Slumpy Solids or Lumpy Liquids

Activity Idea:

In this activity, students explore a range of common household substances to determine if they have the properties of a solid, a liquid, or both. By the end of this activity, students should be able to:

- conduct a series of tests to identify the properties of solids and liquids
- record their observations in a table
- use these results to classify each substance as a Newtonian fluid or a non-Newtonian fluid

Introduction/Background:

Two properties often used to decide if something is a liquid are:

- The substance can be moved from one container to another by pouring.
- The substance will take on the shape of the container.

These liquids are called **Newtonian fluids** (after Sir Isaac Newton). However, some special liquids—such as ketchup, sour cream, toothpaste, custard, honey—sometimes act like a solid and sometimes act like a liquid. These are known as **non-Newtonian fluids.** They change their viscosity when force is applied (called **shear stress**) by stirring, shaking, squeezing, or applying mechanical pressure. The force applied changes their inner structure and changes their viscosity.

Sometimes, these fluids return to their original viscosity immediately. Others will take time, but eventually they also return to their original state.

The effects of shear stress can be different:

- One effect is **shear thinning**—viscosity decreases when the stress is applied. For example, when you shake ketchup to get it out of the bottle, the force makes it temporarily runny.

- **Thixotropic fluids**—for substances like honey, paint, nail polish, sour cream or toothpaste, the force breaks up the structure, allowing it to move more easily. For example, take the cap off toothpaste, and it just sits there. Start squeezing, and the force breaks up its structure allowing it to move more easily out of the tube. It then returns quite quickly to its thicker state so that it doesn't fall off the toothbrush.

- Another effect is **shear thickening**—viscosity increases when the stress is applied. Examples include substances like cornflour custard, oobleck, slime, and Silly Putty. The synovial fluid in joints of the body also acts in this way. When a joint is hit, the fluid that is normally thin (to allow free movement) increases in viscosity to provide some protection from injury. You can also see this effect when walking on wet sand at the beach. The sand becomes firmer below your feet when you first walk or run on it, but if you stand still on wet sand, you start to sink below the surface.

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continued

What You Need:

- Squeeze bottle of ketchup
- Squeeze bottle of honey
- Sour cream
- Shampoo
- Water
- Cornflour custard (Put 1 cup of cornflour into a mixing bowl, add a few drops of food colouring, slowly add ½ cup water a little at a time, mixing it with your fingers until it is the consistency of honey.)
- 6 small containers per group of students
- 6 plastic spoons per group of students
- 6 paintbrushes per group of students
- Newspaper to spread on benches or tables—this activity can be messy!
- Copies of the ***Classifying Fluids*** worksheet on page 3.

What To Do:

1. As a class, discuss the concept of solids and liquids. Is water a liquid? What about shampoo? Is sour cream a solid or liquid? Can something be both solid and liquid? Explain to students that they will be carrying out tests on a range of household substances to decide whether they are a solid or a liquid or can behave as both.

2. Divide the class into groups of three and get them to set up their equipment. As a class, review the ***Classifying Fluids*** worksheet on page 3, which describes the five different tests students must do for each fluid. Explain the concept of Newtonian and non-Newtonian fluids.

3. Have the groups carry out the tests and record their observations on the worksheet.

4. Ask the groups to classify each fluid, and then discuss why they made these classifications.

Discussion Questions:

- Which fluids behaved differently in the tests? What were the differences?
- Why is it fortunate for us that toothpaste is a non-Newtonian fluid?

Extension Ideas:

Students could investigate the history of science in relation to Sir Isaac Newton and the wide contribution he made to science. As part of their research, they should identify some ways science knowledge has changed over time. Sample questions:

- What did British scientist Sir Isaac Newton (1643–1727) have to do with all this?
- What other science ideas did Newton explore?

Name(s): ____

Classifying Fluids

TEST	Custard	Water	Shampoo	Honey	Sour cream	Tomato sauce
Pour test: Pour the fluid from one container to another. Is it runny or is it thick? Does it pour smoothly or does it fall out in a lump?						
Push test: Push the fluid quickly with your finger, and then push it slowly with your finger.						
Shape test: Does the fluid keep its shape or does it take the shape of its container?						
Pick up test: Pick up the fluid slowly, and then pick it up quickly. If you pick some up, does it all come up?						
Stir test: Stir fast with your finger and then stir slowly with your finger.						
Can you classify this fluid?	❑ Newtonian fluid ❑ Non-Newtonian fluid – gets more runny with pressure ❑ Non-Newtonian fluid – gets more solid with pressure	❑ Newtonian fluid ❑ Non-Newtonian fluid – gets more runny with pressure ❑ Non-Newtonian fluid – gets more solid with pressure	❑ Newtonian fluid ❑ Non-Newtonian fluid – gets more runny with pressure ❑ Non-Newtonian fluid – gets more solid with pressure	❑ Newtonian fluid ❑ Non-Newtonian fluid – gets more runny with pressure ❑ Non-Newtonian fluid – gets more solid with pressure	❑ Newtonian fluid ❑ Non-Newtonian fluid – gets more runny with pressure ❑ Non-Newtonian fluid – gets more solid with pressure	❑ Newtonian fluid ❑ Non-Newtonian fluid – gets more runny with pressure ❑ Non-Newtonian fluid – gets more solid with pressure

Newtonian fluids: Liquids that pour smoothly into a container and take the shape of the container into which they are poured.

Non-Newtonian fluids: Fluids that sometimes act like a liquid and sometimes like a solid. These fluids change their viscosity when pressure is applied (e.g. stirring, shaking squeezing or poking):

- Some become more runny (less viscous) with pressure.
- Others become more solid (more viscous) with pressure.