Instructional Scenarios for Benchmark 5E (6-8) #1

Instructional Scenario A

"Today we will do an experiment to find out whether light is necessary for photosynthesis," Mrs. Goodman told her 7th-grade class. "We've just learned that, in photosynthesis, plants make sugar, which then turns into starch. Let's find out whether light is necessary for that process."

She gave each group of four students a geranium plant, as well as written directions for the experiment. Carefully following the directions, each group covered a leaf with aluminum foil. The students then watered the plants.

"Where shall we put them?" asked Roberta.

"Where would you suggest?" responded Mrs. Goodman.

"I think they should go on the window sill, where they'll get lots of light," suggested Bryan.

"Good idea," said Mrs. Goodman. "What would be evidence that light **is** required for photosynthesis?" she asked.

After thinking a moment, Bryan said, "We'd have to find sugar or starch in the leaves that were uncovered so they got light."

"And what would be evidence that light **is not** required for photosynthesis?" asked Mrs. Goodman.

"If we could put a plant in the dark and it did make sugar," said Brent.

"If the leaf we've covered did make sugar or starch," suggested Roberta.

The next day the students practiced testing various items for the presence of starch. They found that an iodine solution turned dark blue, almost black, in the presence of starch, but the iodine solution remained light brown if no starch was present.

The fourth day after they had covered the leaves, the students continued the experiment. Mrs. Goodman donned her safety goggles and gave each student a pair. "Put on your goggles before you work with the hot liquids," she said. The students put on their goggles and set to work. They removed an uncovered leaf from each plant, placed it in boiling water for a few minutes, and then dipped it in a hot alcohol solution until the green color was gone. They then tested it with iodine solution. All the leaves turned blue-black.

Next the students tested the covered leaf from each plant, using the same procedures. They were very careful, for example, to place this leaf in boiling water for the same length of time as the uncovered leaf had been in boiling water. When they tested the leaves that had been covered for the presence of starch, almost all students noted that the iodine solution remained light brown.

In one case, a blue-black splotch appeared on a leaf.

"That proves you can have photosynthesis even without light," said Alex.

"Wait," said Amy. "I was in that group, and I was the one who unwrapped that leaf. I noticed a little tear in the foil. So maybe some light got in through the tear."

"You'd better repeat the experiment," suggested Alex.

"Amy's group may do that," concurred Mrs. Goldman. "How about the other groups' results? What can we conclude from those?"

"You have to have light if leaves are going to make food," said Roberta.

"Does everyone agree?" asked Mrs. Goodman.

All agreed.

"For homework tonight," said Mrs. Goodman, "I'd like you to write a journal entry telling why we had to test both a covered and an uncovered leaf in this experiment."

Instructional Scenario B

Mrs. Grabenstein placed several plants in front of her 8th-grade class. She invited Ms. Evans, who was signing for her two hearing impaired students, to stand next to her.

"We have talked," she said, "about how we all depend ultimately on green plants for food. Today we're going to try to understand the process by which green plants make sugar and oxygen."

Mrs. Grabenstein gave each group a pile of styrofoam balls and some toothpicks. There were red, green, and white balls and blue and yellow toothpicks.

She wrote on the board:

red ball = carbon atom
white ball = oxygen atom
green ball = hydrogen atom
blue toothpick = high energy connection
yellow toothpick = low energy connection

"We're going to work with models of molecules today," Mrs. Grabenstein said. Each ball will represent the kind of atom shown on the board. Remember as we put our models of molecules together that the actual molecules are very tiny, so small that even the most powerful microscope can't see them."

"To make one molecule of sugar, a plant needs six molecules of carbon dioxide," Mrs. Grabenstein continued. "So let's make models of six molecules of carbon dioxide."

She demonstrated how to use four toothpicks to attach two white balls to one red ball. "The red ball represents an atom of carbon," she said, "and the white balls each represent an atom of oxygen."

She held up her model. "So how many atoms of oxygen go with an atom of carbon in carbon dioxide?"

"Two," said Peggy.

