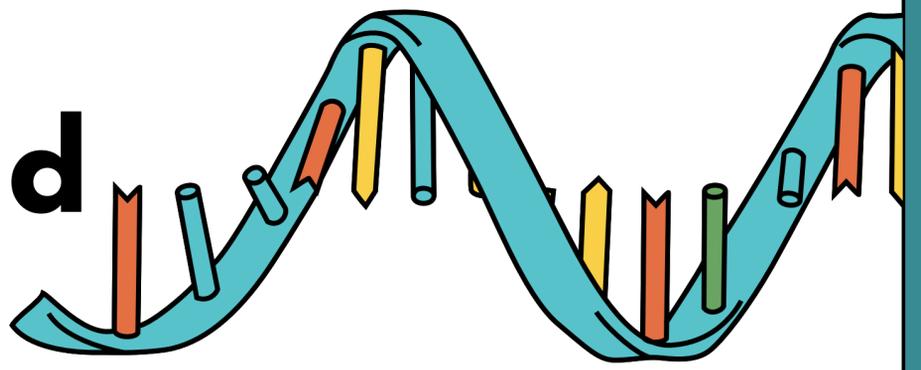
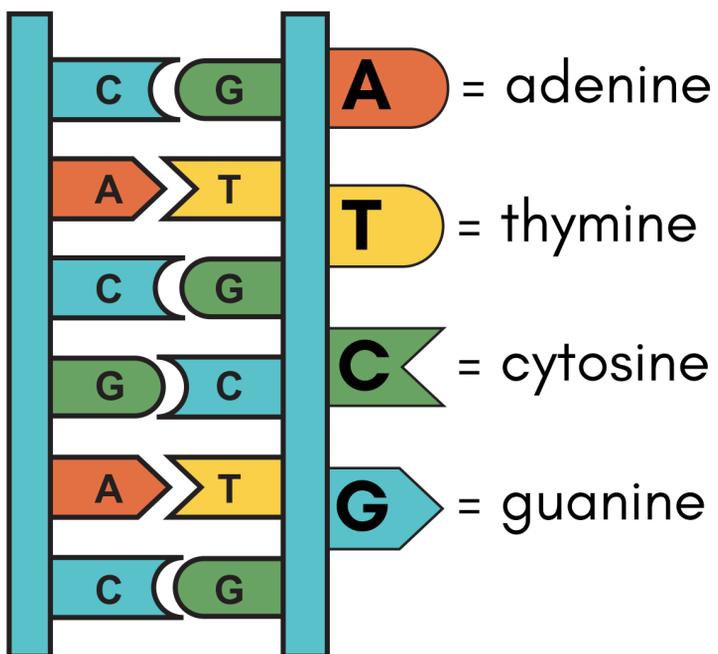


Unit 6: Gene Expression and Regulation



Basics

DNA is a large molecule found inside the cells of living things. It is made up of different elements that carry genetic information. DNA is made up of four basic building blocks called **nucleotides**.

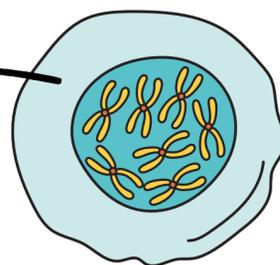
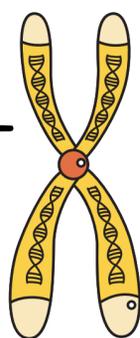
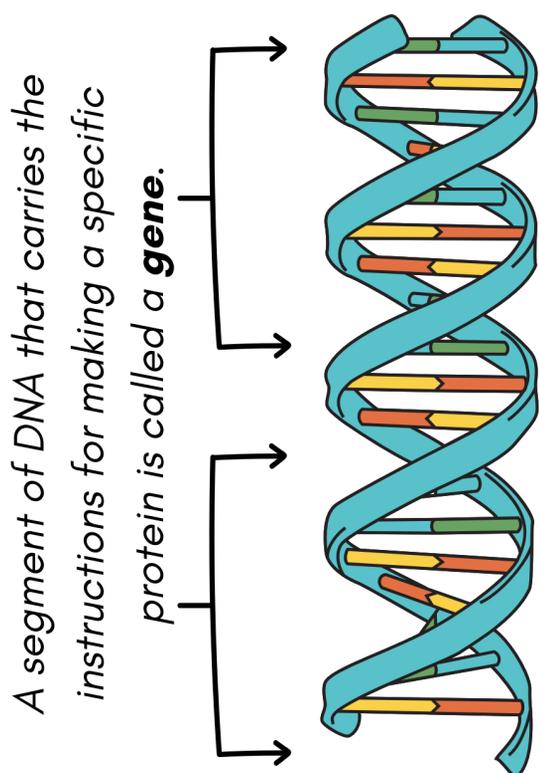


NUCLEOTIDES

The order of nucleotides within a strand of DNA forms a special genetic **code**. This code provides instructions for the development, growth and functioning of all living things.

