HSC Biology – Module 5: Heredity – DNA & Polypeptide Synthesis Study Notes

- **DNA and Polypeptide Synthesis**

Inquiry question: Why is polypeptide synthesis important

❖ *construct appropriate representations to model and compare the forms in which DNA exists in eukaryotes and prokaryotes (ACSBL076)*

Eukaryotes

DNA in eukaryotes is found in chromosomes within the cell nucleus. DNA is wound tightly around proteins called **histones**; DNA then forms **supercoils** which in turn pack together to form a **chromosome**.

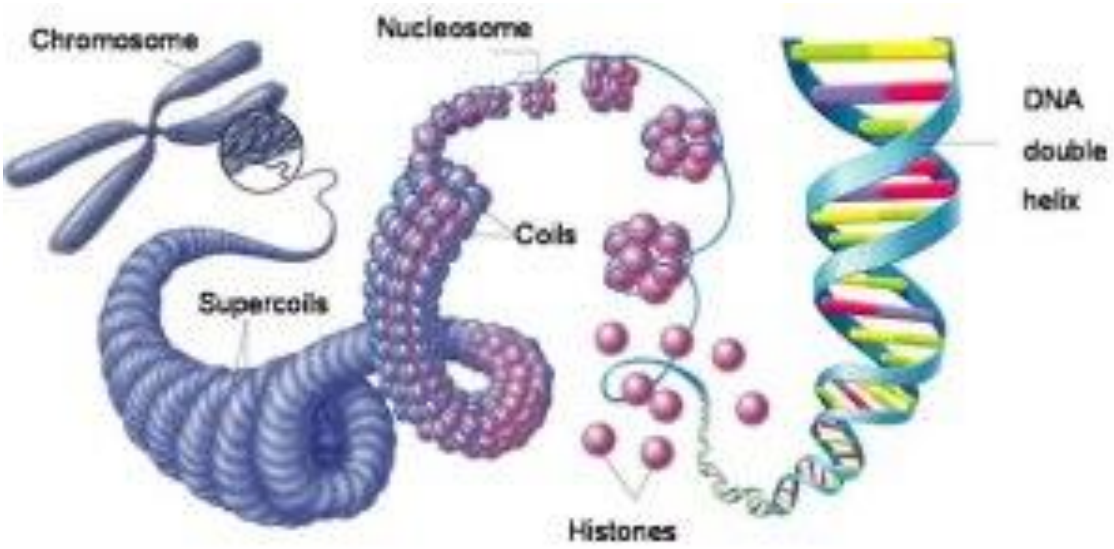


Image: PMG Biology

Prokaryotes

DNA in prokaryotes is found in free floating chromosomes within the cytoplasm, not bound by any proteins. Prokaryotes also have small, extra-chromosomal DNA segments called **Plasmids**.

