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It's Alive! I think . . .: Students Investigate what Defines Something as Living

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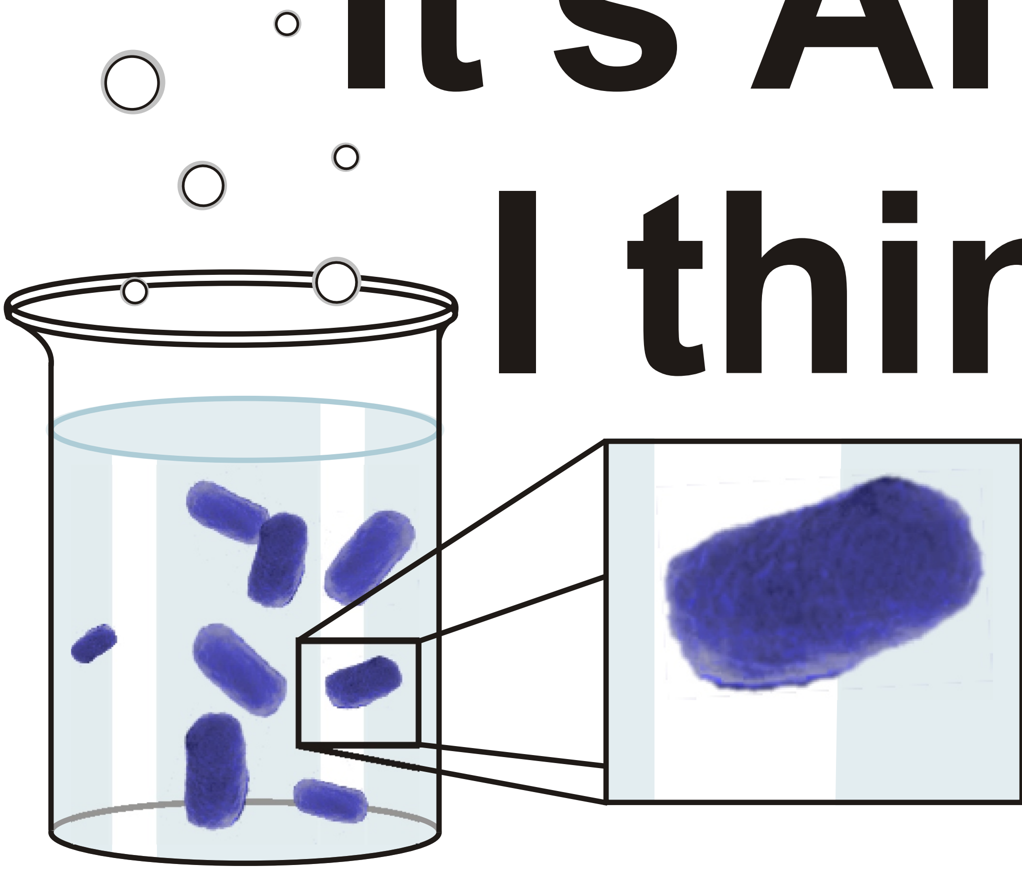

Students Investigate what Defines Something as Living

by **Garrett Hall** and **Jesse Wilcox**

ABSTRACT: Students often have misconceptions about what makes something alive or not, and few have a concept of what characterizes living things similar to that of biologists. The activity presented here mentally engages students in an inquiry-based way to teach students about the characteristics of life that will be revisited throughout the school year. We also use this activity to explicitly draw students' attention to effective inquiry skills, cooperative learning, and promote a deep understanding of the nature of science. *The activity described here promotes National Science Education Content Standards A, C, and G, and Iowa Teaching Standards 1-6.*

Students often struggle to understand and apply characteristics that are important in demarcating living things from non-living things. For example, in one study of 10-15 year-olds (Arnold & Simpson, 1979), students could list examples of living and non-living things, but struggled to accurately categorize

living and non-living things that were provided to them. Twenty-eight percent of the lower achieving 15 year-olds classified items such as fire, water, milk, clouds, energy and cars as living. In another study, college students were asked to explain living/non-living phenomena and gave similar responses to that of younger children (Brumby, 1982). These sorts of misconceptions continue to be reported in more recent research (Venville, 2004). Furthermore, Venville notes the distinction between living and nonliving things is a crucial component of a child's understanding of biology (Siegal & Peterson, 1999; Slaughter, Jaakkola, & Carey, 1999; Springer, 1999) and a prerequisite for all biological thought.

