

Contents

Module - 13 (Genetics & Evolution)

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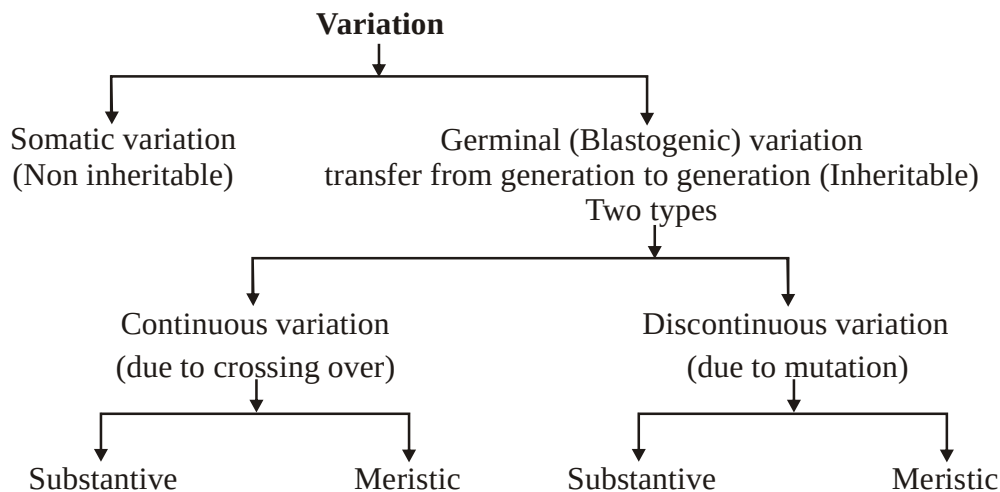
GENETICS

Genetics term was given by **W.Bateson**. (1905) (Father of Modern Genetics).

Genetics = Branch of biology which deals with the study of heredity and variation

Heredity – Transmission of genetic characters from generation to generation.

Variation – Individuals of same species have some difference, these are called variation.



INHERITANCE : HEREDITY AND VARIATIONS

HEREDITY : It is the transmission of genetic characters from parents to the offsprings. It deals with the phenomenon of “like begets like” e.g., human babies are like human beings in overall characteristics.

VARIATIONS : Variations are common in sexually reproducing organisms. Variations are of following two types :

1. **Somatogenic** : These are acquired variations and are non-inheritable in nature. The ability of an organism to alter its phenotype in response to environment is called **phenotypic plasticity**.
- A. **Blastogenic Variations** : These are germinal variations and are hereditary in nature. They are again of two types:
 - (a) **Continuous variations** : These are the fluctuating variations and can not give rise to new species. These are further of two types
 - i. **Substantive** : Variation in size, shape and colour of organism.
 - ii. **Meristic** : Variation in number of parts e.g. number of grains in an ear of wheat.
 - (b) **Discontinuous Variations** : Also known as **mutations, sports** or **saltations**. These variation are responsible for formation of new species and organism thus formed is called **mutant**.

Types of discontinuous variations :

 - i. **Substantive variations** : These influence shape, colour, size etc., e.g., hairless cat, short legged ancon sheep.
 - ii. **Meristic variation** : These affect number of parts e.g. polydactyly in humans.

Variations are significance in evolution as they make the organism better suited to modifying environmental conditions, produce new trait in organism and provide raw material for evolution.

History :

- * **Muller** : Proposed the term “**Cytogenetics**” (Cytology + Genetics)

Father of Actinobiology.

Actinobiology - Study the effect of radiation of living organisms.

- * **Morgan** : Father of Experimental genetics. He experiment on *Drosophila melanogaster* & proposed various concepts

Gene theory : According to gene theory; genes are linearly located on chromosome.

Linkage term, Theory of sex linkage, Crossing over term, Criss - cross inheritance.

EARLY SPECULATIONS (PREMENDELIAN)

- | | | |
|--------------------------|-------------------------|-----------------------------------|
| (1) Vapour Theory | (2) Preformation Theory | (3) Encasement Theory |
| (4) Theory of Epigenesis | (5) Pangenesis Theory | (6) Weismann Theory of Germ plasm |
| (7) Mendelism | | |

(1) **Vapour Theory** :

- Proposed by a Greek philosopher **Pythagoras** in 500 B.C.
- Each organ of an animal body emitted some kind of vapour and that a new individual was formed by combination of the vapour from different organs.

(2) **Preformation Theory (1632 – 1723)** :

- Dutch scientist ‘**Swammerdam**’ propounded the preformation theory. This theory holds that the sex cells (sperm and ova) had the **miniature copy of adults** and the development of embryo was actually only the enlargement of parts that were already present in the sperm or egg.
- This miniature form of the animal present in the gamete was called ‘**Homunculus**’.
- This theory was supported by **Hartsoeker**.
- Those who considered homunculus to be present in sperms were called **Spermist**.
- Those who considered homunculus to be present in ova (eggs) were called **Ovist**.
- **Antony Van Leeuwenhoek** was the **first** to observe human sperms.

(3) **Encasement Theory** :

- ‘**Charles Bonnet**’ and his supporters presumed that every female contains within her body miniature prototypes of all the creatures which will every descend from her, one generation within the other **some what like a series of chinese bones**. (a box inside a box and so on).

(4) **Theory of Epigenesis** :

- **Wolff** proposed that germ cells contain definite but undifferentiated substances which, after fertilization becomes organized into various complex body organs (Differentiated) which form the **adult**. This idea was referred to as **epigenesis**.

(5) **Pangenesis Theory** :

- **Charles Darwin** propounded pangenesis theory.
- According to this theory every cell, tissue and organ of animal body produces many minute particles known as **pangenes** or **gemmules**.
- These gemmules are discharged in the blood stream and are deposited in the reproductive organs. These reproductive cells contain these pangenes and a child develops as a result of blending of the pangenes from two parents.
- Thus the individual would represent the **mixture** of both of the parents.

(6) **Theory of Germplasm** :

- ‘**August Weismann**’ (1889) suggested the theory of continuity of germplasm.
- They referred to the reproductive cells as germplasm and to rest of the body as somatoplasm.

- The **germplasm** forms the bridge of life and passes from one generation to the next.
- Soma is '**Mortal**' because it eventually dies and disintegrates, the germ is "**immortal**", because it continues forever.

(7) **Mendelism :**

- Experiments performed by Mendel on genetics and description of mechanisms of hereditary processes and formulation of principles are known as Mendelism.
- **Gregor Johann Mendel (1822 – 1884)** : Mendel was born on July 22, 1822 at Heinzendorf in Austria a Silesia village. Mendel worked in Augustinian Monastery as monk at Brunn city, **Austria**.
- In 1856-57, he started his historical experiments of heredity on pea (*Pisum sativum*) plant. His experimental work continued on pea plant till 1865 (19th century).
- The results of his experiments were published in the science journal, "**Nature For schender varien**" in 1866.
- This journal was in German language. Title was "**vershue uber Pflangen Hybridan**".
- This journal was published by '**Natural History society of Bruno**'.
- A paper of Mendel by the name of "Experiment in plant Hybridization" published in this journal. Mendel was unable to get any popularity. No one understood of him. He died in 1884 without getting any credit of his work due to kidney disease (Bright disease).
- After 16 years of Mendel's death in 1900, Mendel's postulates were rediscovered. Rediscovery by three scientists independently.
- **Carl Correns** : Germany (Experiment on Maize).
- **Hugo deVries** (Holland) (Experiment on Evening Primrose).
He republished the Mendel's results in 1901 in **Flora** magazine.
- **Erich von Tschermak Seysenegg** - (Austria) (Experiment on different flowering plants).
The credit of rediscovery of Mendelism goes to three scientists.
Correns given two laws of Mendelism
Law of heredity / Inheritance / Mendel

★ **Mendel Results Remain Hidden due to :**

- At that time Darwin's book "Origin of Species" published. Scientists were busy in discussion with this book.
- Mendel's ideas were ahead of that time.
- Mendel used higher statistical calculation in his experiments so the results were complicated to understand.
- Mendel also performed his experiments on Hawkweed (*hieracium*) and beans (*Lablab*) plant on suggestion of Karl Nageli but Mendel did not get succeed in *Hieracium*, Parthenogenesis is present in it.

★ **Reasons for Mendel's success :**

- Mendel studied the inheritance of one or two characters at a time unlike his predecessors who had considered many characters at a time (Kolreuter-Tobacco plant, John Goss & Knight-Pea plant).
- Selection of Material (Pea plant - *Pisum sativum*)
- Selection of garden pea plant is suitable for studies. Which have following advantage.
- Pea plant is annual plant with short life cycle of 2-3 months so large number of offsprings can be analysed within a short period of time.
- It has many contrasting traits.
- Natural self pollination is present in pea plant so purity of character is maintained in it.
- Cross pollination can be performed in it artificially so hybridization can be made possible.
- Pea plant easy to cultivate.
- Pea seeds are large. In addition to pea, Mendel worked on *rajama*.

- Mendel quantitatively analyse the inheritance of qualitative characters.
- He maintained the statistical records of all the experiments.
- ★ **Mendel's work** : Mendel studied 7 characters or 7 pairs of contrasting traits.

Actual data obtained by Mendel in F ₂ progenies in garden pea				
S.No.	Character (Chromosomal position)	Dominant	Recessive	Ratio
1	Length of plant (4)	787 (tall)	277 (dwarf)	2.84:1
2	Colour of flower (1)	705 (violet)	224 (white)	3.15:1
3	Pod or flower position (4)	651 (axial)	207 (terminal)	3.14:1
4	Shape of pod (4)	882 (inflated)	299 (constricted)	2.94:1
5	Colour of pod (5)	428 (green)	152 (yellow)	2.82:1
6	Shape of seed (7)	5,474 (round)	1850 (wrinkled)	2.96:1
7	Colour of cotyledon (1)	6,022 (yellow)	2,001 (green)	3.01:1
Average of all traits studied				2.98:(=3:1)

★ Technique of Mendel

He developed a technique **Emasculation and Bagging** for hybridization in plants.

Flowers of pea plant are bisexual. In this method one considered as male and another as female.

The plant used as female, stamens of this plant are removed at juvenile stage, this is called Emasculation.

Emasculation is done to prevent self pollination.

Emasculated flowers covered by bags, this is called bagging.

Bagging is only used to prevent undesirable cross pollination.

Mature pollen grains are collected from male plants and spread over emasculated flower.

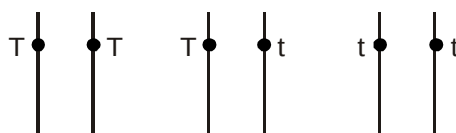
Seeds are formed in the female flower after pollination.

The plants that are obtained from these seeds are called First Filial generation or F₁ generation according to Mendel.

Mendel was great plant breeder (true breeder)

SOME DEFINED TERMS

1. **Factors** : Unit of heredity which is responsible for inheritance and appearance of characters. These factors were referred as genes by **Johannsen** (1909). Mendel used term “**element**” for factor.
2. **Morgan** first use symbol to represent the factor. Dominant factor are represented by capital letter while recessive factor by small letter
3. **Allele** : Alternative forms of a gene which are located on same position [locus] on the homologous chromosome is called Allele. Term allele was coined by **Bateson**.

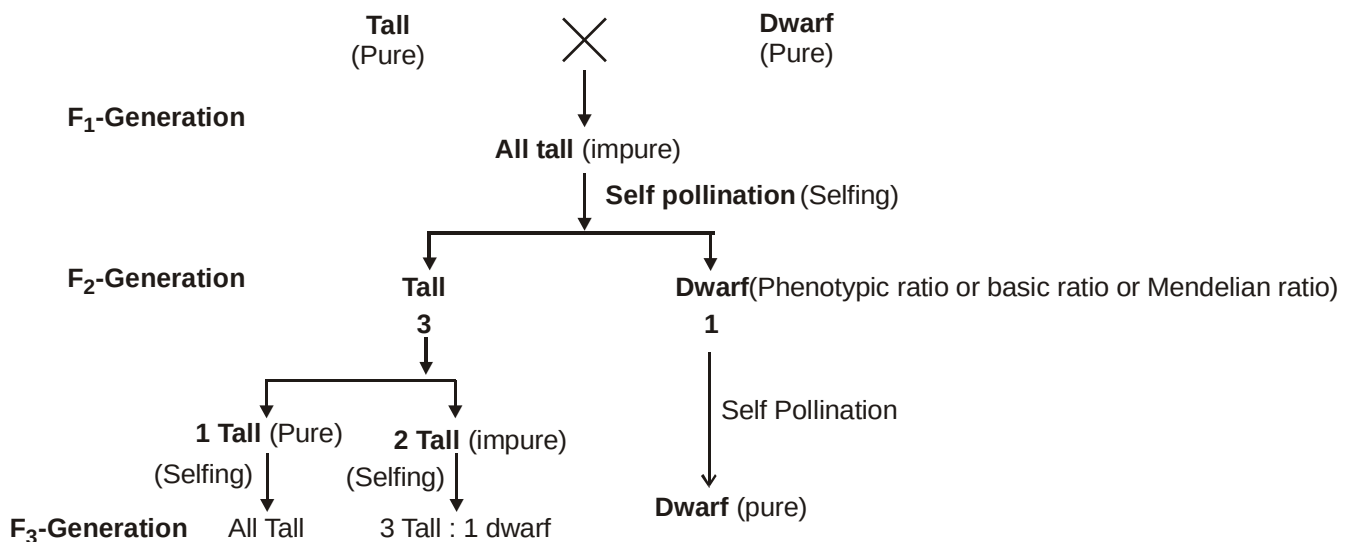


4. **Homozygous** : A zygote is formed by fusion of two gametes having identical factors is called homozygote and organism developed from this zygote is called homozygous. Ex. TT, RR, tt
5. **Heterozygous** : A zygote is formed by fusion of two different types of gamete carrying different factors is called Heterozygous (Tt) (Rr) and individual developed from such zygote is called heterozygous. The term homozygous and heterozygous are coined by **Bateson**.

6. **Hemizygous** : If individual contains only one gene of a pair then individual said to be hemizygous. Male individual is always hemizygous for sex linked gene.
7. **Phenotype** : It is the external and morphological appearance of an organism for a particular character.
8. **Genotype** : The genetic constitution or genetic make-up of an organism for a particular character. Genotype & phenotype terms were coined by **Johannsen**.
9. **Phenocopy** : If different genotypes are placed in different environmental conditions if they produce same phenotype. These individual are said to be Phenocopy of each other.

MONOHYBRID CROSS

When we consider the inheritance of one character at a time by a cross is called monohybrid cross. First of all, Mendel selected tall and dwarf plants



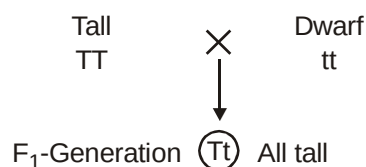
Conclusions (results) of Monohybrid Cross

* Ist Conclusion :

According to Mendel each genetic character is controlled by a pair of unit factor. It is known as conclusion of paired factor or unit factor.

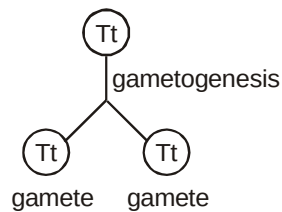
* IInd Conclusion :

This conclusion is based on F₁ - generation. When two different unit factors are present in single individual, then only one unit factor is able to express itself and known as dominant unit factor. Another unit factor fails to express is the recessive factor. In the presence of dominant unit factor recessive unit factor can not express and it is known as conclusion of dominance.



* IIIrd Conclusion :

During gamete formation; the unit factors of a pair segregate randomly and transfer inside different gamete. Each gamete receives only one factor of a pair; so gametes are pure for a particular trait. It is known as conclusion of purity of gametes or segregation.



DIHYBRID CROSS

A cross in which study of inheritance of two pairs of contrasting traits or two characters. Mendel wanted to observe the effect of one character on another character.

Mendel selected traits for dihybrid cross for his experiment as follows :

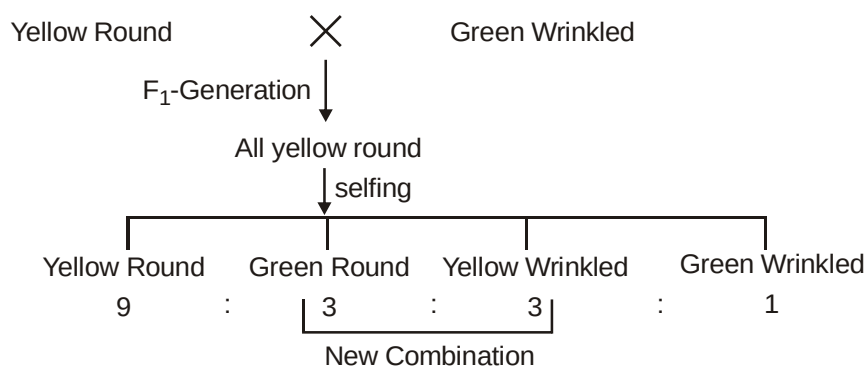
Colour of cotyledons → Yellow (Y) & Green (y)

Seed form → Round (R) and Wrinkled (r)

Yellow and round characters are dominant and green and wrinkled are recessive characters. Mendel crossed yellow and round seeded plants with green and wrinkled seeded plants. All the plants in F_1 -generation had yellow and round seeds.

All the plants in F_1 -generation had yellow and round seeds.

When F_1 plants were self pollinated to produce four kinds of plants in F_2 generation such as yellow round, yellow-wrinkled, green round and green wrinkled, there were in the ratio of 9 : 3 : 3 : 1. This ratio is known as Dihybrid ratio.



Expression of yellow round (9) and green wrinkled (1) traits shows as their parental combination. Green round and yellow wrinkled type of plants are produced by the results of new combination (Recombinant).

★ Conclusion :

The F_2 generation plant produce two new phenotypes, so inheritance of seed coat colour is independent from the inheritance of shape of seed. Otherwise It can not possible to obtain yellow wrinkled and green round type of seeds.

This observation leads to the Mendel's conclusion that different type of characters present in plants assorted independently during inheritance.

This is known as **Conclusion of Independent Assortment**. It is based on F_2 - generation of dihybrid cross. The nonhomologous chromosome show random distribution during anaphase-I of meiosis.

★ Explanation :

A pure yellow and round seeded plant crossed with green and wrinkled seeded plant which are having genotype YYRR and yyrr to produced F_1 generation having YyRr genotype.

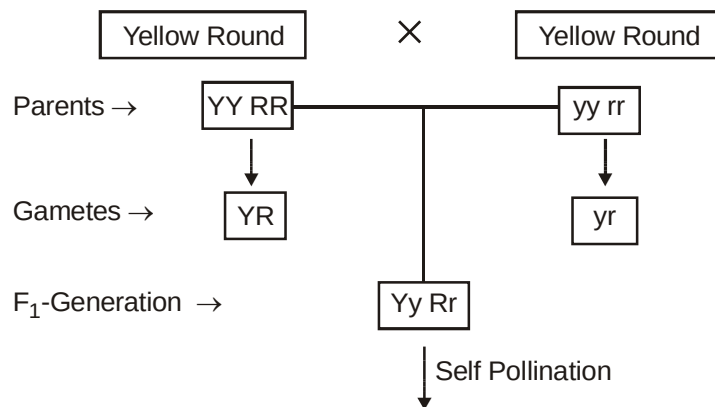
Both the characters recombine independently from each other during gamete formation in F_1 generation. Factor (R) of pair factor (r) is having equal change to (Y) factor or (y) factor of gametes during recombination to form two type of gametes (YR) and (yr).

Similarly (r) factor also having equal change with (Y) factor or (y) factor of gametes to form a two type gamets (Yr) and (yR).

Thus, total four types of gametes - (YR), (yr), (yR), (Yr) are formed.

Therefore during the gametes formation in F_1 generation new combination or recombination appear in F_2 .

★ **Demonstration by checker board method**



F₂ - Generation →

	YR	Yr	yR	yr
YR	YYRR	YYRr	YyRR	YyRr
Yr	YYRr	YYrr	YyRr	Yyrr
yR	YyRR	YyRr	yyRR	yyRr
yr	YyRr	Yyrr	yyRr	yyrr

Yellow Round = 9 / 16

Green Round = 3 / 16

Yellow Wrinkled = 3 / 16

Green Wrinkled = 1 / 16

Phenotypic Ratio = 9 : 3 : 3 : 1

Phenotype

Homozygous yellow & Homozygous Round
Homozygous yellow & Heterozygous Round
Heterozygous yellow & Homozygous Round
Heterozygous yellow & Heterozygous Round
Homozygous yellow & Homozygous wrinkled
Heterozygous yellow & Homozygous wrinkled
Homozygous green & Homozygous Round
Homozygous green & Heterozygous Round
Homozygous green & Homozygous wrinkled

Genotype

— YY RR = 1
— YY Rr = 2
— Yy RR = 2
— Yy Rr = 4
— YY rr = 1
— Yy rr = 2
— yy RR = 1
— yy Rr = 2
— yy rr = 1

F₂ Genotypic Ratio = 1:2:2:4:1:2:1:2:1

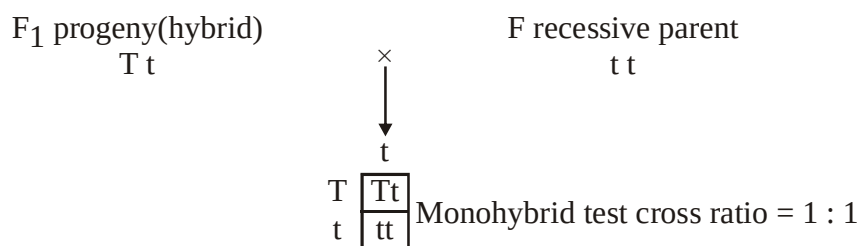
Number of traits hybrid (n)	Experiment	Types of gametes (2 ⁿ)	Number of Zygotes / offsprings (gametes) ²	Number of Phenotype (2 ⁿ)	Number of genotype (3 ⁿ)	Phenotypic Ratio	Genotypic Ratio
1	Monohybrid cross (Aa × Aa)	2 ⁿ = 2 ¹ = 2	2 ² = 4	2 ⁿ = 2 ¹ = 2	3 ¹ = 3	3 : 1	1 : 2 : 1
2	Dihybrid cross (AaBb × AaBb)	2 ² = 4	4 ² = 16	2 ² = 4	3 ² = 9	(3 : 1) ² = 9 : 3 : 3 : 1	(1 : 2 : 1) ² = 2 : 4 : 2 : 1 : 2 : 1 : 1 : 2 : 1
3	Trihybrid cross AaBbCc × AaBbCc	2 ³ = 8	8 ² = 64	2 ³ = 8	3 ³ = 27	(3 : 1) ⁿ	(1 : 2 : 1) ³

★ **Back Cross :**

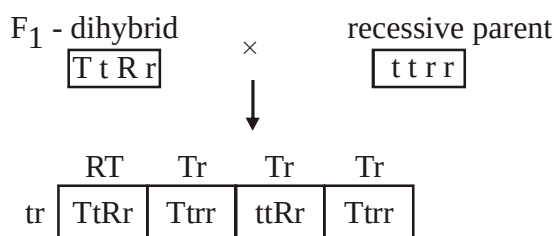
A back cross is a cross in which F_1 individuals are crossed with any of their parents.

When F_1 individual is crossed with dominant parent then it is termed **out cross**. The generation obtained from this cross, all possess dominant character.

- ★ **Test Cross :** When F_1 progeny is crossed with recessive parent then it is called test cross. The total generations obtained from this cross, 50% having dominant character and 50% having recessive character. [Monohybrid test cross]. Test cross helps to find out the genotype of dominant individual. Whether it is homozygous or heterozygous for that character
- **Monohybrid Test Cross :** The progeny obtained, from the monohybrid test cross are in equal proportion, means 50% is dominant phenotypes and 50% is recessive phenotypes. It can be represented in symbolic forms as follows.



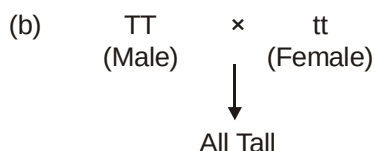
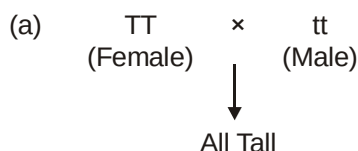
Dihybrid Test Cross : The progeny is obtained from dihybrid test cross are four types and each of them is 25%



Phenotype or Genotype ratio of Dihybrid test cross = 1:1:1:1

- ★ **Conclusion :** In test cross phenotypes and genotypes ratio are same.
- ★ **Trihybrid test cross** (phenotype, genotype) ratio = 1 : 1 : 1 : 1 : 1 : 1 : 1 : 1
- ★ **Reciprocal Cross :**

When two parents are used in two experiments in such a way that in one experiment “A” is used as the female parent and “B” is used as the male parent, in the other experiment “A” will be used as the male parent and “B” as the female parent. Such type of a set of two experiments is called Reciprocal cross. Characters which are controlled by karyogene are not affected by Reciprocal cross. In case of cytoplasmic inheritance result become change by Reciprocal cross.



CYTOPLASMIC INHERITANCE (Correns)

Inheritance of characters which are controlled by cytogene or cytoplasm is called cytoplasmic inheritance. Genes which are present in cytoplasm called ‘**Cytogene**’ or ‘**Plasmagene**’ or **extra nuclear gene**. Total cytogene present in cytoplasm is called ‘**Plasmon**’.

A gene which is located in the nucleus is called '**karyogene**'.

- Inheritance of cytogene in higher plants only through the female.
- The male gamete of higher plant is called male nucleus. It has very minute [equivalent to nil] cytoplasm. So male gamete only inherited karyogene.
- Thus, inheritance of cytogene only through female cytoplasm. (also called maternal inheritance)
- If there is a reciprocal cross in this condition, then result will be effected.

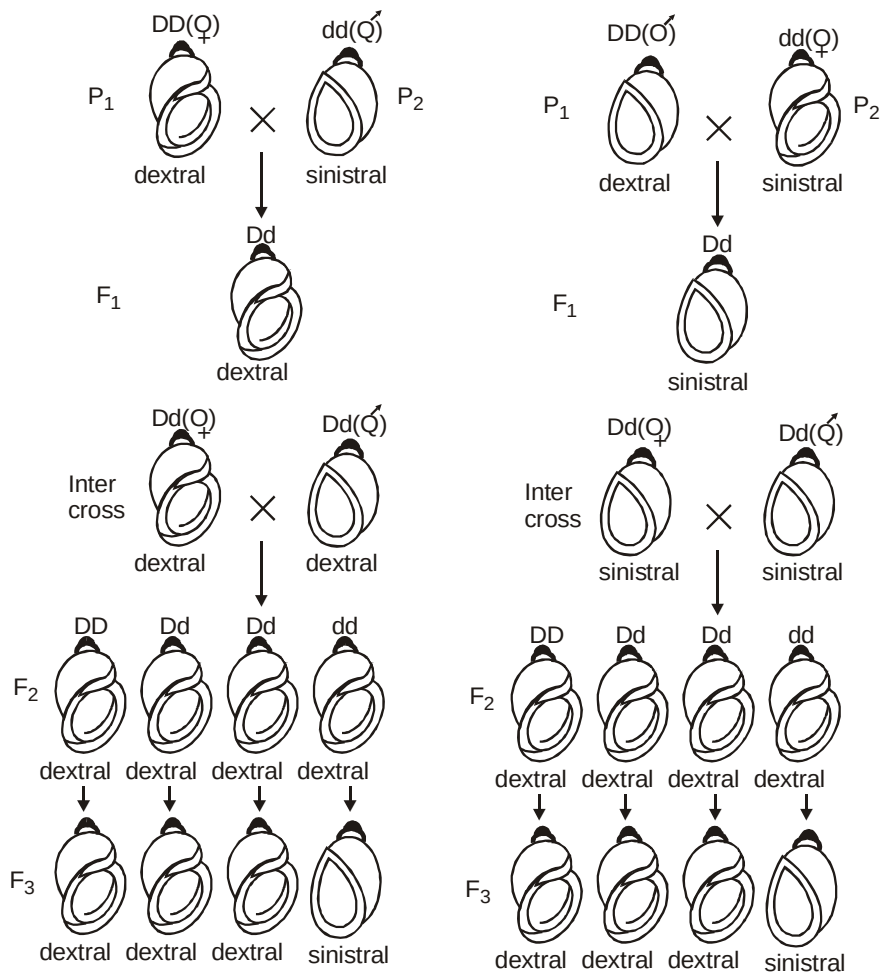
★ **Cytoplasmic inheritance of three types :**

- Maternal effect depending indirectly on nuclear genes and involving no known cytoplasmic hereditary unit called as **predetermination**. maternal effect is determine before fertilization.
- Cytoplasmic inheritance involving dispensable and infective hereditary particle in cytoplasm which may or may not depend on nuclear genes called as **Dauermodification**.
- Cytoplasmic inheritance involving essential organelles like, Chloroplast and mitochondria called as **organellar genetics**.

Example of predetermination :

Shell coiling in snail (*Limnaea peregra*)

In Shell coiling of snail can be dextral (Coiling to the right) or sinistral (coiling to the left). This direction of coiling is genetically the dextral coiling depending upon maternal dominant allele D and sinistral coiling depending upon maternal recessive allele (d).



Above reciprocal cross indicates that phenotype of offspring is decided by genotype of female parent not the phenotype of female parent. If female parent contains only one dominant gene 'D' then phenotype of all offspring will be dextral.

Example :

Dd(♀) × dd(♂)
Sinistral dextral
↓
F₁ - All dextral

Dd(♂) × dd(♀)
Sinistral dextral
↓
F₁ - All Sinistral

★ **Example of Dauermodification -**

- **Sigma particle in Drosophila** these particle are virus like particles which are present in Drosophila and related to CO₂ sensitivity. Inheritance of sigma particle takes place through the egg cytoplasm.
- **Kaapa particle in Paramecium** kappa particles are found in certain “Killer strains” of Paramecium and are responsible for production of substance paramycin which is toxic to strain not possessing Kappa. (Sensitive Strain)

The minimum number of kappa particles is 400 to secrete paramycin. Kappa particles are symbiotic bacteria named “*Caedobacter taeniospiralis*”

★ **Example of Organelar Genetics : (True examples of cytoplasmic inheritance)**

- **Plastid inheritance in Mirabilis jalapa** – cytoplasmic inheritance first discovered by **Correns** in Mirabilis jalapa.

In Mirabilis jalapa plastid inheritance i.e. branch colour is example of cytoplasmic inheritance.

Branch colour

(a) Pale ♀ × Green ♂
↓
F₁ - Pale

(b) Green ♀ × Pale ♂
↓
F₁ - Green

(c) Varigated ♀ × Pale or Green or Variegated ♂
↓
F₁ - Pale, Green and Variegated

- **Male sterility in maize plant** – Gene of male sterility present in mitochondria. If a normal male plant crossed with a female plant which has genes of male sterility then all the generation become male sterile because a particular gene was present in female which inherited by female.
- **Albinism in plant** : Gene of albinism is found in chloroplast. Gene of albinism is lethal in plant.
- **Inheritance of Bacterial plasmid**. In bacteria plasmid inheritance is due to conjugation.
- **Petite form in yeast** = (mitochondrial gene) petite is mutant form of yeast. This mutant form is slow growing on culture medium.
- **Ioja inheritance in Maize** Ioja is characterized by contrasting strip of green and white colour of leaves.
- **Poky Neurospora** - (Mitochondrial gene) poky is mutant form of Neurospora. It is slow growing on culture medium.

★ **Exceptions of conclusions of Mendel :**

- ★ **Exception of Dominance** : There are two exceptions of law of dominance.

(A) Incomplete dominance; (B) Co-dominance,

- A. **Incomplete Dominance** : According to Mendel’s law of dominance. Dominant character must be present in F₁ generation. But in some organisms, F₁ generation is **different** from the both parents.

Both factors such as dominant and recessive are present in incomplete dominance but dominant factors are unable to express their character completely, resulting different type of generation is formed which is different from the both parents.

Incomplete dominance was first discovered by **Correns** in *Mirabilis jalapa*. This plant is also called as '**4 O' clock plant** 'or' **Gul-e-Bans**'.

- Three different types of plant are found in *Mirabilis* on the basis of flower colour, such as red, white and pink. When plants with red flowers is crossed with white flower plants, pink flower obtained in F_1 generation the reason of this is that the genes of red colour incompletely dominant over the genes of white colour.

When F_1 generation of pink flower is self pollinated then the phenotypic ratio of F_2 generation is red, pink, white = 1 : 2 : 1 in placed of normal monohybrid cross - 3 : 1

The ratio of phenotype and genotype of F_2 generation in incomplete dominance is always same.

	Red	×	White	
	R R	↓	r r	
	F ₁ geheration R r (Pink) →			
	↓ Self pollination			
F ₂ – Generation		R	r	RR = Red - 1
	R	RR	Rr	Rr = Pink - 2
	r	Rr	rr	rr = White - 1

- Antirrhinum majus** - Incomplete dominance is also seen in this plant. This plant is also known as '**Snapdragon**' or '**Dog flower**'. Incomplete dominance is found in this plant which is the same as *Mirabilis* flower colour.
- Andalusian Fowls** - Incomplete dominance is present for their feather colour. When a black colour fowl is crossed with a white colour fowl, the colour of F_1 generation is blue.

★ **CO-DOMINANCE** : In this phenomenon, both the gene expressed for a particular character in F_1 hybrid progeny.

Examples : Co-dominance is seen in animals for coat colour.

When a black parent is crossed with white parent, a roan colour F_1 progeny is produced.

When we obtain F_2 generation from the F_1 generation, the ratio of black; black white (Roan);white of animals is 1 : 2 : 1.

Note : F_2 generation is obtained in animals by sib-mating cross.

BLACK	×	WHITE
R ₁ R ₁	↓	R ₂ R ₂
F ₁ generation R ₁ R ₂ (Roan)		
↓ Sib-mating cross		
	R ₁	R ₂
R ₁	R ₁ R ₁	R ₁ R ₂
R ₂	R ₁ R ₂	R ₂ R ₂

R₁R₂ = Roan - 2

R₂R₂ = White - 1

R₁R₁ = Black 1

R₁R₂ = Roan - 2

R₂R₂ = White - 1

It is obvious by above analysis that the ratio of phenotype as well as genotype is 1 : 2 : 1 in co-dominance.

Sp. Note : In incomplete dominance, characters are blended phenotypically, while in co-dominance, both the genes of a pair exhibit both the characters and effect of both the character is independent from each other.

Other Example of Co-dominance :

- AB blood group inheritance ($I^A I^B$)
- Carrier of Sickle cell anaemia ($Hb^A Hb^S$)

* **Conclusion of Segregation** : There is no exception of law of segregation. The segregation is essential during the meiotic division in all sexually reproducing organisms. (Nondisjunction may be exception of the law).

* **Exception of conclusion of independent assortment**

The law of independent assortment is most criticised. Linkage is the exception of this law.

LINKAGE :

Collective inheritance of character is called linkage first time seen by **Bateson and Punnett** in *Lathyrus odoratus* and gave **coupling and repulsion phenomenon**. But they did not explain the phenomenon of linkage. Sex linkage was first discovered by **Morgan** in *Drosophila* & coined the term linkage. He proposed the theory of linkage.

In 1906, **Bateson and Punnett** crossed two varieties of *Lathyrus odoratus* (sweet pea) and observed that the results do not agree with the Mendel's law of independent assortment. They formulated the hypothesis of **coupling and repulsion** to explain the unexpected F_2 results of dihybrid cross between a homozygous sweet pea having dominant alleles for blue flowers (BB) and long grains (LL) with another homozygous double recessive plant with red flowers and round pollen grains (bbll).

Test Cross Ratio of F_1 7 : 1 : 1 : 1 indicated that there was a tendency of the dominant alleles to remain together. Similar was the case with recessive alleles.

Parents	Blue flower & long pollen	×	Red flower & round pollen
	BBLL		bbll
Gametes	BL	×	bl
		↓	
F_1	BbLl		
	Blue flower & Long pollen		
Test cross	BbLl	×	bbll

Test cross Progeny						
7/16	:	1/16	:	1/16	:	7/16
Blue flower & long pollen (BbLl)		Blue flower & round pollen (Bbll)		Red flower & long pollen (bbLl)		Red flower & round pollen (bbll)

It was called **gametic coupling** by Bateson and Punnett. The tendency of two dominant genes to remain together in the process of inheritance was called as **coupling**.

In another cross they took a sweet pea plant with blue flowers and round pollens (BBll) and other plant with red flowers and long pollens (bbLL) and obtained the **ratio of 1 : 7 : 7 : 1** by test crossing F_1 generation.

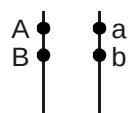
Parents	Blue flower & round pollen	×	Red flower & long pollen
	BBll	↓	bbLL
Gametes	Bl		bL
F ₁	BbLl		
	Blue flower & long pollen		
Test cross	BbLl	×	bbll
	Blue flower & long pollen	↓	Red flower & round pollen
	1/16	:	7/16
	Blue flower & long pollen	:	Blue flower & round pollen
	(BbLl)	:	(Bbll)
	7/16	:	1/16
	Red flower & long pollen	:	Red flower & round pollen
	(bbLl)	:	(bbll)

When two dominant or recessive genes comes from different parents, they tend to remain separate hence, this ratio is called repulsion ratio. **T.H. Morgan** in 1910 showed that coupling and repulsion are two aspects of the same phenomenon called linkage. He suggested that the two genes present on the same chromosome, are in **coupling phase** and when present on two different homologous chromosomes are in **repulsion phase**. Linkage therefore, may be defined as “**The tendency of two genes of the same chromosome to remain together in the process of inheritance**”.

According to Morgan, the degree or the strength of linkage depends upon the distance between the linked genes in the chromosome.

Linkage and independent assortment can be represented in dihybrid plant

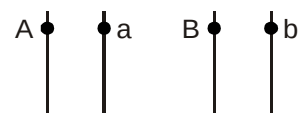
In case of linkage in dihybrid (AaBb)



It produces two types of gamete

AB : ab

In case of independent assortment in dihybrid (AaBb)



It produces four types of gamete

AB : ab : aB : Ab

* Theory of linkage :

Linkage genes are linearly located on same chromosome. They get separated if exchange (crossing over), takes place between them.

Strength of linkage $\propto 1 / \text{distance between the genes}$. It means, if the distance between two genes is increased then strength of linkage is reduced and it proves that greater is the distance between genes, the greater the probability of their crossing over.

Crossing over obviously disturbs or degenerates linkage. Linked genes can be separated by crossing over.

Factors effecting crossing over (C.O.) & Linkage

- Distance $\uparrow$ = C.O. $\uparrow$ Linkage $\downarrow$
- Temperature $\uparrow$ = C.O. $\uparrow$ Linkage $\downarrow$
- X-Ray $\uparrow$ = C.O. $\uparrow$ Linkage $\downarrow$
- Age $\uparrow$ = C.O. $\downarrow$ Linkage $\uparrow$
- Sex- Male C.O. $\downarrow$ (Crossing over totally absent in male Drosophila) Linkage $\text{♂} > \text{♀}$

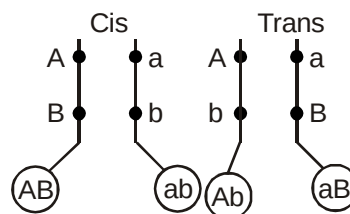
★ **Arrangement of linked Genes on Chromosomes :**

The arrangement of linked genes in any dihybrid plant is two types.

- A. Cis - Arrangement :** When, two dominant genes located on one chromosome and both recessive genes located on another chromosome. Such type of arrangement is termed as cis-arrangement. Cis-arrangement is an original arrangement.

Two type of gametes can be produced in this arrangement → $\textcircled{AB}$ and $\textcircled{ab}$

- B. Trans arrangement :** When a chromosome bears one dominant and one recessive gene, and another chromosome also possess one dominant and one recessive gene, such type of arrangement is called trans-arrangement. Trans arrangement is not an original form. It is due to crossing over. Two types of gamete also formed in trans-arrangement but it is different from cis-arrangement $\textcircled{Ab}$ and $\textcircled{aB}$.



★ **Types of Linkage :**

There are two types of linkage

- A. COMPLETE LINKAGE :** Linkage in which genes always show parental combination. It never forms new combination.

Crossing over is absent in it. Such genes are located very close on the chromosomes. Such type of linkage very rare in nature e.g., male *Drosophila*, female silk moth.

- B. INCOMPLETE LINKAGE :** When new combinations also appear along with parental combination in offsprings, this type of linkage is called incomplete linkage, the new combinations form due to crossing over. The percentage of new combination is equal to the percentage of crossing over. (<50%)

Example : In maize incomplete linkage was observed by **Hutchinson**. w.r.t seed coat colour and seed shape.

The results show that parental combination of alleles (CS/CS and cs/cs) appear in about 96% cases. The other two are new combinations (Cs/cs and cS/cs) appear in about 4% cases. Thus in about 4% cases crossing over has occurred between linked genes.

Parents	Coloured & full	×	Colourless & shrunken
	CS / CS		cs / cs
Gametes	CS	×	cs
		↓	
F ₁	CS / cs		
	Coloured & full		
Test cross	Cs/cs	×	cs / cs
Gametes	cs		
Result :	CS	$\boxed{\text{CS/cs}}$	– Coloured & full 48.2%
	cs	$\boxed{\text{Cs/cs}}$	– Coloured & shrunken 1.8%
	cS	$\boxed{\text{cS/cs}}$	– Colourless & full 1.8%
	cs	$\boxed{\text{cs/cs}}$	– Colourless & shrunken 48.2%

Incomplete Linkage

Another example was demonstrated by Morgan, while working with *Drosophila*. (i) Crossing of yellow bodied (Y) and white eyed (W) female with brown bodied (Y⁺) red eyed (W⁺) male produced F₁ to be brown bodied red eyed. In F₂ generation, obtained by selfing of F₁ hybrids, the ratio deviated significantly from expected. He found 98.7% to be parental and 1.3% as recombinants. (ii) In a second cross between white eyed and miniature winged female (wwmm) wild red eyed normal winged male (W⁺W⁺M⁺M⁺) all hybrids were found to be wild type. Test cross progeny of this hybrid was found to be 62.8% parental and 37.2% recombinant.

Linkage group : All the genes which are located on one pair of homologous chromosome form one linkage group. Genes which are located on homologous chromosomes are allelic so we consider one linkage group.

Linkage group – haploid no. of homologous chromosomes.

	2n	n	Pair	Linkage group
Human	46	23	23	23
Mouse	42	21	21	21
Frog	26	13	13	13
Maize	20	10	10	10
Pea	14	7	7	7
<i>Drosophila</i>	8	4	4	4
<i>Neurospora</i>	7	7	7	7
Bacteria / B.G.A.	–	–	–	1

Application of Linkage :

Distance can be identified by the incomplete linkage. Its unit is centi Morgan (cM).

$$\text{Strength of linkage} \propto \frac{1}{\text{Distance b/w linked gene}} \propto \frac{1}{\text{Crossing Over}}$$

Genetic map / Linkage map / chromosome map – In genetic map different linked genes are linearly arranged or chromosome according to percentage of crossing over ($\propto$ Distance) between them.

With the help of genetic map we can find out the position of a particular gene on chromosome. Genetic map is helpful in the study of genome.

* Sex Linkage

When the genes of vegetative / somatic characters are present on sex-chromosome is termed as sex linked gene and such phenomenon is known as sex-linkage. Two - types of sex linkage :

- * **X-linkage** : Genes of somatic characters are found on x-chromosome. the inheritance of x-linked character may be through the males and females.

e.g., Haemophilia, Colour blindness

- * **Y-linkage** : The genes of somatic characters are located on Y-chromosome. The inheritance of such type of character only through the males, such type of character is called Holandric character these characters only found in male.

e.g. Gene which forms TDF

Hypertrichosis (excessive hair on ear pinna.)

Gene which is located on differential region of Y - chromosome is known as Holandric gene.

Example of X- linkage :

- * **Eye colour in Drosophila** : Eye colour in Drosophila is controlled by a X-linked gene. If a red eyed colour gene is represented as '+' and white eyed colour represented as 'w', then on basis of this different type of genotypes are found in Drosophila.

Gene for red eye dominant (+) and white colour of eye is recessive (w)

Homozygous red eyed female = X^+X^+

Heterozygous red eyed female = X^+X^w

Homozygous white eyed female = X^wX^w

Hemizygous red eyed male = X^+Y

Hemizygous white eyed male = X^wY

It is clear by above different types of genotype that female either homozygous or heterozygous for eye colour. But, for the male eye colour, it is always hemizygous.

- * **Haemophilia** : Haemophilia is also called "**bleeder's disease**" and first discovered by **John Otto** (1803). The gene of haemophilia is recessive and x-linked lethal gene.

On the basis of x-linked, following types of genotype are found.

X^hX = Carrier female

X^hX^h = Affected female

X^hY = Affected male

But X^hX^h type of female dies during embryo stage because in homozygous condition, this gene is lethal and causes death.

- * Haemophilia - A → due to lack of factor - VIII (Antihemophilic globulin AHG)
- * Haemophilia B or Christmas disease - due to lack of factor - IX (plasma thromboplastin component)

Haemophilia -C - due to lack of factor XI (plasma thromboplastin antecedent)

Colour Blindness : The inheritance of colour blindness is like as haemophilia, but it is not a lethal disease so it is found in both male and female (discovered by **Horner**)

Three types of colour blindness are :

- **Protanopia** : It is for **red** colour.
- **Deutanopia** : It is for **green** colour
- **Tritanopia** : **Blue** colour blindness. Colour blindness is checked by **Ishihara - chart**.
- * **Other examples of X - linkage**
 - Diabetes insipidus (recessive).
 - Duchenne muscular dystrophy (recessive)
 - Fragile x syndrome (recessive).
 - Pseudorickets (Dominant)
 - Defective enamel of teeth (Dominant)

Types of Inheritance of sex linked characters :

- * **Criss Cross inheritance (Morgan)** : In criss-cross inheritance male or female parent transfer a X-linked character to grandson or grand daughter through the offspring of opposite sex.
- **Diagenic** : Inheritance in which characters are inherited from father to the daughter and from daughter to grandson.
Father → Daughter → Grand Son
- **Diandric** : Inheritance in which characters are inherited from mother to the son and from son to grand daughter. Mother → Son → Grand Daughter
- * **Non criss-cross inheritance** : In this inheritance male or female parent transfer sex linked character to grand son or grand daughter through the offspring of same sex.

- **Hologenic** : Mother → Daughter → Grand-daughter (female to female)
- **Holandric** : Father → Son → Grand-son (male to male)
- * **Sex-Limited Character** : These characters are expressed in one sex and unexpressed in another sex. But their genes are present on autosome of both the sexes and their expression is depend on sex hormone.
Example : Secondary sexual characters → these genes located on the autosomes and these genes are present in both male and female, but effect of these are depend upon presence or absence of sex-hormones. For example - genes of beard & moustache express their effects only in the presence of male hormone - testosterone.
- * **Sex Influenced Characters** : Genes of these characters are also present on autosomes but they are influenced differently in male and female. In heterozygous condition their effect is different in both the sexes. Example : Baldness : Gene of baldness is dominant (B).

Genotype	Male (♂)	Female (♀)
BB	Baldness present	Baldness present
bb	Baldness absent	Baldness absent
Bb	Baldness present	Baldness absent

Gene Bb shows partiality in male and female, Baldness is found in male, but baldness is absent in female with this genotype.

MULTIPLE ALLELE

More than 2 alternative forms of a gene is called multiple allele.

Multiple allele is formed due to mutation.

Multiple allel located on same locus of homologous chromosome.

A diploid individual contains two allele and gamete contains one allele for a character.

Ex. Blood group - 3 alleles

Coat colour in rabbit - 4 alleles

If n is the number of allele of a gene then number of different possible genotype = $\frac{n(n+1)}{2}$

Example of multiple allele :

- * **ABO blood group** – ABO blood groups are determined by allele I^A , allele I^B , allele I^O

I^A = dominant

I^B = dominant

I^O = recessive

Possible phenotypes - A, B, AB, O

Blood Group	Genotype	Antigen or agglutinuogen	Antibody or agglutinin
A	$I^A I^A, I^A I^O$	A	b
B	$I^B I^B, I^B I^O$	B	a
AB	$I^A I^B$	A & B	None
O	$I^O I^O$	none	a & b

Possible genotype number = $\frac{3(3+1)}{2} = 6$ genotype

✱ **Coat Colour in rabbit** : Four alleles for colour in rabbit

Wild type = Full coloured = agouti = C^+

Himalayan [white with black tip on extremities (like nose, tail and feet)] = c^h

Chinchilla [mixed coloured and white hairs] = c^{ch}

albino = colourless = c^a

These alleles show order of dominance $C^+ > c^{ch} > c^h > c^a$

Possible genotypes –

Coloured = C^+C^+ , C^+c^{ch} , C^+c^h , C^+c^a

Chinchilla = $c^{ch}c^{ch}$, $c^{ch}c^h$, $c^{ch}c^a$

Himalayan = c^hc^h , c^hc^a

Albino = c^ac^a

Possible genotype = $\frac{4(4+1)}{2} = 10$ genotypes

Eye colour in Drosophila and self incompatibility genes in plants are also the example of multiple allelism.

LETHAL GENE

Gene which causes death of individual in early stage when it comes in homozygous condition called lethal gene. Lethal gene may be dominant or recessive both.

Many of these genes which do not cause definite lethality are called semilethals.

In semilethal gene death occurs in late stage.

- Lethal gene was discovered by **L.Cuenot** in coat colour of mice, Yellow body colour (Y) was dominant over brown colour (y).

Gene of yellow body colour is lethal.

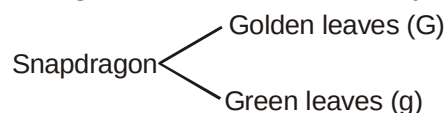
So homozygous yellow mice are never obtained in population. It dies in embryonal stage.

When yellow mice were crossed among themselves segregation for yellow and brown body colour is obtained in 2 : 1 ratio.

	Y	y
Y	YY (Death)	Yy
y	Yy	yy

YY - death in embryonal stage so modified ratio = 2 : 1

In plant lethal gene was first discovered by **E.Baur** in Snapdragon (*Antirrhinum majus*)



	G	g
G	GG (Death)	Gg
g	Gg	gg

Golden (Gg) × Golden (Gg)

Modified Ratio : 2 : 1

Homozygous golden leaves are never obtained.

Sickle cell anaemia in human. In human, gene of sickle cell anaemia Hb^S is the example of sub lethal gene. When two carrier individual of sickle cell anaemia are crossed then offsprings are obtained.

		Hb ^S	Hb ^A	
		Hb ^S Hb ^S (Death)	Hb ^S Hb ^A	
		Hb ^S Hb ^A	Hb ^A Hb ^A	
Hb ^S Hb ^A × Hb ^S Hb ^A	Hb ^S			Modified ratio 2 : 1
	Hb ^A			

PLEIOTROPIC GENE

Gene which controls more than one character is called pleiotropic gene.

This gene shows multiple phenotypic effect.

For example :

In Pea plant : Single gene influences

- Seed coat colour
- Red spot on leaf
- Flower colour

In Drosophila recessive gene of vestigial wings also influence the some another characters

- Structure of reproductive organs
- Longevity (Length of Body)
- Bristles on wings.
- Reduction in egg production.

Example of pleiotropic gene in human.

- **Sickle cell anaemia**- Gene Hb^S provide a classical example of pleiotrophy. It not only causes haemolytic anaemia but also results increased resistance to one type of malaria that caused by the parasite *Plasmodium falciparum*.

The sickle cell Hb^S allele also has pleiotropic effect on the development of many tissue and organs such as bone, lungs, kidney, spleen, heart.

Ⓒ **Cystic fibrosis** - Hereditary metabolic disorder that is controlled by a single autosomal recessive gene. The gene specifies an enzyme that produces a unique glycoprotein.

This glycoprotein results in the production of mucous.

More mucous interfere with normal functioning of several exocrine glands including those in the skin, lungs liver and pancreas.

POLYGENIC INHERITANCE :

Inheritance of characters in which one character is controlled by many genes and intensity of character depends upon the number of dominant allele or gene.

Polygenic inheritance first described by **Nilsson - Ehle** in kernal colour of wheat.

Nilsson - Ehle said explain kernal colour of wheat is regulated by two pairs of gene.

	RRBB	×	rrbb		
	Red		White		
		↓			
F ₁ - gen.	RrBb (intermediate)				
		↓			
	Full	light	Intermediate	very	white
	red	red	red	light	
Number of	4	3	2	1	0
dominant allele					
	1 Red : 14 intermediate : 1 white				

Example - Colour of the skin in Human.

The inheritance of colour of skin in human studied by **Devenport**.

When Negro (AA BB) phenotype crossed with white (aa bb) phenotype, intermediate phenotype produced in F₁ generation. Phenotypes of F₂ generation as follows.

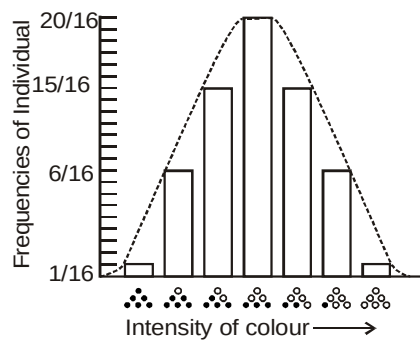
Negro		×	White	
AA BB		↓	aa bb	
F ₁ - generation → Aa Bb (Intermediate)				
↓				
F ₂				
	A B	A b	a B	a b
A B	AA BB Negro	AA Bb Dark	AbBB Dark	AaBb Intermediate
A b	AA Bb Dark	AA bb Intermediate	AaBb Intermediate	Aabb Light
a B	AaBB Dark	AaBb Intermediate	aa BB Intermediate	aa Bb Light
a b	AaBb Intermediate	Aabb Light	aaBb Light	aabb White

Thus, **Phenotypic ratio** of F₂ generation of quantitative inheritance as (2 pair)

Negro	:	Dark	:	Intermediate	:	Light	:	White
1	:	4	:	6	:	4	:	1

If human skin colour and kernal colour in wheat is regulated by **3 pairs** of alleles so phenotypic ratio of F₂ generation

Ratio	1	:	6	:	15	:	20	:	15	:	6	:	1
	Negro				Intermediate or Mullato								White



GENE INTERACTION

Gene interaction is two types (i) allelic interaction : allelic interaction takes place between allele of same gene which are present at same locus.

e.g. Incomplete dominance

Co-dominance

* **Non allelic gene interaction** : When interaction takes place between non allele is called non allelic gene interaction. It changes or modifies other non allelic gene.

★ **Examples of nonallelic interaction :**

- **Epistasis :** When, a gene prevents the expression of another non-allelic gene, then it is known as epistatic gene and this phenomenon is known as Epistasis.

Gene which inhibit the expression of another non-alleleic gene is called epistatic gene and expression of gene which is suppressed by epistatic gene is called hypostatic gene.

Example : Hair Colour in Dog :

B = Dominant allele for black colour of hairs

b = Recessive allele for brown colour of hairs.

I = Epistatic gene (White).

If the genotype bbii for brown colour and BBII for white colour. Following types of generation will be obtained by following crosses.

		bbll	×	BBII	
			↓		
F ₁ generation		BbIi		White colour	
			↓ F ₂ generation		
	BI	Bi	bI	bi	
BI	BBII White	BBIi White	BbII White	BbIi white	
Bi	BBIi White	BBii Black	BbIi White	Bbii Black	
bI	BbII White	BbIi White	bbII White	bbIi white	
bi	BbIi White	Bbii Black	bbIi White	bbii Brown	

It is obviously clear by above analysis, the phenotypic ratio of F₂-generation in epistasis is 12 : 3 : 1.

- ★ **Complementary Gene :** Two pair of non allelic genes are essential in dominant form to produce a particular character.

Such genes that act together to produce an effect that neither can produce, its effect separately are called complementary genes.

Both types of gene must be present in dominant form.

C	–	P	purple coloured
C	–	pp	colour less
cc	–	p	colour less
cc	–	pp	colour less

Row material $\xrightarrow{\text{Gene C}}$ Chromogen $\xrightarrow{\text{Gene P}}$ Anthocyanin (purple)

CC PP	×	cc pp
(coloured)		(Colourless)

↓

F₁ - Generation → CcPp (Coloured)

↓

	C P	C p	c P	c p
C P	CC PP Coloured	CC, Pp Coloured	Cc, PP Coloured	Cc, Pp Coloured
C p	CC Pp Coloured	CC pp Colourless	Cc, Pp Coloured	Cc, pp Colourless
c P	Cc PP Coloured	Cc Pp Coloured	cc PP Colourless	cc Pp Colourless
c p	Cc Pp Coloured	Cc pp Colourless	cc Pp Colourless	cc pp Colourless

Thus phenotypic ratio of complementary genes = Coloured : Colourless [9 : 7]

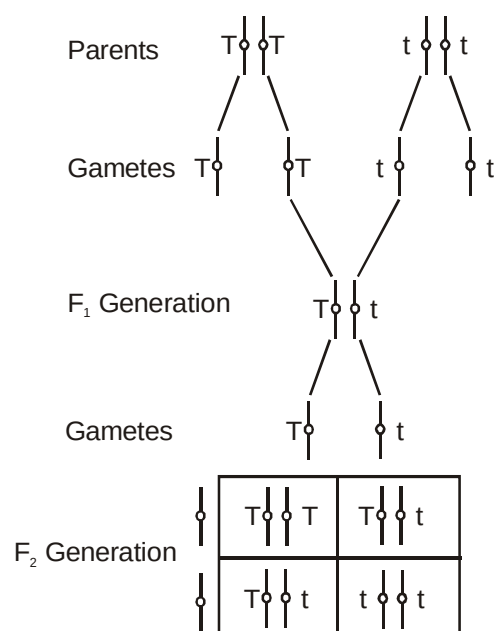
Examples of some autosomal characters in human

Character	Dominant	Recessive
Eye colour	Brown / Black	Blue
Eye size	Large	Small
Hair	Curly hair	Straight
Cheek	Dimple	Normal
Hand	Right Handed	Left Handed
Rolling of tongue	Roller	Non-Roller
Rh Factor	Rh ⁺	Rh ⁻
PTC taster	Taster	Non Taster
Skin pigmentation	Normal	Albino

* CHROMOSOMAL THEORY OF INHERITANCE

This theory was proposed by **Walter Sutton** and **Theodor Boveri** (1902). Following are the main points of the theory :

- Male and Female gametes play an **equal** role in contributing hereditary components of future generation.
- Gametes serve as the **bridge** between two successive generations.
- Only the nucleus of sperm combines with ovum. Thus, the hereditary information is contained in the **nucleus**.
- Chromatin in the nucleus is associated with the cell division in the form of chromosomes.
- Any type of deletion or addition in the chromosomes can cause structural and functional changes in living beings.
- A sort of **parallelism** is observed between Mendelian



factors and chromosomes.

- A number of genes or Mendelian factors are found on chromosome.
- Determination of sex in most of the animals and plants is affected by specific chromosomes. These chromosomes are called sex chromosomes.

★ **Parallelism Between Gene and Chromosomes**

- Chromosomes are also **transferred** from one generation to the next as in the case of genes (Mendelian factors).
- The number of chromosomes is **fixed** in each living species. These are found as homologous pairs in diploid cells. One chromosome from father and the other contributed by the mother constitute a homologous pair.
- Before cell division, each chromosome as a whole and the alleles of genes get **replicated** and are separated during mitotic division.
- Meiosis takes place during **Gamete formation**. Homologous chromosomes form synapses during prophase-I stage which in later course get separated and transferred to daughter cells. Each gamete or a haploid cell has only one allele of each gene present in the chromosome.
- A characteristic diploid number is again established by the **union** of the two haploid gametes.
- Both chromosomes and the alleles (Mendelian factors) behave in **according to Mendel's law of segregation**.

Homologous chromosomes of a pure tall plant, allele (T) is found for tallness in each chromosome. Likewise, in a pure dwarf plant (tt) allele (t) is present in each chromosome.

These homologous chromosomes. Likewise, in a pure dwarf plant (tt) allele (t) is present in each chromosome. These homologous chromosomes get separated during meiotic division. Hence, each gamete possess only one chromosome each pair. Accordingly all the gametes of tall plants possess a chromosome with an allele of tallness (T), while the gametes of dwarf plants possess a chromosome with an allele for dwarfness (t). Their cross to produce F_1 generation will yield tall hybrid plants with homologous chromosomal pair containing Tt allele with homologous chromosomal pair containing Tt allelic pair. In this generation two kinds of gamete will be formed during gametogenesis, 50% with the allele (T) for tallness and 50% with the allele for dwarfness (t). **Random combination** of these gametes will produce offsprings in F_2 generation in the ratio of 25% pure tall (TT), 50% hybrid tall (Tt) and 25% dwarf (tt).

SEX DETERMINATION

SEX DETERMINATION

Establishment of sex through differential development in an individual at an early stage of life, is called sex determination. Various methods operate in sex determination like environmental, non-allosomic genetic determination, allosomic sex determination and haplodiploidy

* Sex Determination on the basis of fertilization.

* Three types :

- **Progamic** : Sex is determined before fertilization. eg. – Drone in honey bee
- **Syngamic** – Sex is determined during fertilization. eg. – most of plants & animals
- **Epigamic** – Sex is determined after fertilization. eg. – Female in honey bee.

Environmental Determination of Sex. It is non genetic determination of sex which is based purely on environmental conditions. The organisms are potentially hermaphrodite and capable of expressing any of the sexes.

- In marine worm **Bonellia**, larva develops into female if it settles down alone in an isolated place. Any larva coming in contact with the already grown female, it changes into male, and lives as a parasite in the uterus of female.
- **Crepidula** (marine mollusca) where larva develops into male in the company of female and develops into female if left alone.
- In **Crocodiles** low temperature induces femaleness and high temperature maleness.
- In **turtles** temperature **below 28°C** induces maleness, above **33°C** femaleness while between **28 - 33°C** equal number of male and female animals are formed.
- In marine fish **Medusa** sex changes according to environmental condition, becoming male in cold water and female in warm water.

* Allosomic determination of sex

Chromosomes are of two types :

- i. Autosomes or somatic chromosomes. These regulate somatic characters.
- ii. Allosomes or Hetersomes or Sex chromosomes

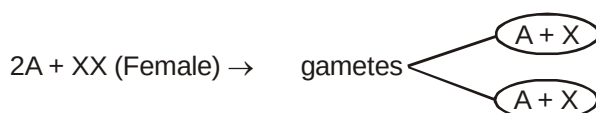
These chromosomes are associated with sex determination. Term “Allosome” & “Heterosome” were given by **Montgomery**.

Sex chromosomes first discovered by “**Mc Clung**” in grass hopper

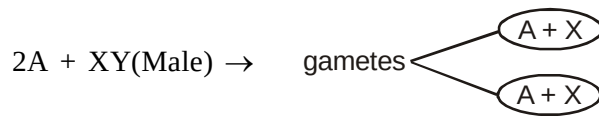
X - Chromosome discovered by “**Henking**” and called ‘x-body’.

Wilson & Stevens proposed **chromosomal theory for sex determination**.

- * **XX - XY type or Lygaeus type** : This type of sex determination first observed by **Wilson & Stevens** in **Lygaeus** insect. Two types.
- **XX female and XY male** : In this type of sex determination female is Homogametic produces one type of gamete



- Male is heterogametic (male produces two types of gamete)

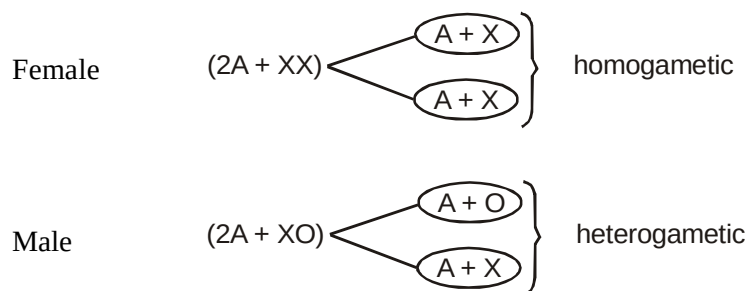


In male X-chromosome containing gametes is called “**Gynosperm**” and Y-chromosome containing gamete is called “**Androsperm**”. e.g. Man and dioecious plants like *Cocinea*, *Melandrium*

- **XY female and XX male or ZW female and ZZ male** : In this type of sex determination female is heterogametic produces two types of gamete and male individual is homogametic produces one type of gamete.

It is found in some insects like **butter flies, moths** and **vertebrates** like **birds, fishes** and **reptiles**. In plant kingdom this type of sex determination is found in ***Fragaria elatior***.

- * **XX female and XO male** : or “**Protenor type**” : In this type of sex determination deficiency of one chromosome in male. In this type, female is homogametic and male is heterogametic.



Example :

Grass hopper

Squash bug *Anasa*

Cockroach

Ascaris and in plants like - *Dioscorea sinuta* & *Vallisneria spiralis*.

GENIC BALANCE THEORY

C.B. Bridges proposed genic balance theory for sex determination in *Drosophila*.

- According to Bridges in *Drosophila* Y-chromosome is heterochromatic so it have no role in sex determination. In *Drosophila* sex determination takes place by sex index ratio.

$$\text{Sex index ratio} = \frac{\text{No. of x chromosomes}}{\text{No. of set of Autosomes}} = \frac{X}{A} \quad (0.5 \text{ is male and } 1 \text{ is female})$$

In *Drosophila* gene of femaleness (*Sxl* = Sex lethal gene) is located on x-chromosome and gene of maleness is located on autosome.

Gene of male fertility is located on y-chromosome and in *Drosophila*, y-chromosome plays addition role in spermatogenesis and development of male reproductive organ, so y-chromosome is essential for the production of fertile male.

$$\text{Sex index ratio} \quad \frac{X}{A} = 1 \rightarrow \text{female} \quad (2A + XX), (3A + XXX)$$

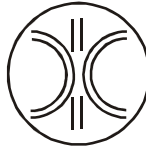
$$\frac{X}{A} = 0.5 \rightarrow \text{male} \begin{cases} (2A + XY) = \text{Fertile male} \\ (2A + XO) = \text{Sterile male} \end{cases}$$

$$\frac{X}{A} = 1.5 \rightarrow \text{Super female or meta female (sterile) (2A + XXX)}$$

$$\frac{X}{A} = \text{less than } 0.5 \rightarrow \text{Super male or meta male (Sterile) (3A + XY)}$$

$$\frac{X}{A} = \text{In between } 0.5 \text{ and } 1 \rightarrow \text{Intersex (Sterile) (3A + XX)}$$

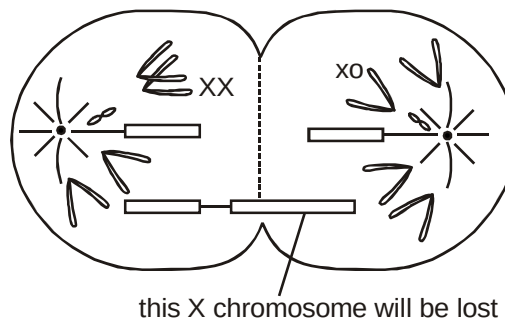
$$\frac{X}{A} = \frac{1}{2} = 0.5 \text{ (Male)}$$



Chromosomal diagram
of Drosophila

* Gynandromorph -

Body of some Drosophila has some cells with male (X0) and some cells with female genotype (XX). Body of such type of Drosophila has half lateral part of male and half lateral part of female and it is called bilateral gynandromorph. It is formed due to **loss of one x-chromosome at metaphase plate** during first zygotic division. Formation of gynandromorph is the best evidence that y-chromosome does not play any role in sex determination.



HAPLOID - DIPLOID MECHANISM

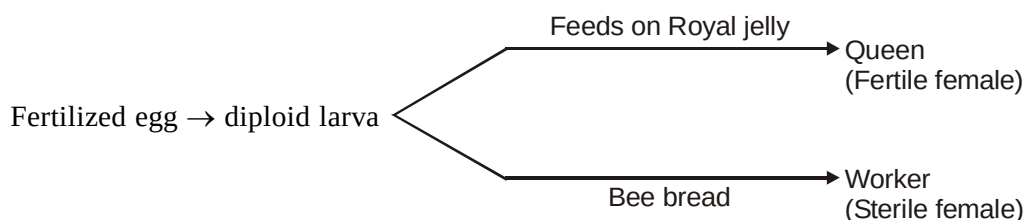
In insects of order Hymenoptera which includes ants, honey bees, wasps etc.

Sex determination takes place by sets of chromosomes.

Diploid (two sets) → Female

Haploid (One set) → Male

In honey bee, male individual (Drone) develops from unfertilized eggs (Haploid.) Male is always parthenote. Queen and worker bees develop from diploid eggs i.e. fertilized egg.



SEX DETERMINATION BY HORMONE

Dizygotic twins are common in cattle like cow, sheep, goat etc. Some times the placenta of the two dizygotic twins fuse forming blood vascular connections between two developing foetus. If twins are dizygotic, one foetus may be male and the other female.

- **Male hormone produced before female** hormone by male twins which suppress the differentiation of female (♀) sex organ. Such a sterile female with underdeveloped ovaries, oviducts, Uterus etc. is called **free martin**.

In free martin conditions, female is sterile & male is normal.

Y spots : Males are identified by **Y spots (Zech 1970)**. **Number of Y spots are equal to number of Y chromosomes.**

CYTOLOGICAL BASIS OF SEX DETERMINATION

Barr body technique or **Lyon's hypothesis** -

Interphasic nucleus of human female contains two X-chromosomes. Out of two, one X - Chromosome becomes heterochromatin and other X - Chromosome is euchromatin. By staining X - heterochromatin, it appears as a dense body which is called Barr body. (Facultative heterochromatin)

No. of Barr body = (No. of X chromosomes - 1)

So a Normal female (2A + XX) → One Barr body

Normal male (2A + XY) → Barr body absent

Turner syndrome (Sterile female) (2A + XO) → No. Barr body

Klinefelter syndrome (Sterile male) (2A + XXY) → One Barr Body

Drum stick which occurs in blood of female of mammals, is also a type of barr body. Drum stick is absent in neutrophils of Male.

SEX DETERMINATION IN HUMAN

There occurs a special gene on differential region of Y-chromosome of human, called Sry - gene (Sex determining region on y-chromosome). This gene forms a proteinaceous factor called TDF (testes determining factor). TDF is responsible for the development of male reproductive organs. So presence and absence of Y-chromosome determines sex.

* Sex determination in plant :

H.E. Warmke discovered sex determination in *Melandrium* plant. In *Melandrium* Y- chromosome is long as compared to X - chromosome. In plant sex chromosomes are found only in unisexual plant.

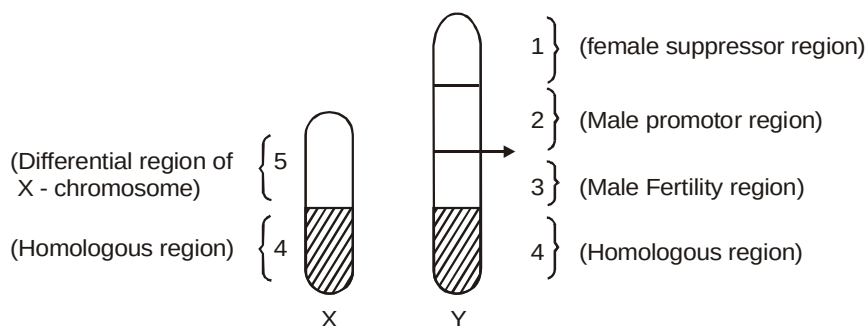
Prof. R.P. Roy gave the importance of Y-chromosome in plant.

He discovered sex determination in **Coccinea Indica** (Family - cucurbitaceae)

Y - Chromosome contains four regions and X - chromosome contains two regions. Different functions of these regions.

- Ist region - (Female suppressor region) : This region suppress the development of female reproductive structures.
- IInd region (Male promotor region) : This region initiates or starts the development of Anther
- IIIrd region (Male fertility region) : This region induces the further development of Anther.
- IVth region (Homologous region) : This region helps in the disjunction & Pairing of X and Y chromosome during meiosis.

- V^{th} region (Differential region of X-chromosome) : This region induces the development of female gonads. So when one or more than one Y - chromosome is present then plant is male and in female plant Y-chromosome is absent.



* Special Case :

If I^{st} region of Y chromosome is removed then plant becomes **bisexual**

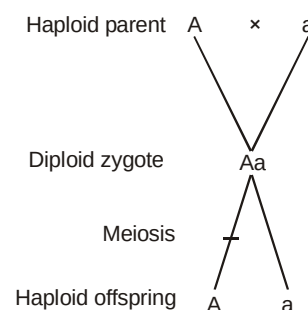
If II^{nd} region of Y chromosome is removed then plant becomes **female** due to absence of II^{nd} region, I^{st} region of Y chromosome does not suppress the V^{th} region of X - chromosome.

If III^{rd} region of Y chromosome is removed then plant becomes **sterile male** due to absence of III^{rd} region so further development of anther does not take place.

PHENOTYPIC EXPRESSION IN HAPLOID ORGANISMS

Diploid organisms such as pea and *Drosophila*, have two alleles for each gene. With the result, the recessive allele is not expressed in the phenotype in presence of the dominant one. However, this is not so in the case of haploid organisms. Contrary to diploid organisms, the genetics of haploid organisms exhibit the following features.

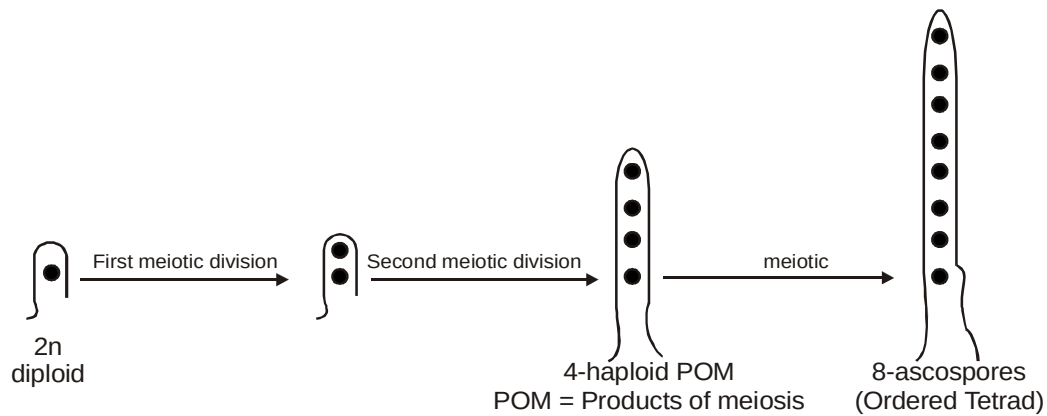
- Haploid organisms contain only one allele of a gene, so there is no complication of dominance. All the genes, whether dominant or recessive, express itself in the offsprings.
- In absence of dominance, any new mutation is immediately expressed, in haploid organism
- Study inheritance of mutated gene, linkage, crossing over and biochemical consequence of a mutation can easily be studied in haploid.



