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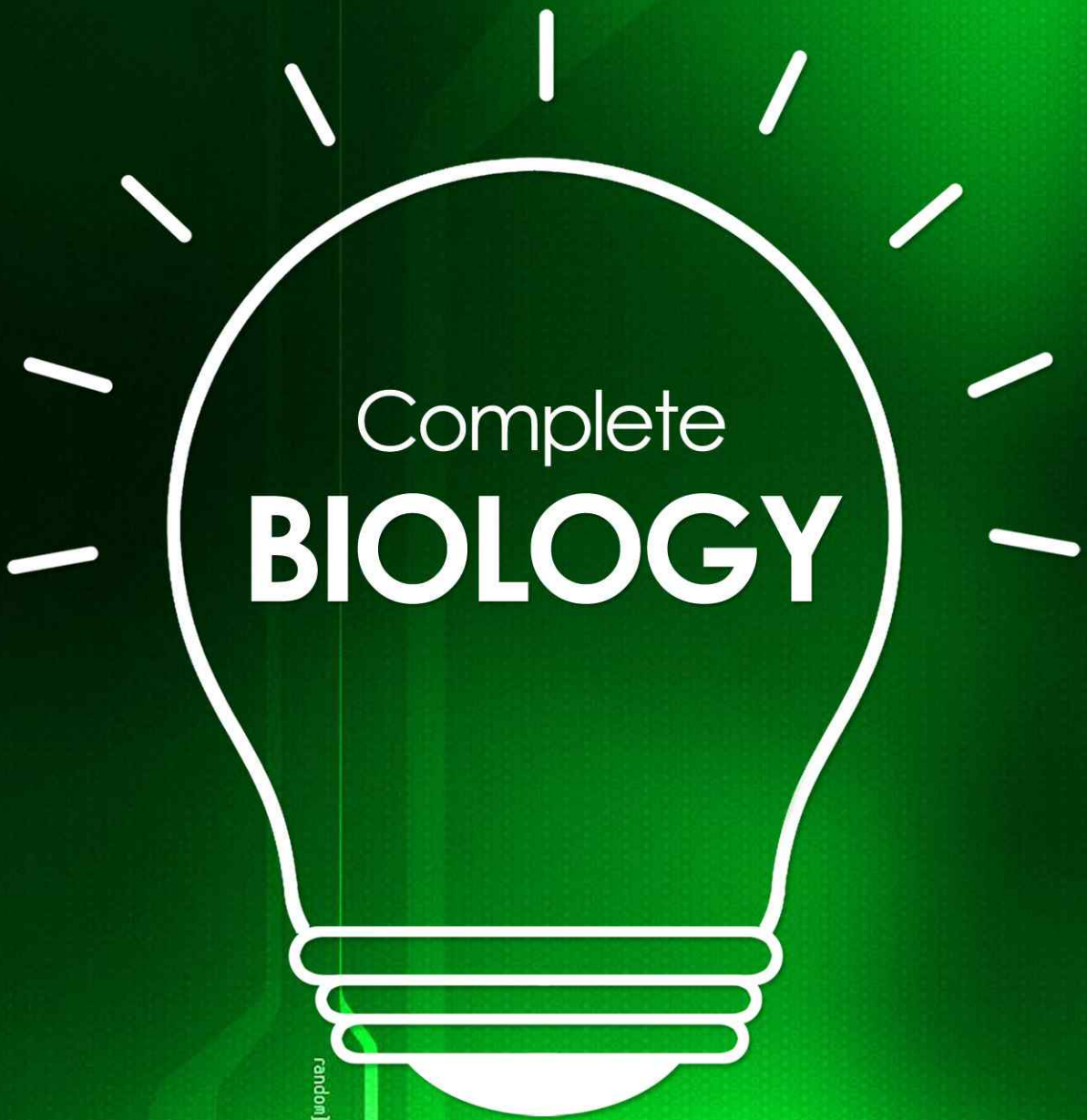

Complete BIOLOGY

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Molecular Basis of Inheritance

01. Introduction

Deoxyribonucleic acid (DNA) and **Ribonucleic acid** (RNA) are the two types of nucleic acid found in living systems. Nucleic acids are polymers of nucleotides. Bacteriophage $\Phi \times$ 174 has 5386 nucleotides, bacteriophage λ has 48502 bp. E. coli has 4.6×10^6 bp and haploid content of human DNA is 3.3×10^9 bp. DNA acts as a genetic material in most organisms, whereas RNA acts as a genetic material in some viruses.

