Lesson 6: Is mycelium water repellent?

Objectives:
1. Distinguish between hydrophilic and hydrophobic molecules.
2. Identify the relationship between polarity and solubility.
3. Conduct a water drop test on mycelium to determine if it's water repellent.

Introduction:
As consumers, it is important to us that our products repel water. 'Water repellent' means a substance that is not easily penetrated by water. Items like coats, gloves, backpacks, phone cases all can repel water to some extent. It is convenient to have household products that do not absorb water easily, as this can cause fibers to break down faster, or the function or integrity of a product to be compromised. Imagine a patio chair was not water repellent. Every time it rained outside, the chair would be soaking and unusable. If you spill a drink across a coffee table, the coated material of the table will prevent it from absorbing the water and possibly degradation of the table. Umbrellas are made of a water repellent material so that rain slides off and doesn't get absorbed.

Quick walk:
Take a brief walk around the classroom or area designated by your instructor. Make a list of the items you see that are water repellent, and items that absorb water easily.

Water-repellent	*Water-absorbing*

Polarity:
Water is a polar molecule. Notice the partial negative and positive charges in Figure 1. Because of oxygen's high electronegativity the electrons are pulled slightly towards it, and away from the hydrogen. This gives oxygen a slight negative charge (δ-) and hydrogen molecules a slight positive charge (δ+).

Partial charges allow for interactions between molecules, as seen below in Figure 2. Water forms hydrogen bonds between the oxygen of one water molecule and the hydrogen of another water molecule. Since oxygen is partially negative, it is attracted to the partially positive nature of hydrogen. This attraction is what causes surface tension in water, and its ability to be cohesive. Noncovalent bonds such as hydrogen bonds, are commonly found between polar molecules.

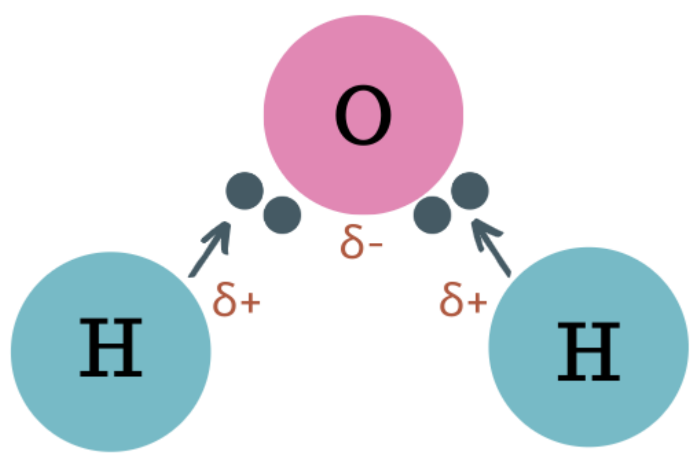


Figure 1; water molecule

Sketch:

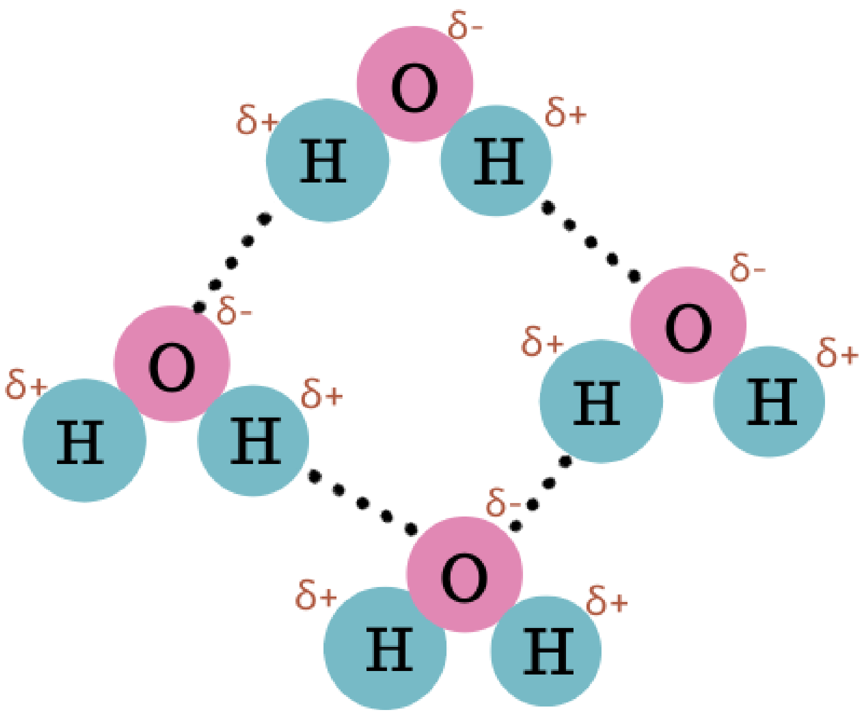


Figure 2: Hydrogen bonding between water molecules

Sketch 3 water molecules bonded together by hydrogen bonds. Use Figure 2 above for help. Then trade with a partner for feedback. Use the checklist below:

☐ Does each water molecule have 1 oxygen and 2 hydrogen atoms?

☐ Are the oxygen atoms partially negative? Are the hydrogen atoms partially positive?

☐ Are the hydrogen bonds shown by use of a dotted line?

☐ Are hydrogen bonds between negative oxygens and positive hydrogens only? (a hydrogen bond would not form between two hydrogen atoms, for example, because they are both positive).

Hydrophilic and hydrophobic molecules:

Polarity of a molecule can determine whether it is hydrophilic ('water-loving') or hydrophobic ('water-fearing'). A hydrophilic molecule will have polar regions, and will contain partial charges that can attract other molecules. A hydrophobic molecule is nonpolar, and cannot attract other molecules with noncovalent bonding. We can apply a material's hydrophilic or hydrophobic nature to its solubility in water. Hydrophilic molecules will dissolve in water by the formation of hydrogen bonds, whereas hydrophobic molecules will not form hydrogen bonds and will not be able to dissolve in water.

Solubility activity:

Sucrose, or table sugar, is a common ingredient in baking. It is hydrophilic and can dissolve in water. We often stir sugar into coffee or tea. In this activity, you will model how sucrose (table sugar) dissolves into water due to its hydrophilic nature.

Materials:

- 3 different colors of playdough
- Toothpicks
- Paper
- Scissors
- Marker

1. Assign colors of play doh to the following atoms:

Oxygen: _______
Hydrogen: ______
Carbon: _______

2. Observe the chemical structure of sucrose in Figure 3 below. Build this structure (flat on the table is fine) using playdough and toothpicks. Remember to adhere to the color key for each atom!

