

BRIGHT SCHOLARS

BIOLOGY SERIES • BOOK 2

CORE

BIOLOGY

BOOK 2 Grades 10–11

A Complete Practice Workbook for Biochemistry, Cell Energy, Molecular
Genetics, Heredity, Evolution, and Ecology

Learn it. Practice it. Prove it.

BIOCHEMISTRY • CELL ENERGY • DNA • GENETICS • EVOLUTION • ECOLOGY

THIS BOOK BELONGS TO

Name _____

Class / Period _____

Teacher _____

School Year _____

Contents

GETTING STARTED

How to Use This Workbook	5
Standards Alignment	6
18-Week Pacing Guide	7
Biology Skills Tracker	8
Vocabulary Tracker.....	9
Study Tips for Biology.....	10

UNITS

1	Biochemistry and Enzymes	11
1.1	Biological Macromolecules.....	12
1.2	Enzyme Structure and Function	13
1.3	Factors Affecting Enzyme Activity.....	15
2	Cell Membrane and Transport	28
2.1	Membrane Structure: The Fluid Mosaic Model	29
2.2	Passive Transport: Diffusion and Osmosis	30
2.3	Active Transport and Bulk Transport.....	32
3	Cellular Respiration	43
3.1	Glycolysis and Fermentation	44
3.2	Pyruvate Oxidation and the Krebs Cycle	45
3.3	The Electron Transport Chain and Chemiosmosis	47
4	Photosynthesis.....	60
4.1	Chloroplasts and the Light Reactions.....	61
4.2	The Calvin Cycle	63
4.3	Factors Affecting Photosynthesis.....	64
☒	Mid-Book Exam	76
5	DNA Structure, Replication, and Repair.....	85
5.1	DNA Structure	86
5.2	DNA Replication.....	87
5.3	DNA Damage and Repair	89
6	Protein Synthesis.....	100
6.1	Transcription and RNA Processing	101
6.2	Translation.....	102
6.3	The Genetic Code and Mutations.....	104
B	Cell Division: Mitosis and Meiosis	116

Protein Synthesis

? BIG QUESTION

Every cell in your body carries the same DNA, yet a muscle cell and a nerve cell make different proteins. How does a cell turn a gene into a working protein?

BY THE END OF THIS UNIT, I CAN

- ☐ state the central dogma and compare DNA, mRNA, tRNA, and rRNA.
- ☐ transcribe a DNA template strand into mRNA and describe RNA processing in eukaryotes.
- ☐ use a codon chart to translate mRNA into a sequence of amino acids.
- ☐ describe the roles of tRNA, ribosomes, and the A, P, and E sites in translation.
- ☐ classify mutations as silent, missense, nonsense, or frameshift and predict their effects.

UNIT ROADMAP

- 6.1 Transcription and RNA Processing p. 101
- 6.2 Translation..... p. 102
- 6.3 The Genetic Code and Mutations..... p. 104
- B.1 The Cell Cycle and Mitosis p. 117
- B.2 Meiosis and Genetic Variation p. 118

