i.e. elimination of the genes of some original characteristics of a species by extreme reduction in a population due to epidemics add to the variability of genotypes as Accessory factors.
- These processes increase the genetic variability available to the populations undergoing the process of evolution.
- **Divergent evolution** is a type of evolution that leads to varying functional developments or changes in similar basic structured organs of organisms belonging to a similar origin or similar ancestry.

- Among the vertebrates from amphibians to mammals, the vertebrae, brain, eye, ears, and gut are constructed on the similar or same basic plan. Such homologous organs suggest common ancestry.
- Adaptive radiation (i.e.; small-scale evolution occurring in a shorter period) leads to divergent evolution.
- Divergence gives rise to speciation i.e variation in species arising from a common genus. It diverges towards dissimilarity giving rise to multiple evolutionary groups from a similar origin.
- The organs or structures of species with similar origins in course of evolution develop a change in their functionality based on their adaptive habitat and are called homologous organs. Divergent evolution leads to homologous structures in organisms. Hence divergent evolution is also known as homologous evolution.
- It is the independent evolution of features that are similar in species spanning over different eras. This evolution produces analogous structures having similar functions or forms. However, they are not seen in the last common ancestor of those units.
- **Parallel evolution** is the type of evolution when two types of species evolve together and starts acquiring the same characteristics as each other at the same time.
- These groups of species are geographically separated but they have the same morphological resemblances.
- Examples: The woolly mammoth which became extinct 4000 years ago and the modern elephant share a common ancestor that lived approximately 6 million years ago.
- Thoatherium, a Miocene litoptern, and Equus, the modern horse share a common ancestor with a five-toed hoof. They evolved independently to a one-toed hoof for faster running

- **Coevolution** is defined as evolution in two or more evolutionary entities brought about by reciprocal selective effects between the entities.
- The term was coined by Paul Ehrlich and Peter Raven in 1964 in a famous article: "Butterflies and plants: a study in coevolution", in which they showed how genera and families of butterflies depended for food on particular phylogenetic groupings of plants.
- For example, sex and recombination may have evolved because of a co-evolutionary arms race between organisms and their parasites; the rate of evolution, and the likelihood of producing resistance to infection (in the hosts) and virulence (in the parasites) is enhanced by sex.

Multiple Choice Questions (MCQs) of Unit I

Question 1. The study of history of life forms on Earth is

A. Cell Biology
B. Evolutionary Biology
C. Genetics
D. None of these

Answer: B

Question 2. Which theory attempts to explain to us the origin of Universe?

A. Big Bang Theory
B. Theory of Biogenesis
C. Theory of Pangenesis
D. Theory of special creation

Answer: A

Question 3. The Earth was supposed to have been formed about

A. 4.1 billion years ago
B. 4.2 billion years ago
C. 4.0 billion years ago
D. 4.6 billion years ago

Answer: D

Question 4. The scientist who by experimentation demonstrated that life comes only from pre-existing life-

A. Robert Hook
B. Louis Pasteur
C. Suawrez
D. Aristole

Answer: B

Question 5. In S.L. Miller Experiment, products found in the closed flask at 800 ^{O}C was

A. N2, CH4, O2, NH3
B. CH4, H2, NH3 and Water Vapour
C. O2, H, N
D. CH3, NaCl, CaO

Answer: B

Question 6. Theory of Panspermia was given by

A. Cuvier
B. Thales
C. Richter
D. F. Redi

Answer: C

Question 7. Primitive atmosphere on Earth was

A. Reducing
B. Oxidising
C. Both
D. None of these

Answer: A

Question 8. In the experiment of S.L. Miller, the gas chamber contained the gases in the ratio of

A. CH4:NH3:H2, 2:3:1
B. CH4:NH3:H2, 2:2:1
C. CH4:NH3:H2, 2:4:1
D. CH4:NH3:H2, 3:2:1

Answer: B

Question 9. In the origin of life, first organism came into existence was

A. Autotrophs, aerobic
B. Mixotrophs, anaerobic
C. Heterotrophs, Anaerobic
D. Hetrotrophs, Aerobic

Answer: C

Question 10. Production of HCN was an important event of origin of life which produced

A. Cytosine
B. Thymine
C. Guanine
D. Adenine

Answer: D

Question 11. Abiotic synthesis of molecules is possible only in

A. Oxidizing atmosphere
B. Reducing Atmosphere
C. Both
D. None of these

Answer: B

Question 12. Who synthesized thermal proteins i.e.; Proteinoids

A. Oparin
B. Von Halmont
C. Sydney Fox et. al.
D. None of these

Answer: C

Question 13. The first membrane bound cells are

A. Coacervates
B. Eobiont
C. Microsphere
D. Progenote

Answer: Progenote

Question 14. The book 'Philosphie Zoologique" was written by

A. Weismann
B. Lamarck
C. Cuvier
D. Aristotle

Answer: B

Question 15. The theory of Continuity of germplasm was given by

A. Pavlov
B. Darwin
C. Lamarck
D. Weismann

Answer: D

Question 16. Which name is associated with Galapagos Island

A. Aristotle
B. Lamarck
C. Darwin
D. None of these

Answer: C

Question 17. According to which theory, every organism has an internal vital force

A. Theory of continuity of germplasm
B. Lamarckism
C. Darwinism
D. Oparinism

Answer: C

Question 18. Lamarckism is also known as

A. Theory of Biogenesis
B. Theory of natural selection
C. Theory of chemical evolution
D. Inheritance of acquired characters

Anaswer: D

Question 19. Rapid decline in the population because of high mortality rate is known as

A. Genetic load
B. Population density
C. Reproductive potential
D. Population crash

Answer: D

Question 20. The name of the ship of Darwin was

A. Titanic
B. Victoria
C. HMS Beagle
D. None of these

Answer: C

Question 21. Which of the following phenomenon can be explained on the basis of theory of natural selection

A. Homologous organs
B. Analogous organs
C. Survival of the fittest
D. Vestigial organs

Answer: C

Question 22. Due to natural selection, the variations favourable to a particular environment slowly accumulate in course of generation leading to

A. Mutations
B. Origin of new species
C. Over population
D. Struggle for existence

Answer: B

Question 23. The basis of modern synthetic theory is

A. Isolation
B. Recombination and natural selection
C. Mutation
D. All of these

Answer: D

Question: 24. In the process of evolution, the role of mutation is

A. Reproductive isolation
B. Genetic variations
C. Genetic drift
D. None of these

Answer: B

Question 25. Who demonstrated that mutation occurs by radiation?

A. Watson
B. Mendel
C. Muller
D. Darwin

Answer: C

Question 26. Darwin did not took following phenomenon in his theory

A. Overproduction
B. Adaptation
C. Variations
D. Mutation

Answer: D

Question 27. Who suggested the role of spatial isolation in the origin of a species?

A. De Vries
B. Correns
C. Wagner
D. Weismann

Answer: C

Question 28. The unit of evolution is

A. Species
B. Population
C. Genus
D. Community

Answer: B

Question 29. Discontinuous variations were also called by Darwin as

A. Pangenesis
B. Sports
C. Both A and B
D. None of these

Answer: B

Question 30. Mutation theory was given by

A. De Vries
B. Darwin
C. Spencer
D. Muller

Answer: A

Question 31. Mutation theory considers only one of the following

A. Discontinuous variations
B. Somatic variation
C. Acquired characters
D. Natural selection

Answer: A

Question 32. The main critic of Lamarckism was

A. Morgan
B. Weismann
C. Carr
D. Gadow

Answer: B

Question 33. Replica plating experiment was given by

A. Land Steiner
B. Fisher
C. Lederberg
D. Kettlewell

Answer: C

Question 34. Adaptation is generally due to selection of pre-existing variations. This was proved by

A. Industrial Melanism
B. Replica Plating Experiment
C. Atavism
D. None of these

Answer. B

Question 35. Industrial Melanism is the example of

A. Directional Selection
B. Disruptive Selection
C. Stabilizing Selection
D. None of these

Answer: A

Question 36. Replica plating Experiment supported which theory of evolution

A. Lamarckism
B. Darwinism
C. Germplasm Theory
D. None of these

Answer: B

Question 37. In which type of natural selection, the graphical curve is bell shaped

A. Progressive selection
B. Balancing Selection
C. Disruptive Selection
D. None of these

Answer: B

Question 38. According to theory of Pangenesis, each and every cell of the body produces minute primordial known as

A. Gametes
B. Genes
C. Gemmules
D. None of these

Answer: C

Question 39. Which selection is used for improving the races of domestic animals and cultivated plants and producing new varieties?

A. Sexual selection
B. Natural selection
C. Disruptive selection
D. Artificial selection

Answer: D

Question 40. The first life originated in/on

A. Water
B. Land
C. Air
D. Trees

Answer: A

Question 41. Which of these is the most essential in the origin of life

A. Proteins
B. Enzymes
C. Nucleic acids
D. Carbohydrates

Answer: D

Question 42. Which compound has very important role in the prebiotic evolution?

A. CO2
B. N2
C. O2
D. CH4

Answer: D

Question 43. Hugo De Vries conducted his experiment on

A. Rose
B. Evening Primrose
C. Sunflower
D. Hibiscus

Answer: B

Question 44. Classical mutation is also known as

A. Saltation theory
B. Chromosomal theory
C. Inheritance theory
D. None of these

Answer: A

Question 45. According to modern synthetic theory, which forms the raw material of evolution

A. Natural Selection
B. Speciation
C. Isolation
D. Genetic variation

Answer: D

Question 46. Which is the most important factor for the speciation

A. Tropical isolation
B. Seasonal isolation
C. Reproductive isolation
D. Behavioural isolation

Answer: C

Question 47. Occurrence of endemic spp. In South America and Australia is because of

A. Progressive evolution
B. Retrogressive evolution
C. Continental separation
D. Mutation

Answer: C

Question48. Parallelism is

A. Adaptive convergence of closely related spp.
B. Adaptive convergence of widely different spp.
C. Adaptive divergence of widely separated spp.
D. Adaptive divergence

Answer: A

Question 49. Humming birds and Hawk shows

A. Parallel evolution
B. Adaptive radiation
C. Convergent evolution
D. None of these

Answer: B

Question 50: when two spp. Of different geneology resemble to each other due to adaptation then this phenomenon is known as

A. Convergent evolution
B. Co-evolution
C. Microevolution
D. Divergent evolution

Answer: A

UNIT II

Population Genetics

UNIT II Population Genetics

● Microevolution and Macroevolution: allele frequencies, genotype frequencies, Hardy-Weinberg equilibrium and conditions for its maintenance

● Forces of evolution: mutation, selection, genetic drift

- ❖ Microevolution results from the interaction of the elemental forces of evolution i.e.; mutation, variation, recombination, natural selection and genetic drift to produce relatively small changes in the population or populations.
- ❖ The basic process of microevolution consists of changes in the gene frequencies in a population from one generation to the next.
- ❖ Microevolution operates to change the genetic equilibrium in a Mendelian population and occurs below the species level.
- ❖ There are many examples of microevolution such as antibiotic and insecticide resistance.
- ❖ Macroevolution results in the production of new adaptive types through a process of population fragmentation and genetic divergence.
- ❖ It operates above the species level and results in the splitting of the population of a species into several sub-types, each of which shows changes in a definite adaptive direction i.e.; adaptive radiation.
- ❖ Allelic frequency refers to how frequently a particular allele appears in a population. It is also possible to calculate genotype frequencies, the fraction of individuals with a given genotype and phenotype frequencies, the fraction of individuals with a given phenotype.
- ❖ Genotype frequency refers to the total number of a kind of individuals from a population all of which exhibit similar character with respect to the locus under consideration.
- ❖ Population genetics is the study of alleles of genes in populations (Demes) and the forces which maintain or change the frequencies of particular alleles and genotypes in populations.

- Hardy-Weinberg equilibrium is also known as Hardy-Weinberg Principle which states that the relative frequencies of various kinds of genes in a large and randomly mating sexual panmictic population tend to remain constant from generation to generation in the absence of mutation, selection and gene flow.
- This principle is a means of calculating expected genotype frequencies from allele frequencies determined in the same population and vice-versa.
- If a population does not fit in Hardy-Weinberg equilibrium then there is evidence of some real effect i.e.; natural selection operating to disturb it.
- This formulas allows to detect some frequencies that change from generation to generation hence allowing a simplified way of determining that evolution is occurring.
- When a population is in **Hardy-Weinberg equilibrium** for a gene, it is not evolving, and allele frequencies will stay the same across generations.
- That is the population in Hardy Weinberg Equilibrium will show
- **No mutation**: No new alleles are generated by mutation, nor are genes duplicated or deleted.
- **Random Mating**: Organisms mate randomly with each other, with no preference for particular genotypes.
- **No gene flow**: Neither individuals nor their gametes (e.g., windborne pollen) enter or exit the population.
- **Infinite population size**
- **No natural selection**: All alleles confer equal fitness (make organisms equally likely to survive and reproduce).
- Population geneticists often check to see if a population is in Hardy-Weinberg equilibrium *because* they suspect other forces may be at work. If the population's allele and genotype frequencies are changing over generations (or if the allele and genotype frequencies don't match the predictions of the Hardy-Weinberg equation), the race is on to find out why.
- Other than these assumptions, there are some other minor ones that Hardy Weinberg Law makes:
- Organisms are **diploid**. Thereby excluding haploid and polyploid organisms.

- Reproduction is **sexual**. Thereby excluding asexually reproducing organisms
- Populations have **non-overlapping generations**. However, this is not always true.
- Most populations have overlapping generations.
- **Allele and genotype frequencies don't differ between males and females**. Thereby excluding sex alleles.
- Let us consider a population which has at a locus two alleles A and a which have frequencies p and q, respectively. We are talking about a single locus here to make things easier.
- In such a scenario, there will be individuals in a population that will have genotype AA, Aa and aa. Which in turn means that the frequency of genotype AA is p^2, of Aa is 2pq and of aa is q^2.
- AA= p^2; Aa=2pq; aa=q^2
- Which means that the total genotype frequencies in a population are **p2 +2pq+q2,** which mathematically is an expansion of (p+q) **2**
- And also equal to 1. Which means that in a population **(p+q) 2 or p2 +2pq+q2=1**
- Hardy-Weinberg demonstrates that Mendelian loci segregating for multiple alleles in diploid populations will retain predictable levels of genetic variation in the absence of forces that change allele frequencies.
- Although mutation is the original source of all genetic variation, mutation rate for most organisms is pretty low
- So, the impact of brand-new mutations on allele frequencies from one generation to the next is usually not large. (However, natural selection *acting* on the results of a mutation can be a powerful mechanism of evolution)
- Genetic drift is also known as Sewall Wright effect as it was given by Sewall Wright in 1930.
- Genetic drift refers to the elimination of the genes of certain traits when a part of population migrates or dies of natural calamity i.e.; it involves changes in allele frequency due to chance events
- Genetic drift can occur in any population of non-indefinite size, but it has a stronger effect on small populations.

- Genetic drift can also operate through founder effect in which genetic drift can cause dramatic changes in the allele frequencies in a population derived from small groups of colonisers known as founders to a new habitat.
- The Bottleneck effect is an extreme example of genetic drift that happens when the size of a population is severely reduced. Events for example natural disasters can decimate a population, killing most members and leaving behind a small random assortment of survivors.

