**Subtopics:**

**2.1 Molecules to Metabolism**

**2.2 Water**

**2.3 Carbohydrates & Lipids**

**2.4 Proteins**

**2.5 Enzymes**

**Unit 2: Biochemistry**

***EQs:*** *What are the basic chemical principles that affect all living things? What are the structure and function of organic molecules that make up living things? What are the criteria that can be used to distinguish scientific claims from pseudoscientific claims? How do we decide between competing views?*

***Major Understandings, Applications & Skills (Study Guide):***

***Water (2.2)***

Proficient:

* Water molecules are polar and hydrogen bonds form between the Hydrogen bonding and dipolarity explain the cohesive, adhesive, thermal and solvent properties of water
* Substances can be hydrophilic or hydrophobic

Exceeds:

* 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.

***Molecules to Metabolism (2.1)***

Proficient:

* 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-catalyzed 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

Exceeds:

* Application: Urea is 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.

***Carbs & Lipids (2.3)***

Proficient:

* Monosaccharides monomers are linked together by condensation reactions to form disaccharides and polysaccharides 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

Exceeds:

* 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 nomogram.

***Proteins (2.4)***

Proficient:

* 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 of 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

Exceeds:

* 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.

***Enzymes (2.5)***

Proficient:

* Enzymes have an active site to which specific substrates bind
* Temperature, pH, and substrate concentration affect the rate of activity of enzymes
* Enzymes can be denatured
* Immobilized enzymes are widely used in industry

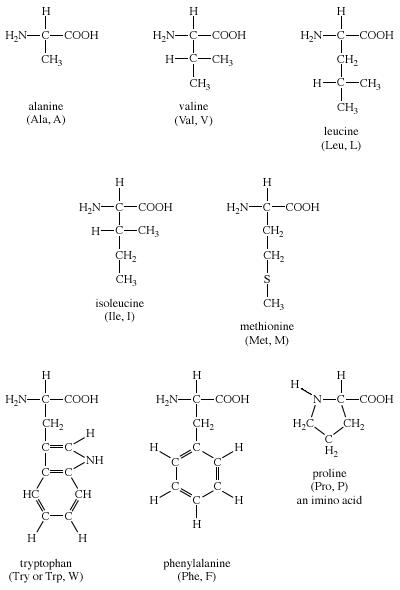
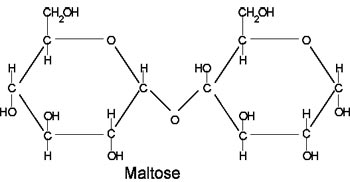
Exceeds:

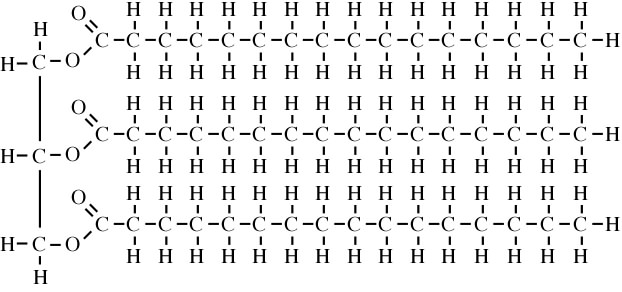
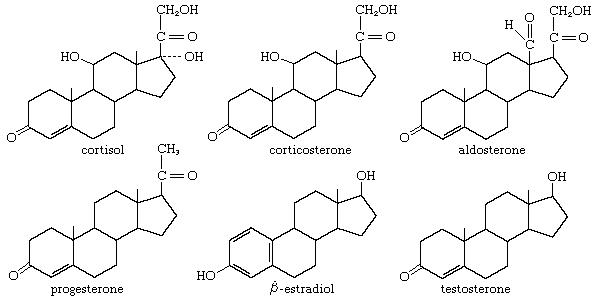
* Enzyme catalysis involves molecular motion and the collision of substrates with the active site
* Application: Methods of production of lactose-free milk and its advantages.
* Skill: Design of experiments to test the effect of temperature, pH and substrate concentration of the activity of enzymes (Practical 3)

