Genetics

Biology Dept.3rd stage

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Lec-11-DNA

DNA as Genetic Material Proof that Genetic Information is Stored in DNA

Functions of the Genetic Material

Genotypic Function: Replication

Phenotypic Function: Gene Expression

Evolutionary Function: Mutation

Searching for Genetic Material

Mendel: modes of heredity in pea plants (1865)

Morgan: genes located on chromosomes (1910)

Griffith: bacterial work; transformation: change in genotype and phenotype due to assimilation of external substance (DNA) by a cell (1928)

Avery et al.: transformation agent was DNA (1944)

Hershey & Chase: proving once and for all that DNA is the genetic material (1952)

1928 – Frederick Griffith – experiments with smooth (S), virulent strain Streptococcus pneumoniae, and rough (R), nonvirulent strain

Bacterial transformation demonstrates transfer of genetic material

1944 – Oswald Avery, Colin MacLeod, and MacIyn McCarty – determined that DNA is the transformation material.

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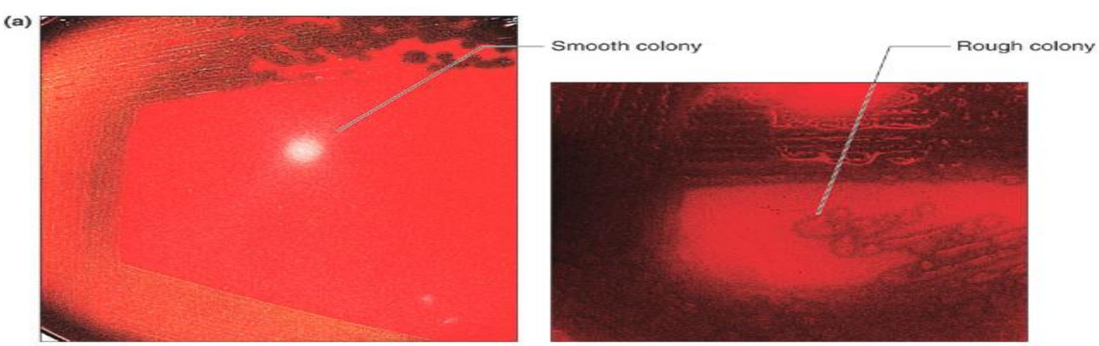
Experimental Proof of the Genetic Function of DNA

An important first step was taken by Frederick Griffith in 1928 when he demonstrated that a physical trait can be passed from one cell to another. He was working with two strains of the bacterium Streptococcus pneumoniae identified as S and R. When a bacterial cell is grown on solid medium, it undergoes repeated cell divisions to form a visible clump of cells called a **colony.** The S type of *S. pneumoniae* synthesizes a gelatinous capsule composed of complex carbohydrate (polysaccharide).

The enveloping capsule makes each colony large and gives it a glistening or smooth (S)appearance. This capsule also enables the bacterium to cause pneumonia by protecting it from the defense mechanisms of an infected animal. The R strains of *S. pneumonia* are unable to synthesize the capsular polysaccharide; they form small colonies that have a rough (R) surface .

