1336963 REV 001

Neo/SCI® Student's Guide

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Milk Madness Lab Investigation

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Background

Milk is a fluid that is widely consumed by humans, especially children and teenagers. With the exception of soymilk, which is made from plants, all the other types of milk that are used in these activities are cow's milk. Milk is a complex fluid that is made up of proteins (e.g., casein), fat, sugar (e.g., lactose), and water. It also contains calcium, phosphorus, salts and vitamins (particularly A and D). For example, whole milk is about 87 percent water, 4.9 percent carbohydrates, 3.5 percent protein, 3.5 percent fat and a residue of ash. More than half of the fat in milk is saturated fat, less than one fourth of its fat is monounsaturated and the rest is polyunsaturated fat. Like many animal fats, milk is relatively low in polyunsaturated fatty acids. However, even though milk contains proteins, carbohydrates and water, it is the fat content that differentiates various types of milk.

Raw milk is made up of tiny globules of butterfat suspended in serum or "skim milk". These globules weigh less than the serum and will gradually rise and form a top layer of cream. To prevent formation of a cream layer, most whole milk undergoes "homogenization," a process in which hot milk is pumped through valves at a pressure between 500 and 2500 pounds per square inch. The pressure prevents the fat from forming a layer of cream on the top of the milk by breaking up the fat globules into very tiny droplets that remain permanently suspended and dispersed uniformly throughout the milk. As the milk is pressurized through the tiny openings, some of the milk protein such as casein denatured, a change that stabilizes milk and makes homogenized milk somewhat more digestible than its non-homogenized counterpart.

In this lab investigation, you will explore a host of key scientific concepts using a familiar drink - milk. You will follow a guided inquiry based set of activities to explore and learn about enzymes; molecular bonds and chemical reactions; organic compounds; as well as health and nutrition. You will produce reasoned predictions, and form and test hypotheses by designing and conducting experiments. In doing so, you will discover the scientific method, including experimental design; interpret data; and draw conclusions.

Objectives

- ***Understand*** and master the scientific method and the inquiry processes.
- ***Produce*** reasoned predictions, propose testable hypotheses, and design and conduct experiments.
- ***Understand*** the cause and effect relationship, and that the final outcomes of a given lab investigation could not have happened without all previously taken steps.
- ***Think*** of everything that took place in a scientific investigation not as separate or isolated events, but as an integrated whole.
- ***Use*** and apply reasoning pattern in other situations.
- ***Identify*** the sources of milk.
- ***Identify*** and differentiate between organisms that produce milk, organisms that produce milk-like substances, and organisms that do not produce milk or milk-like substances.
- ***Understand***, describe the characteristics of and differentiate between various types of milk.
- ***Complete*** a simple laboratory test, using indicators for identifying the major nutrient molecules in milk.
- ***Obtain*** a better understanding of the nutrients in milk and the fat content of various types of milk.
- ***Obtain*** a better understanding of how enzymes work in chemical reactions.
- ***Understand*** a number of scientific concepts such as molecular bonds and chemical reactions.

Neo/SCI® Student's Guide

Name .....

Teacher/Section .....

Date .....

New ideas for teaching science

Safety & Disposal

Be sure to follow proper lab safety techniques as directed by your teacher.

As directed by your teacher, you should always wear safety gloves, goggles, and a lab apron to protect your eyes and clothing when working with any chemicals.

Iodine solution is a poison. Avoid any skin contact. Be sure that you are properly protected when handling it.

Small volumes of any of these reagents may be disposed by flushing them down the drain, followed by copious amounts of water.

Be sure to wash your hands before leaving the laboratory.

Laboratory Preview Activity: How Well Do You Know The Milk You Drink?

What to do...

Read the background section. Your teacher will then discuss and answer the following questions. The objectives of this set of questions are to serve as a warm up activity and to discover how much you know about milk in general.

1. Why do people drink milk?

2. How often do you drink and use milk per day or per week?

3. Where does the milk you usually drink come from?

4. What kind of animals produce milk? Name some.

5. Why are these the only kind of organisms that can produce milk?

6. Do plants produce a milk-like juice or substance?

7. Name all the types of milk that you are aware of.

8. Which types of milk have you never tried before?

9. Which livestock is, by far, the most valuable in milk production?

10. Name all the nutrients that are often present in milk, including vitamins and minerals.

NAME .....