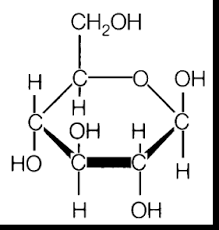
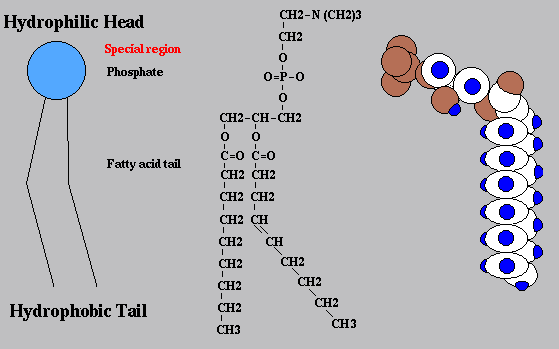
***Key Terms:***

* Molecular biology
* Urea
* Vitalism
* Carbon
* Methane
* Ethanol
* Ethanoic acid
* Covalent bond
* Hydrogen
* Oxygen
* Nitrogen
* Carbohydrates
* Lipids
* Proteins
* Nucleic acids
* Glucose
* Ribose
* Saturated fatty acids
* Amino acids
* Hydroxyl
* Amine
* Carboxyl
* Methyl
* Metabolism
* Anabolism
* Catabolism
* Monomers
* Polymers
* Hydrogen bonds
* Water
* Cohesive properties
* Adhesive properties
* Thermal properties
* High specific heat capacity
* High latent heat capacity
* High boiling point
* Solvent properties
* Triglycerides
* Monosaturated
* Polysaturated
* Cis-fatty acids
* Trans-fatty acids
* Condensation
* Polypeptides
* Ribosomes
* Gene
* Proteome
* Rubisco
* Insulin
* Immunoglobulins
* Rhodopsin
* Collagen
* Spider silk
* Denaturation
* pH
* Protein functions
* Enzymes
* Active site
* Substrate
* Temperature
* Substrate concentration
* Immobilized enzymes

**For Topic 2.1, you should be able to….**

1. Describe how urea can be produced:
   1. by living organisms
   2. artificially
2. Distinguish between organic and inorganic compounds.
3. Describe how the atomic structure of a carbon atom allows it to form a diversity of compounds.
4. Identify the 4 types of organic compounds found in living things and their monomers.
5. Draw the following molecular diagrams:
   1. Glucose (both alpha-D-glucose and beta-D-glucose)
   2. Ribose (D-ribose)
   3. An unnamed saturated fatty acid
   4. Generalized amino acid
6. Identify the following biochemical as carbohydrates, lipids or proteins (what characteristics do you look for to categorize them?):
   1.  b. 

c.  d. 

e.  f. 

1. Define *metabolism, catabolism* and *anabolism*.
2. Describe a specific example of the formation of a macromolecule from monomers by condensation reactions.
   1. For example: describe how amino acids can be joined together by condensation reactions to form polypeptides.
3. Describe a specific example of the hydrolysis of macromolecules into monomers (HINT: it is the reverse of #6!)

**For Topic 2.2, you should be able to….**

1. Draw the molecular structure of water. Label the atoms and the positive and negative ends.
2. Explain why water is a polar molecule and how this allows hydrogen bonds to form between water molecules.
3. Draw a diagram to show a hydrogen bond between two water molecules.
4. Explain what causes the following properties of water and describe one example of a specific benefit to living organisms for each:
   1. Cohesion
   2. Adhesion
   3. High specific heat capacity
   4. High latent heat of vaporization
   5. High boiling point
   6. Solvent abilities
5. Distinguish between hydrophilic and hydrophobic substances and name at least two specific examples of each.
6. Compare the thermal properties of water with those of methane.
   1. Are they polar or nonpolar? Can they form hydrogen bonds?
   2. Which one has a higher specific heat capacity? Higher latent heat of vaporization? Higher boiling point? Higher melting point?
7. Explain how water is used as a coolant in sweat.
8. Complete the following table to describe the modes of transport of certain substances in blood in relation to their solubility.

|  |  |  |  |
| --- | --- | --- | --- |
| **Substance** | **How soluble is it in water?** | **What causes its level of solubility? (Polar or nonpolar? Ion? Etc…)** | **How is it transported in blood?** |
| Glucose |  |  |  |
| Amino acids |  |  |  |
| Cholesterol |  |  |  |
| Fats |  |  |  |
| Oxygen |  |  |  |
| Sodium chloride |  |  |  |

