''बेटी बचाओ, बेटी पढ़ाओ''

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FACULTY OF PHYSIOTHERAPY & DIAGNOSTICS

Faculty Name : **JV'n SMRITI** (Assistant Professor)

Program : 1st Year

Course Name : BPT

Session No. & Name : 2023

Academic Day starts with –

- Greeting with saying **'Namaste'** by joining Hands together following by 2-3 Minutes Happy session, Celebrating birthday of any student of respective class and **National Anthem**.

Lecture Starts with- Review of previous Session:-amino acid.

Topic to be discussed today- Today We will discuss about the nucleic acid and the structure and function of nucleic acid.

- University Library Reference- satyanarayan.

  National song' Vande Mataram'

TOPIC : Nucleic Acid

Nucleic acids, deoxyribonucleic acid (DNA) and ribonucleic acid (RNA), carry genetic information which is read in cells to make the RNA and proteins by which living things function. The well-known structure of the DNA double helix allows this information to be copied and passed on to the next generation. In this article we summarise the structure and function of nucleic acids. The article includes a historical perspective and summarises some of the early work which led to our understanding of this important molecule and how it functions; many of these pioneering scientists were awarded Nobel Prizes for their work. We explain the structure of the DNA molecule, how it is packaged into chromosomes and how it is replicated prior to cell division. We look at how the concept of the gene has developed since the term was first coined and how DNA is copied into RNA (transcription) and translated into protein (translation).

The Structure of deoxyribonucleic acid

Deoxyribonucleic acid (DNA) is one of the most important molecules in living cells. It encodes the instruction manual for life. Genome is the complete set of DNA molecules within the organism, so in humans this would be the DNA present in the 23 pairs of chromosomes in the nucleus plus the relatively small mitochondrial genome. Humans have a diploid genome, inheriting one set of chromosomes from each parent. A complete and functioning diploid genome is required for normal development and to maintain life.

Discovery and chemical characterisation of DNA

DNA was discovered in 1869 by a Swiss biochemist, Friedrich Miescher. He wanted to determine the chemical composition of leucocytes (white blood cells),

his source of leucocytes was pus from fresh surgical bandages. Although initially interested in all the components of the cell, Miescher quickly focussed on the nucleus because he observed that when treated with acid, a precipitate was formed which he called ‘nuclein’. Almost all molecular bioscience graduates would have repeated a form of this experiment in laboratory classes where DNA is isolated from cells. Miescher, Richard Altmann and Albrecht Kossel further characterised ‘nuclein’ and the name was changed to nucleic acid by Altmann. Kossel went on to show that nucleic acid contained purine and pyrimidine bases, a sugar and phosphate. Work in the 1930s from many scientists further characterised nucleic acids including the identification of the four bases and the presence of deoxyribose, hence the name deoxyribonucleic acid (DNA). Erwin Chargaff had found that DNA molecules from a particular species always contained the same amount of the bases cytosine (C) and guanine (G) and the same amount of adenosine (A) and thymine (T). So, for example, the human genome contains 20% C, 20% G, 30% A and 30% T.

There are four different bases in DNA, the double-ring purine bases: adenine and guanine; and the single-ring pyrimidine bases: cytosine and thymine. The carbon within the deoxyribose ring are numbered 1′ to 5′. Within each monomer the phosphate is linked to the 5′ carbon of deoxyribose and the nitrogenous base is linked to the 1′ carbon, this is called an N-glyosidic bond. The phosphate group is acidic, hence the name nucleic acid.

In the DNA chain , the phosphate residue forms a link between the 3′-hydroxyl of one deoxyribose and the 5′-hydroxyl of the next. This linkage is called a phosphodiester bond. DNA strands have a ‘sense of direction’. The deoxyribose at the top of the diagram in is not linked to another deoxyribose; it terminates with a 5′ phosphate group. At the other end the chain terminates with a 3′ hydroxyl.

