**Topic 1b: Additional Higher Level Metabolism—Cell Respiration and Photosynthesis**

*Campbell Chapters 8,9 and 10*

*\*It is strongly recommended that you read and take column notes on all of chapters 8,9 and 10 in addition to answering the “Understandings” and “Sample Questions and Assessment Statements” below. For all other chapters, simply reading the suggested pages and doing any more work that you deem necessary will be enough.*

**Metabolism: Chapter 8**

**Essential Idea:** Metabolic reactions are regulated in response to the cell’s needs.

**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.

**Understandings:**

1. Metabolic pathways consists of chains and cycles of enzyme-catalyzed reactions. ***148-151; 157-159***
2. Enzymes lower the activation energy of the chemical reactions that they catalyze. ***151-155***
3. Enzyme inhibitors can be competitive or non-competitive. ***155-159***
4. Metabolic pathways can be controlled by end-product inhibition. ***157-159***

**Applications and Skills:**

• **Application:** End-product inhibition of the pathway that converts threonine to isoleucine. ***159***

• **Application:** Use of databases to identify potential new anti-malarial drugs. ***Online***

• **Skill:** Calculating and plotting rates of reaction from raw experimental results. ***Activity***

• **Skill:** Distinguishing different types of inhibition from graphs at specified substrate concentration. ***Online***

**Sample Questions and Assessment Statements:**

• State that metabolic pathways consist of chains and cycles of enzyme-catalysed reactions. ***151-159***

• Describe the induced-fit model. ***153-154***

• Explain that enzymes lower the activation energy of the chemical reactions that they catalyse. ***153***

• Explain the difference between competitive and non-competitive inhibition, with reference to one example of each. ***156***

• Explain the control of metabolic pathways by end-product inhibition, including the role of allosteric sites. ***157-159***

**Guidance:**

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

**TOK:**

• 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 ADH, has also been used for antifreeze poisoning.

**AIMS:**

• **Aim 6:** Experiments on enzyme inhibition can be performed.

• **Aim 7:** Computer simulations on enzyme action including metabolic inhibition are available.

**Cell Respiration: Chapter 9**

**Essential Idea:** Energy is converted to a usable form in cell respiration.

**Nature of Science:**

• Paradigm shift—the chemiosmotic theory led to a paradigm shift in the field of bioenergetics.

**Understandings:**

1. Cell respiration involves the oxidation and reduction of electron carriers. ***162-167***
2. Phosphorylation of molecules makes them less stable. ***149-151***
3. In glycolysis, glucose is converted to pyruvate in the cytoplasm. ***167-169***
4. Glycolysis gives a small net gain of ATP without the use of oxygen. ***167-169***
5. In aerobic cell respiration pyruvate is decarboxylated and oxidized, and converted into acetyl compound and attached to coenzyme A to form acetyl coenzyme A in the link reaction. ***170-172***
6. In the Krebs cycle, the oxidation of acetyl groups is coupled to the reduction of hydrogen carriers, liberating carbon dioxide. ***170-172***
7. Energy released by oxidation reactions is carried to the cristae of the mitochondria by reduced NAD and FAD. ***172-177***
8. Transfer of electrons between carriers in the electron transport chain in the membrane of the cristae is coupled to proton pumping. ***172-177***
9. In chemiosmosis protons diffuse through ATP synthase to generate ATP. ***172-177***
10. Oxygen is needed to bind with the free protons to maintain the hydrogen gradient, resulting in the formation of water. ***172-177***
11. The structure of the mitochondria is adapted to the function it performs. ***170-177***

**Application of Skills:**

• **Application:** Electron tomography used to produce images of active mitochondria. ***Online***

• **Skill:** Analysis of diagrams of the pathways of aerobic respiration to deduce where decarboxylation and oxidation reactions occur. ***170-177; Online***

• **Skill:** Annotation of a diagram of a mitochondrion to indicate the adaptations to its function. ***Online***

**Sample Questions and Assessment Statements:**

• State that oxidation involves the loss of electrons from an element, whereas reduction involves a gain of electrons; and that oxidation frequently involves gaining oxygen or losing hydrogen, whereas reduction frequently involves losing oxygen or gaining hydrogen. ***163-164***

