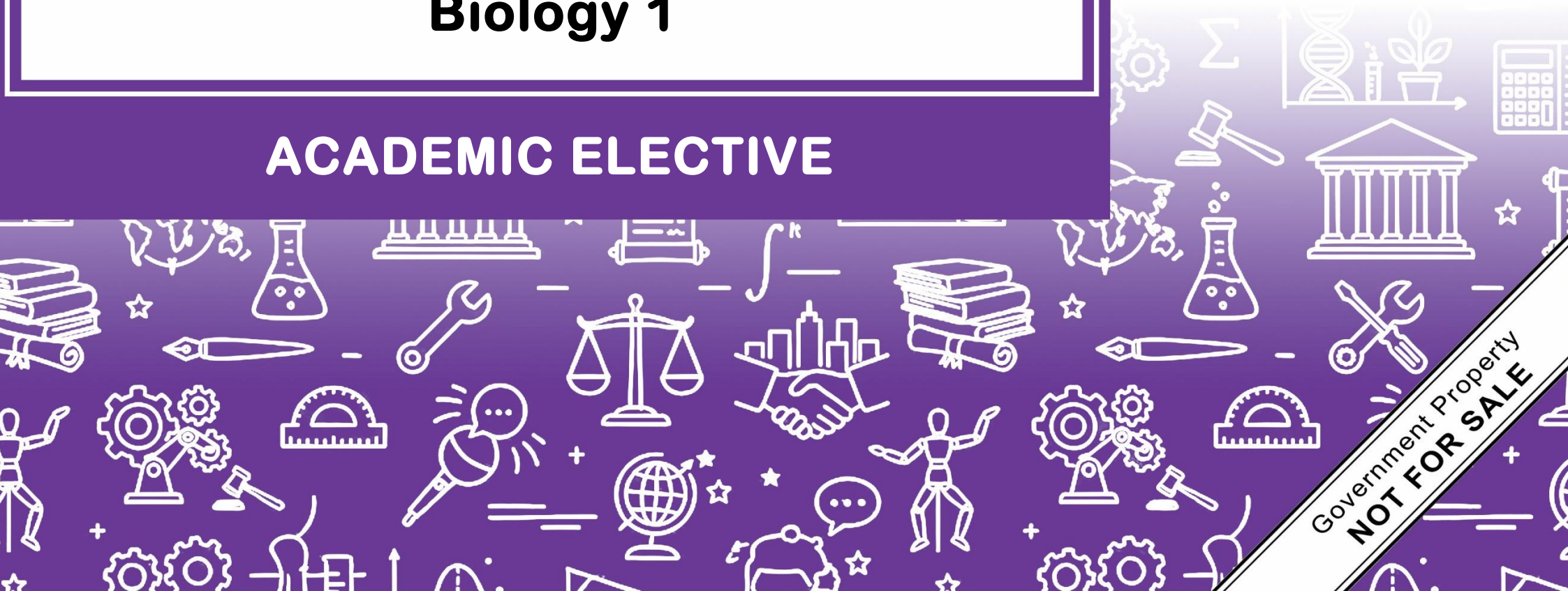
Strengthened Senior High School

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Lesson Exemplars for Biology 1

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Lesson Exemplar for Biology 1

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Table of Contents

The Cell **1**
The Cell **13**
Cell Theory in Action **25**
Classification of Cells Based on Distinguishing Structures and Functions **37**
The Cell Cycle **50**
Differentiating Structural Features of Prokaryotic vs. Eukaryotic Division **63**
Cell Cycle **75**
Cell Cycle **86**
Transport Mechanism **99**
Structural Components and Role of the Cell Membrane **110**
Cellular Abnormalities and Their Roles in Diseases **121**
Autotrophs, Chloroplasts, and Photosynthesis **133**
Cell Requirements: Chlorophylls and Other Pigments **145**
Photosynthesis: An Overview **157**
Metabolism – Photosynthesis **168**
Metabolism – Photosynthesis **179**
Metabolism – Respiration **191**
Metabolism – Respiration **203**
Metabolism – Respiration **216**
Metabolism – Respiration **233**

Lesson Title/Topic	The Cell	Lesson Exemplar	1

I. OBJECTIVES	
A. Content Standard	The learners learn that the cell theory is significant in explaining the structure and function of all living organisms.
B. Performance Standard	By the end of the quarter, learners discuss the scientific value of the interconnectedness of living organisms and their environment. They evaluate the significance of cell theory and its development in explaining the structure and function of living organisms. Learners classify cells based on their structures and functions, explain the stages and significance of the cell cycle, and describe the mechanisms of passive and active transport in maintaining homeostasis. They participate in practical activities and create presentations that showcase how these biological principles contribute to growth, repair, reproduction, and the diversity of life.
C. Learning Competencies	***Prerequisite Knowledge and Skills*** Prior to this lesson, learners are expected to have acquired basic knowledge and skills from previous grade levels that will help them understand the development of cell theory. They should be able to distinguish living from non-living things and describe the characteristics of living organisms, recognize that cells are the basic unit of life, and understand the levels of biological organization such as cells, tissues, organs, and organ systems. Learners are also expected to know that scientific knowledge develops through the contributions of different scientists over time and that microscopes are tools used to observe objects too small to be seen by the naked eye. In terms of skills, they should be able to read and interpret informational texts, gather facts from secondary sources such as books and websites, arrange events in chronological order, compare ideas of different scientists, take notes, summarize information, and communicate their understanding through oral or written responses using appropriate scientific vocabulary. These prior knowledge and skills may also serve as a basis for diagnostic assessments to determine learners' readiness for the lesson.
	The learners use information from secondary sources to prepare a historical analysis to explain the significant contributions of scientists, including Robert Hooke, Antoine van Leeuwenhoek, Matthias Schleiden, and Rudolf Virchow, to the development of cell theory.
II. REFERENCES and MATERIALS (*Selecting Resources and Material*)	*Britannica, The Editors of Encyclopaedia. n.d. "Antonie van Leeuwenhoek." Encyclopedia Britannica. Accessed March 12, 2026. https://www.britannica.com/biography/Antonie-van-Leeuwenhoek.* *Britannica, The Editors of Encyclopaedia. n.d. "Matthias Jakob Schleiden." Encyclopedia Britannica. Accessed March 12, 2026. https://www.britannica.com/biography/Matthias-Jakob-Schleiden.* *Britannica, The Editors of Encyclopaedia n.d. "Robert Hooke." Encyclopedia Britannica. Accessed March 12, 2026. https://www.britannica.com/biography/Robert-Hooke.*

	Science Insights. 2024. "What Did Rudolf Virchow Contribute to the Cell Theory?" Accessed March 12, 2026. https://scienceinsights.org/what-did-rudolf-virchow-contribute-to-the-cell-theory.	
III. CONTENT	The Cell	
IV. OBJECTIVES *(Setting Clear Objectives and Analyzing the Tasks)*	1. Determine relevant information from secondary sources on the works of Robert Hooke and Antoine van Leeuwenhoek, leading to the discovery of the cell 2. Determine relevant information from secondary sources on the works of Matthias Schleiden and Rudolf Virchow, leading to the formulation of the cell theory 3. Prepare a historical timeline on the development of cell theory 4. Explain the historical development of cell theory using the prepared historical timeline	
IV. PROCEDURES		**ANNOTATIONS**
A. Activating Prior Knowledge	***A.1. Activating Prior Knowledge***	
	Check learners' prior knowledge by conducting the following activities: ***Ask the following questions to the students:*** 1. *Why is the cell considered the basic functional unit of life?* 2. *With the size of cells invisible to our eyes, how did scientists in the past come up with the concept of cells?* *Students will answer this question through Think-Pair-Share. If the internet is available, the teacher can use Padlet.com to ask paired students to encode their answers online. Afterwards, tell the students to browse through the answers of other pairs and solicit ideas from them on what response piqued their interest.* *Alternatively, students may write their answers on a sheet of paper and then exchange their responses with at least two (2) pairs of classmates. Afterwards, pin their answers on a Thought Board and ask volunteers from the class which idea piqued their interest and why.* ***Bridging Question**: "How do you think scientists were able to study something they cannot see with the naked eye?"* *From their responses, ask the students to describe a cell and how it served as basic functional units of all living things.*	*This activity targets objectives 1 and 2 by recalling information from past lessons relevant to the concept of cells, which will later be connected to the scientists in the succeeding activities. This activity is guided by the Relevance and Responsiveness principles by allowing learners to actively construct ideas based on their prior knowledge. Constructivist and collaborative approaches are utilized by recalling and building on their existing knowledge and sharing with other learners for inputs and feedback. The strategy applied to this part is scaffolded instruction with collaboration to recall the connected concepts to the lesson. As a note to the teacher, provide clues and stimulate thinking and recall through the art of questioning.*
	A.2. Establishing the Purpose of the Lesson	
	Present a brief discussion about studying about the past. Guide brainstorming using the guide questions to keep discussions focused and	*This activity targets Objectives 1 and 2 by showing the value of studying the past and learning from it. It reflects the IDF principle*

	manage time effectively. The students will brainstorm on the following questions: 1. *In Science, why is studying about the past important in advancing knowledge?*	*of Relevance as learners connect past experiences to scientific advancement through the work of past scientists. Using the 2C-2I-1R approach, it promotes Reflective and Integrative learning. The activity uses the TDAR method.*
B. Instituting New Knowledge	***B.1. Presenting Examples***	
	The teacher will present pictures of Antonie Van Leeuwenhoek, Robert Hooke, Matthias Schleiden, and Rudolf Virchow. Present their occupation, societal role, and origin. *Ask the students the following question:* 1. *How did these individuals' different backgrounds and tools help us discover what all living things are made of?* 2. *Is it necessary to be recognized as a scientist to contribute to the advancement of scientific knowledge?* 3. *What could you learn from the lives of these scientists based on their educational background, profession, societal role and origin?*	*This activity targets Objectives 1 and 2 by introducing scientists who contributed to the development of cell theory. It follows the IDF principle of Reflection, helping learners understand how scientific knowledge builds through cumulative discoveries. Using the 2C-2I-1R approach, it promotes Reflective learning as students examine scientists' contributions to the cell concept and cell theory. If learners struggle, use cue questions, probing questions, or clues to guide them toward the desired response.*
	B.2. Discussing New Concept	
	The teacher will provide several sources of information for the students to analyze and gather information about the contributions of Antonie Van Leeuwenhoek, Robert Hooke, and Matthias Schleiden. *The following options are available as secondary sources:* ***Option 1 (Rigid Source)*** *Access the following link about the biography of the following scientists:* *Antonie Van Leeuwenhoek:* *https://www.britannica.com/biography/Antonie-van-Leeuwenhoek* *Robert Hooke:* *https://www.britannica.com/biography/Robert-Hooke* *Matthias Schleiden:* *https://www.britannica.com/biography/Matthias-Jakob-Schleiden* *Rudolf Virchow:*	*This activity targets objectives 1 and 2 by providing reading materials and/or internet resources to students to look for relevant information about the scientist's work that led to the development of cell theory. This is guided by the Responsive and Reflective instruction of the Instructional Design Framework. This uses an Integrative, Collaborative, Inquiry-based and Reflective framework by allowing students to look for relevant works of the scientists, connect science with their societal roles, occupation and origin, engage with the sharing of ideas with other learners eventually leading to*

	https://scienceinsights.org/what-did-rudolf-virchow-contribute-to-the-cell-theory ***Option 2 (Flexible Source)*** *Ask the students to browse information from the Internet, books, learning modules, available in the classroom about the works of the following scientists leading to the development of cell theory:* - *Antonie Van Leeuwenhoek* - *Robert Hooke* - *Matthias Schleiden* - *Rudolf Virchow* ***Option 3 (Reading Option)*** *Print the following excerpt summary that will serve as the learners' reading material about the four scientists. Access the reading material here:* *https://drive.google.com/drive/folders/1lsZMfct_YqCpra4Ctu23iaIxQLxO1Hqj?usp=drive_link* *Access the activity sheet for table completion here:* *https://drive.google.com/drive/folders/1lsZMfct_YqCpra4Ctu23iaIxQLxO1Hqj?usp=drive_link* *Guide Questions:* 1. *What observations did you make as time passed by from one scientist to another?* 2. *How did these discoveries contribute to the development of cell theory?* 3. *How did each concept evolve over time? Are these changes beneficial or harmful contributions to science? Why?* *Engage students in brainstorming the contributions of each scientist and highlight the importance of each contribution to the development of cell theory.* ***Quick Checks!*** *Ask the following to the students after the brainstorming:* ✓ *Robert Hooke – What did he observe?* ✓ *Antonie Van Leewenhoek – what did he do to the microscope? What did he observe in his microscope?*	*reflection on their researched information. Brainstorming, guided inquiry and guided instruction were used in this activity. The teacher shall select option most convenient to the learning context of the learners (e.g. availability of Internet). Guide the learners while looking for relevant information. Engage the learners in meaningful discussion through art of questioning.* ***Teacher Notes for misconception:*** 1. *Virchow is widely credited in school biology for popularizing the principle that cells arise from pre-existing cells, though earlier works also contributed to this idea.* 2. *Emphasize that Robert Hooke observed cork and described DEAD CORK cells leading to the term cells. Debunk ideas that he first discovered living cells.* 3. *Emphasize Schleiden emphasized that cells made up all plants and Schwann extended this idea to animals leading to the broader cell theory for all organisms.* 4. *Theodor Schwann may be introduced as an important contextual figure who extended cell theory to animals, but the core assessed scientists in this lesson remain in those named in the competency.* 5. *Clarify to students that Hooke observed cork, a dead tissue from the bark of a tree hence, he only observed dead cells at his time. Discovery of cells served as the jumpstart of the development of cell*

	✓ *Matthias Schleiden –What idea did he came up with observing plant cells? Who did he inspire to do parallel work? How did their idea contribute to the cell theory?* ✓ *Rudolf Virchow – hat idea did he contribute to the cell theory?*	*theory. Virchow's statement encompasses biogenesis in the cellular level.*
	B.3. Developing Mastery	
	Historical Timeline Construction *Each group of students will prepare a historical timeline of events leading to the development of the cell theory based on data they have filled into the Table 1. Relay the following instructions to the learners:* 1. *Identify key dates. List the important years in which each scientist made their contribution.* 2. *Compute the timeline scale. Indicate a scale to proportionate the distance to the year gap between each discovery.* 3. *Draw the base timeline. The progression of time must be ascending towards the present from left to right.* 4. *Plot the years proportionally.* 5. *Label each year with the scientist and a brief description of their contributions.* 6. *Use visual organization e.g. color coding, symbols, pictures, arrows etc.* *The students will present their outputs to the class. Solicit feedback from students for peer feedback and provide teacher feedback.* ***Teacher's Checkpoints:*** ● *Robert Hooke – 1665 – observed cork cells under microscope; coined the term "cells"* ● *Antonie Van Leeuwenhoek – 1674 – observed living protists using his enhanced microscope; and 1676 – observed living bacteria* ● *Matthias Jakob Schleiden with Theodor Schwann – 1838 for Schleiden – observed plant tissue and contributed the idea that all plant tissues are made of cells and 1839 for Schwann – studied animal tissues and extended Schleiden's idea to animals.* ● *Rudolf Virchow – 1855 – popularized the principle that new cells arise from pre-existing cells (omnis cellula e cellula), strengthening cell theory at the cellular level. Use Rubric 1 (Historical Timeline) in the appendices to assess accuracy, chronology, explanation of significance, visual organization, and use of evidence.*	*This activity targets objective 3. The learners will prepare a timeline using the data they consolidated in Day 2. This falls within the Relevant guiding principle of delivery by consolidating the researched information into a timeline that requires knowledge from other discipline e.g. computation of line proportion and using visual graphics. This activity is collaborative, integrative and reflective. Learners collaborate to construct their timelines, integrate skills learned from other disciplines and reflect through peer and teacher feedback. This employs project-based learning by requiring an output from the students. Teacher must guide students while working their time to formatively assess their outputs for suggestions and inputs.* ***Teacher's Note:*** ● *Debunk ideas that the discovery of cells is the same as the development of the cell theory. The discovery of the cell is a pioneering breakthrough in the advancement of cell theory. If learners confuse Hooke with living cells and Leeuwenhoek with the discovery of cells, regroup the students and remediate by asking*

	Expected Output: *Accomplished historical timeline with labels and proper length-time proportion* *Access the rubric for evaluating historical timeline here:* *https://drive.google.com/drive/folders/1lsZMfct_YqCpra4Ctu23iaIxQLxO1Hqj?usp=drive_link*	*questions that lead to accurate answers.*
C. Demonstrating Knowledge and Skills	***C.1. Finding Practical Application***	
	Begin by asking the students the significant contributions of each scientist that led to the development of cell theory. Use the data from the reading materials in these tasks. Then students will be grouped accordingly to choose from the following task options suited to their interest: *Option 1:* ***Debate*** ● *Assign each student or group a scientist: Hooke, Leeuwenhoek, Schleiden, or Virchow.* ● *Each group prepares a* ***short presentation*** *as their scientist, explaining:* ● *what they discovered* ● *how it contributed to cell theory* ● *why it was significant* ● *Conduct a classroom debate:* ● *What are the limitations of each scientist' contribution? How did these become a starting point for other scientists to work on these limitations?* *Expected Output Performance: Rational arguments about the limitations of each scientist' contribution.* *Rubric for evaluating Debate:* *https://drive.google.com/drive/folders/1lsZMfct_YqCpra4Ctu23iaIxQLxO1Hqj?usp=drive_link* *Option 2:* ***Milestone checkpoint*** ● *Students will create a timeline of different milestones that led to the development of cell theory. Provide significance for each milestone.* *Example:*	*This activity targets objective 1 and 2. This is guided by the Responsive, Reflective framework of the Instructional Design Framework. Collaborative, Integrative, and Reflective framework of the 2C-2I-1R pedagogical framework. All activities employ collaboration by working as groups. Skills from other disciplines can be used in any of these activities e.g. communication thru debate, logical reasoning thru cause-and-effect, prediction thru scenario imagination, visual graphics thru caricature. This is a differentiated instruction where learners choose a task according to their interest and strengths.* ***Teacher's note****:* *These application tasks should help learners explain how evidence from different scientists accumulated to form the cell theory and shape modern biological understanding. Identify gaps from their presentations and reteach as needed.*

	Discovery of cells by Robert Hooke – this paved the way for Antoine van Leewenhoek to create more powerful lenses for improved microscopy. *Option 3:* ***The Scenario Overthinker*** ● *Students will predict the outcome in the present based on the following scenario. Present this in the form of a cartoon or caricature in digital or physical format.* *<u>Scenario 1: Hooke's Discovery</u>* *Question: What if Robert Hooke had never looked at cork under a microscope and Leeuwenhoek had not improve the resolving power of microscopes?* *Scaffolding questions:* ● *How might this have affected Schleiden, Schwann, and the later development of cell theory?* ● *Would biology have advanced differently? Explain your reasoning.* *<u>Scenario 2: Leeuwenhoek's Microscope</u>* *Question: What if Antonie van Leeuwenhoek had not built microscopes capable of observing microorganisms?* *Scaffolding questions:* ● *How would this have changed scientists' understanding of living cells?* ● *What discoveries might have been delayed, and what would be the impact on medicine or microbiology?* *<u>Scenario 3: Schleiden and Schwann</u>* *Question: Imagine Schleiden or Schwann had concluded that cells are not the basic unit of life.* *Scaffolding questions:* ● *How would this have influenced the formulation of cell theory?* ● *What implications might this have had for understanding plant and animal biology?* *<u>Scenario 4: Virchow and Cell Continuity</u>* *Question: What if Virchow had not proposed that all cells arise from pre-existing cells?* *Scaffolding questions:* ● *How might ideas like spontaneous generation have persisted?*	

	● *How would this have affected medicine, disease study, and cellular pathology?* *Expected output: Poster or digital poster portraying the world situation in each chosen scenario.* ***Evidence Requirement for All Major Tasks:*** *Each group output must include at least three historically accurate facts from the provided secondary sources, with the scientist's name, year, and contribution clearly stated.*	
	C.2. Making Generalization	
	Activity 1: Timeline Gallery Walk *Ask students to display their timelines. Let learners observe other groups' work briefly.* *Ask the learners to recall the following scientists, dates, and significant contributions:* ● *Robert Hooke – 1665 – observed cork cells under the microscope; coined the term "cells"* ● *Antonie Van Leeuwenhoek – 1674 – observed living protists using his enhanced microscope, and 1676 – observed living bacteria* ● *Matthias Jakob Schleiden, with Theodor Schwann – 1838 for Schleiden – observed plant tissue and proposed that all plant tissues are composed of cells; 1839 for Schwann – studied animal tissues and extended Schleiden's idea to animals.* ● *Rudolf Virchow – 1855 – he discovered that all new cells arise from pre-existing cells* *While observing, ask them to think about:* ● *What pattern do you notice in the discoveries?* ● *How did one discovery lead to another?* ***Activity 2:*** *Matching Type. Match the scientist to their contribution.* *_____1. Hooke A. observed cork* *_____2. Leeuwenhoek B. cells continuity* *_____3. Schleiden C. observed living cells* *_____4. Virchow D. Plants are made of cells* ***Activity 3: 4-3-2-1***	*This activity targets objectives 1, 2, 3, and 4. This employs the reflective component of the Instructional Design Framework. Constructivist, collaborative, and reflective framework of 2C-2I-1R pedagogical framework. The timeline gallery walk will help learners recall the historical timeline of the development of the cell theory and reflect on how one discovery leads to another.*

	Ask the students to write down the following on a sheet of paper: *4 scientists, 3 discoveries, 2 important dates 1 synthesized statement of the cell theory based on the contributions of the all the scientists discussed* ***Readiness Check:*** *Arrange Hooke, Leeuwenhoek, Schleiden, and Virchow in chronological order and write one sentence explaining how each contribution led to the next. Use responses to determine who is ready for the end formative assessment and who needs additional scaffolding.*	
	C.3. Evaluating Learning	
	Guided Questions ***About the development of cell theory:*** ● *What are the contributions of the following scientists to the development of cell theory? (Use the following questions for scaffolding)* ✓ *Robert Hooke – What did he observe? What term did he come up with from this observation?* ✓ *Antonie Van Leewenhoek – what did he do to the microscope? What did he observe in his microscope?* ✓ *Matthias Schleiden –What idea did he come up with while observing plant cells? Who did he inspire to do parallel work? How did their idea contribute to the cell theory?* ✓ *Rudolf Virchow – what idea did he contribute to the cell theory?* ● *What is the sequence of events/significant contributions of each scientist that led to the development of cell theory?* ***About scientific development:*** ● *What does the timeline show about how scientific knowledge develops?* ● *What will happen if a scientist fails to contribute one of the ideas of cell theory?* ● *Why is it important to study historical contributions in science?*	*This activity targets objectives 1, 2, and 4. The reflective component of the Instructional Design Framework is used. The pedagogical framework of this activity revolves around reflective and integrative components. Historical accounts led to the development of cell theory, which integrates history into science. Guided reflection is used in this activity.* ***Note to Teachers****: Re-teach the sequence of contributions if learners confuse Hooke and Leeuwenhoek and provide a short comparison task if learners cannot explain how one discovery built on another.*

	Exit Ticket: *(1) State Robert Hooke's contribution in one sentence. (2) Explain how Leeuwenhoek's improved microscope advanced cell study. (3) Identify Schleiden's contribution and its significance. (4) Explain Virchow's contribution and why it matters to cell theory.*	
	C.4. Additional Activities	
	Choose from the following options to enrich the learning of the learners: ***Option 1:*** *Watch the video about cell theory development https://www.youtube.com/watch?v=4OpBylwH9DU and connect additional information to the discussion in a 100 – 150-word essay.* ***Option 2:*** *Research on how cancer cells proliferate in the body and relate to Rudolf Virchow's work to oncology, histology, microbiology, and pathology. Explain in 3 – 5 sentences how cell theory supports modern medicine, such as pathology, microbiology, histology, and oncology.* ***Option 3:*** *Reflect on how cumulative knowledge and collaboration contribute to scientific knowledge advancement. Write your reflection in 3 – 5 sentences.*	*This activity targets objectives 1, 2 and 3. Relevant, Responsive and Reflective framework of the IDF is used. A constructivist, inquiry-based and reflective pedagogical framework was used. Differentiated instruction is employed by giving learners the flexibility to choose their learning task to enrich learning. The teacher must follow up if learners need additional learning through guided questions.*
V. ASSESSMENT *(Assessing Learnings)*	*I.* ***Multiple Choice****. Choose the letter of the BEST answer:* *1. Which of the following breakthroughs was contributed by Robert Hooke and Antoine van Leeuwenhoek?* *A. Cellular reproduction* *B. Use of a microscope in observing cells* *C. All cells came from pre-existing cells.* *D. Cells are the basic functional units of animals and plants.* *2. Which contribution best distinguishes Antonie van Leeuwenhoek in the history of cell theory?* *A. He observed cells in 1665.* *B. He observed pollens, sperm cells, and muscle fibers.* *C. He proposed that cells arose from pre-existing cells.* *D. He enhanced the microscope's resolution by increasing the magnification to 300x.* *3. Which of the following ideas is most directly associated with Matthias Schleiden?* *A. Omnis cellula e cellula* *B. Plants are composed of cells.* *C. Bacteria arise from pre-existing bacteria.* *D. Animals are composed of functional units called cells.* *4. Which of the following is the correct sequence of discoveries/contributions of scientists in the development of cell theory?*	

I. Schleiden II. Virchow III. Leeuwenhoek IV. Hooke

A. IV-III-I-II B. III-IV-II-I C. I-II-III-IV D. I-IV-II-III

5. *Which of the following is founded on the concept that a cell arises from pre-existing cells?*
   A. Metabolism B. Cell locomotion C. Cellular reproduction D. Hierarchy of organization
6. *What did Robert Hooke observe, leading him to coin the term "cell"?*
   A. Tiny compartments in cork
   B. Clumps of pollen from a flower
   C. Sperm cells are immersed in seminal fluid
   D. Strands of muscle fibers from venison meat
7. *What idea is most closely associated with Rudolf Virchow in the history of cell theory?*
   A. Plants are made up of cells.
   B. Animals are made up of cells.
   C. All living things are made of cells.
   D. New cells arise from pre-existing cells.
8. *Why is Antonie van Leeuwenhoek's microscope a breakthrough in advancing the study of cells?*
   A. No microscope was ever invented during Robert Hooke's time.
   B. He was the first to use a microscope to observe cells in plants and animals.
   C. Leeuwenhoek's microscope was recognized by the Royal Society of London.
   D. He improved the magnifying power of previous microscopes, thus enabling better observation of cells.
9. *If Robert Hooke did not discover the cell, what would be the possible consequences to other scientists who contributed to the development of cell theory?*
   A. Scientists would have abandoned the study of living organisms entirely.
   B. Cell theory would have developed exactly the same way, without any delay.
   C. The discovery of cells would have prevented other scientists from contributing to biology.
   D. Other scientists might have lacked a key observation to build upon, potentially slowing the development of cell theory.
10. *If Antonie van Leeuwenhoek had not improved the magnifying power of microscopes, which scientific development would most likely have been delayed?*
   A. Observation of microorganisms and living cells
   B. Discovery of DNA structure
   C. Development of vaccinationD. Discovery of photosynthesis

Answer Key: 1.B 2.D 3.B 4.A 5.C 6.A 7.D 8.D 9.D 10.A

II. ***Timeline Construction.***

Using secondary sources, research the specific contributions of Hooke, Leeuwenhoek, Schleiden, and Virchow to construct and explain a chronological timeline that traces the transition from the first discovery of cells to the formal establishment of Cell Theory. Explain the how scientists' contribution built of cell theory over time using the timeline

	you have constructed. Students may use Manila paper or cartolina in presenting their outputs. Access rubric for evaluating here: https://drive.google.com/drive/folders/1lsZMfct_YqCpra4Ctu23iaIxQLxO1Hqj?usp=drive_link
VI. REFLECTION *(Feedback and Continuous Improvement)*	*Use the following reflection prompts to guide your evaluation of the lesson after implementation. Reflect on learners' performance, determine which activities and lesson parts were most and least effective, identify learners who need enrichment or remediation, analyze the assessment results, and note possible improvements to enhance future lesson delivery.* *• How many learners successfully demonstrated the learning objectives based on the assessment results?* *• Which activity helped learners understand the lesson the most? Which activity helped the least?* *• Which part of the lesson was easiest for learners? Which part was most difficult?* *• How many learners needed enrichment or additional challenge? How many learners needed remediation or additional support?* *• What did the assessment results show about learners' understanding of the lesson?* *• What improvement would you make if you taught this lesson again?* *• Which misconception persisted after the lesson, and what change in instruction would better address it next time?*
VII. USE OF GENERATIVE AI	In preparing this Learning Exemplar (LE), the author used ChatGPT to summarize contents from website references and create rubrics for evaluating students' outputs. The author reviewed and finalized the writing of the content. The author takes full responsibility for the content of this LE.

Lesson Title/Topic	The Cell	Lesson Exemplar	2

I. OBJECTIVES	
A. Content Standard	The learners learn that the cell theory is significant in explaining the structure and function of all living organisms.
B. Performance Standard	By the end of the Quarter, learners describe the processes of photosynthesis and cellular respiration and explain how these cellular mechanisms transform energy for life. They describe the role of cell structures in photosynthesis and differentiate the light-dependent and light-independent reactions. Learners describe the stages of cellular respiration, including glycolysis, the citric acid cycle, and the Electron Transport Chain, and explain their role in ATP production for cellular activities. They also participate in experiments to create models and presentations that demonstrate how these processes sustain ecosystem stability and support life functions.
C. Learning Competencies	***Prerequisite Knowledge and Skills*** Prior to this lesson, learners are expected to have acquired basic knowledge and skills from previous grade levels that will help them understand the differences and advantages of light and electron microscopes in the study of cells. They should know that cells are the basic unit of life and that many cell structures are too small to be seen with the naked eye, making microscopes important tools in science. Learners are also expected to understand parts and functions of a simple light microscope, proper handling of laboratory equipment, and awareness that advances in technology improve scientific investigations. In terms of skills, they should be able to observe and compare objects, interpret diagrams and images, gather information from secondary sources such as books and websites, organize facts using tables or charts, and communicate ideas clearly through oral or written responses using appropriate scientific vocabulary. These prior knowledge and skills may also serve as a basis for diagnostic assessments to determine learners' readiness for the lesson.
	The learners use information from secondary sources to explain the differences and advantages between the light microscope and the electron microscope in the study of cells.
II. REFERENCES and MATERIALS (*Selecting Resources and Material*)	*Test and Measurement World. "SEM vs TEM: Understanding the Differences." Accessed March 12, 2026. https://www.test-and-measurement-world.com/articles/material-science/sem-vs-tem-understanding-the-differences.* *Schädler, Kevin. "An Introduction to the Light Microscope, Light Microscopy Techniques and Applications." Technology Networks. Last modified December 18, 2023. Accessed March 12, 2026. https://www.technologynetworks.com/informatics/articles/an-introduction-to-the-light-microscope-light-microscopy-techniques-and-applications-351924.* *Alberts, Bruce, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, and Peter Walter. Molecular Biology of the Cell. 6th ed. New York: Garland Science, 2014.* *"In the Lab – Complete Blood Count (CBC)." YouTube video, 7:16. January 7, 2015. https://www.youtube.com/watch?v=7kqpOz5VfU0.*
III. CONTENT	The Cell

<table>
<tr><td>IV. OBJECTIVES
(Setting Clear Objectives and Analyzing the Tasks)</td><td colspan="2">1. Determine information from secondary sources about the structure of the light microscope and explain how it forms an image
2. Determine information from secondary sources about the structure of SEM and TEM and explain how each forms an image.
3. Compare and contrast light microscopes and electron microscopes in terms of resolution, magnification, specimen preparation, applications, and limitations.
4. Explain, using evidence from secondary sources, situations in which light microscopes, SEM, or TEM offer specific advantages in cell study.</td></tr>
<tr><td colspan="2">IV. PROCEDURES</td><td>ANNOTATIONS</td></tr>
<tr><td rowspan="2">A. Activating Prior Knowledge</td><td colspan="2">A.1. Activating Prior Knowledge</td></tr>
<tr><td>Option 1 Scientist Recall
The teacher will show pictures of scientists (Hooke, Leewenhoek, Schleiden and Schwann and Virchow) who made contributions to the development of the cell theory. Then the learners will recall the names of each scientist. Ask the learners the following questions:
1. What important contributions did these scientists make to the study of the cell and what invention made this study possible?
2. How has the microscope improved over time? What types are used today and how prototypes help in the development of scientific knowledge?
3. What do you want to know about microscopes?
Option 2 Expected Output: K-W-L Chart
Guide learners in completing the K-W-L chart by eliciting their prior knowledge of microscopes, encouraging them to generate relevant questions about their structure, function, and applications, and directing them to reflect on and record their new learning after the lesson.
<table><tr><td>What I Know</td><td>What I Want To Know</td><td>What I Learned</td></tr><tr><td></td><td></td><td></td></tr></table>The following guide questions may be used by teacher to help students accomplish the KWL chart:
What I know
● What are microscopes used for?
● What things can we see using a microscope?
● Do you think all microscopes are the same? Why or why not?</td><td>These activities collectively target Learning Objectives 1, 2, 3, and 4 by facilitating the gathering of information on microscope structures and setting the stage for comparing their specific applications in cell study. They manifest the IDF guiding principles of relevance, responsiveness, and flexibility by bridging historical scientific contributions with curiosity. Among the 2C-2I-1R approaches, the options demonstrate Constructivist, Inquiry-based, and Collaborative features, as students actively build upon prior knowledge, formulate their own investigative questions via the K-W-L chart, and engage in meaningful exchange during the brainstorming. The specific pedagogical methods applied include visual discovery, metacognitive mapping, and ICT-integrated discussion, all supported by teacher facilitation to help students begin distinguishing between the resolution and magnification capabilities of light and electron microscopy. Teacher Note: Explicitly use the "What I Want to Know" column to categorize student questions into technical specs (resolution/magnification) and practical applications; this ensures that when you transition to secondary sources, students are already primed to look for the specific data points required for their</td></tr>
</table>

	● *Who are the scientists who used microscope to study microscopic living organisms?* *What I want to know* ● *What do you want to know about light microscopes?* ● *What do you want to know about electron microscopes?* ● *What objects can each microscope observe?*	*comparative analysis. You may use the guide questions in Option 2 to guide learners in their responses. These questions will help you guide students in gathering the expected responses from your students.*
	A.2. Establishing the Purpose of the Lesson	
	This activity leads to understanding the need for microscopes in studying cells. ***Option 1*** *(Use this option when access to ICT is available and when the teacher intends to anchor the lesson in real-world professional contexts, such as healthcare, to highlight the relevance and practical application of microscopes.)* *Let the students watch a video showing how blood cells are examined in laboratory practice and discuss how microscopes help medical technologists observe structures too small to be seen clearly with the naked eye.* *Youtube video link:* *https://www.youtube.com/watch?v=7kqpOz5VfU0* *Ask the following guide questions to the students:* 1. *How small are our blood cells?* 2. *If our blood cells are very small, how do medical technologists view them?* 3. *Aside from viewing blood cells, how do pathologists and medical scientists provide data of cells that will lead to diagnosis of diseases?* ***Option 2*** *(Use this option when ICT resources are limited or when the teacher intends to provide a concrete, experiential introduction by using locally available materials to help learners visualize scale and understand the need for microscopes.)* 1. *Group the students accordingly. Give each student samples of specimens (such as Corn kernel, Rice, Ground pepper, Saluyot seed, Sand, Dust, Pollen) where students will compare their sizes and visualize their appearance as clearly as they can:*	*These activities target Learning Objectives 1, 2, and 4 by establishing the practical necessity of microscopic tools through real-world medical contexts and physical scaling exercises. They manifest the IDF's guiding principles of relevance, responsiveness, and inclusivity by grounding scientific inquiry in local and professional contexts—using indigenous specimens such as Saluyot seeds alongside professional healthcare scenarios, such as blood cell counting.* *Among the 2C-2I-1R approaches, the options demonstrate Inquiry-based, Integrative, and Collaborative features, as they challenge learners to confront the limitations of human vision and integrate biological concepts with medical technology. The specific pedagogical methods applied are Contextualized Learning and Discovery Learning, supported by teacher-facilitated guided questioning that bridges the gap between a student's mental visualization and the technical reality of image formation.* ***Teacher note**: use the transition from the "dust and pollen" activity to the "blood cell" video to explicitly discuss the concept of resolution; ask students why a corn kernel can be seen clearly by the eye while a blood cell requires a microscope, setting a strong foundation for the upcoming comparison of light and electron microscopes. This activity leads to*

	2. *Show enlarged images of the samples and discuss that making an image bigger is not the same as increasing its resolution or revealing fine detail.* 3. *Instruct students to look for the fine details of the specimens as close as they can.* 4. *Ask the students to visualize what do they thinks these specimens look like up when magnified further beyond their vision.* *Guide questions:* 1. *Which of the samples matched with your visualized image? Which did not?* 2. *How do we get a picture of very small specimens for close-up study?* 3. *What do you think are the needed specifications of a microscope to see what you would like to observe in the samples?*	*understanding the need for microscopes in studying cells.* ***Safety Note:*** *Use only small, sealed, clearly labeled sample containers. If any learner has allergies or respiratory sensitivity, replace dust and pollen with teacher-prepared photographs or enlarged printed images. Learners must not smell, blow, or directly touch powdered materials.*
B. Instituting New Knowledge	***B.1. Presenting Examples***	
	In Science, measurement is used to provide quantitative data on the 2D dimensions of samples. 1. *To give students idea on the scale of measurement, use a progression of division as follows:* *1 meter → full rope length* *1 decimeter → 1/10 of rope length* *1 centimeter → 1/100 of rope length* *1 millimeter → 1/1000 of rope length* *1 micrometer (µm) → 1/1,000,000 of rope length* *1 nanometer (nm) → 1/1,000,000,000 of rope length* 2. *Present the sizes of the following specimens and provide size scale comparisons:* *(The goal is to introduce the scale and limitations of light microscopy.)* 1. *Basmati Rice grain – 7.5 mm* 2. *Pollen – 10 µm* 3. *Human egg cell – 100 µm* 4. *Human sperm cell head – about 5.1 x 3.1 µm* 5. *Streptococci – 500 nm* 6. *Picornaviridae virus – 20 nm*	*This activity specifically targets Learning Objectives 1, 2, 3, and 4 by using mathematical scaling to illustrate the physical limitations of light microscopy and the technical necessity of electron microscopy for observing nanoscale specimens like Streptococci and Picornaviridae. It manifests the IDF guiding principles of relevance and responsiveness by connecting abstract units of measurement to tangible local industries, such as shrimp hatchlings, pollination techniques, and jewelry assembly, ensuring the lesson is culturally and economically grounded. Among the 2C-2I-1R approaches, the activity demonstrates Integrative, Collaborative, and Inquiry-based features because it merges mathematical ratios (scaling) with biological history while requiring learners to brainstorm in pairs to deduce why certain specimens remained "invisible" to early scientists. The specific pedagogical methods applied are Contextualized Scaffolding and Think-Pair-Share, supported by teacher-facilitated*

	3. *Present a photo comparison of scale sizes of the presented specimens in the following order:* *Apple – Basmati Rice grain* *Basmati Rice grain – human egg cell* *Human egg cell – Pollen* *Pollen – Human sperm cell* *Human sperm cell – Streptococci* *Streptococci* – Picornaviridae virus* 4. *Then ask the following of the students:* a. *What sample can be seen by naked eye? What sample cannot be seen?* b. *Why is visibility limited? How do scientists study this sample?* c. *What do you think a microscope must have to overcome these limitations?* d. *Why do we need to study things that are not visible to our eyes?* 5. *Students can do Think-Pair-Share to brainstorm ideas to come up with answers to the questions above.* 6. *Leave stimulating questions by asking questions on how local products that needs microscopy are studied in your community e.g. shrimp hatchlings, pollination techniques, jewelry assembly etc. Then introduce the answers to these questions by doing the activity in discussion of new concept.* *Clarify that making an image bigger does not automatically increase detail and that the choice of microscope depends on the size of the specimen and the detail the observer needs to see.*	*"stimulating questions" that encourage learners to apply scientific concepts to their immediate community.* ***Teacher Notes****: Streptococcal cells are typically about 0.5–1.0 µm in diameter and may be seen with a light microscope, although fine structural detail is limited. Viruses such as picornaviruses (~20–30 nm) require electron microscopy. Emphasize that microscope choice depends on both specimen size and the level of detail needed. Light microscopes can be used to observe many bacteria, including streptococci, which are nanoscales, although fine structural detail is limited by the resolution of visible light microscopy. It is important to highlight that not all nanoscale objects are invisible under light microscopes. Electron microscopy becomes necessary for much smaller specimens such as viruses, and for ultrastructural details beyond the resolving power of a light microscope. Embed feedback during sharing of ideas to promote exchange of ideas and construction of knowledge.* ***Diagnostic Check****: Ask learners to classify the following as visible to the naked eye, visible only with a light microscope, or requiring electron microscopy: onion cell, pollen grain, bacterium, and virus. Use responses to identify misconceptions about magnification and resolution.*
	B.2. Discussing New Concept	
	Option 1 – Web-based Reading *Provide the following links to the students for them to access and extract information about light and electron microscopes:* ● *https://www.technologynetworks.com/informatics/articles/an-introduction-to-the-light-microscope-light-microscopy-techniques-and-applications-351924*	*These activities specifically target Learning Objectives 1 and 2 by requiring students to extract technical data regarding the structures and image formation processes of both light and electron microscopes. They manifest the IDF guiding principles of flexibility and accessibility by offering dual pathways for information gathering—web-based research for connected classrooms (Option 1) and detailed reading material for resource-limited or*

	• https://www.test-and-measurement-world.com/articles/material-science/sem-vs-tem-understanding-the-differences 1. *Skim and analyze the needed information for this activity by reading the table prepared for this activity. (Access the table thru this link: https://drive.google.com/drive/folders/1MLpy2Lb_OP3ek0VFRMeK9aq2CXjZWu-r?usp=drive_link* 2. *Read the web sources provided. Extract the needed data and fill out the provided table.* 3. *Create a flow chart on how image is formed in light microscopes. Explain how image is formed in each step.* ***Option 2 – Printed and Offline*** *The teacher provides a reading material for the students to gather information about light microscopes and electron microscopes.* *Instructions for learners:* 1. *Skim and analyze the needed information for this activity by reading the table prepared for this activity. (Access the table thru this link:* 2. *https://drive.google.com/drive/folders/1MLpy2Lb_OP3ek0VFRMeK9aq2CXjZWu-r?usp=drive_link* 3. *Read the printed materials provided.* 4. *Extract the needed data and fill out the provided table.* 5. *Create separate flow charts showing how images are formed in a light microscope, scanning electron microscope (SEM), and transmission electron microscope (TEM). For each step, write a one-sentence explanation of what happens to the light or electron beam and how the image is produced.* 6. *Explain how image is formed in each step.* ***Feedback checkpoints after table completion and flow chart construction:*** 1. *What microscope do you think is best suited for observing each sample provided beforehand?* 2. *What is the difference between resolution and magnification?*	*offline environments (Option 2)—ensuring no student is left behind due to technological constraints.* *Among the 2C-2I-1R approaches, the activities utilize Constructive and Inquiry-based features as learners are tasked with actively building their own knowledge base through data extraction and logical sequencing of complex scientific processes. The specific pedagogical methods applied are Differentiated Instruction (through varied resource types) and Graphic Organizing, which scaffold the transition from identifying individual components to understanding the systemic flow of magnification.* ***Teacher Notes:*** *Encourage students to highlight the "media" used in each microscope (light vs. electrons) in different colors in their flow charts; this visual distinction will serve as a critical mental anchor for the upcoming comparative analysis of resolution and magnification limits.* 1. *Teacher may divide the class into groups assigned for Light Microscope, TEM and SEM to reduce complexity and inputs and ask each group to present their outputs.* 2. *Provide guiding prompts or vocabulary support for learners who may struggle with technical source reading on image formation and electron microscopy.* 3. *Emphasize the difference between resolution and magnification.* 4. *Use the virtual simulation for electron microscopes in the "Additional activity" section to reinforce visualization and conceptualization.* 5. *Teacher may use any form of presentation available for the learners in their table presentation and flow chart presentation e.g. Manila paper, slide presentations etc.*

	3. *What are the differences in terms of resolution, magnification and image formation of each microscope?* ***Comparison of the Three Microscopes*** *Discuss the comparison of each microscope in terms of magnification and resolution. (Access the table of comparison thru this link:* *https://drive.google.com/drive/folders/1MLpy2Lb_OP3ek0VFRMeK9aq2CXjZWu-r?usp=drive_link* *Guide Questions:* 1. *How does the imaging medium affect the kind of detail a microscope can reveal?* 2. *Why is higher magnification alone not enough if resolution is poor?* *Expected Output: Completed tables in the provided activity sheet*	
	B.3. Developing Mastery	
	The learners, through the gathered data in the different tables they have filled out, will process the data and compare light microscopes and electron microscopes. *Access the H-map activity sheet here:* 1. *https://drive.google.com/drive/folders/1MLpy2Lb_OP3ek0VFRMeK9aq2CXjZWu-r?usp=drive_link* 2. *Divide the class into groups and, using their individual outputs from discussion, fill out the H-map below to compare the two types of microscopes.* 3. *Ask each group to assign members to comparison categories in terms of image formation, magnification, resolution, applications, and limitations. Present their outputs to class.* 4. *Ask each group to identify and present one response from another group that caught their attention Solicit feedback from peers and provide constructive feedback* *Expected Output: Accomplished H-map*	*This activity targets Learning Objective 3 by having students compare light and electron microscopes using prior research. It reflects IDF principles of flexibility and engagement through both Padlet and Thought Board options for sharing outputs. Using the 2C-2I-1R approach, it promotes Collaborative and Reflective learning through peer instruction and comparative analysis guided by a rubric focused on accuracy in key specifications.* ***Teacher Notes:*** *Have students identify limitations from other groups during exchanges. Ensure each H-map includes at least two supported comparison points. Outputs may be presented through Manila paper, digital slides, or an online board (e.g., Padlet) depending on available resources*
C. Demonstrating Knowledge and Skills	***C.1. Finding Practical Application***	
	Present the following situations to the learners: 1. *Cell samples were taken from a cancer patient for study of cancer cell organelles.*	*This activity specifically targets Learning Objective 4 by requiring students to rationalize and apply their understanding of microscope types to specific*

	2. *Onion root tip slides were prepared to study in a high school Biology class.* 3. *Examining cell membrane topology of antibiotic resistant strain of Helicobacter pylori extracted from a patient diagnosed with gastric ulcer patient.* *For each situation, identify the appropriate microscope and justify your answers based image formation, resolution, specimen preparation, or application. (light microscope, scanning electron microscope, transmission electron microscope):* 4. *Cell samples were taken from a cancer patient for study of cancer cell organelles (This requires high resolution due to nanoscopic sizes of organelles, and they are found inside the cell hence, TEM is the most suitable microscope for this instance.)* 5. *Onion root tip slides were prepared to study in a high school Biology class. (Simple preparation in a low-cost setting. Light microscope is best suited for this context as onion root tip cells are generally 14 – 17 micrometers hence Light microscope is best used.)* 6. *Examining cell membrane topology of antibiotic-resistant strain of Helicobacter pylori extracted from a patient diagnosed with gastric ulcer patient. (The surface of each individual cell is studied in detail thus SEM is best suited for this task to determine the nature of resistance of the bacterial strain extracted.)* *Ask the learners the following questions:* 1. *What are other situations in which the light microscope, SEM, or TEM offers an advantage in studying cells or other very small samples? Why?*	*biological contexts and real-world scenarios. It manifests the IDF guiding principles of relevance and responsiveness by presenting cases that range from clinical medical diagnostics (cancer biopsies) to local environmental observations (butterfly wings), ensuring the science is grounded in both professional and everyday experiences. Among the 2C-2I-1R approaches, the activity demonstrates Inquiry-based and Integrative features because it challenges learners to analyze the specific requirements of a task such as internal versus surface visualization and integrate their technical knowledge to select the appropriate tool. The specific pedagogical strategy applied is Case-Based Reasoning, supported by teacher-led rationalization to help students connect the "why" behind each scientific choice.* ***Teacher Notes****: Emphasize the distinction between topography (SEM) and internal ultrastructure (TEM) when discussing the cancer biopsy and membrane topology examples; this helps students move beyond just "high magnification" and understand the specific categorical advantages of different electron microscopes. For each case, require learners to explain their choice using the criteria of resolution, specimen type, surface versus internal detail, and preparation requirements.*
	C.2. Making Generalization	
	Readiness Check*: Present three short cases and ask learners to choose LM, SEM, or TEM and justify each answer in one sentence. Use this check to determine who is ready for the end formative assessment and who needs additional scaffolding. If they are ready, proceed with any of the following:* ***Option 1. Venn Diagram*** *Using a blank Venn Diagram, ask learners to write the similarities and differences between the light microscope and electron*	*This activity targets Learning Objectives 1–4 by having students compare light and electron microscopes, focusing on their structures, image formation, and practical uses.* ***Teacher Notes:*** *Encourage students to consider shared scientific utility, not just magnification, when identifying overlaps. Venn Diagrams may be done individually, in pairs, or in groups, followed by class presentation*

	microscope. Then under each write situations each type of microscope offers its advantage to. ***Guide Question:*** *1. Why does the choice of microscope depend on the detail needed?* *2. Can one specimen be studied using more than one type of microscope? Explain why the choice depends on the specific detail the scientist wants to observe.* *3. What is the difference between magnification and resolution?* *Access the Venn Diagram Activity Sheet here: https://drive.google.com/drive/folders/1MLpy2Lb_OP3ek0VFRMeK9aq2CXjZWu-r?usp=drive_link* *Expected Output: Venn Diagram* ***Option 2** – Quick Sort Cards: Learners classify statements under Light Microscope, SEM, TEM, or All.* ***Option 3** – Remote Discussion Board: Learners upload a photo or short written explanation comparing the microscopes and respond to one peer using a teacher-provided rubric. Access sample rubric here: _____*	*and output walkthrough to highlight key comparisons and tool selection based on purpose.* ***For Option 2**, you may use these statements: Use the following statements:* *- Electrons are reflected when the electron beam scans the specimen surface, giving surface detail/topography. (SEM)* *- Electrons pass through an ultra-thin specimen, and differences in transmission create the image of internal structures. (TEM)* *- Visible light passes through transparent samples or reflects from opaque ones, then lenses magnify the image. (Light Microscope)* *- Form images by illumination source onto a specimen and detecting how they pass through, bounce off, or are emitted from it.*
	C.3. Evaluating Learning	
	Ask the learners to complete their KWL chart: *What I Know* | *What I Want To Know* | *What I Learned* | | | | *Guide the learners using the following questions to gauge if learning outcomes are aligned with the objectives:* *1. What are the types of microscopes that you have learned?* *2. How does each microscope form an image of the specimen?* *3. What are the differences and similarities between each microscope?* *4. What are the situations where each microscope offers its advantage to?* *5. In 3–4 sentences below the KWL chart, explain how light microscopes and electron microscopes differ, and describe one situation in which each offers a clear advantage in cell study.* *Expected Output: Completed KWL chart*	*This activity targets Learning Objectives 1–4 where students consolidate their understanding of microscope structures, image formation, comparisons, and applications. It reflects IDF principles of relevance and responsiveness by letting learners evaluate their progress and revisit their initial questions. Using the 2C-2I-1R approach, it emphasizes Reflective and Constructive learning as students correct misconceptions and document new knowledge. The strategy used is Metacognitive Self-Assessment guided by teacher questions to ensure accurate and aligned reflections. **Teacher Note:** Encourage students to connect their "What I Learned" responses to their "What I Want to Know" entries, and direct unresolved questions to additional activities or simulations. Re-teach image formation if*

	Exit Ticket: *(1) Identify one structural part of a light microscope and state its function. (2) Explain, in one sentence, how SEM forms an image. (3) State one difference between magnification and resolution. (4) Choose the best microscope for observing ribosomes and justify your answer.*	*many learners miss Items 2 or 4 in the Exit Ticket, and provide a mini-review on magnification versus resolution if Item 3 shows confusion.*
	C.4. Additional Activities	
	Enrichment Activity *1. Virtual Laboratory Simulation:* ● *Light Microscope* *https://www.ncbionetwork.org/educational-resources/elearning/virtual-microscope* ● *Scanning Electron Microscope* *https://myscope.training/SEM_simulator.html* ● *Transmission Electron Microscope* *https://myscope.training/TEM_simulator.html* *2. Light Microscopy Activity* ● *Let students find things around the school they are curious to look under the microscope.* ● *Instruct learners how to use the light microscope by demonstration and guided instruction and practice.* ***Remediation Activity:*** *Provide a partially completed comparison table with the headings:* ***resolution, magnification, specimen preparation, application, and limitation****, then ask learners to complete the missing entries with teacher guidance.*	*These activities support Learning Objectives 1–4 by providing hands-on and virtual experiences in microscope structures and functions. They reflect IDF principles of flexibility and inclusivity through simulations that allow access to electron microscopy and encourage exploration of local specimens. Using the 2C-2I-1R approach, the activities are Inquiry-based and Collaborative, engaging students as active investigators through Simulation-Based Learning and Hands-on Practicum.* ***Teacher Note:*** *Use SEM and TEM simulators to explain "vacuum" and "beam alignment." For light microscopy, have students sketch their observations to strengthen scientific recording skills.* ***Safety Note****: Learners may collect only nonhazardous school specimens such as leaves, threads, paper fibers, and teacher-prepared pond water. Do not collect body fluids, unknown powders, sharp objects, or allergenic materials*
V. ASSESSMENT *(Assessing Learnings)*	***Formative Parallel Task:*** *Before the summative assessment, give learners three short cases that require microscope selection and one item on microscope parts/functions.* ***I. Choose the letter of the BEST answer.*** *1. Which of the following is correct about the image formation in a light microscope?* *A. Light absorbed by the specimen is collected by the objectives to be transmitted to the eyepiece for image viewing.* *B. Light transmitted/reflected by the specimen is collected by the objectives to create a magnified image, which is magnified further and viewed through the eyepiece.* *C. Light reflected by the mirror focuses the specimen and aligns its image, creating a magnified view through the eyepiece.* *D. Light is projected through the condenser and focused onto the specimen to produce a magnified image.* *2. Which of the following parts of the microscope is NOT involved in magnifying the image of the specimen?*	

A. Mirror B. High power objectives C. Eyepiece D. Low power objective

3. Which part of a light microscope is responsible for providing or directing light toward the specimen?
   A. Arm B. Stage C. Objective lens D. Light source or Mirror
4. What serves as the imaging medium in an electron microscope?
   A. Visible light B. Air particles C. Protons D. Electron beam
5. How does scanning electron microscope form a magnified image?
   A. Electron beams are fired at the specimen and the electrons bouncing off the surface of the specimen will be captured by a detector to generate a highly detailed 3D-like image of the specimen's surface.
   B. Electrons are fired through the specimen and detectors at the opposite of the side of the specimen captures the transmitted electrons, forming a 2D-like image of the sample.
   C. Electrons are fired from both sides of the specimens and the transmitted electron beams are collected into codes which will serve as basis for image generation.
   D. Electrons are passed through the specimen, and detectors capture the transmitted electrons to generate 3D-like image of the sample.
6. How does transmission electron microscope form a magnified image?
   A. Electrons are fired at the ultra-thin sample and detectors at the opposite side gathers the transmitted electrons to generate 2D-like images of the internal features of the sample.
   B. Electrons are beamed at 90 degrees relative to the sample and the reflected electrons are captured by the camera for image generation.
   C. The specimen is subjected to an electron stream flow where the traffic flow will be interpreted in generating an image.
   D. The specimen is focused along electron gradient flow where disturbances caused by the specimen are recorded and used to generate its sample.
7. What is the difference between transmission electron microscope and scanning electron microscope in terms of image formed?
   A. In TEM, a 2D image is formed showing the surface features of the sample while SEM provides a cross-sectional image of the specimen.
   B. In TEM, the internal structures of the specimen are magnified, and a 2D-like image is generated while in SEM, it provides a detailed 3D-like image of the sample where surface features are studied.
   C. In TEM it uses electron beam to generate colored image of the sample while in SEM it uses electron beams to create monographic images.
   D. In TEM, a 4D image is formed while in SEM generates a 2D image.
8. How do light and electron microscopes differ in terms of image formation?
   A. Light microscope uses the specimen to absorb light to magnify a specimen while electron microscope uses electricity passing through specimen to generate an image.
   B. Light microscope uses only sunlight to magnify image while electron microscope uses electron flow to create an image through a detector.

	C. Light microscopes use visible light that is reflected from or transmitted through the specimen and then projected through lenses to form an image. In contrast, electron microscopes use electron beams that either reflect off or pass through a specimen, and these electrons are captured by a detector to form an image. *D. Light microscopes generate image through bioluminescence while electron microscopes capture electrons emitted by specimens to generate an image while.* *9. Why is light microscope most recommended in studying mitosis in onion root tips in schools?* *A. It is cheaper, more convenient, easier to use and has the enough magnification power to view the different mitotic stages.* *B. It doesn't require high level of technical knowledge compared to TEM and SEM to operate.* *C. It has the enough resolving power and magnification to properly observe mitosis in onion root tips.* *D. All of the above.* *10. Which microscope is best used to study the surface characteristics of a red blood cell?* *A. Light microscope B. Scanning electron microscope C. Transmission electron microscope D.Compound hand lens* *II.* ***Choosing the Right Tool*** ***Background Information:*** *A research team is studying a sample of seawater. Their goals are to:* *1. observe the* ***swimming behavior*** *of live plankton;* *2. examine the* ***internal structure of a ribosome*** *within a bacterial cell found in the water; and* *3. investigate the detailed structure of the* ***cell walls of diatoms.*** *Using the data from the resources provided, explain and justify which type of microscope is appropriate for each goal above. Include reference specific data points (Resolution, Specimen, etc.) and explain the limitations of the "unselected" microscope for each goal.* ***Scoring Guide for Part II (6 points):*** *2 points for correct microscope selection, 2 points for accurate justification using resolution/specimen/application, and 2 points for explaining why the other microscope or microscopes are less suitable.*
VI. REFLECTION *(Feedback and Continuous Improvement)*	*Reflect on learners' performance, determine which activities and lesson parts were most and least effective, identify learners who need enrichment or remediation, analyze the assessment results, and note possible improvements to enhance future lesson delivery. • How many learners successfully demonstrated the learning objectives based on the assessment results? • Which activity helped learners understand the lesson the most? Which activity helped the least? • Which part of the lesson was easiest for learners? Which part was most difficult? • How many learners needed enrichment or additional challenge? How many learners needed remediation or additional support? • What did the assessment results show about learners' understanding of the lesson? • What improvement would you make if you taught this lesson again?*
VII. USE OF GENERATIVE AI	In preparing this Learning Exemplar (LE), the author used ChatGPT and Gemini AI to create analytical rubrics and review test item alignment to the learning objectives. The author reviewed and finalized the writing of the content. The author takes full responsibility for the content of this LE.

Lesson Title/Topic	Modern Cell Theory	Lesson Exemplar	3

I. OBJECTIVES	
A. Content Standard	1. The cell theory is significant in explaining the structure and function of all living organisms. 2. Cells can be classified according to distinguishing structures and functions.
B. Performance Standard	*By the end of the quarter,* learners discuss the scientific value of the interconnectedness of living organisms and their environment. They evaluate the significance of cell theory and its development in explaining the structure and function of living organisms. Learners classify cells based on their structures and functions, explain the stages and significance of the cell cycle, and describe the mechanisms of passive and active transport in maintaining homeostasis. They participate in practical activities and create presentations that showcase how these biological principles contribute to growth, repair, reproduction, and the diversity of life.
C. Learning Competencies	***Prerequisite Knowledge and Skills*** The students should have foundational or prior knowledge of the building blocks (cells), functions (organelles), heredity (DNA), and reproduction (cell division). The competency now asks them to synthesize these into the four tenets of modern cell theory and appreciate its role in explaining diversity and classification of life.
	Describe the four main parts of modern cell theory.
II. REFERENCES and MATERIALS (*Selecting Resources and Materials*)	• Alberts, Bruce, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter. *Molecular Biology of the Cell*. 6th ed. New York: Garland Science, 2015. • Biology LibreTexts. "Foundations of Modern Cell Theory." *LibreTexts*, 2023. https://bio.libretexts.org. • Campbell, Neil A., and Jane B. Reece. *Biology*. 11th ed. Boston: Pearson, 2018. • OpenStax. *Microbiology: Foundations of Modern Cell Theory*. OpenStax CNX, 2016. https://openstax.org/books/microbiology. • Ramos, A., and J. Ramos. *General Biology 1. Exploring Life Through Science Series*. Manila: Phoenix Publishing House, Inc., 2016. • ScienceInsights. "What Is the Modern Cell Theory?" *ScienceInsights*, 2022. https://scienceinsights.org.
III. CONTENT *(Sequencing Content)*	• Introduction to cells and early observations: Definitions, Hooke's cork cells, and the foundation of cell theory. • Classical cell theory: The three original tenets (all living things are made of cells, cells are the basic unit of structure and function, and cells come from pre-existing cells). • Modern cell theory: Addition of hereditary information (DNA) and its role in the continuity of life. • Experimental evidence against spontaneous generation: Redi's maggot experiment and Pasteur's swan-neck flask. • Applications of cell theory: Medicine, agriculture, and ecology. ***Note to Teacher:*** Textbook statements of modern cell theory may vary, but this lesson will use four main tenets, including hereditary information carried by DNA.
IV. OBJECTIVES *(Setting Clear*	1. Recall the three classical cell theories (Schleiden, Schwann, Virchow). 2. Identify the four main tenets of modern cell theory.

Objectives and Analyzing the Tasks)	3. Using your words, explain each tenet of the modern cell theory clearly. 4. Differentiate the four tenets by giving simple examples or illustrations. 5. Apply the four tenets of the modern cell theory to real-world scenarios by analyzing examples (e.g., medicine, agriculture, and biotechnology) and presenting their insights through practical activities or creative outputs (e.g., case studies, models, or presentations).

IV. PROCEDURES		**ANNOTATIONS**
A. Activating Prior Knowledge	***A.1. Activating Prior Knowledge***	
	OPTION 1 – QUICK RECALL GAME ***Materials:*** Whiteboard, markers, quiz cards, laptop, slides, multimedia. ***Procedure:*** The teacher prepares a short 5-item quiz game (e.g., Who proposed the cell theory? What are the three classical tenets?). Students answer individually or in groups. The teacher summarizes the three classical cell theories on the board and transitions to modern cell theory. **OPTION 2 – TIMELINE ACTIVITY RECALL** ***Materials:*** Timeline strips/cards, chart paper, markers, projector/slides. ***Procedure:*** Groups arrange timeline cards (Schleiden, Schwann, Virchow, Hooke) chronologically, explain contributions, and present. The teacher synthesizes and confirms the correct order. **OPTION 3 – THINK-PAIR-SHARE** ***Materials:*** Whiteboard, markers, pen, and paper. ***Procedure*:** The students recall the classical cell theory individually, share with a partner, and then report to class. The teacher synthesizes responses under the three tenets. ***Here is the link to the complete procedures for all instructional options under Activating Prior Knowledge: https://tinyurl.com/97rb47zm***	*-The students engage in a Quick Recall Game, Timeline Activity Recall, and Think-Pair-Share, reflecting IDF focus (retrieving names, tenets, and contributions); responsiveness (quiz, sequencing, and partner sharing); and relevance (linking classical foundations to modern cell theory). Through 2C–2I–1R, they construct answers, timelines, and reflections; connect ideas through collaboration and teacher synthesis; clarify misconceptions; and reflect on how classical tenets evolved into modern principles, with pedagogy centered on active recall, sequencing, and collaborative sharing to reinforce memory and comprehension of cell theory's development.* ***Note to Teacher for Option 1:*** Encourage peer discussion, use quiz apps (Wayground, Kahoot, Plickers), and stress the transition to modern cell theory. ***Note to Teacher for Option 2:*** Highlight historical context, guide reasoning in sequencing, and use visuals to sustain engagement and continuity. ***Note to Teacher for Option 3:*** Ensure balanced participation, synthesize responses under the three classical cell theories, and stress the transition to modern cell theory for continuity.
	A.2. Establishing the Purpose of the Lesson	
	OPTION 1 – "MYSTERY STATEMENTS": AN INTERACTIVE REVEAL	*-The students engage in Mystery Statements, Predict the Update, and From Lab to Life, reflecting IDF focus (recalling tenets, predicting discovery impacts, connecting lab findings to everyday life);*

	Materials: Slips of paper or slides with four mystery statements partially hidden (e.g., "All living things are made of ____"). ***Procedure:*** The students guess missing words (e.g., "Cells contain _____ information"). The teacher reveals correct answers and emphasizes modern cell theory. **OPTION 2 – "PREDICT THE UPDATE" ACTIVITY** ***Materials:*** Television/Projector, laptop, slides, image of DNA strands or cell division, whiteboard/marker, or digital board. ***Procedure:*** The teacher presents a timeline of discoveries (DNA, microscopes). Students predict how these discoveries updated cell theory. The teacher summarizes and gives an exit ticket ***Exit Ticket (written***): "Name one discovery that changed the original cell theory and explain how it did so." **OPTION 3 – "FROM LAB TO LIFE" ACTIVITY** ***Materials:*** Television/projector/printed timelines, laptop, slides, image of DNA sequencing or cell division photos, whiteboard/marker, or digital board. ***Procedure:*** The teacher presents discoveries (DNA, cell division). Students connect discoveries to modern cell theory with examples (wound healing, plant growth). The teacher bridges to modern cell theory. ***Application Prompt:*** The teacher states, "Choose one tenet of the modern cell theory and give a simple example from everyday life that shows it (e.g., wound healing, plant growth, or hair regrowth)." ***Here is the link to the complete procedures for all instructional options under Establishing the Purpose of the Lesson: https://tinyurl.com/ud7uzpac***	*responsiveness (guessing, predicting, applying examples); and relevance (linking classical to modern cell theory); through 2C–2I–1R, they construct guesses, predictions, and applications; connect insights through peer sharing and teacher synthesis; and integrate clarifications that discoveries like DNA and microscopes* ***disproved spontaneous generation rather than proved it****, reflect on how modern updates explain heredity, diversity, and continuity of life, with pedagogy centered on interactive questioning, predictive reasoning, and applied examples to reinforce that life arises from pre-existing cells, not spontaneously.* ***Note to Teacher for Option 1:*** Encourage pairs to justify guesses and highlight the transition from classical to modern cell theory for continuity. ***Note to Teacher Option 2:*** Encourage multiple perspectives, record key ideas visibly, and use an exit ticket to check understanding and reinforce science as evolving. ***Note to Teacher for Option 3:*** The teacher should ensure clear transitions to modern cell theory, prompt learners for concrete examples, and emphasize the real-world impact of scientific discoveries. Also, make sure that the sample images are clear and relevant.
B. Instituting New Knowledge	***B.1. Presenting Examples***	
	OPTION 1 – CELL THEORY IN ACTION (LAB ACTIVITY ON THE SPONTANEOUS GENERATION OF MAGGOTS) ***Materials:*** 3 glass jars of the same size, 3 slices of fresh meat (pork, beef, or chicken) or mashed fruit (potato, banana, or papaya) as a substitute, clean stockings or gauze, rubber bands, and a worksheet/LAS.	*-Students participate in Cell Theory in Action, Discovering the Four Tenets, and Historical Timeline Discoveries, reflecting IDF focus (disproving spontaneous generation, applying tenets, sequencing discoveries); responsiveness (hands-on setup, example sharing, timeline arrangement); and relevance (linking experiments to modern cell*

	Procedure: Students set up jars (Jar A open, Jar B covered with gauze, Jar C sealed). Observe maggot growth over several days. Record observations. The teacher connects findings to Virchow's tenet: "All cells come from pre-existing cells." ***Safety Note:*** Use this activity only as a teacher-managed demonstration in sealed containers, or replace it with a photo/video sequence if school sanitation policy does not allow decomposing materials. Learners must wash their hands after handling materials, and no open, decaying samples should remain in the classroom. **OPTION 2 – DISCOVERING THE FOUR TENETS THROUGH EXAMPLES** ***Materials***: Handouts or slides with the four tenets, a whiteboard, paper, and pens. ***Procedure:*** The teacher presents each tenet of modern cell theory. Students provide examples (e.g., wound healing, bacteria multiplying). The teacher clarifies misconceptions and synthesizes them. **OPTION 3 – HISTORICAL TIMELINE DISCOVERIES** ***Materials:*** Timeline cards (Hooke, Schleiden, Schwann, Virchow, Redi, Pasteur, Avery-MacLeod-McCarty, Hershey & Chase) ***Procedure:*** The teacher divides the class into groups. Groups arrange cards chronologically, explain contributions, and present. The teacher creates a master timeline. The teacher emphasizes, ***"Each discovery leads to the development of the tenets of the modern cell theory we now accept."*** ***Here is the link to the complete procedures for all instructional options under Presenting Examples: https://tinyurl.com/ycxrhf83***	*theory); through 2C–2I–1R, they construct observations, examples, and timelines; connect insights through collaboration and teacher synthesis; clarify that maggots arise from eggs—not spontaneously; and reflect on how each discovery shaped the four tenets, with pedagogy centered on inquiry, active learning, and historical contextualization to reinforce that "all cells come from pre-existing cells" and show the cumulative development of modern cell theory.* ***Alternative Delivery for Option 1:*** If time, sanitation, or school policy limits the live setup, the teacher may use a photo sequence *(Image Description Example: Illustration showing Redi's three jars side by side, one open jar with maggots on the meat, one gauze-covered jar with maggots on the gauze, and one sealed jar with no maggots, used to discuss the rejection of spontaneous generation)*, video demonstration, or teacher-prepared observation table based on Redi's experiment. Emphasize that the aim is **to disprove spontaneous generation**. Students may think maggots appeared from nothing; clarify that fly eggs were already present, showing life arises from pre-existing life. ***Important Note to Teacher:*** Redi and Pasteur's experiments refuted spontaneous generation, reinforcing biogenesis. Virchow later applied this at the cellular level, stating that new cells arise from pre-existing cells. ***Note to Teacher for Option 3:*** Clarify if students confuse Redi with Virchow. Redi addressed spontaneous generation broadly, while Virchow emphasized the cell-level principle.
	B.2. Discussing New Concept	
	OPTION 1 – GUIDED DISCUSSION – THE CELL THEORY AS A UNIFYING PRINCIPLE ***Materials:*** Slide decks (if available), printed/digital handouts, whiteboard, marker, paper, and pen.	*-The students participate in Guided Discussion, Modern Cell Theory Flowchart, and Cells as Building Blocks Analogies, reflecting IDF focus (explaining four tenets with real-world examples,*

	Procedure: The teacher explains four parts of modern cell theory with real-world examples (e.g., wound healing, heredity). Students share examples and connections. The teacher summarizes: ***"Together, these four tenets explain heredity, diversity, and continuity of life."*** ***Exit Ticket Prompt (choose one or two):*** 1. In one sentence, explain how cell theory unifies biology. 2. List the three key concepts (heredity, diversity, continuity) and connect one of them to cell theory. 3. Write one question you still have about how cell theory explains life processes. **OPTION 2 – THE MODERN CELL THEORY PARTS FLOWCHART: AN INTERACTIVE DIAGRAM** ***Materials:*** Chart paper, markers, flowchart templates. ***Procedure:*** The teacher divides the class into groups. Groups create flowcharts showing connections among the four tenets. Present diagrams; teacher clarifies misconceptions. ***Exit Ticket Prompt (choose one or two):*** 1. Name one tenet of modern cell theory and explain how it connects to other tenets. 2. Draw a mini flowchart (3 boxes) showing how DNA relates to heredity and continuity of life. 3. In one sentence, explain why the four tenets together form a framework for biology. **OPTION 3 – "CELLS AS BUILDING BLOCKS"—REAL"-WORLD ANALOGIES** ***Materials:*** Whiteboard, markers, paper, and pen. ***Procedure:*** Teacher introduces analogy (cells = bricks). Students brainstorm analogies (Lego blocks, puzzle pieces). The teacher connects analogies to tenets. ***Exit Ticket Prompt (choose one or two):*** 1. Write your analogy for cells (e.g., bricks, Lego blocks, puzzle pieces) and explain how it relates to cell theory. 2. Which tenet of cell theory does your analogy best represent? *3.* What are the limitations of the representations that you created? ***Here is the link to the complete procedures for all instructional options under Discussing New Concept: https://tinyurl.com/bdd35rn8***	*diagramming interconnections, and linking analogies to principles), responsiveness (sharing reflections, group flowcharting, brainstorming analogies), and relevance (clarifying how cell theory unifies biology through heredity, diversity, and continuity); through 2C–2I–1R, they construct explanations, diagrams, and analogies; connect insights through collaboration and teacher synthesis; and integrate clarifications that related experiments aimed to disprove spontaneous generation rather than prove it and reflect on how the four tenets form a framework for biology, with pedagogy centered on guided inquiry, visual mapping, and analogy-based reasoning to reinforce mastery and deepen understanding of cell theory as a unifying principle.* ***Note to Teacher for Option 1:*** The teacher should promote equal participation in groups, highlight connections in student responses, and use the exit ticket to assess understanding and curiosity. ***Note to Teacher for Option 2:*** The teacher should focus on the clarity of connections, promote creativity in diagramming, and highlight that the four main ideas create a foundation for biology. ***Note to Teacher for Option 3:*** The teacher should encourage a variety of analogies, clarify how they relate to the main ideas, and stress how analogies make complex scientific concepts easier to grasp. **Additional Note:** If learners confuse heredity with cell division, re-teach using one clear example of DNA inheritance and one of tissue growth before continuing. If they struggle to justify matches, provide a short guided model first.