DNA is the genetic material

Although many scientists, including Miescher, had observed that prior to cell division the amount of nucleic acid increased, it was not believed to be the genetic material until the work of Fredrick Griffith, Oswald Avery, Colin MacLeod and Maclyn McCarty. In 1928, Griffith showed that living cells could be transformed by extracts from heat-killed cells and that this transformation had the potential to permanently change the genetic makeup of the recipient cell. Griffith was working with two strains of the bacterium *Streptococcus pneumoniae*. The encapsulated so-called S strain is virulent, whereas the non-capsulated R strain is nonvirulent. If the S strain is injected subcutaneously into mice, the mice die, whereas, if either live R strain is injected or heat-killed S strain is injected, the mouse lives. However, if a mixture of live R strain and heat-killed S strain is injected into a mouse, the mouse will die, and live S strain can be isolated from the blood. So, in the Griffith experiment a component of the heat-killed S strain is transforming the R strain. In 1944, Avery, MacLeod and McCarty went on to show that it was DNA that could transform the avirulent bacterium.

They isolated a crude DNA extract from the S strain and destroyed any protein, lipid, carbohydrate and ribonucleic acid (RNA) component and showed that this purified DNA could still transform the R strain. However, when the purified DNA was treated with DNAse, an enzyme that degrades DNA, transformation was lost.

Determining the structure of DNA

Once it had been shown that DNA was the genetic material, there was a race to determine the three-dimensional structure of the DNA molecule. At King's

College London, Rosalind Franklin and Maurice Wilkins, having obtained data using X-ray diffraction, had proposed that DNA had a helical structure and Franklin had obtained a particularly good X-ray diffraction pattern. In Cambridge, James Watson and Francis Crick used model building together with data from a variety of sources including Franklin's X-ray diffraction pattern and Chargaff's base composition data to work out the now well-known double helix structure of DNA. Their work was published in *Nature* in 1953. The Watson–Crick structure.

RNA

Another important class of nucleic acids is RNA, the roles of RNA molecules in the cell will be discussed below. Chemically RNA is similar to DNA, it is a chain of similar monomers. The building blocks are nucleotides containing the 5-carbon sugar ribose, a phosphate and a nitrogenous base. The phosphate is attached to the 5′ carbon of the ribose and the nitrogenous base to the 1′ carbon RNA contains four bases adenine, guanine, cytosine and uracil. RNA is more labile (easily broken down) than DNA and most RNA molecules do not form stable secondary structures, some notable exceptions will be discussed below. The properties of RNA make it ideal as a genetic messenger during protein synthesis, the idea of this genetic messenger, mRNA, was proposed by François Jacob and Jacques Monod.

Packaging of DNA into eukaryotic cells

DNA has to be highly condensed to fit into the bacterial cell or eukaryotic nucleus. In eukaryotes, histone proteins are used to condense the DNA into chromatin. The basic structure of chromatin is the nucleosome, a nucleosome contains DNA wrapped almost two times around the histone octamer

(comprising two copies each of the histone proteins H2A, H2B, H3 and H4) . Further levels of compaction are required to fit the DNA into the nucleus , the nucleosomes are folded upon themselves to form the 30-nm fibre, this is then folded again to form the 300-nm fibre and during mitosis further compaction can occur forming the chromatid which is 700 nm in diameter.

DNA replication

Whenever a cell divides there is a need to synthesise two copies of each chromosome present within the cell. For example in a human, prior to cell division, all 23 pairs of chromosomes need to be replicated to form 46 pairs, so that following cell division each daughter cell has a full complement (23 pairs) of chromosomes. The structure of DNA gives us a clue to how it is replicated, this was eloquently postulated by Watson and Crick in their 1953 paper: “It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material”. Each strand can act as a template for the synthesis of the complementary strand, so the replication machinery would ‘unzip’ the double helix and read along the two existing ‘parent’ strands, synthesising a complementary new ‘daughter’ strand with A opposite T, C opposite G etc. This is described as semi-conservative, since each ‘new’ double-stranded DNA molecule has one original parent strand and one newly made daughter ‘strand’