CHROMOSOMES

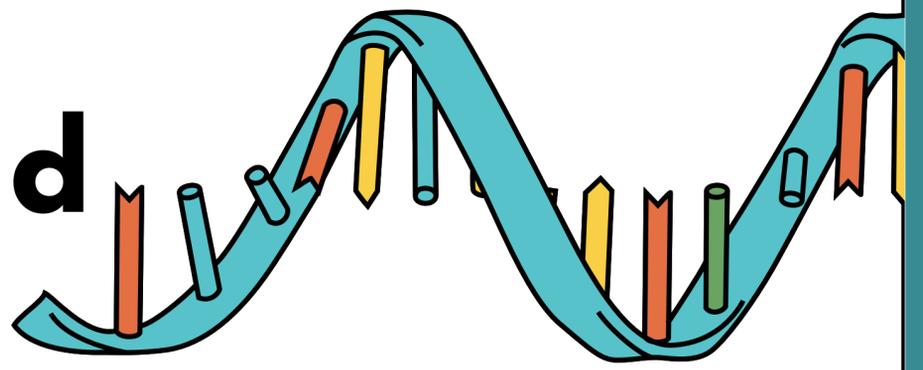
Humans have a total of 46 DNA molecules. These are organised into long, coiled-up structures called **chromosomes**.



Chromosomes are found in the **nucleus** (control centre) of the cell.

They are responsible for the genetic information that is passed down from parents to children. Humans have 23 pairs of chromosomes in each of their cells.

Unit 6: Gene Expression and Regulation



6.1 DNA and RNA: Structure and Function

DNA (deoxyribonucleic acid) is a large molecule made of repeating units called nucleotides. Each nucleotide contains a sugar, a phosphate group, and a nitrogenous base. DNA has four bases: adenine (A), thymine (T), guanine (G), and cytosine (C). The specific order of these bases stores hereditary information.

DNA

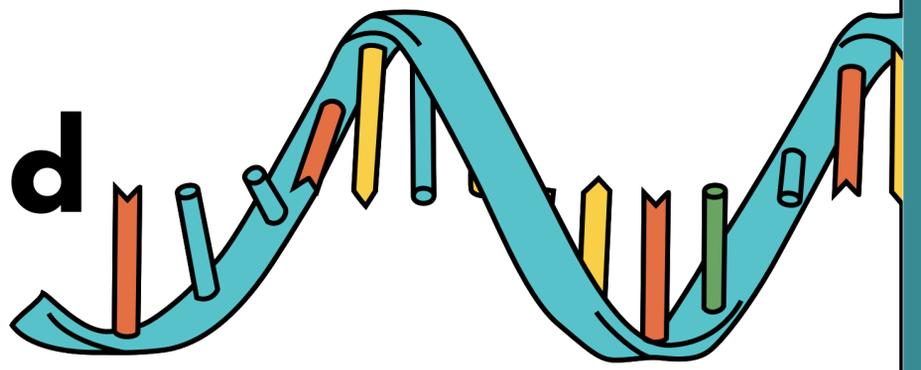
DNA has a double-helix structure made of two complementary strands running in opposite directions. These strands are held together by hydrogen bonds between paired bases (A with T, and C with G). This structure provides stability and allows DNA to be accurately copied during replication.

RNA

RNA (ribonucleic acid) is also composed of nucleotides, but it differs from DNA in both structure and function. RNA contains the bases adenine (A), uracil (U), guanine (G), and cytosine (C). RNA serves as the link between DNA and protein production.

RNA is usually single-stranded and can fold into different shapes depending on its role. For example, tRNA and rRNA form complex structures that are necessary for protein synthesis.

Unit 6: Gene Expression and Regulation



6.2–6.4 DNA Replication, Transcription, and Translation

DNA replication occurs before cell division and ensures that each new cell receives an identical copy of genetic material. The double-helix unwinds, and each strand serves as a template for building a new complementary strand. This process is described as semi-conservative replication.

