Model Answer

B.Sc. (RT) I Semester

AS-2970

Cell Biology

Section - A

1. (i) (a) Ca & Mg pectinate
   (ii) (b) Robertson
   (iii) (d) Centromere
   (iv) (d) Mitochondria
   (v) (d) Waldeyer
   (vi) (b) Ca
   (vii) (c) Picogram
   (viii) (c) Kornberg and Thomas
   (ix) (c) 20 Å
   (x) (c) Nucleosome.

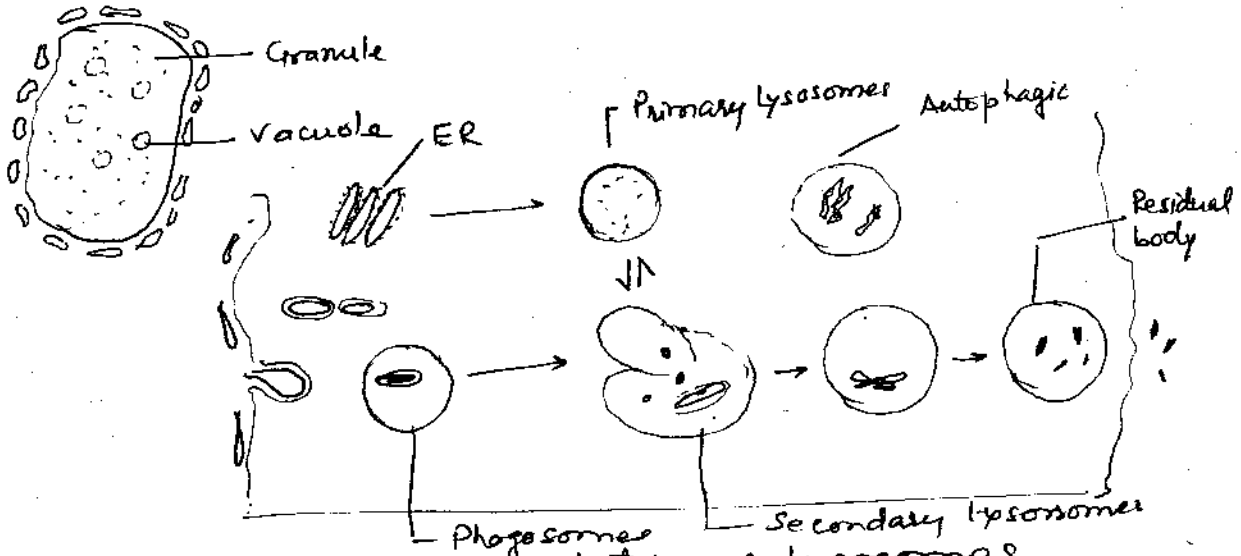
Section - B

2. (a) **Lysosome:**
   Discovered by Christian de Duve (1955)
   in liver cells, also called "suicidal bag of cell."
   Occurrence: Absent in prokaryotes and present in all eukaryotes, except mature RBCs, some fungi likes yeast, Neurospora.
   Shape: Spherical in shape but sometimes irregularly shaped.
   Size: 0.2 – 0.8 µm.

Ultrastructure: Lysosome consists of limiting membrane and matrix. Limiting membrane, is single layered, trilaminar unit membrane. and lipoproteinous in nature. Matrix is finely granular and highly heterogenous ground substance. Matrix contains almost 24 types of digestive enzyme like: proteases, glucosidase, ribonuclease, phosphatases etc.

Types of Lysosomes: Lysosomes may be of following four types:

(i) Primary lysosomes (ii) secondary lysosomes
(iii) Residual body (iv) Autophagic vacuoles.



Origin of different types of Lysosomes

Functions:

- Heterophagy → Digestion of exogenous materials which are engulfed by cells by phagocytosis.
- Autophagy → Digestion of food material stored inside the cell.
- Dead cells inside the body are removed by lysosome.

(b) Significance of Meiosis :

Meiosis consists of two successive divisions of a cells. This result in the formation of four cells from one parent cell. first division is accompanied with the reduction in chromosome number while second division does not involve reduction in chromosome number. The main significance of meiosis are.

(i) After meiosis, haploid (n) gametes are produced in diploid sexually reproducing organisms.

(ii) Through the process of crossing over in pachytene of prophase-I, meiosis produces new combination of genes on chromosomes. Change arrangement of bivalents at equator also produces variations.

