High School Biology

Unit 1: Cellular basis of life

You are made of over 20 trillion cells! In this unit, students will embark on a journey at the microscopic level to explore the foundational building blocks of all living organism, cells! Topics include:

- Cell theory and the basis of life.
- Types of cells and cellular complexity.
- Biomolecules and how they contribute to cell structure and function.
- Homeostasis and cellular transport.
- Differences between viruses and cells and the mechanisms of viral transmission.

### TEKS standards

<table>
<thead>
<tr>
<th>TEKS standards</th>
<th>Example phenomena</th>
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<tr>
<td>BIO.5A Relate the functions of different types of biomolecules, including carbohydrates, lipids, proteins, and nucleic acids, to the structure and function of a cell.</td>
<td>How can our knowledge of cells be used to keep us healthy?</td>
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<td>BIO.5B Compare and contrast prokaryotic and eukaryotic cells, including their complexity, and compare and contrast scientific explanations for cellular complexity.</td>
<td>Getting sick is a part of life—most everyone has experienced being infected by bacteria or viruses. It’s no fun! But through scientific understanding of cells and biomolecules, humans have developed ways to counteract infectious disease. For example, antibiotics such as methicillin and doxycycline work by targeting structures unique to bacterial cells, disrupting cell homeostasis, or preventing formation of crucial biomolecules. Similarly, scientific understanding of viruses has led to powerful antiviral drugs. There are many real-world examples that can be drawn on for this phenomenon, and teachers can choose examples based on the interests or sensitivities of the class.</td>
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<td>BIO.5C Investigate homeostasis through the cellular transport of molecules.</td>
<td><strong>Prompts for students to consider:</strong></td>
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<td>• How do the principles of cell theory relate to eukaryotic cells and prokaryotic (for example, bacterial) cells?</td>
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<td>• How is a eukaryotic cell (such as a human cell) similar to a prokaryotic cell (such as a bacterium)? How are they different?</td>
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<td>• What are the roles of proteins, nucleic acids, lipids, and carbohydrates in eukaryotic and prokaryotic cell structure and function?</td>
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<td>• Do antibiotics target eukaryotic or prokaryotic cells? How do you know?</td>
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<td>• What specific biomolecules or cellular processes do antibiotics target?</td>
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How do bacteria maintain homeostasis, and how do antibiotics like penicillin disrupt this homeostasis?

How does the structure and mode of replication compare between bacteria and viruses?

Why are antibiotics useful against bacteria and not viruses?

Can vaccines prevent infection by bacteria, by viruses, or both?

What is eutrophication and how can we prevent it?

Imagine a nearby lake turning green and murky, becoming so overgrown with algae that fish and other aquatic organisms can no longer survive. This, in essence, is eutrophication, and it results from human activities. When elements such as nitrogen and phosphorus enter bodies of water from farms and factories, algal cells have the nutrients they need for explosive growth. When the overgrown algae die, bacteria break down their cells, using oxygen from the water to do so. This depletes the water of oxygen, leading to dead zones. Exploring eutrophication lets us peek into the world of cells and biomolecules, and see firsthand how they play a part in the health of our environment. This phenomenon can be revisited in later ecology units.

Prompts for students to consider:

- Describe how the principles of cell theory relate to the following organisms in an aquatic ecosystem: algae and fish (both eukaryotes) and bacteria (prokaryotes).
- How is an algal cell different from a bacterial cell? How are they similar?
- In what ways are prokaryotic and eukaryotic organisms involved in the process of eutrophication?
- What role do biomolecules play in algal growth?
- What elements make up biomolecules? Why would nutrients containing nitrogen and phosphorus help algal cells grow and reproduce?
- How do algal cells maintain homeostasis and how might changes in nutrient availability affect these cellular processes?
- How does the structure and mode of replication compare between algae and viruses?
- Could viruses be used to control algal blooms?
# Lesson overview