DNA REPLICATION

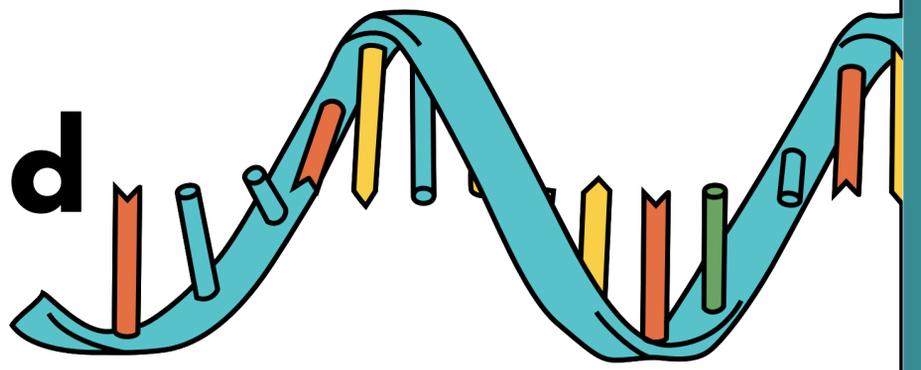
Several enzymes are involved, including helicase, which separates the strands, primase, which lays down RNA primers, DNA polymerase, which builds new DNA strands, and ligase, which connects fragments into a continuous strand.

TRANSCRIPTION

Transcription is the process of creating an RNA molecule from a DNA template. It takes place in the nucleus and is carried out by RNA polymerase. The enzyme binds to a promoter region, separates the DNA strands, and synthesizes a complementary RNA strand.

The initial RNA produced is called a primary transcript and contains both coding and non-coding sequences.

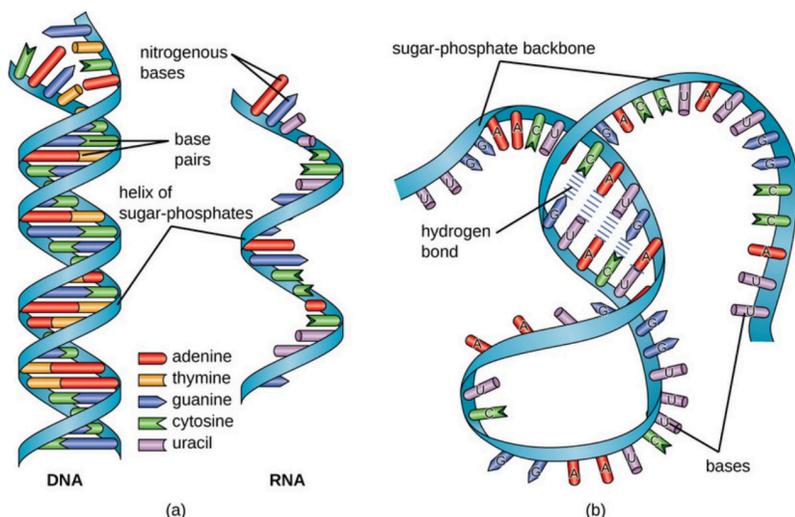
Unit 6: Gene Expression and Regulation



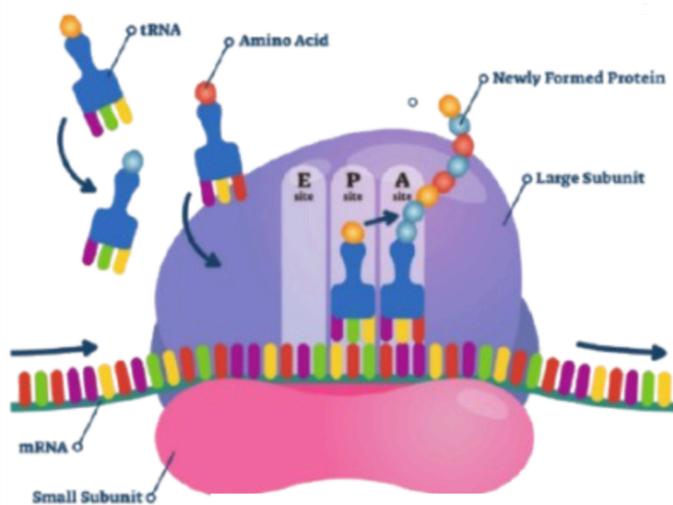
6.2-6.4 DNA Replication, Transcription, and Translation

RNA PROCESSING

RNA processing modifies the primary transcript into a functional RNA molecule. Non-coding regions called introns are removed, and coding regions called exons are joined together. A 5' cap and a poly-A tail are added to protect the RNA and help transport it out of the nucleus.

