AP BIOLOGY

UNIT 1

Chemistry of Life

8–11%
AP EXAM WEIGHTING

~5–7
CLASS PERIODS

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

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

Personal Progress Check 1

Multiple-choice: ~20 questions
Free-response: 2 questions

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

UNIT 1

8–11% AP EXAM WEIGHTING | ~5–7 CLASS PERIODS

Chemistry of Life

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

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

BIG IDEA 4
Systems Interactions SYI
- 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.b

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. Teachers should hold students accountable for the proper use of appropriate terms throughout the course.

UNIT AT A GLANCE

Enduring Understanding	Topic	Suggested Skill	Class Periods ~5–7 CLASS PERIODS
SYI-1	**1.1 Structure of Water and Hydrogen Bonding**	2.A Describe characteristics of a biological concept, process, or model represented visually.	
ENE-1	**1.2 Elements of Life**	2.A Describe characteristics of a biological concept, process, or model represented visually.	
SYI-1	**1.3 Introduction to Biological Macromolecules**	2.A Describe characteristics of a biological concept, process, or model represented visually.	
	1.4 Properties of Biological Macromolecules	1.A Describe biological concepts and/or processes.	
	1.5 Structure and Function of Biological Macromolecules	6.E.b Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on a visual representation of a biological concept, process, or model.	
IST-1	**1.6 Nucleic Acids**	2.A Describe characteristics of a biological concept, process, or model represented visually.	

Go to **AP Classroom** to assign the **Personal 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 intended to give you ideas of 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 free to alter or edit them in any way you choose. 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** Students determine how many drops of water can fit onto a penny. Various substances (e.g., salt, sugar, vinegar) can be added to the water to determine how the surface tension of the water is affected. Students then graph their data and calculate descriptive statistics.
2	1.3	**Index Card Summaries/Questions** Students use diagrams (found online) of water drops, glucose, amino acids, nucleotides, glycerol, and fatty acids to learn how dehydration synthesis builds molecules. The templates can be printed on colored paper so that students can easily differentiate water from the various monomers in order to visualize the formation of the covalent bonds.
3	1.4	**Think-Pair-Share** Students use cards containing pictures of biological molecules to find patterns in the molecules. Functional groups are identified and marked on each card, and then the cards are organized based on similarities in their structure. Students then learn about the properties of the molecules, and the students identify each of the molecules on the cards.

Unit Planning Notes

Use the space below to plan your approach to the unit. Consider how you want to pace your course and your methods of instruction and assessment.

SUGGESTED SKILL

Visual Representations

2.A

Describe characteristics of a biological concept, process, or model represented visually.

TOPIC 1.1
Structure of Water and Hydrogen Bonding

Required Course Content

ENDURING UNDERSTANDING

SYI-1

Living systems are organized in a hierarchy of structural levels that interact.

LEARNING OBJECTIVE

SYI-1.A

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

ESSENTIAL KNOWLEDGE

SYI-1.A.1

The subcomponents of biological molecules and their sequence determine the properties of that molecule.

SYI-1.A.2

Living systems depend on properties of water that result from its polarity and hydrogen bonding.

SYI-1.A.3

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

TOPIC 1.2
Elements of Life

SUGGESTED SKILL

Visual Representations

2.A

Describe characteristics of a biological concept, process, or model represented visually.

Required Course Content

ENDURING UNDERSTANDING

ENE-1

The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.

LEARNING OBJECTIVE

ENE-1.A

Describe the composition of macromolecules required by living organisms.

ESSENTIAL KNOWLEDGE

ENE-1.A.1

Organisms must exchange matter with the environment to grow, reproduce, and maintain organization.

ENE-1.A.2

Atoms and molecules from the environment are necessary to build new molecules—

a. Carbon is used to build biological molecules such as carbohydrates, proteins, lipids, and nucleic acids. Carbon is used in storage compounds and cell formation in all organisms.

b. Nitrogen is used to build proteins and nucleic acids. Phosphorus is used to build nucleic acids and certain lipids.

SUGGESTED SKILL

Visual Representations

2.A

Describe characteristics of a biological concept, process, or model represented visually.

AVAILABLE RESOURCES

- Classroom Resources > **Visualizing Information**

TOPIC 1.3
Introduction to Biological Macromolecules

Required Course Content

ENDURING UNDERSTANDING

SYI-1

Living systems are organized in a hierarchy of structural levels that interact.

LEARNING OBJECTIVE

SYI-1.B

Describe the properties of the monomers and the type of bonds that connect the monomers in biological macromolecules.

ESSENTIAL KNOWLEDGE

SYI-1.B.1

Hydrolysis and dehydration synthesis are used to cleave and form covalent bonds between monomers.

