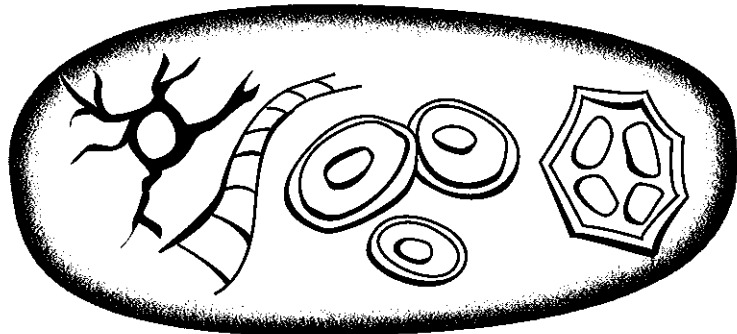


# Is It Made of Cells?

Imagine you could examine the objects and materials listed below with a powerful microscope. This powerful microscope will allow you to see evidence of cell structure.

Put an X next to the objects or materials that are made up, or were once made up, of cells.

- |                                    |                                      |
|------------------------------------|--------------------------------------|
| <input type="checkbox"/> flowers   | <input type="checkbox"/> apples      |
| <input type="checkbox"/> skin      | <input type="checkbox"/> sand        |
| <input type="checkbox"/> proteins  | <input type="checkbox"/> worms       |
| <input type="checkbox"/> rocks     | <input type="checkbox"/> bacteria    |
| <input type="checkbox"/> milk      | <input type="checkbox"/> leaf        |
| <input type="checkbox"/> bone      | <input type="checkbox"/> seeds       |
| <input type="checkbox"/> lungs     | <input type="checkbox"/> water       |
| <input type="checkbox"/> hamburger | <input type="checkbox"/> molecules   |
| <input type="checkbox"/> DNA       | <input type="checkbox"/> sugar       |
| <input type="checkbox"/> calcium   | <input type="checkbox"/> chlorophyll |



- |  |                                      |
|--|--------------------------------------|
| <input type="checkbox"/> paramecium    |                                      |
| <input type="checkbox"/> blood         | <input type="checkbox"/> chromosomes |
| <input type="checkbox"/> cell membrane | <input type="checkbox"/> saliva      |
| <input type="checkbox"/> mushrooms     | <input type="checkbox"/> atoms       |

Explain your thinking. Describe the "rule" or reason you used to decide whether something is or was once made up of cells.

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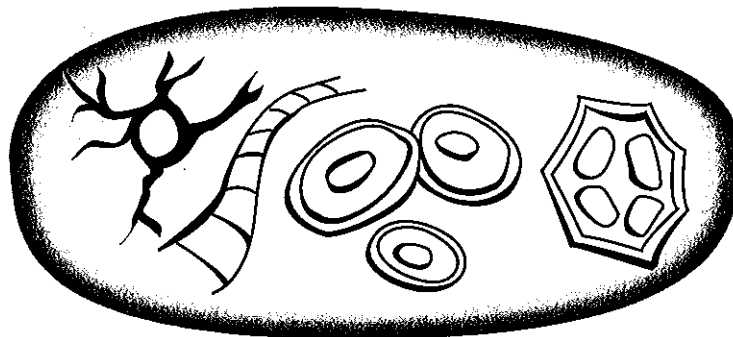
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# Is It Made of Cells?

## Teacher Notes



### Purpose

The purpose of this assessment probe is to elicit students' ideas about objects and materials that are made up of cells. The probe is designed to find out how students decide whether something is or was once made up of cells by providing a variety of examples, including living and once-living things, materials that are manufactured by cells but are not composed of cells, parts of a cell, inorganic substances that did not originate from cells, and building blocks of all matter.

### Related Concept

cells

### Explanation

The cell is the fundamental unit of life. Living or once-living things are made up of one or more cells as well as materials made by cells and inorganic materials, such as water, that

are found within cells. The materials and objects listed in the probe that are made up of cells are the following: flowers, skin, bone, lungs, hamburger, apples, leaf, worms, bacteria, seeds, paramecium, blood, and mushrooms. All of these materials arose from living cells and are cellular in origin, although they may include noncellular materials (e.g., blood contains plasma as well as blood cells). Some materials, such as milk and saliva, are made by cells and are found outside of cells, but are not cellular in structure. They are products of cells and do not give rise to new cells. Materials found inside a cell include molecules such as DNA, sugar, chlorophyll, and proteins as well as elements like calcium that give bone tissue its strength. Objects that are organelles, parts of a cell, include the cell membrane and chromosomes. The remaining items—rocks, water, and sand—are not made up of cells but are made up of matter. Molecules and atoms

are the basic building blocks of cells as well as all matter. Cells use, manufacture, or contain/transform several of the noncellular materials that are commonly associated with cells, such as sugars and proteins, but these materials are not cellular in structure.