LINKAGE AND RECOMBINATION IN NEUROSPORA (Drosophila of plant kindgom)

Detection of linkage and recombination of genes in haploid organisms as in fungi, bacteria etc. is comparatively simple. Fungus **Neurospora** is one of the favourite material with geneticists, because :

- The life cycle is of a short duration.
- The life cycle of **Neurospora** is the product of a single meiosis
- The meiotic products are **linearly arranged** in ascus as 8 ascospores as ordered tetrads (i.e., the eight ascospores are arranged in the same order in which chromatids were on the meiotic metaphase plate. This is called **linear** or **ordered tetrad**. Each of the four products of meiosis can be culutred separately to study their phenotypes and genotypes. This is called **tetrad analysis**.



- **First Division Segregation Between Centromere and Gene - a.**

A cross between two strain of Neurospora, one normal (a^+) and other mutant (a) strain produces 8-ascospores, out of which four are normal (a^+) and other four mutants (a). The linear arrangement of ascospores in ascus is $4a^+ : 4a$. It indicates the absence of crossing over between locus-a and centromere. This described as first division segregation ($4 : 4$).

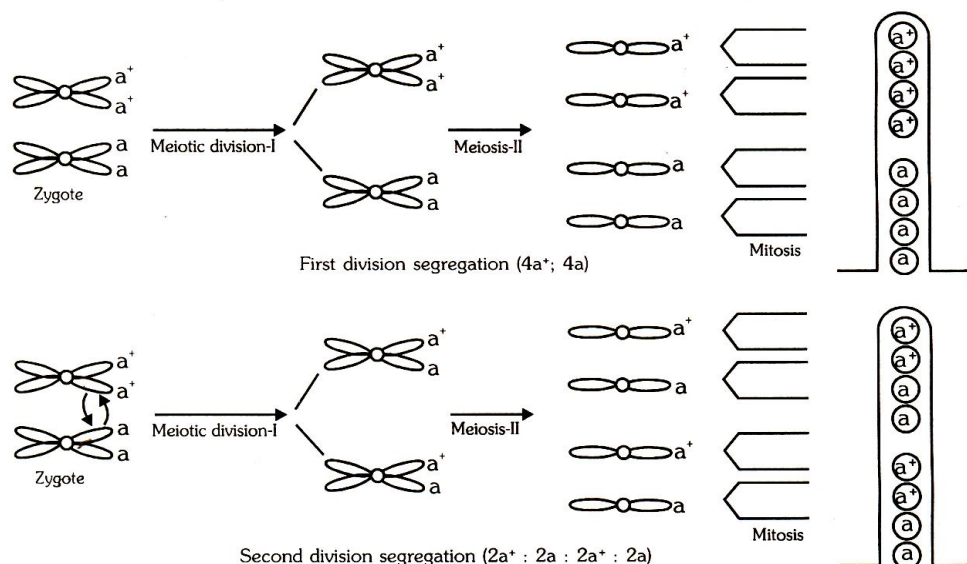
- **Second Division Segregation Between Centromere and Gene-a**

In a similar cross if crossing over takes place leading to paired arrangement of ascospores with a prticular gene, it is described as **second division segregation**. The arrangement of ascospores in the sequence ($2 : 2 : 2 : 2$) is as follows :

$a^+ : a^+ : a : a : a : a : a^+ : a^+$ ($2 : 4 : 2$)

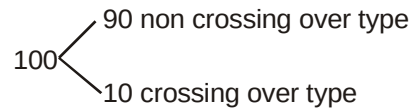
$a : a : a^+ : a^+ : a^+ : a^+ : a : a$ ($2 : 4 : 2$)

$a^+ : a^+ : a : a : a^+ : a^+ : a : a$ ($2 : 2 : 2 : 2$)



- ★ **Single Gene Mapping in Neurspotra**

In Neurospora centromere behaves as a gene for mapping gene pair. In such a case distance of gene from the centromere is calculated by calculating the percentage of cross over between centromere and gene. Que. If 10% asci show crossing over what will be distance between gene and centromere. If total 100 asci are precsent in a Neurospora



1 asci is derivative of 8 spores

100 asci are derivative of $(100 \times 8 = 800 \text{ spore})$

10 asci are derivative of 80 spores

(Out of 80 only 40 will be the recombinant type)

$$\begin{aligned} \% \text{ C.O.} &= \frac{\text{recombinant spore}}{\text{Total spore}} \times 100 \\ &= \frac{40}{800} \times 100 = 5\% \quad \text{Ans. 5 cM} \end{aligned}$$

MUTATION

- Sudden Heritable change in genetic material of an organism is called as Mutation.
- Mutation are discontinuous source of variation.
- Frequency of mutation at present is 1×10^{-6} (1 cell in : 1 million-cell). But it will increase in future due to pollution and destruction of ozone layer.
- Mutation word was given by Hugo De Vries.
- De Vries studied mutations in the plant *Oenothera lamarckiana* (evening primrose). It is a hybrid plant.
- De Vries gave (proposed) mutation theory of evolution.
- This theory was given in support of Darwinism because Darwin was unable to explain the source of variations. Darwin called variation as sport.
- According to De Vries there are two types of variations in evolutions.

* Continuous variations :

- The variations are develop in every generation of an organism.
- These variations are developed by crossing over/meiosis/sexual reproduction.
- Only minor variation are developed by crossing over.

* Discontinuous variations :

- These variations are developed by mutations.
- Suddenly in any generation
- Both minor and major type of variations are developed by mutations mostly major type.

* Seth Right :

- Mutation was first observed by him.
- He observed some short legged sheep (Ancon) variety in a population of long legged sheep.
- It was an example of dominant germinal of mutation.
- Those mutation are only heritable which occur in germinal cell of an organism. While somatic mutations are non heritable.
- Somatic mutations are also heritable in vegetative propagated plants.

* Morgan :

- Credit of discovery of mutation is given to him. He observed some white eyed male *Drosophila* in a population of red eyed *Drosophila*.
- In *Drosophila* eye colour is a sex linked character. Gene of eye colour is located on X chromosome. Gene of Red eye is dominant over the gene of white eye. So in *Drosophila* genotypes for eye colour are of following types.

Male	Female
$X^W Y$ - Red	$X^W Y$ - White
50 - 50% Red & White $X^W X^W$ = Red	$X^W X^W$ = Red $X^W X^W$ = White

★ **Muller :**

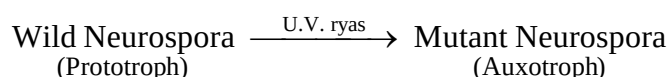
- Discoverer of Induced Mutations.
- He induced mutations in *Drosophila* by the help of X-rays.

★ **Mac Farlane Burnitt, Neil Jerne :**

- Induced mutations in B-lymphocytes of blood to obtain new antibodies.

★ **Beadle and Tatum :**

- Induced mutations in *Neurospora* to study nutritional mutation by the help of U.V. rays. or X-rays.



- Normal-*Neurospora* can be grown in minimal medium (which lacks some nutrients), because it can make all nutrients for it. This is known as prototroph.
- Mutant *Neurospora* doesn't has capability to grow in minimal medium because due to mutation it loses those genes which prepare some special nutrients for it. Eg. Vita. -B or Thiamine.
- When Vit-B or Thiamine was given to mutant *Neurospora* then the growth of *Neurospora* was normal. This form is known as Auxotroph.

★ **M.S. Swaminathan :**

- He induced mutations in wheat by the help of -rays to obtain good varieties for eg. Sharbati Sonora
- Swaminathan established garden in IARI-New Delhi (Pusa Institute).
- Largest Institute in the field of Agriculture in Aisa.

★ **Main Points :**

- Mostly mutations are harmful.
- Sometimes they are lethal which leads to death of organisms.
- But sometimes they are beneficial which are used to obtain good varieties of plants and animals. It is called as **Mutation Breeding**.
- Mostly mutations are recessive and being recessive they never eliminate from a population it is called as hardy-weinberg law.
Which is applicable to large population and random mating.
- Dominant lethal mutation always eliminate from a population either it is large or small.

FORWARD AND BACKWARD MUTATION

- Wild gene $\xrightleftharpoons[\text{Backward}]{\text{Forward}}$ Mutant gene

★ **Mutator gene and Mutable gene :**

- Gene which induce mutation in another gene is called mutator gene and in which mutation is induced is called as mutable gene.

★ **Neutral Mutation/Suppression :**

- Mutation in one gene is neutralized by mutation in another gene called as neutral mutation. So it means mutation without effect and in neutralization two mutations are required.

★ **Complementation :**

- Occur in Heterokaryon or dikaryon cells in which two genetically different nuclei are present in a cell. Mutation effect in one nucleus is neutralized by the another nucleus of heterokaryon. This condition occur in Neurospora during somatogamy.

★ **Hot Spot :**

- Place on DNA or gene where frequency of mutation is high.
- In Prokaryotes frequency of mutation is high than eukaryotes due to naked DNA.

★ **Muton (unit of mutation) :**

- Smallest part of DNA which undergoes mutation.
- It is one nucleotide.

★ **Types of mutation :**

(A) Chromosomal Mutation

(B) Gene Mutation

A. CHROMOSOMAL MUTATIONS

- Change in number or structure of chromosome.

Types of chromosomal mutation :

(a) Heteroploidy/Genomatic mutation → change in chromosome number

(b) Chromosomal aberration → change in structure of chromosome.

(a) Heteroploidy/Genomatic mutation :

- Change in number of sets or chromosomes in sets. Two types-

(i) Euploidy → Change in number of sets.

(ii) Aneuploidy → Change in number of chromosome in set.

(i) Euploidy :

- Change in number of sets/loss or addition of sets of chromosomes.
- In a normal diploid cell two sets of chromosome are present
- Loss of one set ($2n - n = n$) monoploidy
- Addⁿ. of set called as polyploidy

Add ⁿ . of one set	called as Triploidy	$2n + n = 3n$
Add ⁿ . of two sets	called as Tetraploidy	$2n + 2n = 4n$
Add ⁿ . of three sets called as	Pentaploidy	$2n + 3n = 5n$
Add ⁿ . of four sets	called as Hexaploidy	$2n + 4n = 6n$
Add ⁿ . of five fsets	called as Heptaploidy	$2n + 5n = 7n$

- Octaploid plants rarely survive.
- Polyploid plants with even number of sets are always fertile, reproduce sexually and form seeds.
- Polyploid plants with odd number of sets are always sterile don't reproduce by sexual reproduction, They don't produce seeds but they may produce seedless fruits by parthenocarpy.
eg. Banana and seedless grapes.
Polyploidy is of two types :

(1) Autopolyploidy :

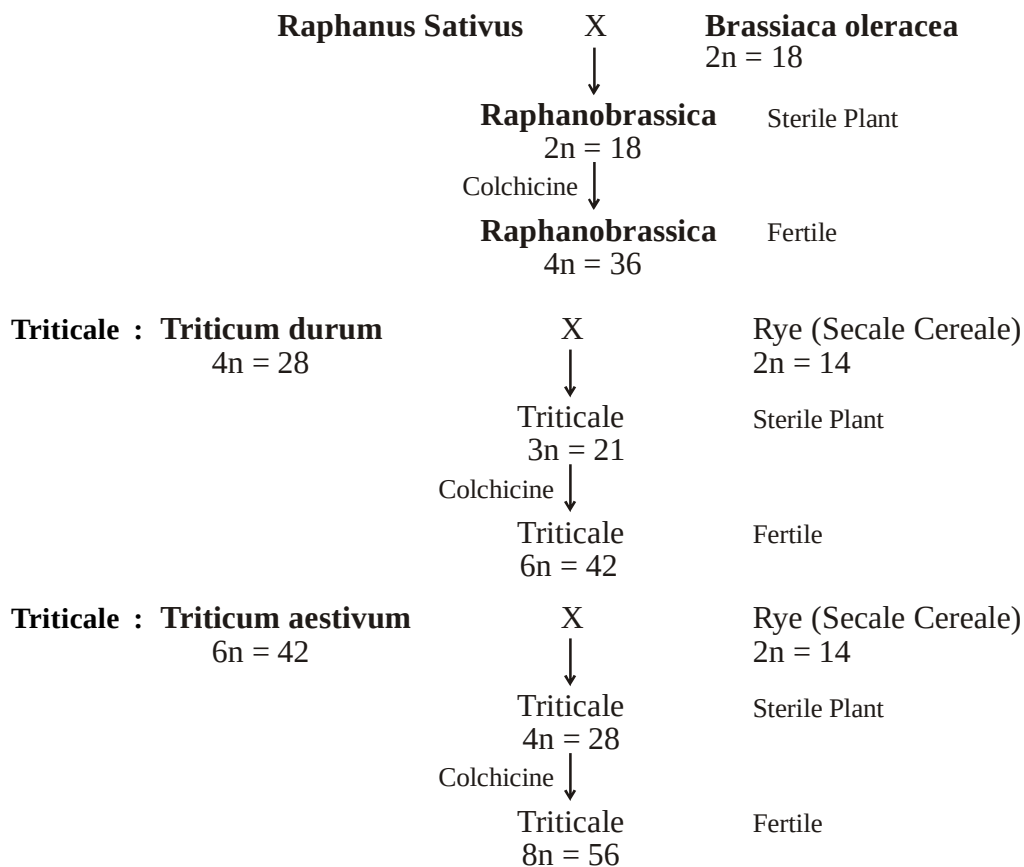
- It is repetition of same set of chromosomes. Eg. AAA.

- **Cyanodon and Rose** → Autotriploid plants
- These are sterile plants.
- Reproduce by vegetative propagation.

(2) Allopolyploidy :

- More than one type of sets are present in these plants eg. AA BB.
- These plants are obtained by intergeneric cross.

e.g., Raphanobrassica is obtained by cross between Raddish and cabbage and first time obtained by Rusian Scientist Karpechenko.



(ii) Aneuploidy :

Loss or addition of chromosomes in sets of chromosomes. Types of Aneuploidy:

(1) Hypoaneuploidy (loss)

- $2n - 1$ = monosomy:- (loss of one chromosome in one set)
- $2n - 1 - 1$ = double monosomy (loss of one chromosome from each set, but these are non homologous.)
- $2n - 2$ = Nullisomy (loss of two homologous chromosome)

(2) Hyperaneuploidy (add.)

- $2n + 1$ = Trisomy: addition of one chromosome in one set.
- $2n + 1 + 1$ = Double Trisomy: addition of one chromosome in each set.
- $2n + 2$ = Tetrasomy: addition of two chromosome in one set.
- Cause of aneuploidy is chromosomal non disjunction means chromosomes fail to separate during meiosis.
- Chances of aneuploidy are more in higher age female due to less activity of oocyte, so chances of syndrome increase in children who are born from higher age female.

(b) Chromosomal Aberrations :

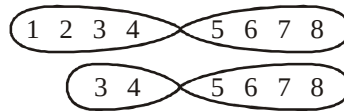
Change in structure of chromosome.

(i) Deletion :

Loss of a part or segment of chromosome which leads to loss of some gene is called as deletion.

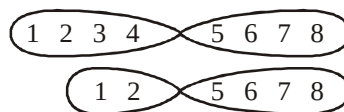
It is of 2 types:-

(1) Terminal deletion- Loss of chromosomal segment from one or both ends. e.g., The cry-du-chat syndrome is an example of terminal deletion in 5th chromosome.



e.g., The cry-du-chat syndrome is an example of terminal deletion in 5th chromosome.

(2) Intercalary deletion- Loss of chromosomal part between the ends.

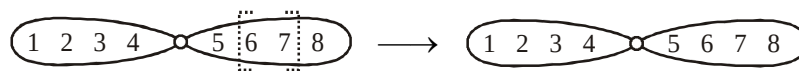


(ii) Inversion :

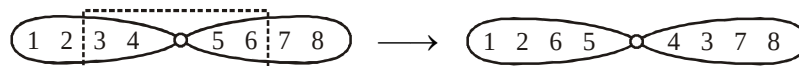
Breakage of chromosomal segment but reunion on same chromosome in reverse orders. It leads to change in distance between genes on chromosome or sequence of genes on chromosome so crossing over is affected.

It is of 2 types :

(a) Paracentric - If inversion occur only in one arm and inverted segment does not include centromere.



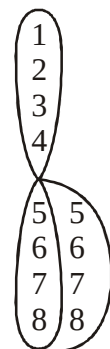
(b) Pericentric - In this type of inversion inverted segment include centromere.



(iii) Duplication :

Occurrence of a chromosomal segment twice on a chromosome. If in this segment any recessive gene is present, then it given it's expression due to homozygous condition. If in this segment any recessive but lethal gene is present, it lead to death of organism.

Example: In drosophila "Bar eye character" is observed due to duplication in X-chromosome. Bar eye is a character where eyes are narrower as compared to normal eye shape.

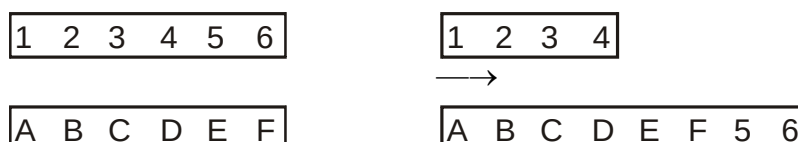


(iv) Translocation :

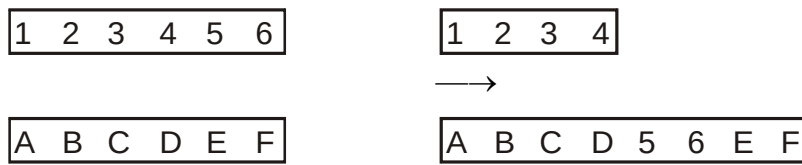
In this, a part of the chromosome is broken and may be joined with non homologous chromosome. This is also known as Illegitimate crossing over (illegal crossing over)

Three types of translocation-

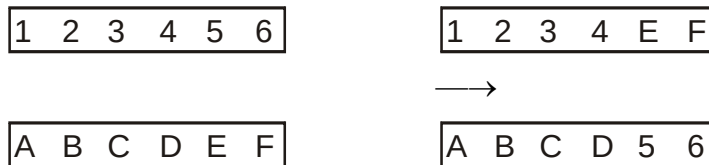
(a) Simple Translocation : When a chromosomal segment breaks and attached to the terminal end of a non-homologous chromosome.



- (b) **Interstitial or shift translocation** : If a segment of chromosome breaks and gets inserted in interstitial position of a non homologous chromosome.



- (c) **Reciprocal Translocation** : Exchange of segments between two non-homologous chromosome.



e.g., Chronic myloid leukemia [C M L] is a type of blood cancer. This disease is a result of reciprocal translocation between 22 and 9 chromosome.

Note: If exchange of segments takes place in between homologous chromosomes then it is called crossing over.

B. GENE MUTATION OR POINT MUTATION

Two types : -

- (1) **Substitution** (2) **Frame shift mutation.**

(1) **Substitution** :

Replacement of one nitrogenous base by another nitrogenous base is called as substitution.

- It causes change in one codon in genetic code which leads to change in one amino acid in structure of protein. *e.g.*, Sickle cell anaemia

Main Point :

- Change may not occur because for one amino acid more than one type of codons are present.

Substitution is of two types :

- (a) **Transition** (b) **Transversion.**

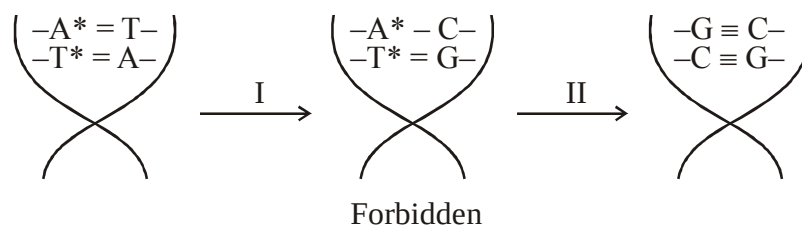
(a) **Transiton** :

Replacement of one purine by another purine or replacement of pyrimidine by another pyrimidine.

Methods of Transition :-

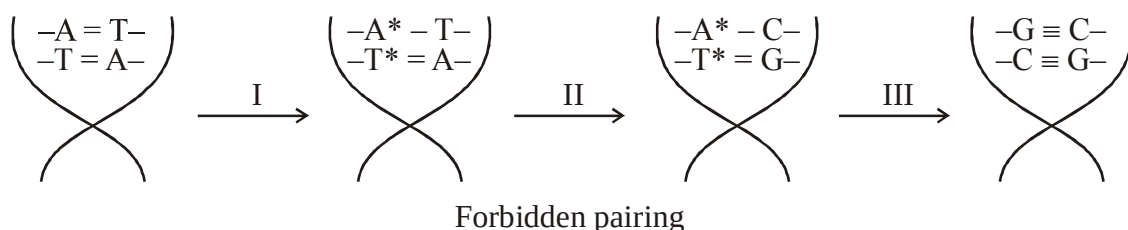
- By Tautomerisation** : By this method transition is induced by HNO_2 . HNO_2 changes normal structure of nitrogenous base and changed nitrogenous base is called as **Tautomer**.

- In structure of adenine and guanine, amino group is present, HNO_2 changes it into imino group.



- In the structure of cytosine and thymine, keto group is present. Which is change into enol group by HNO_2 .
- In first DNA replication, Tautomer of adenine pairs with a normal cytosine and Tautomer of thymine pairs with normal guanine.

- It is unusual pairing which is called as forbidden pairing so a wrong type of DNA is formed in cell.
 - In second DNA replication normal cytosine pairs with normal guanine and normal guanine pairs with normal cytosine.
 - It is usual pairing so transition completes in two DNA replication (Tautomers always perform forbidden pairing).
2. **By Ionisation :** By this method transition is induced by ionizing radiation like X-ray. These radiations convert nitrogenous bases in their ions and ions perform forbidden pairing. So by this method transition is completed in two DNA replications.
3. **By Base Analogues :** Transition is induced by chemicals which are same as nitrogenous base in function. They are called base analogues or duplicates of nitrogenous base.
e.g., Aminopurine is base analogue to Adenine (purine) 5-Bromo uracil is base analogue to thymine (pyrimidine), 5-Iodo uracil is base analogue to guanine, 5-Chloro uracil is base analogue to cytosine.



- In I DNA replication base analogues get establish in normal structure of DNA
 - IN II DNA replication they perform forbidden pairing
 - In III DNA replication transition is completed.
- (b) **Transversion :**
- Replacement of purine by pyrimidine or pyrimidine by purine is called transversion.
 - EMS $\Rightarrow$ Ethyl methane sulphonate
 - MMS $\Rightarrow$ Methyl methane sulphonate
 - These chemicals causes depurination means they remove one purine from structure of DNA. So a gap is formed.
 - If this gap is filled by another purine then it is called as transition.
 - But if this gap is filled by pyrimidine then it is called as transversion.
 - So EMS and MMS may cause both transition and transversion.
- (2) **Frame shift mutation/Gibberish mutation :**

(1) Arredine (2) proflavin

These chemicals causes loss or addition of one or two nitrogenous bases in structure of DNA so complete reading of genetic code is changed. It leads to change in all amino acids in structure of protein so a new protein is formed which is completely different from previous protein.

ATG	ACG	GAC	AGA	AAC.....
ATG	CGG	ACA	GAA	AC.....

- So frame shift mutations are more harmful as compared to substitution.
- Thallesemia (lethal genetic disorder)

Mutagens :

- Mutagens are those substance which cause mutations : -

1. **Radiation :** - They are two types

(i) **Ionising:- α , β , γ , X-ray**

(ii) **Non ionizing:- U.V. rays**

- U.V. rays has less penetration power and skin of higher organisms absorb radiations. So they don't cause any effect in higher animals, but U.V. rays and radiations are effective mutagens in microbes and due to more effect leads to death of microbes. So U.V. rays are used to sterilize operation theatre.

- Radiations mainly cause chromosomal aberrations which cause major change in organisms. So chromosomal mutations are more important in evolution.
- U.V. rays and HNO_2 cause deamination of nitrogenous base means they remove amino group from nitrogenous base by deamination of,

Adenine $\longrightarrow$ Hypoxanthine

Guanine $\longrightarrow$ Xanthine

Cytosine $\longrightarrow$ Uracil

U.V. rays do not cause deamination in thymine. By U.V. rays two adjacent thymine bind together and form **thymine-dimer**.

2. Chemical mutagens :

eg. Mustard gas (first identified Chemical Mutagens)

Carbon tetra sulphide, Nitrous acid (HNO_2)

Organic peroxide, Ethyl urethane, Pesticides etc.

DDT (Dichloro Diphenyl Trichloro Ethane)

LSD (Lysergic acid diethylamide)

- Chemical mutagens are more harmful than radiations because body is not protected against chemicals.
- Source of chemical mutagens are food, air and water.
- Effect of radiation is localized, while chemical mutagens spread in complete body through blood circulation and when they reaching gonads they cause germinal mutation.
- Chemicals also cause chromosomal mutations.

Antibiotics :

1. Neomycin

2. Kenamycin

3. Streptomycin

These antibiotics combine with small subunit of prokaryotic ribosome and Cause misreading of genetic code or induce error in translation.

Main Point :

- Same effect of puromycin antibiotic in eukaryotes.

Special Point

Mis-sense mutation : When a nucleotide change in genetic code cause the change of one amino acid of a polypeptide chain it is called mis-sense mutation.

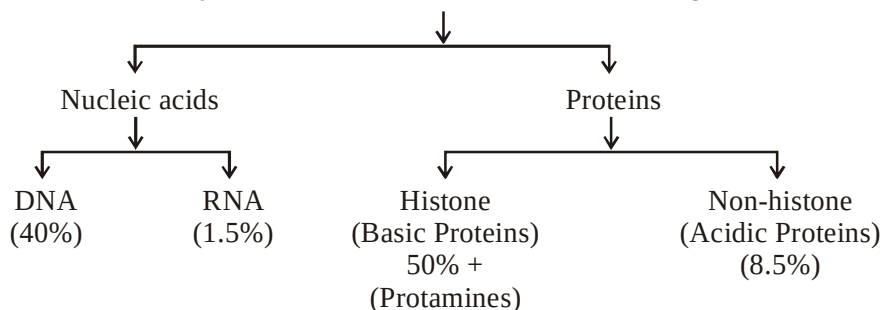
Non-sense mutation : When a nucleotide change in one codon causes termination of polypeptide synthesis by producing non-sense codon.

Same sense codon - A change in one nucleotide in a codon does not change amino acid in polypeptide chain, because both codons code same amino acid.

NUCLEIC ACIDS -

CHEMICAL COMPOSITION :

Chemical analysis of chromosomes reveals the following substances

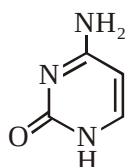


- Meischer discovered nucleic acids in nucleus of pus cell and called it "nuclein". The name nucleic acid proposed by "Altmann".
- Nucleic acids are polymer of nucleotides.

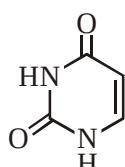
= Nitrogen base + pentose + phosphate

On the basis of structure nitrogen bases are broadly of two types :

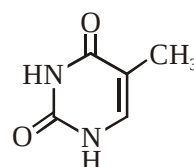
- Pyrimidines** : Consist of one pyrimidine ring. Skeleton of ring composed of two nitrogen and four Carbon atoms e.g. Cytosine, Thymine and Uracil.



Cytosine

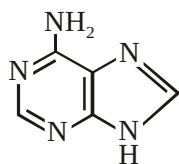


Uracil

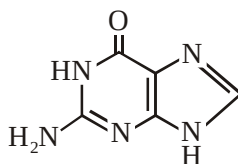


Thymine

- Purines** : Consist of two rings i.e. one pyrimidine ring (2N + 4C) and one imidazole ring (2N + 3C) e.g. Adenine and Guanine.

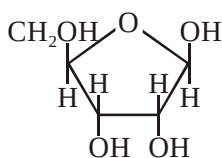


Adenine

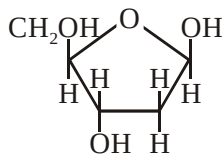


Guanine

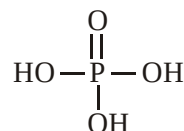
Pentose Sugar :



Ribose



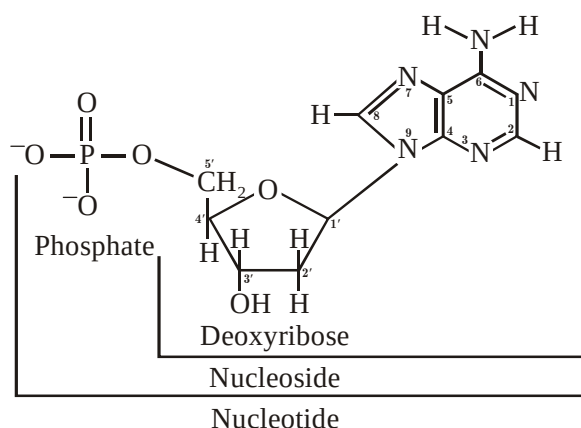
Deoxy Ribose



Phosphoric acid

Nitrogen base forms bond with first carbon of pentose sugar to form a nucleoside. Nitrogen of first place (N_1) forms bond with sugar in case of Pyrimidines while in purines nitrogen of ninth place (N_9) forms bond with sugar.

Phosphate forms ester bond (covalent bond) with fifth carbon of sugar to form a complete nucleotide.



Types of Nucleosides and Nucleotides

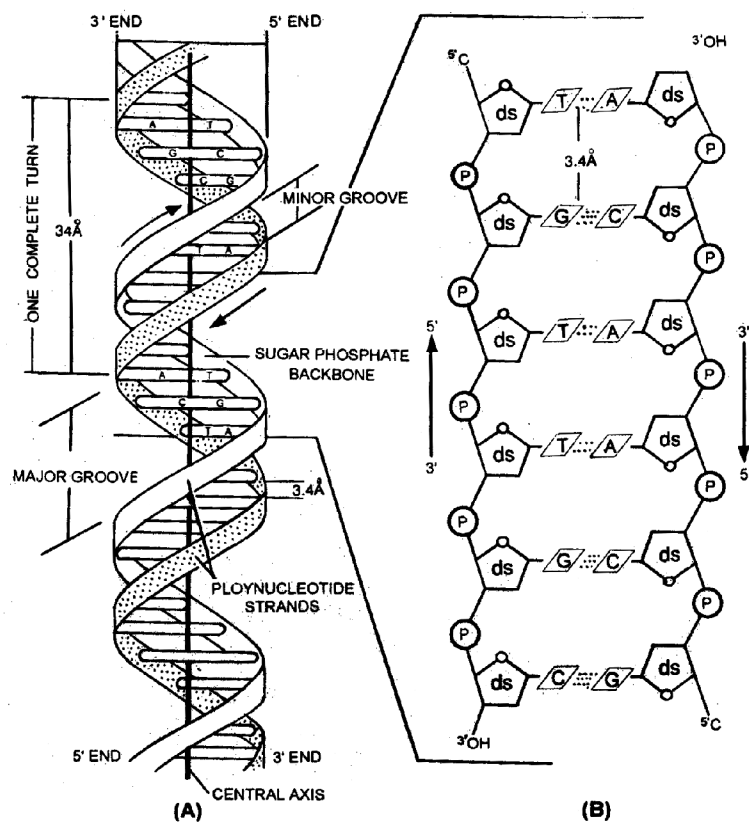
- Adenine + Ribose = Adenosine

Adenosine + Phosphate = Adenylic acid

2. Adenine + Deoxyribose = Deoxy adenosine
Deoxy adenosine + P = Deoxy adenylic acid
3. Guanine + Ribose = Guanosine
Guanosine + P = Guanylic acid
4. Guanine + Deoxyribose = Deoxy guanosine
Deoxy guanosine + P = Deoxy guanylic acid
5. Cytosine + Ribose = Cytidine
Cytidine + P = Cytidylic acid
6. Cytosine + Deoxyribose = Deoxycytidine
Deoxycytidine + P = Deoxycytidylic acid
7. Uracil + Ribose = Uridine
Uridine + P = Uridylic acid
8. Thymine + Deoxyribose = Deoxy thymidine
Deoxythymidine + P = Deoxythymidylic acid

DNA

- Discovered by - **Meischer**
- DNA term given by - **Zacharis**
- In DNA pentose sugar is deoxyribose sugar and four types of nitrogen bases A, T, G, C.
- Wilkins and Franklin studied DNA molecule with the help of X-Ray crystallography.
- With the help of this study, **Watson** and **Crick** (1953) proposed a double helix model for DNA. For this model Watson, Crick and **Wilkins** were awarded by noble prize in 1962.
- According to this model, DNA is composed of two polynucleotide chains.
- Both polynucleotide chains are complementary and antiparallel to each other.



- In both strand of DNA direction of phosphodiester bond is opposite. i.e. If direction of phosphodiester bond in one strand is 5'-3' then it is 3'-5' in another strand.
- Both strand of DNA held together by Hydrogen bonds. These hydrogen bond are present between Nitrogen bases of both strand.
- Adenine binds to Thymine by two hydrogen bonds and cytosine binds to Guanine by three hydrogen bonds.
- Chargaff's equivalency rule - In a double stranded DNA amount of purine nucleotides is equal to amount of pyrimidine nucleotides.

$$\text{Purine} = \text{Pyrimidine}$$

$$[A] + [G] = [T] + [C]$$

- Base ratio = $\frac{[A]+[G]}{[T]+[C]}$ = constant for a given species.
- In a DNA, $A + T > G + C \Rightarrow A - T$ type DNA. Base ratio of A - T type of DNA is more than one. eg. Eucaryotic DNA
- In a DNA $G + C > A + T \Rightarrow G - C$ type DNA. Base ratio of G -C type of DNA is less than one. eg. Procaryotic DNA
- Melting point of DNA depends on G - C contents.
More G - C contents then more Melting point.
- T_m = Temperature of melting.
 T_m = of prokaryotic DNA > T_m of Eucaryotic DNA
- DNA absorbs U.V. rays means 2600Å wavelength.
- Out of two strand of DNA only one strand participates in transcription, it is called **Antisense strand/ Non coding strand / Template strand**.
- Other strand of DNA which does not participate in transcription is called **sense strand/Coding strand**.
- Denaturation and renaturation of DNA - If a normal DNA molecule is placed at high temperature (80 - 90°C) then both strand of DNA will separate to each other due to breaking of hydrogen bonds. It is called **DNA-denaturation**.
When denatured DNA molecule is placed at normal temperature then both strand of DNA attached and recoiled to each other. It is called **Renaturation of DNA**.
- Hyperchromicity - When a double stranded DNA is denatured by heating then denatured DNA molecule absorbs more amount of light, this phenomenon is called **hyperchromicity**.
- Hypochromicity - When denatured DNA molecule cool slowly then it becomes double stranded and it absorb less amount of light. This phenomenon is called **hypochromicity**.

Configuration of DNA Molecule :

- Two strands of DNA are helically coiled like a revolving ladder. Back bone of this ladder (Reiling) is composed of phosphates and sugars while steps (bars) composed of pairs of nitrogen bases.
- Distance between two successive steps is 3.4Å. In one complete turn of DNA molecule there are such 10 steps (10 pairs of nitrogen bases.) So the length of one complete turn is 34Å. This is called **helix length**.
- Diameter of DNA molecule i.e. distance between phosphates of two strands is 20Å.
- Distance between sugar of two strands is 11.1 Å.
- Length of hydrogen bonds between nitrogen bases is 2.8-3.0 Å. Angle between nitrogen base and C_1 Carbon of pentose is 51°.
- Molecular weight of DNA is 106 to 109 dalton.
- In nucleus of eukaryotes the DNA is associated with histone protein to form nucleoprotein. Histone occupies major groove of DNA at 30° angle

- Bond between DNA and Histone is salt linkage (Mg^{+2}).
- DNA in chromosomes is linear while in prokaryotes, mitochondria and chloroplast is circular.
- In $\phi \times 174$ bacteriophage the DNA is single stranded and circular isolated by Sinsheimer. G-4, S-13, M-13, F_1 and Fd-Bacteriophages also contain ss-circular DNA.

Types of DNA

On the basis of direction of twisting, there are two types of DNA.

1. Right Handed DNA -

Clockwise twisting e.g. The DNA for which Watson and Crick proposed model was 'B' DNA. Other e.g. of right handed DNA.

DNA	Helix Length	No. of base pairs	Distance between two pairs	Diameter
'A'	28 Å	11 pairs	2.56 Å	23 Å
'B'	34 Å	10 pairs	3.4 Å	20 Å
'C'	31 Å	9.33 pairs	3.32 Å	19 Å
'D'	24.24 Å	8 pairs	3.03 Å	19 Å

2. Left handed DNA -

Anticlockwise twisting e.g. Z-DNA-discovered by Rich. Phosphate and sugar backbone is zig-zag. Units of Z-DNA are dinucleotides (Purine and pyrimidine in alternate order)

Helix length - 45.6 Å

Diameter - 18.4 Å

No. of Base pairs - 12 (6 dimers)

Distance between base - pairs - 3.75 Å

- Palindromic DNA - Wilson and Thomas

```

      →
C C G G T A C C G G
G G C C A T G G C C
      ←

```

Sequence of nucleotides same from both ends.

Special Points :

- DNA molecule is Dextrorotatory while RNA molecule is Laevorotatory.
- C-value = Total amount of DNA in a haploid genome of organism.

THE SEARCH FOR GENETIC MATERIAL

The experiments given below prove that DNA is the genetic material.

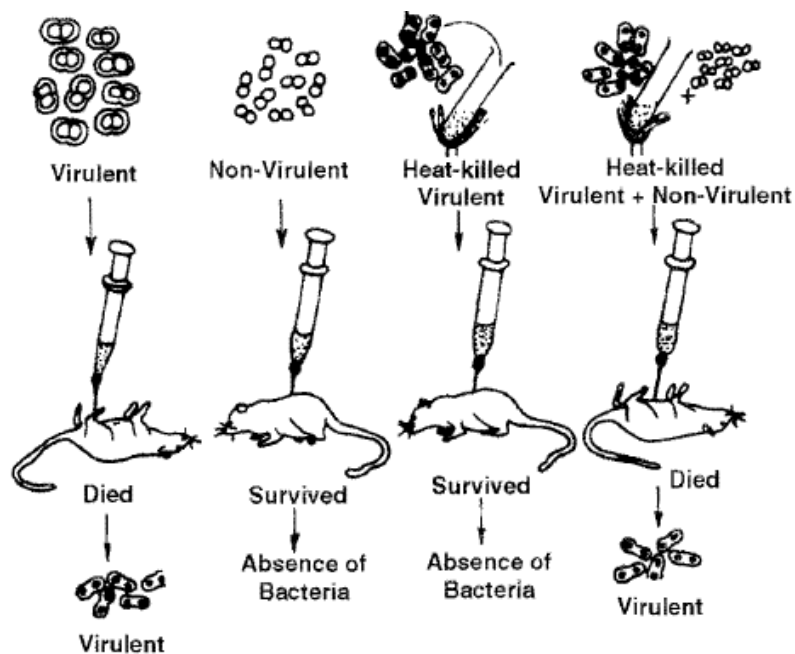
- (I) **Evidence from bacterial transformation.** The transformation experiments, conducted by Frederick Griffith in 1928, are of great importance in establishing the nature of genetic material. He used two strains of bacterium *Diplococcus* or *Streptococcus pneumoniae* or *Pneumococcus* i.e., S-III and R-II.
 - (1) **Smooth (S)** or **capsulated** type which have a mucous coat and produce shiny colonies. These bacteria are virulent and cause pneumonia.
 - (2) **Rough (R)** or **non-capsulated** type in which mucous coat is absent and produce rough colonies. These bacteria are nonvirulent and do not cause pneumonia.

The experiment can be described in following four steps:

- (a) Smooth type bacteria were injected into mice. The mice died as a result of pneumonia caused by bacteria.
- (b) Rough type bacteria were injected into mice. The mice lived and pneumonia was not produced.
- (c) Smooth type bacteria which normally cause disease were **heat killed** and then injected into the mice. The mice lived and pneumonia was not caused.
- (d) Rough type bacteria (**living**) and smooth type **heat-killed** bacteria (both known not to cause disease) were injected together into mice. The mice died due to pneumonia and virulent smooth type living bacteria could also be recovered from their bodies.

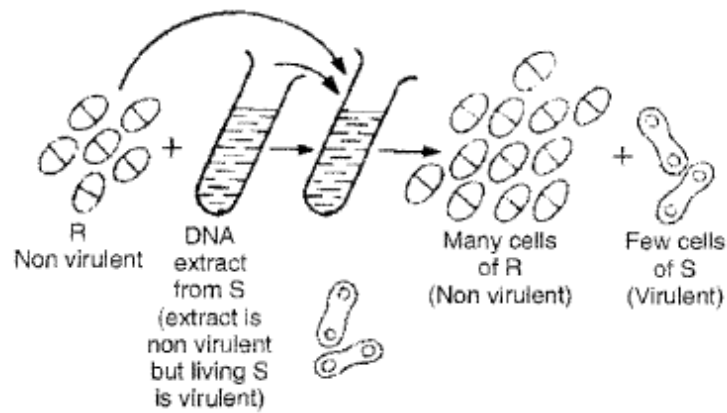
He concluded from fourth step of the experiment that some rough bacteria (nonvirulent) were transformed into smooth type of bacteria (virulent). This occurred perhaps due to absorption of some **transforming substance** by rough type bacteria from heat killed smooth type bacteria. This transforming substance from Smooth type bacteria caused the synthesis of capsule which resulted in production of pneumonia and death of mice. Therefore, transforming principle appears to control genetic characters (for example, capsule as in this case). **However the biochemical nature of genetic material was not defined from his experiments.** Later, **Avery, Macleod and McCarty** (1944) repeated the experiment in vitro to identify transforming substance. They proved that this substance is DNA.

Pneumococcus bacteria cause disease only when capsule is present. Capsule production is under genetic control.



Bacterial transformation experiments conducted by Griffith

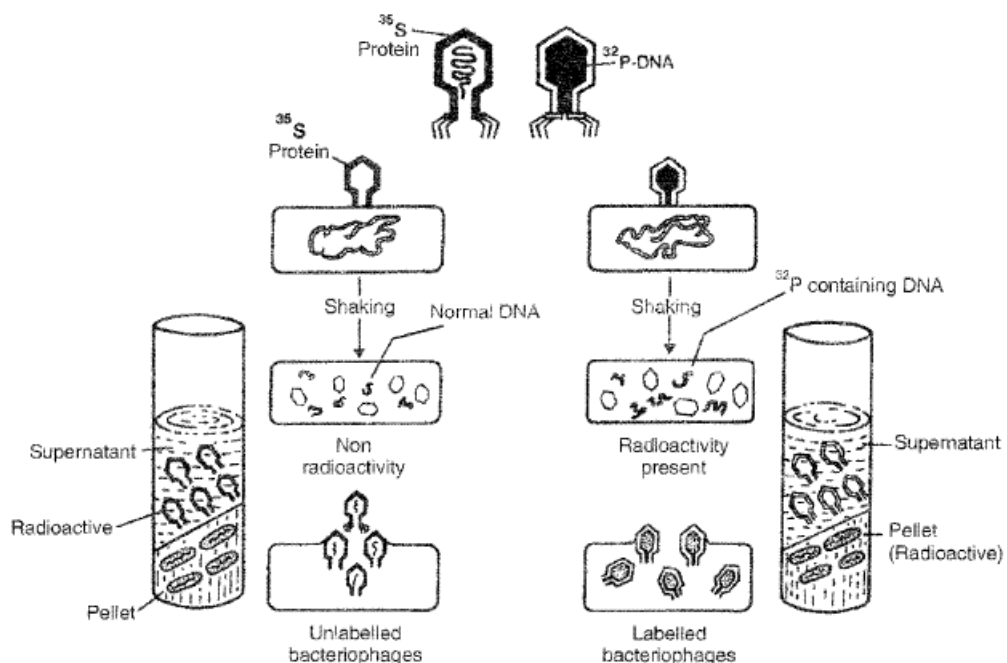
In the experiments, rough type bacteria (non-capsulated and non-virulent) were grown in a culture medium to which DNA extract from smooth type bacteria (capsulated and virulent) was added. Later, the culture showed the presence of smooth type bacteria also in addition to rough type. This is possible only if DNA of smooth type was absorbed by rough bacteria type which thus developed capsule and became virulent. **This process of transfer of characters of one bacterium to another by taking up DNA from solution is called transformation.** When DNA extract was treated with DNAase (an enzyme which destroys DNA), transformation did not occur. The transformation occurs when proteases and RNases were used. **This clearly shows that DNA is the genetic material.**



In vitro experiment of Avery and others demonstrating that DNA is genetic material

(II) **Evidence from experiments with bacteriophage.** T_2 bacteriophage is a virus that infects bacterium *Escherichia coli* and multiplies inside it. T_2 phage is made up of DNA and protein coat. Thus, it is the most suitable material to determine whether DNA or protein contains information for the production of new virus (phage) particles. Hershey and Chase (1952) demonstrated that only DNA of the phage enters the bacterial cell and, therefore, contains necessary genetic information for the assembly of new phage particle.

The functions of DNA and proteins could be found out by labelling them with radioactive tracers. DNA contains phosphorus but not sulphur. Therefore, phage DNA was labelled with P^{32} by growing bacteria infected with phages in culture medium containing $^{32}PO_4$. Similarly, protein of phage contains sulphur but no phosphorus. Thus, the phage protein coat was labelled with S^{35} by growing bacteria infected with phages in another culture medium containing $^{35}SO_4$. Both types of labelled phages were allowed to infect normally cultured bacteria in separate experiments. These bacterial cells were agitated in a blender and radioactivity was observed. The bacterial cells showed the presence of radioactive DNA labelled with P^{32} while radioactive protein labelled with S^{35} appeared on the outside of bacterial cells (i.e., in the medium). Labelled DNA was also found in the next generation of phage. This clearly showed that only DNA enters the bacterial host and not the protein. DNA, therefore, is the infective part of virus and also carries all the genetic information. **This provided the unequivocal proof that DNA is the genetic material.**



Hershey and Chase's experiments with bacteriophages showing that DNA is genetic material or DNA is infective part of virus

Properties of Genetic Material :

Following are the properties and functions which should be fulfilled by a substance if it is to qualify as genetic material.

- (1) It should chemically and structurally be stable.
- (2) The genetic material should be able to transmit faithfully to the next generation, as Mendelian characters.
- (3) The genetic material should also be capable of undergoing mutations.
- (4) The genetic material should be able to generate its own kind (replication).

This can be concluded after examining the above written qualities, that DNA being more stable is preferred as genetic material, as

- (a) Free 2'OH of RNA makes it more labile and easily degradable. Therefore DNA in comparison is more stable.
- (b) Presence of thymine at the place of uracil also confers additional stability to DNA.
- (c) RNA being unstable, mutates at a faster rate.

RNA World

RNA was the first genetic material. There are evidences to suggest that essential life processes, such as metabolism, translation, splicing, etc. evolved around RNA. RNA used to act as a genetic material as well as a catalyst, there are some important biochemical reactions in living systems that are catalyzed by RNA catalysts and not by protein enzymes (e.g., splicing). RNA being a catalyst was reactive and hence unstable. Therefore, DNA has evolved from RNA with chemical modifications that make it more stable. DNA being double stranded and having complementary strand further resists changes by evolving a process of repair. RNA is adapter, structural molecule and in some cases catalytic. **Thus RNA is better material for transmission of information.**

RIBO NUCLEIC ACID (RNA)

Structure of RNA is fundamentally the same as DNA, but there are some differences. The differences are as follows :

- (1) In place of De-Oxyribose sugar of DNA, there is present Ribose sugar in RNA.
- (2) In place of nitrogen base Thymine present in DNA, there is nitrogen base uracil in RNA.
- (3) RNA is made up of only one polynucleotide chain i.e. R.N.A. is Single stranded.

Exception - RNA found in Reo - virus is double stranded, i.e. it has two polynucleotide chains.

Types of RNA :

1. Genetic RNA or Genomic RNA - In the absence of DNA, sometime RNA working as genetic material and genomic RNA transfer informations from one generation to next generation.

eg. Reo virus, TMV, QB bacteriophage.

Non-genetic RNA - 3 types -

(A) r-RNA (B) t-RNA (C) m-RNA

(1) Ribosomal RNA (r-RNA) :

- This RNA is 80% of the cell's total RNA
- It is found in ribosomes and it is produced in nucleolus.
- It is the most stable form of RNA.
- There are present 80s type of ribosomes in Eukaryotic cells. Their subunits are 60s and 40s . In 60s sub unit of ribosome three type of r-RNA are found - 5s, 5.8s, 28s
- In the same way 40s sub unit of ribosome has only one type of r-RNA = 18s.
- So 80s ribosome has total 4 types of r-RNA.
- Prokaryotic cells have 70s type of ribosomes and its subunits are 50s and 30s.

- 50s sub unit of ribosome contains 2 molecules of r-RNA = 5s and 23s.
- 30s sub unit of ribosome has 16s type of r-RNA.
- So 70s RNA has total 3 types of r-RNA.

Functions -

- At the time of protein synthesis r-RNA provides attachment site to t-RNA and m-RNA and attaches them on the Ribosome.
- The bonds formed between them are known as Salt linkages. It attaches t-RNA to the larger subunit on the Ribosome and m - RNA to smaller sub-unit of ribosome.

(2) Transfer - RNA (t-RNA) -

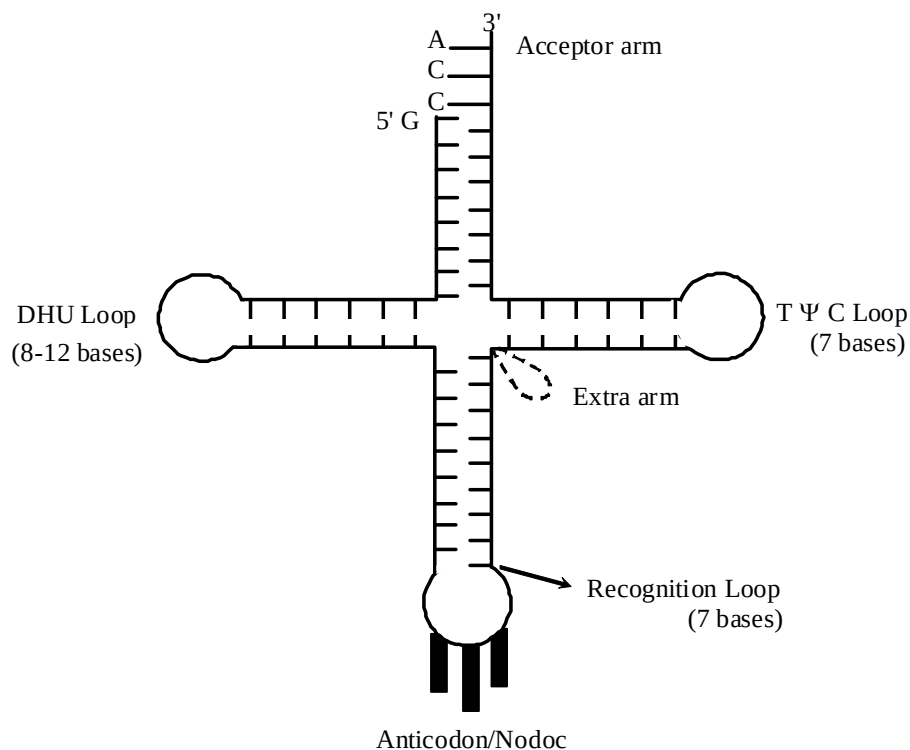
- It is 10-15% of total RNA.
- It is synthesized in the nucleus by DNA.
- It is also known as soluble RNA (sRNA)
- It is also known as Adapter RNA.
- It is the smallest RNA (4s).

Function - At the time of protein synthesis it acts as a carrier of amino-acids.

Discovery - t-RNA was discovered by Hogland, zemecknike and Stephenson.

Structure - The structure of t-RNA is most complicated.

A scientist named Holley presented Clover leaf model of its structure. In two dimensional structure the t-RNA appears clover leaf like but in three dimensional structure (by Kim) it appears L-shaped.



- The molecule of t-RNA is of single strand.
- There are present three nucleotides in a particular sequence at 3' end of t RNA and that sequence is = CCA.
- All the 5' ends i.e. last ends are having G(guanine).
- 3' end is known as Acceptor end.
- t-RNA accepts amino acids at acceptor points. Amino acids binds to 3' end by its -COOH group.

- The molecule of t-RNA is folded and due to folding some complementary nitrogenous bases comes across with each other and form hydrogen bonds.
- There are some places where hydrogen bonds are not formed, these places are known as **loop**.

Loops -

There are some abnormal nitrogenous bases in the loops, that is why hydrogen bonds are not formed.
e.g. Inosine (I), Pseudouracil (Ψ) Dihydrouridine (DHU)

(i) T Ψ C Loop or Attachment loop -

This loop connects t-RNA to the larger subunit of ribosome.

(ii) Recognition Loop -

- This is the most specific loop of t-RNA and different types of t-RNA are different due to this loop. There is a specific sequence of three nucleotides called **Anticodon**, is present at the end of this loop.
- On the basis of Anticodon, there are total 61 types of t-RNA, or, we can also say that there are 61 types of Anticodon.
- t-RNA recognizes its place on m-RNA with the help of Anticodon.
- The anticodon of t-RNA recognizes its complementary sequence on m-RNA. This complimentary sequence is known as codon.

(iii) DHU Loop -

- It is also known as Amino-acyl synthetase recognition loop. Amino-acyl synthetase is a specific type of enzyme. The function of this enzyme is to activate a specific type of amino acid. After activation this enzyme attaches the aminoacid to the 3' end of t-RNA.
- There are 20 types of enzymes for 20 types of aminoacids.
- The function of DHU loop is to recognize this specific Aminoacyl synthetase enzyme.

(3) Messenger RNA (m-RNA) -

- The m-RNA is 1-5% of the cell's total RNA.
Discovery - Messenger RNA was discovered by Huxley, Volkin and Astrachan. The name m-RNA was given by Jacob and Monod.
- The m-RNA is produced by genetic DNA in the nucleus. This process is known as Transcription.

GENETIC CODE

Term Given by George Gamow.

- The relationship between the sequence of amino acids in a polypeptide chain and nucleotide sequence of DNA or m-RNA is called genetic code.
- There occur 20 types of amino acids which participate in protein synthesis. DNA contains information for the synthesis of any types of polypeptide chain. In the process of transcription, information transfer from DNA to m-RNA in the form of complementary N₂-base sequence.
- m-RNA contains code for each amino acid and it is called **codon**. A codon is the nucleotide sequence in m-RNA which codes for particular amino acid; whereas the genetic code is the sequence of nucleotides in m-RNA molecule, which contains information for the synthesis of polypeptide chain.

Triplet Code -

- The main problem of genetic code was to determine the exact number of nucleotide in a codon which codes for one amino acid.
- There are four types of N₂-bases in m-RNA (A, U, G, C) for 20 type amino acids.

	U	C	A	G	
U	UUU } Phe	UUU } Ser	UAU } Phe	UGU } Cys	U
	UUU }	UCC }	UUU }	UGC }	C
	UUU } Leu	UCA }	UAA } Ochre (terminator)	UGA } Terminator	A
	UUU }	UCG }	UAG } Amber (terminator)	UGG } Try	G
C	CUU }	CCU }	CAU } His	CGU }	U
	CUC }	CCC }	CAC }	CGC }	C
	CUA }	CCA }	CAA }	CGA }	A
	CUG }	CCG }	CAG } Gln	CGG }	G
A	AUU }	ACU }	AAU } Asn	AGU } Ser	U
	AUC }	ACC }	AAC }	AGC }	C
	AUA }	ACA }	AAA }	AGA }	A
	AUG } Met	ACG }	AAG } Lys	AGG }	G
G	GUU }	GCU }	GAU } Asp	UGU }	U
	GUC }	GCC }	GAC }	UGC }	C
	GUA }	GCA }	GAA }	UGA }	A
	GUG }	GCG }	GAG }	UGG }	G

Triplet codons of mRNA for amino acids represented in tabular form.

- If genetic code is singlet i.e. codon is the combination of only one nitrogen base, then only four codons are possible A, C, G and U. These are insufficient to code for 20 types amino acids.

A
C
G
U

Codons

Singlet Code : $4 \times 1 = 4$ codons

- Singlet code = 4 = $4 \times 1 = 4$ codons
- If genetic code is doublet (i.e. codon is the combination of two nitrogen bases) then 16 codons are formed.
- Doublet code = 16 = $4 \times 4 = 16$ codons.
- 16 codons insufficient for 20 amino acid

AA	AC	AG	AU
CC	CA	CG	CU
GG	GA	GC	GU
UU	UA	UG	UC

Doublet Code : $4 \times 4 = 16$ condons

Gamow -

- (1954) Pointed out the possibility of three letter code (Triplet code).
- Genetic code is triplet i.e. one codon consists of three nitrogen base.
Triplet code = $4^3 = 4 \times 4 \times 4 = 64$ codons
- In this case there occurs 64 codons in dictionary of genetic code.
- 64 codons are sufficient to code 20 types of amino acids.

Characteristic of Genetic Code -

(1) Triplet in Nature

- A codon is composed of three adjacent nitrogen bases which specifies the one amino acid in polypeptide chain.
For Ex. :
- In m-RNA if there are total 90 N₂ - bases.
- Then this m-RNA determines 30 amino acids in polypeptide chain.
- In above example, number of Nitrogen bases are 90 so codons ==> 30 and 30 codons decide 30 amino acid in polypeptide chain.

(2) Universality

The genetic code is applicable universally. The same genetic code is present in all kinds of living organism including viruses, bacteria, unicellular and multicellular organism.

(3) Non-Ambiguous -

- Genetic code is non ambiguous i.e. one codon specifies only one amino acid and not any other.
- In this case one codon never code two different amino acids. Exception GUG codon which code both valine and methionine amino acid.

(4) Non-Overlapping -

A nitrogen base is a constituent of only one codon.

(5) Comma less -

- There is no punctuation (comma) between the adjacent codon i.e. each codon is immediately followed by the next codon.
- If a nucleotide is deleted or added, the whole genetic code read differently.
- A Polypeptide chain having 50 amino acids shall be specialized by a linear sequence of 150 nucleotides. If a nucleotide is added in the middle of this sequence, the first 25 amino acids of polypeptide will be same but next 25 amino acids will be different.

(6) Degeneracy of Genetic code -

- There are 64 codons for 20 types of amino acids, so most of the amino acids (except two) can be coded by more than one codon. Single amino acid coded by more than one codon is called "Degeneracy of genetic code". This incident was discovered by Baurnfield and Nirenberg.
- Only two amino acids Tryptophan and Methionine are specified by single codon.

┌ UCG for Tryptophan
└ AUG for methionine

- All the other amino acid are specified or coded by 2 to 6 codons.
- Leucine, serine and arginine are coded or specified by 6-codons.

Leucine = CUU, CUC, CUA, CUG, UUA & UUG

Serine = UCU, UCC, UCA, UCG, AGU, AGC

Arginine = CGU, CGC, CGA, CGG, AGA, AGG

- Degeneracy of genetic code is related to third position (3 - end of triplet codon). The third base is described as "Wobbly base"

Exception -

Different Codon -

- Normally UAA and UGA are chain termination codon but in Paramecium and some other ciliated, UAA and UGA code for glutamine amino acid.

Mitochondrial Gene -

- Normally AGG and AGA code for Arginine amino acid but in human mitochondria these function as stop codon.
- UGA, a termination codon corresponds to tryptophan while AUA (Codon for isoleucine) denotes methionine in human mitochondria.

Chain Initiation and Chain Termination Codon -

- Polypeptide chain synthesis is signalled by two initiation codons AUG or GUG.
- AUG codes methionine amino acid in eukaryotes and in prokaryotes AUG codes N-formyl methionine.
- Some times GUG also functions as start codon it codes for valine amino acid normally but when it is present at starting position it code for methionine amino acid.
- Out of 64 codons 3-codons are stopping or nonsense or termination codon. Nonsense codons do not specify any amino acid.

UAA (Ochre)

UAG (Amber) Non-Sense Codon

UGA (Opal)

- So only 61 codons are sense codons which specify 20 amino acid.

WOBBLE HYPOTHESIS

- It was propounded by CRICK.
- Normally an anticodon recognizes only one codon, but sometimes an anticodon recognise more than one codon. This known as Wobbling. Wobbling normally occurs for third nucleotide of codon.
- For e.g. Anticodon AAG can recognize two anticodons i.e. UUU and UUC, both stand for phenyl alanine.

Types of m-RNA : m-RNA is of 2 types -

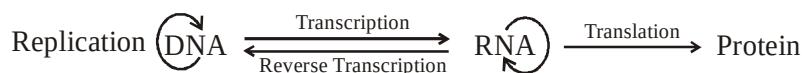
- (1) **Monocistronic** - The m- RNA in which genetic signal for the formation of only one polypeptide chain.
 - (2) **Polycistronic** - The m-RNA, in which genetic signal is present for the formation of more than one polypeptide chains.
- Non sense codons are found in middle position in polycistronic m-RNA.

CENTRAL DOGMA

- Central dogma term was given by **Crick**.
- The formation (production) of m-RNA from DNA and then synthesis of protein from it, is known as **Central Dogma**.



- It means, it includes transcription and translation.
- The central dogma scheme of protein synthesis was presented by **Jacob and Monad**.
- The detailed study of central dogmas is done by **Nirenberg, Mathai and Khorana**.
- **Beedle and Tatum** studied central dogma in a fungus *Neurospora*.

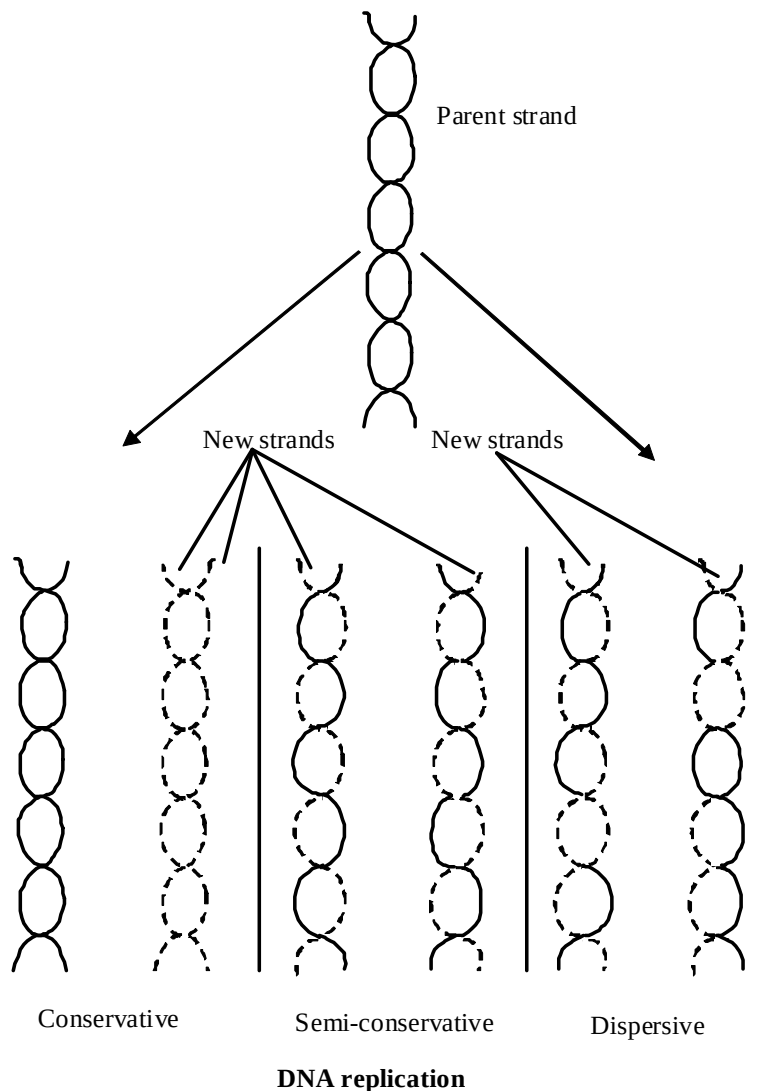


Reverse Transcription -

- The formation of DNA from RNA is known as **Reverse - transcription**. It was discovered by Temin and Baltimore in Rous - sarcoma virus. So it is also called **Teminism**.
- ss-RNA of Rous-Sarcoma virus (Retro virus) produces ds-DNA in host's cell with the help of enzyme reverse transcriptase (DNA Polymerase). This DNA is called **c-DNA (Complimentary DNA)**. Some times this DNA moves in host genome. Such mobile DNA is called **“Retroposon” (Oncogene)**.

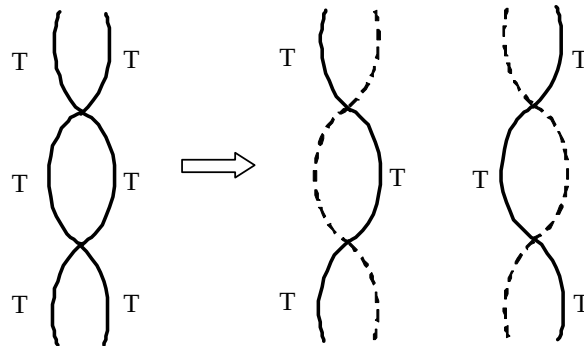
D.N.A. REPLICATION

- D.N.A. is the only molecule capable of self duplication so it is termed as a **“Living molecule”**.
- All living beings have the capacity to reproduce because of this characteristic of D.N.A.
- D.N.A replication takes place in **“S - Phase”** of the cell cycle. At the time of cell division, it divides in equal parts in the daughter cells. Delbruck suggested three methods of DNA-replication i.e.
 - (1) Dispersive
 - (2) Conservative
 - (3) Semi-conservative



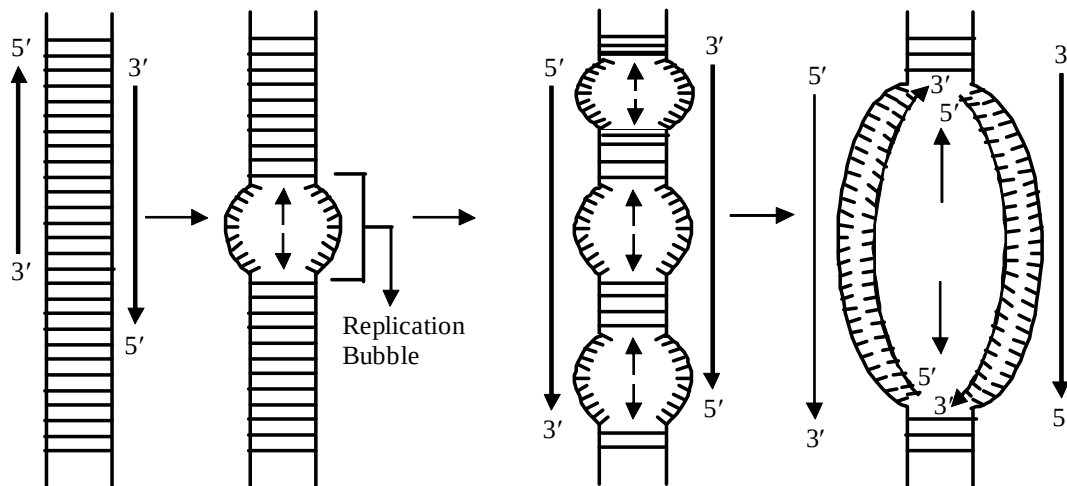
SEMI CONSERVATIVE MODE OF DNA REPLICATION

Semi conservative mode of DNA replication was first theoretically proposed by Watson & Crick. Later on it was experimentally proved by Meselson & Stahl (1958) on E-Coli and Taylor on *Vicia faba*. To prove this method, they used Radiotracer Technique in which Radioisotopes are used. Meselson and Stahl used N15 and Cairns (1963) used radioactive Thymidine (with H3).



- Due to the replication of active Thymidine containing DNA., two DNA. molecules were obtained in which 50% radioactivity was found.
- When these two D.N.A. molecules containing active Thymidine were made to replicate, the next time four D.N.A. molecules were obtained. Out of these 4 D.N.A., 2 D.N.A. molecules were radioactive and remaining 2 were not radioactive.
- In the same sequence, the obtained DNA. molecules were further made to replicate then also, the no. of radioactive DNA remains 2.

MECHANISM OF DNA REPLICATION



The following steps are included in DNA replication -

(1) Unzipping -

- The separation of 2 chains of DNA is termed as unzipping and it takes place due to the breaking of H bonds. The process of unzipping starts at a certain specific point which is termed as initiation point or origin of replication. In prokaryotes there occur only one origin of replication but in eukaryotes there occur many origin of replication i.e. unzipping starts at many points simultaneously.
- The enzyme responsible for unzipping (breaking the hydrogen bonds) is Helicase (= Swivelase). In the process of unzipping Mg^{+2} act as cofactor. Unzipping takes place in alkaline medium.

- At the place of origin, the topoisomerase enzyme (a type of endonuclease) induces a cut in one strand of DNA (Nicking) to relax the two strands of DNA.
- A protein, "Helix destabilizing protein" prevents recoiling of two separated strands during the process of replication. Another protein SSB (single stranded DNA binding protein) prevents the formation of bends of loops in separated strands.

DNA-Gyrase : A type of topoisomerase prevent supercoiling of DNA.

Note -

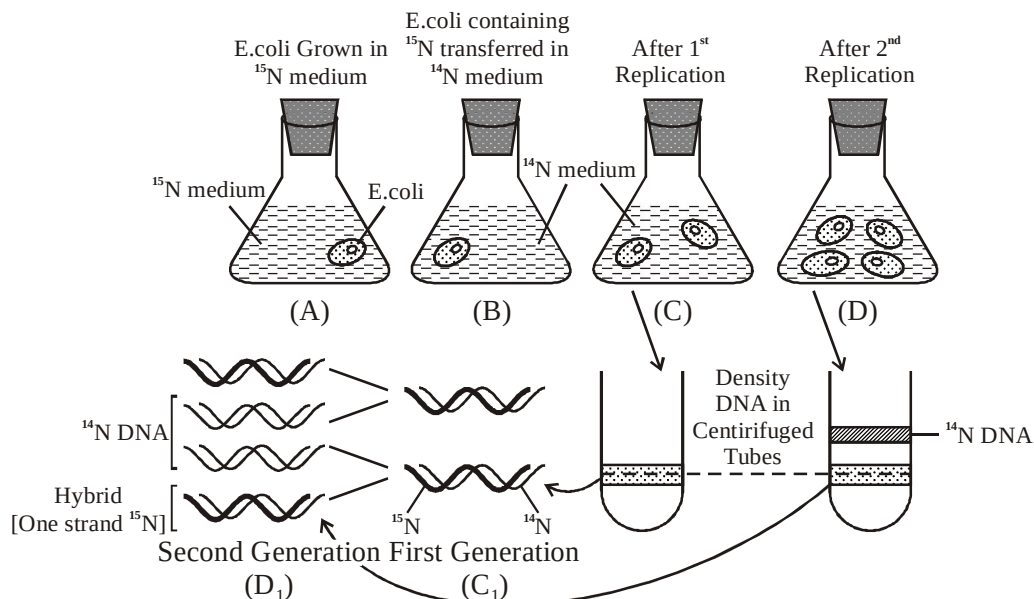
The process of DNA replication takes a few minutes in prokaryotes and few hours in Eukaryotes.

(2) Formation of New Chain -

- To start the synthesis of new chain, special type of RNA. is required which is termed as R.N.A Primer. The formation of RNA. primer is catalysed by an enzyme - RNA. Polymerase (primase) Synthesis of RNA - primer takes place in 5' → 3" direction. After the formation of new chain, this R.N.A. is removed. For the formation of new chain Nucleotides are obtained from Nucleoplasm. In the nucleoplasm, Nucleotides are present in the form of triphosphate like dATP, dGTP, dCTP, dTTP etc.
 - During replication, the 2 phosphate groups of all Nucleotides are separated. In this process energy is yielded which is consumed in D.N.A replication. So, it is clear that D.N.A. does not depend on mitochondria for it's energy requirements.
 - The formation of new chain always takes place in 5' - 3" direction. As a result of this, one chain of D.N.A is continuously formed and it is termed as Leading strand. The formation of second chain begins from the centre and not from the terminal points, so this chain is discontinuous and is made up of small segment called **Okazaki Fragments**. This discontinuous chain is termed as Lagging strand. Ultimately all these segments joined together and complete new chain is formed.
 - The Okazaki segment are joined together by an enzyme DNA Ligase. (Khorana)
 - The formation of new chains is catalysed by an enzyme DNA polymerase. In prokaryotes it is of 3 types :
- (1) **DNA - Polymerase I :** This was discovered by **Kornberg** (1957). So it is also called as **Kornbergs enzyme**. Kornberg also synthesized DNA first of all, in the laboratory. This enzyme functions as exonuclease. It separates RNA - primer from DNA and also fills the gap. It is also known as DNA- repair enzyme.
 - (2) **DNA - Polymerase II :** It is least reactive in replication process. It is also helpful in DNA-repairing in absence of DNA-polymerase-I and DNA polymerase-III.
 - (3) **DNA - Polymerase III :** This is the main enzyme in DNA - Replication . It is most important. It was discovered by **Delucia and Cairns**. The larger chains are formed by this enzyme. This is also known as **Replicase**.
DNA - polymerase III is a complex enzyme composed of seven polypeptides α , α , θ , β , γ , δ , γ_2 .
In Eucaryotes, there occur five types of DNA-polymerase enzyme.
 - (i) α -DNA - polymerase = Similar to DNA - polymerase I
 - (ii) β -DNA - polymerase = It concerned with DNA repair.
 - (iii) γ -DNA - polymerase = It concerned with replication of cytoplasmic DNA
 - (iv) δ -DNA - polymerase = Similar to DNA - polymerase II
 - (v) ϵ -DNA - polymerase = Similar to DNA - polymerase III
- Thus DNA - Replication process is completed with the effect of different enzymes.
 - In the semi conservative mode of replication each daughter DNA molecule receives one chain of polynucleotides from the mother DNA - molecule and the second chain is synthesized.

Special Point :

All DNA polymerase I, II and III enzymes have 5'-3" polymerisation activity and 3'-5" exonuclease activity.



