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BASIS Lesson Plan

Lesson Name: Finding the Perfect Fit! An Introduction to Enzymes

Grade Level Connection(s)

NGSS Standards: Grade 5, Physical Science
FOSS CA Edition: Grade 5, Physical Science

**Note to teachers: Detailed standards connections can be found at the end of this lesson plan.*

Teaser/Overview

Many chemical reactions happen within our bodies, but these reactions happen too slowly on their own. To help speed up these reactions, our body uses something called enzymes! Through hands-on interactive activities, students will explore what an enzyme is and how enzymes speed up reactions in our body to help our systems function!

Lesson Objectives

- Students will understand that chemical reactions proceed at different rates and that catalysts are needed to speed up chemical reactions
- Students will personally explore that enzymes exhibit specificity to their substrate and have an active site for the reaction through a puzzle activity
- Students will participate in a hands-on activity to explore how enzymes can be re-used, record and graph data about the substrate concentration, and interpret how this relates to enzyme effectiveness

Vocabulary Words

- **Chemical reaction:** A reaction where two substances are mixed together to produce a new substance
- **Rate:** how fast or how slow something happens, such as a chemical reaction
- **Catalyst:** something that can speed up or increase the rate of a chemical reaction; it is not changed or destroyed by the chemical reaction, but instead can be reused over and over again

- **Enzyme:** a biological catalyst; produced by living organisms
- **Substrate:** the substance on which an enzyme acts
- **Active Site:** the specific place on an enzyme where the substrate binds and the reaction occurs

Materials

Scientist Volunteers will bring:
Laminated images of enzymes
Matchbook (1)
Washers covered in rust (34)
Low sodium Ritz crackers (34 crackers – one per student)
Puzzle pieces (34 pieces – should be 17 unique pairs)
Laminated images of simple sugars (28)
Laminated images of enzyme (7)
Toothpicks (3400, separated into bundles of 100 toothpicks)
Bowls/containers (17)
Printed copies for Toothpick-ase experiment data sheets (17)

Materials teachers should provide:
Students should have pencils ready.

Classroom Set-Up

Students should start the lesson at their desks and then will proceed through an activity where they will be moving around the classroom. Students will then work in pairs for the Toothpick-ase activity, so please have students paired beforehand. We will need access to a whiteboard, markers, and also a document camera. We would also like to give each student a cracker for part of our lesson, so please let us know if there are any wheat or peanut allergies in the class beforehand. Please provide students with nametags during the lesson so that we may call on students by name.

Classroom Visit

1. Introduction (15 minutes)

Role Model Introduction:
Being a role model for students is an important part of being a BASIS volunteer. Begin your lesson by introducing yourselves! Every team member should take a moment to explain who they are and what they study/do as a scientist. A bonus will be to tell your "story," as if giving an elevator pitch to 10-year-olds: Why did you become a scientist? What made you interested in your topic? Why should students relate to you, or be interested in you? Feel free to draft a script of what you will say here. And remember you can also weave your story throughout your lesson through examples from your own life, and/or return to it with Q&A at the end.

Topic Introduction:
After you introduce yourselves as role models, take some time to introduce the topic of this lesson: *Enzymes and the important role they serve in how our bodies function*
It may be helpful to keep the suggested take-away in the back of your mind throughout the lesson: **The unique characteristics of enzymes enable them to increase the rate of chemical reactions in our bodies.**

Your topic introduction should follow the outline below. As much as possible, try to frame this information as questions posed to the class, rather than as a lecture. This helps activate students' prior knowledge and facilitates student-guided discussion.

- We're going to talk about chemical reactions and our bodies today! What is a chemical reaction? Can someone give me an example of a chemical reaction? [If students do not think of reactions immediately, have them turn to their neighbor to gather thoughts for a moment; Think-Pair-Share]
- Do all chemical reactions happen at the same speed? Are they all fast? All slow? Or does it depend on the reaction?
- Discuss example of a fast chemical reaction [match striking] and a slow reaction [rust forming on metals]. Demo of a match striking should be performed by a BASIS volunteer. Metal washers with rust can be passed out to students so they can observe and think about the rate of this reaction. The speed at which a chemical reaction occurs is called its **rate** [define, write on board].
- What about chemical reactions that occur within our body? [digestion (breakdown of food), respiration (convert oxygen and sugar into energy), etc.] Do you think these need to be fast or slow? What are some of the amazing things that your body does each and every day?
- Engage in a discussion with students about what the rate of these reactions needs to be. [Fast!] Let's explore one chemical reaction together!