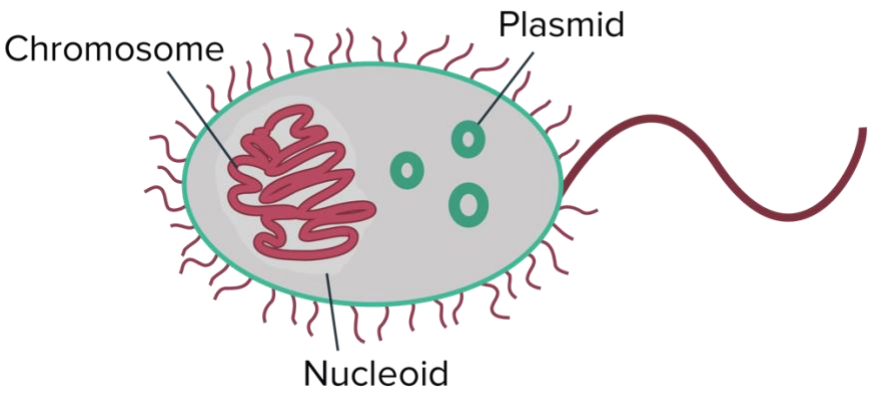


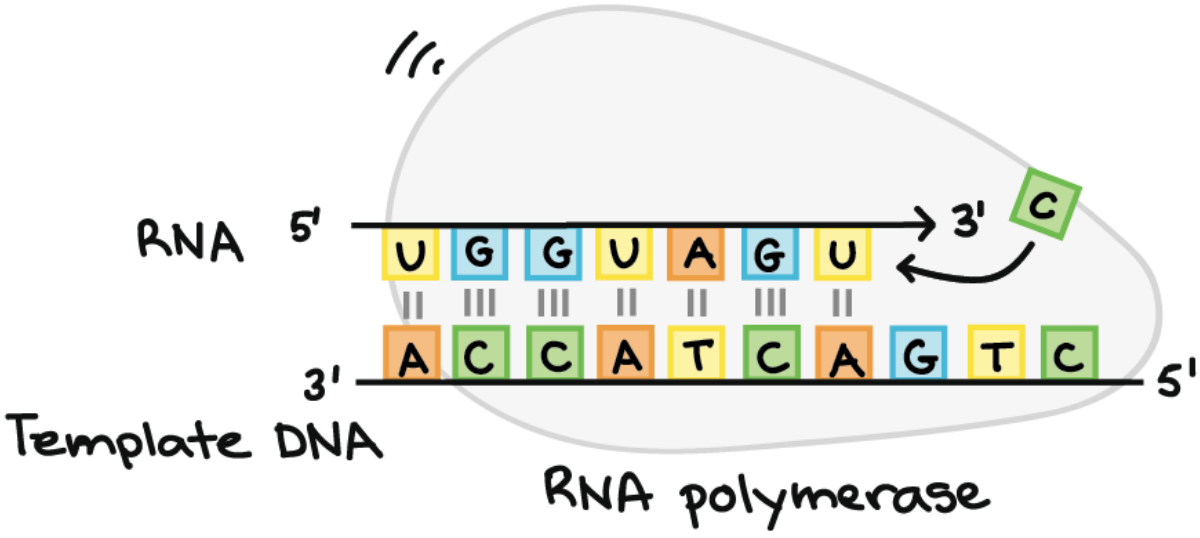
Image: Khan Academy

- model the process of polypeptide synthesis, including: (ACSBL079)
  - *transcription and translation*
  - *assessing the importance of mRNA and tRNA in transcription and translation (ACSBL079)*
  - *analysing the function and importance of polypeptide synthesis (ACSBL080)*
  - *assessing how genes and environment affect phenotypic expression (ACSBL081)*

  - Transcription and translation

Part 1- Transcription→ occurs in nucleus

1. A section of DNA (gene) unzips via enzymes
2. One single strand of the unzipped DNA is exposed and acts as a template
3. Free floating RNA nucleotides join with corresponding pairs (A with U, T with A, G with C)
4. mRNA forms as RNA polymerase joins RNA nucleotides
5. mRNA detaches and leaves the nucleus
6. original DNA template re-zips



Model showing RNA nucleotides joining with corresponding exposed pairs on an unzipped section of DNA.

Image: Khan Academy

Part 2- Translation→ occurs in cytoplasm

- the process by which polypeptides are assembled on the ribosome using the information in the messenger RNA molecule
- mRNA goes to ribosome (in cytoplasm) and threads through to make a polypeptide
- corresponding transfer RNA (tRNA) carrying an anticodon brings an amino acid (20 different AA, floating in cytoplasm) to the ribosome, with each triplet of bases (e.g. UCA) coding for a particular amino acid which is picked up by tRNA in cytoplasm

- The ribosome reads the next codon and the amino acids continue to be deposited until a chain of amino acids (polypeptide) formed
- This process (production of polypeptide) stops when ribosome reads a 'stop' codon, which releases the polypeptide into the cytoplasm
- To make a protein, the polypeptides go to the Golgi apparatus for assembly and packaging

