

BRIGHT SCHOLARS

HIGH SCHOOL SCIENCE • GRADE 11

MASTERING 11TH GRADE

ZOOLOGY

VOLUME 1 Grade 11

Animal Systems and Human Physiology, Volume 1: Tissues, Digestion,
Respiration, Circulation, and Excretion

Learn it. Practice it. Prove it.

TISSUES • DIGESTION • RESPIRATION • CIRCULATION • EXCRETION

THIS BOOK BELONGS TO

Name _____

Class / Period _____

Teacher _____

School Year _____

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Introduction to Zoology and Animal Tissues

? BIG QUESTION

A blue whale, a honeybee, and you are all built from cells that are too small to see. How do trillions of tiny cells organize into tissues that protect, support, move, and coordinate a body, and why can't an animal simply be one giant cell?

BY THE END OF THIS UNIT, I CAN

- ☐ define zoology, describe its major branches, and list the characteristics shared by animals.
- ☐ arrange the levels of biological organization in order and give an animal example of each.
- ☐ identify types of epithelial and connective tissue and relate their structure to their location and function.
- ☐ compare skeletal, cardiac, and smooth muscle and describe the structure of a neuron and its supporting cells.
- ☐ calculate surface-area-to-volume ratios and explain how they limit the size of cells and animals.
- ☐ explain how different animal body plans keep every cell close enough to its supplies.

UNIT ROADMAP

- 1.1 What Is Zoology?..... p. 10
 1.2 Epithelial and Connective Tissue..... p. 12
 1.3 Muscle and Nervous Tissue p. 16
 1.4 Across the Animal Kingdom: Size, Surface Area, and Body Plans p. 19

Suggested time: 1.5 weeks

Standards: HS-LS1-2; SEP 2, 4, 5

KEY VOCABULARY

- | | | | |
|-------------------|------------------------------|------------|----------|
| zoology | physiology | ethology | taxonomy |
| histology | heterotroph | tissue | organ |
| organ system | ecosystem | epithelium | |
| basement membrane | keratin | | |
| connective tissue | extracellular matrix | | |
| collagen | fibroblast | striated | |
| intercalated disc | neuron | neuroglia | |
| myelin sheath | surface-area-to-volume ratio | | |
| diffusion | | | |

movements that shape an embryo. Animals are **heterotrophs**: they cannot make their own food, so they ingest other organisms or their products and digest them. Most animals can move at some stage of life, most reproduce sexually with small swimming sperm and larger eggs, and their embryos pass through a hollow ball stage called a blastula. Almost all animals have true tissues, and two of them, nervous tissue and muscle tissue, are found only in animals. The sponges are the main exception: they have specialized cells but no true tissues.

Levels of organization. Living things are organized in a hierarchy in which each level is built from the levels below it. Atoms form molecules; molecules form organelles; organelles work together in a **cell**, the smallest unit that is alive. Similar cells and the material they secrete form a **tissue**. Two or more tissue types working together form an **organ**, and organs that cooperate form an **organ system**. Beyond the individual **organism**, a **population** is all the members of one species in an area, a **community** is all the populations of different species living there, and an **ecosystem** is the community *plus* its nonliving (abiotic) environment, such as water, soil, sunlight, and temperature. The **biosphere** includes every ecosystem on Earth.

