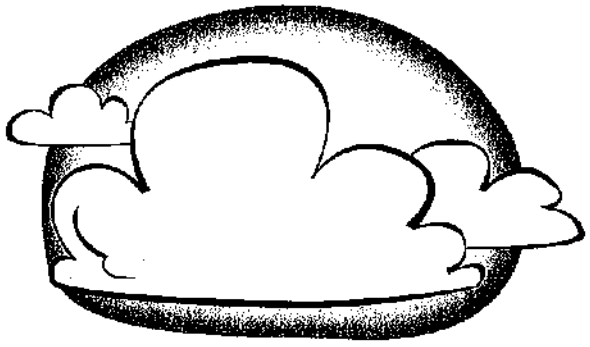
What Are Clouds Made Of?



Six friends were looking at large, white, puffy clouds in the sky. They wondered what the clouds were made of. This is what they said:

Trista: "I think clouds are made of large drops of water."

Lee: "I think clouds are made of soft, cottonlike material."

Manny: "I think clouds are made of smoke that rises from the land."

Rosie: "I think clouds are made of evaporated water in the form of a gas."

Glenda: "I think clouds are made of tiny drops of water or tiny ice crystals."

Leticia: "I think clouds are made of a spongy material that holds water in it."

Which friend do you most agree with? _____

Describe your thinking. Explain the reason for your answer.

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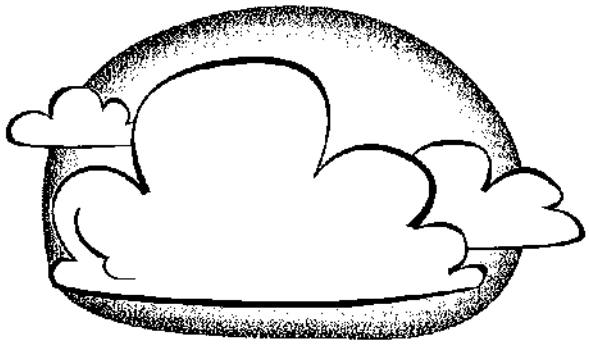
Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about an everyday object in the sky: clouds. The probe is designed to determine whether students recognize that clouds are made up of tiny droplets of water or tiny ice crystals.

Related Concepts

clouds, condensation, water cycle, water vapor

Explanation

The best response is Glenda's: I think clouds are made of tiny drops of water or tiny ice crystals. Clouds come in a variety of forms and shades. Not all are puffy and white. Some can be white and wispy while others are dark and appear to cover the entire sky. Regardless of shape, size, and shade, all clouds are formed when water vapor in the air cools, condenses, and becomes tiny drops of liquid water or tiny ice crystals. When water vapor condenses in the sky it becomes visible as a cloud. Cumulus clouds—the puffy, cottonlike clouds that are relatively low in the sky—are made up of billions and billions of tiny water drops. Other clouds, like the feathery cirrus clouds that are high in the sky, are made up of tiny ice crystals. The water drops and ice crystals are too small to see individually but they are just the right size to scatter the light that strikes them, making the clouds appear white. Rain clouds appear gray and contain bigger water drops. Rain eventually falls when the drops get too big to be held by the rising air that formed the cloud in the first place.

Curricular and Instructional Considerations

Elementary Students

In the early elementary grades the emphasis should be on observing and describing clouds as well as other forms of visible water in the air, such as fog and mist. Their study of matter includes observing how water can go back and forth between different states. They begin to link ideas about states of matter to the water cycle and use their conceptual understanding of ice, liquid water, and water vapor to describe water in the air they can see (clouds and fog) and water in a form they cannot see (the air that surrounds them).

Middle School Students

Middle school students expand on their elementary experiences in observing and describing clouds to more conceptual ideas about the composition and formation of clouds. By middle school, students should know that liquid water or ice crystals in the air are visible and water vapor is not visible. The concept of evaporation is better understood by students at this level than the concept of condensation. These processes are combined with a growing understanding of the behavior of particles in the solid, liquid, and gas state. In addition, their knowledge of the properties of water helps complete their understanding of the water cycle.

High School Students

At the high school level, students should know what clouds are made of and how they are formed. This probe can be useful in diagnosing whether students have an understanding of this aspect of the movement of matter (water) in the Earth system. They expand their knowledge about Earth's atmosphere to an understanding of the Earth as a dynamic system. The water cycle is one of the aspects of that system. Students' growing knowledge of chemistry helps them to appreciate the mechanism of condensation at the particle level. They examine cloud formation at a more complex level and the global implications, including the effect of such aerosols as salt crystals, sand or soil particles, dust, smoke, or volcanic ash on forming cloud condensation nuclei that provide water vapor with a surface to condense upon.

Administering the Probe

All students have experienced seeing clouds in the sky (although in some geographic areas, clouds are more common in the sky on a daily basis). If possible, take students outside to view clouds or show a picture of a cumulus cloud to prompt their thinking before responding to the probe. Further probing can include a picture of a white cloud and a dark cloud; ask students if these clouds are made of the same material and ask them to describe what each cloud is made of. This probe can be used with other probes in this book, such as "Rainfall" (p. 171) and "Where Did the Water Come From?" (p. 163), or combined with "Wet Jeans" from Volume 1 of this series (Keeley, Eberle, and Farrin 2005) to create a cluster of water cycle–related probes.