Meselson and Stahl's Experiment

TRANSCRIPTION

- Formation of RNA over DNA template is called transcription. Out of two strands of DNA, only one strand participates in transcription and is called the “**Antisense strand**”.
- The segment of DNA involved in transcription is the “**Cistron**”.
- RNA polymerase enzyme is involved in transcription. In eukaryotes, there are three types of RNA polymerases.
 - **RNA polymerase-I** for 28S rRNA, 18S RNA, 5.8S rRNA
 - **RNA polymerase-II** for m-RNA.
 - **RNA polymerase enzyme-III** for t-RNA, 5S RNA, SnRNA
- In eukaryotes, RNA polymerase enzyme is composed of 10-15 polypeptide chains.
- Prokaryotes have one type of RNA polymerase which synthesizes all types of RNAs.
- RNA polymerase of E. coli has six polypeptide chains β , β' , α , α , ω , and σ .
- σ Polypeptide chain is also known as **σ factor** (sigma factor).
- Core enzyme + Sigma factor $\Rightarrow$ RNA Polymerase
 $(\beta, \beta', \alpha, \alpha, \omega) + (\sigma)$

Following steps are present in transcription -

(1) Initiation -

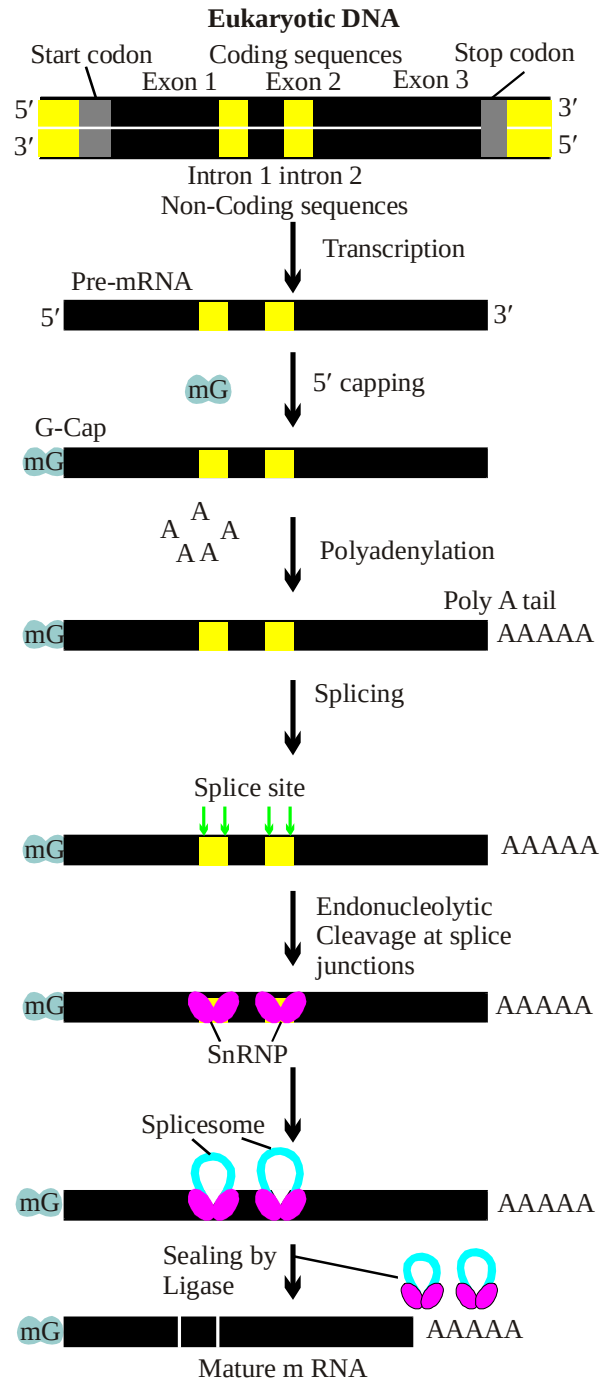
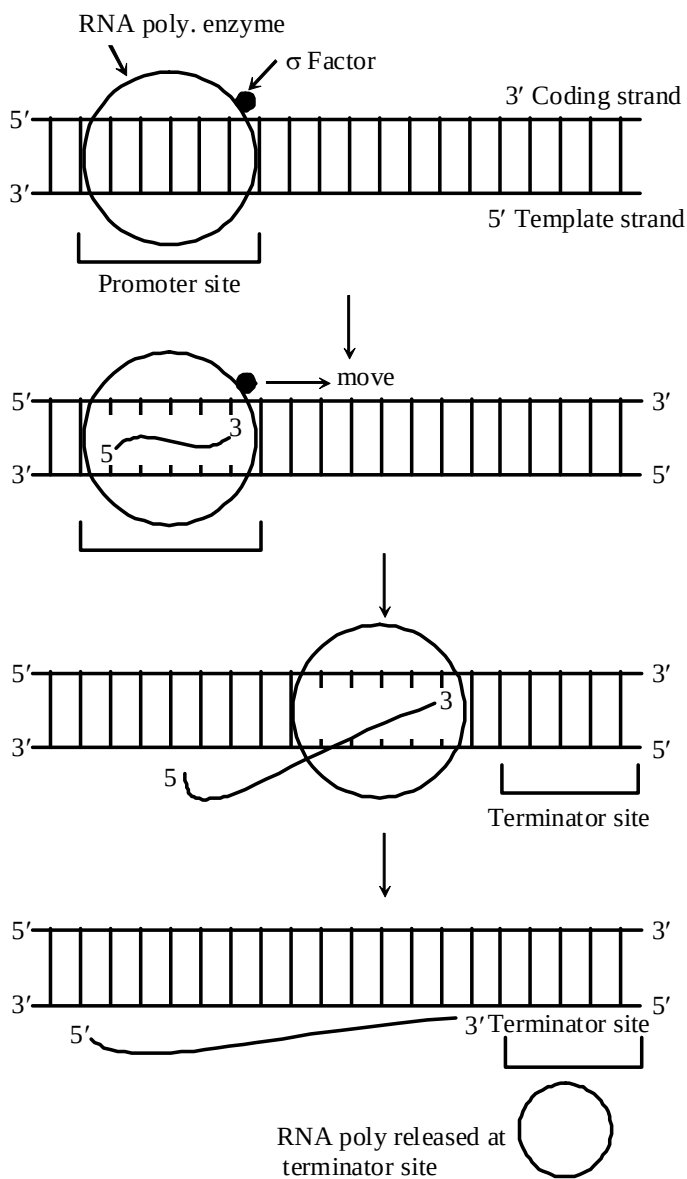
- DNA has a “Promoter site or initiation site” where transcription begins and a “Terminator site” where transcription stops.
- Sigma factor (σ) recognizes the promoter site of DNA.
- With the help of sigma factor, RNA polymerase is attached to a specific site of DNA called the “**Promoter site**”.
- In prokaryotes, before the 10 N₂ base from “Promoter site”, a sequence of 6 base pairs (TATAAT) is present on DNA, which is called the “**Pribnow box**”.
- In eukaryotes, before the 20 N₂ base from “Promoter site”, a sequence of 7 base pairs (TATAAA) or (TATATAT) is present on DNA, which is called the “**TATA box or Hogness box**”.
- At the promoter site, RNA polymerase enzyme breaks H-bonds between two DNA strands and separates them. One of the strands takes part in transcription. Transcription proceeds in 5' $\rightarrow$ 3' direction.
- Ribonucleotide triphosphates come to lie opposite complementary nitrogen bases of the anti-sense strand.
- These ribonucleotides are present in the form of triphosphates ATP, GTP, UTP, and CTP in the nucleoplasm. When they are used in transcription, pyrophosphates hydrolyse two phosphates from each activated nucleotide. This releases energy.
- This energy is used in the process of transcription.

(2) Elongation -

- RNA polymerase enzyme establishes phosphodiester bond between adjacent ribonucleotides.
- Sigma factor separates and core enzyme moves along the anti sense strand till it reaches terminator site.

(3) Termination -

- When RNA polymerase enzyme reaches at terminator site, it separates from DNA templet.
- In terminator site on DNA, N₂ bases are present in palindromic sequence.
- In most cases RNA polymerase enzyme can recognize the "Terminator site" and stop the synthesis of RNA chain, but in prokaryotes, it recognizes the terminator site with the help of Rho factor (factor).
- Rho (ρ) factor is a specific protein which helps RNA polymerase enzyme to recognize the terminator site.

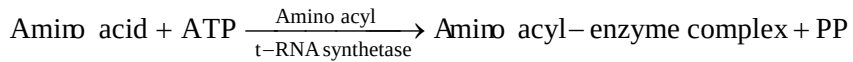


Post : Transcription in eukaryotes

PROTEIN-SYNTHESIS

(1) Activation of Amino acid -

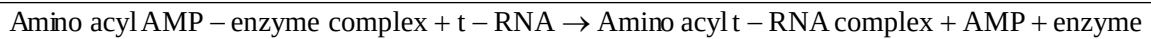
- 20 types of amino acid participate in protein synthesis.
- Amino acid reacts with ATP to form "Amino acyl AMP enzyme complex", which is also known as 'Activated Amino acid.'



- This reaction is catalyzed by a specific 'Amino acyl t-RNA synthetase' enzyme
- There is a separate 'Amino acyl t-RNA synthetase' enzyme for each kind of amino acid.

(2) Charging of t-RNA -

- Specific activated amino acid is recognized by its specific t-RNA.
- Now amino acid attaches to the 'Amino acid attachment site' of its specific t-RNA and AMP and enzyme are separated from it.

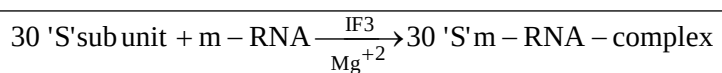


- Amino acyl t-RNA complex is also called '**Charged t-RNA**'.
- Now Amino acyl t-RNA moves to the ribosome for protein synthesis.

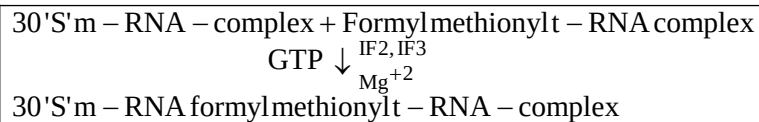
(3) Translation :

(A) Initiation of polypeptide chain

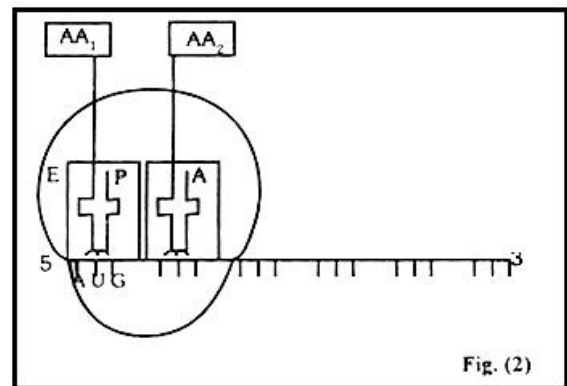
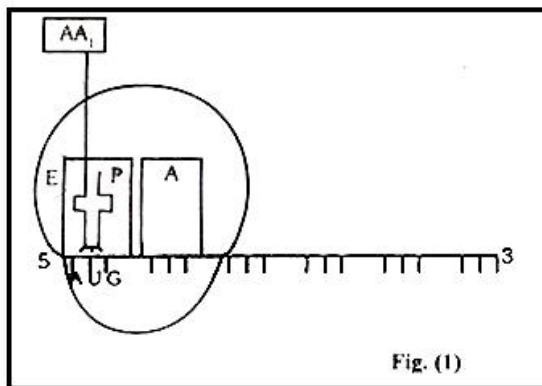
- In this step 30 'S' and 50 'S' sub units of Ribosome, GTP, Mg^{+2} , charged t-RNA, m-RNA and some initiation factors are required.
- In prokaryotes there are three initiation factors present - IF1, IF2, IF3.
- In Eukaryotes there are more than 3 initiation factors are present. 16 initiation factors have been identified in red blood cells-
eIF1, eIF2, eIF3, eIF4A, eIF4B, eIF4C, eIF4D, eIF4E, eIF5, eIF6
- Initiation factors are specific protein.
- GTP and initiation factors promote the initiation process.
- In starting the both sub units of ribosome are separated with the help of IF3 factor.
- In prokaryotes with the help of "SD sequences" (Shine-Delgarno sequence) m-RNA recognizes the smaller sub unit of ribosome. A sequence of 8 N_2 base is present before the 4-12 N_2 base of initiation Condon on mRNA, called "**SD sequence**". In smaller subunit of ribosome, a complementary sequence of "SD sequence" is present on 16 'S' rRNA, which is called "**Anti Shine-delgarno sequence**".
(ASD sequence)
- With the help of 'SD' and 'ASD' sequence m-RNA recognizes the smaller sub unit of ribosome.
- While in Eukaryotes smaller sub unit of ribosome is recognised by "7mG cap".
- In Eukaryotes, 18 'S' rRNA of smaller sub unit has a complementary sequence of "7mG cap".



- This "30 'S' m-RNA - complex" reacts with 'Formyl methionyl t-RNA-complex' and "30 'S' mRNA -Formyl methionyl t-RNA-complex" form. This t-RNA attaches with codon part of m-RNA. A GTP molecule is required.

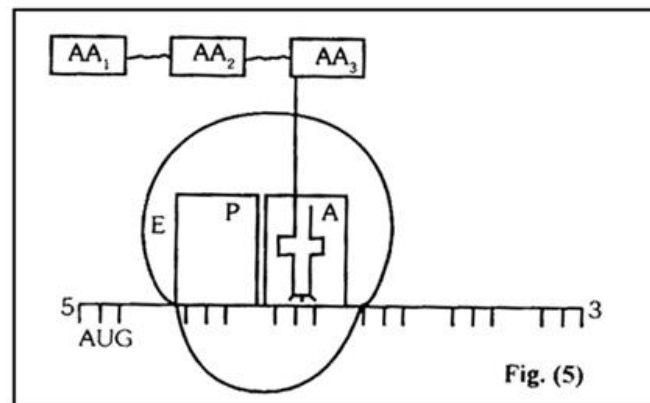
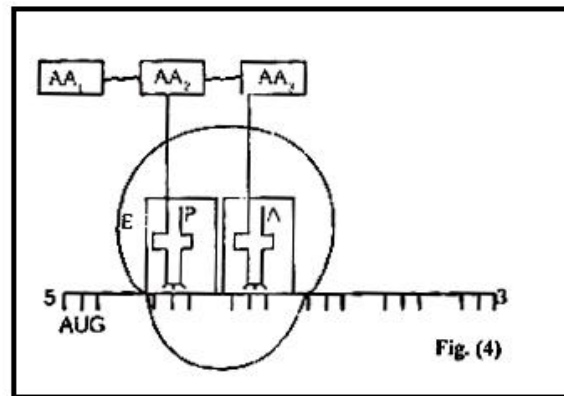
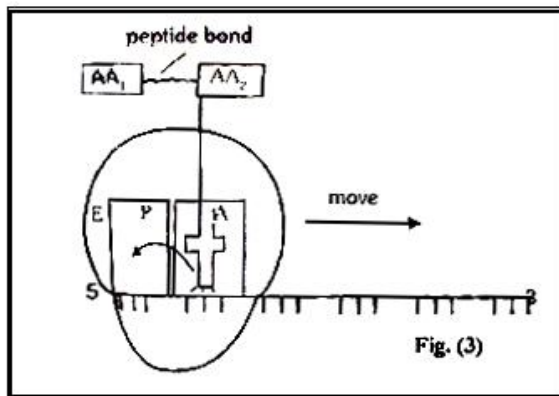


- Now larger sub unit of ribosome (50'S' Sub unit) joins this complex. The initiation factor released and complete 70 'S' ribosome is formed.
- In larger sub unit of ribosome there are three sites for t-RNA.
'P' site = Peptidyl site
'A' site = amino acyl site
E-site = exit site
- Starting codon of m-RNA is near to 'P' site of ribosome, so t-RNA with formyl methionine amino acid first attached to 'P' site of ribosome and next codon of m-RNA is near to 'A' site of ribosome. So new t-RNA with new amino acid always attach at 'A' site of ribosome but in initiation step 'A' site is empty.



(B) Chain elongation

- New tRNA with new Amino acid at 'A' site of Ribosome.
- First of all t-RNA of P-site is discharged so-COOH of p-site A.A. becomes free.
- Now peptide bond formation takes place between -COOH group of P site amino acid and -NH₂ group of A site amino acid.
- Peptidyl transferase enzyme induces the formation of peptide bond. In Peptide bond formation, a 23 'S' r-RNA, 28 'S' r-RNA in eukaryotes is also helpful. This r-RNA acylt acts as an enzyme so it is also called "**Ribozyme**".
- After formation of peptide bond t-RNA of P site released from ribosome via E-site and dipeptide attaches with A site.
- Now t-RNA of A site is transferred to P site and A site becomes empty.
- Now ribosome slides over m-RNA strand in 5' → 3" direction. Due to sliding of ribosome on m-RNA, new condon of m-RNA continously available at A site of ribosome and according to new codon of m-RNA new amino acid attaches in polypeptide chain.
- Translocase enzyme helpful in movement of ribosome. GTP provides energy for sliding of ribosome.
- In elongation process some protein factors are also helpful, which known as '**Elongation factors**'.
- In prokaryotes three 'Elongation factors' are present -EF - Tu, EF - Ts, EF - G..
- In Eukaryotes two elongation factors are present-eEF1, eEF2.



(C) Chain - Termination

- Due to sliding of ribosome over m-RNA when any Nonsense codon (UAA, UAG, UGA) available at A site of ribosome, then polypeptide chain terminate.
- The linkage between the last t-RNA and the polypeptide chain is broken by three release factor called **RF1, RF2, RF3** with the help of GTP.
- Peptidyl transferase enzyme also catalysed the releasing process.
- In eukaryotes only one Release factor is known - **eRF1**.

SPECIAL POINTS :

1. The Chargaff's rule is not valid (true) for RNA. It is valid only for double helical DNA.
2. The duplication of DNA was first of all proved in E.coli bacterium.
3. E.coli Bacterium is mostly used for the study of DNA duplication.
4. **Hargovind singh Khurana** first of all recognized the triple codon for Cysteine and Valine amino acids
5. Cytoplasmic DNA is 1-5% of total cells **DNA**.
6. Three lady scientists named Avery, McLeod and McCarty (by their transformation experiments on bacteria) proved that DNA is a genetic material.
7. Hershey and Chase first of all proved that DNA is genetic material in bacteriophages.
8. Franklin and Crick proved, RNA as a genetic material in viruses (g-RNA).
9.

AUC
 ACU
 AUU

 } These anticodons do not exist.
10. The structure formed by the combination of m-RNA and Ribosomes is known as polyribosomes / Polysomes / Ergosomes.
11. The formation of t-RNA takes place from the heterochromatin part of DNA.

12. The formation of m-RNA takes place from the Euchromatin part of DNA.
13. m-RNA is least stable. It is continuously formed and finished.
14. In cytoplasm, t-RNA is present in the form of soluble colloid.
15. **Nucleases** - These breaking enzyme of nucleic acids are of two types :
 - (i) Endo - Nucleases - These break down the nucleic acids from the inside.
 - (ii) Exo-nucleases - These break down the nucleic acids from the ends (terminal ends)
 These separate each nucleotide.
16. Tay-Sachs-diseases. This disease takes place due to excess storage of glycolipids
17. Excess storage of cerebrosides leads to Gaucher's disease.

Some Inhibitors of Bacterial Protein Synthesis	
Antibiotic	Effect
Tetracycline	Inhibits binding of amino-acyl tRNA to ribosome
Streptomycin	Inhibits initiation of translation and causes misreading
Chloramphenicol	Inhibits peptidyl transferase and so formation of peptide bonds
Erythromycin	Inhibits translocation of ribosome along mRNA
Neomycin	Inhibits interaction between t-RNA and mRNA

18. **Spilt gene** : Discovered by **Sharp and Roberts** in Adenovirus 2 They were awarded by Nobel Prize in 1993. Gene which contains non functional part along with functional part is known as split gene. Non functional part is called **intron** and functional part is called **exon**. By transcription split gene produces a RNA which contains coding and non coding sequence and called **hn RNA (Heterogenous nuclear RNA)**. This hn RNA is unstable. Now 200 nucleotides of adenylic acid are added to its 3' end, which is called **poly 'A' tail**. Now it becomes stable. 7 methyl guanosine is also added to its 5' end a cap like structure is formed. It is called **capping**. By the process of RNA splicing hn-RNA produces functional RNA that is exonic RNA. In RNA splicing non coding parts removed with the help of ribonuclease enzyme and coding part join together with the help of RNA ligase. Some specific proteins are also helpful in RNA-splicing called '**Small nuclear ribonucleoprotein**' or 'SnRNP' or 'Snurps'. These SnRNP proteins combine with some other proteins and SnRNA and form spliceosome complex. This spliceosome complex uses energy of ATP to cut the RNA, releases the non-coding part and joins the coding-part to produce functional RNA.

Noncoding part of hn RNA remained inside the nucleus and not translated into protein. Only coding part moves from nucleus to cytoplasm and translated into protein.

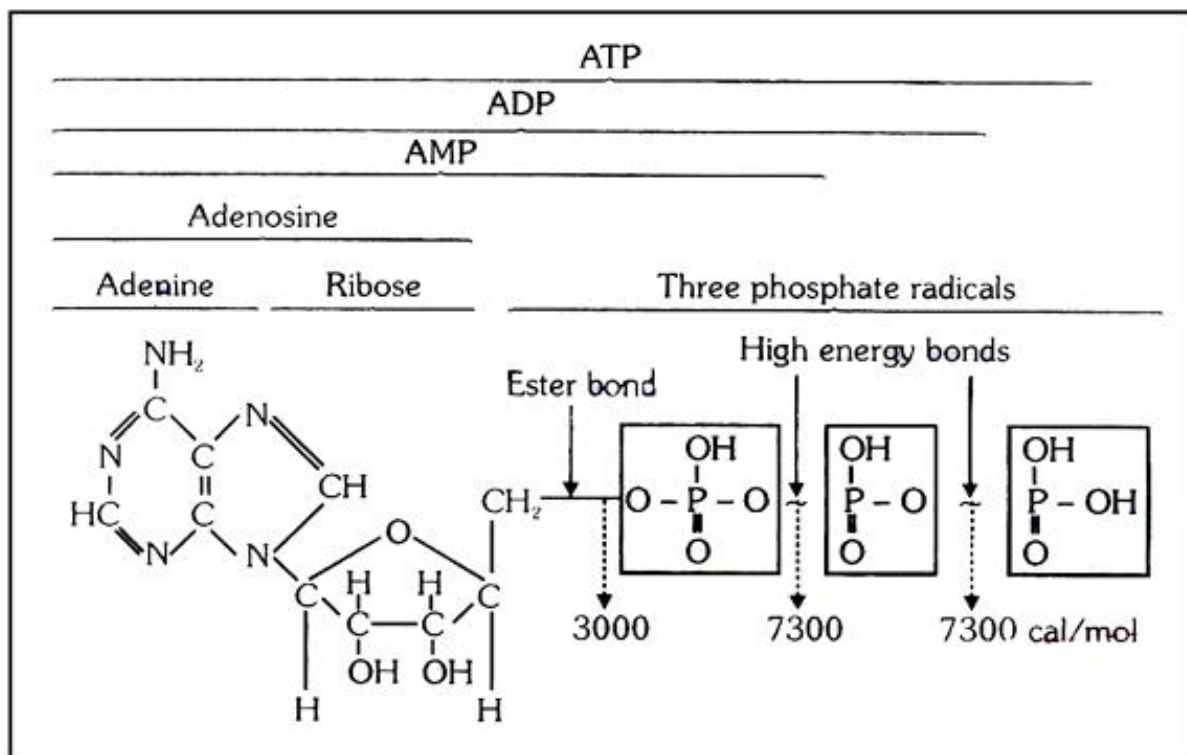
Mostly prokaryotic genes are example of non split gene.

Special Points :

- In human mitochondria, 4 initiation codons present : AUG, AUA, AUU, AUC.
- **Mic RNA** : It is synthesized sometime on the sense of DNA which is complementary of Antisense strand which is used for mRNA synthesis. Such RNA is used for regulation of gene expression at the level of translation.

- **Higher Energy Nucleotide** : Nucleotides which contain more than one phosphate i.e. ATP, ADP.

ATP : Discover-Karl Lohmann. It is made up by Adenine, D-Ribose and three phosphate. It is a high energy compound that release energy when the bond between the phosphate is broken. In ATP two high energy bonds are present. ATP is also called **energy currency** of cell.



- **Iodine number** : It is the amount of iodine in gram absorbed by 100 gram fat. It is used to determine the degree of unsaturation of fat.
- **Second genetic code** : Interaction between specific t-RNA and amino acyl synthetase enzyme is known as **second genetic code**.

GLUT-4 (Glucose transport 4) Proteins : It is a transport protein that allows glucose to enter a cell. GLUT-4 moves into the plasma membrane in response to insulin or muscle contraction. When amount of glucose increased in blood, more insulin is secreted GLUT-4 then responds to the presence of the insulin and enters the plasma membrane, allowing glucose to enter the cell.

- **DNA-quenching** : Rapid cooling of denatured DNA, fix it in permanently denatured form, it is called **DNA quenching**.
- $\phi \times 174$ bacteriophage has 5386 nucleotides, λ -bacteriophage has 48502 base pairs, Escherichia coli has 4.6×10^6 base pair and 6.6×10^6 base pairs in human (2n).
- 2-OH groups present at every nucleotide in RNA as reactive group and makes RNA labile and easily degradable and RNA also has catalytic function so it is more reactive. DNA is chemically less reactive and structurally more stable as compared to RNA.
- DNA is more stable so preferred for storage of genetic information but for the transmission of genetic information RNA is better.
- An mRNA also have some additional sequences that are not translated and are referred as untranslated regions (UTR). The UTRs are present at both 5' end (before start codon) and at 3' end (after stop codon).

- **RNA Interference** : It is a method of gene silencing. In this method a ds RNA is inserted in a cell and enzyme Dicer break this ds RNA into small ds fragments of 20-25 base pairs with a few unpaired overhang bases on each end. This short ds fragments are called small interfering RNA (si RNA). Now siRNA associated with specific protein to form a complex RISC (RNA induced silencing complex). Now RISC attached with targeted m-RNA and inhibit its translation.
- For RNA-interference in *Caenorhabditis elegans* Andrew fire and Craig C. Mello got Noble Prize in 2006 in physiology and medicine.

GENE EXPRESSION

The second important characteristic (first is transmission) of the gene is to store and express the genetic information that will contribute towards the phenotype.

DNA carries information for the synthesis of all proteins required for the function of a cell. A close relationship between genes and enzymes (or gene control the metabolism) was first discovered by a British physician **Archibald Garrod** in 1909 (Father of human biochemical genetics. Concept - **One mutant gene one metabolic block**). He observed that certain hereditary diseases in man such as **alkeptonuria** (black urine disease), **albinism** (absence of melanin pigment) **phenylketonuria** etc. are inborn errors of metabolism and are due to the defect in the enzyme that catalyses the conservation of one metabolic substance to another. Thus, the inherited genetic defect is reflected in the deficiency of an enzyme.

Beadle and Tatum's Hypothesis (One gene one enzyme hypothesis)

The concept that genes have the information to produce enzymes, or gene metabolism relationship was experimentally proved by **Beadle and Tatum** (1948), on the basis of experiments conducted on pink bread mould (***Neurospora crassa***). This mould can normally grow in a simple minimal medium containing salts and sugar, making all other chemicals such as amino acids, purines, pyrimidines etc. through enzyme catalysed reactions. This wild type of the mould is called '**protoroph**'. Beadle and Tatum exposed the pink bread mould to X-rays, which can bring about a change in the nucleotide sequence of DNA and thus causes mutation. They found that the mutants were unable to grow on a minimal medium. Each type of mutant required some extra nutrient in the minimal medium for its normal growth. Such nutritional mutants are called '**auxotrophs**'. They obtained different nutritional mutants requiring amino acids ornithine or citrulline or arginine for growth. The mutants could be classified into three types:

Some could grow on ornithine -, or citrulline -, or arginine - containing medium,

Some could grow on citrulline - or arginine containing medium,

Some could grow on arginine supplemented medium

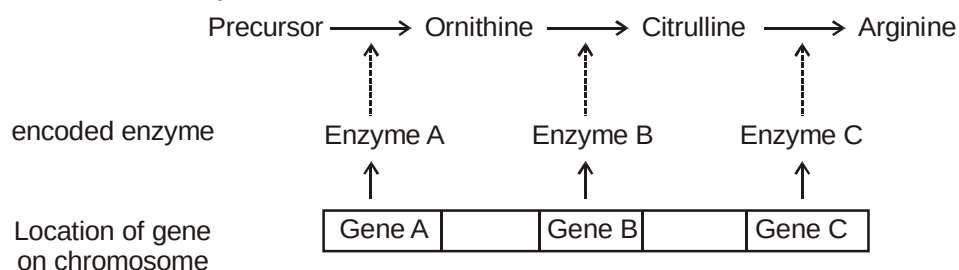
Effect of medium supplement on the growth of mutants *Neurospora crassa*

Growth on Medium supplemented with			
Mutant Type	Ornithine	Citrulline	Arginine
I	+	+	+
II	–	+	+
III	–	–	+

+ = growth

– = No growth

Biochemical Pathway



- This shows that all mutants could grow on arginine supplemented medium suggesting that arginine is the final product of this pathway.
- Since some mutants could not grow on ornithine, this compounds must be synthesized earlier than citrulline and or arginine.
- Beadle and Tatum taking clue from this growth behaviour of *Neurospora* and other experiments, proposed the **arginine biosynthetic pathway**. The precursor compound first gives rise to ornithine, ornithine then gives rise to citrulline and the latter is finally converted into arginine; each of these steps is mediated by an enzyme.
- The mutant of **class I**, could grow on ornithine, citrulline or arginine suggesting that they lack the capacity to synthesize ornithine, but beyond that they could complete the pathway.
- Similarly, mutants of **class II**, could not convert ornithine to citrulline, but if supplied citrulline could Synthesize arginine.
- The last mutants of **class III** could not convert citrulline to arginine and had to be supplied Arginine for growth.
- Beadle and Tatum reasoned that these defects could arise due to defective enzymes in each mutant. Since such changes were mutational, they held that one gene controls one enzyme in a pathway leading to their famous ‘**One gene one enzyme hypothesis**’.

The hypothesis states that each gene controls synthesis of a specific enzyme or protein. Beadle and Tatum were awarded with Noble prize for this work in 1958. Their work founded the new science of ‘**biochemical genetics**’. Beadle and Tatum used **total isolation method** to detect the nutritional mutant of *Neurospora*. **Modification of Beadle and Tatum’s Hypothesis** : One gene one enzyme hypothesis held that a gene has information to produce one enzyme. The enzymes are proteins, but all proteins are not enzymes. Recently some RNAs have also been found to manifest enzyme activity. Proteins are complex molecules and may be composed of one or more polypeptide chains. For example, haemoglobin consists of four polypeptide chains - **2 α and 2 β chains**. Thus, more than one gene may control the synthesis of a protein. It is now held that one gene is responsible for the formation of one polypeptide chain. Therefore, one gene one enzyme hypothesis has been replaced by ‘**one gene one polypeptide hypothesis**’ Further modification came when one gene was identified as a **functional unit** or **cistron** and the same was called ‘**one cistron-one polypeptide hypothesis**’.

REGULATION OF GENE EXPRESSION

- The mechanism which stimulates the expression of certain genes and inhibits other is called **regulation of gene expression**.
- It is possible only if the organism has a mechanism of regulating gene activity by allowing some to function and others to restrain their activity through switching on and switching off system. This means, the genes are turned ‘on’ or ‘off’ as per requirement.
- A set of genes is ‘switched on’ when enzymes are required to metabolise a new substrate. The enzymes produced by these genes metabolise the substrate.

- The molecules of metabolite that come to switch on of the genes are termed as **inducers** and the phenomenon is called **induction**.
- Similarly, certain genes which are in their 'switch on state, continue to synthesise a metabolite till the later is produced in amount more than required or, it is supplied to the cell from outside. In other words genes continue to express themselves till the end product inhibits or repress their expression. Inhibition by end product is known as '**feed back repression**'.

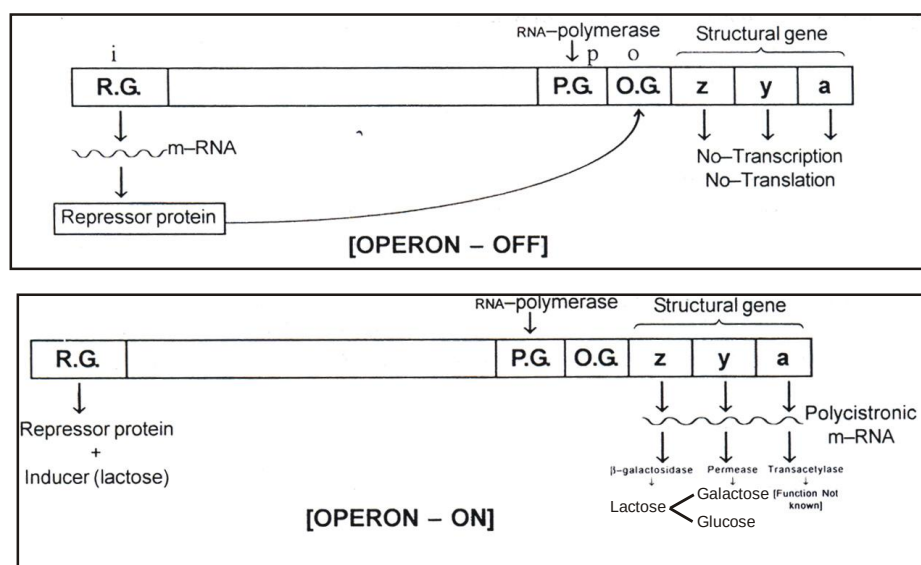
OPERON CONCEPT :

- In 1961, two French microbiologists **Francis Jacob** and **Jacques Monod** at the Pasteur Institute in Paris, proposed a mechanism called **operon model** for the regulation of gene action in *E. coli*.
- An operon is a part of genetic material or DNA, which acts as a single regulated unit having one or more structural genes—an operator gene, a promoter gene, a regulator gene.
- Operon is **unit of Transcription**.
- Operons are of two types (i) **Inducible**, (ii) **Repressible**.

(i) Inducible System (Lac operon of *E. coli*)

An inducible operon system normally remains in **switched off** condition and begins to work only when the substance to be metabolised (Inducer) by it is present in the cell. Inducible operon system generally occurs in catabolic pathways. e.g. Lac operon of *E. coli*.

Active repressor + inducer = inactive repressor



An inducible operon system consists of four types of genes :

- Structural genes :** These genes synthesise mRNAs, which in turn synthesise polypeptide or enzyme over the ribosomes. An operon may have one or more structural genes. Each structural gene of an operon is called a cistron. The lac operon (lactose operon) of *Escherichia coli* contains three structural genes (z, y and a). These genes occur adjacent to each other and thus are linked. They transcribe a polycistronic mRNA molecule, that helps in the synthesis of three enzymes - β galactosidase or **Lactase**, **lactose permease** and **transacetylase**.
- Operator gene :** It lies adjacent to the structural genes and directly controls the synthesis of mRNA over the structural genes. It is switched off by the presence of a repressor. An inducer can take away the repressor and switch on the gene that directs the structural genes to transcribe.

- (c) **Promoter gene** : This gene is the site for initial binding of RNA polymerase. When the operator gene is turned on, the enzyme RNA polymerase moves over it and reaches the structural genes to perform transcription.
- (d) **Regulator gene** : It produces a repressor that binds to operator gene and stops the working of the operator gene.

- **Repressor** : It is a protein, produced by the regulator gene. It binds to the operator gene so that the transcription of structural gene stops. Repressor has two allosteric site (1) operator gene (2) effective molecule (inducer / corepressor)
- **Inducer** : It is a chemical (substrate, hormone or some other metabolite) which after coming in contact with the repressor, forms an **inducer repressor complex**. This complex cannot bind with the operator gene, which is thus switched on.

The inducer for lac operon of *Escherichia coli* is lactose. When the sugar lactose is added to the culture of *E. coli*, a few molecules of lactose gets into the bacterial cells by the action of the enzyme permease, a small amount of this enzyme is present in the cell even when the operon is not working. These few lactose molecules are then converted into an active form which acts as an inducer and binds to the repressor protein. (allolactose an isomer of lactose) **Allolactose is real or true inducer of lac operon**

The inducer repressor complex fails to join with the operator, which is turned on. The three genes are expressed as three enzymes to metabolise lactose. Gratuitous inducer → Some molecules resemble with natural inducer but are **not metabolize** by the enzyme. Example : **Isopropyl this galactoside (IPTG)** : This resembles lactose and thus have the property of induction. Such inducer which induces enzyme synthesis, without getting metabolized are called **gratuitous inducer**.

(ii) **Repressible System (Tryptophan operon of *E. coli*)**

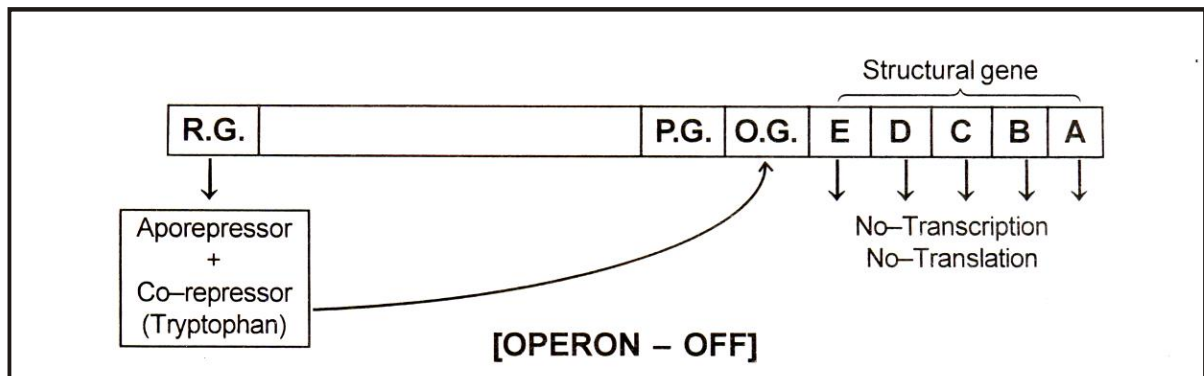
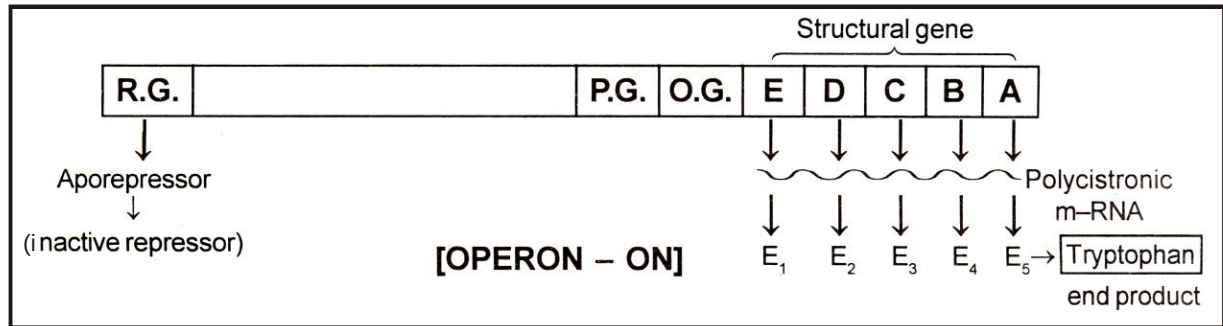
A repressible operon system is normally in its **switch on** state and continue to synthesise a metabolite till this metabolite is produced in amount more than required, or else it becomes available to the cell from outside. Repressible operon system is commonly found in anabolic pathway. e.g. Tryptophan operon of *E. coli*.

[Inactive repressor + co-repressor = active repressor]

- **Tryptophan operon** of *Escherichia coli* is an example of repressible system. It consists of the following:
- (a) **Structural operon** These genes are meant for transcription of mRNA which in turn synthesis enzyme :Tryptophan operon has five structural genes E.D.C. B and A. They lie in continuation and synthesis enzymes for five steps of tryptophan synthesis.
- (b) **Operater gene (trp O)** It lies adjacent to the structural genes and controls the functioning of the structural genes. Normally, it is kept switched on, because the apo-repressor produced by the regulator gene does not bind to it. The operator gene is switched off when a co-repressor is available alongwith apo-repressor.
- (c) **Promoter gene (trp P).** It marks the site at which the RNA polymerase enzyme binds. When the operator gene is switched on, it moes from promotor gene to structural genes for transcription.
- (d) **Regulator gene (trp R).** It produces a regulatory protein called apo-repressor for (Inactive repressor) blocking the activity of operator gene.
- (e) **Apo-repressor.** (Inactive repressor) It is a regulatory protein synthesised by regulator gene. When a co-repressor substance is available in the cell, the apo-repressor combines with the co-repressor to form a apo-repressor co-repressor complex. This complex binds with the operator gene and switches it off. Presence of apo-repressor alone, the operator gene is kept **switched on** because, by itself the apo-repressor-is unable to back the working of operator gene.

Co-repressor – It is an end product of reaction by enzyme produced by the structure gens. In the presence of tryptophan some molecules of tryptopham acts as co-repressor, co repressor bind with inactive

repressor, inactive repressor. **co-repressor complex** bind with operator region and prevent the binding of RNA polymerase to the promoter, the trp-operon is off.



Differences between Induction and Repression

Sr.No.	Induction		Repression
1	It is switching on of an operon which is normally in switched off state (off-on).	1	It is switching-off an operon which is normally in switched on state (on-off).
2	It starts transcription and translation.	2	It stops transcription and translation.
3	It is caused by a new metabolite which needs enzymes to get metabolised.	3	It is caused by increased formation or availability of a metabolite (Feedback repression).
4	It generally operates in a catabolic pathway.	4	It generally operates in an anabolic pathway.

The **repressor molecules** has **key role in regulation** of lac-operon. Repressor molecule active or inactive. Active repressor may be inactive by addition of an inducer while the inactive repressor can be made active by addition of a co-repressor.

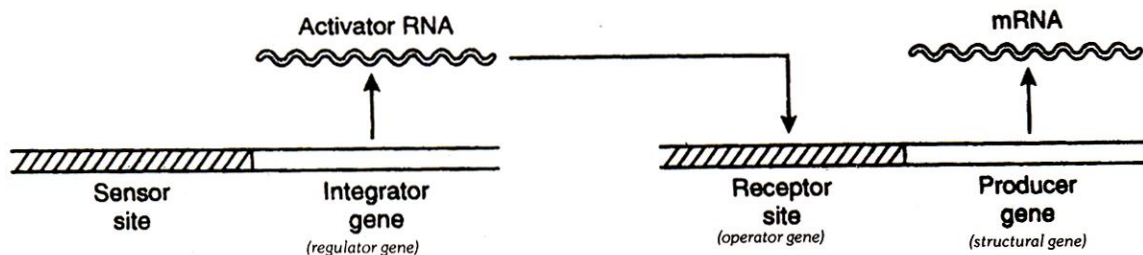
Because the product of regulator gene the repressor act by shutting off the transcription of structural gene the operon model, as originally proposed by Jacob & Monod is referred as **negative** control system.

GENE EXPRESSION IN EUKARYOTES :

- Operon concept is not applicable for eukaryotes
- The most popular model is known as '**Britten-Davidson model**' or '**Gene-battery model**' proposed by **Britten** and **Davidson** in 1969.
- A set of structural genes controlled by one sensor site combinedly called battery.
- Gene battery model assumes the presence of four class of sequences

- (a) **Producer gene** : A producer gene is comparable to structural gene of prokaryotic operon.
- (b) **Receptor site** : A receptor site is comparable to **operator gene** of bacterial operon and one such receptor site is assumed to be present adjacent to each producer gene.
- (c) **Integrator gene** : Integrator gene is comparable to **regulator gene** and is responsible for synthesis of an **activator RNA**. It activates the receptor site.
- (d) **Sensor site** : A sensor site regulates the activity of integrator gene. Activator gene can be transcribed only when the sensor site is activated.

The sensor sites are recognized by agents which change the patterns of gene expression like hormones and proteins. When a transcription factor (protein, hormone) bind to the sensor site it cause the transcription of integrator.



Britten-Davidson model or Gene-battery model

TYPES OF GENE

All the genes do not play the same role nor all genes are active all the time. With regard to their role and activity, the genes are of following types :

(1) Jumping Genes :

It is a segment of DNA which moves from one chromosome to another chromosome within the genome of an individual. McClintock (1983) got nobel prize for the discovery of jumping gene in maize. Two transposable controlling elements (Ds) and activator (Ac), which can jump to any chromosome from their original location on chromosome 9. Also in bacteria plasmid transposone carry gene for antibiotic resistance (ampicilline).

Other Examples :

Transposable element (TE) in *Drosophila* - As much as 10% of the genome consist of transposons, most important of these are **copia like element**, **Fold back (FB)** (for eye colour), and **P** and **I** element (for sterility). Ty element in yeast.

- (2) **Overlapping Gene** : A few genes in certain bacteria and animal viruses code for two different polypeptides. These are called overlapping genes. For example – in $\phi \times 174$ virus, SV -40 virus.
- (3) **Constitutive genes (House keeping genes)**: These genes are expressed constantly, because their products are constant needed for cellular activity e.g. genes for glycolysis, gene of ATPase enzyme.
- (4) **Non-constitutive genes (Smart gene or Luxury gene)** – These genes remain silent and are expressed only when the gene product is needed. They are switched 'on' or 'off' according to the requirement of cellular activities. Non-constitutive genes are of two types; **inducible and repressible**. The inducible

genes are switched on in presence of a chemical substance called **inducer**, required for the functioning of gene activity. The repressible genes continue to express themselves till a chemical, often an end product of the metabolism inhibits or represses their activity. Such type of inhibition is called **feed back inhibition** or **feed back repression**.

- (5) **Homeotic genes** : Homeotic gene regulates the organ differentiation in embryo.

Homeobox : related to transcription of homeotic gene.

If mutation takes place in homeotic gene organ formation is disturbed.

- (6) **Pseudoallele** : Allele which is located on non homologous chromosome or gene which is located on different locus on homologous chromosome produces identical phenotype called as pseudoallele. eg Duplicate gene
- (7) **Isoallele** : If several alleles exhibit same phenotype then they are said to **Isoallele**. In *Drosophila* allele $W^{+c} W^{+S} W^{+9} \rightarrow$ produce red eye colour
- (8) **Hybrid vigour / Heterosis** – Superiority of offsprings over it's parents is called as **Hybrid vigour** or **Heterosis**.

Hybrid vigour can be maintained for long time in vegetatively propagated crops.

Hybrid vigour can be lost by inbreeding (selfing) because inbreeding induces the Homozygosity and reduced heterozygosity in offsprings. Loss of Hybrid vigour due to inbreeding, is called as **inbreeding depression**.

EXERCISE - 1

- | | |
|--|--|
| <p>Q.1 Who first proved that heredity is controlled by nucleus not by cytoplasm -
 (1) Hershey and Chase
 (2) Strassburger
 (3) Hammerling (4) Mendel</p> <p>Q.2 Mendelism is genetics of -
 (1) Haploids (2) Diploids
 (3) Prokaryotes (4) All the above</p> <p>Q.3 Which technique is used by Mendel for hybridisation -
 (1) Emasculation (2) Bagging
 (3) Protoplast fusion (4) 1 & 2 both</p> <p>Q.4 The word "Genetics" coined by -
 (1) Mendel (2) Johannsen
 (3) Bateson (4) Morgan</p> <p>Q.5 Dihybrid plants form how many types of pollen grains -
 (1) One (2) Two
 (3) Four (4) Eight</p> <p>Q.6 When flowers are unisexual then emasculation is done in -
 (1) Female (2) male
 (3) 1 & 2 both (4) None of these</p> <p>Q.7 How many plants are dihybrid in F_2 generation of dihybrid cross -
 (1) One (2) Two
 (3) Four (4) Sixteen</p> <p>Q.8 Mendel's conclusion first published in -
 (1) Journal of plants breeding
 (2) Journal of genetics & plant breeding
 (3) Nature forschender verein
 (4) None</p> <p>Q.9 When a plant has two alleles of contrasting characters it is called -
 (1) Homozygous (2) Dioecious
 (3) Heterozygous (4) Monoecious</p> <p>Q.10 Phenotypic ratio 3:1 proves -
 (1) Dominance
 (2) Segregation
 (3) Crossing-over
 (4) Independent assortment</p> | <p>Q.11 What is the ratio of one pair of contrasting characters in F_2 of a dihybrid cross -
 (1) 5:3 (2) 3:1
 (3) 9:3:3:1 (4) 1:2:2:4:1:2:1:2:1</p> <p>Q.12 What is ratio of homozygous and heterozygous individuals in F_2 of a monohybrid cross -
 (1) 1:1 (2) 3:1
 (3) 2:1 (4) 1:2</p> <p>Q.13 What is ratio of homozygous plants for both dominant characters in F_2 of a dihybrid cross-
 (1) 1/16 (2) 3/16
 (3) 4/16 (4) 9/16</p> <p>Q.14 Which is Mendelian ratio -
 (1) 3:1 (2) 1:2:1
 (3) 1:1 (4) 4:9:3:3:1</p> <p>Q.15 Which of the following is significance of dominance -
 (1) Organisms with dominant genes are more vital
 (2) Harmful mutations are not expressed due to dominant gene
 (3) Heterosis is due to dominant gene
 (4) All the above</p> <p>Q.16 An offspring of two homozygous parents differing from one another by alleles at only one gene locus is known as -
 (1) Back cross (2) Monohybrid
 (3) Dihybrid (4) Trihybrid</p> <p>Q.17 From a single ear of corn, a farmer planted 200 kernels which produced 140 tall & 40 short plants. The genotypes of these of springs are most likely -
 (1) TT, Tt & tt (2) TT & tt
 (3) TT & Tt (4) Tt & tt</p> <p>Q.18 A useful process for determining whether an individual is homozygous or heterozygous is-
 (1) Cross-breeding (2) Self fertilization
 (3) Back-crossing (4) Test cross</p> <p>Q.19 Genetic recombinations occur through -
 (1) Mitosis & Fertilisation
 (2) Mitosis & Meiosis
 (3) Meiosis & Fertilisation
 (4) None of the above</p> |
|--|--|

- Q.20** Disease resistant varieties can be produced by -
 (1) Crossing a plant with wild variety
 (2) Treating with colchicine
 (3) Crossing with hormones
 (4) Treating with low temperature
- Q.21** Heterozygous tall plants were crossed with dwarf plants. What will be the ratio of dwarf plants in the progeny -
 (1) 50% (2) 25%
 (3) 75% (4) 100%
- Q.22** A pure tall plant can be differentiated from a hybrid tall plant -
 (1) By measuring length of plant
 (2) By spraying gibberalins
 (3) If all plants are tall after self-pollination
 (4) If all plants are dwarf after self-pollination
- Q.23** Which of the following is the unit of inheritance-
 (1) Phenotype (2) Genotype
 (3) Gene (4) None of these
- Q.24** If the cell of an organism heterozygous for two pairs of genes represented by Aa,Bb, undergoes meiosis, then the possible genotypic combination of gametes will be -
 (1) AB, Ab, aB, ab (2) AB, ab
 (3) Aa, Bb (4) A, a, B, b
- Q.25** Allele is the -
 (1) Alternate trait of gene pair
 (2) Total number of genes for a trait
 (3) Total number of chromosomes of a haploid set
 (4) Total number of genes present on a chromosome
- Q.26** Sex linkage first observed by -
 (1) Bateson (2) Corrense
 (3) Morgan (4) Muller
- Q.27** Types of genotypes in F_2 generation of dihybrid cross -
 (1) 4 (2) 16
 (3) 8 (4) 9
- Q.28** A character which is expressed in a hybrid is called -
 (1) Dominant (2) Recessive
 (3) Co-dominant (4) Epistatic
- Q.29** Cross AABb X aaBb yields AaBB : AaBb : Aabb : aabb of spring in the ratio of -
 (1) 0:3:1:1 (2) 1:2:1:0
 (3) 1:1:1:1 (4) 1:2:1:1
- Q.30** Genetic constitution of an individual is represented by -
 (1) Genome (2) Genotype
 (3) Phenotype (4) Karyotype
- Q.31** Genes do not occur in pairs in -
 (1) Zygote (2) Somatic cell
 (3) Endosperm cell (4) Gametes
- Q.32** "Like begets like" an important and universal phenomenon of life, is due to -
 (1) Eugenics (2) Inheritance
 (3) dominance (4) Crossing-over
- Q.33** The genes for same trait present on non-homologous chromosomes are -
 (1) Alleles (2) Linked genes
 (3) Multiple alleles (4) None of these
- Q.34** Genotype-phenotype concept was first produced by -
 (1) Bateson (2) Johannsen
 (3) Sutton & Boveri (4) Punnett
- Q.35** How many types of gametes are expected from the organism with genotype AABbCC-
 (1) One (2) Two
 (3) Four (4) Eight
- Q.36** One of the following did not constitute the seven contrasting pairs of characters noticed by Mendel -
 (1) Height of the plants
 (2) Shape of the leaves
 (3) Shape of pod
 (4) Colour of pod
- Q.37** The scientist who worked on garden pea before Mendel was -
 (1) Goss (2) Kolreuter

Q.38 The plant which made Hugo-de vries famous is -

- (1) Antirrhinum majas
- (2) Lathyrus odoratus
- (3) Oenothera lamarckina
- (4) Pisum sativum

Q.39 If 3^n is the theoretically possible number of different genotypes (when n = the number of chromosome pairs with each carrying one pairs of heterozygous alleles). the different genotypes produced by pea plant is -

- (1) 3^{10}
- (2) 3^{12}
- (3) 3^{14}
- (4) 3^7

Q.40

		Male gametes			
Female gametes	?	AB	Ab	aB	ab
		AaBB	AaBb	aaBB	aaBb

In the Punnet square given above, the genotype of the female parents and male parents respectively -

- (1) AaBB, AaBb
- (2) AaBB, AaBb
- (3) aaBB, AaBb
- (4) AaBb, AaBb

Q.41 A trihybrid cross is made between two plants with genotypes A/a B/b C/c how many offspring of such cross will have a genotype a/a b/b c/c -

- (1) $1/64$
- (2) $1/4$
- (3) $1/16$
- (4) $1/32$

Q.42 How is the arrangement of Mendel's selected seven characters on four chromosomes -

- (1) One in ch. no. 1, 4 in ch. no. 4, one in ch. no. 5 and one in ch. no. 7
- (2) 2 in ch. no. 1, 3 in ch. no. 4, one in ch. no. 5 and one in ch. no. 7
- (3) 3 in ch. no. 1, 1 in ch. no. 4, 2 in ch. no. 5 and one in ch. no. 7
- (4) 2 in ch. no. 1, 3 in ch. no. 4, 1 in ch. no. 5 and 1 in ch. no. 7

Q.43 Out of three characters on chromosome no. 4, two characters indicate linkage and not mentioned by Mendel. These characters were -

- (1) Pod form - stem length
- (2) Pod form - pod position
- (3) Pod form - pod colour
- (4) Pod position - stem length

Q.44 Mrs. verma has a autosomal gene pair 'Bb' and she contain x-linked gene 'd' What is the percentage of gamete which contain 'bd' genes-

- (1) $1/2$ or 50%
- (2) $1/4$ or 25%
- (3) $3/4$ or 75%
- (4) 1 or 100%

Q.45 When two different genotypes produce the same phenotype due to environmental difference, then each one is known as -

- (1) Phenotype
- (2) Phenocopy
- (3) Progeny
- (4) Independent offspring

Q.46 The Punnett square shown below represents the pattern of inheritance in dihybrid cross when yellow (Y) is dominant over white (y) and round (R) is dominant over wrinkled (r) seeds -

	YR	Yr	yR	yr
YR	F	J	N	R
Yr	G	K	O	S
yR	H	L	P	T
yr	I	M	Q	U

A plant of type 'H' will produce seeds with the genotype identical to seeds produced by the plants of -

- (1) Type M
- (2) Type J
- (3) Type P
- (4) Type N

Q.47 1:1:1:1 ratio shows -

- (1) Monohybrid cross
- (2) Dihybrid cross
- (3) Back cross
- (4) Dihybrid test cross

Q.48 If a heterozygous tall plant is crossed with a homozygous dwarf plant then what shall be the percentage of dwarf in offspring -

- (1) 25%
- (2) 100%
- (3) 75%
- (4) 50%

- (1) All heterozygous tall
- (2) Two tall & Two dwarf
- (3) 1:2:1
- (4) All homozygous dwarf

(1) 50% (2) 6.25%

(3) 12.5% (4) 50%

(1) 50% (2) 12.5%

(3) 6.25% (4) 18.75%

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	3	2	4	3	3	4	3	3	3	2	2	1	1	1	2	2	1	4	3	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	3	3	1	1	3	4	1	2	2	4	2	4	2	1	2	1	3	4	3
Ques.	41	42	43	44	45	46	47	48	49	50	51									
Ans.	1	4	1	1	2	4	4	4	1	3	3									

EXERCISE- 2

- | | |
|--|--|
| <p>Q.1 With increasing age the linkage becomes-</p> <p>(1) Strong (2) Weak</p> <p>(3) Terminates (4) Remains unchange</p> <p>Q.2 Coupling and Repulsion theory produced by-</p> <p>(1) Morgan (2) Bateson</p> <p>(3) Muller (4) De vries</p> <p>Q.3 In which type of inheritance the result are affected by reciprocal cross-</p> <p>(1) Nuclear (2) Cytoplasmic</p> <p>(3) Blending (4) All the above</p> <p>Q.4 If there were only parental combinations in F_2 of a dihybrid cross then Mendel might have discovered -</p> <p>(1) Independent assortment</p> <p>(2) Atavism</p> <p>(3) Linkage</p> <p>(4) Repulsion</p> <p>Q.5 Plants similar to mother plant can be obtained from -</p> <p>(1) Seeds (2) Stem cutting</p> <p>(3) Both of these (4) None of these</p> <p>Q.6 Linkage discovered in Drosophila by -</p> <p>(1) Bateson (2) Morgan</p> <p>(3) Muller (4) Correns</p> <p>Q.7 Mendelian dihybrid and dihybrid with linkage are respectively related with how many chromosomes -</p> <p>(1) 1 pair & 2 pair (2) 2 pair & 1 pair</p> <p>(3) 2 pair & 2 pair (4) 1 pair & 1 pair</p> <p>Q.8 Incomplete dominance occurs in -</p> <p>(1) Mirabilis (2) Antirrhinum</p> <p>(3) Andulasion fowl (4) All of the above</p> <p>Q.9 A dihybrid plant with incomplete linkage on test cross may produce how many types of plants -</p> <p>(1) 2 (2) 4</p> <p>(3) 8 (4) 1</p> | <p>Q.10 How many linkage group are there in nucleoid of bacteria -</p> <p>(1) One (2) Two</p> <p>(3) Four (4) None</p> <p>Q.11 Which cross yields red, white & pink flowers variety of dog flower -</p> <p>(1) $RR \times Rr$ (2) $Rr \times RR$</p> <p>(3) $Rr \times Rr$ (4) $Rr \times rr$</p> <p>Q.12 What shall be ratio in offspring when a roan cow is crossed with a white bull -</p> <p>(1) 1:2:1 (2) 3:1</p> <p>(3) 1:1 (4) All roan</p> <p>Q.13 If distance between gene on chromosome is more, then gene shows -</p> <p>(1) Weak linkage (2) Strong linkage</p> <p>(3) Less crossing (4) 1 & 3 both</p> <p>Q.14 Linked gene shows -</p> <p>(1) Always parental combination</p> <p>(2) Sometimes new combinations</p> <p>(3) Always new combination</p> <p>(4) New combination more</p> <p>Q.15 The number of linkage groups in a cell having 10 pairs of chromosomes are -</p> <p>(1) 5 (2) 10</p> <p>(3) 15 (4) 20</p> <p>Q.16 Cytology + genetics were merged into "Cytogenetics" by one of following -</p> <p>(1) Bateson (2) Punnett</p> <p>(3) Morgan (4) Muller</p> <p>Q.17 Phenotypic ratio in codominance -</p> <p>(1) 1:2:1 (2) 3:1</p> <p>(3) 2:1 (4) 2:1:3</p> <p>Q.18 Which of the following is exception to Mendel's laws -</p> <p>(1) Linkage</p> <p>(2) Incomplete dominance</p> <p>(3) Co-dominance</p> <p>(4) All of the above</p> |
|--|--|

- Q.19** The association of parental characters combinations in the offsprings of a dihybrid is excess to non-parental combination is said to be due to -
 (1) Co-dominance
 (2) Blending inheritance
 (3) Linkage
 (4) Duplicate genes
- Q.20** Complete linkage is found in -
 (1) Birds
 (2) Snakes
 (3) Female-Drosophila
 (4) Male-Drosophila
- Q.21** A phenomenon which works opposite to the linkage is -
 (1) Independent assortment
 (2) Crossing-over
 (3) Segregation
 (4) Mutation
- Q.22** The scientist who first discovered cytoplasmic inheritance was -
 (1) Correns (2) Rhoades
 (3) Mendel (4) Morgan
- Q.23** Shell coiling in Limnaea (Snail) is an example of -
 (1) Maternal inheritance
 (2) Biparental inheritance
 (3) Predetermination
 (4) Dauermodification
- Q.24** Kappa particles were discovered by -
 (1) Correns (2) Sonneborn
 (3) Rhoades (4) Bycott et.al.
- Q.25** Kappa particles make an animal killer when thier number in an individual is -
 (1) 6 (2) 60
 (3) 400 (4) 150
- Q.26** The killer chemical secreted by kappa particles is -
 (1) Secretin (2) Paramycin
 (3) Plasmon (4) Poky
- Q.27** Which is not an example of cytoplasmic inheritance -
 (1) Female sterility in maize
 (2) Sigma particle inheritance
 (3) Kappa particle inheritance
 (4) Plastid inheritance
- Q.28** Cytoplasmic male sterility is passed down-
 (1) Throgh bacteriophages
 (2) Paternally
 (3) Maternally
 (4) Biparentally
- Q.29** The two eukaryotic organelles responsible for cytoplasmic inheritance are -
 (1) Lysosome & Mitochondria
 (2) Chloroplasts & Lysosomes
 (3) Mitochondria & chloroplasts
 (4) Mitochondria & Golgi-complex
- Q.30** In a dihybrid cross, when one pair of alleles show incomplete dominance, genotypic ratio comes to -
 (1) 3 : 6 : 3 : 1 : 2 : 1
 (2) 1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1
 (3) 9 : 3 : 3 : 1
 (4) 1 : 2 : 1
- Q.31** Which of the following is the example of codominance -
 (1) $Hb^A Hb^A, I^A I^B$ (2) $Hb^s Hb^s, I^A I^B$
 (3) $Hb^A Hb^s, I^A I^B$ (4) $Hb^s Hb^s, I^A I^A$
- Q.32** Cross over value (COV) of gene A and B is 5% while COV of genes B and C is 15% the possible sequence of three genes on chromosome is -
 (1) A-B-C (2) C-A-B
 (3) B-C-A (4) Both (1) & (2)
- Q.33** A test cross of F_1 files + a/+b produced the following offspring
 $++/ab = 9$
 $ab/ab = 9$
 $+b/ab = 41$
 $a+/ab = 41$
 What will be distance between linked gene-
 (1) 82 cm. (2) 18 cm. (cis)
 (3) 20 cm. (4) 18 cm. (trans)

Q.34 Which of the following conditions represent a case of co-dominant genes -

- (1) A gene expresses itself, suppressing the phenotypic effect of its alleles
- (2) Genes that are similar in phenotypic effect when present separately, but when together interact to produce a different trait
- (3) Allele, both of which interact to product a trait, which may resemble either of the parental type.
- (4) Alleles, each of which produces an independent effect in heterozgous condition.

Q.35 A sinistral shelled female snail having Dd genotype cross with dextral shelled male having dd genotype. What type of shell will be present in the progeny -

- (1) All dextral
- (2) All sinistral
- (3) 50% dextral, 50% sinistral
- (4) None

Q.36 In female Drosophila the linked gene exhibit recombination during meiosis of gamete formation, but such a recombination does not occur during the formation of sperm in male Drosophila -

- (1) Male Drosophila is sterile
- (2) Male Drosophila is parthenogenic male
- (3) No crossing over occur in male Drosophila
- (4) Male Drosophila is haploid

Q.37 Hypertrichosis is -

- (1) Holandric character
- (2) X-Linked character
- (3) Diagenic character
- (4) Sex-influenced character

Q.38 Organisms with two or more than two types of genotypes in their tissues are called -

- (1) Wobble
- (2) Heterozygous
- (3) Heterosis
- (4) Chimera

Q.39 Products of somatic hybridisation are -

- (1) Hybridoma
- (2) Hybrid-vigour
- (3) Heterosis
- (4) Super-hybrids

Q.40 In which of the following the inheritance takes place only by male -

- (1) Nuclear
- (2) Cytoplasmic
- (3) co-dominance
- (4) Holandric inheritance

Q.41 Which of the following is not a sex linked characters -

- (1) Haemophilia
- (2) Colour blindness
- (3) Hypertrichosis
- (4) Baldness

Q.42 A gene located on Y-chromosome and therefore, transmitted from father to son is known as -

- (1) Supplementary gene
- (2) Complementary gene
- (3) Duplicate gene
- (4) Holandric gene

Q.43 The condition in which only one allele of a pair is present is known as -

- (1) Homozygous
- (2) Heterozygous
- (3) Hemizygous
- (4) Incomplete dominance

Q.44 Colourblindness is a -

- (1) Sex limited character
- (2) Sex linked character
- (3) Sex influenced character
- (4) None

Q.45 What is the effect of sexual reproduction -

- (1) Offspring is weak
- (2) Offspring is like the parent
- (3) Offspring is more vigorous
- (4) Offspring is diseased

Q.46 Blue eye colour in human is recessive to brown eye colour. The expected children of a marriage between a blue eyed woman and a brown eyed man who had a blue eyed mother will be -

- (1) All black eyed
- (2) All blue eyed
- (3) All brown eyed
- (4) One blue eyed and one brown eyed

- Q.47** Baldness in man is a -
 (1) Autosomal character
 (2) Sex linked character
 (3) Sex influenced character
 (4) 1 and 2 both
- Q.48** A colourblind man marries a daughter of colourblind father, then in the offspring -
 (1) All sons are colourblind
 (2) All daughters are colourblind
 (3) Half sons are colourblind
 (4) No daughter is colourblind
- Q.49** A woman with normal vision marries a man with normal vision and gives birth to a colourblind son. Her husband dies and she marries a colourblind man. What is the probability of her children having the abnormality -
 (1) 50% colourblind sons + 50% colourblind daughters
 (2) All sons colourblind & daughter carrier
 (3) All daughter colourblind & sons normal
 (4) 50% sons colourblind and all daughters normal
- Q.50** A hybrid is generally more vigorous than either of the parents, this is due to -
 (1) Homozygosity
 (2) Heterozygosity
 (3) Superior genes in hybrid
 (4) Mixing of cytoplasm
- Q.51** Albinism is determined by a recessive gene in man. The presence of albinism in 50% children born to a couple proves that -
 (1) Both parents are heterozygous for albinism
 (2) Father is homozygous normal and mother is heterozygous
 (3) Father is homozygous for albinism but mother is heterozygous
 (4) Both are homozygous
- Q.52** Epistatic gene differs from dominant gene in -
 (1) Epistatic gene in non-allelic
 (2) Epistatic gene never expresses itself independently
 (3) Epistatic and hypostatic genes are present at different loci
 (4) All the above
- Q.53** A dihybrid ratio of 1:4:6:4:1 is obtained instead of 9:3:3:1. This is an example of -
 (1) Complementary gene
 (2) Supplementary gene
 (3) Polygenic inheritance
 (4) Incomplete dominance
- Q.54** A gene that shows its effect on more than one character is -
 (1) Polygene (2) Pleiotropic gene
 (3) Multifactor gene (4) Multiple gene
- Q.55** In multiple allele system a gamete possesses -
 (1) Two alleles (2) Three alleles
 (3) One allele (4) Several alleles
- Q.56** An example of the quantitative trait in man is -
 (1) Hair colour (2) Colour of eye
 (3) Skin colour (4) Shape of nose
- Q.57** Polygenic inheritance was first noted by -
 (1) Devenport (2) Galton
 (3) Mendel (4) Kolreuter
- Q.58** A single recessive trait which can express its effect should occur on -
 (1) Any autosome
 (2) Any-chromosome
 (3) X-chromosome of male
 (4) X-chromosome of female
- Q.59** Sex-linked characters are generally -
 (1) Lethal (2) Recessive
 (3) Dominant (4) Not inherited
- Q.60** The technique of the production of monoclonal antibodies was initially developed by -
 (1) Stewards & Skoog
 (2) Lister & Koch
 (3) Arber & Haberlandt
 (4) Kohler & Milstern
- Q.61** In a lymphocyte - myeloma type of hybridoma the antibody forming ability is derived from -
 (1) Myelomas only
 (2) Lymphocytes only
 (3) Partly from lymphocyte and partly from myelomas
 (4) Myelomas to greater extent and lymphocytes to a lesser extent

Q.62 If dominant C and P genes are essential for the development of purple colour in sweet pea flowers, what would be the ratio of white and purple colour in a cross between CcPpxCc^{pp}-

- (1) 5 : 3 (2) 9 : 7
(3) 2 : 6 (4) 6 : 2

Q.63 Blood grouping in humans is controlled by -

- (1) 4 alleles in which 1^A is dominant
(2) 3 alleles in which 1^A and I^B are dominant
(3) 2 alleles in which none is dominant
(4) 3 alleles in which 1^A is recessive

Q.64 In Drosophila crossing over occurs in female but not in male. Gene A and B are 10 map unit apart on chromosome. A female Drosophila with genotype $\frac{AB}{ab}$ and male Drosophila with genotype $\frac{AB}{ab}$. How many type of gametes are produced by female and male Drosophila respectively -

- (1) 4 types : 2 type
(2) 2 types : 2 types
(3) 4 types : 4 type
(4) 4 types : one types

Q.65 In polygenic inheritance trait which controlled by three pairs of genes. Two individuals which are heterozygous for three alleles, Crossed each other. Such type of cross produced phenotypic ratio in what ratio-

- (1) 1 : 2 : 1 (2) 9 : 3 : 3 : 1
(3) 1 : 4 : 6 : 4 : 1
(4) 1 : 6 : 15 : 20 : 15 : 6 : 1

Q.66 In jersey hog, the coat colour is dependant on two pairs of alleles, R and r or S and s. Any genotype containing at least one R-gene and at least one S-gene result in red coat colour. The double recessive genotype results in white coat colour. All other genotypes results in sandy coat colour. If one hog with genotype "RrSs" mated with another hog will be produced by above cross-

- (1) 9 red : 6-sandy : 1 white
(2) 9 red : 3-sandy : 4 white
(3) 12 red : 3-sandy : 1 white
(4) 1 red : 2-sandy : 1 white

Q.67 Multiple alleles are present -

- (1) In different chromosomes
(2) At different loci on chromosome
(3) At the same locus on homologous chromosomes
(4) At the non homologous chromosomes

Q.68 A scientist performed the gene mapping experiments in maize. He mapped the genes on chromosomes on the basis of % crossing over between different genes. One map unit corresponds to one% crossing over or recombination. The genes showing more than 50% recombination were not supposed to be linked on same chromosome. In crossing over studies on maize, scientist observed the following % crossing over between genes A, B,C,D- between. A and D 10% between A and D 10% between genes A and B 5% and between genes C and B 8% On the basis of above observation find out the correct sequence of genes A, B, C and D on chromosomes -

- (1) BCDA (2) ABCD
(3) BACD (4) DACB

Q.69 In a cross between individuals homozygous for (a, b) and wild type (++) In this cross 700 out of 1000 individuals were of parental type. Then the distance between a and b is-

- (1) 70 map unit (2) 35 map unit
(3) 30 map unit (4) 15 map unit

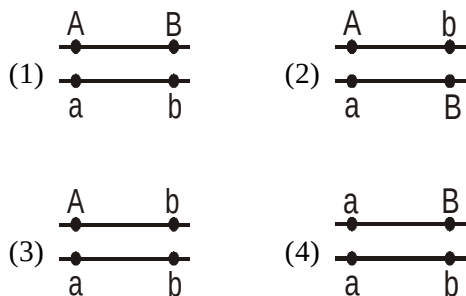
Q.70 In maize coloured endosperm (C) is dominant over colourless (c) and full endosperm (R) is dominant over shrunken (r). When a dihybrid of F₁ generation was test crossed it produced four phenotype in the following percentage -

- Coloured and Full = 45%
Coloured - Shrunken = 5%
Colourless - Full = 4%
Colourless - Shrunken = 46%

From these data what would be distance between the two allelic genes -

- (1) 48 unit (2) 9 unit
(3) 4 unit (4) 12 unit

Q.71 Which of the following show linkage group in coupling phase -



Q.72 In a family, father has a blood group 'A' and mother has a blood group 'B'. Their children show 50% probability for a blood group 'AB' indicating that -

- (1) Father is heterozygous
- (2) Mother is heterozygous
- (3) Either of parent is heterozygous
- (4) Mother is homozygous

Q.73 In a plant three dominant independently assorting gene A, B and C are essential for production of purple pigment. If any of the genes or all three genes are present in recessive condition then flower is colourless

Raw material $\xrightarrow{A} X \xrightarrow{B} Y \xrightarrow{C} Z$ pigment

A purple plant with genotype AABBCC crossed with a colourless plant with genotype aabbcc gives purple F_1 hybrid. On selfing of F_1 - what proportion of coloured offspring in F_2 -

- (1) $\frac{27}{64}$ (2) $\frac{1}{64}$
- (3) $\frac{9}{64}$ (4) $\frac{37}{64}$

Q.74 When a red grain variety of wheat is crossed with another white grain variety a F_1 - hybrid is produced. On selfing of this F_1 hybrid, how many offsprings of F_2 -generation resemble phenotypically to it's parents (let grain colour of wheat controlled by three gene pairs)

- (1) $\frac{2}{16}$ (2) $\frac{20}{64}$
- (3) $\frac{15}{64}$ (4) $\frac{2}{64}$

Q.75 Epistasis differs from dominance because-

- (1) In epistasis one gene pair mask the expression of another pair of genes
- (2) Epistasis is an allelic interaction
- (3) Many genes collectively controls a particular phenotype
- (4) One gene pair independently controls a particular phenotype

Q.76 In a plant flower colour is the example of polygenic trait and controlled by one gene pair. How many plants show parental phenotype in F_2 generation -

- (1) $\frac{2}{16}$ (2) $\frac{2}{4}$
- (3) $\frac{2}{64}$ (4) $\frac{2}{256}$

Q.77 In Drosophila several alleles exhibit same phenotype for eg. W^{+s}, W^{+c}, W^{+g} exhibit eye colour these alleles are called -

- (1) Pseudoalleles (2) Iso alleles
- (3) Multiple alleles (4) All of above

Q.78 (a) Pleiotropic genes have multiple phenotypic effect

(b) Multiple alleles exhibit same phenotypic expression.