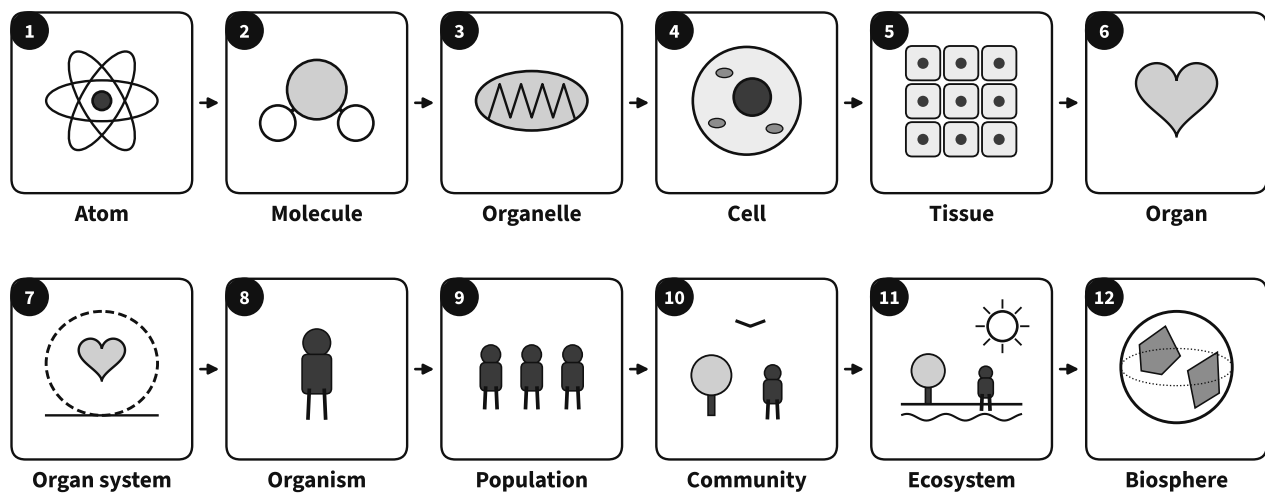


FIGURE 1.1 The levels of biological organization, from atom to biosphere. Each level includes the levels below it. An ecosystem is a community together with its abiotic environment.

At each level, new abilities appear that the parts do not have alone. A single heart muscle cell can contract, but only the whole heart, with its chambers and valves, can pump blood in one direction. These new abilities are called **emergent properties**, and they are the reason zoologists study animals at every level, from molecules to ecosystems.

Across the Animal Kingdom: Size, Surface Area, and Body Plans

KEY TERMS surface area • volume • surface-area-to-volume ratio • diffusion • diffusion distance • exchange surface • transport system • flatworm • hydra • sponge • choanocyte

Every living cell must exchange materials with its surroundings. Oxygen and nutrients must come in, and carbon dioxide and other wastes must go out, all across the cell's surface. A cell's needs depend on its **volume** (how much cytoplasm is using resources), but its supply depends on its **surface area**. As an object gets larger, its volume grows faster than its surface area, so its **surface-area-to-volume ratio** (SA:V) falls. For a cube with side length L , surface area = $6 \times L^2$, volume = L^3 , and $SA:V = 6 \div L$.

WORKED EXAMPLE: SURFACE AREA TO VOLUME RATIO

- 1 cm cube: 6 faces of 1 cm^2 each, so $SA = 6 \text{ cm}^2$; $V = 1 \text{ cm}^3$; $SA:V = 6 : 1$.
- 2 cm cube: $SA = 6 \times (2 \text{ cm} \times 2 \text{ cm}) = 24 \text{ cm}^2$; $V = 2 \times 2 \times 2 = 8 \text{ cm}^3$; $SA:V = 24 \div 8 = 3 : 1$.
- 4 cm cube: $SA = 6 \times 16 = 96 \text{ cm}^2$; $V = 64 \text{ cm}^3$; $SA:V = 96 \div 64 = 1.5 : 1$.

Pattern: each time the side length doubles, surface area increases 4 times, volume increases 8 times, and SA:V is cut in half.

Diffusion works only over short distances. Diffusion is fast across the width of a cell but very slow over larger distances, because the time needed grows with the square of the distance: doubling the distance makes diffusion take about four times as long. In living tissue, diffusion alone can supply oxygen only to cells within roughly a millimeter of a surface, and often less. This limit is one reason most cells are microscopic, and why a very long cell, such as a neuron, is extremely thin.