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<th>Lesson</th>
<th>Objective</th>
<th>Teaching tips</th>
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<tr>
<td><strong>Lesson 1: The cellular basis of life</strong>&lt;br&gt;TEKS standard: BIO.5B</td>
<td>Explain the fundamental principles of cell theory.&lt;br&gt;Apply cell theory to various living organisms, illustrating how it serves as a unifying concept in biology.</td>
<td>• Frame the development of the cell theory through a historical perspective. What was the year? Who were the main scientists involved? What else was happening during that time? Students can create a timeline to showcase this scientific development.&lt;br&gt;• Give students multiple opportunities to explore how cell theory applies to a wide range of living organisms. <em>Hint: Use all of the biological kingdoms.</em></td>
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<td><strong>Lesson 2: Prokaryotic and eukaryotic cells</strong>&lt;br&gt;TEKS standards: BIO.5B</td>
<td>Identify the fundamental differences and shared characteristics between prokaryotic and eukaryotic cells.&lt;br&gt;Compare and contrast different scientific explanations for the complexity of eukaryotic cells and evaluate the evidence supporting these explanations.&lt;br&gt;Understand how the differences in cellular complexity between prokaryotic and eukaryotic cells contribute to the diversity of life.</td>
<td>• Venn diagrams can help build understanding of similarities and differences. Constructed collaboratively as a class, in pairs, or individually, they can include pictures and micrographs along with words and phrases in each category.&lt;br&gt;• At first glance, “endosymbiosis” might seem like a long, complicated word, but broken down it truly means “living together within.” Breaking down words into roots can be a helpful vocabulary strategy.&lt;br&gt;• Helpful analogy for cellular complexity: Imagine you have a toolbox and each tool has a specific job. The more tools you have, the more things you can build or fix. Similarly, the complexity of eukaryotic cells allows for more specialized functions and diversity in living organisms.</td>
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<td><strong>Lesson 3: Biomolecules</strong>&lt;br&gt;TEKS standard: BIO.5A</td>
<td>Identify and describe the main types of biomolecules (carbohydrates, lipids, proteins, and nucleic acids) found in cells.&lt;br&gt;Explain how biomolecules are integral to the structure and function of cells, including their role in energy storage, cell membranes, and genetic information.</td>
<td>• A four-door foldable can be a great tool to help students organize information on the main biomolecules. On the outside of each flap include: name of molecule and drawn images of model structure. Inside, include: notes on functions, location within the cell, and any other key info.&lt;br&gt;• Examples, examples, examples. Every biomolecule serves various purposes within the cell. Set students on a timed mission to find varying examples for each biomolecule. Follow this up with a class share-out and create a master list together.</td>
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### Lesson 4: Cell structure and function

**TEKS standard:** BIO.5B, 5C

- **Video:** 2
- **Article:** 4
- **Exercise:** 2

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<th>Explain how organelles work collaboratively within cells to support essential functions. Describe the structure of the cell membrane and its role in controlling the movement of substances into and out of the cell. Analyze how the structure of a cell is related to its function, considering examples from various cell types.</th>
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<td>● Organelles do not operate in isolation. When introducing organelles, tag on cellular processes that rely on organelle-organelle interactions: Nucleus-ER (protein synthesis), ER-Golgi Apparatus (protein transport), and many more. ● Explore the dynamic structure and role of the cell membrane using interactive visuals such as animations, 3D models, and online simulations. Encourage connections to real-world examples. E.g. compare and contrast the structure and function of epithelial cells in the intestine vs. skin. ● Explore cellular adaptations in extreme environments. Discuss how extremophiles have cellular structures adapted to withstand high temperature, pressure, or acidity.</td>
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### Lesson 5: Homeostasis in cells

**TEKS standard:** BIO.5C

- **Video:** 2
- **Article:** 2
- **Exercise:** 2

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<th>Explain the concept of homeostasis and how cellular transport processes help maintain a stable internal environment in cells. Investigate the different types of cellular transport, including passive and active transport, and their roles in maintaining homeostasis.</th>
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<td>● Keep it cellular. When exploring homeostasis it is easy to focus on the organismal level but reinforce that homeostasis takes place at the cellular level as well. Check out online videos researchers have recorded through microscopes to see it in action! ● Emphasize the relevance of homeostasis to human health. Students can become disease detectives and explore diabetes, cystic fibrosis, and osteoporosis at the cellular transport level. ● Connect the concept of cellular transport to real-world disciplines: pharmacology (drug molecules transversing the membrane) and environmental science (pollutant uptake).</td>
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### Lesson 6: Viruses

**TEKS standard:** BIO.5D

- **Video:** 3
- **Article:** 1
- **Exercise:** 1

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<th>Differentiate between the structural characteristics of viruses and cells. Investigate how viruses spread through various means, including direct contact, airborne transmission, and vector transmission.</th>
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<td>● With any comparison between viruses and cells, be sure that students have an understanding of scale. ● Use concept mapping as a tool for students to organize and visually represent the structural characteristics of viruses and cells. ● Discuss the role of epidemiologists in identifying sources, vectors, and transmission dynamics during outbreaks. Showcase how scientists investigate patterns of virus transmission.</td>
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Best practices

COMMON MISCONCEPTIONS AND HOW TO ADDRESS THEM

“All cells look like the models shown in class.”
Students are often presented with a singular generic image of each cell type when learning the types and structures of cells. Similarly, this often occurs with biomolecules. Doing this perpetuates the notion that every cell is the same and each biomolecule has one structure and one function.

