Purpose: To learn about hydrophobic and hydrophilic molecules.

Learning Objectives:
1. Substances can be classified as hydrophilic, hydrophobic, or both.
2. Emulsifiers enable hydrophobic and hydrophilic substances to mix.

Next Generation Science Standards (est. 2013)
- ETS1.B: Developing Possible Solutions
- ETS1.C: Optimizing the Design Solution

National Science Education Standards (valid 1996-2013):
- Standard B: Physical Science
  o Properties and changes in properties of matter
- Standard F: Science in Personal and Social Perspectives:
  o Science and Technology in Society

Grade Level: 2-8

Time: 1 hour

Preparation ahead of time:
Portion sand into individual samples for students.
Pour liquids for testing into dropper bottles.
Dispense solids for testing into small jars.

Materials:
- Samples of magic sand
- Samples of regular sand
- Water
- Oil
- Paper towels
- Soap
- Egg substitute
- Fruit Juice
- Tooth picks
- Butter
- Mustard
- Honey
- Mayonnaise
- Vinegar
Introduction:
Define the words hydrophobic and hydrophilic. Define these words as “does not mix with water” and “does mix with water”, or “has interactions with water molecules” or “does not have interactions with water molecules” to give both a macroscopic and particulate context.

Procedure:
1. Observations of sand
   a. Allow students to experiment with samples sand, magic sand, and water.
      i. Make sure they first keep the sands separated, testing each with water individually.
      ii. Students may experiment beyond adding water, but you can tell them that once the magic sand gets wet (by oil, or adding soap to the water, etc.) it won’t dry out. They may choose to take just a small sample of the magic sand and add oil or soap to see what happens, which will preserve the integrity of the bulk of their sample.
      iii. Students may take home their magic sand sample.
      iv. Make sure students dispose of used/unwanted sand samples in the garbage, not in the sink! Dishes should be wiped as much as possible before rinsing into the sink.

2. Polarity testing
   a. Tell the students they will be testing the substances in the data table to see whether they mix with water or oil.
   b. To test a substance, have them add a small amount to a plastic Petri dish, then add a few drops of water. Stir well with a toothpick and observe to see whether mixing occurs. Use a second Petri dish to repeat with oil.
   c. Students should use two Petri dishes so they can compare the water and oil side-by-side; however, they should not be allowed to dirty more than 2 dishes. After each substance is tested, they must wash and dry their dishes before testing the next substance.

3. Surface tension (extra activity if there is extra time)
   a. Put water on a Petri dish.
   b. Sprinkle some pepper flakes over the water.
   c. Allow the students to observe the pepper flakes floating.
   d. Add one drop of soap to the water.
Discussion:
Ask the students to define the substances they tested as hydrophobic or hydrophilic, and provide reasoning for their answers.

For a more advanced explanation, discuss how the molecular structure affects the polarity. Explain how to “read” the figures on the data sheet, pointing out that every bend in the diagram represents a carbon atom, every line represents a bond between two atoms, and oil is composed of many carbons linked together. Water has no carbons, just an oxygen attached to two hydrogen atoms. Ask students to analyze the structures of the key ingredients in the substances that they tested to provide further justification for the results of their test (or if the test hasn’t been performed yet, to provide reasoning for their predictions.)

Evaluation:
Have them compare their results with their peers. There might be some conflicting answers. Use the disagreement in data to present the third option of “both”, and define emulsifiers. Tell them emulsifiers are molecules that have both hydrophobic and hydrophilic parts, which enables hydrophobic and hydrophilic things to mix.

What is a hydrophilic substance?
What is a hydrophobic substance?
Why doesn’t oil mix with water?
Why does vinegar mix with water?