## Curricular and Instructional Considerations

### Elementary Students

Upper elementary students are just beginning to learn about cells as the basic unit of structure. Experiences include looking at cells in tissues of familiar plants and animals as well as single-celled organisms. Items on the list should be limited to those that students are familiar with. This probe is useful in finding out if students have beginning ideas that all living or once-living organisms and parts of organisms are made of cells. It may be useful to combine this probe with "Is It Living?" (p. 123).

### Middle School Students

Middle school students expand their developing knowledge about cells to include materials made by cells and materials that are inside of cells. They also recognize that structures such as tissues and organs are part of a hierarchy that is traced back to the cell. They may begin developing additional hierarchies that include cell structures as well as molecules found inside of cells. The challenge with middle school students is in helping them overcome the idea that living

things do not contain cells but rather that living things are cellular. Knowing that anything living is made up of cells, which would include most parts of an organism, is a grade-level expectation in the national standards. In middle school, students are also developing ideas about fundamental units of matter such as atoms and molecules. Often these ideas are taught separately and students may confuse the two when the context changes. This probe is useful in probing beyond the idea that the cell is the basic unit of living material and finding out if students can apply this idea to determine if various materials are or were once cellular.

### High School Students

Students' understanding of cells has expanded to include intracellular structures, biomolecules within the cell, and materials produced and secreted by cells. Ideas in chemistry and biology converge so that students begin to understand that atoms and molecules make up living matter, including cells, as well as nonliving matter. This probe is useful in determining if students prior to and after biological instruction have an understanding of what determines whether materials are made of cells as well as an understanding of the hierarchical nature of cellular composition, including atoms, molecules, and organelles found within the cell.

### Administering the Probe

Limit the items to materials with which students have had direct experience or those with which students have some familiarity. Even though

items on the list such as atoms and molecules are beyond the scope of elementary instruction, it may be interesting to find out students' initial conceptions as they are words young students encounter frequently in the media but have limited conceptions of. Knowing how students formulate ideas early on may provide useful information at the middle level and above.

This probe may be used as a card sort. Have students work in pairs or small groups to discuss and sort the cards into two piles: made of cells and not made of cells. Listen carefully to students' ideas as they discuss their reasons. The probe "Is It Made of Molecules?" (p. 85) may be used along with this probe to determine if middle and high school students confuse the concepts of "cell" and "molecule."

**Related Ideas in National Science Education Standards (NRC 1996)**

**5-8 Structure and Function in Living Systems**

- Important levels of organization for structure and function include cells, organs, tissues, organ systems, whole organisms, and ecosystems.
- ★ All organisms are composed of cells, the fundamental units of life. Most organisms are singlecells; other organisms, including humans, are multicellular.
- Specialized cells perform specialized functions in multicellular organisms. Groups of specialized cells cooperate to form a tissue, such as a muscle. Different tissues

are in turn grouped together to form larger functional units, called organs.

**5-8 Reproduction and Heredity**

- Hereditary information is contained in genes, located in the chromosomes of each cell.

**9-12 The Cell**

- Cells have particular structures that underlie their functions. Every cell is surrounded by a membrane that separates it from the outside world. Inside the cell is a concentrated mixture of thousands of different molecules that form a variety of specialized structures.
- Cells store and use information to guide their functions. The genetic information stored in DNA is used to direct the synthesis of the thousands of proteins each cell requires.
- Plant cells contain chloroplasts, the site of photosynthesis.
- Most of the cells in a human contain two copies of each of 22 different chromosomes.

**Related Ideas in Benchmarks for Science Literacy (AAAS 1993)**

**3-5 Cells**

- Some living things consist of a single cell.
- ★ Microscopes make it possible to see that living things are mostly made up of cells. Some organisms are made of a collection of similar cells that benefit from cooperating.

★ Indicates a strong match between the ideas elicited by the probe and a national standard's learning goal.

### 6–8 Cells

- ★ All living things are composed of cells, from just one to many millions, whose details usually are visible only through a microscope. Different body tissues and organs are made up of different kinds of cells.