(iii) Genetic variations produced through meiosis help in evolution and improvement of races of useful plants and animals

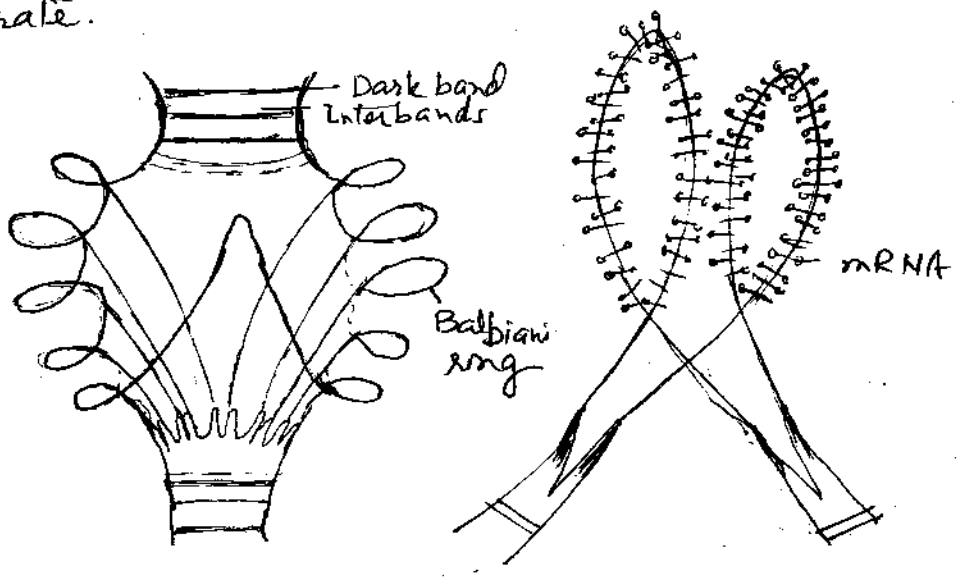
(iv) On the behaviour of chromosomes during meiosis in a hybrid plant interrelationship between organisms and their species can be established.

(v) Chromosomal and genomic mutations caused by non-disjunction etc. are also sources of useful variations.

(C) Balbiani rings :

Balbiani rings are found in polytene chromosomes or salivary gland chromosomes. Polytene chromosomes were first observed and studied by E.G. Balbiani (1881) in the salivary gland chromosomes. Polytene chromosome is composed of numerous strands, each strand representing one chromatid. Each chromosome contain dark staining regions called bands which are separated by relatively light staining or unstained interband regions.

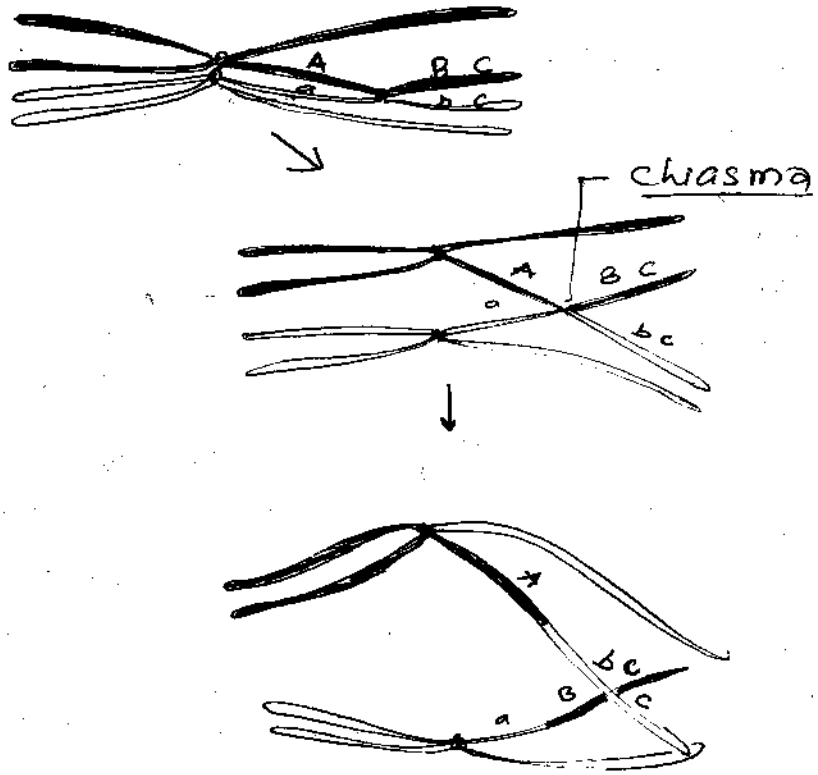
Banding pattern in these chromosomes helped in mapping of chromosomes, studying deletion, inversion and duplication. These bands occasionally greatly increase in size (diameter) and form puff or ring-like structure. These structures are so produced are called 'puffs' or 'balbiani rings'. Theses 'balbiani rings are believed to be produced due to uncoiling of chromatin fibre in the concerned transverse band. Puffs are not permanent rather reversible in nature. These puffs are transcriptionally much active. They produce mRNA at a much rapid rate.