"Good," said Mrs. Grabenstein. "Notice something else. I've used yellow toothpicks to connect the oxygen atoms with the carbon. These connections don't have much energy. Later we will use blue toothpicks to stand for connections that have a lot of energy. Okay. Now I'd like each group to make six of these models of carbon dioxide."

The students built their models.

"Nice work," said Mrs. Grabenstein. "Who remembers where plants get the carbon dioxide they need to make sugar?"

"I do," said Alicia, who was hearing-impaired. "It is all around in the air, and it goes into the plant through tiny holes in the leaves."

"Do you agree, Ben?" asked Mrs. Grabenstein.

"I think so," Ben said tentatively.

"She's right," called out Peggy. "I remember the diagram."

"All right. Now let's make models of the water molecules the plant will use in making sugar. To make one molecule of sugar, a plant needs 6 molecules of water."

Mrs. Grabenstein showed the class how to connect two green balls with one white ball to represent a molecule of water.

“As before, the white balls represent oxygen atoms. Now we are using the green balls to represent hydrogen atoms. How many atoms of hydrogen are there in a molecule of water?” she asked.

“Two,” replied Dontay.

“Is that why we call water H_2O?”asked Lauretta.

“That’s exactly why,” answered Mrs. Grabenstein.

“Notice that again I’m using yellow toothpicks because these are low energy connections. Each group will now need to make six models of water molecules.”

As they worked, Mrs. Grabenstein asked, “We know that the plant will use both carbon dioxide and water to make sugar. Where does the water come from?”

“From the ground,” Claire said promptly. “It comes in the roots and goes up the stems to the leaves.”

“Did we do any experiments that showed us how water moves through plants?” asked Mrs. Grabenstein.

“We did the one with celery and colored water,” said Dontay. “That was neat. We could see how the water moved up to the leaves.”

“And what happens to it in the leaves?” asked Mrs. Grabenstein.

“That’s where it’s used to make food,” Alicia said.

Finally, each group had its twelve molecules ready—six molecules of water; six of carbon dioxide.

“Now that you have your water and carbon dioxide all ready to be made into sugar,” said Mrs. Grabenstein, “we’re going to take these molecules apart and reassemble most parts of them as a model of one molecule of sugar.”

“Wow!” said Lauretta. “That’s going to be one big molecule!”

Mrs. Grabenstein demonstrated how to remove the white balls from the carbon dioxide models. She then connected five red balls and one white ball in a ring. She added another red ball so that it stuck out from the ring. This time, however, she used blue toothpicks.

“Notice that the carbon and oxygen are connected in the sugar molecule with high energy connections,”she said. “That’s why we’re using blue toothpicks for these connections. I’d like each group to check the work of another group,” she continued, “so that we can be sure everyone’s model is right up to this point.”

When all the models were correct, she continued.

“Now let’s see how the parts of the water molecules get rearranged,” Mrs. Grabenstein said. She disconnected each water molecule into an -H part and an -OH part. She used blue toothpicks to attach an -H and -OH model to four of the carbon atoms in the ring. She attached only an -H part to the carbon atom next to the one sticking out. She attached an -OH and two -H’s to the carbon atom that was sticking out at the end of the ring. Again, she waited for each group to do the same thing and to have its work checked by another group.

Claire tried to pick up her group's model. A section of it came off.

"It really is a big molecule," said Lauretta, as she helped put the model back together.

"What's left?" Mrs. Grabenstein asked.

"All these white balls," said Ben.

"Oxygen, you mean," said Dontay.

"Yes, it's oxygen," said Mrs. Grabenstein, "and each atom of oxygen will join with another atom of oxygen." She connected them with yellow toothpicks. "But notice, please, that this time we are using yellow toothpicks to stand for a low energy connection. This shows us that, when plants make sugar, they also produce oxygen."

Each group constructed six models of the oxygen molecule.

"Look closely at your sugar molecule," she continued. "Where do you suppose the energy came from that is present in the connections in this molecule?"