TEACHER/SECTION .....

DATE .....

11. Your teacher will discuss with you the following terms:

Terms	Definition/Description
Catalyst:	
Chemical Bonds:	
Chemical Reactions:	
Colloid:	
Compound:	
Emulsification:	
Enzymes:	
Homogenization:	
Immiscibility:	
Lactase:	
Lactose:	
Milk:	
Mixture:	
Molecule:	
Nutrients:	
Product:	
Reactant(s):	
Solute:	
Solution:	
Surface tension:	
Suspension:	

Neo/SCI®
STUDENT'S
GUIDE

NAME .....
TEACHER/SECTION .....
DATE .....

New ideas for teaching science

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ACTIVITY 1

Milk Madness: Using the Scientific Method

What you need

Per group

20 mL	Various types of milk samples (1% milk, 2% milk, whole milk, half & half milk, fat-free milk, and soy milk)
4	Medicine cups
	Food coloring
1	Pipets
	Paper towels
	Liquid detergent
	Toothpicks

What to do...

Part I
Making Reasonable Predictions

Read the following questions, discuss them with your group and then write down your answers.

Step 1

What do you think will happen if you place a drop of food coloring in a medicine cup 2/3 filled with 2% milk?

What do you think will happen if, you then dip a toothpick into detergent and gently touch the toothpick to the drop of food coloring that you placed on the surface of the 2% milk? Write down all your predictions in Table 1.

Step 2

Challenge your group's predictions by discussing them one by one; then keep only those predictions that make sense to all the members of your group.

Part II
Challenge Your Predictions by Conducting Experiments

When there are no more challenges to stated predictions, perform the experiment to verify your hypotheses.

Step 1

Fill a medicine cup 2/3 full with 2% milk. Then place one drop of food coloring on the surface of the milk.

Step 2

Using the toothpick, gently place a drop of detergent on the drop of food coloring. Keep your eyes fixed on the medicine cup and observe what happens. Describe in writing what actually happened. Record your observations in Table 2.

Step 3

Using a pipet, gently place one more drop of detergent on the surface area of the milk that has higher concentration of food coloring. This area is usually around the inside edge of the medicine cup. Observe and describe in writing what actually happened. Record your observations in Table 2.

Step 4

Using a pipet, again gently place one more drop of detergent on one more drop of food coloring. Keep your eyes fixed on the medicine cup and observe what happens. Describe in writing what actually happened. Record your observations in Table 2.

NAME .....

TEACHER/SECTION .....

DATE .....

Step 5

What do you think will happen if you add more drops of food coloring and gently touch each one of them with one drop of detergent? Write down your predictions then conduct the experiment. Describe in writing what actually happened. Record your observations in Table 2.

Step 6

How and to what degree did your group's predictions agree or differ from what actually happened? Record your observations in Table 3.

Step 7

Review all the previous steps that you have already taken before you go to Part III.

Part III

Using What You Have learned To Predict What Would Happen In Related Situations

Step 1

Predict whether or not the same results will be observed using 1% milk, whole milk, half & half milk (10%), skim milk (0.5%), fat-free milk and soy milk. Record your observations in Table 4.

Step 2

Challenge your group predictions by discussing them one by one and then keep only those predictions that make sense to all the members of your group.

Part IV

Challenge Your Predictions by Conducting Experiments

Step 1

Fill a medicine cup 2/3 full with 1% milk. Then place one drop of food coloring on the surface of the milk.

Step 2

Using the pipet, gently place a drop of detergent on the drop of food coloring. Keep your eyes fixed on the medicine cup and observe what happens. Observe and describe in writing what actually happened. Record your observations in Table 4.

Step 3

Repeat Steps 12-13 using whole (4%) milk, half & half milk (10%), skim milk (0.5%), fat-free milk and soy milk. Record your observations in Table 4.

Step 4

How and to what degree did your group's predictions agree or differ from what actually happened using whole (4%) milk, half & half milk, skim milk or fat-free milk, and soy milk? Record your observations in Table 4.