02. Structure of Polynucleotide Chain

A nucleotide has three parts, i.e. a nitrogenous base, a pentose sugar (deoxyribose in DNA and ribose in RNA) and a phosphate group. **Nitrogenous bases** can be purines, i.e. adenine and guanine or pyrimidines i.e. cytosine, uracil and thymine. Cytosine is common for both DNA and RNA and thymine is present in DNA. Uracil is present in RNA at the place of thymine. A nitrogenous base is linked to the first carbon of pentose sugar though **N-glycosidic linkage** to form a nucleoside, e.g. adenosine, guanosine, etc. When a phosphate group is linked to 5`—OH of a nucleoside on the fifth carbon of pentose sugar through phosphodiester linkage, a corresponding nucleotide is formed. Two nucleotides are linked through **3`→5` phosphodiester linkage** to form a dinucleotide. Several nucleotides can be joined to form a polynucleotide chain. In this polynucleotide chain at one end free phosphate group is present which is known as 5` end, while at one end free OH group is present, which is known as 3` end. The backbone is a polynucleotide chain is formed of sugar and phosphates. The nitrogenous bases linked to sugar moiety project from the backbone.
In case of RNA, every nucleotide residue has an additional N—OH group present at 2`-position in the ribose. Also, the uracil is found at the place of thymine (5-methyl uracil).

03. Discoveries Related to Structure of DNA

(i) **Friedrich Meischer** (1869), first identified DNA as an acidic substance present in the nucleus and named it as `nuclein`.

(ii) **Levene** (1910), found DNA to contain phosphoric acid as well as deoxyribose sugar. He characterised four type of nucleotides present DNA.

(iii) **Erwin Chargaff** proposed that for a double-stranded DNA, the ratios between adenine (A) thymine (T) and guanine (G), cytosine (C) are constant and equals to one. $\frac{A+T}{C+G}=1$

(iv) **James Watson** and **Francis Crick,** in 1953 proposed a very simple **double helix** model for the structure of DNA based on X-ray diffraction data, produced by **Maurice Wilkins** and **Rosalind Franklin** in the same year.

04. Salient Features of Double Helix Structure of DNA

(i) DNA is a long polymer of deoxyribonucleotides. It is made up of two polynucleotide chains, where the backbone is constituted by sugar-phosphate and the bases project inside. So, nitrogenous bases can be considered as steps of the coiled helix.

(ii) The two chains have anti-parallel polarity, i.e. 5`→3` for one, 3`→5` for another.

(iii) The bases in two strands are paired through hydrogen bonds (H—bonds) forming base pairs (bp). Adenine forms two hydrogen bonds with thymine from opposite strand and *vice-versa.* Guanine bonds with cytosine by three H—bonds. Due to this, purine always comes opposite to a pyrimidine. This forms a uniform distance between the two strands of the helix.

(iv) The two chains are coiled in a right-handed fashion. The pitch of the helix is 3.4nm and there are roughly 10 bp in each turn. Due to this, the distance between a base pair in helix is about 0.34 nm.

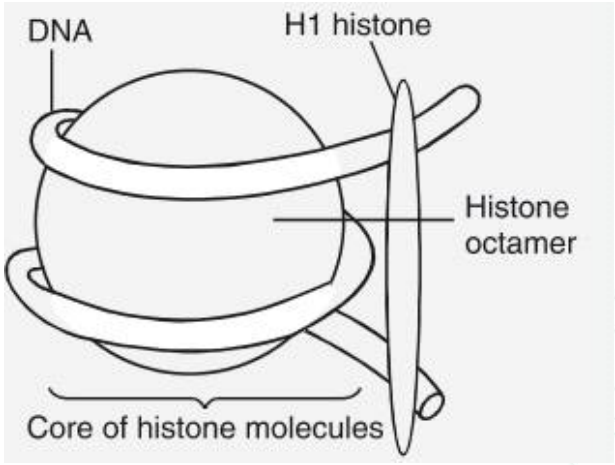
(v) The plane of one base pair stacks over the other in double helix. This confers stability to the helical structure in addition to H—bonds.

(vi) Diameter of DNA double helix is 20 Å.

(vii) The length of a DNA double helix is about 2.2 metres (6.6×10^{9}bp$\times0.34\times10^{-9}$m/bp). Therefore, it needs special **packaging in a cell.**

05. Packaging of DNA Helix

(i) **In prokaryotic cells** (which do not have a defined nucleus), such as E. *coli,* DNA being negatively charged is held with some proteins that have positive charge in a region called as **nucleoid.** The DNA in nucleoid is organised in large loops held by proteins.



(ii) **In eukaryotes,** there is a set of positively charged proteins called histones that are rich in basic amino acid residues, lysines and arginines (both positive). There are 5 types of histone proteins known as H_1, H_2A, H_2B, H_3 and H_4. Histones are organised to form a unit of eight molecules called histone octamer. In each octamer 2 molecules of each H_2A, H_2B, H_3 and H_4 are present. The negatively charged DNA is wrapped around the positively charged histone octamer to form a structure called nucleosome. Two nucleosomes are connected to each other with the help of linker DNA, on which H_1 histone is present, so H_1 is also known as linker histone.