Activity: Is It Alive?
Biology is the study of life. What is life? What does it mean to be alive? Form a working definition of *alive*.

Practice(s): Planning and Carrying Out Investigations
Crosscutting Concept(s): Structure and Function, Patterns
Disciplinary Core Idea(s): LS1.A Structure and Function

Teacher Tips
This activity can be structured in a number of different ways depending on your goals for the activity and your classroom management style. The following are three options:

- Compile boxes of objects and give them to student groups, allowing students to go through objects in their own order.
- Demonstrate objects, using our suggested progression or another sequence, to force students to look at objects in a certain order.
- Have objects in stations around the room, students rotate through stations and examine each object individually, but in different orders.

Suggested progression with eight objects (actual objects or pictures):

1. Hermit crab (or other organism easily recognized as "alive")
2. Wind-up toy (demonstrates movement, but easily recognized as "not alive")
3. Smartphone (complex, communicates and responds to stimuli, but not alive. Phones might also be categorized as having "cellular structure" as well, even though their cells are not living cells.)
4. Candle/Fire (grows/reproduces, "consumes/metabolizes" oxygen and fuel, releases heat and light, "dies", but not alive)
5. Seeds (e.g. mangrove seed, coconut, pinto beans), active dry yeast, brine shrimp eggs, or other organism in cryptobiosis state (These organisms are alive, but do not exhibit many properties of living things in their cryptobiosis state.)
6. Crustose coralline algae (or other organism difficult to recognize as alive, e.g. fungi or slime mold)
7. Sterile animal (e.g. mule, worker bee, or neutered animal – e.g. dog, or other organisms recognizable as alive, but that cannot breed). Some of these organisms may bring up discussions of the definitions of species.
8. Virus (viruses can be considered alive, but they do not have cellular structure so the classification of viruses is conditionally dependent on the working definition of "living")

Other demonstrations and/or object options:

- Picture of sun (which is "born" and has a "life cycle", moves, and generates energy via nuclear fusion)
- Picture of DNA (contained in all living things but not alive)
- Magnet and iron fillings
- Picture of computer virus (which "reproduces", "dies", and "moves")
- Picture of top-of-the-line car (responds to stimuli, sensitive to light, requires fuel)
- Solar panel (utilizes the sun to produce energy, has "cells")

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- Rock
- Fossils
- Pond water (without any visible organisms, but which has organisms visible under a microscope)
- Calcium carbonate object (e.g. snail operculum, piece of shell or coral) added to vinegar (the calcium carbonate will produce bubbles)
- Plant
- Leaf (a part of a plant that will die)
- Piece of algae (many algae propagate via fragmentation, unlike a leaf of a land plant, so a piece of algae can survive and reproduce)
- Oobleck (cornstarch in water, looks and feels different under pressure)
- Magic capsule (starts out looking like a "pill" and "grows" into a sponge animal)
- Examples of live and dried up organism (e.g. sponge)
- Duco cement in water. Put water in Petri dish and place on overhead projector, drop Duco cement into the water. The Duco cement should form a teardrop/tadpole shape that spins and moves around the surface. You can add talcum powder or pepper "food". See detailed explanation below.
- Quick-growing crystals (can grow, following a well-defined pattern or structure determined at the molecular level, but do not contain any hereditary information). See detailed explanation below.

Detailed information on some of the demonstration object options:

Duco cement:
Duco cement is made up of a polymer in a water-soluble solvent. Before the drop of glue even hits the water, a skin of polymer forms around it. When the bead of cement hits and is immersed in water, solvent diffuses out of the skin, causing the bead to shrink and the skin to rupture on one side of the bead. The solvent squirts out of the hole and the surface tension of the water on that side of the bead suddenly falls. Since the surface tension is now uneven, the bead will move away from the hole, towards the area with greater surface tension. The hole quickly repairs itself but the skin then bursts in another location. Thus, the bead appears to wiggle and twist as the surface tension changes depending on where the skin bursts.

Quick-growing crystals:
Here is a good link on magic rocks (aka crystals) that gives background information and a procedure:

http://chemistry.about.com/od/growingcrystals/a/aa060704a.htm

You do not need to put sand in the bottom of the container. In addition to the list the website provides, you can use Epsom salts (magnesium sulfate). You can buy Epsom salts at most drug stores. We do not recommend making the sodium silicate. You can buy sodium silicate from art and craft supply stores (e.g. The Ceramic Hobbyist in Honolulu (~$5 per pint) at 1204 Kona St, Honolulu, HI), or online. You can also buy complete kits by doing an online search for "magic rocks."

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Please consult the MSDS for disposal of extra crystals and the metal/silicate salts. Here is a good link for MSDS sheets:

http://www.flinnsci.com/search_MSDS.asp.

Cryptobiosis

Cryptobiosis is an ametabolic state of life entered into by organisms in response to adverse environmental conditions, the most common being desiccation (or drying out). In the cryptobiotic state, all metabolic procedures stop, preventing reproduction, development, and repair. An organism in a cryptobiotic state can essentially live indefinitely until environmental conditions return to being hospitable. When this occurs, the organisms will return to its previous metabolic state of life. Examples of organisms with desiccation tolerance include nematodes (round worms), brine shrimp, the majority of plant seeds, the resurrection plant *Craterostigma plantagineum*, and many microorganisms like yeast.