Balbiani ring (Puffs) and loops in puffs.

(d) Crossing over: The process of crossing over starts in pachytene of Prophase - I during meiosis. This continues and ends in diplotene. After the pairing of homologous chromosomes or synapsis, each of homologous chromosome coil around each other and form cross (X) like structure

at places and exchange of segments between non homologus chromatids takes place. This process is called as crossing over.



Diagrammatic representation of crossing over

(e) rRNA: This RNA is found in ribosomes. It is also known as soluble RNA. Its quantity in a cell is much larger than that of mRNA and tRNA. It constitute about 80% of total RNA. On the basis of their sedimentation coefficient or rate of sedimentation, rRNA molecules may be classified into following categories.

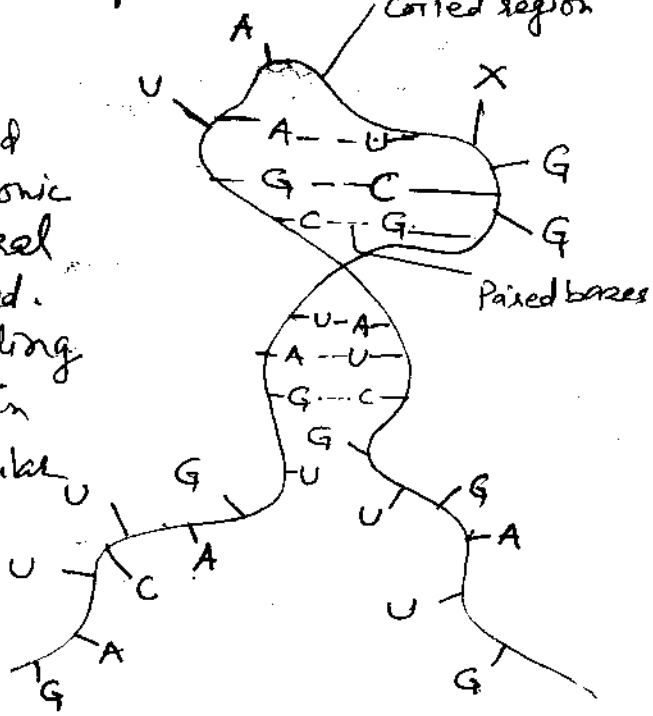
(i) 28S-rRNA (ii) 18S-rRNA (iii) 5S-rRNA

(i) 28S-rRNA: It has molecular weight more than 10,00000. Sedimentation coefficient is between 21s and 29s. It is found in 60s subunit of eukaryotic ribosomes.

(ii) 18S-rRNA: Its molecular weight is less than a million. Sedimentation varies between 12S to 18S. It is found in 40S subunit of ribosomes.

(iii) 5S-rRNA: It has much lower molecular weight and is found in 30S unit of ribosomes.

Structure: Ribosomal RNA molecules are single stranded but in the solution of high ionic concentration, irregular spiral coiling of rRNA is formed. The degree of irregular coiling of rRNA also increases. In this coiling the intramolecular bases show base pairing.



Secondary structure of rRNA

Function: The main function of rRNA is the formation of ribosomes both in prokaryotes and Eukaryotes.

(f) Z-DNA: Z-DNA was reported by Wang (1979). It has a left-handed coiling and follows a zig-zag course therefore, has been named as Z-DNA. It has following main features:

(i) It is double stranded and both strands are antiparallel to each other.

(ii) Base pairing is similar to B-DNA e.g. A=T and G≡C pairing.

(iii) It is thinner than B-DNA, diameter 18A°

(iv) Z-DNA has zigzag-course in phosphate sugar backbone.

(v) The sugar residues in Z-DNA have alternating orientation. So that repeating unit is a dinucleotide.

(vi) The Z-DNA has 12 base pairs of six repeating units in one complete helix.