Step 5

Compare the result of what actually happened in 2% milk to what actually happened in 1% milk, whole (4%) milk, half & half milk, skim milk or fat-free milk, and soy milk.

Part V

Developing reasoned and testable hypotheses

Step 1

Develop reasoned and testable hypotheses (i.e., tentative explanations) to why this happened. Use Table 5 to write your answers.

Step 2

Propose testable mechanisms for each generated hypothesis to explain why this happened. Use Table 5 to write your answers.

Your tentative explanations (i.e., testable hypotheses) should reflect your ideas, experiences and understanding. And you should be aware that only those hypotheses that have produced testable mechanisms must be considered. Any hypotheses without a testable mechanism will be rejected.

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NAME .....

TEACHER/SECTION .....

DATE .....

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Data Table 1

Prediction	Description of the Prediction
All the predictions generated. (You should have at least three predictions)	
Selected predictions by the group as being the most logical	

Data Table 2

2% Milk Plus Food Coloring & Detergent	Observation and Description
Touching One Drop of Food Coloring on the Surface of 2% Milk with a Drop of Detergent.	
Gently Placing One More Drop of Detergent on the Surface Area of the Milk That Has a Higher Concentration of Food Coloring.	
Gently Placing One More Drop of Detergent to One More Drop Of Food Coloring.	
Placing More Drops of Food Coloring and Gently Touching Each One of Them With One Drop of Detergent?	

NAME .....

TEACHER/SECTION .....

DATE .....

Data Table 3

How and to what degree do your predictions agree or differ from what actually happened?

Selected Prediction (The Most logical One)	Detailed Summary of What Actually Happened

Data Table 4

How and to What Degree Students' Predictions Agreed or Differed From What Actually Happened In Various Types of Milk?

Type of Milk	Prediction	What Actually Happened
1% Milk		
Whole Milk (4%)		
Half & half milk (10%)		
Skim (0.5%) or Fat Free Milk		
Soy Milk		

Data Table 5

Generated Hypothesis and Proposed Testable Mechanisms For Each Generated Hypothesis

Number	Generated Hypotheses (Tentative Explanations)	Proposed Testable Mechanisms For Proposed Hypothesis
1.		
2.		
3.		

NAME .....

TEACHER/SECTION .....

DATE .....

New ideas for teaching science

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ACTIVITY 2

Investigating the Nutrient Make-Up of Milk

What you need

Per group

5mL	Milk sample
1	Pipe
1	Spot plate
	Iodine potassium iodide (I_2KI)
	Biuret reagent
	Sudan III
1	Glucose test strip
	Water (tap or distilled)

Inquiry Question:

What are some of the nutrients that milk contains?

Prediction:

Write down all your predictions. Discuss them one by one. Then select the prediction that is the most reasonable.

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Testing Your selected Prediction:

Test your prediction by conducting the following lab investigation.

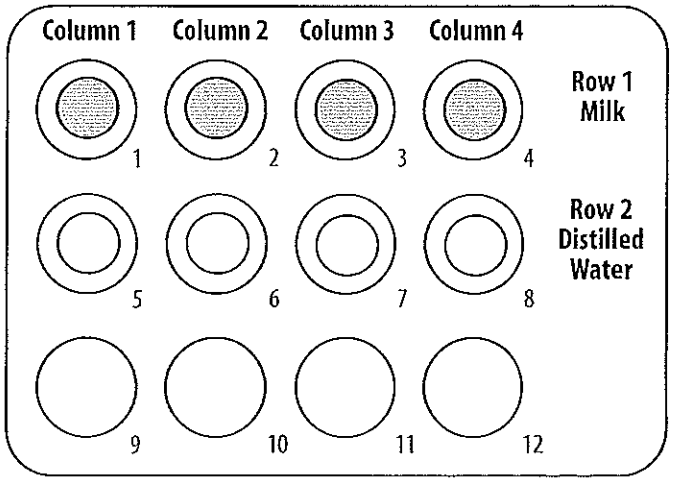
What to do...

Step 1

Put on safety goggles and be sure to follow any appropriate safety procedures carefully before you proceed with the experiment. Your teacher will provide you with a milk sample in a medicine cup.

Step 2

Using a pipet, transfer 1 mL of milk to each of the four wells across row 1 of the spot plate as shown in the figure below.



