Summary

Unit 2 - Molecular Biology Current

Subject	Year	Start date	Duration
Biology	IB1	Week 1, May	5 weeks 21 hours

Course Part

Curriculum

Aims

Appreciate scientific study and creativity within a global context through stimulating and challenging opportunities

Acquire a body of knowledge, methods and techniques that characterize science and technology

Apply and use a body of knowledge, methods and techniques that characterize science and technology

Develop an ability to analyse, evaluate and synthesize scientific information

Develop a critical awareness of the need for, and the value of, effective collaboration and communication during scientific activities

Develop experimental and investigative scientific skills including the use of current technologies

Develop and apply 21st century communication skills in the study of science

Become critically aware, as global citizens, of the ethical implications of using science and technology

Develop an appreciation of the possibilities and limitations of science and technology

Develop an understanding of the relationships between scientific disciplines and their influence on other areas of knowledge

Objectives

Demonstrate knowledge and understanding of

- facts, concepts, and terminology
- methodologies and techniques
- communicating scientific information

Apply

- facts, concepts, and terminology
- methodologies and techniques
- methods of communicating scientific information

Syllabus Content

Core

2. Molecular biology

2.1 Molecules to metabolism

Nature of science:

Understandings:

Molecular biology explains living processes in terms of the chemical substances involved.

Carbon atoms can form four covalent bonds allowing a diversity of stable compounds to exist.

Life is based on carbon compounds including carbohydrates, lipids, proteins and nucleic acids.

Metabolism is the web of all the enzyme-catalysed reactions in a cell or organism.

Anabolism is the synthesis of complex molecules from simpler molecules including the formation of macromolecules from monomers by condensation reactions.

Catabolism is the breakdown of complex molecules into simpler molecules including the hydrolysis of macromolecules into monomers.

Applications and skills:

Application: Urea as an example of a compound that is produced by living organisms but can also be artificially synthesized.

Skill: Drawing molecular diagrams of glucose, ribose, a saturated fatty acid and a generalized amino acid.

Skill: Identification of biochemicals such as sugars, lipids or amino acids from molecular diagrams.

2.2 Water

Nature of science:

Use theories to explain natural phenomena - the theory that hydrogen bonds form between water molecules explains the properties of water.

Understandings:

Water molecules are polar and hydrogen bonds form between them.

Hydrogen bonding and dipolarity explain the cohesive, adhesive, thermal and solvent properties of water.

Substances can be hydrophilic or hydrophobic.

Applications and skills:

Application: Comparison of the thermal properties of water with those of methane.

Application: Use of water as a coolant in sweat.

Application: Modes of transport of glucose, amino acids, cholesterol, fats, oxygen and sodium chloride in blood in relation to their solubility in water.

2.3 Carbohydrates and lipids

Nature of science:

Evaluating claims - health claims made about lipids in diets need to be assessed.

Understandings:

Monosaccharide monomers are linked together by condensation reactions to form disaccharides and polysaccharide polymers.

Fatty acids can be saturated, monounsaturated or polyunsaturated.

Unsaturated fatty acids can be cis or trans isomers.

Triglycerides are formed by condensation from three fatty acids and one glycerol.

Applications and skills:

Application: Structure and function of cellulose and starch in plants and glycogen in humans.

Application: Scientific evidence for health risks of trans fats and saturated fatty acids.

Application: Lipids are more suitable for long-term energy storage in humans than carbohydrates.

Application: Evaluation of evidence and the methods used to obtain the evidence for health claims made about lipids.

Skill: Use of molecular visualization software to compare cellulose, starch and glycogen.

Skill: Determination of body mass index by calculation or use of a nomogram.

2.4 Proteins

Nature of science:

Looking for patterns, trends and discrepancies - most but not all organisms assemble proteins from the same amino acids.

Understandings:

Amino acids are linked together by condensation to form polypeptides.

There are 20 different amino acids in polypeptides synthesized on ribosomes.

Amino acids can be linked together in any sequence giving a huge range of possible polypeptides.

The amino acid sequence of polypeptides is coded for by genes.

A protein may consist of a single polypeptide or more than one polypeptide linked together.

The amino acid sequence determines the three-dimensional conformation of a protein.

Living organisms synthesize many different proteins with a wide range of functions.

Every individual has a unique proteome.

Applications and skills:

Application: Rubisco, insulin, immunoglobulins, rhodopsin, collagen and spider silk as examples of the range of protein functions.

Application: Denaturation of proteins by heat or by deviation of pH from the optimum.

Skill: Drawing molecular diagrams to show the formation of a peptide bond.

2.5 Enzymes

Nature of science:

Experimental design—accurate, quantitative measurements in enzyme experiments require replicates to ensure reliability.

Understandings:

Enzymes have an active site to which specific substrates bind.

Enzyme catalysis involves molecular motion and the collision of substrates with the active site.

Temperature, pH and substrate concentration affect the rate of activity of enzymes.

Enzymes can be denatured.

Immobilized enzymes are widely used in industry.

Applications and skills:

Application: Methods of production of lactose-free milk and its advantages.

Skill: Design of experiments to test the effect of temperature, pH and substrate concentration on the activity of enzymes.