Multiple Choice Questions (MCQs) of Unit II

Question 1. Species diversification represents

A. Mutation
B. Megaevolution
C. Microevolution
D. Macroevolution

Answer: C

Question 2. Adaptive radiation is also known as

A. Macroevolution
B. Microevolution
C. Both A & B
D. None of these

Answer: A

Question 3. Retrogressive evolution can be seen in

A. Fishes
B. Mammals
C. Aves
D. Tunicates

Answer: D

Question 4. Closely related organisms with similar traits shows

A. Convergent evolution
B. Divergent evolution
C. Co-evolution
D. None of these

Answer: A

Question 5. Which evolution occurs below the species level?

A. Macroevolution
B. Microevolution
C. Megaevolution
D. Co-evolution

Answer: B

Question 6. Industrial melanism is the example of

A. Parallel evolution
B. Macroevolution
C. Convergent evolution
D. Microevolution

Answer: D

Question 7. Evolution of horse is an example of

A. Microevolution
B. Divergent evolution
C. Convergent evolution
D. Macroevolution

Answer: D

Question 8. Who coined the term Adaptive radiation?

A. Simpson
B. H.F. Osborn
C. Darwin
D. Linnaeus

Answer: B

Question 9. Darwin's finches show

A. Microevolution
B. Macroevolution
C. Parallel evolution
D. None of these

Answer: B

Question 10. If evolution occurs for large scale such as that of families, orders, classes and phyla, then such evolution is referred to as

A. Megaevolution
B. Microevolution
C. Macroevolution
D. None of these

Answer: A

Question 11. Eyes of vertebrates and eyes of cephalopods are the example of

A. Divergent evolution
B. Co-evolution
C. Convergent evolution
D. None of these

Answer: C

Question 12. The observed tendency of a part or organ to change progressively in size is known as

A. Orthogenesis
B. Anagenesis
C. Macromutation
D. Homeotic mutation

Answer: A

Question 13. The evolution of aquatic ichthyosaurs and of fishes is an example of

A. Divergent evolution
B. Convergent evolution
C. Co-evolution
D. Parallel evolution

Answer: B

Question 14. Phyletic evolution is also known as

A. Orthogenesis
B. Anagenesis
C. Megaevolution
D. None of these

Answer: B

Question 15. The evolution of speed in elk and speed in gray wolves is an example of

A. Co-evolution
B. Parallel evolution
C. Microevolution
D. None of these

Answer: A

Question 16. Adaptation of organisms is its

A. Regular character
B. Distinct character
C. Hereditary character
D. Acquired character

Answer: C

Question 17. Ant eaters and monkeys are the example of

A. Adaptive divergence
B. Parallel evolution
C. Orthogenesis
D. Anagenesis

Answer: B

Question 18. Darwin's finches are represented by

A. 12 distinct species
B. 13 distinct species
C. 14 distinct species
D. 15 distinct species

Answer: C

Question 19. Which of the following genus does not belong to Darwin's finches

A. *Pinaroloxias*
B. *Camarhynchus*
C. *Certhidea*
D. *Edynamis*

Answer: D

Question 20. Darwin's finches differ among the species in

A. Size and shape of the tail
B. Size and shape of the wing
C. Size and shape of the Beak
D. Size and shape of the head

Answer: C

Question 21. The famous Galapagos Islands lie on the equator west of

A. Australia
B. Africa
C. South America
D. North America

Answer: C

Question 22. The unit of evolution is

A. Population
B. Species
C. Genus
D. Family

Answer: A

Question 23. The total number of genes at any one time in a population is known as

A. Gene pool
B. Genotype
C. Demes
D. Cline

Answer: A

Question 24. Genetic drift occurs in the populations that are very

A. Closely related
B. Smaller in size
C. Isolated population
D. Large in size

Answer: B

Question 25. Blood group of human beings are the example of

A. Punctuated equilibrium
B. Parallel evolution
C. Polymorphism
D. None of these

Answer: C

Question 26. A lethal gene has a selection coefficient of

A. 1
B. 0.5
C. 50
D. 1/50

Answer: A

Question 27. When reduction in allele frequencies caused by drastic reduction in population size, such phenomenon is known as

A. Population Crush
B. Population flush
C. Population density
D. Population potential

Answer: A

Question 28. Founder principle was proposed by

A. Simpson
B. Ernst Mayr
C. Wallace
D. Sewall wright

Answer: B

Question 29. When small group of individuals migrate from main population then this small group of colonizers produce a phenomenon known as

A. Founder effect
B. Whitten effect
C. Bruce effect
D. None of these

Answer: A

Question 30. Hardy-Weinberg principle operates in the absence of

A. Gene flow
B. Natural selection
C. Mutation
D. All of these

Answer: D

Question 31. In Hardy-Weinberg equation, P^2 means that individuals are

A. Having lethal allele
B. Homozygous dominant
C. Heterozygous dominant
D. Homozygous recessive

Answer: B

Question 32. If any population namely a has 36% of homozygous recessive genotype aa then what will be the frequency of allele a?

A. 26%
B. 40%
C. 60%
D. 80%

Answer: C

Question 33. How many factors affect the Hardy-Weinberg Principle?

A. 3

B. 4

C. 5

D. 6

Answer: C

Question 34. Genetic drift occurs when gene migration occurs

A. Slowly

B. Due to natural calamity

C. By chance

D. Spontaneously

Answer: C

Question 35. Select the correct Hardy-Weinberg Equation

A. $P^2+q^2=1$

B. $P+q=1$

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

D. None of these

Answer: C

Question 36. For a diploid organism, p and q of the Hardy-Weinberg equation represent the frequency of

A. Only allele a

B. Only allele A

C. Allele p

D. Allele A and a

Answer: D

Question 37. According to Hardy-Weinberg principle, the total sum of all frequencies of the allele is

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

Answer: A

Question 38. In disruptive selection

A. Average value selected
B. Average value rejected
C. Four peaks selected
D. Members of both extreme selected

Answer: D

Question 39. Genetic drift reduces genetic variability in

A. Large population
B. Small population
C. Mixed population
D. None of these

Answer: B

Question 40. The chemicals which cause mutation known as

A. Mutagen
B. Morphogen
C. Hormone
D. All of these

Answer: A

Question 41. Which mutagen is a base analogue?

A. Acridine orange
B. NO
C. Proflavine
D. 5BU

Answer: D

Question 42. Which mutagen is a base deaminating agent?

A. Proflavine
B. 5 Bromouracil
C. NO
D. Acridine dyes

Answer: C

Question 43. Addition or deletion of one or two chromosome is known as

A. Aneuploidy
B. Polyploidy
C. Euploidy
D. All of these

Answer: A

Question 44. A random change in the base sequence of a gene known as

A. Chromosomal mutation
B. Induced mutation
C. Gene mutation
D. Spontaneous mutation

Answer: C

Question 45. 2n individuals are referred to as

A. Haploid
B. Diploid
C. Triploid
D. None of these

Answer: B

Question 46. Spontaneous mutation is caused by

A. Artificial agents
B. man
C. natural agents
D. none of these

Answer: C

Question 47. De Vries gave his theory working on

A. *Pisum sativum*
B. *Drosophila*
C. *Caenorhabditis*
D. *Oenothera lamarckiana*

Answer: D

Question 48. 2n+1 individuals are known as

A. Haploid
B. Tetrasomic
C. Trisomic
D. Pentasomic

Answer: C

Question 49. Convergent evolution can be explained by

A. Starfish and cuttle fish
B. Bacteria and protozoa
C. Dog fish and whale
D. Rat and dog

Answer: C

Question 50. Stabilizing selection favours

A. Environmental difference
B. Intermediate form of a trait
C. Both extreme form of a trait
D. All of these

Answer: B

UNIT III

Direct Evidences of Evolution

UNIT III Direct Evidences of Evolution

Types of fossils, Incompleteness of fossil record, Dating of fossils, Phylogeny of horse

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- Fossils are the preserved remains of animals & Plants, found in the various strata of Earth's crust
- The term fossil is derived from a Latin world Fossilium i.e., something dug out literally means anything dug out of the Earth

TYPES OF FOSSILS-

1. Actual Remains-

- Organisms got embedded in permafrost of Arctic/ Alpine snow remain preserved in actual state
- Frozen in ice (Best natural preservative)
- Ex. Woolly Mammoth (25000 years Old), Giant Elk of Ireland

2. Petrifications- /Premineralization

- Fossils in which organic materials replaced by mineral matter. In some petrified fossils, even cellular details are found.
- Majority of the fossils are formed by Petrifaction. It is the process of replacement of organic matter by minerals like sand, lime, iron oxides, silica etc.
- In petrifaction decomposers decompose the organic matter of dead organism
- This decomposed material is carried away by the seepage of water. In such places minerals precipitate.
- The minerals become hard to form into a rock. This rock resembles to the dead organism. Such fossils are called as petrified fossils

3. Compressions –

- Internal structure is absent but a thin carbon film indicates the outline of external features
- i.e; Oils in the plant's cells are leached out and the remaining matter is reduced to a carbon film.

- Plants have an inner structure of rigid organic walls that may be preserved in this manner, revealing the framework of the original cells. Plants are mostly fossilized through carbonization. For example: Coal.

4. Moulds-

- If the soft bodied animal or plant get buried and their surrounding get hardened, their organic matter gets disintegrated leaving only a hollow cavity known as mould.
- Thus, a mould is an impression of the organism which is exact replica of the organism
- Hardened encasements formed in the outer parts of extinct organic remains which later decay leaving cavities

5. Casts-

- When moulds get filled with minerals they are known as casts. They form replicas of buried organisms. For example, fossils of coelenterates, molluscs shells, jelly fishes etc.
- Such fossils depict only the external features of the organisms. Hardened pieces of mineral matter deposited in the cavities of moulds

6- Tracks & Tails-

- While moving the footprints/tracks of organisms left in sand/ moist mud got hardened into rocks, preserving the prints
- Trails are impression left in sedimentary rocks by body parts e.g. Dinosaurs foot & worm trail

7. Palynofossils/Microfossils-

- Such as fossil spores, pollen, & microscopic organisms (Less than 0.5 mm – 1/50 inches in size). Some of them help in locating the fossil fuels

8. Impression/Imprints-

- Like moulds, impressions are also formed when an organism or their parts come in contact with soft clay or mud leaving an impression. These impressions become permanent and form the fossils.

- Many such type of fossils e.g. impression of leave, feather, wing membrane of flying reptiles, skin of dinosaurs etc have been recovered from the stones.
- External features of organisms or their parts left in hardening rocky matter before complete decay Ex. *Archaeopteryx* feathers
- Pseudo fossils are the pattern developed in rocky matter during crystallization of mineral substances

9. Macro fossils-

- Larger than 1 cm in size, Ex. Fossils of more advanced plants & animals (Clams, Corals, or skeleton of Vertebrates)

10. Coprolites / Trace Fossils-

- Fossils of droppings of animals or faecal matter, later compressed in sedimentary rocks
- Vary in size from tiny faecal pellets of Sea snail to large coprolites of Crocodiles, Dinosaurs or Mammals. Found in the association of the animal fossils who made them. Ex . Coenozoic mammals

11. Gastroliths-

- Found in abundance in the body cavities of certain reptiles
- i.e. structures used in grinding the stomach contents of the extinct reptiles

Dating of fossils:

- Carbon dating method was discovered by W.F.Libby
- Useful in determining age of Pleistocene fossils
- The half-life of Carbon-14 is 5600 years
- Uranium –lead method was proposed by Boltwood
- Very common method of determining the age of igneous rocks
- The half life of uranium is 45 crore years
- Potassium Argon method can be used to determine the age of earliest known hominids.
- Half life of potassium is about 1.3 billion years

Evolution of Horse:

Eohippus:

- It was found in the beginning of Eocene about 52 million years ago.
- It was small, browsing with a size of fox about 250-450 mm, called Down Horse.
- The ulna and fibula were stout and were separate from radius and tibia respectively.
- Fore limb had four toes (II, III, IV, V) and hind limbs had three toes (II, III, IV), the 4th and 5th digits of hind limbs were represented by splints.
- The total no. of teeth were 44 (less crowned molar and pre-molar)

Orohippus:-

- It was originated in middle Eocene approximately 50 million years ago at North America and New Mexico. It increased slightly in size (about 13.5 inches)
- The last premolars (IV) became molariform at it was still browser.
- The number of toes fore limb and hind limbs remains but splints of rest digits were lost.

Mesohippus:-

- It was nearly the size of a sheep (18-24 inches).
- Neck was short and less flexible.
- It walked on three toes on each of its front and hind feet (the first and fifth toes remained, but were small and not used in walking).
- Three pre-molars (II to IV) were molariform

Merychippus:-

- It appeared in the middle and upper Miocene and become extinct in Pliocene.
- It was the 1st grazing horse, 40 inch in size.
- Both limbs had three toes. Central toes was hat-like but side toes (II & IV) became very thin.
- Teeth was high crowned.

Pliohippus:-

- It originated from the *Merychippus* in middle Miocene around 12 million years ago. It was the 1st one toed horse.
- The height of teeth was greater than that of *Merychippus*.
- There was a pit in front of the eye orbit

Equus:-

- It originated from the *Pliohippus* at the end of Pliocene.
- Earliest records of *Equus* are found in North America from where it migrated to whole world. It is the modern horse which achieved the height of 60 inches. Its middle toe is enlarged and is in possession of a well-developed hoof.
- Incisors are highly crowned, canines are absent. First premolar is reduced and these exists a diastema between incisor and pre-molar. There are 3 pre-molars and 3 molars.

Multiple Choice Questions (MCQs) of Unit III

Question 1. Fossils are dated by

A. Bone structure
B. Radioactive carbon content
C. Content of calcium
D. Content of chloride

Answer: B

Question 2. Living fossil means

A. Fossil made from living form
B. Fossil in amber
C. Living organism having very primitive features
D. None of these

Answer: C

Question 3. Which of the following is a living fossil?

A. Deer
B. Whale
C. Dolphin
D. Sphenodon

Answer: D

Question 4. The study of fossil is known as

A. Ethology
B. Oology
C. Paleontology
D. None of these

Answer: C

Question 5. The type of fossil where hard parts such as bone or trunks of trees are preserved are known as

A. Cast
B. Moulds
C. Petrified
D. Compressed

Answer: C

Question 6. The fossil of Archaeopteryx were discovered from the rock beds of

A. Permian
B. Jurassic
C. Miocene
D. Coenozoic

Answer: B

Question 7. A fossil may support the theory of organic evolution as

A. An incomplete evidence
B. A complete evidence
C. Both A and B
D. None of these

Answer: A

Question 8. Which is a living fossil?

A. Peripatus
B. Limulus
C. Tuatara
D. All of these

Answer: D

Question 9. Who is the father of paleontology?

A. Libby
B. Stebbins
C. Leonardo da Vinci
D. Haeckel

Answer: C

Question 10. Who is the founder of Modern Paleontology?

A. G. Cuvier
B. Mayr
C. Simpson
D. Boltwood

Answer: A

Question 11. Fossils can be obtained from

A. Igneous rocks
B. Sedimentary rocks
C. Metamorphic rocks
D. All of these

Answer: B

Question 12. Wooly mammoth is an example of which type of fossil?

A. Petrified
B. Compression
C. Cast
D. Actual remains

Answer: D

Question 13. Birbal Sahni Institute of Palaeobotany is situated at

A. Kanpur
B. New Delhi
C. Bangaluru
D. Lucknow

Answer: D

Question 14. Trace fossils are also known as

A. Moulds
B. Casts
C. Impression
D. Coprolites

Answer: D

Question 15. The fossil type of Archaeopteryx is

A. Mummies
B. Imprints
C. Petrified
D. Impression

Answer: D

Question 16. Fossils of droppings of animals or faecal matter is known as

A. Macrofossils
B. Microfossils
C. Coprolites
D. Imprints

Answer: C

Question 17. Which fossil is considered as best preserved fossil?