How to address this misconception
When presenting, discussing, and exploring any components of cells, use micrographs and multiple examples of each cellular concept. Similarly, provide multiple examples for each biomolecule: (e.g., proteins for movement vs. support, lipids that are good for health vs. bad, carbs for energy vs. support).

“All interactions between prokaryotic and eukaryotic cells are ‘bad’ for the eukaryotic cells.”
Everyone has experienced being sick. Students often conclude that all bacteria will make them sick and do not realize that there are many examples of positive interactions between prokaryotes and eukaryotes.

How to address this misconception
When presenting prokaryotic cells, differentiate between pathogenic and non-pathogenic strains. Showcase examples of beneficial prokaryotes; those involved in nitrogen fixation, digestion, or fermentation. Arrange for guest speakers (in-person or via video conferencing) to provide students with real-world insights into the positive contributions of prokaryotes.

“All viruses are bad and make us sick.”
Many students have experienced being sick with a viral illness, and so they think all viruses are "bad." However, there are examples of positive interactions between viruses and humans.

How to address this misconception
Highlight that there are many types of viruses, each with its own characteristics, and not all of them cause diseases. For example, there are viruses that infect bacteria (bacteriophages) that can be used in place of antibiotics, as well as viruses that are used in genetic engineering and biotechnology.

CLASSROOM ACTIVITIES

Bio-Bites: Analyzing the building blocks of food
In this investigation, students will use chemical tests to analyze their favorite foods, uncovering biomolecules and revealing the roles of proteins, lipids, and carbohydrates in health.

Materials: food items that can be pureed or crushed finely; solutions and equipment to test for biomolecules- Biuret (proteins), Sudan III (lipids), and Lugol’s iodine (carbohydrates).

☐ Have students present their findings and conduct a class discussion to highlight common trends, differences, and important takeaways from the investigation.
Microscopic Marvels: Exploring cell diversity
Unlock the microscopic world! In this exploration, students will observe and identify different types of cells under a microscope to understand cell structure. Like medical professionals diagnosing diseases, they will analyze and document live samples and micrographs. This connects to the biology concepts of cell structure, function, and the diversity of life.

☐ Students view and label live samples, prepared specimens, or micrographs.
☐ Students can document what they see and add structure and function labels, as well as identify differences and similarities between samples.

Osmosis in action
Investigate osmosis by observing changes in potato slices, gummy bears, or dialysis tubing in various solutions. Like food scientists studying food preservation, students will measure and record changes to understand osmosis, connecting to concepts like water movement across cell membranes and solute concentration effects. This investigation can also be performed as a class demonstration.

☐ Set up an osmosis experiment using dialysis tubing (can be finicky), potato slices, or gummy bears in various solutions (ex: tap water, distilled water, salt water, sugar water) of varying concentrations.
☐ If using potato slices or gummy bears, students can measure the change in size, weight, and/or volume over hours or days. If using dialysis tubing, students can measure glucose levels.
☐ Make it an open investigation—Have students bring in various liquids they wish to test.
☐ Require students to make and justify predictions and record results for each solution through the use of data, drawings, and connections to real world situations.

The great virus debate
Students will debate, "Are viruses alive?" by researching the characteristics of living organisms and viruses. Like scientists, they will construct evidence-based arguments and engage in critical thinking. This connects to biology concepts such as the definition of life and organism classification. This activity can be conducted in groups or as individuals. You can assign sides or let students choose.

☐ Clearly state the debate question: "Are viruses alive?" and instruct students to research the characteristics of living organisms and the unique attributes of viruses. Encourage the use of reliable scientific sources, articles, and textbooks to gather information.
☐ Guide students in constructing clear and concise arguments based on their research findings. Emphasize the need for logical reasoning, evidence-based claims, and support from relevant scientific literature.
☐ Conclude the debate with a class discussion, encouraging students to reflect on the strengths and weaknesses of each argument.
GENERAL CLASSROOM IMPLEMENTATION RESOURCES:

- **Weekly Khan Academy Quick Planning Guide**: Use this template to easily plan your week using Khan Academy.
- **Student Learning Templates**: Choose a template for students to record their learning. There are templates for watching videos, reading articles, and doing exercises.
- **Using Khan Academy in the Classroom**: Learn about teaching strategies and structures to support your students in their learning with Khan Academy.
- **Differentiation Strategies for the Classroom**: Read about strategies to support the learning of all students.