(c) Polygenes exhibit continuous variation

- (1) Statement (a), (b) and (c) are correct
- (2) Statement (a), (c) correct and (b) is incorrect
- (3) Statement (a), (b) and (c) are incorrect
- (4) Statement (a) and (c) are correct and (a) is incorrect

Q.79 Which is not correctly matched :

- (1) Agrobacterium $\Rightarrow$ Ti-plasmid
- (2) Cosmid $\Rightarrow$ Vector DNA
- (3) Rhizobium $\Rightarrow$ Asymbiotic N_2 -fixer
- (4) Albinism $\Rightarrow$ Autosomal recessive gene

- Q.80** In *Drosophila* a set of homeotic genes which controls body plan at the time of organ differentiation known as -
 (1) TATA-box (2) Homeobox
 (3) Pribnow box (4) All the above
- Q.81** The longer the chromosome of an organism, the more genetic variability it gets from -
 (1) Independent assortment
 (2) Linkage
 (3) Crossing over (4) Mutation
- Q.82** Which statement is incorrect about linkage-
 (1) It helps in maintaining the valuable traits of new varieties
 (2) It helps in forming new recombinants
 (3) Knowledge of linkage helps the breeder to combine all desirable traits in a single variety
 (4) It helps in locating genes on chromosome
- Q.83** The concept of sudden genetic change which breeds true in an organism is visualized as:-
 (1) Natural selection
 (2) Inheritance of acquired characters
 (3) Mutation
 (4) Independent assortment
- Q.84** Term 'sport' was used for the sudden appearance of heritable trait by-
 (1) Morgan (2) Muller
 (3) Darwin (4) De Vries
- Q.85** Who coined the term mutation
 (1) Morgan (2) Darwin
 (3) Stadler (4) De Vries
- Q.86** True mutation was first discovered by-
 (1) Muller (2) Morgan
 (3) Stadler (4) De Vries
- Q.87** Mutation is-
 (1) An abrupt or discontinuous change which is inherited
 (2) A factor for plant growth
 (3) A change which affects parents only and is never inherited
 (4) A change which affects the offspring of F_2 generation
- Q.88** Mostly mutations are-
 (1) Heritable (2) Non-heritable
 (3) Harmful (4) Beneficial
- Q.89** Abrupt and distinct changes in the structure of a gene is called-
 (1) Point mutation (2) Forward mutation
 (3) Backward mutation
 (4) Chromosomal aberration
- Q.90** Micromutations involve changes in-
 (1) Satellite region of the chromosomes
 (2) Mini-chromosomes
 (3) Microsomes (4) Single gene
- Q.91** The change of chromosomal parts between non homologous pairs of chromosome
 (1) Crossing over/Transduction
 (2) Translocation
 (3) Inversion (4) Transition
- Q.92** Which of the following can be called a mutation-
 (1) The halving of the chromosome number at meiosis
 (2) The doubling of the chromosome after syngamy
 (3) The possession of an additional chromosome
 (4) All the above
- Q.93** Mutation causes normally-
 (1) Small changes (2) Negligible changes
 (3) Large changes (4) No change
- Q.94** Mutations are generally-
 (1) Dominant (2) Recessive
 (3) Codominant
 (4) Incompletely dominant
- Q.95** The first mutant reported by Morgan on *Drosophila* was-
 (1) Red eyed male (2) Red eyed female
 (3) White eyed male (4) White eyed female
- Q.96** The earliest record of point mutation is -
 (1) Short legged sheep by Sneth Wright
 (2) White eyed male *Drosophila* by Morgan
 (3) Autotrophic mutants of *Neurospora* by Beadle and Tatum
 (4) Mutants of *Escherichia coli* discovered by Joshua Lederberg

- Q.97** Short-legged variety of sheep is an example of-
- (1) Recessive germinal mutation
 - (2) Dominant germinal mutation
 - (3) Recessive somatic mutation
 - (4) Dominant somatic mutation
- Q.98** Genetic mutations occur in -
- (1) DNA
 - (2) RNA
 - (3) Protein
 - (4) RNA & protein both
- Q.99** Which of the following undergoes change in mutation -
- (1) Chromosome
 - (2) Structure of gene
 - (3) Sequence of gene
 - (4) Any of the above
- Q.100** The locus of mutation is -
- (1) Gene
 - (2) Chromosome
 - (3) Centromere
 - (4) Nucleus
- Q.101** Gene mutation is caused -
- (1) Due to reproduction
 - (2) Due to linkage
 - (3) Due to change in sequence of N_2 base
 - (4) Due to changes in sequence of genes in DNA
- Q.102** The natural rate of mutation is -
- (1) 1×10^{-10}
 - (2) 1×10^{-6}
 - (3) 1×10^5
 - (4) 1×10^{10}
- Q.103** Mutagenic nature of X-ray and UV-radiations was discovered by -
- (1) Beadle and Tatum
 - (2) Madam Curie
 - (3) Muller
 - (4) Hardy & Weinberg
- Q.104** The title "Artificial transmutation by X-rays" was published by-
- (1) Morgan
 - (2) Muller
 - (3) Stadler
 - (4) DeVries
- Q.105** H.J. Muller received Noble Prize for-
- (1) Discovering linked genes
 - (2) Discovering the mutations induced by X-rays
 - (3) His studies on the genetics of *Drosophila*
 - (4) Proving that DNA was a genetic material
- Q.106** X-rays generally cause-
- (1) Polyploidy
 - (2) Frame shift mutations
 - (3) Chromosomal aberrations
 - (4) Paramutations
- Q.107** α & β rays do not cause mutations in human beings because:-
- (1) They are non ionizing
 - (2) They do not react with DNA
 - (3) They do not penetrate through skin
 - (4) They are not un-natural
- Q.108** Which of the following causes mutation (not polyploidy)
- (1) Crossing-over
 - (2) NaCl
 - (3) Colchicine
 - (4) γ -rays
- Q.109** Non-ionizing radiations commonly used for inducing mutations in organisms are
- (1) UV-rays
 - (2) Beta-rays
 - (3) X-rays
 - (4) Gamma-rays
- Q.110** The best mutagen for micro-organisms is-
- (1) X-rays
 - (2) UV-rays
 - (3) γ -rays
 - (4) α -rays
- Q.111** The sites in the gene at which the mutations occur with unusually high frequency are referred to as-
- (1) Recons
 - (2) Palindromes
 - (3) Hot spots
 - (4) Mutons
- Q.112** The smallest unit of genetic material which upon mutation produce a phenotypic effect is
- (1) Sexual reproduction
 - (2) Meiosis
 - (3) Mutation
 - (4) Independent assortment
- Q.113** Ultimate source of genetic variations is (OR) the process which provides raw material for evolution is
- (1) Sexual reproduction
 - (2) Meiosis
 - (3) Mutation
 - (4) Independent assortment
- Q.114** Continuous variations are due to
- (1) Chromosomal aberrations
 - (2) Polyploidy
 - (3) Mutations
 - (4) Crossing over

- Q.115** Genetic mutation occurs in-
 (1) DNA (2) RNA
 (3) Chromosome (4) All
- Q.116** To be evolutionary successful the mutation must occur in (OR) important mutations occur in-
 (1) Somatoplasm
 (2) Germplasm
 (3) Karyolymph/Zygote
 (4) Ergastoplasm
- Q.117** Chemical mutagens are far more hazardous than radiations because
 (1) The exposure to chemicals is more prevalent
 (2) The organism possess protection for radiation but no protection for chemicals
 (3) The chemically induced mutations are move deleterious
 (4) The chemicals are synthetics
- Q.118** Mutations involving a single base substitution are induced by
 (1) Infra red rays
 (2) Ultrasonic vibrations
 (3) Violet rays
 (4) X-rays
- Q.119** Triticum durum is
 (1) 8n (2) 4n
 (3) 6n (4) 8n
- Q.120** X-rays cause mutations by
 (1) Breeding spindle fibers
 (2) Rupturing nuclear envelope
 (3) Changing chromosome morphology
 (4) Inhibiting chtokinesis
- Q.121** Mutagens which are effective on replication DNA only are-
 (1) Base analogues and Acridines
 (2) Alkylating agents
 (3) HNO_2
 (4) α and β rays
- Q.122** Which of the following is the most effective chemical mutagen which induce mutations
 (1) Caffeine
 (2) Guanine
 (3) Methane
 (4) Carbon-tetra-sulphide
- Q.123** Which of the following agents cause mutation through deamination
 (1) 2-Aminopurine
 (2) 5-Bromo uracil & X-rays
 (3) HNO_2 & UV
 (4) Alkyl sulphonates & N_2 mustards
- Q.124** The antibiotic commonly used in inducing the mutations in cytoplasmic genes is
 (1) Tetramycin (2) Streptomycin
 (3) Tetracycline (4) Cyclosporin
- Q.125** Streptomycin, kenamycin & neomycin binds to smaller sub-unit of prokaryotic ribosomes and cuase-
 (1) Inhibition of protein syntheis
 (2) Mis reading of the genetic code
 (3) Inhibition of translation
 (4) Hydrolysis of peptide bonds
- Q.126** Mutagenic effect of X-rays was discovered by-
 (1) Muller (2) Luria
 (3) Morgan (4) De Vires
- Q.127** Most mutagens have more adverse effects on
 (1) Diploids (2) Triploids
 (3) Tetraploids (4) Haploids
- Q.128** Induced mutations are very common in
 (1) Lentils
 (2) Millets
 (3) Cereals
 (4) Vegetatively propagated plants
- Q.129** On which of the following crops, mutations studies havemore intensively been done.
 (1) Wheat (2) Millets
 (3) Legumes (4) Tube crops
- Q.130** Which of the popular variety of wheat has been developed by mutation
 (1) Triticale (2) Kalyan Sona
 (3) Sonalika (4) Sharbati sonora
- Q.131** A favourite material for the study of mutagenesis at the molecular level is-
 (1) TMV
 (2) E.coli
 (3) Drosophila
 (4) Isolated protoplasts of Arabiodopsis thaliana

Q.132 Haploids are preferred over diploids for mutation studies because:-

- (1) Recessive mutation is expressed in F_1
- (2) Recessive mutation is expressed in F_2
- (3) Dominant phenotype is expressed
- (4) Dominant phenotype is suppressed

Q.133 Type of gene mutation which involves replacement of purine with pyrimidine or vice versa (OR) The substitution of one type of base with another type of base is

- (1) Transduction (2) Transversion
- (3) Translocation (4) Transcription

Q.134 Replacement of a purine N_2 base with another purine base (OR) Replacement of a pyrimidine N_2 base with another pyrimidine is termed as-

- (1) Transition (2) Transversion
- (3) Translocation (4) Transcription

Q.135 Mutations induced by 5-Bromo uracil are-

- (1) Transversional mutations
- (2) Transitional mutations
- (3) Frame shift mutations
- (4) Backward mutations

Q.136 A point mutation which involves change of A G, C T, C G and T A in DNA are:-

- (1) Transition, Transition, Transversion Transversion
- (2) Transition, Transversion, Transition transversion
- (3) Transversion, Transition, Transversion, Transition
- (4) None of the above

Q.137 Base substitution caused by base analogues is:

- (1) Transition
- (2) Transversion
- (3) Complementation
- (4) None

Q.138 The minimum requirement for mutation is-

- (1) Change of triplet codon
- (2) Change in single nucleotide
- (3) Change in whole DNA
- (4) Change in single strand of DNA

Q.139 A segment of DNA has a base sequence: AAG, GAG, GAC, CAA, CCA-, Which one of the following sequence represents a frame shift mutation.

- (1) AAG, GAG, GAC, CAA, CCA-
- (2) AAG, AGG, ACC, AAC, CAA-
- (3) ACG, GAG, GAC, CAG, CCA-
- (4) AAG, GCG, GAC, CAG, CCA-

Q.140 If the DNA-codons are ATGATGATG and a cytosine base is inserted at the beginning which of the following would be the result-

- (1) A non sense mutation
- (2) CA, TGA, TGA, TG
- (3) CAT, GAT, GAT, G
- (4) C, ATG, ATG, ATG

Q.141 Which of the mutagen causes frame shift mutation

- (1) 2 Aminopurine (2) Proflavine
- (3) 5 Bromouracil
- (4) Methane sulphonates

Q.142 Mutations are-

- (1) Always useful (2) Mostly useful
- (3) Never useful (4) Rarely useful

Q.143 If a mutation is not visible in successive generations it is called as a-

- (1) Deletion (2) Dominant mutation
- (3) Recessive mutation
- (4) Segregation

Q.144 Which of the following is most difficult to detect-

- (1) Auxotrophic mutation
- (2) Lethal mutation
- (3) Recessive non-lethal mutation
- (4) Dominant mutation

Q.145 What is an auxotroph-

- (1) A plant that responds by bending towards then sun
- (2) A mutant (organism) which has lost its ability to synthesize one or more essential compounds
- (3) An organism that depends on another organism for meeting its nutritional requirements
- (4) A plant that is able to synthesize its own carbohydrates

- Q.146** Recessive mutations are not lost from a gene pool, This is known as-
- (1) Survival of the dominant
 - (2) Survival of the recessive
 - (3) Hardy-Weinberg's law
 - (4) Darwin's gene mutation law
- Q.147** Blood cancer is known as-
- (1) Leukemia
 - (2) Thrombosis
 - (3) Haemophilia
 - (4) Haemolysis
- Q.148** When the mutation at one locus is neutralized by the mutation at another locus of same or different chromosome it is termed:-
- (1) Gibberish mutation
 - (2) Backward mutation
 - (3) Crossing over
 - (4) Neutral mutation
- Q.149** Mutation theory was proposed by-
- (1) Hugo De Vries
 - (2) J. G. Mendel
 - (3) Lamarck
 - (4) Kolreuter
- Q.150** Lethal mutations were first detected by-
- (1) Morgan
 - (2) Muller
 - (3) De Vries
 - (4) Bateson
- Q.151** Deamination of adenine and guanine by HNO_2 and UV rays produces-
- (1) Cytosine and uracil
 - (2) Xanthine and hypoxanthine
 - (3) Hypoxanthine and xanthine
 - (4) Xanthine and uracil
- Q.152** Who performed the popular "Replica Plating Experiment"-
- (1) Nirenberg and Kornberg
 - (2) Kornberg and Lederberg
 - (3) Joshua Lederberg & Esther Lederberg
 - (4) Holley, Khorana & Mathi
- Q.153** Which of the following substance was used as a screening agent in Replica Plating Experiment-
- (1) Vitamin B_{12}
 - (2) Cofactors & Streptomycin
 - (3) Amino acid Lysine
 - (4) Antibiotic streptomycin

- Q.154** Sickle cell anaemia is an example of-
- (1) Frame shift mutation
 - (2) Point mutation
 - (3) Segmental mutation
 - (4) Gibberish mutation
- Q.155** The most striking example of frame shift mutation was found in a disease called-
- (1) Sickle cell anaemia
 - (2) Colour blindness
 - (3) Laesh-Nyhn Syndrome
 - (4) Thallesemia
- Q.156** Thallesemia is an example of-
- (1) Point mutation
 - (2) Frame-shift mutation
 - (3) Translocation and transition
 - (4) Transversion
- Q.157** Change in sequence of nucleotide in DNA is called as-
- (1) Mutagen
 - (2) Mutation
 - (3) Recombination
 - (4) Translation
- Q.158** In a random mating population in equilibrium, which of the following brings about a change in gene frequency in a non-directional manner
- (1) Mutation
 - (2) Random drift
 - (3) Selection
 - (4) Migration
- Q.159** In a mutational event, when adenine is replaced by guanine, it is a case of -
- (1) Transcription
 - (2) Transition
 - (3) Transversion
 - (4) Frameshift mutation
- Q.160** The most likely reason for the development of resistance against pesticides in insects damaging a crop is -
- (1) Genetic recombination
 - (2) Directed mutation
 - (3) Acquired heritable changes
 - (4) Random mutations
- Q.161** A nutritionally wild type organism, which does not require any additional growth supplement is known as -
- (1) Holotype
 - (2) Auxotroph
 - (3) Prototroph
 - (4) Phenotype

Q.162 Using imprints from a plate from complete medium and carrying bacterial colonies, you can select streptomycin resistant mutants and prove that such mutations do not originate as adaptation. These imprints need to be used -

- (1) One plates with and without streptomycin
- (2) Only on plates with streptomycin
- (3) On plates with minimal medium
- (4) Only on plates without streptomycin

Q.163 Which of the following is generally used for induced mutagenesis in crop plants -

- (1) Gamma rays (from cobalt 60)
- (2) Alpha particles
- (3) X-rays
- (4) UV (260 nm)

Q.164 There are two opposing views about origin of modern man. According to one view Homo erectus in Asia were the ancestors of modern man. A study of variation of DNA however suggested African origin of modern man. What kind of observation of DNA variation could suggest this -

- (1) Greater variation in Asia than in Africa
- (2) Similar variation in Africa and Asia
- (3) Variation only in Asia and no variation in Africa
- (4) Greater variation in Africa than Asia

Q.165 De Vries gave his mutation theory on organic evolution while working on -

- (1) *Oenothera lamarckiana*
- (2) *Frosophila melanogaster*
- (3) *Pisum sativum*
- (4) *Althea rosea*

Q.166 Cri-du-chat syndrome in humans is caused by the

- (1) Fertilization of an XX egg by a normal Y-bearing sperm
- (2) Loss of half of the short arm of chromosome 5
- (3) Loss of half of the long arm of chromosome 5
- (4) Trisomy of 21st chromosome

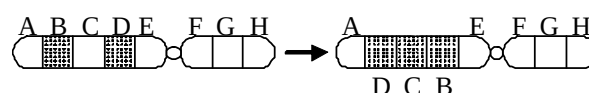
Q.167 Tricicle, the first man-made cereal crop, has been obtained by crossing wheat with -

- (1) Rye
- (2) Pearl millet
- (3) Sugarcane
- (4) Barley

Q.168 Sickle cell anemia has not been eliminated from the African population because -

- (1) It is controlled by recessive genes
- (2) It is not a fatal disease
- (3) It provided immunity against malaria
- (4) It is controlled by dominant genes

Q.169 Given below is the representation of a kind of chromosomal mutation :



What is the kind of mutation represented

- (1) Deletion
- (2) Duplication
- (3) Inversion
- (4) Reciprocal translocation

Q.170 Potato and sweet potato -

- (1) Have edible parts which are homologous organs
- (2) Have edible parts which are analogous organs
- (3) Have been introduced in India from the same place
- (4) Are two species of the same genus

Q.171 The "cri-du-chat" syndrome is caused by change in chromosome structure involving-

- (1) Deletion
- (2) Duplication
- (3) Inversion
- (4) Translocation

Q.172 Mutations occur in :

- (1) Dominant genes
- (2) Recessive genes
- (3) Lethal genes
- (4) Mendel's genes

Q.173 In the hexaploid wheat, the haploid (n) and basic (x) numbers of chromosomes are :

- (1) n = 7 and x = 21
- (2) n = 21 and x = 21
- (3) n = 21 and x = 14
- (4) n = 21 and x = 7

Q.174 Chromosome with genes abcdefg becoming abedcfg is :

- (1) duplication
- (2) deletion
- (3) translocation
- (4) inversion

Q.175 Haploids are more suitable for mutation studies than the diploids. This is because :

- (1) haploids are more abundant in nature than diploids
- (2) All mutations, whether dominant or recessive are expressed in haploids
- (3) Haploids are reproductively more stable than diploids
- (4) Mutagens penetrate in haploids more effectively than in diploids

Q.176 Which one of the following scientist's name is correctly matched with the theory put forth by him ?

- (1) de Vries - Natural selection
- (2) Mendel - Theory of pangenesis
- (3) Weismann - Theory of continuity of Germplasm
- (4) Pasteur - Inheritance of acquired characters

ANSWER KEY

EXERCISE-2

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	2	2	3	2	2	2	4	2	1	3	3	1	2	2	4	1	4	3	4
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	2	1	3	2	3	2	1	3	3	2	3	4	4	4	1	3	1	4	1	4
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	4	3	2	3	4	3	3	1	2	3	4	3	2	3	3	4	4	2	4
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	1	2	1	4	4	3	3	3	2	1	3	1	4	1	2	2	2	3	2
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	3	2	3	3	4	2	1	1	1	4	2	3	3	2	3	2	2	1	4	1
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	3	2	3	2	2	3	3	4	1	2	3	1	3	4	4	2	2	4	2	3
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	1	4	3	2	2	1	4	3	1	4	2	1	2	1	2	1	1	2	2	3
Ques.	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
Ans.	2	4	3	3	2	3	1	4	1	2	3	3	4	2	4	2	2	2	2	4
Ques.	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176				
Ans.	3	2	1	1	1	2	1	3	3	2	1	4	4	4	2	3				

EXERCISE- 3

PREVIOUS YEAR'S QUESTIONS

Q.1 Germplasm concept was proposed by :
[RPMT-93]

- (1) Mendel (2) De-vries
(3) Aristotlle (4) Weismann

Q.2 On which plant mendel had carried out his investigation :-
[RPMT-87,88]

- (1) Garden-pea (2) Wild pea
(3) Cow-pea (4) Pigeon pea

Q.3 Which of the following is non-heritable :
[AIPMT-95]

- (1) Point mutation
(2) Chromosomal mutation
(3) Gene mutation
(4) Somatic mutation

Q.4 The year 1900 AD is highly significant for geneticists due to the-
[RPMT-92,95]

- (1) Discovery of genes
(2) Principle of Linkage
(3) Mendelian rediscovery
(4) Chromosome theory of heredity

Q.5 During breeding the removal of anthers from a flower is called -
[MP PMT-95]

- (1) Anthesis (2) Pollination
(3) Emasculation (4) Vasectomy

Q.6 When a heterozygous tall pea plant of F_1 generation upon self fertilization produces tall and dwarf phenotypes it proves the principle of -
[RPMT-85,90]

- (1) Dominance
(2) Segregation
(3) Independent assortment
(4) Inheritance & purity of gametes

Q.7 Mendel formulated the law of purity of gametes on the basis of -
[RPMT-90]

- (1) Dihybrid cross (2) Monohybrid cross
(3) Back cross (4) Test cross

Q.8 Mendelian monohybrid ratio is - [RPMT-93]

- (1) 1:2:1 (2) 3:1
(3) 9:3:1 (4) 9:3:4

Q.9 In a monohybrid cross the genotype ratio of the offspring is -
[MP PMT-96]

- (1) 3:1 (2) 1:2:1
(3) 1:1:1:1 (4) 4:0

Q.10 A cross between $AaBB \times aaBB$ yields a genotypic ratio of -
[AIPMT-90]

- (1) 1 $AaBB$: 1 $aaBB$
(2) 1 $AaBB$: 3 $aaBB$
(3) 3 $AaBB$: 1 $aaBB$
(4) All $AaBb$

Q.11 In monohybrid cross what is the ratio of homozygous dominant and homozygous recessive individuals in F_2 -generation -
[RPMT-89-92-93-96]

- (1) 1: 2:1 (2) 2:1/1:2
(3) 3:1/1:3 (4) 1:1

Q.12 Back cross is a cross between -[RPMT-87]

- (1) $F_1 \times F_1$ (2) $F_1 \times$ Recessive
(3) $F_1 \times$ Dominant (4) $F_1 \times$ any parent

Q.13 The cross between recessive to its hybrid or its F_1 plant is called -
[RPMT-92,93,96]

- (1) Back cross (2) Test cross
(3) Monohybrid cross (4) Dihybrid cross

Q.14 What is the genotypic and phenotypic ratio of monohybrid test cross -
[RPMT-86]

- (1) 1:1 (2) 1:2
(3) 3:1 (4) 1:2:1

Q.15 What is the ratio of a progeny of cross between F_1 heterozygous and recessive - [RPMT-87]

- (1) 3:1 (2) 1:2:1
(3) 1:1 (4) 2:1

Q.16 Dihybrid cross proves the law of -
[AIPMT-92]

- (1) Segregation
(2) Purity of gametes
(3) Dominance
(4) Independent assortment

- Q.17** How many types & in what ratio the gametes are produced by a dihybrid heterozygous - **[AIPMT-92]**
 (1) 4 types in the ratio of 9:3:3:1
 (2) 2 types in the ratio of 3:1
 (3) 3 types in the ratio of 1:2:1
 (4) 4 types in the ratio of 1:1:1:1
- Q.18** How many gametes are produced in F_1 generation of a trihybrid - **[MP PMT-88]**
 (1) 3 (2) 4
 (3) 8 (4) 16
- Q.19** Which genotype represents a true dihybrid condition - **[AIPMT-91]**
 (1) tt rr (2) Tt rr
 (3) Tt Rt (4) TT Rt
- Q.20** Mendel enunciated how many principles of inheritance - **[MP PMT-95]**
 (1) One (2) Two
 (3) Three (4) Four
- Q.21** Mendelian ratio 9:3:3:1 is due to-**[RPMT-95]**
 (1) Law of segregation
 (2) Law of purity of gametes
 (3) Law of independent assortment
 (4) Law of unit characters
- Q.22** In a cross between a pure tall plant with green pod & a pure short plant with yellow pod. How many short plants are produced in F_2 generation out of 16 - **[AIPMT-94]**
 (1) 1 (2) 3
 (3) 4 (4) 9
- Q.23** In a dihybrid cross between AABB and aabb the ratio of AABB, AABb, aaBb, aabb in F_2 generation is - **[AIPMT-92-94]**
 (1) 9:3:3:1 (2) 1:1:1:1
 (3) 1:2:2:1 (4) 1:1:2:2
- Q.24** Branch of biology dealing with heredity and variation is called - **[MP PMT-98]**
 (1) Palaeontology (2) Evolution
 (3) Genetics (4) Ecology
- Q.25** A dihybrid ratio is - **[MP PMT-98]**
 (1) 1:1:1:1 (2) 3:1
 (3) 9:3:3:1 (4) 9:5:1:1
- Q.26** AABbCc genotype forms how many types of gametes - **[AIPMT-98]**
 (1) 4 (2) 8
 (3) 2 (4) 6
- Q.27** Who rediscovered the results of Mendel's experiments - **[RPMT-97]**
 (1) DeVries, Tschermak, Correns
 (2) DeVries, Tschermak, Morgan
 (3) Tschermak, Morgan, Correns
 (4) Tschermak, Bateson, Punnett
- Q.28** Crossing AABB & aabb, the ratio of AaBb would be in F_2 generation - **[RPMT-97]**
 (1) 1/16 (2) 2/16
 (3) 8/16 (4) 4/16
- Q.29** On crossing Black & white flowered plants the ratio of Black and white flowered plants in F_2 gen. was 120:40, then on selfing the heterozygous Black flowered plants, the offsprings would be - **[RPMT-97]**
 (1) 144:48 (2) 40:60
 (3) 52:48 (4) 84:16
- Q.30** In Mendel's experiments, colour of seed coat, nature of flower, position of flower, colour of pod, height of stem, are called - **[RPMT-97]**
 (1) Alleles (2) Genotype
 (3) Phenotype (4) All of the above
- Q.31** 120 Plants are produced on crossing pure red and pure white flowered pea plants, this ratio is - **[RPMT-96]**
 (1) 90 Red : 30 White
 (2) 30 Red : 90 White
 (3) 60 Red : 60 White
 (4) All Red
- Q.32** According to Mendel's law of segregation the ratio of F_2 generation is - **[RPMT-96]**
 (1) 1:2:1 (2) 3:1
 (3) 1:1 (4) 2:1
- Q.33** Mendel worked in - **[CPMT-80]**
 (1) 17th century (2) 18th century
 (3) 19th century (4) 20th century

- Q.34** Pea plants were more suitable than cattle for Mendel's experiment because - **[CPMT-88]**
 (1) There were no breeding records of cattles
 (2) Pea plants can be self-fertilised
 (3) Cattle are not easy to maintain
 (4) All pea plants have 2X chromosomes and fewer genetic traits
- Q.35** An individual with two identical members of a pair of genetic factors is called - **[CPMT-81]**
 (1) Heteromorphic (2) Heterozygote
 (3) Homomorphic (4) Homozygote
- Q.36** Two allelic genes are located on - **[AFMC-84]**
 (1) The same chromosome
 (2) Two homologous chromosomes
 (3) Two non-homologous chromosomes
 (4) Any two chromosomes
- Q.37** The percentage of AB gametes produced by Aa Bb parent will be - **[AIIMS-88]**
 (1) 12.5 (2) 25
 (3) 50 (4) 75
- Q.38** Gregor Mendel was born in - **[CPMT-93]**
 (1) Britain (2) Austria
 (3) Russia (4) America
- Q.39** Mendel's principles are related to - **[CPMT-95]**
 (1) Evolution (2) Reproduction
 (3) Variations (4) Heredity
- Q.40** Different forms of a gene are called - **[MP PMT-94]**
 (1) Heterozygotes
 (2) Alleles
 (3) Complementary genes
 (4) Supplementary genes
- Q.41** How many characters of pea pod were chosen by Mendel - **[MP PMT-94]**
 (1) 7 (2) 2
 (3) 4 (4) 3
- Q.42** Mendel chose character in pea - **[CPMT-94]**
 (1) Three (2) Two
 (3) One (4) Seven

- Q.43** Mendel's law of segregation is based on separation of alleles during - **[MP PMT-93]**
 (1) Gamete formation
 (2) Seed formation
 (3) Pollination
 (4) Embryonic development
- Q.44** In a cross 45 tall & 14 dwarf plants were obtained, genotype of parents was - **[BHU-93]**
 (1) TT X TT (2) TT X Tt
 (3) Tt X Tt (4) TT X tt
- Q.45** First geneticist was - **[AIPMT-91]**
 (1) De Vries (2) Mendel
 (3) Darwin (4) Morgan
- Q.46** An organism with two identical alleles is - **[AIPMT-93]**
 (1) Dominant (2) Hybrid
 (3) heterozygous (4) Homozygous
- Q.47** Gametes of AaBb individual can be - **[AIIMS-91]**
 (1) Aa, Bb (2) AB, ab
 (3) AB,ab,aB (4) AB,Ab,aB, ab
- Q.48** Mendel did not propose - **[BHU-91,MPPMT-90]**
 (1) Dominance
 (2) Incomplete dominance
 (3) Segregation
 (4) Independent assortment
- Q.49** When two hybrids TtRr & Rrtt are crossed, the phenotypic ratio of offspring will be - **[CPMT-90]**
 (1) 3:1 (2) 1:1:1:1
 (3) 1:1 (4) 9:3:3:1
- Q.50** Body features are - **[MP PMT-88]**
 (1) Phenotype (2) Genotype
 (3) Sex of individual
 (4) Controlled by atmosphere
- Q.51** The allele which is unable to express its effect in the presence of another is called - **[AIPMT-91]**
 (1) Co-dominant (2) Supplementary
 (3) Complementary (4) Recessive

- Q.52** Genotype is - [BHU-83]
 (1) Genetic composition of many organisms
 (2) Genetic composition of plastids
 (3) Genetic composition of germ cells
 (4) Genetic composition of an individual
- Q.53** When AABbCc is crossed with Aa Bb Cc then the ratio of hybrid for all the three genes is - [AIPMT-1999]
 (1) 1/8 (2) 1/4
 (3) 1/16 (4) 1/32
- Q.54** According to Mendelism which character is showing dominance - [AIPMT-2000]
 (1) Terminal position of flower
 (2) Green colour in seed coat
 (3) Wrinkled seeds
 (4) Green pod colour
- Q.55** Due to the cross between TTRr x ttrr the resultant progenies showed how many percent plants would be, tall, red flowered:- [AIPMT-2000]
 (1) 50% (2) 75%
 (3) 15% (4) 100%
- Q.56** Irregularity is found in Drosophila during the organ differentiation for example-inplace of wing, long legs are formed. Which gene is responsible for - [AIPMT-2000]
 (1) Double dominant gene
 (2) Homeotic gene
 (3) Complimentary gene
 (4) Plastid
- Q.57** Mendel obtained wrinkled seeds in pea due to deposition of sugars instead of starch. It was due to which enzyme - [AIPMT-2001]
 (1) Amylase (2) Invertase
 (3) Diastase
 (4) Absence of starch branching enzyme
- Q.58** A gene said to be dominant if - [AIPMT-2002]
 (1) It express its effect only in homozygous stage
 (2) It expressed only in heterozygous condition
 (3) It expressed both in homozygous and heterozygous condition
 (4) It never expressed in any condition

- Q.59** A plant of F_1 generation with genotype "AABbCC" On selfing of this plant what is the phenotypic ratio in F_2 -generation- [AIPMT-2002]
 (1) 3 : 1
 (2) 1 : 1
 (3) 9 : 3 : 3 : 1
 (4) 27 : 9 : 9 : 9 : 3 : 3 : 3 : 1
- Q.60** Which one of the following traits of garden pea studied by Mendel, was a recessive feature - [AIPMT-2003]
 (1) Axial flower position
 (2) Green seed colour
 (3) Green pod colour
 (4) Round seed shape
- Q.61** In a plant, red fruit (R) is dominant over yellow fruit (r) and tallness (T) is dominant over shortness (t). If a plant with RRTt genotype is crossed with a plant that is rrrt - [AIPMT-2004]
 (1) All the offsprings will be tall with red fruit
 (2) 25% will be tall with red fruit
 (3) 50% will be tall with red fruit
 (4) 75% will be tall with red fruit
- Q.62** When a red flower homozygous pea plant is crossed with a white flower plant what colour is produced in F_1 - [RPMT-87]
 (1) Red (2) White
 (3) Pink (4) Red + white
- Q.63** How many different types of gametes can be formed by F_1 progeny, resulting from the following cross, : AA BB CC x aa bb cc - [AIIMS-2004]
 (1) 3 (2) 8
 (3) 27 (4) 64
- Q.64** In order to find out the different types of gametes produced by a pea plant having the genotype AaBb, it should be crossed to a plant with the genotype - [AIPMT-2005]
 (1) AaBb (2) aabb
 (3) AABB (4) aaBB

- Q.65** Gene word was coined by - **[RPMT-2005]**
 (1) mendel (2) Hugo-de-vires
 (3) Morgan (4) Johanson
- Q.66** Discoverer of incomplete dominance - **[RPMT-2005]**
 (1) Von Tschermak (2) Carl correns
 (3) Hugo-de-vries (4) None of the above
- Q.67** Test cross is - **[RPMT-2005]**
 (1) $Tt \times Tt$ (2) $Tt \times TT$
 (3) $TT \times TT$ (4) $Tt \times tt$
- Q.68** Law of independent assortment of mendel was proved by - **[RPMT-2005]**
 (1) Monohybrid cross
 (2) Test cross
 (3) Dihybrid (4) Back cross
- Q.69** Mendel does not select which character in his experiment - **[RPMT-2005]**
 (1) Plant height (2) Plant colour
 (3) Pod shape (4) Pod colour
- Q.70** In *Mirabilis* & *Antirrhinum* plant the appearance of the pink hybrid (Rr) between cross of a red (RR) and white (rr) flower parent indicates - **[RPMT-88-89-90]**
 (1) Incomplete dominance
 (2) Segregation
 (3) Dominance (4) Heterosis
- Q.71** Exception to mendel's law is found in flower colour of - **[RPMT-96]**
 (1) *Mirabilis* (2) Sweet-pea
 (3) Garden-pea (4) Beans
- Q.72** RR (red) is crossed with ww (white). All Rw off springs are pink. This indicates that R -gene is - **[CPMT-76-81-85]**
 (1) Hybrid
 (2) Incompletely dominant
 (3) Recessive
 (4) Mutant
- Q.73** In case of incomplete dominance the monohybrid ratio of phenotype in F_2 generation is - **[RPMT-85]**
 (1) 1:2:1 (2) 3:1:1
 (3) 9:3:3:1 (4) 2:3:1

- Q.74** A white flowered *mirabilis* plant rr was crossed with red coloured RR , If 120 plants are produced in F_2 generation. the result would be- **[RPMT-96]**
 (1) 90 uniformly coloured & 30 white
 (2) 90 Non-uniformly coloured (Pink) & 30 white
 (3) 60 Non-uniformly coloured (Pink) & 60 white
 (4) All coloured & No white
- Q.75** When the phenotypic and genotypic ratios resemble in the F_2 generation it is an example of - **[RPMT & DPMT-85]**
 (1) Independent assortment
 (2) Qualitative inheritance
 (3) Segregation of factors
 (4) Incomplete dominance
- Q.76** Which one carries extra nuclear genetic material - **[BHU-87]**
 (1) Plastids (2) Ribosomes
 (3) Chromosomes (4) Golgi-complex
- Q.77** When certain character is inherited only through the female parent, it probably represents the case of - **[AIPMT-92]**
 (1) Mendelian nuclear inheritance
 (2) Multiple plastid inheritance
 (3) Cytoplasmic inheritance
 (4) Incomplete dominance
- Q.78** Cytoplasmic male sterility is inherited - **[MP-PMT-86]**
 (1) Maternally
 (2) Paternally
 (3) Both
 (4) Bacteriophage multiplication
- Q.79** Mendel did not include in his laws - **[RPMT-90]**
 (1) Segregation (2) Dominance
 (3) Purity of gametes (4) Linkage
- Q.80** If mendel has chosen to study traits determined by linked genes he would not have discovered- **[AIIMS-87]**
 (1) Law of segregation
 (2) Law of dominance
 (3) Law of independent assortment
 (4) Law of unit character

Q.81 Which law would have been violated if Mendel has chosen eight characters in garden pea -
[RPMT-90, AIPMT-90-96]

- (1) Law of dominance
- (2) Law of segregation
- (3) Principle of independent assortment
- (4) Law of purity of gametes

Q.82 Mendel had a difficulty in explaining the linked character due to - [AIPMT-90]

- (1) Law of dominance
- (2) Law of segregation
- (3) Law of independent assortment
- (4) All the above

Q.83 In *Mirabilis jalapa* when homozygous red flowered and white flowered plants are crossed, all F_1 plants have pink coloured flowers. In F_2 produced by selfing of F_1 plants, red, pink, white flowered plants would appear respectively in the ratio of - [MP PMT-98]

- (1) 1:1:2
- (2) 2:1:1
- (3) 1:0:1
- (4) 1:2:1

Q.84 The main aim of plant breeding is - [MP PMT-98]

- (1) To produce improved varieties
- (2) To make soil fertile
- (3) To control pollution
- (4) To become more progressive

Q.85 Plants having similar genotypes produced by plant breeding are called - [MP PMT-98]

- (1) Clone
- (2) Haploid
- (3) Autopolyploid
- (4) Genome

Q.86 If Mendel might have studied 7 pairs of characters in a plant with 12 chromosomes instead of 14, then - [AIPMT-98]

- (1) He could not discover independent assortment
- (2) He might have not discovered linkage
- (3) He might have discovered crossing-over
- (4) He might have not observed dominance

Q.87 Plant, which does not obey Mendel's laws - [RPMT-96]

- (1) *Mirabilis jalapa*
- (2) *Pisum sativum*
- (3) *Cicer auriethinum*
- (4) *Lycopersicon esculentum*

Q.88 The first attempt to show linkage in plants was done - [BHU-84]

- (1) *Pisum sativum*
- (2) *Lathyrus odoratus*
- (3) *Zea mays*
- (4) *Oenothera lamarckiana*

Q.89 In case of incomplete dominance, F_2 generation has - [BHU-95]

- (1) Genotypic ratio equal to phenotypic ratio
- (2) Genotypic ratio is 3:1
- (3) Phenotypic ratio is 3:1
- (4) None

Q.90 Genes controlling seven traits in pea studied by Mendel were actually located on - [BHU-94]

- (1) Seven chromosomes
- (2) Six chromosomes
- (3) Four chromosomes
- (4) Five chromosomes

Q.91 Hybridoma is - [AIPMT-1999]

- (1) Collection of DNA from DNA
- (2) Collection of RNA from DNA
- (3) A fusion of tumour sex cell with non tumour sex cell
- (4) A fusion of tumour somatic cell with non tumour somatic cell

Q.92 When dominant and recessive alleles express themselves together it is called - [AIPMT-2001]

- (1) Co-dominance
- (2) Dominance
- (3) Amphidominance
- (4) Pseudo dominance

Q.93 Extrachromosomal inheritance occurs in - [AIPMT-2001]

- (1) Killer paramecium
- (2) Killer Amoeba
- (3) Euglena
- (4) Hydra

Q.94 Nucleus of a donor embryonal cell/somatic cell is transferred to an enucleated egg cell. Then after the formation of organism, what shall be true : [AIPMT-2002]

- (1) Organism will have extranuclear genes of the donor cell.
- (2) Organism will have extra nuclear genes of recipient cell.
- (3) Organism will have extra nuclear genes of both donor and recipient cell.
- (4) Organism will have nuclear genes of recipient cell.

Q.95 Genes for cytoplasmic male sterility in plants are generally located in - **[AIPMT-2003]**

- (1) Chloroplast genome
- (2) Mitochondrial genome
- (3) Nuclear genome
- (4) Cytosol

Q.96 Two crosses between the same pair of genotypes or phenotypes in which the source of the gametes are reversed in one cross, is known as - **[AIPMT-2003]**

- (1) Test cross
- (2) Reciprocal cross
- (3) Dihybrid cross
- (4) Reverse cross

Q.97 The genes controlling the seven pea characters studied by Mendel are known to be located on how many different chromosomes -

[AIPMT-2003]

- (1) Seven
- (2) Six
- (3) Five
- (4) Four

Q.98 Extranuclear inheritance is a consequence of presence of genes in - **[AIPMT-2004]**

- (1) Lysosomes and ribosomes
- (2) Mitochondria and chloroplasts
- (3) Endoplasmic reticulum and mitochondria
- (4) Ribosomes and chloroplast

Q.99 Mendel observed the certain characters did not assort independently. Later researches, found it to be due to - **[MP PMT-98]**

- (1) Amitosis
- (2) Linkage
- (3) Dominance
- (4) Crossing over

Q.100 The phenomenon of incomplete dominance was observed by -

- (1) De vries
- (2) Correns
- (3) Tschermak
- (4) None

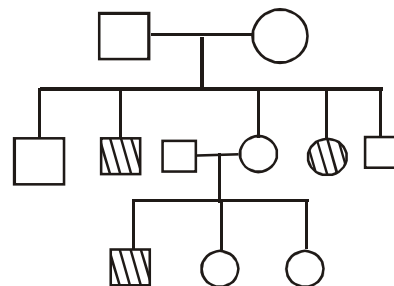
Q.101 Genes for cytoplasmic male sterility in plants are generally located in - **[AIPMT-2005]**

- (1) Nuclear genome
- (2) Chloroplast genome
- (3) Cytosol
- (4) Mitochondrial genome

Q.102 Sickle cell anemia is - **[AIPMT-2009]**

- (1) Characterized by elongated sickle like RBCs with a nucleus
- (2) An autosomal linked dominant trait
- (3) Caused by substitution of valine by glutamic acid in the beta globin chain of haemoglobin
- (4) Caused by a change in a single base pair of DNA

Q.103 Study the pedigree chart given below -



What does it show - **[AIPMT-2009]**

- (1) Inheritance of a recessive sex-linked disease like haemophilia
- (2) Inheritance of a sex-linked inborn error of metabolism like phenylketonuria
- (3) Inheritance of a condition like phenylketonuria as an autosomal recessive trait
- (4) The pedigree chart is wrong as this is not possible

Q.104 The most popularly known blood grouping is the ABO grouping. It is named ABO and not ABC, because "O" in it refers to having :

[AIPMT-2009]

- (1) No antigens A and B on RBCs
- (2) Other antigens besides A and B on RBCs
- (3) Overdominance of this type on the genes for A and B types
- (4) One antibody only-either anti-A or anti-B on the RBCs

Q.105 Select the incorrect statement from the following - **[AIPMT-2009]**

- (1) Baldness is a sex-limited trait
- (2) Linkage is an exception to the principle of independent assortment in heredity
- (3) Galactosemia is an inborn error of metabolism
- (4) Small population size result in random genetic drift in a population

Q.106 Which one of the following is commonly used in transfer of foreign DNA into crop plants ?
[AIPMT-2009]

- (1) *Penicillium expansum*
- (2) *Trichoderma harzianum*
- (3) *Meloidogyne incognita*
- (4) *Agrobacterium tumefaciens*

Q.107 The bacterium *Bacillus thuringiensis* is widely used in contemporary biology as -
[AIPMT-2009]

- (1) Source of industrial enzyme
- (2) Indicator of water pollution
- (3) Insecticide
- (4) Agent for production of dairy products

Q.108 Polyethylene glycol method is used for -
[AIPMT-2009]

- (1) Energy production from sewage
- (2) Gene transfer without a vector
- (3) Biodiesel production
- (4) Seedless fruit production

Q.109 Transgenic plants are the ones -
[AIPMT-2009]

- (1) Grown in artificial medium after hybridization in the field
- (2) Production by a somatic embryo in artificial medium
- (3) Generated by introducing foreign DNA into a cell and regenerating a plant from that cell
- (4) Produced after protoplast fusion in artificial medium

Q.110 What is true about Bt toxin?[AIPMT-2009]

- (1) The concerned *Bacillus* has antitoxins
- (2) The inactive protoxin gets converted into active form in the insect gut
- (3) Bt protein exists as active toxin in the *Bacillus*
- (4) The activated toxin enters the ovaries of the pest to sterilise it and thus prevent its multiplication

Q.111 The genetic defect-adenosine deaminase (ADA) deficiency may be cured permanently by -
[AIPMT-2009]

- (1) Enzyme replacement therapy
- (2) Periodic infusion of genetically engineered lymphocytes having functional ADA cDNA
- (3) Administering adenosine activators
- (4) Introducing bone marrow cells producing ADA into cells at early embryonic stage

Q.112 Epistasis was discovered by - [AIPMT-90]
(1) Johanson (2) Shull
(3) Bateson (4) Mendel

Q.113 A normal woman whose father was albino, marries an albino man. what proportion of normal and albino are expected among their off springs -
[AIPMT-94]
(1) All normal
(2) 2 normal : 1 Albino
(3) All albino
(4) 1 normal : 1 Albino

Q.114 What is the inheritance of colour blindness of both parents having a normal vision but mother has a recessive gene for colour blindness -
[AIPMT-90-96]

Son	Daughter
(1) 50%	Nil
(2) 100%	Nil
(3) Nil	100%
(4) Nil	Nil

Q.115 What would be the nature of children if a colour blind woman marries a normal man-
[AIPMT-95]

- (1) Colourblind daughter & normal sons
- (2) Colourblind sons and carrier daughters
- (3) Normal sons & carrier daughters
- (4) Normal sons & Normal daughters

Q.116 A colourblind man marries a normal lady whose father was colour blind. If it produces two sons & two daughters. how many of them would be suffer - [AIIMS-85,AFMS-88]
(1) Both sons
(2) Both daughters
(3) One son & one daughter
(4) Both sons & both daughters

Q.117 Inheritance of skin colour in human beings is an example of - **[BHU-80]**

- (1) Complementary gene
- (2) Monogenic inheritance
- (3) Polygenic inheritance
- (4) Mendelian inheritance

Q.118 The phenomenon in which an allele of one gene suppresses the expression of an allele of another gene is known as - **[AIPMT-95]**

- (1) Dominance
- (2) Inactivation
- (3) Epistasis
- (4) Suppression

Q.119 When two independently assorting dominant genes interact with each other to produce particular phenotype but when they present alone they did not produce phenotype they are called - **[AIPMT-96]**

- (1) Complementary gene
- (2) Supplementary gene
- (3) Duplicate gene
- (4) Inhibitory gene

Q.120 Polygenic genes show - **[AIPMT-96]**

- (1) Identical phenotype
- (2) Identical biochemistry
- (3) Different phenotype
- (4) Identical genotype

Q.121 AB-Blood group shows - **[AIPMT-89]**

- (1) Co-dominance
- (2) Complete dominance
- (3) Mixed inheritance
- (4) Composite inheritance

Q.122 ABO blood group is an example of - **[AIPMT-90]**

- (1) Epistasis
- (2) Multiple allelism
- (3) Pleiotropism
- (4) Complementary genes

Q.123 A child is blood group is 'O' His parents blood group can not be - **[AIPMT-94]**

- (1) B & O
- (2) A & O
- (3) AB
- (4) A & B

Q.124 If selfing occurs in the plant having genotype RrYy, then ratio of given genotype will be-RRYY. RrYY. RRYy. RrYy **[RPMT-2006]**

- (1) 1 : 2 : 2 : 4
- (2) 1 : 2 : 2 : 1
- (3) 1 : 1 : 1 : 1
- (4) 2 : 2 : 2 : 1

Q.125 If one parent has blood group A and the other parent has blood group B. The offspring have which blood group - **[MP PMT-98]**

- (1) AB
- (2) O
- (3) BO
- (4) A, B, AB, O

Q.126 A colourblind daughter is born when - **[MP PMT-98]**

- (1) Father is colourblind, mother is normal
- (2) Mother is colourblind, father is normal
- (3) Mother is carrier, father is normal
- (4) Mother is carrier, father is colourblind

Q.127 The process of mating between closely related individuals is - **[AIPMT-94]**

- (1) Out-breeding
- (2) Inbreeding
- (3) Hybridisation
- (4) Heterosis

Q.128 Ratio 9:7 is due to - **[AMU-93]**

- (1) Supplementary genes
- (2) Lethal genes
- (3) complementary genes
- (4) Epistatic genes

Q.129 A man of A blood group marries a woman of AB blood group. which type of progeny would indicate that man is heterozygous A - **[AIPMT-93]**

- (1) AB
- (2) A
- (3) O
- (4) B

Q.130 A child of O blood group. has B-blood group father, the genotype of father would be - **[AIPMT-92]**

- (1) I^0I^0
- (2) I^BI^B
- (3) I^AI^B
- (4) I^BI^0

Q.131 Marriages between close relatives should be avoided because it includes more - **[MP PMT-90]**

- (1) Recessive alleles to come together
- (2) Mutations
- (3) Multiple births
- (4) Blood group abnormalities

Q.132 What ratio is expected in off springs if father is colour blind and mother's father was colour blind - **[AIPMT-1999]**

- (1) 50% daughter - colour blind
- (2) All the sons are colour blind
- (3) All the daughters colour blind
- (4) All the sons are normal

Q.133 Independent assortment of genes does not take place when - **[AIPMT-2001]**

- (1) Genes are located on homologous chromosomes
- (2) Genes are linked and located on same chromosome
- (3) Genes are located on non-homologous chromosome
- (4) All the above

Q.134 What is true for monoclonal antibodies - **[AIPMT-2001]**

- (1) These antibodies obtained from one parent and for one antigen
- (2) These obtained from different parents and for one antigen
- (3) These obtained from one parents and for many antigen
- (4) These obtained from many parents and for many antigen

Q.135 Ratio of complementary genes is - **[AIPMT-2001]**

- (1) 9 : 3 : 4 (2) 12 : 3 : 1
- (3) 9 : 3 : 3 : 4 (4) 9 : 7

Q.136 A and B genes are linked. What shall be genotype of progeny in a cross bet. AB/ab and ab/ab - **[AIPMT-2001]**

- (1) AAbb and aabb (2) AaBb and aabb
- (3) AABb and aabb (4) None

Q.137 Two nonallelic genes produces the new phenotype when present together but fail to do so independently then it is called - **[AIPMT-2001]**

- (1) Epistasis
- (2) Polygen
- (3) Non complementary gene
- (4) Complimentary gene

Q.138 Male XX and female XY sometime occur due to - **[AIPMT-2001]**

- (1) Deletion
- (2) Transfer of segments in X and Y chromosomes
- (3) Aneuploidy
- (4) Hormonal imbalance

Q.139 Which of the following is the example of pleiotropic gene - **[AIPMT-2002]**

- (1) Haemophilia
- (2) Thalassemia
- (3) Sickle cell anaemia
- (4) Colour blindness

Q.140 There are three genes a,b,c percentage of crossing over between a and b is 20% b and c is 28% and a and c is 8% What is the sequence of genes on chromosome - **[AIPMT-2002]**

- (1) b, a c (2) a, b, c
- (3) a, c, b (4) None

Q.141 The linkage map of X-chromosome of fruitfly has 66 units, with yellow body gene (y) at one end and bodied hair (b) gene at the other end. The recombination frequency between these two genes (y and b) should be- **[AIPMT-2003]**

- (1) 60% (2) > 50%
- (3) ≤ 50% (4) 100%

Q.142 Pattern baldness, moustaches and beard in human males are examples of - **[AIPMT-2003]**

- (1) Sex linked traits
- (2) Sex limited traits
- (3) Sex differentiating traits
- (4) Sex-determining

Q.143 When a cluster of genes show linkage behaviour they - **[AIPMT-2003]**

- (1) Do not show a chromosome map
- (2) Show recombination during meiosis
- (3) Do not show independent assortment
- (4) Induce cell division

Q.144 Genetic Map is one that - [AIPMT-2003]

- (1) Establishes sites of the genes on a chromosome
- (2) Establishes the various stage in gene evolution
- (3) Shows the stage during the cell division
- (4) Shows the distribution of various species in a region

Q.145 One of the genes present exclusively on the X-chromosome in humans is concerned with- [AIPMT-2003]

- (1) Baldness
- (2) Red green colour blindness
- (3) Facial hair/Moustaches in males.
- (4) Night blindness

Q.146 The recessive genes located on X-chromosome in humans are always - [AIPMT-2004]

- (1) Expressed in females
- (2) Lethal
- (3) Sub-lethal
- (4) Expressed in males

Q.147 Lack of independent assortment of two genes A and B in fruit fly **Drosophila** is due to - [AIPMT-2004]

- (1) Crossing over (2) Repulsion
- (3) Recombination (4) Linkage

Q.148 A normal woman, whose father was colour-blind is married to a normal man. The sons would be - [AIPMT-2004]

- (1) All colour-blind (2) 75% colour-blind
- (3) 50% colour-blind (4) All normal

Q.149 In tomato, genotype aabbcc produces 100g tomatoes and AABBCc produces 160g tomatoes. What is contribution of each polygene in the production of tomatoes -

- (1) 10 g (2) 20 g
- (3) 30 g (4) 40 g

Q.150 If father shows normal genotype and mother shows a carrier trait for haemophilia - [OLYMPIAD-2004]

- (1) All the female children will be carrier
- (2) A male child has 50% chances of active disease
- (3) Female child has probability of 50% to active disease
- (4) All the female children will be colourblind

Q.151 In a genetic cross having recessive epistasis, F_2 phenotypic ratio would be - [AIPMT-90]

- (1) 9 : 6 : 1 (2) 15 : 1
- (3) 9 : 3 : 4 (4) 12 : 3 : 1

Q.152 Which of the following is not a hereditary disease - [AIPMT-2005]

- (1) Haemophilia (2) Cretinism
- (3) Cystic fibrosis (4) Thalassaemia

Q.153 A woman with normal vision, but whose father was colour blind, marries a colour blind man. Suppose that the fourth child of his couple was a boy. This boy - [AIPMT-2005]

- (1) Must have normal colour vision
- (2) May be colour blind or may be normal vision
- (3) Will be partially colour blind since he is heterozygous for the colour blind mutant allele
- (4) Must be colour blind

Q.154 Haemophilia is more commonly seen in human males than in human females because- [AIPMT-2005]

- (1) This disease is due to a Y-linked recessive mutation
- (2) This disease is due to an X-linked recessive mutation
- (3) This disease is due to an X-linked dominant mutation
- (4) A greater proportion of girls die in infancy

Q.155 A man and a woman, who do not show any apparent signs of a certain inherited disease, have seven children (2 daughters and 5 sons). Three of the sons suffer from the given disease but none of the daughters are affected. Which of the following mode of inheritance do you suggest for this disease - [AIPMT-2005]

- (1) Sex-limited recessive
- (2) Autosomal dominant
- (3) Sex-linked recessive
- (4) Sex-linked dominant

Q.156 Grain colour in wheat is determined by three pairs of polygenes. Following cross AABBCC (dark colour) x aabbcc (light colour), in F_2 generation what proportion of the progeny is likely to resemble either parent ?

[AIIMS-2005]

- (1) None (2) Less than 5 percent
(3) One third (4) Half

Q.157 The genotype of a plant showing the dominant phenotype can be determined by –

[CPMT - 2010]

- (1) Test cross (2) Dihybrid cross
(3) Pedigree analysis (4) Back cross

Q.158 ABO blood groups in humans are controlled by the gene I. It has three alleles – I^A , I^B and i . Since there are three different alleles, six different genotypes are possible. How many phenotypes can occur –

[CPMT - 2010]

- (1) Three (2) One
(3) Four (4) Two

Q.159 Select the correct statement from the ones given below with respect to dihybrid cross –

[CPMT - 2010]

- (1) Tightly linked genes on the same chromosome show higher recombinations
(2) Genes far apart on the same chromosome show very few recombinations
(3) Genes loosely linked on the same chromosome show similar recombinations as the tightly linked ones
(4) Tightly linked genes on the same chromosome show very few recombination

Q.160 Which one of the following palindromic base sequences in DNA can be easily cut at about the middle by some particular restriction enzyme?

[CPMT - 2010]

- (1) 5' ____ CG TTCG ____ 3'
3' ____ ATGGTA ____ 5'
(2) 5' ____ GATATG ____ 3'
3' ____ CTACTA ____ 5'
(3) 5' ____ GAATTC ____ 3'
3' ____ CTTAAG ____ 5'
(4) 5' ____ CACGTA ____ 3'
3' ____ CTCAGT ____ 5'

Q.161 Hybrid breakdown is failure of

[AFMC 1997]

- (1) Hybrid zygote to develop into offspring
(2) Hybrid adult to produce fertile offspring
(3) Fusion failure of ova and sperms of two species
(4) All the above

Q.162 Hexaploid wheat developed through

[AIIMS 1997]

- (1) Hybridomas
(2) Chromosome doubling
(3) Hybridisation
(4) Hybridisation and chromosome doubling

Q.163 Genetic drift in mendelian population takes place in-

[CPMT 1998]

- (1) Small population (2) Large population
(3) Oceanic population (4) Never occurs

Q.164 Industrial melanism is example of

[CPMT 1999]

- (1) Natural selection (2) Mutation
(3) Racial difference (4) Predation

Q.165 Frequency of an allele in an isolated population may change due to

[CPMT 2001]

- (1) Genetic drift (2) Gene flow
(3) Mutation (4) Natural selection

Q.166 In Lederberg's replica plating experiment what shall be used to obtain streptomycin resistant strain:

[CPMT 2001]

- (1) Minimal medium and streptomycin
(2) Complete medium and streptomycin
(3) Only minimal medium
(4) Only complete medium

Q.167 Forecoming generations are less adaptive than their parental generation due to-

[CPMT 2001]

- (1) Natural selection (2) Mutation
(3) Genetic drift (4) Adaptation

Q.168 Some bacteria are able to grow in Streptomycin containing medium due to

[CPMT 2002]

- (1) Natural selection
(2) Induced mutation
(3) Reproductive isolation
(4) Genetic drift

Q.169 Genetic drift operates in-

[CPMT 2002]

- (1) Small isolated population
(2) Large isolated population
(3) Fast reproductive population
(4) Slow reproductive population

Q.170 Sequence of which of the following is used to know the phylogeny- **[CPMT 2002]**

- (1) m-RNA (2) r-RNA
(3) t-RNA (4) DNA

Q.171 Random genetic drift in a population probably results from:- **[CPMT 2003]**

- (1) Highly genetically variable individuals
(2) Interbreeding within this population
(3) Constant low mutation rate
(4) Large population size

Q.172 Industrial melanism is an example of- **[CPMT 2003]**

- (1) Drug resistance
(2) Darkening of skin due to smoke from industries
(3) Protective resemblance with the surroundings
(4) Defensive adaptation of skin against ultraviolet radiations

Q.173 A class of mutation induced by addition or deletion of a nucleotide is called - **[AMU 2002]**

- (1) Missense (2) Non-sense
(3) Substitution (4) Frame shift

Q.174 The number of chromosomes present in the cells of the bread wheat (*Triticum aestivum*) suggests that it is - **[AMU 2003]**

- (1) Hexaploid (2) Diploid
(3) Tetraploid (4) Pentaploid

Q.175 A gene mutation which does not result in phenotypic expression is termed - **[AMU 2004]**

- (1) Nonsense mutation
(2) Silent mutation
(3) Missense mutation
(4) Frame shift mutation

Q.176 Breeding is possible between two members of - **[AMU 2005]**

- (1) Genus (2) Family
(3) Order (4) Species

Q.177 In which one of the following combinations (1-4) of the number of chromosomes is the present day hexaploid wheat correctly represented **[AIIMS 2006]**

Combination	(1)	(2)	(3)	(4)
Monosomic	21	7	21	41
Haploid	28	28	7	21
Nullisomic	42	40	42	40
Trisomic	43	42	43	43

Q.178 Which of the following may be true for RNA- **[RPMT - 96]**

- (1) $A = U \neq G = C$
(2) $A \neq U \neq G \neq C$
(3) $A = U = G = C$
(4) Purines = Pyrimidines

Q.179 The enzyme which can cut molecules of DNA into segments is known as - **[MP PMT-94]**

- (1) DNA Polymerase (2) DNA Ligase
(3) Restriction enzyme (4) DNA Gyrase

Q.180 The genes concerned with the production of cancer are called - **[MP PMT-95]**

- (1) Cancer genes (2) Carcino genes
(3) Carcinomas (4) Onco genes

Q.181 Quantity of nucleic acids in animal cells is - **[RPMT - 95]**

- (1) 2% (2) 5%
(3) 10% (4) 15%

Q.182 Nucleic acids are made up of - **[RPMT - 95]**

- (1) Amino acids (2) Pentose sugars
(3) Nucleosides (4) Nucleotide

Q.183 Nucleic acids are polymers of - **[RPMT - 94, 85 AIPMT 78, 81]**

- (1) Nucleotides (2) Nucleosides
(3) Amino acids (4) Nitrogen bases

Q.184 Who proved DNA as genetic material- **[RPMT - 94]**

- (1) Griffith (2) Bacteria
(3) PPLO (4) Hershey and Chase

Q.185 Circular and double stranded DNA occurs in **[RPMT - 94]**

- (1) Golgi body (2) Mitochondria
(3) Nucleus (4) Cytoplasm

Q.186 If there are 10,000 base pairs in DNA, then its length - **[RPMT - 94]**

- (1) 340 nm (2) 3400 nm
(3) 34000 nm (4) 340000 nm

Q.187 Code in RNA corresponding to AGCT in DNA- **[RPMT - 94]**

- (1) TACA (2) UCGA
(3) TCGA (4) AGUC

Q.188 Double helix model of DNA which was proposed by Watson and crick was of -

[RPMT - 93]

- (1) C-DNA (2) B-DNA
(3) D-DNA (4) Z-DNA

Q.189 Mitochondrial DNA is - [RPMT - 93]

- (1) Naked (2) Circular
(3) Double stranded (4) All the above

Q.190 If there are 10,000 nitrogenous base pairs in a DNA then how many nucleotides are there -

[RPMT - 93]

- (1) 500 (2) 10,000
(3) 20,000 (4) 40,000

Q.191 The process of m RNA sythesis on a DNA is known as - [RPMT - 92]

- (1) Translation (2) Transcription
(3) Transduction (4) ransformation

Q.192 Double helix model of DNA is proposed by - [RPMT - 92, DEIHI PMT' 92]

- (1) Watson and Crick
(2) Schleiden and schwann
(3) Singer and Nicholson
(4) Kornberg and Khurana

Q.193 Which of the following nitrogen base is not found in DNA - [AIPMT 8; RPMT - 92]

- (1) Thymine (2) Cytosine
(3) Guanine (4) Uracil

Q.194 Back bone of structure of DNA molecule is made up of - [RPMT - 91]

- (1) Pentose Sugar and phosphate
(2) Hexose sugar and phosphate
(3) Purine and pyrimidine
(4) Sugar and phosphate

Q.195 Which of the following is called adaptor molecule - [RPMT - 91]

- (1) DNA (2) m-RNA
(3) t-RNA (4) RNA

Q.196 Substance common in DNA and RNA - [RPMT - 90]

- (1) Hexose Sugar (2) Histamine
(3) Thymine (4) Phosphate groups

Q.197 Which of following base pair is wrong -

[RPMT - 88]

- (1) A-T (2) G-C
(3) A-C (4) A-U

Q.198 Which may be attached with Adenine base in RNA - [RPMT - 88]

- (1) Guanine (2) Cytosine
(3) Uracil (4) Thymine

Q.199 Nucleotide is - [RPMT - 88]

- (1) N₂-base, pentose sugar and phosphoric acid
(2) Nitrogen, Hexose sugar and phosphoric acid
(3) Nitrogen base, pentose sugar
(4) Nitrogen base, trioses and phosphoric acid

Q.200 DNA differs from RNA in - [RPMT - 88]

- (1) Only Sugar
(2) Nitrogen base only
(3) Nitrogen base and sugar
(4) None

Q.201 Who propounded the theory one gene one enzyme one chemical reaction- [BHU - 82'83]

- (1) Watson & Crick
(2) George Beadle and Edward Tatum
(3) Abraham Trembley
(4) T.H. Morgan

Q.202 A codon in m-RNA has - [BHU - 83]

- (1) 3-bases
(2) 2-bases
(3) 1- base
(4) Number of bases vary

Q.203 Unit of nucleic acids are - [NCERT - 76]

- (1) Phosphoric acid
(2) Nitrogenous bases
(3) Pentose Sugar
(4) Nucleotide

Q.204 Which element is not found in nitrogenous base- [NCERT - 76]

- (1) Nitrogen (2) Hydrogen
(3) Carbon (4) Phosphorus

Q.205 The link between successive generation is provided by - [AIPMT - 81,84]

- (1) Nucleus (2) Cytoplasm
(3) Chromosomes (4) Nucleic acid

Q.206 DNA was first discovered by -
[AIPMT - 76, 85]

- (1) Meischer (2) Robert Brown
(3) Flemming (4) Watson & Crick

Q.207 Nucleic acids are found in - [AIPMT - 80]

- (1) Nucleus
(2) Cytoplasm
(3) Both nucleus & Cytoplasm
(4) Nucleus & ribosome

Q.208 DNA is found in -
[AIPMT' 78, 80, MP. PMT - 86]

- (1) ER & Ribosomes
(2) Mitochondria, Plastid & nucleolus
(3) Sphersome & Peroxysome
(4) Plasma membrane & lysosome

Q.209 Nucleic acids are found in -
[RPMT' 90, MP. PMT - 90]

- (1) Nucleus & nucleolus
(2) Spherosome & Plastid
(3) Mitochondria & plastid
(4) Chloroplast & Nucleosome

Q.210 The contribution of cytoplasmic DNA in the total DNA of a cell - [DELHI PMT - 86]

- (1) 90-99% (2) 65-75%
(3) 5-15% (4) 1-5%

Q.211 DNA is not present in -
[DELHI PMT '83, RPMT' 89]

- (1) Mitochondria (2) Chloroplast
(3) Bacteriophage (4) TMV

Q.212 A nucleic acid contains thymine or methylated uracil then it should be - [BHU' 81]

- (1) DNA
(2) RNA
(3) Either DNA or RNA
(4) RNA of bacteria

Q.213 Prokaryotic genetic system contains -
[RPMT' 85]

- (1) DNA & histones
(2) RNA & histones
(3) Either DNA or histones
(4) DNA but no histones

Q.214 DNA histone complex can be removed from chromosome by treatment with - [JIPMER -85]

- (1) 6 M NaCl + Mg [OH]₂
(2) 1 M , NaCl
(3) Mg [OH]₂
(4) Non-Separable

Q.215 Genetic information is carried by the long chain molecules which are made up of-
[BANGALORE PMT' 85]

- (1) Amino acids (2) Nucleotides
(3) Chromosomes (4) Enzymes

Q.216 A N₂-base together with pentose sugar and phosphate forms (or) building-block unit of nucleic acid is -

[MPPMT' 85; ALIGARH PMT' 86]

- (1) Nucleoside (2) Polypeptide
(3) Nucleotide (4) Aminoacid

Q.217 One of the characteristics of DNA is -
[DELHI PMT' 84]

- (1) Uracil (2) Deoxyribose sugar
(3) Single strandedness
(4) Ability of protein synthesis

Q.218 What replaces thymine in RNA -
[AIPMT' 81, ALLMS' 82, BHU' 85]

- (1) Guanine (2) Adenine
(3) Uracil (4) Water

Q.219 Purine bases of DNA are -
[AIPMT' 83, 89, RPMT' 92]

- (1) U & G (2) A & G
(3) A & C (4) None

Q.220 Which of the following N₂ bases are pyrimidines
[RPMT' 89]

- (1) T & C (2) T & A
(3) A & C (4) G & T

Q.221 Which of the following is not a pyrimidine N₂ base -
[JIPMER' 85]

- (1) Thymine (2) Cytosine
(3) Guanine (4) Uracil

Q.222 The base sequence of nucleic acid is AGG, GGA, CGA, CCA from this it can be inferred that it is a segment of - [RPMT' 90]

- (1) DNA (2) m-RNA
(3) t-RNA (4) Data insufficient

- Q.223** Kinds of N2 bases in nucleic acids are - **[AIPMT' 81, 84, 90]**
- (1) Three (2) Four
(3) Five (4) Eight
- Q.224** The purine & pyrimidine pairs of complementary strands of DNA are held together by - **[AIPMT' 80]**
- (1) H-bonds (2) Q-bonds
(3) C-bonds (4) N-bonds
- Q.225** Which purine & pyrimidine bases are paired together by H-bonds in DNA- **[BHU' 85]**
- (1) AC & GT (2) GC & AT
(3) GA & TC (4) None of the above
- Q.226** Watson & crick proposed the model of DNA structure in - **[AIPMT' 85]**
- (1) 1953 (2) 1943
(3) 1955 (4) 1963
- Q.227** A single stranded DNA is present in - **[AIPMT 80; ALLM'86, MPPMT'90]**
- (1) TMV (2) Salmonella
(3) Coliphage $\phi \times 174$ (4) Bacteria
- Q.228** What is the nature of the 2 strands of a DNA duplex - **[MPPMT'90]**
- (1) Identical & Complimentary
(2) Antiparallel & complimentary
(3) Dissimilar & non complimentary
(4) Antiparallel & none complimentary
- Q.229** DNA Replication occurs at - **[RPMT' 85; MP PMT'85]**
- (1) Go & G-1 (2) G2 -stage
(3) S-Stage (4) Mitotic phase
- Q.230** RNA synthesis is controlled by - **[AIPMT-89]**
- (1) Rho-factor (2) Sigma factor
(3) Endo-nuclease (4) RNA-polymerase
- Q.231** Duplication of DNA is called - **[AFMC;82, 84]**
- (1) Replication (2) Transduction
(3) Transcription (4) Translation
- Q.232** DNA polymerase enzyme is required for the synthesis of - **[BHU 87]**
- (1) DNA From DNA (2) DNA from RNA
(3) Both the above
(4) DNA from nucleosides

- Q.233** Ligase enzyme is used for - **[BHU' 85]**
- (1) Denaturation of DNA
(2) Splitting DNA into small bits
(3) Joining bits of DNA
(4) Digestion of lipids
- Q.234** In the base sequence of one strand of DNA is GAT, TAG, CAT, GAC what shall be the sequence of its complementary stand - **[AIMPT-90; MP PMT'90]**
- (1) CAT, CTG, ATC, GTA
(2) GTA, ATC, CTG, GTA
(3) ATC, GTA, CTG, GTA
(4) CTA, ATC, GTA, CTG
- Q.235** In the base sequence of one strand of DNA is CAT, TAG, CAT, CAT, GAC what would be the base sequence of its complementary m-RNA- **[AFMC' 82]**
- (1) GUA, GUA, CUG, AUC, CUG
(2) AUG, CUG, CUC, GUA, CUG
(3) GUA, AUC, GUA, GUA, CUG
(4) GUC, CUG, CUG CUA, CUU
- Q.236** A DNA strand is directly involved in the synthesis of all the following except - **[AIIMS' 81,85]**
- (1) Another DNA (2) t-RNA & m-RNA
(3) r-RNA (4) Protein
- Q.237** Strongest evidence that DNA is genetic material comes from - **[AIPMT 85; MP.PMT 84]**
- (1) Chromosomes contain DNA
(2) Transformation of bacterial cells
(3) DNA is present in nucleus
(4) DNA is not present in cytoplasm
- Q.238** Genetic code was discovered by - **[BHU 87]**
- (1) Nirenberg & Mathei
(2) Kornberg & Crick
(3) Khorana & Kornberg
(4) Gamow
- Q.239** Genetic code was deciphered by chemically synthesizing the trinucleotides by - **[MP PMT 90]**
- (1) Wastson & Crick (2) Beadle & Tatum
(3) Briggs & King (4) M.W. Nirenberg

Q.240 Nitrenberg synthesized an m-RNA containing 34 poly-Adenine (A-A-A-A-A-A.....) and found a polypeptide formed of 11 poly-lysine this proved that genetic code for lysine was -

[AIPMT-'90; RPMT'91]

- (1) one-adenine (2) A-A doublet
(3) A-A-A triplet (4) Many adenines

Q.241 64 Codons constitute genetic code because

[AIPMT 90]

- (1) There was 64 types of amino acid
(2) 64 types of t-RNA
(3) Genetic code is triplet
(4) There are 64 enzymes

Q.242 Degeneracy of genetic code was discovered by-

[BHU' 86]

- (1) Mc Clintock (2) Khorana
(3) Ochoa
(4) Baurfield & Nirenberg

Q.243 Genetic code consists of - [AIPMT' 88]

- (1) Adenine & Guanine
(2) Guanine & Cytosine
(3) Cytosine & uracil
(4) All

Q.244 Which codon gives signal for the start of polypeptide (protein) chain synthesis-

[AIIMS 86]

- (1) AUG (2) UGA
(3) GUA (4) UAG

Q.245 The function of non-sense codons is -

[AIIMS 85]

- (1) To release polypeptide chain from t-RNA
(2) To form an unspecified amino acid
(3) To terminate the message of a gene controlled protein synthesis -
(4) To convert a sense DNA into non sense DNA

Q.246 Termination of chain growth in protein synthesis is brought about by - [AIIMS' 83]

- (1) UUG, UGC, UCA (2) UCG, GCG, ACC
(3) UAA, UAG, UGA (4) UUG, UAG, UCG

Q.247 Genetic code determines - [AIPMT' 83]

- (1) Structural pattern of an organism
(2) Sequence of amino acid in protein chain
(3) Variation in offsprings
(4) constancy of morphological trait

Q.248 Which of the following is employed in recombinant DNA technology - [BHU' 87]

- (1) Plastids (2) Plasmids
(3) Ribosomes (4) Histones

Q.249 Fuelgen reaction is employed to establish the presence of -

[BHU' 83' AFMC'83' AIPMT'85]

- (1) DNA (2) RNA
(3) Protein (4) Lipids

Q.250 Chargaff 's' rule is given as - [RPMT 1998]

- (1) Purines Pyrimidines
(2) $A + G = T + C$
(3) $A + U = G + C$
(4) $A + T/G + C = \text{Constant}$

Q.251 In RNA, Nucleotides are bonded by -

[RPMT 1998]

- (1) H - bonds
(2) Phospo diester bonds
(3) Ionic bonds
(4) Salt linkage

Q.252 m-RNA is attached with - [RPMT 1997]

- (1) E.R. (2) Ribosome
(3) Nucleus (4) Lysosome

Q.253 DNA of E.COLI - [AIPMT 1998]

- (1) ds circular (2) ss circular
(3) ds linear (4) ss linear

Q.254 Knife of DNA is - [AIPMT 1998]

- (1) DNA ligase
(2) Restriction endonuclease
(3) Exonuclease (4) Peptidase

Q.255 Segments of DNA which can move in genome-

[AIPMT 1998]

- (1) Introns (2) Exons
(3) Transposons (4) Cistrons

Q.256 Transcription means synthesis of -

[MP PMT 1998]

- (1) DNA (2) Protein
(3) m-RNA (4) Enzyme

Q.257 A nucleoside differs from a nucleotide is not having - [MP PMT 1998]

- (1) Phosphate (2) Sugar
(3) Phosphate & sugar (4) Nitrogen base

Q.258 Wilkins X-ray diffraction showed the diameter of the DNA helix is - **[MP PMT 1998]**

- (1) 10 Å (2) 20 Å
(3) 30 Å (4) 40 Å

Q.259 DNA fingerprinting method is very useful for - **[MP PMT 1998]**

- (1) DNA tests for identity & relation ships
(2) Forensic studies
(3) Polymorphism
(4) All of the above

Q.260 A sequence of three consecutive bases in a t-RNA molecule which specifically binds to a complementary codon sequence in m- RNA is known as - **[MP PMT 1998]**

- (1) Triplet (2) Non - sense codon
(3) Anti codon (4) Termination codon

Q.261 Number of base pairs in human chromosomes - **[AIPMT -99]**

- (1) 3×10^9 (2) 3×10^7
(3) 6×10^8 (4) 6×10^7

Q.262 Gene composed of - **[AIPMT -99]**

- (1) Amino acids (2) Polynucleotide
(3) Fatty acid (4) Nitrogen bases

Q.263 Function of Nucleases - **[AIPMT - 99]**

- (1) Break the polynucleotide chain by breaking the each terminal nucleotide
(2) Breaks phosphodiester bond
(3) Breaks peptide bonds
(4) Breaks ester bonds

Q.264 Molecular wight of DNA in yeast is - **[AIPMT - 99]**

- (1) 2.56×10^9 (2) 0.5×10^9
(3) 7×10^7 (4) 6×10^6

Q.265 Similarity in DNA and RNA - **[AIPMT-2000]**

- (1) Both are polymer of nucleotides
(2) Both have similar pyrimidine
(3) Both have similar sugar
(4) Both are genetic material

Q.266 Length of one loop of B-DNA- **[AIPMT - 2000]**

- (1) 3.4 nm. (2) 0.34 nm.
(3) 20 nm. (4) 10 nm.