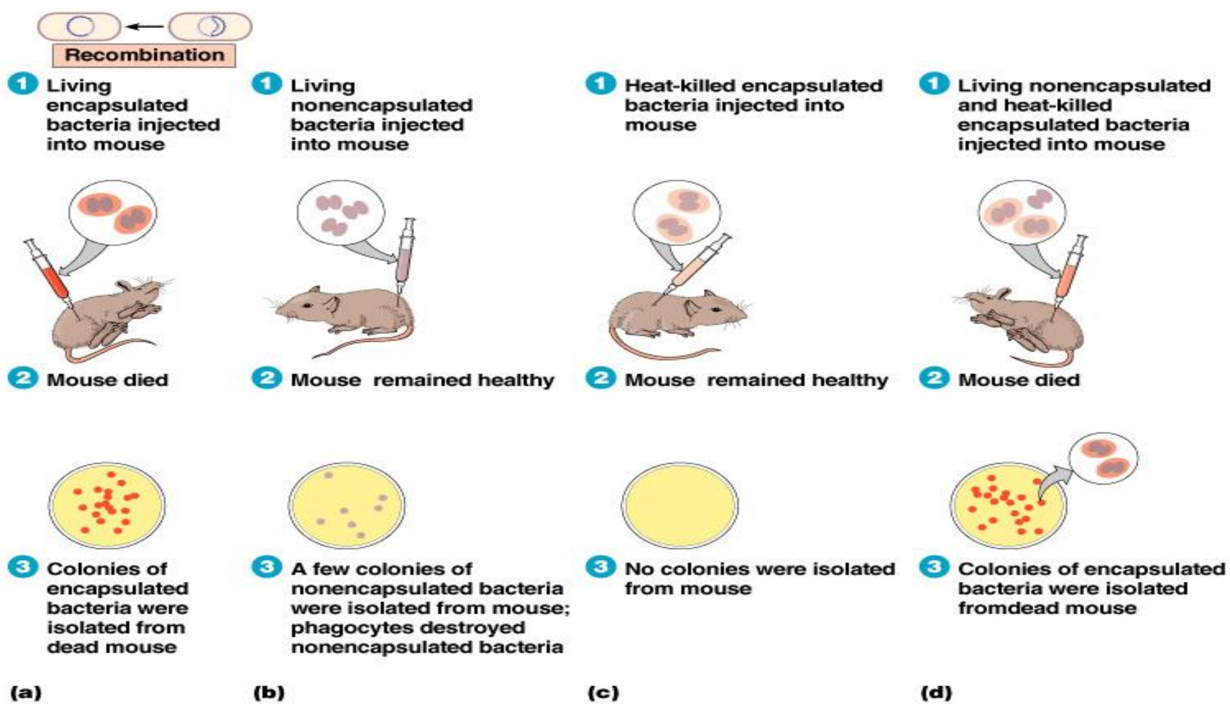


This strain of the bacterium does not cause pneumonia, because without the capsule the bacteria are inactivated by the immune system of the host. either S or R. Mice injected with living S cells get pneumonia. Mice injected either with living R cells or with heat-killed S cells remain healthy. Here is Griffith's critical finding:

mice injected with a *mixture* of living R cells and heat-killed S cells contract the disease— they often die of pneumonia .

Bacteria isolated from blood samples of these dead mice produce S cultures with a capsule typical of the injected S cells, even though the injected S cells had been killed by heat. Evidently, the injected material from the dead S cells includes a substance that can be transferred to living R cells and confer the ability to resist the immunological system of the mouse and cause pneumonia.

In other words, the R bacteria can be changed—or undergo transformation— into S bacteria. Furthermore, the new characteristics are inherited by descendants of the transformed bacteria.



These experiments implied that the substance responsible for genetic transformation was the DNA of the cell—hence that DNA is the genetic material

What is DNA?

DNA, or deoxyribonucleic acid, is the hereditary material in humans and almost all other organisms. Nearly every cell in a person's body has the same DNA. Most DNA is located in the cell nucleus (where it is called nuclear DNA), but a small amount of DNA can also be found in the mitochondria (where it is called mitochondrial DNA or mtDNA).

The information in DNA is stored as a code made up of four chemical bases: adenine (A), guanine (G), cytosine (C), and thymine (T). Human DNA consists of about 3 billion bases, and more than 98 percent of those bases are the same in all people. The order, or sequence, of these bases determines the information available for building and maintaining an organism, similar to the way in which letters of the alphabet appear in a certain order to form words and sentences.

DNA bases pair up with each other, A with T and C with G, to form units called base pairs. Each base is also attached to a sugar molecule and a phosphate molecule. Together, a base, sugar, and phosphate are called a nucleotide. Nucleotides are arranged in two long strands that form a spiral called a double helix. The structure of the double helix is somewhat like a ladder, with the base pairs forming the ladder's rungs and the sugar and phosphate molecules forming the vertical sidepieces of the ladder.

An important property of DNA is that it can replicate, or make copies of itself. Each strand of DNA in the double helix can serve as a pattern for duplicating the sequence of bases. This is critical when cells divide because each new cell needs to have an exact copy of the DNA present in the old cell.

Where is DNA found?

DNA is found inside a special area of the cell called the nucleus. Because the cell is very small, and because organisms have many DNA molecules per cell, each DNA molecule must be tightly packaged. This packaged form of the DNA is called a chromosome.

Besides the DNA located in the nucleus, humans and other complex organisms also have a small amount of DNA in cell structures known as mitochondria. Mitochondria generate the energy the cell needs to function properly.

In sexual reproduction, organisms inherit half of their nuclear DNA from the male parent and half from the female parent. However, organisms inherit all of their mitochondrial DNA from the female parent. This occurs because only egg cells, and not sperm cells, keep their mitochondria during fertilization

What is DNA made of?