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

K–4 Properties of Objects and Materials

- Materials can exist in different states, as a solid, liquid, or gas. Some common materials, such as water, can be changed from one state to another by heating or cooling.

K–4 Objects in the Sky

- The Sun, Moon, stars, clouds, birds, and airplanes all have properties, locations, and movements that can be observed and described.

5–8 Structure of the Earth System

- Water evaporates from the Earth's surface, rises and cools as it moves to higher elevations, condenses as rain or snow, and falls to the surface where it collects in lakes, oceans, soil, and in rocks underground.
- ★ Clouds, formed by the condensation of water vapor, affect weather and climate.

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

K–2 The Earth

- Water can be a liquid or a solid and can go back and forth from one form to another.

3–5 The Earth

- ★ When liquid water disappears, it turns into a gas (vapor) in the air and can reappear as a liquid when cooled or as a solid if cooled below the freezing point of water. Clouds and fog are made of tiny droplets [or frozen crystals] of water. (Note: The brackets indicate language added to the original benchmark. This revised benchmark appears in AAAS 2007, p. 21.)

6–8 The Earth

- Water evaporates from the surface of the Earth, rises and cools, condenses into rain or snow, and falls again to the surface.

Related Research

- A study by Bar (1986) examined a sample of students ages 5–15 for their conceptions about aspects of the water cycle. He found certain ideas are more prevalent with certain ages. When students ages 5–7 were asked what causes rain, there was little evidence of a relationship between clouds and rain. Several students described clouds as being made of smoke or cotton wool. Of those that did see a link between rain and clouds, clouds were often described as bags of water kept high in the sky; when they collide, they rip open and the water falls out. Students ages 6–8 often described clouds as collecting water from the oceans and then moving to places in the sky above land. At ages 6–9, several students described clouds as being made of water vapor from the Sun heating the sea or water vapor that comes from kettles. At ages 7–10, some students visualize a cloud

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

as a sponge that has drops of water in it. The common idea at ages 9 and 10 is that clouds are made of water evaporated from puddles. At ages 11–15, students begin to describe clouds as made of small drops of water and water vapor that gets cold (Driver et al. 1994).

- A study by Phillips (1991) found that students at the high school level had beliefs similar to younger students. For example, students believed that clouds are formed by boiling—vapors from a kettle or the Sun boiling the sea; clouds are mostly smoke; clouds are made of cotton or wool; or clouds are bags of water.
- Field-test results of this probe with fourth through eighth graders revealed the commonly held idea that clouds are made of evaporated water in the form of water vapor. Students describe water evaporating from bodies of water as part of the water cycle and eventually forming clouds, but they failed to link the idea that the water vapor condensed to form clouds.

Suggestions for Instruction and Assessment

- Provide younger students with opportunities to make long-term observations of clouds and encourage them to talk about what they think they are made of.
- Have students research different types of clouds. The descriptions of different clouds often include their composition. Be aware that it is more common for students to know that clouds are made up of tiny droplets of water than it is for them to know that they can be made of tiny droplets of water or tiny ice crystals.
- With young students, beware of art-related activities that use cotton balls to simulate clouds. This can lead to the misconception that clouds are made of a cottonlike substance.
- To compare condensation in the air (fog or clouds) with condensation against a surface (such as the dew on the grass in the morning), observe what happens inside a large glass jar. Put a spoonful of water in a large jar filled with air. With the jar in a warm place, vigorously swirl and shake the jar, pour the water out and put the top of the jar on upside down. This will raise the humidity inside the jar. Make sure there is no (or minimal) water on the walls of the jar. Put ice cubes in the upside-down top of the jar. Students will see the condensation on the inside of the lid and around the top of the jar but the air inside the jar will be relatively clear. This is similar to the dew forming on the grass in the morning while the air is clear.

  Allow the jar to warm up, and repeat the procedure, only this time light a match and drop it into the jar. As soon as the match goes out, put the lid on the jar and place ice cubes in the lid. As it cools, students will see the fog form at the top of the jar and slowly sink to the bottom. The jar will not be clear. Discuss what happened and why it is different from what happened in the first jar (this time the water vapor con-

densed on the suspended smoke particles). Relate this to the formation of fog near the ground and clouds higher up (Foster 1991).

- Connect the idea of fog formation to dew point. Have students explain why fog tends to form in the evening or is visible in the morning but generally not during the day.
- When teaching about the water cycle, be careful not to overemphasize the terms *evaporation, condensation,* and *precipitation* at the expense of understanding what is actually happening to the water during these processes both in terms of its physical form and its location. Many students believe that the water evaporates to form a cloud and is still in the form of water vapor and that rainfall is the result of condensation.
- Ask students to draw a sequence of pictures to show and explain how they think clouds form.
- Be aware of poor diagrams of the water cycle that often show water evaporating and rising to form a "white cloud" and then moving to a "dark cloud." While the picture is intended to show changes in the same cloud before it rains, to a student it looks like two different clouds made up of seemingly different material—one made of evaporated water and the other made of condensed water. Representations that look like this are pervasive on the web and teachers need to be aware of the misconception these representations can promote.
- Older students can research technological applications of increasing the possibility of rain cloud seeding by shooting small particles up into the clouds to create more condensation nuclei.

Related NSTA Science Store Publications and NSTA Journal Articles

American Association for the Advancement of Science (AAAS). 1993. *Benchmarks for science literacy.* New York: Oxford University Press.

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Related Curriculum Topic Study

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