Step 3

Using a clean pipet, transfer 1mL of distilled water to each of the four wells across row 2 of the spot plate.

Caution: *Iodine Potassium iodide solution (I_2KI), is a poison. Avoid any skin contact. Be sure to wear proper safety equipment.*

Step 4

Using a clean pipet, add 1 drop of the Iodine Potassium Iodide solution (I_2KI), to Wells #1 and #5. If starch is present, it will change from yellow-brown to blue-black. Compare any color change in the wells and record your observations in Table 6.

Name .....

Teacher/Section .....

Date .....

Step 5

Using a clean pipet, add 1-2 drops of Biuret reagent to Wells #2 and #6. In the presence of protein, the mixture will change color from light blue to pinkish or purplish violet. Compare any color change in the wells and record your observations in Table 6.

Step 6

Using the dropper bottle, add 1-2 drops of Sudan III, to Wells #3 and #7. In the presence of lipids, the mixture will stain red. Compare any color change in the wells and record your observations in Table 6.

Step 7

Dip a separate glucose test strip into Wells #4 and #8 to test for the presence of glucose. If glucose is present, the color of the pad at the bottom of the strip will turn from yellow to light green for low glucose concentration and change to a darker shade of green for high glucose concentration. Compare any color change in the wells and record your observations in Table 6.

Step 8

Rinse the spot plate before repeating the experiment using a different milk sample.

Step 9

As directed by your teacher, be sure to wash your hands and clean up the area before leaving the laboratory.

Questions

1. Did your lab results validate your predictions?

2. How would your results vary if you tested half & half milk or fat-free milk instead of whole milk?

3. What is the purpose of testing a corresponding water sample for each test?

Data Table 6

Well #1 Iodine Potassium Iodide Solution		Well #2 Biuret Reagent		Well #3 Sudan III		Well #4 Glucose Test	
Color	Presence of Starch (+/-)	Color	Presence of Starch (+/-)	Color	Presence of Starch (+/-)	Color	Presence of Starch (+/-)

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STUDENT'S
GUIDE

NAME .....

TEACHER/SECTION .....

DATE .....

New ideas for teaching science

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ACTIVITY 3

The Reaction of Sodium Polyacrylate With the Milk Content

What you need

Per group

15 mL	Fat-free milk, whole milk, and half & half milk
4	Medicine cups
0.5g	Sodium polyacrylate
	Water

Inquiry Question:

What do you think will happen if you add 1/4 teaspoon of sodium polyacrylate into a cup half full with 2% milk?

Predictions:

Write down all your predictions to the inquiry question above. Discuss them one by one. Then select the prediction that is the most reasonable.

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Testing the Selected Prediction:

Test your prediction by conducting the following lab investigation.

What to do...

Step 1

Put on safety goggles and be sure to follow any appropriate safety procedures carefully before you proceed with the experiment. Students label 4 medicine cups as follows: "Water", "Fat-Free Milk", "Whole Milk", "Half & Half Milk".

Step 2

Fill each cup half-full with its corresponding type of milk.

Step 3

Pour 1/4 teaspoon of sodium polyacrylate into the cup with fat-free milk and observe the reaction. Explain how your predictions agree or differ from what actually happened. Record your observations in Table 7.

Step 4

Based on your observations of what actually happened in Step 3, predict what will happen when you pour 1/4 teaspoon of sodium polyacrylate into the plastic cups labeled "Whole Milk", "Half & Half Milk" and "Water". Record your prediction in Table 7.

Step 5

Pour 1/4 teaspoon of sodium polyacrylate into the cups labeled "Whole Milk", "Half & Half Milk" and "Water"; Then observe and record what happens in Table 7. Compare all your observations and then draw conclusions.

NAME .....

TEACHER/SECTION .....

DATE .....

Data Table 7

Test	Selected Prediction	Detailed Summary of What Actually Happened
Sodium polyacrylate plus fat-free milk		
Sodium polyacrylate plus whole-milk		
Sodium polyacrylate plus half & half milk		
Sodium polyacrylate plus water		

Questions

1. Do you think the results you obtained and your explanation of what actually happened can be affected by the following, and why:

   a. The kind of milk used in the experiment?