Suggested time: 1–2 weeks

Standards: HS-LS1-1; HS-LS3-1; SEP 2, 6

KEY VOCABULARY

central dogma transcription RNA polymerase

promoter template strand coding strand

intron exon splicing 5' cap poly-A tail

codon anticodon tRNA ribosome

translation silent mutation

missense mutation nonsense mutation

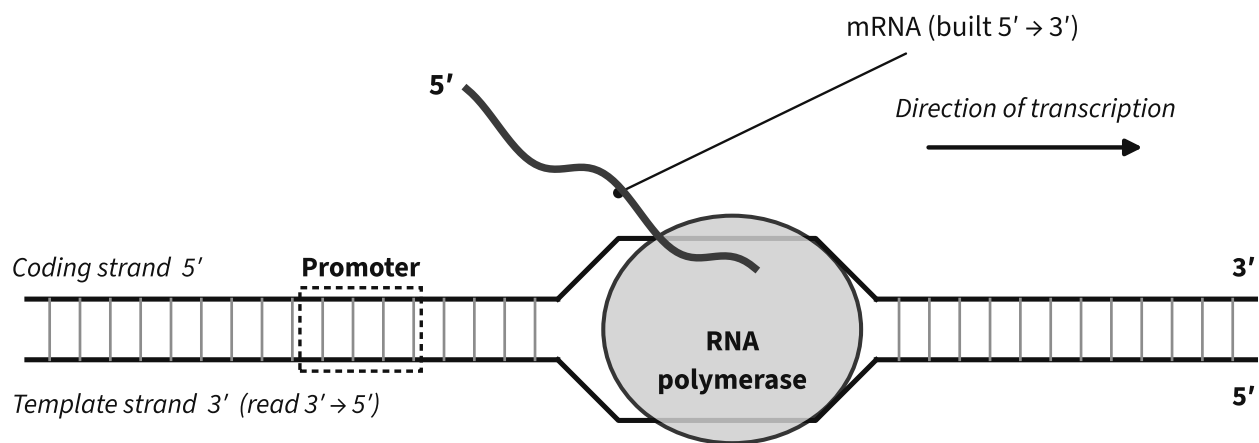
frameshift mutation

Transcription and RNA Processing

KEY TERMS central dogma • transcription • RNA polymerase • promoter • template strand • coding strand • pre-mRNA • 5' cap • poly-A tail • intron • exon • splicing

Genes are instructions for making proteins, and proteins do most of the work of a cell. Information flows from **DNA → RNA → protein**, a pattern called the **central dogma** of molecular biology. The first step, copying a gene into RNA, is **transcription**. The second, using the RNA to build a protein, is **translation**.

RNA differs from DNA in three ways: it contains the sugar **ribose** instead of deoxyribose, it uses **uracil (U)** in place of thymine, and it is usually single-stranded. Cells make three main kinds of RNA: **messenger RNA (mRNA)** carries a gene's instructions to the ribosome; **transfer RNA (tRNA)** brings amino acids; **ribosomal RNA (rRNA)** forms the core of ribosomes and catalyzes peptide bonds.



Mature eukaryotic mRNA: 5' cap + exons (introns spliced out) + poly-A tail

FIGURE 6.1 Transcription. RNA polymerase binds the promoter, unwinds the DNA, and builds mRNA 5' → 3' using the template strand. The mRNA matches the coding strand, with U in place of T.

Transcription begins when **RNA polymerase** binds a **promoter**, a DNA sequence just before the gene; in eukaryotes, many promoters contain a "TATA box" recognized by helper proteins. RNA polymerase unwinds a short section of DNA and reads one strand, the **template strand**, building a complementary RNA in the 5' → 3' direction. RNA polymerase, unlike DNA polymerase, needs no primer. The other DNA strand, the **coding strand**, has the same sequence as the mRNA except that it has T where the RNA has U. At the end of the gene, a terminator sequence signals RNA polymerase to release the RNA.

In prokaryotes, the mRNA is ready at once, and ribosomes can begin translating it before transcription is even finished. In eukaryotes, transcription happens in the nucleus and the first product, **pre-mRNA**, is processed before it leaves: 1. A **5' cap** (a modified guanine) is added to the front end; it helps ribosomes attach and

THE GENETIC CODE (MRNA CODONS)

First base	Second base U	Second base C	Second base A	Second base G
U	UUU Phe UUC Phe UUA Leu UUG Leu	UCU Ser UCC Ser UCA Ser UCG Ser	UAU Tyr UAC Tyr UAA Stop UAG Stop	UGU Cys UGC Cys UGA Stop UGG Trp
C	CUU Leu CUC Leu CUA Leu CUG Leu	CCU Pro CCC Pro CCA Pro CCG Pro	CAU His CAC His CAA Gln CAG Gln	CGU Arg CGC Arg CGA Arg CGG Arg
A	AUU Ile AUC Ile AUA Ile AUG Met (Start)	ACU Thr ACC Thr ACA Thr ACG Thr	AAU Asn AAC Asn AAA Lys AAG Lys	AGU Ser AGC Ser AGA Arg AGG Arg
G	GUU Val GUC Val GUA Val GUG Val	GCU Ala GCC Ala GCA Ala GCG Ala	GAU Asp GAC Asp GAA Glu GAG Glu	GGU Gly GGC Gly GGA Gly GGG Gly

