

BRIGHT SCHOLARS

BIOLOGY SERIES • BOOK 1

FOUNDATIONS OF
BIOLOGY

BOOK 1

Grades 9–10

**A Complete Practice Workbook for Scientific Inquiry, the Chemistry of Life,
Cells, Energy, and Ecology**

Learn it, practice it, prove it.

SCIENCE PRACTICES • CHEMISTRY OF LIFE • CELLS • ENERGY • ECOLOGY

THIS BOOK BELONGS TO

Name _____

Class / Period _____

Teacher _____

School Year _____

Foundations of Biology Workbook, Grades 9–10 (Bright Scholars Biology Series, Book 1)

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This workbook is a supplemental practice resource. It does not replace a full course, laboratory instruction, or the guidance of a qualified teacher. Medical and health topics are included for science education only and are not medical advice.

All passages, case studies, data sets, and illustrations are original to this book. Data sets labeled as practice data are simplified or fictional and are designed for skill-building; real-world figures are cited to their public sources in the answer key and were current at the time of writing.

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First edition

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How to Use This Workbook

Every unit in this workbook follows the same path, so you always know what comes next. Read the lesson, try the Quick Check, then move into practice that gets steadily harder. Finish each unit with real data, a real-world case, and a self-check.

Part	What you do	Look for
Unit Opener	Read the Big Question and check your starting goals	The UNIT number page
Lessons	Read the mini lesson and study the figure	Black LESSON bar
Quick Check	Answer 2–3 fast questions before moving on	Boxed check icon
Practice	Multiple choice, true/false, fill-in, and short answer	Pencil icon
Data Lab	Read tables, graph data, and draw conclusions	Bar-chart icon
Case Study	Apply ideas to a real situation	Magnifier icon
Misconceptions	Compare common myths with the science	Warning icon
Unit Review and Challenge	Pull the unit together and stretch further	Star icon

Chemistry of Life

? BIG QUESTION

Why does a substance as simple as water make life possible?

BY THE END OF THIS UNIT, I CAN

- ☐ describe the structure of an atom and the particles inside it.
- ☐ explain how covalent, ionic, and hydrogen bonds differ.
- ☐ connect water's polarity to its properties that support life.
- ☐ use the pH scale and explain why it is logarithmic.
- ☐ explain how enzymes speed up reactions and why they can denature.

UNIT ROADMAP

3.1 Atoms and Chemical Bonds p. 6

3.2 Water: The Molecule of Life p. 8

Suggested time: 2 weeks (8–10 class periods)

Standards: HS-LS1-6; HS-LS1-2; SEP 4, 6

KEY VOCABULARY

atom element proton neutron electron

ion covalent bond ionic bond

hydrogen bond polarity cohesion

adhesion specific heat pH buffer

enzyme activation energy denature

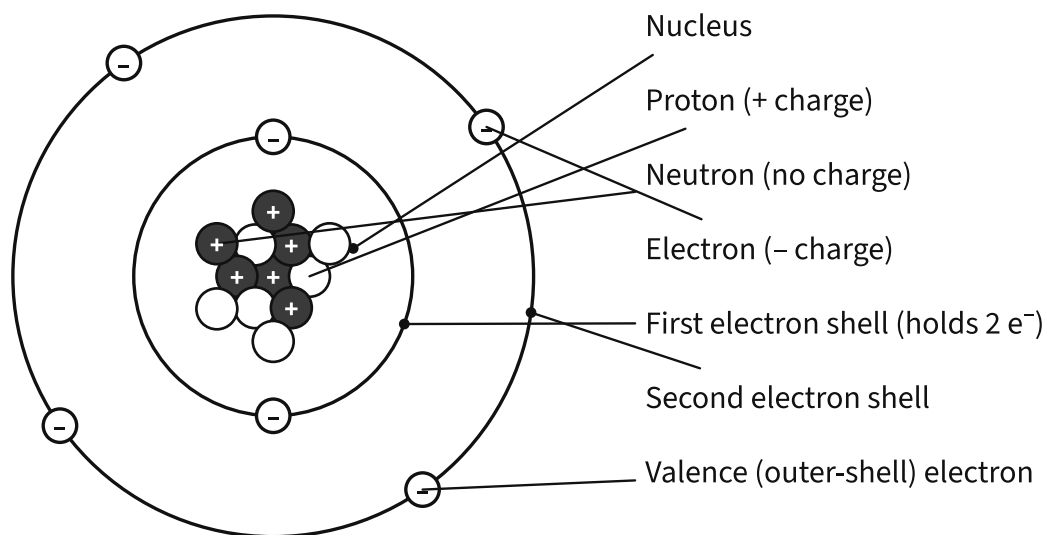
Atoms and Chemical Bonds

KEY TERMS atom • element • proton • neutron • electron • ion • covalent bond • ionic bond • hydrogen bond

