Characteristics of Life on Earth

What Is Life?

It's not too difficult to tell that some things are alive. Dogs chasing tennis balls are alive. Birds chattering in a tree are alive. Fish swimming around the plants in an aquarium are alive. In fact, animals are the first things we learn to recognize as **living**.

Things that are alive, like the animals described above, are called **organisms**. Any living thing is an organism. But not all organisms are animals. In the photos to the right, the fruiting tree is alive, and the plants in the aquarium are alive.

It's not always easy to tell that plants are alive because they don't move around, breathe, eat, or make sounds. Even so, they are alive, and there are ways to figure out that they are living things.

Living, Dead, and Nonliving

One way to look at the question *What is life?* is to think about what makes life come to an end. Every living organism dies after a period of time. An organism is **dead** when it is no longer alive. A fish out of water will die after a short period of time. The fish is still there, it is still made out of the same materials, and it still looks the same as it did when it was living in the water, but it is no longer alive. And this is important—something can be dead only if it once lived. A rock can never be dead because a rock was never alive. We describe a rock as **nonliving**.

Living organisms can be described in terms of two sets of characteristics. One is the needs or requirements that all organisms have to satisfy to stay alive. The second is the **functions** that all organisms perform.

What Do Living Organisms Need?

What do you need to stay alive? It has been said that a person can live about 3 minutes without air, about 3 days without water, and about 3 weeks without **food**. People need air, water, and food to stay alive.

You breathe air to stay alive. When you breathe in, you bring oxygen into your lungs, where it dissolves into your blood. When you breathe out, carbon dioxide, carbon monoxide, and other **waste** gases leave your body and go into the air. The process of moving gases into and out of your body is called **gas exchange**. Birds do it, bees do it, lizards, fish, baboons, stink bugs, and even trees do it. All living organisms engage in gas exchange, and the most common gases exchanged are oxygen and carbon dioxide.

A stink bug

You drink water to stay alive. Even if you don't actually drink pure water, there is water in the **fruit**, vegetables, soft drinks, milk, and everything else you eat and drink. Water is essential for life as we know it on Earth. It's just that simple: all living organisms need water.

You eat food to stay alive. Food provides **energy**. Energy is required to make things happen. You can't move, breathe, see, hear, think, or do anything else without energy. All living organisms use energy to live.

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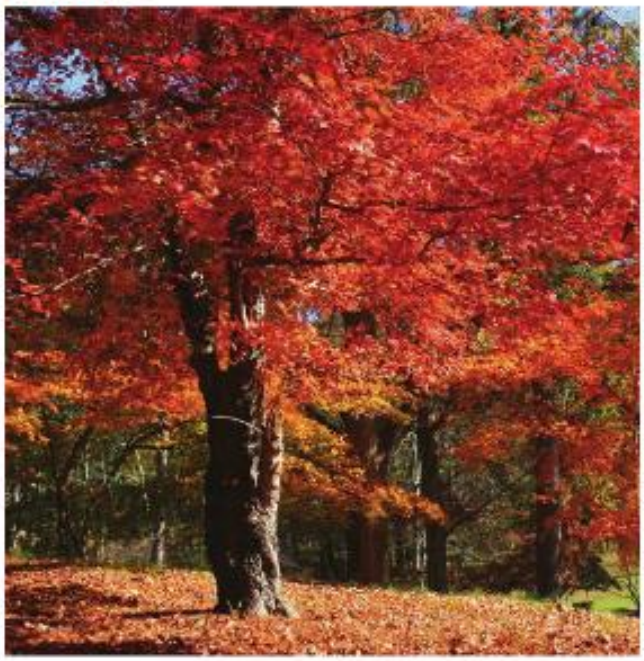
The process of living creates by-products that are of no use to the organism. In fact, many by-products are dangerous to the organism if they are allowed to build up. For this reason, organisms must get rid of waste products. These might be gases, liquids, or solids. All living organisms eliminate waste.

It is a universal truth that everything has to be somewhere. That somewhere for an organism is its **environment**. Every organism lives in an environment that is suitable to fulfill its needs. Organisms have **adaptations** that allow them to live in their environment, or **habitat**.

The ocean and lakes are suitable environments for fish which have adaptations such as gills and fins. The desert is a suitable environment for scorpions, the forest for maple trees, fresh water and moist soil for **paramecia**, and so on.

Maple trees



A scorpion has adaptations to live in a hot and dry environment.

If the environment is not suitable, an organism will not survive. Some organisms form protective **spores** or capsules to survive unfavorable times. These spores do not appear to be living. They are **dormant**. But when suitable circumstances exist, they suddenly start to exhibit the characteristics of life. They were always living, but now you can tell.

Five basic needs are common to all living organisms. They are the need for *gas exchange,* the need for *water,* the need for *energy (food),* the need to *eliminate waste,* and the need for a *suitable environment.*

What Do Living Organisms Do?

Once an organism's basic needs are met, it gets on with the process of life. When things happen in the environment, organisms respond. All organisms respond to the environment.

The ocean fish swims away when the sea lion comes by, the scorpion scurries under a rock when the Sun heats up the ground, and the maple tree's leaves turn red and fall off in the autumn. These are all **responses** to the environment.

When organisms start life, they are small. As time passes, they get bigger. An increase in size is called **growth**. The chemical building blocks for growth come from food, water, and from the environment in the form of minerals. All organisms grow.

