**Essential idea**: Information stored as a code in DNA is copied onto mRNA.

## 7.2 Transcription and gene expression

**Nature of science:**

Looking for patterns, trends and discrepancies—there is mounting evidence that the environment can trigger heritable changes in epigenetic factors. (3.1)

**Understandings:**

- Transcription occurs in a 5′ to 3′ direction.
- Nucleosomes help to regulate transcription in eukaryotes.
- Eukaryotic cells modify mRNA after transcription.
- Splicing of mRNA increases the number of different proteins an organism can produce.
- Gene expression is regulated by proteins that bind to specific base sequences in DNA.
- The environment of a cell and of an organism has an impact on gene expression.

**Application and skills:**

- Application: The promoter as an example of non-coding DNA with a function.
- Skill: Analysis of changes in the DNA methylation patterns.

**Guidance:**

- RNA polymerase adds the 5´ end of the free RNA nucleotide to the 3´ end of the growing mRNA molecule.

**Theory of knowledge:**

- The nature versus nurture debate concerning the relative importance of an individual's innate qualities versus those acquired through experiences is still under discussion. Is it important for science to attempt to answer this question?

**Utilization:**

Syllabus and cross-curricular links:
Biology
Topic 2.7 DNA replication, transcription and translation

**Essential idea**: Information transferred from DNA to mRNA is translated into an amino acid sequence.

## 7.3 Translation

**Nature of science:**

Developments in scientific research follow improvements in computing—the use of computers has enabled scientists to make advances in bioinformatics applications such as locating genes within genomes and identifying conserved sequences. (3.7)

**Understandings:**

- Initiation of translation involves assembly of the components that carry out the process.
- Synthesis of the polypeptide involves a repeated cycle of events.
- Disassembly of the components follows termination of translation.
- Free ribosomes synthesize proteins for use primarily within the cell.
- Bound ribosomes synthesize proteins primarily for secretion or for use in lysosomes.
- Translation can occur immediately after transcription in prokaryotes due to the absence of a nuclear membrane.
- The sequence and number of amino acids in the polypeptide is the primary structure.
- The secondary structure is the formation of alpha helices and beta pleated sheets stabilized by hydrogen bonding.
- The tertiary structure is the further folding of the polypeptide stabilized by interactions between R groups.
- The quaternary structure exists in proteins with more than one polypeptide chain.

**Application and skills:**

- Application: tRNA-activating enzymes illustrate enzyme–substrate specificity and the role of phosphorylation.
- Skill: Identification of polysomes in electron micrographs of prokaryotes and eukaryotes.

**Utilization:**

Syllabus and cross-curricular links:
Biology
Topic 2.7 DNA replication, transcription and translation
Option B: Biotechnology and bioinformatics

| 7.3 Translation | |
|---|---|
| • Skill: The use of molecular visualization software to analyse the structure of eukaryotic ribosomes and a tRNA molecule.<br>**Guidance:**<br>• Names of the tRNA binding sites are expected as well as their roles.<br>• Examples of start and stop codons are not required.<br>• Polar and non-polar amino acids are relevant to the bonds formed between R groups.<br>• Quaternary structure may involve the binding of a prosthetic group to form a conjugated protein. | |

# Topic 8: Metabolism, cell respiration and photosynthesis — 14 hours

**Essential idea:** Metabolic reactions are regulated in response to the cell's needs.

## 8.1 Metabolism

**Nature of science:**

Developments in scientific research follow improvements in computing—developments in bioinformatics, such as the interrogation of databases, have facilitated research into metabolic pathways. (3.8)

**Understandings:**

- Metabolic pathways consist of chains and cycles of enzyme-catalysed reactions.
- Enzymes lower the activation energy of the chemical reactions that they catalyse.
- Enzyme inhibitors can be competitive or non-competitive.
- Metabolic pathways can be controlled by end-product inhibition.

**Applications and skills:**

- Application: End-product inhibition of the pathway that converts threonine to isoleucine.
- Application: Use of databases to identify potential new anti-malarial drugs.
- Skill: Calculating and plotting rates of reaction from raw experimental results.
- Skill: Distinguishing different types of inhibition from graphs at specified substrate concentration.

**Guidance:**

- Enzyme inhibition should be studied using one specific example for competitive and non-competitive inhibition.

**Theory of knowledge:**

- Many metabolic pathways have been described following a series of carefully controlled and repeated experiments. To what degree can looking at component parts give us knowledge of the whole?

**Utilization:**

- Many enzyme inhibitors have been used in medicine. For example ethanol has been used to act as a competitive inhibitor for antifreeze poisoning.
- Fomepizole, which is an inhibitor of alcohol dehydrogenase, has also been used for antifreeze poisoning.

Syllabus and cross-curricular links:
Biology
Topic 2.7 DNA replication, transcription and translation
Chemistry
Topic 6.1 Collision theory and rates of reaction

**Aims:**

- **Aim 6:** Experiments on enzyme inhibition can be performed.
- **Aim 7:** Computer simulations on enzyme action including metabolic inhibition are available.