A. Mould
B. Entire organism
C. Casts
D. Impressions

Answer: B

Question 18. Amber is a type of fossil in which

A. A fossil resin from pines
B. A chemical
C. A bone like material
D. All of these

Answer: A

Question 19. Palynofossils are

A. Amber
B. Organic remains
C. Pollen
D. None of these

Answer: C

Question 20. The dating of rocks is known as

A. Geochronology
B. Paleontology
C. Geology
D. Geography

Answer: A

Question 21. Who discovered Carbon dating method?

A. Cuvier
B. Simpson
C. Libby
D. Boltwood

Answer: C

Question 22. Which method is known as radioactive clock method for dating of fossils?

A. Carbon dating method
B. Uranium lead method
C. Potassium argon method
D. None of these

Answer: B

Question 24. Radioactive carbon dating is used to determine the age of up to

A. 35000 year old
B. 40000 year old
C. 45000 year old
D. 50000 year old

Answer: C

Question 25. The age of igneous rocks can be determined by

A. Uranium Lead method
B. Carbon dating method
C. Potassium Argon method
D. None of these

Answer: A

Question 26. Which method is used to determine the age of hominids?

A. Carbon dating method
B. Potassium Argon method
C. Uranium Lead method
D. All of these

Answer: B

Question 27. *Ichthyostega* is a primitive fossil which belongs to

A. Reptlia
B. Aves
C. Amphibia
D. Mammalia

Answer: C

Question 28. Evolution of Horse was described by

A. Huxley
B. Marsh
C. Osborn
D. Haeckel

Answer: B

Question 29. The evolution of Horse spans about

A. 55 million years
B. 60 million years
C. 70 million years
D. 75 million years

Answer: B

Question 30. In the evolution of Horse, first horse like animal was

A. *Eohippus*

B. *Mesohippus*

C. *Pliohippus*

D. None of these

Answer: A

Question 31. Which sequence is correct?

A. *Eohippus> Mesohippus>Equus>Pliohippus*

B. *Eohippus>Mesohippus>Merychippus>Pliohippus>Equus*

C. *Pliohippus> Mesohippus>Equus> Eohippus*

D. *Equus>Mesohippus>Merychippus>Eohippus*

Answer: B

Question 32. Which horse is commonly known as Dawn horse?

A. *Mesohippus*

B. *Pliohippus*

C. *Merychippus*

D. *Eohippus*

Answer: D

Question 33. The height of Eohippus was

A. 25 CM

B. 26 CM

C. 27 CM

D. 28 CM

Answer: D

Question 34. Mesohippus is regarded as

A. Modern horse
B. Ruminating horse
C. Intermediate horse
D. Dawn horse

Answer: C

Question 35. The number of functional toe in Eohippus was

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

Answer: B

Question 36. The evolution of horse started in

A. Eocene
B. Miocene
C. Pliocene
D. Pleistocene

Answer: A

Question 37. *Hyracotherium* was the name of

A. *Mesohippus*
B. *Merrychippus*
C. *Eohippus*
D. *Pliohippus*

Answer: C

Question 38. Which horse had single functional toe (3rd) and splints (2nd & 4th) per foot?

A. *Mesohippus*
B. *Merychippus*
C. *Pliohippus*
D. *Equus*

Answer: C

Question 39. Modern horse evolved in

A. Africa
B. Asia
C. South America
D. North America

Answer: D

Question 40. Which rock is an example of metamorphic rocks?

A. Basalt
B. Sandstone
C. Shale
D. Marble

Answer: D

Question 41. Which rock is formed by solidification of Magma?

A. Metamorphic rocks
B. Igneous rocks
C. Sedimentary rocks
D. None of these

Answer: B

Question 42. Quantum evolution is also known as

A. Macroevolution
B. Microevolution
C. Megaevolution
D. None of these

Answer: A

Question 43. Which rocks are commonly known as stratified rocks?

A. Igneous rocks
B. Sedimentary rocks
C. Metamorphic rocks
D. None of these

Answer: B

Question 44. Which rocks are useful to interpret geologic history?

A. Sedimentary rocks
B. Igneous rocks
C. Metamorphic rocks
D. All of these

Answer: A

Question 45. Wooly mammoth arose how many years ago?

A. 25000 years
B. 30000 years
C. 35000 years
D. 50000 years

Answer: A

Question 46. Which medium is considered as best natural preservative for fossil?

A. Sand
B. Water
C. Ice
D. Mud

Answer: C

Question 47. Which process of fossilization is known as Premineralizarion?

A. Castings
B. Mouldings
C. Impressions
D. Petrifications

Answer: D

Question 48. The word petrified means

A. Turning into stone
B. Turning into sand
C. Turning into water
D. None of these

Answer: A

Question 49. When moulds get filled with minerals, known as

A. Tracks and trails
B. Casts
C. Impressions
D. None of these

Answer: B

Question 50. Gastroliths fossils are found in the body cavities of

A. Fishes

B. Amphibians

C. Coelenterates

D. Reptiles

Answer: D

UNIT IV

Species Concept and Extinction

UNIT IV Species Concept and Extinction

- Biological species concept (Advantages and Limitations); Modes of speciation (Allopatric, Sympatric)
- Mass extinction (Causes, Names of five major Extinctions

- **Species**- the basic taxonomic units of biological classification i.e. the grouping of organisms of like kind into discrete & stable units.
- According to the biological species concept given by Mayer, Species are groups of interbreeding natural populations that are reproductively isolated from other such groups.

BIOLOGICAL SPECIES CONCEPT-

- Members of a species actually or potentially interbreed in nature, not according to similarity of appearance.
- Although appearance is helpful in identifying species, it does not define species.
- When two organisms breed within a species, their genes pass into their combined offspring.
- As this process is repeated, the genes of different organisms are constantly shuffled around the species gene pool & the shared gene pool gives the species its identity.
- The strength of the biological species concept is that it gives emphasis on reproductive isolation but the no. of species to which this concept can be usefully applied is limited.
- This concept does not apply to organisms that reproduce asexually all or most of the time, e.g. Prokaryotes.
- In this concept, the species are designated by the absence of gene flow.
- There are many pairs of species that are morphologically & ecologically distinct & yet gene flow occurs between them.
- The natural selection can cause such species to remain distinct despite gene flow.
- Due to limitations of the biological species concept, alternative species concepts are useful in certain situations.

SPECIATION-

- It is a lineage-splitting evolutionary process that produces two or more separate species.
- It refers to the creation of new & distinct biological species by branching off from the ancestral population.
- It occurs when gene flow is reduced sufficiently between sister populations.
- Reduced gene flow probably plays a critical role in speciation, a single evolutionary lineage splits into two or more genetically independent lineages due to reduced gene flow.
- Speciation is divided into 3 types-

1- ALLOPATRIC SPECIATION- (Allo= other, patric = place)

- Ernst Mayr (1963) proposed that speciation occurs through Allopatry i.e. geographical isolation.
- Allopatric speciation is a genetic divergence permitted by geographic isolation.
  It is dependent on random mutation that accumulates steadily after a population has been subdivided in space.
- This subdivision can take place because of geographic barriers e.g. mountain ranges & water bodies.
- Because the two sub-populations are then reproductively isolated, each of the populations accumulates in different mutations & the two populations diverge.
- This divergence become stronger where the population size of one or both of the sub-populations is small due to sampling error is high in smaller populations.
- These differences lead to reproductive incompatibilities that will be keeping the populations distinct.
- Ex. Divergence of Drosophila populations in the Hawaii Islands
- Reproductive isolating mechanisms usually originate incidentally in the speciation process.
- i.e. they arise incidentally during the process of evolution in isolated populations rather than being selected for.
- When isolated populations come together again, incomplete isolating mechanisms may allow hybrids to form.

- If the hybrids are normal, viable & can freely interbreed with individuals of each parent population, then no speciation occurs.
- If the hybrids are at a disadvantage, then the natural selection may favour stronger isolating mechanisms.
- The organisms that mate with individuals from other populations leave fewer offspring.
- The result is a more effective barrier to hybridization.
- The regions in which previously isolating populations come into contact & produce hybrids are k/a Hybrid Zones.

2. SYMPATRIC SPECIATION- (Sym= same & Patric = place)

- Does not require geographic isolation.
- It relies on the development of reproductive isolation mechanisms to allow divergence of the two sub-populations.
- This reproductive isolation is the result of a no. of factors, including competition for resources, disruptive selection & sexual selection.
- In this speciation, selection acts against individuals of an intermediate type, either through decreased viability, or decreased fecundity.
- It produces the evolution of mating preferences & other mechanisms that result in decreased hybridization.
- In such speciation, selection enhances traits that promote the divergence of the populations.
- It is different from allopatric speciation in which mutation passively leads to differences that allow divergence of the Populations.
- Ex- Divergence of Rhagoletis pomonella (Maggot fly)
- This species has recently diverged into 2 sub-species due to the introduction of Apple trees in the northeastern U.S., where hawthorn trees were native.
- In the beginning, the flies used the hawthorn fruits to reproduce & to lay their eggs.
- The introduction of the Apple trees provided a more nutritious food source for developing maggots, as well as an escape from parasitic wasps.
- The difference between the two types of fruits, such as maturation timing, allowed for the evolution of isolating mechanisms & subsequent divergence of the two subspecies.

3- PARAPATRIC SPECIATION- (Para= beside, Patric= place)

- In this, the evolution of reproductive isolating mechanisms take place when a population enters a new niche or habitat within the range of the Parent species.
- Generally, it occurs when there has been a drastic change in the environment within the original species habitat.
- In this speciation, there is no specific extrinsic barrier to gene flow.
- The population is continuous, but nonetheless, the population does not mate randomly.
- Individuals are more likely to mate with their geographic neighbours than with individuals in a different part of the population's range.
- In this, divergence may happen because of reduced gene flow within the population & varying selection pressures across the population's range.
- i.e. in Allopatric, reproductive isolation evolves after the population has been geographically isolated, in Parapatric, reproductive isolation evolves when a segment of the population enters a new niche.
- In sympatric, reproductive isolation evolves while incipient group is still in the vicinity of the Parent Population.
- Death and disappearance of large group of organism over a short span of time is known as Mass Extinction.
- The largest mass extinction came at the end of Permian i.e.; at the time of formation of Pangaea II, about 250 million years ago.
- The most well known extinction occurred at the boundary of Cretaceous and Tertiary periods which resulted in the extinction of Dinosaurs.
- 1. Ordovician-Silurian Extinction- 440 MYA, 86% life was lost.
- 2. Late Devonian Extinction – 365 MYA, 75% life lost
- 3. Permian-Triassic Extinction- 252 MYA, 96% life lost
- 4. Triassic-Jurassic Extinction – 201.3 MYA, 80% life lost
- 5. Cretaceous-Paleogene Extinction- 66 MYA, 60-76% life lost
- 6. Holocene Extinction to present- 11,700 years ago to present

Multiple Choice Questions (MCQs) of Unit IV

Question 1. The term species was given by

A. Linnaeus
B. John Ray
C. Mayr
D. Simpson
Answer: B

Question 2. Which is the smallest taxon in taxonomy?

A. Species
B. Genus
C. Family
D. Order
Answer: A

Question 3. A groups of interbreeding natural populations that are reproductively isolated from other such groups known as

A. Phylum
B. Order
C. Species
D. Genus
Answer: C

Question 4. Biological species concept does not apply to following organism

A. Hydra
B. Octopus
C. Man
D. Bacteria
Answer: D

Question 5. In the biological species concept, species are designated by the

A. Presence of gene flow
B. Absence of gene flow
C. Both A & B
D. None of these

Answer: B

Question 6. Who gave evolutionary species concept?

A. Mayr
B. Linnaeus
C. Simpson
D. Ray

Answer: C

Question 7. The key to speciation of population is

A. Extinction
B. Reproductive isolation
C. Reproductive potential
D. None of these

Answer B

Question 8. Which selection can cause a steeper cline?

A. Strong selection against heterozygotes
B. Stabilizing selection
C. Migration
D. Drift

Answer: A

Question 9. Which isolating factor occurs when a sperm and egg are incompatible?

A. Temporal isolation
B. Gametic isolation
C. Behavioural isolation
D. Ecological isolation

Answer: B

Question 10. According to biological species concept in relation with species, which is applicable to the breeding populations that are

A. Enough large
B. Uniform
C. in nature
D. in experimental situations

Answer: C

Question 11. Concept of genetic bottlenecks includes

A. increased efficiency to resist diseases
B. increased gene flow
C. increased genetic load
D. a loss of genetic diversity in descendent populations

Answer: D

Question 12. Which of the following is not considered as reproductive isolating mechanism?

A. Behavioural isolation
B. Individual isolation
C. Temporal isolation
D. Ecological isolation

Answer: B

Question 13. Which speciation enables to produce hybrids between two species?

A. Founder effect
B. Bottleneck effect
C. Allopatric
D. Parapatric

Answer: D

Question 14. According to the biological species concept, organisms are part of the same species if they

A. Look the same and act the same.
B. Can produce offspring that can also breed
C. Look the same
D. Breed

Answer: B

Question 15. Which of the following is less general in characters if, it is compared with the genus?

A. Class
B. Order
C. Species
D. Family

Answer: C

Question 16. Taxonomy hierarchy is a

A. A list of Zoologists
B. Classification of species
C. Nomenclature of species
D. Stepwise arrangement of all categories for classification of organisms

Answer: D

Question 17. Whose existence is real in taxonomic hierarchy?

A. Order
B. Genus
C. Species
D. Cohort

Answer: C

Question 18. A true species consists of a population which shows following characteristics?

A. Reproductively isolated
B. Sharing the same habitat
C. Sharing the same food
D. Can interbreed

Answer: A

Question 19. First step in the taxonomy is

A. Naming
B. Classification
C. Identification
D. Description

Answer: C

Question 20. A taxon is a

A. Type of organisms
B. Group of related families
C. Taxonomic group of any ranking
D. Group of related genera

Answer: C

Question 21. The full form of ICZN is

A. International code of Zoological Nomenclature
B. Indian code of Zoological Nomenclature
C. Indian congress of Zoological Nomenclature
D. None of these

Answer: A

Question 22. Monophyletic groups include

A. A different ancestor and some of its descendants
B. A common ancestor and all of its descendants
C. A common ancestor and some of its descendants
D. None of these

Answer: B

Question 23. Polyphyletic group include organisms that

A. Share a recent common ancestor
B. Share a distant ancestor
C. Do not share a recent common ancestor
D. None of these

Answer: C

Question 24. Paraphyletic groups include

A. A common ancestor and some, but not all, of its descendants
B. A different ancestor and all its descendants
C. A common ancestor and all its descendants
D. None of these

Answer: A

Question 25. Darwin' finches are the example of

A. Parapatric speciation
B. Sympatric speciation
C. Allopatric speciation
D. None of these

Answer: C

Question 26. The speciation where, two populations of the same species become isolated from each other due to geographical factors is

A. Sympatric
B. Allopatric
C. Parapatric
D. None of these

Answer: B

Question 27. When two groups of the same species live in the same geographical area, the speciation is called

A. Allopatric
B. Sympatric
C. Parapatric
D. All of these

Answer: B

Question 28. In allopatric speciation, geographical isolation is

A. Required
B. Not required
C. Sometimes required
D. None of these

Answer: A

Question 29. In which speciation, natural selection is a major differentiation method

A. Sympatric
B. Allopatric
C. Both A & B
D. None of these

Answer: B

Question 30. In which speciation, polyploidy is a major selection method

A. Parapatric
B. Allopatric
C. Sympatric
D. None of these

Answer: C

Question 31. Which concept suggests that the observed diversity of the universe reflects the existence of a limited number of underlying universals or types?