"From chlorophyll?" suggested Lauretta.

"No," said Mrs. Grabenstein. "Chlorophyll is involved in a plant's production of sugar, but the energy comes from outside the plant. Indeed, it comes from outside the earth."

"The sun!" Dontay and Claire said at the same time.

"Yes," said Mrs. Grabenstein. "The energy comes from the sun."

She looked at the clock.

"Can we summarize what we demonstrated today? I'd like you each to use some think time and then write a sentence or two summarizing what we've learned."

Mrs. Grabenstein asked several students to read their summaries.

"We showed how plants take little molecules and arrange them into big molecules when they make sugar," read Alicia.

"We showed how carbon dioxide and water get broken up and rearranged into sugar," read Dontay.

"And we need to add that the carbon dioxide and water have low energy connections, but the sugar has high energy connections," said Ben.

"Please remember that these are **models**," said Mrs. Grabenstein. "They show us how the parts of the molecules get rearranged. But this is not exactly the way in which the rearrangement happens in leaves. And parts of molecules certainly are not connected by toothpicks. You'll learn lots of interesting things about how atoms are connected in molecules when you study chemistry."

She moved to the chalkboard, where she wrote[1]:

$$\mathbf{6\ CO_2 + 6\ H_20 \rightarrow C_6H_{12}O_6 + 6\ O_2}$$

"This is how chemists represent what happens when plants make sugar," Mrs. Grabenstein said. "Tomorrow when you come in, you might try to find out what the numbers mean by counting atoms in your molecules. Now it's time for you to leave. Please place your models carefully on the shelf before you go. See you tomorrow!"

[1] Please note that the classic equation for photosynthesis that is used in this scenario summarizes the net numbers of molecules consumed and produced in the photosynthetic process.

Instructional Scenario C

"Okay, everybody," said Ms. Lafferty to her 7th-grade class. "I'd like you to stand up next to your desks, make sure you have lots of room so you won't bump into anyone, and, when I say, 'Go!', do 12 jumping jacks. When you've finished, you may sit down. Go!"

"Whew!" breathed Larry, sinking into his chair after everyone had completed the jumping-jacks. "I thought this was science, not physical education."

"Now," said Ms. Lafferty, "I'd like you to think about how you got the energy to do those jumping jacks."

"From eating lunch," said Beverly promptly.

"Can we be a little more detailed and specific?" asked Ms. Lafferty. "What parts of your body needed energy to do the jumping jacks?"

"My brain and my muscles," said Andy.

"And your eyes," said Marjorie, "to make sure you wouldn't crash into anybody else."

"Let's think just about muscles," said Ms. Lafferty. "Do you remember what happens when your muscle cells produce energy?"

Larry responded. "They break down sugar in that process called..."

"Respiration," finished Beverly. "I used to think respiration just meant breathing, but then we learned that it's also what happens inside your cells."

"And where," asked Ms. Lafferty, "does the sugar in your cells come from?"

"From your food," answered Dominic. "But the food has to be digested so the blood can carry it to your muscle cells."

"What sort of food did you eat for lunch today?" asked Ms. Lafferty.

The students gave a variety of responses.

"Let's consider the hamburger," said Ms. Lafferty. "Where did it come from?"

"From cattle," responded Marjorie. "Brown-eyed cows. That's why I don't eat meat," she added.

"Whether you eat meat or not," said Ms. Lafferty, "we are all ultimately dependent on what for food?"

"Plants," said several students together.

"And where do plants get their food?"

"Photosynthesis," said Andy. "Plants make their own food. Out of carbon dioxide and water. And chlorophyll has to be present."

"Good," said Ms. Lafferty. "How do plants get the energy to do this?"

Again, several students knew. "From the sun," they said.

"Fine," said Ms. Lafferty. "Now I'd like you each to work with a partner to construct a flowchart to show how energy from the sun made it possible for you to do jumping jacks in the classroom today."

Instructional Scenario D

Dr. Osefo led the class across the field. The group gathered under a large tree.

