RAMA UNIVERSITY

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FACULTY OF AGRICULTURAL SCIENCES

AND ALLIED INDUSTRIES

DNA STRUCTURE AND FUNCTION

Nature of the genetic material

A Swiss Biologist Miescher (18690 identified a chemical compound in Pus cells and Salmon sperm in the large nuclei of these cells. The chemical was named 'Nuclein'. As it was found to be acidic, it was called 'Nucleic acid".

There are two kinds of proteins associated with nucleic acid and they are prolamine and histone. Because of the complexity of proteins, they were originally thought as the genetic material. Proteins have long chemical chains consisting of many amino acids and they were considered to be capable of carrying many complex messages that course variation in the biological material.

There are two types of nucleic acid, the De-oxy ribo nucleic acid (DNA) and Ribo-Nucleic acid (RNA). By staining Nucleic acid, DNA was localized in the nucleus, while the RNA was found to occur outside the nucleus in the cytoplasm.

The experiments of Griffith (1928) with pneumonia bacterium and the inter pretation of results by Avery, Macheod and Mc carty (1944) confirmed the DNA as the hereditary material.

Griffith Experiment

Griffith (1928) worked on the Phenomena causing spherical shaped bacterium, *Diplococcus pneumonia*. Some of the strains of this bacterium have a smooth polysaccharide capsule, which causes the disease and hence called Virulent 'S' strains. A mutent strain has no capsule and is a virulent or non-pathogenic and is called 'R' strain. In agar medium, the virulent, strain produces smooth surfaced rough surfaced colonies. There are several types of strains, SI, SI, SIII, RI, RII, RIII etc., that differ in the type of antigen they produce.

The kind of antigen produced in genetically determined. The 'S' type sometimes mutates to 'R' type but rot in the reverse.

Griffith injected the lab mice with live RII bacteria and the mice did not get phenomena as RII in avirulent.

When injected with Virulent SIII, the mice suffered of Phenomena and died. When S III bacteria were heat killed at 65^{o}C and then injected into the mice, they did not suffer of the disease and lived.

Later, heat killed SIII strain and the live avirulent RII strain were mixed and injected into the mice. Contrary to expectations, the mice suffered of pneumonia and died. On analyzing the blood sample of the affected mice, live SIII and live R II bacteria were found in it. This could not be possible due to the mutation of avirulent RII the virulent types. Evidently, some heat stable component present in the heat killed and hence dead SIII strain could have conferred the Virulent nature to the live RII strain. Griffith designated this as the 'transferring principle"

that transformed the hereditary property of avirulent RII to virulent SIII. This phenomenon is called “Griffith effect” or “Bacterial transformation”.

Griffith did not understood the cause of bacterial transformation. Avery, Macleod and Mc Cartly (1944) tested a fraction of the heat killed S III bacteria for the transforming ability. They removed proteins, lipids, polysaccharides and RNA from SIII extract by a variety of chemical and enyzymatic methods without diminishing its ability to transfer RII into SIII strain. They found that a cell- free and highly purified DNA found that a cell- free and highly purified DNA extracts of SIII bacteria could bring about transformation of RIII into SIII and concluded that DNA in transforming principle and hence the genetic material in bacteria.

Transformation

It is the process of adding a foreign DNA fragment from a donor genome into the genome of a recipient cell. The donor fragment passes through the cell membrane of the recipient cell and becomes incorporated in the genome of the recipient cell through recombination.

DNA as the genetic material in viruses

Harshey and Chase (1952) provided direct proof that DNA is the genetic material in certain bacterial viruses.

Bacteriophage is a virus that infects or feeds on certain specific bacteria. T2 bacteriophage that infects the Escherichia coli was involved in the studies.

Bacteriophage is electron microscopic. It has a head and a tail. Inside the head there is a long chain of DNA molecule. The phage attaches itself by its tail to the bacteria and infects the DNA into the bacillus. It dictates the cell to produce many copies of the viral DNA.