	B.3. Developing Mastery	
	OPTION 1 – MATCHING ACTIVITY ***Materials:*** Scenario cards (e.g., "Cell division observed under a microscope," "DNA passed from parent to child," "Bacteria multiplying in food," "Plant tissue culture in a lab"), chart paper, markers. ***Procedure:*** The teacher groups the class. Groups match scenarios to the correct tenet of modern cell theory. Present matches to the class; the teacher confirms and clarifies misconceptions. **OPTION 2 – WORKSHEET PRACTICE** ***Materials:*** Worksheets (printed/digital) and incomplete statements. • ***Sample Worksheet with Model Answer:*** -*Cancer* → Tenet: Cells come from pre-existing cells. Explanation: Cancer shows uncontrolled division of existing cells. -*Children inherit traits* → Tenet: Cells contain DNA. Explanation: DNA passes from parent to child. -*Bacteria in food* → Tenet: Cells come from pre-existing cells. Explanation: Bacteria multiply by division. -*Tissue culture* → Tenet: All living things are made of cells. Explanation: Plant cells divide to form new tissues. ***Procedure:*** The students answer individually, then share aloud. The teacher writes correct answers on the board, clarifies reasoning, and synthesizes. The teacher concludes, ***"These examples show how cell theory explains heredity, diversity, and continuity of life."*** **OPTION 3 – PEER TEACHING CHALLENGE** ***Materials:*** Notes on the tenets of Modern Cell Theory (if any). ***Procedure:*** Each student is assigned one tenet. They prepare a short explanation with an everyday example, then teach it to a partner. The teacher circulates, supports, and summarizes all four tenets. Students write reflections: "What did I learn from teaching my partner?" ***Here is the link to the complete procedures for all instructional options under Developing Mastery: https://tinyurl.com/2m4bnu68***	*-The students engage in activities such as Matching Activity, Worksheet Practice, and Peer Teaching Challenge, which are representative of the IDF approach (scenario-to-tenet match, statement completion with rationale, and teaching peers with examples); responsiveness (group matching, individual worksheet completion, and partner explanation); and relevance (explanation of how cell theory accounts for heredity, diversity, and continuity); by means of 2C-2I-1R, students can develop scenario matches, worksheet solutions, and peer explanations; relate concepts via collaboration and synthesis on the part of the instructor; and incorporate explanations that show life is not spontaneously created but emerges from pre-existing cells—that spontaneous generation is false—and contemplate the practicality of each tenet, wherein the teaching philosophy centers on application, peer teaching, and synthesis.* ***Note to Teachers for Option 1:*** The teacher should have groups explain their matches with reasoning and offer more examples to strengthen their connections. ***Note to Teacher for Option 2:*** The teacher should stress the reasoning behind each answer, not just identification, and use worksheet corrections to address misconceptions. ***Note to Teacher for Option 3:*** Observe interactions for accuracy, guide students to simplify explanations, and use reflections to check understanding and give feedback. **Potential misconceptions to flag** ● Learners may equate modern cell theory with only four points, without knowing that textbook formulations can vary.

<table>
<tr><td rowspan="2">C. Demonstrating Knowledge and Skills</td><td colspan="2">C.1. Finding Practical Application</td></tr>
<tr><td>OPTION 1 – LINKING REDI, PASTEUR, AND VIRCHOW TO MODERN SCIENCE

Materials: Images of food spoilage, food safety posters, medical sterilization practices, and simple visuals of Redi's and Pasteur's experiments.
Procedure: Show spoiled vs. covered food → recall Redi (maggots) and Pasteur (swan-neck flask). Clarify these disproved theories of spontaneous generation. Connect to Virchow's tenet: "Cells come from pre-existing cells." Students give modern examples (covering food, sterilization, and pasteurization).

OPTION 2 – CANCER AND STEM CELLS: A CASE STUDY

Materials: Case study handouts (short text describing cancer and stem cell therapy), chart paper, markers for group notes, and multimedia/projector/slides (optional visuals of cell division).
Procedure: The teacher groups the class accordingly. Groups read the case study and discuss which tenet explains cancer and stem cell therapy. Present findings. The teacher clarifies: cancer = dysregulated cell division; stem cells = living cells that divide and differentiate.

OPTION 3 – CELL THEORY: AN EVERYDAY LIFE CONNECTION

Materials: Whiteboard/markers, sticky notes for student brainstorming (optional).
Procedure: The teacher asks, "Where do you see cell theory daily?". The students brainstorm (wound healing, plant growth, hair regrowth). Share aloud or post notes. The teacher groups ideas under four tenets.

*For all the instructional options, all application outputs must include at least one correct tenet and one scientifically accurate or historical reference.

Here is the link to the complete procedures for all instructional options under Finding Practical Application: https://tinyurl.com/7h4vmfyb</td><td>-In the given activities, Students engage in Linking Redi, Pasteur, and Virchow to Modern Science, Cancer and Stem Cells Case Study, and Cell Theory in Everyday Life Connection, showing IDF through historical experiments disproving spontaneous generation, medical case studies, and everyday examples; responsiveness via poster-making, case discussions, and brainstorming; and relevance in clarifying how cell theory explains inheritance, variation, and continuity. Through 2C–2I–1R, they create posters, analyze cases, and brainstorm examples; link insights via teamwork and teacher synthesis; highlight that Redi and Pasteur refuted spontaneous generation of maggots and microbes arising from pre-existing life; and reflect on Virchow's principle and modern tenets in food safety, medicine, and daily processes, with pedagogy grounded in historical linkage, inquiry, and practical application.

Note to Teacher for Option 1: Emphasize evidence-based science in disease prevention and highlight parallels between Redi's experiment and current industry practices.

Note to Teacher for Option 2: Ensure that the students distinguish uncontrolled vs. controlled cell division, and emphasize how cell theory underpins both disease understanding and treatment development.

Note to Teacher for Option 3: Encourage diverse examples, cluster them under correct tenets, and emphasize how cell theory explains growth, repair, and heredity.

Potential misconceptions to flag
● Learners may think Redi directly proved a cellular principle when his experiment more directly addressed the spontaneous generation of organisms.</td></tr>
</table>

		• Learners may think DNA heredity is the only explanation for stem cell therapy when division and differentiation are more direct.
	C.2. Making Generalization	
	OPTION 1 – POSTER/SLOGAN: FROM EXPERIMENTS TO MODERN SCIENCE ***Materials:*** Poster paper or bond paper, markers, crayons or colored pencils, and a short description or picture of Redi's jars experiment and Pasteur's swan-neck flask. ***Procedure:*** Group students to design posters with slogans (e.g., "Cells come from cells") and simple drawings of Redi's or Pasteur's experiments. Emphasize that the aim is ***to disprove spontaneous generation***, clarify that maggots or microbes come from eggs or existing life, not from nothing. Summarize: Redi and Pasteur disproved spontaneous generation; Virchow's principle became part of modern cell theory. **OPTION 2 – EXIT SLIP REFLECTION** ***Materials:*** Small slips of paper or index cards, pens/pencils. ***Procedure:*** Students write a one-sentence poem or song summarizing the cell theory's role. The teacher collects and reviews for understanding and misconceptions. **OPTION 3 – CONCEPT MAPPING** ***Materials:*** Blank concept map templates (or plain paper), markers/pens. ***Procedure:*** Students map connections among the four tenets of modern cell theory with examples. Groups will present, and the teacher highlights generalizations and corrects misconceptions. ***Here is the link to the complete procedures for all instructional options under Making Generalization: https://tinyurl.com/mr2deum6***	*-The Poster/Slogan, Exit Slip Reflection, and Concept Mapping are activities that students engage in, showing IDF characteristics as illustrated by students engaging in making posters (focus), making reflections individually or in groups (responsiveness), and relating to the topic by making concept maps (relevance). These activities are performed using the strategy 2C–2I–1R, where students make posters, reflections, and concept maps and connect their ideas with sharing and synthesis made by the teacher. Students also make clarifications about the purpose of the experiments done by Redi and Pasteur by stating that maggots and microbes come from living things and not from "nothing." Students also relate the tenet by Virchow and the other tenets to the concepts of heredity, diversity, and continuity.* ***Note to Teacher for Option 2:*** Use responses to identify misconceptions, adjust instruction, and provide targeted feedback in the next lesson. ***Note to Teacher for Option 3:*** Emphasize accuracy in connections, encourage examples to reinforce tenets, and highlight how the map shows unity and diversity of life.
	C.3. Evaluating Learning	
	OPTION 1 – POSTER/INFOGRAPHIC MAKING	*-Students participate in Poster/Infographic Making, Essay Reflection, and Case Study Analysis & Presentation, reflecting IDF focus (illustrating tenets*

	Materials: Poster paper or bond paper, markers, crayons, or colored pencils, handouts or notes on the four tenets and supporting experiments ***Procedure:*** Divide students into small groups. Groups design posters/infographics showing the four tenets of modern cell theory with one supporting experiment (e.g., Redi, Pasteur). Present briefly (2–3 minutes). The teacher evaluates with a rubric (accuracy, creativity, clarity, effort) and displays posters. **OPTION 2 – ESSAY: "CELL THEORY AS THE FOUNDATION OF BIOLOGY"** ***Materials:*** Writing paper or notebooks, pens/pencils ***Procedure:*** The teacher presents the essay prompt: "***Explain why cell theory is considered the foundation of biology. Use examples to support your answer."*** The students write essays explaining why cell theory is the foundation of biology, using examples. The teacher collects and evaluates with a rubric (accuracy, clarity, organization, and examples). Feedback will be given in the next session. **OPTION 3 – CASE STUDY ANALYSIS & PRESENTATION** ***Materials:*** Short case study handouts (e.g., stem cell therapy, cancer research, agricultural biotechnology), paper for notes, projector or chart paper for presentations. ***Procedure*:** Divide the class into small groups, each assigned a case study (medicine, agriculture, or biotechnology). Groups analyze, identify tenets, and prepare short presentations (5 minutes). The teacher facilitates questions & answers, evaluates with a rubric (accuracy, clarity, application, and teamwork), and may compile outputs into a digital portfolio. **Readiness Check for Evaluating Learning:** Ask learners to identify the tenet in three short scenarios and justify each in one sentence. Use results to spot misconceptions and decide who needs reteaching before the summative test. ***Rubric:*** Accuracy–4, Explanation–3, Use of example/evidence–2, Clarity–1 ***Here is the link to the complete procedures for all instructional options under Evaluating Learning: https://tinyurl.com/yr6a46u6***	*with experiments, explaining cell theory's foundational role, applying tenets to real-world cases); responsiveness (creative poster design, organized essay writing, collaborative case study presentations); and relevance (clarifying how experiments like Redi's and Pasteur's aimed to disprove spontaneous generation and how modern cell theory explains heredity, diversity, and continuity); through 2C–2I–1R, they construct posters, essays, and case analyses and connect insights through peer sharing and teacher synthesis, integrate clarifications that maggots and microbes do not arise from nothing but from pre-existing life, and reflect on how Virchow's principle and modern applications unify biology, with pedagogy centered on creative expression, structured writing, and applied inquiry to reinforce mastery and ensure accurate understanding of modern cell theory.* ***Note to Teacher for Option 1:*** Emphasize scientific accuracy, encourage creativity, and use the rubric to balance clarity with effort. ***Note to Teacher for Option 2:*** Guide students in outlining, encourage clear examples, and provide specific feedback to strengthen scientific writing. ***Note to Teacher for Option 3:*** Select age-appropriate, relevant case studies (e.g., stem cell therapy, cancer research, crop improvement). Guide students to connect each explicitly to the four tenets, scaffold with guiding questions, and use a rubric emphasizing accuracy, clarity, application, and teamwork.

	C.4. Additional Activities	
	OPTION 1 – THE MODERN CELL THEORY: A COMIC STRIP ***Materials:*** Bond paper or illustration paper, markers, crayons, or colored pencils, notes/handouts on the four tenets of modern cell theory, and tape or pins for display. ***Procedure:*** The teacher tells students, ***"We will create comic strips to explain the four tenets of modern cell theory."*** The students design comic strips showing the four tenets with at least one example (e.g., Redi's jars, wound healing). Display comics in a gallery walk. The teacher highlights creativity and accuracy, connecting comics back to the lesson. **OPTION 2 – "ARE VIRUSES ALIVE?": AN EXPLORATION OF THE MODERN CELL THEORY** ***Materials:*** Short description or diagram of a virus (e.g., influenza, HIV, bacteriophage)**,** handouts or slides with the four tenets of modern cell theory, and chart paper or whiteboard for group notes. ***Procedure:*** The teacher presents a virus diagram and asks if viruses are living. Students brainstorm individually, then discuss in groups. Groups test viruses against cell theory tenets and share conclusions. The teacher clarifies: viruses are acellular, cannot reproduce independently, but contain genetic material and evolve. **OPTION 3 – THE MODERN CELL THEORY: A BIOTECHNOLOGY CONNECTION** ***Materials:*** Textbooks or online references, poster paper or bond paper, markers/pens ***Procedure:*** The teacher divides the class into small groups. Groups research biotechnology topics (tissue culture, genetic engineering, stem cells). Prepare short reports/posters and present. The teacher summarizes and corrects misconceptions. Students reflect briefly. ***Here is the link to the complete procedures for all instructional options under Additional Activities: https://tinyurl.com/34ak99e9*** ***The scoring rubrics are available through this link: https://tinyurl.com/2r9ksrjy***	*-Students participate in Poster/Infographic Making, Essay Writing, and Case Study Analysis & Presentation, reflecting IDF focus (illustrating tenets with experiments, explaining cell theory's foundation, applying principles to real cases); responsiveness (group poster design, individual essay writing, collaborative case study presentations); and relevance (clarifying that Redi and Pasteur's experiments aimed to disprove spontaneous generation—maggots and microbes arise from pre-existing life—and showing how Virchow's principle became part of modern cell theory; through 2C–2I–1R, they create outputs, reflect through writing and analysis, integrate clarifications on heredity, diversity, and continuity, and recognize cell theory's role as biology's foundation, with pedagogy centered on creativity, structured writing, and inquiry.* ***Note to Teacher for Option 1:*** Remind students to keep scientific content accurate while being creative, encourage varied examples, and emphasize how storytelling makes scientific ideas easier to understand and remember. ***Note to Teacher for Option 2:*** Emphasize that viruses contain genetic material but lack cells and independent reproduction. Clarify that they show the limits of cell theory, not a contradiction. **Extension Note:** Use the virus discussion only after learners master the four tenets. Emphasize that viruses are an exception/challenge case, not evidence against cell theory. ***Note to Teacher for Option 3:*** Guide students toward reliable sources, ensure they clearly connect their topic to the four parts of modern cell theory, and emphasize how biotechnology demonstrates the continued importance of cell theory in modern science.

V. ASSESSMENT *(Assessing Learnings)*	**Summative test:** Administer a 10-question test (the type of test varies depending on the teacher administering it) covering all the topics discussed, presented in a traditional paper-and-pencil format, a Google Forms digital quiz, or an interactive exam application such as Kahoot, Wayground, or Plickers. Multiple Choice (sample questions) 1. Which scientist added the idea that "cells come from pre-existing cells"? A. Hooke B. Schleiden C. Schwann D. Virchow 2. Which of the following is NOT part of the modern cell theory? A. All living things are made of cells. C. Cells arise from non-living matter. B. Cells are the basic unit of life. D. DNA carries hereditary information. 3. The statement *"Cells are the basic unit of structure and function"* means: A. Cells are the smallest living units that carry out life processes. C. Cells are made up of organelles B. Cells can only exist in multicellular organisms. D. Cells are visible without microscopes. 4. Which tenet of modern cell theory explains why children inherit traits from their parents? A. All living things are made of cells. C. DNA carries hereditary information. B. Cells come from pre-existing cells. D. Cells are the basic unit of structure and function. 5. A scientist observes that new cells are continuously forming from existing cells in a tissue sample. Which tenet of modern cell theory explains this observation? A. Cells come from pre-existing cells. C. All living things are made of cells. B. DNA carries hereditary information. D. Cells are the basic unit of structure and function. 6. Stem cell therapy relies on living cells that divide from existing cells and differentiate into specialized types. Which tenet of modern cell theory directly supports this medical application? A. Cells come from pre-existing cells C. Cells are the basic unit of structure and function B. DNA carries hereditary information D. All living things are made of cells 7. Healing of wounds demonstrates which principle of modern cell theory? A. DNA carries hereditary information. C. Cells come from pre-existing cells. B. Cells are the basic unit of structure and function. D. All living things are made of cells. 8. If cells did not exist, which of the following would be impossible? A. Growth of plants B. Transmission of DNA C. Repair of tissues D. All of the above 9. Which everyday example BEST illustrates the tenet *"DNA carries hereditary information"*? A. A cut healing on your skin C. A plant growing towards the sunlight B. A child having the same eye color as a parent D. Bacteria dividing rapidly in a petri dish 10. Which experiment most directly showed that sterile broth remains free of microbial growth unless contaminants can enter from the environment?? A. Mendel's pea plant experiment C. Pasteur's swan-neck flask experiment B. Redi's jars experiment D. Darwin's finches' study. **Short Answer (Sample Questions)** In 3–4 sentences, describe how the four tenets of modern cell theory explain life.

	Short-Answer Scoring Guide (4 points): 1 point for identifying cells as the basic unit of life, 1 point for stating that all living things are made of cells, 1 point for explaining that cells arise from pre-existing cells, and 1 point for accurately describing DNA/heredity or continuity of life. ***The answer key for the summative test is available through this link: https://tinyurl.com/5xnvjzfr***
VI. REFLECTION *(Feedback and Continuous Improvement)*	*Use the following reflection prompts to guide your evaluation of the lesson after implementation. Reflect on learners' performance, determine which activities and lesson parts were most and least effective, identify learners who need enrichment or remediation, analyze the assessment results, and note possible improvements to enhance future lesson delivery.* ● *How many learners successfully demonstrated the learning objectives based on the assessment results?* ● *Which activity helped learners understand the lesson the most? Which activity helped the least?* ● *Which part of the lesson was easiest for learners? Which part was most difficult?* ● *How many learners needed enrichment or additional challenge? How many learners needed remediation or additional support?* ● *What did the assessment results show about learners' understanding of the lesson?* ● *What improvement would you make if you taught this lesson again?*
VII. USE OF GENERATIVE AI	In preparing this Learning Exemplar (LE), the author(s) used the Copilot and Grammarly in order to improve the grammar and consistency of the instructions in the different instructional options and in the annotations. The author(s) reviewed and finalized the writing of the content. The author(s) take(s) full responsibility for the content of this LE.

Lesson Title/Topic	Classification of Cells Based on Distinguishing Structures and Functions	Lesson Exemplar	4

I. OBJECTIVES	
A. Content Standard	1. The cell theory is significant in explaining the structure and function of all living organisms. 2. Cells can be classified according to distinguishing structures and functions.
B. Performance Standard	*By the end of the quarter,* learners discuss the scientific value of the interconnectedness of living organisms and their environment. They evaluate the significance of cell theory and its development in explaining the structure and function of living organisms. Learners classify cells based on their structures and functions, explain the stages and significance of the cell cycle, and describe the mechanisms of passive and active transport in maintaining homeostasis. They participate in practical activities and create presentations that showcase how these biological principles contribute to growth, repair, reproduction, and the diversity of life.
C. Learning Competencies	***Prerequisite Knowledge and Skills*** For students to successfully meet the competency "Explain by drawing scaled diagrams the differences between prokaryotic and eukaryotic cells and their significance in the diversity and classification of life forms," they should already have prerequisite knowledge of the basic cell theory and its modern extensions, including the idea that all living things are made of cells, cells are the basic unit of life, and DNA carries hereditary information. They should also recall the historical contributions of scientists like Hooke, Leeuwenhoek, Schleiden, Schwann, and Virchow, and understand the differences between light and electron microscopes in studying cells. In terms of skills, students should be able to draw and label simple cell structures, compare and contrast scientific concepts, organize information through charts or outlines, and work collaboratively in group tasks. They should also have basic critical thinking skills to connect scientific ideas to real-world contexts such as medicine, agriculture, and biotechnology. These prerequisites ensure that learners are ready to move into comparing prokaryotic and eukaryotic cells and will provide a strong foundation for the next competencies on the cell cycle, cell division, and genetic variation.
	Explain by drawing scaled diagrams the differences between prokaryotic and eukaryotic cells and their significance in the diversity and classification of life forms
II. REFERENCES and MATERIALS (*Selecting Resources and Material*)	Bailey, Regina. 2018. *Learn about Plant Cell Types and Organelles.* ThoughtCo. https://www.thoughtco.com/what-is-a-plant-cell-373384.. Farabee, M. J. 2006. "Animal Cells and Tissues." *Online Biology Book.* Estrella Mountain Community College. Farabee, M. J. 2007. *Plants and Their Structure. Online Biology Book.* Estrella Mountain Community College. https://www2.estrellamountain.edu/faculty/farabee/biobk/BioBookPLANTANAT.html#Links.. Pedersen, Traci. 2019. *Prokaryotic vs. Eukaryotic Cells: What's the Difference?* Live Science. https://www.livescience.com/65922-prokaryotic-vs-eukaryotic-cells.html.. DepEd, Region II – Cagayan Valley. 2020. *Learning Activity Sheet in General Biology 1 (Grade 11).* Tuguegarao City: DepEd RO No. 02.

III. CONTENT *(Sequencing Content)*	● Define prokaryotic and eukaryotic cells and their role in classification. ● Show diagrams of both types and compare the nucleus, organelles, size, complexity, and reproduction. ● Explain how differences shape unicellular vs. multicellular life and specialization. ● Link prokaryotes to Bacteria/Archaea and eukaryotes to Eukarya. ● Highlight applications in medicine, agriculture, and biotechnology. ● Conclude by noting that understanding these structures prepares students to study cell division (binary fission vs. mitosis/meiosis) and its role in growth, repair, and variation.	
IV. OBJECTIVES *(Setting Clear Objectives and Analyzing the Tasks)*	1. Identify the basic structures of prokaryotic and eukaryotic cells. 2. Construct a scaled and labeled diagram of prokaryotic and eukaryotic cells. 3. Compare and contrast the similarities and differences between prokaryotic and eukaryotic cells using the scaled and labeled diagram. 4. Explain the significance of these differences in the diversity of life forms.	
IV. PROCEDURES		**ANNOTATIONS**
A. Activating Prior Knowledge	***A.1. Activating Prior Knowledge***	
	OPTION 1 – QUICK SKETCH RECALL ***Materials:*** Bond paper or notebook, pencils or pens ***Procedure:*** The teacher distributes paper and asks students to sketch a generic cell from memory, allowing 3–5 minutes before pairing them to compare sketches and note similarities and differences; a brief sharing follows to identify common and missing parts, then the teacher transitions to distinguishing prokaryotic and eukaryotic cells, and concludes the activity with a sample picture. **OPTION 2 – CELL STRUCTURE SORTING** ***Materials:*** Cards with organelle names (e.g., nucleus, ribosome, mitochondrion, cell wall), two labeled areas: *"Common to All Cells"* and *"Specialized Structures."* ***Procedure:*** In small groups, students sort organelle cards into universal vs. eukaryote-specific structures, review as a class with immediate feedback, then the teacher highlights that some structures are shared while others distinguish prokaryotic from eukaryotic cells, setting the lesson focus. **OPTION 3 – THINK-PAIR-SHARE**	*-The students' activation of prior knowledge through Quick Sketch Recall, Cell Structure Sorting, and Think-Pair-Share. These reflect IDF focus (recall, distinguish, answer), responsiveness (peer comparison, group sorting, class sharing), and relevance (linking to prokaryotic vs. eukaryotic cells). Using 2C–2I–1R, they construct, connect, integrate, and reflect. Pedagogy centers on visual recall, collaborative categorization, and structured reflection to reveal misconceptions, ensure accountability, and build comprehension of cell diversity.* ***Note to Teacher for Option 1:*** *Encourage students to draw freely and remind them that the goal is to recall ideas, not produce perfect artwork. Use the sharing stage to point out common structures and gently correct inaccurate or missing parts.* ***Note to Teacher for Option 2:*** *Monitor groups closely to ensure accurate sorting. During the review, emphasize that ribosomes are found in*

	Materials: Whiteboard, markers, pen, paper, and a prompt written on the board: "What makes a cell alive?" ***Procedure:*** The teacher poses the question "*What makes a cell alive?"* and gives students 2 minutes to think individually before pairing them to share answers, then invites pairs to present insights to the class; the teacher summarizes key points such as genetic material, reproduction, and metabolism, and transitions by explaining that these features are expressed differently in prokaryotic and eukaryotic cells, which will be explored in the lesson. ***Here is the link to the complete procedures for all instructional options under Activating Prior Knowledge:*** ***https://tinyurl.com/ywpcrvwk***	*all cells, whereas structures such as the nucleus are present only in eukaryotic cells. Explain how this activity prepares students for comparing cell types.* ***Note to Teacher for Option 3:*** *Guide students toward key characteristics of living cells, such as genetic material, metabolism, and reproduction. In your summary, clarify that all cells share these traits, but prokaryotic and eukaryotic cells carry them out in different ways.*
	A.2. Establishing the Purpose of the Lesson	
	OPTION 1 – THE CELL: A GUIDING QUESTION ***Materials Needed:*** Whiteboard, projector/television, slide decks, and marker. ***Procedure:*** The teacher writes the guiding question, *"How do differences in cell structure and function account for the diversity between bacteria, plants, and animals?"*, on the board, gives students 2–3 minutes to reflect silently, facilitates a class discussion to share ideas, highlights key points such as complexity, nucleus presence, and multicellularity, then transitions by explaining that the lesson will deepen understanding through diagrams of prokaryotic and eukaryotic cells. **OPTION 2 – THE CELL: A REAL-WORLD CONNECTION** ***Materials:*** Projected images or printed pictures of bacteria (prokaryotic) and human/plant cells (eukaryotic), chart paper or board for noting observations. ***Procedure:*** The teacher displays side-by-side images of bacteria and human/plant cells, asks guiding questions about differences, organelles, and classification, records student observations such as size, nucleus presence, and complexity, then explains that these differences are fundamental to how life is classified, and transitions by telling students they will explore these distinctions further through diagrams and comparisons.	*-Students engage with The Cell: Guiding Question, Real-World Connection, and Lesson Roadmap. This reflects IDF focus (prior knowledge, real examples, structured roadmap), responsiveness (silent reflection, discussion, peer observation), and relevance (linking structures to diversity, classification, real-world contexts). Through 2C–2I–1R, they construct, connect, integrate, and reflect. Pedagogy centers on inquiry, visual observation, and structured sequencing to build comprehension and contextualize cell differences in scientific and everyday perspectives.* ***Note to Teacher for Option 1:*** *Encourage students to share ideas openly, even if unsure. Highlight responses mentioning complexity, nucleus, or multicellularity, and use them to guide discussion toward the main lesson concepts.* ***Descriptive Text for Teacher Visual:*** A side-by-side comparison diagram of a prokaryotic cell and a eukaryotic cell, showing the plasma membrane, cytoplasm, ribosomes, and

	OPTION 3 – THE CELL: A LESSON ROADMAP ***Materials Needed:*** Television/Projector, laptop, slides, and a prepared roadmap outline of the steps of the lesson. ***Procedure:*** The teacher presents a roadmap like recall prior knowledge, compare prokaryotic and eukaryotic cells, draw scaled diagrams, connect differences to diversity and classification, and apply knowledge to real-world contexts, then explains that by the end of the lesson students will be able to explain and illustrate these differences and why they matter, encourages them to keep the roadmap in mind throughout the activities, and transitions to examining examples of both cell types. ***Here is the link to the complete procedures for all instructional options under Establishing the Purpose of the Lesson: https://tinyurl.com/nywf7kw4***	genetic material in both cells, plus a distinct nucleus and membrane-bound organelles in the eukaryotic cell. ***Note to Teacher for Option 2:*** *Guide students to notice differences in size, complexity, and nucleus presence. Emphasize these features as key in distinguishing prokaryotic and eukaryotic cells.* ***Note to Teacher for Option 3:*** *Clearly explain each step of the roadmap and remind students of lesson goals. Show how each activity builds toward understanding cell structure and diversity.*
B. Instituting New Knowledge	***B.1. Presenting Examples***	
	OPTION 1 – DIAGRAM COMPARISON + LABELING ***Materials:*** Printed or projected diagrams of prokaryotic and eukaryotic cells, worksheets for labeling, markers/pens ***Procedure:*** The teacher displays side-by-side diagrams of prokaryotic and eukaryotic cells, briefly explains their structures, gives worksheets for labeling parts, reviews answers to clarify misconceptions, and transitions by emphasizing that these structural differences form the foundation of life's diversity. **OPTION 2 – GROUP JIGSAW + VENN DIAGRAM** ***Materials:*** Reading materials or handouts on prokaryotic/ eukaryotic cells, chart paper, and markers ***Procedure:*** The teacher divides the class into two groups to study prokaryotic and eukaryotic cells, with each group listing key features before regrouping to share findings. Together, they construct a Venn diagram of similarities and differences, and the teacher concludes by emphasizing that classification systems are based on these distinctions. ***Important Note:*** All cells have a plasma membrane, cytoplasm, ribosomes, and genetic material, but prokaryotic and eukaryotic cells differ in their organization, including the presence of a nucleus and membrane-bound organelles in eukaryotes.	*-The students engage with Diagram Comparison + Labeling, Group Jigsaw + Venn Diagram, and Cell Showdown. These reflect IDF focus (identify, compare, organize), responsiveness (individual work, group sharing, class review), and relevance (linking structures to diversity, classification, evolution). Through 2C–2I–1R, they construct diagrams and charts, collaborate and receive teacher guidance, integrate corrections, and reflect on distinctions. Pedagogy centers on visual analysis, collaborative synthesis, and comparative charting to reinforce accuracy, address misconceptions, and deepen understanding of prokaryotic vs. eukaryotic cells.* ***Note to Teacher for Option 1:*** *Remind students to label clearly and correctly. Emphasize that eukaryotic cells have a nucleus and membrane-bound organelles, while prokaryotic cells do not.* ***Note to Teacher for Option 2:*** *Ensure all group members participate. Emphasize that all*

	OPTION 3 – CELL SHOWDOWN: PROKARYOTES VS. EUKARYOTES ***Materials:*** Blank comparison chart (size, nucleus, organelles, reproduction, complexity), pens/markers ***Procedure:*** The teacher provides a blank chart template for comparing prokaryotic and eukaryotic cells. Guide students to fill in details such as nucleus presence, encourage group discussion for accuracy, review charts with immediate feedback to correct misconceptions, and conclude by explaining that these comparisons reveal evolutionary significance. ***Here is the link to the complete procedures for all instructional options under Presenting Examples: https://tinyurl.com/kx3nd8ze***	*cells share ribosomes and genetic material, while eukaryotes have specialized structures like the nucleus and mitochondria.* ***Note to Teacher for Option 3:*** *Encourage students to write specific answers (for example, "nucleus absent" instead of "no nucleus"). In the summary, explain that these differences also show how different types of cells evolved.* ***For all the instructional Options,*** *before the comparison tasks, remind students that prokaryotic and eukaryotic cells differ not only in structures but also in typical size, which should be reflected in their diagrams.*
	B.2. Discussing New Concept	
	OPTION 1 – GUIDED DISCUSSION ***Materials:*** Whiteboard for key points, marker ***Procedure:*** The teacher writes the question "How do these structural differences affect how organisms live?" on the board, invites volunteers to share ideas, steers discussion toward unicellular vs. multicellular life, highlights examples like bacteria and humans/plants, summarizes that prokaryotes are simpler and usually unicellular while eukaryotes have compartmentalization supporting specialization, then gives an exit ticket where students classify an organism with a reason, and uses responses to check understanding before moving to diagram/model activities. **OPTION 2 – CLASSIFICATION LINK** ***Materials:*** Chart of the domains of life, slips of paper for exit tickets ***Procedure:*** The teacher presents a chart of the three domains (Bacteria, Archaea, and Eukarya), asks students to place prokaryotes and eukaryotes correctly, discusses classification based on cell structure, gives an exit ticket where students identify the domain of an organism like E. coli, yeast, or an oak tree, and then quickly reviews responses to confirm understanding before moving to the next activity.	*-The students engage with Guided Discussion, Classification Link, and Evolutionary Perspective. These reflect IDF focus (structural differences, domain links, evolutionary complexity), responsiveness (volunteer sharing, exit tickets, class discussion), and relevance (connecting structures to diversity, classification, biotechnology). Through 2C–2I–1R, they construct ideas and insights, connect reasoning with peers and teacher prompts, integrate corrections, and reflect on diversity and applications. Pedagogy centers on guided inquiry, classification practice, and evolutionary framing to deepen understanding and prepare for applied contexts.* ***Note to Teacher for Option 1:*** *Encourage many students to participate. Use the exit tickets to identify students who may still confuse unicellular and multicellular organisms, and remind them that differences in cell structure help explain the diversity of life.*

	OPTION 3 – EVOLUTIONARY PERSPECTIVE ***Materials:*** Timeline or diagram of evolutionary progression, slips of paper for exit tickets ***Procedure:*** The teacher displays a timeline showing prokaryotes first and then eukaryotes, asks what advantages eukaryotes gained by becoming more complex, guides discussion toward specialization, multicellularity, and diversity, summarizes that complexity enabled specialized functions and diverse organisms, then administers an exit ticket where students explain how eukaryotic complexity benefits multicellular life, and transitions by reviewing responses to gauge readiness for biotechnology applications in the next part. ***Here is the link to the complete procedures for all instructional options under Discussing New Concept: https://tinyurl.com/bdz8hha9***	***Note to Teacher for Option 2:*** *Use clear examples when explaining the domains. Emphasize that classification is based on cell structure, not simply on the size or complexity of the organism.* ***Note to Teacher for Option 3:*** *Guide students to think of clear examples of specialized cells, such as nerve cells or photosynthetic plant cells. Use the exit tickets to check if students understand how complex cells make multicellular life possible.*
	B.3. Developing Mastery	
	OPTION 1 – DIAGRAM DRAWING + 3D MODEL ***Materials:*** Bond paper, pencils, markers, recyclable and indigenous materials for 3D model making (carton, plastic bottles, caps, clay, etc.), rubric for diagrams/models, exit ticket slips ***Procedure:*** The teacher sets the task for students to draw scaled diagrams of prokaryotic and eukaryotic cells, then build 3D models in groups using recyclable materials, guiding accuracy with prompts and labels; groups present their models with explanations assessed by rubric, followed by an exit ticket where each student writes one structural difference and its significance, and the activity transitions by emphasizing that visualizing structures shows how cell differences shape life's diversity. **OPTION 2 – MATCHING EXERCISE + VENN REFINEMENT** ***Materials:*** Matching worksheets (features like "nucleus," "circular DNA," "membrane-bound organelles"), Venn diagram from earlier activity, exit ticket slips ***Procedure:*** The teacher distributes matching worksheets for individual work, pairs students to compare and correct answers, then has groups refine their Venn diagrams with new insights before reviewing as a class to clarify misconceptions; formative assessment follows with an exit ticket where	*-The students engage with Diagram Drawing + 3D Model, Matching Exercise + Venn Refinement, and Peer Teaching + Chart Update, reflecting IDF focus (visualizing structures, identifying features, explaining functions), responsiveness (teacher prompts, peer corrections, chart updates), and relevance (linking outputs to classification, diversity, and real-world application); through 2C–2I–1R they construct diagrams, worksheets, and peer explanations, connect ideas through collaboration and rubric criteria, integrate corrections and feedback during review, and reflect on differences and their significance, with pedagogy centered on visual modeling, collaborative refinement, and peer teaching to reinforce mastery, clarify misconceptions, and prepare knowledge for applied contexts.* ***Note to Teacher for Option 1****: Encourage creativity, but ensure that the cell structures are accurate. Use a rubric to evaluate clarity, effort, and correctness.*

	students write one unique feature of prokaryotes and one of eukaryotes, and the activity transitions by stressing that accurate identification of features is the foundation of classification. **OPTION 3 – PEER TEACHING + CHART UPDATE** ***Materials:*** Completed charts from earlier activity and exit ticket slips ***Procedure:*** Students are paired and assigned cell features to explain to each other, update charts with new details, and share some explanations with the class while the teacher checks accuracy; formative assessment follows with an exit ticket where each student explains how one cell feature contributes to life's diversity, and the activity transitions by highlighting that peer teaching strengthens mastery and prepares knowledge for real-world application. ***Here is the link to the complete procedures for all instructional options under Developing Mastery: https://tinyurl.com/3p9nsbmf***	***Note to Teacher for Option 2:*** *Observe peer discussions and correct misconceptions when needed. Emphasize that features like a nucleus or circular DNA help distinguish prokaryotic and eukaryotic cells.* ***Note to Teacher for Option 3:*** *Assign different features to ensure both prokaryotic and eukaryotic traits are covered. Check the updated charts to make sure students have recorded accurate information.* ***For all the Instructional Options,*** *especially in the diagram task, provide a simple scale guide or size reference so learners can show relative size differences more accurately.*
C. Demonstrating Knowledge and Skills	***C.1. Finding Practical Application***	
	OPTION 1 – MEDICINE CONNECTION ***Materials:*** Short case study or scenario (e.g., bacterial infection vs. human cell), whiteboard or chalkboard for notes, exit ticket slips ***Procedure:*** The teacher presents a scenario about antibiotics (scenario: ***"A patient has a bacterial infection. Doctors prescribe antibiotics, which kill bacteria but do not harm human cells.")*** targeting bacteria but not human cells, writes the guiding question on the board ***("Why do antibiotics kill bacteria but not human cells?"),*** gives students two minutes to jot ideas, invites volunteers to share, and guides discussion toward structural and biochemical differences such as peptidoglycan cell walls, 70S ribosomes, and bacterial enzymes; key points are recorded and misconceptions corrected, and the teacher concludes by emphasizing that antibiotics work through selective toxicity by targeting bacterial structures and processes distinct from those of human cells. The teacher reads aloud or projects a short scenario: ***Exit Ticket:*** Each student writes: ***"One structural difference that explains why antibiotics affect bacteria but not human cells is..."*** **OPTION 2 – AGRICULTURE CONNECTION**	*-The students involve with Medicine Connection, Agriculture Connection, and Biotechnology Connection, reflecting IDF focus (structural differences in antibiotic action, plant cell totipotency, complementary roles in genetic engineering), responsiveness (case analysis, group sharing, pair reflection), and relevance (linking cell biology to medicine, agriculture, and biotechnology); through 2C–2I–1R they construct ideas from scenarios, observations, and diagrams, connect insights through discussion and collaboration, integrate teacher clarifications and peer feedback, and reflect via exit tickets on how cell differences explain selective toxicity, agricultural regeneration, and biotechnological applications, with pedagogy centered on case-based learning, applied observation, and collaborative reasoning to contextualize cell biology in real-world practices.*

	Materials: Images or examples of plant tissue culture, chart paper or whiteboard for group notes, exit ticket slips ***Procedure:*** The teacher shows an image of plant tissue culture and asks how whole plants can grow from a few cells, gives students time to reflect individually, then let them share in groups highlighting totipotency and specialization; group insights are collected and written on the board, and the teacher concludes by explaining that plant tissue culture is possible because many plant cells retain totipotency, allowing them under suitable conditions to divide, differentiate, and regenerate into a whole plant. ***Exit Ticket:*** Each student writes: ***"One way cell specialization benefits agriculture is..."*** ***Sample Response:*** "One way cell specialization benefits agriculture is that plant cells have the ability for cell regeneration, meaning certain plant cells or tissues can dedifferentiate and, under suitable culture conditions, regenerate into a whole plant, which makes tissue culture useful in agriculture that allows farmers and scientists to use tissue culture to grow disease-free crops and produce more food efficiently." **OPTION 3 – BIOTECHNOLOGY CONNECTION** ***Materials:*** Diagram of plasmid use in bacteria and gene transfer to eukaryotes, short reading excerpt (e.g., about insulin production using bacteria and human cells, and exit ticket slips ***Procedure:*** The teacher shows a plasmid diagram, explains that bacteria clone DNA while eukaryotic cells express complex proteins, and then asks why both are used in genetic engineering. Students reflect in pairs, share answers, and are guided toward complementary roles—bacteria for cloning, eukaryotes for protein expression. The teacher concludes that biotechnology relies on the strengths of both cell types. ***Exit Ticket:*** Each student writes: ***"One role of prokaryotic cells and one role of eukaryotic cells in biotechnology are..."*** ***Here is the link to the complete procedures for all instructional options under Finding Practical Application: https://tinyurl.com/ycxfn44x***	***Note to Teacher for Option 1:*** *Emphasize that antibiotics work because they target structures found in prokaryotic cells but not in eukaryotic cells. Use the exit tickets to check if students can explain at least one structural difference.* *Also, present a* ***visual representation*** *of peptidoglycan so students can clearly see and understand its structure. Using diagrams or images will help students form a clearer picture of how peptidoglycan is arranged in the cell wall.* ***Note to Teacher for Option 2:*** *Highlight totipotency as the main concept. Explain how tissue culture helps produce disease-free crops and supports food security.* ***Note to Teacher for Option 3:*** *Guide students to understand the different roles of each cell type—prokaryotes are often used to clone genes, while eukaryotic cells are used to produce complex proteins. Use exit tickets to confirm students understand both roles.* ***For all the Instructional Options,*** *kindly require the students to identify the exact structure or property involved, such as peptidoglycan, ribosomes, totipotency, plasmids, or organelles.*
	C.2. Making Generalization	
	OPTION 1 – GUIDED CLASS DISCUSSION ***Materials:*** Whiteboard or chalkboard for brainstorming and exit ticket slips	*-In the given activities, students engage with Guided Class Discussion, Concept Mapping, and Reflection Writing, reflecting IDF focus (imagining a world with only prokaryotes, mapping structural differences, writing*

	Procedure: The teacher sets the context by asking students to imagine a world with only prokaryotic cells, writes the guiding question on the board, gives time for individual reflection, then facilitates discussion with prompts about multicellularity, complexity, and diversity; key ideas are recorded under "Lost Complexity," "Lost Diversity," and "Possible Outcomes," and the teacher summarizes that without eukaryotes life would lack complex multicellular plants, animals, and fungi, leaving most organisms microbial though prokaryotes would still show remarkable metabolic and ecological diversity. ***Exit Ticket:*** Each student writes: ***"One way life would be different if only prokaryotic cells existed is…"*** **OPTION 2 – CONCEPT MAPPING** ***Materials:*** Chart paper and markers, concept map template with "Prokaryotic Cells" and "Eukaryotic Cells" as starting points, exit ticket slips ***Procedure:*** The teacher distributes concept map templates and instructs groups to add features of prokaryotic and eukaryotic cells, linking them to diversity and classification; students brainstorm and draw arrows showing how differences like compartmentalization and gene regulation lead to specialization and multicellularity, then display maps for class review as the teacher highlights strong connections and clarifies misconceptions, concluding that concept maps show how structural differences connect directly to diversity and classification. ***Exit Ticket:*** Each student writes: ***"One connection I learned from the concept map is…"*** **OPTION 3 – REFLECTION WRITING** ***Materials:*** Paper or notebooks, pen, exit ticket slips ***Procedure:*** The teacher writes the guiding question "How do cell differences explain the diversity of life?" on the board, gives students 3–5 minutes to write reflections, invites a few volunteers to share aloud, records recurring themes such as complexity, specialization, and classification, and concludes by emphasizing that cell differences are the foundation of life's diversity. ***Exit Ticket:*** Each student condenses their reflection into one sentence: ***"Cell differences explain diversity because…"***	*reflections on diversity), responsiveness (volunteer sharing, group brainstorming, individual writing), and relevance (connecting cell structures to complexity, specialization, and classification); through 2C–2I–1R they construct ideas, maps, and reflections, connect insights through discussion and peer collaboration, integrate teacher highlights and corrections, and reflect on how differences explain diversity, with pedagogy centered on guided inquiry, visual mapping, and reflective writing to consolidate understanding, reveal misconceptions, and strengthen comprehension of how cell differences shape life's diversity.* ***Note to Teacher for Option 1:*** *Use guiding questions to help students realize that without eukaryotic cells, there would be no multicellular organisms or specialized cells. Use exit tickets to quickly check individual understanding.* ***Note to Teacher for Option 2:*** *Encourage students to make clear links such as "nucleus → specialization → multicellularity." Display some concept maps to highlight strong ideas and correct misconceptions.* ***Note to Teacher for Option 3:*** *Encourage students to include specific examples such as nuclei, organelles, or cell specialization in their writing. Highlight common themes in their responses to reinforce the idea that cell differences are the foundation of life's diversity.* ***Support Note****: Provide a vocabulary box for key terms—nucleoid, organelle, peptidoglycan, ribosome, totipotency, plasmid, specialization, and compartmentalization, and allow learners to use the word bank during discussion and diagram tasks.*

	Here is the link to the complete procedures for all instructional options under Making Generalization: https://tinyurl.com/3rz7p7uu	
	C.3. Evaluating Learning	
	OPTION 1 – SHORT INTERACTIVE QUIZ ***Materials:*** 5-item multiple-choice quiz (Preferably prepared using an interactive quiz app like Wayground and Kahoot, but it could be printed or projected as well), pen, and paper. ***Procedure:*** The teacher announces a short quiz to check understanding of prokaryotic and eukaryotic cell differences, projects a 5-item interactive quiz where students set their names, allows 5 minutes for individual answers with leaderboard tracking, then collects or reviews responses as a class, clarifies misconceptions immediately, and reinforces correct answers with brief explanations. ***Learner Reflection Prompt:*** *Which difference between prokaryotic and eukaryotic cells do you understand best now, and which one still needs clarification for you?* **OPTION 2 – DIAGRAM CHECK** ***Materials:*** Student outputs (diagrams, Venn diagrams, 3D models), Rubric (criteria: accuracy, clarity, completeness) ***Procedure***: The teacher collects student outputs such as diagrams, Venns, and models, evaluates them using a rubric focused on accuracy, clarity, and completeness, provides quick oral or written feedback (e.g., "Good labeling of nucleus, but ribosomes missing"), and concludes by sharing common strengths and areas for improvement with the class. ***Learner Reflection Prompt:*** "*Which difference between prokaryotic and eukaryotic cells do you understand best now, and which one still needs clarification for you?"* **OPTION 3 – ORAL RECAP** ***Materials:*** Whiteboard or chalkboard for recording key points ***Procedure*:** The teacher asks each student to share one difference between prokaryotic and eukaryotic cells and explain its significance, records key points on the board under categories like "Structure," "Function," and "Significance," then synthesizes the class responses by summarizing how these differences explain diversity and classification.	*-Students engage with Short Interactive Quiz, Diagram Check, and Oral Recap. These reflect IDF focus (understanding differences, checking accuracy, synthesizing responses), responsiveness (app participation, rubric feedback, class sharing), and relevance (clarifying misconceptions, reinforcing classification, linking to diversity). Through 2C–2I–1R, they construct answers and diagrams, connect through peer review and teacher synthesis, integrate corrections, and reflect on which differences they grasp best. Pedagogy centers on formative assessment, peer evaluation, and oral synthesis to reinforce mastery, ensure accuracy, and deepen comprehension of prokaryotic vs. eukaryotic cells.* ***Note to Teacher for Option 1:*** *Use the explanations after each question to reinforce the correct ideas and address misconceptions immediately.* ***Note to Teacher for Option 2:*** *Give balanced feedback by recognizing what students did well while pointing out missing or incorrect features. Share common observations with the class to reinforce learning.* ***Note to Teacher for Option 3:*** *Encourage students to give short but clear explanations. Use the board to organize responses and highlight how cell differences explain the diversity of life.* ***Remote or low-tech alternative:*** *When devices or projection are unavailable, replace*

	Learner Reflection Prompt: *Which difference between prokaryotic and eukaryotic cells do you understand best now, and which one still needs clarification for you?* ***Here is the link to the complete procedures for all instructional options under Evaluating Learning: https://tinyurl.com/5e93fjuf***	*digital images and quiz apps with printed handouts, teacher-drawn board sketches, and paper exit tickets. Provide take-home comparison sheets for asynchronous learning.*
	C.4. Additional Activities	
	OPTION 1 – COMIC STRIP ***Materials:*** Drawing/bond paper, markers, colored pencils, or crayons ***Procedure:*** The teacher assigns the task of creating a comic strip showing bacteria and human cells in action with at least two differences, gives students 10–15 minutes to draw while circulating to encourage creativity and check accuracy, then has them display and share their comics with volunteers explaining their work, and concludes by highlighting the differences illustrated in the strips. **OPTION 2 – GALLERY WALK** ***Materials:*** Student outputs (charts, posters, reflections, comics), sticky notes or slips of paper for feedback ***Procedure:*** The teacher asks students to display their outputs around the room, instructs them to walk around and leave one positive comment or suggestion on sticky notes during a 10-minute gallery walk, then gathers the class to debrief by summarizing common strengths and areas for improvement, and concludes by emphasizing that peer feedback refines understanding and presentation of cell differences. **REMEDIATION OPTION:** Complete a guided table matching cell structures to prokaryotic cells, eukaryotic cells, or both, then write one sentence explaining why each distinction matters for classification. ***Here is the link to the complete procedures for all instructional options under Additional Activities: https://tinyurl.com/5n8vsxph*** ***All the scoring rubrics are available through this link: https://tinyurl.com/2xcrd97d***	*-In these activities, the students who work with Comic Strip and Gallery Walk, reflecting IDF focus (illustrating structural differences, reviewing peer outputs), responsiveness (creative drawing, peer feedback), and relevance (linking visual storytelling and peer evaluation to classification and diversity); through 2C–2I–1R they construct comics and feedback notes, connect ideas through sharing and collaborative review, integrate corrections and teacher highlights, and reflect on how differences matter for understanding, with pedagogy centered on creative expression and peer feedback to reinforce mastery, encourage accountability, and strengthen comprehension of prokaryotic vs. eukaryotic distinctions.* ***Note to Teacher for Option 1:*** *Encourage creativity, but remind students to include scientifically accurate differences, such as the presence of a nucleus or cell wall.* ***Note to Teacher for Option 2:*** *Ask students to give one positive comment and one suggestion. During the class discussion, highlight common strengths and correct misunderstandings about cell differences.*

V. ASSESSMENT *(Assessing Learnings)*	**Summative test:** Administer a 10-question test (the type of test varies depending on the teacher who will administer the test) covering all the topics discussed, presented in a traditional paper-and-pencil format, a Google Forms digital quiz, or an interactive exam application such as Kahoot Wayground, or Plickers. ***Multiple Choice (sample questions)*** 1. Which structure is present in eukaryotic cells but absent in prokaryotic cells? A. Cell membrane B. Cytoplasm C. Nucleus D. Ribosomes 2. Which feature is common to both prokaryotic and eukaryotic cells? A. DNA B. Membrane-bound organelles C. Mitochondria D. Nucleus 3. Why are eukaryotic cells generally more complex than prokaryotic cells? A. They reproduce at a faster rate than many other types of cells. B. They are consistently larger in overall size compared to other cells. C. They do not possess ribosomes that are needed for protein synthesis. D. They contain specialized organelles that perform different functions inside the cell. 4. Which statement best explains why eukaryotic cells can perform specialized functions compared to prokaryotic cells? A. Prokaryotic cells are not considered living cells in this description. B. Prokaryotic cells have no DNA present for storing genetic information. C. Eukaryotic cells are always larger in overall size compared to prokaryotic cells. D. Eukaryotic cells contain membrane-bound organelles that compartmentalize functions. 5. Doctors prescribe antibiotics for bacterial infections, not viral infections, because antibiotics target bacterial structures or pathways such as cell walls, ribosomes, or enzymes that viruses do not have. Which structural difference explains this? A. Human cells lack the DNA required for storing and transmitting genetic information. B. Viruses lack ribosomes and cell walls needed for basic cellular functions. C. Bacteria are always harmful and cannot provide any beneficial effects. D. Viruses are multicellular organisms composed of more than one cell. 6. A farmer uses tissue culture to grow new plants. Which property of certain plant cells makes this possible? A. Presence of plasmids B. Totipotency C. Circular DNA D. Lack of nucleus 7. If all cells were prokaryotic, which outcome would most likely occur? A. Complex multicellular organisms would thrive and dominate living systems. B. Life would remain simple and limited without complex cell structures. C. Specialized tissues would evolve to support more advanced functions. D. Diversity of life would increase with greater cellular complexity. 8. Which classification domain includes organisms with prokaryotic cell structures? A. Archaea and Eukarya B. Bacteria and Archaea C. Bacteria only D. Eukarya only 9. Scientists often use bacteria to clone genes, while eukaryotic cells may be used to produce proteins that require more complex processing. Why is this useful? A. Bacteria are always better at producing all types of proteins. B. Eukaryotic cells have no ribosomes needed for protein synthesis. C. Bacteria are multicellular organisms composed of more than one cell.

	D. Bacteria clone genes efficiently, while eukaryotic cells produce more complex proteins. 10. Which statement best summarizes how cell differences explain the diversity of life? A. All cells are identical, so diversity is limited and organisms remain similar. B. Diversity is unrelated to cell structure and does not depend on cellular differences. C. Only eukaryotic cells contribute to diversity by enabling complexity and specialization. D. Prokaryotic simplicity and eukaryotic complexity together create a wide variety of organisms. ***The answer key for the summative test is available through this link: https://tinyurl.com/yxvx3beb***
VI. REFLECTION *(Feedback and Continuous Improvement)*	*Use the following reflection prompts to guide your evaluation of the lesson after implementation. Reflect on learners' performance, determine which activities and lesson parts were most and least effective, identify learners who need enrichment or remediation, analyze the assessment results, and note possible improvements to enhance future lesson delivery.* ● *How many learners successfully demonstrated the learning objectives based on the assessment results?* ● *Which activity helped learners understand the lesson the most? Which activity helped the least?* ● *Which part of the lesson was easiest for learners? Which part was most difficult?* ● *How many learners needed enrichment or additional challenge? How many learners needed remediation or additional support?* ● *What did the assessment results show about learners' understanding of the lesson?* ● *What improvement would you make if you taught this lesson again?*
VII. USE OF GENERATIVE AI	In preparing this Learning Exemplar (LE), the author(s) used the Copilot and Grammarly in order to improve the grammar and consistency of the instructions in the different instructional options and in the annotations. The author(s) reviewed and finalized the writing of the content. The author(s) take(s) full responsibility for the content of this LE.

Lesson Title/Topic	The Cell Cycle	Lesson Exemplar	5

I. OBJECTIVES		
A. Content Standard	The cell cycle consists of a series of phases, stages, and events	
B. Performance Standard	By the end of the quarter, learners discuss the scientific value of the interconnectedness of living organisms and their environment. They evaluate the significance of cell theory and its development in explaining the structure and function of living organisms. Learners classify cells based on their structures and functions, explain the stages and significance of the cell cycle, and describe the mechanisms of passive and active transport in maintaining homeostasis. They participate in practical activities and create presentations that showcase how these biological principles contribute to growth, repair, reproduction, and the diversity of life.	
C. Learning Competencies	***Prerequisite Knowledge and Skills*** ● Learners are expected to recall the difference between mitosis and meiosis, the role of DNA and chromosomes in inheritance, and the idea that cells divide for growth, repair, and reproduction.	
	Explain the phases of the cell cycle (interphase, M-phase, and cytokinesis) and their control points;	
II. REFERENCES and MATERIALS (*Selecting Resources and Material*)	OpenStax. 2018. Biology 2e. Houston, TX: OpenStax. Accessed April 23, 2026. "10.2 The Cell Cycle." OpenStax. 2018. Biology 2e. Houston, TX: OpenStax. Accessed April 23, 2026. "10.3 Control of the Cell Cycle."	
III. CONTENT *(Sequencing Content)*	The Cell Cycle	
IV. OBJECTIVES *(Setting Clear Objectives and Analyzing the Tasks)*	1. Describe the major stages of the cell cycle, including interphase, the M-phase, and cytokinesis. 2. Illustrate the stages of mitosis (prophase, metaphase, anaphase, telophase) 3. Demonstrate the importance of cell cycle control mechanisms in maintaining normal cell growth and preventing abnormal cell division.	
IV. PROCEDURES		**ANNOTATIONS**
A. Activating Prior Knowledge	***A1. Activating Prior Knowledge***	
	Optional Activity 1: Cell Cycle Life Stages Analogy **Goal:** Connect the cell cycle to familiar life experiences. **Procedure:** 1. Begin with Question1: *What specific processes are occurring in the cell at this stage, and how do they prepare it for the next phase of the cycle?* (This primes students to think about the cell cycle stages directly.) 2. Then introduce the **life stages analogy**: ● Ask students to list human life phases (infancy → childhood → adolescence → adulthood).	The activities activate prior knowledge about cell division and prepares learners to connect familiar experiences to the cell cycle. It uses guided discussion and pair sharing to surface misconceptions. Teacher note: clarify that the analogy is a learning aid and does not mean human life stages are identical to cell-cycle stages.

	● In pairs, they discuss: *What does a cell need to do in each "life stage" to prepare for division?* 3. Students match each life stage to a cell cycle counterpart: ● Growth → G1 ● Preparation → S ● Checking readiness → G2 ● Big change/event → M-phase ● Transition to new individuals → Cytokinesis **Why it works:** It helps students connect abstract cell processes to meaningful real-life stages they already know. **Note to Teachers:** Use the life stages analogy only to show the *sequence* of cell cycle stages. Emphasize that human stages do not literally correspond to cellular processes. Follow up with accurate explanations and visuals, and remind students that analogies are simplified aids, not scientific descriptions. Encourage reflection on where the analogy breaks down to avoid misconceptions. **Optional Activity 2: Microscope Memory Prompt** **Goal:** Connect previous lab experiences to new content. Ask students: ● *Have you ever seen onion root tip cells under a microscope in earlier grade levels?* ● *Have students illustrate how the chromosomes looked like during cell division.* Students share memories or impressions. This primes them for identifying real mitosis images later in the lesson.	
	A.2. Establishing the Purpose of the Lesson	

	Optional Activity 1. Mini lecture: **Title:** Why Cells Divide—and Why It Matters to You **Teacher Engagement Script (5 minutes)** **Teacher asks:** Have you ever wondered how your body repairs a wound, how your hair grows, or how your organs stay healthy even as you age? *(Allow a few students to answer.)* **Teacher continues:** All these everyday processes occur because your cells follow a highly organized schedule called the cell cycle. Today, we are learning about this cycle—not just for academic purposes—but because it explains how life maintains itself at the smallest level. **Ask:** ● How does learning about these processes connect to challenges we face today **Expectation Setting and Motivation** **Teacher:** Today's lesson will help you understand how your body keeps you alive at the microscopic level, and what happens when this system goes wrong. This isn't just biology—it's about your health, your growth, and your future. As we move through the activities, challenge yourself with these guiding questions: 1. **Analysis:** *What specific processes are occurring in the cell at this stage, and how do they prepare it for the next phase of the cycle? (Note to teacher:* The cell cycle is not synchronized across all cells, so stages do not occur simultaneously throughout the body. Clarify this when asking students what processes are happening at a given stage, to prevent the misconception that the entire organism's cells move through the cycle together.) 2. **Evaluation:** *Why is this step critical for maintaining normal cell function, and what evidence shows its importance for growth, repair, or reproduction?* 3. **Application and Prediction:** *If this step fails or is bypassed, what consequences might arise for the organism? How could this lead to real-world conditions such as cancer or genetic disorders?*	**Optional Activity 1. Mini lecture:** **Title: Why Cells Divide-and Why It Matters to You** This mini lecture supports the lesson objectives by clearly establishing the relevance of learning the cell cycle, mitosis, and cell cycle regulation. It introduces real-life applications—such as growth, healing, and disease prevention—helping students understand why these concepts matter beyond the classroom. The Activity demonstrates Relevance by connecting content to students' daily bodily experiences, and Responsiveness by engaging them through reflective questions that surface their initial understanding. It aligns with Constructivism and Inquiry, as students are prompted to think critically about cellular processes and their consequences. The teaching method applied is a guided conceptual introduction through motivational questioning. Teachers should ensure that student responses are acknowledged and used to build curiosity, and that the transition from everyday examples to scientific terminology is clear and well-paced to prepare learners for deeper exploration of the cell cycle. **Teacher explains:** ● Every time you grow taller, heal a cut, or regenerate skin cells, the cell cycle is at work. ● Understanding mitosis helps explain how your body maintains millions of cells every day. ● Learning about cell cycle control helps us understand diseases like cancer, which occur when the checkpoints fail. ● Scientists, doctors, and medical professionals use this knowledge to develop treatments, detect abnormalities, and save lives.
B. Instituting New Knowledge	***B.1. Presenting Examples***	
	Activity: Cells on Red Light: Understanding Why Checkpoints Matter	**Activity: Cells on Red Light: Understanding Why Checkpoints Matter**

	A. What You Need to Know (Short Reading Input) Inside your body, cells divide regularly to replace old or damaged cells. But before a cell divides, it must pass through checkpoints, which act like traffic lights. These checkpoints make sure the cell is healthy, its DNA is correct, and conditions are right for division. If these checkpoints fail, cells may divide too quickly or with damaged DNA—leading to tumor formation or cancer. Before analyzing checkpoints, recall that the cell cycle includes interphase (G1, S, G2), mitosis, and cytokinesis. Checkpoints monitor whether the cell is ready to move safely from one part of the cycle to the next. **Checkpoint Summary:** • G1 Checkpoint: Is the cell healthy and ready to copy DNA? • G2 Checkpoint: Is the DNA copied correctly? • M Checkpoint: Are chromosomes lined up properly before separation? When checkpoints work properly, they help maintain normal tissue growth. When checkpoint control fails, abnormal cell division may occur and can contribute to tumor formation or cancer. **B**. **What You Need to Do (Optional Activity Task)** Read each real-life situation below. Identify the checkpoint involved and explain why that checkpoint is important in preventing abnormal cell growth. **Situation 1:** A skin cell detects major DNA damage after sun exposure. Division must pause to repair the DNA. Checkpoint involved: _____ Why this checkpoint matters: _____ **Situation 2:** A cell finishes copying its DNA, but some chromosomes did not duplicate correctly. Checkpoint involved: _____ Why this checkpoint matters: _____ **Situation 3:** During cell division, chromosomes fail to line up in the middle. The cell must stop to fix spindle attachment. Checkpoint involved: _____ Why this checkpoint matters: _____ **Situation 4:**	This self-paced Optional Activity supports the objective of explaining the importance of cell cycle control mechanisms by guiding learners through real-life scenarios that highlight the role of checkpoints in maintaining normal cell division. It emphasizes Relevance, as students connect cellular safety mechanisms to familiar health-related situations such as DNA damage, chromosome errors, and tumor formation. The Optional Activity demonstrates Responsiveness by allowing teachers to assess students' understanding through their written interpretations of each scenario. Aligned with Constructivism and Inquiry, students actively analyze cases, identify the correct checkpoints, and reason about consequences when regulatory mechanisms fail. The primary teaching strategy here is scenario-based application, which encourages independent thinking and reinforces conceptual understanding. Teachers should remind students to refer to the reading input for accurate checkpoint functions and ensure that learners explain their answers clearly, using proper scientific terms for cell cycle regulation.

	A cell continues dividing rapidly even though DNA is severely damaged. A tumor begins to form. Checkpoint involved (which one failed?): _____ Explain what went wrong: _____ **Please refer to the scoring rubric attached to the printable Learning Activity Sheet for this.**	
	B.2. Discussing New Concept	
	Explicit Teaching / Guided Exploration Lesson Segment **Part 1: Introducing the Cell Cycle (Objective 1)** **IA. Define the Concept** **Teacher explanation:** The cell cycle is the repeating sequence of events that a cell undergoes as it grows, copies its DNA, prepares for division, and finally splits into two daughter cells. It has three main parts: **Interphase**, **M-phase**, and **Cytokinesis**. **IB. Explain Each Stage Using a Clear Model** Use a **circular diagram** or show a simple cycle model. **Teacher explanation (guided):** • **G1 (Growth 1):** This is when the cell grows, produces proteins, and prepares materials for DNA replication. • **S (Synthesis):** The cell copies its DNA—every chromosome is duplicated. • **G2 (Growth 2):** The cell double-checks its DNA and prepares its machinery for division. **Ask learners:** *Which stage of interphase do you think takes the longest? Why?* **IC. Use an Analogy** **Analogy:** Interphase is like preparing for a school project: gathering materials (G1), making copies of all needed documents (S), and checking everything before submission (G2). M-phase is the actual presentation. Cytokinesis is submitting two separate project outputs. **Part 2: Guided Exploration of Mitosis** **2A. Transition Explanation** To divide properly, the cell must separate its duplicated chromosomes in a precise order. This process is called mitosis, and it has four main stages.	**Explicit Teaching / Guided Exploration Lesson Segment** This explicit teaching segment supports all three learning objectives by clearly defining key cell cycle and mitosis terms, modeling each stage with diagrams and analogies, and guiding students through structured explanations. It demonstrates Relevance by using familiar comparisons—such as school projects and traffic lights—to anchor abstract cellular processes in learners' everyday experiences. The segment shows Responsiveness through purposeful questioning that reveals students' prior knowledge and prompts them to reason about the importance of each phase and checkpoint. Aligned with Constructivism and Inquiry, it encourages learners to build understanding through guided prompts, visual models, and conceptual connections. The primary strategies used are direct instruction paired with guided exploration, including visual modeling and analogy-driven explanations. Teachers should ensure that diagrams are clear, terminology is reinforced consistently, and questioning is used to check comprehension before transitioning between stages of the cell cycle, mitosis, and checkpoint regulation.

	Show a 4-panel diagram or colored strips representing chromosomes. **2B. Teach Each Stage with Visual Models & Guiding Questions** **Prophase – Chromosomes Condense** • Chromatin coils into visible chromosomes. • Nuclear membrane breaks down. Guided Question: **Why do you think chromosomes need to condense into thicker, visible structures?** **Metaphase – Chromosomes Line Up** • Chromosomes align at the cell's equator. • Spindle fibers attach. Guided Prompt: **If chromosomes did not line up correctly, what problem might this cause later?** **Anaphase – Chromatids Separate** • Sister chromatids are pulled apart to opposite poles. Teacher analogy: This is like splitting identical sets of instructions so each new cell receives a complete copy. **Telophase – Two New Nuclei Form** • Chromosomes uncoil. • Nuclear membranes reform. Guided Reflection: **How can we tell the cell is almost done dividing at this stage?** **2C. Connect Mitosis to Cell Structures** **Teacher explanation:** During mitosis, microtubules, centrioles, and spindle fibers work together to pull chromosomes apart. Chromosomes themselves shift from coiled, paired structures to separated chromatids. **Ask:** **Which structure is responsible for pulling the chromatids apart?** **3B. Real-Life Application** Show image of healthy tissue vs. tumor growth. **Teacher:** When checkpoints work properly, your body maintains healthy tissues and when checkpoints fail, abnormal growth such as cancer can begin.	

	Guided Reflection: **Why is it important that cells do not divide with damaged DNA?**	
	B.3. Developing Mastery	
	Option 1: Cell Cycle Checkpoint Scenarios **Instructions:** Read each scenario carefully. Based on what you have learned about the **G1, G2, and M checkpoints**, identify: 1. Which checkpoint is involved, and 2. Why that checkpoint is important in preventing abnormal cell division. ● Write your answers in complete but concise sentences. **Learners individually read and answer:** 1. A skin cell has heavy UV damage; division pauses for repair. o **Checkpoint**: **G1** (DNA damage control) o **Why it matters**: prevents replication of damaged DNA. 2. DNA replication completed, some chromosomes imperfectly duplicated. o **Checkpoint: G2** o **Why it matters**: ensures fidelity before mitosis. 3. Chromosomes not all attached to spindle fibers, misaligned at equator. o **Checkpoint**: **M (spindle assembly)** o **Why it matters**: prevents unequal chromosome numbers. 4. A cell keeps dividing with damaged DNA → mass of cells forms. o Which failed? **G1/G2 and/or M checkpoint** o What went wrong? **Unchecked DNA damage/misalignment → abnormal growth/tumor formation.** **Option 2: Stage-and-Checkpoint Card Sort** Students match event cards (DNA replication, spindle attachment, chromatid separation, cytokinesis) with the correct stage or checkpoint. **Option 3: Two-Minute Exit Explanation** Students answer: Why is it dangerous for a cell to divide with damaged DNA?	Activities in the Developing Mastery reinforce learners' understanding of cell cycle control mechanisms by having them independently analyze real-life scenarios and identify the appropriate checkpoints. It supports Relevance by connecting checkpoint functions to familiar situations such as UV damage and DNA replication errors, and demonstrates Responsiveness because learners' written explanations allow the teacher to assess understanding and identify misconceptions. The task aligns with Constructivism and Inquiry as students apply conceptual knowledge to interpret cellular events and reason about the consequences of checkpoint failure. The instructional method used is scenario-based application, which strengthens comprehension of regulatory roles in the cell cycle. Teachers should monitor student responses for accurate use of scientific terminology and provide scaffolding—such as checkpoint reminders or guided prompts—for learners who struggle to explain the relationship between checkpoint function and prevention of abnormal cell division.

	ESRU Checkpoint: Elicit student explanations, recognize whether they correctly identify the stage/checkpoint, respond with a brief correction if needed, and use the results to decide whether reteaching is necessary before the summative assessment.	
C. Demonstrating Knowledge and Skills	***C.1. Finding Practical Application***	
	Activity: Where Checkpoints Protect Us Everyday **Optional Activity Overview:** Students connect the concept of *cell cycle checkpoints* to *real-life processes* in the body where these mechanisms prevent damage, disease, or abnormal growth. They then explain how checkpoint failure leads to risk. This Optional Activity helps learners see the *real-world importance* of regulation—not just as a biology concept but as a health concept. **Instructions to Students** **Step 1 : Choose one real-life situation involving cell growth or repair.** Pick one example from below or create your own: • Skin cells repairing a cut or wound • Bone cells responding to a fracture • Cells in the stomach lining that replace themselves daily • Growth of a child or teenager • Hair or nail regrowth • The immune system making new white blood cells • Lung cells repairing after smoke exposure • Cells exposed to UV radiation from sunlight • Cells near a polluted environment (smoke, chemicals, toxins) **Step 2 :Apply the concept of cell cycle checkpoints.** **For the chosen situation, answer the following:** 1. Which checkpoints (G1, G2, M) are essential in this process? 2. What damage or error might the cell detect in this real-life example? (e.g., UV damage, toxins, chromosome misalignment) 3. How does the checkpoint protect the body in this specific scenario? 4. What would happen if the checkpoint failed? (e.g., tumor formation, mutation accumulation, tissue malfunction) *Write your answers in paragraph or structured bullet form.* **Step 3 : Pair Share**	**Activity: Where Checkpoints Protect Us Everyday** This Activity supports the objective of explaining the importance of cell cycle control mechanisms by prompting learners to apply checkpoint concepts to familiar real-life biological situations. It demonstrates Relevance as students connect the abstract idea of cellular checkpoints to everyday processes such as wound healing, growth, immune responses, and environmental exposure. The Optional Activity shows Responsiveness through learners' written and verbal explanations, allowing the teacher to identify misconceptions about checkpoint functions and the consequences of their failure. It aligns with Constructivism and Inquiry, as students independently analyze scenarios, reason through which checkpoint is involved, and evaluate the potential outcomes of disrupted regulation. The instructional strategy used is application-based analysis, encouraging deeper understanding of how G1, G2, and M checkpoints protect the body from abnormal cell division. Teachers should monitor for oversimplified or incorrect interpretations and provide scaffolds—such as word banks or guided prompts—for students who need support, ensuring all learners can accurately link checkpoint mechanisms to real-world biological processes.