All matter, including every living thing, is made of **atoms**. An atom is the smallest unit of an element that keeps that element's chemical properties. Each atom has a dense center called the nucleus, which holds positively charged protons and neutral neutrons. Negatively charged electrons move around the nucleus in regions called electron shells.

Particle	Location	Charge	Relative mass
Proton	Nucleus	Positive (+1)	about 1 amu
Neutron	Nucleus	Neutral (0)	about 1 amu
Electron	Electron shells	Negative (-1)	about 1/1836 amu

The **atomic number** is the number of protons, and it identifies the element. The **mass number** is protons plus neutrons. A neutral atom has equal numbers of protons and electrons. When an atom gains or loses electrons, it becomes a charged particle called an **ion**.



Carbon-12: 6 protons, 6 neutrons, 6 electrons

FIGURE 3.1 A carbon-12 atom. Carbon's four valence electrons let it form four covalent bonds, which is why it can build the long chains and rings found in living things.

Three bonds that matter in biology

- **Covalent bonds** form when atoms share electron pairs. They hold the atoms of water and of most biological molecules together.
- **Ionic bonds** form when one atom transfers electrons to another, and the oppositely charged ions attract. Table salt (Na^+Cl^-) is an example.
- **Hydrogen bonds** are weak attractions between a slightly positive hydrogen atom and a slightly negative oxygen or nitrogen atom nearby. One is weak, but millions together hold DNA's two strands together and give water its special properties.

✓ QUICK CHECK

- 1 Carbon has 6 protons and 6 neutrons. What is its atomic number, and what is its mass number?

- 2 A sodium atom loses one electron. Is the new particle positive or negative? Explain.

Water: The Molecule of Life

KEY TERMS polarity • cohesion • adhesion • surface tension • specific heat • solvent

In a water molecule, the oxygen atom pulls shared electrons more strongly than the two hydrogen atoms do. This unequal sharing gives oxygen a partial negative charge (δ^-) and each hydrogen a partial positive charge (δ^+). A molecule with charged ends like this is **polar**. Because opposite partial charges attract, each water molecule forms hydrogen bonds with its neighbors.

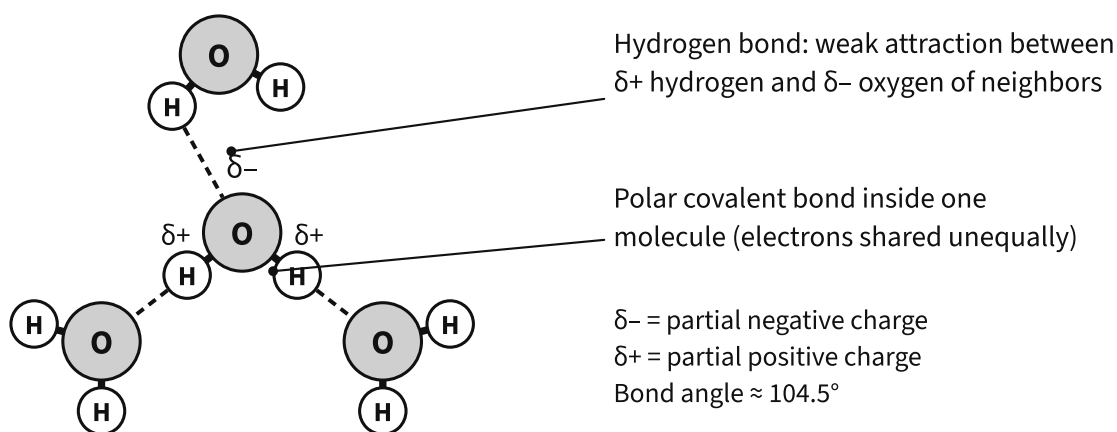


FIGURE 3.2 Polar water molecules attract one another through hydrogen bonds (dashed lines).