What identifies something as living appears intuitively obvious, but upon closer scrutiny is quite difficult. Effectively teaching about the characteristics of life demands an understanding of students' ideas, and then mentally engaging them in confronting those identified misconceptions. Teaching for conceptual understanding is certainly complex. Time honored strategies such as lecture, worksheets, and cookbook activities simplify the act of teaching, but do not often encourage students to reflect on their prior ideas and consider new and more productive ways of thinking. We want our students to deeply understand how biologists characterize life and why they characterize it in the ways they do. In order to have effective experiences that move towards those ends requires modification of many available activities. As Clark, Clough, and Berg (2000) state,

> *In rethinking laboratory activities, too often a false dichotomy is presented to teachers that students must either passively follow a cookbook laboratory procedure or, at the other extreme, investigate a question of their own choosing. These extremes miss the large and fertile middle ground that is typically more pedagogically sound than either end of the continuum.*

When modifying activities, teachers should consider how to help students make connections to the main idea of the activity while keeping student decision making intact. Furthermore, the teacher should not only be teaching the students how to inquire, but why inquiry is important. The activity presented below was modified from a far more prescriptive activity that permitted students to complete the exercise without deeply thinking about the characteristics of life. In our modified activity, students must take a stand on what is living and non-living, and their ideas, thinking, and actions are the basis from which teacher decisions are made. Hence, the teacher’s role is crucial because he or she must create scaffolds that help students move toward the desired conceptual understanding of life and inquiry. Especially at the beginning of the year, teachers need to explicitly discuss aspects of sharing ideas, analyzing the pros and cons of various decisions, and recording observations, in order to develop student confidence and decision making abilities that are essential for inquiry and understanding.

Investigation

This modified activity begins with the students being presented with multiple items on tables around the classroom. These objects range from soil, water, rocks, coral, insects, plants, tree bark, fossils, etc. and can include a variety of things that will challenge students and eventually raise questions regarding the characteristics of life. Include items such as a computer, a seed, and a Lithops plant (a plant that looks like a rock). These kinds of items are important because they cause students to pause and think as they consider how to classify them. Before beginning the activity, we ask questions to focus students on the task. For example, “To accurately convey the characteristics of what you are observing to someone who may not see the object, what types of observations are important?”, “What are some ways that can be used to keep track of your many observations?” and “What is the value in writing down what you observe?” After their ideas exhausted, students are informed that their job is to observe the items at each station, determine characteristics that may be useful for classifying them into groups, and then develop a classification scheme.

We have students work in groups of two as they visit each station observing the objects. This decision is important because in groups of two the students talk to each other about the object, what observations are important, and potential schemes for classification. In groups larger than two, off-task behavior is far more common. While students are making their original observations and classification decisions, the teacher should be closely observing students' work and listening to what they say. Doing so keeps students' on task, and provides a window into students' thinking. We interject only when necessary, usually to ask questions that play off what students are doing or saying. Students, particularly early in the school year, are apt to perceive a teacher's questioning as indicating something is wrong. Hence, the teacher must be sure to express inquisitive and friendly facial expressions and body actions, use appropriate voice intonation, wait at least 3-4 seconds for students to respond, listening intently to student responses, and use students' ideas in follow-up questions (Rowe, 1986; Penick, Crow & Bonnestetter, 1996; Bergman, 2005).

In addition to providing the teacher key insights into students thinking, this purposeful strategy also encourages students to closely observe the objects, critically think about what may be important characteristics, and be creative in developing several classification schemes. After approximately 30-40 minutes, most groups have observed all the objects and are well into developing several possible classification schemes. We then have students write their ideas on two by two foot whiteboards, and have each group use the white boards for sharing their classification ideas and the rationale behind them. This permits everyone, including us, to understand students' thinking, and it also makes clear that students' observations and ideas have value.

From our experiences we have found that most students will suggest that one of their classifications was made on whether or not the items were living or dead/not living. If this scheme is not provided, ask questions that spark this idea. For instance, we might ask, “What can you tell me about this insect?” How is it different from the computer? These and potentially other questions are important for raising possibilities including the categories of living and non-living. Eventually, when the idea of living versus non-living is raised, we ask questions such as, “How can you tell if the other objects are living or non-living? What can you do, without damaging the objects, to test if they are living or non-living? What characteristics determine whether or not an object is living or non-living?” Note the importance of scaffolding questions to drive at the overarching big idea of the activity – characteristics of living things.