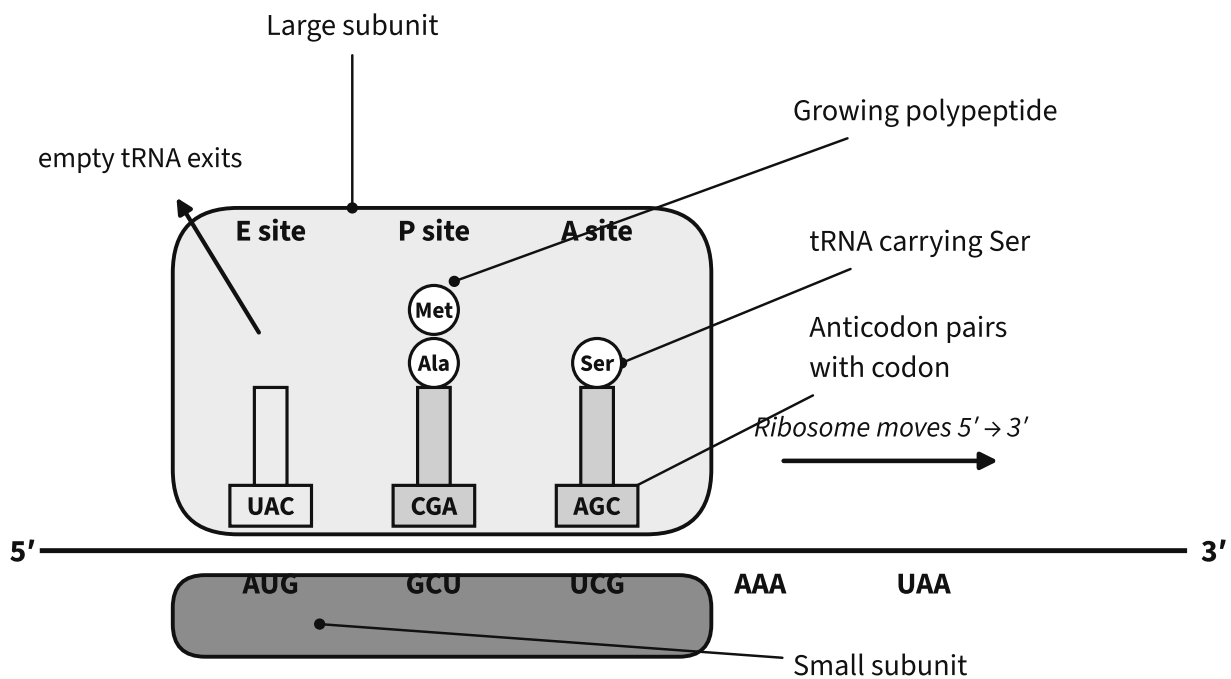


FIGURE 6.2 Translation at the ribosome. A new tRNA enters the A site, the growing chain is passed onto its amino acid, and the empty tRNA leaves from the E site as the ribosome moves along the mRNA.

A **ribosome** has a small subunit and a large subunit made of rRNA and protein. Translation has three stages: 1. **Initiation.** The small subunit binds the mRNA near its 5' end and finds the start codon AUG. A tRNA carrying methionine pairs with it, and the large subunit joins. The Met-tRNA sits in the **P site**. 2. **Elongation.** A tRNA whose anticodon matches the next codon enters the **A site**. The ribosome forms a **peptide bond**, transferring

Unit 6 Practice



MULTIPLE CHOICE

Fill in the bubble for the best answer. Use the codon chart in Lesson 6.2 when needed.

- 1 In eukaryotes, transcription takes place in the
 - (A) cytoplasm.
 - (B) ribosome.
 - (C) Golgi apparatus.
 - (D) nucleus.
- 2 RNA differs from DNA because RNA contains
 - (A) uracil and ribose.
 - (B) thymine and deoxyribose.
 - (C) two strands.
 - (D) amino acids.
- 3 RNA polymerase first binds to the
 - (A) start codon.
 - (B) promoter.
 - (C) poly-A tail.
 - (D) ribosome.
- 4 During RNA splicing, the segments that are removed are
 - (A) exons.
 - (B) codons.
 - (C) introns.
 - (D) promoters.
- 5 Which molecule carries amino acids to the ribosome?
 - (A) mRNA
 - (B) rRNA
 - (C) DNA
 - (D) tRNA
- 6 How many different codons are there in the genetic code?
 - (A) 20
 - (B) 64
 - (C) 61
 - (D) 3
- 7 What happens when a stop codon enters the A site?
 - (A) A release factor binds and the polypeptide is released.
 - (B) A tRNA brings methionine.
 - (C) The ribosome moves backward.
 - (D) A peptide bond forms with a new amino acid.

Data Lab: Which Step Does the Drug Block?