	Discuss with a partner: • Your example • The checkpoint involved • The consequence if regulation fails Partners give one question or comment for clarification. **Step 4 : Class Connection** Volunteers complete this sentence aloud: In my example, the _____ checkpoint protects the body by _____. Without it, _____ could happen.	
	C.2. Making Generalization	
	Activity: Whole Class Guided Generalization Use any of the following prompts to help students summarize the lesson's key ideas: **Guiding Questions:** • What patterns do you observe in how cells prepare, divide, and finish division? • How do the stages of mitosis ensure accurate distribution of chromosomes? • What role do checkpoints play in protecting your body from harmful or abnormal cells? Teacher writes student responses on the board and helps consolidate them into a clear generalization. **Expected Generalization:** The cell cycle is a controlled sequence of events where cells grow, replicate DNA, divide their chromosomes through mitosis, and split into two cells. Proper regulation through checkpoints ensures normal growth and prevents abnormal or uncontrolled cell division. **Activity 2: Part C -Readiness Check (Before Final Evaluation)** These short tasks determine if learners can apply concepts independently. **Readiness Check: Quick Questions** 1. Which stage of the cell cycle includes DNA replication? 2. In which mitosis stage do sister chromatids separate? 3. Why is the M checkpoint important? 4. Which stage prepares the cell for mitosis by checking DNA accuracy? 5. What might happen if damaged DNA passes through G1 without repair? (Teacher listens/collects answers. If majority cannot answer correctly, reteach briefly before assessment.)	**Activity 1: Whole Class Guided Generalization.** This whole-class guided generalization Optional Activity supports all three learning objectives by helping students synthesize the major concepts of the cell cycle, mitosis, and checkpoint regulation. It demonstrates Relevance as learners connect earlier activities to a big-picture understanding of how cells grow and divide in an orderly and controlled manner. The Optional Activity shows Responsiveness because the teacher collects and organizes student responses, allowing misconceptions to surface and be clarified immediately. It also aligns with Constructivism, as students collaboratively build a unified generalization from their shared observations and reflections. The instructional strategy used is a guided summarization discussion, which reinforces conceptual connections among interphase, mitosis, cytokinesis, and cell cycle checkpoints. Teachers should ensure that learners' ideas are accurately consolidated into the expected generalization and provide additional clarification for students who struggle to articulate the relationships between the stages and regulatory mechanisms. **Activity 2: Part C -Readiness Check (Before Final Evaluation)** This readiness check ensures learners can independently apply core ideas about the cell cycle, mitosis, and checkpoint regulation before moving to the final evaluation. It demonstrates Responsiveness by quickly surfacing

	Expected Answers: 1. S-phase (Synthesis phase) of Interphase 2. Anaphase 3. It ensures that all chromosomes are properly attached to the spindle fibers and aligned correctly before the cell separates chromatids. This prevents unequal chromosome distribution and reduces the risk of abnormal cells. 4. G2 phase (G2 checkpoint) 5. The cell may copy damaged DNA, leading to mutations, abnormal cell division, or possibly tumor formation due to unregulated growth.	misconceptions and guiding reteaching if needed. The activity aligns with Constructivism and Inquiry, as students retrieve and articulate essential information such as DNA replication timing, chromatid separation, and checkpoint roles. The strategy is a brief formative assessment that reinforces accuracy and clarity in sequencing and regulation. Teachers should monitor responses closely, provide immediate feedback, and clarify misconceptions—especially around mitotic stages and checkpoint functions—to confirm readiness for summative assessment.
	C.3. Evaluating Learning	
	Differentiated Summarization Tasks (Choose based on learner need) **Option 1: Concept Map (For visual learners / advanced learners)** **Instruction:** Show how each phase relates to DNA, chromosomes, and cell growth. Include arrows showing cause-and-effect**.** • Interphase → G1, S, G2 • Mitosis → Prophase, Metaphase, Anaphase, Telophase • Cytokinesis • Checkpoints → G1, G2, M **Option 2: Sentence Stem Completion (For learners needing scaffolding). Students will complete each sentence in their own words** Provide sentence starters: 1. In interphase, the cell… 2. During mitosis, chromosomes… 3. The G2 checkpoint helps by… 4. If a checkpoint fails, the cell might… **Exit Ticket:** 1. Name the stage of interphase in which DNA is replicated. 2. Arrange prophase, metaphase, anaphase, and telophase in order. 3. Explain in one or two sentences why checkpoints are necessary for normal cell growth.	This differentiated summarization activity helps learners consolidate understanding of the cell cycle, mitosis, and checkpoint regulation through varied formats suited to different strengths. It highlights relevance by having students synthesize key ideas, and responsiveness by allowing teachers to observe how well concepts are internalized. Aligned with constructivism and inquiry, it encourages learners to generate generalizations and reflect on how cell growth, chromosome behavior, and checkpoints interconnect. Strategies such as concept mapping, sentence completion, structured summaries, and Think–Pair–Share provide multiple entry points. Teachers should monitor accuracy, provide scaffolds when misconceptions arise, and ensure learners articulate clear, scientifically sound summaries before moving to the final assessment.
	C.4. Additional Activities	
	Optional Activity 1 — Remediation Task (For learners who need reteaching) **Title: Fix the Cell Cycle Errors**	This remediation task targets misconceptions by engaging learners in error analysis and correction of an intentionally flawed cell cycle/mitosis diagram. It supports all three objectives by

	Purpose: Address misconceptions through error analysis **Target learners:** Those who show gaps in formative tasks **Instructions:** Provide students with a one-page Incorrect Cell Cycle Diagram that includes errors such as: • DNA replication drawn in G1 instead of S • Chromosomes separating during metaphase • G2 checkpoint missing • Cytokinesis placed before telophase **Students must:** 1. Identify the incorrect elements (highlight or list them) 2. Explain why each error is wrong 3. Correct the diagram by redrawing or rewriting steps **Supports included:** • Checklist of correct functions of each stage • Pair support: students check each other's corrections • Visual reference of an accurate diagram **Learning Impact:** This task targets misconceptions directly and strengthens foundational understanding before moving forward. **Optional Activity 2 — Enrichment Task (For advanced learners)** **Cell Failure Investigation: Mini Case Study Challenge** **Purpose:** Enrich critical thinking using real-world biomedical reasoning **Target learners:** Fast finishers / high-performing students **Instructions:** Students receive a short biomedical case study, such as: • A cell accumulates DNA damage from chemical exposure • Chromosomes fail to attach to spindle fibers • A cell with replicated DNA divides prematurely Each case includes microscope images or brief descriptions. **Students must:** 1. Identify which stage (G1, S, G2, M) is malfunctioning 2. Predict the structural error occurring 3. Propose what type of abnormal growth/disease may result 4. Recommend a cell intervention (e.g., apoptosis, checkpoint repair, cycle arrest) **Optional Activity 3: Printed Case Card Review** Students read a short printed case about failed cell-cycle control, identify the affected stage or checkpoint, and suggest a	requiring students to (1) re-locate DNA replication to S-phase, (2) correctly sequence PMAT with corresponding structural changes, and (3) reinsert/justify G1, G2, and M checkpoints to prevent abnormal division. The Optional Activity demonstrates Relevance as it mirrors authentic learning from mistakes and Responsiveness through immediate teacher feedback while circulating. It aligns with Constructivism and Inquiry, prompting learners to diagnose, explain, and correct errors rather than passively receive answers. The primary strategy is guided reteaching via error analysis, reinforced with a checklist of correct stage functions, peer checking, and a clean reference diagram. Teachers should watch for persistent confusions (e.g., interphase = rest, metaphase vs. anaphase, mitosis vs. cytokinesis, checkpoint roles) and provide scaffolds such as sentence frames, word banks, color-coding for chromosomes/chromatids, and partial diagrams. Success is evident when learners can explain why each correction is necessary and reconstruct an accurate sequence linking interphase, mitosis, cytokinesis, and checkpoints.

	correction. **Mini-rubric:** Scientific accuracy (4), clarity of explanation (3), correct use of terms (3).	

V. ASSESSMENT *(Assessing Learnings)*	**Multiple Choice**. Read and understand each item carefully and write the letter of your answer. **1. A teacher compares the G1, S, and G2 stages of the cell cycle to infancy, childhood, and adolescence. What key idea does this analogy you understand?** A. Cells grow at the same speed throughout all stages. C. Only one stage affects the final outcome of division. B. Each stage prepares the cell for the next major event D. Human development is identical to the cell cycle. **2. During a microscope Optional Activity, a student recalls seeing chromosomes lined neatly at the center of an onion root tip cell. What process was the student likely observing?** A. Cytokinesis B. Metaphase C. Prophase D. Telophase **3. A city experiences a traffic-light malfunction at a major intersection, leading to accidents and delays. Which cell process best matches this situation?** A. Correct formation of spindle fibers C. Slowdown in DNA replication B. Unregulated passage through cell cycle checkpoint D. Proper separation of chromatids **4. A scraped knee heals because body cells repeatedly produce new identical cells. Which process directly explains this healing?** A. Apoptosis B. Mitosis C. Metaphase D. Telophase **5. When modeling mitosis, students show chromosomes being pulled apart to opposite poles. What structural change are they demonstrating?** A. Chromosome condensation C. Separation of sister chromatids B. Spindle fiber disintegration D. Nuclear membrane formation **6. A student creates a diagram showing the nuclear membrane dissolving and chromosomes becoming visible. What conclusion can be drawn?** A. The cell is preparing for cytokinesis C. The cell is entering prophase B. The cell is beginning DNA replication D. The cell is checking for chromosome alignment **7. A mutation prevents a cell from repairing DNA damage before replication. Which stage will be most directly affected?** A. M-phase B. S-phase C. G1 checkpoint D. Cytokinesis **8. During a class Optional Activity, a group is asked to match mitosis stages with possible errors. They identify chromosomes failing to attach to spindle fibers. Which checkpoint prevents this error?** A. G1 B. S C. G2 D. M checkpoint

	9. In a medical headline, scientists report discovering a gene that causes cells to ignore internal signals to stop dividing. This gene most likely disrupts— A. DNA replication speed B. Chromosome condensation C. Cell cycle checkpoints D. Cytoskeleton structure **10. A plant cutting begins forming new roots. Students analyze which processes allow this growth. Which explanation best demonstrates higher-order thinking?** A. The plant grows because it absorbs water. B. The roots extend because old cells are dying. C. Root cells divide because mitosis creates identical copies. D. Mitosis ensures new root cells each receive complete chromosomes. **Answer Key:** **1.B 2. B 3. B 4. B 5. C 6. C 7. C 8. D 9. C 10. D**
VI. REFLECTION (Feedback and Continuous Improvement)	*Use the following reflection prompts to guide your evaluation of the lesson after implementation. Reflect on learners' performance, determine which activities and lesson parts were most and least effective, identify learners who need enrichment or remediation, analyze the assessment results, and note possible improvements to enhance future lesson delivery.* ● *How many learners successfully demonstrated the learning objectives based on the assessment results?* ● *Which activity helped learners understand the lesson the most? Which activity helped the least?* ● *Which part of the lesson was easiest for learners? Which part was most difficult?* ● *How many learners needed enrichment or additional challenge? How many learners needed remediation or additional support?* ● *What did the assessment results show about learners' understanding of the lesson?* ● *What improvement would you make if you taught this lesson again?*
VII. USE OF GENERATIVE AI	In preparing this Learning Exemplar (LE), the author(s) used Microsoft M365 Copilot to help draft initial wording, organize lesson components, and refine the clarity of instructional text. All scientific explanations, assessment items, and final revisions were reviewed and validated by the author(s), who take full responsibility for the accuracy, quality, and appropriateness of the content.

Lesson Title/Topic	Differentiating Structural Features of Prokaryotic vs. Eukaryotic Division	Lesson Exemplar	6

I. OBJECTIVES		
A. Content Standard	The cell cycle consists of a series of phases, stages, and events	
B. Performance Standard	By the end of the quarter, learners discuss the scientific value of the interconnectedness of living organisms and their environment. They evaluate the significance of cell theory and its development in explaining the structure and function of living organisms. Learners classify cells based on their structures and functions, explain the stages and significance of the cell cycle, and describe the mechanisms of passive and active transport in maintaining homeostasis. They participate in practical activities and create presentations that showcase how these biological principles contribute to growth, repair, reproduction, and the diversity of life.	
C. Learning Competencies	***Prerequisite Knowledge and Skills*** Understanding of cell reproduction through mitosis for growth, repair, and regeneration, and meiosis for genetic variation and reproduction, including the role of genes, mutations, and their significance in sustaining life.	
	explain the processes of crossing over and recombination in meiosis that result in genetic variation among the meiotic offspring;	
II. REFERENCES and MATERIALS (*Selecting Resources and Material*)	Alberts, Bruce, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, and Peter Walter. Molecular Biology of the Cell. 6th ed. New York: Garland Science. Pollard, Thomas D., William C. Earnshaw, Jennifer Lippincott-Schwartz, and Graham Johnson. Cell Biology. 4th ed. Philadelphia: Elsevier.	
III. CONTENT *(Sequencing Content)*	Differentiating Structural Features of Prokaryotic vs. Eukaryotic Division	
IV. OBJECTIVES *(Setting Clear Objectives and Analyzing the Tasks)*	a. Describe the major stages of cell division in prokaryotes b. Outline the stages of eukaryotic cell division, in mitosis (prophase, metaphase, anaphase, telophase) and cytokinesis. c. Differentiate the structural features involved in prokaryotic vs. eukaryotic cell division, such as circular vs. linear chromosomes and absence vs. presence of spindle fibers.	
IV. PROCEDURES		**ANNOTATIONS**
	A.1. Activating Prior Knowledge	

A. Activating Prior Knowledge	**Activity 1: Concept Connection Web** 1. **Visual Prompt:** Display a diagram showing a cell dividing, with two branches labeled **Mitosis** and **Meiosis**. Ask learners to brainstorm what they already know about each process and write their ideas on sticky notes (or digitally, if online). 2. **Guiding Questions:** o What is the purpose of mitosis in living organisms? o How does meiosis contribute to genetic variation? o What role do genes play in the transmission of traits? o What happens when mutations occur in DNA or chromosomes? o Why is mitosis important for growth and repair, and meiosis for reproduction? Learners place their sticky notes around the diagram, creating a knowledge web that visually connects prior concepts After the activation, pose short diagnostic questions to reveal readiness and misconceptions. Choose from any of the following activities. 1. **True or False:** o Mitosis results in four daughter cells. (False) o Crossing over occurs during mitosis. (False) o Mutations can be caused by environmental factors like radiation. (True) o Meiosis ensures genetic variation among offspring. (True) 2. **Short Task:** Ask learners to compare mitosis and meiosis in one sentence each. Example: Mitosis produces identical cells for growth, while meiosis produces varied cells for reproduction. **Corrective Explanations** Based on common misconceptions: • **Misconception:** Mitosis produces four cells. **Correction:** Mitosis produces **two genetically identical cells**, while meiosis produces **four genetically varied cells**. • **Misconception:** Crossing over happens in mitosis. **Correction:** Crossing over occurs **only in meiosis (Prophase I)**, leading to genetic recombination. • **Misconception:** Mutations are always harmful. **Correction:** Mutations can be **neutral, harmful, or beneficial**. Some drive evolution and adaptation. • **Misconception:** Genes directly control traits without variation.	This activity engages learners in connecting prior knowledge of cell division, genes, and mutations to new concepts in the cell cycle. The visual prompt and sticky-note web encourage active recall and collaborative construction of ideas, while guiding questions direct attention to the purposes of mitosis and meiosis, the role of genes, and the impact of mutations. Diagnostic questions and short comparison tasks serve as formative checks, revealing readiness and surfacing misconceptions. The activity supports the objectives of describing cell cycle stages, illustrating mitosis, and explaining control mechanisms. It reflects the principles of relevance, rigor, and reflection, and applies the 2C–2I–1R approach by emphasizing concepts, connections, inquiry, integration, and reflection. Pedagogically, it combines concept mapping with formative assessment in a constructivist framework. Teachers should ensure broad participation, use visuals or color coding to clarify distinctions, and address misconceptions promptly with corrective explanations and analogies. Responses should be treated as indicators of readiness to guide pacing and instructional emphasis.

	Correction: Genes carry instructions, but **recombination and mutations** introduce variation in traits. **Targeted Guidance** • Use analogies: ○ **Mitosis** is like making a photocopy of a document (identical). ○ **Meiosis** is like shuffling a deck of cards before dealing (variation). • Provide alternative explanations: ○ Show animations of mitosis vs. meiosis to highlight differences. ○ Use real-life examples: wound healing (mitosis), gamete formation (meiosis). • Encourage peer discussion: Learners explain concepts to each other, reinforcing correct understanding and clarifying misconceptions.	
	A.2. Establishing the Purpose of the Lesson	
	Describe the major stages of cell division in prokaryotes **Activity 1: Bacteria Growth Simulation** **Purpose:** Learners understand that prokaryotic division is crucial in medicine (controlling infections) and industry (using microbes for production). • **Step 1:** Present a scenario: Imagine one bacterium enters your body. How does it multiply so quickly that it can cause illness within hours? • **Step 2:** Learners use counters or paper circles to simulate binary fission stages. • **Step 3:** Discuss how rapid prokaryotic cell division explains bacterial infections, fermentation in food, and biotechnology applications. **Activity 2: Differentiate structural features in prokaryotic vs. eukaryotic cell division** **Purpose:** Learners see how structural differences are exploited in medicine and agriculture, making the lesson relevant to real-world problem-solving. • **Step 1:** Provide a blank Venn diagram. One circle labeled *Prokaryotes*, the other *Eukaryotes*. • **Step 2:** Learners fill in features: circular vs. linear chromosomes, absence vs. presence of spindle fibers, simple vs. complex division.	**Activity 1: Bacteria Growth Simulation** This activity targets the objective of describing the major stages of prokaryotic cell division. It reflects the 3Rs of IDF-Relevance (linking bacterial growth to health and biotechnology), Responsibility (learners simulate division themselves), and Reflection (considering implications of rapid reproduction). The 2C-2I-1R approach is evident through Conceptual understanding (binary fission stages), Contextualization (infection spread, fermentation), Inquiry (simulation task), Integration (connecting science to real-world issues), and Reflection (discussion of applications). The pedagogical method applied is experiential learning through simulation and guided discussion. Teachers should note that learners may confuse binary fission with mitosis; emphasize that prokaryotic division is simpler and lacks spindle fibers. **Activity 2: Differentiate structural features in prokaryotic vs. eukaryotic cell division** This activity focuses on differentiating prokaryotic and eukaryotic cell division. It

	• **Step 3:** Discuss applications: antibiotics target bacterial division, while cancer treatments target uncontrolled eukaryotic division.	highlights relevance through applications in medicine and agriculture, responsibility by having learners construct comparisons, and reflection by evaluating differences and implications. The 2C–2I–1R framework is evident in conceptual understanding (chromosome structure, spindle fibers), contextualization (antibiotics vs. cancer treatments), inquiry (diagram completion), integration (linking features to division), and reflection (applications). The method is comparative analysis using graphic organizers. Teachers should clarify that prokaryotes divide by binary fission without spindle fibers, emphasizing structural simplicity.
B. Instituting New Knowledge	***B.1. Presenting Examples***	
	Activity 1 Option 1: Sibling Variation Example Present a simple family trait chart and ask learners why siblings from the same parents are not genetically identical. Use the example to introduce homologous chromosomes, crossing over, and recombination during meiosis. **Guided Inquiry** • Ask learners to match examples from the chart (e.g., different eye colors) to the processes of crossing over and recombination. • Encourage reasoning: *Which step in meiosis explains this difference?* **Reflection and Clarification** • Discuss how meiosis ensures diversity in populations. • Clarify misconceptions (e.g., siblings are not identical copies of parents). **Activity 2: Healing a Cut – Mitosis in Action** **Purpose:** Learners connect mitosis to their own bodies, making the process meaningful and memorable. • **Step 1:** Present a relatable scenario: *When you get a small cut, how does your skin heal?* • **Step 2:** Show a short animation or diagram of mitosis stages (prophase, metaphase, anaphase, telophase, cytokinesis).	**Activity 1: Sibling Variation Example** This activity uses a simple family trait chart to make meiosis relevant and memorable. By asking why siblings from the same parents are not genetically identical, learners are guided to discover homologous chromosomes, crossing over, and recombination. It emphasizes relevance through everyday family traits, responsibility as students reason out genetic differences, and reflection as they connect these to the mechanisms of meiosis. The strategy combines visualization and inquiry within a constructivist framework, helping learners see how genetic variation arises naturally. Teachers should clarify misconceptions, such as assuming identical inheritance, and highlight how recombination ensures diversity. **Activity 2: Healing a Cut – Mitosis in Action** This activity focuses on outlining the stages of eukaryotic cell division, including mitosis and cytokinesis. It connects relevance to real-life processes like wound healing and growth, responsibility by having learners sequence and explain stages, and reflection by evaluating how division maintains health. The 2C–2I–1R

	• **Step 3:** Learners match each stage to what's happening in the healing process: cells preparing, lining up chromosomes, separating, and forming new identical cells. • **Step 4:** Discuss how mitosis ensures growth, repair, and regeneration.	framework is evident in conceptual understanding of mitotic stages, contextualization through healing, inquiry via sequencing, integration with everyday life, and reflection on outcomes. The strategy is active learning through sequencing, visualization, and collaboration. Teachers should anticipate misconceptions such as mixing up stage order or overlooking cytokinesis, and use animations or analogies to clarify.
	B.2. Discussing New Concept	
	Describe the major stages of cell division in prokaryotes Teaching Flow: 1. **Define Key Term**: Introduce binary fission as the primary method of prokaryotic cell division. 2. **Explain Relationship**: Show how one cell divides into two identical cells, emphasizing the simplicity compared to eukaryotic division. 3. **Model/Analogy**: Use a simple analogy-binary fission is like photocopying a single-page document: one becomes two identical copies. 4. **Learner Interaction**: Ask learners to sketch the sequence (1 → 2 → 4 → 8) and explain why rapid division is advantageous for bacteria. 5. **Clarify Misconceptions**: Emphasize that prokaryotes do not undergo mitosis and lack spindle fibers. **Outline the stages of eukaryotic cell division (mitosis and cytokinesis)** **Teaching Flow:** 1. **Define Key Terms:** Present the stages-prophase, metaphase, anaphase, telophase, and cytokinesis. 2. **Explain Relationships:** Highlight how each stage ensures accurate chromosome distribution. 3. **Model/Analogy:** Use a classroom analogy-students lining up (metaphase), moving apart (anaphase), and forming two groups (telophase/cytokinesis).	**Prokaryotic Cell Division – Bacteria Growth Simulation** This activity targets the objective of describing the major stages of cell division in prokaryotes. It reflects the 3Rs of IDF-Relevance (linking bacterial division to food fermentation and infections), Responsibility (learners simulate growth patterns), and Reflection (considering implications of rapid reproduction). The 2C-2I-1R approach is evident through Conceptual understanding (binary fission stages), Contextualization (real-life bacterial growth), Inquiry (worksheet modeling task), Integration (connecting science to biotechnology), and Reflection (guided questions). The pedagogical method applied is experiential learning through modeling and guided questioning. Teachers should note that learners may confuse binary fission with mitosis; emphasize that prokaryotic division is simpler and lacks spindle fibers. **Eukaryotic Cell Division – Mitosis Sequencing** This activity addresses the objective of outlining the stages of eukaryotic cell division, including mitosis and cytokinesis. It demonstrates the 3Rs-Relevance (connecting mitosis to wound healing and growth), Responsibility (learners

	4. **Learner Interaction:** Provide stage cards or diagrams and have learners arrange them in sequence, explaining what happens at each stage. 5. **Clarify Misconceptions:** Emphasize that cytokinesis is distinct from telophase and that mitosis produces identical cells for growth and repair. **Differentiate structural features in prokaryotic vs. eukaryotic cell division** **Teaching Flow:** 1. **Define Key Terms:** Contrast *circular chromosomes* (prokaryotes) with *linear chromosomes* (eukaryotes), and note the absence/presence of spindle fibers. 2. **Explain Relationships:** Show how these structural differences dictate division mechanisms. 3. **Model/Analogy:** Compare prokaryotic division to a simple split of a ring (circular DNA), while eukaryotic division is like organizing books on shelves (linear chromosomes with spindle fibers). 4. **Learner Interaction:** Guide learners in completing a Venn diagram comparing features of prokaryotic and eukaryotic division. 5. **Clarify Misconceptions:** Reinforce that spindle fibers are unique to eukaryotic division and that structural complexity increases with organism complexity. **Teacher's Notes** • Use visual aids (animations, diagrams, charts) to strengthen understanding. • Encourage learners to explain concepts in their own words to check comprehension. • Address misconceptions immediately with clear corrective explanations. • Keep connections to real-life applications visible (e.g., bacterial infections, wound healing, cancer treatments).	arrange and match stages), and Reflection (evaluating how cell division maintains health). The 2C-2I-1R approach is applied through Conceptual understanding (mitotic stages), Contextualization (healing process), Inquiry (sequencing and matching tasks), Integration (linking cell division to everyday life), and Reflection (worksheet questions). The pedagogical strategy is active learning through sequencing, visualization, and collaborative explanation. Teachers should anticipate misconceptions such as mixing up stage order or overlooking cytokinesis; use diagrams and analogies to clarify. **Comparing Prokaryotic vs. Eukaryotic Division – Venn Diagram** This activity targets the objective of differentiating structural features of prokaryotic vs. eukaryotic cell division. It embodies the 3Rs-*Relevance* (medicine and agriculture applications), *Responsibility* (learners complete the Venn diagram), and *Reflection* (evaluating differences and implications). The 2C-2I-1R approach is evident through *Conceptual understanding* (chromosome structure, spindle fibers), *Contextualization* (antibiotics vs. chemotherapy), *Inquiry* (diagram completion), *Integration* (linking structural features to treatments), and *Reflection* (worksheet guiding questions). The pedagogical method is comparative analysis using graphic organizers and real-life medical contexts. Teachers should note that learners may mistakenly assume all cell divisions use spindle fibers; clarify that prokaryotes divide without them and highlight how structural differences are exploited in medicine.
	B.3. Developing Mastery	
	Activity Process: Modeling Crossing Over with Chromosome Strips **Step 1: Preparation**	This activity provides a hands-on model of crossing over, helping learners visualize how homologous chromosomes exchange segments and create new allele combinations. It

	• Provide learners with paper or card strips representing homologous chromosomes. • Label each strip with different alleles (e.g., A/a, B/b, C/c). **Step 2: Pairing Homologues** • Ask learners to pair homologous chromosome strips side by side, showing how each parent contributes one set. • Highlight that homologues carry the same genes but may have different alleles. **Step 3: Crossing Over Demonstration** • Instruct learners to model one crossing-over event by exchanging a segment between the paired strips. • Show how this creates recombined chromatids with new allele combinations. **Step 4: Gamete Formation** • Have learners separate the chromatids to represent gametes. • Trace how each gamete now carries a unique allele combination, demonstrating genetic variation. **Step 5: Guided Inquiry** • Ask learners to explain how recombination produces diversity among offspring. • Prompt them to compare gametes before and after crossing over. **Step 6: Comparison with Mitosis** • Discuss how mitosis produces identical cells without crossing over, while meiosis introduces variation. • Emphasize that this difference explains why siblings are genetically unique. **Step 7: Reflection and Clarification** • Encourage learners to reflect on how crossing over contributes to diversity in populations. • Clarify misconceptions, such as thinking mitosis also involves recombination. **Step 8: Extension** • Encourage learners to reflect on why meiosis, unlike mitosis, is essential for diversity and evolution.	emphasizes relevance by linking recombination to genetic diversity, responsibility as students construct and explain gamete outcomes, and reflection through comparison with mitosis. The strategy uses modeling and inquiry to make abstract processes concrete. Teachers should clarify that mitosis does not involve crossing over, highlight how recombination ensures variation among offspring, and scaffold with diagrams or sentence frames for learners who struggle with sequencing or terminology.
C. Demonstrating Knowledge and Skills	***C.1. Finding Practical Application***	
	Cell Division in Real Life – Case Study Presentation **Task Overview** Learners will apply their knowledge of prokaryotic and eukaryotic cell division by analyzing real-life scenarios and presenting solutions or explanations. This performance task integrates **description,**	**The tasks Cell Division in Real Life Case Study Presentation** integrate the 3Rs of IDF-*Relevance* (authentic case scenarios), *Responsibility* (group collaboration and individual reflection), and *Reflection* (connecting science to real-life applications). The 2C-2I-1R

	sequencing, comparison, and application of concepts into one authentic output. **Instructions for Learners** 1. **Form Groups of 3–4.** Each group will be assigned one of the following case scenarios: o **Case 1:** Food left unrefrigerated overnight caused food poisoning. Explain how bacterial cell division (binary fission) contributed to the rapid spread of illness. o **Case 2:** A patient's wound healed within a week. Explain how mitosis and cytokinesis enabled tissue repair. o **Case 3:** Two siblings inherit different trait combinations from the same parents. Explain how crossing over and recombination during meiosis contributed to these differences. Use a chromosome diagram in your group presentation. **Group Output:** Prepare a **short presentation (5–7 minutes)** that includes: • **Definition of key terms** (binary fission, mitosis, cytokinesis, spindle fibers, chromosomes). • **Explanation of relationships** (how division stages lead to growth, repair, or reproduction). • **Visual model or analogy** (diagram, role-play, or chart). • **Application to the case scenario** (clear explanation of how cell division explains the real-life situation). 2. **Individual Reflection**: After the group presentation, each learner writes a short reflection (5–7 sentences) **Reflection Question:** How does understanding cell division help us in everyday life?	approach is evident through *Conceptual understanding* (division stages), *Contextualization* (food safety, wound healing, medicine), *Inquiry* (case analysis), *Integration* (linking biology to health and biotechnology), and *Reflection* (individual written responses). The pedagogical method is case-based learning with collaborative presentation and personal reflection, ensuring mastery of concepts and their practical significance.
	C.2. Making Generalization	
	Readiness Check: Crossing Over and Recombination **Process:** 1. **Prompt Recall** – Ask learners to write one to two sentences explaining *where crossing over occurs* (during prophase I of	This readiness check functions as a brief formative assessment, surfacing misconceptions before the final evaluation. It emphasizes responsiveness by guiding reteaching if needed, relevance by linking recombination to everyday genetic diversity, and reflection as learners articulate why meiosis is essential for variation. Teachers should monitor

	meiosis), *how recombination changes allele combinations*, and *why this matters for variation among offspring*. 2. **Quick Response Collection** – Have students jot answers individually on slips of paper or digital notes. 3. **Immediate Feedback** – Collect or sample responses to quickly identify misconceptions (e.g., thinking crossing over happens in mitosis, or that recombination produces identical gametes). 4. **Clarification** – Reinforce that crossing over occurs between homologous chromosomes, reshuffling alleles to create unique gametes. 5. **Reflection** – Ask learners to connect this process to real-world variation, such as differences among siblings or diversity in populations. **Sample Responses** • *Crossing over happens in prophase I of meiosis, where homologous chromosomes exchange segments. This recombination creates new allele combinations, which is important for genetic variation among offspring.* • *During meiosis I, homologous chromosomes cross over and swap parts. This reshuffling of alleles produces unique gametes, ensuring diversity in siblings and populations.* • *Crossing over occurs between homologous chromosomes in meiosis. It changes allele arrangements, making each gamete genetically different, which explains variation among offspring.*	accuracy in terminology, provide scaffolds for struggling learners, and ensure all students can clearly explain the role of crossing over in diversity. **Note to Teacher:** **Quick Guide to Checking Responses** **Look for three key elements:** 1. **Where** – Crossing over occurs in *prophase I of meiosis* between homologous chromosomes. 2. **How** – Recombination *reshuffles alleles* by exchanging chromosome segments, creating new allele combinations. 3. **Why** – This process *ensures genetic variation* among offspring, explaining differences between siblings. **Common misconceptions to watch for:** • Saying crossing over happens in mitosis • Forgetting to mention homologous chromosomes • Assuming gametes remain identical after recombination
	C.3. Evaluating Learning	
	Describe Prokaryotic Cell Division (Binary Fission) **Activity 1: Written Response** • Learners write a short explanation (5–6 sentences) of how binary fission occurs, including DNA replication and cell splitting. • Teacher Check: Ensure learners mention key elements such as circular DNA, the replication process, and the resulting rapid multiplication of bacterial cells **Activity 2: Performance-Based Check** • Learners use coins or beads to model binary fission. Each round represents one division.	These evaluation activities measure knowledge, reasoning, and application across all objectives. The 3Rs of IDF are evident: *Relevance* (authentic contexts like food safety and medicine), *Responsibility* (learners demonstrate mastery through varied formats), and *Reflection* (written and oral explanations). The 2C-2I-1R approach is applied through *Conceptual understanding* (division stages), *Contextualization* (real-life scenarios), *Inquiry* (problem-solving tasks), *Integration* (medical and food safety

	• They narrate the process as they demonstrate. • Teacher Check: Observe if learners can explain the sequence clearly. **Outline Eukaryotic Cell Division** **Activity 1: Written Response** • Learners write a paragraph describing the sequence of mitosis stages and how they contribute to wound healing. • **Teacher Check:** Look for correct order (Prophase → Metaphase → Anaphase → Telophase → Cytokinesis). **Activity 2: Short Problem-Solving Task** • Learners are given stage cards with descriptions (e.g., chromosomes line up in the middle). • Task: Arrange cards in correct order and match them with stage names. • **Teacher Check:** Accuracy of sequencing and matching. **Differentiate Structural Features of Prokaryotic vs. Eukaryotic Division** **Activity 1: Written Response** • Learners complete a Venn diagram comparing prokaryotic and eukaryotic division. • Then, ask learners to summarize one similarity and one difference between prokaryotic and eukaryotic cell division in a short written response of 2–3 sentences • Teacher Check: Ensure that learners highlight circular vs. linear chromosomes, spindle fibers, and identical outcomes. **Activity 2: Short Problem-Solving Task** • Case Analysis: *A doctor prescribes antibiotics for bacterial infection and chemotherapy for cancer. Explain why these treatments differ.* • Learners write a short explanation linking structural differences to treatment. • Teacher Check: Accuracy in connecting medicine to cell division features.	applications), and *Reflection* (summaries and case analyses).
	C.4. Additional Activities	
	Enrichment (Advanced Learners): • **Activity:** Learners analyze medical case studies (antibiotics vs. chemotherapy) and present findings in a short oral report. • **Purpose:** Encourages higher-order application of structural differences to real-life contexts. **Reinforcement (On-Level Learners):**	These differentiated activities ensure inclusion and scaffolding: • Enrichment challenges advanced learners with research and synthesis. • Reinforcement consolidates learning through structured practice. • Remediation supports struggling learners with concrete, guided tasks.

	• **Activity:** Learners complete a Venn diagram comparing prokaryotic and eukaryotic division, then summarize one similarity and one difference. • **Purpose:** Reinforces comparison skills through structured graphic organizer. **Remediation (Struggling Learners):** • **Activity:** Teacher provides a matching exercise (e.g., circular chromosomes → prokaryotes, spindle fibers → eukaryotes). Learners match features to cell type. • **Purpose:** Simplifies differentiation into clear, direct associations.	The 3Rs of IDF are evident: *Relevance* (authentic contexts like food safety and medicine), *Responsibility* (learners engage at their readiness level), and *Reflection* (summaries and case analyses). The 2C-2I-1R approach is applied through conceptual understanding, contextualization, inquiry, integration, and reflection at each level.
V. ASSESSMENT *(Assessing Learnings)*	1. **A family left cooked rice at room temperature overnight. The next day, several members experienced food poisoning. Based on what you know about bacterial cell division, what explains this situation?** a. Bacteria divide rapidly by binary fission, increasing their number overnight. b. Mitosis in bacteria produced harmful toxins. c. Crossing over during bacterial division created new harmful strains. d. Cytokinesis in bacteria slowed down their growth. **2. A student scraped her knee, and within a week, the wound closed and new skin formed. Which stage of mitosis ensured that new skin cells received identical genetic material?** a. Anaphase b. Metaphase c. Prophase d. Telophase **3. Doctors prescribe antibiotics for bacterial infections but chemotherapy for cancer. Why are different treatments used for these conditions?** a. Antibiotics target spindle fibers, chemotherapy targets cell walls. b. Antibiotics target structures unique to bacteria, chemotherapy targets uncontrolled mitosis in human cells. c. Both treatments target binary fission. d. Both treatments target cytokinesis. **4. Prokaryotic cells divide faster than eukaryotic cells.Which structural feature explains this difference?** a. Linear chromosomes requiring spindle fibers c. Crossing over during division b. Circular chromosomes with simpler replication d. Larger cell size in prokaryotes **5. Yogurt production relies on bacterial growth. Why is binary fission important in this process?** a. It allows bacteria to reproduce quickly, fermenting milk sugars. b. It ensures bacteria undergo mitosis to produce lactic acid. c. It slows down bacterial growth, preventing spoilage. d. It creates genetic variation needed for fermentation. **6. If spindle fibers fail to attach to chromosomes, which stage would be most directly disrupted?** a. Prophase b. Metaphase c.. Telophase d. Cytokinesis **7. Chemotherapy often causes side effects like hair loss. Why does chemotherapy affect hair cells?** a. Hair cells divide rapidly, so chemotherapy affects them too. b. Chemotherapy targets only bacteria, not human cells. c. Hair cells undergo binary fission, which chemotherapy blocks. d. Chemotherapy prevents cytokinesis in prokaryotes. **8. Comparative Understanding. Which statement best summarizes the difference between binary fission and mitosis?**	

	a. Binary fission is complex, mitosis is simple. b. Binary fission produces variation, mitosis does not. c. Binary fission occurs in humans, mitosis occurs in bacteria. d. Binary fission is simpler with circular DNA, mitosis is complex with spindle fibers and linear DNA. **9. A farmer stores milk in a cold room to prevent spoilage. How does refrigeration slow bacterial growth?** a. It destroys linear chromosomes. b. It accelerates mitosis in bacteria. c. It prevents spindle fibers from forming. d. It slows down binary fission by reducing metabolic activity. **10. Which conclusion best integrates all concepts of cell division?** a. Cell division is unrelated to everyday life. b. Cell division is only important for bacteria. c. Cell division is identical in prokaryotes and eukaryotes. d. Cell division explains growth, repair, reproduction, and medical treatments. **Answer key** 1. a 2.a 3. b 4.b 5.a 6,b 7.a 8.d 9.d 10.d
VI. REFLECTION *(Feedback and Continuous Improvement)*	*Use the following reflection prompts to guide your evaluation of the lesson after implementation. Reflect on learners' performance, determine which activities and lesson parts were most and least effective, identify learners who need enrichment or remediation, analyze the assessment results, and note possible improvements to enhance future lesson delivery.* ● *How many learners successfully demonstrated the learning objectives based on the assessment results?* ● *Which activity helped learners understand the lesson the most? Which activity helped the least?* ● *Which part of the lesson was easiest for learners? Which part was most difficult?* ● *How many learners needed enrichment or additional challenge? How many learners needed remediation or additional support?* ● *What did the assessment results show about learners' understanding of the lesson?* ● *What improvement would you make if you taught this lesson again?*
VII. USE OF GENERATIVE AI	In preparing this Learning Exemplar (LE), the author(s) used Microsoft M365 Copilot (Generative AI tool) in order to assist in drafting ideas, organizing content, and enhancing clarity and coherence of instructional materials. The author(s) reviewed, revised, and finalized all sections of the LE. The author(s) take(s) full responsibility for the accuracy, quality, and appropriateness of the content of this LE.

Lesson Title/Topic	Cell Cycle	Lesson Exemplar	7

I. OBJECTIVES	
A. Content Standard	*The learners learn that the cell cyce consists of a series of phases, stages, and events.*
B. Performance Standard	*By the end of the quarter,* learners discuss the scientific value of the interconnectedness of living organisms and their environment. They evaluate the significance of cell theory and its development in explaining the structure and function of living organisms. Learners classify cells based on their structures and functions, explain the stages and significance of the cell cycle, and describe the mechanisms of passive and active transport in maintaining homeostasis. They participate in practical activities and create presentations that showcase how these biological principles contribute to growth, repair, reproduction, and the diversity of life.
C. Learning Competencies	*Prerequisite Knowledge and Skills* *Prior to lesson learners are expected to recall that chromosomes are made up of DNA tightly coiled around proteins, be able to identify that centromere and chromatids, and , explain how DNA replication results in identical sister chromatids. They should also be able to distinguish mitosis as a process for growth and repair that produces genetically identical cells, and meiosis as a process of gametes formation that produces genetically varied cells. In addition, they are expected to recall that genes are specific segments of DNA coding for traits, while alleles are alternative forms of gene and be able to apply this knowledge to simple inheritance patterns.*
	Learners are expected to recall basic chromosome structure, the difference between mitosis and meiosis, the meaning of genes and alleles, and how DNA replication produces sister chromatids.
II. REFERENCES and MATERIALS (*Selecting Resources and Material*)	● OpenStax. Biology 2e. Chapter 13.1: Chromosomal Theory and Genetic Linkage.https://openstax.org/books/biology-2e/pages/13-1-chromosomal-theory-and-genetic-linkage ● Stuart, D. T. (Ed.). Meiosis. Springer, 2017. https://link.springer.com/book/10.1007/978-1-4939-6340-9 ● Keeney, S. (Ed.). *Meiosis: Volume 1, Molecular and Genetic Methods*. Springer, 2009. https://link.springer.com/book/10.1007/978-1-59745-527-5 ● Crossing Over in Meiosis Prophase 1 | Step-by-Step Biology Tutorial https://www.youtube.com/watch?v=PxYXnV9aJlg
III. CONTENT *(Sequencing Content)*	***Cell Cycle*** ● Stages of crossing over and recombination ● New gene combinations produced by crossing-over ● Crossing over with diagram ● Increases genetic variation through crossing over students to study cell division (binary fission vs. mitosis/meiosis) and its role in growth, repair, and variation.
IV. OBJECTIVES *(Setting Clear Objectives and Analyzing the Tasks)*	1. Identify the stages where crossing over and recombination occur 2. Describe how crossing over produces new genetic combinations. 3. Illustrate the results of a crossing-over event using a diagram. 4. Explain how crossing over increases genetic variation in real-life contexts.

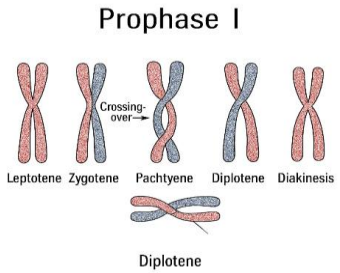
IV. PROCEDURES		ANNOTATIONS
A. Activating Prior Knowledge	***A.1. Activating Prior Knowledge***	
	To activate learners' prior knowledge, the teacher begins the lesson by guiding students through an activity about heredity and variation. **Option 1: Visual Prompt** The teacher shows an image of siblings and instructs students to think about the question individually, discuss their ideas with a partner, and be prepared to share their responses with the class. *"Why can siblings with the same parents still show different combinations of traits?"* **Option 2: Mix-and-Match Socks Activity** The teacher shows a set of differently colored or patterned socks and asks students to mix and match the socks in pairs to create a new combination. The teacher then asks the students to reflect on the question and share their ideas verbally. *What process in Biology creates new combinations of traits in offspring?* **Option 3: AnswerGarden: Exploring What Makes Us Different?** The teacher launches an AnswerGarden activity titled 'AnswerGarden: Exploring What Makes Us Different.' The teacher instructs students to submit short responses to the prompt, 'Why don't siblings look exactly alike?' using their devices.	*The activities reflect **relevance** and **responsiveness** by using familiar, simple prompts that connect science concepts to real-life experiences.* *The method used is **guided discovery and discussion** through visual, hands-on, or digital prompts.* ***Note to Teacher*** *Use prompts, visuals, simple objects, and digital tools to help students explore why siblings differ in traits. Emphasize that crossing over and genetic recombination during meiosis create new allele combinations, leading to variation among individuals.* *Teachers should let students think individually first, then discuss with partners or the class to refine their ideas.*
	A.2. Establishing the Purpose of the Lesson	
	After reviewing the students' responses, the teacher highlights student responses related to traits and genetic differences. The teacher explains that the lesson will focus on the meiotic process that creates these differences—crossing over and recombination—and identifies the stage where it occurs. **Option 1. Quick Think Prompt (1 Minute Writing)** Students answer a short prompt on a quarter sheet of paper then share it to the class verbally: *Why it is important to understand how traits vary among organisms?* **Option 2: Variation Hunt** Students quickly look around the class and identify two visible variations among classmates (eye shape, height, hair texture, etc.).	*The activities reflect **relevance and responsiveness** by using familiar examples.* *The approach is mainly **constructivist and collaborative**.* ***For option 1*** *Ask students to quickly write a short response on why it is important to understand how traits vary among organisms, then share their ideas verbally. Emphasize that this reflection helps them connect genetic variation to real-world relevance, such as biodiversity, adaptation, and ecosystem resilience.*

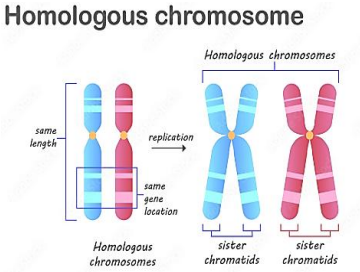
	They share one observation aloud. *Process Questions:* 1. *What differences did you observe among your classmates?* 2. *Do these traits come only from parents, or is there something happening inside the cell that mixes traits?* **Option 3: Short Ranking Task** The teacher presents the list of possible causes of trait differences and instructs students to choose the one they think contributes the most to differences among individuals. They may rank all the factors from most to least. Each student writes a brief reason for their choice and briefly shares answers with the class. **Which Causes Differences?** Environment DNA Randomness Genes Chromosomes	***For option 2*** *Have students spot two visible variations among classmates and share one aloud, then highlight that traits come not only from parents but also from recombination during meiosis, which mixes genetic material and creates differences* ***Option** 3* *Have students rank possible causes of trait differences from most to least important, then justify their choice. Emphasize that the goal is not a single 'right' answer but to encourage reasoning, discussion, and connections between genetic and environmental factors that shape variation.*
B. Instituting New Knowledge	***B.1. Presenting Examples***	
	After reviewing cell division, the teacher presents an illustration of homologous chromosomes during meiosis and explains that these chromosome pairs align closely in Prophase I. The teacher uses the example to show how segments of genetic material can be exchanged between chromosomes, introducing the concept of crossing over and how it creates new combinations of traits **Option 1: Stage Sorting** The teacher will group the students. Each group will receive cards showing the stages of prophase I: Leptotene, Zygotene, Pachytene Diplotene, and Diakinesis. They will be instructed to work together to examine the images, identify the correct stage, and arrange them in proper sequence and answer the process questions **Process Questions:** 1. What visible changes in the chromosomes help you identify which substage of Prophase I you are looking at?	*The activities reflect relevance and responsiveness by offering multiple entry points—sorting, labeling, and comparing—that support different learning needs.* *The approach is primarily constructivist and interactive. The activities target the objective 1,2 and 3* ***For option 1*** *Have groups arrange the prophase I substages in order—Leptotene, Zygotene, Pachytene, Diplotene, and Diakinesis—using the images provided. Emphasize that students should focus on visible chromosome changes (pairing, crossing over, separation) to identify each stage and explain their reasoning.*

2. Which stage shows homologous chromosomes fully paired and capable of crossing over, and what feature tells you that?

Option 2: Label-and-Identify

The teacher provides a diagram of homologous chromosomes and instructs students to label the key parts to familiarize themselves with structures involved in crossing over.





Process Questions:

1. What do the labels tell you about how chromosomes are organized before crossing over happens?
2. Which chromosome parts are likely to exchange segments during crossing over?
3. What similarities show that the two chromosomes are homologous?

Option 3. Compare and Contrast

The teacher asks students to compare and contrast the two chromosomes in the example using a simple T-chart, noting their similarities and differences.

Process Questions:

1. What differences and similarities can you observe between the two chromosomes?
2. How do these similarities and differences help you determine whether they are homologous chromosomes?
3. How do these similarities and differences help you determine whether they are homologous chromosomes?

Note for the images

Two homologous chromosomes, one maternal and one paternal, are shown side by side during Prophase I.

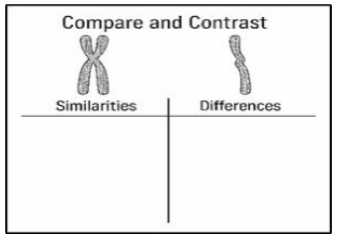
For option 2

Provide students with a diagram of homologous chromosomes to label key parts, then guide them to explain how chromosomes are organized before crossing over, identify that non-sister chromatids exchange segments, and note similarities that show the chromosomes are homologous

For option 3

*A **T-chart** is a simple graphic organizer shaped like the letter **T**.*
*It helps students sort information into **two categories**—in this case:*

- ***Similarities***
- ***Differences***



***Possible Answer**:*
Shape, structure, presence of chromatids, etc.,
Length, thickness, banding pattern, curvature, etc.,

B.2. Discussing New Concept

Option 1: Guided Concept Presentation

The activities aim to help learners understand how crossing over occurs during

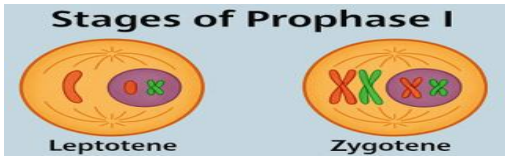
During meiosis, in Prophase I, the **Pachytene stage**, the homologous chromosomes lie side-by-side so closely that they can exchange matching segments. This exchange is called crossing over."

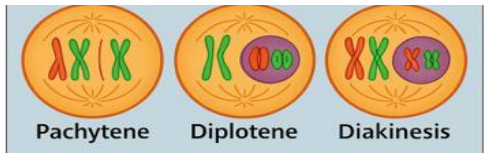
Definition of Terms

- Chiasma (Chiasmata) – the visible point where chromatids cross and exchange segments
- Crossing Over – Crossing over is the physical exchange of corresponding DNA segments between non-sister chromatids of homologous chromosomes during Prophase I
- Genetic recombination is the result of that exchange: new allele combinations on the chromatids that may appear in gametes.
- Homologous Chromosomes – a matching pair of chromosomes, one from each parent, same size, same shape, same kinds of genes
- Sister Chromatids – identical copies of a chromosome formed after DNA replication
- Tetrad – the structure formed when both homologous chromosomes (each with two sister chromatids) pair together

Stages of Prophase 1

Substage	Key Features	Crossing Over?
Leptotene	Chromosomes start condensing	No
Zygotene	Homologs start pairing (synapsis)	No
Pachytene	**Homologs fully paired; exchange segments**	**YES**
Diplotene	Homologs pull apart; chiasmata visible	Already done
Diakinesis	Fully condensed; prepare for metaphase	Already done





Real-Life Examples

- Variation in **eye color** among siblings

Prophase I and how it creates new trait combinations.

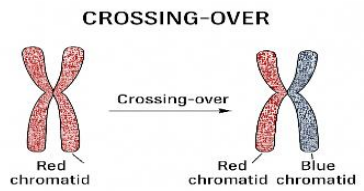
They show relevance by linking chromosome behavior to real-life examples of variation and responsiveness through visual supports such as diagrams, definitions, and videos. The approach is mainly constructivist and integrative, as students build understanding by examining chromosome structures, comparing before-and-after crossing over, and connecting these to familiar traits.

For option 1

Present the Pachytene stage of Prophase I and define key terms—chiasma, crossing over, genetic recombination, homologous chromosomes, sister chromatids, and tetrad. Emphasize how crossing over between non-sister chromatids produces new allele combinations, reinforcing the link between meiosis and genetic variation.
Allow time for learners to discuss how the visual changes relate to genetic variation.

Use real-life examples—such as sibling eye color differences, flower color variation, animal coat patterns, and crop breeding—to show how recombination creates genetic diversity. Emphasize that variation helps species adapt to environmental changes and is applied in different areas like agriculture to improve varieties.

For option 2
Play a short video highlighting the exchange of genetic material during crossing over. Emphasize that students should focus on

	• Different **flower colors** in the same plant species • Genetic diversity in populations helps organisms **adapt** to changes in the environment • Crop breeders rely on recombination to create **better varieties** **Before Crossing Over:** **After Crossing Over:** *Red Chromatid* *Red Chromatid* | A | B | C | | A | b | C | *Blue Chromatid* *Blue Chromatid* | a | b | c | | a | B | c |  *Crossing over shuffles gene combinations **Option 2. Video Guided concept** The teacher plays a short video to highlights the exchange of genetic materials **Crossing Over in Meiosis Prophase 1 | Step-by-Step Biology Tutorial** https://www.youtube.com/watch?v=PxYXnV9aJlg **Meiosis Crossing Over** https://youtu.be/YFxjZ8otNu4 *Process Question:* *How does crossing over create new allele combinations in gametes*?	*how non-sister chromatids exchange segments, forming recombinant chromatids, and connect this process to the importance of genetic variation.* ***Possible answer to process question for option 2*** *Crossing over creates new allele combinations in gametes because non-sister chromatids of homologous chromosomes exchange matching DNA segments during Prophase I of meiosis. This exchange shuffles alleles between chromatids, so the resulting recombinant chromatids carry unique combinations of genes that differ from the original parental chromosomes. When gametes form, they contain these new allele arrangements, increasing genetic variation in offspring*
	B.3. Developing Mastery	
	The teacher engages the students in guided and independent practice activities to reinforce the concepts. **Options 1. Draw and Explain** Students will draw their own crossing-over diagram and label the following: Homologous chromosomes, sisters' chromatids, non-sister chromatids, chiasma, exchanged segments, new recombinant chromatids. *Process Questions:* 1. Which parts of your diagram represent recombination? 2. What evidence shows that your chromatids are now genetically different?	*These activities reinforce students' understanding of crossing over by allowing them to represent, model, and apply the concept in real-life contexts.* ***For option 1*** *Have students draw and label a crossing-over diagram, then explain that the exchanged segments represent recombination and that the new recombinant chromatids provide evidence of genetic differences.*

	Option 2: Build-A-Chromosome Using clay, yarn, pipe cleaners, or paper strips: 1. Build two homologous chromosomes (maternal and paternal). 2. Represent alleles using colored beads, paper dots, or markers. 3. Perform "crossing over" by exchanging equivalent segments. 4. Show before and after allele combinations. *Process Questions* *1. Explain the outcome of segment exchange in terms of genetic variation.* *2. Which chromatids exchanged segments—sister or non-sister?* *3. Why are new allele combinations formed after crossing over?* ***Option 3: Real-life Variation*** Students work in pairs to identify three real-life examples of genetic variation caused by recombination (e.g., siblings with different eye colors, plant variations, animal coat patterns) *Process Questions:* *1. Why don't siblings look identical even with the same parents?* *2. How does recombination benefit species in nature?* *3. Can you think of a situation where variation is an advantage?*	***For option 2*** *Guide students to model homologous chromosomes with alleles, perform crossing over by exchanging segments, and show before-and-after allele combinations. Emphasize that non-sister chromatids exchange segments, producing new allele combinations that increase genetic variation and highlight why diversity benefits species.* *Link for the complete procedure* *https://docs.google.com/document/d/1vp2BVJwunKIlS8hUDANuabS-lxo0muQE/edit?usp=sharing&ouid=105286949008851356769&rtpof=true&sd=true* ***For option 3*** *Encourage students to work in pairs to identify real-life examples of genetic variation caused by recombination, such as differences among siblings, plant traits, or animal coat patterns. Guide them to answer the process questions by explaining that siblings differ because of meiosis and recombination, that crossing over benefits species by increasing biodiversity, and that variation provides advantages like resilience to environmental changes or disease*
C. Demonstrating Knowledge and Skills	***C.1. Finding Practical Application***	
	Students apply knowledge of crossing over to predict real-life trait outcomes using a simulated meiosis process. **Option1. Predicting Trait Outcomes** Students work in pairs. Each pair receives a Trait Card Set showing alleles on homologous chromosomes for a fictional organism (human, plant, or animal). Example Trait Cards: • Chromosome 1: A (straight hair) / a (curly hair) • Chromosome 2: B (purple flower color) / b (white color flower) • Chromosome 3: C (long tail) / c (short tail) *Process Questions* *1. Which new allele combinations formed after your simulated crossing over?* *2. How would these new combinations affect the traits of possible offspring?*	*These activities help learners apply their understanding of crossing over to real-life situations by predicting trait outcomes, explaining family variation, and observing natural diversity.* *They demonstrate relevance by linking meiosis and recombination to everyday traits, family differences, and biodiversity, and show responsiveness by offering different ways for students to express understanding—through prediction, explanation, or observation.*

	3. *How does this recombination process explain variation seen in real families or populations?* **Option 2. Genetic Counselor** Learners apply their understanding of crossing over, allele recombination, and variation to explain real-life genetic outcomes in a simulated counseling scenario. **Scenario for Students:** A couple is curious why their three children have different traits: Child 1: Straight hair, dimples Child 2: Curly hair, no dimples Child 3: Straight hair, no dimples The parents ask: *"How can our children look so different when they come from the same parents?"* **Student Task:** Learners write a short explanation (5–6 sentences) that children may inherit different allele combinations because meiosis reshuffles genetic information through crossing over and independent assortment before fertilization or create a simple diagram showing: Learners explain Which traits (alleles) may have been on maternal and paternal chromosomes, where crossing over might have occurred, and how recombination created new allele combinations? **Option 3. Variation in Cultivars of Plants in Farming** Students observe differences in leaf shapes, flower colors, heights, more persistent to pest or droughts, etc., then answer the following question. 1. *Which differences could be caused by recombination?* 2. *How does crossing over contribute to biodiversity in the garden?* 3. *Why is this diversity beneficial for the ecosystem?*	*The approach is mainly constructivist and integrative, as students use learned concepts to make sense of real genetic patterns and ecological variation.* *The teaching method used is application-based problem solving, where learners extend classroom knowledge to authentic scenarios.* *Teachers should encourage students to justify their answers using allele combinations and recombination events, and guide them to clearly connect crossing over to observable variation* ***For option 3:*** *Guide students to connect observable differences in cultivars—such as leaf shapes, flower colors, plant height, or resistance to pests and drought—to underlying genetic processes. Emphasize that recombination during meiosis can cause some of these differences, that crossing over contributes to biodiversity in the garden, and that this diversity strengthens the ecosystem by enhancing resilience and stability.*
	C.2. Making Generalization	
	The teacher guides the student to summarize, synthesize, and draw conclusions about crossing over and recombination. **Option 1. 3-2-1 Summary** Students write: • 3 key ideas they learned about crossing over • 2 things that explain why it happens	***For option 1*** *Have students write 3 key ideas about crossing over, 2 reasons why it happens, and 1 conclusion about its effect on genetic variation. Emphasize that this activity helps them organize their learning and connect the mechanism of crossing over to its role in creating diversity.* ***For option 2***

<table>
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• 1 conclusion about how it affects genetic variation
Option 2. One Big Idea
Student answer in 2-3 sentences the following question
“What is the most important idea you learned today about crossing over, and why is it important for living organisms?”
Option 3. Concept Map Generalization
Students create a concept map linking homologous chromosomes, synapsis, crossing over, chiasma, recombinant chromatids, and genetic variation. They write one sentence explaining why Pachytene is the key substage for the lesson.
</td><td>
Emphasize that their responses should connect the concept to its role in creating genetic variation and explain why this variation is important for living organisms
For option 3
Encourage students to use arrows and linking phrases to show relationships, focus on clarity of connections rather than artistic design, check that they correctly identify Pachytene as the stage where crossing over occurs, and emphasize that genetic variation is the ultimate biological significance of these processes.
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<tr><td></td><td colspan="2">C.3. Evaluating Learning</td></tr>
<tr><td></td><td>
To determine the learners’ understanding of the stages of Prophase I and to assess how well they met the learning objectives, the teacher asks the students to accomplish the given task.
Option 1 Written Response / Short Answer
Learners answer the following:
• Describe the sequence of events in each stage of Prophase I.
• Why is crossing-over important in genetic variation?
• Compare pachytene and diplotene based on chromosomal behavior.

Option 2. Genetic Variation Problem-Solving Task
Students are presented with problem scenarios related to genetic variation, such as crossing-over, independent assortment, or differences among siblings. They are expected to analyze each situation, apply the concepts learned in class, and provide clear, logical explanations in their own words to show how genetic variation occurs.
Possible scenarios
1. A pair of homologous chromosomes undergoes crossing-over during prophase I. Explain how this process contributes to genetic variation in the offspring
2. Siblings from the same parents often look different from each other. Use the processes of meiosis to explain why this happens
Option 3. Compare Before and After
The teacher asks the students to fill a two-column chart.
<table>
<tr><td>What Students Must Describe</td><td>Before Crossing Over</td><td>After Crossing Over</td></tr>
<tr><td>1. Allele Combination</td><td></td><td></td></tr>
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The activities promote constructivist and integrative learning. Using a performance-based approach, teachers guide students to ensure accuracy and clarity in presenting key meiotic stages and mechanisms.
For option 1
Ask students to describe the sequence of events in each substage of Prophase I, explain why crossing over is important for genetic variation, and compare pachytene and diplotene based on chromosomal behavior. Emphasize that their answers should highlight visible changes in chromosomes and connect these to the role of crossing over in creating diversity
For option 2
Encourage students to analyze each scenario by applying the concepts of meiosis—such as crossing over and independent assortment—and to explain in their own words how these processes generate genetic variation. Emphasize that crossing over during prophase I produces recombinant chromatids, while independent assortment ensures unique combinations of chromosomes, both of which explain why siblings differ and why genetic diversity is essential for populations.

Possible Answer
</td></tr>
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2. Appearance of Chromatids		
3. Relationship between chromatids (identical or not)		
4. Presence of Chiasma		
5. Degree of Genetic Variation		

Before Crossing Over	After Crossing Over
Same as inherited	New combinations
No exchanged segments	Exchanged segments
Sister chromatids identical	Sister chromatids no longer identical
None	Present at crossover site
No variation yet	Increased variation

C.4. Additional Activities

After completing the assessment tasks, learners' performance will be reviewed to identify areas of strength and concepts that may require further support.

Option 1. Meiosis Infographic

Student design infographic comparing:

- Mitosis vs. Meiosis
- Crossing-over vs. Independent Assortment

Option 2. Micro-Learning Video

Students produce a 1–3-minute educational video explaining the major events in each stage of Prophase I (Leptotene, Zygotene, Pachytene, Diplotene, Diakinesis). They may use hand-drawn illustrations, digital slides, or real objects as models.

Option 3. Remediation Card Sort

Students sort cards labeled homologous chromosomes, sister chromatids, non-sister chromatids, chiasma, crossing over, and recombination, then justify each match orally or in writing.

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Possible Rubric for Meiosis Infographic or Micro learning Video

https://docs.google.com/document/d/1vp2BVJwunKIlS8hUDANuabS-lxo0muQE/edit?usp=sharing&ouid=105286949008851356769&rtpof=true&sd=true

For option 3

Encourage students to carefully distinguish between homologous chromosomes, sister chromatids, and non-sister chromatids, and to connect these with chiasma, crossing over, and recombination. Emphasize the importance of using precise terminology, guide them to justify each match orally or in writing, and focus on reinforcing the conceptual differences and relationships rather than speed or memorization

V. ASSESSMENT *(Assessing Learnings)*

The teacher will facilitate the given assessment to evaluate students' learning.

Multiple Choice: Choose the letter of the correct answer

1. During which stage of meiosis does crossing over occur?
   A. Anaphase II B. Metaphase I C. Telophase D. Pachytene
2. What event makes crossing over possible during Prophase I?
   A. Sister chromatids separate and duplicate C. Chromosomes line up at the equator at duplicate
   B. Nuclear membrane reforms into original form D. Homologous chromosomes pair through synapsis
3. What structure forms at the point where chromatids exchange genetic material?
   A. Chiasma B. Centromere C. Centrosome D. Nucleolus
4. How does crossing over produce new genetic combinations?
   A. Crossing over begins after DNA is duplicated in the cell.
   B. New combinations are ensured when chromatids separate during anaphase.
   C. The process is completed by dividing the cell into two new identical daughter cells.

	D. New genetic combinations form when allele segments are exchanged between non-sister chromatids. 5. In a crossing-over diagram, what do the exchanged segment(s) represent? A. DNA mutations B. Centromeres switching position C. Sections that were damaged during meiosis D. Allele segments swapped between homologous chromosomes 6. If a diagram shows two chromatids with mixed maternal and paternal alleles after Prophase I, what does this indicate? A. A mutation has occurred C. Independent assortment has not taken place B. The chromatids failed to replicate D. Crossing over has produced recombinant chromatids 7. Which meiosis-related process helps explain one reason siblings from the same parents can differ genetically? A. Chromosome condensation B. . Crossing over C. Cytokinesis D. DNA replication 8. Which of the following BEST explains why crossing over increases genetic variation? A. It ensures the cell divides evenly into two cells C. It makes chromosomes more visible under a microscope B. It causes each gamete to receive the same set of genes D. It reshuffles alleles, creating combinations not found in either parent 9. A plant produces flowers with new color patterns that neither parent shows. Which meiotic process most likely contributed to this? A. Cytokinesis of telophase in mitosis C. DNA replication in S phase of interphase B. Genetic recombination during crossing over D. Sister chromatids pulled apart during anaphase 10. During which substage of Prophase I are chromosomes fully paired and crossing over occurs? A. Diplotene B. Leptotene C. Pachytene D. Zygotene **Answer** **D 2. D 3. A 4. D 5. D 6. D 7. B 8. D 9. B 10. C**
VI. REFLECTION *(Feedback and Continuous Improvement)*	•*How many learners successfully demonstrated the learning objectives based on the assessment results?* _____ •*Which activity helped learners understand the lesson the most?* _____ •*Which activity helped the least?* _____ •*Which part of the lesson was easiest for learners?* _____ •*Which part was most difficult?* _____ •*How many learners needed enrichment or additional challenge? How many learners needed remediation or additional support?* ____ •*What did the assessment results show about learners' understanding of the lesson?* _____ *What improvement would you make if you taught this lesson again?* _____. **Teacher Reflection Prompts:** -Which misconception appeared most often: -Which activity best helped learners draw and explain scaled diagrams accurately? -Which assessment item showed the weakest understanding of significance and classification? -Which learning objective showed the weakest mastery, what evidence supports this conclusion, and what specific reteaching or enrichment step will be used in the next lesson?
VII. USE OF GENERATIVE AI	In preparing this Learning Exemplar (LE), the author(s) used the Copilot and Grammarly in order to improve the grammar and consistency of the instructions in the different instructional options and in the annotations. The author(s) reviewed and finalized the writing of the content. The author(s) take(s) full responsibility for the content of this LE.

Lesson Title/Topic	Cell Cycle	Lesson Exemplar	8

I. OBJECTIVES	
A. Content Standard	*The learners learn that the cell cycle consists of a series of phases, stages, and events.*
B. Performance Standard	*By the end of the quarter,* learners discuss the scientific value of the interconnectedness of living organisms and their environment. They evaluate the significance of cell theory and its development in explaining the structure and function of living organisms. Learners classify cells based on their structures and functions, explain the stages and significance of the cell cycle, and describe the mechanisms of passive and active transport in maintaining homeostasis. They participate in practical activities and create presentations that showcase how these biological principles contribute to growth, repair, reproduction, and the diversity of life.
C. Learning Competencies	*Prerequisite Knowledge and Skills* *Learners are expected to recall that cells contain chromosomes carrying hereditary information, that body cells and sex cells have different roles, and that cell division produces new cells. They should also be able to distinguish growth and repair from reproduction, interpret simple biological diagrams, and use basic terms such as chromosome, gamete, and tissue.*
	The learners explain the significance of mitosis in growth, repair, and regeneration of damaged cells, and the significance of meiosis in reproduction, genetic variation, and species continuity.
II. REFERENCES and MATERIALS (*Selecting Resources and Material*)	● "Cell Reproduction: Mitosis, Meiosis, & DNA – High School Biology." Accessed March 12, 2026. https://studylib.net/doc/10111303/chapter-4--cell-reproduction. ● "Chapter 7: Mitosis and Meiosis." Human Biology. Accessed March 12, 2026 https://slcc.pressbooks.pub/humanbiology/chapter/10-cell-reproduction. ● "General Biology Study Guide: Mitosis vs Meiosis Explained." Accessed March 12, 2026 . https://www.pearson.com/channels/biology/study-guides/mitosis-and-meiosis-processes-and-biological-significance. ● "Cell Division: Mitosis and Meiosis." Biological Principles. Accessed March 12, 2026. https://bioprinciples.biosci.gatech.edu/module-4-genes-and-genomes/4-1-cell-division-mitosis-and-meiosis
III. CONTENT *(Sequencing Content)*	***Cell Cycle*** ● Roles of mitosis and meiosis ● Mitosis in growth and repair ● Meiosis in reproduction ● Importance of mitosis and meiosis for survival and species continuity
IV. OBJECTIVES *(Setting Clear Objectives and Analyzing the Tasks)*	*1.Identify the roles of mitosis and meiosis in organisms.* *2. Explain how mitosis supports growth/repair and how meiosis supports reproduction* *3. Differentiate real-life situations where mitosis or meiosis occurs* *4. Justify the importance of mitosis and meiosis for survival and species continuity.*

<table>
<tr><th colspan="2">IV. PROCEDURES</th><th>ANNOTATIONS</th></tr>
<tr><td rowspan="4">A. Activating Prior Knowledge</td><td colspan="2">A.1. Activating Prior Knowledge</td></tr>
<tr><td>To activate learners' prior knowledge, the teacher begins the lesson by guiding students through an activity about growth, heredity and variation.
Option 1: Science Behind Healing
The teacher shows an image of an injury (scraped knee healing, wound healing, etc.,)
Process Question:
1. How does the body repair this?
2. Where do the new cells come from?
Option 2. Prediction Card Sort (Mitosis or Meiosis)
The teacher will instruct each student to work independently by spreading the cards with words such as Growth, Wound Healing, Sperm, Egg, Variation, Identical, and Unique on their desk and reading each one carefully. The teacher will then direct the students to sort the cards into the appropriate categories—mitosis or meiosis—based on their understanding of the processes
Process Question:
1. What idea or clue on the card helped you decide whether it belongs to mitosis, meiosis, or both
2. Which cards show processes that create identical cells, and which show processes that create variation?
Option 3. Sibling Variation
The teacher will present the prompt, "Why don't siblings look exactly alike even if they have the same parents?" and instruct each student to think about the question quietly before writing a brief response. The teacher will then encourage students to reflect on their own ideas about family resemblance and variation, preparing them for the upcoming discussion on how meiosis and recombination create differences among siblings.</td><td>The activities demonstrate the IDF principles of relevance and responsiveness.

The main pedagogical strategies include guided questioning, sorting tasks, and reflective writing.

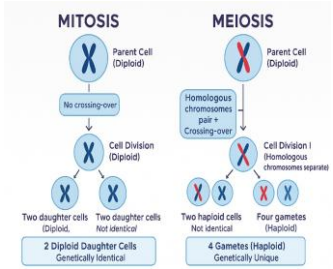
Note to the teacher, provide sufficient thinking time and encourage learners to share different perspectives to prepare them for deeper exploration of the new lesson.