Body plans that keep cells close to the surface. Small animals and simple body plans can rely on diffusion. A **flatworm** is flattened, so no cell is far from the water around it, and its gut branches throughout the body to bring food close to every cell. A **hydra** and its relatives have a body wall only two cell layers thick wrapped around a central cavity, so each cell touches either the outside water or the water in the cavity. A **sponge** has no true tissues at all. Its loosely organized cells line a system of pores and canals, and flagellated collar cells called **choanocytes** pump water through the body, bringing food and oxygen within reach of every cell. Sponge cells are so loosely joined that, in classic experiments, cells separated by sieving could crawl back together into small sponges.

- 3 Explain why stratified squamous epithelium covers the skin, but simple squamous epithelium lines the alveoli of the lungs.

- 4 Describe the path of a nerve impulse through a myelinated neuron and explain how myelin speeds it.

DATA LAB

Data Lab: Size, Shape, and Diffusion

DATA SET A: AGAR CUBES OF DIFFERENT SIZES

A class made agar containing phenolphthalein, an indicator that is pink in basic conditions and colorless in acid. They cut the agar into cubes, placed them in dilute hydrochloric acid, and recorded the time for the pink color to disappear completely (acid reaching the center). Each time is the mean of 4 cubes.

Cube side (cm)	Surface area (cm ²)	Volume (cm ³)	Time to clear completely (min)
0.5	1.5	0.125	4
1.0	6	1	16
2.0	24	8	61
3.0	54	27	138

Unit 1 Quiz

? QUIZ DIRECTIONS

Suggested time: 30 minutes. 30 points. Part A: 10 multiple choice (1 point each). Part B: 5 fill in the blank (1 point each). Part C: 3 short answer (5 points each).

✓ PART A: MULTIPLE CHOICE

- 1 Which branch of zoology studies how organs and organ systems function?

☐ (A) Morphology	☐ (B) Taxonomy
☐ (C) Physiology	☐ (D) Paleontology

- 2 Which statement best describes a tissue?

☐ (A) A group of similar cells and their extracellular material that share a function
☐ (B) Two or more organs that work together for a major body function
☐ (C) All the members of one species living in the same area
☐ (D) A membrane-bound structure that performs a job inside a cell

- 3 Which of the following is NOT a connective tissue?

☐ (A) Bone	☐ (B) Adipose tissue
☐ (C) Blood	☐ (D) Simple cuboidal epithelium

- 4 The tubules of the kidney, which secrete and absorb substances, are lined by

☐ (A) stratified squamous epithelium.
☐ (B) simple cuboidal epithelium.
☐ (C) transitional epithelium.
☐ (D) pseudostratified columnar epithelium.

- 5 Which feature is found in skeletal muscle but NOT in smooth muscle?

☐ (A) A single central nucleus	☐ (B) Spindle-shaped cells
☐ (C) Involuntary control	☐ (D) Striations

- 6 The region of a neuron where an impulse usually begins before it travels down the axon is the

☐ (A) axon hillock.	☐ (B) dendrite.
☐ (C) node of Ranvier.	☐ (D) myelin sheath.

waves that sweep the mucus up toward the throat, where it is swallowed or coughed out.

SHORT ANSWER

1. Epithelium: cells tightly packed in sheets with little matrix, resting on a basement membrane; no blood vessels of its own (nourished by diffusion from below); covers surfaces, lines cavities, forms glands; protects, absorbs, secretes, filters. Connective tissue: cells scattered in abundant extracellular matrix of ground substance and fibers; most types have a blood supply (cartilage does not); supports, binds, cushions, stores energy, and transports (blood).
2. Cardiac muscle cells contain very many mitochondria and receive a rich, steady blood supply, so they make ATP mostly by aerobic respiration and do not build up an oxygen debt. Each contraction is followed by a long recovery period, so the cells relax and refill between beats rather than staying contracted.
3. The skin faces friction, microbes, and drying, so many layers (keratinized at the surface) protect underlying tissues. The alveoli must exchange O_2 and CO_2 by diffusion, which is fast only over very short distances, so a single layer of flat cells gives the thinnest possible barrier. Each tissue suits its function: protection versus exchange.
4. Signals are received by the dendrites and passed to the cell body; an impulse begins at the axon hillock and travels along the axon to the axon terminals, which release neurotransmitter onto the next cell. Myelin insulates the axon, so the impulse jumps from one node of Ranvier to the next instead of traveling continuously along the membrane, which greatly increases conduction speed.