"Let's sit down here in the shade," Dr. Osefo suggested to his 8th-grade class.

Tired from their spring hike, the students flopped down. Belinda put her head on her book bag and closed her eyes.

"Wait," Dr. Osefo said with a laugh. "We're not ready to relax just yet. We have a little more thinking to do first. I'd like you to look around and think about all the things that are happening here. I want each one of you to tell me one thing that is going on here right now."

At first the students were puzzled as they looked around the sunny, quiet place.

"I hear a bee," ventured Arthur.

"I feel the sun," Belinda said, yawning. "I guess you could say that's something that's happening: the sun is shining."

"Plants are growing," said Germaine.

"So are we," added Evelyn.

"Because of the apples and sandwiches we had for lunch," said Bill. "In fact, that's something else that's happening. Our food is being digested so our bodies can use it."

"Dr. Osefo's not growing," said José.

"True," agreed Evelyn. "But he's **repairing**. And **maintaining**. Don't you remember learning that? And he's using food for energy. Like, to take this hike."

"Speaking of food, the plants are making food," offered Wai Ming.

Patricia had taken out her hand lens and was studying an ant. "There are lots of things happening that we can't see," she said. "Think about all the things worms and bacteria are doing in the soil."

Evelyn picked up a stick and started to dig in the soil.

"Good," said Dr. Osefo. "You've identified lots of things that are going on here in this quiet place where it seems like nothing is happening. Let me ask you a few questions about your ideas. Let's focus on food and feeding relationships."

"He's always **teaching** us something," Germaine whispered to José.

"Wai Ming said the plants here are making food. What kind of food are they making?" Dr. Osefo asked.

"I don't see any lettuce like I had on my sandwich," said Bill.

"Dummy!" Germaine gave him a little push. "They're making sugars. All plants make sugars. Even lettuce plants."

"What do they make sugars out of?" asked Dr. Osefo.

"They use water and carbon dioxide," said Patricia.

"Are you telling me," asked Dr. Osefo, "that non-living things are involved in what's going on here, too?"

There was a moment of silence.

"Yeah. Sure," said Bill. "The plants are making oxygen as well as sugar. Oxygen isn't living."

"And don't forget they need light. We proved that in that experiment with the geranium plant," said Wai Ming.

"I remember about how the plants use food to grow but they also store some of it and that's the food we eat when we eat carrots and celery and things," added José.

"Sometimes animals eat plants and then get eaten by other animals," said Belinda.

"That's a food chain," added Arthur.

Evelyn held out a worm on the end of her stick. "What eats worms?" she asked.

"Fish, dummy," answered Bill.

"Very good," said Dr. Osefo. "You perceive many of the interactions that are going on in this place. I think you can see how complex all these interactions are. Maybe it's only in a place like this that we can think clearly about how they all happen together. Your assignment for next Monday will be to represent this situation and the things that are happening in it."

"Wow!" said Latonya. "I need some time to think about that!"

"A good idea," said Dr. Osefo. "Why don't we all take about five more minutes for thinking and observing before we go on. In fact, you might want to write down some notes."

On Monday Dr. Osefo had the students share their representations.

"I made a food web," said Patricia, holding up a large poster. "I thought of all the organisms that would be there, even at night, when we weren't there, like an owl, and what each organism eats. Then I connected them."

"I listed all the changes that would be going on there," said Evelyn, offering a notebook. "For example, carbon dioxide and water being changed into sugar. Or digestion. Or bacteria decomposing an old log."

"I represented the situation with a painting," said José, holding up a large paper. On the paper was an intricate mix of patterns. "I call it 'A Complex Jumble of Interactions.' The yellow represents food giving us energy, and red stands for how food builds the parts that our bodies are made of. You can see, every place there's a living thing, yellow and red are both shown."

After all had shared their products, Dr. Osefo complimented them. "You've done well," he said. "For tomorrow I'd like you to consider all the representations except your own. I'd like you to decide which one you believe most accurately represents all the things that were happening that day under the tree. Of course, you will need to write a justification of your conclusion."