A. Typological species concept
B. Nominalistic species concept
C. Biological species concept
D. None of these

Answer: A

Question 32. Which concept deny the existence of real universals and for them only individuals exist and species are man made abstractions?

A. Biological species concept
B. Nominalistic species concept
C. Typological species concept
D. None of these

Answer: B

Question 33. A group of interbreeding natural populations that are reproductively isolated from other such groups is known as

A. Family
B. Order
C. Species
D. Genus

Answer: C

Question 34. A taxonomic group of any rank that is sufficiently distinct to be worthy of being assigned to a definite category known as

A. Type
B. Taxon
C. Both A & B
D. None of these

Answer: B

Question 35. According to which concept the members of a species constitute a genetic unit consisting of a large intercommunicating gene pool

A. Typological species concept
B. Nominalistic species concept
C. Biological species concept
D. None of these

Answer: C

Question 36. Biological species concept was given by

A. Simpson
B. Ray
C. Aristotle
D. Mayr

Answer: D

Question 37. The concept that states that a species is a set of organisms that are phenotypically similar and look different from other sets of organisms

A. Evolutionary species concept
B. Phenetic species
C. Phylogenetic species concept
D. None of these

Answer: B

Question 38. The concept which states that a species a group of organisms whose members are descended from a common ancestors and all having a combination of certain defining or derived traits

A. Phenetic species concept
B. Evolutionary species concept
C. Phylogenetic species concept
D. None of these

Answer: C

Question 39. The speciation in which there is no specific extrinsic barrier to gene flow

A. Allopatric
B. Parapatric
C. Sympatric
D. None of these

Answer: B

Question 40. Which speciation generally occurs when there has been a drastic change in the environment within the original species habitat?

A. Parapatric
B. Sympatric
C. Allopatric
D. None of these

Answer: A

Question 41. Divergence of Maggot fly represents which type of speciation?

A. Parapatric
B. Sympatric
C. Allopatric
D. All of these
Answer: B

Question 42. Which speciation relies on the development of reproductive isolation mechanisms to allow divergence of the two sub-populations?

A. Allopatric
B. Sympatric
C. Paraptric
D. All of these
Answer: B

Question 43. In which speciation, selection acts against individuals of an intermediate type, either through decreased viability or decreased fecundity?

A. Parapatric
B. Sympatric
C. Allopatric
D. None of these
Answer: B

Question 44. Who gave the concept of mass extinction?

A. Haeckel
B. Darwin
C. J. Sepkoski and D.M. Raup
D. John Ray
Answer: C

Question 45. In which extinction 96% of all life was lost?

A. Triassic Jurassic
B. Permian Jurassic
C. Late Devonian
D. Ordovician Silurian

Answer: B

Question 46. Which extinction include disappearance of Dinosaurs?

A. Holocene
B. Triassic Jurassic
C. Cretaceous Paleogene
D. Late Devonian

Answer: C

Question 47. The extinction in which most of the lost life was marine

A. Holocene
B. Late Devonian
C. Ordovician Silurian
D. None of these

Answer: C

Question 48. Which extinction is considered as deadliest in the history?

A. Permian Triassic
B. Late Devonian
C. Ordovician- Silurian
D. None of these

Answer: A

Question 49. Which extinction started 11,700 years ago to present?

A. Cretaceous Paleogene
B. Late Devonian
C. Holocene
D. None of these

Answer: C

Question 50. Triassic –Jurassic extinction took place

A. 201.3 million years ago
B. 202.3 million years ago
C. 203.3 million years ago
D. 204.3 million years ago

Answer: A

UNIT V

Gamete Fertilization and Early Development

UNIT V Gamete Fertilization and Early Development

- Gametogenesis, Fertilization
- Cleavage pattern
- Amphibian Gastrulation and fate maps

- The male contains primordial germ cells, which develop in the embryo and come to inhabit the differentiating male gonad (testis)
- These primordial germ cells also are intimately associated with accessory cells, known as **Sertoli cells** in mammals
- Germ cells and their associated accessory cells line the perimeter of connective tissue tubes called seminiferous tubules. Between the tubules, there is a vascularized connective tissue containing supporting cells
- Spermatogenesis is the developmental pathway from germ cell to mature sperm—begins at puberty and occurs between the Sertoli cells

1. A **proliferative phase** where sperm stem cells (spermatogonia) increase by mitosis
2. A **meiotic phase**, involving the two divisions that create the haploid state
3. A **post meiotic** "shaping" phase called spermiogenesis, during which the round cells (spermatids) eject most of their cytoplasm and become the streamlined sperm

- Spermiogenesis
- The transformation of spermatids into spermatozoa is called spermiogenesis or spermateliosis or differentiation phase.
- The different changes occurring during spermiogenesis are:

(i) Formation of acrosome by Golgi apparatus

(ii) Elongation of nucleus

(iii) Separation of centrioles

(iv) Formation of axial filament from distal centriole

(v) Development of mitochondrial spiral around upper parts of axial filament

(vi) Formation of flagellum

- ❖ The process of formation of a mature female gamete (ovum) is called oogenesis. It occurs in ovaries and involves three phases:
- ❖ Multiplication, growth and maturation.

Growth Phase

- ❖ At birth, ovaries contain approx. 2 to 4 million oogonia (egg mother cells). No more oogonia are formed and added after birth.
- ❖ During fetal life, cells of germinal epithelium divide to produce oogonia which multiply by mitosis and develop into primary oocytes.
- ❖ Now, they undergo a first meiotic division by replicating their DNA, however, they do not complete the division in the fetus. The oocytes are arrested in the meiotic prophase I, this is the first resting stage.

Maturation Phase

- ❖ They undergo a round of DNA synthesis, and chromosome pairing takes place. There is accumulation of food materials and other resources for nourishment of the oocyte.
- ❖ At puberty, primary oocyte continues meiosis I and produces first polar body and secondary oocyte. The secondary oocyte proceeds with meiosis II but gets arrested in metaphase II stage. This is the second resting stage.
- ❖ The first polar body may divide to form two second polar bodies. They did not play any role in reproduction and soon degenerate due to lack of cytoplasm and food.
- ❖ The actual female gamete is ovum. From one oogonium, one ovum and three polar bodies are formed.
- ❖ Cleavage is the early mitotic division of zygote. It is of following types-

1. **Meridional Plane**: the plane of cleavage lies on the animal vegetal axis resulting the egg into two equal halves.
2. **Vertical plane**: The cleavage furrows may lie on either side of the meridional plane. The furrows pass from animal to vegetal pole. The cleaved cells may be unequal in size.

3. **Equatorial plane**: This cleavage plane bisects the egg at right angles to the main axis. It lies on the equatorial plane. It divides the egg into two halves.
4. **Latitudinal plane**: It is similar to the equatorial plane, but it lies on either side of the equator. It is also called as **transverse** or **horizontal cleavage**

❖ Accordingly several cleavage patterns have been recognized.

1. **Total** or **holoblastic cleavage** - In this type the cleavage furrow bisects the entire egg. Such a cleavage may be either equal or unequal.

(a) **Equal holoblastic cleavage** - In microlecithal and isolecithal eggs, cleavage leads to the formation of blastomeres of equal size. Eg: Amphioxus and placental mammals.

(b) **Unequal holoblastic cleavage** - In mesolecithal and telolocithal eggs, cleavage leads to the formation of blastomeres of unequal size. Among the blastomeres there are many small sized micromeres and a few large sized macromeres.

2. **Meroblastic cleavage** - In this type the cleavage furrows are restricted to the active cytoplasm found either in the animal pole (macrolecithal egg) or superficially surrounding the egg (centrolecithal egg). Meroblastic cleavage may be of two types.

(a) **Discoidal cleavage** - Since the macrolecithal eggs contain plenty of yolk, the cytoplasm is restricted to the narrow region in the animal pole. Hence cleavage furrows can be formed only in the disc-like animal pole region. Such a cleavage is called **discoidal meroblastic cleavage**. Eg: birds and reptiles.

(b) **Superficial cleavage** - In centrolecithal eggs, the cleavage is restricted to the peripheral cytoplasm of the egg. Eg: insects.

❖ **Fertilization** is the process whereby two sex cells (gametes) fuse together to create a new individual with genetic potentials derived from both parents.

❖ Fertilization accomplishes two separate ends: sex (the combining of genes derived from the two parents) and reproduction (the creation of new organisms).

❖ Thus, the first function of fertilization is to transmit genes from parent to offspring, and the second is to initiate in the egg cytoplasm those reactions that permit development to proceed.

❖ Although the details of fertilization vary from species to species, conception generally consists of four major events:

- Contact and recognition between sperm and egg. In most cases, this ensures that the sperm and egg are of the same species.
- Regulation of sperm entry into the egg. Only one sperm can ultimately fertilize the egg. This is usually accomplished by allowing only one sperm to enter the egg and inhibiting any others from entering.
- Fusion of the genetic material of sperm and egg.
- Activation of egg metabolism to start development.

- A chart or topographical surface mapping showing the fate of each part of an early embryo, in particular a blastula k/a FATE MAP

- These diagrams "map" larval or adult structures onto the region of the embryo from which they arose

- Fate maps constitute an important foundation for experimental embryology, providing researchers with information on which portions of the embryo normally become which larval or adult structures
- Fate maps can be generated in several ways and The ability to follow cells with molecular dyes and computer imaging has altered our understanding of the origins of several cell types

Different cell's behavior during Gastrulation of Frog:

- Epiboly: The thinning and spreading of the animal cap cells over the vegetal hemisphere, powered by proliferation and radial intercalation.
- Vegetal rotation: Vegetal cells asymmetrically press up against the inner blastocoel roof on the dorsal side.
- Bottle cell formation and invagination: Localized apical constriction at the dorsal blastopore lip creates anisotropic forces that foster invagination.
- Involution and cell migration: The leading edge of invaginating cells crawls up onto the blastocoel roof.
- Convergence and extension: The targeted medial-to-lateral intercalation of cells on the midline (convergence) drives anterior-posterior axis elongation (extension).

Multiple Choice Questions of Unit V

Question 1. The process of formation of sperm is known as

A. Spermatogenesis
B. Spermiogenesis
C. Oogenesis
D. None of these
Answer: A

Question 2. The primordial germ cells are associated with some accessory cells, called

A. Mother cells
B. Nutritive cells
C. Sertoli cells
D. None of these
Answer: C

Question 3. Glial cell line derived neutrotrophic factor (GDNF) is synthesized by

A. Germ cells
B. Spermatogonia
C. Spermatid
D. Sertoli cells
Answer: D

Question 4. The mammalian spermatid is

A. Flagellated, haploid
B. Unflagellated, haploid
C. Flagellated, diploid
D. None of these
Answer: B

Question 5. The acrosome part of spermatozoan is derived from which part of the cell?

A. Endoplasmic reticulum

B. Mitochondria

C. Golgi apparatus

D. Lysosomes

Answer: C

Question 6. What is the number of sperms made in human testicle per day?

A. 100 million

B. 200 million

C. 300 million

D. 400 million

Answer: A

Question 7. Each ejaculation releases ……sperms

A. 100 million

B. 200 million

C. 300 million

D. 400 million

Answer: B

Question 8. A human male can produce how many sperms during his life time?

A. 10^{11} to 10^{12}

B. 10^{12} to 10^{13}

C. 10^{13} to 10^{14}

D. 10^{14} to 10^{15}

Answer: B

Question 9. One spermatid can produce how many spermatozoa?

A. 1

B. 2

C. 3

D. 4

Answer: D

Question 10. Secondary spermatocyte is

A. Haploid

B. Diploid

C. Tetraploid

D. Triploid

Answer: A

Question 11. In the human embryo, primary germ cells reaching the developing ovary divide rapidly from-

A. 2^{nd} to 7^{th} month of gestation

B. 5^{th} to 8^{th} month of gestation

C. 1^{st} to 2^{nd} month of gestation

D. 3^{rd} to 4^{th} month of gestation

Answer: A

Question 12. Primary germ cells in human female embryo can produce

A. 5 million oogonia

B. 6 million oogonia

C. 7 million oogonia

D. 8 million oogonia

Answer: C

Question 13. Which acid helps in the initiation of first meiotic division in oogonia to become primary oocytes?

A. Formic acid
B. Lactic acid
C. Retinoic acid
D. Acetic acid

Answer: C

Question 14. Primary oocytes remain arrested in which stage of first meiotic prophase?

A. Zygotene
B. Leptotene
C. Pachytene
D. Diplotene

Answer: D

Question 15. The oocyte meiotic spindle lacks

A. Centriole
B. Nucleus
C. Golgi body
D. E.R.

Answer: A

Question 16. The total number of polar bodies formed during oogenesis is

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

Answer: C

Question 17. The total number of primary oocytes present in the ovaries at the time of birth in female is

A. One million
B. Two million
C. Three million
D. Four million
Answer: B

Question 18. How many primary oocytes survive until puberty and remain arrested in diplotene stage?

A. 30 thousand
B. 60 thousand
C. 50 thousand
D. 40 thousand
Answer: D

Question 19. How many oocytes (approx.) are actually ovulated from menarche up to menopause?

A. 200
B. 300
C. 400
D. 500
Answer: C

Question 20. First cleavage of Frog' egg was observed by

A. Von Baer
B. Haeckel
C. Swammerdam
D. Anton Von Leeuwenhock
Answer: C

Question 21. The cleavage results in the formation of

A. Blastula
B. Morula
C. Gastrula
D. Neurula

Answer: B

Question 22. Which affects the process of cleavage?

A. Yolk
B. Nucleus
C. Spindle fibre
D. Centromere

Answer: A

Question 23. In holoblastic cleavage, the cleavage furrow divide the egg

A. Incompletely
B. Completely
C. Partially
D. None of the above

Answer: B

Question 24. Equal holoblastic cleavage occurs in

A. Insects
B. Birds
C. Reptiles
D. Amphioxus

Answer: D

Question 25. Human egg is

A. Alecithal
B. Microlecithal
C. Macrolecithal
D. Megalecithal

Answer: A

Question 26. Discoidal cleavage is found in

A. Sea Urchin
B. Macropus
C. Man
D. Crow

Answer: D

Question 27. When cleavage furrows are restricted to the small part of animal pole or superficially surrounding the egg, it is called

A. Holoblastic cleavage
B. Equal holoblastic cleavage
C. Meroblastic cleavage
D. None of these

Answer: C

Question 28. Superficial cleavage is the characteristic of

A. Birds
B. Reptiles
C. Herdmania
D. Insects

Answer: D

Question 29. In insects, which type of egg is found?

A. Microlecithal
B. Mesolecithal
C. Megalecithal
D. Centrolecithal

Answer: D

Question 30. Radial cleavage is found in

A. Protostomes
B. Deuterostomes
C. In both
D. None of these

Answer: B

Question 31. In vertebrates, the cleavage is

A. Determinate
B. Indeterminate
C. Spiral
D. None of these

Answer: B

Question 32. In mammals, the vitelline envelope is a thick extracellular matrix called

A. Zona Pellucida
B. Corona radiata
C. Cell membrane
D. Envelope

Answer: A

Question 33. Sea Urchin egg contain ..... Cortical granules

A. 11,000
B. 12000
C. 14000
D. 15000
Answer: D

Question 34. Which protein is called sperm binding protein?

