Scope, Sequence & Coordination

A National Curriculum Development and Evaluation Project for High School Science Education

SS
&C

A Project of the National Science Teachers Association

NATIONAL SCIENCE FOUNDATION

NSTA National Science Teachers Association

This project was suppported in part by the National Science Foundation.
Opinions expressed are those of the authors and not necessarily those of the Foundation.

Scope, Sequence & Coordination

SS&C Research and Development Center

Bill G. Aldridge, *Principal Investigator and Project Director**
Dorothy L. Gabel, *Co-Principal Investigator*
Erma M. Anderson, *Associate Project Director*
Nancy Erwin, *SS&C Project Editor*
Rick McGolerick, *Project Coordinator*

Evaluation Center

Frances Lawrenz, *Center Director*
Doug Huffman, *Associate Director*
Wayne Welch, *Consultant*
University of Minnesota, 612.625.2046

Houston SS&C Materials Development and Coordination Center

Linda W. Crow, *Center Director*
Godrej H. Sethna, *School Coordinator*
Martha S. Young, *Senior Production Editor*
Yerga Keflemariam, *Administrative Assistant*
Baylor College of Medicine, 713.798.6880

Houston School Sites and Lead Teachers
Jefferson Davis H.S., Lois Range
Lee H.S., Thomas Goldsbury
Jack Yates H.S., Diane Schranck

California Coordination Center

Tom Hinojosa, *Center Coordinator*
Santa Clara, Calif., 408.244.3080

California School Sites and Lead Teachers
Lowell H.S., Marian Gonzales
Sherman Indian H.S., Mary Yarger
Sacramento H.S., Brian Jacobs

Iowa Coordination Center

Robert Yager, *Center Director*
Keith Lippincott, *School Coordinator*
University of Iowa, 319.335.1189

Iowa School Sites and Lead Teachers
Pleasant Valley H.S., William Roberts
North Scott H.S., Mike Brown

North Carolina Coordination Center

Charles Coble, *Center Co-Director*
Jesse Jones, *Center Co-Director*
East Carolina University, 919.328.6172

North Carolina School Sites and Lead Teachers
Tarboro H.S., Ernestine Smith
Northside H.S., Glenda Burrus

Puerto Rico Coordination Center**

Manuel Gomez, *Center Co-Director*
Acenet Bernacet, *Center Co-Director*
University of Puerto Rico, 809.765.5170

Puerto Rico School Site
UPR Lab H.S.

Pilot Sites
Site Coordinator and Lead Teacher
Fox Lane H.S., New York, Arthur Eisenkraft
Georgetown Day School, Washington, D.C., William George
Flathead H.S., Montana, Gary Freebury
Clinton H.S., New York, John Laffan**

* Western NSTA Office, 394 Discovery Court, Henderson, Nevada 89014, 702.436.6685
** Not part of the NSF-funded SS&C project.

National Science Education Standard—Physical Science
Chemical Reactions
Catalysts, such as metal surfaces, accelerate chemical reactions. Chemical reactions in living systems are catalyzed by protein molecules called enzymes.

Teacher Materials

Learning Sequence Item:

969

Catalysts and Enzymes

March 1996
**Adapted by:Mary Yarger and Ema I. Gluckman*

Chemical Reactions. Students should observe the decomposition of hydrogen peroxide. Adding manganese dioxide, they should observe the rapid evolution of a gas. They should also observe other examples of catalysts and their effects on chemical reactions, including the action of yeast in fermentation as an example of the action of an enzyme. (*Chemistry, A Framework for High School Science Education, p. 72.)*

Contents

This micro-unit was created by **Mary Yarger** (Sherman Indian High School, Riverside, Calif.) and **Ema I. Gluckman** (Sacramento High School, Sacramento, Calif.)

969
Learning Sequence

Chemical Reactions. Students should observe the decomposition of hydrogen peroxide. Adding manganese dioxide, they should observe the rapid evolution of a gas. They should also observe other examples of catalysts and their effects on chemical reactions, including the action of yeast in fermentation as an example of the action of an enzyme. (*Chemistry, A Framework for High School Science Education, p. 72.)*

Science as Inquiry	Science and Technology	Science in Personal and Social Perspectives	History and Nature of Science
"Genie, Come Out of this Bottle!" **Activity 1**	Lead-burn Catalyst **Reading 2**	Breads around the World **Assessment 2**	
How Eggsciting! **Activity 2**	Processing More of U.S. Oil **Reading 3**	Michael Foster: Warrior for a Cleaner Environment **Reading 1**	
The Liver's Enzyme **Assessment 1**	To Rise or Not to Rise, That is the Question **Activity 3**	From Vine to Wine **Reading 5**	
Yeast in Bread **Assessment 3**	New Chemistry Boosts Promise of Natural Gas **Reading 4**	The Teff Also Rises **Reading 7**	
Catalysts in Animal Systems **Assessment 4**	Yeast at Work **Reading 6**		