Q.267 ATP is - **[AIPMT - 2000]**

- (1) Nucleotide (2) Nucleoside
(3) Nucleic acid (4) Vitamin

Q.268 In three dimensional view the molecule of t-RNA is - **[AIPMT - 2000]**

- (1) L-shaped (2) S-shaped
(3) Y-shaped (4) E-shaped

Q.269 Which of the following is initiation codon - **[AIPMT - 2000]**

- (1) UAG (2) AUC
(3) AUG (4) CCU

Q.270 Method of DNA replication in which two strands of DNA separates and synthesize new strands- **[AIPMT - 2000]**

- (1) Dispersive (2) Conservative
(3) Semiconservative (4) Non conservative

Q.271 In which stage of cell cycle, DNA replication occurs- **[AIPMT - 2000]**

- (1) G1 - phase (2) S - phase
(3) G2 - phase (4) M - phase

Q.272 Extranuclear DNA is found in - **[AIPMT - 2000]**

- (1) Lysosome and chloroplast
(2) Chloroplast and mitochondria
(3) Mitochondria and lysosome
(4) Golgi body and E.R.

Q.273 Which one of the following triplet codes, is correctly matched with its specificity for an amino acid in protein synthesis or as start or stop codon - **[AIPMT - 2003]**

- (1) UCG - Start (2) UUU - Stop
(3) UGU - Leusine (4) UAC - Tyrosine

Q.274 During translation initiation in prokaryotes, a GTP molecule is needed in - **[AIPMT - 2003]**

- (1) Formation of formyl-met-tRNA
(2) Binding of 30 S subunit of ribosome with mRNA
(3) Association of 30 S-mRNA with formyl-met RNA
(4) Association of 50 S subunit of ribosome with initiation complex

Q.275 In recent years, DNA sequences (nucleotide sequence) of mt-DNA and Y chromosomes were considered for the study of human evolution because- **[AIPMT - 2003]**

- (1) They are small, and therefore, easy to study
- (2) They are uniparental in origin and do not take part in recombination
- (3) Their structure is known in great detail
- (4) They can be studied from the samples of fossil remains

Q.276 Degeneration of a genetic code is attributed to the - **[AIPMT - 2003]**

- (1) First member of a codon
- (2) Second member of a codon
- (3) Entire codon
- (4) Third member of a codon

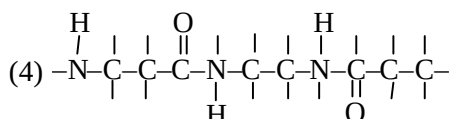
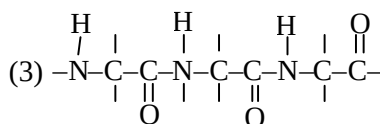
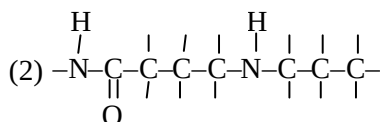
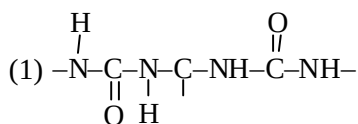
Q.277 What would happen if in a gene encoding a polypeptide of 50 amino acids, 25th codon (UAU) is mutated to UAA- **[AIPMT - 2003]**

- (1) A polypeptide of 24 amino acids will be formed
- (2) Two polypeptides of 24 and 25 amino acids will be formed
- (3) A polypeptides of 49 amino acids will be formed
- (4) A polypeptide of 25 amino acids will be formed

Q.278 During transcription, the DNA site at which RNA polymerase binds is called - **[AIPMT - 2003]**

- (1) Promoter
- (2) Regulator
- (3) Receptor
- (4) Enhancer

Q.279 Which of the following structures represents the peptide chain? **[AIPMT - 2004]**



Q.280 Which one of the following is a chain growth polymer ? **[AIPMT - 2004]**

- (1) Starch
- (2) Nucleic acid
- (3) Polystyrene
- (4) Protein

Q.281 The correct statement in respect of protein haemoglobin is that it - **[AIPMT - 2004]**

- (1) functions as a catalyst for biological reactions
- (2) maintains blood sugar level
- (3) acts as an oxygen carrier in the blood
- (4) forms antibodies and offers resistance to diseases.

Q.282 Number of chiral carbons in β -D-(+) - glucose is - **[AIPMT - 2004]**

- (1) five
- (2) six
- (3) three
- (4) four

Q.283 The helical structure of proteins is stabilized by- **[AIPMT - 2004]**

- (1) dipeptide bonds
- (2) hydrogen bonds
- (3) ether bonds
- (4) peptide bonds

Q.284 Chemically hormones are **[AIPMT - 2004]**

- (1) Biogenic amines only
- (2) Proteins, steroids and biogenic amines
- (3) Proteins only
- (4) Steroids only

Q.285 In a mutational event, when adenine is replaced by guanine, it is case of - **[AIPMT - 2004]**

- (1) Frameshift mutation
- (2) Transcription
- (3) Transition
- (4) Transversion

Q.286 In which one of the following enzymes, is copper necessarily associated as an activator ? **[AIPMT - 2004]**

- (1) Carbonic anhydrase
- (2) Tryptophanase
- (3) Lactic dehydrogenase
- (4) Tyrosinase

Q.287 During transcription, if the nucleotide sequence of the DNA strand that is being coded is ATACG, then the nucleotide sequence in the mRNA would be - **[AIPMT - 2004]**

- (1) TATGC
- (2) TCTGG
- (3) UAUGC
- (4) UATGC

Q.288 Which one of the following hormones is a modified amino acid ? **[AIPMT - 2004]**

- (1) Epinephrine (2) Progesterone
(3) Prostaglandin (4) Estrogen

Q.289 The most abundant element present in the plants is - **[AIPMT - 2004]**

- (1) Carbon (2) Nitrogen
(3) Manganese (4) Iron

Q.290 The following ratio is generally constant for a given species - **[AIPMT - 2004]**

- (1) $A + G / C + T$ (2) $T + C / G + A$
(3) $G + C / A + T$ (4) $A + C / T + G$

Q.291 Which form of RNA has a structure resembling clover leaf ? **[AIPMT - 2004]**

- (1) rRNA (2) hnRNA
(3) mRNA (4) tRNA

Q.292 After a mutation at a genetic locus the character of an organism changes due to the change in - **[AIPMT - 2004]**

- (1) protein structure (2) DNA replication
(3) protein synthesis pattern
(4) RNA transcription pattern

Q.293 During replication of a bacterial chromosome DNA synthesis starts from a replication origin site and - **[AIPMT - 2004]**

- (1) RNA primers are involved
(2) is facilitated by telomerase
(3) moves in one direction of the site
(4) moves in bi-directional way

Q.294 A sequence of how many nucleotide in messenger RNA makes a codon for an amino acid ? **[AIPMT - 2004]**

- (1) Three (2) Four
(3) One (4) Two

Q.295 Which one of the following pairs is correctly matched with regard to the codon and the amino acid coded by it - **[AIIMS - 2004]**

- (1) UUU-Valine (2) AAA-Lysine
(3) AUG-Cysteine (4) CCC-Alanine

Q.296 DNA is present in - **[AIIMS - 2004]**

- (1) Chromosomes and dictyosome
(2) Chloroplast and lysosomes
(3) Mitochondria and chloroplasts
(4) Mitochondria and endoplasmic reticulum.

Q.297 Which of the following is the simplest amino acid- **[AIPMT - 2005]**

- (1) Alanine (2) Asparagine
(3) Glycine (4) Tyrosine

Q.298 Enzymes, vitamins and hormones can be classified into a single category of biological chemicals, because all of these - **[AIPMT - 2005]**

- (1) Are exclusively synthesized in the body of a living organism as at present
(2) Enhance oxidative metabolism
(3) Are conjugated proteins
(4) Help in regulating metabolism

Q.299 Which one of the following makes use of RNA as a template to synthesize DNA - **[AIPMT - 2005]**

- (1) DNA dependant RNA polymerase
(2) DNA polymerase
(3) Reverse transcriptase
(4) RNA polymerase

Q.300 Nucleotides are building blocks of nucleic acids. Each nucleotide is a composite molecule formed by - **[AIPMT - 2005]**

- (1) Base-sugar-OH
(2) Base-sugar-phosphate
(3) Sugar-phosphate
(4) (Base-sugar-phosphate)

Q.301 Protein synthesis in an animal cell occurs- **[AIPMT - 2005]**

- (1) On ribosomes present in cytoplasm as well as in mitochondria
(2) On ribosomes present in the nucleolus as well as in cytoplasm
(3) Only on ribosome attached to the nuclear envelope and endoplasmic reticulum
(4) Only on the ribosomes present in cytosol

Q.302 Which one of the following hydrolyses internal phosphodiester bonds in a polynucleotide chain- **[AIPMT - 2005]**

- (1) Lipase (2) Protease
(3) Exonuclease (4) Endonuclease

Q.303 Carbohydrates, the most abundant biomolecules on earth, are produced by- **[AIPMT - 2005]**

- (1) Some bacteria, algae and green plant cells
- (2) All bacteria, fungi and algae
- (3) Fungi, algae and green plants cells
- (4) Viruses, fungi and bacteria

Q.304 Production of a human protein in bacteria by genetic engineering is possible because

[AIPMT - 2005]

- (1) Bacterial cell can carry out the RNA splicing reactions
- (2) The mechanism of gene regulation is identical in humans and bacteria
- (3) The human chromosome can replicate in bacterial cell
- (4) The genetic code is universal

Q.305 During transcription holoenzyme RNA polymerase binds to a DNA sequence and the DNA assumes a saddle like structure at that point. What is that sequence called-

[AIPMT - 2005, 07]

- (1) CAAT box
- (2) GGTT box
- (3) AAAT box
- (4) TATA box

Q.306 Which functional group participates in disulphide bond formation in proteins - **[AIPMT - 2005]**

- (1) Thioether
- (2) Thiol
- (3) Thioester
- (4) Thiolactone

Q.307 Physical basis of life is - **[RPMT - 2005]**

- (1) Cytoplasm
- (2) Protoplasm
- (3) Nucleoplasm
- (4) Endoplasm

Q.308 Ribosomes are sites of which reaction-

[RPMT - 2005]

- (1) Respiration
- (2) Photosynthesis
- (3) Protein synthesis
- (4) Fat synthesis

Q.309 In DNA purine nitrogen bases are -

[RPMT - 2005]

- (1) Uracil and Guanine
- (2) Guanine and Adenine
- (3) Adenine and cytosine
- (4) None

Q.310 Which of the following disaccharide gives two molecules of glucose on hydrolysis -

[RPMT - 2005]

- (1) Maltose
- (2) Lactose
- (3) (1) and (2) both
- (4) Sucrose

Q.311 Which of the following is the example of acidic amino acid - **[RPMT - 2005]**

- (1) Lysine
- (2) Glutamic acid
- (3) Aspartic acid
- (4) (2) and (3) both

Q.312 Specificity of protein is due to -

[RPMT - 2005]

- (1) Types of amino acid
- (2) Sequence of amino acid
- (3) Number of amino acid
- (4) Quantity of amino acid

Q.313 Bond between phosphate and sugar in a nucleotide is - **[RPMT - 2005]**

- (1) H-bond
- (2) Covalent bond
- (3) Phosphodiester bond
- (4) Sulphide bond

Q.314 The other name for glucose is - **[RPMT - 2005]**

- (1) Grape sugar
- (2) Cane sugar
- (3) Fructose
- (4) Galactose

Q.315 Which of the following is formed in nucleolus -

[RPMT - 2005]

- (1) r RNA
- (2) t RNA
- (3) m-RNA
- (4) DNA

Q.316 Ribosomes are composed of **[RPMT - 2005]**

- (1) DNA + Protein
- (2) DNA
- (3) RNA + Protein
- (4) RNA + DNA

Q.317 The chemical in ovum which attracts sperms

[RPMT - 2005]

- (1) Fertilizin
- (2) Antifertilizin
- (3) Agglutinin
- (4) Thrombin

Q.318 DNA probes are copied from the messenger RNA molecules with the help of -

[AIIMS - 2005]

- (1) Restriction enzymes
- (2) Reverse transcriptase
- (3) DNA polymerase
- (4) Adenosine deaminase

Q.319 Which of the following biomolecule is insoluble in water - **[AIIMS - 2005]**

- (1) α -Keratin
- (2) Haemoglobin
- (3) Ribonuclease
- (4) Adenine

Q.320 Which one of the following statement is true for protein synthesis (translation) -

[AIIMS - 2005]

- (1) Amino acids are directly recognized by m-RNA
- (2) The third base of the codon is less specific
- (3) Only one codon codes for an amino acid
- (4) Every t-RNA molecule has more than one amino acid attachment site

Q.321 Which antibiotic inhibits interaction between tRNA and mRNA during bacterial protein synthesis ?

[AIPMT - 2006]

- (1) Erthromycin
- (2) Neomycin
- (3) Streptomysin
- (4) Tetracycline

Q.322 Amino acid sequence, in protein synthesis is decided by the sequence of -

[AIPMT - 2006]

- (1) tRNA
- (2) mRNA
- (3) cDNA
- (4) rRNA

Q.323 One gene-one enzyme hypothesis was postulated by -

[AIPMT - 2006]

- (1) R.Franklin
- (2) Hershay and Chase
- (3) A.Garrod
- (4) Beadle and Tatum

Q.324 One turn of the helix in a B-form DNA is approximately -

[AIPMT - 2006]

- (1) 20 nm
- (2) 0.34 nm
- (3) 3.4 nm
- (4) 2 nm

Q.325 Antiparallel strands of a DNA molecule means that -

[AIPMT - 2006]

- (1) one strand turns anti-clockwise
- (2) the phosphate group of two DNA stands, at their ends, share the same position
- (3) the phosphate groups at the start of two DNA stands are in opposite position (pole)
- (4) one strand turns clockwise

Q.326 The causative agent of mad-cow disease is -

[AIPMT - 2006]

- (1) Bacterium
- (2) Prion
- (3) Worm
- (4) Virus

Q.327 During protein synthesis in an organism, at one point the process comes to a halt. Select the group of the three codons from the following from which any one of the three could bring about this halt-

[AIIMS - 2006]

- (1) UUU, UCC, UAU
- (2) UUC, UUA, UAC
- (3) UAG, UGA, UAA
- (4) UUG, UCA, UCG

Q.328 Thymine is - [AIIMS - 2006]

- (1) 5-Methyl uracil
- (2) 4-Methyl uracil
- (3) 3-Methyl uracil
- (4) 1-Methyl uracil

Q.329 Molecular basis of organ differentiation depends on the modulation in transcription by

[AIPMT - 2007]

- (1) RNA polymerase
- (2) Ribosome
- (3) Transcription factor
- (4) Anticodon

Q.330 The Okazaki fragments in DNA chain growth -

[AIPMT - 2007]

- (1) Result in transcription
- (2) Polymerize in the 3'-to-5' direction and froms replication fork
- (3) Prove semi-conservative nature of DNA replication
- (4) Polymerize in the 5' to 3' direction and explain 3'-to-5' DNA replication

Q.331 The two polynucleotide chains in DNA are

[AIPMT - 2007]

- (1) Parallel
- (2) Discontinuous
- (3) Antiparallel
- (4) Semiconservative

Q.332 About 98 percent of the mass of every living organism is composed of just six elements including carbon, hydrogen, nitrogen, oxygen and-

[AIPMT - 2007]

- (1) Phosphrous and sulphur
- (2) Sulphur and magnesium
- (3) Magnesium and sodium
- (4) Calcium and phoshorus

Q.333 A plant requires magnesium for -

[AIPMT - 2007]

- (1) Holding cells together
- (2) Protein synthesis
- (3) Chlorophyll synthesis
- (4) Cell wall development

Q.334 Polysome is formed by - [AIPMT - 2008]

- (1) A ribosome with several subunits
- (2) Ribosomes attached to each other in a linear arrangement
- (3) Several ribosomes attached to a single mRNA
- (4) Many ribosomes attached to a strand of endoplasmic recticulum

Q.335 Which one of the following pairs of nitrogenous bases of nucleic acids, is wrongly matched with the category mentioned against it ?

[AIPMT - 2008]

- (1) Guanine, Adenine-Purines
- (2) Adenine, Thymine-Purines
- (3) Thymine, Uracil-Pyrimidines
- (4) Uracil, Cytosine-Pyrimidines

Q.336 In the DNA molecule - [AIPMT - 2008]

- (1) the proportion of Adenine in relation to thymine varies with the organism
- (2) there are two strands which run antiparallel one in 5', 3' direction and other in 3', 5'
- (3) the total amount of purine nucleotide and pyrimidine nucleotides is not always equal
- (4) there are two strands which run parallel in the 5', 3' direction

Q.337 Which one of the following pairs of codons is correctly matched with their function or the signal for the particular amino acid ?

[AIPMT - 2008]

- (1) AUG, ACG-Start/Methionine
- (2) UUA, UCA-Leucine
- (3) GUU, GCU-Alanine
- (4) UAG, UGA-Stop

Q.338 What is antisense technology?

[AIPMT - 2008]

- (1) When a piece of RNA that is complementary in sequence is used to stop expression of a specific gene
- (2) RNA polymerase producing DNA
- (3) A cell displaying a foreign antigen used for synthesis of antigens
- (4) Production of somaclonal variants in tissue cultures

Q.339 What is not true for genetic code -

[AIPMT - 2009]

- (1) It is unambiguous
- (2) A codon in m RNA is read in a non-contiguous fashion
- (3) It is nearly universal
- (4) It is degenerate

Q.340 Removal of introns and joining the exons in a defined order in a transcription unit is called ?

[AIPMT - 2009]

- (1) Capping
- (2) Splicing
- (3) Tailing
- (4) Transformation

Q.341 Semiconservative replication of DNA was first demonstrated in - [AIPMT - 2009]

- (1) Salmonella typhimurium
- (2) Drosophila melanogaster
- (3) Escherichia coli
- (4) Streptococcus pneumoniae

Q.342 Whose experiments cracked the DNA and discovered unequivocally that a genetic code is a "triplet" - [AIPMT - 2009]

- (1) Beadle and tatum
- (2) Nirenberg and Mathaei
- (3) Hershey and Chase
- (4) Morgan and Sturtevant

Q.343 If one strand of DNA has the nitrogenous base sequence as ATCTG, what would be the complementary RNA strand sequence ?

[AIPMT Pre 2012]

- (1) UAGAC
- (2) AACTG
- (3) ATCGU
- (4) TTAGU

Q.344 A normal-visioned man whose father was colour-blind, marries a woman whose father was also colour-blind. They have their first child as a daughter. What are the chances that this child would be colour-blind ? [AIPMT Pre 2012]

- (1) zero percent
- (2) 25%
- (3) 50%
- (4) 100%

Q.345 F₂ generation in a Mendelian cross showed that both genotypic and phenotypic ratios are same as 1 : 2 : 1. It represents a case of :

[AIPMT Pre 2012]

- (1) Dihybrid cross
- (2) Monohybrid cross with complete dominance
- (3) Monohybrid cross with incomplete dominance
- (4) Co-dominance

Q.346 Removal of RNA polymerase III from nucleoplasm will affect the synthesis of :

[AIPMT Pre 2012]

- (1) hn RNA
- (2) m RNA
- (3) r RNA
- (4) t RNA

Q.347 Which one of the following is not a part of a transcription unit in DNA?

[AIPMT Pre 2012]

- (1) A terminator
- (2) A promoter
- (3) The structural gene
- (4) The inducer

Q.348 A certain road accident patient with unknown blood group needs immediate blood transfusion. His one doctor friend at once offers his blood. What was the blood group of the donor ?

[AIPMT Pre 2012]

- (1) Blood group AB (2) Blood group O
(3) Blood group A (4) Blood group B

Q.349 Removal of introns and joining of exons in a defined order during transcription is called :

[AIPMT Pre 2012]

- (1) Inducing (2) Slicing
(3) Splicing (4) Looping

ANSWER KEY

EXERCISE- 3

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	4	4	4	3	3	2	2	2	2	1	4	4	2	1	3	4	4	3	3	4
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	3	3	3	3	3	1	1	4	1	3	4	2	3	2	4	2	2	2	4	2
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	4	1	3	2	4	4	2	2	1	4	4	1	4	1	2	4	3	1	2
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	3	1	2	2	4	2	4	3	2	1	1	2	1	2	4	1	3	1	4	3
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	3	3	4	1	1	1	1	2	1	3	4	1	1	2	2	2	4	2	2	2
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	4	4	3	1	1	4	3	2	3	2	4	3	4	1	2	3	3	3	1	3
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	1	2	3	1	4	4	2	3	4	4	1	1	2	2	4	2	4	2	3	1
Ques.	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
Ans.	3	2	3	1	2	4	4	3	1	2	3	2	2	2	3	2	1	3	4	3
Ques.	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
Ans.	2	4	1	1	1	2	2	1	1	2	3	3	4	1	2	4	4	2	3	4
Ques.	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
Ans.	1	4	1	4	2	2	2	2	4	3	2	1	4	1	3	4	3	3	1	3
Ques.	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220
Ans.	2	1	4	4	4	1	3	2	1,3	4	4	1	4	2	2	3	2	3	2	1
Ques.	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
Ans.	3	4	3	1	2	1	3	2	3	4	1	3	3	4	3	4	2	1	4	3
Ques.	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260
Ans.	3	4	4	1	3	3	2	2	1	2	2	2	1	2	3	3	1	2	4	3
Ques.	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280
Ans.	1	2	2	1	1	1	1	1	3	3	2	2	4	3	2	4	1	1	3	3
Ques.	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300
Ans.	3	1	2	2	3	4	3	1	1	3	4	1	4	1	2	3	3	4	3	2
Ques.	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320
Ans.	1	4	1	4	4	2	2	3	2	1	4	2	2	1	1	3	1	2	1	2
Ques.	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340
Ans.	2	2	4	3	3	2	3	1	3	4	3	1	3	3	2	2	4	1	2	2
Ques.	341	342	343	344	345	346	347	348	349											
Ans.	3	2	1	1	3,4	4	4	2	3											

EXERCISE- 4

AIIMS SPECIAL

- Q.1** Which of the following terms represents a pair of contrasting factors of a character?
(1) Homozygous (2) Allele
(3) Heterozygous (4) Phenotypes
- Q.2** Maize has ten pairs of chromosomes. How many linkage groups will be present, if all the genes are mapped?
(1) 20 (2) 5
(3) 40 (4) 10
- Q.3** The complete set of chromosome, inherited as a single unit from one parent, is known as
(1) Genome (2) Linkage
(3) Gene pool (4) Genotype
- Q.4** Which of the following explains, how progeny can possess the combinations of traits that none of the parent possessed?
(1) Law of segregation
(2) Chromosome theory
(3) Law of independent assortment
(4) Polygenic inheritance
- Q.5** The presence of continuous phenotypic variation in an F_2 -generation suggests that a character is inherited by
(1) Gene linkage
(2) Epistasis
(3) Polygenic inheritance
(4) Recombination
- Q.6** Colour blindness, in which all colours are perceived as gray, is termed as
(1) Monochromasia (2) Chromasia
(3) Dichromasia (4) All of these
- Q.7** The daughters born to haemophilic father and normal mother could be
(1) Haemophilic (2) Normal
(3) Carrier (4) All of these
- Q.8** Which of the following are famous for chromosome heredity?
(1) Morgan and Sutton
(2) Beadle and Tatum
(3) Bridges and Morgan
(4) Sutton and Boveri
- Q.9** Polyploidy results in rapid formation of new species because of
(1) Isolation behaviour
(2) Genetic recombination
(3) Development of multiple sets of chromosomes
(4) Mutation therapy
- Q.10** Cis-trans test is related with
(1) Crossing over (2) Mutation
(3) Genetic map (4) Heredity
- Q.11** Which of the following is an example of sex-linked inheritance?
(1) Night-blindness (2) Anaemia
(3) Colour-blindness (4) Cretinism
- Q.12** A pregnant woman, who has done amniocentesis test, finds an extra barr body in her embryo. The syndrome which is likely to be associated with embryo is
(1) Edward's syndrome
(2) Down's syndrome
(3) Klinefelter's syndrome
(4) Patau's syndrome
- Q.13** Genes present on V-chromosome are called
(1) Polygenic gene (2) Basic gene
(3) Pleiotropic gene (4) Holandric gene
- Q.14** The hexaploid wheat is obtained by
(1) Chromosomes map
(2) Hybridomas
(3) Hybridization (4) Both (2) & (3)
- Q.15** In sweet peas, genes C and P are necessary for colour in flowers. The flowers are white in the absence of either or both the genes. What will be the percentage of coloured flowers in the offspring of the cross $CcPp \times ccPp$?
(1) 75% (2) 25%
(3) 100% (4) 50%

- Q.16** Epistatic effect, in which the dihybrid cross $9 : 3 : 3 : 1$ between $AaBb \times AaBb$ is modified as
- (1) Interaction between two alleles of the same loci
 - (2) Dominance of one allele on another allele of the same loci
 - (3) Interaction between two alleles of different loci
 - (4) Dominance of one allele on another allele of both loci
- Q.17** When a tall and red flowered individual is crossed with a dwarf and white flowered individual, phenotype in the progeny is dwarf and white. What will be the genotype of tall and red flowered individual?
- (1) $TtRr$
 - (2) $TTRr$
 - (3) $TTRR$
 - (4) $TtRR$
- Q.18** Distance between two linked genes upon a chromosome is measured in the unit as
- (1) Ratio of crossing over between them
 - (2) Cross-over value
 - (3) Number of other genes between them
 - (4) Interference value
- Q.19** The genes, which are confined to differential region of Y-chromosome only, are called
- (1) Mutant
 - (2) Autosomal
 - (3) Holandric
 - (4) Sex-linked
- Q.20** XO-chromosomal abnormality in human beings causes
- (1) Turner's syndrome
 - (2) Down's syndrome
 - (3) Klinefelter's syndrome
 - (4) Jacob's syndrome
- Q.21** The root cell of wheat plant has 42 chromosomes. What would be the number of chromosomes in the synergid cell?
- (1) 21
 - (2) 7
 - (3) 28
 - (4) 14
- Q.22** If a homozygous red-flowered plant is crossed with a homozygous white-flowered plant, the offsprings will be
- (1) Half-white flowered
 - (2) Half red-flowered
 - (3) All white-flowered
 - (4) All red-flowered
- Q.23** "Gametes are never hybrid". This is a statement of
- (1) Law of dominance
 - (2) Law of independent assortment
 - (3) Law of segregation
 - (4) Law of random fertilisation
- Q.24** Mendel was not able to say anything about recombination and crossing over because
- (1) He did not have a large and strong microscope
 - (2) He chose only pure type
 - (3) Traits he chose, were not linked and present on different chromosomes or were far apart
 - (4) Traits he chose had no genes
- Q.25** Albinism and phenylketonuria are disorders due to
- (1) Recessive autosomal genes
 - (2) Dominant autosomal genes
 - (3) Recessive sex genes
 - (4) Dominant sex genes
- Q.26** Which of the following is the best way to determine paternity?
- (1) Protein analysis
 - (2) Chromosome counting
 - (3) DNA finger printing
 - (4) Gene counting
- Q.27** A man has enlarged breasts, sparse hair on body and sex complement as XXV. He then suffers from
- (1) Down's syndrome
 - (2) Klinefelter's syndrome
 - (3) Edward's syndrome
 - (4) Turner's syndrome

Q.28 Gene which suppresses other gene's activity but does not lie on the same locus is called as

- (1) Epistatic (2) Supplementary
(3) Hypostatic (4) Codominant

Q.29 Barr Body is found in the cytoplasm during

- (1) Interphase in cell of female mammal
(2) Interphase in cell of male mammal
(3) Prophase in cell of female mammal
(4) Prophase in cell of male mammal

Q.30 The ratio in a dihybrid test cross between two individuals is given by

- (1) 2: 1 (2) 1 : 2 : 1
(3) 3: 1 (4) 1 : 1 : 1 : 1

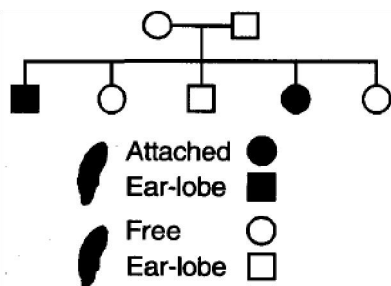
Q.31 A chromosome carrying the centromere at one of the ends is called

- (1) Acentric (2) Acrocentric
(3) Telocentric (4) Metacentric

Q.32 One of the genes present exclusively on the X-chromosome in humans is concerned with .

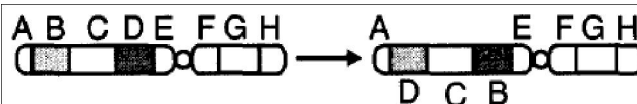
- (1) Baldness
(2) Red-green colour blindness
(3) Facial hair/moustaches in males
(4) Night blindness

Q.33 Given below is a pedigree chart of a family with five children. It shows the inheritance of attached earlobes as opposed to the free ones. The squares represent the male individuals and circles the female individuals. Which one of the following conclusions drawn is correct?



- (1) The parents are homozygous recessive
(2) The trait is Y-linked
(3) The parents are homozygous dominant
(4) The parents are heterozygous

Q.34 Given below is a representation of a kind of chromosomal mutation. What is the kind of mutation represented?

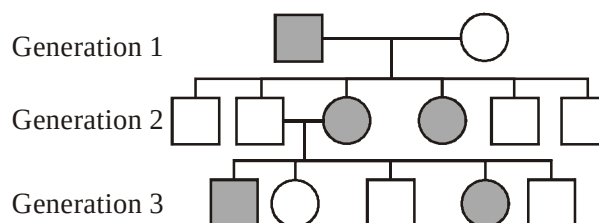


- (1) Deletion
(2) Duplication
(3) Inversion
(4) Reciprocal translocation

Q.35 How many different types of gametes can be formed by F_1 progeny, resulting from the following cross : AA BB CC x aa bb cc?

- (1) 3 (2) 8
(3) 27 (4) 64

Q.36 Given below is a pedigree chart showing the inheritance of a certain sex-linked trait in humans.



The trait traced in the above pedigree chart is

- (1) Dominant X-linked
(2) Recessive X-linked
(3) Dominant V-linked
(4) Recessive V-linked

Q.37 Grain colour in wheat is determined by three pairs of polygenes. Following the cross AABBCC (dark colour) x aabbcc (light colour), in F_2 generation what proportion of the progeny is likely to resemble either parent?

- (1) None
(2) Less than 5 percent
(3) One third (4) Half

Q.38 Primary source of allelic variation is

- (1) Independent assortment
(2) Recombination
(3) Mutation (4) Polyploidy

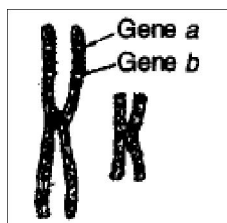
Q.39 Which one of the following pair~ of features is a good example of polygenic inheritance?

- (1) Human height and skin colour
- (2) ABO blood group in humans and flower colour of Mirabi/is jalapa
- (3) Hair pigment of mouse and tongue rolling in humans
- (4) Human eye colour and sickle cell anaemia

Q.40 Mating of an organism to a double recessive in order to determine whether it is homozygous or heterozygous for a character under consideration is called

- (1) Reciprocal cross (2) Test cross
- (3) Dihybrid cross (4) Back cross

Q.41 Given below is a highly simplified representation of the human sex chromosomes from a karyotype. The gene a and b could be of



- (1) Colour blindness and body height
- (2) Attached ear lobe and Rhesus blood group
- (3) Haemophilia and red-green colour blindness
- (4) Phenylketonuria and haemophilia

Q.42 Philadelphia chromosome is found in the patient suffering from

- (1) Albinism
- (2) Insomnia
- (3) Myelocytic Leukaemia
- (4) Hepatitis

Q.43 Nitrous acid causes mutation by

- (1) Acting as a base analogue
- (2) Addition of a base pair
- (3) Hydrolysing base sugar linkage
- (4) Removing amino group from the bases

Q.44 The "cri-du-char" syndrome is caused by change in chromosome structure involving

- (1) Deletion (2) Duplication
- (3) Inversion (4) Translocation

Q.45 Which one of the following combinations of the number of chromosomes is the correct representation of present day hexaploid wheat?

Combination	Monosomic	Haploid	Nullisomic
Trisomic			
(1) 21 28	42	43	
(2) 7 28	40	42	
(3) 21 7	42	43	
(4) 41 21	40	43	

Q.46 Which of the following are initiator codons?

- (1) UGA and UAG (2) UUU and UUC
- (3) AUG and GUG (4) UAA and UAG

Q.47 The jumping genes are called

- (1) Cistrons (2) Mutons
- (3) Transposons (4) Recons

Q.48 The new strand synthesised, in small pieces and then joined together during DNA replication, is called

- (1) Dead strand (2) Lagging strand
- (3) Leading stand (4) All of these

Q.49 Teminism is same as

- (1) Transcription
- (2) Translation
- (3) Reverse transcription
- (4) DNA synthesis

Q.50 Which of the following is not required for protein synthesis?

- (1) t-RNA (2) r-RNA
- (3) m-RNA (4) None of these

Q.51 Which of the following RNAs picks up specific amino acid from amino acid pool in the cytoplasm to ribosome during protein synthesis?

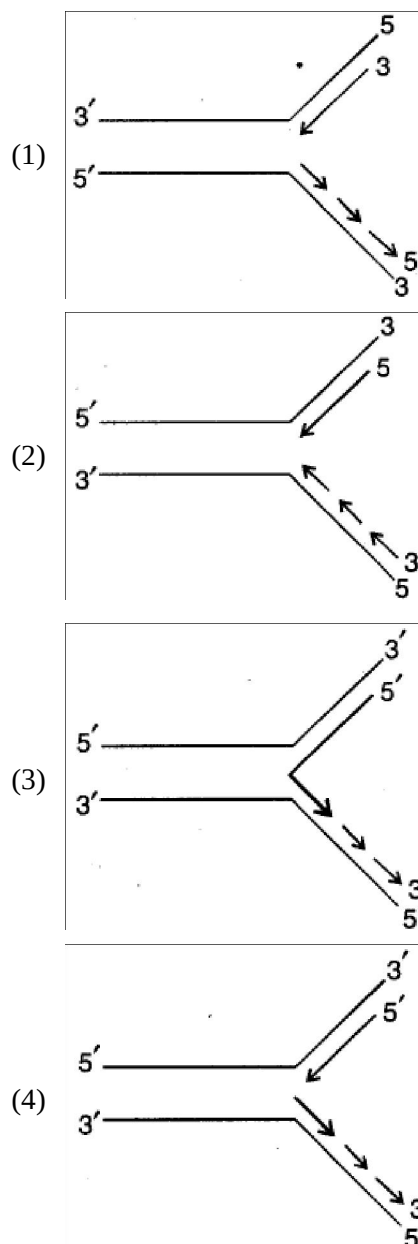
- (1) t-RNA (2) m-RNA
- (3) r-RNA (4) All of these

Q.52 If one strand of DNA has the nitrogenous base sequence ATGCTTGA, the sequence in the complementary strand will be

- (1) TAGGTAGT (2) TACGTACT
- (3) TACGAACT (4) TCCGAACT

- Q.53** Restriction endonucleases are utilised in genetic engineering as
 (1) Molecular scalpels for cutting DNA at specific sites
 (2) Molecular builder of nucleotides
 (3) Molecular degradation to DNA break up
 (4) Molecular cement for combining DNA bits into long chains
- Q.54** Extranuclear genes occurs in
 (1) Plastids - and not inherited
 (2) Plasmid - and not inherited
 (3) Mitochondria - and inherited by female
 (4) Mitochondria - and inherited by male
- Q.55** In RNA thymine is replaced by
 (1) Uracil (2) Adenine
 (3) Methyl uracil (4) Guanine
- Q.56** A point mutation comprising the substitution of a 63. purine by pyrimidine is called
 (1) Transition (2) Translocation
 (3) Deletion (4) Transversion
- Q.57** Frameshift mutation occurs when
 (1) Base is deleted
 (2) Base is deleted or added
 (3) Base is added
 (4) Anticodons are not present
- Q.58** Wobble hypothesis was given by
 (1) R. W. Holley (2) M. Nirenberg
 (3) H.G. Khorana (4) F.H.C. Crick
- Q.59** Which one of the following pairs of terms / names mean one and the same thing?
 (1) Gene pool - genome
 (2) Codon - gene
 (3) Cistron - triplet
 (4) DNA fingerprinting - DNA profiling
- Q.60** What is false about tRNA?
 (1) It binds with an amino acid at it 3' end
 (2) It has double stranded regions
 (3) It has a codon at one end which recognizes the anticodon on messenger RNA
 (4) It looks like clover leaf in the two dimensional structure
- Q.61** Which one of the following codons codes for the same information as UGC?
 (1) UGU (2) UGA
 (3) UAG (4) UGG

- Q.62** The total number of nitrogenous bases in human genome is estimated to be about
 (1) 3.5 million (2) 35 thousand
 (3) 35 million (4) 3.1 billion
- Q.63** Which one of the following correctly represents the manner of replication of DNA?



- Q.64** What is the first step in the Southern Blot technique?
 (1) Denaturation of DNA on the gel for hybridization with specific probe
 (2) Production of a group of genetically identical cells
 (3) Digestion of DNA by restriction enzyme
 (4) Isolation of DNA from a nucleated cell such as the one from the scene of crime

- Q.65** Which one of the following pairs is correctly matched with regard to the codon and the amino acid coded by it?
 (1) UUA - valine (2) AAA - lysine
 (3) AUG - cysteine (4) CCC - alanine
- Q.66** cDNA probes are copied from the messenger RNA molecules with the help of
 (1) Restriction enzymes
 (2) Reverse transcriptase
 (3) DNA polymerase
 (4) Adenosine deaminase
- Q.67** During protein synthesis in an organism at one point the process comes to a halt. Select the group of the three codons from the following, from which anyone of the three could bring about this halt,
 (1) UUU, UCC, UAU
 (2) UUC, UUA, UAC
 (3) UAG, UGA, UAA
 (4) UUG, UCA, UCG
- Q.68** Which of the following correctly represents the flow of genetic information?
 (1) DNA → RNA → protein
 (2) RNA → DNA → protein
 (3) RNA → protein → DNA
 (4) Protein → RNA → DNA

INSTRUCTIONS FOR Q. NO. 69 TO 82

In the following questions (69 to 82), a statement of assertion (A) is followed by a statement of reason (R)

- (1) If both Assertion & Reason are true and the reason is the correct explanation of the assertion, then mark (1).
- (2) If both Assertion & Reason are true but the reason is not the correct explanation of the assertion, then mark (2).
- (3) If Assertion is true statement but Reason is false, then mark (3).
- (4) If both Assertion and Reason are false statements, then mark (4).

- Q.69** **A :** *Drosophila melanogaster* is widely used in genetic research.
R : *Drosophila melanogaster* is readily available insect.
- Q.70** **A :** In humans, the gamete contributed by the male determines whether the child produced will be male or female.
R : Sex in humans is a polygenic trait depending upon a cumulative effect of some genes on X-chromosome and some on Y-chromosome.
- Q.71** **A :** A father may be a haemophilic only if his mother is carrier.
R : The father cannot pass on a sex-linked gene to his son.
- Q.72** **A :** A single strand of m-RNA is capable of forming a number of polypeptide chains.
R : Termination codons occur in m-RNA.
- Q.73** **A :** The non-allelic genes for red hair and freckles are usually inherited together.
R : The genes for red hair and freckles are located on same chromosome in close association.
- Q.74** **A :** Chromosomal aberrations are caused by a break in the chromosome or its chromatid.
R : Duplication, deficiency, transversion and trans locations are the cause of chromosomal aberrations.
- Q.75** **A :** 'Lac Operon Model' is applicable to *E. coli*.
R : *E. coli* lacks a definite nucleus.
- Q.76** **A :** Amber codon is a termination codon.
R : If in m-RNA, a termination codon is present, the protein synthesis stops abruptly whether the protein synthesis is completed or not.
- Q.77** **A :** DNA codes are not copied in the synthesis of transfer RNA.
R : Transfer RNA move out of the nucleus and after attaching on the ribosomes, form the template.

Q.78 A : Watson and Crick provided experimental proof of semiconservative nature of DNA replication.

R : RNA polymerase binds nucleotides in replication.

Q.79 A : The mRNA attaches itself to the ribosome via its 3' end.

R : The mRNA has nucleotide and bases of lagging sequence.

Q.80 A : Replication and transcription occur in the nucleus but translation occurs in the cytoplasm.

R : mRNA is transferred from the nucleus into the cytoplasm where ribosomes and amino acids are available for protein synthesis.

Q.81 A : An organism with lethal mutation may not even develop beyond the zygote stage.

R : All types of gene mutations are lethal.

Q.82 A : Cancer cells are virtually immortal until the body in which they reside dies.

R : Cancer is caused by damage to genes regulating the cell division cycle.

ANSWER KEY

EXERCISE - 4

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	3	4	1	3	3	1	3	4	3	1	3	3	4	3	2	3	1	2	3	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	4	3	3	1	3	2	1	1	4	3	2	4	3	2	1	2	2	1	2
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	3	3	4	1	4	3	3	2	3	4	1	3	1	3	1	4	2	4	4	3
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	1	4	4	1	2	2	3	1	2	3	1	2	1	2	2	2	4	4	4	1
Ques.	81	82																		
Ans.	3	2																		

Bansal Quick Review Table

Instruction to fill

- (A) Write down the Question Number you are unable to solve in column A below, by Pen.
- (B) After discussing the Questions written in column A with faculties, strike off them in the manner so that you can see at the time of Revision also, to solve these questions again.
- (C) Write down the Question Number you feel are important or good in the column B.

EXERCISE NO.	COLUMN : A	COLUMN : B
	Question I am unable to solve in first attempt	Good / Important questions
Exercise # 1		
Exercise # 2		
Exercise # 3		
Exercise # 4		
Other Exercise		

Advantages

1. It is advised to the students that they should prepare a question bank for the revision as it is very difficult to solve all the questions at the time of revision.
2. Using above index you can prepare and maintain the questions for your revision.

ORIGIN OF LIFE AND EVOLUTION

Big-Bang Theory :

This theory was proposed by **Abbe Lemaitre**. According to it, the universe originated about 15 billion years ago due to a thermonuclear explosion of a dense entity. This thermonuclear explosion is called **Big-bang**.

About 4.6 billion years ago, the origin of our solar system took place by the gaseous clouds formed due to this explosion.

These gaseous clouds collapsed and converted into flat disc-like structure made up of atoms and small particles due to their own gravitational pull.

These flat-disc like structure is called **SOLAR-NEBULA**.

The very hot central part of this solar Nebula became still hotter & converted into the **sun**. Now, due to condensation of atoms & dust particles moving around the sun formation of the other planets took place [**Mercury, venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune**].

The solid part of our planet earth was called Lithosphere & the gaseous part was known as atmosphere.

When the earth's surface cooled down and its temperature decreased to 100°C, water formed on it.

Ancient Theories for origin of life :

1. Theory of special creation –

The greatest supporter of this theory was **father Suarez** According to Bible life and everything was created by god in 6 days.

on first day : Earth and heaven

on second day : Sky and water

on third day : Land and plants

on forth day : Sun, moon and stars

on fifth day : Fishes and birds

on sixth day : Land animals and first man Adam and from his 12th Rib first woman Eve.

According to **hindu mythology** the world was created by **God Brahma**. (The first man was **Manu** and the first woman was **Shraddha**)

According to it life has not changed ever since its origin.

Special creation theory lacks scientific evidences so is not accepted.

2. Theory of Spontaneous Generation (Abiogenesis or Autogenesis) –

This hypothesis was supported by ancient Greek philosophers like Thales, Anaximander, Xenophanes, Plato. Empedocles, Aristotle.

According to this theory life was originated from nonliving things spontaneously.

They believed that the mud of the **Nile** river could give rise to frogs, snakes, crocodiles.

Abiogenesis was strongly supported by **Von Helmont**. He claimed formation of mice in 21 days. If a sweat soaked dirty shirt is kept in wheat barn.

3. Cosmozoic Theory –

Proposed by **Richter**.

Protoplasm reached on earth in the form of **spores** or other simple particles from some unknown part of the universe with cosmic dust and they gave rise to various forms of life.

4. Cosmic panspermia theory –

Proposed by **Arrhenius**.

According to this theory organisms existed throughout the universe and their spores could freely travel through space from one star to the other.

5. Theory of Eternity of Life –

Helmholz believed that life is **immortal**.

6. Theory of Biogenesis –

Harvey (1651) and Huxley (1870) {Omnis vivum ex ovo or vivo.}

New organisms can be originated on earth only by pre-existing life.

This theory rejected the theory of Spontaneous generation but cannot explain origin of life.

To prove Biogenesis and to disprove a biogenesis experiments were performed by –

- **Francesco Redi's Experiment (Italian 1668) –**

He took cooked meat in three jars one was uncovered, the second was covered with parchment and the third was air tight.

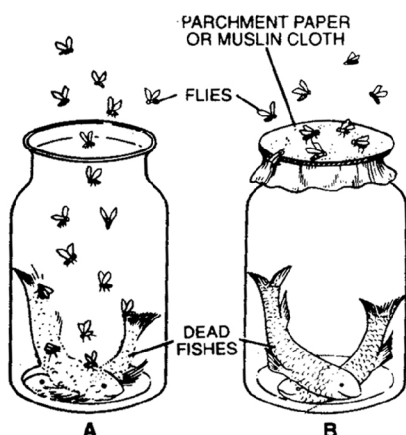
He observed that maggots developed only in the uncovered jar while maggots could not developed in the meat in closed jars.

This proved that larvae were formed from eggs laid by the flies in open jars. Since the meat in closed jars could not be visited by flies so no larvae could develop. Therefore life originated from pre existing life.

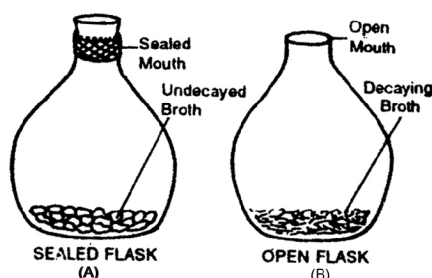
- **Lazzaro Spallanzani (Italian 1767) –**

He boiled vegetables and meat to prepare a sterilized nutritive soup and he kept some of it in air sealed flasks and some in loosely corked flasks. He observed that the soup in sealed flask remained sterile while micro organisms appeared in the soup in loosely corked flasks.

Thus even micro organisms were formed from pre existing ones in the air rather than spontaneously.



Francesco Redi's experiment



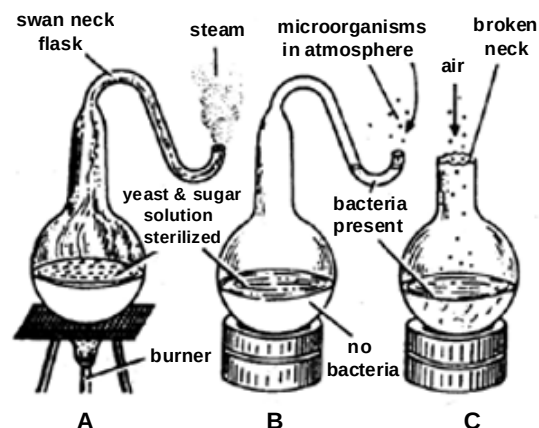
Spallanzani's experiment. A broth remained undecayed indefinitely in sealed jars. B, broth decayed in open jar.

Louis Pasteur (French 1862) –

Pasteur is popular for **Germ Theory of Diseases or Germ theory** and he disproved abiogenesis.

He prepared sterilized **syrup** of sugar and yeast by boiling them in flasks.

He took two flasks one of broken neck and another of curved neck (swan neck flask). No life appeared in swan neck flask because germ laden dust particles in the air were trapped by the curved neck which serves as filter while in broken neck flask colonies of microorganism were developed.



Louis Pasteur's Experiment

Modern theory of origin of life : (Oparin-Haldane theory of origin of life)

- **Naturalistic theory Or Theory of Chemical Evolution –**

This theory was proposed by Russian Scientist **A.I. Oparin** and **J.B.S Haldane** (England born Indian scientist)

Oparin's theory was published in his book 'ORIGIN OF LIFE'.

- **Important Points**

- According to this theory life originated by the composition of chemicals.
- Oparin's theory is based on Artificial Synthesis. So also called as **artificial synthetic theory**.
- Ist life originated in the water of oceans. So water is essential for origin of life.
- There is no life on moon due to absence of water.
- At the time of origin of life free O_2 was absent, so first life was **anaerobic**.
- In the primitive atmosphere free oxygen was present but complete oxygen consumed in composition so primitive atmosphere of earth was **reducing**.
- Oxygen was reproduced by photosynthesis and atmosphere converted in oxydising.

- **Chemical Evolution**

1. **The atomic stage –**

The earth was originated about 4.6 billion years ago. Early earth had free atoms of all elements which are essential for the formation of protoplasm.

The lightest atoms like **carbon, hydrogen, nitrogen and oxygen** formed the primitive atmosphere.

2. **Molecular stage (Origin of molecules and simple Inorganic compounds) –**

Free atoms combined to form molecules and simple inorganic compounds.

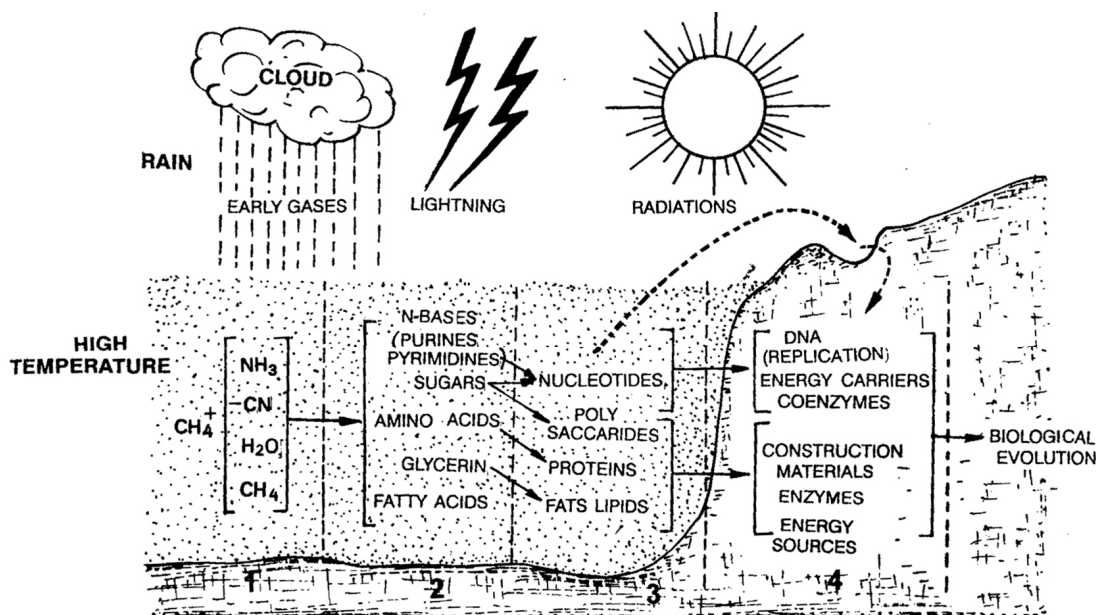
Due to presence of high temperature, active hydrogen atoms combined with all oxygen atoms to form water and leaving no free oxygen.

Thus the primitive atmosphere was **reducing** (without free oxygen) unlike present **oxidising** atmosphere (with free oxygen).

Hydrogen atoms also combined with nitrogen to form NH_3 .

(The first molecular compounds formed were probably water and Ammonia).

These Lighter elements also formed CO_2 , CO , N_2 , H_2 etc.



Evolution of 'Biochemicals' in the origin of life.

3. Origin of early organic compounds –

The nitrogen and carbon of the atmosphere combined with metallic atoms forming nitrides and carbides. Water vapour and metallic carbides reacted to form the **first organic compound Methane (CH_4)**. Later on **hydrogen cyanide (HCN)** was formed.

Water which formed on earth due to high temperature evaporated so **clouds** were formed.

Water vapour changed into rain drops and by the collection of water on earth primitive oceans were formed.

4. Origin of simple organic compounds –

Water of primitive oceans contained large amount methane, ammonia, hydrogen, cyanides, carbides, nitrides.

These early compounds interacted and formed simple organic compounds like, aldehyde, Ketones. Alcohols Pentose and hexose sugar, Amino Acids, Glycerol, Fatty Acids, Purines, Pyrimidines etc.

Energy was obtained from U.V. Rays of sunlight, cosmic rays and heat of volcanic eruptions.

5. Origin of complex organic compounds –

The small simple organic molecules combined to form large complex organic molecules, e.g –

- Amino acids Joined to form polypeptides and proteins, which were non-enzymatic.
- Simple sugar units combined to form polysaccharides.
- Fatty acids and glycerols united to form fats and lipids.
- Sugar, nitrogenous bases, phosphates combined into nucleotides which polymerized into nucleic acid, which unable to replicate.

These macromolecules forms main component of protoplasm hence the possibility of origin of life in primitive oceans could be established.

After long time the water of primitive oceans became rich mixture of organic compounds as a result of chemical evolution.

Haldane called this saturated water of oceans as prebiotic soup or hot dilute soup.

The major requirement for promoting polymerization is the availability of continuous source of energy and removal of water from the surface of reactants so that they can concentrate and prevent depolymerisation.

- **Experimental evidence for formation of simple organic compounds –**

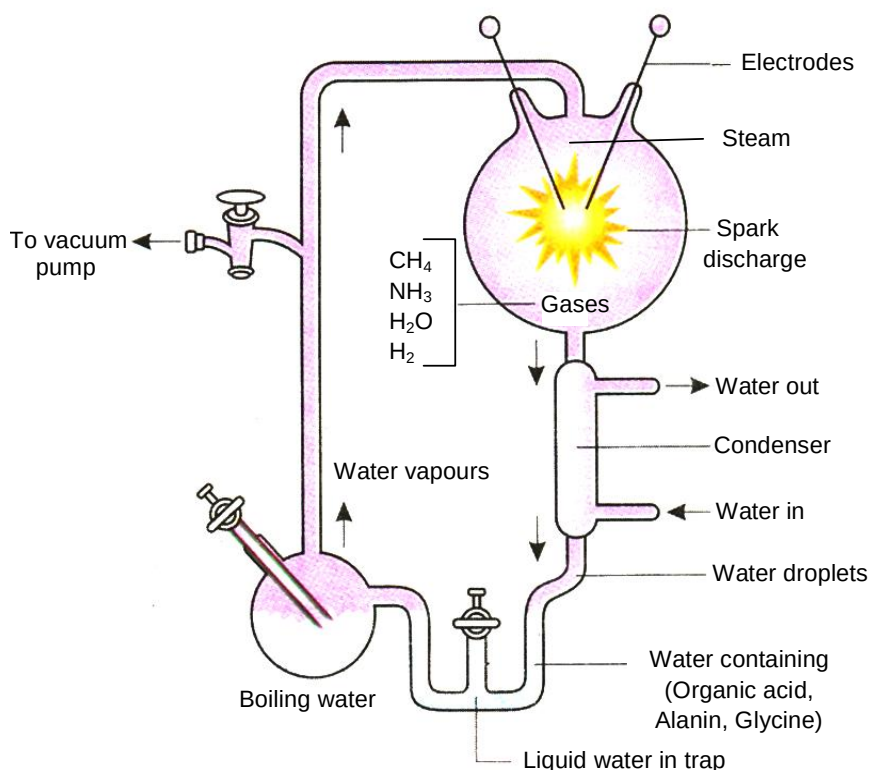
By Stanley Miller who was a student of **Harold Urey**.

In this experiment Miller took the mixture of **methane, ammonia and hydrogen (ratio 2 : 1 : 2)** in a large flask and passed steam over it by boiling water and connecting it with a glass tube.

Electric spark discharged in the mixture by using two tungsten electrodes as **source of energy**.

After **18 days** this fluid was collected and analysed. This dark red fluid was found to contain.

- Simple amino acids – glycine, alanine, aspartic acid.
- Simple organic acids – formic, acetic, oxalic, lactic, succinic acids.
- Pentose, hexose, aldehyde, ketone etc.



Diagrammatic representation of Miller's experiment

BIOLOGICAL EVOLUTION :

1. Origin of Protobionts and Nucleoprotein (Coacervates) :

Macromolecules which were synthesized abiotically in primitive ocean later came together and formed large colloidal drop like structures named as Protobionts (**Later called coacervates by oparin, Fox and called them Microsphere and Deamer called them vesicles**).

Each protobiont was **cluster** of macromolecule.

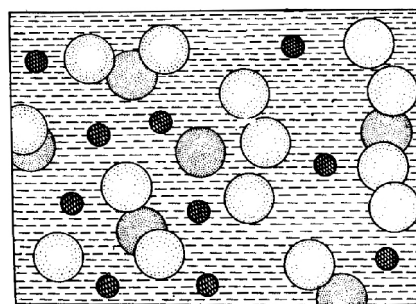
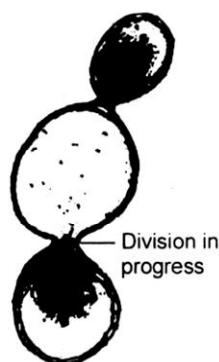
They contain proteins, nucleic acids, lipids, polysaccharides etc.

They grew by absorbing molecules from their environment.

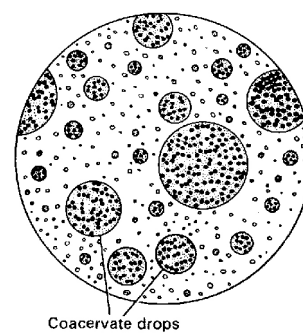
They could divide by budding like bacteria, many chemical reactions including the decomposition of glucose took place inside the protobionts.

The sun provide energy for chemical reaction.

According to oparin **coacervates were the first sole living molecules** which gave rise to cell.



Fox Microspheres



Oparin's Coacervates

Different type of Protobionts obtained by scientists

Oparin (1924) took a solution of carbohydrate and large protein. The solution was shaken. It caused separation of coacervates.

In coacervates higher concentration of protein, carbohydrate were present with small amount of water.

Oparin's coacervates could grow and exhibit simple form of metabolism. However a lipid membrane and reproduction was absent.

Fox (1957) obtain **microspheres** with a primitive membrane. He heated a dry mixture of Amino acids at $130^{\circ} - 180^{\circ} \text{C}$. It formed **PROTEIDS/PROTENOIDS** (Polymer of amino acid).

When these proteids poured in Cool water along with lipids, microsphere get separated. (size $1-2 \mu\text{m}$) **Deamer** (1993) Microsphere and coacervates could fused to form protobionts having various type of chemicals like proteins, Nucleic acids, Carbohydrates etc. enclosed inside a lipid membrane. Deamer called them **vesicles**.

2. Origin of protocells [Eobiont :

The first living form named **protocell** originated in the primitive oceans.

The protocell were clusters of nucleo-proteins which formed by composition of nucleic acids and enzymetic proteins.

Nucleoproteins had the property of self duplication.

Nucleoproteins were first sign of life.

The protocell represented the beginning of life.

From protocells or eobionts few core of nucleoproteins gets separated free in oceans and became inactive but when they enter in another eobionts they became active so virus like structures were formed.

Origin of virus like structure is an example **retrogressive evolution** (complex to simple).

Important

Khorana (1970) *artificially synthesized 77 nucleotide RNA molecule out side a living cell which suggests that probably RNA was the primordial genetic material rather than DNA.*

Zaug, Thomas cech and Altman described that some RNA molecules have enzymatic activity hence probably the RNA enzymes called **ribozymes** were able to replicate the primordial RNA.

The discovery of RNA molecule working as enzyme has also changed our thinking about origin of life.

It is now believed that about 4 billion years ago earth was an 'RNA world' in which RNA molecule carried out all the process of life without the help of either protein or DNA,

By this discovery evolution is named as RNA world.

[CBSE 2002]

(1) It is estimated that life originated about 3.9 billion years ago as protocell (eobionts) in precambrian era which was anaerobic heterotrophic.

3. Origin of Prokaryotes –

As a result of mutation the protocells became more complex and efficient and used the materials available in the surrounding medium and condensed themselves into prokaryotic cells.

Thus the first living being were prokaryotic, like bacteria they were single celled and consisted of naked DNA. Nutritionally they were **chemoheterotrophs** (saprotrophs), respiration was **anaerobic**.

4. Origin of Autotrophism –

It includes the origin of **chemosynthesis** and **photosynthesis**.

(a) Origin of chemosynthesis :

Due to continue withdrawal of organic molecules by chemoheterotrophs organic material decreased in oceans.

Before the organic material disappeared in sea, new modes of Nutrition developed, one of them was **chemosynthesis**.

The organism which perform chemosynthesis are called as **chemoautotrophs**. They were anaerobic and synthesise organic molecules from inorganic material. The energy was obtained by oxidizing inorganic materials present in the sea.

Such mode of nutrition is found in Bacteria e.g. sulphur bacteria, nitrifying bacteria.

(b) Origin of Photosynthesis :

After some time bacteriochlorophyll developed in some autotrophic bacteria like organism.

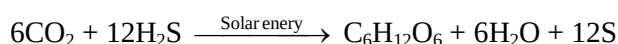
They could absorb solar energy and convert it into chemical form these organism called **photoautotrophs**.

They utilize solar energy in synthesizing organic compounds. The process is called **photosynthesis**.

They were anaerobic and utilized hydrogen from sources other than water like H₂S.

Therefore, no oxygen was evolved and atmosphere remained reducing .

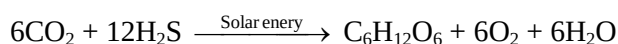
This stage of photosynthetic autotrophism is represented by planktonic sulphur bacteria of today.



The Bacterio chlorophyll by molecular changes formed true chlorophyll.

Such organism which were bearing true chlorophyll are similar to today's **Cyanobacteria (B.G. Algae)**.

They utilized water as hydrogen donor and evolved oxygen.



Oxygen revolution –

Liberation of free O₂ by blue green algae like prokaryotes due to photosynthesis was a revolutionary change in the history of earth. It is called **oxygen revolution**.

It includes important changes like –

(1) Atmosphere of earth changed from reducing to oxidising, hence possibilities of further chemical evolution and abiogenesis got over, because chemical evolution always take place in reducing environment.

- (2) Free O_2 oxidized CH_4 and NH_3 to form gases like CO_2 , N_2 and H_2O .
- (3) Accumulation of free O_2 formed a layer of **O_3 (ozone)** above the atmosphere of earth. Which started absorbing most of the U.V. rays of sunlight.

• Origin of Eukaryotic cell –

About 2.7 billion years ago conditions become suitable for aerobic respiration with the release of free O_2 . Aerobic respiration yields about **20 times more energy** than anaerobic respiration hence the prokaryotes adapted themselves for aerobic mode of respiration.

Nucleus, mitochondria and other cell organelles developed in the cell and free living eukaryotic cell like organism originated about 1.5 billion years ago in the primitive ocean.

1. Free Atoms	H (Hydrogen), C (Carbon), N (Nitrogen)
2. Inorganic Molecules	H_2 (Hydrogen), H_2O (Water), CH_4 (Methane), NH_3 (Ammonia), CO_2 (Carbon Dioxide)
3. Simple organic Molecules	$CH_4 \cdot H_2O \longrightarrow$ Sugars, Fatty acids, Glycerol $CH_4 \cdot H_2O, NH_3 \longrightarrow$ Amino Acids $CH_4 \cdot H_2O, NH_3, HCN \longrightarrow$ Nitrogenous Bases (Purines, Pyrimidines)
4. Complex organic Molecules	Sugar + Sugar $\longrightarrow$ Polysaccharides Fatty Acids + Glycerol $\longrightarrow$ Fats Amino acid + Amino Acid $\longrightarrow$ Proteins Nitrogen Bases + Sugars + Phosphates $\longrightarrow$ Nucleotides, Adenosine phosphates Nucleotides + Nucleotides $\longrightarrow$ Nucleic acids
5. Coacervates or Microspheres	Aggregates of large complex organic molecules capable of growth and division
6. Eobionts	Nucleic Acid—Controlled coacervates
7. First primitive cells	Lipid–Protein membrane-bound units with enzyme-controlled metabolism and nucleic acid regulation without organised nucleus

Special Points :

1. Life originated in water.
2. Atmosphere of earth just before the origin of life consisted of CH_4 , NH_3 , H_2 and water vapours.
3. O_2 was absent in the atmosphere at the time of origin of life.
4. English scientist J.B.S. Haldane worked on origin of life and settled in India.
5. Gaseous mixture used by Miller for synthesis of amino acids through heat and electric discharge included CH_4 , NH_3 , H_2 and water vapours.
6. Moon does not possess life because it is without water.
7. The age of big bang is roughly 104 millions years.
8. Spontaneous generation theory of origin of life was disproved through experiment involving swan neck flasks by Louis Pasteur.
9. Experiment proof that some simple molecules like H_2 , NH_3 , CH_4 and H_2O gave rise to amino acids during origin of life was provided by Stanley Miller.
10. Oxygen was not present freely in the early atmosphere of the earth.

11. Rapid increases in world population in recent times is primarily due to decrease in death rate. (Mortality).
12. Earth originated in the past period of about 4.5 billion years.
13. Experiment to prove that synthesis of organic compounds formed the basis of life performed by Stanley Miller.
14. Present population explosion is mainly due to better health care.
15. Indian population has grown rapidly in the present century because of more children reaching reproductive age.
16. The first organisms were chemoheterotrophs.
17. The scientist associated with formulation of modern theory of origin of life and having written "origin of life" was Oparin [he was Russian Scientist].
18. World population has grown rapidly in the past 250 years because of industrial revolution.
19. Planet nearest to sun is "Mercury".
20. Ozone layer is important as it filters out ultra-violet radiations.
21. Under certain conditions, scientists have got cell like structures but without its true organisation. They are called "Coacervates".
22. The correct sequences during formation of chemicals on early earth is Ammonia, Proteins, Carbohydrate, Nucleic acid.
23. Biogenesis is the name of theory which states that life develops from life.
24. Saturn is a planet of our solar system which has nine moons.
25. An ideal agriculture should lay stress on "Permaculture".
26. Rising of mountain is due to aggregation.
27. N_2 gas is dissolved in blood but has no metabolic OR Chemical activity.
28. Rodents possess growing, Incisors.
29. Panther is the fastest land animal.
30. Coacervates were formed by polymerisation and aggregation.
31. Balance of nature is maintained by photosynthesis and respiration.
32. Our galaxy is Milky-way.
33. Big-bang theory was proposed by "Lemaître".
34. Tethys sea occurred in the region of present day Anas.
35. Organic compounds first evolved on earth required for origin of life were protein and nucleic acids.
36. CH_4 was a compound who important in prebiotic evolution.
37. Approximate age of earth is 4600 million years.
38. Nucleic acids are the most essential for origin of life.
39. Chemical theory of origin of life was given by Oparin and Haldane.
40. Oldest rock is dated 3.8 billion years.
41. Flow of energy in ecosystem is unidirectional.
42. Father Saurez was one of the greatest advocates of the theory of special creation.
43. Cyanobacteria - like organisms developed on earth 3600 billion years ago.
44. Presence of NaCl in fluid indicates that life originated in primitive ocean.
45. Theory of spontaneous creation was supported by Van Helmont.
46. Protobiogenesis occurred more than 3.5 billion years ago.

47. Evolution up to formation of coacervates termed as **chemical evolution**, in which complex organic compound were formed which were essential for formation of cellular structure.
48. Evolution from coacervates to simple cell structure known as **biological evolution**.
49. From simple cell to recent....evolution is called **organic evolution**, in which organism developed structures and modified them by which they became more adaptive in their changing environment.
50. First protein which is formed during evolution in primitive oceans were not structural.
51. First nucleic acid which was formed in primitive oceans from combination of nucleotides, did not have power of replication. They obtained power of replication later by mutation.
52. Evolution term introduced by - **Herbert Spencer**.
53. **What is evolution ?**
The word evolution means to unfold or unroll or to reveal hidden potentialities. Evolution simple means an orderly change from one condition to another.
54. **Stellar Evolution** –
Changes in planets and stars from their origin to death.
55. **Inorganic evolution** – The matter, elements change in time called Inorganic evolution.
56. Evolution is a slow but continuous process which never stop-**Buffon**.
57. **Dollo's law** – it states that evolution is irreversible.
58. According to **Theodosius Dobzhansky** (1973), nothing in biology makes sense except in the light of evolution.
59. **Scala nature or ladder of nature** : –
Aristotle represented the evolution of complex organism from simple organism in the form of a ladder which is called **Scala Nature or Ladder of nature**.
He kept simple organism at the bottom of ladder and complex organism at the top of this ladder.
George Cuvier studied the evolutionary history of organism by studying fossils and rejected Scala nature.
60. **The history of life actually comprises two events** :
(i) The origin of life
(ii) Evolution of life [the mechanism involved in the changes of living organisms through time]
61. Two great themes of evolutionary biology :
(i) The diversity of life, including both the differences and similarities.
(ii) The characteristics of organism, both adaptive and non-adaptive.
62. For origin of life, at least **three conditions** needed to have been fulfilled.
(i) There must have been a supply of replicators i.e. self producing molecules.
(ii) Copying of these replicators must have been subject to error via mutation.
(iii) The system of replicators must have required a perpetual supply of free energy and partial isolation from the general environment.
63. Cosmology–Study of universe.
64. Biological evolution is also known as biogeny.
65. Unit of evolution is population.
66. Oparin's theory also known as primary abiogenesis.
67. Evolutionary biology-Study of history of life forms on earth.

ORGANIC EVOLUTION

1. Though life originated by chemical evolution on primitive earth, was later replaced by organic evolution.
2. Organic evolution states "Descent with modification". i.e. the present day complex organism have evolved from earlier simpler organism by small but gradual changes which have occurred over millions of years.
3. Though living organisms show diversity in size, structure, function, behaviour etc. they also show basically similar metabolic processes indicating **common ancestry**.
4. Concept of evolution was given by Empedocles. He is also called **founder of concept of evolution**. But Buffon explained the organic evolution properly & scientifically. Thus father of evolutionary concept is Buffon.

Evolution can be of following types :

(a) Progressive evolution : Evolution from simplicity to complexity

(b) Retrogressive evolution : Evolution from complexity to simplicity

Example :

Virus : Virus was originated from bacteria which were intracellular obligate parasites.

(c) Microevolution : Changes in variety or subspecies due to crossing over or Gene mutation Microevolution – changes below the species level.

(d) Macroevolution – (Changes in Genus or Species) When there is a change in species or Genus due to evolution. In this there is a major change in chromosome number

(e) Megaevolution : Changes in **Family** or **Order** or **Class** is called Megaevolution.

(f) Convergent evolution : Same character in different groups of animals

Example : (Analogous organ) Wings are present in insects, birds and bat but they all are from different groups

(g) Divergent evolution : (Adaptive radiations) Development of different structure from same part of ancestors. **Example :** Homologous organ Limbs of horse, hands of man, wings of bat. They all have same origin.

Development of different structure from same part of embryo. Only there is change in external morphology but internal morphology remains same.