Researchers treated bacteria and human cells with four drugs and measured how much new RNA and new protein each made, as a percent of untreated cells. (Practice data based on how each drug acts.)

Drug	Bacteria: new RNA (%)	Bacteria: new protein (%)	Human cells: new RNA (%)	Human cells: new protein (%)
None	100	100	100	100
Rifampin	5	6	98	97
Tetracycline	97	8	99	94
Streptomycin	98	12	99	96
Cycloheximide	99	97	98	5

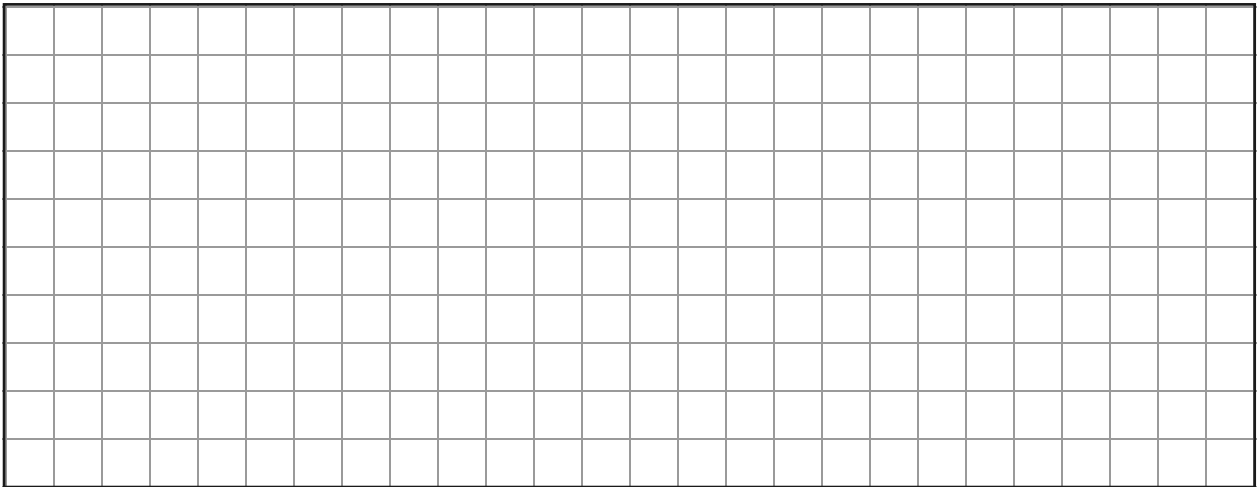
- 3 Rifampin blocks both RNA and protein production in bacteria. Which step does it most likely block, and why does protein production fall too?

- 4 Tetracycline and streptomycin lower bacterial protein but not RNA. Which step do they block?

- 5 Which drug would be useless as an antibiotic? Explain using the data.

- 6 Explain why tetracycline can block bacterial translation while human cells keep making protein. What does a small drop in human cells suggest?

Make a bar graph of new protein (%) in bacteria and in human cells for each drug.



CASE STUDY

Case Study: Sickle Cell Disease

CASE STUDY

Hemoglobin, the oxygen-carrying protein in red blood cells, is made of four chains. In sickle cell disease, the gene for the β -globin chain carries a single base change: the sixth codon in the mRNA changes from **GAG to GUG**. The sixth amino acid becomes valine instead of glutamate. Glutamate is charged and hydrophilic; valine is hydrophobic. The change creates a "sticky" patch on the outside of the hemoglobin molecule. When oxygen levels are low, these patches make hemoglobin molecules stick together into long fibers that bend red blood cells into a stiff sickle shape. Sickled cells block small blood vessels and break down quickly, causing pain crises, anemia, infections, and organ damage. A person must inherit two copies of the sickle allele to have the disease. People with one copy (sickle cell trait) are usually healthy, and they are partly protected from severe malaria. That is why the allele is common in parts of Africa, the Middle East, and India, where malaria has been widespread. New treatments include the drug hydroxyurea, bone marrow transplants, and gene therapies approved in 2023 that edit or add genes in a patient's own blood stem cells.