Data Lab: Size, Shape, and Diffusion (p. 25)

1. $1.5 \div 0.125 = 12 : 1$; $6 \div 1 = 6 : 1$; $24 \div 8 = 3 : 1$; $54 \div 27 = 2 : 1$.
2. As SA:V decreases (larger cubes), the time to clear increases sharply. The 3 cm cube, with SA:V of $2 : 1$, took about 35 times longer than the 0.5 cm cube, with SA:V of $12 : 1$.
3. $61 \div 16 \approx 3.8$, or about 4 times. Doubling the diffusion distance roughly quadruples the time, because diffusion time increases with the square of the distance. Diffusion is effective only over short distances.
4. Slab SA = $2(4 \times 4) + 4(4 \times 0.5) = 32 + 8 = 40 \text{ cm}^2$. SA:V: cube $24 \div 8 = 3 : 1$; rod $34 \div 8 = 4.25 : 1$; slab $40 \div 8 = 5 : 1$.
5. The distance from the surface to the center (set by the thinnest dimension). Time fell from 63 min (1.0 cm) to 17 min (0.5 cm) to 4 min (0.25 cm), about four times faster each time the distance halved. Higher SA:V goes with shorter distance.
6. The slab is like a flatworm: thin and flat, so diffusion reaches every cell quickly and no circulatory system is needed. The rod is like an earthworm: longer and thicker,

so the center is farther from the surface; the earthworm needs a circulatory system to carry gases and nutrients.

Case Study: A Sprained Ankle (p. 28)

1. Dense regular connective tissue. Its main protein is collagen. The fibers are packed tightly and run parallel, so they resist strong pulling forces along one direction, which holds bones together at a joint.
2. Blood leaking from torn capillaries delivers platelets and clotting proteins, which form a clot that seals the damaged vessels. White blood cells arrive to remove dead cells and debris, and blood flow brings oxygen, nutrients, and signals that attract fibroblasts to begin repair.
3. The skin's epithelium divides rapidly and has a rich blood supply in the connective tissue beneath it. Ligaments have few blood vessels and relatively few fibroblasts, so repair materials arrive slowly, and new collagen must be laid down and then remodeled over months to regain strength.
4. Nervous tissue (sensory neurons). Swelling can press on small nerves, and the twisting injury can stretch nerve fibers near the ankle. Gradual, controlled loading signals fibroblasts to align new collagen fibers along the direction of pull, producing a stronger ligament; balance training also retrains sensory receptors in the joint.

Unit 1 Review and Challenge (p. 30)

CHALLENGE QUESTIONS

1. Without myelin, impulses can no longer jump from node to node; conduction slows, becomes unreliable, or fails, so signals for movement, vision, or sensation may be delayed or lost. The disease targets myelin made by oligodendrocytes in the central nervous system. Peripheral nerves are myelinated by Schwann cells, a different cell type that is not the main target, so their myelin is usually spared.
2. IV: temperature of the acid bath (for example, 10°C , 20°C , 30°C , 40°C). DV: time for the pink color to clear from the cube (or depth of clearing after a fixed time). Controls: cube size and shape, agar and indicator concentration, acid concentration and volume, cutting method, timing method. Reliability: several cubes per temperature, calculate means, repeat the experiment, use a water bath and thermometer to hold temperature steady, use the same observer or a color standard to judge the endpoint.
3. Epithelial tissue (simple columnar with microvilli and goblet cells) lines the inside, secretes mucus and enzymes, and absorbs nutrients. Connective tissue beneath it holds the layers together and carries blood capillaries and lymph vessels that take absorbed nutrients away. Smooth muscle layers mix the contents and push them along by peristalsis. Nervous tissue