- Hand out crackers to each student [ask about allergies beforehand].
- Ask students to make observations about the taste of the cracker when they first put it into their mouths and then after they chew it up, right before they swallow it.
- Instruct students to put the cracker in their mouth and chew it up before swallowing it. What happens? [Students should notice that at first the cracker is salty, but after chewing, becomes sweet]
- This is a chemical reaction in our body! There are thousands of reactions happening right now, but often these reactions are very slow on their own. They need something to help speed up that reaction. That something is called a **catalyst** [define, write on board].
- When a catalyst is produced by a living organism, the catalyst is called an **enzyme** [define, write on the board]. Enzymes are incredibly important because without them our bodies wouldn't be able to function, or they would function too slowly to enable us to live. Understanding the characteristics of enzymes and how they work can also help to improve our daily lives. [Show images with everything that enzymes are involved in making/doing circled.]
- Enzymes have several characteristics that make them well-suited for the purpose that they serve in our bodies. We're going to explore some of these characteristics together today!

Teaching Tip: Say, Write, Show

- Bring in photos and props to illustrate the topic intro
- Write new vocabulary words, key terms, and brainstorm lists on the board
- Refer back to the board to engage visual learners and English Language Learners

2. Learning Experience (35 minutes)

Students will walk around the room for Activity 1 and then go back to their desks, work with table partners for Activity 2, and work in pairs for Activity 3. Remember that all of these activities are designed to address the take-away in a particular way: **The unique characteristics of enzymes enable them to increase the rate of chemical reactions in our bodies.**

Activity 2: Enzyme Specificity

1. Distribute one puzzle piece to each student. [There is one unique puzzle set per pair of students].
2. Instruct students that they will be going around the room to find the other student with the matching puzzle piece to their own. Do not force the puzzle pieces to fit! One you find your correct partner, you will proceed through a "reaction" – this reaction will be a secret handshake that you and your partner decide on!
3. Allow students to go around the classroom to figure out their partner. When two students find a complementary puzzle piece, they can start their reaction.
4. Once all partner pairs are found, instruct students to return to their desks.

5. Engage students in a discussion about what they just did in this activity. Were you able to react with just anybody? What was needed in order for you to have the reaction? How did you know you found the correct partner?
6. This is very similar to how enzymes work! One important characteristic about enzymes is that they are very specific to the reaction that they have.
7. Each type of enzyme has a specific shape to what is called the **active site** [define, write on board]. The chemical substrate that the enzyme reacts with fits perfectly into this **active site**. Just like two puzzle pieces fit together! But a chemical reaction with an enzyme can only occur if the correct enzyme and the correct **substrate** are present together.
8. Let's do another activity to explore the chemical reaction that happened when you ate the Saltine cracker at the beginning of the lesson.

Activity 2: Carbohydrates to Sugar

9. If students are in table groups of 4, give three students a simple sugar sign and then give one student an enzyme sign. Hand them out picture face down.
10. Ask students to put the pictures over their heads and have the sugar players stand up and link arms together. Talk about how the students linked up as sugars is called a starch. This starch is what we initially taste in the saltine crackers that we just ate.
11. The remaining student in each group will stand up and, with a scissor-like motion, cut links between the simple sugars. Then instruct the simple sugars to sit back down at their desks.
12. This is a model of what just happened in our mouths. The starch was the substrate and this substrate fit into the active site of the enzyme. The reaction then proceeded and the links between each of those sugars was broken. That's why the cracker starts to taste sweet!
13. Each type of enzyme has a specific shape to what is called the **active site** [define, write on board]. The chemical substrate that the enzyme reacts with fits perfectly into this **active site**. Just like two puzzle pieces fit together! But a chemical reaction with an enzyme can only occur if the correct enzyme and the correct **substrate** are present together.
14. What do you think would happen if there is a lot of substrate? Would the reaction happen faster or slower? Why?
15. Let's do another activity to explore this question!