A. ZP1
B. ZP3
C. ZP4
D. ZP5
Answer: B

Question 35. How many human sperms reach the ampullary region of the fallopian tube?

A. 100
B. 300
C. 200
D. 500
Answer: C

Question 36. The set of physiological changes that allow the sperm to be competent to fertilize the egg is called

A. Translocation
B. Capacitation
C. Hyperactivation
D. None of these
Answer: B

Question 37. Which is considered as the initiator of cortical granule reaction?

A. Na
B. Mg
C. Cl
D. Ca
Answer: D

Question 38. In mammals, which enzyme functions during sperm entry into the ovum?

A. Lysin
B. Acrosin
C. Hyaluronidase
D. None of these
Answer: C

Question 39. Axial body or acrosomal cone is found in the sperm of

A. Man
B. Crocodile
C. Fowl
D. Dog fish
Answer: C

Question 40. A temporary collar around the head of the sperm that serves to shape the developing head and as a conduit to transport protein to the base of the tail is known as

A. Nucleus
B. Middle piece
C. Axial filament
D. Manchette
Answer: D

Question 41. In sperm, Jensen's ring is also known as

A. Axoneme
B. Axial filament
C. Ring centriole
D. Primary centriole

Answer: C

Question 42. Non-flagellate sperms are found in

A. Amphioxus
B. Labeo
C. Rattus
D. Crab

Answer: D

Question 43. In amphibian embryo, about a quarter to third of the surface cells is sucked inside by a rolling process called

A. Delamination
B. Involution
C. Epiboly
D. None of these

Answer: B

Question 44. Which group of animals are among the most difficult to map

A. Amphibian
B. Aves
C. Reptilian
D. Mammalia

Answer: D

Question 45. The fates of different areas of amphibian eggs by applying vital dyes was traced by

A. Conklin
B. Vogt
C. Von Baer
D. None of these
Answer: B

Question 46. For fate map, using vital dyes is sometimes difficult as

A. Become diluted with each cell division
B. Become more clear
C. Hard to say
D. None of these
Answer: A

Question 47. When the fate of various egg portion is pre determined, called

A. Mosaic
B. Determinate
C. Regulative
D. Both A & B
Answer : D

Question 48. When yolk is present at one end in egg called

A. Isolecithal
B. Telolecithal
C. Alecithal
D. Megalecithal
Answer: B

Question 49. Microlecithal eggs are found in

A. Lung fishes
B. Ascaris
C. Cyclostomes
D. Tunicates

Answer: D

Question 50. Megalecithal eggs are found in

A. Frogs
B. Toads
C. Platypus
D. Sycon

Answer: C

UNIT VI

Developmental Genes

UNIT VI Developmental Genes

- Genes and development
- Molecular basis of development in drosophila

- ❖ Development connects genotype and phenotype.
- ❖ Nuclear genes are not lost or mutated during development. The genome of every cell is equivalent.
- ❖ The exceptions to the rule of genomic equivalence are the lymphocytes. During differentiation, these cells rearrange their DNA to create new immunoglobulin and antigen receptor genes.
- ❖ Genomic equivalence is implied by metaplasia, in which one differentiated cell type becomes another differentiated cell type. An example is the transdifferentiation of the salamander dorsal iris into a lens when the lens is removed.
- ❖ The ability of nuclei from differentiated cells to direct the development of complete adult organisms has recently confirmed the principle of genomic equivalence.
- ❖ The cloning of human beings, as well as regenerating damaged organs or enhancing physical abilities, may soon be possible through cloning technology and the use of embryonic stem cells.
- ❖ Only a small percentage of the genome is expressed in any particular cell.
- ❖ Polytene chromosomes, in which the DNA has replicated without separating (as in larval Drosophila salivary glands), show regions where DNA is being transcribed. Different cell types show different regions of DNA being transcribed.
- ❖ Northern blots, in situ hybridization, and the polymerase chain reaction can show which cells are transcribing particular genes.
- ❖ The functions of a gene often can be ascertained by antisense mRNA, transgenic expression, or (in the case of mammals) gene knockouts.
- ❖ Knowledge of gene activity in humans can be obtained by candidate gene mapping or positional cloning

- ❖ Differential gene expression is the process by which cells become different from one another based on the unique combination of genes that are active, or "expressed." By expressing different genes, cells can create different proteins that lead to the differentiation of different cell types
- ❖ Every somatic cell nucleus of an organism contains the complete genome established in the fertilized egg. The DNA of all differentiated cells is identical.
- ❖ The unused genes in differentiated cells are neither destroyed nor mutated; they retain the potential for being expressed.
- ❖ Only a small percentage of the genome is expressed in each cell, and a portion of the RNA synthesized in each cell is specific for that cell type.

1. Level 1: Differential gene transcription regulates which of the nuclear genes are transcribed into pre- messenger RNA.
2. Level 2: Selective pre-messenger RNA processing regulates which parts of the transcribed RNAs are able to enter the cytoplasm and become messenger RNAs.
3. Level 3: Selective messenger RNA translation regulates which of the mRNAs in the cytoplasm are translated into proteins.
4. Level 4: Differential posttranslational protein modification regulates which proteins are allowed to remain and/or function in the cell.

- ❖ Some genes (such as those coding for the globin protein subunits of hemoglobin) are regulated at all these levels. It is because of these many different ways to regulate gene expression that a relatively small number of genes can offer an extreme diversity in the possible patterns of protein expression, which yields the enormous array of different cell types constituting both plants and animals.
- ❖ Evidence from molecular biology, cell biology, and somatic cell nuclear cloning has shown that each cell of the body (with very few exceptions) carries the same nuclear genome.
- ❖ Differential gene expression from genetically identical nuclei creates different cell types. Differentialv gene expression can occur at the levels of gene transcription, pre-mRNA processing, mRNA translation, and protein modification.

- Chromatin is made of DNA and proteins. The histone proteins form nucleosomes, and the methylation and acetylation of specific histone residues can repress or activate gene transcription, respectively.
- Histone methylation is often used to silence gene expression. Histones can be methylated by histone methyltransferases and can be demethylated by histone demethylases.
- Acetylated histones are often associated with active gene expression. Histone acetyltransferases add acetyl groups to histones, whereas histone deacetylases remove them.
- Polycomb and Trithorax proteins antagonize each other's histone modifications, which is a mechanism conserved from plants to humans. Maintaining active gene expression is often accomplished by Trithorax proteins, whereas active repression is maintained by Polycomb protein complexes that contain histone methyltransferases.
- Eukaryotic genes contain promoter sequences to which RNA polymerase II can bind to initiate transcription. To do so, the RNA polymerases are bound by a series of proteins called transcription factors.
- Eukaryotic genes expressed in specific cell types contain enhancer sequences that regulate their transcription in time and space. Enhancers usually activate only genes on the same chromosome.
- Enhancer sequences can be upstream or downstream or within introns; they can even be millions of base pairs away from the gene they activate. Silencers act to suppress the transcription of a gene in appropriate cell types.
- Specific transcription factors can recognize specific sequences of DNA in the promoter and enhancer regions. These proteins activate or repress transcription from the genes to which they have bound.
- Enhancers work in a combinatorial fashion. The binding of several transcription factors can act to promote or inhibit transcription from a certain promoter. In some cases, transcription is activated only if both factor A and factor B are present; in other cases, transcription is activated if either factor A or factor B is present.

- Enhancers work in a modular fashion. A gene can contain several enhancers, each directing the gene's expression in a particular cell type.
- Transcription factors act in different ways to regulate RNA synthesis. Some transcription factors stabilize RNA polymerase II binding to the DNA, and some disrupt nucleosomes, increasing the efficiency of transcription.
- A transcription factor usually has three domains: a sequence-specific DNA-binding domain, a trans-activating domain that enables the transcription factor to recruit histone-remodeling enzymes, and a protein-protein interaction domain that enables the transcription factor to interact with other proteins on the enhancer or promoter.
- Class A, B, C, D, and E transcription factors function as homeotic proteins for floral organ identity.
- Even differentiated cells can be converted into another cell type by the activation of a different set of pioneer transcription factors.
- Low CpG-content promoters are usually methylated, and their default state is "off," but they can be activated by transcription factors.
- High CpG-content promoters have a default state that is "on," and they have to be actively repressed by histone methylation.
- DNA methylation can block transcription by preventing the binding of certain transcription factors or by recruiting histone methyltransferases or histone deacetylases to the chromatin.
- Differences in DNA methylation can account for genomic imprinting, wherein a gene transmitted through the sperm is expressed differently than the same gene transmitted through the egg. Some genes are active only if inherited from the sperm or the egg.
- Some chromatin is "poised" to respond quickly to developmental signals. In high CpG-content promoters, RNA polymerase II binds to poised chromatin without beginning transcription, and its histones have both active and repressive marks.
- Alternative pre-mRNA splicing can create a family of related proteins by causing different regions of the pre-mRNA to be read as exons or introns. Based on the

splicing site recognition factors present in a cell, what is an exon in one set of circumstances may be an intron in another. The resulting proteins (splicing isoforms) can play different roles that lead to alternative phenotypes and disease.

- ❖ Some messages are translated only at certain times. The oocyte, in particular, uses translational regulation to set aside certain messages that are transcribed during egg development but used only after the egg is fertilized. This activation is often accomplished either by the removal of inhibitory proteins or by the polyadenylation of the message.
- ❖ MicroRNAs can act as translational inhibitors, binding to the 3′ UTR of the RNA. The microRNA recruits an RNA-induced silencing complex that either prevents translation or leads to the degradation of the mRNA.
- ❖ Many mRNAs are localized to particular regions of the oocyte or other cells. This localization appears to be regulated by the 3′ UTR of the mRNA.
- ❖ Ribosomes can differ in different cell types, and ribosomes in one cell may be more efficient at translating certain mRNAs than ribosomes in other cells.
- ❖ A variety of molecular tools have enabled the study of differentially expressed genes, among them in situ hybridization for gene expression, ChIP-Seq to identify regulatory regions of the DNA that proteins bind to, and gene knockdown (RNA interference) and knockout (CRISPR/Cas9) to test gene function.
- ❖ Differential gene expression is more like interpreting a musical score than decoding a code script. There are numerous events that have to take place, and each event has its own numerous interactions among component parts.
- ❖ Drosophila cleavage is superficial. The nuclei divide 13 times before being compartmentalized. Before cell formation, the nuclei reside in a syncytial blastoderm. Each nucleus is surrounded by actin-filled cytoplasm.
- ❖ When the cell membranes form around the nuclei, the Drosophila embryo undergoes a mid-blastula transition, wherein the cleavages become asynchronous and new mRNA is made. At this time, there is a transfer from maternal to zygotic control of development.

- Gastrulation begins with the invagination of the most ventral region (the presumptive mesoderm), which involves formation of a ventral furrow. The germ band expands such that the future posterior segments curl just behind the presumptive head.
- Actomyosin contractile arrays generate the driving force for apical constriction in ventral cells and ventral furrow morphogenesis. The cytoskeletal orientation and resulting tension is anisotropic, which influences the shape of the folding tissue.
- The genes regulating pattern formation in Drosophila operate according to certain principles:
- 1. There are morphogens—such as Bicoid and Dorsal—whose gradients determine the specification of different cell types. In syncytial embryos, these morphogens can be transcription factors.
- 2. Boundaries of gene expression can be created by the interaction between transcription factors and their gene targets. Here, the transcription factors transcribed earlier regulate the expression of the next set of genes.
- 3. Translational control is extremely important in the early embryo, and localized mRNAs are critical in patterning the embryo.
- 4. Individual cell fates are not defined immediately. Rather, there is a stepwise specification wherein a given field is divided and subdivided, eventually regulating individual cell fates.
- There is a temporal order wherein different classes of genes are transcribed, and the products of one gene often regulate the expression of another gene.
- Maternal effect genes are responsible for the initiation of anterior-posterior polarity. bicoid mRNA is bound by its 3′UTR to the cytoskeleton in the future anterior pole; nanos mRNA is sequestered by its 3′UTR in the future posterior pole; hunchback and caudal messages are seen throughout the embryo.
- Bicoid and Hunchback proteins activate the genes responsible for the anterior portion of the fly; Caudal activates genes responsible for posterior development.
- The unsegmented anterior and posterior extremities are regulated by the activation of Torso protein at the anterior and posterior poles of the egg.

- The gap genes respond to concentrations of the maternal effect gene proteins. Their protein products interact with each other such that each gap gene protein defines specific regions of the embryo.
- The gap gene proteins activate and repress the pair-rule genes. The pair-rule genes have modular enhancers such that they become activated in seven "stripes." Their boundaries of transcription are defined by the gap genes. The pair-rule genes form seven bands of transcription along the anterior- posterior axis, each one comprising two parasegments.
- The pair-rule gene products activate segment polarity genes engrailed and wingless expression in adjacent cells. The engrailed-expressing cells form the anterior boundary of each parasegment. These cells form a signaling center that organizes the cuticle formation and segmental structure of the embryo.
- Homeotic selector genes are found in two complexes on chromosome III of Drosophila. Together, these regions are called Hom-C, the homeotic gene complex. The genes are arranged in the same order as their transcriptional expression. Genes of the Hom-C specify the individual segments, and mutations in these genes are capable of transforming one segment into another.
- Dorsal-ventral polarity is initiated when the nucleus moves to the dorsal-anterior of the oocyte and sequesters the gurken message, enabling it to synthesize proteins in the dorsal side of the egg.
- Dorsal protein is activated in a gradient as it enters the various nuclei. Those nuclei at the most ventral surface incorporate the most Dorsal protein and become mesoderm; those more lateral become neurogenic ectoderm.
- Organs form at the intersection of dorsal-ventral and anterior-posterior regions of gene expression.

Multiple Choice Questions of Unit VI

Question 1. Eukaryotic genes contains promoters sequences to which RNA Polymerase bind

A. I
B. II
C. III
D. IV
Answer: B

Question 2. Chromatin is made of

A. DNA
B. DNA and RNA
C. DNA+ protein
D. Only RNA
Answer: C

Question 3. Histone methylation is used to

A. Increase gene expression
B. Decrease the gene expression
C. No effect on gene expression
D. Silence the gene expression
Answer: D

Question 4. Enhancers usually activate only genes on the

A. Different chromosome
B. Same chromosome
C. Both A and B
D. All of these
Answer: B

Question 5. A transcription factor usually has

A. 3 domains
B. 2 domains
C. 4 domains
D. 5 domains

Answer: A

Question 6. Pax 6 gene has an important role in Drosophila in

A. Head construction
B. Abdomen construction
C. Thorax construction
D. Eye construction

Answer: D

Question 7. Which technique is also known as Gene editing?

A. CRISPR/CAS9
B. GAL4-UAS Technique
C. CRE-LOX Technique
D. ChIP

Answer: A

Question 8. Which technique allows a researcher to look at entire embryo without sectioning them?

