# SCOPE, SEQUENCE, and COORDINATION

A National Curriculum Project for High School Science Education

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# SCOPE, SEQUENCE, and COORDINATION

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## Student Materials

Learning Sequence Item:

# 969

# Catalysts and Enzymes

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

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### Contents



This micro-unit was created by **Mary Yarger** (Sherman Indian High School, Riverside, Calif.) and
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Science as Inquiry

# "Genie, Come Out of this Bottle!"

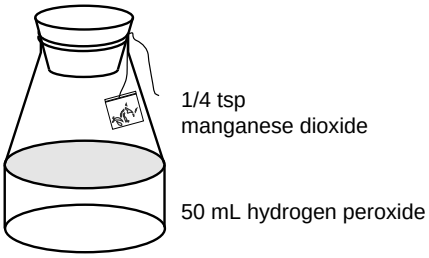
### What is an oxothermic reaction?
### Demonstration

**Overview:**

This is a special tea bag with very special effects.

**Procedure:**

Watch carefully as changes occur.




**Questions:**

1. What happens in a reaction?

2. Which is more stable—hydrogen peroxide or water?

3. How does the amount of catalyst change during this process?

*Student Sheet*

Science as Inquiry

# How Eggsciting!

### What is a catalyst?

**Overview:**

There's a reaction in your stomach. Let's recreate part of digestion in a test tube.

**Procedure:**

You have been given hydrochloric acid, pepsin (an enzyme) and egg white. Design an experiment to determine the effects of hydrochloric acid and pepsin on egg whites. After your test tubes are set up, make initial observations and then place the tubes in an incubator overnight. The next day, make observations as to which test tube underwent the most digestion. Record all of your data in a data table.

**Questions:**

1. How did your design test the effects of the acid on the egg white?

2. Which test tube shows evidence of the most digestion? Why do you think this is so?

3. What do you think is the function of HCl in your stomach? Of pepsin in your stomach?

4. How do you think that the condition of excess acid (heartburn) that affects some people affects their rate of digestion? How do you think the use of an antacid affects the rate of digestion? Design an experiment to test your hypothesis.

*Student Sheet*

Science and Technology

# To Rise or Not to Rise, That is the Question

### What is a catalyst?

**Overview:**

Homework, but it is still an experiment and produces something good to eat.

**Procedure:**

Your goal is to compare the effect of baking a loaf of bread with commercial yeast and one without yeast. You may choose any standard bread recipe you wish. However, you can not use any instant bread mix. Bake your loaves of bread, bring them to class for a class comparison (and tasting session).

**Questions:**

1. How did the two loaves compare?

2. Do you think that your bread dough would keep rising if you let it sit longer than your recipe calls for? Why or why not? Explain your answer thoroughly.

3. Why do some cultures make breads without using yeast?

4. Do you prefer breads made with or without yeast? Explain your answer.

Science and Technology

# Lead-burn Catalysts

Mention copper zeolite in certain circles these days and you suddenly get the attention of the whole room—at least if the room is full of automotive engine designers, who find them themselves more concerned with esoteric chemistry than with their favorite engine configuration.

The reason is that today's Holy Grail of engine technology is the development of a successful catalyst that treats oxides of nitrogen ($NO_X$) gases. An $NO_X$ catalyst would allow new applications of diesel engines, two-strokes, and lean-burn fourstroke engines designs that today are perversely condemned by pending emissions standards for being too efficient in the way they burn their respective fuels.

The root of the problem is that unlike most regulated exhaust emissions gases, which consist mainly of unburned fuel, oxides of nitrogen can be created simply by heating atmospheric nitrogen in the presence of oxygen. Today's engines run deliberately rich, both to cool down the combustion process and to produce enough unburned hydrocarbons to send a so-called stoichiometric mixture to the catalyst, where the hydrocarbons strip off the oxygen molecule from the $NO_X$. The final result is a relatively clean exhaust stream.

But burning up fuel in the catalyst doesn't help fuel economy, so engineers now want to switch to a "clean-burn" mixture where an oxygen-rich combustion process ensures that little unburned fuel reaches the catalyst. Fuel mixtures scarce on fuel and rich in oxygen are characteristic of diesels modern two-strokes, and lean-burn fourstroke engines, which actually produce lower emissions prior to treatment with a catalyst than rich-burning engines. Unfortunately, when an oxygen-rich mixture reaches the catalyst, it won't strip the oxygen molecule from the $NO_X$ the gas that is a prime culprit in photochemical smog.

Enter the zeolites.