Activity 3: Rate of Product Formation in Enzymatic Reaction

- In this activity students will pretend to be an enzyme where they are converting the "substrate" toothpicks into smaller sized toothpicks.
- Discuss the activity with students. All students will work in pairs and have the opportunity to serve as both roles (the enzyme and the recorder). The "Toothpickase" person will be the enzyme and the **active site** [define again] will be your fingers. The toothpicks will be the **substrate** [define again]. In our activity, "Toothpickase is a digestive enzyme – it breaks down toothpicks into two units. The reaction happens when you take one toothpick, place it between your thumb and your pointer finger and then break it into two pieces.

- Before explaining the rules of the game, ask the students what they expect to happen to the rate of the reaction after each round. Ask each pair of students who will be working together to make a hypothesis as to what will happen. Will the rate of product formation increase, decrease, or stay the same? Why?
- The rules of the game are:
    - Only use one hand and your fingers for the reaction.
    - Broken and unbroken toothpicks must be kept in the same bowl.
    - When you are Toothpick-ase, you MUST close your eyes. Keep your eyes closed!
    - You CANNOT break toothpicks that are already broken!
    - When time is up, you must immediately stop the reaction!
- Pass out bowl of toothpicks (100 toothpicks in each bowl) and data sheet to each pair of students.
- Without looking at the bowl, the "Toothpickase" person should break as many toothpicks as they can in 10 seconds. The recorder should be tallying the number of toothpicks being broken while it is happening (it's too difficult to count after each round). Broken toothpicks should be kept in the bowl with unbroken toothpicks. Remember, do not break toothpicks already broken! Data recorder should watch to make sure this rule is followed!
- After 10 seconds has passed, the data recorder should count up the tally of broken toothpicks. Record this number in the correct column on the data sheet.
- Student pairs should now switch roles and repeat the activity. We will do this activity six times so that each student will be the "Toothpickase" role three times and the data recorder role three times. A total of 60 seconds will have elapsed, as the time for each round should remain consistent at 10 seconds each.
- What happens to the reaction rate as the supply of toothpicks runs out? Do your data support or reject your initial hypothesis? [Emphasize to students that rejecting a hypothesis is completely okay! Actually, that's how science works through problems.]
- What would happen to the reaction rate if more toothpicks (substrate) were added?
- What would happen to the reaction rate if there were two Toothpickase enzymes?
- What would happen if you were wearing bulky gloves when picking up the toothpicks?

3. Wrap Up: Review and Discuss the Learning Experience (5 minutes)

It's important to leave time to **review** and **discuss** the learning experience at the end of the lesson. This might take the form of discussing conclusions from an experiment; or review of the take-away of the lesson

- What did we learn/observe about enzymes today?
- What are some important characteristics of enzymes?
- How do you think enzymes are importan?

Prompt students to think about what other questions they would investigate in the future to understand enzymes and how they function in chemical reactions.

4. Connections & Close (5 minutes)

Connections to the real world around students:
Why should students care about the phenomenon they've been exploring? How does their exploration fit into the bigger picture of why scientists study it? What connections can students draw to their own lives? How can they learn more?

Close:
Wrap up as a role model by leaving a few minutes for students to ask questions about science, about being a scientist, and about becoming a scientist. Then, thanks and goodbye!

Follow Up: After the Presentation

Teachers who wish to extend the impact of this lesson may find the following CRS web pages useful:

- http://www.crscience.org/educators/helpfulreports
- http://www.crscience.org/educators/treasuretrove

Standards Connections

NGSS:

- Connections by topic
  - Physical Science: 5. Structure and Properties of Matter
- Connections by disciplinary core ideas
  - Physical Science: 5-PS1. Matter and Its Interactions
- Connections by scientific & engineering practices
  - 2. Developing and using models
  - 4. Analyzing and interpreting data
  - 5. Using mathematics and computational thinking
- Connections by crosscutting concepts
  - 2. Cause and Effect: Mechanism and explanation
  - 6. Structure and Function: Determine properties of things
- Connections by performance expectation
  - 5-PS1-1. Develop a model to describe that matter is made of particles too small to be seen.
  - 5-PS1-4. Conduct an investigation to determine whether the mixing of two or more substances results in new substances.