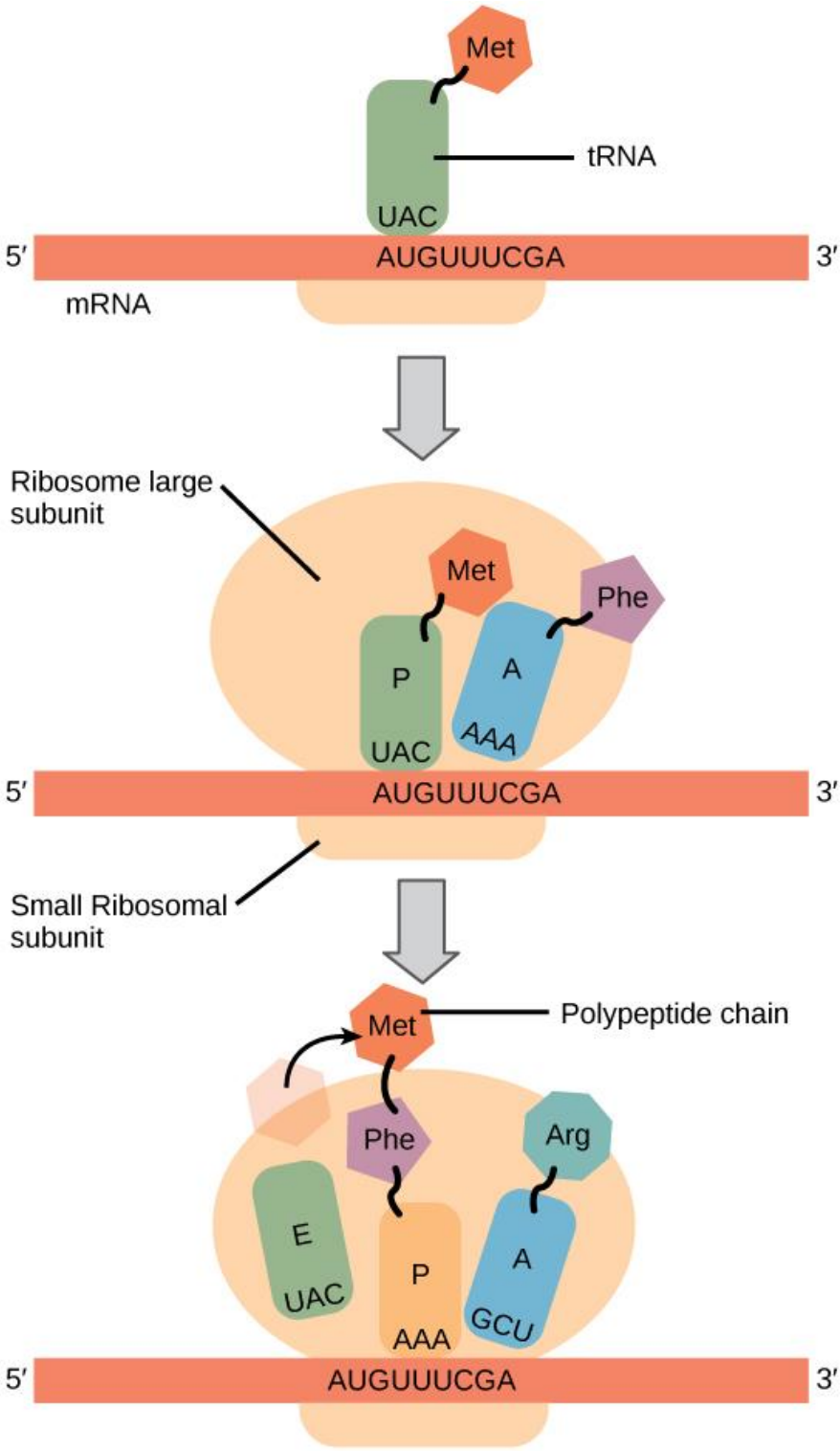


Image: Philschatz.com

- Assessing importance of mRNA and tRNA in transcription and translation
  - mRNA- messenger RNA
    - conveys genetic material in DNA to ribosome
    - during translation, each triplet of bases (codon) is used to identify the appropriate anti-codon
    - mRNA sequence must therefore be accurate for correct polypeptide to be produced at ribosome and therefore to maintain healthy cell function
    - Hence mRNA is of critical importance in both transcription and translation
  - tRNA- transfer RNA
    - tRNA is responsible for decoding the mRNA as it threads through the ribosome, using the mRNA codon during translation. The corresponding tRNA carries a complementary anticodon which codes for a specific amino acid.
    - As the tRNA decodes the mRNA molecule, a chain of amino acids is formed via peptide bonds, which then forms a polypeptide
    - Hence, the tRNA molecule is extremely important, as it decodes the mRNA molecule and supplies the appropriate amino acid so that ultimately the correct polypeptide & protein can be formed to maintain cell function.

- Function and importance of polypeptide synthesis
  - Role of polypeptide synthesis is to express a sequence of DNA to form an appropriate polypeptide that will ultimately be packaged to form a protein.
  - Proteins are fundamental to all cell structures and functioning. They are large, complex macromolecules made up of one or polypeptides.
  - Proteins control all aspects of cellular life- enzymes, antibodies are both examples of proteins.
  - As this process involves the expression of genetic material into observable proteins, it is of critical importance that polypeptide synthesis occurs correctly, without error, or else diseases can result.
  - Without protein synthesis, we would not be able to express genetic material so that it becomes an observable, functioning characteristic.

- How genes and environment affect phenotypic expression

An individual's phenotype is a combination of environment and genetic expression.

  - Nature vs. nurture debate
  - Some variations are genetically inherited, others are influenced by environment (and on a wide spectrum)
  - Variations may arise as a result of interaction: GENES + ENVIRONMENT = PHENOTYPE

Genes

