Separating Mixtures

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Purpose: To learn about chromatography.

Learning Objectives:
1. Chromatography is how scientists separate substances that are mixed together.
2. Particles that are mixed together can be separated by using their unique properties.
3. Inks contain many different colors of dyes that can be separated using chromatography.

Next Generation Science Standards (est. 2013):
- ETS1.A: Defining and Delimiting Engineering Problems
- ETS1.B: Developing Possible Solutions
- ETS1.C: Optimizing the Design Solution

National Science Education Standards (valid 1996-2013):
- Standard B: Physical Science
  - Properties and changes in properties of matter
  - Transfer of energy
- Standard C: Life Science
  - Structure and function in living systems
- Content Standard D: Science and Technology
  - Abilities of technological design
  - Understandings about science and technology
- Content Standard F: Science in Personal and Social Perspectives
  - Science and technology in local, national, and global challenges

Grade Level: 2-8

Time: approx. 1 hour

Materials:
- Mixture of sand, salt, cork shavings, and iron filings in small glass vials (1 per student)
- Funnels, filter paper
- Beakers
- Scoopulas
- 3 oz. cups
- Magnets
- Washable markers
- Permanent markers
Pre-Activity Prep:
Mix equal parts sand, salt, cork shavings (use a grater to shave off pieces of cork stoppers), and iron filings. Distribute mixture into small glass vials.

Introduction:
Many chemical reactions produce more than one type of molecule, even if only one of the products is of interest. In order to separate out the desired product from all of the other byproducts, scientists use the process of chromatography. There are many different chromatographic techniques and methods, but they all utilize the variance in properties of the substances mixed together in order to achieve separation. Today, the students will use what they know about the physical properties of iron filings, sand, cork, and salt to separate the components of a mixture and they will also learn a chromatography technique to separate the dyes in pens.

Procedures:
1. Iron, Sand, Salt, Cork Separation
   a. Give the students the vial containing the mixture. Have them identify whether it is homogeneous or heterogeneous.
   b. Tell the students the components of the mixture. Alternately, have them guess the identity of the components by observations. If they are unfamiliar with the components (especially cork and iron) it may be necessary to describe what they are (cork is a very low-density wood; iron filings are tiny pieces of bars of iron metal).
   c. Ask the students to brainstorm ways to separate the pieces (other than to manipulate each particle and move it into the appropriate pile). Help the students if they seem to struggle for ideas. Narrow it down to "How would you separate sand and cork?"; "How would you separate cork and iron?" Encourage them to use what they know about the physical properties of each substance.
      i. Iron is attracted to magnets, so you could bring a magnet near the mixture to attract the filings. **Note: Iron filings will not be easy to remove from a magnet once they are stuck! Use a piece of paper or cloth to shield the magnet from direct contact with the iron filings.)
      ii. Cork floats in water, so adding water to the mixture will cause it to separate and rise to the top. You can then skim it off of the top using a scoopula or other device.
      iii. Salt dissolves in water (becomes a homogeneous mixture with the water molecules) so if the water is poured off, the salt will be separated with it.
      iv. Sand sinks in water, so it will remain behind when the water is poured off.
v. If the water is allowed to evaporate, only the salt will remain behind.

d. Allow the students to carry out the separation. Rather than tell them the order to apply the separation techniques, prompt them to think of what will happen, e.g. "Should you pour out the water first, or remove the cork first?"

2. Ink Separation
   a. Ask the students to choose whether to test permanent markers or washable markers.
   b. Cut two rectangles (size does not matter, but bigger is better) from a coffee filter.
   c. Have the student orient the rectangles so that the short edge is parallel to them and the long edge is perpendicular (hot dog-style).
   d. Tell them to use the marker to make a dot about one inch from the bottom of each rectangle.
   e. Help them crease the rectangles lengthwise (to help it stand in the beaker) and then place each one into a separate beaker. Pour a few mL of water in one beaker, and a few mL of isopropyl alcohol into another beaker.
   f. Repeat steps b-e with additional colors of markers.
   g. Repeat steps b-e with additional type of marker (permanent vs. washable).

Discussion:
Ask students to define a mixture. They should be able to describe it as many substances that are combined together, but the individual pieces are not attached to (chemically combined with) each other. Define homogeneous (uniform composition) mixtures and heterogeneous (non-uniform composition) mixtures.

Just as the students utilize the physical properties of the substances in the mixture, scientists have techniques to separate out molecules. Emphasize this analogy, and use the opportunity to discuss the size difference between the particles that the students separated (e.g. grain of sand) and molecules.

Washable markers have water-based inks, so the separation of the inks is much greater when water is used as the solvent in chromatography. Permanent markers have alcohol-based inks, so the isopropyl alcohol is much more successful at achieving separation. Describe this phenomenon as being attributed to the properties of the ink molecule (water-like or alcohol-like) and reiterate that because different mixtures have different properties, different techniques are needed to do the separation. Remind the students the previous separation technique of applying a magnet and adding water would not separate the ink molecules; not all solvents will work for all ink molecules, either.
Evaluation
Ask them to think of examples of mixtures in their lives, and ask whether they are homogeneous or heterogeneous. Possible examples are: salad (heterogeneous), milk (homogeneous), air (homogeneous), concrete (heterogeneous), Kool-Aid (homogeneous), etc.

Ask students to tell you why separating might be an important procedure.

Have students identify the colors of ink present in the various types of markers. If time permits, create a group chart that displays the information.