The instructional options provided targeted objectives 1 and 2

For option 1
This activity encourages learners to recall prior knowledge about mitosis and cell regeneration while linking it to a real-life context.
For option 2
This activity helps learners actively apply their knowledge by categorizing and justifying their choices.
For option 3
The teacher then encourages reflection and discussion, guiding learners toward the concept of meiosis and recombination as sources of genetic variation. This activity builds curiosity and prepares students for deeper exploration of inheritance patterns.</td></tr>
<tr><td colspan="2">A.2. Establishing the Purpose of the Lesson</td></tr>
<tr><td>The teacher will explain that this lesson will explore the processes of mitosis and meiosis to help learners understand why these processes are essential for growth, repair, regeneration, and reproduction.</td><td>These instructional options target Learning Objectives 1 and 2.
For option 1</td></tr>
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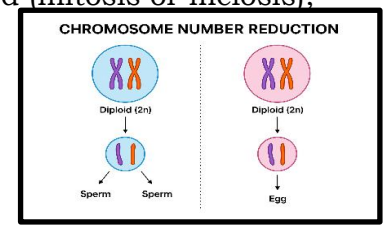
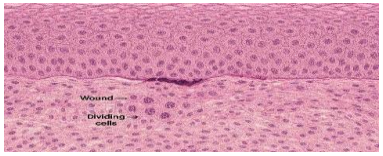
	Option 1. Scenario Card The teacher will present a short scenario such as: "*What would happen if your cells stopped dividing for just one week?"* Learners briefly predict possible outcomes (no growth, wounds not healing, organs failing) to see the importance of mitosis. **Option 2. Object Match** The teacher prepares three objects (or pictures): *a bandage* *a baby photo* *a family photo* Students match each object to *growth, repair,* or *reproduction* and predict why cell division is needed. **Option 3. Quick Reflection Slip** The teacher ask student to write~~s~~ a short answer to: ***"Where in real life do you think cell division plays an important role?"*** This helps students connect the lesson to everyday life. *Process questions for options 1, 2, and 3* 1. How does the example connect to growth, repair, or reproduction in living organisms? 2. What do you think might happen inside living things that makes growth, repair, or reproduction possible?	*Learners are asked to predict possible outcomes like no growth, wounds not healing, or organs failing. This activity helps students recognize the importance of mitosis in maintaining life processes and prepares them to connect cell division with growth and repair.* ***For option 2*** *Learners predict why cell division is needed in each case. This activity encourages students to apply their understanding of mitosis and meiosis to everyday examples, reinforcing the role of cell division in different biological functions.* ***For option 3*** *Learners reflect individually and connect the lesson to their own experiences. This activity builds relevance by showing how cell division is not just a classroom concept but a process that impacts daily life.* *As a note to the teacher, ensure that students share brief predictions before the main explanation so their initial ideas can be used as a springboard for the lesson's purpose.*
B. Instituting New Knowledge	***B.1. Presenting Examples***	
	The teacher will introduce the new concept by presenting a simple, relatable real-life example that illustrates how cell division works. **Option 1: Video Teaser (30-45 seconds)** The teacher plays a quick video clip showing: • plants growing • cells healing a cut • different siblings This builds curiosity before the lesson. *Video Link* • *"Plant Growth in Seconds | Satisfying Nature Short" https://www.youtube.com/watch?v=J8xGLD8eYII* • *Watch Live Plant Cells Build Their Cell Walls https://www.sciencenews.org/article/live-plant-cells-build-walls-grow* *Process Question* 1. What changes did you observe happening in the video, and what do you think is causing those changes inside the organism?	*The activities reflect the IDF principles of relevance and responsiveness.* *The activities implied Constructivist and Integrative approaches by encouraging learners to observe, compare, and reason about what they see in the videos and demonstrations.* *Teacher Note: Use the model only to represent the number and relatedness of resulting cells. Clarify that meiosis creates genetic variation through homologous chromosome pairing, crossing over, and independent assortment, not through random color changes in the classroom model.*

	2. How do you think the organism was able to grow or repair the damaged area shown in the video? **Option 2. Object Demonstration** The teacher uses clay or paper circles. First, one becomes two identical circles. Then, two circles become four genetically different cells. Explain that meiosis creates variation through chromosome separation, crossing over, and recombination, not through random color mixing alone. *Process Questions* 1. Why did one process make identical copies while the other produced unique combinations? 2. In the model, which step creates new variations, and why does this not happen in mitosis?	***For option 2*** *This activity allows learners to connect abstract genetic processes with a simple, hands-on model, reinforcing the contrast between mitosis and meiosis. The teacher explains that meiosis creates variation through chromosome separation, crossing over, and recombination, not simply by random color mixing. This demonstration helps students visualize the difference between producing identical cells and generating unique combinations.*
	B.2. Discussing New Concept	
	The teacher will begin introducing the new concept by guiding learners through a clear explanation of how mitosis and meiosis work, using simple models and visual examples. **Option 1: Guided Discussion** The teacher will facilitate the discussion of the lesson, defining terms, explaining how mitosis and meiosis connect to real-life process. Throughout the discussion, the teacher will encourage learners to observe, compare, and describe what they see in the images, ensuring that students interact actively with the new concepts rather than passively listening. *1. Roles of Mitosis and Meiosis* • **<u>Mitosis</u>** → growth, repair, regeneration (produces identical somatic cells) Mitosis is the type of cell division that produces **two identical daughter** cells from one parent cell. Organisms grow—from infancy to adulthood—their bodies increase in size **not because cells get bigger**, but because **they produce more cells.** Mitosis ensures that new cells have the **exact same DNA** as the original cell, allowing tissues and organs to grow. When the body is injured, such as when skin is cut or damaged, mitosis rapidly replaces old, dead, or damaged cells. **Why Mitosis Is Necessary for Survival**	*The pedagogical strategy used is explicit teaching supported by guided questioning and visual analysis.* ***Note for teacher for Figure 1*** *This visual shows mitosis and meiosis side by side to highlight their differences. On the left, mitosis begins with one diploid parent cell and proceeds without chromosome pairing or crossing over. It results in two identical diploid cells used for growth, development, and tissue repair.* *On the right, meiosis also starts with a diploid parent cell, but homologous chromosomes pair and crossing over occurs. After two cell divisions, meiosis produces four unique haploid gametes. This process supports sexual reproduction and promotes genetic diversity for species survival.*

	▪ Maintains healthy tissues ▪ Replaces damaged cells ▪ Ensures stable body function ▪ In multicellular organisms, mitosis helps replace worn-out or damaged cells so tissues can continue to function properly. **Meiosis** → reproduction (produces gametes with unique combinations of alleles. Meiosis results in four **genetically unique cells**, each with **half the number of chromosomes** (haploid). Humans have **46** chromosomes (2n). Meiosis reduces this to **23** (n), ensuring that when sperm and egg unite during fertilization, the offspring has the normal 46 chromosomes again. Two key events in meiosis generate diversity: • **Crossing over** is the exchange of equivalent DNA segments between non- sister chromatids of homologous chromosomes during meiosis. • **Independent assortment** is the random distribution of homologous chromosome pairs during meiosis. Together with crossing over, it usually produces genetically varied gametes  ***Fig.1 Mitosis and Meiosis*** **Why Meiosis Is Necessary for Species Continuity?** ● Prevents chromosome doubling every generation ● Produces gametes for reproduction ● Ensures genetic diversity ● Strengthens populations through variation *2. Chromosome Behavior* ● Mitosis → sister chromatids separate ● Meiosis I → homologous chromosomes pair and separate ● Crossing over happens in Prophase I ● Meiosis II → resembles mitosis but results in 4 unique cells *3. Outcomes of Each Process* ● Mitosis → 2 identical cells (diploid) ● Meiosis → 4 unique gametes (haploid)	*Link for the Figure 1 Mitosis and Meiosis and illustration for Cause-and-Effect Chain* *https://docs.google.com/document/d/1vp2BVJwunKIlS8hUDANuabS-lxo0muQE/edit?usp=sharing&ouid=105286949008851356769&rtpof=true&sd=true* ***For option 2*** *The teacher provides students with key words such as Growth/repair, Crossing Over, Chromosome, Variation, Cell, Unique gametes, Species continuity, More identical cells, Reproduction, and Division. Students are asked to arrange these words into a chain diagram that shows the sequence of events in either mitosis or meiosis. The teacher emphasizes that each link in the chain represents a cause-and-effect relationship, helping learners visualize how cell division leads to outcomes like growth, repair, reproduction, or genetic variation.* ***For option 3*** *The teacher plays a short-animated sequence showing the stages of mitosis and meiosis. While the animation runs, the teacher pauses at key points to highlight important differences, such as identical cell production in mitosis versus genetic variation in meiosis. The teacher encourages students to observe carefully and connect what they see to the concepts of growth, repair, reproduction, and variation. This activity provides a visual reinforcement of abstract processes, making it easier for learners to grasp the sequence and outcomes of cell division.*

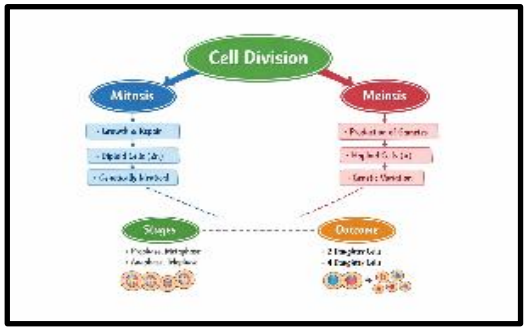
	4. Real-Life Applications • Wound healing (mitosis) • Growth during childhood (mitosis) • Sperm and egg formation (meiosis) • Sibling differences are partly explained by meiosis, because crossing over and independent assortment generate varied gametes before fertilization. • Biodiversity (meiosis) *5. Importance for Survival* • Mitosis → maintains tissue health • Meiosis → ensures variation and species continuity **Option 2. Cause and Effect Chain** *The teacher asks students to build a chain diagram of mitosis and meiosis using the following words:* Growth/repair Crossing Over Chromosome Cell Variation Unique gametes Species continuity More identical cells Reproduction Division *Process Questions* 1. How does each step in your chain connect to the next, and what does this show about the role of mitosis or meiosis in living organisms? 2. Why is the final outcome of your chain—such as growth, repair, variation, or species continuity—impossible without the earlier steps? 3. What key difference between mitosis and meiosis explains why one chain ends in identical cells while the other ends in genetically unique gametes? **Option 3. Animation Walkthrough** The teacher plays a short-animated sequence of mitosis and meiosis. • *What is Mitosis & Meiosis? | Complete | Animated Explanation* (Link: https://www.youtube.com/watch?v=xlvLQtNF-Lk) • *Cell Division in 60 Seconds | 3D Animated Explanation | Mitosis & Meiosis Visualized* (Link: https://www.youtube.com/watch?v=1e0vAYKjodM) *Process Question*	

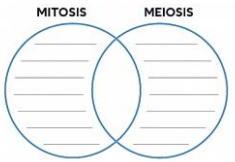
	1. What do you think will happen next based on the chromosome movement you see? 2. What evidence from the animation shows that genetic variation is being created during meiosis?	
	B.3. Developing Mastery	
	understanding where mitosis and meiosis occur in real life. **Options 1. Mitosis- Meiosis Concept Circuit Stations** Students rotate through four stations, each designed to target one objective — but together, they reinforce all key ideas of the lesson ***STATION 1- Roles and Processes*** Students label diagrams of mitosis and meiosis showing: • Somatic vs. gamete production • Identical vs. unique cell outcomes • Number of divisions and number of cells produced ***STATION 2-Growth/Repair vs. Reproduction*** Students answer guided prompts such as: • *"How does mitosis help a wound heal?"* • *"Why does meiosis need to reduce chromosome number for reproduction?"* Use "photocopier" to represent mitosis and "card shuffler" to represent meiosis as a general source of variation, while clarifying that meiosis creates variation through crossing over and independent assortment. ***STATION 3-Real-Life Situations*** Students sort scenario cards: • Growth spurt • Skin regeneration Gamete formation • Sibling differences • Plant root tip cell division They decide: **Mitosis or Meiosis?** and explain why. **STATION 4 -Why It Matters** Students complete a Cause-and-Effect Chain: Mitosis: Cell → ____ → _____→ _____→ Survival Meiosis: Chromosomes → _____→ _____ → _____→ _____ → Species Continuity Then they answer:	*The activities reflect the IDF principles of relevance and responsiveness* *They use Constructivist and Integrative approaches allowing learners to manipulate models, interpret diagrams, and actively discuss relationships between concepts.* ***For option 1*** *Students rotate through the stations, working in small groups or individually, so that by the end they have reinforced all the key ideas of the lesson. At* ***Station 1 (Roles and Processes)****, students label diagrams to compare somatic versus gamete production, identical versus unique cell outcomes, and the number of divisions and cells produced. At* ***Station 2 (Growth/Repair vs. Reproduction)****, students respond to prompts about wound healing and chromosome reduction, using analogies like a "photocopier" for mitosis and a "card shuffler" for meiosis, while clarifying that variation arises from crossing over and independent assortment. At* ***Station 3 (Real-Life Situations)****, students sort scenario cards into mitosis or meiosis categories and explain their reasoning. Finally, at* ***Station 4 (Why It Matters)****, students reflect on the importance of these processes for survival, continuity, and variation in living organisms.* ***For option 2*** *The teacher guides learners to connect the evidence to either mitosis or meiosis, encouraging them to justify their reasoning. This activity helps students practice critical thinking and apply conceptual knowledge to real-life scenarios, reinforcing the idea that cell*

	1. *What would happen if mitosis stopped?"* 2. *"What if meiosis produced identical cells?"* **Option 2. Cell Division Case Investigation** Students work in pairs or individually to analyze **two case files.** Each case file provides evidence about: • *What happened?* • *What the cells are doing?* • *What visible traits or outcomes appear?* Students must identify which process is involved (mitosis or meiosis), explain why, and justify its significance. **Case File 1: Gamete** Diagram of sperm/egg formation showing chromosome number reduction. Task: Identify → Meiosis 1. Explain → Gamete formation and haploid cells 2. Justify → Prevents chromosome doubling and ensures species continuity  ***Fig.2 Sperm and Egg formation*** **Case File 2. Growth and Repair Scenario** A microscope image of skin cells dividing after a cut and~~+~~ a child's growth chart.  ***Fig.3 Microscopic Image of Skin Cells Dividing After a Cut***  ***Fig.4 Growth Chart*** ***Process Question*** 1. What process of cell division is happening in the scenario, and what evidence from the image supports your answer? 2. How does the type of cell division shown in the scenario contribute to the organism's survival or continuation of the species?	*division underlies growth, repair, reproduction, and variation. For case 2, students are asked to analyze the evidence and connect it to the process of mitosis. Students are guided to analyze the evidence and identify the process as **mitosis**, since the cells are producing identical copies to replace damaged ones and to support growth. The teacher emphasizes that mitosis is essential for healing wounds and for the continuous development of the body. By linking the image and chart, students see how mitosis contributes both to healing and to the overall development of the organism.*
C. Demonstrating Knowledge and Skills	***C.1. Finding Practical Application***	
	The teacher will guide learners in applying their understanding of mitosis and meiosis to real-life or simulated situations. **Option1. Reasoning Task**	*The pedagogical strategies used include scenario-based learning, applied reasoning,*

	Students answer a scenario using terms such as chromosome number, gamete, variation, identical cells, and species continuity. 1. *What would happen if meiosis produced genetically identical gametes instead of varied ones?* 2. *How does mitosis support an organism's daily survival?* 3. *What if mitosis stopped for 48 hours? What if crossing over never occurred?* 4. *Why would species continuity be threatened if meiosis did not produce haploid gametes?* **Option 2. Gamete Formation Mapping** Students analyze sperm/egg formation and answer the following questions using terms such as chromosome number, gamete, variation, identical cells, and species continuity. 1. *How is chromosome number reduced during meiosis?* 2. *Why is this reduction important?* 3. *How does it prevent chromosomes doubling across generations?* 4. *How does it ensure species continuity?* ***At the end of each practical application task, require learners to explain how the process involved supports survival, repair, reproduction, or species continuity.***	*and guided problem solving. As a note to the teacher, ensure learners justify their answers using scientific reasoning* ***For option 1*** *Success Criteria: A strong response must (1) identify mitosis or meiosis correctly, (2) use at least one accurate scientific term, (3) explain the chromosome outcome or cell outcome, and (4) connect the process to growth, repair, reproduction, variation, or species continuity.* ***For option 2*** *The teacher guides students to analyze sperm and egg formation by mapping out the steps of meiosis. Emphasizes that meiosis reduces chromosome number by half, ensuring gametes carry only one set of chromosomes. This reduction is important because it prevents chromosome doubling across generations when gametes fuse during fertilization. Students are encouraged to see how this process not only maintains species continuity but also introduces genetic variation through crossing over and independent assortment.*
	C.2. Making Generalization	
	The teacher will help learners formulate a clear generalization that integrates all concepts discussed. **Option 1. One- Statement Generalization** Students write one powerful generalization, 2–3 sentences long, that must include: ● The role of mitosis ● The role of meiosis ● Why organisms need both Students share their generalizations, compare ideas with peers, and refine their statements**.** The class co-constructs the final "Lesson Generalization", recorded on the board. **Option 2. Big Idea Synthesis Carousel** A collaborative generalization-building activity. The teacher will set up four chart papers around the room labeled: Growth, Repair, Reproduction, and	***For option 1*** *Students share their statements, compare ideas, and refine them through peer discussion. The teacher then facilitates the co-construction of a final "Lesson Generalization" on the board, ensuring that the class arrives at a unified understanding of the essential roles of cell division.* ***Possible Answer*** *Mitosis ensures growth and repair by producing identical cells, while meiosis enables reproduction and genetic variation by creating unique gametes. Organisms need both processes because mitosis maintains the body's survival, and meiosis secures species continuity across generations.* ***For option 2***

	Variation. The teacher will instruct students to move in groups from one station to another, adding one sentence that explains how either mitosis or meiosis contributes to the concept written at that station. After the rotation, the teacher will gather the class to examine the assembled ideas and guide them in forming a clear, overarching generalization that summarizes the essential roles of mitosis and meiosis in organisms. **Option 3. Mitosis-Meiosis Connection Web** The teacher provides students with a blank "connection web." At the center, the teacher writes, "*Why Organisms Need Both Mitosis and Meiosis"* Students then create four branches labeled: *Growth* *Reproduction* *Repair/Regeneration* *Variation* Students fill in each branch with 1–2 key ideas showing how mitosis or meiosis contributes to that concept. After completing the web, students write one generalization sentence based on the connections they made. *Process Question* 1. Why are both mitosis and meiosis necessary in multicellular sexually reproducing organisms? 2. If an error occurred and meiosis produced gametes with the same chromosome number as somatic cells, what long-term effects would this have on the survival and evolution of a species?	*The teacher gathers the class to review the collective ideas and guides them in synthesizing a clear overarching generalization. This collaborative activity helps students see how individual contributions build toward a shared "big idea."* ***For option 3*** *Students are asked to fill in each branch with one or two key ideas that explain how mitosis or meiosis contributes to that concept. For example, under Growth, students may write that mitosis produces identical cells to increase body size. Under Repair/Regeneration, they may note that mitosis replaces damaged or dead cells. Under Reproduction, they explain that meiosis produces gametes with half the chromosome number. Under Variation, they highlight that meiosis introduces diversity through crossing over and independent assortment. This activity helps learners visually organize their ideas, connect specific examples to broader concepts, and synthesize their understanding into a concise generalization.*
	C.3. Evaluating Learning	
	The teacher asks students which role of mitosis or meiosis they now understand best and which idea still needs clarification before they complete the evaluation task. **Option 1. Mini-quiz** The teacher will instruct the students to answer the quiz individually, applying the key ideas discussed in the lesson. 1. *Why must mitosis produce identical cells?* 2. *Why must meiosis reduce chromosome number?* *3. Why is variation important for species survival?* **Option 2. Concept Correction** The teacher gives the students a set of statements about mitosis and meiosis. Students read each statement carefully and determine if the	*These evaluation activities target Learning Objectives 2, 3, and 4 by checking whether learners can explain the roles of mitosis and meiosis, differentiate real-life situations, and justify the importance of these processes for survival and reproduction* ***Answer for Option 2. Concept Correction*** *1. False → Replace "mitosis" with meiosis* *2. True* *3. False → Replace "two" with four daughter cells with half the chromosome number.* *4. True* *5. False → Replace "diploid" with haploid* *Link for sample mind map*

	underline word/s is true or false, and correct only the incorrect part if the statement is false. 1. *Mitosis occurs in sex cells to ensure genetic variation in offspring.* 2. *Mitosis is the process that enables organisms to grow from a single fertilized egg into a multicellular adult.* 3. *Meiosis results in two daughter cells, each with the same number of chromosomes as the parent cell.* 4. *Mitosis and meiosis both ensure the continuity of life, but they serve different roles in the organism.* 5. *Meiosis helps maintain the diploid chromosome number across generations.* **Option 3. Mind Map** The teacher will instruct each student to create an individual mind map. The teacher will direct learners to place the main concept, "Cell Division," at the center of the page and branch out to show how mitosis supports growth and repair, how meiosis supports reproduction and variation, and why both processes are essential for survival and species continuity. *Reflection: In 3–4 sentences, explain why mitosis is necessary for growth and repair and why meiosis is necessary for reproduction and species continuity*	*https://docs.google.com/document/d/1vp2BVJwunKIlS8hUDANuabS-lxo0muQE/edit?usp=sharing&ouid=105286949008851356769&rtpof=true&sd=true,* *As a note to the teacher, ensure that feedback is provided promptly and that questions encourage deeper reasoning rather than simple recall to confirm genuine understanding.* ***Possible mind map*** 
	C.4. Additional Activities	
	understanding of the importance of mitosis and meiosis. **Option 1. Mitosis and Meiosis in Pictures** The teacher will ask the students to create a simple illustration that shows how mitosis helps in growth and repair, and how meiosis helps in reproduction. Students will draw the two processes on one page, add short labels, and include one real-life example for each. The teacher will remind students to keep the drawings clear and to focus on showing the main idea of each process. **Option 2. Similarities and Differences** The teacher instructs the students to use the Venn diagram provided to compare mitosis and meiosis by listing their differences in each outer circle and their similarities in the overlapping section. Students will be required to focus on the role of	*As a note to the teacher, remind students to clearly label key structures and include short explanations.* ***Possible Rubric for Option 1, 2, 1nd 3*** *https://docs.google.com/document/d/1vp2BVJwunKIlS8hUDANuabS-lxo0muQE/edit?usp=sharing&ouid=105286949008851356769&rtpof=true&sd=true* *Note:* *Accessibility Note: Permit digital, oral, or handwritten outputs depending on learner needs and available resources.*

	organisms, the type of cells involved, chromosome number, results of each process, and why each is important for life. **Option 3. Mitosis and Meiosis in 3D** The t The teacher will instruct the students to create a simple 3D model that shows the difference between mitosis and meiosis and explains why each process is important. Students may use clay, yarn, colored paper, beads, or any available materials to build their models. The model should show how mitosis produces identical cells for growth and repair, and how meiosis produces unique gametes for reproduction and variation.	***Sample Venn diagram for option 2*** 
V. ASSESSMENT *(Assessing Learnings)*	*The teacher will facilitate the given assessment to evaluate students' learning.* 1. Which statement best describes the role of mitosis in the body? A. It produces gametes needed for reproduction. C. It produces identical cells needed for growth and repair B. It creates genetically unique cells for variation. D. It reduces chromosome number to maintain species continuity. 2. What is the main purpose of meiosis in organisms? A. To heal damaged tissues C. To create haploid gametes B. To produce identical daughter cells D. To replace old or dead body cells 3. A child grows taller over several years. Which cellular process made this possible? A. Meiosis, because it creates genetic variety C. Mitosis, because it produces gametes B. Mitosis, because it increases the number of body cells D. Meiosis, because it repairs tissues and produces gametes 4. Which meiosis-related process helps explain why siblings from the same parents may still look different from one another? A. DNA repair C. Mitosis during growth B. Cell specialization D. Recombination during meiosis 5. Which event best explains how wounds heal? A. Meiosis produces new skin cells C. Crossing over repairs tissue B. Mitosis replaces damaged cells with identical ones D. Meiosis reduces chromosome number in skin cells 6. What would most likely happen if meiosis did NOT reduce chromosome number? A. Organisms would grow faster C. Chromosome number would double every generation B. It would have the proper number of chromosomes D. Individuals would heal from wounds more slowly 7. Which of the following best represents the outcome of mitosis? A. Four genetically unique gametes C. Four diploid sex cells B. Two genetically identical somatic cells D. Two haploid gametes 8. Which process during meiosis contributes greatly to genetic variation in a population? A. Cytokinesis during mitosis C. Crossing over during meiosis B. DNA replication during mitosis D. Cell specialization during growth 9. Which scenario best illustrates regeneration through mitosis? A. Production of sperm in the testes C. A plant forming seeds	

	B. An injured lizard growing back part of its tail D. Siblings having different hair colors 10. What is the significance of meiosis for species continuity? A. It creates identical cells needed for body repair C. It produces gametes that allow sexual reproduction B. It ensures offspring inherit the same traits as parents D. It helps organisms grow by increasing cell number B. **Short Response**: Scoring Guide (5 points) 5 – clearly identifies the correct process and explains its importance using accurate terms; 4 – mostly correct with minor omissions; 3 – partially correct but reasoning is unclear; 2 – minimal response 1 - inaccurate response. 1. Explain a real-life situation where mitosis occurs and another where meiosis occurs. How do these processes serve different purposes in living organisms?" 2. Why are both mitosis and meiosis essential for the survival and continuity of species? Support your answer with reasoning. Answer: 1. **C 2.C 3.B 4.D 5.B 6.C 7.B 8.C 9.B 10.C**
VI. REFLECTION *(Feedback and Continuous Improvement)*	*Use the following reflection prompts to guide your evaluation of the lesson after implementation. Reflect on learners' performance, determine which activities and lesson parts were most and least effective, identify learners who need enrichment or remediation, analyze the assessment results, and note possible improvements to enhance future lesson delivery.* ● *How many learners successfully demonstrated the learning objectives based on the assessment results?* ● *Which activity helped learners understand the lesson the most? Which activity helped the least?* ● *Which part of the lesson was easiest for learners? Which part was most difficult?* ● *How many learners needed enrichment or additional challenge? How many learners needed remediation or additional support?* ● *What did the assessment results show about learners' understanding of the lesson?* ● *What improvement would you make if you taught this lesson again?* **Teacher Reflection Prompts:** -Which misconception appeared most often: -Which activity best helped learners draw and explain scaled diagrams accurately? -Which assessment item showed the weakest understanding of significance and classification? -Which learning objective showed the weakest mastery, what evidence supports this conclusion, and what specific reteaching or enrichment step will be used in the next lesson?
VII. USE OF GENERATIVE AI	In preparing this Learning Exemplar (LE), the author(s) used the Copilot and Grammarly in order to improve the grammar and consistency of the instructions in the different instructional options and in the annotations. The author(s) reviewed and finalized the writing of the content. The author(s) take(s) full responsibility for the content of this LE.

Lesson Title/Topic	Transport Mechanisms	Lesson Exemplar	9

I. OBJECTIVES	
A. Content Standard	The learners learn that cells have mechanisms that regulate the transport of substances in and out of the cell.
B. Performance Standard	By the end of the quarter, learners discuss the scientific value of the interconnectedness of living organisms and their environment. They evaluate the significance of cell theory and its development in explaining the structure and function of living organisms. Learners classify cells based on their structures and functions, explain the stages and significance of the cell cycle, and describe the mechanisms of passive and active transport in maintaining homeostasis. They participate in practical activities and create presentations that showcase how these biological principles contribute to growth, repair, reproduction, and the diversity of life.
C. Learning Competencies	***Prerequisite Knowledge and Skills*** ● Cell Concept ● Molecules and Movement ● Solutions and Concentrations
	The learners describe the transport mechanisms in cells, including passive transport (diffusion, osmosis, and facilitated diffusion) and active transport (pumps, endocytosis, and exocytosis);
II. REFERENCES and MATERIALS	● Capco, Lourdes, and Erlinda Yang. You and the Natural Series: Biology. Quezon City: Sibs Publishing, 2005, 72–83. ● Department of Education–SOCCSKSARGEN Region. General Biology 1: Module 12, Transport Mechanisms in Cell. Koronadal City: Department of Education–SOCCSKSARGEN, 2020. PDF file. ● Evangelista, Luisito T. General Biology 1 for Senior High School. Quezon City: C&E Publishing Inc., 2017, 23–29. ● Concepcion, Bryan R., Jonabelle A. Gamino, Cristy C. Mercado, Victor C. Allam, Reinalyn F. Cacayan, Mark Anthony A. Maraggun, and Julien Rezally Q. Mara. 2020. Learning Activity Sheet in General Biology 1 (Grade 11). 1st ed. Tuguegarao City: Department of Education – Regional Office No. 02. ● Rocero, Rosewin P. Explaining Transport Mechanisms in Cells. General Biology 1, Grade 11, Quarter 1, Week 7. Negros Oriental, Philippines: Department of Education, 2021.
III. CONTENT	**Transport Mechanisms** ● Introduction to Passive and Active Transport ● Discussion of Passive and Active Transport ● Process of Passive Transport ● Process of Active Transport ● Red Blood cells that use Passive and Active Transport
IV. OBJECTIVES *(Setting Clear Objectives and Analyzing the Tasks)*	1. Differentiate between passive transport mechanisms (diffusion, osmosis, and facilitated diffusion) and active transport mechanisms (pumps, endocytosis, and exocytosis). 2. Illustrate the movement of particles in passive and active transport 3. Explain the importance of transport mechanisms in maintaining cell homeostasis

<table>
<tr><th colspan="2">V. PROCEDURES</th><th>ANNOTATIONS</th></tr>
<tr><td rowspan="4">A. Activating Prior Knowledge</td><td colspan="2">A.1. Activating Prior Knowledge</td></tr>
<tr><td>To activate prior knowledge, the teacher will present questions, short activities, visual prompts, or discussions that may touch on the transport mechanism in the cell.

Option 1. Think-Pair-Share (Quick Recall)
Procedure:
● Ask learners:

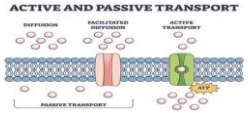
a. How oxygen, water, and nutrients move across the cell membrane?
b. Learners explain their ideas orally with a partner.
c. The teacher notes whether learners confuse osmosis with diffusion or assume that all transport requires ATP.
d. The teacher clarifies the misconception immediately and adjusts the next example based on the responses gathered.</td><td>The Think-Pair-Share activity targets Objective 1 by engaging learners to differentiate passive and active transport, visualize particle movement, and connect it to homeostasis through diagnostic questioning and peer collaboration.

This activity activates prior knowledge of diffusion and osmosis from earlier science lessons.
Teacher Notes: The questions can be answered through oral recitation or short response essay

Click the link for the Alternate Activity Option for Teachers:

Option 2. Quick Concept Mapping
https://docs.google.com/document/d/1cMCaX7fL1VtGHVw9t9CfIPCpq6UTszYu/edit

Option 3. Prediction Exercises
https://docs.google.com/document/d/13UQxHfqfCmCWuviclH_iA0Y7e6CKOUYU/edit</td></tr>
<tr><td colspan="2">A.2. Establishing the Purpose of the Lesson</td></tr>
<tr><td>The teacher will introduce the lesson gradually to build on the previous activity.

Option 1. Picture Analysis 1
Present a diagram of active and passive transport.

</td><td>The picture analysis 1 activity on active and passive transport helps learners distinguish the two processes by focusing on energy use and direction of movement. It targets objectives 1 and 2, interpreting diagrams, and connecting visual cues to scientific concepts. The activity reflects IDF principles by being relevant through visual context, and reflective as students compare differences. It applies constructivist approach through building meaning from diagrams, inquiry-based (guided questions), integrative (linking</td></tr>
</table>

	A diagram showing particles moving across a cell membrane, with one panel illustrating passive transport down the concentration gradient and another panel showing active transport using a membrane protein and ATP to move substances against the gradient *Guiding questions:* 1. *How does energy use distinguish passive transport from active transport in cells?* 2. *In the illustration, how can you describe the direction of substance movement in passive transport compared to active transport?* **Expected Output:** Short Explanation	*visuals to concepts), and reflective (evaluating understanding).* *The teaching method used is **visual analysis with guided questioning**, supported by formative assessment and discussion. Teachers should ensure diagrams are clear and labeled, reinforce scientific vocabulary (ATP, gradient, membrane), encourage justification of answers, and connect the activity to real-life applications like nutrient absorption or nerve impulses. This makes the abstract concept of cell transport mechanisms more concrete and meaningful.* ***Click the link for the Alternate Activity Option for Teachers:*** ***Option 2. Picture Analysis 2*** *https://docs.google.com/document/d/1zFgYgae9C5Kq2RyuRioV4633ocI7sMUz/edit* ***Option 3. The Cell Transport Relay Challenge*** *https://docs.google.com/document/d/1KkSB6ybsF_pMO_oB4S7FllmJEBzLvl1J/edit*
B. Instituting New Knowledge	***B.1. Presenting Examples***	
	In this section, the teacher will present a simple task highlighting the targeted objectives **Option 1: Perfume Diffusion Test (Passive Transport)** This captures the essence of the task—using the spread of perfume scent in a room as a simple and relatable way to demonstrate how particles move and how diffusion works in everyday life. In this activity, the teacher will spray or pour perfume and later ask the students if they smell it. Process Question: 1. Who among you here smelled the perfume first? Who smelled it last? 2. What do you call the phenomenon wherein the scent of the perfume is smelled at different times? ***Safety note:*** *Do not use perfume if any learner has asthma, fragrance sensitivity, or allergies. Use a low-risk alternative such*	*The **Perfume Diffusion Test** demonstrates passive transport under Objective 1 by showing how scent spreads in a room, making diffusion observable and relevant to learners' everyday experiences. It uses a constructivist, collaborative approach with guided questioning and oral recitation, as students compare who smelled the perfume first or last.* ***Teacher Notes:*** *The questions can be answered through oral recitation or short response essay* ***Click the link for the Alternate Activity Option for Teachers:*** **Option 2. ATP Token Active Transport** https://docs.google.com/document/d/1r_f5SIeBTGhkzY5Ub_m1rUaciElT8NYc/edit

	as vanilla extract, food coloring diffusion in water, or a short animation of particle diffusion.	**Option 3. Bead & Barrier Simulation (Passive vs. Active)** https://docs.google.com/document/d/1-PxFziDS3iWtNeCHnMb4ZoFZmkQ895HC/edit
	B.2. Discussing New Concept	
	For better understanding, the teacher will present guided discussions on the topic, engaging students in interaction **Option 3. Group Report** The teacher will group the students into three (3) groups and assign them the following topic: ● Group 1: Difference of Active and Passive Transport ● Group 2: The Movement of Particles in Passive and Active Transport ● Group 3: The Importance of Transport Mechanisms in the Cell **Expected Output:** Group report papers/ power point presentation output. Link for the lecture: https://docs.google.com/document/d/1_qGhwft7wIHZIilhHKpmiFDkL3OqJqdT/edit	*The **Group Report** activity targets Objectives 1–3 by engaging students in collaborative exploration of cellular transport, embodying IDF principles of relevance, responsiveness, engagement, and collaboration through the 2C–2I–1R approach with group reporting, discussion-based learning, and corrective teaching, supported by teacher facilitation to ensure equal participation, clarify misconceptions, reinforce vocabulary, and connect topics to real-life applications.* **Teacher Notes:** ● *Students may opt to use PowerPoint presentation for their report or written report depending on the availability of the resources* ● *Use the group report rubric flexibly depending on time and depth expected and may be accessed thru the link above of this exemplar* ● *The teacher uses power point presentation to deliver the discussion* ● *Provide images or videos to help learners visualize the processes.* ● *Provide targeted feedback after scoring, highlighting both strengths and areas for improvement.* ***Click the link for the Alternate Activity Option for Teachers:*** ***Option 1. Peer-to-Peer Interaction*** *https://docs.google.com/document/d/1dLBMoQvKSBYsb9EDYXsuBngjguxcm4e0/edit* ***Option 2. Using Venn Diagram*** *https://docs.google.com/document/d/1YKT7qLD-slPp1FtxBgNBLmWxfXZJoc1e/edit*

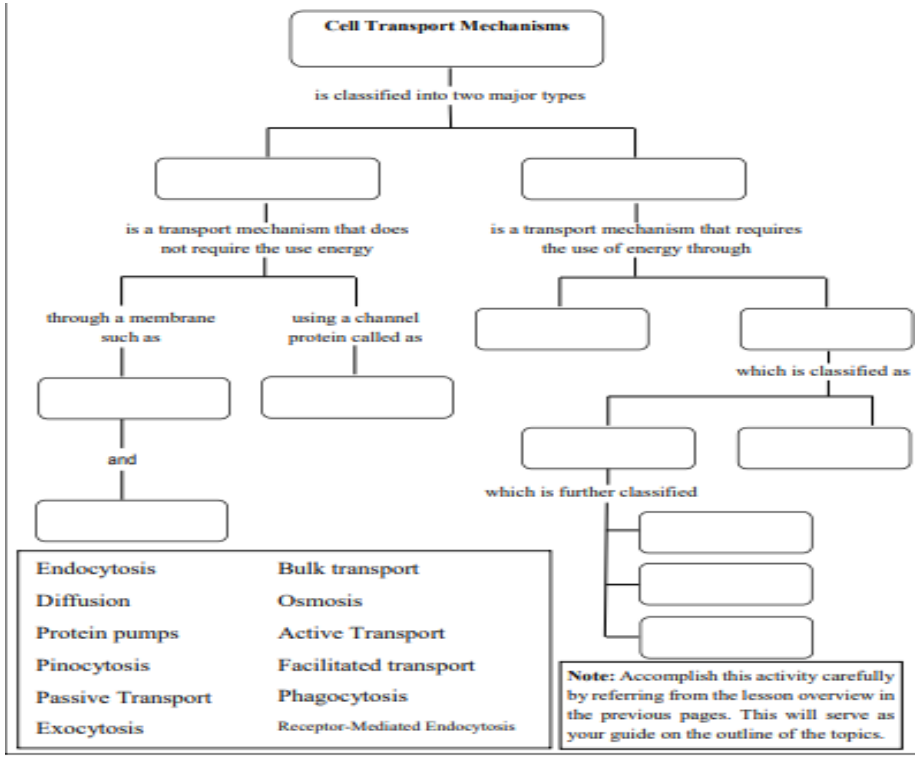
	B.3. Developing Mastery	
	In this stage, the teacher will again group the students to carry out the drills for the following days. **Option 1. Simple Dialysis Tubing Demonstration** **Materials:** • Dialysis tubing (soaked and prepared) • Starch solution (inside the tubing) • Iodine solution (outside the tubing in a beaker) • Beaker, string/rubber bands, dropper **Procedure:** 1. Fill the dialysis tubing with starch solution and tie both ends securely. 2. Place the tubing into a beaker containing iodine solution. 3. Observe after several minutes: iodine molecules (small) pass through the tubing and react with starch, turning the inside blue-black. Starch molecules (large) remain inside. **Guided Questions:** **Passive Transport (Diffusion/Osmosis):** 1. How does the movement of iodine into the tubing demonstrate passive transport? 2. Why were iodine molecules able to pass through the tubing without energy input? 3. How does this experiment show the principle of selective permeability? **Active Transport (Protein Pumps & Energy Use):** 4. Why couldn't starch molecules move out of the tubing, even though there was a concentration difference? 5. How would the cell move very large molecules like starch if needed? 6. Why do cells require ATP energy and protein pumps to move certain molecules against their concentration gradient? 7. Why can some substances cross the membrane easily, while others need proteins or vesicles? **Homeostasis Connection:**	*The **Simple Dialysis Tubing Demonstration** activity targets Objective 1 by showing selective permeability as iodine diffuses into starch-filled tubing while starch remains inside, embodying IDF principles of responsiveness, relevance, and reflection through constructivist, inquiry-based, and reflective strategies with a hands-on laboratory demonstration and guided questioning supported by observation notes and teacher emphasis on safety, vocabulary, and misconceptions. Teachers should emphasize safety in handling iodine, reinforce scientific vocabulary like diffusion, selective permeability, and ATP, and clarify misconceptions by explaining why large molecules such as starch require active transport mechanisms like protein pumps or vesicles.* ***Safety note:** Use diluted iodine solution, gloves, and protective eyewear during the demonstration. Handle all materials under teacher supervision, dispose of iodine solution properly, and use a teacher-led simulation if dialysis tubing or laboratory materials are unavailable.* ***Accessibility notes:** Provide individual or digital options for learners who cannot join relay or group performance tasks* ***Click the link for the Alternate Activity Option for Teachers:*** ***Option 2. Particle Movement Simulation*** *https://docs.google.com/document/d/1usBF2HFPE8m3hlGPlJliBpvsbN6oacUl/edit* ***Option 3. Cell Engulfment Simulation + Reflection*** *https://docs.google.com/document/d/10EWmmZhNC-I_CsBbyHCslqlxG_Ewpwtw/edit*

	7. How does selective permeability help the cell maintain balance in changing environments? 8. Why is it important for cells to regulate which molecules enter and exit, rather than allowing everything to pass freely? **Expected Output:** Observation Notes	
C. Demonstrating Knowledge and Skills	***C.1. Finding Practical Application***	
	For this stage, the teacher will connect the concepts learned by the students. **Option 1. Salted Fish Activity** For this activity, instruct the students to form a group and prepare the fish ahead of time before the activity **Procedure:** • Provide two small fish samples (or slices of fish). • Rub one with salt, leave the other unsalted. • Place both in separate containers and observe over time. • Students record differences in texture, moisture, and smell. • Ask students to explain the science behind this practice using osmosis and how salt draws water out of fish cells, reducing bacterial growth. • Reflection question: *Why does removing water from fish cells help prevent spoilage?* Food preservation: Salting fish creates a hypertonic environment that prevents bacterial growth. ***Follow up question:*** *From this activity, what transport mechanism is involved, and explain how it helps maintain homeostasis or affects a real-life situation.* **Expected Output:** Observation Notes/Pictures	*The **Salted Fish Activity** Targets Objectives 1 and 3 by engaging learners in a hands-on experiment comparing salted and unsalted fish to observe osmosis, applying IDF principles of responsiveness, relevance, and reflection through constructivist, collaborative, inquiry-based, integrative, and reflective approaches with experiential observation and guided inquiry linking food preservation to homeostasis.* ***Teacher note:*** *Use small prepared samples, gloves, sealed containers, and proper disposal to avoid odor, contamination, and unnecessary food waste. If fish is not practical, use cucumber or eggplant slices soaked in salt solution as a safer substitute.* ***Accessibility notes:*** *Provide individual or digital options for learners who cannot join relay or group performance tasks* ***Click the link for the Alternate Activity Option for Teachers:*** ***Option 2. Effects of Tonicity*** *https://docs.google.com/document/d/1UXvDtNdgeF0NRMAAdZzfQw8rGpDnlTUj/edit* ***Option 3. "Medicine Crossing the Barrier" Simulation*** *https://docs.google.com/document/d/1ET6FoE8hXnis628Y9ypzHMrC3_nQtTiC/edit*
	C.2. Making Generalization	

In this stage, learners will wrap-up the lesson.

Option 1. Take on the Map to Avoid being Trapped

Based on the presented background information, complete the concept map by filling up the boxes respectively with the correct items provided in the box below.



Process Question: *Explain the connection of the following terms such as concentration gradient, ATP, selectively permeable membrane, tonicity, endocytosis, and exocytosis.*

Expected Output: Written Work Activity/ Completed Concept Map

*The **Take on the Map to Avoid Being Trapped** activity targets Objectives 1–3 by engaging learners in completing a concept map and answering a process question that connects concentration gradient, ATP, selectively permeable membrane, tonicity, endocytosis, and exocytosis, applying IDF principles of responsiveness, relevance, and reflection through constructivist, inquiry-based, and reflective strategies with concept mapping and guided inquiry supported by teacher facilitation to clarify misconceptions, reinforce vocabulary, and link processes to practical contexts.*

Teacher Notes:

- *Ensure that learners already understand the lesson well*
- *Teachers may provide printed worksheet for this written work activity*

Click the link for the Alternate Activity Option for Teachers:

Option 2. Reflective Questions on Cellular Transport

https://docs.google.com/document/d/1vnWFgXiqFfA1NfKuvZYOIKgtEwFTVYPF/edit

Option 3. Analogy or Real-Life Connection

https://docs.google.com/document/d/1JM1RJ7-Dc9eMe4v56qFUul1owD2RlFpL/edit

	C.3. Evaluating Learning	
	At this stage, the teacher checks how much the student learned **Option 1. Short Constructed Response** Students write brief answers to the following questions a. What is the main difference between passive and active transport in terms of energy use and direction of movement relative to the concentration gradient? b. Why do protein pumps require ATP while passive transport does not? c. Why is cellular transport essential for maintaining homeostasis in the cell? d. Which transport mechanism do you understand best now, and which one still needs more clarification for you? Explain briefly. **Expected Output:** Short Response Essay	*The **Short-Constructed Response** activity targets Objectives 1–3 by engaging learners in brief written explanations about passive vs. active transport, ATP use, and homeostasis, while reflecting on their own understanding. It embodies IDF principles of responsiveness, relevance, and reflection through constructivist synthesis, inquiry-based exploration, integrative connections, and reflective self-assessment with short responses as the pedagogical strategy.* **Teacher Notes:** ● *Use rubric in checking the essay* ***Click the link for the Alternate Activity Option for Teachers:*** ***Option 2. Matching Type Test: Cellular Transport Mechanisms*** *https://docs.google.com/document/d/1aVAA5J5o2i0QxhavRA52Ctll37SugLSW/edit* ***Option 3. Cell Transport in Motion: A Multimedia Exploration*** *https://docs.google.com/document/d/1QQ29RCn9h7jvUhJeI96RHK1MeJLnRrW4/edit*
	C.4. Additional Activities	
	To reinforce conceptual understanding and allow for creative expression, the teacher asks the students to do the performance task as extension to the learning journey. **Option 2: Transport Real!** **Task Description:** Give examples of diffusion processes you have observed in your home, in school, and in public places you have been during the past week. **Process Questions:** a. At home: What everyday example shows diffusion happening (e.g., smell of food, perfume, smoke)?	*The **Transport Real!** activity targets Objective 1 by engaging learners in identifying everyday diffusion examples and connecting them to passive transport, embodying IDF principles of responsiveness, relevance, and reflection through constructivist, integrative, and reflective strategies with experiential and reflective learning that bridge theory and practice.* **Teacher Notes:** ● *Encourage learners to provide diverse examples across contexts (home, school, public).* ● *Clarify misconceptions (e.g., diffusion is not "carried by air" but driven by particle movement).*

	b. At school: Can you recall a situation where a substance spread naturally in the classroom or laboratory without stirring or mixing? c. In public places: What observation shows diffusion in action (e.g., scent in a mall, air freshener in a restroom)? d. How do these examples prove that diffusion does not require energy? e. Why is diffusion important for cells just as it is important in these everyday situations? **Expected Output:** Reflection Activity	***Click the link for the Alternate Activity Option for Teachers:*** **Option 1: Membrane-Label-and-Justify** *https://docs.google.com/document/d/1_okLZqsqQvrOCO7lgLeWzqD6EIf4QoxU/edit* ***Option 3: Fill Me In!*** *This is a supplementary activity for those struggling students* *Click the link for the complete procedure:* *https://docs.google.com/document/d/1dHj8kvSJCfeAfhcZTckkbNSmU8gupzhV/edit*
VI. ASSESSMENT *(Assessing Learnings)*	I. Directions. Read each item carefully. Write the letter of the best answer on a separate sheet of paper. For Items 11–14, refer to the labeled diagram with panels A–C. **1.** Which of the following is a passive transport process? A. Endocytosis B. Exocytosis C. Osmosis D. Protein Pumps **2.** What is the main difference between passive and active transport? A. Passive transport requires ATP, while active transport does not. B. Active transport requires ATP, while passive transport does not. C. Passive transport moves molecules against the gradient, while active transport moves with it. D. Active transport only moves water molecules, while passive transport moves other substances. **3.** In diffusion, molecules move: A. Molecules move from low concentration to high concentration using ATP. B. Molecules move from high concentration to low concentration without ATP. C. Molecules move only through protein channels in the membrane. D. Molecules move only inside vesicles within the cell. **4.** Facilitated diffusion differs from simple diffusion because: A. It requires ATP. B. It uses transport proteins but no ATP. C. It moves molecules against the gradient. D. It only moves water molecules. **5.** Which transport mechanism is responsible for moving large particles into the cell by forming vesicles? A. Endocytosis B. Exocytosis C. Facilitated diffusion D. Osmosis **6.** Which process releases substances like neurotransmitters or hormones out of the cell? A. Endocytosis B. Exocytosis C. Osmosis D. Diffusion **7.** Protein pumps are classified as active transport because: A. They move molecules down the gradient without ATP. B. They move molecules against the gradient using ATP. C. They only transport water molecules. D. They use vesicles to move large particles. **8.** Why is osmosis important for cells? A. It regulates water balance across membranes. B. It moves large molecules into the cell.	

C. It requires ATP to transport ions.
D. It releases waste products.

9. Why must IV fluids be isotonic?
A. IV fluids must be isotonic to prevent red blood cells from shrinking or swelling.
B. IV fluids must be isotonic to increase ATP production inside the patient's cells.
C. IV fluids must be isotonic to promote active transport of nutrients across cell membranes.
D. IV fluids must be isotonic to stimulate endocytosis within the patient's cells.

10. Passive transport helps move substances such as water and certain solutes along concentration gradients, while active transport uses energy to move ions or materials against gradients or through vesicle-mediated processes, together helping maintain homeostasis. How do passive and active transport mechanisms work together in the cell?
A. Passive transport maintains water balance, while active transport moves nutrients and ions against the gradient.
B. Passive transport requires ATP, while active transport does not, making them function in opposite ways.
C. Passive transport and active transport both only move water molecules inside the cell.
D. Passive transport and active transport both only occur during cell division in the cell.

✅ **Answer Key**
1. C 2. B 3. B 4. B. 5. A 6. B 7. B 8. A 9. A 10. A

II. Refer to the diagram below.

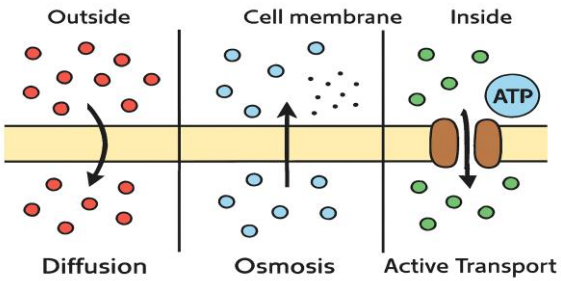


Figure 1. Particle movement across the cell membrane. Panel A shows diffusion: particles move from high to low concentration. Panel B shows osmosis: water moves across a selectively permeable membrane toward the side with higher solute concentration. Panel C shows active transport: a membrane protein uses ATP to move particles from low to high concentration.

Question 11: Diffusion Which diagram best illustrates diffusion across the cell membrane? A. Particles moving from low concentration to high concentration using ATP B. Water molecules moving toward higher solute concentration C. Particles moving from high concentration to low concentration without energy D. Large molecules entering the cell through vesicle formation
Correct Answer: C
Question 12: Osmosis In osmosis, the arrows in your diagram should show: A. Water moving from high solute concentration to low solute concentration B. Water moving from low solute concentration to high solute concentration C. Solute particles moving freely across the membrane without energy D. ATP being used to pump water molecules against their gradient
Correct Answer: B
Question 13: Active Transport Which diagram correctly represents active transport? A. Molecules moving from high concentration to low concentration without ATP B. Molecules moving from low concentration to high concentration through a protein pump with ATP C. Water molecules diffusing across the membrane toward higher solute concentration D. Large molecules passing freely through the lipid bilayer
Correct Answer: B
Question 14: Homeostasis Connection Why should arrow in your diagrams show different directions of movement for diffusion, osmosis, and active transport? A. To highlight that all processes require ATP B. To show that only diffusion and osmosis move substances down their gradients, while active transport moves them against the gradient

	using energy C. To demonstrate that all molecules move randomly without regulation D. To indicate that vesicle-mediated transport is the only way molecules cross membranes **Correct Answer:** B III. Short Response Essay: a. "Explain how passive and active transport work together to help red blood cells maintain homeostasis in the bloodstream." b. "In 3–4 sentences, explain how passive and active transport both help a cell maintain homeostasis. Give one example of each."
VII. REFLECTION *(Feedback and Continuous Improvement)*	*Use the following reflection prompts to guide your evaluation of the lesson after implementation. Reflect on learners' performance, determine which activities and lesson parts were most and least effective, identify learners who need enrichment or remediation, analyze the assessment results, and note possible improvements to enhance future lesson delivery.* ● *How many learners successfully demonstrated the learning objectives based on the assessment results?* ● *Which activity helped learners understand the lesson the most? Which activity helped the least?* ● *Which part of the lesson was easiest for learners? Which part was most difficult?* ● *How many learners needed enrichment or additional challenge? How many learners needed remediation or additional support?* ● *What did the assessment results show about learners' understanding of the lesson?* ● *What improvement would you make if you taught this lesson again?*
VIII. USE OF GENERATIVE AI	In preparing this Learning Exemplar (LE), the author(s) used Microsoft Copilot in order to improve the grammar, generate diagram image and consistency of the instructions in the different instructional options and in the annotations. The author(s) reviewed and finalized the writing of the content. The author(s) take(s) full responsibility for the content of this LE.

Lesson Title/Topic	Structural Components and Role of the Cell Membrane	Lesson Exemplar	10

I. OBJECTIVES	
A. Content Standard	The learners learn that cells have mechanisms that regulate the transport of substances in and out of the cell.
B. Performance Standard	By the end of the quarter, learners discuss the scientific value of the interconnectedness of living organisms and their environment. They evaluate the significance of cell theory and its development in explaining the structure and function of living organisms. Learners classify cells based on their structures and functions, explain the stages and significance of the cell cycle, and describe the mechanisms of passive and active transport in maintaining homeostasis. They participate in practical activities and create presentations that showcase how these biological principles contribute to growth, repair, reproduction, and the diversity of life.
C. Learning Competencies	***Prerequisite Knowledge and Skills*** ● Basic Cell Structures and Function ● Homeostasis ● Energy in Cells ● Molecules and Particles
	The learners explain the role of the cell membrane in maintaining cellular function and homeostasis
II. REFERENCES and MATERIALS (*Selecting Resources and Material*)	● Cadivida, Andrei Ariel B. Self-Learning Kit General Biology 1. DepEd-SDO Negros Oriental. ● Domingo, Gladys F. 2020. General Biology – Grade 12: Contextualized Learning Activity Sheets (CLAS), First Semester – Week 5: Transport Mechanism. 1st ed. ● Aguirre, Romer T., and Mark Richie S. Lasque. 2020. General Biology 1 – Grade 12: Alternative Delivery Mode. 1st ed. Cagayan de Oro City: Department of Education – Division of Cagayan de Oro City. ● Concepcion, Bryan R., Jonabelle A. Gamino, Cristy C. Mercado, Victor C. Allam, Reinalyn F. Cacayan, Mark Anthony A. Maraggun, and Julien Rezally Q. Mara. 2020. Learning Activity Sheet in General Biology 1 (Grade 11). 1st ed. Tuguegarao City: Department of Education – Regional Office No. 02. ● Capco, Carmelita M., and Gilbert C. Yang. 2006. You and the Natural World Series: Biology II. 2nd ed. Quezon City: SIBS Publishing House.
III. CONTENT *(Sequencing Content)*	● Structural Components of the Cell Membrane ● Role of the Cell Membrane in Maintaining Homeostasis
IV. OBJECTIVES *(Setting Clear Objectives and Analyzing the Tasks)*	a. Identify and label the major structural components of the cell membrane. b. Explain how selective permeability helps the cell maintain homeostasis. c. Predict and describe what happens when homeostasis is disrupted in different solution concentrations.

<table>
<tr><th colspan="2">V. PROCEDURES</th><th>ANNOTATIONS</th></tr>
<tr><td rowspan="2">A. Activating Prior Knowledge</td><td colspan="2">A.1. Activating Prior Knowledge</td></tr>
<tr><td>Students recall that the phospholipid bilayer forms the basic structure, proteins act as channels/pumps, cholesterol maintains fluidity, and carbohydrate chains help in recognition and signaling.

Option 1. KWL Chart
Do this as a starter
Before the lesson:
● Students fill in the K column with what they already know about cell boundaries or balance.
● Then, they add questions in the W column about what they’re curious to learn.
● Leave the Column for L blank at this point in time
During/After the lesson:
● As you cover objectives (definition, selective permeability, homeostasis disruption), students complete the L column through an exit ticket so students can reflect more thoughtfully on what they’ve learned after the lesson.

Expected Output: Activity Notes

Option 2. What’s in the Cell Membrane
Directions. Encircle all the terms you can find in the activity below that is related to the structure of the cell membrane using a red pen. Download the LAS here: https://docs.google.com/document/d/1FMW8x9aZfLCXZp2EbPtGpbgE-sfGHrwa/edit

Process Questions:
1. What is a cell membrane?
2. Which terms did you encircle that you already recognize as parts of the cell membrane?
3. Can you describe certain terms related to its function?

Expected Output: Learning Activity Worksheet</td><td>The KWL Chart activity targets Objectives 1–3 by activating prior knowledge, sparking curiosity, and consolidating reflection, embodying IDF principles of responsiveness, relevance, and reflection through constructivist, inquiry-driven, and reflective strategies with staged completion as a pedagogical scaffold.
Teacher Notes:
● Emphasize that the L column should be completed gradually (e.g., daily exit tickets) to avoid distraction during lessons.
● Reinforce scientific vocabulary (phospholipid bilayer, selective permeability, homeostasis).
● Collect L column responses as formative assessment to track learning progression.

The Cell Membrane Worksheet Diagnostic activity targets Objectives 1 and 2 by engaging learners in encircling familiar terms and answering guided questions, embodying IDF principles of responsiveness and relevance through constructivist and inquiry-based strategies, with worksheet-based reflection using a LAS to clarify misconceptions and connect concepts to cell membrane structure and function.
Teacher Notes:
● Clarify misconceptions by reviewing terms that are often confused (e.g., phospholipid vs. protein channel).
● Consider pairing students for peer discussion to enhance collaborative learning.</td></tr>
</table>

		• *Reinforce vocabulary by connecting terms to diagrams or models of the cell membrane.* ***Click the link for the Alternate Activity Option for Teachers:*** **Option 3. Cell Membrane Mystery Match** *https://docs.google.com/document/d/1OIBx_q8YbP55PvIF53OdvkA04588fTj0/edit*
	A.2. Establishing the Purpose of the Lesson	
	After activating what the learners know about the cell membrane, the teacher will give an overview activity that sets their motivation. **Option 1. Decode the Cell's Secret** The teacher will show to the students a rebus puzzle so that they will feel curious and engaged. CELL + 🚪 + ↔ + ⚖️ • **CELL** → the living unit we're studying • 🚪 **(Door)** → the membrane acting like a gate • ↔ **(Arrows)** → movement in and out • ⚖️ **(Balance scale)** → homeostasis, stability **Student Task:** • Ask learners to solve the rebus: "What message does this puzzle give us about cells?" • Guide them toward: "The cell membrane is like a door that controls movement to keep balance." ***"Why are we learning this?"****: Because just like doors and filters protect our homes, the cell membrane protects and balances the cell—without it, life couldn't survive.* **Question:** 1. Why is it important for the cell to regulate what passes through its membrane? 2. How does the cell membrane act like a door in controlling what enters and leaves the cell? 3. How does the movement of molecules in and out of the cell help maintain balance?	*The **Decode the Cell's Secret** activity targets Objectives 1 and 3 by using a rebus puzzle to connect visual symbols with the cell membrane's role in regulating movement and maintaining homeostasis, embodying IDF principles of responsiveness, relevance, and reflection through constructivist, inquiry-based, integrative, and reflective strategies with analogy-based puzzle-solving.* ***Teacher notes:*** • *Present this using power point presentation* • *Explain that substances cross the membrane based on molecular properties and transport mechanisms, not because the membrane consciously decides.* • *Encourage multiple interpretations before guiding toward the intended meaning to foster creativity.* • *Clarify misconceptions (e.g., not all molecules pass freely through the membrane).* • *The questions can be answered through oral recitation or short response essay* ***Click the link for the Alternate Activity Option for Teachers:*** ***Option 2. Gatekeeper Challenge***

		https://docs.google.com/document/d/1bgSrGq8IfMuQIrE5CEUPB-NlmGzyWBcd/edit ***Option 3. 5 Minutes Membrane Quick Challenge*** *https://docs.google.com/document/d/1an3X9T4toRHLs1kCQOLAsZ2yznCMweXe/edit*
B. Instituting New Knowledge	***B.1. Presenting Examples***	
	This time to concretize the motivation, the learners will be subject to different examples showing relatable, concrete, or real-life situations. **Option 2. Cell Membrane Look- Alike** **Directions.** Think of an object or structure that can be likened to a cell membrane. List at least 3 then explain elaborately why it is alike to a cell membrane. Sketch or draw your answers and put labels on it. Process Questions: 1. Why is this object a good analogy for the cell membrane? 2. What specific feature of the cell membrane does it represent (protection, selective permeability, communication)? 3. What would happen if this "membrane-like" object failed to do its job? **Expected Output** Written Worksheet	*The* ***Cell Membrane Look-Alike*** *activity targets Objectives 1–3 by engaging learners in creating and sketching everyday analogies of the cell membrane, embodying IDF principles of responsiveness, relevance, and reflection through constructivist, inquiry-based, and integrative strategies with analogy-based creative sketching that makes abstract concepts concrete.* ***Teacher notes:*** ● *Encourage diverse analogies (e.g., doors, filters, security guards, communication systems) to highlight multiple functions.* ● *Remind learners that no analogy is perfect—guide them to identify both strengths and limitations.* ***Click the link for the Alternate Activity Option for Teachers:*** ***Option 1. Label the Cell Membrane*** *https://docs.google.com/document/d/1Wn4Arljl8BAhLalFWlKdh4gsqiDtD9wI/edit* ***Option 3. The School Security System*** *https://docs.google.com/document/d/1TmQwePiiKeqv8PoLEL9-T8An9St-NFeF/edit*
	B.2. Discussing New Concept	
	At this point, the teacher will discuss the lesson to help students correct their misconceptions. **Option 3. Interactive Pause-and-Discuss** **Direction:** The learners will be allowed to view a you tube video explaining the role of the cell membrane in maintaining cellular function and homeostasis.	*This activity specifically targets all three learning objectives.* *The* ***Interactive Pause-and-Discuss*** *activity targets Objectives 1–3 by using a video on cell membrane structure and function with teacher-led pauses for processing questions, embodying IDF principles of responsiveness, relevance, and reflection through constructivist, collaborative,*

	Watch the video the link of the video here: https://www.youtube.com/watch?v=fJfTDc3WzQ8 For specific segment while playing the video, the teacher will pause it and ask these questions for processing up to the end*:* 1. *What is another name for the cell membrane?* 2. *How is the cell membrane similar to human skin?* 3. *What are the main components of the cell membrane?* 4. *What are the two parts of a phospholipid molecule?* 5. *Why do the phospholipid heads face outward while the tails face inward?* 6. *What is the term for the two-layer arrangement of phospholipids?* 7. *What does it mean when we say the cell membrane is "selectively permeable"?* 8. *How did it affect the entire cell if it's not selectively permeable?* 9. *Which types of molecules can pass through the phospholipid bilayer more easily?* 10. *What role does cholesterol play in the cell membrane?* 11. *How do carbohydrates on the cell membrane help with cell identification?* 12. *"Why would loss of membrane regulation threaten cell survival?"* **Expected Output** Written Notes/ Accomplished Answers	*inquiry-based, integrative, and reflective strategies with interactive multimedia learning and guided questioning.* ***Teacher notes:*** ● *If the school has no internet connection, it is advised for the teacher to download the video ahead of time* ● *Before playing the video, show the set of questions to be answered by the learners* ● *Pause at key segments to scaffold understanding and clarify misconceptions.* ● *Encourage learners to connect video content to real-life contexts (e.g., skin protection, nutrient absorption).* ***Click the link for the Alternate Activity Option for Teachers:*** ***Option 1. Guided Discussion*** *https://docs.google.com/document/d/1-ZVDa1no34l3d_91l23IEW7rY38HEj4b/edit* ***Option 2. My Answer, My Reason*** *https://docs.google.com/document/d/1xejHP-mvtJhlD74dsvx9BWZ5WFI_Q7p_/edit*
	B.3. Developing Mastery	
	In this part learners will engage in guided and independent practice activities to reinforce the concept. This may include drills, problem-solving, application tasks, or peer collaboration. **Option 2. Plasma Membrane – Sandwich Analogy** **Direction:** Follow the instructions and perform the activity. After performing, answer the question below	*The **Plasma Membrane – Sandwich Analogy** engages learners in hands-on analogy-based experiential learning to illustrate selective permeability, applying IDF principles and the 2C–2I–1R approach through constructivist, inquiry-driven reflection.* ***Teacher notes:***

	Materials: 2 pcs sliced bread, Softened Butter, Water, Dropper **Procedure:** 1. Get a slice of bread. 2. Put sliced softened butter on a piece of bread. 3. Overlay the remaining piece of bread. 4. Pour water, using a dropper, on top of the bread. 5. Observe what happens. **Question:** 1. What happens when you drop water on top of the butter sandwich? Write your answer on a sheet of paper. 2. How does this analogy show the importance of selective permeability? 3. What might happen to a cell if its membrane lost this property. 4. In what ways this analogy help you understand the cell membrane? What is lacking on this analogy. Justify your answer. **Expected Output** Learning Activity Sheet	• *Use this activity only as a simple analogy for selective passage, then clarify that the plasma membrane is a fluid phospholipid bilayer with proteins, not a solid waterproof barrier.* • *Group the students so that it will minimize the cost of the materials* • *Clarify that the plasma membrane is a **fluid mosaic bilayer**, not a solid waterproof barrier like butter.* • *Students should note that the water does not easily penetrate the butter layer, instead staying mostly on the bread surface* • *Emphasize the analogy's limits (e.g., real membranes have proteins, cholesterol, and dynamic movement).* • *Use the activity as a springboard for discussing how analogies can aid but also oversimplify scientific concepts.* • *Encourage learners to propose alternative analogies (e.g., security systems, filters) to deepen understanding.* ***Click the link for the Alternate Activity Option for Teachers:*** ***Option 1. Fill in the Blanks*** *https://docs.google.com/document/d/15g1feS0HLlS0v_ri9Nkhc_Lzek8PWnc1/edit* ***Option 3. Concept Organizer*** *https://docs.google.com/document/d/1mUmT72Xw-h7K1_q6WWD1rvPTG3qdd_9v/edit*
C. Demonstrating Knowledge and Skills	***C.1. Finding Practical Application***	
	In this stage learners apply what they have learned to real-life or simulated scenarios, problems, or tasks. This involves transferring knowledge and skills to authentic contexts and this will serve as scaffolding for the performance task. **Option 1. Problem Scenario** **Direction:** Analyze the scenario and answer the questions *"A patient is accidentally given pure water intravenously instead of a saline solution. After a few minutes, their red blood cells begin to swell and some burst."* Guided Discussion Questions:	*The **Problem Scenario activity** engages learners in problem-based analysis of a medical case on osmosis, applying IDF principles and the 2C–2I–1R approach through collaborative, inquiry-driven reflection on homeostasis.* ***Teacher notes:*** • *Emphasize the seriousness of medical errors to highlight relevance.*

	1. Which part of the cell membrane is responsible for transport?" 2. Why did the red blood cells swell when exposed to pure water? 3. How does this situation demonstrate the importance of homeostasis? 4. What would have happened if the patient was given a very salty solution instead? 5. When pure water is accidentally introduced into the bloodstream, red blood cells swell and burst. Which property of the cell membrane and which transport mechanism explain this outcome? ***Answer:*** *The membrane is selectively permeable, and osmosis drives water into the cell.* **Expected Output** Written Scenario Answer	• *Clarify that red blood cells burst in hypotonic conditions due to osmotic water influx.* • *Contrast with hypertonic conditions (shrinking) to reinforce understanding of tonicity.* • *Encourage learners to connect the scenario to real-life medical practices (e.g., IV fluid regulation).* ***Click the link for the Alternate Activity Option for Teachers:*** ***Option 2. Cell Membrane in Action – Osmosis and Homeostasis*** *https://docs.google.com/document/d/1e-0uBFgk3GF0KTrRVS5GsCjgZ2QJ6UMj/edit* ***Option 3. Problem-Solving*** *https://docs.google.com/document/d/1Gkd15FCBBLYc0zretumhPM4IzwXyoDp7/edit*
	C.2. Making Generalization	
	This section the learners will draw conclusions or summarize the key takeaways from the lesson. It can be done through discussions, reflective questions, or concept mapping. **Option 1: GenAI Concept Mapping** Instructions: Create a concept Map detailing everything you've learned about the role of the Cell Membrane in maintaining homeostasis. Start with "Cell Membrane" at the center and branch out to other ideas. **Instruction for Teachers:** • Ask students to list everything they've learned about the structure and function of cell membrane and its role in maintaining balance • Guide them to use a generative AI tool to turn their notes into a concept map. • Remind them that they will pass their original notes that they used as prompts for the Ai. Student Instructions:	The GenAI Concept Mapping activity has learners generate and refine AI-created concept maps on the cell membrane and homeostasis, applying IDF principles and the 2C–2I–1R approach through constructivist, inquiry-based, and reflective visual learning. ***Teacher notes:*** • *If internet or AI tools are unavailable, learners may create the concept map manually using their notes, textbook, or teacher-provided summary. Any AI-generated output must be checked against the lesson content for scientific accuracy before sharing.* • *Remind learners that AI-generated maps are only as strong as the notes provided.* • *Encourage critical evaluation of AI outputs to avoid misconceptions.*

	• Write down biological ideas about the cell membrane, selective permeability, and homeostasis. • Use a generative AI tool to create a **concept map** from your notes. • Compare your generated concept map with your notes and revise any inaccurate or incomplete ideas before submission. • The original notes will be passed along the generated concept map. **Expected Output:** Completed Concept Map	• *Guide students to use their own words in notes and revisions for deeper comprehension.* ***Click the link for the Alternate Activity Option for Teachers:*** ***Option 2. Visual and Listening Activity*** *https://docs.google.com/document/d/1IW48heDO5tZCc5apIsag7x2_iv4pqplC/edit* ***Option 3: One-Minute Summary Activity*** *https://docs.google.com/document/d/1sAzHGzuCXsZF9-1ShnPkZrwya3leRezS/edit*
	C.3. Evaluating Learning	
	These assessment tasks measure whether learners can identify membrane structures, explain selective permeability, and predict how cells respond when homeostasis is disrupted in different solution concentrations. **Option 2: Essay Activity** Write a short essay (3–4 paragraphs) addressing the following objectives: • Describe the cell membrane and label its parts (phospholipid bilayer, proteins, cholesterol, carbohydrates). • Explain why the cell membrane is selectively permeable. • Describe what happens when homeostasis is disrupted in the cell. Follow the format below as guide: • Introduction: Briefly introduce the cell membrane as the "gatekeeper" of the cell. • Body Paragraph 1: Define the cell membrane and describe its parts. • Body Paragraph 2: Explain selective permeability and its importance in maintaining balance. • Body Paragraph 3: Describe scenarios of disrupted homeostasis (e.g., swelling, shrinking, loss of function). • Conclusion: Summarize the importance of the cell membrane in protecting and balancing the cell.	The Essay Activity engages learners in structured writing on the cell membrane, applying IDF principles and the 2C–2I–1R approach through inquiry-based synthesis, integrative analysis, and reflective conclusions. ***Teacher notes:*** • *Remind learners to follow the essay format (introduction, body, conclusion) for clarity.* • *Encourage inclusion of at least two specific membrane components in explanations.* • *Highlight the importance of connecting structure to function rather than listing parts.* ***Click the link for the Alternate Activity Option for Teachers:*** ***Option 1: Identification Quiz*** *https://docs.google.com/document/d/1ZqdJ6sglNBRC_FHaA8Ed9gvSgv7e5dVv/edit*

	Expected Output: Written Response Essay *Access the link for the rubric here: https://docs.google.com/document/d/1IBCTMpw96UaZVDvd_OmBIMcpgz4__oTI/edit*	
	C.4. Additional Activities	
	This section should include enrichment, reinforcement, or remediation options to support diverse learners. Writers should provide two to three differentiated activities that address varied readiness levels while ensuring inclusion and providing additional scaffolding where necessary. **Option 1: Do-It-Yourself CELL MEMBRANE** In this activity, you will be able to build a simple 3-D model of the plasma membrane using materials you can easily find at home. *Access the link for the complete guided model:* https://www.education.com/activity/article/build-cell-membrane-model/ **Expected Output:** DIY Cell Membrane Model **Option 2: Cell Membrane Story** **Direction:** Write a creative science fiction short story entitled ***"The Day the Plasma Membrane Stopped Working."*** • Imagine what would happen if the plasma membrane of a cell suddenly failed. • Use scientific concepts (such as diffusion, osmosis, transport of molecules, or cell survival) to explain the consequences in your story. • Be creative—your story can be dramatic, humorous, or futuristic, but it must show an understanding of the plasma membrane's role. • After writing, share your story with the class for discussion. **Expected Output:** Cell Membrane Story Worksheet	*The **DIY Cell Membrane activity** engages learners in building a 3-D model to visualize structure and function, applying IDF principles and the 2C–2I–1R approach through hands-on, inquiry* ***Teacher notes:*** • *Remind students that the model is a simplified representation, not a perfect replica.* • *Highlight how the arrangement of components supports selective permeability and homeostasis.* *The **Cell Membrane Story activity** engages learners in creative writing about plasma membrane failure, applying IDF principles and the 2C–2I–1R approach through scientific storytelling, collaborative sharing, and reflective analysis.* ***Teacher notes:*** • *Remind learners to balance creativity with scientific accuracy.* • *Encourage inclusion of at least two specific membrane processes (e.g., osmosis, transport proteins).*

	Access the link for the scoring rubric of story: https://docs.google.com/document/d/1nRFRffJbIkP9dRo7OwZYpm3chUc_yyMo/edit **Option 3: Short Response Essay** In short bond paper, *"Explain how the selective permeability of the cell membrane helps prevent cell damage in changing environments"* *Access the link for the scoring rubric of short response essay here: https://docs.google.com/document/d/1DP-JrBt1DfbZSZ2dSfYdItyptXMMeTXb/edit?usp=drive_web&ouid=106950616858732005618&rtpof=true* **Expected Output:** Essay	*The **Short Response Essay activity** asks learners to explain selective permeability's protective role, applying IDF principles and the 2C–2I–1R approach through inquiry-based writing, integrative analysis, and reflective synthesis.* ***Teacher notes:*** ● *Use student responses to identify misconceptions (e.g., confusing isotonic with hypotonic, or assuming membranes are rigid).* ● *Provide targeted guidance: clarify how selective permeability works with transport proteins and aquaporins.*
VI. ASSESSMENT *(Assessing Learnings)*	*This section will serve as a culminating assessment intended to evaluate the entire learning competency, including both the Content Standard and the Performance Standard.* ***Key Answer in bold*** A. Directions. Read each item carefully and highlight the letter and the word of the correct answer in a separate sheet of paper. 1. Which of the following correctly describes the basic framework of the cell membrane? a. The cell membrane consists of a single layer made up of carbohydrates and proteins. **b. The cell membrane is formed by a double layer of phospholipids with embedded proteins and cholesterol.** c. The cell membrane is described as a rigid wall composed of cellulose and glycoproteins. d. The cell membrane is structured as a layer of nucleic acids surrounded by lipids. 2. Which of the following is NOT a primary function of the cell membrane? a. The cell membrane regulates the entry and exit of various substances. **b. The cell membrane provides rigid structural support similar to that of a cell wall.** c. The cell membrane helps the cell maintain a stable internal environment called homeostasis. d. The cell membrane acts as a boundary between the cell and its surrounding environment. 3. The cell membrane is mainly composed of: a) Proteins and nucleic acids **b) Lipids and proteins** c) Carbohydrates and DNA d) Water and salts 4. The "fluid mosaic model" describes the cell membrane as: a) Rigid and immovable **b) Flexible with proteins embedded in lipids** c) A solid wall of cellulose d) A layer of nucleic acids 5. Why is the cell membrane called "selectively permeable"? a. The cell membrane allows all substances to pass through freely without restriction. b. The cell membrane blocks the passage of all molecules completely and prevents any movement. **c. The cell membrane allows certain molecules to pass while blocking others from entering or leaving.** d. The cell membrane permits only water molecules to pass through while excluding all other substances. 6. Which process involves water moving across the cell membrane?	

	a) Diffusion **b) Osmosis** c) Active transport d) Endocytosis 7. Predict the immediate effect on a cell if the membrane could no longer regulate what enters and exits.”? a. The nucleus of the cell would eventually disappear completely. **b. There would be uncontrolled movement of substances in and out of the cell.** c. The cell wall would become stronger and provide additional structural support. d. The process of DNA replication inside the cell would immediately stop. 8. Homeostasis refers to: a. Homeostasis refers to the cell’s ability to divide and produce new cells. **b. Homeostasis refers to the balance of internal conditions despite external changes.** c. Homeostasis refers to the process by which proteins are synthesized inside the cell. d. Homeostasis refers to the breakdown of glucose molecules for cellular energy. 9. What happens when homeostasis is disrupted in a cell? a. The cell continues to function normally without experiencing any immediate changes. **b. The cell may become damaged or eventually die due to the loss of internal balance.** c. The cell wall becomes thicker and provides additional structural reinforcement. d. The nucleus grows larger and occupies more space within the cell. 10. Which part of the cell membrane helps cells recognize and communicate with one another? a) Phospholipid bilayer b) Transport proteins **c) Carbohydrate chains** d) Cholesterol molecules
VII. REFLECTION *(Feedback and Continuous Improvement)*	*Use the following reflection prompts to guide your evaluation of the lesson after implementation. Reflect on learners’ performance, determine which activities and lesson parts were most and least effective, identify learners who need enrichment or remediation, analyze the assessment results, and note possible improvements to enhance future lesson delivery.* ● *How many learners successfully demonstrated the learning objectives based on the assessment results?* ● *Which activity helped learners understand the lesson the most? Which activity helped the least?* ● *Which part of the lesson was easiest for learners? Which part was most difficult?* ● *How many learners needed enrichment or additional challenge? How many learners needed remediation or additional support?* ● *What did the assessment results show about learners’ understanding of the lesson?* ● *What improvement would you make if you taught this lesson again?*
VIII. USE OF GENERATIVE AI	In preparing this Learning Exemplar (LE), the author(s) used Microsoft Copilot in order to ensure accuracy of scientific concepts, save time and increase efficiency, support alignment with pedagogy, and maintain clarity and organization. The author(s) reviewed and finalized the writing of the content. The author(s) take(s) full responsibility for the content of this LE.

