AP BIOLOGY

UNIT 1

Chemistry of Life

8–11%
AP EXAM WEIGHTING

~9–11
CLASS PERIODS

Remember to go to **AP Classroom** to assign students the online **Progress Checks** for this unit.

Whether assigned as homework or completed in class, the **Progress Checks** provide each student with immediate feedback related to this unit's topic and skills.

Progress Check 1

Multiple-choice: ~24 questions
Free-response: 2 questions

- Conceptual Analysis (partial)
- Analyze Model or Visual Representation (partial)

UNIT 1

8–11% AP EXAM WEIGHTING | ~9–11 CLASS PERIODS

Chemistry of Life

BIG IDEA 2
Energetics
- What is the role of energy in the making and breaking of polymers?

BIG IDEA 3
Information Storage and Transmission
- How do living systems transmit information in order to ensure their survival?

BIG IDEA 4
Systems Interactions
- How would living systems function without the polarity of the water molecule?

Developing Understanding

This first unit sets the foundation for students to understand the chemical basis of life, which is needed for mastery of future areas of focus and provides students with a survey of the elements necessary for carbon-based systems to function. Students learn that water and the properties of water play a vital role in the survival of individuals and biological systems. They also learn that living systems exist in a highly complex organization that requires input of energy and the exchange of macromolecules. This unit also addresses in detail how and in what conformations molecules called monomers bond together to form polymers. The structure of monomers and polymers determines their function. In the units that follow, students will need to understand and explain the interaction and bonding of atoms to form molecules.

Building Science Practices

1.A 2.A 6.E

The ability to describe biological processes, principles, and concepts is central to the study of biology. Visual representations and models are important tools to help students understand relationships within biological systems. In this unit the successful student should use visual representations to demonstrate understanding of how the properties of water allow it to play a major role in biological systems and to show the properties and structure of biological macromolecules.

In biology, an argument involves making a claim, supporting it with evidence, and providing reasoning to support the claim. Beginning in this unit and throughout the course, students should become proficient in argumentation by predicting the causes or effects of a change in, or disruption to, one or more components in a biological system. The instructional focus of this unit should be on describing the structure and function of biological macromolecules and describing the relationship between structure and function.

Preparing for the AP Exam

The AP Biology Exam requires students to make predictions and justify their reasoning in real-world scenarios. Students are expected to interpret and evaluate experimental results, analyze biological concepts and scientific investigations, and perform data analysis and statistical testing.

A foundational concept for students to understand is that biological systems depend on relationships that, when compromised, can have far-reaching consequences within the system. These consequences can sometimes be deleterious for cells, organisms, and even ecosystems. This understanding will help students make and justify predictions about how the changes in a biological system affect its function.

On the exam, students tend to struggle with the use of language and similar terms, for example, protein versus proton. This confusion often results in a failure to earn points on free-response questions. Hold students accountable for the proper use of appropriate terms throughout the course.

UNIT AT A GLANCE

Topic	Suggested Skill	Class Periods ~9-11 CLASS PERIODS
1.1 Structure of Water and Hydrogen Bonding	2.A Describe characteristics of visual representations of biological concepts and processes.	
1.2 Elements of Life	2.A Describe characteristics of visual representations of biological concepts and processes.	
1.3 Introduction to Macromolecules	2.A Describe characteristics of visual representations of biological concepts and processes.	
1.4 Carbohydrates	1.A Describe biological concepts and processes.	
1.5 Lipids	6.E Predict the causes or effects of a change in, or disruption to, one or more components in a biological system.	
1.6 Nucleic Acids	2.A Describe characteristics of visual representations of biological concepts and processes.	
1.7 Proteins	6.E Predict the causes or effects of a change in, or disruption to, one or more components in a biological system.	
Go to **AP Classroom** to assign the **Progress Check** for Unit 1. Review the results in class to identify and address any student misunderstandings.		

SAMPLE INSTRUCTIONAL ACTIVITIES

The sample activities on this page are optional ways to incorporate varied instructional approaches in the teaching of this course. You do not need to use these activities or instructional approaches and are encouraged to adapt the activities to best support students in your classroom. The following examples were developed in partnership with teachers from the AP community to share ways that they approach teaching some of the topics in this unit. Please refer to the Instructional Approaches section beginning on p. 171 for more examples of activities and strategies.

Activity	Topic	Sample Activity
1	1.1	**Graph and Switch** Have students determine how many drops of water can fit onto a penny. They can add various substances (e.g., salt, sugar, vinegar, dish detergent) to the water to investigate how the surface tension of the water is affected. Ask students to graph their data and calculate descriptive statistics. Finally, students should switch graphs with a peer to compare and discuss findings.
2	1.1 1.3	**Index Card Summaries/Questions** Have students use diagrams of water, glucose, amino acids, nucleotides, glycerol, and fatty acids to learn how dehydration synthesis builds molecules. Find the diagrams online and print the templates on colored paper so that students can easily differentiate water from the various monomers in order to visualize the formation of the covalent bonds. Then, ask students to respond to each diagram, using index cards to summarize their understanding or ask any outstanding questions.
3	1.4 1.5 1.6 1.7	**Think-Pair-Share** Distribute cards containing pictures of biological molecules to students and ask them to find patterns in the molecules. They should identify the building blocks, functional groups, and monomers and mark them on each card, and then organize the cards based on similarities in their structures. After students mark up the molecules on their set of cards, have them pair up with another student and identify each of the molecules on the cards with their classmate.