A. ChIP
B. CRE-LOX Technique
C. In Situ hybridization
D. None of these

Answer: C

Question 9. Nanos in Drosophila are a type of

A. t-RNA
B. m-RNA
C. r-RNA
D. None of these
Answer: B

Question 10. Spliceosomes are made up of small heterogeneous nuclear

A. DNA
B. RNA
C. Ribosome
D. Chromatin
Answer: B

Question 11. Bicoid and hunchback represents the signaling center

A. Anterior
B. Posterior
C. Lateral
D. None of these
Answer: A

Question 12. In drosophila gurken gene is located in the cells of

A. Anterior cell
B. Posterior cells
C. Lateral cells
D. None of these
Answer: B

Question 13. Which genes are the first genes in Drosophila which are expressed and encode transcriptional factors?

A. Nanos
B. Bicoid
C. Gap
D. Gruken
Answer: C

Question 14. Pair rule genes in Drosophila, their transcription results in a striped pattern of

A. 4 transverse bands
B. 5 transverse bands
C. 6 transverse bands
D. 7 transverse bands
Answer: D

Question 15. Which gene is pair rule gene in Drosophila?

A. Orthodenticle
B. Kruppel
C. Knirps
D. Fushi-tatazu
Answer: D

Question: 16. Which is of the following a gap gene?

A. Hairy runt
B. Even skipped
C. Buttonhead
D. Paired
Answer: C

Question 17. Which gene is a Homeotic selector genes?

A. Armadillos
B. Pangolin
C. Gooseberry
D. Antennapedia

Answer: D

Question 18. Which gene is considered as anterior morphogen in Drosophila?

A. Torso
B. Nanos
C. Bicoid
D. None of these

Answer: C

Question 19. How many complexes for homeotic selector genes in drosophila?

A. 2
B. 3
C. 4
D. 5

Answer: A

Question 20. In Drosophila, homeotic selector genes are found on chromosome

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

Answer: C

Question 21. The gap gene proteins activate and repress the

A. Homeotic selector genes
B. Pair rule genes
C. Both A & B
D. None of these

Answer: B

Question 22. The pair rule gene products in Drosophila activate

A. Engrailed
B. Bicoid
C. Nanos
D. None of these

Answer: A

Question 23. Sry gene occurs on

A. Small arm of Y chromosome
B. Long arm of X- chromosome
C. Small arm of X chromosome
D. Long arm of Y chromosome

Answer: A

Question 24. Sry gene has a single function as to activate

A. Sox9 gene
B. Sox10 gene
C. Sox 11 gene
D. Sox 12 gene

Answer: A

Question 25. Sry gene in human contains

A. 10 Kb

B. 11Kb

C. 13Kb

D. 14Kb

Answer: D

Question 26. Which is critical in the formation of ovary?

A. Beta catenin

B. Alpha catenin

C. Gamma catenin

D. None of these

Answer: A

Question 27. Wnt4 pathway in sex determination targets follistatin gene which futher act

A. To organizes spermatogonia

B. To organizes the granulosa cells of ovary

C. To maintain prostate gland

D. None of these

Answer: B

Question 28. In *Drosophila*, how many maternal effect genes are involved in pattern formation?

A. 10

B. 20

C. 30

D. 40

Answer: C

Question 29. Whose genes products regulate the formation of posterior parts of embryo of *Drosophila*?

A. Nanos, caudal
B. Bicoid
C. Hunchback
D. All of these
Answer: A

Question 30. Whose gene products regulate the formation of anterior parts of embryo of *Drosophila*?

A. Nanos
B. Caudal
C. Bicoid, hunchback
D. All of these
Answer: C

Question 31. In *Drosophila* development, which genes divide the embryo into broad regions?

A. Segment polarity genes
B. Pair rule genes
C. Gap genes
D. All of these
Answer: C

Question 32. In *Drosophila* development, which genes divide the embryo into stripes about two segments wide?

A. Pair rule genes
B. Gap genes
C. Segment polarity genes
D. None of these
Answer: A

Question 33. In Drosophila development, which genes divide segments into anterior and posterior halves?

A. Gap genes
B. Segment polarity genes
C. Pair rule genes
D. Homeotic genes

Answer: B

Question 34. Which genes determine the identities of the individuals segments?

A. Homeotic selector genes
B. Gap genes
C. Pair rule genes
D. None of these

Answer: A

Question 35. How many homeotic gene clusters are found in Drosophila?

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

Answer: B

Question 36. How many homeotic gene clusters are found in vertebrates?

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

Answer: D

Question 37. Which chromosome contain homeotic gene clusters in Drosophila?

A. First
B. Second
C. Third
D. Four

Answer: C

Question 38. Homeobox is a conserved DNA sequence in homeotic genes of

a. 150 bp
b. 150 bp
c. 170 bp
d. 180 bp

Answer: D

Question 39. Each somatic cell nucleus has the same chromosome and therefore the same set of genes as all other somatic cell nuclei, it is called

A. Allele equivalence
B. Genomic equivalence
C. Cell equivalence
D. None of these

Answer: B

Question 40. A nucleosome consists of

A. Trimer of histones
B. Dimer of histones
C. Octamer of histones
D. None of these

Answer: C

Question 41. Nucleosome contain two loops of DNA having

A. 147 bp
B. 167 bp
C. 157 bp
D. 187 bp
Answer: A

Question 42. In Each Human cell, Nucleosome results in a remarkable packing of more than

A. 8 feet DNA
B. 6 feet DNA
C. 10 Feet DNA
D. 15 Feet DNA
Answer: B

Question 43. Which gene is used to identify enhancer in embryo?

A. Homeotic gene
B. Gap gene
C. Reporter gene
D. None of these
Answer: C

Question 44. Which gene is responsible for the pituitary gland development?

A. Pax
B. Lim
C. POU
D. Hox
Answer: C

Question 45. Which gene encodes a membrane adhesion protein that prevents dendrites from the same neuron from touching?

A. Antennapedia
B. Hunchback
C. DSCAM
D. None of these
Answer: C

Question 46. The *Drosophila* genome contains

A. 11 thousand genes
B. 12 thousand genes
C. 13 thousand genes
D. 14 thousand genes
Answer: D

Question 47. What the percentage of human genes that produce multiple types of mRNA?

A. 70%
B. 80%
C. 92%
D. 60%
Answer: C

Question 48. Human genome contain .....genes

A. 20000
B. 25000
C. 15000
D. 10000
Answer: A

Question 49. A nematode Caenorhabditis elegans contains …….. cells

A. 969

B. 959

C. 979

D. 999

Answer: A

Question 50. Drosha and Dicer is a type of

A. RNases

B. DNases

C. Ligases

D. Hydrolases

Answer: A

UNIT VII

Early Vertebrate Development

UNIT VII Early Vertebrate Development

- Early development of vertebrates (fish, birds & mammals)
- Metamorphosis, regeneration and stem cells
- Environmental regulation of development

- Cleavage in fish is meroblastic. The deep cells of the blastoderm form between the yolk syncytial layer and the enveloping layer. These deep cells migrate over the top of the yolk, forming the hypoblast and epiblast.
- On the future dorsal side, the hypoblast and epiblast intercalate to form the embryonic shield, a structure homologous to the amphibian organizer.
- Transplantation of the embryonic shield into the ventral side of another embryo will cause a second embryonic axis to form.
- In both amphibians and fish, neural ectoderm is permitted to form where the BMP-mediated induction of epidermal tissue is prevented.
- The fish embryonic shield, like the amphibian dorsal blastopore lip, secretes the BMP antagonists.
- Like the amphibian organizer, the shield receives its abilities by being induced by β-catenin and by underlying endodermal cells expressing Nodal-related paracrine factors.
- Reptiles and birds, like fish, undergo discoidal meroblastic cleavage, wherein the early cell divisions do not cut through the yolk of the egg. These early cells form a blastoderm.
- In chick embryos, early cleavage forms an area opaca and an area pellucida. The region between them is the marginal zone.
- Gastrulation begins in the area pellucida next to the posterior marginal zone, as the hypoblast and primitive streak both start there.
- The primitive streak is derived from epiblast cells and the central cells of Koller's sickle. As the primitive streak extends rostrally, Hensen's node is formed.

- Cells migrating out of Hensen's node become prechordal mesendoderm and are followed by the head process and notochord cells.
- The prechordal plate helps induce formation of the forebrain; the chordamesoderm induces formation of the midbrain, hindbrain, and spinal cord.
- The first cells migrating laterally through the primitive streak become endoderm, displacing the hypoblast.
- The mesoderm cells then migrate through the primitive streak. Meanwhile, the surface ectoderm undergoes epiboly around the yolk.
- In birds, gravity helps determine the position of the primitive streak, which points in a posterior-to- anterior direction and whose differentiation establishes the dorsal-ventral axis.
- The left-right axis is formed by the expression of Nodal protein on the left side of the embryo, which signals Pitx2 expression on the left side of developing organs.
- The hypoblast helps determine the body axes of the embryo, and its migration determines the cell movements that accompany formation of the primitive streak and thus its orientation.
- Mammals undergo a variation of holoblastic rotational cleavage that is characterized by a slow rate of cell division, a unique cleavage orientation, lack of divisional synchrony, and formation of a blastocyst.
- The blastocyst forms after the blastomeres undergo compaction. It contains outer cells—the trophoblast cells—that become the chorion, and an inner cell mass that becomes the amnion and the embryo.
- The inner cell mass cells are pluripotent and can be cultured as embryonic stem cells. They give rise to the epiblast and to the visceral endoderm (hypoblast).
- The chorion forms the fetal portion of the placenta, which functions to provide oxygen and nutrition to the embryo, to provide hormones for the maintenance of pregnancy, and to block the potential immune response of the mother to the developing fetus.
- Mammalian gastrulation is not unlike that of birds. There appear to be two signaling centers, one in the node and one in the anterior visceral endoderm.

- The latter center is critical for establishing the body axes, while the former is critical in inducing the nervous system and in patterning axial structures caudally from the midbrain.
- Hox genes pattern the anterior-posterior axis and help specify positions along that axis.
- If Hox genes are knocked out, segment-specific malformations can arise. Similarly, causing the ectopic expression of Hox genes can alter the body axis.
- The homology of gene structure and the similarity of expression patterns between Drosophila and mammalian Hox genes suggest that this patterning mechanism is extremely ancient.
- The mammalian left-right axis is specified similarly to that of the chick, but with some significant differences in the roles of certain genes.
- In amniote gastrulation, the pluripotent epithelium, or epiblast, produces the mesoderm and endoderm, which migrate through the primitive streak, and the precursors of the ectoderm, which remain on the surface.
- By the end of gastrulation, the head and anterior trunk structures are formed. Elongation of the embryo continues through precursor cells in the caudal epiblast surrounding the posteriorized Hensen's node.
- In each class of vertebrates, neural ectoderm is permitted to form where the BMP-mediated induction of epidermal tissue is prevented.
- Fraternal twins arise from two separate fertilization events. Identical twins result from the splitting of the embryo into two cellular groups during stages where there are still pluripotent cells in the embryo.
- Experimental evidence suggests that conjoined twins may occur through the formation of two organizers within a common blastodisc.
- Amphibian metamorphosis includes both morphological and biochemical changes.
- Some structures are remodeled, some are replaced, and some new structures are formed.

- The hormone responsible for amphibian metamorphosis is tri-iodothyronine (T3). The synthesis of T3 from thyroxine (T4) and the degradation of T3 by deiodinases can regulate metamorphosis in different tissues.
- T3 binds to thyroid hormone receptors and acts predominantly at the transcriptional level.
- Many changes during amphibian metamorphosis are regionally specific. The tail muscles degenerate; the trunk muscles persist.
- An eye will persist even if transplanted into a degenerating tail.
- Metamorphic change in amphibians can be brought about by cell death, cell differentiation, or by cell-type switching.
- The specific timing of metamorphic events can be orchestrated by the different events occurring at different levels of thyroid hormones.
- Animals with direct development do not have a larval stage.
- Primary larvae (such as those of sea urchins) specify their body axes differently than the adult, whereas secondary larvae (such as those of insects and amphibians) have body axes that are the same as adults of the species.
- Ametabolous insects undergo direct development. Hemimetabolous insects pass through nymph stages wherein the immature organism is usually a smaller version of the adult.
- In holometabolous insects, there is a dramatic metamorphosis from larva to pupa to sexually mature adult.
- In the stages between larval molts, the larva is called an instar. After the last instar, the larva undergoes a metamorphic molt to become a pupa. The pupa undergoes an imaginal molt to become an adult.
- During the pupal stage, the imaginal discs and histoblasts grow and differentiate to produce the structures of the adult body.
- The anterior-posterior, dorsal-ventral, and proximal-distal axes are sequentially specified by interactions between different compartments in the imaginal discs.
- The disc “telescopes out” during development, its central regions becoming distal.
- Molting is caused by the hormone 20-hydroxyecdysone (20E). In the presence of high levels of juvenile hormone, the molt gives rise to another larval instar.

- In low concentrations of juvenile hormone, the molt produces a pupa; if no juvenile hormone is present, the molt is an imaginal molt.
- The ecdysone receptors are almost identical in structure to the thyroid hormone receptors of amphibians and are evolutionarily related to these receptors.
- The ecdysone receptor gene that can form at least three different proteins.
- The types of ecdysone receptors in a cell may influence the response of that cell to 20E.
- The ecdysone receptors bind to DNA to activate or repress transcription.
- There are four modes of regeneration. In stem-cell mediated regeneration (characteristic of planarians), new cells are routinely produced to replace the ones that die.
- In epimorphosis (seen in regenerating salamander limbs and fish fins), tissues form a regeneration blastema, divide, and redifferentiate into the new structure.
- In morphallaxis (characteristic of hydra), there is a re-patterning of existing tissue with little or no growth.
- In compensatory regeneration (as in the mammalian liver), cells divide but retain their differentiated state.
- Regeneration has been seen in sponges, which may be related to our most basal ancestors.
- However, whether all regenerative abilities today are derived from a basal ancestor or whether the tree of life is filled with examples of the convergent evolution of regeneration remains to be determined.
- Plants can follow both indirect and direct paths for totipotent regeneration through the transdifferentiation of mature cells or the establishment of de novo meristems.
- Hydra appear to have a head activation gradient and a foot activation gradient.
- In planarian flatworms, regeneration occurs by forming a regeneration blastema produced by pluripotent clonogenic neoblasts.
- Gradients of positional control genes such as Wnt appear to direct the anterior-posterior differentiation of these cells in a pattern regulated by the head-expressed Wnt inhibitor Notum.

- In the regenerating limb blastemas of amphibians, cells do not become multipotent.
- Rather, cells retain their specifications, with cartilage arising from preexisting cartilage, neurons coming from preexisting neurons, and muscles coming either from preexisting muscle cells or from muscle stem cells.
- Mitogens such as Neuregulin-1 are provided by the innervating nerves and are capable of inducing the regeneration of limbs even in the absence of nerves.
- Salamander limb regeneration appears to use the same pattern-formation system as the developing limb.
- Multiple modes of regeneration have been discovered to operate in zebrafish.
- Distal regeneration of the zebrafish fin occurs largely through the dedifferentiation of existing cell types followed by the active proliferation of a blastema-like outgrowth.
- Zebrafish heart tissue also employs an initial mode of epimorphosis followed by a compensatory regenerative period of proliferation and transdifferentiation.
- In the mammalian liver, no regenerating blastema is formed, and the liver regenerates the same volume as it lost.
- Each cell appears to generate its own cell type. A reserve population of multipotent progenitor cells divides when these tissues cannot regenerate the missing portions.
- The African spiny mouse has revealed the importance of macrophages in promoting a regenerative environment that prevents fibrotic scar formation.
- A stem cell maintains the ability to divide to produce a copy of itself as well as generating progenitor cells capable of maturing into different cell types.
- Stem cell potential refers to the range of cell types a stem cell can produce. A totipotent stem cell can generate all cell types of both embryonic and extraembryonic lineages.
- Pluripotent and multipotent stem cells produce restricted lineages of just the embryo and of only select tissues or organs, respectively.
- Adult stem cells reside in microenvironments called stem cell niches.