• Outline the process of glycolysis, including phosphorylation, lysis, oxidation and ATP formation. ***167-169***

• Draw and label a diagram showing the structure of a mitochondrion as seen in electron micrographs. ***110; Online.***

• Explain aerobic respiration, including the link reaction, the Krebs cycle, the role of NADH+ H+, the electron transport chain and the role of oxygen. ***170-177***

• Explain oxidative phosphorylation in terms of chemiosmosis. ***173-175***

• Explain the relationship between the structure of the mitochondrion and its function. ***109-110***

• Analyze data relating to respiration. ***Online.***

**Guidance:**

• The names of the intermediate compounds in glycolysis and the Krebs cycle are not required.

**TOK:**

• Peter Mitchell’s chemiosmotic theory encountered years of opposition before it was finally accepted. For what reasons does falsification not always result in an immediate acceptance of new theories or a paradigm shift?

**Photosynthesis: Chapter 10**

**Essential Idea:** Light energy is converted into chemical energy.

**Nature of Science:**

• Developments in scientific research follow improvements in apparatus—sources of 14C and autoradiography enabled Calvin to elucidate the pathways of carbon fixation.

**Understandings:**

1. Light-dependent reactions take place in the intermembrane space of the thylakoids. ***185-189***
2. Light-independent reactions take place in the stroma. ***185-189***
3. Reduced NADP and ATP are produced in the light-dependent reactions. ***190-198***
4. Absorption of light by photosystems generates excited electrons. ***193-196***
5. Photolysis of water generates electrons for use in the light-dependent reactions. ***194-196***
6. Transfer of excited electrons occurs between carriers in thylakoid membranes. ***196-198***
7. Excited electrons from Photosystem II are used to contribute to generate a proton gradient. ***192-198***
8. ATP synthase in thylakoids generates ATP using the proton gradient. ***196-198***
9. Excited electrons from Photosystem I are used to reduce NADP. ***194-196***
10. In the light-independent reactions a carboxylase catalyzes the carboxylation of ribulose bisphosphate. ***198-199***
11. Glycerate 3-phosphate is reduced to triose phosphate using reduced NADP and ATP. ***198-199***
12. Triose phosphate is used to regenerate RuBP and produce carbohydrates. ***198-199***
13. Ribulose bisphosphate is reformed using ATP. ***198-199***
14. The structure of the chloroplast is adapted to its function in photosynthesis. ***196-198***

**Applications and Skills:**

• **Application:** Calvin’s experiment to elucidate the carboxylation of RuBP. ***Online***

• **Skill:** Annotation of a diagram to indicate the adaptations of a chloroplast to its function. ***Online***

**Sample Questions and Assessment Statements:**

• Draw and label a diagram showing the structure of a chloroplast as seen in electron micrographs. ***111; Online.***

• State that photosynthesis consists of light-dependent and light-independent reactions. ***192-195; 198-199***

• Explain the light-dependent reactions. ***194-195***

• Explain photophosphorylation in terms of chemiosmosis. ***196-197***

• Explain the light-independent reactions. ***198-199***

• Explain the relationship between the structure of the chloroplast and its function. ***110; 196-197***

• Explain the relationship between the action spectrum and the absorption spectrum of photosynthetic pigments in green plants. ***190-192***

• Explain the concept of limiting factors in photosynthesis, with reference to light intensity, temperature and concentration of carbon dioxide. ***This is an understanding question.***

• Analyze data relating to photosynthesis. ***Online.***

**TOK:**

• The lollipop experiment is used to work out the biochemical details of the Calvin cycle shows considerable creativity. To what extent is the creation of an elegant protocol similar to the creation of a work of art?

**Utilization:**

• The Global Artificial Photosynthesis (GAP) project aims to create an artificial “leaf” within the next decade. An electronic version of the leaf that creates oxygen and hydrogen from water and sunlight has already been invented and will be developed for use in the next decade.

**AIMS:**

**• Aim 6:** Hill’s method demonstrating electron transfer in chloroplasts by observing DCPIP reduction, immobilization of a culture of an alga such as *Scenedesmus* in alginate beads and measurement of the rate of photosynthesis by monitoring their effect on hydrogencarbonate indicator are all possible experiments.