Property	What causes it	Why it matters for life
Cohesion and surface tension	Hydrogen bonds between water molecules	Water forms drops; insects such as water striders can walk on the surface
Adhesion	Attraction between water and other polar surfaces	Together with cohesion, helps pull water up through a plant's xylem
High specific heat	Energy is needed to break hydrogen bonds before temperature rises	Oceans and body fluids resist rapid temperature change
High heat of vaporization	Evaporating water carries a lot of heat away	Sweating cools the body
Excellent solvent	Polar and ionic substances dissolve in water	Blood, cytoplasm, and digestive juices carry dissolved materials
Ice floats	Hydrogen bonds lock ice into a more open lattice	Floating ice insulates lakes so organisms survive winter

✓ **QUICK CHECK**

- 1 Explain in one sentence why water is called a polar molecule.

Unit 3 Practice

MULTIPLE CHOICE

Fill in the bubble for the best answer.

- 1 What gives an atom its identity as a particular element?
☐ (A) The number of neutrons ☐ (B) The number of protons
☐ (C) The number of electron shells ☐ (D) The mass number
- 2 Which property of water best explains why a lake freezes from the top down?
☐ (A) High specific heat
☐ (B) Adhesion to the lakebed
☐ (C) Ice is less dense than liquid water
☐ (D) Water dissolves many ions
- 3 A solution has a pH of 3. Compared with a solution at pH 5, it has
☐ (A) 2 times more H^+ ions ☐ (B) 20 times more H^+ ions
☐ (C) 100 times more H^+ ions ☐ (D) 100 times fewer H^+ ions

TRUE OR FALSE

Circle T or F. If the statement is false, rewrite it to make it true.

- 1 Enzymes are used up in the reactions they speed up. ☐ (T) ☐ (F)

- 2 Ice is denser than liquid water. ☐ (T) ☐ (F)

FILL IN THE BLANK

WORD BANK

cohesion adhesion ion covalent buffer

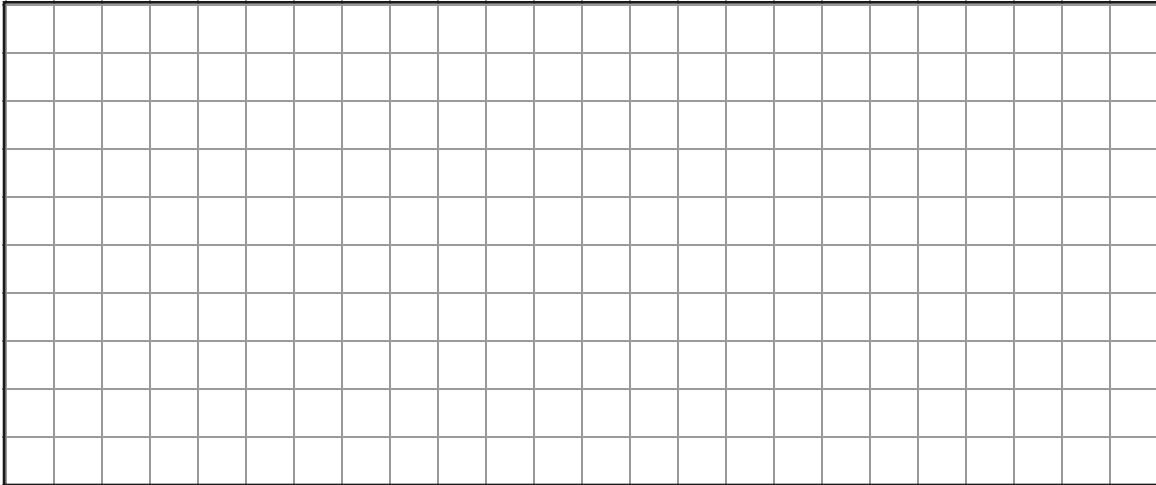
- 1 Water striders can walk on a pond because of _____ between water molecules.
- 2 Atoms that share a pair of electrons are joined by a _____ bond.
- 3 A _____ helps keep the pH of blood between 7.35 and 7.45.

Data Lab: Temperature and Enzyme Activity

A student measured how fast an enzyme broke down its substrate at eight temperatures. Study the data, then answer the questions.

Temperature (°C)	0	10	20	30	37	40	50	60
Reaction rate (units)	2	8	18	30	42	38	15	3

Graph the data: temperature on the x-axis, reaction rate on the y-axis. Add a title and units.