Mid-Book Exam

Units 1–4 • Suggested time: 90 minutes

Name _____ Date _____ Score _____

A Multiple Choice	B Short Answer	C Data Analysis	D Extended Response	Total
____ / 25	____ / 24	____ / 27	____ / 24	____ / 100

? EXAM DIRECTIONS

This exam covers Unit 1 (Biochemistry and Enzymes), Unit 2 (Cell Membrane and Transport), Unit 3 (Cellular Respiration), and Unit 4 (Photosynthesis). Read each question carefully, show your work for calculations, and use scientific vocabulary in written answers.

Section A: Multiple Choice (25 points, 1 point each)

- Which statement best distinguishes lipids from the other three classes of macromolecules?
 - Lipids contain no carbon.
 - Lipids are not polymers of repeating monomers.
 - Lipids are always soluble in water.
 - Lipids never contain oxygen.
- A protein is heated until it loses its function, but its amino acid sequence is unchanged. Which level of structure is still intact?
 - Primary
 - Secondary
 - Tertiary
 - Quaternary
- Which pair correctly matches a polymer with its bond?
 - Protein: glycosidic bond
 - Starch: peptide bond
 - DNA: phosphodiester bond
 - Cellulose: ester bond
- An enzyme-catalyzed reaction and the same reaction without the enzyme have the same
 - activation energy.
 - rate.
 - number of collisions that react.
 - ΔG .

Answer Key

Accept any scientifically accurate wording. Model answers show the key ideas a complete response should include. Multiple-choice answers are in bold.

Unit 1: Biochemistry and Enzymes

Lesson 1.1 Biological Macromolecules (p. 12)

1. Glycogen is the animal storage form. Starch (energy storage) and cellulose (cell walls) are found in plants.
2. Saturated fatty acids have no C=C double bonds, so their straight chains pack tightly. Double bonds in unsaturated fatty acids put kinks in the chains, so they cannot pack closely and stay liquid.

Lesson 1.2 Enzyme Structure and Function (p. 13)

1. Activation energy is the minimum energy needed to start a reaction. An enzyme lowers it, so more molecules react and the reaction goes faster.
2. Lock-and-key treats the active site as a rigid shape that matches the substrate; induced fit says the active site changes shape slightly when the substrate binds, making the fit tighter.

Lesson 1.3 Factors Affecting Enzyme Activity (p. 15)

1. Heat breaks the weak bonds that hold the enzyme's 3-D shape, so the active site changes shape (the enzyme denatures) and can no longer bind substrate.
2. Competitive inhibition can be overcome, because extra substrate outcompetes the inhibitor for the active site. Noncompetitive inhibition cannot, because the inhibitor binds an allosteric site and changes the enzyme's shape no matter how much substrate is present.

Unit 1 Practice (p. 18)

MULTIPLE CHOICE

1. **B**
2. **A**
3. **C**
4. **D**. Long-term energy storage is mainly the job of lipids (fats).
5. **B**
6. **A**
7. **C**
8. **B**
9. **D**

10. **C**

TRUE OR FALSE

1. **F**. Most polysaccharides, such as starch and cellulose, are not sweet.
2. **T**
3. **F**. Enzymes are released unchanged and can be used again.
4. **F**. An enzyme lowers the activation energy but does not change ΔG .
5. **F**. Cold slows enzymes by reducing molecular motion; high heat (and extreme pH) cause denaturation.
6. **T**

FILL IN THE BLANK

1. peptide
2. 20
3. glycogen
4. quaternary
5. ribozymes
6. coenzyme
7. active site
8. noncompetitive

SHORT ANSWER

1. Primary: the sequence of amino acids. Secondary: α -helices and β -sheets held by hydrogen bonds in the backbone. Tertiary: the overall 3-D fold shaped by R-group interactions. Quaternary: two or more polypeptide chains joined, as in hemoglobin.
2. DNA has deoxyribose, the bases A, T, G, C, and is usually double-stranded. RNA has ribose, the bases A, U, G, C, and is usually single-stranded.
3. The changed amino acid can alter how the chain folds (tertiary structure). Because the active site's shape depends on the whole fold, a change anywhere in the sequence can distort the active site so the substrate no longer fits.
4. Human enzymes evolved to work at human body temperature, 37 °C. Taq polymerase comes from *Thermus aquaticus*, a bacterium that lives in hot springs, so its protein has a structure (more stabilizing bonds) that keeps its shape at high temperatures.

GRAPH ANALYSIS: ENZYME KINETICS

1. No inhibitor: about 50 units. Noncompetitive inhibitor: about 25 units (about half).
2. At high substrate concentration, substrate molecules outnumber the competitive inhibitor and fill most active