EVIDENCES OF ORGANIC EVOLUTION

SOME IMPORTANT EVIDENCES

1. Palaeontological Evidences
2. Morphological and Anatomical Evidences
3. Evidences from vestigial organs
4. Evidences from connecting links
5. Evidences from Atavism (Reversion)
6. Evidence from physiology and biochemistry
7. Evidences from bio geographical distribution

8. Evidences from Embryology

9. Evidences from Taxonomy

1. Palaeontological Evidences –

The study of fossils is known as : **Palaeontology.**

Fossils word : **Taken from Fossilis/Fossilium**

Father of palaeontology : **Leonard da vinci**

Founder of modern palaeontology : **George cuvier**

Birbal Sahni is famous for Indian palaeontology.

He is father of **Indian Palaeobotany.**

Birbal Sahni Institute of Palaeobotany (BSIP) situated in Lucknow.

Two branches of palaeontology –

1. **Palaeobotany** : Study of plant fossils

2. **Palaeozoology** : Study of Animals fossils

Definition of Fossils was given by Charles Lyell "Impression of past found in Rocks called fossils" **fossils provide one of the most acceptable evidence in support of organic evolution.**

• Types of Rocks –

(a) Sedimentary Rocks –

These are formed at the bottom of ancient oceans by deposition of sediments of sand, lime, coal and minerals which slowly change into hard layers .

Sedimentary rocks are also called as stratified rocks. Eg. Lime Stone, Sand Stone.

Fossils are mostly found in sedimentary rocks.

(b) Igneous rocks –

Such rocks are formed by ancient volcanic deposits which slowly cooled down and hardened as rocks.

Fossils are absent in it.

e.g. **Granite rocks.**

(c) Metamorphic rocks –

These are formed by change in chemical composition of sedimentary rock and igneous rocks or metamorphosis. Such metamorphosis may be caused by pressure heat and physical movements. e.g.

Marble Slate rocks. Fossils are also absent in it – due to chemical changes in the fossils are destroyed.

• Type of Fossils :

(a) Unaltered Fossils :

In this type whole bodies of extinct organisms are found frozen in ice at the polar regions eg. Woolly mammoths (25000 yrs before extinct fossils were found from Siberian region)

(b) Petrified fossils – Most common type of fossil.

Replacement of organic part by mineral deposits is called **petrification.**

These fossils consist of only the hard parts e.g. bones, teeth, shells, wood etc. of extinct organisms.

In human body first fossilization occurs of teeth.

(c) Mould fossils –

Here no part of the original organism is present, only an impression of the external structure of body is preserved in wet soil.

(d) Cast fossils –

Sometimes minerals fill in the mould, resulting in cast fossils

(e) Print Fossils –

Foot print or prints of wings, skin, leaves, stems etc made in soft mud which subsequently become fossilized are a common type of fossils.

(f) Coprolites –

These fossils include the fossil preservation of contents of the intestine or excreta of many ancient animals including particularly the reptiles or fishes.

By studying fossils following facts about organic evolution are evident –

1. Fossils found in older rocks are of **simple type** and those found in newer rocks are of **complex types**.
2. In the beginning unicellular protozoans were formed from which multicellular animals evolved.
3. Some fossils represent connecting links between two groups
4. Angiosperms among plants and mammals among animals are highly developed and modern organisms
5. By fossils, we can study the evolutionary pedigree of an animal like stages in evolution of horse, elephant and man etc.

• **Archaeopteryx –**

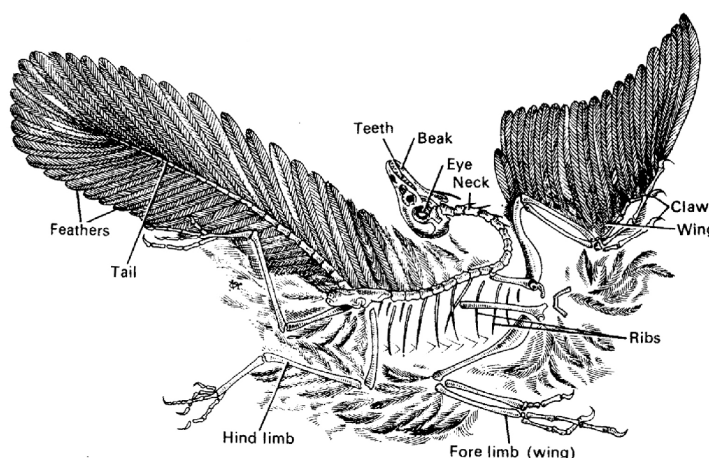
Fossil connective link between birds and reptiles. Fossil was discovered by **Andreas Wagner** from **Bavaria** in Germany. It was found in the rocks of the **Jurassic period**.

• **Reptilian Characters :**

- (a) Long tail is present
- (b) Bones were not pneumatic.
- (c) Presence of weak sternum.
- (d) Presence of free caudal vertebrae is found in Lizard.
- (e) Teeth present in Jaws.

• **Avian Characters :**

- (a) Presence of feathers on the body
- (b) The two jaws were modified into beak
- (c) The fore limbs were modified into wings
- (d) The hind limbs were built in the typical avian plan.



Fossils of Archaeopteryx

“Age of Fossils” or “Dating of fossils” or “The clock of the Rock”

The fossils give valuable information about the history of organic evolution by giving information about the organisms which existed in the past.

This is possible only if the correct age of the fossils can be determined. Methods have been developed to find out the correct age of the fossils by determining the age of the rocks where the fossils are found.

Rocks have been found to contain certain radioactive elements which lose their radioactivity and change into other nonradioactive isotopes at a fixed rate irrespective of the environmental conditions prevailing at different times.

If the rate of this loss of radioactivity of an element is known, the relative proportions of the Quantities of radioactive and nonradioactive element in a given rock will enable us to find out the age of the rock.

This method is called **absolute dating**.

This will be illustrated with the help of four different methods.

- (1) Lead method
- (2) Radio-carbon method
- (3) Potassium – Argon method
- (4) Electron spin resonance method (ESR method)

Potassium ⁴⁰ → Argon ⁴⁰

Carbon ¹⁴ → Nitrogen ¹⁴

Uranium ²³⁸ → Lead ²⁰⁷

Rubidium ⁸⁷ → Strontium ⁸⁷

Thorium ²³² → Lead ²⁰⁶

Fossils park of India –

1. Birbal sahani institute of palaeobotany, Lucknow.
2. 50 million year old fossil forests preserved in mandla district Madhya Pradesh.
3. 100 million year old fossil forest in rajmahal hills Bihar.
4. 260 million year old Coal forming forest in Orissa.

Important living fossils

1. <i>Peripatus</i> (Arthropoda)	2. <i>Limulus</i> (Arthropoda)
2. <i>Nautilus</i> (Mollusca)	4. <i>Neopilina</i> (Mollusca)
5. <i>Lingula</i> (Brachiopoda)	6. <i>Latimeria</i> (Coelacanth fish)
7. <i>Sphenodon</i> (Reptilia)	8. <i>Didelphis</i> (Opossum)

Geological Time Scale – Firstly given by Giovanni Avduina.

Chronological order of the history of organic evolution, which is presented in the form of geological time scale.

This time scale includes the history of earth itself ever since it was formed to formation of its crust from lava of ancient volcanic eruptions.

The period between the origin of gaseous cloud (4.6 billion years ago) from which the earth was formed and the formation of earth's crust is called **Azoic Era** (era of no life).

The remaining period (about 4.0 billion years) is divided in to five Eras namely –

1. Archaeozoic 2. Proterozoic 3. Palaeozoic 4. Mesozoic
5. Coenozoic

The Archaeozoic Era had "**invisible life**" and the remaining four era had "**visible life**" (**Phanerozoic**). Archaeozoic and proterozoic eras are also grouped together as Precambrian because the first part of palaeozoic is Cambrian.

The three eras namely palaeozoic, mesozoic and coenozoic, each is further divided into smaller time spans called **Period** and the periods of coenozoic era are each further subdivided into **Epochs**.

It is also believed that each era of earth's history started with a **revolution or cataclysm** and ended with yet another revolution.

These revolutions meant intense geological disturbances that occurred on earth, so that most of the pre-existing organisms perished in each revolution and the few remaining ones evolved into new and varied organisms.

The first great revolution is believed to have occurred between archaeozoic and proterozoic eras.

The second great revolution between proterozoic and palaeozoic eras.

Appalachian revolution between palaeozoic and Mesozoic eras.

Finally the rocky mountain revolution between Mesozoic and coenozoic eras.

GEOLOGICAL TIME SCALE					
Era	Period	Epochs	Duration	Animals sequence	Plant sequence (vegetation)
COENOZOIC (AGE OF MAMMALS)	QUATERNARY	Holocene of recent (Age of man)	Continuing Till date	Mental age, supremacy of man	Increase of herbaceous Plants evolution of monocots
		Pleistocene	7.0 lakh years	Human appear, Appearance of social life of man decline of giant mammals	Increase of herbs and grasses
	TERTIARY	Pliocene	1.32 crore years	Apelike ancestor of human appeared	Evolution of herbaceous plants
		Miocene (Golden age of Mammals)	1.1 crore years	Mammals at height of evolution evolution of man like apes and other mammals, like sheep, goat, dogs, elephant.	Land or terrestrial plants evolved.
		Oligocene	1.9 crore years	Anthropoid apes evolved from monkeys, crocodiles	Rise of monocots.
		Eocene	1.2 crore years	Evolution of diversified placentals, ancestors of hoofed carnivores marine mammals, and birds	Beginning of grassy plants flowering plants spread into forests.
		Palaeocene	8.0 lakh years	Evolution of insectivorous smaller mammals, carnivorous mammals.	Forests of angiosperm
				ROCKY MOUNTAIN REVOLUTION	
MESOZOIC (AGE OF REPTILES)	CRETACEOUS		7.1 crore years	Extinction of dinosaurs and primitive birds. First modern birds appeared. Primitive placental mammals like insectivorous shrews originated	Beginning the evolution of dicots. Angiosperms appeared
	JURASSIC		5.4 to 5.9 crore years	Giant reptiles like dinosaurs were at peak, evolution of toothed birds like Archaeopteryx , marsupials evolved from prototherians.	Evolution of gymnosperms was at peak
	TRIASSIC		3.5 crore years	Origin of first oviparous prototheria mammals, dinosaurs, flying reptiles.	Forests of Conifers, cycads and other gymnosperms.
				APPLICATION REVOLUTION	
PALAEOZOIC	PERMIAN		5 crore years	extinction of trilobites, origin of mammal like reptiles	Among gymnosperms Evolution of conifer trees.
	CARBONIFEROUS		6.5 crore years	Abundance of sharks, bony fishes and lung fishes. Appearance of first amphibians	Ancestral gymnosperms & ferns dominated bryophytes originated Origin of first seed plant.
	DEVONIAN (age of fishes)		5 crore years	Origin and evolution of sharks, bony fishes and lung fishes. Appearance of first amphibians	Giant clubmoss.
	SILURIAN		3 to 4 crore years	Evolution of arthropods, insects, jawless primitive fishes evolved.	Celophytes and land ferns were in large number. Origin of vascular plants.
	ORDOVICIAN		6 to 7 crore years	Origin of jawless. fishes in fresh water. Abundance of giant molluscs branchiopods, and trilobites Echinoderms. First vertebrates.	Plants reached fresh water. Marine plants abundant.
	CAMBRIAN		7 crore years	Trilobites and brachiopods were dominant . Echinoderms were also present. No life on land.	Marine bacteria colonial, multicellular filamentous algae evolved in oceans.
				SECOND GREAT GEOLOGICAL REVOLUTION	
PROTEROZOIC			1.93 billion years	Invertebrates like protozoa, coelenterate, sponges annelida and mollusca evolved.	Single celled bacteria and blue green algae evolved in sea .
ARCHAEOZOIC			1.5 billion years	Origin of life in sea from organic materials Prokaryotes (monera) and Eukaryotes (Protista) evolved and diversified	Prokaryotic form of life formed blue green algae originated.
AZOIC			1.0 billion years	No life. Only chemical evolution took place.	

2. Morphological and Anatomical Evidences –

Different animals and plants show dissimilarities in their structure but in some characters they show similarities. These similarities are of two types.

1. Homology
2. Analogy

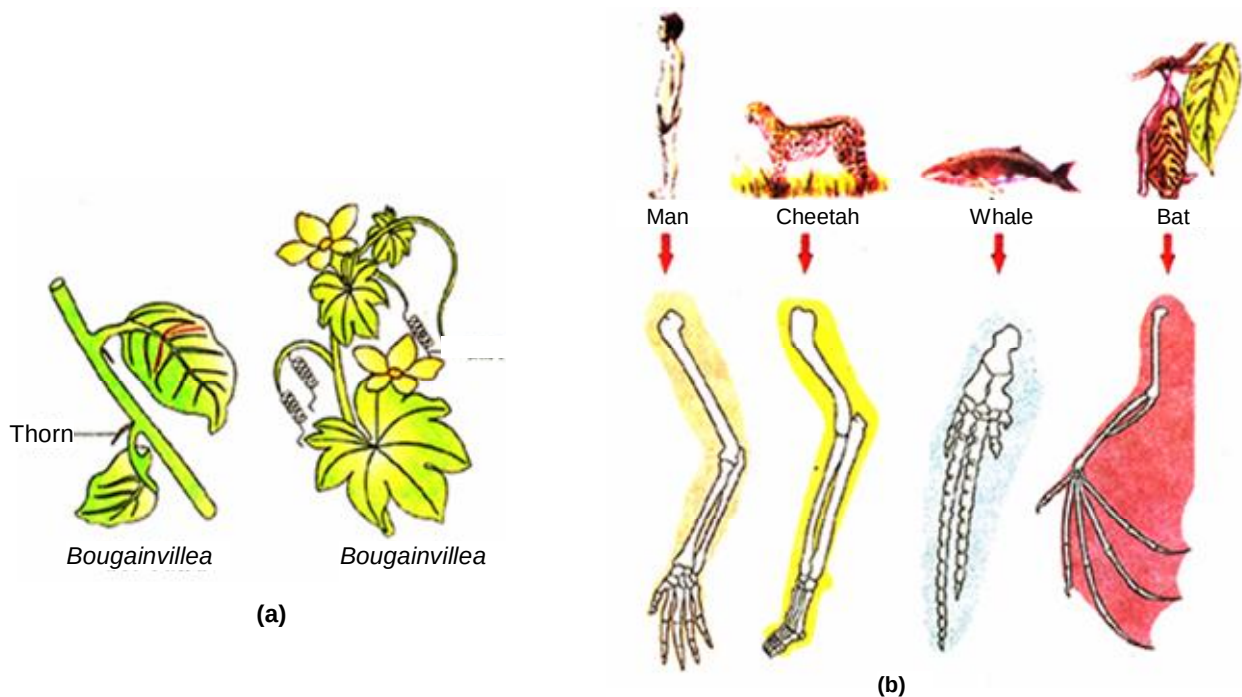
1. Homology –

The similarity based on common origin, similar basic plan of organization and embryonic development is called **homology**.

Similarity in appearance and function is not necessary.

The organs which have common origin, embryonic development and same basic structure but perform different functions are called **Homologous organ**. **Homologous term given by Richard Owen.**

Examples of Homologous organs –



Example of homologous organs in (a) Plants and (b) Animals

(i) Forelimbs of mammals –

	Horse	Bat	Whale	Seal	Man
Appearance	Foot	wings	Paddle	Flipper	Hand
Function	Running	Flying	Swimming	Swimming	Holding

In their fore limbs similar bones are present like – **humerus, radius, ulna, carpal, metacarpals and phalanges.**

(ii) Legs of invertebrates –

Cockroach	Honey bee
Walking	Collecting of pollens

But in both segmented legs are present are segments are same like **coxa, Trochanter, Femur, tibia, 1-5 jointed tarsus.**

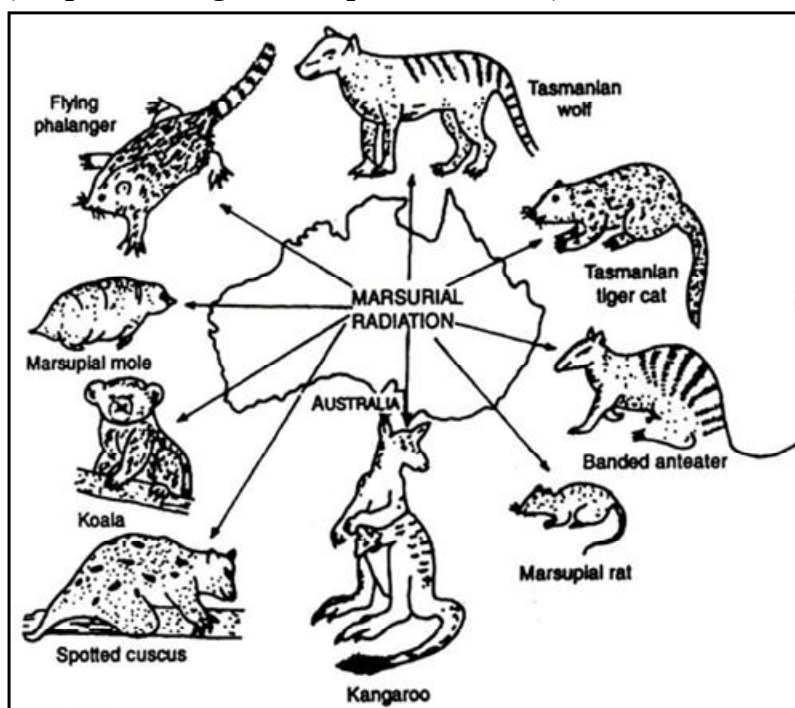
(iii) Mouth parts of insects

Cockroach	Honey Bee	Mosquito
Biting and chewing	Chewing and lapping	Piercing and sucking

In each of these insects the mouth parts comprise **labrum, mandibles and maxillae.**

- (iv) **Homology** is also seen in the skeleton, heart, blood vessels and excretory system of different vertebrates.
- (v) **Thorn of Bougainvillea and tendril of cucurbita (Modification of axillary bud).**
- (vi) Wings of sparrow and pectoral fins of fish.
- (vii) Hind limb of mammals.
- (viii) Potato & ginger.
- (ix) Radish & Carrot
- (x) Homology is also seen amongst the molecule. This is called **molecular homology**. For example the proteins found in the blood of man and apes are similar.
- (xi) Testes in male and Ovaries in female develop from same embryonic tissue.
- (xii) Pectoral fin of fish and flipper of seal.
- (xiii) Flipper of penguin (bird) and dolphin (mammal)

Divergent evolution (adaptive divergence/adaption radiation)



Homology found in different animals indicate their evolution from common ancestors.

Species which have diverged after origin from common ancestor giving rise to new species adapted to new habitats and ways of life is called **adaptive radiation**, exhibit large number of homologous organs.

Homology shows **Divergent evolution**.

For Example Adaptive radiation gave rise to a variety of marsupials in Australia.

2. Analogy –

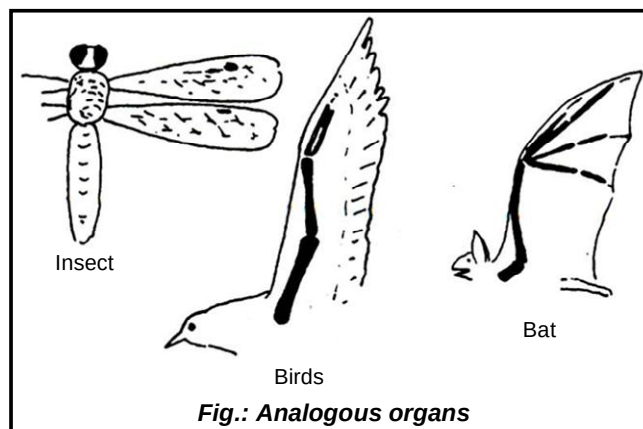
It is similarity in organs based on similar function.

Organs which have different origin and dissimilar fundamental structure but have similar function are called **Analogous organs**.

Examples of Analogous organs –

- (i) Wings of bat & birds are analogous to wings of insects.
- (ii) Pelvic fins of fish, flipper of seal
- (iii) Sting of bee and scorpion.
- (iv) Phylloclade of Ruscus and leaf
- (v) Chloragogen cell of pheretima and liver of vertebrate

- (vi) Hands of man and trunk of elephant
- (vii) Potato and sweet potato.
- (viii) Eyes of Octopus and eyes of mammals (different in their retinal position).
- (ix) Dog fish and whale.



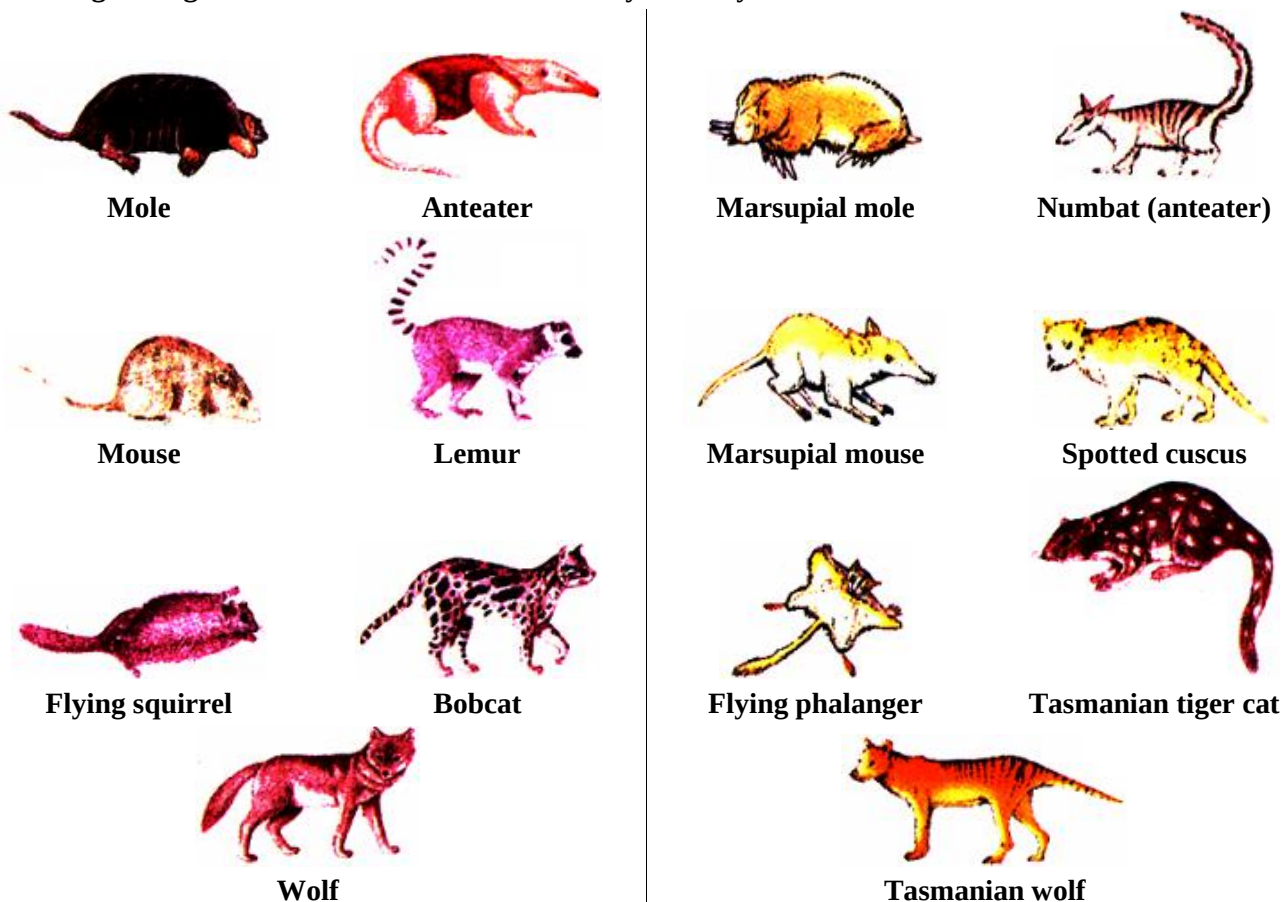
Convergent evolution (adaptive convergence/parallel evolution)

Development of similar adaptive functional structures in unrelated groups of organisms is called **convergent evolution**.

For Example : Some of the marsupials of Australia resemble equivalent placental mammals that live in similar habitats of other continents.

When adaptive convergence is found in closely related species, it is called **parallel evolution**.

Analogous organs do not show common ancestry but they show evolution.



Picture showing convergent evolution of Australian Marsupials and placental mammals

3. Evidences from vestigial organs –

The organs which are present in reduced form and do not perform any function in the body but correspond to the fully developed functional organs of related animals are called vestigial organs.

They are remnants of organs which were complete and functional in their ancestors.

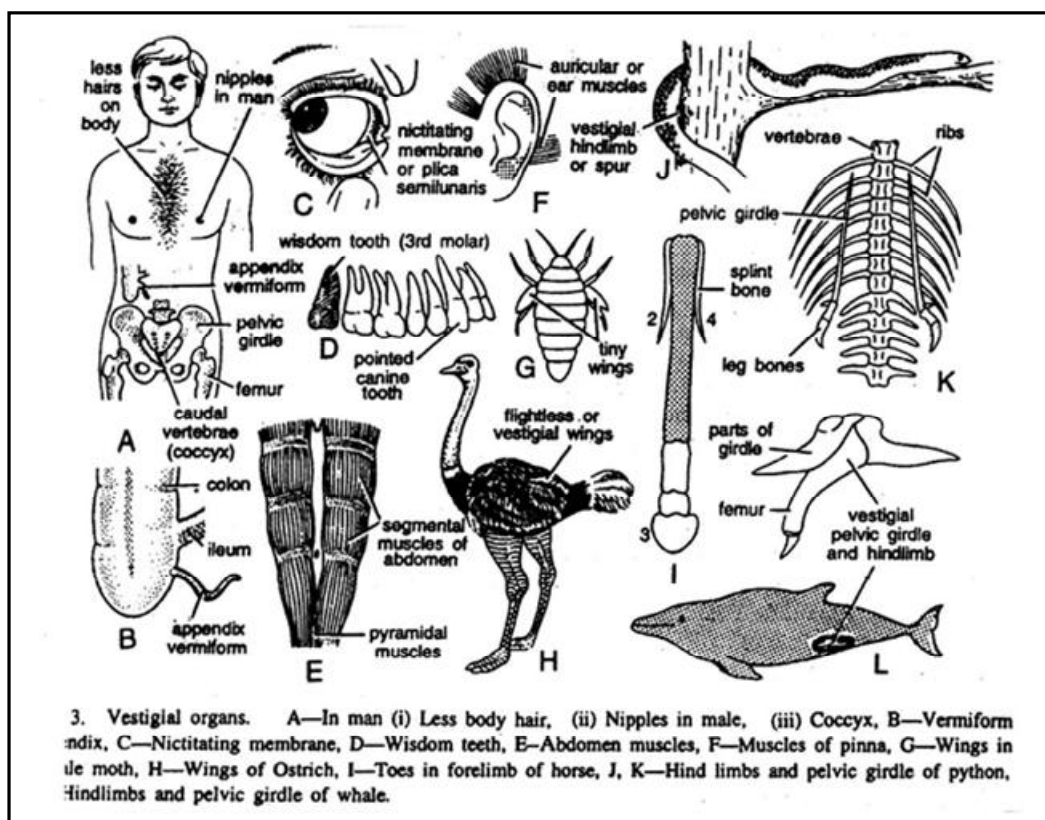
Vestigial organs in Human body –

Human body possesses about 180 vestigial organs

- | | |
|---------------------------------|---|
| eg. a. nictitating membrane | b. muscles of pinna (auricular muscles) |
| c. vermiform appendix | d. coccyx |
| e. canine teeth | f. third molars (wisdom teeth) |
| g. segmental muscles of abdomen | h. caecum |
| i. body hairs | j. nipples in male |
| k. ear pinna | |

Vestigial organs in other animals –

- Hind limb and pelvic girdle of python
- wings of flightless birds such as ostrich, Emu, Kiwi, Dodo, Reha etc. (Dodo recently extinct)
- Eyes of deep sea fishes
- splint bones in feet of horse [2nd and 4th finger]
- external ear in whale
- rudiment of reptilian jaw apparatus.
- Hindlimb and pelvic girdle of whale.



Vestigial organs in plants –

Scale leaves of *Ruscus* and various underground stems.

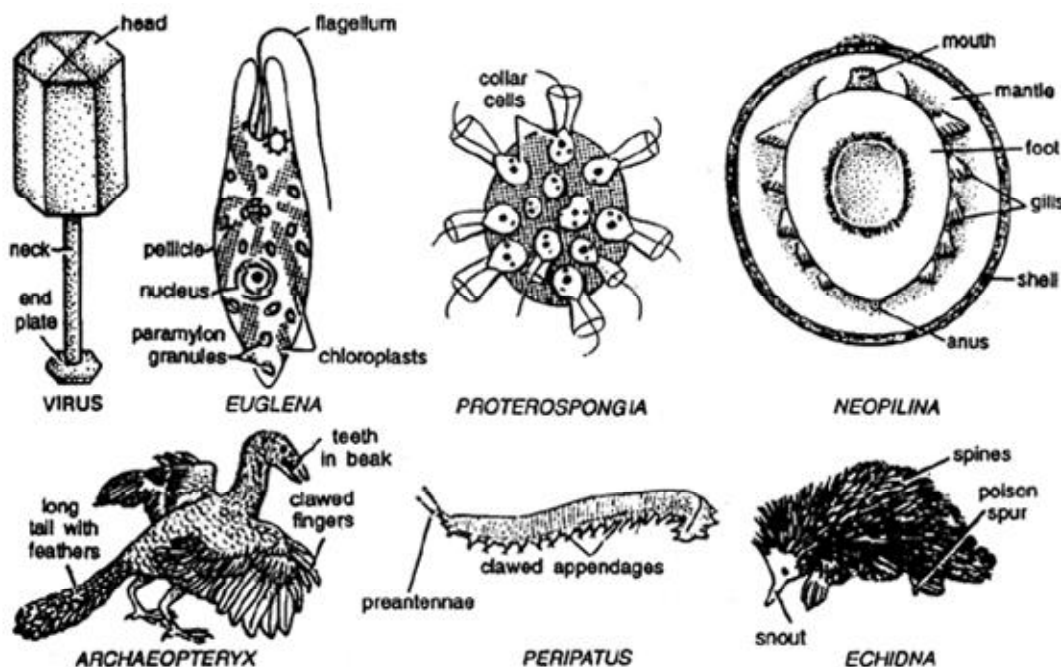
Vestigial organs are example of Lamarckism (Theory of inheritance of acquired character)

4. Evidences from connecting links –

Some animals and plants possess characters of two separate groups. One being primitive and the other is advanced group.

These species as bridge between two taxonomic groups such organism are called **connecting link**. They provide good example of organic evolution of common ancestry.

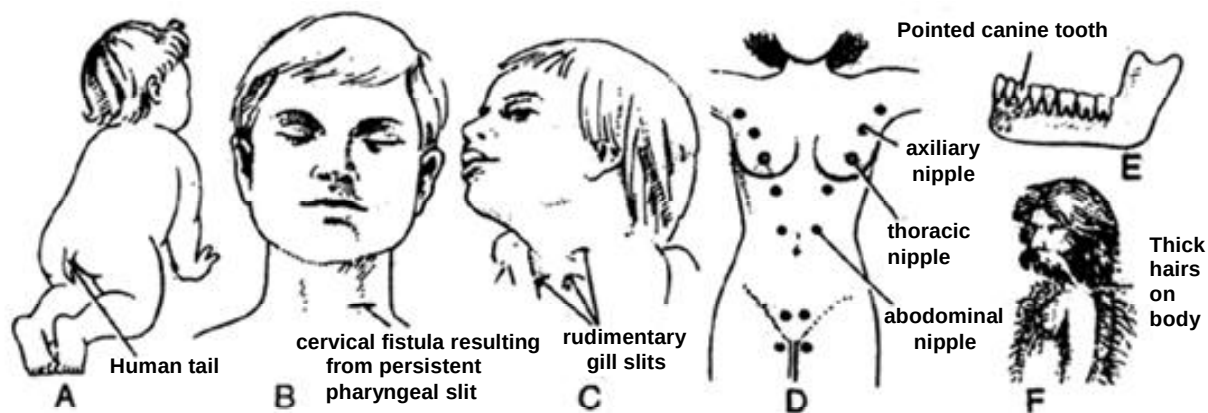
- (i) **Virus** : between living and non living
- (ii) **Euglena** : Between plants and animals
- (iii) **Proterospongia** : Between protozoa and porifera
- (iv) **Neopilina** : Between mollusca and annelida
- (v) **Peripatus** : Between Annelida and arthropoda
- (vi) **Archaeopteryx** : Between reptiles and birds
- (vii) **Balanoglossus** : Between nonchordates and chordates
- (viii) **Chimera** : Between cartilaginous fish and Boney fish
- (ix) **Lung fish (Protopterus)** : Between fishes and amphibia
- (x) **Platypus** : Between reptiles and mammals
- (xi) **Echidina** : Between reptiles and mammals.



5. Evidences from Atavism (Reversion) –

Sometimes in some individuals such characters suddenly appears which were supposed to be present in their ancestors but were lost during the course of development.

This phenomenon is known as **atavism or reversion**. Atavism proves that animals developing atavistic structure have evolved from such ancestors in which these structures were fully developed.



Some human atavistic characters. A–Human baby with tail, B,C–Cervical fistula or rudimentary gill-slits, D–Additional nipples, E–Pointed canine tooth, F–Thick hair on body.

Examples :

1. **Human baby with tail**
2. **Cervical fistula** – in some human babies an aperture is present on neck behind the ear called as cervical fistula. It represents pharyngeal gill slits which were present in aquatic vertebrate ancestors.
3. **Long and pointed canine teeth represented carnivorous ancestors.**
4. **Large and thick body hair reflect our relationship with apes.**
5. **Extra nipples (more than two)**
6. **Evidence from physiology and biochemistry –**

Different organism show similarities in physiology and biochemistry. Some clear examples are –

1. **Protoplasm** : Structure and chemical composition of protoplasm is same from protozoa to mammalia.
2. **Enzymes** : Enzymes perform same function in all animals like **Trypsin** digest protein from amoeba to man. **Amylase** digest starch from porifera to mammalia.
3. **Blood** : Chordates show almost same composition of blood.
4. **ATP** : This energy rich molecule is formed for biological oxidation in all animals.
5. **Hormones** : Secreted in different vertebrates performs same function.
6. **Hereditary material** : Hereditary material is DNA is all organism and its basic structure is same in all animals.
7. **Cytochrome C** is a respiration protein situated in the mitochondria of all organism. In this protein from 78-88 A.A. are identical in all organism, which show common ancestry.

Physiology and biochemistry thus prove that all animals have evolved from some common ancestor.

7. Evidences from bio geographical distribution –

The study of geographical distribution of animal and plant species in different parts of earth is called **Biogeography**.

Different animal species occurring in an area are called **Fauna** and those of plants are called **Flora**.

On the basis of fauna and flora **Alfred Russel Wallace** divided the whole world into six major biogeographical regions called **realms**.

Nearctic : North America from Mexican highlands to Arctic islands and Greenland.

Palaearctic : Europe, North Asia up to Himalayas and North Africa up to Sahara desert.

Neotropical : Central and South America, Mexican lowlands and West Indies.

Oriental : Asia, South of Himalayas; India, Ceylon, Malay, Peninsula, Sumatra, Bornea, Java, Celebes and Philippines.

Ethiopian : South Africa from Sahara Desert, Madagascar and Adjacent islands.



Fig.: Zoogeographical realms

Australian : Australia, Tasmania, New Guinea, New Zealand and Oceanic islands of the Pacific. It is believed that millions of years ago all the continents were present in the form of a single land mass called **Pangaea**.

Later on due to various geological changes, these continents drifted from one another.

As these continents moved away, they got separated from each other by the seas. As these continents had different environmental conditions so plants and animals evolved there were of different varieties. (**New species**).

Palaeartic and oriental realms are separated by high Himalayan Mountains.

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1. Prototheria –

This is sub class of mammalian, which includes egg laying mammals like **Platypus** and **Echidna** found in Australia.

After the evolution of prototherians from reptiles Australia got separated from mainland of Asia.

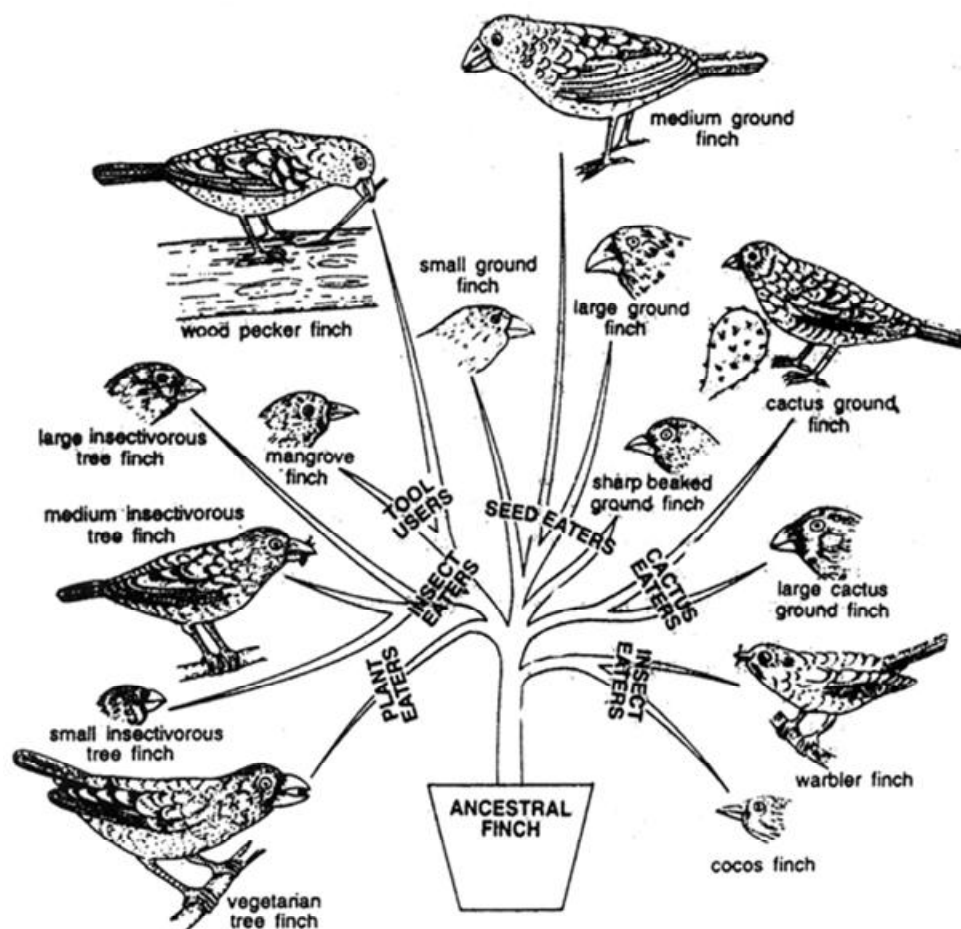
Later on Eutherian mammals evolved in Asia, Due to their carnivorous nature they destroyed prototherians and metatherians from Asia.

So these groups became extinct on the mainland but they survived in Australia due to absence of Eutherians.

Today eutherians are also found in Australia (**they were later transported by man**).

2. Marsupialia – The subclass of class mammalian includes kangaroos and Opossum which are found only in Australia.

3. Darwin's finches – Darwin studied Fauna and Flora of Galapagos island situated near south America (consisted 22 islands). Here he saw 22 types of finches (birds) .



Darwin's finches

A related species of these birds were also present in South American continent.

Probably some member of this species migrated to Galapagos island where these birds evolved into different species as a result of adaptation to environment.

These birds are now known as **Darwin's Finches**.

Darwin described that a particular species is evolved in a particular area, progenies of this species migrate to different geographical areas and are gradually adapted to changing environmental conditions.

These adaptations gradually give rise to new species as a result of isolation.

Special Point :

- *Darwin's finches are also an example of adaptive radiation (different shape of beak and claws due to their habitat)*
 - *Darwin's finches are example of allopatric speciation.*
4. Elephants and lions are mainly found in Africa and India.
 5. Giraffe, Zebra and hippopotamus are found only in Africa.
 6. Main land of human evolution in Africa.

Important Point :

Palaeontological and Biogeographical evidences are considered as best evidences in support of organic evolution.

8. Evidences from Embryology –

Baer's Law : An organism show its ancestor stages in embryonic development. In embryonic stage general characters appear first then specialized characters appear.

Muller : First to propose '**Recapitulation theory**'.

- According to it '**ontogeny recapitulate phylogeny**' it means any organism show its ancestral adult stages during its embryonic development.

It shows that all organism evolved from a common ancestor.

- Ernest Haeckel explained it in detail and gave the name '**Biogenetic law**'

Examples : -

- (a) The Zygotes from which the development of all metazoan bodies starts, are single-celled and quite comparable with the Bodies of simple protozoans.

This indicates the origin of **Metazoans from Protozoan Ancestors**.

- (b) The early stages of Embryonic development, Viz. Morula, Blastula and gastrula are Basically similar in all metazoans, indicating a **Monophyletic Origin** of the latter.

- (c) The Phylogenetically earliest metazoans i.e., the sponges and cnidarians, have retained early gastrula like double – layered (Diploblastic) structure of Body of Metazoans.

- (d) In fishes, the young individual, developing from gastrula, is almost-like the adult, but the tadpole larvae of Amphibians bear more resemblance to the young once of fishes than to their own Adults. This indicates **Origin of Amphibians from fishes**.

- (e) Even after gastrulation in the vertebrates, the early postgastrula stages are quite similar in members of all the different classes, Viz, fishes, amphibians, reptiles, birds and mammals.

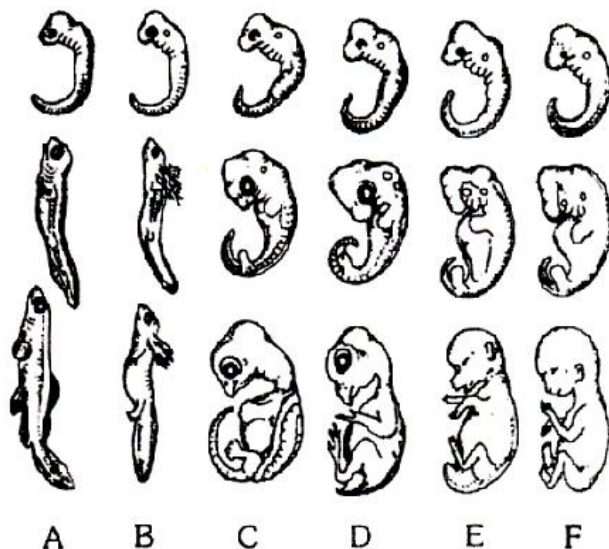
The differentiation of class characters appear in later stages, moreover, the embryo of phylogenetically higher vertebrates pass through the adult stages of lower vertebrates before finally attaining the characters of their respective classes.

This proves that **All Vertebrates** have evolved from common fish like Ancestors and also that both Birds and mammals have evolved from reptiles.

- (f) When the heart develops in the embryos of Amphibians, reptiles, Birds and Mammals, it is 2-chambered same as in the embryos and Adults of fishes. In later stages of Embryonic development in Amphibians, reptiles, the heart become, 3-chambered. In Birds and Mammals the heart is 4-chambered in the last embryonic stages to continue as such in the Adults.

- (g) Modern Scientists have discovered "Biochemical recapitulation" also.

For example, fishes mainly excrete Ammonia. Adult Amphibians Excrete urea, but their tadpoles excrete Ammonia like the fishes.



Comparison of stages in the development of vertebrate embryos. A. Fish, B. Salamander, C. Tortoise, D. Chick, E. Calf, F. Human

Birds excrete uric acid, but their embryos excrete first Ammonia and then urea during earlier stages.

- (i) In embryonic stage birds showed tooth buds for some time, which became extinct later. It shows that birds evolved from toothed reptile like ancestors.

9. Evidences from Taxonomy –

Plants and Animals show a great diversity of form. They also show some similarities among themselves. It is on account of these differences and resemblances that the taxonomists have been to arrange the living things in to smaller and larger groups.

This the taxonomists have recognized that there are about 250,000 different kinds of plants. These different kinds are called species.

The members of each species recognized by their close resemblance to one another, their differences being of a minor type.

Amongst species also there are differences and resemblance of varying degree. Some species resemble one another more closely than they resemble others and form a closely related group.

Similarly, there are other groups of closely resembling species.

The members of each group resemble each other more closely than they resemble the members of other groups.

Each such group of species is called a genus. Genera also show different degrees of resemblances amongst themselves.

Those that resembles one another more closely than others are placed in a large group called a family.

Families are grouped in to larger units called orders, orders into classes and classes in to Phyla.

Evolution has a ready explanation for this system of grouping or classifying plants and animals in groups indicates relationship.

Special points : -

1. The aquatic mammals [eg. **Dolphins, Whales, Seals, Porpoises** etc.] don't have gill slits-**because their adaptation to aquatic life is secondary.**
2. In Acacia tree well developed compound leaves are found. But seedling has simple leaves like those found in all stages of development of its ancestors. This provide a good example of –

Recapitulation

3. Modern day Oaks of southern United State of America retain their foliage throughout the year where as the oaks of northern United States are **deciduous** and shed their leaves during winter. The southern species, on the basis of this character of leaves are considered to be more primitive than the northern oaks. However, the seedling of northern species are generally seen to retain their leaves during winter. This provide a good example of – **Recapitulation.**
4. **Evolutionary trend** : The continuous change of a character within an evolving lineage is termed as **evolutionary trend.**
5. Archaeopteryx is a connecting link between reptiles and birds.
6. Correct order of age is Paleozoic → Mesozoic → Coenozoic.
7. The scientist to propose recapitulation theory was “Haeckel”.
8. Evolution is history and development of race along with variations.

9. Homologous organs are similar origin with similar or dissimilar functions.
10. Vestigial organ of python is "Hind limbs".
11. Process of evolution is **continuous**.
12. Haeckel's biogenetic law or recapitulation theory states that life history of an animal reflects evolutionary history of the same.
13. "Golden age of Dinosaurs"/Age of reptiles was "Mesozoic".
14. Humming birds and Hawk illustrate adaptive radiation.
15. Birds and mammals evolved during Jurassic.
16. Mammals are believed to have evolved from reptiles in "Triassic".
17. Parallelism is adaptive convergence of closely related groups.
18. Some homologous organs are "Paddle of whale", front legs of horse and arms of humans/legs of duck, hind limbs of kangaroo.
19. Analogous organs are different origin but similar functions.
20. Upper strata younger and lower older will be true in sedimentary rocks.
21. Vermiform appendix, wisdom teeth, body hair are the vestigial organs in humans.
22. Palaeozoic era is the era of fishes.
23. Pinna muscles is a vestigial organ in humans.
24. Examples of homologous organs are wings of pigeon and arms of humans.
25. Coccyx is a vestigial organ of human body.
26. Haeckel's recapitulation theory states "Ontogeny repeats phylogeny".
27. Fossilisation is animals buried by natural process.
28. Homologous and analogous, homologous and vestigial organs analogous and vestigial organs are a set of evolution.
29. Dinosaurs were dominant during **Jurassic**.
30. Wings of birds and wings of butterfly are analogous.
31. Angiosperm flourished during **Coenozoic**.
32. Mammoth (Animal) has become extinct recently.
33. Body hair is a vestigial organ in human body.
34. Fossil reptile having mammalian traits was "Pelycosaurus".
35. Origin of first mammals occurred 220 million years.
36. Basic principle of embryonic development were pronounced by "Van Baer".
37. Age of mammals and birds is coenozoic.
38. Dinosaurs disappeared during "Cretaceous".
39. Fossil x is older than fossil y because fossil x was found in deeper sedimentation.
40. Carboniferous period of coal deposition was 300 million years ago.
41. Fossils indicate the evolution of "**Horse**".
42. Fossils do not indicate the evolution of monkey, man and dinosaurs etc.

43. Biogenetic law was pronounced by **“Van bear and haekel”**.
44. Dinosaurs were dominant in Mesozoic.
45. Existence of coal/pterolesum can be known from study of **“Palaeobotny”**.
46. Fossils are dated by **“Radioactive carbon content”**.
47. The earliest fossil from in the phylogeny of horse is **“Eohippus”**.
48. Fossil remains of Archaeopteryx indicates that reptiles given rise to birds during jurassic.
49. Palaeontology provides direct and solid evidence in favour of organic evolution through ages.
50. Study of the fossils comes under “Palaeontology”.
51. By “Allen’s law” animals of cold countries have shorter ears.
52. Mammals occur on land, air and water. It is adaptive radiation Not adaptation.
53. Wings of mosquito, Bat and bird show evolution called “Convergent”.
54. Presence of gill slits in the embryos of all vertebrates supports the theory of “Recapitulation”.
55. Birbal sahani was the famous palaeontologist/palaeobotanist of India.
56. Two geographical regions separated by high mountains are palaerctic and oriental.
57. Organisms present at different places without any traces in between show “Discontinuous distribution”.
58. Nictitating membrane is a vestigial organ in human.
59. Branch of botany dealing with distribution of plants is **“Phytogeography”**.
60. In azoic era had life not originated.
61. Birbal sahani institute of palaeobotany is located in Lucknow.
62. Phylogeny is evolutionary history.
63. Existence of marsupials in australia and newzealand proves continental drift and geological period.
64. Human hand, wing of bat and flipper of whale represents homologous organs.
65. The statement “nothing in biology makes sense except in the light of evolution” was given by “Dobzhansky”.
66. “Genetics and the origin of life” Book had written by “Dobzhansky”.
67. Animals of cold area have shorter and smaller extremities. This is allen’s law.
68. Coal has been mainly formed by pteridophytes/pteridosperms.
69. Vestigial pelvic girdle and bone remnants of hind limbs are characteristic of “Whale”.
70. Organic evolution is change in major portion of population.
71. Archeopteryx is a bird with teeth.
72. Darwin’s friches provide evidence of evolution from “Biogeography”.
73. Living organism with oldest fossil history is “Horse”.
74. Adaptive similarites in animals of the same habitat consititute. “Convergent evolution”.
75. Homologous organs show “Divergent evolution”.
76. Identical to those of man are monkey and some lower groups certain blood groups.

THEORIES OF ORGANIC EVOLUTION

LAMARCKISM :

First theory of evolution was proposed by

Jean Baptiste de Lamarck (17-44 - 1829)

Book : **Philosophie Zoologique (1809)**

Lamarck coined the terms – **Invertebrates, Annelida.**

The term **Biology** was given by **Lamarck & Treviranus.**

Theory of Inheritance of Acquired Character–

Basic Concept of Lamarckism–

(i) Internal Vital Forces :

Some internal forces are present in all organisms. By the presence of these forces organism have the tendency to increase the size of their organs or entire body.

(ii) Effect of environment and new needs:

Environment influences all type of organisms. Changing environment gives rise to new needs. New needs or desires produce new structures and change habit of the organism.

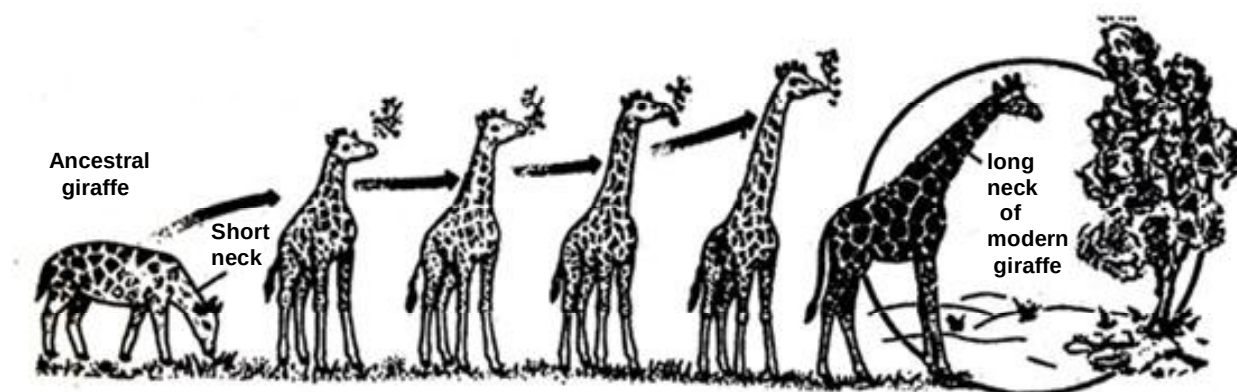
(iii) Use and disuse of organs:

If an organ is constantly used, it would be better developed whereas disuse of organ result in its degeneration.

(iv) Inheritance of acquired character:

During the life of an organism new character develop due to internal vital forces, effect of environment, new needs and use and disuse of organs.

These acquired character are inherited from one generation to another. By continuous inheritance through many generation these acquired characters tend to make new generation quite different from its Ancestors resulting in the formation of new species.



Example in support of Lamarckism :

1. Long neck and high fore limb of Giraffe.
2. Aquatic birds stretched their toes and developed web.
3. Snakes lost their legs.
4. Deers became good runners by the development of strong limbs and streamlined body.
5. Retractable claws of carnivorous animals.

Criticism of Lamarckism -

1. According to first concept organism tends to increase their size but it is not universally true.
For Example among angiosperm the trees seem to be primitive and the shrubs, herbs and grasses have evolved from trees but the size was reduced during evolution.
2. Second concept is false. Can we sprout wings wishing to fly like birds.
3. The third concept is some what true like the well developed biceps muscles of blacksmith and less developed wings in flight less birds.
But this concept also have many objections like the eyes of a student/reader do not increase in size and power with increasing age, the constantly beating heart maintains a constant size through generation.
4. Fourth concept is completely false because acquired characters are not inherited.

Weismann –

Weismann cut off the tails of rats for about 22 generations but there was no reduction in the size of tail on the basis of this experiment Weismann proposed **the theory of continuity of germplasm**.

According to Weismann.

- (i) Two types of matters are present in organism, **somatoplasm and germplasm**.
- (ii) Somatoplasm in somatic cells and germplasm in **Germinal cell**.
- (iii) Somatoplasm dies with the death of organism while germplasm transfers into the next generation.
- (iv) If any **variation** develops in germplasm, it is inherited, while if variation develop in somatoplasm it is not transmitted.

Pyane :

Pyane kept drosophila in dark up to **69 generation**, but there was no reduction in the size or sight of eyes

- Boring of ear and nose in Indians.
- Iron shoes of Chinese.

Neolamarckism-Term by Packard

Although Lamarckism remained controversial but some scientists gave the following evidences in favour of Lamarckism. They are known as **neo-lamarckians**.

According to neolamarckism environment effected the inheritance of acquired character. According to it changing environment give rise some physical and chemical changes in organism, which effect their germplasm, and these acquired characters are definitely inherited.

1. Sumner's Experiment–

Sumner kept white rat in warm temperature resulting in elongation of body, large pinna and long tail. These features were inherited by the offspring.

2. Kammerer's Experiment–

Kammerer kept salamander in dark background. The black spots found on skin were widely spread. In lighter, background the skin became yellow with limited black spots. These character were inherited by the offspring.

3. Mac Dugal's Experiment-

Mac Dugal trained white rats to cross a tank of water following a definite route. These trained rats were mated and their offspring were again trained. It was observed that there was decrease in the number of errors by offsprings of white rats.

Difference between Lamarckism and Neo-Lamarckism

<i>Lamarckism</i>	<i>Neo-Lamarckism</i>
It is original theory by Lamarck.	It is a modification of the original theory of Lamarck in order to make it more suitable to modern knowledge.
The theory lays stress on internal force, appetency and use and disuse of organs.	Neo-Lamarckism does not give any importance to these factors.
It believes that changes in environment brings about a conscious reaction in animals.	The theory stresses on the direct effect of changed environment on the organisms.
According to Lamarckism the acquired characters passes on to the next generation.	Normally only those modification are transferred to next generation which influence germ cells or where somatic cells give rise to germ cells.

Special Points : -

1. **Allen's law** : The homoeothermic animals (Birds and Mammals) of colder region have shorter extremities, like pinna, toes etc., than their counter parts of warmer region.
2. **Bergman's law** : The warm blooded animals (Birds and mammals) of colder region are bigger or larger in size than their counter parts of warmer region.
3. **Cope's law** : The animals of a major adaptive group of region have a tendency of increase in size. For example, the dinosaurs formed the major adaptive group in Mesozoic era.
4. **Dollo's law** : The evolution is an irreversible process.
5. **Gause's law** : Two species with identical food habits or ecological needs can not occupy the same ecological niche for a very long time. Gause's principle was restated by Hardin (1960) as 'Competitive Exclusion Principle', which means that *complete competitors cannot co-exist*.
6. **Golger's law** : The homoeotherms of colder region, with low temperature and low humidity, have less melanin in their skin.
7. **Hardy-Weinberg's law** : This law was proposed in 1908 by G.H.Hardy, a British mathematician, and W.Weinberg, a German physician, and is related to the **Population genetics**. It states that :
'If a population is at equilibrium then the gene frequency and the genotype frequency will remain constant generation after generation.'
 - A population is said to be at equilibrium when there is :
 1. No Mutation
 2. No Natural or Artificial selection
 3. No Gene flow
 4. No Genetic drift

- This also means that sexual reproduction alone cannot bring a change in allele frequency. This law is applicable when above changes do not occur, hence no evolution takes place. (Such conditions can never be achieved in nature).
- The mathematical expression to calculate allele frequency can be given as

$$p + q = 1$$

Where 'p' represents the frequency of dominant allele and 'q' represents the frequency of recessive allele. The binomial expression of Hardy Weinberg's law, to calculate genotype frequency is

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

Where p^2 = homozygous dominant (genotype) individuals, pq = heterozygous (genotype) individuals, and q^2 = homozygous recessive (genotype) individuals.

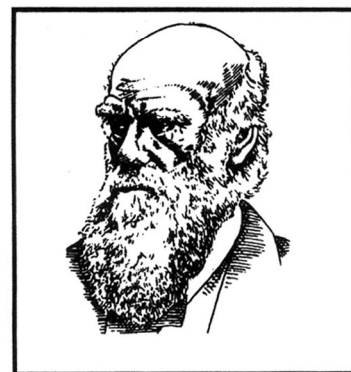
DARWINISM

Charles Robert Darwin was born on 12th feb. 1809 in England. Darwin traveled by **H.M.S. Beagle**.

The ship left on Dec. 27, 1831 and returned on Oct. 2, 1836. He travelled South America, **South Africa, Australia and Galapagos Islands**. Darwin was influenced by two books.

"Principles of population" of Malthus.

"Principles of Geology" of Charls Lyell.



Alfred Russel Wallace :

He travelled South eastern Asia and South America. The idea of natural selection struck in his mind. Wallace wrote an essay and sent it to Darwin. **"On the tendency of varieties to indefinitely from original type"**.

There was striking similarity between the view of Darwin and **Wallace**.

Wallace's chart : Wallace presented a chart to explain main points of theory of Darwin.

"Darwinism" or "The theory of Natural Selection" was proposed by both Charles Darwin and A.R. Wallace.

This theory was later on explained by Darwin in his book '**On the origin of species by the means of Natural Selection**' (1859).

S. No.	Facts	Consequences (Conclusions)
1	(i) Enormous rate of reproduction among animals (ii) Constant number of animals of a species	Struggle for existence
2	(i) Struggle for existence (ii) Heritable variations	Survival of the fittest or natural selection
3	(i) Survival of the fittest (ii) Continuous environmental changes	Continuous natural selection leading to evolution of new species

The main features of theory of Natural Selection are as follows –

(1) Over production : (High rate of Reproduction)

All organisms have capability to produce enormous number of offspring, organisms multiply in geometric ratio.

e.g. – Plants produce thousands of seeds.

– Insects lay hundreds of egg

– One pair elephant gives rise to about six offspring and if all survived in 750 year a single pair would produce about 19 million elephant. Thus some organisms produce more offspring and other produce fewer offspring

This is called **differential reproduction**.

(2) Struggle for existence :

Every individual competes with other of the same and other species for basic necessities like. Space, shelter and food. It is called struggle for existence and it continues for the whole life from zygote stage to its natural death.

The struggle for existence is of three types –

- (i) Intra-specific struggle :** It is competition between the individuals of same species for same needs like food, shelter and breeding (**most acute type of struggle**).
- (ii) Inter-specific struggle :** It is the struggle between the individuals of different species for food and shelter.
- (iii) Environmental struggle :** This struggle is between the organism and their environment. All organism struggle with cold, heat, wind, rain drought and flood etc.

(3) Variations and heredity :

Except identical twins no two individuals are similar and their requirements are also not same. It mean there are differences among the individuals. These differences are called **variations**. Due to variations some individuals would be better adjusted towards the surroundings than the others.

According to Darwin the variations are continuous and those which are helpful in the adaptation of an organism towards its surroundings would be passed on to the next generation, while the others will disappear.

(4) Survival of the fittest or natural selection :

The original idea of survival of fittest was proposed by Herbert Spencer.

According to Darwin most suitable and fit individuals are successful in struggle for existence. The individuals with most favourable adaptations are able to lead most successful life and are able to win over their mating partners. Darwin called I Sexual Selection.

In the struggle for existence only those members survive which possess useful variations means nature selects fit individuals. This was called Natural Selection. Fitness is the end result of the ability to adapt and get selected by nature.

(5) Origin of New Species :

Darwin explained that variations appearing due to environmental changes are transmitted to the next generation. So offspring become different from ancestors. In next generation process of Natural selection repeats so after many generation a new species is formed.

Criticism of Darwinism –

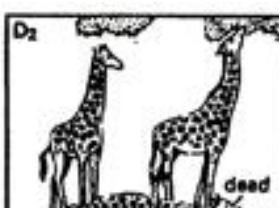
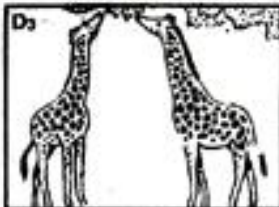
1. Darwin does not explain the development of vestigial organs.
2. This theory has no satisfactory explanation for the cause, origin and inheritance of variation.
3. Darwin is unable to explain why in a population only a few individuals develop useful variation and others have harmful variations.
4. Criticism of Darwinism was based on sexual selection. Why only female selects the male for mating why not vice versa.
5. Darwin was unable to differentiate somatic and germinal variations.
6. This theory was unable to explain over-specialization of some organs like tusk of elephants, antelers of deer.
7. This theory only explain the survival of fittest but unable to explain **arrival of fittest**.
8. The main drawback of Darwinism was lack of the knowledge of **heredity**

Theory of pangenesis

According to this theory all organs of an individual produce Pangenenes, which are minute particles carrying information about the organs.

The pangenes traveling through the blood stream will ultimately reach the gametes, so that each gamete will have pangenes for each of the different organs.

After zygote formation, the pangenes tend to form the same organs from which these pangenes were produced.

	L1 – short neck in ancestral stage of giraffe. Neck was stretched and used to feed on leaves of tall trees.	D1 – In ancestors of giraffe different length of neck was inheritable.	
	L2 – Neck in offsprings increased, this was also stretched and used to feed on leaves of tall trees.	D2 – As a result of struggle for existence giraffes with longer neck were better adapted. Due to natural selection offsprings with long neck increased in number, while those with short neck gradually disappeared.	
	L3 – Neck in the offsprings of giffaffe continued to increase in next generations resulting in the evolution of long neck in modern giraffe.	D3 – Due to above reasons giraffes with only longer neck survived.	

Difference between Darwinism and Neo-Darwinism

<i>Darwinism (Natural Selection)</i>	<i>Neo-Darwinism</i>
1. It is the original theory given by Charles Darwin (1859) to explain the origin of new species. 2. According to this theory accumulation of continuous variations causes changes in individuals to form new species. 3. It believes in the selection of individuals on the basis of accumulation of variation. 4. Darwinism does not believe in isolation. 5. It can explain the origin of new characters. 6. Darwinism cannot explain the persistence of certain forms in the unchanged condition.	1. Neo-Darwin is a modification of the original theory of Darwin to remove its short-comings. 2. Instead of continuous variations, mutations are believed to help form new species. 3. Variations accumulate in the gene pool and not in the individuals. 4. Neo-Darwinism incorporates isolation as an essential component of evolution. 5. The theory can explain the occurrence of unchanged forms over millions of years. 6. Normally only those modification are transferred to next generation which influence germ cells or where somatic cells give rise to germ cells.

NEODARWINISM :

NeoDarwinism is a modified form of Darwinism along with recent researches of **Weismann, Mendel, Devries, Huxley, Gates, Stabbins** etc. They performed many experiments to remove the objections against Darwin's theory.

The salient features of neodarwinism are as follows–

1. **Rapid multiplication** : All organism multiply in geometrical ratio.
2. **Limited food and space** : Food and space are limited.
3. **Struggle for existence** : It is of three types. Intraspecific, Interspecific and environmental.
4. **Genetic Variations** : They are inheritable variation which can occur due to the following reasons.
 - (a) **Mutation** : They are **discontinuous variations** which develop due to permanent changes in genotype. Mutations are of three types–
 - **Genomatic mutations** : Change in number of chromosome.
 - **Chromosomal Aberrations** : Changes in number of chromosome.
 - **Gene Mutation** : Change in nucleotide.
 - (b) **Gene recombination** : They are new combination of genes which are usually caused by **crossing over**.
 - (c) **Hybridisation and gene migration** : It is crossing of organisms which are genetically different in one or more traits.
 - (d) **Genetic drift** : It is the elimination or addition of the genes of certain chartain characters when some animals in population migrate or dies or immigrate. It changes the gene frequency of remain population. Genetic drift operates only in **small population**.
(Changes in frequency of genes in a gene pool is called **drift**.)

Founder Effect : Gene pool is the sum total of all the genes found in a population. Change in the frequency of gene in a gene pool is called genetic drift. Genetic drift always operates in small population. By genetic drift often the phenotype of this small population quickly become different from the parental population and some time form a new sp. Such an effect is called Founder Effect.

Bottleneck Effect : Death of several members of population due to natural calamities (Earthquake , Storm, Flood) also leads to genetic drift. The original size of population is then restored by mating among the survivor. The new population may lack the genes of certain. This may produce a new species after some time. The loss of a section of population by death an after sometime a new species is formed that effect is known as Bottleneck effect.

5. Natural Selection :

If differential reproduction (some individuals produce more, some only few and still others none) Continuous for many generations, genes of the individuals which produce more offspring will become predominant in the gene pool of the population. Thus natural selection occurs through differential reproduction in successive generations.

6. Isolation :

Isolation is a segregation of populations by some barriers which prevent interbreeding. The reproductive isolation between the populations due to certain barriers leads to the formation of **new species**.

Example of Natural Selection –

(1) Industrial Melanism :

This phenomenon was studied by **Barnard kettlewell**.

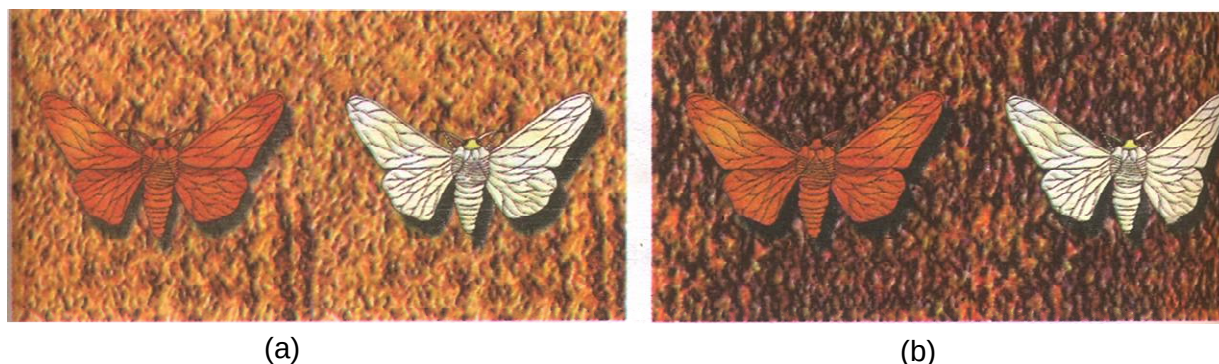


**Figure showing white – winged moth and dark – winged moth (melanised) on a tree trunk
(a) In unpolluted area (b) In polluted area**

Before industrial revolution, the dull grey forms of prepared moth-**Biston betularia** – were dominant; the **Carbonaria** form (Black) was rare because it was susceptible to predation by birds. The reason was that it was **conspicuously** visible while resting on tree trunks.

The industrial revolution, resulted in large scale smoke which got deposited on tree trunks tuning them Black. Now grey varieties became susceptible – the black forms flourished. Replacement of coal by oil and Electricity reduced production of black moth so the frequency of grey moths increased again.

(2) Drug resistance :

The drugs which eliminate pathogens become ineffective in the course of time because those individuals of pathogenic species which can tolerate them, survive, flourish to produce tolerant population.

(3) Sickle cell Anaemia and Malaria :

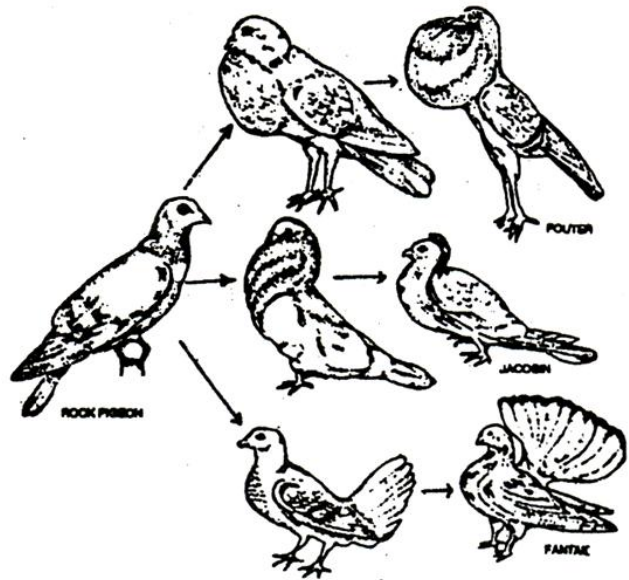
Individuals homozygous for sickle cell Anaemia die at an early age. In heterozygous individuals, the cells containing abnormal haemoglobin **Sickle** shaped. In fact, When an RBC becomes sickle-shaped, it kills Malarial parasite effectively so that these individual are able to cope with malaria infection much better than normal persons. The process of natural selection thus maintains the abnormal form of haemoglobin along with the normal form in a region where Malaria is common.

(4) Malaria and G-6-PD deficiency :

Glucose 6- Phosphate dehydrogenase deficiency is a common abnormality in Negroids. Haemoglobin gets denatured and is deposited on cell membrane. **The disease is called favism.** In these RBC, the malarial parasite cannot complete its cycle. Such persons get protection from Malaria.

Artificial Selection –

Man has been taking the advantage of genetic variations for improving the qualities of **domesticated plants and animals**. He selects the individuals with desired characters and separates them from those which do not have such characters. The selected individuals are interbred. This process is termed as **Artificial Selection**. This process is man made. If it is represented for many generations it produces a new breed with desired characters. By artificial selection animal breeders are able to produce improved varieties of domestic animals like **dogs, horse, pigeons,, poultry, cow, goats, sheep and pigs** from their wild ancestors. Similarly the plant breeders have obtained improved varieties of useful plants like wheat, rice, sugarcane, cotton, pulses vegetables fruits etc.



Artificial Selection is similar to natural selection except that the role of nature is taken over by man and the character selected are of human use.

Special points :

- The breeders have successfully produced the toy-like Shetland pony, the Dane dog, the sleek Arabian race horse by selection.
- Many crop plants like broccoli, kale cabbage, Cauliflower, Brussels sprouts and kohlrabi have been produced through selective breeding.
- The various breeds of fowl ranging from the ceremonial cocks (**the Japanese onagadori**) to the **broiler. leghorns** are all derived from a single jungle fowl **Gallus gallus**.

Reproductive Isolation –

Reproductive isolation is the prevention of inter breeding between the population of two different or closely related species.

It maintains the characters of the species but can lead to the origin of new species.

The mechanism the characters of the species but can lead to the origin of new species.

The mechanism of reproductive isolation is explained by **Stebbins** in his book '**Process of Organic Evolution**'.

Two main subtypes of reproductive isolation are–

1. Premating or prezygotic isolation :

Prevent matting or formation of zygote.

(1) Ecological isolation : Two species live in different habitats and do not meet. (One may be living in fresh water and the other in the sea).

(2) Temporal isolation : Breeding seasons or flowering time may be different in the two species.

(3) Behavioural isolation : The males of one animal species are unable to recognize the females of another species as potential mates.

(4) Mechanical isolation : The structural differences in genitalia of individuals belonging to different animal species interfere with mating.

(5) Gametic isolation : The sperms and ova of different species of animals are unable to fuse. In plants, the pollen coming from a different species may be rejected by the stigma.

2. Postzygotic Isolation : A hybrid zygote is formed but it may not develop into a viable fertile adult.

(1) Hybrid inviability : Hybrid zygotes fail to develop. In plants, embryos arising from interspecific crosses abort.

(2) Hybrid sterility : Hybrid adults do not produce functional gametes. (Mules and henny are common example) in mammals. Several hybrid ornamental plants are sterile.

Exception :

- Africal lioness + Asian tiger = tigon
(panthera leo) (Panthera tigris)
- Male lion + Female tiger = Liger
- Mallard duck + pintail duck
- Polar bear + Alaskan brown bear
- Platy fish + Swordtail fish

3. Hybrid breakdown : Sometime inter specific mating produce a hybrid, which give rise to next hybrid by back cross but they have reduced vigour or fertility or both.

GENETIC BASIS OF ADAPTATIONS :

Joshua Lederberg & Esther Lederberg shown genetic basis of adaptations by experimenting on bacteria. This experiment is known as Ledeberg's Replica plate experiment.

1. Lederberg cultured the bacterial cells on agar plate.

Many bacterial colonies or groups grew on this agar plate.

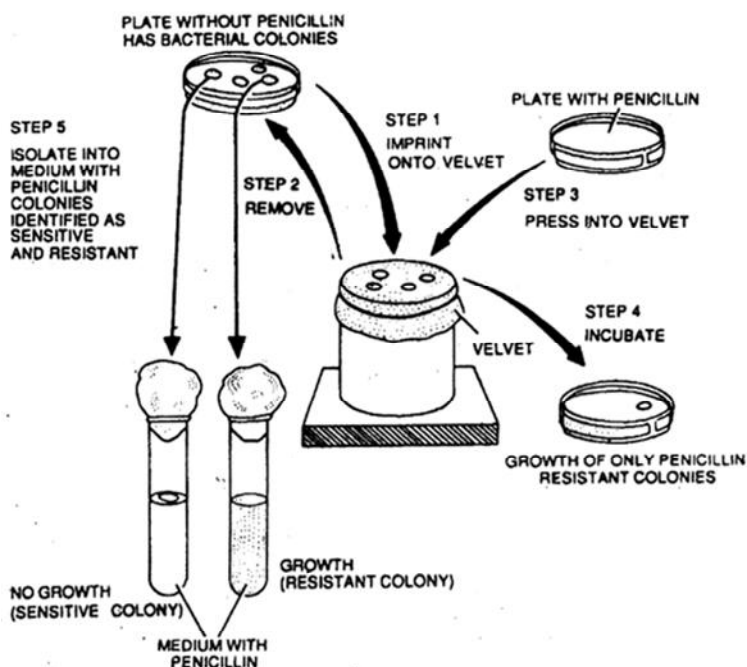
In this every colony is formed by the division of bacterial cells.

