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Title: Photosynthesis
Grade Level: 10-11

Science Concepts to be Learned

Main Concepts to be Learned

1. Photosynthesis converts light energy into chemical energy through complex series of reactions known as biochemical pathways.
2. Autotrophs use photosynthesis to make organic compounds from carbon dioxide and water.
3. The pathway that produces organic compounds using the energy stored in ATP and NADPH during light reactions is the Calvin Cycle.

National Science Content Standards

- All matter tends toward more disorganized states. Living systems require a continuous input of energy to maintain their chemical and physical organizations. With death, and the cessation of energy input, living systems rapidly disintegrate.
- The energy for life primarily derives from the sun. Plants capture energy by absorbing light and using it to form strong (covalent) chemical bonds between the atoms of carbon-containing (organic) molecules. These molecules can be used to assemble larger molecules with biological activity (including proteins, DNA, sugars, and fats). In addition, the energy stored in bonds between the atoms (chemical energy) can be used as sources of energy for life processes.
- The chemical bonds of food molecules contain energy. Energy is released when the bonds of food molecules are broken and new compounds with lower energy bonds are formed. Cells usually store this energy temporarily in phosphate bonds of a small high-energy compound called ATP.
- The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.

Science and Technology

Scientists in different disciplines ask different questions, use different methods of investigation, and accept different types of evidence to support their explanations.

Scientific Nature

Science distinguishes itself from other ways of knowing and from other bodies of knowledge through the use of empirical standards, logical arguments, and skepticism, as scientists strive for the best possible explanations about the natural world.

Learning Objectives

Science Objectives from the State of Ohio Standards

Life Sciences

Students demonstrate an understanding of how living systems function and how they interact with the physical environment. This includes an understanding of the cycling of matter and flow of energy in living systems. An understanding of the characteristics, structure, and function of cells, of organisms and of living systems are developed as well as a deeper understanding of the principles of heredity, biological evolution, and the diversity and interdependence of life. Students also demonstrate an understanding of different historical perspectives, scientific approaches and emerging scientific issues associated with the life sciences.

Grade 10

10. Describe how cells and organisms acquire and release energy (photosynthesis, chemosynthesis, cellular respiration and fermentation).

11. Explain that living organisms use matter and energy to synthesize a variety of organic molecules (e.g., proteins, carbohydrates, lipids and nucleic acids) and to drive life processes (e.g., growth, reacting to the environment, reproduction and movement).

12. Relate how distribution and abundance of organisms and populations in ecosystems are limited by the ability of the ecosystem to recycle materials and the availability of matter, space and energy.

Grade 11

3. Explain that the Sun is essentially the primary source of energy for life. Plants capture energy by absorbing light and using it to form strong (covalent) chemical bonds between the atoms of carbon-containing (organic) molecules.

State of Ohio Benchmark Indicators

A. Explain the flow of energy and the cycling of matter through biological and ecological systems (cellular, organismal and ecological).

Science and Technology-Understanding Technology

Benchmark #2: The importance or value of technology depends on where and how it is used.

- Illustrate that the value of any given **technology** may be different for different groups of people and at different points in time.

Scientific Inquiry-Scientific Investigations

Benchmark #3: Students understand and apply the processes of scientific investigation. They are able to create models and to design, conduct, describe, evaluate, and communicate the results of these investigations.

- Use mathematical **models** to predict and analyze **natural phenomena.**

Scientific Ways of Knowing-Science and Society
Benchmark #5: Scientific literacy develops knowledgable citizens.

- Understand that the decision to develop a new technology is influenced by societal opinions and demands and by-cost benefit considerations.
- Demonstrate the understanding that much can be learned about the internal workings of science and the nature of science from the study of scientists, their daily work, and their efforts to advance scientific knowledge in their area of study.
- Investigate how the knowledge, skills, and interests learned in science classes apply to the careers students plan to pursue.

Driving Inquiry Question
(Use demonstration) By what process do autotrophs make their own energy?