(vii) The length of one complete helix of Z-DNA is 45 A° while in B-DNA it is 34 A°.

(viii) Two adjacent nucleotides are apart from each other by a distance of 3.7 A°.

Section-C

Long answers

(a) **Fluid mosaic model**: This model was proposed by Singer and Nicholson in 1972 and states that plasma membrane is formed of lipoproteins as 'Protein iceberg in sea of lipids'. The main points of this model are -

- Plasma membrane is lipopsoteinous and trilamellar in nature.
- Protein molecules are globular and are of two types
  (a) Extrinsic or peripheral proteins :- These protein molecules lie outside the inner and outer surface of phospholipid bilayer. These are loosely attached to phospholipid molecules and can easily be separated e.g. ATPase
  (b) Intrinsic or Integral proteins :- These protein molecules are partially or completely embedded in the phospholipid bilayer and are strongly held by phospholipid molecules. These can not be easily separated. These forms about 70% of membrane proteins. e.g. cytochrome oxidase, etc.
  These are supposed to functions as charged channels for the passage for water soluble materials.
- Some other proteins functions as carriers e.g. permeases. while some functions as receptors which helps in inflow of material and informations to the cell.

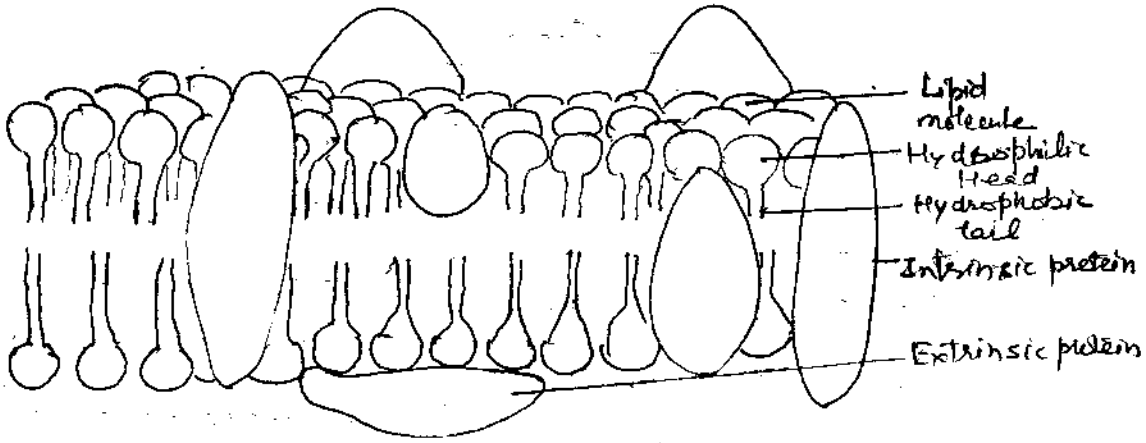
Phospholipid layer:

It is fluidly in nature in which the molecules show two types of movements.

(a) Transition movements (molecules change their position within the same layer)

(b) Flip-flop movements (molecules of two layer can be interchanged).

Each phospholipid molecule is a polar molecule having specific ends, Hydrophilic (head of glycerol) and Hydrophobic (tail of fatty acid).



Fluid mosaic model of plasmamembrane

Due to this reason these are regarded as amphiphatic molecules.

- Heads of phospholipid molecules of two layers are directed in opposite directions while tails of two layers face each other. Due to this type of arrangement, a water resistant barrier is formed.
- The proteins provide the structural and functional specificity to the cell membrane and also provide elasticity and mechanical support to the lipid matrix.
- The glycolipid and glycoprotein molecules help in cell recognition and play important role in immune response, cancer and rejection of transplanted organs.