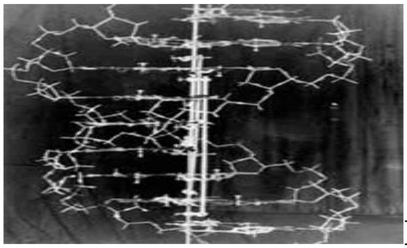
DNA is made of chemical building blocks called nucleotides. These building blocks are made of three parts: a phosphate group, a sugar group and one of four types of nitrogen bases. To form a strand of DNA, nucleotides are linked into chains, with the phosphate and sugar groups alternating.

The four types of nitrogen bases found in nucleotides are: adenine (A), , thymine (T), guanine (G) and cytosine (C). The order, or sequence, of these bases determines what biological instructions are contained in a strand of DNA. For example, the sequence ATCGTT might instruct for blue eyes, while ATCGCT might instruct for brown.Each DNA sequence that contains instructions to make a protein is known as a gene. The size of a gene may vary greatly, ranging from about 1,000 bases to 1 million bases in humans.The complete DNA instruction book, or genome, for a human contains about 3 billion bases and about 20,000 genes on 23 pairs of chromosomes.

Watson and Crick

In 1951, the then 23-year old biologist James Watson traveled from the United States to work with Francis Crick, an English physicist at the University of Cambridge. Crick was already using the process of X-ray crystallography to study the structure of protein molecules. Together, Watson and Crick used X-ray crystallography data, produced by Rosalind Franklin and Maurice Wilkins at King's College in London, to decipher DNA's structure.

This is what they already knew from the work of many scientists, about the DNA molecule:



In 1953, Watson and Crick created their historic model of the shape of DNA: the double helix. COLD SPRING HARBOR LABORATORY ARCHIVES

DNA is made up of subunits which scientists called nucleotides.

Each nucleotide is made up of a sugar, a phosphate and a base.

There are 4 different bases in a DNA molecule:

adenine (a purine)

cytosine (a pyrimidine)

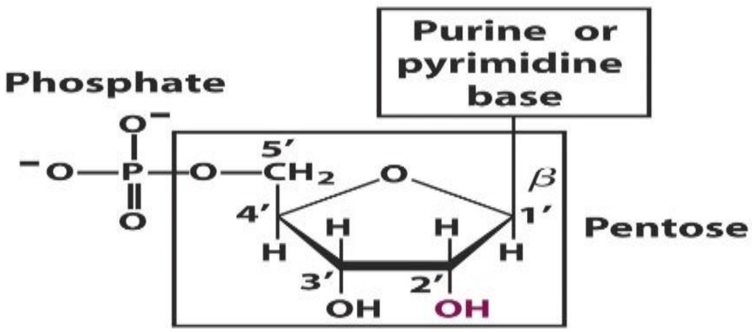
guanine (a purine)

thymine (a pyrimidine)

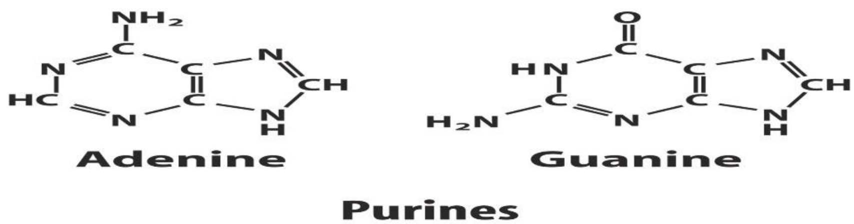
The number of purine bases equals the number of pyrimidine bases

The number of adenine bases equals the number of thymine bases

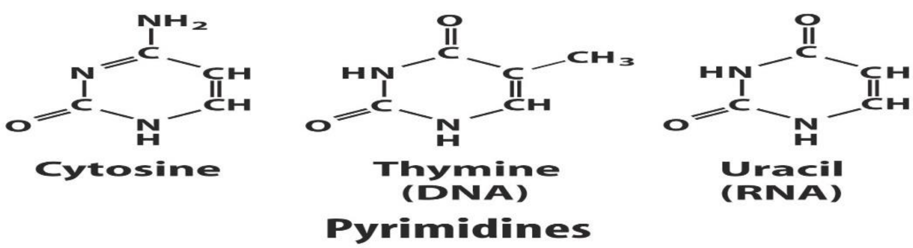
The number of guanine bases equals the number of cytosine bases



Pyrimidine & Purine



- The bases are abbreviated by their first letters (A, G, C, T, U).
- The purines (A, G) occur in both RNA and DNA



- Among the pyrimidines, C occurs in both RNA and DNA, but
- T occurs in DNA, and
- U occurs in RNA