- Most organs and tissues possess stem cell niches, such as the germ cell, hematopoietic, gut epithelial, and ventricular-subventricular niches.
- The niche employs a variety of mechanisms of cell-to-cell communication to regulate the quiescent, proliferative, and differentiative states of the resident stem cell.
- The shoot apical and root apical meristems provide a continuous source of totipotent stem cells for a plant to generate a majority of its aerial and ground tissues throughout life.
- Cross-repressive transcription factor systems (WUS and REV versus PLT) determine shoot and root meristem identities in the Arabidopsis thaliana embryo.
- Negative feedback mechanisms govern the ability to establish a balance between the stem cell pool and differentiation in the shoot apical meristem.
- Inner cell mass (ICM) cells of the mouse blastocyst are maintained in a pluripotent state through E-cadherin interactions with trophectoderm cells that activate the Hippo kinase cascade and repress the function of Yap/Taz as transcriptional regulators of Cdx2.
- Cadherin links the germ stem cells of the Drosophila oocyte to the niche, keeping them within fields of TGF-β.
- Asymmetric divisions push daughter cells out of this niche to promote cell differentiation of germ cells.
- The ventricular-subventricular zone (V-SVZ) of the mammalian brain represents a complex niche architecture of B type stem cells arranged in a “pinwheel” organization, with a primary cilium at the apical surface and long radial processes that terminate with a basal end foot.
- Constant Notch activity in the V-SVZ niche keeps B cells in the quiescent state, whereas increasing oscillations of Notch activity versus proneural gene expression progressively promote maturation of B cells to transit-amplifying C cells and then into migrating neural progenitors (A cells).
- Additional signals—from neural activity and substances like GDF11 from blood vessels to gradients of Shh, BMP4, and Noggin—all influence cell proliferation and differentiation of B cells in the V-SVZ niche.

- The columnar cells located at the base of the intestinal crypt serve as clonogenic stem cells for the gut epithelium, which generates transit-amplifying epithelial cells that slowly differentiate as they are pushed farther up the villus.
- Wnt signals at the base of the crypt maintain stem cell proliferation, whereas opposing gradients of BMP from the cells at the top of the crypt induce differentiation.
- Adhesion to osteoblasts keeps the hematopoietic stem cell (HSC) quiescent in the endosteal niche.
- Increased exposure to CXCL12 signals from CAR cells and mesenchymal stem cells can transition HSCs into proliferative behavior, yet downregulation of CXCL12 in the perivascular niche encourages migration of short-term active HSCs into the oxygen-rich blood vessels.
- Mesenchymal stem cells can be found in a variety of tissues, including connective tissue, muscle, cornea, dental pulp, bone, and more.
- They play dual roles as supportive stromal cells and multipotent stem cells.
- Embryonic and induced pluripotent stem cells can be maintained in culture indefinitely and, when exposed to certain combinations of factors and/or constrained by the physical growth substrate, can be coaxed to differentiate into potentially any cell type of the body.
- Embryonic stem cells (ESCs) and induced pluripotent stem cells (iPSCs) are being used to study human cell development and diseases.
- The use of stem cells to study patient-specific cell differentiation of the rare blood disorder Fanconi anemia or disorders of the nervous system like autism and ALS have already started to provide novel insight into disease mechanisms.
- Pluripotent stem cells can also be used in regenerative medicine to rebuild tissues and to make structures called organoids, which seem to possess many of the multicellular hallmarks of human organs.
- Organoids are being used to study human organogenesis and patient-specific disease progression on the tissue level, all in vitro.
- The environment plays critical roles during normal development. These agents include temperature, diet, and the presence of predators.

- Developmental plasticity makes it possible for environmental circumstances to elicit different phenotypes from the same genotype.
- Reaction norms are phenotypes that quantitatively respond to environmental conditions, such that the phenotype reflects small differences in the environmental conditions.
- Polyphenisms represent "either/or" phenotypes; that is, one set of conditions elicits one phenotype, while another set of conditions elicits another.
- Seasonal cues such as photoperiod, temperature, or type of food can alter development in ways that make the organism more fit under the conditions it encounters.
- Changes in temperature also are responsible for determining sex in several organisms, including many reptiles and fish.
- Predator-induced polyphenisms have evolved such that prey species can respond morphologically to the presence of a specific predator.
- Gene expression can be influenced by environmental factors by methylating genes differentially, inducing gene expression in surrounding cells, and being monitored by the nervous system, which then produces hormones that affect gene expression.
- Behavioral phenotypes can also be induced by the environment. Conditions experienced as the brain matures after birth can alter patterns of DNA methylation and thereby change hormone reception and behaviors.
- Changes in the environment (such as warming) can be dangerous to those organisms whose life cycles are predicated on specific conditions, such as temperature or prey species.
- Organisms usually develop with symbiotic organisms, and signals from the symbionts can be critical for normal development.
- Symbionts can be acquired horizontally (through infection) or vertically (through the oocyte).
- In an obligate mutualism, both partners are needed for the survival of the other; in an obligate developmental mutualism, at least one partner is needed for the proper development of another.

- Plant symbioses are crucial for life on Earth. They convert nitrogen to a form that can be used to support plant growth and sustain the organisms of terrestrial, marine, and aquatic ecosystems.
- Symbioses are critical for organisms to go from one life cycle stage to another. The metamorphoses of many invertebrates from larval to adult stages depend on symbionts.
- The mammalian gut contains symbionts that actively regulate intestinal gene expression needed for intestinal development and function.
- Without these symbionts, the intestinal blood vessels and gut-associated lymphoid tissue of some mammalian species fail to form properly.
- Symbionts can induce normal gene expression in hosts, and the host phenotype is deficient without the bacteria-induced patterns of gene expression.
- In vertebrates, the differentiation of certain immune cells, gut cells, and neural cells may depend on symbiont-induced gene expression.

Multiple choice Questions (MCQs) of Unit VII

Question 1. For study of developmental biology which fish is considered as the best model for the experiments

A. Labeo
B. Catla
C. Clarius
D. Zebra fish
Answer: D

Question 2. In bony fishes, the egg is

A. Centrolecithal
B. Telolecithal
C. Alecithal
D. None of these
Answer: B

Question 3. The cleavage in fishes is

A. Superficial
B. Spiral
C. Meroblastic
D. None of these
Answer: C

Question 4. Germ ring in fishes results from

A. Epiblast
B. Hypoblast
C. Both A & B
D. None of these
Answer: A

Question 5. Niewkoop centre in fishes is located in

A. Embryonic shield
B. Neural keel
C. Germ ring
D. None of these

Answer: A

Question 6. Embryonic shield of fish is homologous to the

A. Lateral blastopore lip
B. Dorsal blastopore lip
C. Ventral blastopore lip
D. None of these

Answer: B

Question 7. The function of allantois in mammals is

A. Digestion
B. respiration
C. Excretion
D. None of these

Answer: C

Question 8. The yolky eggs of birds undergo

A. Spiral cleavage
B. Superficial cleavage
C. Discoidal meroblastic cleavage
D. None of these

Answer: C

Question 9. A cavity is created when the blastoderm cells absorb water from the albumin and secrete a fluid between themselves and the yolk in birds' development is

A. Coelom
B. Blastocoel
C. Subgerminal cavity
D. All of these

Answer: C

Question 10. At the time of egg laying by hen, its blastoderm contains some

A. 20,000 cells
B. 30,000 cells
C. 40,000 cells
D. 50,000 cells

Answer: D

Question 11. Cell fate in bird's embryo can be determined through

A. Area opaca
B. Area pellucida
C. Marginal zone
D. Subgerminal cavity

Answer: C

Question 12. Which part of the embryo of bird is 1 cell thick?

A. Marginal zone
B. Area pellucida
C. Area opaca
D. None of these

Answer: B

Question 13. The avian embryo comes entirely from

A. Epiblast
B. Hypoblast
C. Marginal zone
D. All of these

Answer: A

Question 14. Koller's sickle appears at ..... edge of area pellucida

A. Anterior
B. Posterior
C. Lateral
D. Ventral

Answer: B

Question 15. Avian gastrulation take place through

A. Blastopore
B. Area opaca
C. Subgerminal cavity
D. Primitive streak

Answer: D

Question 16. The primitive groove in birds is homologous to the amphibian

A. Blatocoel
B. Blastopore
C. Both of these
D. None of these

Answer: B

Question 17. The primitive streak in birds is homologous to the amphibian

A. Archenteron
B. Blastocoel
C. Blastopore lip
D. Blastopore

Answer: C

Question 18. Hensen's node in the embryo of bird's is functionally equivalent to ..... lip of blastopore of amphibian

A. Ventral
B. Dorsal
C. Lateral
D. All of these

Answer: B

Question 19. Hensen's node in the embryo of bird's is functionally equivalent to which part of embryo of fish?

A. Embryonic shield
B. Blastoderm
C. Hypoblast
D. Epiblast

Answer: A

Question 20. The axis of bird's primitive streak is equivalent to the ..... axis of amphibians

A. Ventral dorsal
B. Dorsal ventral
C. Lateral ventral
D. Lateral lateral

Answer: B

Question 21. Which part is produced by the Hensen's node?

A. Notochord
B. Somites
C. Heart
D. Kidney

Answer: A

Question 22. How much primitive streak extends of the length of the area pellucida?

A. 50-55%
B. 55-60%
C. 40-45%
D. 60-75%

Answer: D

Question 23. In avian embryo, which part is considered as Nieuwkoop centre in amphibians?

A. Posterior marginal zone
B. Anterior marginal zone
C. Lateral marginal zone
D. None of these

Answer: A

Question 24. The human zygote has a diameter of

A. 200 µm
B. 100 µm
C. 300 µm
D. 500 µm

Answer: B

Question 25. In mammals, the part where fertilization take place?

A. Isthumus
B. Uterus
C. Ampulla
D. Infundibulum

Answer: C

Question 26. In which group of embryo, the blastomeres do not divide exponentially?

A. Fishes
B. Aves
C. Mammals
D. Reptiles

Answer: C

Question 27. In mammals, in the second cleavage, one of the two blastomeres divides meridionally and the other divides equatorially, this cleavage is called

A. Spiral cleavage
B. Determinate cleavage
C. Superficial cleavage
D. Rotational cleavage

Answer: D

Question 28. In mammals, after 3rd cleavage the blastomeres form a compact ball of cells having tightly packed arrangement involving E-cadherin, the phenomenon is known as

A. Involution
B. Ingression
C. Compaction
D. None of these

Answer: C

Question 29. Mammalian morula is

A. 8 celled

B. 4 celled

C. 12 celled

D. 16 celled

Answer: D

Question 30. The part which give rise to the embryo in mammals, is

A. Trophoblast

B. Trophoectoderm

C. Inner cell mass

D. None of these

Answer: C

Question 31. Mammalian blastula is called

A. Blastocyst

B. Amphiblastula

C. Discoblastula

D. Meroblastula

Answer: A

Question 32. The cells of the inner cell mass are said to be

A. Totipotent

B. Unipotent

C. Pluripotent

D. Bipotent

Answer: C

Question 33. Hox genes do specify which type of polarity in vertebrates?

A. Anterior posterior
B. Posterior anterior
C. Both
D. None of these

Answer: A

Question 34. Amphibian metamorphosis is initiated by the hormones

A. Only T3
B. Only T4
C. Both T3 and T4
D. None of these

Answer: C

Question 35. When regeneration occurs through the re-patterning of the existing tissues, then such regeneration is called

A. Compensatory
B. Morphallaxis
C. Epimorphosis
D. Stem cell mediated

Answer: B

Question 36. In which type of regeneration, blastema formation take place?

A. Morphallaxis
B. Compensatory
C. Stem cell mediated
D. Epimorphosis

Answer: D

Question 37. The morphallaxis is shown by

A. Mammals
B. Amphibians
C. Hydra
D. None of these

Answer: C

Question 38. Mammalian liver shows which type of regeneration?

A. Compensatory
B. Epimorphosis
C. Morphallaxis
D. Stem cell mediated

Answer: A

Question 39. In Hydra during regeneration which part acts as organizer?

A. Tentacles
B. Hypostome
C. Coelenteron
D. Hypodermis

Answer: B

Question 40. Salamander's limb can be regenerated by

A. Stem cell mediated
B. Compensatory
C. Epimorphosis
D. Morphallaxis

Answer: C

Question 41. In mammals, whose cells are totipotent?

A. Blastula
B. Gastrula
C. Zygote and 4-8 cell stage
D. Morula

Answer: C

Question 42. Organoids are the structures which are made from

A. Totipotent cells
B. Multipotent cells
C. Mesenchymal cells
D. Pluripotent cells

Answer: D

Question 43. The ability of an organism to react to an environmental input with a change in form, state, movement or rate of the activity is known as

A. Developmental plasticity
B. Phenotypic plasticity
C. Both a and b
D. None of these

Answer: B

Question 44. Sex determination in turtles by temperature is the example of

A. Polyphenism
B. Developmental plasticity
C. Symbiosis
D. None of these

Answer: A

Question 45. The part of sperm to contain proteolytic enzymes is

A. Acrosome
B. Nucleus
C. Middle piece
D. Tail

Answer: A

Question 46. Haploid nuclei that fuse at the time of fertilization are called

A. Centrioles
B. Nucleoli
C. Homunculi
D. Pronuclei

Answer: D

Question 47. The first week of human development is characterized by the formation of

A. Blastocyst
B. Trophoblast
C. ICM
D. All of these

Answer: D

Question 48. The most common site for implantation in ectopic pregnancy is

A. Ovary
B. Mesentry
C. Fallopian tube
D. None of these

Answer: C

Question 49. During 2nd week of development in human, trophoblast differentiate into

A. Ectoderm
B. Syncytiotrophoblast
C. Yolk sac
D. mesoderm

Answer: B

Question 50. In human development, the blastocoel becomes

A. primary yolk sac
B. amniotic cavity
C. chorionic cavity
D. secondary cavity

answer: A

UNIT VIII

Late Developmental Processes

UNIT VIII Late Developmental Processes

- The dynamics of organ development: Development of eye,
- Metamorphosis: the hormonal reactivation of development in amphibians
- Regeneration: salamander limbs, Hydra
- Aging: the biology of senescence

- The most basic parts of the embryonic vertebrate eye include the retinal pigmented epithelium, the neural retina, and the lens.
- While the retinal pigmented epithelium and the neural retina arise from the central nervous system, the lens, which starts out as a lens placode, is derived from the non-neural ectoderm.
- Unlike most other sensory placodes, the lens placode does not form neurons. Rather, it forms the transparent lens that focuses incoming light onto the neural retina.
- The retina develops from the optic vesicle that forms as a lateral bulge of the diencephalon, a region of the forebrain.
- The interactions between the cells of the lens placode and the presumptive retina structure the eye via a cascade of reciprocal signaling events that enable the construction of an intricately complex organ.
- During gastrulation, the involuting prechordal plate and foregut endoderm interact with the overlying pre-placodal region, inducing it to have an anterior character and conferring upon it a lens-forming bias.
- These tissues induce a number of anterior genes, including Pax6, which codes for a transcription factor that is critical for the ectoderm to respond to subsequent signals.
- Interestingly, the entire pre-placodal region is initially specified as lens, even cells that normally form the ear or other placodes.