Lesson Title/Topic	Cellular Abnormalities and Their Roles in Diseases	Lesson Exemplar	11

I. OBJECTIVES	
A. Content Standard	The learners learn that cells have mechanisms that regulate the transport of substances in and out of the cell.
B. Performance Standard	By the end of the quarter, learners discuss the scientific value of the interconnectedness of living organisms and their environment. They evaluate the significance of cell theory and its development in explaining the structure and function of living organisms. Learners classify cells based on their structures and functions, explain the stages and significance of the cell cycle, and describe the mechanisms of passive and active transport in maintaining homeostasis. They participate in practical activities and create presentations that showcase how these biological principles contribute to growth, repair, reproduction, and the diversity of life.
C. Learning Competencies	***Prerequisite Knowledge and Skills*** **G7 Q2** Recognize that cells reproduce through two types of cell division, mitosis and meiosis, and describe mitosis as cell division for growth and repair; 6. explain that genetic information is passed on to offspring from both parents by the process of meiosis and fertilization. **G9 Q3** Explain the role of DNA, genes, and chromosomes in the transmission of traits; 3. describe mutations as changes in DNA or chromosomes and discuss some of the factors that cause mutations, such as infectious agents, radiation, and chemicals; 4. use information from secondary sources to explain the beneficial, harmful, and neutral effects of mutations; **G10 Q4** Describe homeostasis as a state of balance among all the body systems in humans that needs to be maintained for survival and proper functioning; its indicators include body temperature, glucose level, and blood pressure; 2. explain how homeostasis is maintained through various feedback mechanisms, both positive and negative
	● The learners use information from secondary sources to explain how cellular abnormalities contribute to diseases, such as cancer, diabetes, and genetic disorders.
II. REFERENCES and MATERIALS (*Selecting Resources and Material*)	● American Cancer Society. 2023. "What Is Cancer?" Last revised July 12, 2023. https://www.cancer.org/cancer/understanding-cancer/what-is-cancer.html. ● California State University, Chico. "Library Guides: Evaluating Resources and Misinformation: CRAAP Test." UChicagoLibrary. Accessed April 22, 2026. https://guides.lib.uchicago.edu/c.php?g=1241077&p=9082343. ● CSHL DNA Learning Center. n.d. "3D Animations - Disease & Mutation: Sickle Cell." Accessed March 12, 2026. https://dnalc.cshl.edu/resources/3d/17-sickle-cell.html. ● Gavin, Mary L. 2022. "Cancer Basics." KidsHealth. Last reviewed October 2022. https://kidshealth.org/en/teens/cancer.html. ● Lodish, Harvey, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Kelsey C. Martin, Michael Yaffe, and Angelika Amon. 2021. Molecular Cell Biology. 9th ed. New York: W. H. Freeman. ● National Cancer Institute. "What Is Cancer?" Accessed March 12, 2026. https://www.cancer.gov/about-cancer/understanding/what-is-cancer. ● National Institute of Diabetes and Digestive and Kidney Diseases. n.d. "What Is Diabetes?" Accessed March 12, 2026. https://www.niddk.nih.gov/health-information/diabetes/overview/what-is-diabetes. ● National Human Genome Research Institute (NHGRI). n.d. "Genetic Disorders." Genome.gov. Accessed March 12, 2026. https://www.genome.gov/For-Patients-and-Families/Genetic-Disorders. ● Nemours KidsHealth. "What Is Type 2 Diabetes? (for Teens)." Accessed March 12, 2026. https://kidshealth.org/en/teens/type2.html

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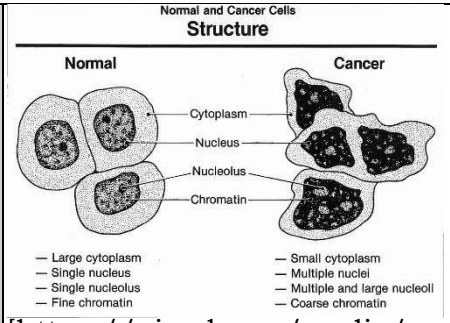
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</td></tr>
<tr><td>III. CONTENT
(Sequencing Content)</td><td colspan="2">Cellular abnormalities and their roles in diseases such as cancer, diabetes, and genetic disorders</td></tr>
<tr><td>IV. OBJECTIVES
(Setting Clear Objectives and Analyzing the Tasks)</td><td colspan="2">At the end of the lesson, the learners will be able to.
1. Describe cellular abnormalities and their effects on normal cell function.
2. Compare the structure and function of normal cells and abnormal cells.
3. Use information from secondary sources to explain how cellular abnormalities contribute to diseases such as cancer, diabetes, and genetic disorders.
4. Explain how cellular abnormalities lead to physical symptoms in these diseases.</td></tr>
<tr><td colspan="2">V. PROCEDURES</td><td>ANNOTATIONS</td></tr>
<tr><td rowspan="2">1. Activating Prior Knowledge</td><td colspan="2">A.1. Activating Prior Knowledge</td></tr>
<tr><td>Option 1: Activity: Fact or Bluff
Instructions: Read each statement carefully. Stand if you think it's a Fact. Sit if you think it's a Bluff. When called explain your choice.
Suggested Statements:
1. All cells in the human body look and function the same way. (Bluff)
2. Mitochondria are responsible for protein synthesis. (Bluff)
3. Abnormal cells may ignore signals that normally tells cells to stop dividing. (Fact)
4. The cell membrane controls what enters and exits the cell. (Fact)
5. All cellular abnormalities are visible under a microscope. (Bluff)
6. Sickle-shaped red blood cells carry oxygen more efficiently than normal cells. (Bluff)
7. DNA mutations can lead to abnormal cell behavior. (Fact)
8. Cancer cells undergo apoptosis more often than normal cells. (Bluff)
9. Diabetes involves abnormalities in how cells respond to insulin. (Fact)
10. Cell abnormalities always cause immediate symptoms. (Bluff)</td><td>The lesson targets the first learning objective, introducing the connection between cellular abnormalities and diseases such as cancer and diabetes. It reflects responsive and reflective principles and applies an inquiry-based, collaborative, and reflective approach through a pre-assessment activity.
Additional Notes for the Teacher: Present one cell or disease statement at a time via slides, have students respond by standing for “Fact” or sitting for “Bluff,” then call volunteers to justify answers. Discuss correct responses and note misconceptions for later clarification.</td></tr>
</table>

	Option 2: Cell Inspection This activity develops students' ability to observe and classify cell images by distinguishing normal from abnormal cells and relating visible structures to health and disease concepts. Observe and classify each cell image by voting if it is normal (thumbs up) or abnormal (thumbs down) based on visual characteristics, then briefly explain the reason for the choice when called on. Answer the follow-up questions by explaining what makes a cell normal and giving ideas on where diseases like cancer may come from based on observation and prior knowledge Follow-up Question: 1. What do you think makes a cell "normal"? 2. Where do you think diseases like cancer come from? Link for Sample Activity with Procedures: https://drive.google.com/file/d/1F5TNi6MrkJ_5wn3MuPye8OXqbziPidYq/view?usp=sharing	The lesson targets Learning Objectives 1–4, reflects responsive and reflective principles, and applies an inquiry-based, constructivist, collaborative, and reflective approach through visual analysis and engagement activities. **Additional Notes for the Teacher:** Prepare 8 cell images (normal and abnormal) one at a time, allow brief silent observation, then have students vote using thumbs up if (normal) /down (if abnormal). Invite explanations, record responses, and reveal correct answers afterward while encouraging reasoning and discussion before validation.
	A.2. Establishing the Purpose of the Lesson	
	Option 1: Visible Clues Instruction: Look at each image pair on the screen. With your partner, think of differences between the healthy and diseased versions for 30 seconds. When called on, share one word describing a difference. Then answer the following questions: 1. What do you think happened to cause such a big change?" 2. Does the trouble always come from outside the body, or can it start inside? Explain • Pair 1: healthy lung tissue beside lung tissue with tumor nodules. • Pair 2: normal red blood cells beside sickle-shaped red blood cells. Guide question: What cell-level change can you infer from each diseased image, and how might that change affect organ function? **Option 2: Signal Breakdown** All students stand beside their seats. The teacher explains the hand signals: • GREEN = raise both arms, YELLOW = extend arms to the side, RED = lowers both arms Round 1: Normal Operation The teacher calls out colors in a normal sequence: • GREEN, YELLOW, RED, GREEN . . . Round 2: Signal Malfunction The teacher explains the NEW hand signals:	These activities target Objectives 1, 2, and 4 by embedding responsive, relevant, and reflective principles within a collaborative, inquiry-based, and constructivist framework. Through visual analysis, analogy, experiential learning, and inquiry-based exploration of how cellular abnormalities lead to physical symptoms, learners are scaffolded toward deeper conceptual understanding. These approaches foster collaboration, inquiry, and reflection, ensuring alignment with objectives and readiness for more advanced performance tasks. **Notes for the Teacher Option 1:** Use contextual images such as lung cancer (https://commons.wikimedia.org/wiki/File:Lung_cancer_-_Healthy_lung_Smokers_lung_with_cancer_--_Smart-Servier.jpg) and Sickle Cell Anemia (https://commons.wikimedia.org/wiki/File:Sickle_Cell_Anaemia_red_blood_cells_in_blood_vessels.png) **Notes for the Teacher Option 2:** Ensure all students can participate comfortably; those unable to do the movement activity may observe

	• GREEN = lowers both arms, YELLOW = raise both arms, RED = extend arms to the side The teacher calls out colors in a random sequence: • GREEN, YELLOW, YELLOW, RED, YELLOW . . . Teacher asks: "What happened when the signals got mixed up?"	and describe signal patterns instead. Highlight the contrast between normal and disrupted signals during discussion.
11. Instituting New Knowledge	***B.1. Presenting Examples***	
	Option 1: Abnormality Gallery **Instruction:** Visit each station with a partner and discuss the following questions at every stop: 1. List at least two visual differences seen between the normal cell and the abnormal cell. 2. Based on the cells' location or appearance in the body, what do you think is its main job in a healthy body? 3. How might the visual abnormality you observed from question 1 cause it to fail at its job? What could be the effect in the body? After visiting all stations, join another pair with similar answers and be ready to share your observations with the class. **Option 2: Abnormality in Action** **Instruction:** Watch the video clips of each video showing cellular process in normal versus abnormal states for each disease. The three diseases are: Cancer (How Cancer Divide), Diabetes (Type II), Sickle Cell Anemia. Then answer the following: Guide Questions: 1. Cancer: What are the normal cells doing that the cancer cells are not? What evidence from the source supports your explanation?" 2. Diabetes (Type II): What is happening at the cell membrane? Is sugar getting in or not? What evidence from the source supports your explanation?" 3. Sickle Cell Anemia: How does the shape of the cell affect its movement through the blood vessel? What evidence from the source supports your explanation?" **Option 3: Microscopy Investigation** This activity engages students in a microscopy investigation where they observe and compare normal squamous cells and cancerous squamous cell carcinoma to identify structural differences and understand how abnormal cell growth affects tissues. It promotes careful observation, comparison, and connection of cellular changes to health conditions.	These activities target Objectives 1–4 using a constructivist, collaborative, integrative, and inquiry-based approach grounded in responsive, relevant, and reflective principles. Learning is supported through varied strategies such as station rotation, discussions, video analysis, and microscopy work with structured scaffolding and reflection. **Notes for the Teacher Option 1:** Set up three stations showing normal vs. abnormal cells for cancer, sickle cell anemia, and Type 2 diabetes. For diabetes, use a diagram of insulin resistance to highlight functional cell dysfunction affecting glucose uptake (https://www.shutterstock.com/image-vector/medical-illustration-shows-simple-schematic-way-2492866277?trackingId=c98ff81c-c766-4c63-989e-a9b23d1d5358&listId). **Notes for the Teacher Option 2**: Students must cite evidence from three videos on cancer, type II diabetes, and sickle cell anemia. Prepare guide questions in advance, pause after each video for quick responses, and facilitate discussion based on specific observed details. Type 2 diabetes should be explained as a functional cellular abnormality. In this disease, target cells respond weakly to insulin, so glucose uptake is reduced even when the cells do not show an obvious visible change in shape under routine classroom images. URL used: Cancer:https://embryology.preprod.med.unsw.edu.au/embryology/index.php?title=File:How_Cancer_Cells_Divide.mp4 Diabetes:https://nmal.nucleusmedicalmedia.com/biology-the-cell-10-cell-division-mitosis-and-

	Students work in small groups to observe prepared microscope slides of healthy and cancerous squamous cells. They compare the two samples by describing cell arrangement, similarity, boundaries, nucleus appearance, and number of cells. After observation, learners will reflect on guided health-related questions that connect abnormal cell behavior to how a person may feel and experience symptoms in real life. Link for Sample Activity with Procedures: https://drive.google.com/file/d/1j8MxfhCeSHJMXgVFzfJU13gSXT30GjBN/view?usp=sharing	cytokinesis/biology-the-cell-10-cell-division-mitosis-and-cytokinesis/view-item?ItemID=80994 SickleCellAnemia:https://dnalc.cshl.edu/resources/3d/17-sickle-cell.html. **Notes for the Teacher Option 3:** Review proper microscope use and lab safety, ensure PPE is worn, and manage station rotations with time limits. Low-resource alternative: If microscopes or pathology slides are unavailable, use printed or projected micrographs of healthy squamous cells and squamous cell carcinoma. Learners may annotate the images, compare nucleus size, tissue arrangement, and cell boundaries, and answer the same guide questions used in the microscopy version.
	B.2. Discussing New Concept	
	Option 1: Explicit Teaching These activities provide explicit instruction on normal cell functions and cellular abnormalities, emphasizing comparison, cause-and-effect relationships, and links to real-world health conditions. Learners engage with key concepts such as growth, communication, differentiation, and apoptosis while contrasting normal and abnormal cells. Through analysis of cancer, diabetes mellitus, and genetic disorders like sickle cell anemia and Down syndrome, students examine causes, cellular changes, and resulting symptoms. By connecting mutations and dysfunctions at the cellular level to observable health outcomes, the lesson scaffold understanding of how microscopic processes manifest as disease. Link for Sample Activity with Procedures: https://drive.google.com/file/d/1BCTcy1v-vzp9N5x7qQIZjogxC0lIG6jZ/view?usp=sharing **Option 2: Mix and Match** Part 1: Normal and Abnormal Cells	These activities target Objectives 1, 2, and 4 by embedding responsive, relevant, and reflective principles within a constructivist, integrative, and inquiry-based framework. Through direct instruction, comparative analysis, guided questioning with formative checks, visual comparison, matching tasks, and conceptual bridging, learners are scaffolded toward deeper understanding. These approaches foster inquiry, reflection, and integration, ensuring alignment with objectives and readiness for more advanced performance tasks. **Notes for the Teacher Option 1:** Genetic disorders do not all arise in the same way. For this lesson, use sickle cell disease as an example of a gene mutation and Down syndrome as an example of a chromosomal abnormality. Emphasize that both are genetic disorders, but they involve different kinds of cellular change. **Notes for the Teacher Option 2:**Highlight connections between cellular behavior and disease outcomes, especially how uncontrolled division leads to cancer, insulin resistance leads to diabetes, and genetic mutations lead to structural/functional changes in cells. Use the activity as a formative assessment to identify gaps



[https://picryl.com/media/normal-and-cancer-cells-structure-cfabd4?zoom=true]

Instructions:
Left image: normal cell. Right image: abnormal cell.
Infer from the image and match each description to the correct cell. Write N for Normal or A for Abnormal.

No.	Description	Normal (N) or Abnormal (A)?
1	Cell has uniform size and shape	
2	Cell division is uncontrolled	
3	Cell has enlarged, dark nucleus	
4	Cell responds properly to signals	
5	Cell avoids death even when damaged	
6	DNA is intact and stable	
7	Cell loses specialized function	
8	Cell stays in its original location	
9	Cell can invade other tissues	
10	Cell performs its specific job	

Part 2: Match Description to diseases

Instructions: Match each description to the correct disease. Write **C** for Cancer, **D** for Type 2 Diabetes, or **G** for Genetic Disorder.

No.	Description	C, D, or G?
1	Cells divide uncontrollably; form tumor	
2	Body cells resist insulin; high blood sugar	
3	DNA mutation causes sickle-shaped red blood cells	
4	Frequent urination and extreme thirst	

in understanding before proceeding to more complex disease mechanisms.

5	Extra chromosome 21 affects development and health		
6	Cells spread to other body parts		
7	Thick mucus in lungs from faulty gene		
8	Weight loss from cancer cells consuming energy		
9	Pain crises when sickle cells block vessels		
10	High blood sugar damages nerves		

B.3. Developing Mastery

Option 1: Tracing Diseases from Cell to Symptoms
I DO: Teacher will show an example:
Cell Problem→ Cell Can't Work → Organ Affected→ Symptom
Cancer (Lung)
Ex: Cell ignores stop signal → Cell divides nonstop → Tumor forms in the lungs → worsening cough
Flowchart explanation:
"The cell problem causes the cell to stop working. This affects the organ. The symptoms are the result. Each arrow means 'leads to'."
We Do: Teacher Guides Students
Student will choose their starting cell problem, another student will then be called to fill up the flowchart. Then the final student will state Flowchart explanation:
You Do: Students Work Independently
Learners will perform the activity by pairs (or individually).
The leaners will make their own flowchart.
Learners must support at least one step in their disease flowchart with information from a secondary source used earlier in the lesson.
After completing, pairs join another pair with a different disease.
Each pair explains their flowchart:
"First, the cell problem is..." → "This means the cell can't..." → "So the organ affected is..." → "That's why the patient feels..."
Link for Sample Activity with Procedures:
https://drive.google.com/file/d/1iHfOV086vkIkk6lVRn7zxtNL1pOV6t_o/view?usp=sharing
Option 2: Complete the Table
The activity engages the student identifying the cellular abnormality, its effect on cell function, the organ affected, and the resulting symptoms for Cancer, Diabetes, and Sickle Cell.
Link for Sample Activity with Procedures:
https://drive.google.com/file/d/1dSXdFlEFXAJjessSD7F1VXVcXYjNmGVj/view?usp=sharing

The lesson targets Objectives 1, 2, and 4, reflects responsive, relevant, and reflective principles, and uses a constructivist, collaborative, integrative, and reflective approach through the gradual release of responsibility (I Do, We Do, You Do), flowchart construction, and peer explanation.
Notes for the Teacher Option 1: Students complete a flowchart as the "You Do" activity, supported by peer comparison and explanation, using the provided rubric:
https://tinyurl.com/BIO1Q1L11-RUB001
Notes for the Teacher Option 2: Teachers can provide support to students in completing a table for cancer, diabetes, and sickle cell disease by identifying cellular abnormalities, affected cell functions, organs, and resulting symptoms, through a word bank scaffolding.

3. Demonstrating Knowledge and Skills	***C.1. Finding Practical Application***	
	Option 1: Story Challenge This activity engages students in a creative storytelling task where they apply their understanding of cellular biology and disease by personifying biological components and explaining how cellular abnormalities lead to health conditions in a simplified but scientifically accurate way. **Task to be accomplished:** Create a short, simplified but scientifically accurate 5-sentence story about a chosen disease (Cancer, Type 2 Diabetes, or a Genetic Disorder) by assigning characters to biological components, showing normal cell function, explaining the cellular abnormality, and describing its effect on the body, while also including at least one credible source used in the story. **Option 2: Finding Reliable Health Information Online** Instructions: 1. Choose your disease (cancer, diabetes, any genetic disorders) 2. Find Three Websites 3. Write Down the following information a. Name of the Website b. Full URL Address of Article c. Title of Article 4. Evaluate the site by answering using the CRAAP Test: *https://guides.lib.uchicago.edu/c.php?g=1241077&p=9082343 5. Synthesize your evaluation to write a 150-word or less to explain why their chosen sites are reliable websites to be used as reference their chosen diseases	The activities address Learning Objectives 2–4 using a constructivist, integrative, and inquiry-based approach grounded in responsive, relevant, and reflective principles. They involve analogical reasoning, structured scaffolding, and information literacy using the CRAAP framework to connect cellular abnormalities to disease and symptoms. **Notes for the Teacher Option 1:** Provide an example analogy before the activity, monitor students during planning to ensure scientific accuracy and prevent misconceptions, and require at least one cited secondary source. Remind learners to use person-first and non-stigmatizing language, such as “a person with diabetes” rather than labels. Do not require learners to share personal or family medical experiences. Remind the class that disease is a medical condition, not a personal failure. **Rubrics:** https://tinyurl.com/BIO1Q1L11-RUB002 **Notes for the Teacher Option 2:** Teachers must emphasize using the CRAAP Test to evaluate each source: Currency, Relevance, Authority, Accuracy, and Purpose. A source should be used only if it is current enough for the topic, clearly relevant to the disease, written by a credible author or institution, accurate and evidence-based, and created for an appropriate purpose
	C.2. Making Generalization	
	Option 1: Concept Mapping Instructions: Create a concept Map detailing everything you’ve learned about Cellular Abnormality. Start with "Cellular Abnormalities" at the center and branch out to other ideas. **Option 1.A: GenAI Concept Mapping** Instructions: Write key ideas about cellular abnormalities, their effects, and related diseases. Use a GenAI tool to create a concept map based on your notes. Before submitting, compare your output with your notes and revise any errors or gaps before submitting. Pass your original notes along with your generated concept map. **Option 2: Reflective Question Circle** Instructions: Students will answer the following questions:	The activities target Learning Objectives 1–4, focusing on understanding cellular abnormalities, their effects, disease connections, and resulting symptoms. They reflect responsive, relevant, and reflective principles and apply a constructivist, integrative, and collaborative approach through concept mapping, GenAI-assisted learning, reflective questioning, and structured discussion. **Notes for the Teacher Option 1:** Instruct students to place “Cellular Abnormalities” at the center and branch out to key concepts (e.g., causes, effects, diseases, symptoms). Encourage inclusion of evidence from secondary sources and

	1. What is the most important difference between normal and abnormal cells? 2. How do cellular abnormalities explain the symptoms we see in patients? 3. Why is it important to use secondary sources when studying diseases? 4. Which secondary source helped you understand one disease best, and what specific information from it did you use in your explanation?	clear connections between ideas to demonstrate understanding. **Notes for Teacher Option 1a:** Use only for proficient learners. For students opting to use Ai Require students to submit both their prompts and original notes and remind them to critically compare AI outputs with their own work to identify and correct inaccuracies.
	C.3. Evaluating Learning	
	Option 1: Making Infographics This activity engages students to work in groups to research a disease (e.g., cancer, diabetes, genetic disorders) and create an infographic showing difference between normal vs abnormal cells, the cellular abnormality involved, how it causes the disease, and its symptoms, using and citing credible sources. Link for Sample Activity with Procedures: https://drive.google.com/file/d/1x41xml8wSVKwVvO3eTvE43dSt3rty4Sy/view?usp=sharing **Option 2: Disease Mechanism** Instructions: Choose one disease (cancer or diabetes). Read the assigned secondary source of your choice. *Follow this structure for your paragraph:* 1. **Opening:** Define the core cellular abnormality. 2. **Evidence:** Include one paraphrased explanation and one specific fact from the assigned source. Identify the source clearly in your paragraph 3. **Analysis:** Explain in your own words how the cellular abnormality leads to the disease. 4. **Conclusion:** Summarize how this specific cellular failure prevents the body from maintaining normal homeostasis. Suggested Sources: • **Cancer**: Khan Academy "Cancer and the cell cycle", https://www.khanacademy.org/science/ap-biology/cell-communication-and-cell-cycle/regulation-of-cell-cycle/a/cancer • **Diabetes**: Mayo Clinic "Type 2 diabetes" , https://www.mayoclinic.org/diseases-conditions/type-2-diabetes/symptoms-causes/syc-20351193	These activities address Learning Objectives 1–4 using a constructivist, collaborative, and integrative approach. Through project-based tasks, concept mapping, GenAI-assisted evaluation, and guided reflection, learners connect cellular changes to diseases and symptoms, promoting understanding, collaboration, and readiness for advanced tasks. **Notes for the Teacher Option 1:** Students create infographics to demonstrate understanding, guided by the rubric: https://tinyurl.com/BIO1Q1L11-RUB003 **Notes for the Teacher Option 2:** Provide printed articles and allow task differentiation. Support struggling learners with a structured response template and require use of evidence from sources. Use the rubric for assessment: https://tinyurl.com/BIO1Q1L11-RUB04 For struggling learners, teachers can provide a template to help them write their answer "In [Disease Name], the cellular problem is [state the abnormality]. According to [Source Name], '[Insert direct quote].' This means that [paraphrase: explain in your own words how the cells behave differently now]. Because the cells are acting this way, they cannot perform their normal job of [state normal function], which leads to the disease."

<table>
<tr><td></td><td colspan="2">C.4. Additional Activities</td></tr>
<tr><td></td><td>Option 1: Revisiting Fact or Bluff
Instruction for Teachers: Teacher may revisit the Fact or Bluff Activity during Activation of Prior Knowledge. Teacher can opt to use the same suggested statements or raise the difficulty of the statements.
After the activity, ask learners to write one sentence explaining how a cellular abnormality can lead to a visible disease symptom.
Option 2: Remediation – Concept Builder
This activity provides remediation support for students who struggled with basic concepts by strengthening their understanding of cellular abnormalities and how these lead to disease through guided practice in matching and completion tasks.
Link for Sample Activity with Procedures:
https://drive.google.com/file/d/1d0xMUOwmNPmuzXXsRtEWtsRTzmIASmAh/view?usp=sharing
Option 3: Enrichment – New Disease, Same Principles
Instructions for Teachers: This activity challenges students to independently research or use provided information on a new disease.
Disease Options: Parkinson's Disease, Huntington's Disease, Muscular Dystrophy, Alzheimer's Disease, HIV/AIDS.
Instructions: Create a one page-report about your chosen disease. Use at least 2 reliable secondary sources to complete the report.
Guide Questions:
1. What specific cell type is affected?
2. How does the structure and function of a normal cell differ from the affected cell?
3. How does this cellular problem lead to the development of the disease?
4. List 2-3 symptoms. For each, explain how it connects back to the cellular problem.
5. What are the sources you used and how does it support your answer for questions 1-4?</td><td>These activities address Learning Objectives 1–4 using a constructivist, inquiry-based approach. Through Fact or Bluff, guided instruction, and independent research, learners build understanding of cellular processes and abnormalities while developing inquiry, reflection, and integration skills for advanced tasks.
Notes for the Teacher Option 1: Adjust the difficulty of statements based on student performance to challenge those who have mastered the basics.
Notes for the Teacher Option 2: Use the activity to identify misconceptions and provide immediate, targeted feedback before advancing to more complex concepts.
Notes for the Teacher Option 2: Students should trace symptoms back to cellular causes and are encouraged to use a simple flowchart to show the cause-and-effect relationship during reporting.</td></tr>
<tr><td>VI. ASSESSMENT
(Assessing Learnings)</td><td colspan="2">PART 1: Multiple Choice:
1. Which of the following best describes a "cellular abnormality"?
A. A cell performing its regular metabolic functions in the body.
B. The movement of water across a semi permeable membrane.
C. A structural or functional change from the normal state of a cell.
D. The process of a cell dividing into two identical daughter cells.</td></tr>
</table>

	2. In Type 2 diabetes, what is the primary cellular problem? A. Loss of hemoglobin within the cells of the body. B. Rapid and uncontrolled division of cells in the body. C. Destruction of myelin surrounding nerve cells in the body. D. Insulin resistance that reduces the cell response to insulin. 3. When comparing a cancer cell to a normal cell, which structural feature is most characteristic of the cancer cell? A. A smaller nucleus with more cytoplasm in the cell. B. An irregular shape and a large variably shaped nucleus. C. Highly organized arrangements within the tissue layer. D. A rigid cell wall made of cellulose in the cell. 4. Normal cells undergo "apoptosis" (programmed cell death) when damaged. How do cancer cells differ in this function? A. Cancer cells undergo apoptosis more rapidly than normal cells. B. Cancer cells undergo apoptosis only after entering the bloodstream. C. There is no difference as both cell types die at the same rate. D. Cancer cells show reduced apoptosis leading to uncontrolled growth. 5. Which secondary source would be most reliable for explaining the link between genetic mutations and Sickle Cell Anemia? A. A peer reviewed journal article from a recognized genetics institute. B. A personal blog post discussing general healthy eating habits. C. A fictional movie describing medical discoveries and breakthroughs. D. An advertisement promoting a new brand of multivitamin supplements. 6. A short health article states that some body cells in type 2 diabetes do not respond well to insulin. Based on this source, which outcome best explains frequent urination? A. Glucose enters body cells too quickly during metabolism processes. B. Glucose builds up in blood drawing water into urine output. C. Cells stop producing ATP leading to total energy failure. D. Kidneys completely stop filtering blood during normal body function. 7. A patient with cancer often develops a "tumor." Which cellular behavior directly leads to this physical symptom? A. Failure of cell cycle checkpoints resulting in uncontrolled growth of cells. B. Cells shrinking due to lack of water within the surrounding environment. C. Cells transforming into fat cells to store excess energy in the body. D. The immune system attacking healthy tissue within the body by mistake. 8. Why do individuals with untreated diabetes often experience excessive urination? A. Glucose in the urine draws more water increasing total urine output. B. Cells in the bladder multiply quickly affecting normal urine storage. C. The body removes excess insulin through urine increasing fluid loss. D. The heart pumps less blood to kidneys reducing normal fluid balance. 9. Which of the following correctly matches the disease to its cellular cause? A. Cancer caused by excessive production of insulin in the body. B. Diabetes caused by mutation in the hemoglobin gene of cells. C. Genetic disorders caused by DNA mutations or chromosomal changes. D. Cancer caused by blockage of salt transport in lung cells.

	10. Using information from multiple secondary sources, a student concludes that cellular abnormalities cause physical symptoms in different ways. Which statement best integrates this idea across cancer, diabetes, and genetic disorders? A. All cellular abnormalities directly destroy cells and immediately cause organ failure. B. Symptoms arise when abnormal cells fail to perform their normal functions properly. C. Symptoms only develop when abnormalities occur in stem cells of the body. D. Cellular abnormalities always produce the same symptom such as fatigue only. *KEY: 1. C, 2. D, 3. B, 4. D, 5. A, 6. B, 7. A, 8. A, 9. C, 10. B* PART 2: Short Form Answers 1. Explain briefly how a cellular abnormality in diabetes leads to the physical symptom of frequent urination, based on what happens to the affected cell. Expected Answer: In diabetes, a cellular abnormality prevents cells from properly taking in glucose from the blood, either because the cells do not respond to insulin or because insulin is not available. As a result, glucose builds up in the bloodstream, and the excess glucose draws water into the urine, leading to frequent urination. Link for Extended Activities Compilation: https://tinyurl.com/2rema6yb
VII. REFLECTION *(Feedback and Continuous Improvement)*	*Use the following reflection prompts to guide your evaluation of the lesson after implementation. Reflect on learners' performance, determine which activities and lesson parts were most and least effective, identify learners who need enrichment or remediation, analyze the assessment results, and note possible improvements to enhance future lesson delivery.* ● *How many learners successfully demonstrated the learning objectives based on the assessment results?* ● *Which activity helped learners understand the lesson the most? Which activity helped the least?* ● *Which part of the lesson was easiest for learners? Which part was most difficult?* ● *How many learners needed enrichment or additional challenge? How many learners needed remediation or additional support?* ● *What did the assessment results show about learners' understanding of the lesson?* ● *What improvement would you make if you taught this lesson again?*
VIII. USE OF GENERATIVE AI	In preparing this Learning Exemplar (LE), the author(s) used Microsoft Copilot, OpenAI ChatGPT, Google Gemini, Claude AI, and DeepSeek in order to find references, correct grammar and spelling, critique content, develop activities and rubrics, look for sources, and find possible misinformation. The author(s) reviewed and finalized the writing of the content. The author(s) take(s) full responsibility for the content of this LE.

Lesson Title/Topic	Autotrophs, Chloroplasts, and Photosynthesis	Lesson Exemplar	12

I. OBJECTIVES	
A. Content Standard	The learners learn that all cells require energy, nutrients and removal of wastes.
B. Performance Standard	By the end of the Quarter, learners describe the processes of photosynthesis and cellular respiration and explain how these cellular mechanisms transform energy for life. They describe the role of cell structures in photosynthesis and differentiate the light-dependent and light-independent reactions. Learners describe the stages of cellular respiration, including glycolysis, the citric acid cycle, and the Electron Transport Chain, and explain their role in ATP production for cellular activities. They also participate in experiments to create models and presentations that demonstrate how these processes sustain ecosystem stability and support life functions.
C. Learning Competencies	***Prerequisite Knowledge and Skills*** **G6 Q2:** 5. describe the roles of producers, consumers, scavengers, and decomposers in a food web. **G7 Q2:** 4. differentiate plant and animal cells based on their organelles 9. describe the trophic levels of an organism as levels of energy in a food pyramid; and 10. use examples of food pyramids to describe the transfer of energy between organisms from one trophic level to another. **G8 Q1:** 9. describe the process of photosynthesis and respiration, and identify its raw materials needed and products; 10. using information from secondary sources identify the different parts of the cell where photosynthesis and respiration occur;
	The learners identify that photosynthesis takes place within the cells of autotrophs with the aid of chloroplasts.
II. REFERENCES and MATERIALS (*Selecting Resources and Material*)	● Alberts, Bruce, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, and Peter Walter. 2015. *Molecular Biology of the Cell*. 6th ed. New York: Garland Science. ● BD Editors. 2017a. "Autotroph Definition." Biology Dictionary. April 28, 2017. Accessed March 15, 2026. https://biologydictionary.net/autotroph/. ● BD Editors. 2017b. "Heterotroph Definition." Biology Dictionary. April 28, 2017. Accessed March 15, 2026. https://biologydictionary.net/heterotroph/. ● *Encyclopaedia Britannica Online*. 2023. "Photosynthesis." Accessed March 15, 2026. https://www.britannica.com/science/photosynthesis. ● *File:Plant Cell structure.png - Wikimedia Commons*. n.d. *Wikipedia Commons*. Accessed March 15, 2026. https://commons.wikimedia.org/wiki/File:Plant_cell_structure.png. ● *File:Celery Cells (400x).Jpg - Wikimedia Commons*. 2024. *Wikimedia Commons*. Accessed March 15, 2026. https://commons.wikimedia.org/wiki/File:Celery_Cells_%28400x%29.jpg. ● LadyofHats. 2006. *Plant Cell Structure*. Wikimedia Commons. Digital image file. Accessed March 15, 2026. https://commons.wikimedia.org/wiki/File:Plant_cell_structure.png. ● OpenStax. 2016. *Biology*. Houston: OpenStax College, Rice University. Accessed March 15, 2026. https://openstax.org/books/biology/pages/1-introduction. ● Raven, Peter H., George B. Johnson, Kenneth A. Mason, Jonathan B. Losos, and Susan R. Singer. 2017. *Biology*. 11th ed. New York: McGraw-Hill Education. ● Ryan, Berkshire. 2011. *Celery Cells (400x)*. Wikimedia Commons. Digital image file. https://commons.wikimedia.org/wiki/File:Celery_Cells_%28400x%29.jpg.

<table>
<tr><td>III. CONTENT
(Sequencing Content)</td><td colspan="2">Autotrophs, chloroplasts, and photosynthesis</td></tr>
<tr><td>IV. OBJECTIVES
(Setting Clear Objectives and Analyzing the Tasks)</td><td colspan="2">This section outlines the unpacked learning competencies.
1. Identify autotrophs as organisms that produce their own food.
2. Locate chloroplasts in a plant cell diagram.
3. Explain that chloroplasts are the organelles where photosynthesis occurs in plant cells.</td></tr>
<tr><td colspan="2">V. PROCEDURES</td><td>ANNOTATIONS</td></tr>
<tr><td rowspan="2">A. Activating Prior Knowledge</td><td colspan="2">A.1. Activating Prior Knowledge</td></tr>
<tr><td>Option 1: Producers or Consumers.
This activity reviews students' understanding of producers and consumers through a group sorting task. Learners classify given organisms into two categories and discuss how each obtains food, including how producers make their own.
Process Questions:
1. If consumers need to eat other organisms to get food, where do you think those other organisms get their food from?
2. If producers do not eat other organisms, where do you think they get their food from?
3. If this organism produces its own food, what specific part of its body do you think does that job?
Link for Sample Activity with Procedures:
https://tinyurl.com/BIOQ2LE1A1O1
Option 2: 4 Panel and 1 Big Question?
Activity Instructions:
This activity activates prior knowledge by having students answer a worksheet with four panels and a bonus question, using only what they already know.
Panel Questions:
1. Panel A: Name at least two living things that make their own food and describe how you think they do it.
2. Panel B: Explain or draw how a plant gets food differently from how an animal like a lion gets food.
3. Panel C: Draw a simple plant cell from memory. Label any parts you know. Draw a circle or arrow pointing to where you think food is made inside it.
4. Panel D: Write anything you already know about the word "chloroplast." If you have never heard it, write your best guess of what it might mean or do.
5. My Big Question: After answering all four panels, write one question you want the lesson to answer.</td><td>These activities holistically address Learning Objectives 1–3 by embedding responsive, relevant, and reflective principles within a constructivist, inquiry-based framework. Through varied strategies such as pre-assessment, sorting tasks, KWL charting, prior knowledge activation, guided discussion, and student-generated questioning, learners are scaffolded toward self-directed engagement. These activities collectively foster collaboration, inquiry, and reflection, ensuring readiness for deeper performance tasks while aligning classroom practice with the intended objectives.
Notes for Teacher Option 1: Prepare cards or slides of familiar organisms (e.g., carabao, mango tree, eagle, rice plant, mushroom, milkfish, coconut palm, wild boar). Organize students into small groups to sort these into "producers" and "consumers," then have them answer guide questions and share insights in a teacher-led discussion.
Notes for Teacher Option 2: Provide worksheet or project it on the board. If done via slides, present the panel questions individually to maximize engagement and class duration. After a brief sharing session, collect the papers to identify any student misconceptions to be corrected in future lessons.
Notes for Teacher Option 3: Complete only the K and W columns to identify student interests and misconceptions, which will help guide instructional pacing. Reserve the L column for the exit activity (A2 & C3) to serve as a formative assessment.</td></tr>
</table>

Link for Sample Activity with Procedures:
https://tinyurl.com/BIOQ2LE1A1O2

Option 3: KWL Chart
Activity Instruction: Fill in the columns KNOW and WANT TO KNOW only. What I LEARNED will be answered at the end of the lesson.
Topic: How and where do living things, especially producers, make their own food?

What I already KNOW (K)	What I WANT to know (W)	What I LEARNED (L)

A.2. Establishing the Purpose of the Lesson

Option 1: Food Chain Starter
Activity Instructions:
- Analyze the food chain and describe the energy movement, (ex: Sun → Grass → Cow → Human).
- Guide questions:
  - Which organism starts the food chain?
  - Why do many food chains begin with plants?
  - If animals depend on plants for food, how do plants obtain or produce their food?

Transition: "Since producers, like plants, are the primary energy source, we will now examine how they manufacture their own food. This lesson explores autotrophs, chloroplast, and the simplified process of photosynthesis.

Option 2: The BIG Questions – Concept Mapping
Activity Instructions:
- Read the question carefully and think quietly for 30 seconds.

"*How do certain living things produce their own food and what exactly are inside their cells makes this possible?*"
- In your notebook, write your best answer right now in two to three sentences.
- When called, share your answer to the class.

Transition: "You've already provided some great insights into how organisms produce their own food and the internal structures that make it possible. To track your progress, we'll revisit these same questions at the end of the lesson so you can compare your new insights with your initial thoughts about autotrophs, the role of chloroplasts, and the simplified process of photosynthesis within plant cells."

Option 3: KWL Bridge (continuation)
Activity Instructions:

These activities comprehensively address Learning Objectives 1–3 by embedding responsive, relevant, and reflective principles within a constructivist, inquiry-based framework. Through strategies such as visual analysis, guided and open-ended questioning, think-write-share, concept highlighting, KWL charting, and student question sharing, learners are scaffolded toward deeper understanding. These approaches foster collaboration, reflection, and alignment with objectives, ensuring formative assessment and smooth transitions that support readiness for more complex tasks.

Notes for Teacher Option 1: Present a sample food chain and have students analyze how energy flows, focusing specifically on the role of the first organism, the producer. Use the provided guide questions to prompt discussion on why food chains begin with plants and how they produce energy.

Notes for Teacher Option 2: Post the question on the board and have students record a brief response in their notebooks. Call on learners to share their thoughts, highlighting specific words or ideas directly related to the lesson to bridge their prior knowledge with the upcoming content.

Notes for Teacher Option 3: Students revisit their KWL charts, share selected "W" questions, and the teacher maps and highlights those aligned with the lesson to establish the lesson

	● Look at the W column of your KWL chart. ● Share one question you wrote with the class. ● Listen as your teacher writes these questions on the board. **Transition**: " Your insightful questions about producers show you are ready to explore how these organisms manufacture food. Accordingly, our next lesson will focus on autotrophs, chloroplast structure, and the process of photosynthesis within plant cells.	
B. Instituting New Knowledge	***B.1. Presenting Examples***	
	Option 1: Autotrophs and Heterotrophs This activity guides students in observing and comparing plant and animal structures from whole organisms down to the cellular level, with a focus on identifying how they obtain food. Learners answer guided questions at each level and analyze differences between plant and animal cells, particularly the role of chloroplasts. ● Wrap-up Questions In your own words, what is an autotroph? Give one example from today's activity. ● Complete the sentence. Chloroplasts are organelles found in _____ cells. They are where _____ takes place, which allows the plant to _____. Link for Sample Activity with Procedures: https://tinyurl.com/BIOQ2LE1B1O1 **Option 2: Plant and Animal Cell** This activity engages students in comparing plant and animal cell structures through careful observation of diagrams, focusing on identifying similarities and differences and linking structure to function. Guide Questions: 1. What similarities do you observe between the plant cell and animal cell? 2. What structures are present in the plant cell but not in the animal cell? 3. Why do you think these structures are only found in plant cells? 4. Could these structures be related to how plants produce their own food? Link for Sample Activity with Procedures: https://tinyurl.com/BIOQ2LE1B1O2	These activities address Learning Objectives 1–3 by embedding responsive, relevant, and reflective principles within a constructivist, inquiry-based framework. Using strategies such as visual progression, comparative visual analysis, guided questioning and observation, and transitions to direct instruction, learners are scaffolded toward deeper conceptual understanding. These approaches foster inquiry, reflection, and alignment with objectives, ensuring that formative engagement supports readiness for more complex tasks. **Notes for Teacher Option 1:** In this lesson, we focus on plant and algal autotrophs, whose chloroplasts carry out photosynthesis. Clarify that Cyanobacteria can carry out photosynthesis without chloroplasts because they are prokaryotic cells and lack the membrane-bound organelles. Instead, they contain thylakoid membranes located in the cytoplasm, where photosynthesis takes place. **Notes for Teacher Option 2:** Present plant and animal cell images (https://commons.wikimedia.org/wiki/File:Plant_cell_structure.png and https://commons.wikimedia.org/wiki/File:0312_Animal_Cell_and_Components.jpg), guide students in comparing structures, and highlight chloroplasts in plant cells to support understanding of autotrophs, heterotrophs, and photosynthesis.

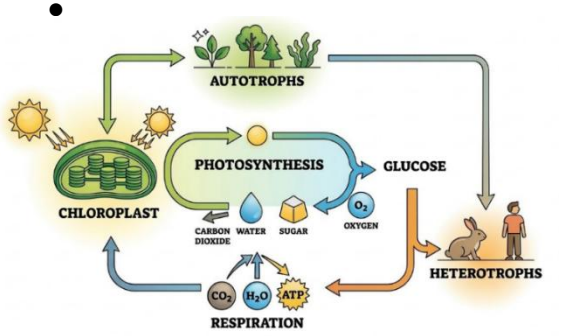
	B.2. Discussing New Concept	
	Option 1: Explicit Teaching This activity introduces and develops understanding of autotrophs, heterotrophs, chloroplasts, and photosynthesis through a structured learning process consisting of teacher modeling, guided practice, and independent work. **I DO – Teacher Led Discussion:** This activity presents the teacher's explanation of autotrophs, heterotrophs, chloroplasts, and photosynthesis, including definitions, examples, and location and how chloroplasts enable plants to produce their own food. **WE DO – Remembering Details:** This activity involves students working together to match key science terms with their correct descriptions to reinforce understanding of the lesson concepts. **YOU DO – Checking your understanding:** This activity requires students to independently summarize the entire lesson in one paragraph using their own understanding. Link for Sample Activity with Procedures: https://tinyurl.com/BIOQ2LE1B2O1 **Option 2: Let's Read** **Activity Instructions:** ● Access this online resource: https://openstax.org/books/biology/pages/8-1-overview-of-photosynthesis ● Alternate Option: Read the teacher provided excerpt or handouts on autotrophs, heterotrophs, chloroplasts and photosynthesis. Then answer the guide question using the information from the ● Answer the given guide questions. 1. What are autotrophs? Give two examples of organism classified as Autotrophs. 2. What are heterotrophs? Give two examples of organism classified as Heterotrophs. 3. What is a Chloroplast? 4. Where can we find Chloroplasts? 5. What happens inside the Chloroplasts that is important for food production? 6. What is photosynthesis? 7. How does being an autotroph relate to food production?	These activities comprehensively address Learning Objectives 1–3 by embedding responsive, relevant, and reflective principles within a constructivist, integrative, and inquiry-based framework. Through strategies such as direct instruction (I Do, We Do, You Do), matching activities, one-sentence reflections, guided reading, independent research, and whole-class sharing, learners are scaffolded toward deeper understanding. These approaches foster integration of knowledge, reflection, and collaboration, ensuring alignment with objectives and readiness for more complex performance tasks. **Notes for Teacher Option 1:** In WE DO, Teacher may prepare a matching type as formative assessment for the I DO part. It is also encouraged to ask the learners the reason for their matching. **Notes for Teacher Option 2:** Teacher may provide printed excerpts from the online resource for accessibility.

	B.3. Developing Mastery	
	Option 1: What am I? **Activity Instructions:** ● Read each statement carefully and answer the following based on your understanding. Statements: 1. I am an organism that produces my own food using sunlight. I have chloroplasts in my cells. Who am I? 2. I am an organism that must eat other organisms to survive. I do not have chloroplasts. Who am I? 3. I am the organelle inside autotroph cells where photosynthesis happens. I contain chlorophyll. Who am I? 4. I am a carabao. Am I an autotroph or a heterotroph? Explain. 5. I am a mango tree. Am I an autotroph or a heterotroph? Why? **Option 2: Short Response** **Activity Instruction:** ● Read each statement carefully and answer the following based on your understanding. **Questions:** 1. An organism has chloroplasts in its cells. Is this organism an autotroph or a heterotroph? Explain your answer and describe how it gets its food. 2. Compare a carabao and a mango tree. Which one is a heterotroph, and which one is an autotroph? Explain the difference in how they obtain energy. 3. Describe the role of the chloroplast in a plant cell. Why would an animal cell, like those in a carabao, not need this organelle? 4. A scientist discovers a new microscopic organism. It does not have any chloroplasts. Based on this information only, what can you conclude about how this organism survives? Explain your reasoning. **Option 3: Fill in the blanks.** **Activity Instruction:** Complete the paragraph by filling in each blank with the correct word based on your understanding of how organisms obtain food. "All organisms can be classified by how they get food. _____ are organisms that produce their own food. They have special organelles called _____ inside their cells. Inside these organelles, a process called _____ happens.	These activities comprehensively address Learning Objectives 1–3 by embedding responsive, relevant, and reflective principles within a constructivist, integrative, and inquiry-based framework. Through strategies such as identification activities, formative assessments, short essay responses, analytical questioning, scaffolded tasks, and fill-in-the-blank exercises on autotrophs, chloroplasts, photosynthesis, and heterotrophs, learners are guided toward deeper conceptual understanding. These approaches foster reflection, integration of knowledge, and inquiry, ensuring alignment with objectives and readiness for more advanced performance tasks. **Notes for Teacher Option 1:** Teacher may choose to prepare worksheet or project the following statements on the board. **Notes for Teacher Option 2:** Questions are arranged that progresses from basic recall to application and inference, encouraging students to complete them in order to scaffold their understanding. **Notes for Teacher Option 3:** Teacher may opt use a fill-in-the-blank paragraph (with optional word bank or letter clues for support) to reinforce key concepts on autotrophs, chloroplasts, photosynthesis, and heterotrophs as a formative assessment of understanding.

	This process uses sunlight, water, and carbon dioxide to produce _____ and _____. Organisms that cannot make their own food are called _____. They must eat other organisms to survive."	
C. Demonstrating Knowledge and Skills	***C.1. Finding Practical Application***	
	Option 1: Domino Effect **Activity Instructions:** ● Discuss the scenario with a small group. ● Scenario: Predict the domino effect on the global food web if autotrophs vanished from the ecosystem. ● Process Questions ▪ What would happen to animals if plants disappeared? ▪ Why are plants important for the survival of other organisms? ▪ How does photosynthesis in plant cells support life on Earth? ● Share your group's explanation with the class. **Option 2: Photosynthesis in the Locality** This activity engages students in observing real-life environments within their municipality to identify autotrophs and heterotrophs and evaluate where photosynthesis is likely occurring based on environmental conditions and organism presence. Task to be accomplished: List three local places, identify autotrophs and heterotrophs found in each area, determine whether photosynthesis is occurring with supporting evidence, and explain how autotrophs and photosynthesis support food chains and ecosystem survival. Link for Sample Activity with Procedures: https://tinyurl.com/BIOQ2LE1C1O002 Guide Question: 1. What is an autotroph? Give two examples of autotrophs you would find in your community. 2. What conditions must be present in a location for photosynthesis to occur? Explain each condition briefly. 3. A classmate says, "Photosynthesis happens in the park." Is this statement completely accurate? How would you improve it to make it more scientifically precise? 4. Explain how autotrophs and chloroplast-based photosynthesis support food chains and ecosystem survival.	These activities target Learning Objectives 1–3 by embedding responsive, relevant, and reflective principles within a collaborative, inquiry-based, and constructivist framework. Through scenario-based discussions, guided questioning, group sharing, place-based learning, classification, and group presentations, learners are scaffolded toward deeper conceptual understanding. These approaches foster collaboration, inquiry, and reflection, ensuring alignment with objectives and readiness for more complex performance tasks. **Notes for Teacher Option 1:** Have students work in groups to predict the consequences if autotrophs disappeared, guiding them to connect their ideas to photosynthesis and chloroplast function, then synthesize responses through whole-class sharing. **Notes for Teacher Option 2:** Encourage students to choose locations they are personally familiar with to maximize relevance and accuracy of observations. Guide students to use specific evidence (presence of green plants, sunlight exposure, organisms present) when justifying whether photosynthesis occurs in their chosen locations rather than simply answering yes or no. For locations where photosynthesis does not occur (e.g., indoors, underground), prompt students to explain the absence of the necessary conditions rather than just the absence of plants.

	C.2. Making Generalization	
	Option 1: Concept Map **Activity Instructions:** ● **Use the following key terms to create a concept map:** o Autotrophs, Heterotrophs, Chloroplasts, Photosynthesis, Sunlight, Food (Sugar), Oxygen, Cells ● The concept map must show how the terms are connected. o Draw box for each item. o Use arrow to show connections. o Write a short explanation between each connection. **Option 1a: GenAi Concept Map** **Activity Instructions:** ● List everything you learned about autotrophs, heterotrophs, chloroplasts, and photosynthesis. Use a generative AI tool to convert these notes into a concept map. Submit both your original notes and the generated map. Be prepared to share your work for teacher feedback. **Option 2: The three sentence summary.** **Activity Instructions:** ● Write a three-sentence summary of the lesson that was discussed. ● Sentence 1 must define Autotrophs and Heterotrophs ● Sentence 2 must identify the specific organelle involved and its function. ● Sentence 3 must summarize in simple terms the process involved in the cell of autotrophs	These activities target Learning Objectives 1–3 by embedding responsive, relevant, and reflective principles within a constructivist, integrative, and inquiry-based framework. Through concept mapping, visual organization, class sharing, GenAI-assisted mapping with critical evaluation, note-based prompting, and reflective closure via timed structured summaries and sentence-frame scaffolding, learners are guided toward deeper conceptual understanding. These approaches foster integration, reflection, and inquiry, ensuring alignment with objectives and readiness for more advanced performance tasks. **Notes for Teacher Option 1:** Provide key terms for students to create a concept map with labeled connections, then facilitate sharing and discussion to clarify understanding and address misconceptions. **Notes for Teacher Option 1a:** Use this option only if the learner has shown enough proficiency to check against some misconceptions. Students must first write their own notes on key concepts, then use a generative AI tool to convert them into a concept map. Require submission of both original notes and Ai-enhanced outputs and provide immediate feedback to address possible misconceptions introduced. **Notes for Teacher Option 3:** Use students' written summaries as a quick formative assessment before concluding the lesson.
	C.3. Evaluating Learning	
	Option 1: Revisiting KWL Chart – What I Know now! **Activity Instructions:** ● Take-out your KWL Chart from earlier and reflect from what you have written there. ● Complete the What I LEARNED COLUMN ● Listen and participate during class discussion. ● Additional Question for further clarification: o "What idea about autotrophs or chloroplasts became clearer to you today."	These activities target Learning Objectives 1–3 by embedding responsive, relevant, and reflective principles within a constructivist, integrative, and reflective framework. Through KWL chart completion, reflective writing, class sharing, multi-format formative assessments that progress from recall to application, and end-of-lesson reflective writing as an exit activity, learners are scaffolded toward deeper understanding. These approaches foster reflection, integration, and alignment with

	Option 2: Post-Instruction Formative Check This activity assesses students' understanding of autotrophs, heterotrophs, chloroplasts, and photosynthesis through a structured post-instruction formative assessment consisting of true or false items, matching type questions, and a short answer explanation. **Task 1: True or False** Students determine whether each statement about plants, animals, chloroplasts, and photosynthesis is true or false to check their conceptual understanding. **Task 2: Matching Type** Students match key terms (autotroph, heterotroph, chloroplast, photosynthesis) with their correct definitions to reinforce correct scientific meanings. **Task 3: Short Form Answer** 1. How do certain living things produce their own food and what exactly is inside their cells that makes this possible? Link for Sample Activity with Procedures: https://tinyurl.com/BIOQ2LE1C3O2 **Option 3: End of Lesson Reflection** In 3–4 sentences, explain why chloroplasts are important to plant cells and how autotrophs help support other organisms in an ecosystem.	objectives, ensuring readiness for more advanced performance tasks. **Notes for Teacher Option 2:** Have students complete the KWL chart, use guiding questions for deeper reflection, and compare K and L responses during discussion to track learning progress and address misconceptions. **Notes for Teacher Option 3:** Sequence tasks from True or False, Matching, to Short Answer to assess understanding levels, address misconceptions about mushrooms and chloroplasts, and use short answers to evaluate mastery before moving to the next topic.
	C.4. Additional Activities	
	Option 1: Remediation This activity provides remediation support by reinforcing key concepts about autotrophs, heterotrophs, chloroplasts, and photosynthesis through guided recall, identification, and completion tasks. **Part 1: Autotrophs and Heterotrophs** **Task to be accomplished:** Classify each organism as an autotroph (A) or heterotroph (H) and provide a reason for each classification based on how it obtains food. **Part 2: Locate the Chloroplasts** **Task to be accomplished:** Draw and label a plant cell showing the nucleus, chloroplasts, and cell wall, then complete a sentence describing the location, color, shape, and position of chloroplasts in the cell. **Part 3: What happens inside a Chloroplasts?** **Task to be accomplished:** Fill in the blanks to complete statements about photosynthesis, including its name, raw materials, products, and where it occurs in plant and algal cells.	These activities target Learning Objectives 1–3 by embedding responsive, relevant, and reflective principles within a constructivist, integrative, and inquiry-based framework. Through scaffolded remediation, guided practice, and structured multi-part activities, alongside image-based analysis, paragraph synthesis, conceptual integration, and hands-on experiments with observation and comparative analysis, learners are guided toward deeper conceptual mastery. These approaches foster collaboration, inquiry, reflection, and integration, ensuring alignment with objectives and readiness for more advanced performance tasks. **Notes for Teacher Option 1:** Each part directly addresses one learning objective, allowing the teacher to pinpoint which specific concept a student is struggling with. **Notes for Teacher Option 2:** Guide students to connect autotrophs, chloroplasts, photosynthesis,

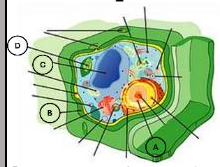
	Link for Sample Activity with Procedures: https://tinyurl.com/BIOQ2LE1C4O01 **Option 2: Reinforcement** **The Relationship** **Activity Instructions:** ● Study the image provided and answer. ● Explain how the terms autotrophs, heterotrophs, chloroplasts and photosynthesis are connected in one short paragraph. ●  **Option 3: Enrichment** **Growing Munggo Seeds Experiment** This activity engages students in an experimental investigation to observe how sunlight affects plant growth using munggo seeds, helping them connect real-life observations to photosynthesis and autotrophic nutrition. **Task to be accomplished:** **1. Set up and observe an experiment** by growing munggo seeds in two conditions—sunlight and shade/darkness—while keeping records of daily changes such as growth, leaf color, and plant health. **2. Compare and analyze results** after one week by identifying which seeds grew better and describing how sunlight affected plant development. **3. Answer guide questions** that explain the role of sunlight in plant growth and why plants need sunlight to produce their own food. Link for Sample Activity with Procedures: https://tinyurl.com/BIOQ2LE1C4O003	and food production to explain how heterotrophs depend on autotrophs. **Notes for Teacher Option 3**: students understand that seeds can initially grow in the dark using stored food, but long-term differences (e.g., leaf color and health) highlight the role of sunlight in photosynthesis within chloroplasts. Guide learners to connect observations to photoautotroph function.

VI. ASSESSMENT
(Assessing Learnings)

PART 1: MULTIPLE: CHOICE:

Read and understand each item carefully and write the letter of your answer on the space provided for.

1. Which of the following best describes an autotroph?
   A. An organism that produces its own food.
   B. An organism that decomposes dead matter.
   C. An organism that moves from place to place.
   D. An organism that eats other organisms for food.
2. Which of these organisms is an example of an autotroph?
   A. Carabao B. Chicken C. Mango tree D. Mushroom
3. Why are plants classified as autotrophs?
   A. Because they grow in soil using nutrients from earth.
   B. Because they need water to survive and stay alive.
   C. Because they can produce their own food using sunlight.
   D. Because they have roots stems and leaves for structure
4. Where in a plant cell are chloroplasts typically located?
   A. Inside the nucleus where genetic material is stored
   B. Suspended in the cytoplasm near the cell periphery
   C. Outside the cell wall surrounding the plant cell
   D. Inside the vacuole where water and waste are stored.
5. A student is looking at a plant cell under a microscope. Which feature would help them most directly identify a chloroplast?
   A. Its large size and round shape.
   B. Its connection to the cell wall.
   C. Its location inside the nucleus.
   D. Its green color and oval shape.
6. What is the primary function of the chloroplast?
   A. To perform photosynthesis and produce food for the cell
   B. To control all of the cell's activities and genetic processes
   C. To store water and nutrients inside the plant cell structure
   D. To provide strength and support within the plant structure



7. Which organelle in plant cells contains chlorophyll and carries out photosynthesis?
   A. Nucleus
   B. Cell Wall
   C. Vacuole
   D. Chloroplasts

[Image description: Diagram of a plant cell showing the cell wall, cell membrane, nucleus, vacuole, and several green oval chloroplasts distributed in the cytoplasm near the cell edge. The chloroplasts are highlighted as the organelles where photosynthesis occurs. Source: https://commons.wikimedia.org/wiki/File:Plant_cell_structure.png.

8. The process of photosynthesis happens inside which organelle?
   A. Chloroplast B. Nucleus C. Mitochondria D. Vacuole
9. Why do plant and algal cells have chloroplasts while typical animal cells do not?
   A. Animal cells once had chloroplasts but gradually lost them over time.
   B. Chloroplasts take up too much space for normal animal cell functions.
   C. Plant and algal cells use chloroplasts for photosynthesis to make food.
   D. Animal cells rely on ingestion of organic food rather than photosynthesis.
10. A new plant cell is observed. It is green and makes its own food. What can you most likely conclude?
   A. It is an autotroph and contains chloroplasts for photosynthesis.
   B. It is an autotroph but obtains food from surrounding organisms.
   C. It is a heterotroph but temporarily stores chlorophyll in vacuoles.
   D. It is a heterotroph and relies on external food despite being green.

KEY: 1.A, 2.C, 3.B, 4.B, 5.D ,6. A, 7.D, 8.A, 9.C, 10.A

	PART 2: SHORT FORM ANSWER 1. Explain why chloroplasts are important to autotrophs and how this affects other organisms in an ecosystem? **Expected Answer**: "Chloroplasts are important to autotrophs because they are the organelles where photosynthesis takes place, allowing autotrophs to produce their own food in the form of glucose. Since autotrophs are able to produce their own food through photosynthesis in their chloroplasts, they become the primary source of energy in an ecosystem, which means that other organisms such as animals depend on autotrophs for their nutrition and survival." Link for Word Document of Assessment: https://tinyurl.com/BIOQ2LE1-ASSESSWORD Link for Extended Activities Compilation: https://tinyurl.com/BIOQ2LE1-EA-COMPILE
VII. REFLECTION *(Feedback and Continuous Improvement)*	*Use the following reflection prompts to guide your evaluation of the lesson after implementation. Reflect on learners' performance, determine which activities and lesson parts were most and least effective, identify learners who need enrichment or remediation, analyze the assessment results, and note possible improvements to enhance future lesson delivery.* ● *How many learners successfully demonstrated the learning objectives based on the assessment results?* ● *Which activity helped learners understand the lesson the most? Which activity helped the least?* ● *Which part of the lesson was easiest for learners? Which part was most difficult?* ● *How many learners needed enrichment or additional challenge? How many learners needed remediation or additional support?* ● *What did the assessment results show about learners' understanding of the lesson?* ● *What improvement would you make if you taught this lesson again?* *Lesson specific Reflection:* 1. *Which misconception appeared most often: "all producers are plants," "all autotrophs have chloroplasts," or "photosynthesis produces energy as a separate product"?* 2. *Which activity best helped learners locate chloroplasts correctly?*
VIII. USE OF GENERATIVE AI	In preparing this Learning Exemplar (LE), the author(s) used Microsoft Copilot, OpenAI ChatGPT, Google Gemini, Claude AI, and DeepSeek in order to find references, correct grammar and spelling, critique content, develop activities and rubrics, look for sources, image generation, and find possible misinformation. The author(s) reviewed and finalized the writing of the content. The author(s) take(s) full responsibility for the content of this LE.

Lesson Title/Topic	Cell Requirements: Chlorophylls and Other Pigments	Lesson Exemplar	13

I. OBJECTIVES	
A. Content Standard	1. all cells require energy, nutrients and removal of wastes.
B. Performance Standard	By the end of the Quarter, learners describe the processes of photosynthesis and cellular respiration and explain how these cellular mechanisms transform energy for life. They describe the role of cell structures in photosynthesis and differentiate the light-dependent and light-independent reactions. Learners describe the stages of cellular respiration, including glycolysis, the citric acid cycle, and the Electron Transport Chain, and explain their role in ATP production for cellular activities. They also participate in experiments to create models and presentations that demonstrate how these processes sustain ecosystem stability and support life functions.
C. Learning Competencies	***Prerequisite Knowledge and Skills*** Learners demonstrate prior understanding of photosynthesis, chloroplasts, and plants as autotrophs that use sunlight to produce food. Learners also demonstrate understanding of basic light concepts, including visible light, color, wavelength, absorption, and reflection. Learners are able to observe patterns, interpret diagrams, compare concepts, and participate in scientific discussions and collaborative learning activities.
	2. describe the role of chlorophyll and other pigments in capturing light energy in plants required for the photosynthesis reaction to take place.
II. REFERENCES and MATERIALS (*Selecting Resources and Material*)	Agati, Giovanni, Lucia Guidi, Marco Landi, and Massimiliano Tattini. "Anthocyanins in Photoprotection: Knowing the Actors in Play to Solve This Complex Ecophysiological Issue." *New Phytologist* 232, no. 6 (2021): 2228–2235. https://doi.org/10.1111/nph.17648 Bianchi, Thomas S., and Elizabeth A. Canuel. "Photosynthetic Pigments: Chlorophylls, Carotenoids, and Phycobilins." In *Chemical Biomarkers in Aquatic Ecosystems*, 221–247. Oxford: Princeton Scholarship Online, 2011. https://academic.oup.com/princeton-scholarship-online/book/23119/chapter/183980540. Bozeman Science. *"Light Absorption, Reflection & Transmission."* AP Physics Essentials video overview. June 15, 2015. Accessed March 12, 2026. https://www.bozemanscience.com/ap-phys-118-light-switching-mediums. CognitoEdu. *"Chemical Analysis."* Cognito Education – GCSE Chemistry CIE Extended Triple, Topic 8.2: Paper Chromatography. May 5, 2019. Accessed March 12, 2026. https://puppeteer.cognitoedu.org/coursesubtopic/c2-gcse-cie-h-t_8.02. CognitoEdu. *"Waves."* Cognito Education – GCSE Physics AQA Higher Triple, Topic 6.11: Visible Light & Colour. October 14, 2025. Accessed March 12, 2026. https://cognitoedu.org/coursesubtopic/p2-gcse-aqa-h-t_4.13.

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III. CONTENT *(Sequencing Content)*	Cell Requirements: Chlorophylls and Other Pigments
IV. OBJECTIVES *(Setting Clear Objectives and Analyzing the Tasks)*	1. Describe the role of pigments such as chlorophyll found in the chloroplast. 2. Relate chlorophyll's efficiency in capturing light energy to the concept of light wavelengths. 3. Differentiate between chlorophyll a and chlorophyll b in terms of their roles and absorption spectra. 4. Enumerate other accessory pigments (carotenoids, anthocyanins, phycobilins) and describe their roles in the cells of the organisms containing them for adaptation.