**For Topic 2.3, you should be able to….**

1. Write a chemical equation or describe how the following disaccharides and polysaccharides are formed from monosaccharides:
   1. Sucrose
   2. Lactose
   3. Maltose
   4. Cellulose
   5. Starch (both amylose and amylopectin)
   6. Glycogen
2. Describe the molecular structure and function of cellulose and starch (both amylose and amylopectin) in plants and glycogen in humans. In other words:
   1. What monomers make up each polysaccharide?
   2. What is the overall shape of each polysaccharide?
   3. What is the function of each polysaccharide? How does its structure allow it to perform its function?
3. Explain how triglycerides are formed by condensation reactions from 3 fatty acids and 1 glycerol. You can describe it OR write a chemical equation.
4. Explain why lipids are more suitable for long term energy storage than carbohydrates.
5. Determine the body mass index (BMI) of the following individuals. Then classify them as underweight, normal weight, overweight or obese:
   1. A man with a mass of 80.0 kg and a height of 2.0 meters
   2. A woman with a mass of 93.5 kg and a height of 1.5 meters
   3. A man with a mass of 71.0 kg and a height of 1.7 meters
6. Distinguish between saturated, monounsaturated and polyunsaturated fatty acids. How is their molecular structure different?
7. Describe the structure of *cis* and *trans* isomers of unsaturated fatty acids. How do these differences in structure affect their properties?
8. Read “Health Risks of fats” on p.83 and “Evaluating the Health Risks of Foods” on p. 84.
   1. What evidence supports the claim that trans-fat and saturated fats are bad for your health?
   2. What evidence disputes this claim?
   3. What are some of the challenges in testing claims about food? What are some of the limitations?

**For Topic 2.4, you should be able to….**

1. Draw a molecular diagram to show how amino acids are linked together by condensation reactions to from polypeptides. Use two of the amino acids shown on page 88.
   1. Label the *peptide bond* in the newly formed dipeptide.
   2. Label the *amino terminal* and the *carboxyl terminal* ends of the dipeptide.
2. Compare and contrast the *general* structure of the 20 different amino acids.
   1. What identical features do all amino acids have?
   2. What is differs between the 20 different amino acids?
3. There are only 20 kinds of amino acids that most organisms use. Explain how 20 amino acids can produce such a wide range of polypeptides.
4. Describe the roles of genes and ribosomes in the formation of polypeptides.
5. Explain the relationship between polypeptides and proteins.
6. Distinguish between fibrous and globular proteins.
   1. How does the amino acid sequence determine if a protein is fibrous or globular?
7. Define *denaturation*.
   1. What happens when a protein becomes denatured?
   2. How can heat cause denaturation?
   3. How can extremes in pH cause denaturation?
8. Outline the functions of the following proteins (be specific!):
   1. Rubisco
   2. Insulin
   3. Immunoglobulin
   4. Rhodopsin
   5. Collagen
   6. Spider silk
9. Define proteome and explain why every individual’s proteome is unique (even for identical twins!)

**For Topic 2.5, you should be able to….**

1. Describe the major characteristics of enzymes. Make sure to include:
   1. The type of macromolecule that enzymes are
   2. Whether they are globular or fibrous
   3. Their role in organisms
   4. Enzyme-substrate specificity
   5. The general structure of enzymes (particularly the active site)
2. Explain HOW an enzyme catalyzes a reaction. Make sure to include the role of activation energy, molecular motion and the collision of substrates with the active site.
3. Sketch a graph to show how each of the following variables affect the rate of enzyme activity:
   1. Temperature
   2. pH
   3. Substrate concentration
4. Explain the patterns or trends in each of the graphs in #3. You can write your explanation directly under each graph if you want!
5. Explain what happens when enzymes are denatured.
6. Explain HOW enzymes can be immobilized for use in industry.
   1. What are the advantages of using immobilized enzymes in industry?
7. Describe the causes and symptoms of lactose-intolerance. Make sure to include the role of the enzyme lactase!
8. Describe how lactose-free milk can be produced and why this is beneficial for many people.