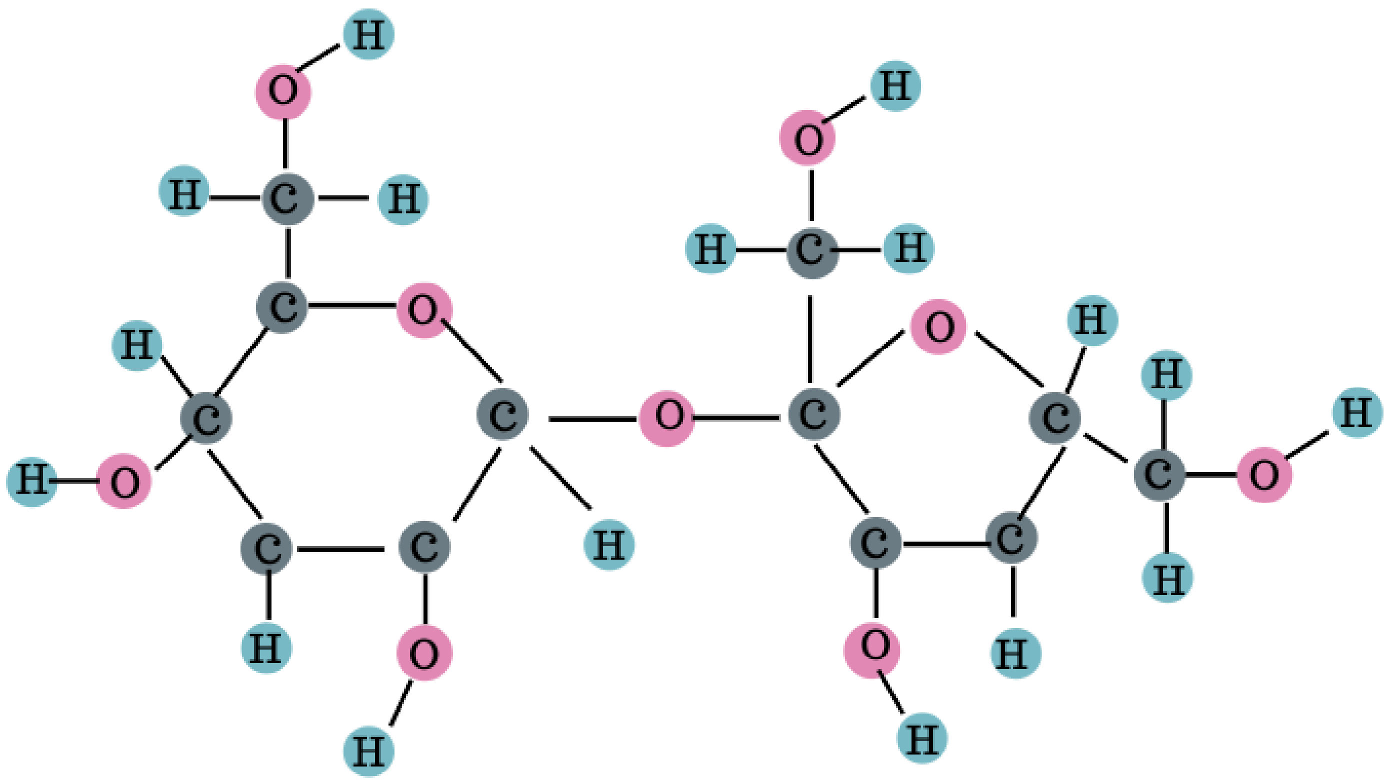
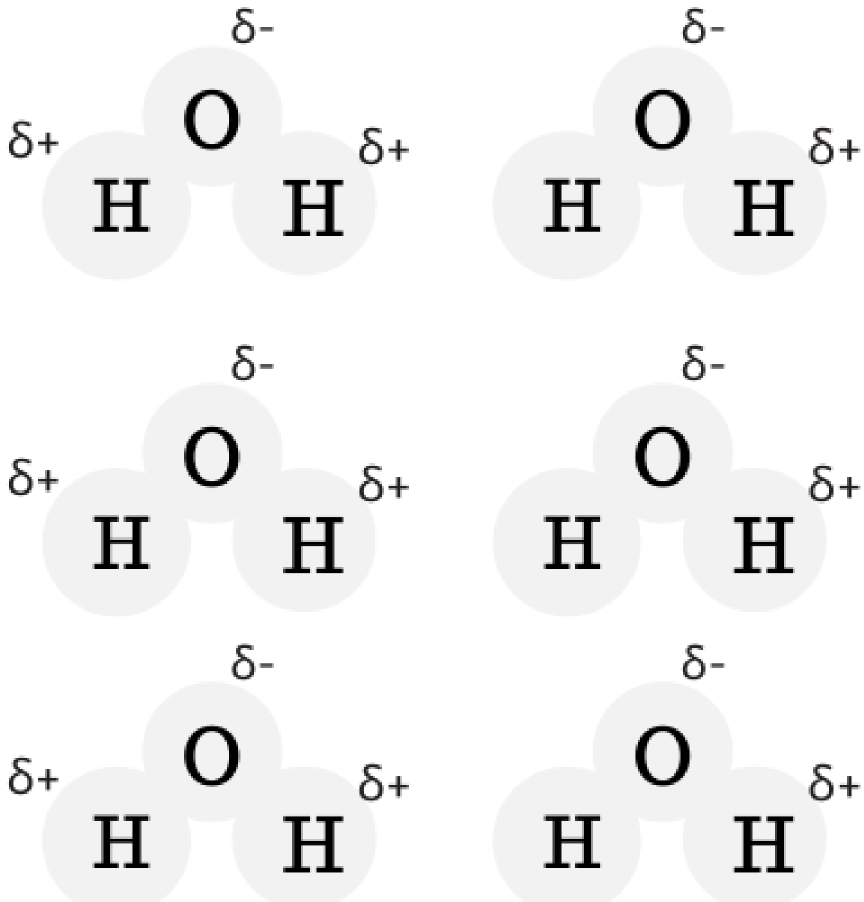


Figure 3: Chemical structure of sucrose

3. Label sucrose:
   a. Recall from Figure 1 that oxygen has a high electronegativity and will take on a negative charge. Using the cutouts, label the oxygens with a **δ-**.
   b. Since oxygen is strongly electronegative, it will pull electrons towards it and away from whatever it is bonded to. Now, view the atoms that each oxygen is bonded to. Make those atoms partially positive, giving each a label of **δ+**.