Skill: Experimental investigation of a factor affecting enzyme activity. (Practical 3)

2.6 Structure of DNA and RNA

Nature of science:

Using models as representation of the real world - Crick and Watson used model making to discover the structure of DNA.

Understandings:

The nucleic acids DNA and RNA are polymers of nucleotides.

DNA differs from RNA in the number of strands present, the base composition and the type of pentose.

DNA is a double helix made of two antiparallel strands of nucleotides linked by hydrogen bonding between complementary base pairs.

Applications and skills:

Application: Crick and Watson’s elucidation of the structure of DNA using model making.

Skill: Drawing simple diagrams of the structure of single nucleotides of DNA and RNA, using circles, pentagons and rectangles to represent phosphates, pentoses and bases.

2.7 DNA replication, transcription and translation

Nature of science:

Obtaining evidence for scientific theories - Meselson and Stahl obtained evidence for the semi-conservative replication of DNA.

Understandings:

The replication of DNA is semi-conservative and depends on complementary base pairing.

Helicase unwinds the double helix and separates the two strands by breaking hydrogen bonds.

DNA polymerase links nucleotides together to form a new strand, using the pre-existing strand as a template.

Transcription is the synthesis of mRNA copied from the DNA base sequences by RNA polymerase.

Translation is the synthesis of polypeptides on ribosomes.

The amino acid sequence of polypeptides is determined by mRNA according to the genetic code.

Codons of three bases on mRNA correspond to one amino acid in a polypeptide.

Translation depends on complementary base pairing between codons on mRNA and anticodons on tRNA.

Applications and skills:

Application: Use of Taq DNA polymerase to produce multiple copies of DNA rapidly by the polymerase chain reaction (PCR).

Application: Production of human insulin in bacteria as an example of the universality of the genetic code allowing gene transfer between species.

Skill: Use a table of the genetic code to deduce which codon(s) corresponds to which amino acid.

Skill: Analysis of Meselson and Stahl's results to obtain support for the theory of semi-conservative replication of DNA.

Skill: Use a table of mRNA codons and their corresponding amino acids to deduce the sequence of amino acids coded by a short mRNA strand of known base sequence.

Skill: Deducing the DNA base sequence for the mRNA strand.

2.8 Cell respiration

Nature of science:

Assessing the ethics of scientific research - the use of invertebrates in respirometer experiments has ethical implications.

Understandings:

Cell respiration is the controlled release of energy from organic compounds to produce ATP.

ATP from cell respiration is immediately available as a source of energy in the cell.

Anaerobic cell respiration gives a small yield of ATP from glucose.

Aerobic cell respiration requires oxygen and gives a large yield of ATP from glucose.

Applications and skills:

Application: Use of anaerobic cell respiration in yeasts to produce ethanol and carbon dioxide in baking.

Application: Lactate production in humans when anaerobic respiration is used to maximize the power of muscle contractions.

Skill: Analysis of results from experiments involving measurement of respiration rates in germinating seeds or invertebrates using a respirometer.

2.9 Photosynthesis

Nature of science:

Experimental design—controlling relevant variables in photosynthesis experiments is essential.

Understandings:

Photosynthesis is the production of carbon compounds in cells using light energy.

Visible light has a range of wavelengths with violet the shortest wavelength and red the longest.

Chlorophyll absorbs red and blue light most effectively and reflects green light more than other colours.

Oxygen is produced in photosynthesis from the photolysis of water.

Energy is needed to produce carbohydrates and other carbon compounds from carbon dioxide.

Temperature, light intensity and carbon dioxide concentration are possible limiting factors on the rate of photosynthesis.

Applications and skills:

Application: Changes to the Earth's atmosphere, oceans and rock deposition due to photosynthesis.

Skill: Drawing an absorption spectrum for chlorophyll and an action spectrum for photosynthesis.

Skill: Design of experiments to investigate the effect of limiting factors on photosynthesis.

Skill: Separation of photosynthetic pigments by chromatograph. (Practical 4)

ATL Skills

Approaches to Learning

Thinking

- In this unit, we will
  - ask students to formulate a reasoned argument to support their opinion or conclusion
  - give students time to think through their answers before asking them for a response
  - reward a new personal understanding, solution or approach to an issue
  - ask open questions
  - set students a task which required higher-order thinking skills (such as analysis or evaluation)
  - build on a specific prior task
  - help students to make their thinking more visible (for example, by using a strategy such as a thinking routine)
  - require students to take an unfamiliar viewpoint into account when formulating arguments
  - ask questions that required the use of knowledge from a different subject from the one you are teaching
  - include a reflection activity
  - make a link to TOK

Social

- In this unit, we will
  - have students work in small groups
  - allocate, or ask students to allocate among themselves, different roles in a classroom discussion or activity
  - have students peer assess their group performance or process
  - support students in resolving a conflict in a team
  - give a group assessment task
  - give students feedback on how they worked as a group
  - have students discuss their understanding of a text or idea among themselves and come up with a shared understanding
  - provide an opportunity for students to analyse the impact of their behaviour on the class or on a group performance
  - encourage students to consider alternative points of view or to take the perspective of others
  - provide opportunities for students to make decisions

Developing IB Learners

Learner Profile

- Inquirers
- Knowledgeable
- Thinkers
- Balanced
- Reflective