Brine Shrimp

Brine shrimp (aquatic crustaceans genus *Artemia*) live worldwide in inland salty lakes, they are often sold as Sea-Monkeys. Brine shrimp have the ability to produce dormant eggs (known as cysts) when conditions are unfavorable (e.g. low oxygen levels or high salinity). Cysts are metabolically inactive and can remain in total stasis for two years in dry oxygen-free conditions, even at temperatures below freezing. Cysts can also survive boiling.

Yeast

Active dry yeast is a form of baker's yeast (species *Saccharomyces cerevisiae,* a fungi) that is commonly used as a leavening agent in baking. It consists of coarse oblong granules of yeast, with live yeast cells encapsulated in a thick jacket of dry, dead cells with some growth medium. Under most conditions, active dry yeast must first be proofed or rehydrated (this appears in recipes as "allow dough to rise"). It can be stored at room temperature for a year, or frozen for more than a decade.

Virus

A virus is a small infectious agent that can only replicate inside the living cells of organisms. Most viruses are small, but some (giruses) have large genomes with more protein-encoding genes than many bacteria. All viruses have genetic material (DNA or RNA) and a protein coat that protects these genes.

Opinions differ on whether viruses are a form of life, or organic structures that interact with living organisms. Viruses possess genes, evolve by natural selection, and reproduce by creating multiple copies of themselves through self-assembly. Although they have genes, viruses do not have a cellular structure. Viruses do not have their own metabolism, and they require a host cell to make new products. Viruses therefore cannot naturally reproduce outside a host cell – although other species, such as the

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bacteria *Chlamydia*, are considered living organisms despite the same limitation. Viruses spontaneously assemble within cells rather than reproducing via cell reproduction.

Definition of Life

Unlike many definitions, the definition of life is charged with meaning. Some of the most passionate debates, for example over stem cells or the right to die, revolve around the definition of life. Whether talking about when life begins or when it ends, most people have a clear idea of what they mean when they talk about life. However, it often turns out that people mean different things by living. This activity demonstrates how defining the characteristics of life are difficult and not completely clear-cut. Life is often defined by what we know, thus it is often easier to say what life *isn't*. Furthermore, there is an exception to almost every general feature that might be thought of as characterizing life.

At the end of this activity it is useful to give an authoritative definition of life so your students have a jumping-off point upon which to base the study of biology. Because there is no unequivocal definition of life, you will find different criteria for life from different sources. The following are criteria from Campbell's *Concepts and Connections* and are characteristics most scientists agree all living things share:

Living organisms

1. use enzymes to speed and mediate reactions.*
2. store hereditary information.
3. adapt to the environment and have an evolutionary history.**
4. maintain homeostasis.
5. have cellular organization.

If properties 1–3 are used to define life, a virus is considered alive.
If properties 4–5 are also included in the definition of life, a virus would not be considered alive.

*For younger students this can be simplified to "Living things respond to the environment". Sometimes this response takes the form of motion such as an animal running away from danger or a plant orienting towards the sun. Sometimes the response is subtler, such as closing membrane channels in response to changing salt concentrations.

**A basic assumption of evolution is heredity, the passing of traits through generations through some type of genetic material. This means that, over many generations, the traits of the species will change by natural selection to better fit current environmental conditions. In other words, living things adapt to their environment.

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Alive Misconceptions (Many of these can be cleared up during the filling out and discussing of Table 1.2.)

Living things…	What about…
Move (have locomotion)	**Living -** Many living things do not appear to move with the naked eye (e.g. a tree). **Non-living** – Many examples, e.g. clouds move
Reproduce	**Living -** Species need to be able to reproduce, but this does not mean each individual can reproduce. For example, worker bees cannot reproduce. **Non-living** - Robots can make copies of themselves, and some proteins can self-replicate.
Consume food and produce waste	**Living -** Many living things do not consume food or produce waste, for example eggs, sperm, spores, seeds and (based on your definition of life) viruses. **Non-living** - Many non-living things consume fuel and produce waste (e.g. cars, fire).
Grow larger and develop over time	**Living -** Bacteria grow only to a fixed size and older organisms can actually shrink and break down over time rather than grow or develop. **Non-living** – Temperature and pressure can cause chemicals to grow and explode.
Are complex	**Living –** Unicellular prokaryotes are single-celled organisms with no nucleus or organelles. **Non-living** - Computers are complex and are developing artificial intelligence.
Respond to stimuli	**Living -** Many living things, such as plants, do not appear to respond to stimuli (although not all responses are readily apparent to the human eye). **Non-living** – A video game responds to a push of a button by the player.
Have the ability to think	**Living -** Many living things do not have a conscious mind or rational thought process. **Non-living** – Robots use artificial intelligence to make choices.
Have cell structure	**Living –** Many definitions of life are partially based on the evidence that all known living things are made of one or more cell(s). **Non-living** – Teachers often use analogies for cells of non-living objects, such as a city or a building, objects can be composed of “cells”, e.g. solar cells.
Utilize the sun’s energy	**Living –** Plants photosynthesize, but other organisms utilize the sun’s energy indirectly, through eating plants. **Non-living** – Solar cells utilize the sun’s energy.
Are made of organic molecules	**Non-living** - Many non-living things are made of organic molecules too (wood, gasoline, etc).
Die	It is hard to know to know if something is dead if you don’t know if it was alive.

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