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   b. The temperature of the milk used in the experiment?

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Neo/SCI® STUDENT'S GUIDE

NAME .....

TEACHER/SECTION .....

DATE .....

New ideas for teaching science

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ACTIVITY 4

Investigating the Effect of Enzymes on Milk Content

In this activity you will investigate the effect of enzymes on organic molecules using milk and Lactaid caplets that contain the lactase enzyme. Over 50 million in the United States alone are unable to completely digest cow's milk sugar, lactose. Even though lactose intolerance is not a serious threat to good health and life, people who are lactose intolerant can take commercially produced enzymes such as Lactaid.

Enzymes are proteins that are needed to keep living cells alive by acting as catalysts in speeding up chemical reactions that would otherwise occur very slowly or not at all. They play a role as catalysts for metabolic reactions as well as movement, transport, buffer, defense, control and coordination of activities within living organisms. However, while enzymes such as lactase alter the rate of chemical reactions, they are not changed by that reaction. Excessive acidity or alkalinity or a temperature above 60°C (140°F) would affect the structure of the enzyme and the chemical reaction. In short, each enzyme has its optimum pH, temperature and concentration of enzyme molecules for proper function.

Treatment of lactose with the lactase enzyme splits the molecule into equal amounts of D-(+) glucose and D-(+) galactose.

What you need

Per Group

10 mL	Milk samples
2	Medicine cups
1	Lactaid tablet
3	Glucose test strips

What to do...

Step 1

Label two small cups as: "Milk" and "Milk + Lactaid".

Step 2

Pour 10 mL of milk in each cup. Crush 1 Lactaid tablet in a mortar and pestle and add it to the cup labeled "Milk + Lactaid". Stir the mixture to dissolve as much of the enzyme as possible and allow it to stand for 2-3 minutes before proceeding to the next step.

Step 3

Dip a separate glucose test strip into each cup to test for the presence of glucose. If glucose is present, the color of the pad at the bottom of the strip will turn from yellow to light green for low glucose concentration and change to a darker shade of green for high glucose concentration. Record your glucose test results in Table 8 and any additional observations such as production of gas and precipitation.

NAME .....

TEACHER/SECTION .....

DATE .....

Neo SCI®
New ideas for teaching science

Data Table 8

Solution	Color of Solution	Initial Color of Test Strip Pad	Final Color of Test Strip Pad	Presence of Glucose
Milk				
Milk + Lactase				

Questions

1. How does a Lactaid Caplet affect the milk content?

2. Which specific substance does the Lactaid Caplet have an effect on in milk content?

3. Did a chemical reaction take place in the experiment that you performed? What kind of findings or evidence do you have to indicate that a chemical reaction had or had not taken place in the experiment that you performed?

4. Can you name at least three more digestive enzymes and explain their function and how they work?

5. What is the relationship between the enzyme's structure and how it works and or functions?

6. Explain how your results would be affected by the following variables.
   a. The kind of milk used in the experiment. For example, cow milk, goat milk, soy milk, and others.

b. The temperature of the milk used in the experiment.

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c. The amount of the milk used in the experiment.

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e. The number of Lactaid Caplets used in the experiment.

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Going Further

- Using the procedures and reagents you used in this investigation, test for the nutrient content in other foods such as egg whites, butter, bread, cookies and other foods of your choice.
- Design an experiment to investigate how foods are digested in the stomach. Investigate the effects of dilute hydrochloric acid and pepsin on proteins and the action of amylase on carbohydrates.

Neat Websites

Information on food science and technology.
http://www.ift.org/car/car_b00.html
http://www.ift.org/car/food_ind/intro.html

A collection of food and nutrion links
http://www.library.tufts.edu/hsl/hsl_nutr_resources.html

A comprehensive site of information on food composition, nutrition, dietary guidelines and other related information.
http://www.nal.usda.gov/fnic/

Chemistry of carbon
http://cwis.nyu.edu/pages/mathmol/modules/carbon/carbonl.html

Read More About It

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Kozlov, Alex (1986). *Born to Milk.* Science Digest, Sept, 86, p. 63-69.

Leeds, Marcy J. (1998). *Nutrition For Healthy Living.* Boston, Massachusetts: WCB Publisher.

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