IV. PROCEDURES		**ANNOTATIONS**
A. Activating Prior Knowledge	***A.1. Activating Prior Knowledge***	
	Critical Thinking (10 Minutes) ***Why are plants green?*** **Introduction of the Concept of Pigments** 1. Plants are green because of chlorophyll, a green pigment. 2. A pigment is a molecule that absorbs certain wavelengths of light and reflects or transmits others, giving an organism or structure its observed color. 3. Chlorophyll is green because it reflects green light and absorbs red and blue light. **Option A: Socratic Questioning (Guided Critical Dialogue)** The teacher facilitates a whole-class discussion using probing questions to surface prior knowledge and deepen reasoning. Learners respond orally, building on each other's ideas, while the teacher refines their responses toward the concepts of light absorption and reflection. **Option B: Think–Pair–Share (Concept Reasoning)** Learners individually think about the question "*Why are plants green?*" and write or mentally prepare their answer. Then, they: ● Pair with a classmate to compare explanations	**Questioning Tips** 1. Learners may say plants are green because of chlorophyll, the pigment in chloroplasts associated with photosynthesis. Follow up with: *"Why is chlorophyll green among all possible colors?"* 2. Revisit photosynthesis. Learners may explain that plants (autotrophs) make food using sunlight. Emphasize that: 3. The energy humans obtain from plants and animals ultimately comes from sunlight. 4. Autotrophs must absorb wavelengths that provide the most efficient energy transfer. 5. Introduce pigments by asking: *"Chlorophyll is a pigment—but what exactly is a pigment?"* **Physics Concept Integration** ● Energy is inversely proportional to wavelength *Illustrators: Show a photo of wavelengths, with the amount of energy they emit mapped.* ● Violet to Blue (400-470, shortest) gives off the

	● Refine their ideas based on discussion ● Share a consolidated answer with the class The teacher guides synthesis toward: ● chlorophyll as a pigment ● selective absorption of light ● green light being reflected **Option C: Visual Analysis (Light–Color Interpretation Task)** The teacher presents a diagram of the visible-light spectrum, showing wavelength vs. energy (violet to red). Learners analyze and answer: ● Which colors have higher energy? ● Which colors are most/least absorbed by chlorophyll? ● Why might a pigment reflect green light instead of absorbing it? Learners then connect the visual model to the idea that: ● perceived color = reflected light ● absorbed light = energy used in photosynthesis	strongest photon energy, while Red (640-680, longest) gives off the least. ● The "True Color" we perceive is reflected light, not the absorbed light. ● A surface appears dark under a given light when it absorbs most of that light instead of reflecting it to the observer. **Teacher Notes:** ● Address misconceptions about reflected light. Learners may think plants are green because they absorb green light, when in fact green light is reflected. ● Prompt learners to consider the adaptive advantage of this characteristic, especially for low-lying plants or in environments with excessive or limited light. Relate this to the previous discussion on autotrophs.
	A.2. Establishing the Purpose of the Lesson	
	Engaging Activity (15 minutes) ***"In this lesson, we will understand how pigments interact with light to produce the colors we see."*** ● *Chlorophyll looks green because it reflects green light. The other colors are absorbed."* **Option A: True Colors (Interactive Demonstration)** 1. Dim the lights and call a volunteer wearing a green shirt. 2. Say: *"Imagine you are chlorophyll. Let's see your true color."* 3. Shine a flashlight with different colored cellophane on the shirt, one at a time. 4. After each color, ask: *"Do we still see green, or does it look dark?"* 5. Repeat until the green light is used and the shirt appears clearly green. 6. Conclude: *"Chlorophyll looks green because it reflects green light. The other colors are absorbed."*	***Teacher Notes:*** *Ensure classroom visibility by dimming the lights enough so the color changes are clearly noticeable. Also, make sure the necessary materials are prepared beforehand. Lastly, ensure you clarify that objects appear green because they reflect green wavelengths and absorb others.* **Option A** is an energizer that reinforces key concepts through movement, music, and visuals, making learning more relatable. Sing the "True Colors" chorus while flashing different colored lights (using cellophane) on the learner after each round until the shirt appears green. *"I see your true colors, shining through* *I see your true colors… (Pause, then flash the light)* ● *If the shirt turns dark, the song is cut and sung again.* ● *If it makes it green, continue the song ("And*

	Option B: Pigment Detective (Predict–Observe) 1. Show a green cartolina and ask: *"What color do you see?"* 2. Hold up a colored cellophane and ask: *"What do you think will happen if we place this over it?"* 3. Let learners predict, then place the cellophane and observe. 4. Ask: *"Did it stay green or become darker? Why?"* 5. Try a few more colors, repeating the predict–observe pattern. 7. Conclude: *"We only see the color that is reflected. Chlorophyll looks green because it reflects green light. The other colors are absorbed."*	*that's why I love you so don't be afraid!)* **Option B** is a more direct alternative activity that still works well for all learners. It engages learners in prediction, observation, and reasoning, and can be completed in 15 minutes or less.
B. Instituting New Knowledge	***B.1. Presenting Examples***	
	In the said Activities, have the learners observe where the green object is darkest and where green coloration actually shines through. **Option A Question Construction:** ● *At what color of light did the object appear darkest?" (Red and Blue – absorbed)* ● *At what color did its green color appear most visible?" (Green – reflected)* ● *"Based on this, what does chlorophyll do?" (It reflects green light and absorbs red and blue light.)* **Option B Question Construction:** ● *"At what color of cellophane did the green cartolina appear darkest?" (Red and Blue – absorbed)* ● *"At what color was the green most visible?" (Green – reflected)* ● *"What does this tell us about chlorophyll?" (It reflects green light and absorbs red and blue light.)*	**Diagnostic Check:** Ask learners to classify the following statements as correct or incorrect, then justify each answer: (1) Plants are green because they absorb green light. (2) Shorter visible wavelengths carry more energy per photon. (3) A pigment's visible color is the light it reflects most strongly. **Note to Teachers:** If many learners miss Items 1 or 3, reteach reflected versus absorbed light using a simple object-and-light demonstration before proceeding.
	B.2. Discussing New Concept	
	Chlorophyll a and Chlorophyll b (15 minutes)." *"Did you know that we actually have two forms of Chlorophyll in plants? These are Chlorophyll a and b."* ***Wait…. There's more! (20 minutes)*** *"Aside from chlorophyll, plants also have pigments of other colors (Through a slideshow, introduce the following)"* A. Carotenoids (Yellow, Orange, and Red Pigments)	**Photosynthetic Pigments in Plants and Other Photosynthetic Organisms** **Chlorophyll a** ● Main pigment in photosynthesis ● Absorbs blue-violet and red light ● Directly converts light energy into chemical energy

	• **Beta-carotene** – found in carrots and sweet potatoes; also acts as an antioxidant • **Lutein** – found in spinach, kale, and corn; helps protect plant cells from excess light • **Zeaxanthin** – found in corn, kale, and paprika; supports light absorption and protection B. Anthocyanins (Red, Purple, Blue) • **Cyanidin** – found in berries, grapes, and red onions • **Delphinidin** – found in blueberries and eggplants • **Pelargonidin** – found in strawberries and raspberries C. Phycobilins • **Phycoerythrin (red)** – found in red algae and cyanobacteria • **Phycocyanin (blue)** – found in Spirulina and other cyanobacteria **Option A:** Guided Graphic Organizer followed by recitation. The teacher completes a pre-made graphic organizer template, then initiates classroom recitation to review the concepts (differentiating chlorophyll a and b, enumerating other pigments, describing their notable characteristics). This is more suited for classes that respond well to verbal interaction and discussion. This whole-class participation setup will work well without some learners dominating as long as learners can offer ideas, even brief ones. **Option B:** Direct Instruction followed by Graphic Organizer. The teacher presents a slide show of the pigments, then the class constructs the graphic organizer. Choose this option if you are working with a heterogeneous class where learners have varying ability levels or very limited schema. It works well with large classes and learners who need more scaffolding.	**Chlorophyll b** • Accessory pigment that helps widen light absorption • Absorbs blue and red-orange light • Transfers energy to chlorophyll a **Carotenoids (Yellow, Orange, Red pigments)** • Accessory pigments that absorb blue and green light • Help protect plants and support light absorption **Anthocyanins (Red, Purple, Blue pigments)** • Non-photosynthetic pigments that absorb UV and green light • Responsible for many red, purple, and blue plant colors • Help protect plants from light stress **Phycobilins** • Accessory pigments found in cyanobacteria and red algae • Absorb green, yellow, and orange light • Help organisms capture more light for photosynthesis ***Teacher Notes:*** • *Clarify that phycobilins are mainly found in cyanobacteria and red algae (not higher plants) as major accessory pigments.* • *Relate the discussion back to the earlier wavelength diagram.*

	B.3. Developing Mastery	
	Low-Stakes Activity (15 minutes) **Option A: Quiz Bee (Group Activity)** – Learners are grouped in a Group Quiz Bee Style to earn additional points on their upcoming quiz by answering a question from the discussion correctly as a group. The teacher assigns roles (speaker, recorder, thinker) to ensure participation. Roles are rotated to give all learners opportunities to contribute. The teacher provides immediate feedback after each item to reinforce correct concepts and address misconceptions. **Option B: Rapid-Fire Question –** Volunteering Learners (2 to 5 total, depending on preference) will be asked to stand at the back of the classroom, advancing a step each time the fastest learner recites and answers the question correctly. The fastest learner to reach the teacher's table is declared the winner and will be awarded with additional points on the upcoming quiz. The rest of the learners act as the audience, answering in their minds at their seats. Non-participating learners remain cognitively engaged by answering silently or noting responses. The teacher may conduct multiple rounds to increase participation. **Option C: Simple Individual Assessment**. The teacher administers the items like a typical quiz. The items will be checked with the class as a form of review. *https://docs.google.com/document/d/1oMTDkie3OyKMrqH4hgk9SZu8HybUCUV2/edit?usp=drive_link&ouid=109882373177720224395&rtpof=true&sd=true*	Low-stakes activities are formative assessments designed to support learning and participation without the pressure of graded performance. Emphasize that these activities are for learning and review, maintain a supportive and inclusive classroom environment, and ensure fair participation. **Differentiation Strategies for Diverse Learners** • **Struggling learners:** Provide cue cards, key terms, and simplified prompts; allow additional thinking time and peer support when appropriate. • **Advanced learners:** Offer extension tasks (e.g., deeper explanation of wavelength-specific absorption and energy transfer); assign higher-order roles such as facilitator or concept explainer. • **Shy or anxious learners:** Allow written pre-response before sharing; provide non-verbal roles (e.g., recorder, note-taker) or structured group consensus reporting. • **Collaboration vs. independence:** Option B supports collaborative learning, while Option C supports independent work; learners may be guided toward the most suitable format.
C. Demonstrating Knowledge and Skills	***C.1. Finding Practical Application***	
	Critical Thinking (15 minutes) *"As you observe in everyday life, not all plants or plant parts are green. Some leaves turn red, orange, or purple, and many fruits and flowers display bright colors. This raises a question about plant biology and pigment function."* **Critical Question:** "*If chlorophyll already ensures the most efficient absorption of light*	**Pigment Focus Guide** **Carotenoids** (Found in: Leaves, fruits, and autumn-colored plant parts) • Accessory pigments that broaden light absorption and protect plants from excess light damage (photoprotection), an antioxidant commonly associated with eye health (Lutein),

	energy, why do plants still have other pigments with different colors?" **Real-World Context Exploration** To connect the lesson to everyday experiences, the teacher presents familiar examples of pigments found in nature and daily products: ● Carrots (orange color → carotenoids) ● Colored fruits, flowers, and young leaves (anthocyanins) ● Red algae and cyanobacteria (phycobilins) ● Food or health products containing lutein or similar compounds (e.g., vision supplements) Learners are guided to connect **where these pigments are found** with their **functions in plants and their relevance in human use**. **Activity Options** **Option A: Class Recitation (Application Discussion)** The teacher calls on learners to explain the function of a pigment using real-world clues (e.g., carrot color, red leaves, algae). Responses must include both *location and function explanation.* **Option B: Group Quiz Bee (Application-Based Collaboration)** Learners work in groups to answer pigment-based application questions in a quiz bee format. Each answer must include: ● where the pigment is found ● its biological function ● one real-world connection or example	and are included in some foods and dietary supplements. **Anthocyanins** (Found in: Flowers, fruits, and young leaves) ● Responsible for red, purple, and blue coloration; also helps reduce light stress and provides photoprotection in plant tissues. They are flavonoid compounds known for their antioxidant and anti-inflammatory properties. **Phycobilins** (Found in: Red algae and cyanobacteria) ● Accessory pigments that absorb light wavelengths not captured by chlorophyll, enhancing photosynthetic efficiency, they are naturally fluorescent compounds used in scientific research (e.g., fluorescence-based laboratory techniques like ELISA) and are also utilized as natural colorants. **Teacher Notes:** ● Emphasize that answers must go beyond naming pigments and should include function and real-world connection. ● Encourage participation from all learners by rotating roles in group discussions. ● Be careful with overemphasizing potential uses, as it might misdirect the target objectives.

	C.2. Making Generalization	
	Summing Up (15 minutes) **Learners should provide answers to the following questions (Reflection Prompts):** 1. *Why are plants (and chlorophylls) green?* 2. *What is the difference between chlorophyll a and chlorophyll b?* 3. *If chlorophyll already ensures the most efficient light energy absorption, then why do plants still possess other pigments with different colors?* 4. *To sum it up, what are pigments?* **Option A: Exit Ticket *("What I have learned today").*** On a ¼-sheet of paper, have learners summarize what they have learned so far. Collect the papers, then raffle 3-5 entries (depending on remaining time availability) to read in front of the class. The teacher may address any misconceptions, incomplete ideas, or corrections extracted from the responses. If the objectives did not appear in the responses, the teacher may reemphasize them before closing the discussion. **Option B: Classroom Recitation.** Initiate classroom recitation by encouraging the learners to answer the said questions. **Option C: Think-pair-share.** Instead of asking the questions directly, give learners time to think about a question related to the discussion (5 minutes), then let them discuss it among themselves (5 minutes). Finally, let them share their findings in class (5 minutes, depending on remaining time).	This section ties up the entire lesson, each of which corresponds to the set objectives. It is especially strong because it ensures learners reflectively **construct the generalization themselves** rather than have the teacher simply state the summary—an approach strongly encouraged in learner-centered instruction. **Teacher Notes:** • When addressing misconceptions, incomplete ideas, or corrections to their answers, use the STAR Feedback method. • Watch out for potential misconceptions and correct them right away: ➢ Plants are not green because they absorb green light; they appear green because green wavelengths are more strongly reflected. ➢ Chlorophyll a is primary; chlorophyll b is accessory. ➢ Anthocyanins are important pigments, but they are not the same kind of core light-harvesting pigments as chlorophylls.
	C.3. Evaluating Learning	
	Option A: Written Assessment An individual paper-and-pencil test using multiple-choice and constructed-response items to assess understanding of light properties, chlorophyll function, and accessory pigments in photosynthesis and light absorption. **Option B: Performance-Based Assessment** *("Pigment Analysis Presentation and Light Interpretation Task"*) A group presentation where learners analyze a biological	**Teacher Notes** 1. **Option A:** Ensure items go beyond recall and assess understanding of relationships among wavelength, energy, and pigment function. 2. **Option B:** Emphasize justification over listing; prompt learners on absorbed vs reflected light, wavelength–energy links, and accessory pigment functions while ensuring visuals

	specimen or scenario and explain pigment–light interactions, including chlorophyll function, wavelength–energy relationships, differences between chlorophyll a and b, and the roles of accessory pigments in adaptation. **Option C: Individual Creative Performance Assessment** *("Bio-Design Challenge: A Light-Adapted Plant")* An individual task in which learners design a plant adapted to a specific light environment, explaining how pigment composition affects light absorption, photosynthetic efficiency, and survival through a visual output and a written justification.	support explanation. 3. **Option C:** Require individual work and scientific accuracy; ensure learners clearly connect light environment, wavelength, pigment composition, and survival advantage. Access the Evaluation Tools Here: **https://docs.google.com/document/d/1m8MEBDWrr7NFKP6Kdoac089VwCjAWuow/edit?usp=drive_link&ouid=109882373177720224395&rtpof=true&sd=true**
	C.4. Additional Activities	
	Day 3 **Extension Option:** Implement the following activities when time, materials, and learner readiness allow. These tasks may be used for enrichment, laboratory extension, or remote/alternative delivery as appropriate. **Option A:** In this activity, learners will use paper chromatography to separate and observe the different pigments present in green leaves. This allows them to visually identify chlorophyll a, chlorophyll b, and accessory pigments, such as carotenoids, by observing how they move through the paper with a solvent. **Option B:** Have a Good Dye! In this activity, learners will extract plant pigments from natural materials and use them as dyes to create simple artistic outputs, while identifying their biological sources and recognizing their roles in plant pigmentation and adaptation. **Option C: Remote / no-lab alternative:** Use teacher-prepared photos, video demonstrations, or ready-made chromatography strips. **Guide Questions** 1. What changes did you observe in the plant material after the pigments were separated or extracted? 2. Why do you think different pigments separated or appeared as different colors during the activity? 3. How does the presence of multiple pigments in one leaf help	**Option A** is well-suited if the teacher handles a class that aims for a career path where laboratory skills and experiences are integral (e.g., chemist, medical technologist) Meanwhile, **Option B** links the lesson to tangible experience by focusing on pigment extraction from plant sources. It is suitable for classes oriented toward practical, career-based applications (e.g., industry, arts, and design). Access the Laboratory Activities Here: https://docs.google.com/document/d/16e77w1mCpjMToVZwzIX3ckesrq002OJU/edit?usp=drive_link&ouid=109882373177720224395&rtpof=true&sd=true **Option C** is appropriate if no laboratory materials or equipment are ready for the class to use. **Teacher Notes:** 1. Make sure materials are ready before conducting the activity. 2. Ensure that the learners observe safety protocols and ethical guidelines throughout the activity (See: Link to the activities for the details)

	explain how plants capture light energy? 4. What does this activity reveal about chlorophyll not being the only pigment involved in photosynthesis?	3. Process what happened with the guide questions after the learners performed the chosen activity.
V. ASSESSMENT *(Assessing Learnings)*	**Multiple Choice.** Choose the Letter of the Best Answer. 1. Which of the following visible light colors has the shortest wavelength? A. Blue B. Green C. Red B. Yellow 2. A scientist is designing a lamp to provide the least energetic visible light for a plant experiment. Which color should the lamp emit? A. Blue B. Green C. Red D. Violet 3. Which of the following correctly describes the relationship between wavelength and photon energy? A. Longer wavelength → higher energy per photon C. Longer wavelength → stronger absorption B. Shorter wavelength → higher energy per photon D. Wavelength and energy are unrelated 4. A leaf is illuminated with pure red light in a dark room. How will the leaf most likely appear? A. Bright blue B. Bright green C. Dark or nearly black D. White 5. When a light hits a surface and the surface appears darker, this indicates that the light is: A. Absorbed B. Reflected C. Both Reflected and Absorbed D. Neither 6. Chlorophyll appears green because: A. It absorbs green light and reflects red and blue C. It reflects all colors equally B. It absorbs red and blue light and reflects green D. It absorbs green and blue light and reflects red light 7. Which of the following is true about chlorophyll a? A. It is the primary pigment for photosynthesis C. It reflects red and blue light B. It is an accessory pigment only D. It is stored in vacuoles 8. A plant mutant lacks chlorophyll b but still contains chlorophyll a. What is the most likely effect on photosynthesis? A. Photosynthesis stops completely C. The plant absorbs more green light B. The plant absorbs a narrower range of light wavelengths D. The plant produces more glucose than normal 9. Which statement correctly compares chlorophyll a and chlorophyll b? A. Chlorophyll a is accessory; chlorophyll b is primary B. Chlorophyll a converts light to chemical energy; chlorophyll b assists in light absorption C. Both are stored in vacuoles and reflect green light D. Both are found only in red algae 10. Chlorophyll a and b differ mainly in the wavelengths they absorb. Which of the following is correct? A. Chlorophyll a absorbs mainly green light; chlorophyll b absorbs blue light B. Chlorophyll a absorbs blue-violet and red; chlorophyll b absorbs blue and red-orange. C. Chlorophyll a and b both absorb green light efficiently D. Chlorophyll a absorbs UV; chlorophyll b absorbs infrared	

	11. Plants growing in areas with intense sunlight often rely on pigments that protect chloroplasts from excess light energy. Which pigment mainly performs this role? A. Anthocyanin B. Carotenoid C. Chlorophyll a and b D. Phycobilin 12. A flower develops bright purple petals that attract pollinators and also protect tissues from oxidative damage. Which pigment is primarily responsible? A. Chlorophyll a B. Carotenoid C. Anthocyanin D. Phycobilin 13. Which pigment is red or blue, found in phycobilisomes, and helps cyanobacteria and red algae absorb green and yellow light? A. Anthocyanin B. Carotenoid C. Chlorophyll a and b D. Phycobilin 14. A botanist observes that young leaves appear reddish before turning green as they mature. Which pigment most likely causes this coloration and protects the leaf from excessive sunlight? A. Anthocyanin B. Carotenoid C. Chlorophyll a and b D. Phycobilin 15. Carotenoids are found in chloroplasts and serve what purpose? A. Reflect green light for photosynthesis C. Produce glucose directly B. Accessory pigments that broaden light absorption and provide photoprotection D. Store water and minerals **Answer Key** 1. A 3. B 5. A 7. A 9. B 11. B 13. D 15. B 2. C 4. C 6. B 8. B 10. B 12. C 14. A
VI. REFLECTION *(Feedback and Continuous Improvement)*	● *How many learners successfully demonstrated the learning objectives based on the assessment results?* ● *Which activity helped learners understand the lesson the most? Which activity helped the least?* ● *Which part of the lesson was easiest for learners? Which part was most difficult?* ● *How many learners needed enrichment or additional challenge? How many learners needed remediation or additional support?* ● *What did the assessment results show about learners' understanding of the lesson?* ● *What improvement would you make if you taught this lesson again?*
VII. USE OF GENERATIVE AI	In preparing this Learning Exemplar (LE), the author(s) used ChatGPT and Grammarly to organize ideas and enhance the writing quality. The author(s) reviewed and finalized the writing of the content. The author takes full responsibility for the content of this LE.

Lesson Title/Topic	Photosynthesis: An Overview	Lesson Exemplar	14

I. OBJECTIVES	
A. Content Standard	The learners learn that photosynthesis is the chemical reaction that transforms light energy into chemical energy.
B. Performance Standard	The learners describe the processes of photosynthesis and cellular respiration and explain how these cellular mechanisms transform energy for life. They describe the role of cell structures in photosynthesis and differentiate the light-dependent and light-independent reactions. Learners describe the stages of cellular respiration, including glycolysis, the citric acid cycle, and the Electron Transport Chain, and explain their role in ATP production for cellular activities. They also participate in experiments to create models and presentations that demonstrate how these processes sustain ecosystem stability and support life functions.
C. Learning Competencies	***Prerequisite Knowledge and Skills*** Learners demonstrate prior understanding of chlorophyll and other pigments as light-absorbing molecules involved in photosynthesis. Learners also demonstrate understanding of basic chemical reactions, including reactants, products, and balancing simple chemical equations, as well as the role of light as an energy source. Learners are able to interpret diagrams, follow laboratory procedures, observe patterns, and explain simple cause-and-effect relationships in biological processes. 3. explain the balanced chemical equation for the process of photosynthesis and the synthesis of glucose (organic compound) from carbon dioxide, water, and light;
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III. CONTENT *(Sequencing Content)*	Photosynthesis: An Overview	
IV. OBJECTIVES *(Setting Clear Objectives and Analyzing the Tasks)*	*This section outlines the unpacked learning competencies.* 1. Identify the reactants and products in the photosynthesis equation. 2. Write the balanced chemical equation for photosynthesis. 3. Determine how oxygen becomes a by-product of photosynthesis from the chemical equation. 4. Explain how glucose is derived as the main product of photosynthesis from the chemical equation.	
IV. PROCEDURES		**ANNOTATIONS**
A. Activating Prior Knowledge	***A.1. Activating Prior Knowledge***	
	Recalling Previous Topic (5 minutes) 1. What are pigments? Why are plants green? 2. Chlorophyll a and b 3. Other pigments (Carotenoids, Anthocyanin, Phycobilin) **Photosynthesis Revisited (5 minutes) (Expected Current Learner Level of Knowledge)** 1. Etymology: Photo means light, while synthesis means to put together. Together, it means “to put together with light.” 2. Photosynthesis is the process by which plants make their own food. 3. To create the food, plants need sunlight, water, and carbon dioxide. **Option 1: One Word at a Time – Team Edition.** The learners form their respective groups and play as a team in a game. In this game, a member is given a word that their group must figure out by taking turns saying words to form a thought. The words gradually build a sentence that describes the secret word. The thought serves as the clue for the group to guess the word correctly. Example: *Secret word: photosynthesis* *Member 1: Plants* *Member 2: use* *Member 3: sunlight*	This activity ensures continuity of the lessons, transitioning from the previous topic on chlorophyll to the conceptual understanding of Photosynthesis as an endergonic process. While the objectives have yet to be achieved, the options are designed to set the tone for the entire discussion. Each of these options has strengths and caveats that align with the teacher's personality, management style, and current situation. **Option 1** is a fast-paced, game-based activity that promotes active kinesthetic engagement and collaboration but requires clear instructions and flexible facilitation to manage time and flow effectively. **Option 2** is a direct diagnostic assessment that efficiently checks prior knowledge and misconceptions, though items should be paraphrased to avoid memorization bias. **Option** 3 is a teacher-led, inquiry-based approach that uses questioning to diagnose understanding and guide thinking, but it is best suited to time-limited, more structured sessions.

	Member 4: to *Member 5: make* *Member 1: food.* *The group guesses: Photosynthesis!* Each word guessed is equal to one point. If the group cannot answer, even if the thought is complete, they may pass to change a different word. Each group is given 3 minutes, and the points they accumulate will be added as a bonus point to their quiz in this lesson (positive reinforcement). **Option 2: Formative Assessment (Ubd-Aligned).** Beginning with the end in mind, the teacher conducts a formative assessment in the form of a multiple-choice question (See evaluation; just rearrange the item placement and options). This is to elicit learners' prior knowledge and misconceptions about pigments and photosynthesis. **Option 3: Socratic Method (Art of questioning).** The teacher starts the lesson with questions to stir the flow of the discussion. Sample questions: *"What have we learned previously?" "Tell me more about pigments. What is the difference between chlorophyll a and b?" "If photo means light and synthesis means to put together, then photosynthesis means to 'put together with light.' Then what is being put together in photosynthesis?" "So, in simplest terms, photosynthesis is…?" "And how do the plants do these? What materials do they need to 'make food' with light?*	***Teacher Notes:*** • Ensure that learners clearly understand the **connection between pigments and light absorption** (prerequisites) • Do not call the same learners to avoid a few learners dominating the class and social loathing/passivity. Encourage learners to speak their minds (give them time to think through their responses if they cannot answer impromptu) and ensure inclusivity. • Note any misconceptions and address them later in the lesson as it progresses. • Keep the activity within the allotted **5-minute time frame** to maintain pacing for the rest of the lesson. • Common misconceptions that might be encountered: ➢ **Plants get their food from the soil.** Students may believe that plants absorb food directly from the soil rather than **producing glucose through photosynthesis**. ➢ **Plants are green because they absorb green light**. This idea is supposed to be squashed in the previous lesson.
	A.2. Establishing the Purpose of the Lesson	
	Engagement Activity (5-10 minutes) *Cue: "Today is the day that we will officially focus on Photosynthesis."* ***Energizer by Photosynthesis Song by Peter Weatherall*** *https://www.youtube.com/watch?v=HKjSVbDM5Ds* As a multimodal activity, learners integrate scientific concepts through a repetitive, memorable song that anchors key ideas as the lesson progresses from simple to more complex. This scaffolding helps maintain engagement and reduces cognitive overload.	**Option 1** allows learners to internalize concepts at a personal level. It functions as a brain break and pairs well with a more active Option 1 in A.1, helping balance energy and refocus attention before the main lesson. **Option 2** is more active, combining song with visuals and movement to support visual, auditory, and kinesthetic learning. It works best when paired with a less energetic A.1 option, but

	Option A: Quiet Cool Down/Immersion. *The learners are exposed to the song for at least 2 repeats until they can internalize the lyrics and sing along without reading.* ***Option B: Sing and Dance.*** *Learners familiarize themselves with the lyrics and learn the movements (about 2 song repeats) until they can sing and dance with it.*	may require careful pacing to avoid learner fatigue. **Teacher Notes:** The lyrics are oversimplified to cater to a younger audience. Make sure to point out the details that need to be unfolded in B.1 so learners can easily assimilate added complexities appropriate for Grade 12 Learners.
B. Instituting New Knowledge	***B.1. Presenting Examples***	
	Cue: "Now that we've internalized a simple idea of photosynthesis through the song, let's deepen our understanding by looking at its more accurate scientific definition." **Photosynthesis: The More Accurate Definition (15 Minutes)** Photosynthesis is an **endergonic** biological process in which **plants, algae, and some bacteria** convert **light energy** from the sun into **chemical energy** in the form of **sugar.** **Introduce the general equation of Photosynthesis:** $6CO_2 + 6H_2O + \text{light} \rightarrow C_6H_{12}O_6 + 6O_2$ Expound its definition by explaining the following concepts: 1. Photosynthesis is an endergonic process; it means that the reaction requires an input of energy to occur. 2. Photosynthesis is done by plants, algae, and some bacteria. 3. Light energy is converted to chemical energy 4. Glucose ($C_6H_{12}O_6$) is the end product of photosynthesis. In the balanced photosynthesis equation, glucose is used as the representative carbohydrate product. More precisely, the Calvin cycle first produces G3P, which can later be used to form glucose and other carbohydrates. 5. Oxygen is a byproduct of photosynthesis. **Option A**: **Let's Make Food!** In this option, the teacher likens Photosynthesis to a cooking show, where: Ingredients (Cutouts): ● 6 CO_2 (cutouts of six C, each attached with two cutouts of O (a total of 12 O), which can be detached such that they can also become six pieces of C, 12 pieces of O)	This stage marks the formal acquisition of all learning objectives, following the scaffolding sequence and preparing learners for deeper analysis. It integrates Physics (thermodynamics) and Chemistry (reactions), maintaining continuity while refining learners' understanding of photosynthesis. **Option 1** uses visual modeling and familiar analogies to show molecular changes in photosynthesis, reinforcing conservation of matter but requiring careful guidance to avoid misconceptions. **Option 2** is an interactive approach that promotes engagement and active recall but requires strong facilitation to move learners beyond recall to conceptual understanding. **Option C** uses structured graphic organizers to illustrate photosynthesis as a process, supporting organized understanding but requiring guided questioning to prevent passivity. **Teacher Notes:** $6CO_2 + 6H_2O + \text{light} \rightarrow C_6H_{12}O_6 + 6O_2$ ● The 6 carbon atoms in glucose come from 6 CO_2. ● The hydrogen atoms come from water (H_2O). ● Light energy provides the energy needed to rearrange these atoms.

	• 6 H_2O (cutouts of six O, each attached with two cutouts of H (total of 12 H), which can also be detached, such that it can also become 12 pieces of H and 6 O • Sunlight (Cutout Stove) Cooking Instructions (10 minutes): 1. *"Bring to an Endergonic Process – which means, to start the process, open the stove"* – translate to: to start photosynthesis, light is absorbed by chlorophyll and other pigments in the thylakoid membranes of chloroplasts. Plants are not the only organisms that have pigments: cyanobacteria and algae do it, too! 2. *"Mix all the ingredients until well-combined"* – by this point, the teacher reconstructs CO2 and H2O to create C6H12O6 instead. Learners observe how atoms are reorganized rather than created or destroyed, illustrating conservation of matter. 3. *"Release the extra oxygen"* to indicate that some oxygen atoms combine to form O_2, which is released as a byproduct. 4. *"Serve well and enjoy,"* which means the resulting product is ready and is called glucose. To be exact, the teacher may briefly introduce G3P (Glyceraldehyde-3-Phosphate, also known as Phosphoglyceraldehyde), the 3-carbon compound that serves as a precursor to Glucose (2 G3P combine to Form Glucose). After the "cooking show", the teacher calls for a volunteer to replicate what happened (5 minutes). **Option B: Say Something!** In this option, the teacher presents the information first (10 minutes), then gives learners 5 minutes to process it. After which, they will play a game where each learner should contribute a word (one word at a time) to finish the following concept: 1. Photosynthesis is _____. 2. Photosynthesis is _____. 3. Light _____. 4. Glucose _____. 5. Oxygen _____.	• During this process, oxygen (O_2) is released as a by-product (from water). • Prepare the materials beforehand **Misconception Corrections:** ➢ **Photosynthesis happens only in plants.** This is addressed in concept #2. ➢ **Sunlight is a material ingredient of photosynthesis.** Students may treat sunlight like a substance. Unlike water or carbon dioxide, it is the energy source that drives the reaction. ➢ **Oxygen produced during photosynthesis comes from carbon dioxide.** Most of the oxygen released comes from the splitting of water molecules through Photolysis, a topic that will be discussed in the next lesson. ➢ **Photosynthesis directly produces glucose as the immediate product.** G3P (PGAL) is the first stable product that can later form simple sugars, such as glucose, and complex polymers, such as cellulose (as mentioned previously in the song). G3P will be further elucidated in the next lessons. ➢ **Photosynthesis is simply "plants making oxygen."** Emphasize that oxygen is a byproduct of photosynthesis. ➢ **Atoms disappear or are formed during the reaction.** Teachers should emphasize during discussion that water and carbon dioxide molecules are rearranged to produce the products of photosynthesis. ➢ **Oxygen is a waste product for plants.** While they produce oxygen during photosynthesis, they also consume it during respiration. In low-oxygen conditions (e.g.,

	● If a learner can contribute a word accurately, he/she gets a plus point (for positive reinforcement). He/she may pass if he/she can't give. ● The awarding of points stops until the thought is completed (flashed in the PowerPoint Presentation). **Option C:** Direct Instruction followed by Graphic Organizer. The teacher presents the lesson and concept, then the class constructs a graphic organizer depicting the photosynthetic concepts (15 Minutes). ***Diagnostic Check**: Ask learners to identify the reactants and products in the expression $CO_2 + H_2O \rightarrow$ glucose + O_2, then count the number of carbon, hydrogen, and oxygen atoms on each side. Use their responses to identify who needs support on balancing and matter conservation before formal instruction.*	waterlogged soil), they switch to fermentation. ➢ **Plants do not release CO2.** Yes, plants release carbon dioxide during cellular respiration and consume oxygen, especially at night when photosynthesis stops. They take in O_2 and release CO_2. By day they are net oxygen producers; by night, net CO_2 producers. This will be discussed in the next lesson on the light-dependent and light-independent reactions of photosynthesis.
	B.2. Discussing New Concept	
	Sparking Curiosity: *"Do all plants photosynthesize at the same rate?"* *"Will photosynthesis occur uniformly across all plants regardless of light intensity, pigment concentration, or environmental conditions?"* **Demonstration of Laboratory Activity (20 minutes)** In this activity, the teacher brings abstract concepts to life by introducing learners to ways to observe photosynthesis in real time.https://docs.google.com/document/d/1SmC2RDHOjcmluXf5yxjmPs-yB-v8PX32/edit?usp=drive_link&ouid=109882373177720224395&rtpof=true&sd=true **Option 1 Observation of Hydrilla (or Elodea or Any Aquatic Plant Available) Photosynthesis** **Option 2: The Leaf Disk Assay** **Guide Questions to Realign with Objective:** 1. *"Why do bubbles form around the disk?"* 2. *"Why is baking soda needed in the assay?"* 3. *"If photosynthesis is a process to create sugar, where is the sugar in the observation?"*	**Teacher Notes:** ● Prepare the materials beforehand ● Set the classroom arrangement ● Observe Strict Adherence to Safety and Ethical Protocols **Answers to Guide Questions** 1. The bubbles are oxygen (O_2), a byproduct of photosynthesis. As the plant converts CO_2 and water into glucose using light energy, oxygen is released and becomes trapped in leaf tissues (or seen directly in Hydrilla), causing bubbles or flotation. 2. Baking soda provides carbon dioxide (CO_2), a reactant for photosynthesis. As photosynthesis occurs, oxygen is produced, and in leaf disk assays, this oxygen accumulates, causing the disks to float. 3. Glucose is produced inside chloroplasts during photosynthesis, but cannot be directly observed. Oxygen bubbles serve as indirect evidence that sugar production is occurring,

		since both are products of the same light-driven process.
	B.3. Developing Mastery	
	Laboratory Activity Test Run (30 minutes) The learners replicate what the laboratory activity the teacher demonstrated (**Option 1 or 2**). Teacher scaffolds depending on the learner's abilities and pacing. https://docs.google.com/document/d/1gGSHCX3t9eLS1Zs071YexRXAIF-fPz8M/edit?usp=drive_link&ouid=109882373177720224395&rtpof=true&sd=true	**Teacher Notes:** ● Prompt Learners to prepare materials beforehand (a day or two before the experiment) ● Emphasize Safety Precautions and Ethical Research Laboratory Procedure
C. Demonstrating Knowledge and Skills	***C.1. Finding Practical Application***	
	Laboratory Activity Level Up (30 minutes) The teacher increases the level of difficulty of the laboratory activity by adding procedures that allow learners to manipulate variables and observe different outcomes. **If they select Option 1 in B.2**, the learners will conduct a scientific investigation to observe oxygen production by Hydrilla (or Elodea or Water Hyacinth) under different light conditions. They will measure the rate of bubble formation using a beaker, water, and a light source to indicate photosynthesis activity. **If they select Option 2 in B.2**, the learners are tasked to perform the Leaf Disk Assay Themselves, but they will experiment by altering the following variables: 1. Setup 1: With Sunlight vs. Without Sunlight (light sources such as those from projectors and UV lights can also do the trick) 2. Setup 2: With Baking Soda vs. Pure Water	**Reflection Prompts/Guide Questions** 1. What differences did you observe in oxygen production or leaf disk movement under different conditions? 2. How did light availability affect the rate of photosynthesis in your setup? What evidence supports your answer? 3. Why did changing a single variable affect the outcome of the experiment? 4. How did baking soda influence the rate of photosynthesis in the leaf disk assay? 6. What can you conclude about the roles of light and carbon dioxide in photosynthesis based on your results?
	C.2. Making Generalization	
	Laboratory Activity Processing (30 minutes) **Option 1: Capture it, Remember it*!*** The learners select a documented photo they captured during the lab activity collaboration to best represent what they have learned from conducting the said activity. They will present the photo to the class and explain why it was selected (Their answers should point to the objective acquisition). Afterward, the teacher provides	All of the options offer a quick way to extract generalizations from learners' perspectives, minimizing downtime and maximizing engagement. **Option A** works well with learners to express their wits and creativity.

	feedback, determines whether the objectives were met, checks for misconceptions, and notes corrections using the STAR Feedback Method. **Option 2: Exit Ticket Raffle.** On a ¼ sheet of paper, learners write their insights on what they have learned so far today ("What I've Learned So Far"), serving as an exit ticket. The teacher then draws at least 5 entries to read aloud to the class. Afterward, the teacher provides feedback, determines whether the objectives were met, checks for misconceptions, and notes corrections using the STAR Feedback Method. **Option 3: Q&As in All Ways**. After the experiment, the teacher gathers the learners in a reflective setup and initiates classroom recitation. The teacher encourages participation by asking questions that cue objective attainment. Afterward, the teacher provides feedback, determines whether the objectives were met, checks for misconceptions, and notes corrections using the STAR Feedback Method.	**Option** works best with learners who have difficulty expressing their thoughts verbally and helps learners develop their writing skills. **Option 3** works well with learners who are good at speaking and helps them build confidence and communicate ideas fluently. **Teacher Notes:** In any of these options, teacher feedback is key to ensuring competencies are met, motivating learner engagement, and reducing the likelihood of misinformation in the lesson. **Readiness Check:** Ask learners to write the balanced chemical equation for photosynthesis, circle the reactants, underline the products, and write one sentence explaining why oxygen is considered a by-product.
	C.3. Evaluating Learning	
	Option 1: Laboratory Activity Report (Written Format). Learners collaboratively submit a written report using the provided template (due at the end of the week). Best for structured scientific writing, data interpretation, and guided formal reporting. **Option 2: Laboratory Activity Report (Video Format).** Learners collaboratively submit a video report (MP4, max 15 minutes, due at the end of the week) covering the required parts. Best for communication, collaboration, and engagement through multimedia presentation. **Option 3. Paper and Pencil Test.** Can be done along with either option 1 or 2. https://docs.google.com/document/d/1-04Q_Ak2fUPjydyakVQGI0vSuVr-yE32/edit?usp=drive_link&ouid=109882373177720224395&rtpof=true&sd=true	**Teacher Notes** 1. Laboratory report options extend learning by promoting reflection, real-world application, and development of scientific communication, research, and collaboration skills. Access the Learner Activity Sheet Here: https://docs.google.com/document/d/1gGSHCX3t9eLS1Zs071YexRXAIF-fPz8M/edit?usp=drive_link&ouid=109882373177720224395&rtpof=true&sd=true 2. **Option 3 (Paper-and-Pencil Test):** A Bloom's Taxonomy–based assessment of conceptual understanding that may be used independently or alongside either lab report option to strengthen objective coverage.
	C.4. Additional Activities	

	Learner Laboratory Enrichment Options *https://docs.google.com/document/d/1iKE6AFU83-b1vthzdH4wTDNpvCbT9WxO/edit?usp=sharing&ouid=109882373177720224395&rtpof=true&sd=true* **Option 1: Staining of Starch in Plant Leaves.** This is one of the simplest ways for learners to observe an actual product of photosynthesis: starch, a polymer of glucose. This completes the photosynthetic experience for the learner, emphasizing the process's end product. **Option 2: *The Stomata in the Nail Polish Method*. Option 2** allows the learners to witness stomata and guard cells: the openings responsible for gas exchange in plants and the specialized cells that control it. Stomata allow the intake of carbon dioxide (CO_2) and the release of oxygen (O_2) during photosynthesis, while guard cells regulate the opening and closing of these pores. Through this activity, learners observe differences in stomatal size and density across plants, and it can spark curiosity about plant adaptations related to photosynthesis.	**Teacher Notes:** • Inform the learners of the materials they need to bring for the activity beforehand. • Set up the laboratory room and equipment before starting the laboratory activity to maximize time. • Make Sure to emphasize Appropriate Laboratory Etiquette, compliance with ethical protocols, and safety procedures. **Option 1 Observation Guide**: If the leaf has undergone photosynthesis, the iodine solution will turn blue-black, indicating the presence of starch produced during photosynthesis. **Option 2 Observation Guide:** At 400x Magnification (field of view = 0.16 mm²), count the stomata, then calculate stomatal density per slide: Stomatal Density = Number of Stomata in the Field of View/Area of Field of View (mm²)
V. ASSESSMENT *(Assessing Learnings)*	**Multiple Choice.** Encircle the Letter of the Best Answer. 1. Which of the following is the **correct balanced chemical equation for photosynthesis**? **A. $6CO_2 + 6H_2O + light \rightarrow C_6H_{12}O_6 + 6O_2$** B. $6H_2O + 6CO_2 \rightarrow C_6H_{12}O_6 + 6O_2$ C. $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ D. $6CO_2 + 6H_2O \rightarrow 6O_2 + C_6H_{12}O_6$ 2. Photosynthesis is an endergonic process. What does this mean? A. It releases energy spontaneously C. It happens without light **B. It requires an input of energy to occur** D. Oxygen is produced without energy input 3. Which organisms are capable of performing photosynthesis? A. Plants Only **C. Plants, algae, and some bacteria** B. Plants and Algae D. All living organisms 4. In photosynthesis, light energy is converted into which type of energy? A. **Chemical** B. Kinetic C. Mechanical D. Thermal energy 5. Which statement best explains how CO_2 and H_2O contribute to glucose formation? A. CO_2 and H_2O form only energy C. **CO_2 provides C and O; H_2O provides H for $C_6H_{12}O_6$** B. CO_2 and H_2O are converted entirely into oxygen D. CO_2 provides oxygen only; H_2O provides carbon only	

	6. In photosynthesis, oxygen is released as a byproduct. Where does it come from? A. Carbon dioxide (CO_2) B. Glucose ($C_6H_{12}O_6$) C. Sunlight **D. Water (H_2O)** 7. In the leaf disk assay or Hydrilla observation, why do oxygen bubbles form? A. The air trapped in the leaves escapes B. Baking soda reacts to form gas during photosynthesis **C. Oxygen is produced as a byproduct of photosynthesis** D. Dish soap causes foaming, which contributes to start the process of photosynthesis. 8. What is the purpose of baking soda ($NaHCO_3$) in these experiments? A. Baking Soda directly produce oxygen B. Baking soda makes the solution frothy C. Baking Soda colors the water to make observation visible **D. Baking soda supplies carbon dioxide (CO_2) for photosynthesis** 9. Why can glucose not be directly seen in the leaf disk assay or Hydrilla observation? A. It is released as a gas as a byproduct of photosynthesis. B. It is only produced during photosynthesis when the leaves are mature enough C. **It remains inside the plant cells, and oxygen bubbles act as indirect evidence** D. It dissolves immediately in the solution during photosynthesis as soon as the plant is in the water. 10. Which statement best summarizes the relationship between light, glucose, and oxygen in photosynthesis? A. Light energy splits glucose to form oxygen, releasing chemical energy. B. Oxygen is converted into glucose using chemical energy from sunlight processed by water. C. Light energy is converted into chemical energy which is released by consuming Glucose and oxygen. D. **Light energy is converted into chemical energy stored in glucose, and oxygen is released as a byproduct** **Answer Key** 1. A 2. B 3. C 4. A 5. C 6. D 7. C 8. D 9. C 10. D
VI. REFLECTION *(Feedback and Continuous Improvement)*	• *How many learners successfully demonstrated the learning objectives based on the assessment results?* • *Which activity helped learners understand the lesson the most? Which activity helped the least?* • *Which part of the lesson was easiest for learners? Which part was most difficult?* • *How many learners needed enrichment or additional challenge? How many learners needed remediation or additional support?* • *What did the assessment results show about learners' understanding of the lesson?* • *What improvement would you make if you taught this lesson again?*
VII. USE OF GENERATIVE AI	In preparing this Learning Exemplar (LE), the author(s) used ChatGPT and Grammarly to organize ideas and enhance the writing quality. The author(s) reviewed and finalized the writing of the content. The author takes full responsibility for the content of this LE.

Lesson Title/Topic	Metabolism- Photosynthesis	Lesson Exemplar	15

I. OBJECTIVES	
A. Content Standard	The learners learn that photosynthesis is the chemical reaction that transforms light energy into chemical energy.
B. Performance Standard	The learners submit one annotated diagram of photosynthesis and a short explanation describing how light energy is converted into chemical energy and how the Calvin cycle contributes to carbohydrate formation.
C. Learning Competencies	***Prerequisite Knowledge and Skills*** The students have foundational or prior knowledge of the basic cell in biology as structure and function of plant cells and the role of chloroplasts in energy conversion; Molecules in Biology as understanding of ATP as the cell's energy currency, role of NADPH as an electron carrier and basic knowledge of glucose as a product of photosynthesis.
	The learners use a diagram to explain the key processes of photosynthesis, including the light-dependent reactions (ATP and NADPH generation) and the light-independent reactions (Calvin cycle and glucose synthesis);
II. REFERENCES and MATERIALS (*Selecting Resources and Material*)	**OpenStax. *Biology 2e*. Houston, TX: OpenStax, 2018.** https://s3.amazonaws.com/microsite-cuny-prod/media/courseware/openstax/m66473/Figure_08_01_06.jpg *Image of labeled chloroplast* *https://www.youtube.com/watch?v=Le7KOX91w7U The light-dependent reactions and the light-independent reactions).* Science Facts. "Light-Dependent Reaction." Accessed March 12, 2026. https://www.sciencefacts.net/light-dependent-reaction.html. OpenStax. *Concepts of Biology*. Houston, TX: OpenStax, 2013. Accessed April 23, 2026. https://openstax.org/books/concepts-biology/pages/1-introduction National Center for Biotechnology Information (NCBI). *Molecular Biology of the Cell.* By Bruce Alberts et al. New York: Garland Science, 2002. Accessed April 23, 2026. https://www.ncbi.nlm.nih.gov/books/NBK21054/ Encyclopedia Britannica. *"Chloroplast."* Accessed March 12, 2026. https://www.britannica.com/science/chloroplast Encyclopedia Britannica. *"Photosynthesis."* Accessed March 12, 2026. https://www.britannica.com/science/photosynthesis

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III. CONTENT *(Sequencing Content)*	Metabolism- Photosynthesis
IV. OBJECTIVES *(Setting Clear Objectives and Analyzing the Tasks)*	1. Draw a diagram showing the light- dependent reactions and how the Calvin cycle produces glucose in the light independent reactions. 2. Explain how ATP and NADPH are produced in the light-dependent reactions and how they are used in the Calvin cycle during the light-independent reactions. 3. Illustrate the complete photosynthesis pathway including ATP and NADPH formation and glucose synthesis.

IV. PROCEDURES		**ANNOTATIONS**
A. Activating Prior Knowledge	***A.1. Activating Prior Knowledge***	
	Option 1: "Light it Up Activity": *The learners will list everything they already know about how plants use sunlight through a quick sketching or drawing a diagram of a plant and have them label where they think sunlight energy goes.* *Guided questions:* ● *What do plants need in order to make their own food?* ● *What do you remember about two stages of photosynthesis?* ● *Where in the plant cell does photosynthesis occur* ***Option 2: "Matching Energy Path Activity":*** *The learners will sort the cue cards into "Made in Light Reactions" VS. "Used in Calvin Cycle." Learners will receive and sort cue cards with different terms relating to "Made in light reactions and terms used in Calvin Cycle.*	***Annotation:*** *The activity specifically targets Learning Objectives 1 and 2. The IDF guiding principles that are present in this activity is that learners are able to sketch or draw a diagram and construct meaning from what they've already known as they begin the activity with their prior knowledge and experience based on their everyday observation of plants and sunlight. It applies to active learning wherein students are directly involved in the learning process through activities like diagramming. As a note to the teacher, during the activity, walk around their classroom to monitor their student's understanding as they explain their diagrams or summarize what they have drawn so far.*

	Option 3: Mapping the Photosynthesis Process Activity: Ask learners to draw a simple diagram showing where the light-dependent reactions occur, where the Calvin cycle occurs, and how glucose is formed from the products of the light reactions.	
	A.2. Establishing the Purpose of the Lesson	
	As you know from your previous experimentation when a Hydrilla plant is immersed in water and exposed to light, bubbles form on the leaves. These bubbles are oxygen, a ***product of photosynthesis*** *and the observable change is that gas release indicates that plants transform light energy into chemical energy, producing oxygen.* ***Option 1:" Plant Energy Investigation Activity":*** *The teacher will shine a flashlight on the leaves of the plant and ask students using a small potted plant or leaves and a flashlight or lamp (to simulate sunlight).* *To start the demonstration, the teacher shines a flashlight on the leaves of the plant and asks:* ● *What do you think will happen to this plant when it receives sunlight?* ● *Where does the energy go? Let the students make their predictions.* ***Option 2: Illustrate or draw a simple diagram of a plant cell/chloroplast.*** ● *Why is it important for us to understand how plants make food?* ● *How does it affect the food we eat or the oxygen we breathe?*	***Annotation:*** *1. The introductory demonstration sets the stage for understanding photosynthesis by helping learners connect the concept to real-life experiences. By observing how a plant responds to simulated sunlight, the learners begin to explore how the light energy is transformed into chemical energy. The activity also aligns with the learning goals by establishing the relevance of photosynthesis to daily life and ecosystems and encouraging curiosity and prediction to our learners which is the key to scientific thinking. The approach used in this activity is inquiry-based learning that prompts learners to make predictions and observations about how plants respond to light. The teacher uses a demonstration method as the teacher uses a flashlight and plant to visually simulate sunlight exposure, making the abstract concept of energy transformation tangible and use open-ended questions that lead learners to reflect, predict, and reason through the process of photosynthesis.* *and air quality. Teachers should encourage conceptual accuracy over artistic detail and guide learners to see how plant energy production sustains life on Earth.*

	Option 3: **Photo Prompt Activity:** Show a printed or projected image of a sunlit plant and a shaded plant. Ask learners to compare the two and infer why light is necessary for food production. Teacher note: Guide learners to connect plant food production to oxygen release, food supply, and ecosystem balance. **Safety and Accessibility Note:** Use only teacher-prepared plant samples and safe classroom materials. Keep walkways clear during role-play, provide seated or paper-based alternatives when needed, and read directions aloud while also displaying them in print for learners who need visual or language support.	
B. Instituting New Knowledge	***B.1. Presenting Examples***	
	Option 1: "From Sunlight to Food Activity": *Students will understand how plants use sunlight to produce energy molecules (ATP and NADPH) and how these are used in the Calvin cycle to produce glucose using Flashcards with words, manila paper/ cartolina/ marker.* *Learners will have a group formation and ask groups to arrange the cards in the correct sequence of energy flow.* ● *Class will form into small groups of 3-4 students. Each group has a set of cards containing terms related to photosynthesis. Ask the groups to arrange the cards in the correct order showing how energy flows during photosynthesis. Each group briefly explains their arrangement to class.* ***Step-by-Step Arrangement:*** ● *Ask groups to arrange the cards in the correct sequence of energy flow:* ● ***light-dependent reactions (Stage 1):*** *Sunlight + Water → ATP + NADPH + Oxygen* ● ***light-independent reactions (Stage 2):*** *ATP + NADPH + Carbon dioxide → G3P (a three-carbon sugar) glucose* ***Option 2: Diagram Mapping:***	*This activity targets the learning objective of helping students understand the sequential flow of energy in photosynthesis, specifically how sunlight and water drive the light-dependent reactions to produce ATP, NADPH, and oxygen, and how these energy carriers fuel the Calvin cycle to fix carbon dioxide into glucose. It reflects IDF guiding principles such as inquiry-based learning, functional learning, and contextualization, since learners actively arrange terms, map diagrams, and explain their reasoning. The 2C-2I-1R approach is evident through* ***Constructivism*** *(card sequencing and diagramming),* ***Contextualization*** *(linking molecular steps to plant energy production),* ***Inquiry*** *(answering guide questions),* ***Integration*** *(connecting both stages of photosynthesis), and* ***Reflection*** *(predicting plant behavior in darkness). Pedagogically, it applies cooperative learning, visual mapping, and guided questioning strategies to foster collaboration and deeper comprehension.*

	● *On manila paper, groups draw a simple two-box diagram:* *Box 1: Light-dependent reactions in thylakoid membrane (inputs: sunlight, water; outputs: ATP, NADPH, oxygen).* *Box 2: Light-independent reactions in stroma (Calvin cycle) (inputs: ATP, NADPH, carbon dioxide; output: glucose) and provide guided questions.*	*Teachers should note the importance of facilitating discussion so students not only memorize sequences but also grasp the interdependence of both stages, emphasizing ATP and NADPH as the "bridge" between capturing sunlight and producing glucose.*
	B.2. Discussing New Concept	
	The teacher introduces and explains important terms such as: ● *Photosynthesis- the process by which plants use sunlight to convert water and carbon dioxide into glucose and oxygen.* Photosynthesis has two interdependent stages: the light-dependent reactions and the Calvin cycle. The Calvin cycle does not directly require light, but it depends on ATP and NADPH from the light-dependent reactions. Rather than producing glucose in one step, the Calvin cycle first produces G3P, which can later be used to form glucose and other carbohydrates. *The light energy is trapped by a pigment in the chloroplast and converted into chemical energy. During this process, usable molecules like ATP and NADPH are generated as energy-carriers.* ● *During the light-dependent reactions, light energy drives the splitting of water (photolysis) and the production of ATP and NADPH.* ● *ATP (Adenosine Triphosphate)- the molecule that stores and provides energy for cellular processes.* ● *NADPH- a molecule that carries high-energy electrons used in the Calvin Cycle.* *ATP and NADPH are produced during the light-dependent reactions in the thylakoid membranes of the chloroplast. ATP supplies usable energy, while NADPH supplies high-energy electrons needed in the Calvin cycle for the reduction of carbon compounds.*	*This activity, where the teacher introduces and explains key terms of photosynthesis and supplements the lesson with a short video, targets the learning objective of clarifying the two stages of photosynthesis and the roles of molecules like ATP, NADPH, and glucose. It reflects IDF guiding principles of* ***inquiry-based learning*** *and* ***functional learning****, as students are guided to connect abstract biochemical processes with real-life outcomes such as food and oxygen production. The 2C–2I–1R approach is evident through* ***Constructivism*** *(building knowledge from definitions and visual explanations),* ***Contextualization*** *(relating photosynthesis to everyday life),* ***Inquiry*** *(exploring how stages are connected),* ***Integration*** *(combining molecular concepts with ecosystem relevance), and* ***Reflection*** *(considering the importance of photosynthesis for survival). Pedagogically, it applies* ***direct instruction*** *combined with* ***multimedia learning****, using clear explanations and a video to reinforce understanding. Teachers should note the importance of scaffolding and ensuring learners grasp the vocabulary before moving to complex processes and encouraging discussion after the video so students can*

	Light energy, captured by chlorophyll, facilitates the splitting of water molecules in photolysis, releasing electrons, protons, and oxygen. ● *Calvin Cycle- (**light-independent reactions**)- the stage where carbon dioxide is converted into glucose using ATP and NADPH. The Calvin cycle takes place in the stroma of the chloroplast and produces G3P, a three-carbon sugar that is used to form glucose and other carbohydrates.* *https://www.youtube.com/watch?v=Le7KOX91w7U*	*articulate how the light-dependent and light-independent reactions are interdependent.*
	B.3. Developing Mastery	
	Option 1: Peer Collaboration (Interactive Drill Activity): *Learners are given cards with molecules (H_2O, O_2, CO_2, ATP, NADPH, Glucose). In small groups, they arrange the cards into the correct sequence of photosynthesis with provided guided questions.* ***Option 2: Fill-in-the blanks-diagram of the light dependent reactions and the light independent reactions with provided diagram.*** *Students will complete a partially labeled diagram of photosynthesis by filling in the missing terms related to the light-dependent reactions and the light-independent reactions (Calvin Cycle). The diagram will include key components such as location (e.g., thylakoid, stroma), inputs (light, water, carbon dioxide), and outputs (oxygen, ATP, NADPH, glucose).* *Students are expected to correctly identify where each process occurs and match the appropriate inputs and outputs to each stage.* **Formative Check:** Ask each group to explain why ATP and NADPH move from the light-dependent reactions to the Calvin cycle. **Teacher Use:** If learners confuse the products and reactants, reteach the sequence using a color-coded diagram before moving to the next task.	*This Peer Collaboration (Interactive Drill Activity) targets the learning objective of reinforcing students' understanding of the sequence of photosynthesis and the roles of key molecules (H_2O, O_2, CO_2, ATP, NADPH, Glucose). It reflects IDF guiding principles of **inquiry-based learning** and **functional learning**, since learners actively manipulate terms and connect them to real-life ecological outcomes. The 2C–2I–1R approach is evident through **Constructivism** (arranging molecules into sequence), **Contextualization** (linking photosynthesis to plant survival and ecosystem energy flow), **Inquiry** (answering critical guide questions), **Integration** (connecting molecular processes with ecological benefits), and **Reflection** (predicting outcomes such as survival in darkness or oxygen release). Pedagogically, it applies **collaborative learning** and **interactive drills**, encouraging teamwork and peer explanation to deepen comprehension. Teachers should note the importance of guiding discussions so students move beyond memorization, emphasizing how the interdependence of light-*

		dependent and light-independent reactions sustains both plants and ecosystems.
C. Demonstrating Knowledge and Skills	***C.1. Finding Practical Application***	
	Option 1:*Photosynthesis in Action in Real-World Scenarios* ***Scenario 1:*** *A farmer notices that his crops are not growing well even though he waters them regularly. Upon closer inspection, he realizes that many of the leaves have been eaten by insects (defoliators). At the same time, the weather has been cloudy for several days, limiting the amount of sunlight reaching the plants.* ***Application Task:*** *Analyze how reduced light or leaf damage affects ATP/NADPH production and glucose formation.* ***Option 2: Energy Molecule Role Play Activity:*** *Learners will group them of 5–6 members each group and are assigned roles as molecules or energy sources. "Sunlight" energizes "Water," which produces "Oxygen" and hands energy to "ATP" and "NADPH." "ATP" and "NADPH" then move to the "Calvin cycle" group, where "CO_2" is fixed into "Glucose." Each group acts out the process and narrates the flow of energy.* *Note: Rubrics are provided for scoring*	**Annotation:** *Targets understanding of factors affecting photosynthesis and its real-life applications. It reflects inquiry, contextualization, and integration (2C–2I–1R) through problem-solving. Uses scenario-based learning with guided questions. Teachers should prompt reasoning and connect responses to plant structure and function.* *The teacher Uses role-play as an interactive strategy. Teachers should ensure accurate representation of processes and guide reflection after the activity.*
	C.2. Making Generalization	
	Learners illustrate the complete photosynthesis pathway (light-dependent reactions, ATP/NADPH formation, Calvin cycle, glucose synthesis) through concept mapping and reflection: ***Option 1: Concept Mapping Activity:*** *Learners illustrate the complete photosynthesis pathway (light-dependent reactions, ATP/NADPH formation, Calvin cycle, glucose synthesis) through concept mapping and reflection.* ***Option 2: Discussion & Reflection Questions:*** *Learners discuss and answer the following:* • *Why is photosynthesis important for both plants and humans?*	*This Concept Mapping and Reflection on Photosynthesis activity targets the learning objective of enabling students to visualize the complete pathway of photosynthesis, from light-dependent reactions to glucose synthesis, and to articulate the role of ATP and NADPH as energy carriers. It reflects IDF guiding principles of* ***inquiry-based learning*** *and* ***functional learning****, since learners actively construct a concept map and connect molecular processes to their importance for plants and humans.*

	• *How do ATP and NADPH act as "bridges" between the two stages?* • *What would happen if plants could not perform photosynthesis?* ***Option 3: Wrap-up Activity:*** Learners will write 3–4 sentences explaining how ATP and NADPH are produced in the light-dependent reactions and how these molecules are used in the Calvin cycle. **Readiness Check**: Ask learners to identify one input and one output for each stage of photosynthesis before proceeding to the evaluation.	***Constructivism*** *(building knowledge through mapping),* ***Contextualization*** *(relating photosynthesis to food and oxygen supply),* ***Inquiry*** *(answering reflection questions),* ***Integration*** *(linking both stages of photosynthesis in one map), and* ***Reflection*** *(summarizing insights in writing). Teachers should note the importance of guiding learners to show clear arrows for energy flow, prompting them to connect ATP and NADPH as bridges, and encouraging thoughtful reflections that highlight the interdependence of both stages.*
	C.3. Evaluating Learning	
	Option 1: Written Response Task Activity: 1.Explain how ATP and NADPH are produced during the light-dependent reactions. 2.Describe how the Calvin cycle uses ATP and NADPH to synthesize glucose. **Option 2: Performance-Based Checks** 1.Learners draw a complete diagram of photosynthesis, showing both light-dependent and light-independent reactions, with arrows indicating energy flow. **Option 3: Concept Application Activity** 1. Given a scenario where light intensity decreases, predict how ATP and NADPH production would be affected and explain the impact on glucose synthesis.	*This Written Response Task Activity targets the learning objective of deepening students' understanding of how ATP and NADPH are produced in the light-dependent reactions and how they drive glucose synthesis in the Calvin cycle. It reflects IDF guiding principles of* ***inquiry-based learning*** *and* ***functional learning****, as learners explain processes in writing, apply knowledge to diagrams, and predict outcomes in scenarios.*
	C.4. Additional Activities	
	Option 1: Reinforcement: Complete a guided comparison table of the light-dependent reactions and the Calvin cycle. **Option 2 : Enrichment:** Prepare a short comparative infographic on photosynthesis pathways.	***Annotation:*** *It reflects IDF guiding principles of* ***inquiry-based learning*** *and* ***functional learning****, since learners conduct research and present findings in comparative charts or infographics that connect molecular processes to plant adaptations. The*

	Option 3: Remote/Low-Tech: Write a one-page illustrated explanation of the complete photosynthesis pathway using handwritten labels and arrows.	*2C–2I–1R approach is evident through **Constructivism** (building knowledge through research and comparison), **Contextualization** (relating pathways to plant survival in diverse environments), **Inquiry** (investigating efficiency differences), **Integration** (linking molecular energy carriers to ecological strategies), and **Reflection** (considering why plants evolved different pathways). Pedagogically, it applies **research-based learning** and **visual presentation strategies**, encouraging learners to synthesize information and communicate it clearly.*
V. ASSESSMENT *(Assessing Learnings)*	*Part A. Here are 10 multiple-choice questions to assess learning:* *1.In the light-dependent reactions, which molecule is split to release oxygen?* *a. ATP* *b. Carbon dioxide* *c. Glucose* *d. Water* *2. Which organelle is the site of photosynthesis?* *a. Chloroplast* *b. Mitochondria* *c. Nucleus* *d. Ribosome* *3.Which products of the light-dependent reactions are used in the Calvin cycle?* *a. ATP and NADPH* *b. Carbon dioxide and water* *c. Glucose and starch* *d. Oxygen and glucose* *4.Where in the chloroplast does the Calvin cycle occur?* *a. Intermembrane space* *b. Outer membrane* *C. Stroma*	

	d. Thylakoid membrane *5.If ATP production in the light-dependent reactions decreases, what is the most immediate effect on the Calvin cycle?* *a. Faster NADPH formation* *b. Increased glucose synthesis* *c. More oxygen release* *d. Reduced carbon fixation* *6. How are the light-dependent and light-independent reactions connected?* *a. ATP and NADPH from the light-dependent reactions power the Calvin cycle.* *b. Glucose from the Calvin cycle is broken down in the thylakoid.* *c. Oxygen from the Calvin cycle fuels the light-dependent reactions.* *d. The Calvin cycle produces ATP for the light-dependent reactions.* *7. A rice farmer is experimenting with planting under shade nets to reduce heat stress. However, the plants under heavy shade show reduced yield compared to those in open sunlight. Which of the following best explains the reduced yield under shaded conditions?* *A. Shade prevents carbon dioxide from entering the leaves, so the Calvin cycle cannot occur.* *B. Reduced light intensity limits ATP and NADPH production in the light-dependent reactions, slowing glucose synthesis in the Calvin cycle.* *C. Photosynthesis is unaffected by light intensity, so the reduced yield must be due to soil nutrients.* *D. The plants under shade use oxygen instead of water, which stops glucose formation.* *8. What would most likely happen to a plant if NADPH production in the light-dependent reactions is severely reduced?* *A. The Calvin cycle would continue normally, since ATP alone is sufficient.* *B. Carbon dioxide fixation would slow down because NADPH provides the reducing power needed to form glucose.* *C. Oxygen release would stop immediately, since NADPH is required for splitting water.* *D. The plant would produce more glucose because less energy is wasted.* *9. A plant is placed in complete darkness. Which process will be directly affected first?* *a. Calvin cycle* *b. Glucose breakdown* *c. Light- dependent reactions* *d. Oxygen release from mitochondria* *10. Consider the complete pathway of photosynthesis. Which statement best explains its importance to ecosystems?* *a. It eliminates carbon dioxide completely from the atmosphere.* *b. It provides oxygen only for plants.* *c. It stores energy in mitochondria for cellular respiration.* *d. It transforms light energy into chemical energy, forming the basis of food chains.*

	Pre-Assessment Check: (1) Identify the chloroplast structures where the light-dependent reactions and the Calvin cycle occur. (2) State how ATP and NADPH from the light reactions support the Calvin cycle. (3) Predict what will happen to glucose synthesis when light intensity decreases and explain why. *Answer key:* *Part A.* *(1.d,2.a,3.a,4.c,5.d,6.a,7.b,8.b,9.c,10.d)*
VI. REFLECTION *(Feedback and Continuous Improvement)*	*Use the following reflection prompts to guide your evaluation of the lesson after implementation. Reflect on learners' performance, determine which activities and lesson parts were most and least effective, identify learners who need enrichment or remediation, analyze the assessment results, and note possible improvements to enhance future lesson delivery.* ● *How many learners successfully demonstrated the learning objectives based on the assessment results?* ● *Which activity helped learners understand the lesson the most? Which activity helped the least?* ● *Which part of the lesson was easiest for learners? Which part was most difficult?* ● *How many learners needed enrichment or additional challenge? How many learners needed remediation or additional support?* ● *What did the assessment results show about learners' understanding of the lesson?* ● *What improvement would you make if you taught this lesson again?* ● *Did learners correctly use terms like ATP, NADPH, Calvin cycle, and photolysis in their explanations or role plays?* ● *How many learners response in formative tasks, accuracy in diagrams, and oral presentations?*
VII. USE OF GENERATIVE AI	In preparing this Learning Exemplar, the author(s) used Copilot AI to improve and summarize content from website references and to create rubrics for evaluating students. The author(s) reviewed, revised, and finalized the content and take full responsibility for it.

Lesson Title/Topic	Metabolism- Photosynthesis	Lesson Exemplar	16

I. OBJECTIVES	
A. Content Standard	The learners learn that photosynthesis is the chemical reaction that transforms light energy into chemical energy.
B. Performance Standard	This section outlines the goal of ensuring that learners can apply their knowledge to real-life situations. It defines how students transfer their learning to various contexts beyond the classroom. Learners will demonstrate this through performance tasks that involve authentic, novel, and challenging scenarios related to the unit. Success in these tasks requires the thoughtful application of knowledge, skills, and attitudes.
C. Learning Competencies	***Prerequisite Knowledge and Skills*** Describe how cells obtain nutrients from food and convert them into energy through cellular processes to sustain life in plants and animals.
	Use information from secondary sources to evaluate how photosynthesis can help reduce carbon dioxide levels in the environment.
II. REFERENCES and MATERIALS (*Selecting Resources and Material*)	Sinauer Associates, Inc. *Plant Physiology and Development, 6th ed.* Sunderland, MA: Sinauer Associates, 2015. Accessed April 23, 2026. https://www.sinauer.com/plant-physiology-and-development.html Macmillan Learning. *Raven Biology of Plants, 8th ed.* By Peter H. Raven, Ray F. Evert, and Susan E. Eichhorn. Accessed April 23, 2026. https://www.macmillanlearning.com/college/us/product/Raven-Biology-of-Plants/p/1429219610 Macmillan Learning. *Lehninger Principles of Biochemistry, 8th ed.* By David L. Nelson and Michael M. Cox. Accessed April 23, 2026. https://www.macmillanlearning.com/college/us/product/Lehninger-Principles-of-Biochemistry/p/1319228003 Island Press. *The Global Carbon Cycle: Integrating Humans, Climate, and the Natural World.* Edited by Christopher B. Field and Michael R. Raupach. Washington, DC: Island Press, 2004. Accessed April 23, 2026. https://islandpress.org/books/global-carbon-cycle *NASA Earth Observatory. "The Carbon Cycle." Accessed April 23, 2026. https://earthobservatory.nasa.gov/features/CarbonCycle* *National Geographic Society. "Keeling Curve." Accessed April 23, 2026. https://education.nationalgeographic.org/resource/keeling-curve/Climate/* *NASA Earth Observatory. "The Carbon Cycle." Accessed April 23, 2026. https://earthobservatory.nasa.gov/features/CarbonCycle*
III. CONTENT *(Sequencing Content)*	Metabolism- Photosynthesis
IV. OBJECTIVES *(Setting Clear*	1. Interpret data or information showing the relationship between photosynthesis and carbon dioxide reduction in the atmosphere. 2.Construct models showing the stages of photosynthesis (the light-dependent reactions and light- independent reactions).

Objectives and Analyzing the Tasks)	3. Create a visual representation illustrating how photosynthesis reduces carbon dioxide in the environment.