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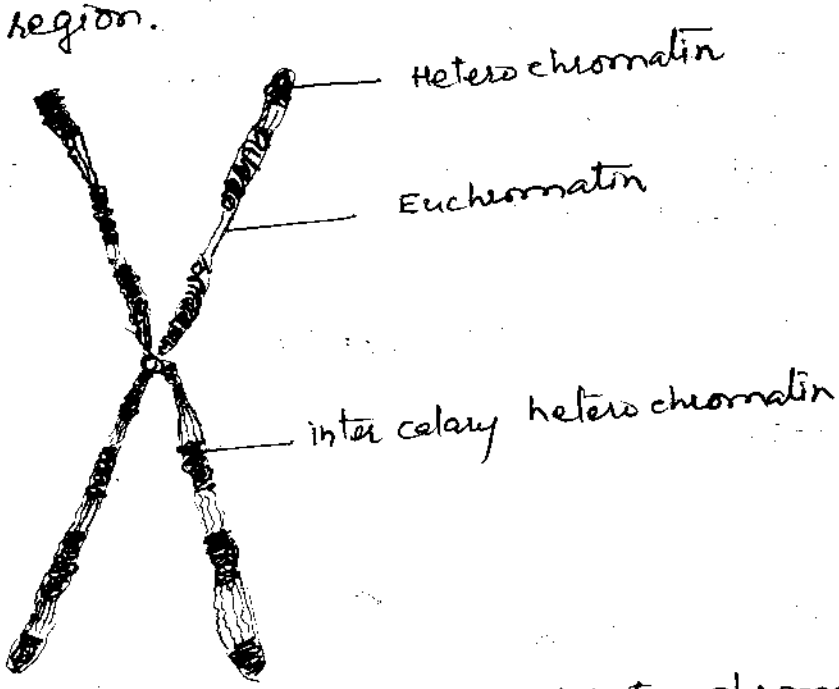
(b) Structure and function of euchromatin and heterochromatin:

Chromatin fibre are the basic unit of chromosomes. Average diameter of chromatin fibre is about 230A°.

Emil Heitz studied the differential staining of chromatids with basic dyes like acetocarmine, acetoorcein, feulgan etc. chromatin are of two types.

(i) Euchromatin (ii) Heterochromatin

(i) Euchromatin: Lightly stained regions of chromatin is called euchromatin. This is highly active and non-condensed region of chromatin. Most of functional genes on the chromosomes is found in this region. These fibres are 30-80A° in thickness. It is made up of diffused or uncoiled chromatin fibres. Acetylation of euchromatin is comparatively easier. Genetic exchange through crossing over takes place mainly in euchromatin region.



Euchromatin and heterochromatin

(ii) Heterochromatin: Darkly stained regions of chromatin during interphase of cell division is called heterochromatin.

It is classified into two groups:

(a) Facultative heterochromatin

(b) Constitutive heterochromatin

(a) Facultative heterochromatin: This is the heterochromatin which is actually euchromatin but become heterochromatin through the process of heterochromatization. This process may involve a segment of a chromosome or whole chromosome.

(b) Constitutive heterochromatin: Position of this type of heterochromatin is fixed and permanent on chromosome. This type of heterochromatin is found in the centromeric and telomeric regions of a chromosomes.

Functions:

(i) Heterochromatic regions on a chromosome play important role in the synthesis of chromosome.

(ii) Centromeric heterochromatin helps in separation of chromosomes and their chromatids during cell divisions.

(iii) It attracts homologous chromosomes for pairing during cell division.

(iv) It functions as spacers between two adjacent cistrons.

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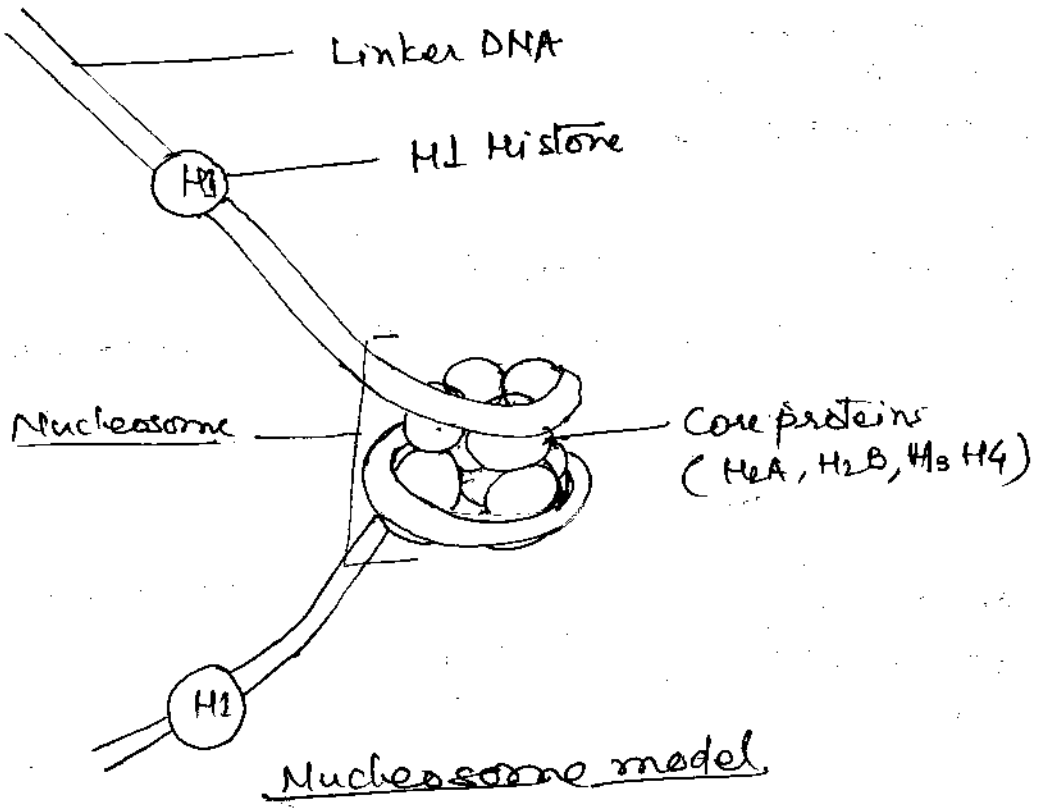
(c) Nucleosome Model :