  - A section of DNA (gene) will affect phenotypic expression when it is undergoes protein synthesis to produce an appropriate protein that can then be observed in the individual –i.e. it becomes part of an individual's phenotype
  - E.g. for the trait of hair type, an individual may be heterozygous for that trait and have an allele for straight hair and an allele for curly hair. As curly hair is

dominant over straight hair, the allele for curly hair will be expressed, and therefore become part of the individual's observable characteristics (phenotype)
- Hence, genes play a fundamental role in phenotypic expression and can significantly affect an individual's phenotype.

Environment

- Environment affects the expression of genes → may be enhanced or masked
- E.g. studies with twins – same genotypes but different phenotypes due to environment
- E.g. lack of nutrients → stunted growth
- E.g. hydrangeas – colour depends of the acidity of the soil → acidic – bright blue, alkaline – pale pink, off white

❖ *Investigate the structure and function of proteins in living things*

Structure

- A protein is a large, complex macromolecule made up of one or more polypeptides.
- A polypeptide is made up of a chain of amino acids- up to 20 different amino acids.
- 'One gene – one polypeptide' → genes don't necessarily code for an entire protein but each polypeptide chain making up that protein
- To form a protein, one or more polypeptide chains is folded into a specific shape- this shape is determined by the sequence of amino acids in the chain, and this results in the overall structure of the protein.
    - Primary structure = amino acid sequence
    - Secondary structure = formation of alpha helices & beta sheets
    - Tertiary structure= interactions of side chains→ proteins will fold to form the most stable structures→ produces a 3D structure depending on how it folds
    - Quaternary structure = interaction of protein subunits

Function

- Proteins are fundamental to all cellular functions
- Proteins give the cell its structure (e.g. keratin), they form enzymes (e.g. pepsin), are messengers (e.g. hormones), antibodies, toxins and receptors.
- This diversity is achieved by the many different combinations of amino acids which are determine the protein's unique shape and function.