IV. PROCEDURES		**ANNOTATIONS**
A. Activating Prior Knowledge	***A.1. Activating Prior Knowledge***	
	These activities activate prior knowledge about photosynthesis, carbon dioxide, and environmental change. They help learners surface misconceptions, connect the lesson to prior science learning, and prepare to interpret evidence from secondary sources. **Option 1**:***Video/Infographic Starter:*** *Watch this short video clip of forests absorbing CO_2 and ask learners to predict what process is happening.* *https://www.youtube.com/watch?v=HJ9yzkwX5N8* ● *Where does carbon dioxide in the atmosphere come from?* ● *Can you recall any information from science class or readings that explain how trees help reduce greenhouse gases?* ***Option 2: KWL Chart****:(students write what they Know, Want to know, and later Learn). Draw a three-column chart on the board or provide handouts/ digital templates: After reading secondary sources (textbooks, articles, infographics, or environmental reports), students fill in this column.* ***Option 3: Quik Poll Instructions-Photosynthesis and CO Reduction:*** ● *Create a quick poll about how might students think photosynthesis helps reduce carbon dioxide in the atmosphere.* ● *Provide clear, limited choices so students can respond quickly: (YES or NO) and collect their responses.*	*For each varied activity in each section, identify the following:* 1. *Which specific learning objectives does the activity target?* 2. *Which IDF guiding principles are evident in the activity?* 3. *Which 2C-2I-1R approach is utilized in the activity?* 4. *Which specific pedagogical strategy or teaching method is applied?* 5. *What additional note(s) to the teacher should be considered in facilitating the activity?* ***Sample Annotation:*** *he three activities, the video starter, KWL chart, and quick poll are designed to help students understand how plants reduce carbon dioxide through photosynthesis while building engagement and critical thinking. Each activity targets specific learning objectives, applies key instructional principles, and uses appropriate teaching strategies.*
	A.2. Establishing the Purpose of the Lesson	

	Option 1:Presenting Scenario: ● *Imagine a city with rising carbon dioxide levels. How do you think can plants help? Provide with guided questions.* ***Option 2:*** **Quick Data Dive:** *Show a simple graph showing CO_2 levels before and after reforestation. What do they notice? How do they think photosynthesis is involved here? Learners share quick insights that will primes them for data interpretation later.* Use Appendix A: Graph of atmospheric CO_2 trend in reforested versus sparsely vegetated areas, adapted from a secondary source. Ask learners to identify the overall pattern, compare the two contexts, and explain how photosynthesis may account for the difference. ***Option 3: Personal Reflection*** ● *Ask learners to think about their daily routine like for example: riding a jeepney, using electricity, eating food. Which of these activities might increase carbon dioxide in the atmosphere?"* ● *Learners jot down 2–3 examples in their notebooks.*	*The three activities presenting a scenario, conducting a quick data dive, and engaging in personal reflection are designed to help students understand how human activities affect carbon dioxide levels and how plants play a role in reducing them through photosynthesis. Each activity supports clear learning objectives, applies key instructional principles, and uses appropriate teaching strategies to deepen student understanding. These activities are simple yet effective in helping students connect scientific concepts to real-world contexts as they promote critical thinking, engagement, and reflection while building a deeper understanding of carbon dioxide, photosynthesis, and environmental responsibility.*
B. Instituting New Knowledge	***B.1. Presenting Examples***	
	Option 1: Situational Scenario Activity: ● *Present a short scenario in their community. Now imagine if more trees were planted around your schools, roads, and homes. How do they think planting more trees help their community? Learners discuss in pairs how photosynthesis in trees can reduce CO_2 in this real-life situation.* ***Option 2: CO_2 Data Interpretation Activity*** ● *Show a simple chart comparing CO_2 levels in areas with dense forests vs. areas with little vegetation. Learners interpret the data: "What does this tell us about the role of photosynthesis in reducing carbon dioxide?"* **Option 3: Guided Connection:** Let the learners explain *"As they breathe out carbon dioxide, the plant can take it in. Through*	*The three activities like situational scenario, CO_2 data interpretation, and guided connection are designed to help learners understand how photosynthesis helps reduce carbon dioxide and supports environmental balance. Each activity focuses on clear learning goals while applying effective instructional principles and strategies.* *Teachers should ensure the explanation is clear and simple, reinforcing correct scientific terms while allowing students to express ideas in their own words. It encourages participation, critical thinking, and real-life application, making the learning process meaningful and engaging.*

	photosynthesis, it uses light energy to transform that carbon dioxide and water into glucose for food and releases oxygen back into the air for them to breathe." *Plants absorb carbon dioxide from the air through their leaves. During photosynthesis, they use light energy to convert carbon dioxide and water into organic compounds such as glucose, while oxygen is released as a by-product.*	
	B.2. Discussing New Concept	
	Option 1: Data Interpretation (problem-Solving) Activity: *Instructions: Study the table shown in the activity sheet and answer the given guided questions.* ***Option 2: Matching Analogy Activity:*** *Match each part of the analogy with its scientific term in photosynthesis. After matching the analogy, ask learners to identify one part that accurately represents photosynthesis, one part that is limited, and one correction they can make based on the secondary source they examined.* ***Guided Questions:*** *1.Which parts of the analogy clearly explain photosynthesis? Which parts might be incomplete or misleading?* *2.If the "electricity supply" (sunlight) is cut off, what happens to the factory's production? How does this compare to real plants during nighttime or cloudy days?*	*The two activities data interpretation and matching analogy are designed to strengthen learners' understanding of photosynthesis and its role in reducing carbon dioxide while developing their analytical and critical thinking skills. Each activity aligns with clear learning objectives, instructional principles, and effective teaching strategies.* *The objective is for students to explain the process of photosynthesis using analogies and evaluate which comparisons are accurate or misleading. This demonstrates IDF principles such as conceptual understanding, inquiry, and learner-centeredness.*
	B.3. Developing Mastery	
	Option 1: Concept Drill (Defining & Understanding Terms): ***Instructions:*** *Through given table, match each term with its correct definition, then explain its role in photosynthesis.* ***Option 2: Model Construction Activity (Guided Practice)***	*The three activities concept drill, model construction, and mastery quiz are designed to help learners build a clear and complete understanding of photosynthesis, from basic terms to processes and overall mastery. Each activity supports specific learning objectives, reflects key instructional principles, and applies appropriate teaching strategies. The mastery quiz assesses students' overall understanding of the lesson. The learning objective is to evaluate how well students have*

	Instructions: Using the molecule cutouts provided (CO_2, H_2O, ATP, NADPH, glucose, O_2), complete the diagram and answer the given guided questions. ***Diagram Outline:*** • ***Light-Dependent Reactions:*** *Inputs → Outputs* • ***Light-Independent Reactions:*** *Inputs → Outputs* *Main Mastery Task: Using a short reading and one data display, trace where carbon dioxide appears in the photosynthesis equation and explain how it becomes part of plant-produced organic compounds. Optional Enrichment: Build a simplified model of the two major stages of photosynthesis.* ***Option 3: Mastery Quiz:*** *The students will answer the questions and let see how the students understand the lesson very well.*	*understood photosynthesis and identify areas that need improvement. This reflects IDF principles such as assessment for learning, feedback, and accountability. In the 2C-2I-1R approach, students connect what they have learned, are challenged by the questions, interact through responding, and reflect on their performance. The strategy used is formative or summative assessment.*
C. Demonstrating Knowledge and Skills	***C.1. Finding Practical Application***	
	Option 1: Eco-Poster Campaign Activity: (Group Task). *Learners design posters or infographics showing how photosynthesis reduces CO_2 and benefits humans and posters should include visuals (sunlight, leaves, CO_2 entering, O_2 exiting, glucose formation).* *Each poster or council proposal must include: (1) one scientifically accurate explanation of how photosynthesis reduces atmospheric carbon dioxide, (2) one fact or data point from a secondary source, and (3) one realistic community action supported by that evidence.* ***Note to teacher:*** *Require learners to include at least one fact or data point from a secondary source to support their proposed solution.* ***Option 2: Role Play Activity/ Problem-Solving Application***	*The eco-poster campaign and role play activities are designed to help learners apply their understanding of photosynthesis in meaningful and creative ways. These tasks move beyond basic knowledge by encouraging students to communicate ideas, solve real-world problems, and work collaboratively. Teachers should guide the process using a clear sequence (planning, discussion, presentation), assign roles if needed, and ensure that all students participate actively. These activities effectively develop learners' ability to apply scientific concepts in practical and creative contexts. They promote collaboration, critical thinking, and real-world awareness, helping students see the importance of photosynthesis in addressing environmental challenges.*

	Instructions: *The learners each group will act as a city council committee. Write their assigned role below:* • *Committee Name: _____* • *Members: _____* *Follow the sequence format for this activity.*	
	C.2. Making Generalization	
	Option 1:Exit Ticket Activity: "One Thing I Learned, One Thing I'll Apply" *Instructions for Students (to be read aloud or written on the paper):* *Answer the following prompts before leaving class:* • ***One Thing I Learned Today:*** *Write one key idea about photosynthesis and its role in reducing carbon dioxide.* • ***One Thing I'll Apply:*** *Write one way you can apply this knowledge in real life (e.g., planting trees, caring for plants, supporting green spaces).* ***Option 2: Think-Pair-Share Activity:*** ***Think (2 minutes):*** • *Individually reflect on what they learned today.* • *Write down one generalization about photosynthesis and its role in reducing carbon dioxide.* ***Pair (3 minutes):*** • *Share your generalization with a partner.* • *Compare your ideas and discuss similarities or differences.*	*The exit ticket, think-pair-share, and concept mapping activities are designed to help learners consolidate their understanding of photosynthesis and reflect on its role in reducing carbon dioxide. These activities focus on synthesis, application, and reflection, allowing students to internalize what they have learned.* *The concept mapping activity asks learners to organize key ideas about photosynthesis into a visual diagram and write a generalization at the end. The learning objective is for students to explain the process of photosynthesis, including inputs, outputs, and stages, and show how it reduces carbon dioxide. This reflects IDF principles such as organization of knowledge, metacognition, and active learning. Through the 2C-2I-1R approach, students connect concepts, are challenged to organize them logically, interact with the content, investigate relationships among ideas, and reflect by summarizing their understanding.* *The teaching method used is graphic organizer strategy and conceptual mapping. Teachers should guide students in connecting concepts correctly and check for misconceptions in both the diagram and the generalization. These activities effectively help learners review, organize, and apply their knowledge of photosynthesis. They promote reflection, collaboration, and deeper understanding, ensuring that students can*

	• *Work together to refine your generalization into one clear statement.* ***Sharing:*** • *Each pair will share their refined generalization with the class.* • *As a group, we will highlight common themes and agree on one collective generalization that represents our learning.* ***Option 3:Concept Mapping:*** *Write Photosynthesis in the center of your paper. Branch out to key concepts by drawing arrows or lines to connect the following:* • *Light energy → absorbed by chlorophyll* • *Light-dependent reactions → produce ATP & NADPH* • *Light-independent reactions (Calvin Cycle) → use ATP, NADPH, and CO_2 to form glucose* • *Outputs → Glucose (energy storage), Oxygen (released to atmosphere)* • *Photosynthesis reduces carbon dioxide in the atmosphere is a peer-reviewed scientific overview such as a review from **NASA Earth Observatory** on the global carbon cycle and photosynthesis.* ***Teacher Support Note:** NASA Earth Observatory explains that plants absorb atmospheric carbon dioxide during photosynthesis and store carbon in plant biomass. Use this source to reinforce the idea that photosynthesis is an important natural process in the global* *carbon cycle.* *NASA Earth Observatory. "The Carbon Cycle." Accessed April 23, 2026. https://earthobservatory.nasa.gov/features/CarbonCycle*	*clearly explain how photosynthesis contributes to reducing carbon dioxide in the environment.*

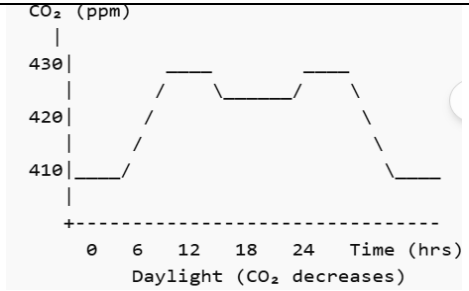
	C.3. Evaluating Learning	
	This section should include assessment activities that measure learners' understanding and skills related to the lesson objectives. Provide **possible assessment formats**, such as written responses, short problem-solving tasks, or performance-based checks aligned with the objectives. **Option 1: Case File activity:** Instructions: Complete the missing parts of the photosynthesis "case file." • Location of Light-Dependent Reactions: _____ • Inputs: _____ • Outputs: _____ • Location of Light-Independent Reactions (Calvin Cycle): _____ • Inputs: _____ • Outputs: _____ **Option 2: Evidence board activity:** • Draw or sketch a simple "evidence board" showing how photosynthesis reduces CO_2. • Include arrows showing inputs (CO_2, H_2O, light) and outputs (Glucose, O_2). • Add a short caption: ***"Photosynthesis reduces CO_2 by..."*** • Share your evidence board with a partner and compare your ideas.	*Each activity supports students' understanding of photosynthesis while applying different learning approaches and teaching strategies.* *In the Case File activity, students identify the locations, inputs, and outputs of the light-dependent and light-independent reactions. This targets conceptual understanding of the stages of photosynthesis and how they are connected. It reflects IDF principles such as active learning and structured inquiry, since learners complete missing information in an organized format. The 2C-2I-1R approach is seen through concept building and making connections between processes, with some level of independent information processing. This activity uses guided inquiry and a graphic organizer strategy. Teachers should ensure students have prior knowledge and provide visual aids to avoid misconceptions.* *In the Evidence Board activity, students draw and explain how photosynthesis reduces carbon dioxide, then share their work with a partner. This develops understanding of matter flow and strengthens communication skills. It highlights IDF principles like creativity, collaboration, and contextual learning. The 2C-2I-1R approach appears through connecting concepts, interacting with peers, and reflecting through captions. The teaching method combines visual learning and think-pair-share.*
	C.4. Additional Activities	
	These assessment tasks measure whether learners can explain the role of photosynthesis in reducing carbon dioxide, identify key inputs and outputs, and communicate evidence through a short written or visual response. **Option 1: Enrichment Part Activity**	The enrichment activity targets the learning objective of explaining how photosynthesis reduces carbon dioxide and applying this concept to real-life environmental problems. It reflects IDF guiding principles such as contextual learning, problem-solving, and creativity, as students design practical

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Instructions: Imagine you are part of a city planning team tasked to reduce carbon dioxide in your community. Using your knowledge of photosynthesis, design a Community Green Plan.
Table A – Problem and Solution Outline
<table>
<tr><th>Problem (High CO2 Source)</th><th>How Photosynthesis Helps</th><th>Proposed Solution</th><th>Expected Outcome</th></tr>
<tr><td>Example: Heavy traffic</td><td>Plant absorbs CO_2</td><td>Plant trees along roads</td><td>Reduced CO_2 levels</td></tr>
</table>
Write one generalization: “Photosynthesis reduces CO_2 in the environment by…”

Option 2: Remediation Part Activity:
Instructions: Complete the sentences and match the terms with their correct descriptions.
Part A – Fill-in-the-Blanks
1. Plants absorb _____ during photosynthesis.
2. Photosynthesis produces _____, which humans and animals need to breathe.
3. The sugar formed in photosynthesis is called _____.
Part B – Matching
Match the term to its description:
</td>
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solutions for CO_2 reduction. The 2C-2I-1R approach is evident through concept application, integration of ideas, interaction between causes and solutions, and reflection in the generalization statement. The pedagogical strategy used is problem-based learning with collaborative planning and table-based graphic organization. Teachers should guide students in linking scientific concepts to realistic community issues and encourage feasible, well-explained solutions.
The remediation activity targets basic recall of key concepts in photosynthesis, including inputs, outputs, and terminology. It reflects IDF principles of mastery learning and structured support, helping learners strengthen foundational understanding. The 2C-2I-1R approach is mainly focused on concept reinforcement with limited interaction and minimal reflection.
The pedagogical strategy used is drill-and-practice combined with guided recall and matching exercises. Teachers should ensure clear instructions, provide immediate feedback, and address misconceptions during checking to support learners who need remediation.
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<td>V. ASSESSMENT
(Assessing Learnings)</td>
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Here are 10 multiple choice question to assess learnings:
1.Two cities are compared: City A has many parks, City B has few green spaces. Which conclusion is most valid?
A. City B has more photosynthesis due to buildings.
B. City A has higher CO_2 because of more oxygen .
C. City B has more photosynthesis due to buildings.
D. City A has lower CO_2 due to photosynthesis in plants.

2.An infographic shows inputs (CO_2, H_2O, light, glucose and O_2. Which chloroplast component captures light energy and helps drive the process?
A. ATP
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	B. Chlorophyll *C. Nitrogen* *D. Respiration* *3. "Plant more trees to fight climate change." Which scientific principle supports this?* *A. Trees produce fossil fuels.* *B. Trees reduce oxygen levels.* *C. Trees absorb CO_2 during photosynthesis.* *D. Trees release CO_2 during photosynthesis.* *4. If a school plants 500 trees, what environmental impact is most likely?* *A. Increase in CO_2 levels.* *B. Increase in fossil fuel use.* *C. No change in CO_2 levels.* *D. Decrease in CO_2 levels due to photosynthesis.* *5. Which input is directly used in the Calvin Cycle (light-independent reactions)?* *A. Carbon dioxide* *B. Oxygen* *C. Sunlight* *D. Water* *6. Which statement best generalizes the role of photosynthesis in environmental balance?* *A. Photosynthesis converts light energy and reduces CO_2.* *B. Photosynthesis only produces glucose for plants.* *C. Photosynthesis increases greenhouse gases.* *D. Photosynthesis occurs only in artificial light.* *7. In which part of the chloroplast do light-dependent reactions occur?* *A. Cytoplasm* *B. Nucleus* *C. Stroma* *D. Thylakoid membranes* *8. A graph shows atmospheric carbon dioxide decreasing in a densely vegetated area during daylight hours. Which explanation best accounts for the pattern?*



A. Plants absorb carbon dioxide during photosynthesis and incorporate it into organic molecules.
B. Plants destroy carbon dioxide completely.
C. Oxygen changes directly into carbon dioxide
D. Photosynthesis stops during daylight.

9. A poster shows arrows: CO_2 → Photosynthesis → Glucose + O_2. What message does this best illustrate?
A. Photosynthesis only produces glucose.
B. Photosynthesis occurs only at night.
C. Photosynthesis increases CO_2 in the atmosphere.
D. Photosynthesis reduces CO_2 and produces oxygen.

10. Which output of the light-dependent reactions is essential for the Calvin Cycle?
A. ATP and NADPH
B. Carbon dioxide
C. Glucose
D. Oxygen

Part II: Reflection Activity
Instructions: Write your final verdict as a detective: *"Based on the evidence, I conclude that photosynthesis…"*

Answer key:
1.d
2.b
3.c
4.d
5.a
6.a
7.d

	8.a *9.d* *10.a*
VI. REFLECTION *(Feedback and Continuous Improvement)*	*Use the following reflection prompts to guide your evaluation of the lesson after implementation. Reflect on learners' performance, determine which activities and lesson parts were most and least effective, identify learners who need enrichment or remediation, analyze the assessment results, and note possible improvements to enhance future lesson delivery.* *• How many learners successfully demonstrated the learning objectives based on the assessment results?* *• Which activity helped learners understand the lesson the most? Which activity helped the least?* *• Which part of the lesson was easiest for learners? Which part was most difficult?* *• How many learners needed enrichment or additional challenge? How many learners needed remediation or additional support?* *• What did the assessment results show about learners' understanding of the lesson?* *• What improvement would you make if you taught this lesson again?*
VII. USE OF GENERATIVE AI	In preparing this Learning Exemplar, the author(s) used Copilot AI to improve and summarize content from website references and to create rubrics for evaluating students. The author(s) reviewed, revised, and finalized the content and take full responsibility for it.

Lesson Title/Topic	Metabolism-Respiration	Lesson Exemplar	17

I. OBJECTIVES	
A. Content Standard	The learners learn that cell respiration is the chemical reaction that converts chemical energy into usable forms of energy.
B. Performance Standard	By the end of the Quarter, learners describe the processes of photosynthesis and cellular respiration and explain how these cellular mechanisms transform energy for life. They describe the role of cell structures in photosynthesis and differentiate the light-dependent and light-independent reactions. Learners describe the stages of cellular respiration, including glycolysis, the citric acid cycle, and the Electron Transport Chain, and explain their role in ATP production for cellular activities. They also participate in experiments to create models and presentations that demonstrate how these processes sustain ecosystem stability and support life functions.
C. Learning Competencies	***Prerequisite Knowledge and Skills*** Describe how cells obtain nutrients from food and convert them into energy through cellular processes to sustain life in plants and animals Differentiate basic features and importance of photosynthesis and respiration.
	The learners use a diagram to explain the steps in aerobic respiration, including glycolysis, acetyl coenzyme A, citric acid cycle, electron transport system, and chemiosmosis, including the importance of ATP as the energy carrier in cells and the role of enzymes.
II. REFERENCES and MATERIALS (*Selecting Resources and Material*)	1. The Biology Corner. n.d. *Plant and Animal Cells – Labeled Graphics*. Accessed March 15, 2026. https://www.biologycorner.com. 2. Vedantu. *Plant and Animal Cell Comparison Diagram*. Accessed March 15, 2026. https://www.vedantu.com/question-sets/82ebdc91-9646-4917-86a3-e3e32592fe8d2421664017561505163.png 3. Biology Online. Cellular Respiration Definition Diagram. October 2019. Accessed March 15, 2026. https://www.biologyonline.com/wp-content/uploads/2019/10/cellular-respiration-definition.jpg 4. BioMan Biology: - https://www.biomanbio.com/HTML5GamesandLabs/PhotoRespgames/respiration-interactive-page.html 5. Cellular Respiration (UPDATED) - https://www.youtube.com/watch?v=eJ9Zjc-jdys&t=2s 6. Cellular Respiration - https://www.youtube.com/watch?v=eBl3U-T5Nvk 7. Cellular Respiration – Virtual Science Teachers - https://virtualscienceteachers.org/cellular-respiration/
III. CONTENT *(Sequencing Content)*	Metabolism-Respiration

IV. OBJECTIVES *(Setting Clear Objectives and Analyzing the Tasks)*	*This section outlines the unpacked learning competencies.* 1. Use a detailed diagram of Glycolysis to identify the energy investment and the resulting net yield of ATP and NADH. 2. Illustrate pyruvate oxidation (decarboxylation) and the formation of acetyl-CoA before the citric acid cycle, including the role of enzymes in aerobic respiration using a diagram. producing NADH. 3. Create a functional model of the inner mitochondrial membrane to demonstrate how the electron transport chain (ETC) generates a proton gradient that powers ATP synthase through chemiosmosis.. 4. Summarize the total energy yield of aerobic respiration into a single flow-chart explaining how the resulting ATP provides the energy necessary for specific cellular tasks like active transport or muscle contraction and the role of enzymes in aerobic respiration.	
IV. PROCEDURES		**ANNOTATIONS**
A. Activating Prior Knowledge	***A.1. Activating Prior Knowledge***	
	Conduct a simple activity on animal and/or plant cell structure to recall the student's prior knowledge on the location of aerobic respiration and source of energy of the cellular activities. The review may be done through any of the following/suggested activities: ***Option 1: The Cellular Geography Map*** ***Instruction:*** *Provide a diagram of an animal or plant cell for each student, pair or group. Have students label the cytoplasm (cytosol) and the mitochondria, then ask them "what specific function does these parts play for plant production or animal metabolic activities?". Refer to the link for sample diagram:* https://tinyurl.com/Bio1Q2LA6 ***Option 2: Biochemical Breakdown*** ***Instruction:*** *Draw a simplified 6-carbon chain representing Glucose. Refer to the link for sample diagram:* https://tinyurl.com/Bio1Q2LA6. *This helps learners to identify the functional groups or simply count the carbons present on the chain. Ask the learners, "if you had to break this 6-carbon molecule into two equal pieces, where would you cut it?".* ***Option 3: ATP: The Energy Currency*** ***Think:*** *Recall the component of ATP and how it releases energy.*	*This lesson sequence builds students' understanding of respiration by linking cell structures to processes through collaborative discussion, visual modeling, and guided sharing. Learners explore biochemical foundations by sketching glucose, analyzing its bonds and energy storage role, and then deepen their grasp of ATP through think-pair-share activities that connect its components to glycolysis's investment and payoff phases. Across all parts, the design reflects IDF principles such as relevance, responsiveness, intentionality, and focus, while applying the 2C-2I-1R framework through constructivism, contextualization, inquiry, integration, and reflection. Differentiated instruction, conceptual scaffolding, and collaborative reasoning ensure students actively engage with respiration as a core biological concept.* ***Note to teacher:*** *– Have students share their answers first in pairs or groups before presenting to the class to encourage participation. Ensure drawings show a clear, simplified glucose structure, clarify the roles of hydroxyl groups and*

	Pair: *Learners pair-up to share their ideas for 2-3 minutes.* ***Share:*** *Ask volunteer to share their insights to the class.* *The teacher relates the ideas to "Business Investment" to activate knowledge on the investment and payoff phase of glycolysis.* *Rubrics for the activities can be found in this link:* https://tinyurl.com/Bio1Q2L6R *After the activity, ask learners to answer the following on mini whiteboards or exit slips:* *(1) In what part of the cell does glycolysis occur?* *(2) In what organelle does most aerobic respiration occur in eukaryotes?* *(3) What molecule serves as the immediate energy currency of the cell?* *Use the responses to identify misconceptions and provide immediate clarification before proceeding.*	*carbon chains, and correct misconceptions about energy storage. Emphasize that glucose's bonds hold potential energy, which is released through enzymatic pathways like glycolysis and cellular respiration.*
	A.2. Establishing the Purpose of the Lesson	
	Now that learners explored the structure and function of the plant and animal cell focusing on the mitochondria and the cytoplasm (cytosol), dive deeper on the structure and connection of the mitochondria and cytoplasm to the process of glycolysis. *Choose one activity from the options below:* ***Option 1: The Universal language*** ● *Oral recitation on student's prior knowledge about the lesson. Ask learners to name organisms, identify mitochondria as the site of respiration in eukaryotes, and explain how bacteria use cytoplasm for glycolysis. Refer to the link for the activity sheet:* https://tinyurl.com/Bio1Q2LA6 ***Option 2: The Emergency Backup*** ● *Discuss scenarios such as:* o *A hydrilla that is fully submerged in water.* o *A sprinter running a 100-meter dash.*	***The Universal language***, ***The Emergency Backup, and The Cellular Relay Race*** *clarify glycolysis and respiration by using comparisons, real-life scenarios, and role-play. They reflect IDF principles of relevance, responsiveness, and inclusivity, helping learners connect abstract processes to familiar contexts. The 2C-2I-1R approach is evident in collaboration (peer sharing, role-play), constructivist meaning-making through comparative analysis or scenario reasoning, inquiry via guide questions on structural differences and oxygen dependence, integration of glycolysis with bacterial and eukaryotic respiration or compartmentalization, and reflection on misconceptions and outcomes. Pedagogically, they employ comparative charts, scenario analysis, and experiential simulation to*

	• *Ask the learners a few questions such as "*Explain how glycolysis provides quick ATP when oxygen is limited" *and give the learners 2-3 minutes to process the question.* • *Ask volunteers to share their insights on the scenario and to answer the question.* https://tinyurl.com/Bio1Q2LA6 ***Option 3: The Cellular Relay Race*** • *Students will explore how glycolysis in the cytoplasm links to mitochondrial processes through a relay or role-play activity. Refer to the link for sample scenarios of the role-play.* https://tinyurl.com/Bio1Q2LA6 *Rubrics for the activities can be found in this link:* https://tinyurl.com/Bio1Q2L6R	*strengthen understanding of glycolysis's role and location in cellular respiration.* ***Note to teacher for Option 1:*** *Teachers include a quick comparison chart of the organisms to help students analyze the structural differences.* ***Note to teacher for Option 2:*** *Teachers must correct misconceptions that glycolysis "needs oxygen" to continue the process- it does not.* ***Note to teacher:*** *The teacher will explain that glycolysis is an immediate-response energy pathway because it begins glucose breakdown quickly and can still provide a small amount of ATP even when oxygen is limited, allowing cells to continue functioning briefly during periods of high energy demand.*
B. Instituting New Knowledge	***B.1. Presenting Examples***	
	Begin the discussion with a short review on the connection of cellular respiration to real-world energy conversion. Use any option below to activate prior knowledge of the lesson: ***Option 1: The Power Plant Analogy*** • *Show an image of a cell and a city with walls and gates. The cell-city image compares the cell membrane to city walls, transport channels to gates, the nucleus to a control center, and the mitochondria to power plants.Ask student "how are these two similar to each other?". Refer to the link for the activity sheet:* https://tinyurl.com/Bio1Q2LA6 ***Option 2: The Bioluminescent Glow*** • *Show a short clip of bioluminescence such as firefly or deep-sea jelly fish and ask learners to observe the changes on the light of the organisms. The bioluminescence clip shows organisms producing light through energy-dependent*	***The Power Plant Analogy*** *--- This activity reflects IDF principles of responsiveness and intentionality, applies the 2C-2I-1R framework through constructivism and contextualization, and uses analogy-based teaching strategies to elicit prior knowledge and contextualize energy conversion.* ***The Bioluminescent Glow*** *-- It reflects IDF principles of intentionality, development, and focus, applies the 2C-2I-1R framework through constructivism, contextualization, inquiry, integration, and reflection, and uses multimedia engagement and guided questioning as teaching strategies to correct misconceptions about bioluminescence.* ***The Electric Eel***

	chemical reactions. Refer to the link for the activity sheet: https://tinyurl.com/Bio1Q2LA6 ***Option 3: Cellular Respiration Check*** ● *Show a blank diagram of cellular respiration matrix. Have students label each stages including the inputs and outputs to analyze their prior knowledge to the lesson.* *The teacher can relate these activities to respiration pathways by showing how cells convert energy: Option 1 highlights mitochondria as the cell's power source through a city–cell comparison, Option 2 demonstrates energy use in bioluminescent organisms powered by ATP, and Option 3 has students label glycolysis, Krebs cycle, and the electron transport chain to trace glucose breakdown and ATP production. Together, these activities reinforce aerobic respiration as the foundation of cellular energy conversion.* *Rubrics for the activities can be found in this link:* https://tinyurl.com/Bio1Q2L6R	*-- A video of an eel producing electric shocks demonstrates ATP's role in powering electrocytes. This activity reflects IDF principles of intentionality, development, and focus, applies the 2C-2I-1R framework through constructivism, contextualization, inquiry, integration, and reflection, and uses multimedia engagement and guided inquiry as teaching strategies to clarify how ATP fuels ion gradients for electrical discharge.* ***Note to teachers:*** *The teacher should – Clarify that light production requires energy and is not automatic; emphasize that limited food intake lowers ATP, causing dimmer bioluminescence. For eels, explain that electrocytes depend on ATP-powered ion gradients, correct the misconception that they "store electricity like a battery," and highlight that they must rest and replenish oxygen and nutrients to restore ATP for future shocks.*
	B.2. Discussing New Concept	
	Start the discussion on cellular respiration by giving learners a flowchart of glycolysis, the citric acid cycle, and the electron transport chain, then ask where the process begins—highlighting that it starts with glycolysis in the cytosol, which can be explored through interactive activities. Refer to this link for sample diagram: https://tinyurl.com/Bio1Q2LA6*.* ***Glycolysis*** *can be discussed through this activity:* ***Option 1: The "Energy Loan" Simulation*** *(Kinesthetic)* *This activity uses a simple ledger-based movement to show why the cell spends energy to make energy. Learners move from an Investment Zone, where they spend 2 ATP to split glucose into two 3-carbon pyruvates, into a Payoff Zone, where they gain 4 ATP,*	***The "Energy Loan" Simulation*** *-- It reflects IDF principles of intentionality and responsiveness, applies the 2C-2I-1R framework through concrete experience, integration, and reflection, and uses experiential learning strategies to correct misconceptions about gross versus net ATP yield.* ***Note to teacher:*** *The teacher should clarify that ATP must be spent to phosphorylate and destabilize glucose, correct misconceptions that glycolysis "produces 4 ATP," and highlight the importance of the 2-ATP net gain in supporting life when oxygen is unavailable.*

	illustrating glycolysis as an energy-requiring process that yields a net gain of 2 ATP. *End the glycolysis session with a synthesis question: "If glycolysis only yields 2 ATP, why is it still vital in low-oxygen environments?" Review the process, highlighting ATP investment and net yield, then explain pyruvate's conversion to acetyl-CoA before entering the* ***Citric Acid Cycle****. Conclude by introducing the mitochondria's structure to transition into the TCA discussion. Teacher may use/ choose an activity from the options on the link provided on the annotation section.* *Understanding the mitochondrion matrix is crucial to the discussion of how the Citric Acid cycle works for the cellular respiration.* *The pyruvate produced during glycolysis enters the mitochondrial matrix, where pyruvate oxidation occurs. In this step, pyruvate is converted into acetyl-CoA, which then enters the citric acid cycle.* *To discuss the TCA process, choose an activity from the options below:* ***Option 3: The Electron Shuttle Simulation*** *– Role Play* ● *Learners role-play the Citric Acid Cycle by acting out pyruvate decarboxylation, Acetyl-CoA entry, intermediates, energy harvesting, and CO_2 release with assigned roles, then reset the cycle with oxaloacetate and discuss guiding questions about efficiency in the matrix.* *The Citric Acid Cycle occurs in the mitochondrial matrix after pyruvate is converted to acetyl-CoA, and it is followed by the Electron Transport Chain in the inner membrane (cristae); teachers can choose an activity to introduce the ETC and connect it to the overall process of cellular respiration.*	***The Electron Shuttle Simulation*** *-- –It reflects IDF principles of intentionality (focusing on molecule flow and energy capture), development (embodied learning to simplify an abstract cycle), and focus (centering on the mechanics of the pathway). It aligns with the 2C-2I-1R framework through constructivism (physical modeling of steps), contextualization (linking food carbons to exhaled CO_2), inquiry (questions on cycle function and energy carriers), integration (connecting decarboxylation, carbon tracking, and electron transport), and reflection (analyzing cycle regeneration). Teaching strategies include kinesthetic learning, role-playing, guided inquiry, and conceptual linking to reinforce comprehension of the cycle's processes.* ***Note to teacher:*** *The teacher should emphasize that the cycle regenerates oxaloacetate rather than consuming it, clarify that two carbons from acetyl-CoA become two CO_2 molecules, reinforce that NADH and $FADH_2$ act as "batteries" for the ETC, and highlight the importance of the mitochondrial matrix as a confined space ensuring efficient cycling.* ***The "Hydroelectric Dam" Analogy*** *-- –It reflects IDF principles of intentionality (energy capture), development (simplifying chemiosmosis with a real-world model), and focus (proton flow and ATP formation). It aligns with 2C-2I-1R through constructivism (analogy building), contextualization (linking mitochondria to dams),*

	Option 2: The "Hydroelectric Dam" Analogy *(Conceptual Modeling)* ● *Students compare the ETC to a hydroelectric dam by mapping proton flow to water driving a turbine, diagramming how ATP synthase produces ATP, and discussing what happens if the inner membrane "leaks" and why proton movement is called chemiosmosis rather than simple diffusion.* *The teacher will provide a reflective statement through Pair-Share on how the three cellular respiration (Glycolysis. TCA, and ETC) work together to produce ATP. This will help student find the connection of the mitochondria and cytosol structure to their function on the cellular respiration.*	*inquiry (questions on leaks and chemiosmosis), integration (connecting models to biochemical mechanisms), and reflection (reasoning about controlled proton flow). Teaching strategies: conceptual modeling, guided analogy, visual representation, and inquiry-based questioning.* ***Note to teacher:*** *The teacher should clarify that a "leaky membrane" collapses the proton gradient and reduces ATP output, and emphasize that chemiosmosis is not simple diffusion but a membrane-regulated flow through ATP synthase coupled to ATP generation.* *Use the sample activity sheet and additional activities on the link for reference:* https://tinyurl.com/Bio1Q2LA6 *Rubrics for the activities can be found in this link:* https://tinyurl.com/Bio1Q2L6R
	B.3. Developing Mastery	
	Perform any of the following task to better understand the connection of different cellular respiration and ATP yield during the process: ***Option 1: The Energy Currency Flow-Mapper*** *(Individual Task)* ● *Students design a single-page infographic or flowchart that traces energy flow from glucose through glycolysis, the citric acid cycle, and the ETC, then branches from the final ATP "bank" to real cellular tasks, producing an annotated map that shows the transition from chemical energy of glucose ($C_6H_{12}O_6$) to mechanical energy (muscle movement) and gradient energy (active transport). Use the sample activity sheet on the link for reference:* https://tinyurl.com/Bio1Q2LA6 **Formative Check (ESRU):**	***The Energy Currency Flow-Mapper*** *-- –It reflects IDF principles of intentionality (ATP flow), development (visual scaffolding), and focus (inputs, outputs, usage). It aligns with 2C-2I-1R through constructivism (map creation), contextualization (ATP in real tasks), inquiry (questions on yield and mechanisms), integration (biochemistry to physiology), and reflection (annotating energy transformations). Teaching strategies: visual synthesis, analytical mapping, application-based reasoning.* ***Note to teacher:*** *The teacher should emphasize that aerobic respiration yields about 30–32 ATP per glucose, ensure students understand how ATP hydrolysis powers pumps and muscle filaments, and correct*

	Elicit—Ask, "Which stage produces the most ATP and why?" Student Response—Learners answer orally or in writing. Recognize—Identify whether responses correctly connect the proton gradient, ATP synthase, and electron carriers. Use—Provide feedback, reteach misconceptions, and assign a short follow-up task before the performance activity.	*misconceptions such as equating all ATP production solely with glycolysis.* *Use the sample activity sheet and additional activities on the link for reference:* https://tinyurl.com/Bio1Q2LA6 *Rubrics for the activities can be found in this link:* https://tinyurl.com/Bio1Q2L6R
C. Demonstrating Knowledge and Skills	***C.1. Finding Practical Application***	
	To further understand the importance of cellular respiration, do any of the activities below: ***Option 1: The Sprint vs. Marathon Energy Profile*** *(Data Analysis)* ● *Students compare athletic performance by creating a table or graph showing how sprinters rely on glycolysis (anaerobic, quick but limited) while marathoners depend on the citric acid cycle and ETC (aerobic, slower but sustainable), then reflect on why muscles "burn" during short sprints but can sustain long-distance running at a slower pace. Refer to this link for the activity procedure:* https://tinyurl.com/Bio1Q2LA6 ***Option 2: Medical Mystery: ETC Blockage*** *(Problem Solving)* *This activity tests their understanding of the Electron Transport Chain (ETC) by analyzing what happens when the pathway is interrupted.* ● *Provide a "Medical Mystery" case study.* *Scenario: A patient is exposed to a substance (like Cyanide) that blocks Complex IV of the ETC.* ● *Students must trace the flow of energy:*	***The Sprint vs. Marathon Energy Profile*** *-- –It reflects IDF principles (pathway comparison, athletic context, oxygen/mitochondrial focus) and aligns with 2C-2I-1R through constructivism (tables/graphs), contextualization (sports scenarios), inquiry (muscle burn, endurance limits), integration (biochemistry and physiology), and reflection (anaerobic vs. aerobic sustainability). Teaching strategies: data analysis, real-life application, guided questioning, comparative reasoning.* ***Note to teachers:*** *The teacher should emphasize that glycolysis is fast but limited due to lactate accumulation, while aerobic respiration is slower but highly efficient, enabling sustained effort, and help correct misconceptions such as the idea that sprinters simply "have more energy" rather than relying on different metabolic systems.* ***The "Poisoned Pipeline" Case Study*** *-- It reflects IDF principles of intentionality (pathway interdependence), development (medical scenario), and focus (ETC's critical role). It aligns with 2C-2I-1R through constructivism (reasoning consequences), contextualization (toxicology),*

	○ *If the ETC stops, what happens to the Proton Gradient in the ETC??* ○ *Is the Citric Acid Cycle a closed system, or does it require constant substrate input to maintain steady-state flux?* ○ *How does this affect the cell's ability to maintain a heartbeat or muscle contraction?* ● *Ask "Why is blocking the Electron Transport Chain fatal, even though the citric acid cycle is where most of the 'processing' happens?"* *Rubrics for the activities can be found in this link:* https://tinyurl.com/Bio1Q2L6R	*inquiry (probing gradients and cycles), integration (molecular to organism effects), and reflection (why ETC failure is fatal). Teaching strategies: problem-based learning, case analysis, guided questioning, systems thinking.* ***Note to teacher:*** *The teacher should help students see that blocking Complex IV prevents oxygen from acting as the final electron acceptor, causing backups in NADH/$FADH_2$ oxidation, halting the Citric Acid Cycle, and ultimately cutting off ATP supply needed for vital processes.* ***Safety Note:*** *The cyanide example is for paper-based case analysis only. No chemicals, samples, or demonstrations involving toxic substances shall be used. Emphasize that learners are analyzing a medical scenario to understand the role of Complex IV in the electron transport chain.*
	C.2. Making Generalization	
	Readiness Check: *Before the summative assessment, ask learners to complete a 3-item quick check: (1) identify the location of glycolysis, the citric acid cycle, and the ETC; (2) state one main input and one main output of each stage; and (3) explain in one sentence why oxygen is necessary for efficient ATP production.* *To generalize the discussion on cellular respiration—moving from glycolysis to the Citric Acid Cycle and the Electron Transport Chain learners must complete a table showing the input and output for each process.* Activity Title: **Aerobic Respiration Table Completion**. *Use the activity provided on the link:* https://tinyurl.com/Bio1Q2LA6 *Rubrics for the activities can be found in this link:* https://tinyurl.com/Bio1Q2L6R	*-- It reflects IDF principles of intentionality (essential components), development (scaffolded table), and focus (inputs/outputs). It aligns with 2C-2I-1R through constructivism (active completion), contextualization (products to ETC), inquiry (carriers vs. ATP, mitochondria's role), integration (location, carriers, yield), and reflection (synthesizing ATP production). Teaching strategies: structured tabulation, guided questioning, synthesis-based review.* ***Note to teacher:*** *The teacher should emphasize that NADH and $FADH_2$ are produced in large amounts because they feed electrons into the ETC, clarify that glycolytic products must enter the mitochondrion for full ATP yield, and reinforce that the ETC produces the most ATP due to proton-gradient-driven oxidative phosphorylation.*

	C.3. Evaluating Learning	
	Group work activity and concept mapping 1. *The class will be divided into small groups.* 2. *Ask each group to create a diagram that connects the aerobic respiration concepts to a real-life situation (ex. Muscle contraction, active transport).* 3. *Each group should explain how ATP is produced and used during aerobic respiration and analyze how reduced mitochondrial function affects ATP yield and cellular activities such as active transport and muscle contraction.* 4. *Each group will present their work in class.* *The teacher will provide an opportunity for open class discussion, encouraging learners to share ideas and reflections about the importance of aerobic respiration.*	*-- –It reflects IDF principles (conceptual connections, peer collaboration, ATP focus) and aligns with 2C-2I-1R through constructivism, contextualization, inquiry, integration, and reflection. Teaching strategies: cooperative learning, concept mapping, reflective discussion.* ***Note to teacher:*** *The teacher should encourage accurate linking of pathway steps, emphasize ATP's role across multiple cellular tasks, highlight how mitochondria enable high ATP yield, and provide space for students to share insights about aerobic respiration's importance to real-world biological function.*
	C.4. Additional Activities	
	Here are additional, creative activities that cater to different learning styles while emphasizing the flow and logic of cellular energy. 1. **The Molecular Stop-Motion Animation** (Group Project) Create a short animation showing how molecules change during one of the three main respiration pathways. 2. **Biochemical Pathway Relay** Students draw a complete flowchart of aerobic respiration, labeling the location (Cytoplasm vs. Mitochondria) and the net ATP yield of each stage. 3. **Concept Mapping** Create a class-wide concept map on the board connecting Food, Enzymes, Mitochondria, and ATP. *Rubrics for the activities can be found in this link:* https://tinyurl.com/Bio1Q2L6R	*-- It reflects IDF principles of intentionality (reinforcing the respiration framework), development (supporting diverse learning styles), and focus (highlighting metabolism–energy links). It aligns with the 2C-2I-1R framework through constructivism (building animations and flowcharts), contextualization (linking food energy to ATP outcomes), inquiry (exploring pathway interconnections), integration (combining biochemistry and cell biology), and reflection (concept maps consolidating understanding). Teaching strategies include project-based learning, visual modeling, collaborative mapping, and multimedia reinforcement.* ***Note to teacher:*** *The teacher should ensure accuracy in ATP yields and pathway locations, guide students in clearly representing molecular changes, and use the shared visual outputs to strengthen whole-class understanding of how respiration fuels all cellular work.*

V. ASSESSMENT *(Assessing Learnings)*	***OPTION 1: Summative Assessment*** ***PART I. MULTIPLE CHOICE*** *1. What is the primary purpose of the Investment Phase in glycolysis?* *A. Another important step is to reduce NAD^+ to NADH.* *B. The purpose of glycolysis is to produce 4 ATP molecules immediately.* *C. One role of cellular respiration is to transport glucose directly into the mitochondria.* *D. The function of the initial phosphorylation step is to destabilize glucose so it can be split.* *2. What is the net ATP yield from one molecule of glucose during glycolysis?* *A. 0 ATP B. 2 ATPs C. 4 ATPs D. 32 ATPs* *3. Which molecule acts as the "Gatekeeper" that enters the Citric Acid Cycle after pyruvate is decarboxylated?* *A. Acetyl-CoA B. Citrate C. Lactate D. Oxaloacetate* *4. Why is the Citric Acid Cycle referred to as a cycle?* *A. The cycle is unique because it can run in reverse.* *B. The cycle is significant because it happens in the mitochondria.* *C. The cycle cannot continue because it consumes all of its intermediates.* *D. The cycle is able to continue because it regenerates the starting molecule, oxaloacetate.* *5. Which statement best explains how the electron transport chain produces most ATP in aerobic respiration?* *A. It converts pyruvate into acetyl-CoA.* *B. It directly splits glucose in the cytoplasm.* *C. It regenerates glucose from carbon dioxide.* *D. It uses high-energy electrons to create a proton gradient that drives ATP synthase.* ***Answer Key*** *1. D ; 2. B ; 3. A ; 4. D ; 5. D* ***PART II. Diagram-base explanation*** *Complete the diagram of the cellular respiration. Using a labeled diagram, explain how glucose is broken down through glycolysis, pyruvate oxidation, the citric acid cycle, and the ETC, and show where ATP is produced and used.* ***Rubric** (10 points):* *Accuracy of diagram labels and locations – 3 pts* *Explanation of ATP and electron carriers – 3 pts* *Structure–function relationship (mitochondria) – 2 pts* *Clarity, coherence, and scientific terms – 2 pts* *Notes to Teacher:* *Provide a diagram template for learners who need scaffolding. For advanced learners, allow independent diagram creation. Allow group work to support inclusivity.*

	For remediation, accept simplified models focusing only on glycolysis and ATP synthase. *For enrichment, require comparison of aerobic vs anaerobic ATP yield.* *Refer to this link for other Assessment options:* https://tinyurl.com/Bio1Q2LA6
VI. REFLECTION *(Feedback and Continuous Improvement)*	*Reflect on learners' performance, determine which activities and lesson parts were most and least effective, identify learners who need enrichment or remediation, analyze the assessment results, and note possible improvements to enhance future lesson delivery.* ● *How many learners successfully demonstrated the learning objectives based on the assessment results?* ● *Which activity helped learners understand the lesson the most? Which activity helped the least?* ● *Which part of the lesson was easiest for learners? Which part was most difficult?* ● *How many learners needed enrichment or additional challenge? How many learners needed remediation or additional support?* ● *What did the assessment results show about learners' understanding of the lesson?* ● *What improvement would you make if you taught this lesson again?*
VII. USE OF GENERATIVE AI	In preparing this Learning Exemplar (LE), the author(s) used Microsoft copilot in order to correct grammar and simplify activities. The author(s) reviewed and finalized the writing of the content. The author(s) take(s) full responsibility for the content of this LE.

Lesson Title/Topic	Metabolism-Respiration	Lesson Exemplar	18

I. OBJECTIVES		
A. Content Standard	The learners learn that cell respiration is the chemical reaction that converts chemical energy into usable forms of energy.	
B. Performance Standard	By the end of the Quarter, learners describe the processes of photosynthesis and cellular respiration and explain how these cellular mechanisms transform energy for life. They describe the role of cell structures in photosynthesis and differentiate the light-dependent and light-independent reactions. Learners describe the stages of cellular respiration, including glycolysis, the citric acid cycle, and the Electron Transport Chain, and explain their role in ATP production for cellular activities. They also participate in experiments to create models and presentations that demonstrate how these processes sustain ecosystem stability and support life functions.	
C. Learning Competencies	***Prerequisite Knowledge and Skills*** Describe how cells obtain nutrients from food and convert them into energy through cellular processes to sustain life in plants and animals Differentiate basic features and importance of photosynthesis and respiration.	
	The learners describe how the structure of mitochondria relates to their function in cellular respiration;	
II. REFERENCES and MATERIALS (*Selecting Resources and Material*)	● *OpenStax. Biology 2e. Houston: OpenStax, 2018. https://openstax.org/details/books/biology-2e. (Accessed March 16, 2026.)* ● *Alberts, Bruce, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, and Peter Walter. Molecular Biology of the Cell. 6th ed. New York: Garland Science, 2015.* ● *Science Facts. "Mitochondria (Diagram and Parts)." 2020. https://www.sciencefacts.net/mitochondria.html. (Accessed March 16, 2026.)* ● *Peebedu. "Electron Transport Chain Simulator." n.d. https://peebedu.com/interactive/electron-transport-chain-simulator/. (Accessed March 16, 2026.)*	
III. CONTENT *(Sequencing Content)*	Metabolism-Respiration	
IV. OBJECTIVES *(Setting Clear Objectives and Analyzing the Tasks)*	*This section outlines the unpacked learning competencies.* 1. Identify the major parts of the mitochondrion and describe their roles in cellular respiration. 2. Explain how the folding of the cristae increases surface area and supports ATP production. 3. Explain how the intermembrane space helps maintain the proton gradient needed for ATP synthesis.	
IV. PROCEDURES		**ANNOTATIONS**
A. Activating Prior Knowledge	***A.1. Activating Prior Knowledge***	
	Conduct a simple review to recall learners existing knowledge on cellular respiration. This review may be done through the following activities:	*-- The Energy Pathway Sort, What Powers Life?, and Where Does Your Breakfast Go? activities all strengthen learners' understanding of cellular respiration by*

	Option 1: Energy pathway Sort ● *In groups of 3–4, students sort word cards (glucose, ATP, mitochondrion, oxygen, diffusion, cytoplasm, chloroplast, carbon dioxide) into three categories—Energy Source, Energy Converter, and Energy Product—using folder papers, then briefly explain their choices while the teacher clarifies misconceptions.* ***Option 2: What powers Life?*** ● *Students draw a circle labeled Energy in Cells in the center of their paper, write what they remember about how cells obtain and use energy, then share their ideas in pairs and with the class.* ***Option 3: Where does your breakfast go?*** ● *Students recall what they ate in their last meal, describe what happens to food after digestion, connect it to cellular respiration, and highlight ATP as the energy currency.* *Invite few volunteers to share their ideas with the whole class. Based on the activity, define cellular respiration and how ATP is used by the cell.* *Use the link for guided procedure and rubric for each activity: https://tinyurl.com/Q2Bio1LA7*	*connecting biological processes to prior knowledge, everyday experiences, and common misconceptions. Each reflects IDF principles by being learner-centered, inclusive, accessible, and engaging through group work, multimodal participation, and real-life relevance. The 2C-2I-1R approach is consistently applied: collaboration (pair/class sharing, group explanations), constructivist knowledge building from prior experiences, inquiry through guide questions, integration of organelles, energy sources, and life processes, and reflection on learners' ideas. Pedagogically, they employ strategies such as concept sorting, cooperative learning, guided discovery, contextualization, think-pair-share, brainstorming, and formative assessment to surface and deepen conceptual understanding.* ***Note to Teacher for Option 1:*** *The teacher should facilitate discussion carefully, encourage justification of answers, ensure equal participation, and use errors as opportunities to clarify and deepen understanding.* ***Note to Teacher Option 2:*** *The teacher should emphasize that all ideas are welcome, use responses to identify misconceptions early, and connect learners' answers to formal concepts that will be developed in subsequent lessons.* ***Note to Teacher Option 3:*** *The teacher should guide learners from general ideas to scientific explanations, clarify why ATP is needed instead of direct glucose use, and synthesize responses into a clear definition of cellular respiration and ATP's role in the cell.*
	A.2. Establishing the Purpose of the Lesson	
	Now that learners recall their understanding of the cellular respiration, let's take a moment to reflect by asking the following questions: ● *What is the primary purpose of cellular respiration?* ● *Where do the major ATP-producing stages of cellular respiration occur, and how is this different from glycolysis in the cytoplasm?* ● *What would happen to ATP production in the mitochondria if oxygen were not available for the electron transport chain?*	*-- These activities deepen learners' understanding of ATP, mitochondria, and oxygen in cellular respiration by linking direct bodily experiences, hypothetical reasoning, and system-level thinking. Each reflects IDF principles by being learner-centered, experiential, inclusive, and engaging through sensation, imagination, and discussion. The 2C-2I-1R approach is consistently applied: collaboration (class/group sharing), constructivist meaning-making from experience or prediction, inquiry with guide questions,*

	• *Why is the inner mitochondrial membrane highly folded?* *Conduct a simple activity to answer these questions. Select from the options below:* ***Option 1: ATP Mini Exercise*** • *Students repeatedly clench and unclench their fists for 15 seconds, rest briefly, then discuss muscle fatigue and connect it to ATP demand.* ***Option 2: What If Energy Stops?*** • *Students imagine mitochondria stop working for 10 seconds, predict cellular and organism effects, share ideas in groups, and present conclusions to highlight the importance of mitochondria.* ***Option 3: Breath-Hold Mini-Test*** • *Students hold their breath for 15–20 seconds, describe how they felt, then connect the discomfort to oxygen's role in ATP production.* *The teacher will clarify ATP as a source of energy is being consumed when we do intensive exercise and that production of ATP is also disrupted when supply of oxygen is scarce such as halting breathing.* *Use the link for guided procedure and rubric for each activity: https://tinyurl.com/Q2Bio1LA7*	*integration of muscular activity, oxygen use, and cellular processes, and reflection on sensations or imagined outcomes. Pedagogically, they employ experiential learning, scenario-based reasoning, guided discussion/questioning, and formative assessment to make abstract energy concepts concrete and meaningful.* ***Note to Teacher for Option 1:*** *The teacher should ensure the activity is brief and safe, help learners link fatigue to ATP depletion rather than muscle pain alone, and clearly reinforce the role of mitochondria in ATP production.* ***Note to Teacher for Option 2:*** *The teacher should emphasize that even short interruptions in ATP production can affect vital systems, guide learners to prioritize energy-dependent organs (e.g., muscles, brain), and synthesize responses to highlight the critical importance of mitochondria for life.* ***Note to Teacher for Option 3:*** *The teacher should ensure safety by limiting breath-holding time, clarify that discomfort is due to oxygen demand rather than harm, and clearly connect learners' experiences to the necessity of oxygen for efficient ATP production in mitochondria.* ***Safety note****: Do not require breath-holding. Any learner with asthma, anxiety, cardiovascular concerns, recent illness, or discomfort may opt out and instead analyze a short teacher demonstration, a video clip, or a written oxygen-limitation scenario. No learner should be pressured to perform the activity.*
B. Instituting New Knowledge	***B.1. Presenting Examples***	
	Begin by informing learners that to help them see how mitochondria is structured, they will have to do an activity. The goal of the activity is to build a mental image so they can understand later how structure affects function. *Select one of the following activities:*	*-- These activities strengthen learners' understanding of mitochondrial structure and function by using analogies, diagrams, and multimedia to clarify ATP production. Each reflects IDF principles by being learner-centered, accessible, multimodal, and meaningful, supporting diverse learners in grasping abstract processes. The 2C-2I-1R approach is evident in*

	Option 1: Power Plant Analogy ● *Students examine a power plant diagram and compare its parts to mitochondrial structures (inner membrane, ETC, ATP synthase, matrix), then identify similarities and design their own analogy for ATP production.* ● *Teacher should guide the learner and specify the parts that are only relevant to the lesson.* ***Option 2: Mitochondrion Diagram Walkthrough*** ● *Students study a labeled mitochondrion diagram, discuss each structure (outer membrane, inner membrane, cristae, matrix, intermembrane space), and annotate the diagram to show their understanding.* ***Option 3: Video Clip*** ● *Students watch a short video on mitochondrial structure, take notes on key features (inner membrane, cristae, matrix), and create an analogy to explain their significance in energy production.* *Use the link for guided procedure and rubric for each activity: https://tinyurl.com/Q2Bio1LA7*	*collaboration (class interaction, shared observation), constructivist meaning-making from prior knowledge or visuals, inquiry through guide questions, integration of structure with cellular respiration processes, and reflection on how analogies or visuals clarify function. Pedagogically, they employ analogical teaching, visual scaffolding, multimedia-assisted instruction, guided discussion/observation, and formative assessment to deepen comprehension.* ***Note to Teacher for Option 1:*** *The teacher should emphasize the limits of the analogy, clarify the specific roles of each mitochondrial component, and guide learners to connect the analogy back to accurate scientific explanations.* ***Note to Teacher for Option 2:*** *The teacher should emphasize the importance of cristae in increasing surface area, clearly distinguish processes occurring in each mitochondrial region, and use learner annotations to check and address misconceptions.* ***Note to Teacher for Option 3:*** *The teacher should select a clear, age-appropriate video, pause strategically to highlight key structures such as the inner membrane and cristae, and guide learners in connecting what they observe to the function of mitochondria in ATP production.*
	B.2. Discussing New Concept	
	The teacher will emphasize that the goal is to analyze how mitochondrial structures—particularly the cristae and intermembrane space—increase the efficiency of ATP production. Encourage learners to think critically and connect structural features to their functional consequences. ***Option 1.1: Visualizing the Geometry*** ● *Students imagine two rooms of equal volume—one with flat walls and one with pleated walls—and analyze which allows more enzymes to "stand" on the surface, connecting this to cristae folding in mitochondria.* ***Option 1.2: Surface Area Activity***	*-- These activities help learners understand how cristae folding increases mitochondrial surface area and ATP production. They reflect IDF principles by being learner-centered, accessible, and supportive, using imagination, analogy, and tangible models to simplify abstract concepts. The 2C-2I-1R approach is evident in collaboration (class interaction and idea sharing), constructivist meaning-making from spatial or physical comparisons, inquiry through guide questions on efficiency and enzyme placement, integration of geometry, structure, and respiration processes, and reflection on how cristae prevent ATP bottlenecks. Pedagogically, they employ analogical reasoning,*

	• *Students compare a flat sheet of paper with one folded accordion style to visualize how folding increases surface area, then connect this to cristae.* *Ensure participants understand that more surface area allows for a higher density of protein complexes, which translates to a higher throughput of proton pumping and ATP synthesis.* *Understanding the intermembrane space is key to unlocking how mitochondria generate cellular energy. At its core is a section of potential energy—building up a "reservoir" of protons to drive the molecular machinery of ATP synthase.* *To explain the importance of the intermembrane space in maintaining a concentration gradient during the Electron Transport Chain, here are some activities to help in discussing this concept.* ***Option 2.1: Proton Gradient Demo*** • *Students use cups of clear and colored water to demonstrate diffusion, then connect the concept to how mitochondria maintain a proton gradient for ATP production.* ***Option 2.2: The Dam and Reservoir*** • *Students compare a dam diagram to mitochondrial cristae, mapping high pressure, ATP synthase as the turbine, and predicting what happens if the "dam" leaks.* *The teacher will discuss how the electron transport chain pumps protons across the inner mitochondrial membrane, creating an electrochemical gradient. As protons flow back through ATP synthase, the stored gradient energy helps drive ATP production.* *Use the link for guided procedure and rubric for each activity: https://tinyurl.com/Q2Bio1LA7*	*manipulative-based demonstration, guided inquiry/discussion, and conceptual visualization to strengthen understanding.* ***Note to Teacher for Option 1.1:*** *The teacher should clearly connect the analogy to real mitochondrial structures, emphasize that ETC proteins and ATP synthase are membrane-bound, and guide learners to articulate how increased surface area leads to more efficient energy production.* ***Note to Teacher for Option 1.2:*** *The teacher should explicitly link the folded paper to cristae, emphasize that more surface area allows more ETC proteins and ATP synthase, and guide learners to infer that a smooth inner membrane would significantly reduce ATP production efficiency.* *-- These activities build learners' understanding of the proton gradient and chemiosmosis in ATP production by making abstract electrochemical concepts visible through demonstrations and analogies. They reflect IDF principles by being learner-centered, hands-on, accessible, and meaningful, using simple materials and familiar systems to support diverse learners. The 2C-2I-1R approach is evident in collaboration (group experimentation and discussion), constructivist meaning-making from concrete or real-world comparisons, inquiry through guide questions on gradients, diffusion, and leaks, integration of mitochondrial structure, membrane function, and ATP synthesis, and reflection on consequences of losing the gradient. Pedagogically, they employ demonstration-based learning, analogical reasoning, visual scaffolding, guided inquiry, and formative assessment to deepen conceptual understanding.* ***Note to Teacher for Option 2.1:*** *The teacher should clearly explain the limits of the water analogy, emphasize that the inner membrane's impermeability is critical for maintaining the electrochemical gradient, and reinforce that without this gradient, ATP synthase cannot function efficiently.*

		Note to Teacher for Option 2.2: *The teacher should clearly explain the limits of the analogy, emphasize the role of the inner mitochondrial membrane in maintaining the electrochemical gradient, and carefully guide learners to understand how uncoupling disrupts ATP production rather than stopping electron transport entirely.*
	B.3. Developing Mastery	
	The teacher will reinforce the mastery of the concept through guided activities, practice, explanation, and visualization. Teacher should inform students that activities are opportunities to demonstrate comprehension, not just recall. ***Option 1.1: Mito-Match Cards*** ● *Students match structure cards (cristae, matrix, intermembrane space) with function cards, then take a short quiz to check mastery.* ***Option 1.2: Clay Mitochondrion Model*** ● *Students build a mitochondrion model using recycled materials, label each part, and present their model to the class.* *The teacher will explain that the intermembrane space is small, which allows for a rapid increase in H^+ concentration, and that the electrical charge (the membrane potential) is just as important as the chemical concentration. Select one activity to further understand this concept.* ***Option 2.1: Modeling the Gradient*** ● *Students simulate the buildup of the electrochemical gradient using paper, tokens, and group roles, then connect the activity to ATP synthase function.* *Once the activity is finished, have them hold their paper "membrane" in a zigzag pattern. Ask them if they could fit more tokens on the "intermembrane" side if they had more paper. This visually links the surface area objective from the previous prompt to the gradient activity.* ***Option 2.2: Peebedu Online Simulation***	*-- These activities reinforce learners' understanding of mitochondrial structures and their functions by combining interactive matching with creative model-building. They reflect IDF principles by being learner-centered, inclusive, experiential, and supportive of diverse learners through hands-on engagement and multimodal approaches. The 2C-2I-1R approach is evident in collaboration (peer interaction, group model-building), constructivist meaning-making through active linking or creation, inquiry with guide questions on structure and function, integration of organelle form with respiration processes, and reflection on challenges or design choices. Pedagogically, they employ matching strategies, active recall, model-based and project-based learning, guided questioning, and formative/performance assessment to deepen conceptual mastery.* ***Note to Teacher for Option 1.1:*** *The teacher should observe which pairings cause difficulty, emphasize the role of the intermembrane space in proton gradient formation, and use quiz results to determine whether reteaching or enrichment is needed.* ***Note to Teacher for Option 1.2:*** *The teacher should emphasize accuracy over artistic detail, guide learners in clearly representing cristae and the matrix, ensure proper labeling, and use presentations to assess both conceptual understanding and scientific communication skills.* *-- These activities deepen learners' understanding of the proton gradient, electron transport chain, and ATP*

	Students use the Peebedu ETC simulator to test variables like oxygen and fuel supply, observe ATP production, and record results. *Teacher will wrap up the discussion by connecting the concept of surface area to yield ATP by asking if we had fewer cristae folds, it would be like having fewer pumps in this simulation. How would that decrease the 'maximum speed' of our ATP counter?* *Use the link for guided procedure and rubric for each activity: https://tinyurl.com/Q2Bio1LA7*	*synthesis by making invisible biochemical processes tangible through physical modeling and interactive simulation. They reflect IDF principles by being learner-centered, experiential, flexible, and accessible, engaging diverse learners through tactile, visual, and digital modes. The 2C-2I-1R approach is evident in collaboration (group roles, peer discussion), constructivist meaning-making from modeling or simulation, inquiry through prediction, variable manipulation, and guided questions, integration of membrane structure, electron transport, ATP synthase, and real-world implications, and reflection on outcomes such as resistance, directionality, or gradient collapse. Pedagogically, they employ model-based learning, simulation-based learning, guided inquiry, predict-observe-explain strategies, and formative assessment to strengthen conceptual understanding.* ***Note to Teacher for Option 2.1:*** *The teacher should clearly frame the limits of the model, emphasize that resistance represents both concentration and electrical forces, ensure all learners actively participate, and explicitly connect the release of the gradient through the "slit" to ATP synthesis, reinforcing that without a stored gradient, ATP production cannot occur.* ***Note to Teacher for Option 2.2:*** *The teacher should ensure students make predictions before changing variables, guide them in interpreting simulation results rather than focusing on numbers alone, and explicitly connect reduced oxygen, damaged cristae, and gradient loss to decreased ATP production and chronic fatigue.*
C. Demonstrating Knowledge and Skills	***C.1. Finding Practical Application***	
	The teacher will explain that classroom ideas are better understood when they are connected to real-life experiences. ***Option 1.1: Quick Move, Quick ATP*** ● *Students do a short march in place, record breathing and effort, then complete a diagram linking mitochondrial structures (cristae, ETC, ATP synthase, intermembrane space) to ATP production.*	*-- These activities highlight how mitochondrial structure supports efficient ATP production, whether during rapid energy demands or through cristae folding that enhances surface area and gradient strength. They reflect IDF principles by being learner-centered, inclusive, flexible, and cognitively engaging, offering options for physical participation, data analysis, or structured peer discussion. The 2C-2I-1R approach is evident in collaboration (shared observation, peer*

	Teacher explains the following idea from the activity: ● *Our slight increase in breathing during the micro-burst reflects higher ATP demand, which requires more electron transfer along the ETC on the inner mitochondrial membrane (cristae).* ● *As the ETC pumps H^+ into the intermembrane space, the electrochemical gradient increases.* ● *When H^+ flows back through ATP synthase, the cell produces more ATP to meet demand.* ● *When the cristae increase surface area, more ETC complexes and ATP synthase can operate simultaneously, raising ATP output.* ***Option 1.2: Think-Pair-Share approach*** ● ***Think:*** *Have students write down their explanation for why "folding = power."* ● ***Pair:*** *Have them explain their reasoning to a partner, specifically using the terms surface area, protein density, and electrochemical potential.* ● ***Share:*** *Bring the group together to compare their explanations. Correct any misconceptions—specifically, ensure they understand that the folding itself doesn't make ATP, but provides the necessary real estate for the machinery that does.* *Use the link for guided procedure and rubric for each activity: https://tinyurl.com/Q2Bio1LA7* *The teacher clarifies that folding is a passive structural requirement. It is the real estate provided for the enzymes that perform the work. Without the folding, the cell lacks the surface area to house enough pumps to maintain a strong electrochemical gradient.* *If the intermembrane space is "leaky," the energy usually captured as ATP is instead released as heat, because the gradient cannot be maintained.* ***Option 2.1: The Uncoupler Investigation*** *Students analyze a scenario where cyanide binds to a component of the electron transport chain, preventing electrons from being passed to oxygen. They debate or write about what*	*explanation), constructivist meaning-making from bodily responses or articulated reasoning, inquiry through guide questions and analogies on ATP demand and gradients, integration of structure–function relationships with bioenergetics and physiological responses, and reflection as learners clarify misconceptions or explain component interactions. Pedagogically, they employ experiential learning, think-pair-share, structure–function mapping, conceptual explanation, analogical reasoning, and formative assessment to deepen understanding.* ***Note to Teacher for Option 1.1:*** *The teacher should ensure safety and inclusivity, guide learners to focus on immediate ATP regulation rather than long-term fatigue and reinforce that increased cristae surface area allows more ETC complexes and ATP synthase to operate simultaneously, enabling quicker ATP output.* ***Note to Teacher for Option 1.2:*** *The teacher should emphasize that folding is a passive structural feature that provides "real estate" for ETC complexes and ATP synthase, ensure correct use of key terms (surface area, protein density, electrochemical potential), and guide learners to connect reduced cristae folding with lower ATP output in high-energy tissues.* *-- The Uncoupler Investigation activity targets learners' understanding of the critical role of the proton gradient and the integrity of the intermembrane space in efficient ATP production during cellular respiration. It reflects IDF principles by being learner-centered, intellectually engaging, and conceptually inclusive, as students analyze a real-world biochemical scenario and express understanding through debate or written explanation rather than physical performance. The activity applies the 2C-2I-1R approach through group discussion and argumentation (collaborative), construction of understanding by reasoning through a cause-and-effect scenario (constructivist), inquiry prompted by the central question about energy fate when ATP synthesis is disrupted (inquiry-based),*

	happens when oxygen is present but cannot be used, focusing on how ATP production halts, energy is trapped in reduced electron carriers, and why this leads to cellular failure. The teacher explains why the structure matters. *The physical confinement of the intermembrane space is essential. If the protons were dispersed throughout the entire cell, the concentration gradient would never become steep enough to drive the mechanical rotation of ATP synthase.* *Use the link for guided procedure and rubric for each activity: https://tinyurl.com/Q2Bio1LA7*	*integration of mitochondrial structure, electron transport, and energy transformation concepts (integrative), and reflection as learners reconcile continued oxygen consumption with reduced ATP output. Pedagogically, it uses case-based learning, conceptual debate, and guided explanation to deepen understanding of chemiosmosis.* ***Note to Teacher for Option 2.1:*** *The teacher should emphasize that uncouplers divert energy into heat rather than ATP, clarify that oxygen use alone does not guarantee ATP production, and reinforce that the confined intermembrane space is essential for building a steep proton gradient capable of driving ATP synthase.*
	C.2. Making Generalization	
	Teacher will stress the importance of seeing the "big picture" and recognizing that all structures work together for efficient energy production. ***Option 1: Mitochondria Connections Map*** ● *Students create a concept map linking mitochondrial structures (cristae, intermembrane space, matrix) to their functions in ATP production, then share with the class.* ***Option 2: Finish the Logic Chain*** ● *Students complete incomplete logic chains that connect mitochondrial structure → process → function, then post and compare answers with the class.* ***Option 3: If One Part Fails…*** ● *Students fill in a three-column chart predicting ATP production effects when cristae, intermembrane space, or matrix are damaged, then discuss as a class.* *Use the link for guided procedure and rubric for each activity: https://tinyurl.com/Q2Bio1LA7*	*-- These activities strengthen learners' ability to explain and analyze the structure–function relationship of mitochondria by organizing, sequencing, and predicting how parts contribute to ATP production. They reflect IDF principles by being learner-centered, inclusive, creative, and scaffolded, supporting diverse learners through visual mapping, structured prompts, and prediction charts. The 2C-2I-1R approach is evident in collaboration (peer sharing, small-group comparison), constructivist meaning-making through concept maps, logic chains, or hypothetical reasoning, inquiry via guide questions and scenario prompts, integration of mitochondrial structures with bioenergetic processes, and reflection on crucial structures or predicted failures. Pedagogically, they employ concept mapping, guided reasoning, scenario-based learning, conceptual scaffolding, and formative assessment to reveal depth of understanding and strengthen scientific explanation skills.* ***Note to Teacher for Option 1:*** *The teacher should guide learners to focus on clear and accurate connections rather than artistic detail, ensure key relationships (cristae–surface area–ATP; intermembrane space–proton gradient) are explicitly shown, and use student maps to identify*

		misconceptions and reinforce correct structure–function links. ***Note to Teacher for Option 2:*** *The teacher should encourage precise scientific language in each step, guide learners to avoid vague links, and use differences among group answers as opportunities to reinforce accurate reasoning about how surface area and proton gradients directly enable ATP synthase to function.* ***Note to Teacher for Option 3:*** *The teacher should guide learners to justify predictions using scientific reasoning, emphasize that loss of cristae folding and proton gradients severely limits ATP output, and synthesize responses to clearly highlight how mitochondrial structure is essential for efficient cellular energy production.*
	C.3. Evaluating Learning	
	To demonstrate learning of the students, teacher will guide the students in some activities to clarify misconceptions of the lesson. ***Option 1: Mitochondria Role-Play Simulation*** ● *Students act out roles of mitochondrial structures and molecules while the teacher narrates the Electron Transport Chain, showing how electrons, protons, and ATP synthase interact to produce ATP.* ***Option 2: Surface Area Challenge: Design the Best Cristae*** ● *Groups fold and modify paper to maximize surface area, measure results, and explain how more folds allow more ETC proteins and ATP synthase to operate.* ***Option 3: Proton Gradient in a Bottle*** ● *Students compare bottles with different concentrations, drip colored water to show diffusion, and connect the demonstration to how mitochondria maintain a proton gradient for ATP production.* *Use the link for guided procedure and rubric for each activity:*	*-- These activities make mitochondrial processes—electron transport, cristae folding, and proton gradients—tangible through role-play, design challenges, and hands-on demonstrations. They reflect IDF principles by being learner-centered, inclusive, concrete, and engaging, supporting diverse learners through movement, modeling, and accessible materials. The 2C-2I-1R approach is evident in collaboration (group role-play, design, shared observation), constructivist meaning-making from physical enactment or modeling, inquiry through guide questions and problem-solving about gradients, efficiency, and diffusion, integration of structure, molecular movement, and ATP synthesis, and reflection during debriefs or predictions about structural changes. Pedagogically, they employ role-play simulation, design-based learning, model-based instruction, demonstration-based learning, analogical reasoning, guided inquiry, and formative assessment to strengthen conceptual understanding.*

	https://tinyurl.com/Q2Bio1LA7 *Teacher may use ESRU routine to check understanding of the lesson:* *Elicit—Ask learners to explain how cristae and the intermembrane space affect ATP production. Student Response—Learners answer orally, in writing, or through a labeled diagram.* *Recognize—Check whether learners link surface area and proton gradient correctly.* *Use—If learners focus only on 'folding' without function, reteach using the inner-membrane/ATP synthase explanation and give one follow-up item.*	***Note to Teacher for Option 1:*** *The teacher should clearly explain each role beforehand, manage classroom movement for safety and clarity, and explicitly connect each acted role to its real biological function to reinforce accurate understanding of how ATP synthase depends on the coordinated action of all mitochondrial components.* ***Note to Teacher for Option 2:*** *The teacher should emphasize that folding increases functional "real estate" without increasing volume, guide students to relate their paper models directly to biological membranes and synthesize group explanations to reinforce why extensive cristae folding is essential for efficient cellular energy production.* ***Note to Teacher for Option 3:*** *The teacher should clearly explain the limits of the liquid analogy, emphasize that the inner mitochondrial membrane restricts proton movement, and reinforce that without a maintained gradient in the intermembrane space, ATP synthase cannot produce ATP efficiently.*
	C.4. Additional Activities	
	These enrichment activities are meant to reinforce, extend, and clarify learning. ***Option 1: Label & Justify*** ● *Students label an unlabeled mitochondrion diagram and write short explanations of each part's function in ATP production, focusing on cristae folding and the proton gradient in the intermembrane space.* ***Option 2: Cause-and-Effect Card Analysis*** ● *Groups receive scenario cards describing changes to mitochondrial structures, predict effects on ATP production, and share reasoning with the class. Examples:* o *"Cristae become smooth and lose folds."* o *"Protons leak out of the intermembrane space."* o *"ATP synthase is reduced in number."* o *"Inner membrane surface area doubles."*	*-- These activities strengthen learners' mastery of mitochondrial structure–function relationships and their ability to explain, analyze, and recall how parts contribute to ATP production. They reflect IDF principles by being learner-centered, structured, scaffolded, and inclusive, ensuring equitable engagement through diagrams, scenario cards, and short written responses. The 2C-2I-1R approach is evident in collaboration (teacher feedback, group discussion, class comparison), constructivist meaning-making through labeling, linking, or reasoning about hypothetical changes, inquiry via justification prompts and probing questions, integration of mitochondrial anatomy with electron transport, gradients, and chemiosmosis, and reflection on consequences of structural failure or clarity of explanations. Pedagogically, they employ diagram-based assessment, explanatory writing, cause-and-effect analysis, scenario-based learning,*

	Option 3: Short Explanation ● *Tell students they have 3 minutes to answer all three items concisely.* ● *Display/write the following prompts:* 1. *Identify and describe the function of two major parts of the mitochondrion.* 2. *Explain how the folding of the cristae increases ATP production.* 3. *Explain why maintaining a proton gradient in the intermembrane space is important.* ● *Students write 2–4 sentence explanations for each.* ● *Collect for checking; this evaluates depth of understanding and recall.* *Guide Questions:* 1. *Did you clearly explain both the structure AND its function?* 2. *Did your explanation describe how surface area affects ATP?* 3. *Did you mention the role of protons, gradients, or ATP synthase?* 4. *Are your explanations accurate and complete?* *Use the link for guided procedure and rubric for each activity:* *https://tinyurl.com/Q2Bio1LA7*	*retrieval practice, conceptual scaffolding, and formative evaluation to check and deepen conceptual understanding.* ***Note to Teacher for Option 1:*** *The teacher should emphasize clarity and scientific accuracy in explanations, look for correct cause-and-effect reasoning (especially for cristae folding and proton gradient maintenance), and use student responses to identify misconceptions that may require reinforcement or reteaching.* ***Note to Teacher for Option 2:*** *The teacher should encourage learners to justify predictions using clear scientific reasoning, emphasize the central role of cristae folding and proton gradients in ATP synthesis, and use group responses to identify misconceptions and reinforce accurate structure–function relationships.* ***Note to Teacher for Option 3:*** *The teacher should emphasize concise but accurate scientific language, look for explicit links between structure and function (especially cristae folding and proton gradients), and use student responses to identify areas needing reinforcement or enrichment.*
V. ASSESSMENT *(Assessing Learnings)*	***Summative Assessment*** *Directions: Choose the letter of the correct answer.* *1. Which part of the mitochondrion contains the enzymes for the Krebs cycle?* *a. Cristae* *c. Matrix* *b. Intermembrane space* *d. Outer membrane* *2. The highly folded inner membrane increases ATP production by—* *A. The highly folded inner membrane increases ATP production by storing more glucose.* *B. The highly folded inner membrane increases ATP production by allowing more DNA replication.* *C. The highly folded inner membrane increases ATP production by making the mitochondrion lighter.* *D. The highly folded inner membrane increases ATP production by increasing the surface area for ETC proteins.* *3. What is the function of the intermembrane space?* *A. The function of the intermembrane space is to provide storage of ATP.* *B. The function of the intermembrane space is to provide storage of ribosomes.* *C. The function of the intermembrane space is to serve as the site of glycolysis.* *D. The function of the intermembrane space is to act as the space where the proton gradient builds.* *4. 4. ATP synthase is embedded in the—* *a. Outer mitochondrial membrane* *b. Inner mitochondrial membrane* *c. Matrix* *d. Nucleus*	

	5. Which statement best describes the relationship between structure and function? *a. Folds are unrelated to ATP* *b. Fewer folds produce more ATP* *c. More folds produce less ATP* *d. More folds increase efficiency of ATP production* *6. The electron transport chain occurs primarily in the—* *a. Cytoplasm* *b. Inner mitochondrial membrane* *c. Matrix* *d. Ribosomes* *7. What would happen if the intermembrane space could no longer maintain the proton gradient needed for oxidative phosphorylation?* *a. Photosynthesis would increase* *b. DNA replication would accelerate* *c. Glycolysis would move into the mitochondrion* *d. ATP production by oxidative phosphorylation would drop sharply* *8. Why is the inner mitochondrial membrane more directly involved in ATP production than the outer membrane?* *a. It contains DNA* *b. It performs glycolysis* *c. It stores glucose* *d. It contains ATP synthase and ETC complexes* *9. Which structure is MOST responsible for maximizing ETC efficiency?* *a. Cristae* *b. Lysosome* *c. Matrix* *d. Outer membrane* *10. In cellular respiration, ATP is produced when—* *a. Oxygen enters the cytoplasm* *b. Glucose leaves the mitochondria* *c. Water is pumped into the matrix* *d. Protons flow through ATP synthase* ***ANSWER KEY*** *1 – c; 2 – d; 3 – d; 4 – b; 5 – d; 6 – b; 7 – d; 8 – d; 9 – a; 10 – d*
VI. REFLECTION *(Feedback and Continuous Improvement)*	*Reflect on learners' performance, determine which activities and lesson parts were most and least effective, identify learners who need enrichment or remediation, analyze the assessment results, and note possible improvements to enhance future lesson delivery.* ● *How many learners successfully demonstrated the learning objectives based on the assessment results?* ● *Which activity helped learners understand the lesson the most? Which activity helped the least?* ● *Which part of the lesson was easiest for learners? Which part was most difficult?* ● *How many learners needed enrichment or additional challenge? How many learners needed remediation or additional support?* ● *What did the assessment results show about learners' understanding of the lesson?* ● *What improvement would you make if you taught this lesson again?*
VII. USE OF GENERATIVE AI	In preparing this Learning Exemplar (LE), the author(s) used Copilot in order to assist in refining scientific accuracy, alignment, and language clarity. The author(s) reviewed and finalized the writing of the content. The author(s) take(s) full responsibility for the content of this LE.