- 1 At what temperature was the reaction rate highest?

- 2 Describe what happens to the rate above 40 °C and name the process responsible.

- 3 Is this enzyme more likely to come from a human or from a bacterium living in a 75 °C hot spring? Use the data to justify your answer.

CASE STUDY

Case Study: Acid Rain and Mountain Lakes

CASE STUDY

In the 1970s and 1980s, rain falling on the Adirondack Mountains of New York often had a pH between about 4.0 and 4.5. Sulfur dioxide and nitrogen oxides from power plants upwind dissolved in rain to form sulfuric and nitric acids. Many lakes became too acidic for fish, and acidic water also released aluminum from soils, which harms fish gills. After the 1990 Clean Air Act Amendments sharply reduced sulfur dioxide emissions, the acidity of rain fell and many lakes began a slow, partial recovery. Some fish populations have returned, but recovery is still uneven decades later.

- 1 How many times more acidic is rain at pH 4.0 than water at pH 6.0? Show your reasoning.

- 2 Use the idea of an enzyme's optimal pH to explain one reason fish populations declined.

Common Misconceptions

Common Misconception	What Scientists Actually Know
MYTH Fire is alive because it grows, moves, and uses fuel.	FACT Fire has no cells, no genetic material, and cannot reproduce or maintain homeostasis, so it fails the characteristics of life.
MYTH Hydrogen bonds are the bonds inside a water molecule.	FACT The bonds inside one water molecule are polar covalent bonds. Hydrogen bonds are weaker attractions between neighboring molecules.
MYTH A pH of 4 is only a little more acidic than a pH of 5.	FACT The pH scale is logarithmic. pH 4 has 10 times the H^+ concentration of pH 5.

Mid-Book Exam

Units 1–4 • 90 minutes

Name _____ Date _____ Score _____

A Multiple Choice	B Matching	C Short Answer	D Data	E Extended	Total
____ / 25	____ / 15	____ / 24	____ / 16	____ / 20	____ / 100

Section A: Multiple Choice (1 point each)

- Which level of organization includes all the different species living in a pond?

☐ (A) Population	☐ (B) Community
☐ (C) Ecosystem	☐ (D) Biosphere
- In an experiment testing whether caffeine changes heart rate, what is the dependent variable?

☐ (A) The dose of caffeine	☐ (B) The type of animal
☐ (C) Heart rate in beats per minute	☐ (D) Room temperature

Answer Key

Accept answers that are scientifically equivalent. Model answers show the key ideas a complete response should include.

Unit 3: Chemistry of Life

Lesson 3.1 Atoms and Chemical Bonds (p. 6)

1. Atomic number 6 (protons); mass number 12 (6 protons + 6 neutrons).
2. Positive (Na^+). It still has 11 protons but only 10 electrons, so there is one more positive charge than negative charge.

Lesson 3.2 Water: The Molecule of Life (p. 8)

1. Oxygen attracts the shared electrons more strongly than hydrogen, so the oxygen end is partly negative and the hydrogen ends are partly positive.

Unit 3 Practice (p. 10)

1. **B.** The atomic number (number of protons) defines the element.
2. **C.** Hydrogen bonds hold ice in an open lattice, so ice is less dense and floats.
3. **C.** Each pH unit is a $10\times$ change, so two units is $10 \times 10 = 100\times$.
1. **F.** Enzymes are not consumed; they are released unchanged and can be reused.
2. **F.** Ice is less dense than liquid water, which is why it floats.
1. cohesion
2. covalent
3. buffer

Data Lab: Temperature and Enzyme Activity (p. 11)

1. 37°C (42 units).
2. The rate falls sharply ($38 \rightarrow 15 \rightarrow 3$ units) because heat disrupts the bonds holding the enzyme's shape, so the active site changes and the enzyme denatures.
3. **A** human: its optimum is about 37°C , which matches human body temperature; a hot-spring enzyme would work best near 75°C .

Case Study: Acid Rain and Mountain Lakes (p. 12)

1. 100 times: two pH units is $10 \times 10 = 100$ times more H^+ .

2. Fish enzymes work best near a particular pH; very acidic water shifts internal conditions away from that optimum and can denature proteins, so vital reactions slow or stop.

Mid-Book Exam

Section A: Multiple Choice (p. 14)

1. **B.** A community is all the populations of different species in one area.
2. **C.** The dependent variable is what is measured.