Bacteriophages are used in many finer analyses of the genetic material since they are haploid organisms and there is no hiding of mutant effect. As there is no differential sex, there is no need for two different individuals to unite for reproduction. They multiply enormously and have a short life span. Recombination’s and mutations, even if in a very low frequency, could be recognized with relative ease. When a population is raised from a single phage all the descendents will be identified. But occasionally, through errors in copying of genetic material, rate mutants appear and such mutants are called ‘Cop errors”.

In a chemically defined cultural medium known quantities of radioactive isotopes of phosphorus P^{32} and Sulphur S^{35} were added. E coli were grown in the medium and the labelled E coli cells were used as hosts for unlabelled T2 bacteriophage. The virus progeny that multiplied inside the bacteria could be traced in the culture medium on lysis (cell wall breakage) of the bacteria.

The viral DNA was labelled with P^{32} and the viral capsid (protein coat) with S^{35}, since DNA contained ‘P’ and viral capsid contained ‘S’. Then the labelled viruses were allowed to in feet unlabelled E coli and get multiplied. Later the

viruses were separated from the bacterial host cell by agitation, and the content of P^{32} and S^{35} of the virus and bacteria was assessed. P^{32} could be traced in the injected bacterial cells. Hershey and chase inferred that DNA of the virus entered the bacterium and played a role in viral multiplication, whereas the protein of the virus did not play any role in the intercellular replication of the virus. Thus it was established that the genetic material of the virus was DNA.

Transduction

The transfer of genetic information (DNA) from one bacterial strand to another, mediated by a phage (virus) that kills the DNA donor and carries some of its DNA to a recipient cell, which is not killed, by the phage is called transduction.

CHEMCIAL COMPOSITION OF DNA

DNA is a complex macromolecular or polymeric chemical compound, which contains four kinds of monomeres (small building blocks) called ,"Deoxy ribo nucleotides". Each deoxy ribo necleotide is made up of ;

i. a phosphoric acid molecule, biologically called phosphate, discovered by Levene (1910).
ii. A penotose sugar called 2-deoxy ribose.
iii. Four nitrogen bases
Adenine (A), Guanine (G) – Purines (two ringed)

Cytosine (c) and thymine (T) – Pyrimidines (one ringed) – discovered by Fischer (1980).

Nucleotide = N- base + sugar + phosphoric acid

Nucleoside = N base + Sugar

Levene and Todd (1910) demonstrated that, the components of DNA were joined together to form along chain of alternating deoxribose and phosphoric acid units with side chains of the nitrogen bases.

Double helical model of DNA

Chargoff (195) found that, the total amount of purines equalled the total amount of pyrimidins (A +G = T + C), that the amount of adenine equalled to amount of thymine (A=T) and the amount of quanine equalled to the amount of cytosine (G=C) and that the ratio between total purines and total pyrimidines was always not far from one, (A+G) : (T+C) = 1.

The double helical model of DNA was constructed by Watson an American biologist and crick a British physicists in 1953. The DNA molecule was conceived as a two stranded structure coiled like a rope and hence called plaetonemic, so that if the ends are permitted to revolve freely, the complementary stands could easily separate. The coil was propose to the helical and conceived to resemble a circular staircase, maintaining the same diameter through out the length and

having a constant width between steps. The steps are connected on liker side by a railing.

The helix has a diameter of 20 A and maked a complete turn at every 34'A along its length. The distance between nucleotides in 3.4^{o} A. Each complete turn has a stack of 10 necleotides.

Adenine pairs with thymine with two H bonds (A=T) and guanine with cytosine with three H bonds (G=C), there N bases are connected to each other by deoxyribose and phosphoric acid.

IMPORTANT QUESTIONS:

1. DESCRIBE DOUBLE HELICAL MODEL OF DNA.
2. EXPLAIN CHARGAFF'S RULE.
3. WHAT ARE THE FUNCTIONS OF DNA?
4. EXPLAIN THE EXPERIMENT WHICH PROVES DNA AS GENETIC MATERIAL.
5. DIFFERENTIATE BETWEEN DNA AND RNA.