The teacher can encourage multiple student answers by modeling positive non-verbals, waiting before and after student responses, and writing down all student responses without judging them. Writing students’ responses on the board not only conveys that you value their input, but it also provides a concrete list to visualize. When students’ ideas are exhausted, we ask questions about the ideas on the board. Such questions could include, “If growth is a characteristic of life, in what sense is a fire alive?” “What are the pros and cons of using shape as a characteristic of life?” Our use of students' ideas in the questions we ask makes clear that we value their contributions, and it encourages critical thinking about suggested characteristics. This discussion eventually results in students suggesting that particular characteristics while intuitive, do not work in determining living from non-living.

We next have students consider performing tests on the objects to gather information useful for creating a common system of classification based on living versus non-living. This pushes students to further their ideas about what makes something living. Students have to ask for materials and provide a rationale for what they need. Such requests demand that students think about the task, how they might accomplish the task, what materials are necessary, and in what quantity materials are needed. Too often all these decisions are made for students without having them consider the rationale for stated procedures, or how the same task may be accomplished in other ways. Not surprisingly, critical thinking, curiosity, creativity and understanding all suffer. For example, we do not tell students to use magnifying devices or set these out for students to see. Typically, one or more students will ask for a magnifying glass, a dissecting scope, or a microscope. If not, as students struggle to make more detailed observations, we might ask, “What might assist you in making more accurate and detailed observations?” Engaging students in decisions regarding procedures and materials is important for promoting a deep and robust understanding of science concepts and the nature of science.

When students complete their investigations, a class discussion ensues regarding what characteristics are crucial for distinguishing living from non-living. We begin the discussion with questions such as, “What tests did you perform?”, “How did your interpretation of the tests relate to your conclusions?” After consensus has been reached regarding a common system for classifying the objects, we ask questions such as, “How do scientists decide how to classify living things?,” “What characteristics did you use to classify living things?,” And “What about these make them different than non-living things?” Students are far more engaged in the above classroom discussion because they have concrete experiences to draw from, and have thought hard about the task at hand. This does not mean that students, on their own, come to an understanding of all the characteristics of life. However, this activity serves as an introduction that confronts intuitive, but unproductive, ideas regarding the characteristics of living things. It also provides a foundation on which many complex characteristics of life (e.g. cells, respiration) can be built.

The above discussion can be used in scaffolding to an application activity by posing the questions, “What happens when organisms die?,” “What characteristics of life no longer exist?,” and “How could we test your ideas?” A compost pile could be set up by students in the classroom to study their ideas. This might be used later as a long-term extension project to teach students about many important biological concepts, and how they may be applied outside the classroom.

Time Well Spent

With the overwhelming demands placed on teachers, time is very precious. Modifying highly directive activities so that they mentally engage students does take time, but doing so is crucial for promoting a deep understanding of science concepts, the nature of science, and other goals such as critical thinking, problem solving, effective communication and others. We modified the original version of the activity to have students investigate and compare a number of objects as well as develop ways to examine the objects and place them into categories that they developed. This demanded critical thinking, problem solving, creativity, and effective communication--all hallmarks of mental engagement that is necessary for developing deep conceptual understanding.

We chose to use common objects that students can connect to their everyday lives to encourage connecting science concepts to experiences outside the classroom. Students are encouraged to use effective social skills when communicating ideas to classmates and the teacher. Students also develop cooperative learning and effective communication skills through working in small groups, recording observations, and presenting their ideas to the class.

The modified activity is an important first step in promoting a deep understanding of the targeted science concepts. Throughout the school year we refer students back to this concrete experience that they wrestled with, and use it to further develop what scientists' mean when they characterize life. We understand that deep learning involves mentally wrestling with ideas and coming back to content again and again, but in a deeper, more meaningful way. For example, when students later observe living cells and understand their significance, we ask questions that scaffold back to the activity described above.

Another often-cited goal promoted by this activity is an understanding of the nature of science. Observing phenomena, making sense of those observations, sharing results and interpretations, disagreements, and efforts to resolve disagreements are all part of what makes doing science so interesting. To ensure students come to understand the nature of science, we explicitly draw students' attention to the similarities and differences between what they do in class and what scientists do in their work. Moreover, asking students to consider what scientists would do when posed with similar problems helps them understand that scientists must figure out what to do, how

how that is similar to what scientists do. These connections to the work of authentic scientists should be made explicit so that students' understanding of the nature of science is not left to chance.

Final Thoughts

The use of inquiry in the classroom has been a focus of the National Science Education Standards (NRC, 1996) and is a current science initiative in Iowa titled “Every Learner Inquires (Heiting, 2005). Common science activities can be made more inquiry oriented so that they encourage student decision-making, require active mental engagement, and promote the goals we have for students. This is crucial if we truly want our students to build deep understandings of science concepts and how science and scientists work.

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