Technology Objectives

- Basic operations and concepts
- Technology productivity tools
- Technology communications tools
- Technology problem-solving and decision-making tools
- Technology research tools.

Materials

Computer Functions

- Palm Pilots
- Palm Probes-light, oxygen and temperature

Software Needed

- Power Point Presentation
- Web access- *Netscape/Explorer*
- Proscreen
- Probe software

Materials Needed
For exploration phase

- 75 Watt Bulb
- 1 tsp Baking Soda
- Water plant-Elodea
- Large bowl of H2O
- Tall Glass

For explanation phase

- Power Point
- Computer Screen Projector
- Laptop or computer
- Power Point handout

For expansion phase

- Palm Pilots
- Probe ware-light, oxygen and temperature

Classroom Management/Teaching Strategies

How will you organize the students?

For exploration phase

- Students will be in groups of 4 or 5

For explanation phase

- Students will continue in groups, and also in groups of 2 and 3, and be involved in whole class discussion.

For expansion phase

- Students continue with groups.

How will you use the computers available with your students?

They will research terms, definitions and processes through the use of the internet, resource books, and learning centers. Student groups will answer main inquiry question.

What are the safety issues you should address as the students participate in each of the unit activities?

- The school's internet policies should be observed.
- Watch computer cords, water should not be next to them.
- Care should be used with heat source.
- Clean up all spills immediately.
- Palms and probes should be handled with care.

Activities to Support Concept Development

Exploration Phase (Student Activities)

Which process skill will be used?

Observing, comparing, inferring, making hypothesis.

What will the students do?

Use their previous knowledge to infer what process is occurring.

Activity 1

Students will watch a plant make oxygen. They will also observe pigments in plant leaves.

Teacher will fill a bowl with fresh water. Then mix baking soda into the water. This will provide the CO2 the plant needs to produce oxygen. Then place a water plant (e.g. Elodea) inside a drinking glass. Lower the glass sideways into the bowl of water until the glass fills with water and no air bubbles are left in the glass. Then turn the glass upside down in the bowl without letting in air. The glass should rest on the bottom of the bowl. Aim the light from the lamp toward one side of the glass. Bubbles should form on the leaves in the water. Most bubbles will come from the side of the plant nearest the light.

After about an hour you will see that a large bubble has accumulated on top of the water inside the glass. This bubble contains the oxygen that the plant has made.

After students observe the first bubbles on the plant, group them and ask them to infer what they think is going to happen by answering the questions. Then set the demonstration aside, and allow it to continue to bubble up. During the last ten minutes of class, let students discuss if their findings were correct.

Activity 2

In their groups, students will choose a tree sapling outside and cover a leaf on it with each of the following. One with plastic wrap, one with foil, and they need to observe the other leaves as their control. The students will then go back inside and discuss what they believe will happen. The next class, the leaves will be brought inside and the students' results will be discussed.

Explanation Phase (Teacher Activities)

What is the main idea?

1. Photosynthesis converts light energy into chemical energy through complex series of reactions known as biochemical pathways.
2. Autotrophs use photosynthesis to make organic compounds from carbon dioxide and water.
3. The pathway that produces organic compounds using the energy stored in ATP and NADPH during light reactions is the Calvin Cycle.

Part 1.

After students do their activities; they will discuss the questions in their groups. Then as a class we will discuss the answers from each group.

Activity 1

1. What process is occurring?
2. What is the product of this process (what is leaving the plant)?
3. What does the plant take in?
4. How much oxygen (O2) do you think that you use a day?
5. How many plants would you need to produce this amount a day?
6. If this experiment was left alone for an hour, what do you think will occur?

Activity 2

Compare all three leaves

1. What do you think will happen to the leaf with plastic wrap?
2. What do you think will happen to the leaf with tin foil?
3. Is there a difference, why? What factors are being exposed to each leaf?