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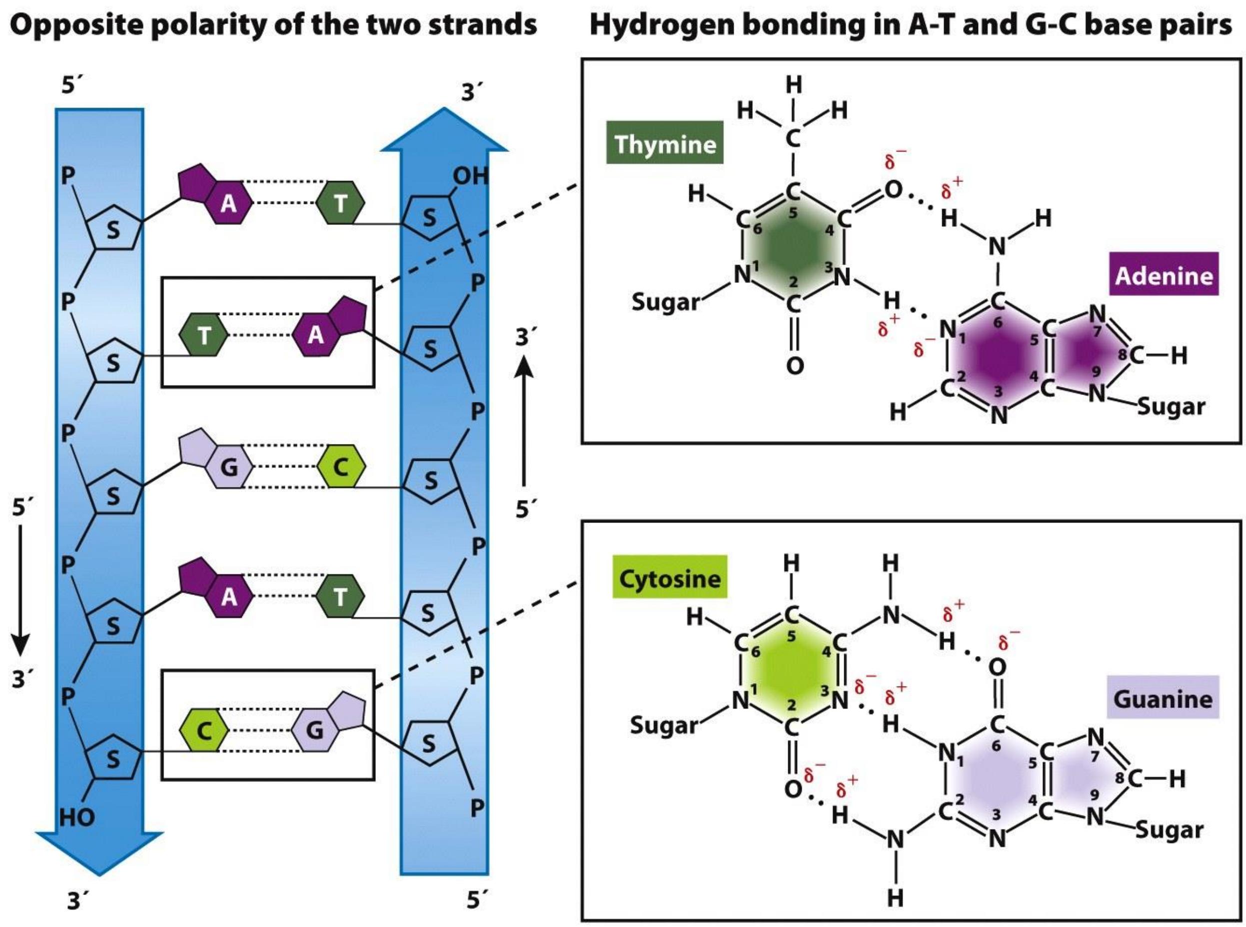

Nucleotide monomers can be linked together via phosphodiester linkage formed between the 3' -OH of a nucleotide and the phosphate of the next nucleotide Two ends of the resulting poly- or oligonucleotide are defined The 5' end lacks a nucleotide at the 5' position and the 3' end lacks a nucleotide at the 3' end position

- **DNA consists of two helical chains wound around the same axis in a right-handed fashion aligned in an antiparallel fashion.**
- **There are 10.5 base pairs, or 36 Å, per turn of the helix.**

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- **Alternating deoxyribose and phosphate groups on the backbone form the outside of the helix.**
- **The planar purine and pyrimidine bases of both strands are stacked inside the helix.**