**STUDENT HANDOUT**

Dairy Discoveries: Physical & Chemical Properties of Components of Milk

*Every day, we encounter different types of mixtures.* ***Mixtures*** *are composed of two or more substances physically combined together. Some mixtures, such as saltwater, are* ***homogeneous****, which means that the molecules of each substance are evenly mixed at the molecular level. Homogeneous solutions are sometimes referred to as* ***solutions****. Other mixtures are* ***heterogeneous,*** *meaning that their particles are not evenly dispersed at the molecular level. Milk is a* ***colloid* *–*** *a heterogeneous mixture where one substance is dispersed in small aggregates in another solution.* *Although milk is mostly water, there are lots of different substances dissolved in or suspended in milk. Ions such as sodium, potassium, and calcium, as well as sugars such as lactose, are dissolved in the milk. Larger molecules, such as certain proteins and fats, are suspended in the milk in the form of small, microscopic dispersions.*

 *Scientists often describe a substance in terms of its physical and chemical properties.* ***Physical properties*** *can generally be observed without a chemical reaction – these include density, color, solubility, etc. A* ***physical process*** *does not involve a change in the identity of the substances involved.* ***Chemical properties*** *include ways that a substance reacts with other chemicals. A* ***chemical reaction*** *results in products whose chemical identity and whose properties are different from that of the reactants. In this activity, you will be separating the different components of milk on the basis of their physical and chemical properties. A* ***centrifuge*** *is a commonly-used laboratory instrument that separates components of a mixture based on density by rapidly spinning samples. Denser substances fall to the bottom of the tube, whereas substances that are less dense end up on top.*

**ENGAGE:**

1. Consider different items you encounter on an everyday basis: juice, milk, trail mix, even the air you breathe. Which of these are mixtures?
2. Consider the demonstration of oil and water used in class. What occurs at the molecular level that causes the colored water to separate from the oil? How is this related to physical & chemical properties? Draw a picture of the demonstration model.
3. Why does the oil layer end up on top of the water layer? How can we account for this?

**During the experiment:**

* Keep your safety goggles on at **all times**.
* **Never** eat or drink substances used in this science experiment.
* Follow instructions carefully!

**EXPLORE:**

1. Pour 10 mL of milk into a labeled centrifuge tube. Make sure to label the tube with the fat content of the milk.
2. Shake the milk inside the tube vigorously (making sure the cap is tightly on!) for 5-10 minutes.
3. Using a pipet, add 2 mL of acid and invert several times to mix thoroughly.
4. Centrifuge on medium-high speed (~3,000 RPM) for 7-9 minutes, or until the proteins and lipids are adequately separated from the fluid.
5. Record **qualitative** and **quantitative** observations in the diagram below.
6. Repeat with your other samples of milk.



**EXPLAIN:**

1. Measure the thickness of the protein and lipid layers using a ruler. If the substance is asymmetrically distributed due to the angle of centrifugation, measure the maximum and minimum thickness, and calculate the average of the two.
2. Create a bar graph depicting the thickness of the lipid and protein layers in various types of milk. How did the relative quantities of protein and lipid in each milk sample correlate to the percentage of fat in the milk nutrition label?

|  |  |  |
| --- | --- | --- |
| Type of Milk | Thickness of Lipid Layer (cm) | Thickness of Protein Layer (cm) |
| Skim |  |  |
| Low-Fat |  |  |
| Whole |  |  |

*Answer the following questions on a separate sheet of paper in 3-5 sentences each. Be sure to incorporate relevant key terms and vocabulary in your responses!*

1. What sorts of molecules were present in each of the layers of the centrifuged milk? Why did they separate?
2. What was the purpose of shaking the milk? What was the purpose of adding acid (vinegar) to the milk? Which of these is a physical change, and which of these constitutes a chemical change?
3. What *physical properties* and *chemical properties* of different components of milk were used in the fractionation of milk in today’s experiment?

**EXTEND:**

*Real-World Application: Making Butter from Cream*

In this extension, we will be investigating a practical application of using physical processes to separate components of a mixture. You will be churning butter by shaking different types of dairy. The physical agitation causes the small globules of fat in the milk to come together and separate from the rest of the liquid.

1. Obtain a 150 mL glass jar from your teacher.
2. Pour enough milk/cream into the jar to fill it halfway to the top.
3. Tightly cap the jar so that it does not leak.
4. Vigorously shake the jar containing the cream for 8-10 minutes. If you get tired of shaking, let your partner take a turn.
5. Carefully re-open the jar and record your observations.
6. Repeat the above steps with: Heavy Whipping Cream, Half and Half, and Whole Milk.

**EVALUATE:**

*Answer the following questions on a separate sheet of paper in 3-5 sentences each. Be sure to incorporate relevant key terms and vocabulary in your responses!*

1. How did the appearance of different types of milk differ before and after shaking, acidification, and centrifuging? Why is this the case?
2. How might a scientist use centrifugation to investigate something, either related to milk or unrelated?
3. What are some real-world examples of using physical and chemical properties to separate components of a mixture? (These can be examples we discussed in class or ones that you think of on your own.)