Lesson Title/Topic	Metabolism- Respiration	Lesson Exemplar	19

I. OBJECTIVES	
A. Content Standard	This section presents the key understanding of the essential concepts that cell respiration is the chemical reaction that converts chemical energy into usable forms of energy.
B. Performance Standard	The learners will apply their knowledge on chemical energy which is converted to useful forms of energy for the functioning of the body. The learners will create an infographic, poster, narrated slide deck, or short video that compares aerobic and anaerobic respiration in terms of major steps, location, ATP yield, byproducts, and one real-life application for each. Learners will create culminating product such as an infographic, case explanation, or mini-investigation with rubric criteria **Minimum criteria:** - correct pathway sequence - correct ATP comparison - correct byproducts - one human-body example - one food/biotechnology example - explanation using accurate scientific vocabulary
C. Learning Competencies	***Prerequisite Knowledge and Skills*** Prior to lesson objectives have a description of the assumed prior knowledge and skills that learners have acquired in the previous grade level(s), which are essential for their successful engagement with the current lesson. These assumptions can also serve as a basis for designing diagnostic assessments. The learners are expected to differentiate between aerobic and anaerobic respiration, including their steps, ATP production, and byproducts;
II. REFERENCES and MATERIALS (*Selecting Resources and Material*)	*Alberts, Bruce, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter. Molecular Biology of the Cell. 4th ed. New York: Garland Science, 2002.* *Clark, Mary Ann, Jung Choi, and Matthew Douglas. Biology 2e. Houston, TX: OpenStax, 2018.* *Melkonian, Edward A., and Jessica A. Asprer. "Biochemistry, Anaerobic Glycolysis." In StatPearls. Treasure Island, FL: StatPearls Publishing, 2023.* *Robergs, Robert A., Farzenah Ghiasvand, and Darrell Parker. "Biochemistry of Exercise-Induced Metabolic Acidosis." American Journal of Physiology-Regulatory, Integrative and Comparative Physiology 287, no. 3 (2004): R502–R516.* *Rabago, Lilia M., Joaquin, Crescencia C., Lagunzad, Catherine Genevieve B.and Carvajal, Josefina C. Functional Biology.2003 .281-284*

	Urry,Lisa A.,Cain, Michael L.,Wasserman, Steven A. , Minorsky, Peter V. and Orr, Rebecca B. Campbell Biology (12th Ed.) *https://chemistry.com.pk/books/campbell-biology-12e/* *E-sources*: *https://www.sciencefacts.net/alcoholic-fermentation.html* *https://www.dreamstime.com/lactic-acid-fermentation-process-scheme-labeled-vector-illustration-diagram- biological-stages-glucose-pyruvate-lactate-image169878458* *https://byjus.com/biology/cellular-respiration-concept-map/*
III. CONTENT *(Sequencing Content)*	Metabolism- Respiration
IV. OBJECTIVES *(Setting Clear Objectives and Analyzing the Tasks)*	1. Differentiate anaerobic from aerobic respiration in terms of major steps; 2. Differentiate aerobic from anaerobic respiration in terms of ATP production 3. Distinguish aerobic and anaerobic respiration in terms of byproducts.

IV. PROCEDURES		**ANNOTATIONS**
A. Activating Prior Knowledge	**A.1. Activating Prior Knowledge**	
	Activity 1: The "Wall Sit Challenge" Materials: Stopwatch and a wall The Activity Divide the class into two groups (or have anyone participated simultaneously) Phase 1 – THE EASY BREATH Have students stand comfortably and take deep, slow breaths for 30 seconds. Ask : "How do your muscles feel? Do you think that you could do this all day? Phase 2-THE BURN Note to Teacher: Safety Note: Ask learners about asthma, recent injury, dizziness, heart-related concerns, or other medical conditions before participation. Those who should not participate may serve as observers and record breathing pattern, posture, and signs of fatigue during a peer or teacher demonstration. 1. Have students perform the Wall Sit (back against the wall, knees at a 90-degree angle) for as long as they can hold.	**Annotation for Activity 1** The "Wall Sit Challenge" activity targets physical awareness, endurance, and self-regulation by guiding students through breathing exercises and sustained wall sits while encouraging reflection on muscle sensations. It embodies IDF principles of inclusivity, engagement, active learning, and reflection, as students are allowed to observe if medically restricted and are prompted to think critically about their physical state. The 2C-2I-1R approach is evident through clear content (breathing and wall sit), context (classroom setting), integration (linking physical exertion with reflection), interaction (group participation), and reflection (teacher-led questioning). Pedagogically, it applies experiential learning, guided practice, questioning, and challenge-based learning to foster motivation and awareness. Teachers should ensure proper warm-up, monitor posture, encourage hydration, provide alternatives for non-participants, and

	Precautionary Statement for Teachers If you have any pre-existing medical conditions (such as cardiovascular, respiratory, or musculoskeletal concerns), **do not attempt intense physical demonstrations yourself**. Instead, use the alternative option: show a short video clip or conduct a light demonstration that does not strain your body. Always prioritize your health and safety. Alternative Option: Learners will watch a short teacher demonstration or video of intense exercise, then analyze the observed breathing pattern, fatigue, and likely energy pathway used. This activity is designed for student observation and analysis, so the learning objectives can be fully achieved through **watching and discussing** rather than performing. Ensure that demonstrations are safe, controlled, and adapted to your personal health needs. Transition: Explain that when muscles receive enough oxygen, cells favor aerobic respiration; when energy demand rises faster than oxygen delivery, cells rely more on anaerobic pathways for short periods.	emphasize listening to one's body to maintain safety and inclusivity. Note to Teacher : The teacher may also use Activity 2:Observation which may be accessed through this link https://docs.google.com/document/d/1uO7AyMftQjJBoyonOtgb14Makqz3EvkF/edit#heading=h.9ewo7umf2p6
	A.2. Establishing the Purpose of the Lesson	
	Activity 1: The "Balloon and Yeast" Race (Demonstration) The class will be divided into 5 groups Setup: Put warm water, sugar and yeast in a plastic bottle. Stretch a balloon over the top. The teacher may give the following guide questions before performing the activity. 1. Observe the bubble formation. Until when or how long the bubble formation lasted? 2. Did the rate of bubble formation the same throughout the experiment?	**Annotation for Activity 1** The "Balloon and Yeast Race" demonstration helps students understand fermentation and anaerobic respiration by observing bubble formation and balloon inflation when yeast metabolizes sugar without new air. It targets learning objectives of recognizing gas production (carbon dioxide), comparing aerobic and anaerobic processes, and linking scientific concepts to observable phenomena. The IDF principles of engagement, inquiry, and reflection are evident, as students actively observe, analyze, and connect the experiment to prior knowledge. The 2C-2I-1R approach is applied through

	After the demonstration, the teacher will ask the following hook question: 1. If the yeast is "trapped in the bottle without new air , why is the balloon inflating? 2. Is this similar to what you have studied previously on aerobic respiration? Guide Questions: 1. What visible evidence shows that yeast is metabolizing sugar? 2. What gas is likely inflating the balloon? 3. Why does this setup model an anaerobic condition for yeast after the available oxygen is used up? 4. Why must the balloon fit tightly around the bottle neck with no air leak in the bottle-balloon setup? 5. How would a leak affect your interpretation of gas production and fermentation? 6. Based on the setup, what variables could be changed to test how fermentation rate is affected?	content (yeast experiment), context (group demonstration), integration (connecting biology concepts to real-life fermentation), interaction (group observation and guided questioning), and reflection (hook questions bridging to respiration). Pedagogically, it uses demonstration-based teaching combined with inquiry learning, encouraging students to discover scientific explanations through guided observation. Teachers should ensure safety in handling yeast and bottles, manage group participation effectively, and emphasize the connection between the experiment and cellular respiration to deepen conceptual understanding. Note to Teacher: Teacher may use the marking rubric for the Activity1 which may be accessed through this link https://docs.google.com/document/d/1BCdS9ZVv-P2i0eD6-xMQ4yHjA3OWf0sB/edit Note to Teacher: Teacher may also consider Activities 2 and 3 with marking rubrics which can be accessed through this link https://docs.google.com/document/d/1yQdW9TaxFiiA4GHKL-gNb8XZM9ZhuuMh/edit
B. Instituting New Knowledge	**B.1. Presenting Examples**	
	Here are some relatable experiential examples that students can feel, smell or see in their everyday lives. Cellular respiration consists of a series of chemical reactions, which happen very fast. It uses up oxygen and releases carbon dioxide. 1.Aerobic Respiration: Aerobic respiration is like a slow-burning candle. It is efficient, steady and requires a constant "breeze" of oxygen to keep the flame going. It is the highly efficient metabolic process by which cells break down glucose in the presence of oxygen to produce energy in the form of ATP, releasing carbon dioxide and water as waste. 1.1The Hiking or Walking Experience -think about when you are walking to school or hiking a trail. You can talk comfortably with a friend while moving. Explanation : Because your movement is moderate ,your lungs can supply enough oxygen to your mitochondria. They are performing all three major steps (Glycolysis – Krebs Cycle- ETC)	**Annotation** The experiential examples of aerobic and anaerobic respiration aim to move biological concepts from textbook theory into sensory, relatable experiences that students can feel, see, or smell. They target learning objectives of distinguishing aerobic respiration's efficiency and steadiness from anaerobic respiration's short-term energy bursts, while connecting these processes to everyday activities like walking, sleeping, sprinting, carrying groceries, or noticing fermentation in fruit. The IDF principles of engagement, integration, and reflection are evident, as students link scientific ideas to real-life contexts and reflect on their own bodily sensations. The 2C-2I-1R approach is applied through content (respiration processes), context

	to give you a massive and steady supply of 36-38 ATP. Aerobic respiration produces far more ATP than anaerobic respiration, making it more efficient for sustained activity. Aerobic respiration produces far more ATP than anaerobic pathways. In many school-level models, it is presented as about 36–38 ATP per glucose. 1.2The Sleep and Recovery" State -Even when you sleep, your body is purely aerobic. Explanation: Your body is using oxygen to slowly "burn" stored fats and sugars to keep your organs functioning and repair tissues. 2.Aerobic Respiration: The Emergency Turbo **2.1 The Missed Jeepney/Bus Sprint** Imagine you see your ride pulling away and you sprint at full speed for about 20 seconds to catch it.**What do you feel?** Your muscles demand energy faster than your cardiovascular and respiratory systems can deliver oxygen. **Explanation:** During this short burst of intense activity, oxygen supply becomes insufficient to meet the muscles' immediate energy needs. Cells continue glycolysis to rapidly generate ATP, but because oxygen is limited, pyruvate is diverted into fermentation pathways. This regenerates NAD^+, allowing glycolysis to continue briefly, though with much lower efficiency compared to aerobic respiration.The result is the accumulation of metabolic byproducts such as lactate, which contributes to the burning sensation in your muscles. After the sprint, you experience an **oxygen debt**—your body must increase breathing (panting) to restore oxygen levels, clear lactate, and repay the deficit created during anaerobic activity. **2.2 The Heavy Grocery Carry Challenge** You try to carry all the heavy grocery bags from the car to the kitchen in one trip. Describe your feeling?	(daily life scenarios), integration (bridging science with lived experience), interaction (teacher-led discussion and student sharing), and reflection (students analyze oxygen's role and lactic acid buildup). Pedagogically, it uses analogy-based teaching and experiential learning, making abstract processes concrete and memorable. Teachers should ensure clarity in connecting each analogy to the scientific principle, encourage students to share personal experiences, and emphasize the contrast between aerobic efficiency and anaerobic "emergency turbo" responses.

	Explanation: The squeezed muscles are cutting off blood flow (and oxygen) . Your cells switch to the 1-step anaerobic pathway .It keeps you moving for those last few meters but the lactic acid buildup makes your grip fail. 2.3 The Over-ripe Fruit A sealed bag of grapes or bruised apple that starts to smell sharp or fermented. Describe the experience with what you smell when the change occurred? Explanation: When oxygen becomes insufficient, cells continue glycolysis and may rely on fermentation to regenerate NAD^+ so ATP production can continue briefly. **Activity: Everyday Respiration Scenarios** Analyze each situation and identify whether aerobic respiration or anaerobic pathways are emphasized. (a) Steady walking or hiking at a moderate pace (b) A short, intense sprint to catch a ride (c) Yeast fermentation used for dough rising For each case, explain oxygen availability, main pathway used, approximate ATP yield at the school level, and expected byproducts.	
	B.2. Discussing New Concept	
	The teacher will discuss the anaerobic respiration to the students. Cellular respiration consists of a series of chemical reactions, which happen very fast. Aerobic respiration uses oxygen and includes glycolysis, pyruvate oxidation, the Krebs cycle, and the electron transport chain, producing a much higher ATP yield than anaerobic pathways. When oxygen is unavailable or insufficient for current demand, cells can continue glycolysis if NAD+ is regenerated through fermentation. In alcoholic fermentation, pyruvate is converted to ethanol and carbon dioxide, while in lactic acid fermentation, pyruvate is converted to lactate. In both fermentation pathways, the net ATP obtained per glucose comes only from glycolysis. Aerobic respiration is a type of cellular respiration that uses oxygen to help cells release energy from glucose, producing a high yield of ATP, with carbon dioxide and water as byproducts.	**Annotation** The teacher-led discussion on anaerobic respiration focuses on fermentation as an oxygen-free metabolic pathway, highlighting alcoholic and lactic acid fermentation. It targets learning objectives of distinguishing anaerobic from aerobic respiration, identifying the steps and byproducts of each fermentation type, and understanding their energy yield compared to aerobic respiration. The IDF principles of engagement, inquiry, and reflection are evident, as students are guided through diagrams, flow charts, and probing questions that connect theory to application. The 2C-2I-1R approach is applied through content (fermentation processes), context (classroom discussion with visual aids), integration (linking respiration concepts to

	Two processes are 1. Fermentation -Fermentation is an anaerobic pathway that allows glycolysis to continue by regenerating NAD+ when oxygen is unavailable. It is a form of anaerobic respiration carried out by certain bacteria and other organisms such as yeast. In this process the reduced compounds NADH generated in glycolysis are oxidized through dehydrogenation reactions. This form of respiration releases much less energy than aerobic respiration. It is however important for the retention of NAD + without going through the electron transport chain. There are two types of fermentation namely: 1.Alcoholic fermentation – as a specialized anaerobic (oxygen-free) metabolic pathway used primarily by yeasts and some bacteria such as Zymomonas mobilis (ethanol-producing bacterium) and Sarcina ventriculi (bacterium -producing ethanol and CO_2). It is a biological bypass that allows cells to continue producing energy when their mitochondria are shut down to a lack of oxygen. (Teacher will elaborate the process of alcoholic fermentation using the flow chart below which may be accessed through this link https://docs.google.com/document/d/1z3jUcQkPpltCWTrrpMclLxw-6hqMxKWn/edit#heading=h.8pujimsur8bb 2.Lactic acid fermentation – is defined as an anaerobic metabolic pathway where pyruvate is reduced directly by NADH to form lactate as an end product, with no release of CO_2. In lactic acid fermentation, pyruvate is reduced to lactate and NADH is oxidized back to NAD+, allowing glycolysis to continue. This process is the “survival mode” for the human muscle cells during intense exercise and the primary method used by certain bacteria to produce dairy products like yogurt. Lactobacillus is a primary genus of bacteria that performs lactic acid fermentation. (Teacher may elaborate the process of lactic acid fermentation using the diagram found through this link https://docs.google.com/document/d/1z3jUcQkPpltCWTrrpMclLxw-6hqMxKWn/edit#heading=h.8pujimsur8bb In both lactic acid fermentation and alcoholic fermentation, the cell gains a net of 2 ATP per glucose from glycolysis; fermentation mainly regenerates NAD+ so glycolysis can continue. Ask the following questions:	microbial activity and human muscle function), interaction (teacher questioning and student responses), and reflection (students compare similarities and differences with aerobic respiration). Pedagogically, it uses direct instruction combined with inquiry-based learning, encouraging students to analyze processes and outcomes critically. Teachers should emphasize clarity in explaining the reduced ATP yield, ensure students grasp the role of NAD^+ regeneration, and connect fermentation to real-world examples such as yeast in baking and lactic acid buildup in muscles.

1.Identify the major steps in alcoholic fermentation and lactic acid fermentation.
2.Differentiate the two anaerobic processes- alcoholic fermentation and lactic acid fermentation.
3. Are there similarities between alcoholic fermentation and lactic acid fermentation?
4. How many ATP produced in alcohol fermentation? in lactic acid fermentation?
5. What are the byproducts of alcoholic fermentation? lactic acid fermentation? Can you cite some differences?
6.How do aerobic and anaerobic respiration differ from each other in terms of major steps? ATP production? Byproducts?
7. Are they similar to the major stages of aerobic respiration previously discussed?

B.3. Developing Mastery

Activity 1: Complete Me Activity

Compare Aerobic and Anaerobic Respiration
Complete the table below using the following features: oxygen requirement, location, major steps, ATP yield, efficiency, and byproducts. After completing the table, write two to three sentences explaining why aerobic respiration is generally more efficient than anaerobic pathways.

Feature	Aerobic Respiration	Anaerobic respiration
Presence of Oxygen		
Location		
Major Steps		
Byproducts		
ATP Production / Efficiency / ATP Yield		

Annotation for Activity 1

The "Complete Me" activity strengthens students' comparative understanding of aerobic and anaerobic respiration by requiring them to fill in a structured table on oxygen presence, location, major steps, byproducts, and ATP yield. It targets learning objectives of clearly distinguishing the two processes, reinforcing knowledge of cellular respiration, and practicing analytical organization of scientific information. The IDF principles of engagement, integration, and reflection are evident, as students actively recall prior lessons, connect them to a structured framework, and reflect on differences in efficiency and outcomes. The 2C-2I-1R approach is applied through content (respiration features), context (table completion in class), integration (linking scientific concepts to comparative analysis), interaction (teacher guidance and peer discussion), and reflection (students evaluate efficiency and byproducts). Pedagogically, it uses comparative analysis and structured learning strategies, encouraging clarity and retention. Teachers should remind students to be precise in their entries, emphasize accuracy in ATP yield and byproducts, and encourage discussion to

		deepen understanding of why aerobic respiration is more efficient than anaerobic pathways. Note to Teacher: To truly differentiate this lesson for Grade 12 learners, you can group students based on their learning styles or readiness levels. This ensures that while everyone is hitting the same objective (differentiating major steps, ATP, and byproducts), they are doing so through a lens that matches their strengths. Note to Teacher: Rubric may be accessed through this link https://docs.google.com/document/d/173XMcRilWRQOencfAwGhReYxYZQ0oBqo/edit Note to Teacher: Teacher may also consider using Activity 2:Essay which can be accessed through this link https://docs.google.com/document/d/14S81A9uHfZHUUKDjq-FSXK49UFWWAimX/edit Note to Teacher: Teacher may also consider using Activity 3:The Metabolic Media Fair which can be accessed through this link https://docs.google.com/document/d/1L1EoUdVbQf0EnQWpPV2_6MsfatXYZow4/edit Note to Teacher: Teacher may also consider using Activity 4:The Universal Assessment (Exit Ticket) which can be accessed through this link https://docs.google.com/document/d/1g2AwtuqJBS-CeRUBVK_sgSgBr-pJPSDb/edit
C. Demonstrating Knowledge and Skills	**C.1. Finding Practical Application**	
	The students will be asked by the teacher on the practical application or real-world application. Guide questions: 1. In what real-life situations do organisms rely on anaerobic pathways?	The practical application activity encourages students to connect their knowledge of anaerobic respiration to real-world scenarios, targeting learning objectives of applying scientific concepts to human physiology and biotechnology. The IDF principles of engagement, integration, and reflection are evident, as students analyze how

	2. How is lactic acid fermentation relevant to human muscle activity and food processing? 3. How is alcoholic fermentation used in bread making and other biotechnology applications? Response Frame: The pathway used is _____. It occurs in _____. It produces about _____ ATP per glucose at the school level, and the main byproduct(s) are _____. This pathway is important in this situation because _____. Possible answers that may be elicited from the students are the following: **1.In human physiology, when you sprint or lift heavy weights, your lungs cannot deliver oxygen fast enough to your muscle cells.** The cells switch to lactic acid fermentation. The cells rely more on anaerobic glycolysis, producing lactate so that glycolysis can continue for a short time when oxygen delivery cannot keep up with demand. The buildup of lactate and the resulting drop in pH contribute to that heavy, burning sensation and temporary muscle fatigue. Once you stop and breathe deeply, your body converts the lactate back into pyruvate or glucose in the liver. During intense exercise, muscles may rely more on anaerobic pathways. The burning sensation is associated with metabolic stress during high-intensity activity and changes linked to rapid energy use; it should not be explained as being caused only by "lactic acid buildup." **2. Biotechnology /Food Science -Certain bacteria such as Lactobacillus, perform this naturally:** 2.1 production of yogurt and cheese- bacteria ferment the lactose (milk sugar) into lactic acid. The acid causes the milk proteins to denature and clump giving yogurt its thick texture and sour taste. 2.2 Pickling – the lactic acid produced by bacteria acts as a natural preservative, preventing the growth of bad bacteria in kimchi and sauerkraut. Application: Identify whether the example illustrates aerobic respiration, lactic acid fermentation, or alcoholic fermentation, and explain your answer using steps, ATP, and byproducts. In this stage learners apply what they have learned to real-life or simulated scenarios, problems, or tasks. This involves transferring knowledge and skills to authentic contexts and this will serve as scaffolding for the performance task.	lactic acid fermentation explains muscle fatigue during sprints or weightlifting, and how bacteria use fermentation in food production like yogurt, cheese, kimchi, and sauerkraut. The 2C-2I-1R approach is applied through content (anaerobic respiration applications), context (classroom discussion with everyday examples), integration (linking cellular processes to human health and food science), interaction (teacher-guided questioning and student responses), and reflection (students evaluate how respiration knowledge applies beyond theory). Pedagogically, it uses inquiry-based learning and contextualization, making abstract processes meaningful through lived experiences and practical examples. Teachers should encourage students to share personal observations, highlight the importance of oxygen debt recovery, and emphasize the role of fermentation in biotechnology to deepen understanding and relevance.
	C.2. Making Generalization	

	Readiness Check: Before the formative assessment, explain in 2–3 sentences how aerobic and anaerobic respiration differ in terms of oxygen use, ATP yield, and byproducts. **Activity 1: Conclusion -Drawing Activity** The teacher may use the following ask learners to draw conclusions or generalizations: Activity 1 Teacher will ask the following questions: 1.Explain anaerobic respiration and its two types namely: 1.1. alcoholic fermentation 1.2. lactic acid fermentation 2.Differentiate aerobic and anaerobic respiration in terms of: 2.1. major steps 2.2. ATP produced 2.3. byproducts **Activity 2: Reflection** Ask the following reflective questions: 1.How important is anaerobic respiration in our survival? 2. How do aerobic respiration differ from anaerobic respiration? 3. What is the importance of aerobic and anaerobic respiration in maintaining life and responding to different energy demands? 4. Do you think we can survive without anaerobic respiration? why or why not? 5. What will likely to happen if anaerobic respiration did not exist as a process? 6. What will likely to occur if aerobic respiration did not exist as a process? 7.Why is anaerobic metabolism useful when oxygen supply cannot keep up with energy demand?	**Annotation for Activity 1** This conclusion-drawing activity helps students synthesize their understanding of respiration by explaining anaerobic respiration and its two types—alcoholic and lactic acid fermentation—while contrasting them with aerobic respiration in terms of steps, ATP yield, and byproducts. It targets learning objectives of reinforcing conceptual clarity, encouraging comparative analysis, and fostering higher-order thinking through generalization. The IDF principles of engagement, inquiry, and reflection are evident, as students respond to guiding questions that prompt them to analyze and differentiate processes. The 2C-2I-1R approach is applied through content (respiration pathways), context (teacher-led questioning and student responses), integration (linking fermentation to aerobic respiration concepts), interaction (discussion and explanation), and reflection (students articulate differences and similarities). Pedagogically, it uses inquiry-based learning and comparative analysis, encouraging students to move beyond memorization toward deeper comprehension. Teachers should ensure students provide accurate details on ATP yield and byproducts, guide them in recognizing the efficiency gap between aerobic and anaerobic respiration, and emphasize real-world relevance to strengthen retention. **Annotation for Activity 2** This reflective questioning activity encourages students to think critically about the importance and essence of aerobic and anaerobic respiration, targeting learning objectives of applying biological concepts to survival, energy production, and real-world relevance. The IDF principles of engagement, inquiry, and reflection are evident, as students are prompted to analyze respiration beyond memorization and consider its necessity for human life. The 2C-2I-1R approach is applied

		through content (respiration processes), context (classroom reflection exercise), integration (linking scientific knowledge to survival and physiology), interaction (teacher-led questioning and student responses), and reflection (students evaluate whether life is possible without anaerobic respiration). Pedagogically, it uses inquiry-based learning and reflective questioning, fostering deeper comprehension and critical thinking. Teachers should encourage open discussion, validate diverse perspectives, and emphasize that while aerobic respiration is more efficient, anaerobic respiration is vital in situations where oxygen is limited, making it essential for survival in both human physiology and microbial processes. Note to Teacher: Teacher may also consider Activity 3: Concept Map which can be accessed through this link : https://docs.google.com/document/d/1fqU2zR1jwNTHtRzMtp63z6e3DeBSE_y8/edit Note to Teacher: Teacher may also consider using the Additional Reflection Prompt which can be accessed through this link : https://docs.google.com/document/d/10fUImb0zY5-y0u1PEXGRI9pNzcyzNyRA/edit
	C.3. Evaluating Learning	
	Activity 1 Teacher Use: Check whether learners correctly distinguish oxygen requirement, location, major steps, ATP yield, and byproducts. Re-teach any criterion that many learners confuse, especially ATP yield and byproducts, before proceeding to the summative assessment. Scoring Guide: 1 point per correct table entry and 3 points for the written explanation, for a total of ____ points.	**Annotation for Formative Assessment 1** The "Summary Comparison" formative assessment reinforces students' understanding of aerobic and anaerobic respiration by requiring them to complete a structured table comparing oxygen use, major steps, location, ATP yield, and byproducts. It targets learning objectives of consolidating knowledge, practicing analytical organization, and clearly distinguishing the two processes. The IDF principles of engagement,

Instruction: Complete a comparison table and write a three-sentence explanation of which pathway is more efficient and why.

Summary Comparison:
Aerobic vs Anaerobic Respiration

Feature	Aerobic Respiration	Anaerobic Respiration
Oxygen		
Major Steps		
Location		
ATP produced /Yield		
Byproducts		

KEY TO CORRECTION
Summary Comparison:
Aerobic vs Anaerobic Respiration

Feature	Aerobic Respiration	Anaerobic Respiration
Oxygen	Required	Not required
Major Steps	Glycolysis- Krebs-ETC	Glycolysis - Fermentation
Location	Cytoplasm + mitochondria	Cytoplasm only
ATP produced /Yield	High (-36-38 ATP)	Low (2 ATP)
Byproducts	CO_2 +H_2O	Lactic acid (in animal cells)or Ethanol + CO_2 (in yeast and some microorganisms)

integration, and reflection are evident, as students actively recall prior lessons, connect them to a comparative framework, and reflect on efficiency and outcomes. The 2C-2I-1R approach is applied through content (respiration features), context (table-based assessment), integration (linking scientific concepts to structured analysis), interaction (teacher guidance and student responses), and reflection (students evaluate differences in energy yield and byproducts). Pedagogically, it uses comparative assessment and structured learning strategies, encouraging clarity, retention, and critical thinking. Teachers should emphasize accuracy in ATP counts and byproducts, guide students to recognize the efficiency gap between aerobic and anaerobic respiration, and use the table as a springboard for deeper discussion.

Note to Teacher : The teacher may also use Formative Assessment 2 which can be accessed through this link https://docs.google.com/document/d/1KQV3-y1ilOszm49Ld9m0ChKNRhjO_tya/edit

C.4. Additional Activities

FOR ENRICHMENT:
The teacher may provide the following activity for the enrichment activity.

Activity 1
The Energy Logic Map
Word Bank: Glycolysis; cytoplasm; mitochondria; Krebs cycle and electron transport chain; lactic acid fermentation; alcoholic fermentation; lactate; ethanol + CO2; 2 ATP; 36-38 ATP.

Annotation for Activity 1

The "Energy Logic Map" enrichment activity deepens students' understanding of cellular respiration by having them place scrambled terms into a concept map skeleton, reinforcing the relationships between aerobic and anaerobic pathways. It targets learning objectives of organizing knowledge, distinguishing oxygen-dependent and oxygen-independent processes, and recognizing ATP yield differences. The IDF

	Direction: Place each term in the correct numbered box, then explain in two sentences how oxygen availability changes the pathway and ATP yield. The Scrambled Word Bank Terms – Lactic acid Mitochondria. Glycolysis, 36-38 ATP, 2 ATP, Ethanol & CO_2, cytoplasm, Krebs cycle & ETC, alcohol fermentation, Lactic acid fermentation The Concept Map Skeleton: The teacher will start here. All respiration begins with (Box 1) which occurs in the (Box 2) 2.The branch: If oxygen is present: the process moves into the (Box 3) to perform the (Box 4). This results in a high energy yield of (Box 5) . If oxygen is absent; the process stays in the cytoplasm and enters anaerobic respiration. 3.The anaerobic sub-branch: In animals /muscles the cell performs box 6 , resulting in the byproducts (Box 7) In yeast /bacteria: the cell performs (Box 8) resulting in the byproduct (Box 9) 4.The low yield of both anaerobic paths is only a total of (Box 10) .	principles of engagement, integration, and reflection are evident, as students actively manipulate terms, connect them to pathway steps, and reflect on energy efficiency. The 2C-2I-1R approach is applied through content (respiration pathways and terms), context (concept map completion), integration (linking glycolysis, fermentation, and mitochondrial processes), interaction (teacher guidance and student collaboration), and reflection (students evaluate why oxygen presence changes outcomes). Pedagogically, it uses concept mapping and problem-solving strategies, encouraging active recall and visual organization. Teachers should emphasize accuracy in placing terms, highlight the efficiency gap between aerobic (36–38 ATP) and anaerobic (2 ATP) respiration, and use the completed maps as a springboard for discussion on real-world applications such as muscle fatigue and fermentation in food science. Note to Teacher: Teacher may use the RUBRIC provided for evaluating the above activity which can be accessed through this link https://docs.google.com/document/d/1UeSuoD7mfHHCQIpqRk6W05AMeCVHWFxH/edit Note to Teacher :The teacher may also consider the remediation activity which may be accessed through this link https://docs.google.com/document/d/1WVLvx-4y4snYegZG7UEKG8ibntnGL7ma/edit
V. ASSESSMENT *(Assessing Learnings)*	**Summative Assessment:** MULTIPLE CHOICE: Read and understand each item carefully. Choose the best answer. 1. Which specific step is common to both aerobic respiration and all types of fermentation? A. Electron Transport Chain B. Glycolysis	

C. The Krebs Cycle
D. Pyruvate Oxidation
Correct answer: **B.Glycolysis**
Explanation: Explanation: Glycolysis occurs in the cytosol and is the common first step shared by aerobic respiration and fermentation pathways.

2. What are the primary byproducts of alcoholic fermentation in yeast cells?
A. Ethanol and CO_2
B. Lactic acid only
C. Lactic acid and CO_2
D. Water and CO_2
Correct answer: **A. Ethanol and CO_2**
Explanation: Yeast enzyme decarboxylate pyruvate to release carbon dioxide and then reduce the remaining fragment to ethyl alcohol or ethanol.

3. Which statement accurately describes the net ATP production per glucose molecule in anaerobic vs. aerobic respiration?
A. Aerobic produces 2 ATP; anaerobic produces 38 ATP.
B.. Aerobic produces 4 ATP; anaerobic produces 32 ATP.
C. Both processes produce equal amounts of ATP during the fermentation stage
D. Aerobic respiration produces much more ATP than anaerobic pathways, while fermentation yields only the ATP generated in glycolysis (net 2 ATP per glucose)
Correct answer: **- D. Aerobic respiration produces much more ATP than anaerobic pathways, while fermentation yields only the ATP generated in glycolysis (net 2 ATP per glucose)**
Explanation: Aerobic respiration extract far more energy because it fully oxidizes glucose through Krebs Cycle and oxidative phosphorylation.

4. In the absence of oxygen, why must a cell perform fermentation if it doesn't generate any additional ATP beyond glycolysis?
A. To recycle NAD^+ from NADH-.
B. To build complex glucose molecules.
C. To produce oxygen for the mitochondria.
D. To prevent the cell from becoming too basic.
Correct answer: **A. To recycle NAD^+ from NADH** –
Explanation:Glycolysis requires a steady supply of NAD^+ to accept electrons; fermentation provides this by oxidizing NADH

5. How does the fate of pyruvate differ between lactic acid fermentation and aerobic respiration?
A. In fermentation, it is reduced in the cytoplasm; in aerobic, it is oxidized in the mitochondria.
B. Both pathways result in the same chemical end product but at different speeds.
C. In fermentation, it enters the Krebs cycle; in aerobic, it stays in the cytoplasm
D. In fermentation it becomes CO_2 ; in aerobic, it becomes lactic acid
Correct answer: **A. In fermentation, it is reduced in the cytoplasm; in aerobic, it is oxidized in the mitochondria**.
Explanation: Oxygen allows pyruvate to enter the mitochondria for further breakdown, whereas its absence forces a cytoplasmic reduction to lactate.

6. Which sequence correctly describes aerobic respiration?
A. Glycolysis -> Fermentation -> Electron Transport Chain
B. Krebs Cycle -> Glycolysis -> Pyruvate Oxidation
C. Glycolysis -> Pyruvate Oxidation -> Krebs Cycle -> Electron Transport Chain
D. Fermentation -> Glycolysis -> Krebs Cycle -> Electron Transport Chain

Correct answer: C. Glycolysis -> Pyruvate Oxidation -> Krebs Cycle -> Electron Transport Chain
Explanation : This represents the logical flow of carbon and electrons from the cytosol into and through the mitochondrial compartments.

7. During a high-intensity sprint, a runner's muscle cells produce large amounts of lactate. What is the most likely cause of this?
A. The Krebs cycle is working too efficiently, creating a pyruvate backup.
B. The muscle cells are attempting to produce ethanol for extra energy.
C. The rate of ATP demands exceeds the rate of oxygen delivery to the mitochondria.
D. The runner has too much oxygen causing a feedback loop in the cytoplasm.
Correct answer: **C. The rate of ATP demands exceeds the rate of oxygen delivery to the mitochondria**.
Explanation:When oxygen is scarce, the electron transport chain stalls,forcing the cell to rely on anaerobic lactic acid fermentation for quick ATP.

8. Which statement best compares the role of NADH in aerobic respiration and fermentation?
A. In aerobic respiration, NADH transfers electrons to the electron transport chain, whereas in fermentation, it helps regenerate NAD+ by reducing pyruvate or its derivative.
B. In both pathways, NADH is used in exactly the same way and at the same location.
C. In aerobic respiration, NADH is produced only in the mitochondria, whereas in fermentation, it is produced only in the nucleus.
D. In aerobic respiration, NADH is a waste product, whereas in fermentation, it is the main end product
Correct Answer:A. In aerobic respiration, NADH transfers electrons to the electron transport chain, whereas in fermentation, it helps regenerate NAD+ by reducing pyruvate or its derivative.
Explanation: The destination of electrons from NADH defines the pathway; the mitochondria for high ATP, or pyruvate for N AD+ recycling.

9. Why does alcoholic fermentation cause bread dough to rise, while lactic acid fermentation (used in yogurt) does not?
A. Lactic acid is a solid and weighs the dough down.
B. Yeast cells are larger than bacteria, physically pushing the dough up.
C.Alcoholic fermentation releases CO_2 while lactic acid fermentation does not.
D .Alcoholic fermentation produces more ATP providing energy for expansion.
Correct answer : **C. Alcoholic fermentation releases CO_2 while lactic acid fermentation does not.**
Explanation: The decarboxylation of pyruvate to acetaldehyde in yeast releases the gas bubbles that expand the dough.

10. If a metabolic poison specifically blocked the transport of pyruvate into the mitochondria, which process would a eukaryotic cell be forced to rely on?
A .Chemiosmosis

	B..Enhanced aerobic respiration C. Fermentation D. The Calvin Cycle Correct Answer: **C. Fermentation** Explanation: If pyruvate cannot enter the mitochondria, the Krebs cycle and ETC cannot function, leaving fermentation as the only way to recycle NAD^+
VI. REFLECTION *(Feedback and Continuous Improvement)*	Use the following reflection prompts to guide your evaluation of the lesson after implementation. Reflect on learners' performance, determine which activities and lesson parts were most and least effective, identify learners who need enrichment or remediation, analyze the assessment results, and note possible improvements to enhance future lesson delivery. ● How many learners successfully demonstrated the learning objectives based on the assessment results? ● Which activity helped learners understand the lesson the most? Which activity helped the least? ● Which part of the lesson was easiest for learners? Which part was most difficult? ● How many learners needed enrichment or additional challenge? How many learners needed remediation or additional support? ● What did the assessment results show about learners' understanding of the lesson? ● What improvement would you make if you taught this lesson again?
VII. USE OF GENERATIVE AI	In preparing this Learning Exemplar (LE), the author(s) used Co-pilot in order to improve the grammar and annotation. The author(s) reviewed and finalized the writing of the content. The author(s) take(s) full responsibility for the content of this LE.

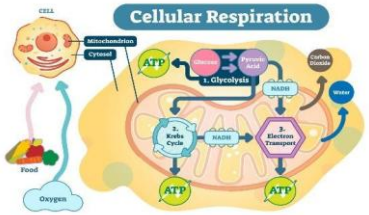
Lesson Title/Topic	Metabolism- Respiration	Lesson Exemplar	20

I. OBJECTIVES		
A. Content Standard	This section presents the key understandings the essential concepts that cell respiration is the chemical reaction that converts chemical energy into usable forms of energy.	
B. Performance Standard	The learners will apply their knowledge on chemical energy which is converted to useful forms of energy for the functioning of the body. Learners will also demonstrate through a performance task.	
C. Learning Competencies	***Prerequisite Knowledge and Skills*** Prior to lesson objectives have a description of the assumed prior knowledge and skills that learners have acquired in the previous grade level(s), which are essential for their successful engagement with the current lesson. These assumptions can also serve as a basis for designing diagnostic assessments. Before this lesson, learners are expected to recall the basic stages and purpose of cellular respiration, identify the mitochondrion as the major site of aerobic respiration, and explain the relationship between metabolism and respiration. They should also be able to read simple diagrams and extract relevant information from secondary sources.	
	The learners are expected to use information from secondary sources to explain how cellular respiration provides energy for everyday activities, such as running, thinking, and digesting food.	
II. REFERENCES and MATERIALS (*Selecting Resources and Material*)	Rabago, Lilia M., Crescencia C. Joaquin, Catherine Genevieve B. Lagunzad, and Josefina C. Carvajal. 2023. Functional Biology. Biology Online. n.d. “Cell Respiration.” Accessed [insert date]. BCcampus. n.d. “10.3 Muscle Fiber Contraction and Relaxation.” Accessed [insert date]. ScienceDirect Topics. n.d. “Muscle Contraction.” Accessed [insert date].Book: Rabago, Lilia M., Crescencia C. Joaquin,	
III. CONTENT *(Sequencing Content)*	Metabolism- Respiration	
IV. OBJECTIVES *(Setting Clear Objectives and Analyzing the Tasks)*	1. Explain why cellular respiration is essential for the survival of organisms. 2. Use information from secondary sources to explain how cellular respiration provides energy for running, thinking, and digesting food.	
IV. PROCEDURES		**ANNOTATIONS**
	A.1. Activating Prior Knowledge	

A. Activating Prior Knowledge	***Activity1: Game Activity – Family Feud Game Activity*** *The teacher will ask the students to form 2 teams. Each team will be represented by 4 members. The teacher will ask the students if the are familiar with the famous TV game -Family Feud.* *Time:5 minutes* *Materials: LED TV, Laptop, Family Feud Template . (https://www.slideegg.com/powerpoint/family-feud-powerpoint-templates?srsltid=AfmBOorz8Hr842MfytG-In85S3hzHLKD2wd3jK85j63Ns5CyK--RpAEb)* *Instruction:* *1.The students must familiarize themselves with the mechanics of the game.* *2. The teacher will flash each question using the Family Feud Template.* *3.The following questions may be lifted from the previous lesson on cellular respiration (LE6) to be used to motivate the students* *3.1 Glycolysis* • *What are the net products of glycolysis? 2 Pyruvate, 2 net ATP,and 2 NADH per glucose molecule* • What are the 3 irreversible/regulatory enzymes? Hexokinase (Step 1), Phosphofructokinase-1 (PFK-1, Step 3), and Pyruvate Kinase (Step 10). *3.2 Citric Acid Cycle* • What are the key products (per Acetyl-CoA): 2 , 3 NADH, 1 $FADH_2$ and 1 ATP/GTP • What are the key products (per Glucose): 4 CO_2 , 6 NADH, 2 $FADH_2$ and 2 ATP *3.3Electron Transport Chain* • What are the main products (outputs) of the ETC: Water (H_2O), ATP (via oxidative phosphorylation), NAD+, FAD, Heat • What are the three components required for oxidative phosphorylation? $NADH/FADH_2$ (electron donors), molecular oxgen (O_2) , ATP synthetase 4. The team with the highest score in Round 1 will be declared the winner. *Note to Teacher:* Since the allotted time is only five minutes, the game will be limited to one round.	***Annotation for Activity 1*** *The Family Feud-style game activity targets the learning objective of reinforcing knowledge of cellular respiration processes—glycolysis, citric acid cycle, and electron transport chain—by recalling key products, enzymes, and steps, while motivating students through competition. The IDF principles of engagement, integration, and reflection are evident, as students are drawn into a familiar game format, connect prior lesson content to the activity, and reflect on their enjoyment and realizations afterward. The 2C-2I-1R approach is applied through content (respiration pathways), context (game-based classroom activity), integration (linking scientific knowledge to a playful format), interaction (team collaboration and teacher facilitation), and reflection (students articulate insights after participation). Pedagogically, the activity uses game-based learning, active recall, collaborative teamwork, and formative assessment, making abstract concepts more accessible and memorable. Teachers should ensure students understand the mechanics before starting, keep the pace brisk within the five-minute limit, prepare questions aligned with lesson objectives, encourage equal participation, and use the reflection questions to connect the fun activity back to meaningful learning outcomes.* *Note to Teacher: The teacher may consider other activities which can be accessed through this link https://docs.google.com/document/d/1V2wUoIzVZ0uUcRgYRJQa9Zxx2iosZw8V/edit*

	5. After the game, the teacher will ask reflective questions: o What did you realize after participating actively in the activity? 6. As a follow-up, students will be required to explain how one recalled respiration process supports a daily activity such as running, thinking, or digestion.	
	A.2. Establishing the Purpose of the Lesson	
	Activity 1: Review of the previous Lesson *1.The teacher will ask the students to recall the major steps in aerobic respiration discussed previously. Recalling the steps in cellular respiration, ask the learners to identify the specific cellular location where each process occurs.* *2.Ask the students to recall the chemical equation showing aerobic respiration.* *Note: Aerobic respiration is summed up in the following equation:* $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$ + energy (ATP + Heat) *3.The teacher must emphasize that in human cells, when oxygen is limited, ATP can still be produced in the cytoplasm through glycolysis followed by fermentation.*	***Annotation for Activity 1*** *The "Activity 1" targets the learning objective of reinforcing knowledge of the major steps in aerobic respiration and identifying their specific cellular locations, as well as recalling and applying the chemical equation for aerobic respiration. The IDF principles of engagement, integration, and reflection are evident, as students actively recall prior content, connect it to cellular structures, and reflect on the necessity of oxygen in completing respiration. The 2C-2I-1R approach is applied through content (steps and equation of aerobic respiration), context (recall-based classroom activity), integration (linking biochemical processes to cellular locations and oxygen requirements), interaction (teacher prompts and student responses), and reflection (students evaluate the difference between aerobic and anaerobic pathways). Pedagogically, the activity uses recall and reinforcement strategies, encouraging students to retrieve and apply knowledge in a structured way. Teachers should emphasize the accuracy of the chemical equation, highlight oxygen's critical role in aerobic respiration, and clarify that anaerobic respiration*

		occurs only in the cytoplasm without oxygen, ensuring students grasp the fundamental distinction between the two processes. *Note to Teacher: The teacher may consider other activities which can be accessed through this link* *https://docs.google.com/document/d/1UvembPPPmH4lwfEmGHVW4zQdEazzrnpb/edit*
B. Instituting New Knowledge	***B.1. Presenting Examples***	
	To understand how we function, we have to look at secondary sources-like peer-reviewed journals, biology textbooks, and academic databases -which synthesize complex laboratory data into understandable models. *These sources explain that cellular respiration is the reason behind every breath.* *Provide learner-friendly excerpts, key vocabulary lists, and guiding questions when using advanced sources such as PET scans, exercise physiology studies, or journal data.* *Note to Teacher : Teacher download the PET application.* ***FOR RUNNING ACTIVITY*** ***Activity 1: The "ATP Delivery Service "Case Study (Running)*** *Objective of the activity: Trace the flow of energy from specific secondary sources (like biology textbook) to the physical act of running.* ● *The class will be divided into 3 teams.* ● *Each team will ask to bring their secondary sources such as Biology textbook, peer-reviewed biology journals and others.* ● *Note to Teacher: Teacher may provide secondary sources like biology books or ask the students to borrow secondary sources from the LRMDS office.* ***Task:*** *1.Students will be asked to look for the diagram of the Krebs Cycle and the Electron Transport Chain (ETC) from the secondary sources available.* *2.Using a secondary source, the students must identify the exact point where energy is captured and provide energy for running activity.*	***Annotation for Running Activity*** ***Option 1: Activity 1*** *The "ATP Delivery Service" case study activity targets the learning objective of tracing the flow of energy from cellular respiration to physical activity, specifically running, by using secondary sources such as biology textbooks and journals. The IDF principles of engagement, integration, and reflection are evident, as students actively consult diagrams of the Krebs Cycle and Electron Transport Chain, integrate knowledge of ATP production with muscle contraction, and reflect on how energy is delivered to support movement. The 2C-2I-1R approach is applied through content (cellular respiration and ATP function), context (case study and team-based research), integration (linking biochemical processes to physical activity), interaction (collaborative team work and teacher facilitation), and reflection (students present findings through a "Shipment Tracking Log" that traces origin, processing, delivery, and result). Pedagogically, the activity uses case-based learning, cooperative research, and application of secondary sources, encouraging students to connect theory with real-life physiology. Teachers should ensure that reliable secondary sources are provided or accessible, guide students in interpreting complex diagrams, and emphasize the critical role of ATP in muscle contraction, particularly the release of the myosin head from*

	3. Research how ATP allows the myosin head to release from an Actin filament in muscle cells *4. Presentation of the output – Create a "Shipment Tracking log"* *a. Origin* *b. Processing center* *c. Delivery point* *d. The Result*  *Source: https://www.biologyonline.com/tutorials/cell-respiration* ***FOR THINKING ACTIVITY*** ***Activity 1:Brain Power and the Glucose Demand (Thinking)*** *Objective: Understand that cellular respiration is a constant process, even without physical movement.* *Secondary Source: An infographic or data table showing the metabolic rates of different organs (highlighting that the brain uses about 20% of the body's energy).* ***Task: The Energy Budget Pie Chart*** *Activity:* *1.Students analyze the secondary source to see how many calories the brain has compared to muscles at rest.* *2.Students write a short paragraph explaining that thinking requires maintaining ion gradients across neurons, which is powered by the constant recharging of ATP through cellular respiration.* *Presentation of Outputs*	*actin filaments, to make the connection between respiration and running clear and meaningful.* ***Annotation for Thinking Activity*** ***Activity 1*** *The "Brain Power and the Glucose Demand" activity targets the learning objective of understanding that cellular respiration is a constant process, even without physical movement, by highlighting the brain's high energy demand and its reliance on ATP. The IDF principles of engagement, integration, and reflection are evident, as students analyze secondary sources such as infographics or data tables, integrate knowledge of organ metabolic rates with cellular respiration, and reflect on how thinking requires continuous ATP production. The 2C-2I-1R approach is applied through content (brain energy use and ATP demand), context (analysis of secondary sources and creation of an energy budget pie chart), integration (linking biochemical processes to cognitive activity), interaction (teacher prompts and student outputs), and reflection (students explain how ion gradients across neurons are maintained by ATP). Pedagogically, the activity uses data analysis, visualization, and explanatory writing, encouraging learners to connect abstract*

	FOR DIGESTING OF FOOD: ***Activity 1:The Metabolic Loop- Digestion*** *Objective: To illustrate how the body uses energy to get energy Secondary Source; A diagram of the human digestive system alongside a text explaining the Thermic Effect of Food (TEF).* ***Task: The Energy ROI (Return of Investment) Analysis*** *Activity:* *1.Students examine how smooth muscle contractions (peristalsis) and enzyme production require ATP.* *2. Research and discuss this point- If cellular respiration stopped ,why would we be unable to digest the food already in our stomach.* *3. Students create a cycle diagram showing how respiration powers the very system that provides the glucose for respiration.* *4. Presentation of Outputs*	*biochemical processes to everyday mental activity. Teachers should ensure that the secondary sources provided are clear and accurate, emphasize that the brain consumes about 20% of the body's energy, and guide students in articulating how ATP supports neuronal function and continuous thinking.* ***Annotation for Digesting of Food -Activity 1*** *The "Metabolic Loop – Digestion" activity targets the learning objective of illustrating how the body uses energy to obtain energy, emphasizing that digestion itself requires ATP through processes like peristalsis and enzyme production. The IDF principles of engagement, integration, and reflection are evident, as students examine diagrams and texts on the thermic effect of food, integrate knowledge of respiration with digestive functions, and reflect on why digestion would cease if cellular respiration stopped. The 2C-2I-1R approach is applied through content (digestion and respiration link), context (diagram analysis and cycle diagram creation), integration (connecting biochemical energy production to digestive activity), interaction (student discussion and teacher facilitation), and reflection (students present outputs showing the cycle of energy use and supply). Pedagogically, the activity uses visual analysis, inquiry-based learning, and diagrammatic representation, encouraging learners to see digestion as both a consumer and provider of energy. Teachers should ensure that secondary sources clearly explain the thermic effect of food, guide students in constructing accurate cycle diagrams, and emphasize that respiration powers the very system that provides glucose for respiration, reinforcing the concept of energy return on investment in biological processes.* *Note to Teacher: The teacher may consider other activities which can be accessed through this link https://docs.google.com/document/d/1d_z5l7EB*

		ZhwKkxX2oHuxjU0mmmee03eX/edit#heading=h.728g1vqxq3gs
	B.2. Discussing New Concept	
	Teacher may define cellular respiration. *What is cellular respiration?* ● *Cellular respiration is the fundamental metabolic engine that powers life. It is the process by which cells break down glucose and other organic molecules to release energy and transfer much of it into ATP. Often called the "energy currency "of the cell, ATP acts as a rechargeable battery that fuels every biological task. Why is cellular respiration essential?* ● *Without a constant supply of ATP, the complex machinery of life would grind to a halt. This process is indispensable because it provides the chemical "fuel" required for:* *a. Mechanical Work: Powering muscle contractions and cellular movement.*	***Annotation:*** The "Cellular Respiration Definition and Importance" activity targets the learning objective of understanding cellular respiration as the fundamental metabolic engine that powers life by breaking down glucose to produce ATP, the energy currency of the cell. The IDF principles of engagement, integration, and reflection are evident, as students are introduced to a clear definition, integrate knowledge of respiration with everyday biological tasks, and reflect on why ATP is indispensable for survival. The 2C-2I-1R approach is applied through content (definition and chemical equation of respiration), context (teacher-led explanation with supporting sources), integration (linking respiration to mechanical work, synthesis, homeostasis, and active transport), interaction (students analyze examples such as muscle contraction and ATP's role in the sliding filament theory), and reflection (students consider how life would halt without ATP). Pedagogically, the activity uses direct instruction, supported by secondary sources and visual aids, to reinforce conceptual understanding. Teachers should emphasize ATP's role as a rechargeable battery that fuels every biological task, highlight mechanical work as the most visible application of respiration, and ensure students grasp that without continuous ATP production, processes like muscle contraction, protein synthesis, repair, and active transport would cease, making cellular respiration essential to all aspects of life. Note to Teacher: Images and the complete discussion may be accessed through this link https://docs.google.com/document/d/1QDw6v

		U8KfmRIduiucdNSMUTDw7Fsquop/edit#heading=h.wq69vlu5oar7
	B.3. Developing Mastery	
	Activity 1: Secondary Source Gallery Walk To develop mastery on the topic , place different secondary source snippets around the room: 1. Source 1: Data on lactic acid buildup in sprinters (Running). 2. Source 2: A study on how the brain uses ATP to maintain membrane potential (Thinking). The Activity: Students move in pairs to each station and complete a "3-2-1 Chart": • 3 Specific steps of respiration mentioned (e.g., "The ETC was used..."). • 2 Real-life connections found. • 1 Question the source didn't answer. After accomplishing the activity for the allotted time specified by the teacher, the students are required to discuss the outputs - their accomplished 3-2-1 Chart by pair. Teacher will ask the following questions after the activity: 1. Which among the secondary sources will give necessary information on the given task? 2. Did you enjoy the activity? Why or why not? 3. What challenges did you encounter in dealing with the task assigned? 4. Did you acquire enough information from the secondary sources provided? 5. How do the data on lactic acid buildup in sprinters show how cellular respiration provides energy for running? 6. How does a study show how the brain uses ATP to maintain membrane potential and how cellular respiration provides energy for thinking? 7. How does an article show how the gut uses ATP to absorb nutrients and how cellular respiration provides energy for digestion?	***Annotation for Activity 1: Secondary Source Gallery Walk*** *The "Secondary Source Gallery Walk" activity targets the learning objective of mastering cellular respiration by connecting scientific evidence from different contexts—running, thinking, and digestion—through secondary sources. The IDF principles of engagement, integration, and reflection are evident, as students move around the room in pairs, actively analyze varied sources, integrate respiration steps with real-life applications, and reflect on unanswered questions. The 2C-2I-1R approach is applied through content (respiration steps and ATP function), context (gallery walk with secondary source snippets), integration (linking lactic acid buildup, brain ATP use, and gut nutrient absorption to respiration), interaction (pair discussions and teacher-guided questioning), and reflection (students present their 3-2-1 charts and respond to deeper prompts). Pedagogically, the activity uses collaborative synthesis, inquiry-based learning, and critical evaluation, encouraging learners to see respiration as a unifying process across multiple systems. Teachers should ensure that the sources provided are accurate and accessible, guide students in identifying specific respiration steps (like glycolysis, Krebs cycle, and ETC), and emphasize how secondary sources reveal the invisible but essential role of cellular respiration in powering running, thinking, and digestion.* Note to Teacher: Images and the complete discussion may be accessed through this link *https://docs.google.com/document/d/1Uv2oR-5FrEOWcR6Dmn96MG8tGRrPR27t/edit*

C. Demonstrating Knowledge and Skills	***C.1. Finding Practical Application***	
	The students will be asked by the teacher on the practical application or real-world application. *In each practical application task, require students to cite at least one specific piece of evidence from a secondary source to support their explanation.* *Guide questions:* *1.How can you apply the knowledge and skills you have learned from the lesson?* *2. Can you cite real-world applications showing the practical utilization of using secondary sources to show how cellular respiration provides energy for daily activities?*	***Annotation:*** *The practical application activity targets the learning objective of connecting cellular respiration to real-world experiences by asking students to apply knowledge gained from secondary sources to daily activities such as running, thinking, and digesting food. The IDF principles of engagement, integration, and reflection are evident, as students analyze sports science data on oxygen debt, neuroscience evidence on brain energy use, and nutrition studies on the thermic effect of food, integrating these findings into practical scenarios and reflecting on how respiration sustains life. The 2C-2I-1R approach is applied through content (respiration pathways and ATP function), context (secondary source analysis in sports, neuroscience, and nutrition), integration (linking biochemical processes to physical activity, cognition, and digestion), interaction (students respond to guide questions and discuss outputs), and reflection (students explain how respiration provides energy for everyday activities). Pedagogically, the activity uses inquiry-based learning, source evaluation, and applied analysis, encouraging learners to see respiration as the invisible power grid behind human performance and survival. Teachers should emphasize that secondary sources reveal how anaerobic and aerobic respiration explain oxygen debt in running, how the sodium-potassium pump accounts for the brain's high ATP demand and mental fatigue, and how digestion itself requires ATP through peristalsis and active transport, reinforcing that cellular respiration is indispensable for every aspect of daily life.* Note to Teacher: Possible answers may be accessed through this link

		https://docs.google.com/document/d/1lTy_94Z5dX7ZuvWGlswJ4NNwT7iMqay1/edit#heading=h.pq6qyrusq3cm
	C.2. Making Generalization	
	The teacher may use the following and ask learners to draw conclusions or generalizations: ***Activity 1*** *Choose one daily activity—running, thinking, or digestion and prepare a four-sentence evidence brief. Sentence 1: identify the activity. Sentence 2: name the kind of cellular work involved. Sentence 3: cite one evidence statement from a secondary source. Sentence 4: explain how cellular respiration provides ATP for that activity.* *1.How important is cellular respiration for the survival of organisms?* *2. Enumerate some secondary sources to explain how cellular respiration provide energy for daily activities such as:* *2.1 running; and* *2.2 thinking?* *3. How does cellular respiration provide energy for daily human activities such as:* *3.1 running; and* *3.2 thinking?* *4.What are the things to be considered in using secondary sources in explaining cellular respiration and its importance for the survival of organisms and for performing daily activities such as running, thinking and digesting of food?* *5.Explain why the secondary source they used is credible and relevant?*	***Annotation for Activity 1*** *This activity targets the learning objective of helping students draw conclusions and generalizations about the importance of cellular respiration for survival and its role in daily activities such as running, thinking, and digestion, while also considering ethical use of secondary sources. The IDF principles of engagement, integration, and reflection are evident, as students respond to structured questions, integrate evidence from secondary sources like data on lactic acid buildup, neuroscience studies on ATP use in the brain, and nutrition charts on digestion, and reflect on how respiration sustains life. The 2C-2I-1R approach is applied through content (cellular respiration and ATP function), context (guided questioning with secondary sources), integration (linking biochemical processes to physical activity, cognition, and digestion), interaction (teacher-led discussion and student responses), and reflection (students generalize the importance of respiration and evaluate ethical considerations in research). Pedagogically, the activity uses inquiry-based questioning, source evaluation, and critical reflection, encouraging learners to see respiration as indispensable for survival and everyday functioning. Teachers should emphasize that cellular respiration provides the energy needed for muscle contraction in running, ion gradient maintenance in thinking, and active transport in digestion, while also guiding students to recognize the importance of using credible, ethically sourced secondary materials in their research and learning.* *Note to Teacher: Question 4 was included to check the knowledge of students in the application of*

	6. Which secondary source helped you most in understanding cellular respiration, and why was it credible? ***Three-Sentence Generalization:*** *1. Cellular respiration is essential because ____.* *2. One credible secondary source showed that respiration supports ____ by ____.* *3. This matters for survival because ____.*	*ethical considerations as applied by students in their research subject (those who are taking research)* Note to Teacher: Possible answers may be accessed through this link *https://docs.google.com/document/d/11jEDTJp8LxCoV0CJbl-dpJh0f_0d6FSe/edit*
	C.3. Evaluating Learning	
	Formative Assessment 1 **Activity 1: The Mystery Box** The teacher may either use mystery box using recycled box with envelopes containing questions or the Mystery box template app (Source : https://games4esl.com/powerpointgames/mystery-box/ Using a Mystery box containing different questions: Instruction: The box will be passed from one student to another . The passer will give a specific number to be followed in determining the next student who will be the acceptor of the box. The acceptor of the box will pick an envelope containing a question. The goal of the activity is to let students answer the questions found inside the mystery box. Note to Teacher: The following questions may be used for the activity. The teacher may add more questions depending on the time allotted for the activity and depending on the number students per class. 1. Which biological process is responsible for converting the chemical energy in glucose into a form that cells can use for mechanical work? Answer: Cellular Respiration Explanation: This process harvests energy from organic molecules to produce ATP, the universal energy currency for cellular tasks. 2. When analyzing a secondary source about 'Oxygen Debt' in sprinters, which byproduct is most frequently cited as evidence of anaerobic respiration? Answer: Lactate	**Annotation for Formative Assessment 1: The Mystery Box** The “Mystery Box” formative test activity targets the learning objective of reinforcing students’ understanding of cellular respiration by engaging them in an interactive Q&A format. The IDF principles of engagement, integration, and reflection are evident, as students actively participate in passing the box, integrate knowledge from secondary sources into their answers, and reflect on how respiration powers daily activities. The 2C-2I-1R approach is applied through content (questions on respiration, ATP yield, oxygen debt, brain energy use, and digestion), context (mystery box game with envelopes or app template), integration (linking biochemical processes to running, thinking, and digestion), interaction (peer-to-peer passing and answering), and reflection (students explain their reasoning with teacher guidance). Pedagogically, the activity uses gamified learning, inquiry-based questioning, and collaborative engagement, encouraging learners to recall and apply concepts in a dynamic way. Teachers should ensure that questions are varied in complexity, guide students in connecting answers to secondary sources, and emphasize that cellular respiration is the universal process providing ATP for mechanical work, active transport, and sustained energy, making it indispensable for survival and everyday functioning.

	Explanation: Lactate accumulation is often cited as evidence that anaerobic pathways contributed during intense activity. 3.Secondary sources in neuroscience state the brain uses of the body's ATP. What is the primary 'work' this energy is used for? Answer: Active transport to maintain ion gradients Explanation: The brain requires constant ATP to power sodium-potassium pumps that reset neurons for signaling. 4.If you are reading a nutritional study about the 'Thermic Effect of Food,' what form of work is being described as you digest a meal? Answer : Mechanical Work and Active Transport Explanation: Digestion involves muscle movement (peristalsis) and pumping nutrients across membranes, both requiring ATP. 5.How does aerobic respiration provide a 'continuous' energy supply for long-distance running compared to anaerobic pathways? Answer: It fully oxidizes glucose to produce high yield of ATP. Aerobic respiration provides a much higher ATP yield than anaerobic pathways because glucose is more completely oxidized in the presence of oxygen. Explanation: The complete breakdown of glucose in the presence of oxygen provides the sustained energy needed for endurance. Exit Ticket: Cite one evidence statement from a secondary source and explain how it shows ATP use in either running, thinking, or digestion. Then write one misconception you corrected today.	Note to Teacher: Possible answers may be accessed through this link https://docs.google.com/document/d/1tM1TGrCHPHKyoSnkpxf3iilvU6NFqaQz/edit
	C.4. Additional Activities	
	FOR REMEDIATION: Option 1:Activity 1: The "Equation Puzzle" (Visual Scaffolding)	***Annotation*** **Note to Teacher :** If remediation is needed, complete activity can be accessed through this link https://docs.google.com/document/d/1K2vCms99cJsCOd5BPStKyiOQFzQUdd6D/edit

V. ASSESSMENT *(Assessing Learnings)*	***Summative Test :*** *Multiple Choice: Read and understand each item carefully. Choose the letter of the best answer.* 1.Which molecule acts as the 'energy currency' produced by cellular respiration to power biological work? A. ATP (Adenosine Triphosphate) *B. Glucose* *C. NADH* *D. Pyruvate* *Answer: A. ATP* *Explanation: This molecule stores and transfers energy in a form that cells can immediately use for various metabolic tasks.* *2.* Based on physiological studies, which process is essential for 'mechanical work' like the contraction of skeletal muscles during a run? A. The fermentation of oxygen into carbon dioxide in the lungs. *B. The storage of heat energy in the cytoplasm to stimulate movement.* *C. The binding and release of myosin heads on actin filaments using ATP.* *D. The passive diffusion of glucose directly into the muscle fibers without energy.* *Answer : C. The binding and release of myosin heads on actin filaments using ATP.* *Explanation: ATP provides the energy for the cross-bridge which is the mechanical basis for muscle contraction.* *3.* Secondary sources in neuroscience highlight that the brain consumes 20% of body energy. What is a primary use of this energy? A.Producing oxygen to be sent to the rest of the body. B.Contracting brain tissue to process thoughts faster. C.Synthesizing glucose from carbon dioxide. D.Powering ion pumps to maintain electrical gradients in neurons. *Answer:* D. Powering ion pumps to maintain electrical gradients in neurons. Explanation: Thinking requires constant electrical signaling which depends on the active transport (ATP) to reset neurons membranes. 4. If a nutritional study discusses the 'Thermic Effect of Food,' it is referring to the energy cost of which daily activity? A.Sprinting at maximum speed. B.Digesting and absorbing nutrients. C.Deep sleep and tissue repair. D.Regulating breathing during meditation. Answer: B.Digesting and absorbing nutrients. Explanation: Mechanical peristalsis and the active transport of nutrients from the gut into blood require significant ATP. 5. According to secondary sources, why is aerobic respiration preferred over anaerobic for daily activities like walking or thinking? A.It provides a much higher ATP yield and does not produce fatiguing lactic acid. Aerobic respiration is preferred for sustained daily activities because it produces much more ATP than anaerobic pathways and can support longer-lasting energy demands.

B.It occurs entirely in the cytoplasm, making it faster to access.
C.It generates more carbon dioxide, which the body uses for energy.
D.It allows the body to function without any glucose intake.
Answer: A.It provides a much higher ATP yield and does not produce fatiguing lactic acid. Aerobic respiration is preferred for sustained daily activities because it produces much more ATP than anaerobic pathways and can support longer-lasting energy demands.
Explanation: Aerobic respiration produces far more ATP per glucose molecule than anaerobic pathways, making it more suitable for sustained daily activities. Aerobic respiration is preferred for sustained daily activities because it produces much more ATP than anaerobic pathways and can support longer-lasting energy demands.
6. When interpreting a graph from a sports journal showing an athlete's '*VO2* max,' what is being measured in relation to cellular respiration? Interpret a simple VO2 max graph and explain what it suggests about aerobic capacity and ATP production.

A.The maximum rate at which the body can take in and use oxygen for ATP production.
B.The amount of glucose stored in the liver.
C.The speed at which lactic acid is converted into alcohol.
D.The total volume of carbon dioxide inhaled from the atmosphere.
Answer: A.The maximum rate at which the body can take in and use oxygen for ATP production.
Explanation: V O_2 is a direct indicator of aerobic capacity and efficiency of the Electron Transport Chain.
7. How does the 'Synthesis and Growth' function of respiration differ from the 'Mechanical Work' function?
A.Synthesis produces ATP, while mechanical work consumes it.
B.Synthesis uses ATP to build complex molecules (DNA/proteins), while mechanical work uses ATP for movement.
C.Synthesis occurs only in the mitochondria, while mechanical work occurs only in the cytoplasm.
D.Synthesis is anaerobic, whereas mechanical work is always aerobic.
Answer: B.Synthesis uses ATP to build complex molecules (DNA/proteins), while mechanical work uses ATP for movement.
Explanation: Synthesis is an anabolic process of building structures whereas mechanical work is the application of force.

8.A secondary source mentions that 'Oxygen Debt' occurs during a sprint. What is the relational connection between this debt and cellular respiration?
A. The body stops respiring entirely until the runner catches their breath.
B. Oxygen debt is the process of turning *CO2* back into glucose to save energy.
C. The lungs temporarily store ATP to be released once oxygen is available.
D. The body must eventually use oxygen to restore normal conditions, including replenishing energy stores and processing byproducts formed during intense activity.
Answer: D. The body must eventually use oxygen to restore normal conditions, including replenishing energy stores and processing byproducts formed during intense activity.
Explanation: oxygen debt represents the amount of oxygen required to restore the body to its pre-exercise state and clear metabolic waste.

9. How would you link 'digesting food' to 'thinking' through the lens of cellular respiration?
A.Digestion breaks down organic molecules into glucose, which is then oxidized via respiration to provide ATP for neural signaling.
B.Both processes are purely mechanical and do not require chemical energy from ATP.
C.Digestion is an anaerobic process that saves oxygen for the brain's aerobic needs.

	D.Thinking produces the oxygen needed for the stomach to digest food. Answer: A.Digestion breaks down organic molecules into glucose, which is then oxidized via respiration to provide ATP for neural signaling. Explanation: This links the source of fuel (digestion)to the energy conversion process (respiration)and the final work (thinking) 10. Using secondary sources to evaluate human survival, what would be the most immediate consequence if the Electron Transport Chain (ETC) was inhibited? A.A massive drop in ATP production leading to cellular failure in energy-demanding organs like the brain and heart. B.The body would stop producing Carbon Dioxide, making breathing unnecessary. C.Lactic acid would become a permanent energy source for the body. D.The body would switch to photosynthesis to survive. Answer: A.A massive drop in ATP production leading to cellular failure in energy-demanding organs like the brain and heart. Explanation: ETC produces the bulk of ATP; without it, the 2 ATP from glycolysis cannot sustain complex human life.
VI. REFLECTION *(Feedback and Continuous Improvement)*	Use the following reflection prompts to guide your evaluation of the lesson after implementation. Reflect on learners' performance, determine which activities and lesson parts were most and least effective, identify learners who need enrichment or remediation, analyze the assessment results, and note possible improvements to enhance future lesson delivery. • How many learners successfully demonstrated the learning objectives based on the assessment results? • Which activity helped learners understand the lesson the most? Which activity helped the least? • Which part of the lesson was easiest for learners? Which part was most difficult? • How many learners needed enrichment or additional challenge? How many learners needed remediation or additional support? • What did the assessment results show about learners' understanding of the lesson? • What improvement would you make if you taught this lesson again?
VII. USE OF GENERATIVE AI	In preparing this Learning Exemplar (LE), the author(s) used Copilot in order to improve the grammar and annotations. The author(s) reviewed and finalized the writing of the content. The author(s) take(s) full responsibility for the content of this LE.