Part 2.
Next a power point presentation will explain photosynthesis. A copy of the slides will be passed out, but students will also take notes during presentations. Leading questions will guide our class discussions so that the students are on task. The students will then be able to research websites containing photosynthesis. We will then discuss their findings.

Technology Applications
Students will work in groups of 2-3 to research photosynthesis by means of the internet and their books and discuss their findings.

Specific Technology Standard(s) Addressed
Student Standard(s)

1. Basic operations and concepts
    - Students demonstrate a sound understanding of the nature and operation of technology systems.
    - Students are proficient in the use of technology.

Teacher Standard(s)
II. Planning and designing learning environments and experiences - Teachers plan and design effective learning environments and experiences supported by technology.
Teachers
A. design developmentally appropriate learning opportunities that apply technology-enhanced instructional strategies to support the diverse needs of learners.

III. Teaching, learning, and the curriculum - Teachers implement curriculum plans that include methods and strategies for applying technology to maximize student learning.
Teachers
A. facilitates technology-enhanced experiences that address content standards and student technology standards.

V. Productivity and professional practice - Teachers use technology to enhance their productivity and professional practice.
Teachers:
D. plan for the management of technology resources within the context of learning activities

VI. Social, ethical, legal, and human issues - Teachers understand the social, ethical, legal, and human issues surrounding the use of technology in PK-12 schools and apply those principles in practice.
Teachers
D. Promotes safe and healthy use of technology resources.
E. Facilitate equitable access to technology resources for all students.

Expansion Phase (Student Activities)

Which process skills will be used?
Students will use the knowledge of photosynthesis that they have gained to measure the light, temperature and oxygen for a tree sapling. They will observe, measure, record, analyze and discuss their findings.

Pre-activity Preparation
Tell students to dress appropriately because they will be outside the entire class. This includes a jacket if it is cold, and appropriate tennis shoes, or boots.

Measuring light, temperature and oxygen that a tree sapling uses
Students should be in their groups of 2 or 3. They need to measure light, temperature and oxygen, for each tree sapling that they took their leaves from in activity 2, using the palm pilot and probes. They should also explain where their saplings were located, e.g. in direct sunlight, or in the forest in the shade, and what was the color of the leaves, dark green, light green, yellowish? They can also record the measurements in the sheet to go on the palms. Then, the students can download their data on the teacher's laptop and create a class data sheet. In the classroom the students should discuss their measurements with the class. After the data sheet is created the teacher can make copies for the students so that they can discuss the similarities and differences.

Specific Technology Standards Addressed

1.) Social, ethical and human issues
- Students practice responsible use of technology systems, information, and software.

2.) Technology productivity tools
- Students use technology to enhance learning, increase productivity and promote creativity.

3.) Technology problem-solving and decision-making tools.
- Students see technology resources for solving problems and making informed decisions.

Evaluation Phase

Cognitive: involve intellectual activities such as memorizing, interpreting, applying, problem solving, reasoning, analyzing and critical thinking.

Students will be given an exam, testing their knowledge of the concepts of photosynthesis. They will also be required to write a lab report including a table of all the results which may be handwritten, it should be at least 2 pages typed. A scheduled time will be arranged for students to use the school computer lab. Students should discuss any problems with computer time they might have. They will be allowed to discuss with their lab partners, but students must turn in their own paper. Lab reports

may be turned in a week after the experiment. They should include any information gathered on the internet, and the websites should be listed. They should follow the standard format of Introduction, Methods, Analysis and Conclusion. Students can use the palm pilot to download their papers or beam them to the teacher, rather than printing their papers out.

Performance: engages students in activities that require them to apply their understanding of the concept in a new context.

Students will be assessed during the expansion phase by their interpreting and discussion of their results in class, and what they write in their lab reports.

References

Project Learning Tree. (2001) Environmental Education Activity Guide. American Forest Foundation. Washington DC.

Holt, Rinehart, and Winston. (1999) Modern Biology. Harcourt Brace and Company. Austin, TX.