Therefore its all cells were of same genetic structure.

This type of group of cells is known as **clone**.

This multi colony agar plate is known as **master plate**.

- On this master plate one sterile velvet plate was pressed slightly so that some bacteria got stuck on velvet plate. In this way this becomes **replica of master plate**.



- Now efforts of preparing replica had been made on those agar plates whose agar contains an antibiotic penicillin. It was seen that some bacteria failed to grow on penicillin agar plate while some bacteria were able to grow and developed new colony.

It was concluded that those bacterial colonies were penicillin resistant. These bacteria have penicillin resistant mutant gene.

***Lamarckian view :** Penicillin induced a change in some bacterial cells enabling them to grow in medium containing penicillin (wrong concept).

****According to Darwin** some bacterias were penicillin resistant in bacterial suspension. In penicillin medium normal bacteria did not survive while mutant bacterias survived, as they are adapted, and form colony.

MODERN SYNTHETIC THEORY OF ORGANIC EVOLUTION :

This theory is the result of the work of a number of scientist namely **Dobzhansky, Fisher, Haldane, Swall wright, Mayr, Stebbins**.

Stebbins discussed this theory in his book "**Process of Organic Evolution**" and Dobzhansky explained it is his book "**Genetics and the origin of species**".

According to this theory new species can not evolved by the presence of variable genotype in a population. Two factors are also required-natural selection and reproductive isolation. Natural selection guides different population in to different adaption direction and reproductive isolation between them due to geographical barriers leads these direction to the evolution of new species.

In this theory following factors are included –

- Gene mutation
- change in chromosome number and structure

- (iii) Genetic recombination
- (iv) Natural selection
- (v) Reproductive isolation.

Besides these factors there are two more processes which cause evolutionary changes. These are –

- (i) Migration of individuals from one population to another.
- (ii) Hybridisation among species and also related genera which causes genetic variation in the population undergoing process of evolution.

Mimicry :

- It is kind of adaptation.
- The term mimicry was given by Bateson (1862)
- The resemblance of one organism to another or to any natural object for the purpose of concealments, Protection or for some other advantages like attack.
- The organism which exhibits mimicry is called a **mimic** and the organism or object which is mimicked is called as **model**.

Types of mimicry :

- (1) Protective (2) Aggressive (3) Conscious

1. Protective mimicry :

It is useful for an organism to protect itself from the predator.

It is of 2 types –

(a) Concealing - The organism resembles the surrounding, so it cannot be easily detected by predators. E.g Stick insect, Leaf insect.

(b) Warning type - The organism resembles a distasteful or poisonous organism. It is also known as **batesian mimicry**.

Eg. Viceroy butterfly

2. Aggressive mimicry :

It is generally used by the predator.

It is of 2 Types –

(a) concealing : In this type the predator cannot be noticed by the prey because it matches with the surroundings involving colour or body shape or both.

Eg. Yellow spider

(b) Alluring Type : The predator attracts the prey by resembling it self to any other object.

Eg. mouth corner of African lizard resembles a flower.

3. Conscious mimicry :

Some organism behave as a dead object to protect them from predator.

Eg. Tenebrinoid beetles become motionless and pebble like when in danger.

Mullerian mimicry :

When two or more inedible or unpalatable species each other this type of mimicry is called mullerian mimicry. Mullerian mimicry is done by two species for increasing warning effect to predators. For example ctenuchid moth resembles a wasp, where both of them are unpalatable.

It is also a kind of protective mimicry.

Mutation Theory

Proposed by Hugo-de-vries on the basis of his experiments on a plant *Oenothera lamarckiana*.

Main Point of mutation theory :

1. Mutation or discontinuous variation are the raw material of evolution.
2. Mutation appears suddenly and produced their effect immediately.
3. Mutants are different from the parents and there are no intermediate stages between the two.
4. The same type of mutation can appear in several individuals of a species.
5. Mutation can appear in all direction and all mutations are inheritable.
6. useful mutations are selected by nature an lethal mutations are eliminated.
7. Mutation are recurring so that the same mutant can appear again & again so change of selection by nature are increased and new species is formed.
8. Mutation is a jerky & discontinuous process. De-vries termed single step large mutation as **saltation**.
9. Mutations are random and directionless while Darwinism variations are small and directional.

Points in favour of mutation theory :

1. Mutations are actually the source of all variations and fountain head of evolution.
2. Mutation theory can explain both progressive & retrogressive evolution.
3. A number of mutations have appeared in nature and mutations are induced which have given rise all of sudden by mutation.
4. *Oenothera lamarchiana* is not normal plant but a complex heterozygous plant from with chromosomal aberration

Significance :

De-vries mutation theory generally accepted because the mutation were found to be inheritable. It was later through that evolution cannot occur by mutation alone, natural selection and isolation of mutants are also necessary for evolution.

Natural Selection & Polymorphism :

A population is called polymorphic for a character if two or more distinct form are present in this population.

Ex.: ABO Blood Group :

There are 4 types of blood group are present in human being A, B, AB. and O. They are due to the presence of different genotype.

Sickle cell anemia is also an example of polymorphism. In this disease on amino acid is changed in polypeptide chain due to change in one N₂ base. That's why the normal shape of RBC is changed into sickle shape.

The organism in which heterozygous condition is present for this characters, the RBC become sickle shaped. In this type of RBC malarial parasite can't have a normal growth that's why these individuals are resistant towards malaria.

The HbS, HbS, condition leads to the death of organism.

The organism with HbS, HbA condition are selected by nature because these are the fittest of all. The lose of HbS gene due to the death of organism having HbS, HbS is recovered & balanced by the reproduction of heterozygous condition (HbS, HbA).

This type of selection is called **balancing selection**.

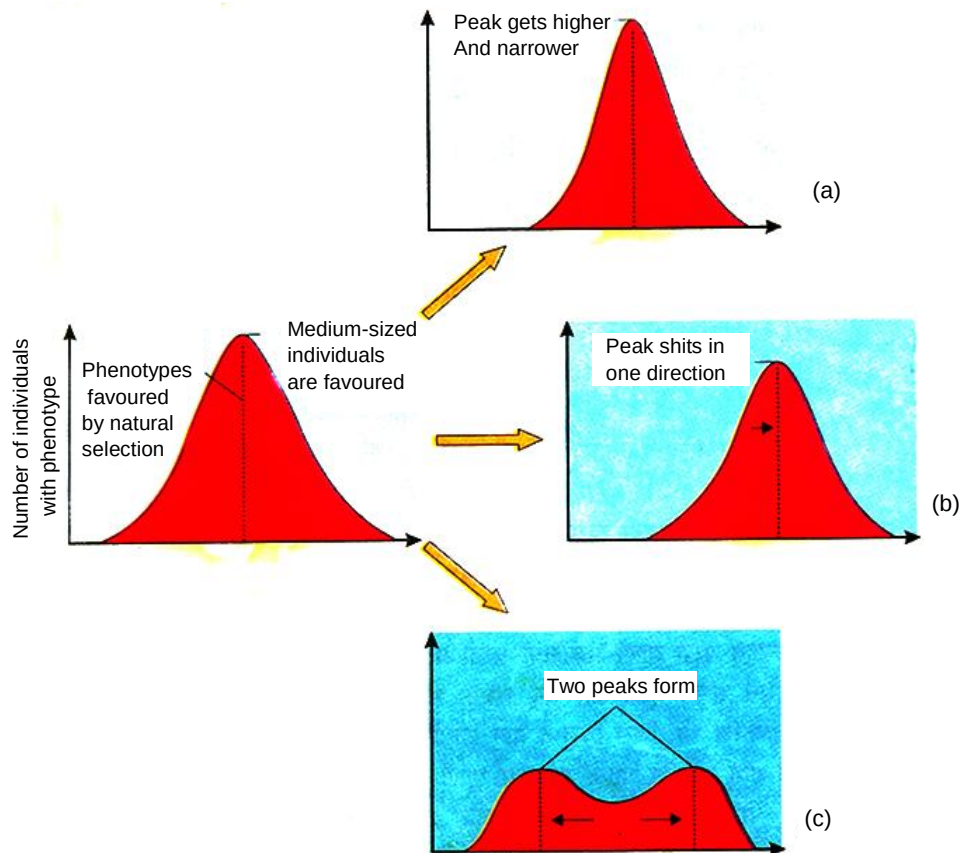
It means the preservation of genetic variability is maintained by the selection of heterozygotes which is called '**Balanced polymorphism**'.

But this kind of balancing selection is found very rarely in nature.

Difference Amongst Lamarckism, Darwinism and Mutation Theory

	Lamarckism	Darwinism	Mutation Theory
1. Vital force	The theory believes that every organism has an internal vital force that tends to increase its size upto a certain limit.	Darwinism does not believe in internal vital force.	No internal vital force is involved.
2. Conscious Reaction	Animals with well developed nervous system react consciously to any change in environments	Darwinism does not involve any conscious reaction.	No conscious reaction is believed to take part in the process of evolution.
3. Appentency	The theory considers appentency or desires on the part of animals an important force in the development of modifications.	It is not a constituent of the theory.	Appentency is not involved.
4. Use and Disuse	The organs put to more use are believed to develop more while organs not used begin to degenerate.	The theory is silent about use and disuse of organs.	The theory is silent about it.
5. Inheritance of Acquired Characters	The characters acquired by an organism during its life are believed to get transferred the next generation.	According to Darwin, all the living cells produce minute particles or pangensis, which pass into germ cells for transmission to the offspring.	Only those variations are transferred to the offspring which originate in germ cells or in the cells which form germ cells.
6. Struggle for Existence	The theory does not clearly spell out struggle for existence in relation to high biotic potential.	Organisms produce more offspring than the available food and space so that a struggle for existence ensues amongst them.	The theory believes in the struggle for existence.
7. Origin of Variations	Variations appear in organisms in response to change in environment, conscious reaction, desire r use and disuse of organs.	Variations appear automatically.	Variations appear due to change in genetic make up.
8. Continuous Variations	The theory is silent about them though it believes in a continuous modification of organs in a particular direction.	It is based on the origin and selection of continuous variations.	The theory is based on discontinuous variations or mutations.
9. Natural Selection	The theory does not take into account natural selection or survival of the fittest.	Darwinism is based on natural selection or survival of the fittest.	Mutations theory believes in natural selection or survival of the fittest.
10. Progress of Evolution	Evolution is a continuous process which moves in a direction governed by environment and appentency.	Evolution is a continuous process, the direction of which is governed by nature.	Evolution is a jerky process, the direction of which is unpredictable though ultimately it is governed by nature.

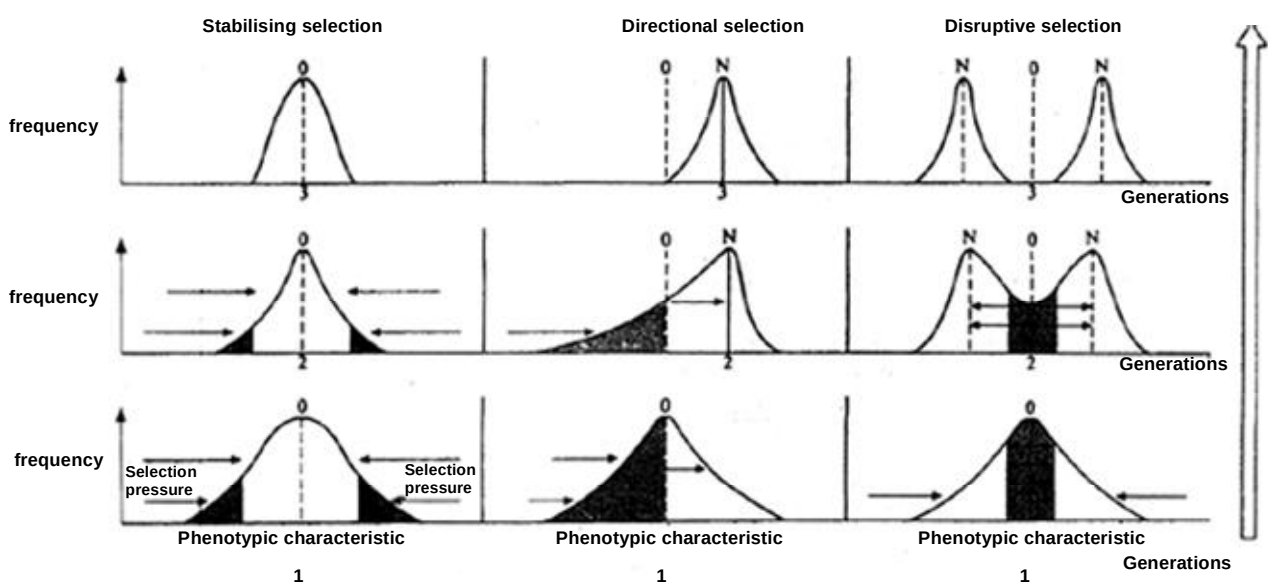
Types of Natural Selection :



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

Based upon different organism – environment relationship. Following different kinds of natural selection have been recognised.

- Stabilising selection.
- Directional selection.
- Disruptive selection.



Diagrams showing the three types of selection operating within populations. 0 indicates the original coincidence between optimum and optimum environmental conditions; N indicates the new position of coincidence of optimum phenotype and optimum environmental conditions. Organisms possessing characteristics in the shaped portions of the normal distribution are at a selective disadvantage and are eliminated by selection pressure. (The number 1-3 indicate the order of generations.)

(1) Stabilising selection :

Stabilizing selection operates when phenotypic feature coincide with optimum environmental conditions and competition is not present.

It keeps a population genetically constant.

If favours the average or normal phenotypes and eliminate the extreme variants, that fall towards both ends of the bell-shaped curve of variability for the distribution of measurements of phenotypic traits.

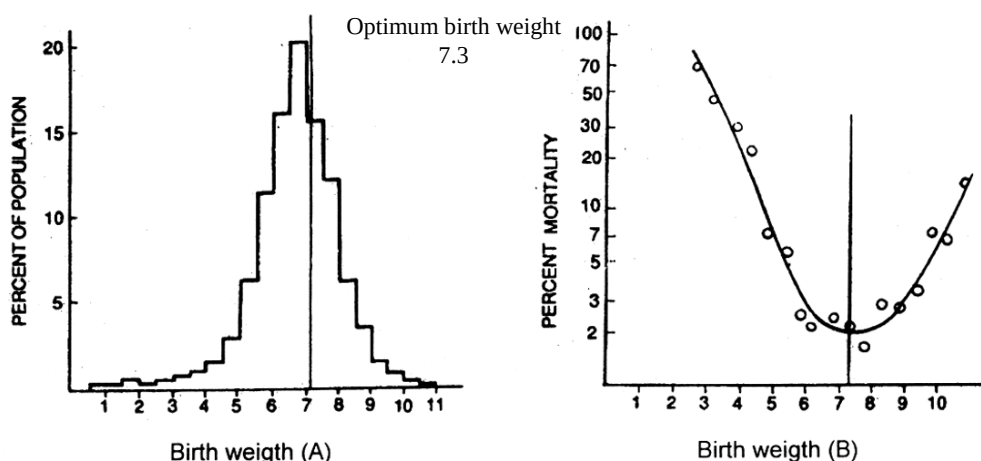
Due to continuous elimination of both extremes, the bell shaped curve tends to narrow.

Stabilising selection always operates in constant or unchanging environment.

Ex. Mortality in babies : The birth weight of human babies provides another example influenced by stabilizing selection.

The optimum birth weight favoured by stabilizing selection is 7.3 pounds.

New born infants less than 5.5 pounds and more than 10 pounds have the highest mortality rate. The curve for mortality is virtually the complement of the curve of survival.



The distribution of birth weight of human infants. A-Histogram showing the proportions of populations falling into various birth weight classes. B-Mortality curve in relation to birth weight of human infants

(2) Directional selection or Progressive selection :

Directional selection produce a regular change in a population in respect to certain traits.

This form of selection operates in response to gradual changes in environmental condition.

It favour individuals that change in response to the environmental change and become best adapted to new environmental condition. If favour the phenotype which is non average or extreme and then pushes the phenotype of the population in that direction.

Directional selection removes more individuals from one end of the normal curve of variability distribution and adds towards the other end and alters the mean value of the trait in the population in a particular direction.

So the mean moves in one direction. Directional selection operates when environment is changing in one direction.

Ex. (1) *Biston betularia*

(2) Resistance of insects to DDT.

(3) Disruptive selection :

This is probably the rarest form of selection but can be very important in bringing about evolutionary change.

Fluctuating conditions within an environment, say associated with season and climate may favour the presence of more than one phenotype in a population.

Selection pressure acting from within the population as a result increased competition may push the phenotype away from the population mean towards the extremes of the population.

This can split a population into two subpopulation.

If the gene flow between the subpopulation is prevented, each population may give rise to a new species. In some cases this form of selection can give rise to the appearance of different phenotype within a population, known as polymorphism.

Eg. Shell pattern in limpets : Shell patterns of limpets (marine mollusca) present a continuous, ranging from pure white to dark tan. These are either attached to white goose neck barnacles or to tan-coloured rocks. The white or light-coloured limpets camouflaged with white barnacles and tanned ones were protected on the tan-coloured rocks. Limpets of intermediate shell patterns, being conspicuous are preyed by predatory shore birds, resulting in disruptive selection.

SPECIES

1. Biological species concept : species is a sexually interbreeding group of individuals separated from other species by the absence of genetic exchange.

Members of a species are capable of breeding with one another and produce living, fertile offspring but are unable to breed with members of other species normally.

Sibling species : Species which are morphologically similar but do not interbreed normally, are known as sibling species.

Eg. *Drosophila pseudoobscura* & *Drosophila ersimilis*.

2. Evolutionary species concept : Proposed by **George Gaylord Simpson**.

Biological sp. Concept explained only sexually reproducing animals.

Animals with asexual reproduction can not be explained like prokaryotes, some protista, some fungi which kept in same sp. On the basis of same morphology & same biochemistry.

According to evolutionary sp. Concept species is defined on the basis of differences which are not base on sexual reproduction.

Supporter of this theory gave more importance to evolutionary isolation as compare to sexual isolation.

According to this concept a species is a lineage (an ancestor descendant sequence of population) which evolved separately from other species and have its own evolutionary role and tendencies.

This concept also include evolution. In this concept morphological, genetic, behavioural and ecological differences are include. But this concept is also not completely true.

3. **Typological concept** : According to this concept a fix pattern of characters is present in the species of every living organism and all the members of the species maximum resemblance with this pattern. [**The most acceptable concept**].

According to this concept species are of 2 types :

- (A) **Monotypic Sp.** In the formation of this type of species main ancestor species do not divide in to small groups and modify into a new species. So the no. of species are not increased.
- (B) **Polytypic.** : In the formation of this type of species the main ancestor sp. Divided into two or more groups and each groups form a new species. So the no. of species will increased.

SPECIATION

Formation of one or more new species from an existing species is called **speciation**. Speciation are to 2 types.

1. **Divergent speciation** : Origin of one or more new species from an ancestor species is called **divergent speciation**.

In this type of speciation ancestor sp. also continuous to exists with new species.

In this type of speciation no. of species are increased.

Demes : Local population of a particular area is called **demes**.

The members of two different demes of same sp. Can interbreed normally.

Race : Races are small groups of a species which are geographically isolated and have some genetical difference, which are controlled by genes.

Divergent speciation are of two types –

- (1) **Allopatric Speciation** : When a species split into two or more geographically isolated population and these population finally form a new species.

This mode of speciation is called allopatric speciation and these sp. are known as allopartic species.

Ex. : Finches of Darwin are example of **Allopatric speciation**.

- (2) **Sympatric species** : In this type of speciation a sub population becomes reproductively isolated from its partental population.

Sympatric speciation is the formation of species without geographical isolation and these sp. are known as sympatric species.

Mainly present in plants due to polyploidy.

2. **Transformation speciation** : in this type of speciation an ancestor species change into a new sp. with time. In this process no. of species is not increased.

Transformation speciation are of two types –

(1) **Phyletic Evolution** : When an ancestor sp. changed in to a new species by gradual change in thousand of years.

E.g. Eohippus → Mesohippus → Merychippus → Pliohippus → equus

(2) **Quantum Species** : In this process suddenly major changes appears in ancestor species and ancestor species immediately changed into new sp. No. connective links are present in this type of speciation. It is caused by major mutation.

Special point :

- **Micro evolution** : - Micro evolution is the occurrence of small-scale changes in gene frequencies in a population, over a few generations.

It occurs at or below the species level. It often cause the formation of new subspecies.

These changes may be due to several process-Natural selection, gene flow. mutation, recombination, genetic drift etc.

eg. Formation of clines.

- **Micro evolution** : - Macro evolution is the evolution, which results is the production of new adaptive types through a process of population fragmentation and genetic divergence.

It is the occurrence of large-scale changes in gene frequencies in a population, over a geological time period (consisting of lots of micro evolution).

Macro evolution operates above the species level and results in the establishment of new genera, families and order.

The changed in the organization occurs due to accumulation of large mutation (macro mutation).

Macro evolution is the actually adaptive divergence.

The divergent evolution of different reptilian group from initial reptile ancestor is example of macro evolution.

- **Mega evolution** : - The origin and evolution if new types of biological organization as a result of general adaptation from its predecessor resulting in the formation of new classes, phylum.

Mega evolutionary changes are rare and have occurred only a few times in the evolutionary history of living beings.

Ex. Origin of Amphibia from fishes, origin of reptiles from amphibian, origin of bird and mammal from reptile.

- **Anagenesis** : - It is the evolution of species involving a change in gene frequency in an antire population. It is also known as phyletic change. Anagenesis may also be reffered to as phyletic species or gradual species.

- **Cladogenesis** : - It is an evolutionary splitting event in which each branch and it's smaller branches form a 'clade' an evolutionary mechanism and a process of adaptive evolution that leads to the development of a greater variety of sister organism.

HUMAN EVOLUTION

Classification of Man :-

Phylum	- Chordata
Subphylum	- Vertebrata
Class	- Mammalia
Subclass	- Eutheria
Order	- Primates
Suborder	- Anthropoidea
Super family	- Hominoidea
Family	- Hominidae
Genus	- Homo
Species	- Sapiens

The primates include **Prosimians** (Lemurs, tarsiers and related forms) and **Anthropoids** (Monkeys, apes and Human). They are descended from small rodent like or insectivorous mammals that evolved about 80 million years ago.

- Carolus Linnaeus called human as **Homo sapiens wiseman**.
- Huxley explained origin of man in his book **'The man's place in nature'**.
- Darwin explained ancestry of man in his book **'The descent of man'**.
- Human is a member of order primates of class mammalia.
- Primates originated 80-100 million years ago in palaeocene epoch of coenozoic era.
- Primates originated from elephant shrews but they were not **real primates**.

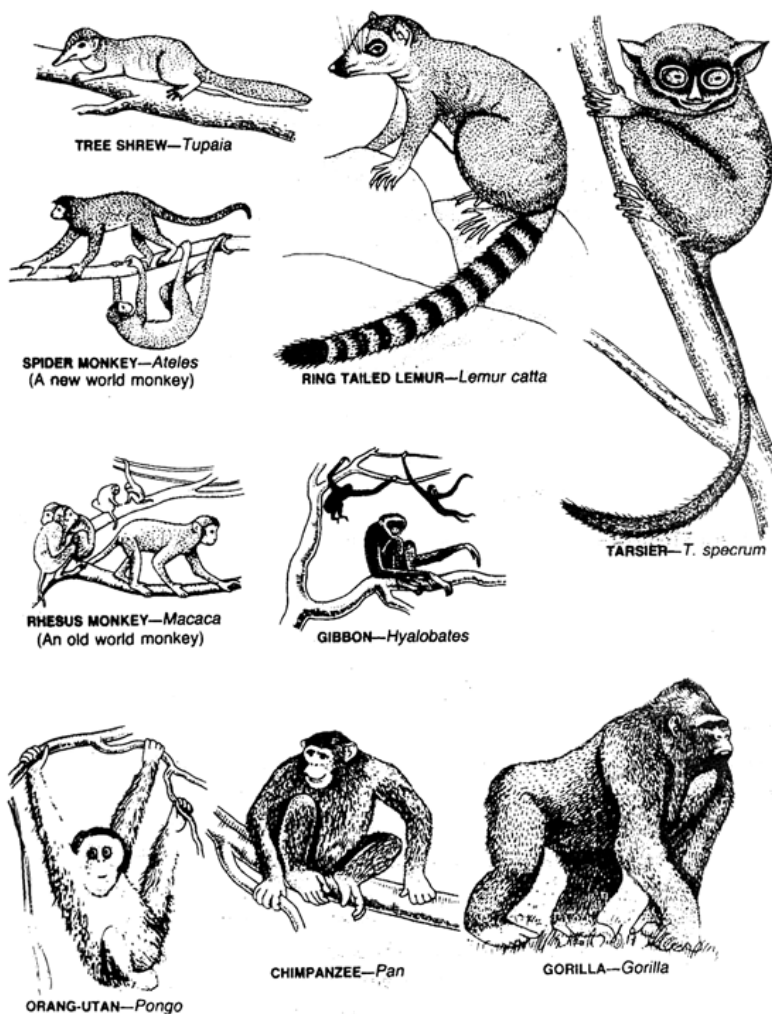
Elephant Shrews :-

- Originated in late Mesozoic era means Cretaceous Period.
- They were not real primates because
 1. In their retina, only rods were present (cones absent).
 2. Nails absent and claws present
 3. Long snout
 4. V-shaped Jaw.
 5. By nature insectivorous.
 6. Two pairs mammary glands are present.

Tree Shrews :-

They were first real primates originated in **Palaeocene epoch**.

1. Both rods and cones are present in their retina.



2. Claws absent and nails presents on digits.
3. Shorter snout.
4. V-shaped jaw.
5. By nature insectivorous
6. Two pairs mammary glands are present.

• **Order primates divided into 2 sub orders.**

(A) Prosimians :	Lemur - Evolved in Medagaskar	↑ 3	Closest relation to human
	Loris - Evolved in China	2	
	Tarsiers - Evolved in Indonesia	1	

They are prosimian ancestors of human,

(B) Anthropoids :	Monkeys
	Apes
	Human

Monkeys : - 2 types

(1) Old world monkeys : - Rhesus (Macaca), Baboon (Old world = Africa. Asia)

- (i) Tail short or long, non prehensile tail.
- (ii) Narrow flat nose with downward direction of nostril.
- (iii) U-shaped Jaw.
- (iv) Dental formula same as human $\frac{2123}{2123} = 32$
- (v) Menstruation cycle is present in female.

(2) New world monkeys : - spider monkey, marmosets (New world = South & Middle America)

- (i) Long, prehensile tail
- (ii) Protruding nose with upward direction of nostril
- (iii) U-shaped jaw
- (iv) Dental formula $\frac{2133}{2133} = 36$
- (v) Menstruation cycle absent but estrous cycle is present.

So, Old world monkeys are more closer to human.

Apes : - 4 types

↓	1. Chimpanzee	→	400 c.c.	Family - Pongideae
	2. Gorilla	→	500 c.c.	
	3. Oranguttan	→	400 c.c.	
	4. Gibbon	→	100 c.c.	Family - Hyalobatideae

Human - Hominideae Family

Similarities between man and apes : -

- (1) Tail absent
- (2) Erect posture
- (3) Grasping hands

- (4) Hairs are present on body
- (5) Larger head, more cranial capacity
- (6) More intelligent than other animals
- (7) Facial muscles are present for expression of surprise, pleasure.
- (8) Menstruation cycle is present in female of both
- (9) Blood group of AB series are present in both.
- (10) Composition of Hb is same in both. Only one amino acid is different in human and gorilla.
- (11) **Chromosomal similarities :** -

- (i) No. of chromosomes are approximately same in man and apes.

Apes = 48

Man = 46

- (ii) DNA contents and DNA matching is same in both. This similarity is

100% with Chimpanzee

94% with Gibbon

88% with Rhesus monkey

- (iii) Banding pattern of chromosome is same in both.

Banding pattern of ch. no. 3, 6 of human and chimpanzee is 100% similar.

Human Chromosomes

Somatic cells of human contain 46 chromosomes (44 Autosomes and 2-sex chromosomes).

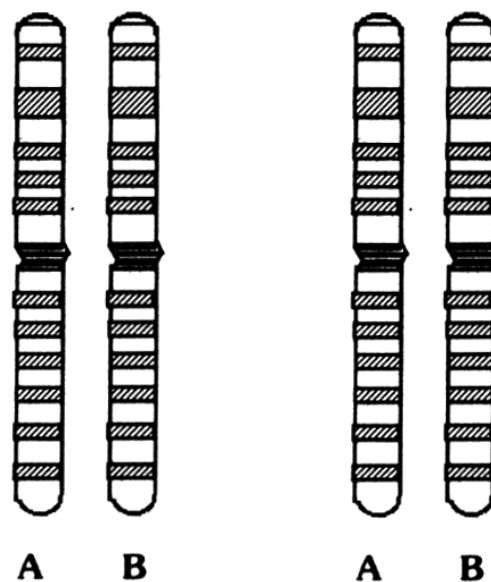
Human chromosomes are usually obtained by culturing certain types of white blood from the peripheral blood.

They can be treated with specific stains to produce characteristic bands along the length of each chromosome. The pattern of Banding so obtained is unique for each of chromosomes.

Banding techniques enable the identification of individual chromosomes and their parts.

The diploid number of chromosomes in Gorilla, chimpanzee and Orangutan is 48.

Comparisons have been made between banded chromosomes of man and those of the great apes.



Diagrammatic representation and comparison of the banding Pattern in 3rd and 6th chromosomes of man (A) and chimpanzee (B)

The total amount of DNA in human diploid cells and that of the great apes are dissimilar.

Similarity in the fine structural organization of the chromosomes is understood only in terms of a common origin for man and chimpanzee.

All human races have the same chromosome number and gross morphology.

Differences : -

Apes	Human
1. Semi erect posture	1. Complete erect posture
2. Shorter neck and embedded.	2. Long and erect neck
3. Thick growth of hairs on complete body	3. Only on certain body part
4. Less cranial capacity (650 c.c.)	4. More cranial capacity (1300-1600 c.c.)
5. Less intelligent	5. More intelligent
6. Forelimbs longer than hind limbs	6. Forelimbs are shorter than hindlimb
7. 'U' shaped jaw	7. Semi circular jaw
8. Chin absent	8. Chin present
9. Thumb is parallel to palm	9. Thumb is opposable
10. Elongated pelvic girdle	10. Broad pelvic girdle
11. Less hair on body	11. More hairs on body

Human evolution :

- (1) **Propliopithecus** : Origin & evolution in Oligocene epoch so called as Oligocene apes. Evolution about 30-35 million years ago.
- (2) **Aegyptopithecus** : Origin and evolution in late Oligocene and Miocene epoch so called as Miocene apes.
- (3) **Proconsul** : - Its fossils were discovered by Leakey from East Africa near Victoria lake in Kenya from Miocene rocks. It walked on its four legs (considered as common ancestor of man and apes).
- (4) **Dryopithecus** : - Evolution $\approx$ 15-20 million years ago.
 - Direct ancestor of modern day apes.
 - They were forest dwellers spending most of the time on the trees.
 - Origin & evolution in **Miocene epoch**.
 - Semi erect posture
 - Quadrapedal locomotion, forelimbs longer than hind limbs.
 - Thick growth of hair
 - U shaped jaws
 - Teeth larger and sharper
 - By nature vegetarian, fruit eater
- (5) **Ramapithecus** } Fossils discovered by Lewis from Shivalik hills in India.
- (6) **Shivapithecus** }
- (7) **Kenyanthropus**]- Fossils discovered from **Kenya** by **Leakey**.
 - Origin and evolution in **Pliocene epoch**.
 - They are considered as ancestors of human but in characteristics same as Dryopithecus, but spending most of the time on the land.
- (8) **Australopithecus** :- **Prof. Raymond dart** discovered a fossil of skull of 5-6 year old baby from the old Pliocene rocks of **Tuana region (S. Africa)**. He named it **Tuana baby**, later on he renamed it **A. africanus**.
 - About 3-2 million years ago it lived in East African grasslands.
 - Evidence shows they hunted with stone.
 - It was an apeman because it has many characters of man and apes so it is also considered as **connecting link between apes and man**.

Apes like characters :

- Less cranial capacity – 600 c.c.
- Thick growth of hair on body
- Jaw U shaped and prognathous.
- Teeth larger and sharper.
- Eyebrow present over eyes

Man like characters :

- Complete erect posture (**first man who stood erect**)
- Forelimb shorter than hindlimbs.
- **Bipedal locomotion (first man)**
- Dental formula same as human.
- Vertebral column with distinct lumbar curve.
- Some other varieties of Australopithecus were also discovered by some other scientist.
- A. boisei [Zinjanthropus] by Leakey from East Africa [Tanzania]
- A. afarensis [Lucy] by Donald Johanson from Ethiopia.

Prehistoric man : -

A number of other species of Homo appeared and became extinct from time on the evolutionary sense before the origin of Homo sapiens. These extinct species are called **prehistoric species of man**.

(1) Homo habilis : - The Tool maker man or Handy man.

- First human being like
- Its fossils were discovered by **Dr. Leakey** from 2 million years old rocks in Africa
- Lived in caves
- Cranial capacity - 650 – 800 c.c.
- Complete erect posture
- **Chin absent, dental formula same as human.**
- Jaw 'U' Shaped (Prognathous)
- **First man who made tools of stones for hunting animals.**
- By nature omnivorous, also show cannibalism

(2) Homo erectus : - direct ancestor of Homo sapiens

- Java man
- Peking man
- Heidelberg man (Branch from main line of Human evolution)

A. JAVA MAN :

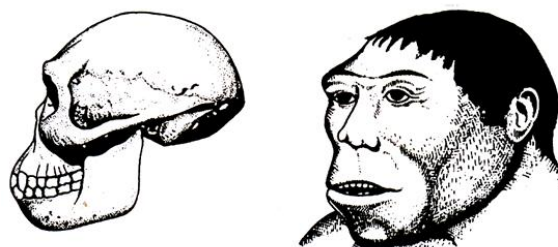
Homo erectus erectus name given by **Mayer**.

or **Pithecanthropus erectus** given by **Dubois**.

- Fossil obtained from central Java by **Eugene**

Dubois.

- Lived in caves
- They used Tools of bones and stones
- Cranial capacity – 800 – 1000 c.c.
- **First man who used fire for hunting, protection and cooking**



Java man

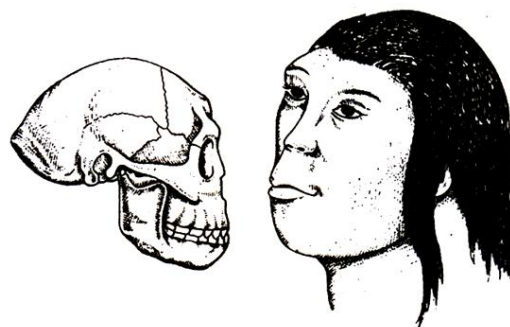
- Origin and evolution, 1.5 – 2million years ago.
- Chin absent, Jaw Prognathous
- Complete erect posture
- Complete erect posture
- Omnivorous, cannibalism have also found.
- **It is also known as erect ape man**

B. PEKING MAN : -

Homo erectus pekinensis name given by **Mayer**

Sinanthropus erectus name was given by **Davidson Black**.

- **W.C. Pai** discovered the fossil of peking man from China.
- Origin & evolution before 6 lakh years
- Lived in caves
- Cranial capacity - 850 - 1300 c.c.
- Complete erect posture
- Chin absent, Jaw Prognathous
- Used sharp **chisel shaped tools** of stones, bones for cutting and killing animals.
- Omnivorous, cannibalism has been also found
- Used fire for cooking meat and for protection.



Peking man

C. HEIDELBERG MAN : -

A fossil of lower jaw obtain from **Heidelberg in germany** it was discovered by **Ottoschotensack**.

- Mandible was large, tooth raw rounded
- Cranial capacity – 1300 c.c.
- Origin & evolution – in Pleistocene epoch. It is believed that this species was evolved as a branch from main line of evolution and got extinct after some time

(3) Homo sapiens : -

- Neanderthal man
- Cromagnon man - Direct ancestor of modern man
- Homo sapiens sapiens - **Modern man (Man of today)**
- (i) **Neanderthal man : - Homo sapiens neanderthalensis**
 - Origin & evolution before 40,000 – 1 lakh years
 - Fossils were discovered by **C. fulhrott** from **Neanderthal vally of Germany**.
 - They live in huts.
 - Cranial capacity 1300 – 1600 c.c (**same as H. sapiens sapiens**) **Average (1400 c.c.)**
 - Complete erect posture
 - Semicircular jaw, Orthognathous
 - Ceremonial burial of dead body
 - Woar cloths of animals skin
 - Less developed chin.
 - Speech centre developed



Neanderthal man

- By nature – omnivorous.
- **First man believed in "immortality of soul"**

(ii) Cromagnon man : - Homo sapiens fossils

- Origin and evolution **10,000 - 50,000 years ago.**
- Fossils discovered by **Mac gregor from Cromagnon rocks of France**
- Lived in caves
- Cranial capacity - 1650 c.c. (**maximum**)
- Complete erect posture
- Larger forehead, well developed speech centre
- Semi circular jaw, well developed chin, orthognathous jaw.
- Wore cloth of animal skin.
- **This man was hunter and used domesticated dogs in hunting, so domestication of animals started by cromagnon man.**
- **They also painted beautiful painting on cave walls**
- **The cromagnon man is regarded as the direct ancestor of modern man.**
- By nature **carnivorous.**



Cromagnon man

(iii) Homo sapiens sapiens (Modern man) : - Man of today

- Origin and Distributed in whole world 10-100 thousand years ago.
- Cranial capacity - 1300 - 1600 c.c.

(Same as Neanderthal man)

- Complete erect body posture
- Semi circular jaw, orthognathous
- Well developed chin, well developed speech centre
- Smaller forehead, front eyes
- Less hairs on body as compared to fossil man
- By nature omnivorous.
- It is believed that modern man evolved in Africa, later its members to westwards, eastwards and south wards
- **Agriculture was also started by them.**

Special Point :

The course of cultural evolution is divided in to three age.

Palaeolithic – Age of tools of stones and bones.

Mesolithic – Age of animals husbandry, language, reading, writing.

Neolithic

(i) Bronze age – Age of agriculture, knowledge and use of clothes.

(ii) Iron age – Present age is also known as Iran age.

Man of future : - homo sapiens futuralis

- **Dr. Shapiro** named man of future as Homo futuralis
- Taller and hairless body
- Tomb like head and larger brain.
- With no fifth finger

Special Point :-

- (1) **Anthropology** :- Study of evolutionary history of man.
- (2) **Ethology** :- Study of animal habits and behaviour.
- (3) **Hylobates hoolock** :- (The Gibbon) is the only ape found in India (forests of Assam)
- (4) **Races of human - 4 types - Caucasoid, Negroid, Mongoloid, Australoid.**
- (5) **Hobbit** :- Recently **Recherd Roberts** scientist discovered a **18,000 years** old fossil of a lady form **flors island** situated near **Australia**. He gave name it to **Hobbit/Dwarf man/Homo floresiensis**.

	Geological time scale	Name of fossil & cranial capacity	Distribution and Characteristics
	Holocene (Epoch)	Homo sapiens sapiens (Modern man) Cr. Cap. ~ 1500 cc.	Appeared about 10,000 years ago in central Asia.
	Late Pleistocene	Homo sapiens fossilis (Cro-Magnon Man) Cr.Cap. 1450-1700cc	Discovered from Cro-Magnon valley (France), and later from Czech & Israel. 1 st Chin-man , used bows and arrows. Had aesthetic sense and was a sculptor, artist and painter. He made articulated language and existed ~34,000 years ago. *Most recent or closest ancestor of present-day-man.
	Late Pleistocene	Homo sapiens neanderthensis (Neanderthal Man) Cr.Cap. ~1450 cc	It was the 1 st fossil man to be discovered (in 1856). It is the best known pre-historic man. Discovered from Neanderthal valley (Germany), so called Neanderthal man. It was a true man with Cranial capacity equal to that of Modern man. Distributed in Eurasia and Africa, and existed about 0.5 million years ago. He believed in 'Immortality of soul' and did <i>Ceremonial burial of the dead ones for the first time</i> , and was God-fearing man. He built huts and used animal hides as clothing. The well developed speech centre indicates that these could communicate with each other.
	Middle Pleistocene	Homo erectus Cr. Cap. 800 - 1200 cc.	1. Java Man (Pithecanthropus erectus) Discovered from Java (Asia), but distributed in Eurasia and Africa. Earlier named <i>H. erectus erectus</i> . Fossile described by Eugene Dubois . Use fire for the first time (?) Its cranial capacity was ~900cc.
	Early Pleistocene	Homo habilis (Handy man) Cr. Cap. ~600 - 700 cc.	2. Peking man (Sinanthropus pekinensis) Discovered from China but distributed in Eurasia and Africa. Fossil described by Davidson Black W.C. Pei . Used fire for cooking. Its cranial capacity was ~1100cc.
	Early Pleistocene	Australopithecus Cr. Cap. 350 - 450 cc.	3. Atlantic man (H. erectus mauritanicus) Discovered from Algeria (in rocks near Ternifier) and commonly called Ternifier man. Its cranial capacity was ~1000 cc. All members of <i>Homo erectus</i> were migratory and existed ~1.7 million years ago.
	Late Pliocene	Ramapithecus Cr. Cap. 350 cc.	Discovered from East Africa by Mrs. and Dr. Leakey. 1 st tool maker man, or nut-cracker man who made tools from stones. It existed about 2 million years ago and marked the beginning of human phase.
	Miocene (epoch)	Dryopithecus Cr. Cap. ~ 300 cc.	1 st bipedal 'man' (walked erect) Omnivorous, and used bones for hunting. Discovered from Africa by Raymond Dart . Described from a child skull, discovered from Tuang valley. Commonly called Tuang baby , W.T. 1500 (male), Lucy (female) or ' African Ape man '. Considered to be a pre-man or ape man, a <i>connecting link between man and apes</i> . It existed about 3-5 million years ago.
			Discovered from Shivalik hills in H.P. (India), by Dr. Lewis . It was more ape-like than human-like. It was herbivorous. It existed about 15 million years ago.
			Common ancestor of apes and man. Discovered from Lake Victoria (Africa) by Mrs. and Dr. Leakey. It is also known as Proconsul . It appeared about 24 million years ago (24 × 10 years).

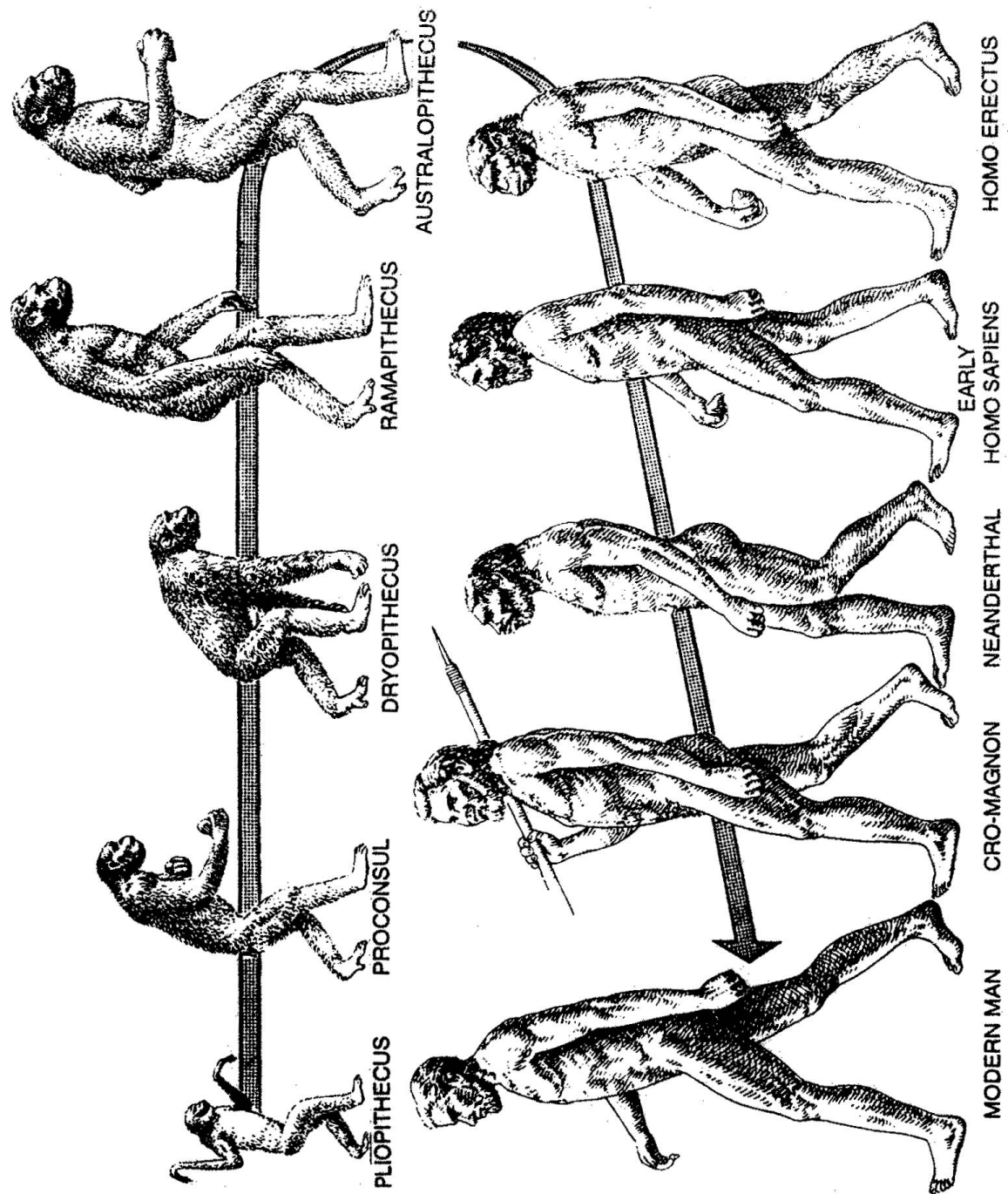
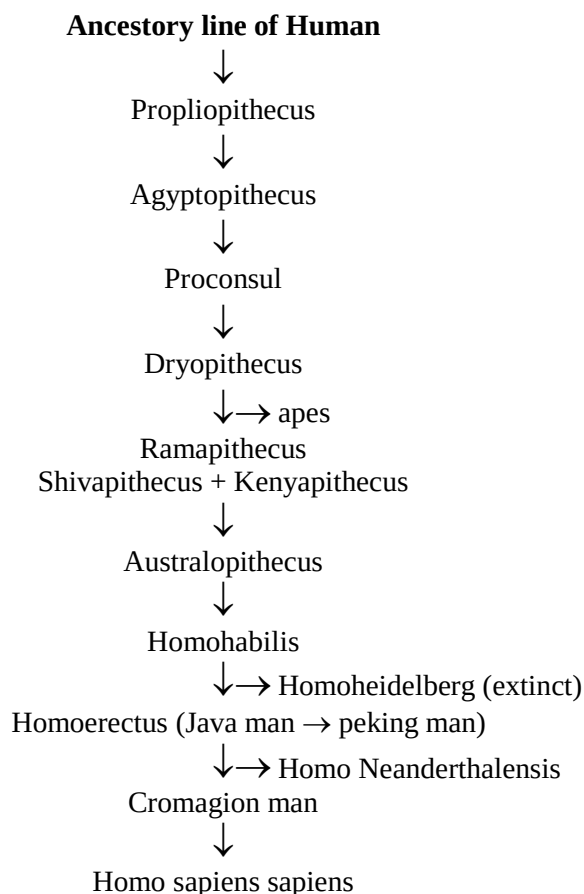


Fig. Progressive evolution of modern man through primitive apes, ape man and prehistoric man.

BRIEF REVIEW



- Tree shrews were first real primates.
- Old world monkeys are more closer to human as compared to new world monkeys.
- Chimpanzee is closest ape to human.
- Australopithecus firstly show bipedal locomotion.
- Homohabilis is also known as handy man or the tool maker man.
- Java man firstly used fire.
- W.C. Pai discovered the fossils of Peking man from China.
- Neanderthal man was first man who believed in 'immortality of soul.'
- Cromagnon man was a painter and regarded s the direct ancestor of modern man.
- Homosapiens sapiens is the man of today.

Evolution of Horse –

Evolution of horse was described by **C.marsh**.

The primitive fossil of the horse was found in North America named **Eohippus**.

Changes during evolution of horse are as follows –

1. Increase in body height
2. Increase in the length of neck

3. Development of high crown on the surface of teeth and formation of cement.
4. There is gradual increase in the length of legs.
5. Number of toes or fingers in legs have reduced in modern horse. Only middle toe touches the ground, other toes reduced gradually.
6. Legs become more powerful for fast running
7. As new species were formed, previous ones becomes extinct.
8. Enlargement of brain size.

Fossils of important Ancestors of horse

1. Eohippus or Hyracotherium –

It evolved in **Eocene** Epoch.

It's size was like a **fox**.

(**Orohippus** : It evolved in middle Eocene epoch.)

2. Mesohippus –

It evolved from eohippus during **Oligocene** epoch.

It's size was like a **sheep**.

(**Miohippus** : In the late oligocene Mesohippus was replaced by another slightly advanced horse like form named miohippus. It was much like mesohippus in a appearance but some what large in size)

(**Parachippus** : It evolved in early miocene).

3. Merychippus –

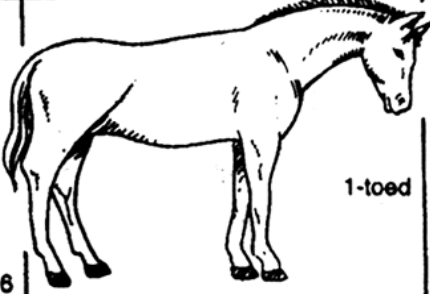
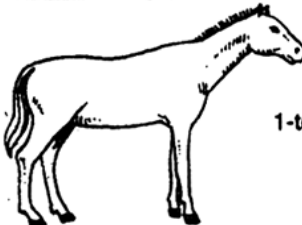
It evolved in middle and upper miocene epoch. It's size was like a **donkey**.

4. Pliohippus –

This horse evolved during **pliocene** epoch. It was of the size of modern pony.

5. Equus –

This is modern horse which evolved from pliohippus during **pleistocene** epoch (height 60-64 inches).

period	million yrs. ago	height in meters	horse	foreleg bones
PLEISTOCENE (RECENT)	1	1.6	 1-toed EQUUS (modern)	
PLIOCENE	13	1.2	 1-toed PLIOHIPPIUS	
MIOCENE	25	1.0	 3-toed MERYCHIPPUS	
OLIGOCENE	36	0.6	 4-toed MESOHIPPIUS	
EOCENE	58	0.4	 5-toed EOHIPPIUS	

EXERCISE – 1

- Q.1** Which of the following was not found in free state during origin of life-
(1) Ammonia (2) Methane
(3) Oxygen (4) Hydrogen
- Q.2** Who gave experimental proof that hydrogen, methane, water and ammonia gave rise to amino acids-
(1) Stanley Miller (2) Charls Darwin
(3) Lamarck (4) Oparin
- Q.3** Life originated in-
(1) Air (2) Earth
(3) Water (4) None of them
- Q.4** Primitive atmosphere was made up of the mixture of-
(1) Oxygen, ammonia, methane, water
(2) Hydrogen, ammonia, methane, carbondioxide
(3) Hydrogen, steam, methane, ammonia
(4) Oxygen, methane, water, nickel
- Q.5** Which compounds were formed in the direction of the origin of life-
(1) Urea, nucleic-acid (2) Urea, amino-acid
(3) Proteins, nucleic-acid
(4) Protein, amino-acid
- Q.6** There was no life in-
(1) Mesozoic period (2) Cambrian period
(3) Palaeozoic period (4) Azoic period
- Q.7** Pasteur gave-
(1) Cellular theory
(2) Recapitulation theory
(3) Germ theory of disease
(4) Germplasm theory
- Q.8** Life originated-
(1) 8 billion years ago
(2) 6 billion years ago
(3) 3 billion years ago
(4) 1 billion years ago
- Q.9** Stanley Miller synthesized in his experiment-
(1) Virus (2) Protein
(3) Amino acid (4) Cell
- Q.10** What is found in bacteriophage-
(1) Nucleoprotein (2) DNA
(3) Carbon & nitrogen
(4) Protein
- Q.11** Nucleoproteins gave first sign of-
(1) Species (2) Evolution
(3) Life (4) None
- Q.12** What is most important for origin of life-
(1) Carbon (2) Oxygen
(3) Water (4) Nitrogen
- Q.13** Miller synthesised simple amino-acid from-
(1) Methane, ammonia, oxygen, nitrogen
(2) Hydrogen, methane, ammonia, water
(3) Ammonia, methane, carbon dioxide, oxygen
(4) Hydrogen, oxygen, water, nitrogen
- Q.14** Origin of life took place in which of the following period-
(1) Mesozoic (2) Proterozoic
(3) Precambrian (4) Devonian
- Q.15** In which group one-celled animals and plants have been included-
(1) Protozoa (2) Monera
(3) Protista (4) Prokaryota
- Q.16** Pasteur succeeded in disproving the theory of spontaneous generation because-
(1) The laboratory was clean
(2) He pulled out the neck of flask into a tube
(3) He was lucky
(4) Yeast used in flask were dead
- Q.17** Spallanzani's experiment proved-
(1) Air is necessary for spontaneous generation
(2) Air from outside while entering the flasks carried small bacteria
(3) Air is unnecessary for spontaneous generation
(4) The contents of flask could not be boiled properly
- Q.18** Believers of spontaneous generation theory believed that-
(1) Life originated from other similar organisms or spontaneously
(2) Life originated only spontaneously from non living material
(3) Life originated from similar organisms
(4) Life originated from air
- Q.19** What it is necessary to boil instruments-
(1) For the comfort of patient
(2) To kill bacteria of operation theatre
(3) To kill bacteria on instruments
(4) For the comfort of doctor

- Q.20** Life is not found on moon because of-
- (1) Absence of carbon
 - (2) Absence of water
 - (3) Absence of nitrogen
 - (4) None of them
- Q.21** Now the basis of origin of life is-
- (1) Spontaneous generation
 - (2) God's desire
 - (3) Sunlight on garbage
 - (4) Chemical change
- Q.22** Oxygen in atmosphere has been formed by-
- (1) Evaporation of water
 - (2) Photosynthesis of plants
 - (3) Metabolism of microorganisms
 - (4) Decaying organisms
- Q.23** Atmospheric carbon dioxide comes from-
- (1) Action of microorganisms
 - (2) Smoke of industries
 - (3) Respiration of organisms
 - (4) Forest fire
- Q.24** Primitive atmosphere was reducing because-
- (1) Hydrogen atoms were few
 - (2) Hydrogen atoms were active and in greater numbers
 - (3) Nitrogen atoms were more
 - (4) Oxygen atoms were more
- Q.25** Stage between living and non-living-
- (1) Euglena
 - (2) Bacteria
 - (3) Virus
 - (4) Protista
- Q.26** Who called larger colloidal particles of primitive sea as coacervates-
- (1) Fox
 - (2) Oparin
 - (3) Ampedocles
 - (4) Haldane
- Q.27** Who called water of primitive sea as pre biotic soup-
- (1) Haldane
 - (2) Oparin
 - (3) Fox
 - (4) Huxley
- Q.28** Who discovered virus-
- (1) Stanley
 - (2) Iwanovsky
 - (3) Fox
 - (4) Ampedocles
- Q.29** On the basis of karyon differentiation is carried out between-
- (1) Protista and Monera
 - (2) Enaima and Anaima
 - (3) Prokaryota and Eukaryota
 - (4) None
- Q.30** Oparin's Theory is based on-
- (1) Artificial synthesis
 - (2) Spontaneous generation
 - (3) God's will
 - (4) All
- Q.31** What is the basis of life-
- (1) Proteins
 - (2) Nucleic acids
 - (3) Nucleo proteins
 - (4) Fatty acids
- Q.32** Which biologist gave most logical biochemical theory of origin of life-
- (1) Urey
 - (2) Oparin
 - (3) Stanley Miller
 - (4) Haeckel
- Q.33** Which of the following set is the best evidence for organic evolution –
- (1) Homologous & vestigial organs
 - (2) Analogous & vestigial organs
 - (3) Homologous & analogous organs
 - (4) All of them
- Q.34** Kiwi is found in –
- (1) India
 - (2) England
 - (3) South America
 - (4) Newzealand
- Q.35** Which of the following structure is a solid proof of organic evolution –
- (1) Wings of birds and bats
 - (2) Jointed legs in Arthropoda and mammals
 - (3) Gill clefts in vertebrate embryos
 - (4) Excretory organs of earthworm and cockroach
- Q.36** Archaeopteryx is a connecting link because –
- (1) It possessed characters of reptiles and aves
 - (2) It had characters of reptiles and mammals
 - (3) It was a reptile not a bird
 - (4) It had characters of nonchordates and chordates
- Q.37** Which of the following set in man includes vestigial organs –
- (1) Coccyx, vermiform appendix and ear muscles
 - (2) Body hair, atlas vertebra and ear muscles
 - (3) Coccyx, wisdom tooth and patella
 - (4) Body hair, cochlea and vermiform appendix
- Q.38** Galapago islands are connected with which scientist –
- (1) Wallace
 - (2) Lamarck
 - (3) Malthus
 - (4) Darwin

- Q.39** According to recapitulation theory –
 (1) Every animal begins as an egg
 (2) Damaged body parts are formed new
 (3) Offsprings are like parents
 (4) Ontogeny repeats phylogeny
- Q.40** Branch of biology which deals with fossils –
 (1) Ethology (2) Ecology
 (3) Paleontology (4) Ornithology
- Q.41** Theory of evolution is best explanation for –
 (1) Variation of animals and plant species
 (2) Matter, energy and life
 (3) Excessive multiplication rate in animals
 (4) Environment
- Q.42** Which animal has become extinct rather recently –
 (1) Dinosaur (2) Pterodactyl
 (3) Mammoth (4) Dodo
- Q.43** Which of the organs in man is not likely to become extinct soon –
 (1) Wisdom tooth (2) Blind spot
 (3) Hair (4) Ear muscles
- Q.44** Theory of evolution is mainly concerned with–
 (1) Spontaneous generation
 (2) Theory of special creation
 (3) Gradual change
 (4) Conditions of environment
- Q.45** Peripatus is connecting link between –
 (1) Mollusca and Arthropoda
 (2) Flat worms and annelida
 (3) Annelida and arthropoda
 (4) Reptilia & Mammalia
- Q.46** Prototheria have developed from –
 (1) Birds (2) Eutheria
 (3) Amphibia (4) Reptilia
- Q.47** According to Haeckel's biogenetic law –
 (1) Development of individual metazoa shows embryonic characters of ancestors
 (2) Ontogeny repeats phylogeny
 (3) Germplasm is immortal
 (4) Every organism is produced by its parents
- Q.48** Homologous organs have –
 (1) Similar origin and similar or dissimilar functions
 (2) Dissimilar origin and structure
 (3) Dissimilar origin and function
 (4) Dissimilar origin and similar functions
- Q.49** Which of the following set has analogous organs –
 (1) Hands of man, monkey and kangaroo
 (2) Wings of insects, birds and bats
 (3) Hind limbs of grasshopper, horse and bat
 (4) Mouthparts of cockroach, mosquito and honey bee
- Q.50** Which of the following set has homologous organs–
 (1) Wings of bird and bat
 (2) Wing of bat and hand of man
 (3) Wings of insect and bird
 (4) Wings of butterfly, bird and bat
- Q.51** Who was the first to explain recapitulation theory –
 (1) Weismann
 (2) Von baer and Haeckel
 (3) Darwin (4) Malthus
- Q.52** Which theory explains 'ontogeny repeats phylogeny'–
 (1) Mutation theory
 (2) Heredity
 (3) Recapitulation theory
 (4) Theory of natural selection
- Q.53** Analogous organs are –
 (1) Similar in function
 (2) Similar in structure
 (3) Non functional
 (4) Similar both in structure and function
- Q.54** Connecting link between protozoa and one-celled plants is –
 (1) Paramecium (2) Euglena
 (3) Amoeba (4) Trypanosoma
- Q.55** Which bird can not fly –
 (1) Stark (2) Emu
 (3) Duck (4) Peacock
- Q.56** Connecting link between annelida and Mollusca–
 (1) Cuttle fish (2) Octopus
 (3) Neopilina (4) Nautilus
- Q.57** Change with descent is the basis of which theory–
 (1) Recapitulation theory
 (2) Oparin's theory
 (3) Theory of organic evolution
 (4) Cell theory

- Q.58** If a particular animal has shelled eggs, hair and teats on the body and has cloaca, it may be a connecting link between –
 (1) Reptiles and birds
 (2) Birds and mammals
 (3) Reptiles and mammals
 (4) None of them
- Q.59** Which of the following sets do not have homologous organs –
 (1) Wings of mosquito and butterfly
 (2) Wings of butterfly and bird
 (3) Mouth parts of cockroach and butterfly
 (4) Forelegs of horse and paddles and butterfly
- Q.60** Who attempted to solve mechanism of evolution for the first time –
 (1) Darwin (2) Lamarck
 (3) Haeckel (4) Oparin
- Q.61** Evolution is defined as –
 (1) Progressive history of race
 (2) History and development of race, with variation's
 (3) History of race
 (4) Development of race
- Q.62** Under which of the following conditions organic evolution could not have taken place –
 (1) Acquired characters were not inherited
 (2) Somatic variations were not inherited
 (3) Individual in a population did not exhibit genetic variations
 (4) All of them
- Q.63** If a starfish possesses 6 arms instead of 5, it is an example of –
 (1) Variation (2) Metamorphosis
 (3) Biogenesis (4) Evolution
- Q.64** Which represents a connecting link as an example of an evidence from comparative anatomy for organic evolution –
 (1) Archaeopteryx between birds & mammals
 (2) Java apeman between modern man and peking man
 (3) Whale between fish and mammals
 (4) Duck bill platypus between reptiles and mammals
- Q.65** Life history of frog reflects evolution as shown by –
 (1) Larva represents living fossil
 (2) Phylogeny repeats ontogeny
 (3) Ontogeny repeats natural selection
 (4) Ontogeny repeats phylogeny
- Q.66** Which of the following is the most primitive mammal–
 (1) Spiny ant eater (2) Scaly ant eater
 (3) Armadillo (4) All ancestors
- Q.67** Primitive mammals providing evidence in organic evolution were found in —
 (1) Africa (2) China
 (3) India (4) Australia
- Q.68** Fossilization can occur where –
 (1) Animals are buried by natural process
 (2) Animals are destroyed by scavengers
 (3) Animals are eaten by predators
 (4) Animals are destroyed by environmental conditions
- Q.69** Why do we dig fossils and study them –
 (1) To find new fossils that have not yet been recovered
 (2) Fossil finding gives occupation to scientists
 (3) Fossil fills the gaps in the evolution of animals of the post
 (4) Fossils throw light on evolution of animals of the post
- Q.70** Which of the following exhibit analogy –
 (1) Paddles of whale and hands of man
 (2) Wings of pigeon and wing of bat
 (3) Wings of birds and wings of butterfly
 (4) None
- Q.71** Fossil X can be considered to have evolved earlier than fossil Y if –
 (1) Y has vestigial structures that are homologous to functional structures in fossil X
 (2) Y is structurally more complex than fossil X
 (3) Y is in better state of preservation than X
 (4) X is found in lower stratum of undisturbed sedimentary rock than Y
- Q.72** Name of the scientist who gave Mutation theory-
 (1) Wallace (2) Mathus
 (3) Darwin (4) De Veries
- Q.73** Darwin's Theory of Natural selection was based on-
 (1) Inheritance of acquired characters
 (2) Mutation
 (3) Enormous rate of production in organism, struggle for existence and survival of the fittest
 (4) Changes due to the use and disuse of organs

- Q.74** What was the basic principle of Lamackism-
 (1) Inheritance of acquired characters
 (2) Survival of the fittest
 (3) Natural selection
 (4) Variations
- Q.75** Book "Philosophie Zoologique" published in the year 1809 was written by-
 (1) Darwin (2) Lamarck
 (3) De Vries (4) Mendel
- Q.76** Which scientist gave theory of continuity of Germplasm-
 (1) Weismann (2) Mendel
 (3) Lamarck (4) Darwin
- Q.77** Which scientist gave the initial idea of survival of the fittest-
 (1) Wallace (2) Spencer
 (3) Darwin (4) Mendel
- Q.78** For organic evolution which theory was given by Lamarck-
 (1) Inheritance of acquired characters
 (2) Inheritance of vestigial organs
 (3) Inheritance of mutant characters
 (4) Inheritance of characters from parents to offsprings
- Q.79** New breeds of domestic dogs are developed by-
 (1) Sexual selection (2) Natural selection
 (3) Youth selection (4) Artificial selection
- Q.80** Adaptation of organism is its-
 (1) Moulting (2) Metamorphosis
 (3) Inheritable trait (4) Acquired character
- Q.81** Darwin explained origin of species through-
 (1) Hybridization (2) Mutation
 (3) Acquired characters (4) Natural selection
- Q.82** The ship on which Darwin worked as naturalist was-
 (1) Beagle (2) Century
 (3) Seagel (4) Norway
- Q.83** There would be no evolution if-
 (1) The inheritance of acquired characters did not take place
 (2) Somatic variation were not inheritable
 (3) Genic variations were not found among members of population
 (4) Somatic variations would not transform into genic variations
- Q.84** The book "Origin of Species" was published in the year-
 (1) 1956 (2) 1809
 (3) 1859 (4) 1844
- Q.85** Who gave theory of Natural Selection-
 (1) Charles Darwin (2) Lamarck
 (3) Malthus (4) De Vries
- Q.86** Which principle is associated with Darwin-
 (1) Every cell is produced by a pre-existing cell
 (2) Survival of the fittest in the struggle for existence
 (3) Inheritance of acquired characters
 (4) Gamete receives only one of the contrasting characters
- Q.87** If population of a species is transferred to more suitable environment then it will show-
 (1) Protection against enemies
 (2) More individuals would survive
 (3) Rate of reproduction increases
 (4) Unlimited food would be available
- Q.88** The weakest point of Darwinism was that it had no explanation for-
 (1) Struggle for existence
 (2) Survival of the fittest
 (3) Variations
 (4) Enormous rate of production
- Q.89** Snakes do not have legs because-
 (1) Legs are lost during their entry in tunnels
 (2) Legs are lost during evolution
 (3) Ancestor of reptiles did not have legs
 (4) There are no legs in lizards
- Q.90** Which of the following facts develop suspicions in Lamarckism-
 (1) Human female are not born with bored ear pinna although they have been bored thousand of years
 (2) Giraffe has long neck to eat leaves of tall trees
 (3) A stag can run fast to protect against the enemies
 (4) None of them
- Q.91** To be successful in evolution a mutation must occur in-
 (1) Plasma proteins (2) Somatoplasm DNA
 (3) Germplasm DNA (4) RNA

- Q.92** Of the following changes involved which one is irrelevant in the evolution of man-
- (1) Change of diet from hard nuts and hard roots to soft food
 - (2) Loss of tail
 - (3) Perfection of hand for tool making
 - (4) Increase in the ability to communicate with other and develop community behavior
- Q.93** One of the revolutionary concepts in biology was Charles Darwin's 'Origin of species' it deals with-
- (1) Gene mutation
 - (2) Use and disuse of organs
 - (3) Germplasm theory
 - (4) Natural selection leading to the survival of the fittest
- Q.94** Initiating force of evolution is-
- (1) Natural selection
 - (2) Mutation
 - (3) Adaptation
 - (4) None of them
- Q.95** What is the ultimate source of organic evolution-
- (1) Mutation
 - (2) Sexual selection
 - (3) Natural selection
 - (4) Inheritance of acquired characters
- Q.96** While explaining theory of Natural selection, Darwin was influenced by-
- (1) Essay on population by Malthus
 - (2) Cell theory
 - (3) Mendel's Laws of inheritance
 - (4) None of them
- Q.97** The concept of sudden genetic change which breeds true in a species is represented as-
- (1) Inheritance of acquired characters
 - (2) Natural selection
 - (3) Laws of inheritance
 - (4) Mutation
- Q.98** Mutations are mainly responsible for-
- (1) Increasing population rate
 - (2) Maintaining genetic continuity
 - (3) Variation in organisms
 - (4) Extinction of organisms
- Q.99** Mutations can be artificially induced by-
- (1) Radiations
 - (2) Chemical
 - (3) None of them
 - (4) Both of them
- Q.100** Mutation rate can be increased by-
- (1) Exposing the individuals to sun
 - (2) Exposing individual to X-rays
 - (3) Giving nutritional changes to individuals
 - (4) Increasing rate of reproduction
- Q.101** Most of the natural mutations are-
- (1) Useful
 - (2) Harmful
 - (3) Neutral
 - (4) Semilethal
- Q.102** Mutation develops due to-
- (1) Nutritional factor
 - (2) Infection of micro-organism
 - (3) Drugs
 - (4) Abrupt changes in genes
- Q.103** Cause of mutation-
- (1) Changes in DNA
 - (2) Changes in chromosomes
 - (3) Changes in gene
 - (4) All of them
- Q.104** Mutations are-
- (1) Inheritable changes
 - (2) Changes which are not inheritable
 - (3) Changes acquired during life time of an individual
 - (4) Changes which may or may not be inheritable
- Q.105** In the population of a species chances of the spreading of a mutant gene increases when it is-
- (1) Recessive
 - (2) Natural selection occurs
 - (3) Dominant
 - (4) Neither dominant nor recessive
- Q.106** We can not mutate particular gene because-
- (1) Genes are very small and can not be seen under light microscope
 - (2) It is very expensive to do so
 - (3) Genes are situated on chromosomes
 - (4) We do not yet know how to exactly do it
- Q.107** Which theory explains pure breeding and abrupt inheritable changes-
- (1) Theory of inheritance of acquired characters
 - (2) Natural selection
 - (3) Mutation theory
 - (4) Theory of continuity of germplasm
- Q.108** Discontinuous variations are-
- (1) Acquired characters
 - (2) Essential factors
 - (3) Mutations
 - (4) Non essential factors

- Q.109** Chances of inheritance and evolutionary changes are more in such species which reproduce by-
- (1) Parthenogenesis
 - (2) Fission
 - (3) Sexual reproduction
 - (4) Asexual reproduction
- Q.110** Mutation theory to explain mechanism of evolution was given by Hugo de Vries and he experiment on the-
- (1) Garden pea (2) Fruit fly
 - (3) China rose (4) Evening primrose
- Q.111** Which of the following is responsible for evolution according to Neo-Darwinism-
- (1) Mutation
 - (2) Natural selection
 - (3) Mutation and Natural selection
 - (4) Either (1) or (2)
- Q.112** A scientist kept 72 generations of *Drosophila* in darkness even after that the flies had normal eyes, this disproves the law of-
- (1) Synthetic theory (2) Natural selection
 - (3) Use and disuse theory
 - (4) Acquired characters are inherited
- Q.113** The ultimate source of organic variation is-
- (1) Mutation (2) Sexual reproduction
 - (3) Natural selection (4) Hormonal action
- Q.114** Which is the most important factor for evolution of new species-
- (1) Geographic isolation
 - (2) Extensive in breeding
 - (3) Extensive out breeding
 - (4) None
- Q.115** Which is a correct match-
- (1) Darlington - DNA replication
 - (2) Mendel - Mutation
 - (3) Morgan - Father of genetics
 - (4) De Vries - *Oenothera lamarckiana*
- Q.116** Theory of continuity of germplasm was given by-
- (1) Darwin (2) Lamarck
 - (3) Weismann (4) De Vries
- Q.117** Gene pool is-
- (1) Genotype of an individual of a population
 - (2) Different genes of all individual of a species found in an area
 - (3) Pool of artificially synthesised genes
 - (4) Genes of a genus
- Q.118** Which of the following evidences does not favour the Lamarckian concept-
- (1) Absence of limbs in snakes
 - (2) Presence of webbed toes in aquatic birds
 - (3) Melanization in peppered moth in industrial area
 - (4) Lack of pigment in cave dwelling animals
- Q.119** Who wrote the book 'Genetics and origin of species' which deals with synthetic theory of evolution -
- (1) Dobzhansky (2) Haldane
 - (3) Mayr (4) De Vries
- Q.120** The evolution of any species can be considered as sum total of the species with adaptive changes preserved by -
- (1) Inheritance of acquired characters
 - (2) Isolation
 - (3) Natural selection (4) Mass conservation
- Q.121** For evolution the most important requirement is-
- (1) Natural selection
 - (2) Adaptation of acquired traits
 - (3) Variations
 - (4) Continuity of germplasm
- Q.122** Use of atomic bombs may lead to abnormalities even in coming generations because of -
- (1) Bodily changes
 - (2) Air pollution
 - (3) Changed atoms in atmosphere
 - (4) Genetic mutation
- Q.123** Occurrence of 4 horns instead of two in goat is an example of -
- (1) Continuous variation
 - (2) Discontinuous variation
 - (3) Inheritable variation
 - (4) Acquired variation
- Q.124** Discontinuous variations are -
- (1) Acquired character (2) Mutation
 - (3) Essential character (4) None of them
- Q.125** Golden age of Dinosaurs was during
- (1) Coenozoic era (2) Palaeozoic era
 - (3) Archeozoic era (4) Mesozoic era
- Q.126** One field in which zoology and geology are closely connected-
- (1) Palaeontology (2) Archeology
 - (3) Zoogeography (4) Morphology