- **EXCLUSION STATEMENT**—*The molecular structure of specific nucleotides and amino acids is beyond the scope of the AP Exam.*
- **EXCLUSION STATEMENT**—*The molecular structure of specific carbohydrate polymers is beyond the scope of the AP Exam.*

TOPIC 1.4
Properties of Biological Macromolecules

Required Course Content

ENDURING UNDERSTANDING

SYI-1

Living systems are organized in a hierarchy of structural levels that interact.

LEARNING OBJECTIVE

SYI-1.B

Describe the properties of the monomers and the type of bonds that connect the monomers in biological macromolecules.

ESSENTIAL KNOWLEDGE

SYI-1.B.2

Structure and function of polymers are derived from the way their monomers are assembled—

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

b. In proteins, the specific order of amino acids in a polypeptide (primary structure) determines the overall shape of the protein. Amino acids have directionality, with an amino (NH_2) terminus and a carboxyl (COOH) terminus. The R group of an amino acid can be categorized by chemical properties (hydrophobic, hydrophilic, or ionic), and the interactions of these R groups determine structure and function of that region of the protein.

c. Complex carbohydrates comprise sugar monomers whose structures determine the properties and functions of the molecules.

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SUGGESTED SKILL

Concept Explanation

1.A

Describe biological concepts and/or processes.

AVAILABLE RESOURCES

- Classroom Resources > Visualizing Information

LEARNING OBJECTIVE

SYI-1.B

Describe the properties of the monomers and the type of bonds that connect the monomers in biological macromolecules.

ESSENTIAL KNOWLEDGE

d. Lipids are nonpolar macromolecules—

i. Differences in saturation determine the structure and function of lipids.

ii. Phospholipids contain polar regions that interact with other polar molecules, such as water, and with nonpolar regions that are often hydrophobic.

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

TOPIC 1.5
Structure and Function of Biological Macromolecules

Required Course Content

ENDURING UNDERSTANDING

SYI-1

Living systems are organized in a hierarchy of structural levels that interact.

LEARNING OBJECTIVE

SYI-1.C

Explain how a change in the subunits of a polymer may lead to changes in structure or function of the macromolecule.

ESSENTIAL KNOWLEDGE

SYI-1.C.1

Directionality of the subcomponents influences structure and function of the polymer—

a. Nucleic acids have a linear sequence of nucleotides that have ends, defined by the 3′ hydroxyl and 5′ phosphates of the sugar in the nucleotide. During DNA and RNA synthesis, nucleotides are added to the 3′ end of the growing strand, resulting in the formation of a covalent bond between nucleotides.

b. DNA is structured as an antiparallel double helix, with each strand running in opposite 5′ to 3′ orientation. Adenine nucleotides pair with thymine nucleotides via two hydrogen bonds. Cytosine nucleotides pair with guanine nucleotides by three hydrogen bonds.

c. Proteins comprise linear chains of amino acids, connected by the formation of covalent bonds at the carboxyl terminus of the growing peptide chain.

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SUGGESTED SKILL

Argumentation

6.E.b

Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on a visual representation of a biological concept, process, or model.

ILLUSTRATIVE EXAMPLE

- Cellulose versus starch versus glycogen

LEARNING OBJECTIVE

SYI-1.C

Explain how a change in the subunits of a polymer may lead to changes in structure or function of the macromolecule.

ESSENTIAL KNOWLEDGE

d. Proteins have primary structure determined by the sequence order of their constituent amino acids, secondary structure that arises through local folding of the amino acid chain into elements such as alpha-helices and beta-sheets, tertiary structure that is the overall three-dimensional shape of the protein and often minimizes free energy, and quaternary structure that arises from interactions between multiple polypeptide units. The four elements of protein structure determine the function of a protein.

e. Carbohydrates comprise linear chains of sugar monomers connected by covalent bonds. Carbohydrate polymers may be linear or branched.

TOPIC 1.6
Nucleic Acids

SUGGESTED SKILL

Visual Representations

2.A

Describe characteristics of a biological concept, process, or model represented visually.

Required Course Content

ENDURING UNDERSTANDING

IST-1

Heritable information provides for continuity of life.

LEARNING OBJECTIVE

IST-1.A

Describe the structural similarities and differences between DNA and RNA.

ESSENTIAL KNOWLEDGE

IST-1.A.1

DNA and RNA molecules have structural similarities and differences related to their function—

a. Both DNA and RNA have three components—sugar, a phosphate group, and a nitrogenous base—that form nucleotide units that are connected by covalent bonds to form a linear molecule with 5′ and 3′ ends, with the nitrogenous bases perpendicular to the sugar-phosphate backbone.
b. The basic structural differences between DNA and RNA include the following:
    i. DNA contains deoxyribose and RNA contains ribose.
    ii. RNA contains uracil and DNA contains thymine.
    iii. DNA is usually double stranded; RNA is usually single stranded.
    iv. The two DNA strands in double-stranded DNA are antiparallel in directionality.