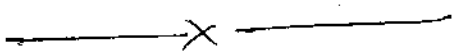
This model was proposed by Kornberg and Thomas (1974) to explain the structure of chromatin fibres. This model has been widely accepted all over the world. According to this model, chromatin is composed of a repeating unit called nucleosome.

- Chromatin fibres of a chromosome is made up of DNA and histone proteins
- The repeating unit of chromatin is called nucleosome. It is disc like structure, 11 nm in diameter and 6 nm in height. The core of a nucleosome is made up of an octamer of proteins having two molecules each of H_2A, H_2B, H_3 and H_4 histones.
- Around this octamer, a DNA segment having the length of 200 base pairs is wound round making $1\frac{3}{4}$ turns. This segment of DNA in chromatin fibre is nuclease (enzyme) resistant.



Nucleosome model

- P. Oudet et al. (1975) proposed that the length of DNA segment in the core of nucleosome is 146 base pairs.
- Two nucleosome units are joined with a segment of DNA which is called linker DNA. It consists of 50-70 base pairs.
- H1 - histone is associated with linker DNA which makes a connection between two adjacent nucleosomes.
- The nucleosome model explain the string on beads' concept of chromatin.



(d) Nucleic acid :

Nucleic acid is the polymer of nucleotide. In a nucleic acid molecule, all the nucleotide units are in the form of a long chain.

The nucleic acid was discover by a swiss scientist. Fredrich Miescher (1869) from pus cell.

Altman (1899) defined as The chemical compound present in all the living organisms which is made up of C, H, O, N and P. and is the polymer of nucleotides, carry out hereditary characters from generation to generation. and also perform other functions in cellular metabolism is known as the nucleic acid..

Nucleotides: Each nucleotide molecule is made up of a nucleoside and a phosphate group. Each nucleoside is in turn consists of a pentose sugar or nitrogenous base. The pentose sugar is the ribose sugar in case of RNA (ribose nucleic acid.

Nucleosides are made up of nitrogenous bases and pentose sugar. Generally, two types of nitrogenous bases are found in nucleic acids.

(i) Purines (ii) Pyrimidines

Purines are two ring nitrogenous bases which are of two types : (i) Adenine
(ii) Guanine

One ring of the two purines (A and G) is the six membered while another ring is five membered.

Pyrimidines : These are the nitrogenous bases consisting of single ring of carbon atoms. It is similar to a benzene ring except that it contains nitrogen (N) in the place of carbon (C) at position 1 and 3. Pyrimidines may be of following three types:

(i) Cytosine (ii) Thymine (iii) Uracil

Out of the three pyrimidines; cytosine and thymine are found in DNA while cytosine and uracil are found in RNA.

Significance :

(i) Different types of nucleotides are the constituents of nucleic acids which mainly function in the inheritance of characters from generation to generation.

(ii) Specifically adenosine functions in the storage and Transfer of cellular energy in the form of ATP, ADP and AMP.

(iii) Many nucleotides function as coenzymes. Some of these are NAD, NADP, FAD, FMN etc.

(iv) Some nucleotides also occur in the form of vitamines.

(v) Sometimes nucleotides function as constituent unit of many cell organelles like ribosomes, mitochondria, chloroplast etc.

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