- Q.127** Fossils are dated by-
- (1) Amount of calcium residues
 - (2) Amount of radioactive carbon compound
 - (3) Association with other mammals
 - (4) Structure of bones
- Q.128** There was no life in which era-
- (1) Mesozoic era
 - (2) Palaeozoic era
 - (3) Coenozoic era
 - (4) Azoic era
- Q.129** What is sequence in the evolution of man-
- (1) Fish → amphibian → bird → man
 - (2) Insect → fish → bird → man
 - (3) Fish → amphibian → reptile → man
 - (4) Fish → amphibians → reptiles → bird → man
- Q.130** What helped reptiles to rule the earth for 10 million years-
- (1) Large teeth
 - (2) Shelled eggs
 - (3) Stiff lungs
 - (4) External protective skeleton
- Q.131** Which animals developed characters of mammals for the first time –
- (1) Synapsid reptiles
 - (2) Anapsid reptile
 - (3) Marsupials
 - (4) Eutherians
- Q.132** The name carboniferous period has been given because –
- (1) Carbon was freely available in atmosphere
 - (2) Forests were buried under swamps forming anthracite
 - (3) Animals and plants started origin in this period
 - (4) Carbon and ferrous compounds were found in plenty
- Q.133** What is the 'Age of Man' –
- (1) Proterozoic
 - (2) Recent
 - (3) Mesozoic
 - (4) 100 years
- Q.134** Age of fishes is the name of –
- (1) Devonian period
 - (2) Ordovician period
 - (3) Mesozoic era
 - (4) Coenozoic era
- Q.135** Rock mountain revolution took place after –
- (1) Coenozoic era
 - (2) Mesozoic era
 - (3) Paleozoic era
 - (4) Proterozoic era
- Q.136** Dinosaurs are –
- (1) Primitive amphibians
 - (2) Extinct reptiles
 - (3) Giant mammals
 - (4) Primitive mammals
- Q.137** Evolution of birds and mammals occurred in –
- (1) Eocene and oligocene periods
 - (2) Silurian and devonian periods
 - (3) Carboniferous and permian epochs
 - (4) Jurassic period
- Q.138** The mesozoic era of earth is called the –
- (1) Age of amphibians
 - (2) Age of armoured fishes
 - (3) Age of primitive man
 - (4) Age of ruling reptiles
- Q.139** Study of fossils is called –
- (1) Taxonomy
 - (2) Teratology
 - (3) Gerontology
 - (4) Palaeontology
- Q.140** Hoofed animals (horse like) originated in –
- (1) Pleistocene epoch
 - (2) Oligocene epoch
 - (3) Miocene epoch
 - (4) Eocene epoch
- Q.141** Dinosaurs originated –
- (1) After evolution of mammals
 - (2) With mammals
 - (3) Much before mammals
 - (4) Before mammals and they formed them
- Q.142** An era "age of birds and mammals" is –
- (1) Mesozoic
 - (2) Palaeozoic
 - (3) Coenozoic
 - (4) Cretaceous
- Q.143** Which geological era / period is regarded as age of reptiles –
- (1) Silurian
 - (2) Carboniferous
 - (3) Mesozoic
 - (4) Proterozoic
- Q.144** Earliest fossil form in the phylogeny of horse is–
- (1) Meshippus
 - (2) Equus
 - (3) Eohippus
 - (4) Merychippus
- Q.145** Java man belongs to-
- (1) Africa
 - (2) China
 - (3) Java
 - (4) Africa, China & Java
- Q.146** Which primate is closest to man during organic evolution-
- (1) Gibbon
 - (2) Gorilla
 - (3) Sinanthropus
 - (4) Orangutan
- Q.147** The prehistoric man which lived on earth during late pleistocene period-
- (1) Neanderthal man
 - (2) Australopithecus
 - (3) Cromagnon
 - (4) Atlantic man
- Q.148** Which character applies to Homo sapiens-
- (1) Opposable toe
 - (2) Large canine
 - (3) Cranial capacity 1450 cc
 - (4) Chin prominence absent

- Q.149** Fossils of pithecanthropus have been recovered from-
 (1) China (2) Germany
 (3) Java (4) Japan
- Q.150** Ancestor of man which for the first time showed bipedal movement-
 (1) Cro-magnon (2) Australopithecus
 (3) Java apeman (4) Peking man
- Q.151** Cro-magnon was-
 (1) Omnivorous (2) Carnivorous
 (3) Herbivorous (4) Frugivorous
- Q.152** Homo erectus is biological name of-
 (1) Solo man (2) Neanderthal man
 (3) Java man (4) Peking and Java man
- Q.153** Homo erectus differed from cro-magnon in having-
 (1) Jaws protruding out
 (2) Tool making
 (3) Sloping jaws (4) Arts and Paintings
- Q.154** The probable direct ancestor of modern man is-
 (1) Java man (2) Peking man
 (3) Cromagnon man (4) Neanderthal man
- Q.155** The probable first prehistoric man was-
 (1) Ramapithecus (2) Homo habilis
 (3) Australopithecus (4) Zinjanthropus
- Q.156** Which of the following statement is correct-
 (1) Proconsul was ancestor of man and ape
 (2) Proconsul was ancestor of man and not of ape
 (3) Apes were ancestor of man anatomically
 (4) None of them
- Q.157** Scientific name of man is-
 (1) Canis familiaris (2) Homo habilis
 (3) Homo erectus (4) Homo sapiens
- Q.158** The first ancestor of man whose fossils have been recovered was-
 (1) Pithecanthropus (2) Zinjanthropus
 (3) Australopithecus (4) Neanderthal man
- Q.159** Which character is not in the direction of evolution of man-
 (1) Prehensile tail
 (2) Steroscopic vision
 (3) Small jaws
 (4) Raised eyebrow ridges
- Q.160** On which continent maximum fossils of prehistoric man have been found-
 (1) Africa (2) Europe
 (3) Asia (4) America
- Q.161** Evolution of man took place because ape-like ancestor had-
 (1) Developed brain (2) Binocular vision
 (3) Large cranial capacity
 (4) Migratory
- Q.162** Most recent man found as fossil was -
 (1) Java man (2) Peking man
 (3) Cro-magnon man (4) Hiedelberg man
- Q.163** The fossil of primitive man recovered from shivalik hills in India-
 (1) Oligopithecus (2) Paranthropus
 (3) Ramapithecus (4) Pliopithecus
- Q.164** What was the cranial capacity of Java man-
 (1) 400 cc (2) 650 cc
 (3) 900 cc (4) 1450 cc
- Q.165** Who discovered Java ape man-
 (1) Leakey (2) Mayr
 (3) Davidson black (4) Dubois
- Q.166** The proper burial of dead bodies for the time started with which prehistoric man-
 (1) Peking man (2) Neanderthal man
 (3) Java man (4) Cromagonon man
- Q.167** Scientific name of Java man is -
 (1) Homo habilis
 (2) Pithecanthropus erectus
 (3) Homo erectus erectus
 (4) 2 & 3 both
- Q.168** Who formed the tools for the first time-
 (1) Australopithecus (2) Pithecanthropus
 (3) Sinanthropus (4) Ramapithecus
- Q.169** Evolution of man was possible because our ape like ancestor-
 (1) Showed bipedal movement in open land
 (2) Used fire
 (3) Felt difficulty in nutrition
 (4) Developed community hunting
- Q.170** What is the contribution of W.C. Pei-
 (1) He discovered Cro-magnon man
 (2) He discovered Peking man
 (3) He discovered Java man
 (4) None of them
- Q.171** C. Fuhlrott made an important discovery in evolution-
 (1) Neanderthal man
 (2) Cro magnon man
 (3) Classification of man
 (4) Characters of modern apes

- Q.172** Character of Tarsius in the direction of hominid evolution-
 (1) Smaller head (2) Nose not flat
 (3) Large eyes (4) All of them
- Q.173** Character of primitive monkey which was in the direction of evolution of man-
 (1) Thumb parallel to fingers
 (2) 32 teeth
 (3) Prehensile tail
 (4) Flat nose
- Q.174** Which of the following is not kept in the family of man-
 (1) Pithecanthropus (2) Homo
 (3) Peking man (4) Shivapithecus
- Q.175** Character of man which is most significant from evolution point of view-
 (1) Foramen magnum shifted forward
 (2) Larger cranial capacity
 (3) Face orthognathous
 (4) All of them
- Q.176** Greatest advantage of bipedal movement-
 (1) Forearms becoming free for carrying out order of brain
 (2) Greater speed
 (3) Supports the body properly
 (4) Loss of weight
- Q.177** Which fossil man had cranial capacity almost equal to modern man-
 (1) Austraopithecus (2) Java ape man
 (3) Neanderthal man (4) Peking man
- Q.178** Fire for protection and cooking was first used by-
 (1) Neanderthal man (2) Cro-Magnon
 (3) Java man (4) Peking man
- Q.179** Coloured rock paintings were first done by-
 (1) Cro-Magnon man (2) Java ape man
 (3) Peking man (4) Neaderthal man
- Q.180** Evolution of man took place in-
 (1) America (2) Australia
 (3) Central Africa (4) Central Asia
- Q.181** Largest cranial capacity was found in-
 (1) Peking man (2) Neanderthal man
 (3) Java man (4) Cro-magnon man
- Q.182** Which ancestor of man first of all stood erect-
 (1) Java apeman (2) Australopithecus
 (3) Peking man (4) Cro-magnon
- Q.183** Closest relative of man is-
 (1) Java man (2) Neanderthal man
 (3) Peking man (4) Cro-magnon man

ANSWER KEY

EXERCISE – 1

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	3	1	3	3	3	4	3	3	3	1	3	3	2	3	3	2	2	2	3	2
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	4	2	3	2	3	2	1	2	3	1	3	2	1	4	3	1	1	4	4	3
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	1	4	2	3	3	4	2	1	2	2	2	3	1	2	2	3	3	3	2	2
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	3	1	4	4	1	4	1	4	1	1	4	3	1	2	1	2	1	4	4
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	4	1	3	3	1	2	2	3	2	1	3	2	4	2	2	1	4	3	4	2
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	2	4	4	4	2	4	3	4	3	4	3	4	2	1	4	3	2	3	1	2
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	3	4	2	2	4	1	2	4	3	4	1	2	2	1	2	2	4	4	4	4
Ques.	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
Ans.	2	3	3	3	4	3	1	3	3	2	2	4	1	3	2	1	4	3	1	1
Ques.	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
Ans.	4	3	3	3	4	2	4	1	1	2	1	4	2	4	4	1	3	3	1	3
Ques.	181	182	183																	
Ans.	4	1	4																	

EXERCISE – 2

- Q.1** Founder of Palaeontology is :
(1) Lamarck (2) Erasmus Darwin
(3) G. Cuvier (4) Empedocles
- Q.2** Which of the following cannot be explained by Lamarckism ?
(1) Absence of lips in snakes
(2) Long neck of giraffe
(3) Degeneration of visual apparatus in cave dwellers
(4) Dull progeny of Noble Laureate
- Q.3** The “use and disuse theory” was proposed by:
(1) Gregor Mendel (2) Konrad Lorenz
(3) Malthus (4) Jean B. Lamarck
- Q.4** The ship in which Charles Darwin travelled was:
(1) H.M.S. Beagle (2) Royal Ship
(3) Victoria (4) None of these
- Q.5** Organic compounds first evolved on earth and required for origin of life were :
(1) Urea and amino acid
(2) Protein & nucleic acid
(3) Protein and amino acid
(4) Urea and nucleic acid
- Q.6** Speciation occurs when :
(1) Populations are isolated by geographical barrier
(2) Populations are reproductively isolated
(3) Both of these
(4) None of these
- Q.7** Struggle for existence and survival of fittest are related to :
(1) Lamarckism (2) Darwinism
(3) Oparin’s theory (4) Mendelism
- Q.8** Lamarckism fails to explain :
(1) Long neck of giraffe
(2) Loss of limbs in snake
(3) Presence of tail in mouse
(4) Webbed feet in swimming birds
- Q.9** Gene frequency in a population remains stable unless and until there is-
(1) Random drift (2) Random mating
(3) Selection (4) Mutation
- Q.10** Which is most important in speciation :
(1) Geographical isolation
(2) Reproductive isolation
(3) Ecological isolation
(4) Ethological isolation
- Q.11** Darwin’s explanation of the way in which evolution occurs is :
(1) God determines which species should evolve
(2) Progressive adaptations enable one species to leave more offsprings
(3) Certain species have ‘built in’ plans of evolution
(4) Those traits used most often persist longer
- Q.12** Life cannot originate from inorganic materials upon the present earth because of
(1) High pollution
(2) Low temperature of earth
(3) Large amount of oxygen in atmosphere
(4) High temperature of earth
- Q.13** Tectonic is the study of :
(1) Earth’s crust (2) Earth quakes
(3) Volcanoes (4) Sand dunes
- Q.14** Diversity in the type of beaks of finches adapted to different feeding habits on the Galapagos islands as observed by Darwin provides evidence for :
(1) Origin of species by natural selection
(2) Intraspecific variations
(3) Interspecific variations
(4) Interspecific competition
- Q.15** Genetic drift operates only in :
(1) Island population (2) Smaller population
(3) Larger population (4) Mendelian population
- Q.16** Successful adaptation simply means :
(1) An increase in fitness
(2) Producing offsprings
(3) Moving to a new place
(4) Evolving new characters
- Q.17** Lamarck’s theory is an evergreen superstition” was reported by :
(1) Charles Darwin (2) Darlington
(3) Hugo de Vries (4) Carlson

- Q.18** Selecting the genetically improved domesticated plants and animals by man is-
 (1) Natural selection (2) Artificial selection
 (3) Hybrid selection (4) Any of above
- Q.19** Theory of Pangenesis was proposed by :
 (1) Lamarck (2) Darwin
 (3) Hugo de Vries (4) Dobzhansky
- Q.20** The phenomenon of Industrial melanism demonstrates :
 (1) Natural selection
 (2) Artificial selection
 (3) Reproductive isolation
 (4) Geographical isolation
- Q.21** Who proposed germplasm theory against Lamarck's principle of 'use and disuse'?
 (1) Darwin (2) Nuttall
 (3) Weismann (4) de Vries
- Q.22** Birbal Sahani Institute of Palaeobotany is located at:
 (1) New Delhi (2) Lucknow
 (3) Kolkata (4) Kanpur
- Q.23** What is evolution ?
 (1) Development of organisms through time
 (2) Development of a cell from chemicals
 (3) Development of DNA nucleotides
 (4) None of these
- Q.24** Charles Darwin's theory of evolution was based on:
 (1) Environment
 (2) Mutations
 (3) Chromosome pairing
 (4) Natural selection
- Q.25** The raw material for organic evolution is :
 (1) Asexual reproduction
 (2) Effect of hormones
 (3) Nutritive substances
 (4) Mutations
- Q.26** Who proposed the mutation theory of evolution:
 (1) Darwin (2) Hugo de Vries
 (3) Lamarck (4) Huxley
- Q.27** Chemical theory of origin of life was given by:
 (1) Stanley Miller (2) Louis Pasteur
 (3) Spallanzani (4) Oparin & Haldane
- Q.28** Who did an experiment to prove that the organic compounds are the basis of life:
 (1) K. Bahadur (2) Miller and Urey
 (3) Melvin Calvin (4) Sydney Fox
- Q.29** The book "Origin of Species" was written by :
 (1) Darwin (2) Hugo de Vries
 (3) Lamarck (4) Huxley
- Q.30** Hugo de Vries worked on :
 (1) Pisum (2) Lathyrus
 (3) Oenothera (4) Mirabilis
- Q.31** Industrial melanism is an example of :
 (1) Natural selection
 (2) Retrogressive evolution
 (3) Adaptive convergence
 (4) Artificial selection
- Q.32** The first amphibians appeared during the period:
 (1) Permian (2) Carboniferous
 (3) Silurian (4) Devonian
- Q.33** As evident from fossil records, which era had no life:
 (1) Azoic (2) Proterozoic
 (3) Palaeozoic (4) Coenozoic
- Q.34** Who wrote the book "Genetics and Origin of Species" ?
 (1) Hugo de Vries (2) Dobzhansky
 (3) Huxley (4) R.A. Fischer
- Q.35** Discontinuous variations were called 'sports' by :
 (1) De Vries (2) Lamarck
 (3) Bateson (4) Darwin
- Q.36** Book "Philosophic Zoologique" was written by:
 (1) Lamarck (2) Darwin
 (3) Hugo de Vries (4) Bateson
- Q.37** Theory of "Continuity of Germplasm" was propounded by :
 (1) August Weismann (2) Gregor Mendel
 (3) Lamarck (4) Darwin
- Q.38** Which of the following are homologous organs:
 (1) Hand of man, wings of bat
 (2) Eyes of man, eyes of squid
 (3) gills of fish, lungs of man
 (4) Leaf of moss, frond of fern

- Q.39** Theory of spontaneous generation was given by
 (1) Spallanzani (2) Von Helmont
 (3) Redi (4) Pasteur
- Q.40** Who disproved the theory of spontaneous generation ?
 (1) Redi (2) Pauling
 (3) Balkman (4) None of these
- Q.41** Darwin's finches show which aspect of evolution ?
 (1) Biogeographical (2) Industrial melanism
 (3) Biochemical (4) Embryological
- Q.42** The synthesis of first protein during the origin of the life was :
 (1) from DNA
 (2) from RNA
 (3) from DNA & RNA both
 (4) without nucleic acid and biocatalyst
- Q.43** Darwin's theory states that :
 (1) Characters are acquired through inheritance
 (2) Nature selects species which can adapt
 (3) Species changes morphologically with nature
 (4) Effect of environment on evolution
- Q.44** Similarities in organism with different genotype indicates :
 (1) Microevolution
 (2) Macroevolution
 (3) Convergent evolution
 (4) Divergent evolution
- Q.45** Which of the following is closely related to man:
 (1) Chimpanzee (2) Gorilla
 (3) Orangutan (4) Gibbon
- Q.46** Which of the following is correct order of the evolutionary history of man :
 (1) Peking man, Homo sapiens sapiens, Neanderthal man, Cromagnon man
 (2) Hedlberg, Peking man, Neanderthal man, Cromagnon man
 (3) Peking man, Hedlberg man, Neanderthal man, Cromagnon man.
 (4) Peking man, Neanderthal man, Homosapiens, Hedlberg man
- Q.47** Which of the following was homologous organs-
 (1) Wing of birds & Locust
 (2) Wings of sparrow & wings of bat
 (3) Wings of bat & butterfly
 (4) Legs of frog and cockroach
- Q.48** There is no life on moon due to the absence of:
 (1) O₂ (2) Water
 (3) Light (4) Temperature
- Q.49** According to fossils which have been discovered up to present time, origin and evolution of man was started from which country -
 (1) France (2) Java
 (3) Africa (4) China
- Q.50** The wings of bat, locust and pigeon are the examples of :
 (1) Vestigial organs
 (2) Analogous organ
 (3) Homologous organs
 (4) Exoskeletal organs
- Q.51** Convergent evolution is illustrated by-
 (1) Rat and dog
 (2) Bacterium and protozoan
 (3) Starfish and cuttle fish
 (4) Dogfish and whale
- Q.52** Which one of the following sequences was proposed by Darwin and Wallace for organic evolution?
 (1) Overproduction, variations, constancy of population size, natural selection
 (2) Variations, constancy of population size, overproduction, natural selection
 (3) Overproduction, constancy of population size, variations, natural selection
 (4) Variations, natural selection, overproduction, constancy of population size
- Q.53** Darwin in his "Natural Selection Theory" did **not** believe in any role of which one of the following in organic evolution ?
 (1) Parasites and predators as natural enemies
 (2) Survival of the fittest
 (3) Struggle for existence
 (4) Discontinuous variations

- Q.54** Which one of the following describes correctly the homologous structures ?
- (1) Organs with anatomical similarities, but performing different functions
 - (2) Organs with anatomical dissimilarities, but performing same functions
 - (3) Organs that have no function now, but had an important functions in ancestors
 - (4) Organs appearing only in embryonic stage and disappearing later in the adult
- Q.55** What kind of evidence suggested that man is more closely related with chimpanzee than with other hominoid apes?
- (1) Evidence from DNA from sex chromosomes only
 - (2) Comparison of chromosomes morphology only
 - (3) Evidence from fossil remains, and the fossile mitochondrial DNA alone
 - (4) Evidence from DNA extracted from sex chromosomes, autosomes and mitochondria
- Q.56** Being all mammals, while dolphins, bat, monkey and horse have some common characters but they also show conspicuous differences. This is due to the phenomenon of-
- (1) Normalisation
 - (2) Genetic drift
 - (3) Divergence
 - (4) Convergence
- Q.57** Which one of the following was most likely absent in free form in the primordial atmosphere at the time of origin of life-
- (1) Methane
 - (2) Hydrogen
 - (3) Ammonia
 - (4) Oxygen
- Q.58** Initiating force of evolution is-
- (1) Variation
 - (2) Natural selection
 - (3) Adaptation
 - (4) Competition
- Q.59** Which one of the following experiments suggests that simplest living organisms could not have originated spontaneously from non-living matter-
- (1) Larvae could appear in decaying organic matter
 - (2) Microbes did not appear in stored meat
 - (3) Microbes appeared from unsterilized organic matter
 - (4) Meat was not spoiled, when the heated and kept sealed in a vessel
- Q.60** De Vries gave his mutation theory on organic evolution while working on-
- (1) *Pisum sativum*
 - (2) *Drosophila melanogaster*
 - (3) *Oenothera lamarckiana*
 - (4) *Althea rosea*
- Q.61** There are two opposing views about origin of modern man. According to one view Homo erectus in Asia were the ancestors of modern man. A study of variation of DNA however suggested African origin of modern man. What kind of observation of DNA variation could suggest this-
- (1) Greater variation in Asia than in Africa
 - (2) Greater variation in Africa than in Asia
 - (3) Similar variation in Africa and Asia
 - (4) Variation only in Asia and no variation in Africa
- Q.62** Which one of the following phenomena supports Darwin's concept of natural selection in organic evolution ?
- (1) Development of transgenic animals
 - (2) Production of Dolly the sheep by cloning
 - (3) Prevalence of pesticide resistance insects
 - (4) Development of organs from stem cells for organ transplantation
- Q.63** Which of the following is the relatively most accurate method for dating of fossils ?
- (1) Radio-carbon method
 - (2) Potassium-argon method
 - (3) Electron spin resonance method of amino acid
 - (4) Uranium lead method
- Q.64** Set which includes only analogous organs is-
- (1) Wings of butterfly, housefly and bat
 - (2) Hindlegs of horse, grasshopper and bat
 - (3) Wings of butterfly and wingspread of bat and birds
 - (4) Mandibles of cockroach, mosquito and honey bee
- Q.65** 'Convergent Evolution' is shown by-
- (1) Homologous organs
 - (2) Analogous organs
 - (3) Vestigial organs
 - (4) All of the above

- Q.66** Example of analogous organs is-
- (1) Wings of bird and insect
 - (2) Forelimbs of horse and man
 - (3) Teeth of elephant and man
 - (4) None of the above
- Q.67** Which extinct animal shows evidences of evolution-
- (1) *Peripatus* (2) *Neopilina*
 - (3) *Echidna* (4) *Archaeopteryx*
- Q.68** The classical example of adaptive radiation in development of new species is-
- (1) Darwin finches
 - (2) Marsupials of Australia
 - (3) Giant turtle (4) All of these
- Q.69** Two organs which are similar in structure and origin, but not necessarily in function are called-
- (1) Homologous (2) Analogous
 - (3) Apocrine (4) None of these
- Q.70** Which one of the following amino acids was not found to be synthesized in Miller's experiment ?
- (1) Alanine (2) Glycine
 - (3) Aspartic acid (4) Glutamic acid
- Q.71** Jurassic period of the meozoic era is characterised by-
- (1) Flowering plants and first dinosaurs appear
 - (2) Gymnosperm are dominant plants and first birds appears
 - (3) Radiation of reptiles and origin of mammals -like reptiles
 - (4) Dinosaurs become extinct and angiosperms appear
- Q.72** Which one of the following is not a living fossil?
- (1) *Peripatus* (2) King Crab
 - (3) *Sphenodon* (4) *Archaeopteryx*
- Q.73** Which one is correct.
- (1) Wings of birds and insects are homologous
 - (2) Caecum and appendix in Rabbit and Man are analogous
 - (3) Paired fins of fish and flippers of whale are analogous
 - (4) *Archaeopteryx lithographica* is missing link between birds and mammals.

- Q.74** The unit of natural selection is.
- (1) A genus (2) A population
 - (3) An individual (4) Oxygen
- Q.75** Which is the correct Aristotle's ladder of nature?
- (1) Inanimate matter → lower plants → higher plants → zoophyta → entoma → ostracoderma → malacia → malacostraca → fish → oviparous → quadrupeds → cetacea → birds → viviparous quadrupeds → humans.
 - (2) Inanimate matter → lower plants → higher → plants → zoophyta → entoma → malacia → malacostraca → ostracoderma → fish → oviparous quadrupeds → cetacea → birds → viviparous quadrupeds → humans .
 - (3) Inanimate matter → lower plats → higher → plants → zoophyta → malacia → malacostrace → ostracoderma → fish → oviparous quadrupeds → humans.
 - (4) Inanimate matter → lower plants → higher plants → zoophyta → entoma → ostracoderma → malacostraca → malacia → fish → cetacea → oviparous → quadrupeds → birds → viviparous quadrupesa → humans.
- Q.76** Among the human ancestors the brain size was more than 1000 CC in-
- (1) *Homo erectus*
 - (2) *Ramapithecus*
 - (3) *Homo habilis*
 - (4) *Homo neanderthalensis*
- Q.77** Industrial melanism as observed in peppered moth proves that-
- (1) The melanic form of the moth has no selective advantage over lighter form in industrial area
 - (2) The lighter form moth has no selective advantage either in polluted industrial area or non-polluted area
 - (3) Melanism is a pollution generated feature
 - (4) The true black melanic forms arise by a reoccurring random mutation

- Q.78** Select the correct statement from the following-
- (1) Fitness is the end result of the ability to adapt and gets selected by nature
 - (2) All mammals except whales and camels have seven cervical vertebrae
 - (3) Mutation are random and directional
 - (4) Darwins variations are small and directionless

- Q.79** What is common to whale , seal and shark ?
- (1) Thick subcutaneous fat
 - (2) Convergent evolution
 - (3) Homiothermy
 - (4) Seasonal migration

- Q.80** One of the important consequences of geographical isolation is-
- (1) Preventing speciation
 - (2) Speciation through reproductive isolation
 - (3) Random creation of new species
 - (4) No change in the isolated fauna

ANSWER KEY

EXERCISE – 2

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	3	4	4	1	2	2	2	3	4	2	2	3	1	1	2	4	2	2	2	1
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	3	2	1	4	4	2	4	2	1	3	1	4	1	2	4	1	1	1	2	1
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	1	4	2	3	1	2	2	2	3	2	4	3	4	1	4	3	4	1	4	3
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	3	3	3	4	1	4	4	1	4	2	4	3	3	4	4	4	1	2	2

EXERCISE – 3

- Q.1** Most advanced theory of origin of life is that of
[CET Chd. 2000]
(1) Catastrophic (2) Haldane and Oparin
(3) Cosmozoic (4) Spontaneous.
- Q.2** Possible early source of energy was
[AIIMS 2000]
(1) Chlorophyll
(2) CO₂
(3) UV radiations and lightning
(4) Green plants.
- Q.3** Swan-necked flask experiment was performed by
[KCET 2001]
(1) Louis Pasteur (2) Robert Koch
(3) Francisco Redi (4) Aristotle.
- Q.4** Spark discharge apparatus for testing chemical origin of life was designed by [KCET 2001]
(1) Urey and Miller
(2) Jacob and Monod
(3) Oparin and Haldane
(4) Dixon and Joly.
- Q.5** Which is the most important for origin of life?
[Pb. PMT 2000]
(1) Oxygen (2) Water
(3) Nitrogen (4) Carbon.
- Q.6** Chemical theory for origin of life was given by [Manipur 2006]
(1) Stanley Miller (2) Oparin and Haldane
(3) Spallanzani (4) Louis Pasteur.
- Q.7** Theory of spontaneous creation was supported by [AFMC 2000]
(1) Van Helmont (2) Redi
(3) Spallanzani (4) Pasteur.
- Q.8** One of the greatest advocates of the theory of special creation was [Pb. PMT 2000]
(1) C. Darwin (2) Aristotle
(3) Father Saurez (4) Huxley.
- Q.9** A compound important in prebiotic evolution was [Har. PMT 2000]
(1) SO₂ (2) CH₄
(3) SO₃ (4) NO

PREVIOUS YEAR'S QUESTIONS

- Q.10** Simple one-celled cyanobacteria-life organisms developed on earth [Kerala 2000]
(1) 5600 million years (2) 5000 million years
(3) 4600 million years (4) 3600 million years
(5) 3000 million years.
- Q.11** Which ones are the most essential for origin of life ? [AIIMS 2001]
(1) Enzymes (2) Proteins
(3) Carbohydrates (4) Nucleic acids
- Q.12** Approximate age of earth (in million years) is [HPPMT 2001]
(1) 3600 (2) 4600
(3) 7200 (4) 6000.
- Q.13** According to theory of abiogenesis, life originates from [Kerala 2002, DPMT 2009]
(1) Non-living
(2) Spontaneously
(3) Chemicals
(4) Other planets.
- Q.14** A biogenesis is [CPMT 2002]
(1) Origin of life from non-living organisms
(2) Origin of microbes from living organisms
(3) Spontaneous
(4) Origin of microbes and viruses.
- Q.15** Experiment to prove chemical basis of origin of life carried out by Urey and Miller used NH₃ and [Bihar PMT 2002]
(1) H₂O and H₂ (2) H₂, CH₄ and H₂O
(3) CH₄ and H₂O (4) CH₄ and O₂
- Q.16** Miller's experiment provided evidence for theory of [Orissa 2002]
(1) Special creation
(2) Biogenesis
(3) Abiogenesis
(4) Organic evolution.
- Q.17** Experimental proof that organic compounds formed the basis of evolution was given by [DPMT 2002]
(1) Oparin (2) Pasteur
(3) Miller and Urey (4) Spallanzani.

- Q.18** Which of the following has been basic to origin of life [CET Chd. 2003]
 (1) Carbohydrates (2) Proteins
 (3) Nucleic acids (4) Nucleoproteins.
- Q.19** Theory of abiogenesis or spontaneous generation was finally disapproved by [Kerala 2003]
 (1) Louis Pasteur (2) A.I. Oparin
 (3) A.R. Wallace (4) Sidney Fox.
- Q.20** Given below are assertion and reason. Point out if both are true with reason being correct explanation (A), both true but reason is not correct explanation (B), assertion true but reason is wrong (C), both are wrong (D).
Assertion. Coacervates are believed to be precursors of life. **Reason.** Coacervates were self duplicating aggregates of proteins surrounded by lipid molecules. [AIIMS 2004, 2008]
 (1) (2)
 (3) (4)
- Q.21** Coacervates were experimentally produced by [KCET 2004]
 (1) Oparin and Sidney Fox
 (2) Fischer and Huxley
 (3) Jacob and Monod
 (4) Urey and Miller.
- Q.22** Who disapproved abiogenesis for the first time? [Manipal 2004]
 (1) Lamarck (2) F. Redi
 (3) Pasteur (4) Darwin.
- Q.23** Which experiment suggests that simplest living organisms could not have originated spontaneously from non-living matter? [CBSE 2005]
 (1) Microbes did not appear in stored meat.
 (2) Microbes appeared from unsterilised organic matter.
 (3) Larvae could appear in decaying organic matter.
 (4) Meat was not spoiled when heated and kept in sealed vessel.
- Q.24** Origin of life from pre-existing life is propounded by [JKCMEE 2005, Har PMT 2007]
 (1) Biogenesis theory
 (2) Abiogenesis theory
 (3) Special creation theory
 (4) Extra terrestrial theory.
- Q.25** Extra terrestrial origin of life was proposed by theory of [DPMT 2005]
 (1) Catastrophism
 (2) Spontaneous generation
 (3) Special creation
 (4) Panspermia.
- Q.26** Stanley Miller's experiment supports+ [Manipal 2005]
 (1) Abiogenesis (2) Biogenesis
 (3) Pangenesis (4) Chemical theory.
- Q.27** Cyanobacteria originated on earth about [HPPMT 2005]
 (1) 4.3–4.8 billion years ago
 (2) 3.3–3.8 billion years ago
 (3) 2.3–2.8 billion years ago
 (4) 1.3–1.8 billion years ago.
- Q.28** Coacervates belong to the category of [Pb. PMT 2005]
 (1) Protozoans
 (2) Molecular aggregates
 (3) Molecular aggregates surrounded by lipid membrane
 (4) Cyanobacteria.
- Q.29** The oldest fossil record of blue-green alga is 2.9 billion years old. It is [Pb. PMT 2005]
 (1) Stromatolites (2) *Archaeopteryx*
 (3) *Archaeopteroides* (4) *Chlamydomonas*.
- Q.30** First life consisted of [Pb. PMT 2005]
 (1) Provirus (2) Virus
 (3) Bacteria (4) Protovirus.
- Q.31** Which of the following amino acids was not found to be synthesised in Miller's experiment? [CBSE 2006, AFMC 2008]
 (1) Alanine (2) Glycine
 (3) Aspartic acid (4) Glutamic acid.

Q.32 Given below are assertion and reason. Point out if both are true with reason being correct explanation (A), both true but reason is not correct explanation (B), assertion true but reason is wrong (C), both are wrong (D).

Assertion. The earliest organisms that appeared on earth were nongreen and presumably anaerobes.

Reason. The first autotrophic organisms were the chemoautotrophs that never released oxygen [AIIMS 2006, 2008]

- (1) (2)
(3) (4)

Q.33 Miller and Urey performed an experiment to prove the origin of life. They took gases ammonia and hydrogen alongwith

[AMU PMDC 2006, 2008]

- (1) N_2 and H_2O (2) CH_4 and N_2
(3) H_2O and CH_4 (4) CO_2 and NH_3

Q.34 The term hot dilute soup was given by

[HPPMT 2007, DPMT 2008]

- (1) Haldane (2) Urey
(3) Oparin (4) None of the above

Q.35 Coacervates are [DPMT 2007]

- (1) Protein aggregates
(2) Protein and lipid aggregates
(3) Chemical aggregates
(4) Protobionts with polysaccharides, proteins and water.

Q.36 Concept of chemical evolution of life is based on [CBSE 2007]

- (1) Effect of solar radiations on chemicals
(2) Interaction of water, air and clay under intense heat
(3) Combination of chemicals under hot moist environment conditions
(4) Crystallisation of chemicals.

Q.37 Select the wrong pair [Keral 2007]

- (1) Haldane Hot dilute soup
(2) Oparin Protobionts
(3) Spallanzani Abiogenesis
(4) Fox Coacervates
(5) Redi Biogenesis.

Q.38 The living form resulting from the final stage of chemical evolution of life is called

[COMED-K's 2007]

- (1) Prebiont (2) Protobiont
(3) Protenoid (4) Probiont.

Q.39 Scientists believe that life on earth originated by [HPPMT 2007, Orissa 2010]

- (1) Spontaneous generation
(2) Chemical evolution/Abiogenesis
(3) Special creation
(4) Extraterrestrial transfer.

Q.40 Which of the following was formed in S. Miller's experiment? [CPMT 2008]

- (1) Microspheres (2) Nucleic acids
(3) Amino acids (4) UV radiations.

Q.41 S.L. Miller's closed flask contained

[JKCMEE 2008]

- (1) CH_4
(2) NH_3 and water vapours
(3) H_2 (4) All the above

Q.42 Microspheres possessed a membrane of

[DPMT 2008]

- (1) Lipid and protein (2) Lipid
(3) Carbohydrates (4) Fats.

Q.43 Which is incorrect about protobionts in abiogenic origin of life? [CBSE 2008]

- (1) They were partially isolated from surroundings
(2) They could maintain an internal environment
(3) They were able to reproduce
(4) They could separate combination of molecules from the surroundings.

Q.44 Origin of life occurred in

[MPPMT 2009, 2010]

- (1) Precambrian (2) Coenozoic
(3) Palaeozoic (4) Mesozoic.

Q.45 In their experiment to prove origin of life, Miller and Urey took gases [CPMT 2009]

- (1) Methane, ethane, hydrogen, ammonia
(2) Methane, ethane, ammonia, water vapours
(3) Methane, ethane, ammonia, water vapours
(4) Ammonia, water vapours, butane, hydrogen.

- Q.46** Miller performed experiment to prove abiogenetic molecular evolution of life. Which molecule was not present in Miller's experiment [CPMT 2010]
 (1) Water (2) Methane
 (3) Oxygen (4) Ammonia.
- Q.47** Which is incorrect [CPMT 2010]
 (1) J.B.S Haldane – Law of continuity of germplasm
 (2) Louis Pasteur – Germ theory of disease and immunology
 (3) De vries – Mutation theory
 (4) Lemaitre – Big bang theory.
- Q.48** In early earth, water and carbon dioxide were produced by the combination of O_2 with [Kerala 2010]
 (1) Ammonia and methane
 (2) Organic matter
 (3) Hydrogen sulphide
 (4) Hydrogen.
- Q.49** Primitive atmosphere of earth contained water vapours, hydrogen, ammonia and [HPPMT 2010]
 (1) CO_2 (2) O_2
 (3) N_2 (4) Methane
- Q.50** Oparin-Haldane's view on the origin of life was first experimentally proved by [JKCME 2010]
 (1) Malthus (2) Plato
 (3) Louis Pasteur (4) Stanley Miller
- Q.51** Fossils are studied for [CET Chd. 2000]
 (1) Tracing evolutionary history of organisms
 (2) Studying extinct organisms
 (3) Filling gaps in our study
 (4) Providing jobs to scientists.
- Q.52** Theory 'Ontogeny recapitulates Phylogeny' was proposed by [AMU 2000]
 (1) Mendel (2) Haeckel
 (3) Erasmus (4) Weismann.
- Q.53** Monkeys and some lower groups have certain blood groups which are [AMU 2000]
 (1) Identical to those of man
 (2) Identical to those of anthropoid apes
 (3) Identical to those of anthropoid apes
 (4) Some what similar to white persons
 (5) Not identical to those of man.
- Q.54** Organic evolution is change in [AMU 2000]
 (1) Single individual
 (2) A few members of population
 (3) Major portion of population
 (4) Entire population.
- Q.55** A bird with teeth is [AMU 2000]
 (1) Kiwi (2) Ostrich/King Vulture
 (3) Dodo (4) Archaeopteryx.
- Q.56** Heart is four chambered in [AMU 2000]
 (1) Amphibia (2) Fishes
 (3) Mammals (4) Reptiles.
- Q.57** Living organism with oldest fossil history is [CPMT 2000, AMU 2000]
 (1) Dinosaur (2) Archaeopteryx
 (3) Horse (4) Man.
- Q.58** Homologous organs are [AMU 2000]
 (1) Human eyes and Squid eyes
 (2) Gills of Fish and lungs of Man
 (3) Hands of Man and wings of Bat
 (4) Leaf of Moss and frond of Fern.
- Q.59** Coal has been mainly formed by [AFMC 2000]
 (1) Bryophytes
 (2) Pteridophytes/pteridosperms
 (3) Angiosperms
 (4) Algae.
- Q.60** Darwin's finches provide evidence evolution from [CBSE 2000, AFMC 2007]
 (1) Anatomy (2) Morphology
 (3) Biogeography (4) All the above.
- Q.61** Which one is not vestigial in humans ? [CBSE 2000, AFMC 2007]
 (1) Third molar
 (2) Coccyx
 (3) Segmental abdominal muscles
 (4) Finger nails.
- Q.62** Vestigial pelvic girdle and bone remnants of hind limbs are characteristic of [Har. PMT 2000]
 (1) Whale (2) Dolphin
 (3) Shark (4) Seal.

- Q.63** The statement "nothing in biology makes sense except in the light of evolution" was given by
[Kerala 2000]
(1) Dobzhansky (2) Darwin
(3) Oparin (4) Hooker
(5) Wallace.
- Q.64** The sequence in evolution of horse was
[Kerala 2000]
(1) *Equus, Eohippus, Mesohippus, Merychippus*
(2) *Eohippus, Mesohippus, Merychippus, Equus*
(3) *Mesohippus, Eohippus, Equus, Mesohippus*
(4) *Merychippus, Mesohippus, Eohippus, Equus*.
- Q.65** Origin of life occurred in [Kerala 2000]
(1) Carboniferous (2) Cambrian
(3) Pre-cambrian (4) Ordovician
(5) Silurian.
- Q.66** Evolution of a species or group can be studied through [CET Chd. 2001]
(1) Fossils (2) Carbon dating
(3) DNA analysis (4) All the above.
- Q.67** Phenomenon of organisms having similar structure with a similar origin is
[Manipal 2001]
(1) Mimicry (2) Analogy
(3) Homology (4) Both A and B
- Q.68** Homologous organs indicate [CPMT 2001]
(1) Convergent evolution
(2) Parallel evolution
(3) Natural selection (4) Common descent
- Q.69** Age of evolution of man is measured by
[CPMT 2001]
(1) Electron microscope
(2) Chemical reaction
(3) Radioactive dating (4) Ultraviolet radiation.
- Q.70** Modern birds rose in [CPMT 2001]
(1) Palaeozoic (2) Coenozoic
(3) Mesozoic (4) Archaeozoic.
- Q.71** Tasmanian Wolf is a marsupial while Wolf is a placental mammal. This shows [DPMT 2001]
(1) Convergent evolution
(2) Divergent evolution
(3) Parallelism
(4) Inheritance of acquired characters.
- Q.72** Ontogeny recapitulates phylogeny. This is
[MPPMT 2004, JKCMEE 2008]
(1) Hardy Weinberg law
(2) Pauling law
(3) Biogenetic law
(4) Thomas law.
- Q.73** Jurassic period belongs to era [Kerala 2001]
(1) Palaeozoic (2) Mesozoic
(3) Coenozoic (4) Proterozoic
(5) Archaeozoic.
- Q.74** Pioneers in the field of organic evolution were
[KCET 2001]
(1) Darwin, Lamarck, Landsteiner and De Vries
(2) Darwin, De Vries, Lamarck, Huxley
(3) Lamarck, Landsteiner, Malthus, De Vries
(4) Landsteiner, De Vries, Malthus, Darwin.
- Q.75** Occurrence of higher number of endemic species in South America and Australia is due to
[CBSE 2001, AFMC 2007]
(1) Retrogressive evolution
(2) Continental separation
(3) These species have become extinct from other regions
(4) Absence of terrestrial links between these places.
- Q.76** Similarities between organisms of different genotypes is due to [CBSE 2001]
(1) Convergent evolution
(2) Divergent evolution
(3) Microevolution
(4) Macroevolution.
- Q.77** Half life of ^{14}C is [CBSE 2001]
(1) 50 years (2) 500 years
(3) 5000 years (4) 5×10^4 years.
- Q.78** Which of the following is not atavistic in humans? [CPMT 2001]
(1) Tail in some babies
(2) Enlarged canines
(3) Six fingers
(4) Dense body hair.

- Q.79** Which are not homologous ? **[CPMT 2001]**
 (1) Fore arm of humans and fins of fishes
 (2) Wings of bat and insects
 (3) Fins of fishes and flippers of Whales
 (4) Human fore arms, Bat's wings and flippers of Whale.
- Q.80** Presence of two chambered heart and gills in tadpole is example of **[Har. PMT 2001]**
 (1) Neo-Darwinism (2) Gause's law
 (3) Chargaff's law (4) Biogenetic law
- Q.81** Presence of tail and coarse hair in human baby is **[Pb. PMT 2007, MPPMT 2007]**
 (1) Radiation (2) Atavism
 (3) Mutation (4) Crossing over.
- Q.82** Unit of evolution is **[MHTCET 2001, Orissa 2008]**
 (1) Population (2) Species
 (3) Individual (4) Subspecies.
- Q.83** Possibility of occurrence of coal in an area is determined by study of **[BHU 2002]**
 (1) Microfossils
 (2) Ecology
 (3) Economic Botany
 (4) Mining contents.
- Q.84** Darwin's finches occur in **[Wardha 2002, Orissa 2007]**
 (1) Australia (2) Galapagos islands
 (3) Siberia (4) India.
- Q.85** Covolution does not occur in case of **[BHU 2002]**
 (1) Parasitism (2) Mutualism
 (3) Both A and B (4) Commensalism.
- Q.86** Ancestral amphibians were tetrapods that evolved during **[BHU 2002]**
 (1) Carboniferous period
 (2) Cretaceous period
 (3) Jurassic period
 (4) Devonian period.
- Q.87** Evidences for evolution from fossils belong to the domain of **[JKCMEE 2002, 2010]**
 (1) Biogeography (2) Embryology
 (3) Palaeontology (4) Anatomy.
- Q.88** Dinosaurs were dominant features during the period of **[JKCMEE 2002]**
 (1) Jurassic (2) Cretaceous
 (3) Triassic (4) Palaeocene.
- Q.89** Which of the following is not correctly paired **[Orissa 2002]**
 (1) Mesozoic–Age of mammals
 (2) Study of fossils–Palaeontology
 (3) Mutation theory–Hugo de Vries
 (4) Origin of Species–Charles Darwin.
- Q.90** Study of plant fossils is **[RPMT 2002]**
 (1) Paedology (2) Palynology
 (3) Palaeoinsectology (4) Palaeobotany.
- Q.91** Interacting populations are **[AMU 2002]**
 (1) Symbiotic (2) Mutualistic
 (3) Parasitic (4) Coevolved.
- Q.92** *Archaeopteryx*, toothed fossil bird occurred during **[AMU 2002, MPPMT 2002]**
 (1) Jurassic (2) Triassic
 (3) Cretaceous (4) Permian.
- Q.93** Mesozoic era is known as golden age of **[Kerala 2003, MPPMT 2007]**
 (1) Fishes (2) Amphibians
 (3) Reptiles (4) Molluscs.
- Q.94** Continental drift explains **[AMU 2002]**
 (1) Mass extinctions
 (2) Distribution of fossils on earth
 (3) Geographical upheavals
 (4) All the above.
- Q.95** Reptilian feature of *Archaeopteryx* is **[EAMCET 2002]**
 (1) U-shaped furcula (2) Beak
 (3) Abdominal ribs (4) Feathers.
- Q.96** *Archaeopteryx* is connecting link between **[CPMT 2007, MHTCET 2007]**
 (1) Fishes and amphibians
 (2) Amphibians and birds
 (3) Amphibians and reptiles
 (4) Reptiles and birds.

- Q.97** Which is not vestigial in man ?
[Kerala 2002, BHU 2008]
- (1) Tail vertebrae
 - (2) Nails
 - (3) Nictitating membrane
 - (4) Vermiform appendix
- Q.98** Development of adaptations along parallel lines in unrelated groups of animals is
[MPPMT 2002]
- (1) Adaptive convergence
 - (2) Adaptive radiation
 - (3) Adaptive divergence
 - (4) Adaptive induction.
- Q.99** Which of the following is vestigial in humans
[AFMC 2002]
- (1) Mammary glands in males
 - (2) Knee bones
 - (3) Nictitating membrane
 - (4) Ear pinna.
- Q.100** Which is a pair of vestigial organs ?
[AIIMS 2002]
- (1) Coccyx and intercostal muscles
 - (2) Coccyx and auricular muscles
 - (3) Facial hairs in ladies
 - (4) Coccyx and premolars.
- Q.101** Which one is used for dating archaeological specimens like bones, shells and wood ?
[JIPMER 2002]
- (1) ^3H
 - (2) ^{14}C
 - (3) ^{121}I
 - (4) ^{32}P
- Q.102** Which is sequenced during study of phylogeny?
[CBSE 2002]
- (1) m-RNA
 - (2) r-RNA
 - (3) t-RNA
 - (4) DNA
- Q.103** Convergent evolution is illustrated by
[CBSE 2003]
- (1) Rat and Dog
 - (2) Bacterium and Protozoan
 - (3) Starfish and Cuttle fish
 - (4) Dogfish and Whale.

- Q.104** Which one correctly describes homologous structures
[CBSE 2003, Pb. PMT 2003]
- (1) Organs with anatomical similarities but performing different functions
 - (2) Organs with anatomical similarities but performing different functions
 - (3) Organs that have no function now but had an important function in ancestors
 - (4) Organs appearing only in embryonic stage and disappearing later in the adult.
- Q.105** The early stage human embryo distinctly possesses
[AIIMS 2003]
- (1) Gills
 - (2) Gill slits
 - (3) External ear (pinna)
 - (4) Eye brows.
- Q.106** Mesozoic era was dominated by
[CPMT 2003]
- (1) Birds
 - (2) Fishes
 - (3) Reptiles
 - (4) Mammals.
- Q.107** Law of embryonic development was proposed by
[CPMT 2003]
- (1) Darwin
 - (2) Von Baer
 - (3) Haeckel
 - (4) Mendel.
- Q.108** Wings of bird and bat are
[Kerala 2003]
- (1) Homologous with no analogy
 - (2) Analogous with no homology
 - (3) Neither homologous nor analogous
 - (4) Both homologous and analogous
- Q.109** Which is not a vestigial organ
[Kerala 2003]
- (1) Flipper of Seal
 - (2) Coccyx of man
 - (3) Pelvic of Python
 - (4) Wings of Kiwi.
- Q.110** Organs related through common descent but now functionally different are
[CPMT 2004, JKCME 2005]
- (1) Analogous
 - (2) Homologous
 - (3) Divergent organs
 - (4) Parallel organs.
- Q.111** Which one is incorrect
[Orissa 2004]
- (1) Wings of insects and birds are analogous
 - (2) Wings of bat and birds are homologous
 - (3) Wings of insects and bat are analogous
 - (4) Wings of insects and birds are homologous.

Q.112 Age of fossils was previously determined by radioactive elements. More precise recent method which has led to revision of evolutionary periods is

[CBSE 2004, AIIMS 2007]

- (1) Study of carbohydrate and protein in fossils
- (2) Study of conditions of fossilisation
- (3) Electron spin resonance and fossil DNA
- (4) Presence of carbohydrate and protein in rocks

Q.113 Flippers of Seal are modified [AFMC 2004]

- (1) Hind limbs (2) Fore limbs
- (3) Fins (4) Gills.

Q.114 Potato and Sweet Potato have edible parts which are [AIIMS 2004, DPMT 2008]

- (1) Homologous
- (2) Analogous
- (3) Recent introductions
- (4) Two species of the same genus.

Q.115 Given below are assertion and reason. Point out if both are true with reason being correct explanation (A), both true but reason is not correct explanation (B), assertion true but reason is wrong (C), both are wrong (D).
Assertion. Natural selection is the outcome of difference in survival and reproduction among individual that show variation in one or more traits.

Reason. Adaptive forms of a given trait tend to become more common. Less adaptive ones become less common or disappear.

[AIIMS 2004]

- (1) (2)
- (3) (4)

Q.116 Organs having similar functions but different origin and development are known as

[JKCME 2004, Har. PMT 2005]

- (1) Homologous organs
- (2) Analogous organs
- (3) Metalogous organs (4) Vestigial organs.

Q.117 The classical example of adaptive radiation during formation of new species is

[CPMT 2004]

- (1) Marsupials of Australia
- (2) Darwin's finches
- (3) Giant Tortoise (4) All the above.

Q.118 Mammals like Whale, Dolphin, Bat, Monkey and Horse have some common characters but also show conspicuous differences. This is due to phenomenon of [MPPMT 2004]

- (1) Divergence (2) Convergence
- (3) Genetic drift (4) Normalisation.

Q.119 Which of the following pairs of structures is homologous ? [MPPMT 2004]

- (1) Wings of Grasshopper and forelimbs of Flying Squirrel
- (2) Tentacles of *Hydra* and arms of Starfish
- (3) Forelimbs of a Bat and forelegs of a Horse.
- (4) Wings of a bird and wings of a Moth.

Q.120 According to Darwinism, fossils of organisms found in South America resemble fossils of

[Orissa 2004]

- (1) North America (2) Africa
- (3) Australia (4) Both B and C.

Q.121 The biogenetic law of Haeckel is

[BHU 2005, CPMT 2009]

- (1) *Omnis vivum e vivum*
- (2) *Omnis cellula e cellula*
- (3) Ontogeny repeats phylogeny
- (4) Phylogeny repeats ontogeny.

Q.122 Given below are assertion and reason Point out if both are true with reason being correct explanation (A), both true but reason is not true explanation (B), assertion true but reason is wrong (C), both are wrong (D).

Assertion. Comparative biochemistry provides a strong evidence in favour of common ancestry of living beings.

Reason. Genetic code is universal.

[AIIMS 2005]

- (1) (2)
- (3) (4)

Q.123 Which is relatively most accurate method of dating of fossils ? **[CBSE 2005]**

- (1) Radiocarbon method
- (2) Potassium–Argon method
- (3) Electron spin–resonance method
- (4) Uranium–lead method.

Q.124 Dinosaurs were present during the **[JKCME 2005]**

- (1) Palaeozoic era (2) Coenozoic era
- (3) Mesozoic era (4) Precambrian era.

Q.125 Which is correct ? **[Orissa 2005]**

- (1) 99% of existed species are extinct
- (2) 65% of existed species are extinct
- (3) 40% of existed species are extinct
- (4) 30% of existed species are extinct.

Q.126 What is correct arrangement of periods of palaeozoic era in ascending order in geological time scale ? **[EAMCET 2005]**

- (1) Cambrian → Devonian → Ordovician → Silurian → Carboniferous → Permian
- (2) Cambrian → Ordovician → Silurian → Devonian → Carboniferous → Permian
- (3) Cambrian → Ordovician → Devonian → Silurian → Carboniferous → Permian
- (4) Silurian → Devonian → Cambrian → Ordovician → Permian → Carboniferous.

Q.127 An important evidence in favour of organic evolution is the occurrence of **[CBSE 2006, DPMT 2008]**

- (1) Homologous and analogous organs
- (2) Homologous and vestigial organs
- (3) Analogous and vestigial organs
- (4) Homologous organs only.

Q.128 Jurassic period of mesozoic era is characterised by **[CBSE 2006]**

- (1) Flowering plants and first dinosaurs appear
- (2) Gymnosperms are dominant plants and first birds appear
- (3) Radiation of reptiles and angiosperms appear
- (4) Dinosaurs become extinct and angiosperms appear.

Q.129 Evolutionary history of an organism is known as **[CBSE 2006, AFMC 2008]**

- (1) Ontogeny (2) Phylogeny
- (3) Ancestry (4) Palaeontology

Q.130 Which is correct Aristotle's ladder of nature? **[Kerala 2006]**

- (1) Inanimate matter → Lower plants → Higher plants → Zoophyta → Entoma → Ostracoderma → Malacia → Malacostraca → Fish → Oviparous quadrupeds → Cetacea → Birds → Viviparous quadrupeds → Humans
- (2) Inanimate matter → Lower plants → Higher plants → Zoophyta → Entoma → Malacia → Malacostraca → Ostracoderma → Fish → Oviparous quadrupeds → Cetacea → Birds → Viviparous quadrupeds → Humans
- (3) Inanimate matter → Lower plants → Higher plants → Zoophyta → Malacia → Entoma → Malacostraca → Ostracoderma → Fish → Oviparous quadrupeds → Cetacea → Birds → Viviparous quadrupeds → Humans
- (4) Inanimate matter → Lower plants → Higher plants → Zoophyta → Entoma → Ostracoderma → Malacostraca → Malacia → Fish → Cetacea → Oviparous quadrupeds → Birds → Viviparous quadrupeds → Humans
- (5) Inanimate matter → Lower plants → Higher plants → Zoophyta → Entoma → Ostracoderma → Malacia → Malacostraca → Fish → Cetacea → Birds → Oviparous quadrupeds → Viviparous quadrupeds → Humans.

Q.131 Major radiation of mammals, birds and pollinating insects took place in the epoch **[Kerala 2006]**

- (1) Oligocene (2) Palaeocene
- (3) Pliocene (4) Eocene
- (5) Miocene.

- Q.132** Which is correct [CET Chd. 2006]
 (1) Wings of birds and insects are homologous
 (2) *Archaeopteryx lithographica* is missing link between birds and mammals
 (3) Paired fins of fish and flippers of whale are analogous
 (4) Caecum and appendix in Rabbit and man are analogous.
- Q.133** First mammals are found in era-period [CPMT 2007]
 (1) Permian Palaeozoic
 (2) Triassic Mesozoic
 (3) Tertiary Coenozoic
 (4) None of these.
- Q.134** Most of the fossils occur in rocks [Orissa 2007]
 (1) Sedimentary (2) Metamorphic
 (3) Igneous (4) None of the above.
- Q.135** Duck-billed Platypus is connecting link between [Orissa 2007, AFMC 2009]
 (1) Echinodermata and chordata
 (2) Arthropoda and mollusca
 (3) Reptilia and mammalia
 (4) Reptilia and aves.
- Q.136** Plants and animals of Galapagos islands resemble plants and animals of main land in [Orissa 2007]
 (1) North Africa (2) South Africa
 (3) North America (4) South America.
- Q.137** Fossils found in Mandla district of M.P. is [MPPMT 2007]
 (1) 260 million years old
 (2) 100 million years old
 (3) 50 million years old
 (4) 20 million years old.
- Q.138** Tendrils of *Cucurbita* and thorns of *Bougainvillea* are [DPMT 2007, CBSE 2008]
 (1) Homologous organs
 (2) Analogous organs
 (3) Vestigial organs (4) Atavistic divergence.
- Q.139** Parallism is due to [DPMT 2007]
 (1) Adaptive divergence
 (2) Adaptive convergence
 (3) Adaptive convergence of unrelated species
 (4) Adaptive convergence of closely related species.

- Q.140** Which one is correct [CBSE 2007]
 (1) There is no evidence of presence of gills in mammalian embryos
 (2) Ontogeny repeats phylogeny
 (3) All plant and animal cells are totipotent
 (4) Stem cells are specialised cells.
- Q.141** Finches of Galapagos provide evidence for [CBSE 2007]
 (1) Retrogressive evolution
 (2) Special creation
 (3) Biogeographical evolution
 (4) Evolution due to mutation.
- Q.142** Two species of different genealogy show resemblance due to similar adaptation. The phenomenon is [CBSE 2007]
 (1) Convergent evolution
 (2) Divergent evolution
 (3) Micro-evolution (4) Co-evolution
- Q.143** Adaptive radiation is [CBSE 2007]
 (1) Evolution of different species from a common ancestor
 (2) Adaptation due to geographical isolation
 (3) Migration of members of a species to different geographical areas
 (4) Power of adaptation of an individual to a variety of environments.
- Q.144** What is common to Whale, Seal and Shark [CBSE 2007]
 (1) Homoiothermy (2) Seasonal migration
 (3) Thick subcutaneous fat
 (4) Convergent evolution.
- Q.145** Which ones are not analogous organs [Kerala 2007, CPMT 2009]
 (1) Wings of birds and wings of butterfly
 (2) Eye of *Octopus* and eye of mammals
 (3) Flippers of penguins and flippers of Dolphin
 (4) Thorns of *Bougainvillea* and tendril of *Cucurbita*
 (5) Tuberous root of Sweet Potato and stem tuber of Potato.
- Q.146** Descendent of fossil *Protylopus* is [MHTCET 2007]
 (1) Giraffe (2) Camel
 (3) Elephant (4) Cow

Q.147 Vestigial organs provide evidence of organic evolution in the category [JKCMEEE 2007]

- (1) Anatomical (2) Embryological
(3) Morphological (4) Palaeontological.

Q.148 Life has existed on earth for the last [HPPMT 2007]

- (1) 2·3 billion years (2) 3·9 billion years
(3) 4·3 billion years (4) 5·0 billion years

Q.149 Darwin's finches show [HPPMT 2007, CBSE 2008, 2010]

- (1) Adaptive radiation
(2) Parallel evolution
(3) Homology (4) Natural selection.

Q.150 Connecting link between annelida mollusca is [BHU 2007, AFMC 2010]

- (1) *Nautilus* (2) *Neopilina*
(3) Glochidium (4) Veliger larva.

Q.151 Which one is the earliest era ? [Orissa 2008]

- (1) Coenozoic (2) Mesozoic
(3) Palaeozoic (4) Pre-cambrian.

Q.152 Wings of birds and fore-limbs of horse are [Orissa 2008]

- (1) Vestigial (2) Analogous
(3) Homologous (4) None of the above

Q.153 Closely related species with different traits exhibit [Orissa 2008]

- (1) Convergent evolution
(2) Divergent evolution
(3) Parallel evolution (4) None of the above.

Q.154 Which isotope is used in finding age of fossil of more than 4500 years ? [DPMT 2008]

- (1) ^{238}U (2) ^{235}U
(3) ^{235}Po (4) ^{12}C .

Q.155 Which period is largely associated with extinction of dinosaurs, increase in flowering plants and reptiles ? [DPMT 2009]

- (1) Triassic (2) Jurassic
(3) Cretaceous (4) Permian.

Q.156 Mass extinction at the end of mesozoic era was probably caused by [DPMT 2009]

- (1) Continental drift (2) Massive glaciation
(3) Collision of earth with large meteorite
(4) Change in earth's orbit.

Q.157 *Tachyglossus* is connecting link between [DPMT 2009]

- (1) Reptiles and mammals
(2) Reptiles and birds
(3) Amphibians and reptiles
(4) Birds and mammals.

Q.158 Phylogeny is [CET Chd. 2009]

- (1) Evolutionary history
(2) Life history
(3) Group of phyla
(4) Genetics of animals.

Q.159 Relatedness of two species is tested through [Orissa 2009]

- (1) RNA and proteins
(2) DNA and proteins
(3) Antibodies and transposons
(4) None of the above.

Q.160 As per Allen's rule, mammals of cold regions conserve body heat through [AMU 2009]

- (1) Larger body mass
(2) Small body mass
(3) Longer extremities
(4) Smaller extremities.

Q.161 *Peripatus* is connecting link between [CBSE 2009]

- (1) Porifera and coelenterata
(2) Ctenophora and platyhelminthes
(3) Mollusca and echinodermata
(4) Annelida and arthropoda.

Q.162 Origin of first toothed birds and gymnosperms occurred during [CPMT 2009]

- (1) Cretaceous (2) Jurassic
(3) Triassic (4) Permian.

Q.163 A living connecting link that provides evidence of organic evolution is [CPMT 2009]

- (1) *Sphenodon* between reptiles and birds
(2) *Archaeopteryx* between reptiles and birds
(3) Lung fishes between pisces and reptiles
(4) Duck-billed *Platypus* between reptiles and mammals.

Q.164 After the industrial revolution, melanic moths survived because [COMED-K's 2010]

- (1) They had black colour
- (2) They had grey body colour
- (3) They shifted to different habitat
- (4) They reproduced vigorously.

Q.165 In evolution of horse, two most important anatomical and morphological changes brought about are [CET Chd. 2010]

- (1) Limbs and tail (2) Limbs and teeth
- (3) Teeth and tail (4) Limbs and height.

Q.166 Vestiges of girdles are found in [AMU 2010]

- (1) Rattle snake (2) Krait
- (3) Cobra (4) Python.

Q.167 An evolutionary pattern characterised by a rapid increase in number of kinds of closely related species is called [AMU 2010]

- (1) Divergent evolution
- (2) Convergent evolution
- (3) Adaptive radiation
- (4) Parallel evolution.

Q.168 The first seed plants appeared in [MPPMT 2010]

- (1) Cretaceous era (2) Carboniferous era
- (3) Devonian era (4) Silurian era.

Q.169 Which was the biggest land dinosaur [HPPMT 2010]

- (1) *Protoceratops*
- (2) *Amptosaurus*
- (3) *Tyrannosaurus rex*
- (4) *Ichthyosaurus*.

Q.170 Organs that perform same function but are not similar in structural details and origin are called [JKCEE 2010]

- (1) Analogous organs
- (2) Homologous organs
- (3) Vestigial organs
- (4) None of these.

Q.171 Homologous organs have [AFMC 2010]

- (1) Similar morphology
- (2) Similar anatomy
- (3) Different anatomy
- (4) All the above.

Q.172 Given below are four statements (a–d) with one or two blanks. Select the option which fills up the blanks in two statements.

- (a) Wings of butterfly and birds look alike and are the result of(i).... evolution
- (b) Miller showed that CH₄, H₂, NH₃ and(i).... when exposed to electric discharge in a flask resulted in formation of(ii) evidence of evolution
- (c) Vermiform appendix is a(i)....organ and(ii)....
- (d) According to Darwin evolution took place due to(i).... and(ii).... of the fittest

[CBSE Mains 2010]

- (1) d – (i) small variations, (ii) survival, a – (i) convergent
- (2) a – (i) convergent, b – (i) oxygen, (ii) nucleolides
- (3) b – (i) water vapours (ii) amino acids c – (i) rudimentary (ii) anatomical
- (4) c – (i) vestigial (ii) anatomical, d – (i) mutations (ii) multiplication.

Q.173 What was the most significant trend in the evolution of modern man (*Homo sapiens*) from his ancestors ? [AIPMT Pre 2012]

- (1) Binocular vision
- (2) Increasing cranial capacity
- (3) Upright posture
- (4) Shortening of jaws

Q.174 Which one of the following options gives one correct example each of convergent evolution and divergent evolution? [AIPMT Pre 2012]

	Convergent evolution	Divergent evolution
(1)	Thorns of Bougainvillia and tendrils of <i>Cucurbita</i>	Wings of butterflies and birds
(2)	Bones of forelimbs of vertebrates	Wings of butterfly and birds
(3)	Thorns of Bougainvillia and tendrils of <i>Cucurbita</i>	Eyes of Octopus and mammals
(4)	Eyes of octopus and mammals	Bones of forelimbs of vertebrates

Q.175 The extinct human who lived 1,00,000 to 40,000 years ago, in Europe, Asia and parts of Africa, with short stature, heavy eye brows, retreating fore heads, large jaws with heavy teeth, stocky bodies, a lumbering gait and stooped posture was : **[AIPMT Pre 2012]**

- (1) Neanderthal human
- (2) Cro-magnan humans
- (3) *Ramapithecus*
- (4) *Homo habilis*

Q.176 Evolution of different species in a given area starting from a point and spreading to other geographical areas is known as :

[AIPMT Pre 2012]

- (1) Naturation
- (2) Migration
- (3) Divergent evolution
- (4) Adaptive radiation

ANSWER KEY

EXERCISE – 3

Ques.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	2	3	1	1	2	2	1	3	2	4	4	2	1	3	2	4	3	3	1	4
Ques.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	1	2	4	1	4	4	2	2	3	4	4	2	3	1	4	3	3	2	2	3
Ques.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	2	3	1	3	3	1	1	4	4	2	2	1	3	4	3	3	3	2	3
Ques.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	4	1	1	2	3	1	3	4	3	2	1	3	2	2	2	1	3	3	2	4
Ques.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	2	1	1	2	4	4	3	1	1	4	4	2	3	4	3	4	2	1	3	2
Ques.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	2	4	4	1	2	3	2	4	1	2	4	3	2	2	1	2	4	1	3	4
Ques.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	3	2	3	3	1	2	1	2	2	4	2	3	2	1	3	4	3	1	4	2
Ques.	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
Ans.	3	1	1	4	4	2	3	2	1	2	4	3	2	1	3	3	1	1	2	4
Ques.	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176				
Ans.	4	3	4	1	2	4	3	2	3	1	2	1	2	4	1	4				

These questions consist of two statements each, printed as Assertion and Reason. While answering to choose any one of the following four responses.

- (1) If both Assertion & Reason are True & the reason is correct explanation of the Assertion.
- (2) If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion.
- (3) If Assertion is True but the Reason is False.
- (4) If both Assertion & Reason are false.

- Q.1** A : There is no life on moon.
R : Water is absent on moon.
- Q.2** A : The first living organism on earth were autotrophs.
R : They were capable to performing chemosynthesis.
- Q.3** A : Base analogous induced transition.
R : Base analogous performs forbidden pairing.
- Q.4** A : Sympatric species are geographically isolated.
R : Sympatric species are reproductively isolated.
- Q.5** A : Somatic mutations are sometime inheritable.
R : Some organism show vegetative propagation.
- Q.6** A : Plant having odd number of sets of chromosomes are fertile.
R : Plant having even number of sets of chromosomes are sterile.
- Q.7** A : Colchicine induces polyploidy.
R : Colchicine causes disjunction of chromosomes.
- Q.8** A : Change in structure of chromosome is called chromosomal aberration.
R : Substitution is an example of chromosomal aberration.

- Q.9** A : First life originated in water.
R : Conditions were favourable for origin of life in water.
- Q.10** A : A single mutation may produce a new species.
R : Mutation may cause major variation in genetic material and these are inheritable.
- Q.11** A : Evolution is not occurring at present.
R : Evolution take a very long time to occur.
- Q.12** A : Analogous organs show common ancestry.
R : Analogous organ show evolution.
- Q.13** A : Lung fish is a connective link between fishes and amphibia.
R : Lung fish show characters of both fishes and amphibia.
- Q.14** A : Bird's embryo show tooth bud's for some time.
R : Ontogeny repeats phylogeny.
- Q.15** A : Liger in a hybrid animal.
R : Liger is fertile.
- Q.16** A : Jurassic period is considered the age of reptiles.
R : Reptiles dominated in all habitats during jurassic period.
- Q.17** A : Muscles of external ears are fully developed in humans.
R : Ear muscles close the ears during excessive noise.
- Q.18** A : Human and apes have a common ancestry.
R : Man and chimpanzee have similar banding pattern of chromosome.
- Q.19** A : Homologous organs suggest same origin.
R : Organs which are similar in function and dissimilar in internal morphology called as Homologous organs.
- Q.20** A : Presence of tail in children is a vestigial character.
R : This happens due to the phenomenon called atavism.

- Q.21 A :** In mammals the forelimbs perform, different functions.
R : The forelimbs in different mammals consist of different sets of bones.
- Q.22 A :** There is no scientific explanation to organic evolution.
R : Evolution is a discontinuous process.
- Q.23 A :** Analogous organs suggest same origin.
R : Fore legs of horse and hand of human are analogous organs.
- Q.24 A :** Mammals have evolved from egg laying species.
R : Prototherians are oviparous.
- Q.25 A :** Missing links are most important to study evolutionary history.
R : They fill the gaps of closely related groups
- Q.26 A :** Ear muscles of external ear in man are vestigial.
R : These muscles in man are useful which move external ear freely to detect sound efficiently.
- Q.27 A :** Vestigial organs are those parts of body which are greatly reduced and are useless.
R : These are the remnants of once fully developed organs which are gradually lost as there were no longer necessary.
- Q.28 A :** Snakes lost their legs. They don't have use of legs.
R : All the living organism can reduced or increase the organ with the help of internal vital force.
- Q.29 A :** Translocation is a illegal crossing over.
R : Translocation is exchange of chromosomal segments between nonhomologous chromosomes.
- Q.30 A :** Chemical mutagens are more harmful than substitution or point mutation.
R : Acridine and proflavin induces frame shift mutation.

- Q.31 A :** Chemical mutagens are more harmful than radiations.
R : Chromosomal mutagens cause more variations.
- Q.32 A :** Substitution or point mutations are more harmful as compared to frame shift mutation.
R : Substitution cause major change in structure of protein.
- Q.33 A :** Chromosomal aberrations are more harmful as compared to gene mutation.
R : Substitution are less harmful as compared to frame shift mutation.
- Q.34 A :** In sickle cell anaemia disease Hbs gene is present in the population.
R : The loss of Hbs gene is balanced by balancing selection.
- Q.35 A :** Australopithecus was first ancestor of man who show bipedal locomotion.
R : Mutation are raw material for evolution.
- Q.36 A :** Reducing atmosphere was essential for origin of life on earth.
R : The early proteins and nucleic acids are formed by non enzymatic process.
- Q.37 A :** Probably DNA evolved after the RNA.
R : RNA has both catalytic and genetic information transfer function.
- Q.38 A :** Electron spin resonance method is used to determine the age of fossils.
R : Fossils mainly present in igneous rocks.
- Q.39 A :** Life originated about 3.9 billion years ago.
R : Life originated in pre cambrian era.
- Q.40 A :** A.R. Wallace divide whole world into six major realms.
R : India is present in oriental realm.
- Q.41 A :** Mimicry is a kind of adaptation.
R : Mullerian mimicry is an example of aggressive mimicry.

- Q.42 A :** Evolution occurs with in populations.
R : Relative frequencies of different variations of DNA change over time.
- Q.43 A :** Duckbilled platypus and spiny anteaters lay egg's like birds (Cleidoic egg) but they are mammals.
R : Presence of cleiodic egg in prototherism show reptilian ancestry of mammals.
- Q.44 A :** Nucleoprotein were first sign of life.
R : The protocell represented the beginning of life.
- Q.45 A :** Origin of virus like structure is an example of retrogressive evolution.
R : "Descent with modification" is a fundamental concept of evolution.
- Q.46 A :** Sedimentary rocks are also called as slate rocks.
R : Rocky mountain revolution took place after paleozoic era.
- Q.47 A :** When the two species are morphologically similar but do not normally interbreed, such species are called sibling species.
R : Stabilising selection reduces variation but does not change the mean value.
- Q.48 A :** Lamarck published the theory of evolution in 1809 the year Charles Darwin was born.
R : According to Lamarckism if an organ is used constantly, it will tend to become developed, whereas disuse results in degeneration.

- Q.49 A :** The aquatic mammals like dolphins whales etc. do not contain gills slits.
R : Their adaptation to aquatic life is secondary.
- Q.50 A :** Unaltered fossils are mostly found in ice-laden areas.
R : These fossils consist of only the hard parts of organisms.
- Q.51 A :** Dinosaurs disappeared due to mass extinction.
R : Mass extinction occurred due to spread of epidemic.
- Q.52 A :** The homologous organs show convergent evolution.
R : The analogous organs show divergent evolution.
- Q.53 A :** Intraspecific struggle occurs between the individuals of different species.
R : Lobster culture in aquarium is an example of interspecific struggle.
- Q.54 A :** Without variations, evolution is impossible.
R : Only useful variations are transmitted to the next generation.
- Q.55 A :** *Australopithecus* is called African ape-man.
R : It had both human as well as ape characters.
- Q.56 A :** *Homo habilis* was the first tool maker.
R : He was cave-dweller.

ANSWER KEY

EXERCISE – 4

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	4	1	4	1	4	3	3	1	1	4	4	1	1	2	1	4	1	3	4
Que.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	3	4	4	1	1	3	1	4	1	2	2	4	2	1	2	2	1	3	2	2
Que.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56				
Ans.	3	1	1	2	2	4	2	2	1	3	3	4	3	3	1	2				

Bansal Quick Review Table

Instruction to fill

- (A) Write down the Question Number you are unable to solve in column A below, by Pen.
- (B) After discussing the Questions written in column A with faculties, strike off them in the manner so that you can see at the time of Revision also, to solve these questions again.
- (C) Write down the Question Number you feel are important or good in the column B.

EXERCISE NO.	COLUMN : A	COLUMN : B
	Question I am unable to solve in first attempt	Good / Important questions
Exercise # 1		
Exercise # 2		
Exercise # 3		
Exercise # 4		
Other Exercise		

Advantages

1. It is advised to the students that they should prepare a question bank for the revision as it is very difficult to solve all the questions at the time of revision.
2. Using above index you can prepare and maintain the questions for your revision.

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Thank you for your love and support, we hope you are always being happy and get success in your life, we are happy to see you again.

Regards from Learnaf team

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