SUGGESTED SKILL

Visual Representations

2.A

Describe characteristics of visual representations of biological concepts and processes.

TOPIC 1.1
Structure of Water and Hydrogen Bonding

Required Course Content

BIG IDEA 4

Systems Interactions: Biological systems interact, and these systems and their interactions exhibit complex properties.

LEARNING OBJECTIVE

1.1.A

Explain how the properties of water that result from its polarity and hydrogen bonding affect its biological function.

ESSENTIAL KNOWLEDGE

1.1.A.1

Living systems depend on the properties of water to sustain life.

i. Water has polarity, because of the formation of polar covalent bonds between hydrogen and oxygen within water molecules. This polarity contributes to hydrogen bonding between and within biological molecules.

ii. Water has a high specific heat capacity, which allows for the maintenance of homeostatic body temperature within living organisms.

iii. Water has a high heat of vaporization, which allows for the evaporative cooling of the surrounding environment. In living organisms, this property allows for body temperature to be maintained.

1.1.A.2

The hydrogen bonds between adjacent polar water molecules result in cohesion, adhesion, and surface tension.

TOPIC 1.2
Elements of Life

SUGGESTED SKILL

Visual Representations

2.A

Describe characteristics of visual representations of biological concepts and processes.

Required Course Content

BIG IDEA 2

Energetics: Biological systems use energy and molecular building blocks to grow, reproduce, and maintain dynamic homeostasis.

LEARNING OBJECTIVE

1.2.A

Describe the composition of macromolecules required by living organisms.

ESSENTIAL KNOWLEDGE

1.2.A.1

Atoms and molecules from the environment are necessary to build new molecules. Carbon, hydrogen, and oxygen are the most prevalent elements used to build biological molecules such as carbohydrates, proteins, lipids, and nucleic acids. Additionally:

i. Sulfur is used in the building of proteins.

ii. Phosphorus is used in the building of phospholipids (a type of lipid) and nucleic acids.

iii. Nitrogen is used in the building of nucleic acids.

SUGGESTED SKILL

Visual Representations

2.A

Describe characteristics of visual representations of biological concepts and processes.

AVAILABLE RESOURCE

- AP Central > Classroom Resources > Visualizing Information

TOPIC 1.3
Introduction to Macromolecules

Required Course Content

BIG IDEA 4

Systems Interactions: Biological systems interact, and these systems and their interactions exhibit complex properties.

LEARNING OBJECTIVE

1.3.A

Describe the chemical reactions that build and break biological macromolecules.

ESSENTIAL KNOWLEDGE

1.3.A.1

Hydrolysis is a chemical reaction involving the cleaving of covalent bonds. This type of reaction breaks down molecules into smaller molecules. When water is added to the bond between monomers in a polymer, the bond is broken. The hydrogen ion from a water molecule is added to one monomer and the hydroxyl group of the water molecule is added to the other monomer, completing the reaction.

1.3.A.2

Dehydration synthesis occurs when two smaller molecules are joined together through covalent bonding. A hydrogen ion is removed from one monomer and a hydroxyl group is removed from the other. This causes the loss of the equivalent of a water molecule from the reactants and the connection of the two remaining monomers. The connection of many monomers is known as polymerization.

TOPIC 1.4
Carbohydrates

SUGGESTED SKILL

Concept Explanation

1.A

Describe biological concepts and processes.

Required Course Content

BIG IDEA 4

Systems Interactions: Biological systems interact, and these systems and their interactions exhibit complex properties.

LEARNING OBJECTIVE

1.4.A

Describe the structure and function of carbohydrates.

ESSENTIAL KNOWLEDGE

1.4.A.1

Monosaccharides (simple sugars) are the monomers for polysaccharides (complex carbohydrates). These monomers are connected by covalent bonds to form polymers such as complex carbohydrates, which may be linear or branched.

EXCLUSION STATEMENT—*The molecular structure of specific carbohydrate polymers is beyond the scope of the AP Exam.*

ILLUSTRATIVE EXAMPLES

EK 1.4.A.1

- Cellulose
- Starch
- Glycogen

SUGGESTED SKILL

Argumentation

6.E

Predict the causes or effects of a change in, or disruption to, one or more components in a biological system.

TOPIC 1.5
Lipids

Required Course Content

BIG IDEA 4

Systems Interactions: Biological systems interact, and these systems and their interactions exhibit complex properties.

LEARNING OBJECTIVE

1.5.A

Describe the structure and function of lipids.