Suggested Sequence of Events

Event #1

Demonstration

1. "Genie, Come Out of this Bottle!" (5 minutes)

Event #2

Demonstration

2. How Eggsciting! (day 1: 50 minutes; day 2: 20–50 minutes)

Event #3

Lab Activity

3. To Rise or Not to Rise, That is the Question (homework)

Event #4

Readings from Inquiry, Science and Technology, Personal and Social Perspectives, and History of Science. Students select two or three from list.

Reading 1 Michael Foster: Warrior for a Cleaner Environment
Reading 2 Lead-burn Catalysts
Reading 3 Processing More of U.S. Oil
Reading 4 New Chemistry Boosts Promise of Natural Gas
Reading 5 From Vine to Wine
Reading 6 Yeast at Work
Reading 7 The Teff Also Rises

The above readings can be found in the student version of this publication.

Assessment items can be found at the back of this volume.

Assessment Recommendations

This teacher materials packet contains a few items suggested for classroom assessment. Often, three types of items are included. Some have been tested and reviewed, but not all.

1. Multiple choice questions accompanied by short essays, called justification, that allow teachers to find out if students really understand their selections on the multiple choice.

2. Open-ended questions asking for essay responses.

3. Suggestions for performance tasks, usually including laboratory work, questions to be answered, data to be graphed and processed, and inferences to be made. Some tasks include proposals for student design of such tasks. These may sometimes closely resemble a good laboratory task, since the best types of laboratories are assessing student skills and performance at all times. Special assessment tasks will not be needed if measures such as questions, tabulations, graphs, calculations, etc., are incorporated into regular lab activities.

Teachers are encouraged to make changes in these items to suit their own classroom situations and to develop further items of their own, hopefully finding inspiration in the models we have provided. We hope you may consider adding your best items to our pool. We also will be very pleased to hear of proposed revisions to our items when you think they are needed.

Science as Inquiry

“Genie, Come Out of that Bottle!”

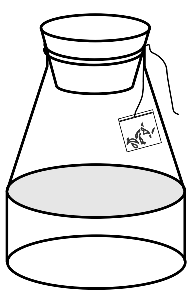
Demonstration

Overview:

This is a demonstration of an oxothermic reaction.

Materials:

50-mL 30% hydrogen peroxide
1/4 tsp manganese dioxide
tea bag
graduated cylinder, 50 mL
opaque glass bottle with stopper
string, 20 cm
safety goggles
plastic gloves
Caution: 30% hydrogen peroxide may cause burns when in contact with the skin.



Procedure:

As part of the drama in this demonstratio, the teacher can repeat the title at the proper moment. Pour 50 mL hydrogen peroxide into the opaque bottle. Remove tea from the teabag, fill the bag with 1/4 teaspoon of manganese dioxide and tie a string to the bag. Place the bag into the neck of the jar—keeping the string outside of the jar—and cover with the stopper.

When ready to perform the demonstration, remove the stopper and drop the tea bag containing the manganese dioxide into the hydrogen peroxide, pointing the neck of the bottle up—or in a safe direction.

Within a few moments, an exothermic reaction in the bottle will produce a large amount of water vapor that will form a large cloud outside the bottle.

Variations:

Solid granulated potassium iodide may be substituted for manganese dioxide to catalyze this reaction. A drug store variety of hydrogen peroxide (3% solution) will not produce the same effect.

Background:

Hydrogen peroxide, a common household antiseptic, decomposes slowly at room temperature forming water and oxygen gas. Decomposition of hydrogen peroxide takes place more rapidly when manganese dioxide is added to hydrogen peroxide. During the decomposition of hydrogen peroxide the manganese dioxide is unchanged.

Catalysts used in industry make possible the production of many useful chemical materials. Without catalysts reactions would require conditions of temperature, pressure, or concentration that would make them expensive and/or dangerous.

One of the enzymes in blood, *peroxidase,* acts similar to manganese dioxide. This is the reason that hydrogen peroxide bubbles when added to an open wound.

In this experiment, the rapid release of oxygen gas in water creates the spray of water vapor into the air.

Other phenomena found in nature somewhat resembles this chemical demonstration. When a whale exhales through its blow-hole, it spurts air. However, because of the amount of water, it looks like water vapor is exhaled.