### 9–12 Cells

- Every cell is covered by a membrane that controls what can enter and leave the cell.
- Within every cell are specialized parts for the transport of materials.
- The work of the cell is carried out by the many different types of molecules it assembles, mostly proteins.
- The genetic information encoded in DNA molecules provides instructions for assembling protein molecules.

### Related Research

- Student may have the notion that organisms “contain” cells as opposed to being “made up of” cells (Driver et al. 1994). In other words, students may believe a living organism is like a “sack” filled with cells rather than being composed of a collection of cells.
- Research conducted by Arnold (1983) indicated that students have difficulty differentiating between the concepts of “cell” and “molecule.” There is a tendency for students to over-apply the idea that cells are smaller components of *living* things. Students identified any materials encountered in a biology class (carbohydrates, proteins, and water) as being made up of smaller parts called cells. Arnold coined the term

*molecell* to describe this notion of organic molecules being considered as cells.

- Many students think that only certain parts of the human body and other living organisms are made up of cells (Driver et al. 1992).
- Dreyfus and Jungwirth (1988, 1989) reported that students confuse orders of magnitude with levels of organization in living systems. Responses from several 16-year-old Israeli students in the study suggest that students think that biomolecules, such as proteins, are bigger than the size of a cell and that single-celled organisms contain miniature replicas of organs like intestines and lungs. Even though students had learned about cells the year before, their knowledge was superficial. Over a third of the students had alternative conceptions about cells.

### Suggestions for Instruction and Assessment

- Issues of size and scale should be addressed when teaching students about cells. Additionally, ideas about materials should be combined with the notion of scale. Students need to understand that cells, like other types of matter, are made up of materials. These materials contain substances that are made up of atoms and molecules. Even though cells are very small and need to be observed with a microscope, help students understand that there are even smaller parts within the cell that are too small to be seen with a microscope.

- As students engage in activities that involve observing cells, encourage precision with the language used to describe cell observations. Reinforce the idea that single-celled organisms are cells and that multicelled organisms are composed of cells. Students may misinterpret a well-intended statement that multicellular organisms are “collections of cells,” believing that these organisms somehow contain or hold cells rather than being structurally built out of cells. With older students the idea that an organism is structurally made of cells, rather than a “sack” filled with cells, can be addressed when students examine the idea of an organism arising from a single cell and repeated cell divisions.
- By the end of middle school, cell observations should be widely varied. Include cells from a number of different life forms and their different body parts—plants, animals, fungi, protists, and monera. Students will begin to discover that cells, regardless of what living thing or body part they come from, look remarkably similar. At the same time, students will also recognize that cells have different parts, depending on the type of organism.
- Explicitly address hierarchical issues by having students engage in activities that focus them at various levels, then “zoom in” to a more detailed level and/or “zoom out” to a larger level so that students can get a sense of parts-and-wholes relationships.
- Present cell ideas in a number of contexts to help students understand that cells are

a type of matter that contains substances, molecules, and atoms. When students investigate matter in physical science, include examples of living materials. Be aware that when students first learn about atoms, they may also be learning about parts of a cell at the same grade level. Students may be confused by a term like *nucleus* if instruction does not address the differences between the nucleus of an atom and the nucleus of a cell.

### Related NSTA Science Store Publications and NSTA Journal Articles

- American Association for the Advancement of Science (AAAS). 2001. *Atlas of science literacy*. (See “Cells and Organs,” pp. 74–75.) New York: Oxford University Press.
- Driver, R., A. Squires, P. Rushworth, and V. Wood-Robinson. 1994. *Making sense of secondary science: Research into children’s ideas*. London and New York: RoutledgeFalmer.
- Keeley, P. 2005. *Science curriculum topic study: Bridging the gap between standards and practice*. Thousand Oaks, CA: Corwin Press.

### Related Curriculum Topic Study Guides

(Keeley 2005)

“Cells”

“Chemistry of Life”

### References

- American Association for the Advancement of Sci-

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- Arnold, B. 1983. Beware the molecell! *Biology Newsletter* (Aberdeen College of Education) 42: 2-6.
- Dreyfus, A., and E. Jungwirth. 1988. The cell concept of tenth graders: Curricular expectations and reality. *International Journal of Science Education* 10 (2): 221-229.
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- Driver, R. et al. 1992. *Life and living processes: Leeds national curriculum support project, Part 2*. Leeds, UK: Leeds City Council and the University of Leeds.
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