ESSENTIAL KNOWLEDGE

1.5.A.1

Lipids are typically nonpolar, hydrophobic molecules whose structure and function are derived from the way their subcomponents are assembled. Fatty acids can be described as either saturated or unsaturated.

i. Saturated fatty acids contain only single bonds between carbon atoms.

ii. Unsaturated fatty acids contain at least one double bond between carbon atoms, which causes the carbon chain to kink.

iii. The more double bonds in a fatty acid tail, the more unsaturated the lipid becomes.

iv. The more unsaturated a lipid is, the more liquid it is at room temperature.

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LEARNING OBJECTIVE

1.5.A

Describe the structure and function of lipids.

ESSENTIAL KNOWLEDGE

1.5.A.2

Lipids provide a variety of functions for living organisms. Some examples of lipids are fats, steroids including cholesterol, and phospholipids.

i. Fats provide energy storage and support cell function. In some cases, they can also provide insulation to help keep mammals warm.

ii. Steroids are hormones that support physiological functions including growth and development, energy metabolism, and homeostasis.

iii. Cholesterol provides essential structural stability to animal cell membranes.

iv. Phospholipids group together to form the lipid bilayers found in plasma and cell membranes.

EXCLUSION STATEMENT—*The molecular structure of specific lipids is beyond the scope of the AP Exam.*

SUGGESTED SKILL

Visual Representations

2.A

Describe characteristics of visual representations of biological concepts and processes.

TOPIC 1.6
Nucleic Acids

Required Course Content

BIG IDEA 3

Information Storage and Transmission: Living systems store, retrieve, transmit, and respond to information essential to life processes.

LEARNING OBJECTIVE

1.6.A

Describe the structure and function of DNA and RNA.

ESSENTIAL KNOWLEDGE

1.6.A.1

In nucleic acids (DNA and RNA), biological information is encoded in sequences of nucleotide monomers. Each nucleotide has the following structural components: a five-carbon sugar (deoxyribose or ribose), a phosphate, and a nitrogenous base (adenine, thymine, guanine, cytosine, or uracil).

1.6.A.2

Nucleic acids have a linear sequence of nucleotides that have ends, defined by the 3′ (three prime) hydroxyl and 5′ (five prime) phosphates of the sugar in the nucleotide. During nucleic acid synthesis, nucleotides are added to the 3′ end of the growing strand, resulting in the formation of covalent bonds between nucleotides.

EXCLUSION STATEMENT—*The molecular structure of specific nucleotides is beyond the scope of the AP Exam.*

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LEARNING OBJECTIVE

1.6.A

Describe the structure and function of DNA and RNA.

ESSENTIAL KNOWLEDGE

1.6.A.3

DNA is structured as an antiparallel double helix, with two strands of nucleotides running in opposite 5′ to 3′ orientation. In DNA, adenine nucleotides pair with thymine nucleotides via hydrogen bonds (A-T), and cytosine nucleotides pair with guanine nucleotides via hydrogen bonds (C-G). In RNA, adenine pairs with uracil (A-U).

1.6.A.4

Structural differences between DNA and RNA include:

i. DNA contains the sugar deoxyribose, and RNA contains the sugar ribose.

ii. DNA contains the nitrogenous base thymine, and RNA contains the nitrogenous base uracil.

iii. DNA is typically double stranded, while RNA is typically single stranded.

SUGGESTED SKILL

Argumentation

6.E

Predict the causes or effects of a change in, or disruption to, one or more components in a biological system.

TOPIC 1.7
Proteins

Required Course Content

BIG IDEA 3

Information Storage and Transmission: Living systems store, retrieve, transmit, and respond to information essential to life processes.

LEARNING OBJECTIVE

1.7.A

Describe the structure and function of proteins.

ESSENTIAL KNOWLEDGE

1.7.A.1

Proteins comprise linear chains of amino acids connected by the formation of covalent (peptide) bonds that form between a carboxyl group (–COOH) of one amino acid and an amine group ($-NH_2$) of the next amino acid, resulting in a growing peptide chain.

1.7.A.2

Amino acids are composed of a central carbon atom with a hydrogen atom, a carboxyl group, an amine group, and a variable R group covalently bound to it. The R group of an amino acid can be categorized by three possible chemical properties: hydrophobic/nonpolar, hydrophilic/polar, or ionic. The interactions of these R groups determine the structure and function of that region of the protein.

1.7.A.3

The specific sequence of amino acids in proteins determines the primary structure of a polypeptide as well as the overall shape of the protein.

EXCLUSION STATEMENT— *The molecular structure of amino acids is beyond the scope of the AP Exam.*

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LEARNING OBJECTIVE

1.7.A

Describe the structure and function of proteins.

ESSENTIAL KNOWLEDGE

1.7.A.4

Secondary structures of proteins are made through the local folding that forms from interactions between atoms of the polypeptide backbone of the amino acid chain. Hydrogen bonding forms shapes such as alpha-helices and beta-pleated sheets.

1.7.A.5

The three-dimensional shape of the tertiary structure of a protein results from the formation of hydrogen bonds, hydrophobic interactions, ionic interactions, or disulfide bridges.

1.7.A.6

The quaternary structure arises from interactions between multiple polypeptides. All four levels of a protein structure determine the function of a protein.