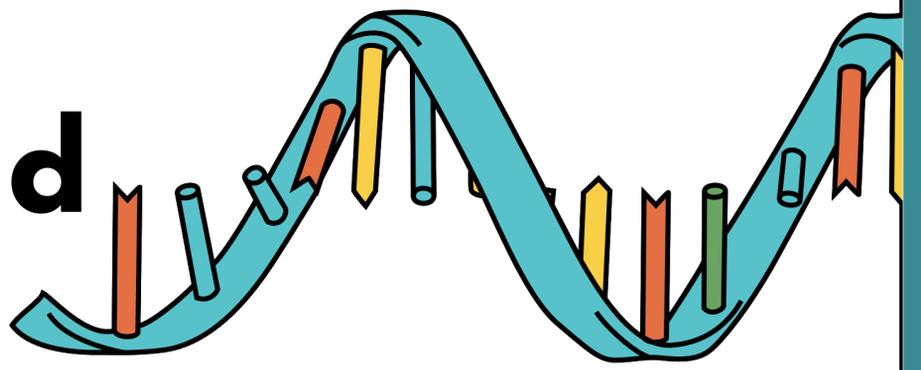


TRANSLATION



Translation occurs in the cytoplasm at ribosomes, where the RNA sequence is used to assemble amino acids into a protein. tRNA molecules deliver specific amino acids based on codons in the RNA sequence. When a stop codon is reached, the completed protein is released and folds into its functional shape.

Unit 6: Gene Expression and Regulation



6.5–6.7 Regulation of Gene Expression, Mutations, and Cell Specialization

GENE EXPRESSION

Examples of regulatory sequences include enhancers, which boost gene expression, and silencers, which reduce it. Some enhancers are located far from the genes they regulate but still influence transcription through DNA looping.

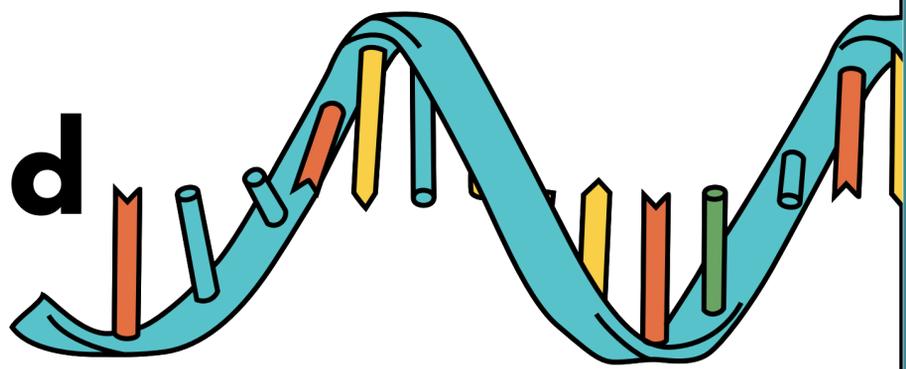
For example, mutations affecting pigment production can change flower color, while differences in gene expression related to metabolism can help organisms survive in extreme environments. Variation in gene expression contributes to biological diversity and evolutionary change.

Gene expression is controlled by regulatory DNA sequences that determine when and how strongly a gene is expressed. These sequences interact with transcription factors, which can either increase or decrease transcription.

Because gene expression varies among cells, organisms with the same DNA can develop different cell types. This leads to cell specialization, where cells perform specific functions.

Changes in gene expression can result from mutations, alterations in regulatory proteins, or environmental influences. These changes can affect an organism's phenotype, or observable traits such as appearance, behavior, and biochemical processes.

Unit 6: Gene Expression and Regulation



6.8 Biotechnology

BIOTECHNOLOGY

Common biotechnological techniques include recombinant DNA technology, PCR, gel electrophoresis, and gene cloning, all of which allow scientists to analyze and manipulate genetic material.

Biotechnology involves using living organisms or biological systems to develop products and technologies. Applications include medicine, agriculture, environmental management, and industrial production.

While biotechnology offers many benefits, it also raises ethical, legal, and social concerns that must be carefully considered.

