

The Replication of Life

In deoxyribonucleic acid—DNA—all the genetic information of a complete organism is found. It has complete control of heredity. A DNA molecule consists of two strands of relatively simple compounds called nucleotides. Each nucleotide consists of a phosphate, sugar, and one of four kinds of nitrogenous bases. The nucleotides on each strand are paired in specific combinations and connected to each other by hydrogen bonds. The two strands coil around each other in the form of a spiral, or double helix.

Complementary

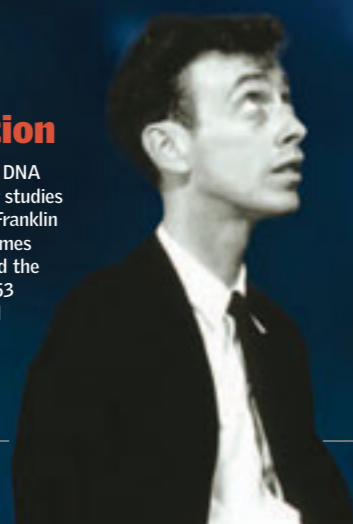
Various specialized proteins called enzymes act as biological catalysts, accelerating the reactions of replication: helicase, which is in charge of opening the double helix of DNA; polymerase, which is in charge of synthesizing the new strands of DNA in one direction; and ligase, which seals and joins the fragments of DNA that were synthesized.

50
nucleotides

PER SECOND IS THE SPEED OF DNA REPLICATION IN HUMANS.

Biological Revolution

Deciphering the molecular structure of DNA was the major triumph of biomolecular studies in biology. Based on work by Rosalind Franklin on the diffraction of X-rays by DNA, James Watson and Francis Crick demonstrated the double-helix composition of DNA in 1953 and for their work won the 1962 Nobel Prize for Physiology or Medicine.



REPLICATION

The genetic information is encoded in the sequence of the bases of the DNA nucleotides aligned along the DNA molecule. The specificity of the pairing of these bases is the key to the replication of DNA. There are only two possible combinations—thymine with adenine and guanine with cytosine—to form the complementary links of the strands that make up the DNA chain.

ORIGINAL
CHAIN

NEW
CHAIN

1

WEAK BRIDGES

Helicase separates the double helix, thus initiating the replication of both chains. The chains serve as a model to make a new double helix.

2

FREED ENERGY

The energy to form new links is obtained from the phosphate groups. The free nitrogenous bases are found in the form of triphosphates. The separation of the phosphates provides the energy to interlace the nucleotides in the new chain that is being built.

3

NEW CONNECTION

The new chains of DNA couple in short segments, and the ligase joins them to form the daughter molecules.

4

PERFECT REPLICATION

The result is two new molecules, each with one strand from the original DNA and one new complementary strand. This is called semiconservative replication. The genetic information of the new strand is identical to that of the original DNA molecule.

ORIGINAL

COPY

BASIC MECHANISM

The new bases join to make a DNA chain that is a daughter of the previous model.

Nucleotides

The nucleotides have three subunits: a phosphate group, a five-carbon sugar, and a nitrogenous base. In DNA these bases are small organic molecules. Adenine and guanine are purines, and cytosine and thymine are pyrimidines, smaller than the purines. All are composed of nitrogen, hydrogen, carbon, and oxygen—except for adenine, which has no oxygen. The adenine is always paired with thymine and guanine with cytosine. The first pair is joined by two hydrogen bonds and the second by three.

ADENINE

GUANINE

HYDROGEN
BOND

CYTOSINE

THYMINE