Organisms don't live forever. To ensure that the **species** (a kind of organism) survives, living organisms make new organisms of their kind. They **reproduce**. That's not to say every individual organism will reproduce, but every population of organisms reproduces to keep the species going.

All organisms do three things. They *respond to the environment,* they *grow,* and they

reproduce. Anything that does not have the ability to do all three of these things is not an organism.

There is actually one more characteristic common to all living organisms. That characteristic is not discussed in this article, but will be introduced in the near future. Can you think of what that characteristic might be? It's true of you, it's true of turtles and beetles, it's true of elm trees and mosses, and it's true of all the tiny living organisms too small to see with the naked eye.

Sometimes it is difficult to decide if something is alive. A car driving down the road exchanges gases, and a washing machine needs water. A burning candle uses energy, and a fire gives off waste. A smoke alarm responds to the environment, clouds grow, and the US Mint produces new dollar bills all the time.

One characteristic, or even three or four, does not qualify an object to join the ranks of the living. In order to qualify as a living organism an object must meet all eight criteria.

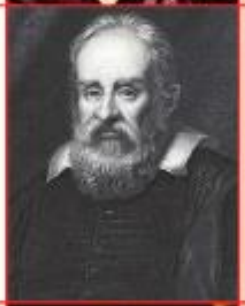
Think Questions

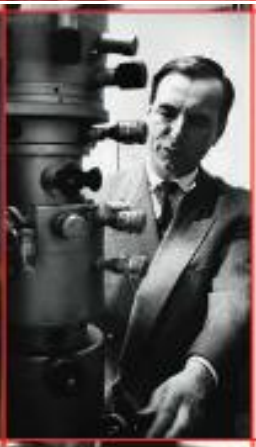
1. What is an organism?
2. What are the *basic needs* of all living organisms?
3. What *functions* are performed by all living organisms?
4. Why do you think movement is not considered a characteristic of life?
5. Under what circumstances might a living organism not appear living?
6. What is the difference between living, nonliving, and dead?

A turtle and a beetle live in different environments, but they both respond to their own specific environment.

The History of the Microscope

It is not known when the first person picked up a piece of clear, curved material and found that it had **magnifying power** that made things look bigger. Roman books from the first century CE speak of "magnifying glasses," indicating that the Romans had some knowledge of what a *lens* does. By 1000 CE, people used glass spheres, called reading stones, that magnified text. The earliest simple **microscope** was just a tube with a lens at the top. It probably magnified no more than ten times, but was helpful for viewing tiny critters such as fleas, so it earned the nickname "flea glass." In 1590, when the first **compound microscope** was constructed, scientists were, for the first time, able to view the microscopic world. Improvements to existing designs and advances in technology continue to allow humans to see the smallest organisms in greater and greater detail (and even view substances at the atomic level!).

Microscope	Scientist	Description
		**1590**. Zacharias Janssen (1585–1631) and his father, Hans, were Dutch opticians in the business of making eyeglasses. They put multiple lenses in a tube to make the first known compound microscope, a microscope that uses two or more lenses. This produced **magnification** greater than any single magnifying glass.
		**1600**. Galileo Galilei (1564–1642), known as the father of astronomy, used a telescope to look at the sky. He also found that a telescope could be used to magnify insects. He then developed the idea behind a microscope that had a focusing mechanism. Galileo's compound microscope had a convex (lentil-shaped) and a concave (oppositely curved) lens.
		**1660**. Antoni van Leeuwenhoek (1632–1723) built a simple microscope with just one lens. He invented methods for grinding and polishing lenses that were the most advanced of that time, with extreme curvatures and magnifications up to 270X. With his microscope, he saw bacteria, yeast, blood cells, and many tiny animals swimming about in a drop of water.

Microscope	Scientist	Description
		**1660**. Robert Hooke (1635–1703) was an English contemporary of Leeuwenhoek who made a copy of Leeuwenhoek's light microscope and then improved upon the design. He looked at cork and noticed cells in it. Hooke confirmed Leeuwenhoek's discovery of the existence of tiny organisms in a drop of water. He wrote a book called *Micrographia* that officially documented many of the observations made through his microscope.
		**1930**. There were many microscope improvements after the 1600s, but the next big breakthrough came when Frits Zernike (1888–1966) invented the phase-contrast microscope. Until then, cell structures were made visible by staining, a process that killed the cells. The phase-contrast microscope made it possible to study living cells. Zernike won the Nobel Prize in Physics in 1953 for his work.
		**1930**. Ernst Ruska (1906–1988) and Max Knoll (1897–1969) coinvented the electron microscope. A visible-light microscope cannot be used for objects smaller than half the wavelength of visible light, about 0.275 micrometers (μm). To see smaller particles, we must use a different sort of "illumination," one with a wavelength shorter than visible light. An electron microscope speeds up electrons until their wavelength is only 100,000th that of visible light, making it possible to view objects as small as the diameter of an **atom**. Ruska won the Nobel Prize in Physics in 1986.
		**1980**. Gerd Binnig (1947–) and Heinrich Rohrer (1933–2013) invented the scanning tunneling microscope. It gives three-dimensional images of objects down to the atomic level. Binnig and Rohrer also won the Nobel Prize in Physics in 1986. The scanning tunneling microscope is one of the most powerful microscopes to date.