Adapted from:
Summerlin, L. R., and James L. Ealy, *The Aladdin's Lamp Reaction Chemical Demonstration*, Vol., 1, American Chemical Society, Washington, D.C., 1988.
Foresman, Scott, *Energy, Matter and Change*, 1973, pp. 435–437.

Science as Inquiry

How Eggsciting!

Overview:

This activity examines the effects of an enzyme.

Materials:

Per lab group:

1 hard boiled egg—whites only (discard yolks prior to distribution)
3 test tubes
water
hydrochloric acid [HCl] (1.0 M solutions—85 mL conc. reagent/liter)
pepsin (6% solution—6 g/94 water))
3 stoppers or corks for test tubes
graduated cylinder
incubator

Procedure:

Students will design their own experiment. One possible design is: the students set up three test tubes with the following ingredients (have them use approximately the same amount of chopped egg white in each of the three test tubes.):

Test Tube 1: egg white with 15 mL of water

Test Tube 2: egg white with 10 mL of water and 5 mL of 1.0 M hydrochloric acid

Test Tube 3: egg white with 5 mL of water, 5 mL of 1.0 M hydrochloric acid, and 5 mL of 6% pepsin solution

In this design the egg white is held constant. After all three tubes are set up, students make initial observations and then place the tubes in an incubator overnight at 37°C (to simulate human body temperature). The next day, they make observations to determine which test tube underwent the most digestion. The tube that has the most digestion should appear the most cloudy and the egg white should no longer appear to be chunky.

Background:

To prepare 1.0 M hydrochloric solution (HCl) use the following formula:

$M_1V_1 = M_2V_2$ where M_1 = concentration (molarity) of concentrated stock solution of HCl used, V_1 = volume of concentrated HCl solution, M2 = 1.0 M, and V_2 = volume needed for class.

Substituting and solving for V1 for a class of 35 students gives you:

(14 M*)(V_1) = (1.0 M)(100 mL)

V_1 = 7 mL of concentrated HC; which you then add to 93 mL of water and mix well.

Check to make sure that the concentrated HCl you use is 14 M (it may be different or you could use a less concentrated starting solution).

To prepare the 6% pepsin solution for a class of 35 students you need 50 mL of total solution. This is a 6% by weight solution. Therefore, dissolve 6 grams of pepsin in 94 mL of water and mix to dissolve well. This will give you enough for 2 classes of 35 students each.

At the 9th grade level it is recommended that students simply understand that a catalyst speeds up a chemical reaction without going into any further detail.

Normally the human stomach contains hydrochloric acid and other digestive enzymes, including pepsin (which is specifically for the digestion of protein (like eggs). Hydrochloric acid will break down the proteins, as well as many other substances. However, the pepsin will speed up the reaction. It is important to note that we are looking at a very basic definition of a catalyst: a substance that speeds up a chemical reaction.

Further Variations:

If time permits, you could allow one week for observations and not put the test tubes in an incubator. Time would be a variable. You could also experiment with different temperatures in the incubator, or even use a refrigerator.

Adapted from:

Science and Technology

To Rise or Not to Rise, That is the Question

Overview:

This homework activity uses bread baking as an experiment.

Materials: (homework)

Per lab group: Students will have to obtain all necessary ingredients to bake their bread. These may already be in their own kitchen, or they may have to purchase some ingredients. The ingredients will vary according to their recipe. Students may work in small groups at one member's home (make sure to get some proof of all the group members' participation). You may want to provide bread recipes or ask them to find their own.

Procedure:

At home, students follow the recipe for the type of bread they have chosen to bake. The only variable they have to manipulate is to bake one loaf with the yeast and one without yeast. The recipe should be identical for both loaves of bread, except for this one variable. Encourage the students to bring in their products and perform comparisons of appearance, texture and taste. Also encourage the students to read the articles about breads from other cultures.

Further Variations:

In Reading 4, there are recipes for Injera and Yesuff Fitfit which the students may attempt for an extension activity.