- Since not all parts of the pre-placodal region eventually form lenses, lens fate must be repressed so that the lens only forms with a precise spatial relationship to the retina.
- The repression of lens potential is achieved by migrating neural crest cells.
- These neural crest cells are blocked from making contact with the pre-lens region by the outgrowing optic vesicle. This, along with signals from the optic vesicle, positions the lens in relation to the retina.
- The optic vesicle, where it contacts the head ectoderm, causes changes in cell shape that create a thickened lens placode.
- The optic vesicle then bends inward, invaginating to form the two-layered optic cup, and, in so doing, draws the developing lens into the forming eye.
- This invagination is accomplished by three changes: (1) The cells of the lens placode extend adhesive filopodia to contact the optic vesicle. (2) The cells at the edge of the invaginating layer undergo basal constriction. (3) Meanwhile, the cells at the center of the invaginating layer undergo apical constriction.
- As the optic vesicle becomes the optic cup, its two layers differentiate.
- The cells of the outer layer produce melanin (being one of the few tissues other than the neural crest cells that can form this pigment) and ultimately become the retinal pigmented epithelium.
- The cells of the inner layer proliferate rapidly and generate a variety of glial cells, ganglion cells, interneurons, and light-sensitive photoreceptor neurons that collectively constitute the neural retina.
- While the photoreceptors are responsible for light perception, the retinal ganglion cells are neurons that transmit this information to the brain.
- Their axons meet at the base of the eye and travel down the optic stalk, which is then called the optic nerve.
- Cross talk between the inner cells of the optic cup (which will become the neural retina) and the lens placode is required for retina differentiation, lens vesicle formation, and lens epithelial and fiber cell differentiation.
- The metamorphic changes of frog development are brought about by (1) the secretion of the hormone thyroxine (T4) into the blood by the thyroid gland; (2) the

conversion of T4 into the more active hormone, tri- iodothyronine (T3) by the target tissues; and (3) the degradation of T3 in the target tissues.

- Once inside the cell, T3 binds to the nuclear thyroid hormone receptors (TRs) with much higher affinity than does T4 and causes these transcription factors to become transcriptional activators of gene expression.
- Thus, the levels of both T3 and TRs in the target tissues are essential for producing the metamorphic response in each tissue.
- The concentration of T3 in each tissue is regulated by the concentration of T4 in the blood and by two critical intracellular enzymes that remove iodine atoms from T4 and T3.
- Type II deiodinase removes an iodine atom from the outer ring of the precursor hormone (T4) to convert it into the more active hormone T3.
- Type III deiodinase removes an iodine atom from the inner ring of T3 to convert it into an inactive compound (T2) that will eventually be metabolized to tyrosin.
- Tadpoles that are genetically modified to overexpress type III deiodinase in their target tissues never complete metamorphosis; therefore, the regulation of metamorphosis involves tissue-specific regulation of the form of the hormone that binds most effectively to its receptor.
- Thyroid hormone receptors are nuclear proteins, and there are two major types. In Xenopus, thyroid hormone receptor α (TRα) is widely distributed throughout all tissues and is present even before the organism has a thyroid gland.
- Yet, in an example of a positive feedback loop, the gene encoding thyroid hormone receptor β (TRβ) is itself directly activated by TRβ bound to thyroid hormone.
- TRβ levels are very low before the advent of metamorphosis; as the levels of thyroid hormone increase during metamorphosis, so do intracellular levels of TRβ.
- This positive regulation of hormone receptor gene expression by its own gene product is a common feature of metamorphosis across animal taxa.
- Limb regeneration in salamanders is powered by the formation of the regeneration blastema at the distalmost end of the amputated limb.

- As is similar in planarians, the blastema is an aggregation of relatively undifferentiated cells. The stages of limb regeneration in the salamander are as follows:
- Blood and immune cells flood the amputated area, and a blood clot quickly forms.
- Wounding triggers an activation of stem/progenitor cell proliferation.
- Epidermal cells along the edge of the cut migrate over the wound to form the wound epidermis.
- Through cell proliferation and continued migration, the wound epidermis thickens into the apical epidermal cap (AEC).
- Signals from the AEC to the amassing population of progenitor cells underneath it foster development of the regeneration blastema.
- Continued proliferation and progressive differentiation of the blastema fuel the outgrowth of the limb regenerate.
- Hydras are diploblastic animals, having only ectoderm and endoderm. Their two epithelial layers are referred to as myoepithelia because they possess characteristics of both epithelial and muscle cells.
- Although hydras lack a true mesoderm, they do contain secretory cells, gametes, stinging cells (nematocytes), and neurons that are not part of the two epithelial layers.
- Hydras can reproduce sexually, but they do so only under adverse conditions (such as crowding or cold temperatures).
- They usually multiply asexually, by budding off a new individual. The buds form about two-thirds of the way down the animal's body axis.
- A hydra's body is not particularly stable. In humans and flies, for instance, a skin cell in the body's trunk is not expected to migrate and eventually be sloughed off from the face or foot—but that is exactly what happens in hydra.
- The cells of the body column are constantly undergoing mitosis and are eventually displaced to the extremities of the column, from which they are shed.
- Thus, each cell plays several roles, depending on how old it is, and the signals specifying cell fate must be active all the time. In a sense, a hydra's body is always regenerating.

- This cellular replacement is generated from three cell types. Endodermal and ectodermal cells are unipotent progenitor cells that divide continuously, producing more lineage-restricted epithelia. The third cell type is a multipotent interstitial stem cell found within the ectodermal layer.
- This stem cell generates neurons, secretory cells, nematocytes, and gametes. The most significant cell proliferation by each of these three types of stem cells occurs within the central region of the body, after which displaced myoepithelia and migrating interstitial progeny move to and differentiate at the apical and basal extremities.
- Compared with the myoepithelial stem cells (endoderm and ectoderm), interstitial stem cells are paused in G2 phase of the cell cycle for a longer period and cycle at a faster rate suggesting that the interstitial stem cells are poised to immediately respond to a need for cell replacement through rapid proliferation.
- These three cell types are all that are needed to form a hydra, and if hydra cells are separated and reaggregated, a new hydra will form.
- The maximum life span of a species is the longest time an individual of that species has been observed to survive.
- Life expectancy is usually defined as the age at which approximately 50% of the members of a given population still survive.
- Aging is the time-related deterioration of the physiological functions necessary for survival and reproduction.
- The phenotypic changes of senescence (which affect all members of a species) are not to be confused with diseases of senescence, such as cancer and heart disease (which affect some individuals but not others).
- Reactive oxygen species (ROS) can damage cell membranes, inactivate proteins, and mutate DNA.
- Mutations that alter the ability to make or degrade ROS can change the life span.
- Proteins that regulate DNA repair and cell division (such as p53 and telomerase) may be important regulators of aging.
- An insulin signaling pathway, involving a receptor for insulin and insulin-like proteins, may be an important component of genetically limited life spans.

- It may upregulate mTORC1 and downregulate Foxo transcription factors.
- Random DNA methylation appears to repress gene expression as a cell ages. Enzymes involved with chromatin modification may be important mediators of such aging events.
- In many cases, the aging phenotype is the result of apoptosis of stem cells or progenitor cells.
- A few animal species (such as turtles) display “negligible senescence” in that their mortality rates do not increase nor do reproductive rates decrease with age.
- Some cnidarian species appear to be potentially immortal.

Multiple Choice Questions (MCQs) of Unit VIII

Question 1. The retina develops from which part of brain

A. Fore brain
B. Mid brain
C. Hind brain
D. All of these
Answer: A

Question 2. Pax 6 is a very critical factor in the development of

A. Heart
B. Brain
C. Eye
D. Kidney
Answer: C

Question 3. Optic vesicles extend from which part of the fore brain?

A. Olfactory lobes
B. Cerebral hemispheres
C. Carpus callosum
D. Diencephalon
Answer: D

Question 4. When the optic vesicle contacts the head ectoderm, it induces the ectoderm to lengthen and form

A. Retina
B. Iris
C. Lens placode
D. Optic nerve
Answer: C

Question 5. Optic vesicles in the development of eye forms

A. optic cup
B. optic rod
C. optic nerve
D. none of these

Answer: A

Question 6. Which pathway plays an important role in the formation of retina?

A. BMP
B. Wnt
C. Noggin
D. None of these

Answer: C

Question 7. If Shh gene is mutated, then the single median eye field does not split and results in

A. Glaucoma
B. Cataract
C. Cyclopia
D. None of these

Answer: C

Question 8. Shh is synthesized by

A. Hypothalamus
B. Notochord
C. Metencephalon
D. Prechordal plate

Answer: D

Question 9. Crystallins protein is found in

A. Retina
B. Optic nerve
C. Lens
D. Cornea

Answer: C

Question 10. Which protein is essential closing of the lens vesicle?

A. Dickkof
B. Otx2
C. Lens1
D. None of these

Answer: C

Question 11. Corneal repair and regeneration is due to

A. Ferritin protein and a layer of basal cells
B. Only ferritin protein
C. UV light
D. None of these

Answer: A

Question 12. The tip of the optic cup on either side of the lens develop into

A. Neural retina
B. Choroid
C. Iris
D. Macula lutea

Answer: C

Question 13. Which organ' development represents the best example of reciprocal embryonic induction?

A. Liver
B. Pancreas
C. Pituitary
D. Eye

Answer: D

Question 14. The control of amphibian metamorphosis by thyroid hormones was first demonstrated by

A. Atkinson
B. Cohen
C. Allen
D. Gudernatsch

Answer: D

Question 15. During metamorphosis, T4 hormone is changed into T3 in the presence of an enzyme

A. Type I deiodinase
B. Type II deiodinase
C. Type III deiodinase
D. Type IV deiodinase

Answer: B

Question 16. T3 hormone is changed into T2 hormone in the presence of

A. Type IV deiodinase
B. Type III deiodinase
C. Type I deiodinase
D. Type II deiodinase

Answer: B

Question 17. Type II deiodinase removes an iodine atom from

A. Inner ring of T4
B. Outer ring of T4
C. Side ring of T4
D. None of these

Answer: B

Question 18. Type III deiodinase remove an iodine atom from the

A. Side ring of T3
B. Outer ring of T3
C. Inner ring of T3
D. Answer: C

Question 19. Thyroid receptors are

A. Cytoplasmic proteins
B. Cell membrane proteins
C. Nuclear proteins
D. None of these

Answer: C

Question 20. How many types of Thyroid hormone receptors are found in amphibians?

A. Two
B. Three
C. Four
D. Five

Answer: A

Question 21. The apical basal axis in Hydra regenerates to form

A. Head
B. Foot
C. Both head and foot
D. None of these

Answer: C

Question 22. The main head inducer of the hypostome organizer is

A. A set of Wnt proteins
B. A set of catenin proteins
C. A set of noggin proteins
D. None of these

Answer: A

Question 23. Planarians flatworms can reproduce asexually by

A. Budding
B. Binary fission
C. Both A and B
D. None of these

Answer: B

Question 24. Which cells act as stem cells in the regeneration of Planaria?

A. cNeoblast
B. epidermal cells
C. gut cells
D. none of these

Answer: A

Question 25. In Salamander, if the limb is amputated, then it forms a new wrist and foot but not a new

A. fingers
B. elbow
C. both a and b
D. none of these
Answer: B

Question 26. The growth of the regeneration blastema depends on the presence of

A. apical epidermal cap
B. nerves
C. Both A and B
D. None of these
Answer: C

Question 27. If the limb of Salamander is first denervated and then amputated, regeneration

A. Regeneration will occur
B. Regeneration will not occur
C. Can not say
D. None of these
Answer: B

Question 28. The name of premature aging syndromes in humans called

A. Down's Syndrome
B. Progeria
C. Edward syndrome
D. None of these
Answer: B

Question 29. Which theory of aging is considered as the oldest hypothesis?

A. Wear and tear theory
B. Endocrine theory
C. Immunological theory
D. Damage and error theory

Answer: A

Question 30. The enzyme complex that maintains telomere integrity is

A. Oxidases
B. Hydrolases
C. Telomerase
D. Ligases

Answer: C

Question 31. Which enzyme can destroy reactive oxygen species (ROS)?

A. Pepsin
B. Trypsin
C. Chymotrypsin
D. Catalase

Answer: D

Question 32. Which transcription factor is one of the most important regulator of cell division?

A. P53
B. P52
C. P54
D. P55

Answer: A

Question 33. In Caenorhabditis elegans, in absence of food larva can enter in a dormant stage namely

A. Dauer larva
B. Rhabditiform larva
C. Filariform larva
D. None of these

Answer: A

Question 34. The pathway that regulate dauer larva formation is identified as

A. Glucagon signaling pathway
B. Somatostatin Signaling Pathway
C. Insulin Signaling pathway
D. None of these

Answer: C

Question 35. Dauer larva stage is a nonfeeding state of diapause in which

A. Development is suspended
B. Aging is suspended
C. Both are suspended
D. None of these

Answer: C

Question 36. In Caenorhabditis elegans, poor environments signal activation of DAF-2 results in

A. Formation of larva
B. Larva will not form
C. Both A and B
D. None of these

Answer: A

Question 37. mTORC1 is a

A. Protein kinase complex
B. Carbohydrate complex
C. A lipid complex
D. None of these

Answer: A

Question 38. Which can increases the amount of autophagy during aging?

A. Increasing mTORC1
B. Reducing mTORC1
C. No relation with it
D. None of these

Answer: B

Question 39. Which gene encode histone deacetylation enzymes?

A. Pax gene
B. Sry gene
C. Vox gene
D. Sirtuin gene

Answer: D

Question 40. Sirtuins help in repair of

A. DNA breaks
B. RNA breaks
C. Protein breaks
D. Chromatin breaks

Answer: D

Question 41. Long term memories are stabilized by chromatin remodeling in the

A. hippocampus and frontal lobe
B. Cerebellum
C. Parietal lobe
D. Hypothalamus

Answer: A

Question 42. The specialized blood vessels of the liver also produce

A. HGF
B. Wnt2
C. Both A and B
D. None of these

Question 43. Which protein can cause blastema cells to proliferate in culture in Salamander limb regeneration?

A. Keratin
B. Myosin
C. Actin
D. nAG

Answer: D

Question 44. Interstitial cells of Hydra are

A. Multipotent
B. Totipotent
C. Pluripotent
D. Unipotent

Answer: A

Question 45. Endodermal cells of Hydra are

A. Unipotent
B. Pluripotent
C. Multipotent
D. None of these

Answer: A

Question 46. In vertebrate eye, the elongation and curvature of lens fibers are controlled by

A. Rho family GTPases
B. ATPases
C. ADPases
D. All of these

Answer: A

Question 47. Which part of body respond to the signals from the optic vesicle?

A. Trunk ectoderm
B. Neck ectoderm
C. Head ectoderm
D. None of these

Answer: C

Question 48. Which is called lens inducer?

A. Cerebrum
B. Olfactory lobe
C. Cerebellum
D. Optic vesicle

Answer: D

Question 49. Aniridia is the condition of eye in the absence of Pax 6 which characterizes the absence of

A. Ciliary body
B. Iris
C. Pupil
D. Retina

Answer: B

Question 50. When a signal from the inducing cell is necessary for initiating new gene expression in the responding cell, such interaction is called

A. Instructive
B. Permissive
C. Both A and B
D. None of these

Answer: A

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