Water molecules



Partial charges

δ- δ- δ+ δ+ δ+ δ+

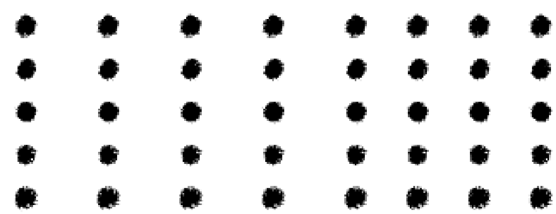
δ- δ- δ+ δ+ δ+ δ+

δ- δ- δ+ δ+ δ+ δ+

δ- δ- δ+ δ+ δ+ δ+

δ- δ- δ+ δ+ δ+ δ+

Hydrogen bonds



c. Observe your playdough chemical structure. Where do you think hydrogen bonding can occur between sucrose and water molecules? Identify locations in the sucrose molecule where positive and negative charges can attract. Position the water molecules to represent a correct hydrogen bond. (Hint: you will have different bonds than your peers, because there are many right ways to do this!).

d. Once you have identified locations where hydrogen bonds can occur, cut out the hydrogen bonds given and place them in the correct orientation (bonds should be between δ- and δ+).

4. Gallery walk:
Congratulations, you have just shown how table sugar dissolves in water at the molecular level! Once you have your finished product labeled, take a picture. Then walk around to other stations to view the finished products of your peers. How do the hydrogen bonds you created differ from theirs?

What's going on?
Table sugar consists of thousands of sucrose molecules that are crystallized together to form a solid. When it dissolves in water, it is causing water to surround and bond with individual sucrose molecules. This is what causes the sugar to 'disappear' as you are stirring, as seen in Figure 4 below.