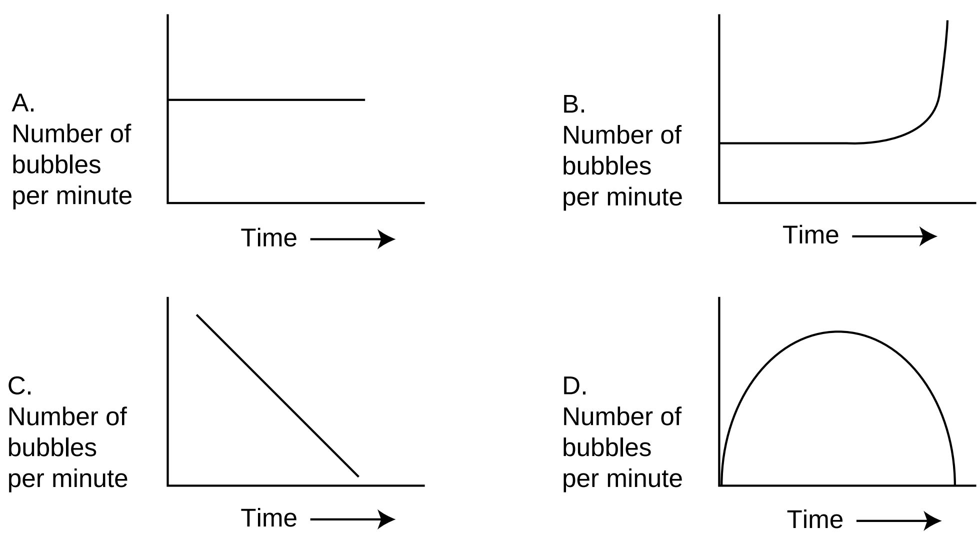
Adapted from:
Unknown.

Science as Inquiry

The Liver's Enzyme

Procedure:

When a small piece of raw liver is dropped into a solution of hydrogen peroxide, the solution bubbles and foams. The liver's enzyme, called *peroxidase,* changes hydrogen peroxide into water and oxygen. Enzymes are affected by environmental conditions such as temperature. An experimenter counts the bubbles observed to form in one minute as the temperature of the mixture of liver with hydrogen peroxide is changed. Which of the following graphs most likely represents the results?



Justification:

Explain how the graph you selected fits with you idea of how an enzyme works.

Answer:

A. Higher molecular motions in the solution speed up the reaction with the enzyme. However, at higher temperatures, the complex organic molecular structure of the enzyme begins to break apart, so the enzyme effectiveness diminishes.

Science in Personal and Social Perspectives

Breads around the World

Idea:

Bread is a common staple in-almost every country in the world. In the United States our melting pot culture allows us the opportunity to try different foods from different cultures and different religions throughout the world. There are many symbolic meanings to food traditions, as well as environmental reasons for dietary choices and traditions.

Use Reading 4 and compare injera (made from teff), to types of breads you enjoy or are familiar with because of your culture or background. For example, you might include tortillas, chapati, wild yeast sourdough, matzos and/or pita bread. Discuss their similarities and differences in terms of ingredients, cooking methods, and cultural significance.

Answer:

Here is a list of characteristics of different types of bread (students may need to do further research):

- uses or does not use commercial yeast
- uses flour, that when wet, began to ferment spontaneously.
- uses the wild yeast method of rising—taking a great deal of time
- used to hold together other parts of a meal
- size differences
- historical differences, i.e., Matzoh is meant to commemorate the Jews exodus from Egypt. They were in such a rush to leave that the Jews did not have the time to let the bread rise—thus unleavened bread.
- special preparations, i.e., Matzoh is prepared with a special dry flour (no moisture, so it would not rise). Once water is added, it must be baked within 18 minutes. The 18 minutes comes from the Hebrew letters for the number 18 which are the same for the word “life.”

Encourage students to talk to their classmates or members of their communities where these types of bread are made.

Science as Inquiry

Yeast in Bread

Item:

Bread is made by adding living yeast to flour, sugar and water. If the yeast were left out, which of the following would result?

A. The bread would not cook completely.
B. The bread would not have a fluffy consistency (would not rise).
C. The bread would have a different flavor.
D. The bread would have a strange color.

Justification:

If the yeast is included, but the sugar is left out, the yeast doesn’t work properly. Explain why this is so.

Answer:

B. The yeast metabolism creates carbon dioxide gas which bubbles through the bread dough leaving gas pockets. (The carbon dioxide will have gone after baking, and cooking kills the yeast.) If the sugar is omitted, then the yeast will not have food to metabolize, since it can’t break down flour, so the dough will not rise.

Science as Inquiry

Catalysts in Animal Systems

Item:

The modern view of a catalyst as a substance that increases reaction rates without altering the energy relations of a process was stated by Wilhelm Ostwald. Ostwald proposed this in relation to the processing of food by animals. Which of the following is a likely reason for this to be the first proposal of this type?

A. The enzymes were easy to isolate.
B. It was easy to control variables using live animals.
C. How animals use food was a very important problem to resolve.
D. Biological systems are generally much simpler to study than chemical molecules.

Justification:

Justify your answer based on how scientists tend to do research.

Answer:

C. The system is very complex but understanding it is very important to Knowing how to improve agricultural and human health. Scientists (and funding agencies) like important problems. Biological systems are inherently much more difficult to study than chemical reactions in the lab.