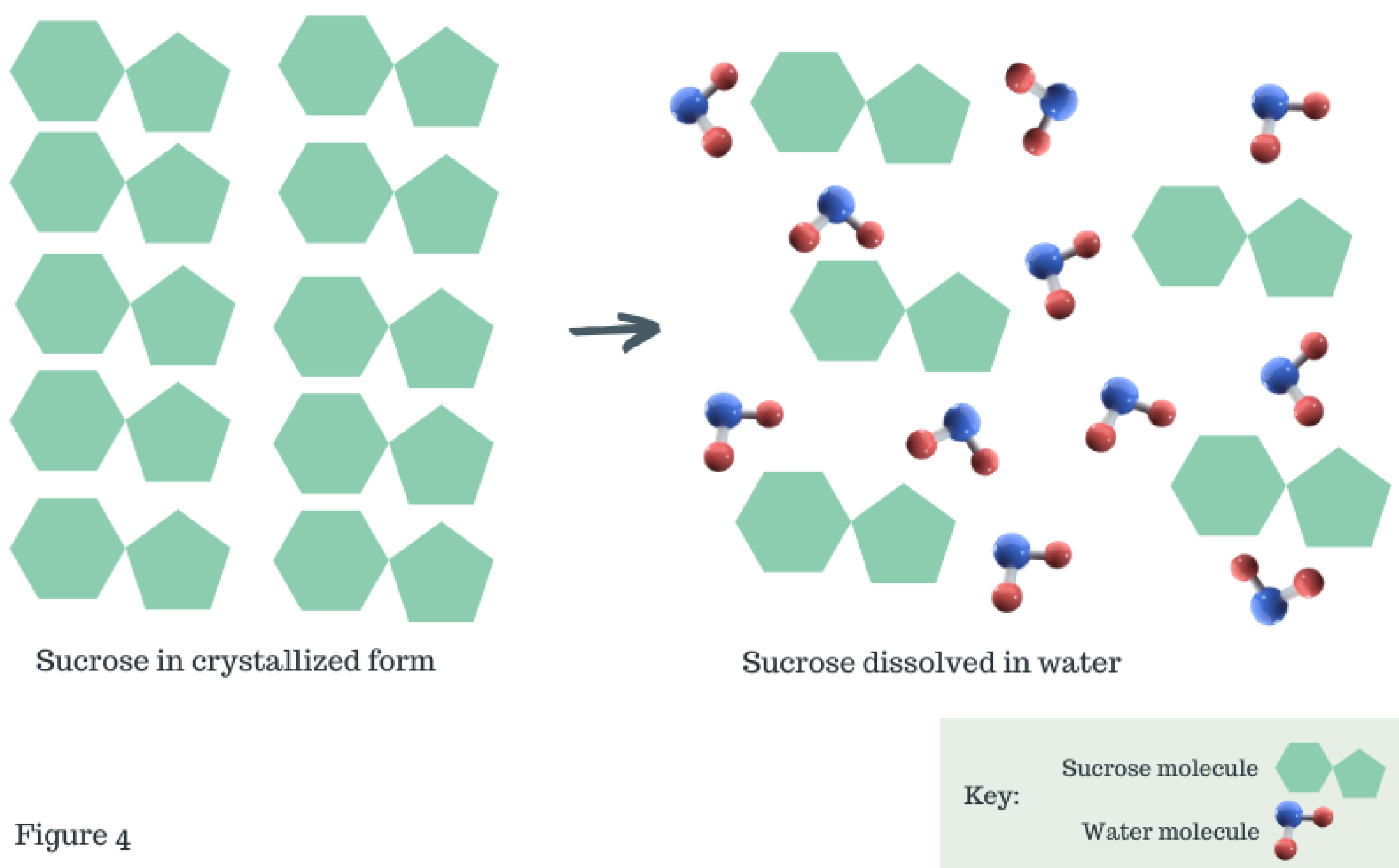


Figure 4

Reflect:
- Based on the activity you just did, how would you describe the terms "dissolve" and "soluble"?
- If a chemical substance is soluble in water, will it absorb or repel water? Why?

Water repellent materials

In the activity above we saw that if a substance is polar, it will be hydrophilic and 'water-loving'. This causes the substance to absorb water into the material. However in order for a product to be water repellent, it should not be soluble in water, and should be hydrophobic, or 'water-fearing'. Depending on the product, you may want to either attract or repel water. A kitchen towel perhaps should be hydrophilic, so that it can absorb as much water as possible from a spill. But you may want the material of your gym clothes to be hydrophobic, so that it repels water and doesn't absorb lots of sweat.

By conducting a water drop test, we can gauge the hydrophobicity of a material. This test will tell us how much water is absorbed or repelled.

Water drop lab:

Materials

- 4-5 flat materials from old or broken household products
- Mycelium planter or other mycelium product
- Protractor
- tape
- Water
- Pipette
- Clipboard

Procedure

1. Select a material to test.
2. Position and attach the material onto a clipboard so it is laying flat. Try not to touch it with your hands, because the oils from our fingers can affect hydrophobicity.
3. While laying the material down flat on the table top, drop 2 drops of water together on the material to create one large drop of water.
4. One person should hold the protractor at the bottom and to the side of the clipboard. (When you raise the clipboard, you should be able to read the angle it is raised to).
5. Slowly raise the clipboard and watch for the moment when the water drop begins to slide. Record this angle.
6. If the water drop does not slide, you can record that the water was absorbed.
7. Repeat steps 1-6 with other materials of your choice.
8. Then test your mycelium planter. This can be done without a clipboard, if you do not want to cut out a strip of the material. Just simply look for the angle on the planter itself.
9. Record results in a data table such as the one below.

Table 1: Angle when water drop fell (°) during water drop test with various materials.

Material	Angle when water drop fell (°)

Reflect:

- Which materials were the most water repellant? What type of molecules do you think this substance contains (polar or nonpolar?) Why?
- Which materials absorbed water? What type of molecules do you think this substance contains (polar or nonpolar?) Why?
- Brainstorm at least 5 household products that you think must be water repellent in order to be effective.