Zeolites are aluminosilicates that form a three-dimensional crystal framework a molecular-size mesh that can be sized to trap unburned hydrocarbons temporarily, concentrating them so that they can be used as an $NO_X$ reducing agent in the presence of a catalyst. A zeolite substrate thus promises to be a part of an effective $NO_X$ catalyst the critical breakthrough that would allow all kinds of lean-burn engines to be used in tomorrow's passenger cars.

The zeolite catalyst has been demonstrated by researchers at Volkswagen and Johnson Matthey, but it requires careful control of the oxygen mixture, and the long-range stability of the system is questionable. Regardless, it is the most promising candidate so far in the quest for a chemical solution to the problem currently delaying development of several promising engines. ❑

"Lead-Burn Catalysts" [Automotive Newsfront], *Popular Science*, Dan McCosh, Ed., May 1992, pp. 42–43. Reprinted with permission from Popular Science magazine, copyright 1992, Times Mirror Magazines, Inc.

Science in Personal and Social Perspectives

# The Teff Also Rises

## Did the first naturally fermenting sourdough bread originate in Ethiopia?

At the height of the cruel Mengistu regime in Ethiopia in 1985, I made a modest proposal in this magazine for exerting indirect pressure on that government to persuade it to treat its starving people with greater compassion.

My plan did not involve an expeditionary force of American soldiers such as recently went to Somalia to guard convoys of food. In fact, all I wanted was to divert some of the immense capacity of U.S. agriculture to the cultivation of Ethiopia's staple gram Eragrostis abyssinica, called "teff" in the classical language of Ethiopia, Amharic. The grain yields a tiny seed, about one hundred-fiftieth the size of a wheat grain, but that smallest of all cultivated grains is the basis of Ethiopian traditional cookery. Teff flour is the main ingredient of the spongy, pleasantly sour pancake-like bread known as "injera," which literally underlies every Ethiopian meal. To set an Ethiopian table, one lays down a circular injera on top of which the other food is arrayed, directly, without the intermediary of any plate. Other injeras are served on the side and torn into pieces to be used as grabbers for the food on the "tablecloth" injera. Eventually, after the meal is finished, you eat the tablecloth, a delicious repository of the juices from the food that has been resting on it.

This method of eating is certainly worlds away from my own traditions, but it has had an immediate appeal for me and everyone I know who has tried it. And a large part of that appeal has been the opportunity to share in the refinement and wholeness of a very old and independent culture's foodways, right down to the table manners. But on its home ground in Ethiopia, this idyllic injera-centered cuisine was in dire trouble. During the catastrophic famine years under Mengistu, teff production had declined abruptly, and people were reportedly consuming the seed stock. Upon hearing this, my first assumption was that enlightened efforts at food relief could bring teff from the outside into Ethiopia. But teff did not really exist as a crop anywhere else. So it began to look as if traditional Ethiopian cuisine were doomed.

Of course, the Ethiopians could survive on other grains. They could even make perfectly traditional types of injera from sorghum, wheat, millet, rice, corn, and barley. And that is precisely what they were doing in the restaurants they established in exile in New York, Washington and other American cities. Nevertheless, it seemed tragic that teff should drop from view and, with it, one of the most defining features of an ancient way of life.

Fortunately, there was a way of saving teff, nonviolently, through a strategy of agronomic bootstrapping that might even save Ethiopia. It turned out that there was a modest seed stock for teff in the United States. My friend, the gardening writer Patti Hagan, located a supplier in Nevada selling teff seed to American gardeners who

By Raymond Sokolov. Reprinted with permission from "The Teff Also Rises," *Natural History*, March 1993, pp. 96–99. 

INJERA

3/4 cup teff, ground fine (this may be done either in a flour mill or in a blender after moistening in 3 1/2 cups water)
salt
sunflower or other vegetable oil

1. Mix ground teff with 3 1/2 cups water and let stand in a bowl covered with a dish towel, at room temperature, until it bubbles and has turned sour. This may take as long as 3 days. The fermenting mixture should be the consistency of pancake batter (which is exactly what it is).
2. Stir in salt, a little at a time, until you can barely detect the taste.
3. Lightly oil an 8- or 9-inch skillet (or a larger one if you like). Heat over medium heat. Then proceed as you would with a normal pancake or crepe. Pour in enough batter to cover the bottom of the skillet. If you use a teacup as a dipper, a little more than half its capacity of batter (about 1/4 cup) will make a thin pancake covering the surface of an 8-inch skillet if you spread the batter around immediately after pouring it in, by turning and rotating the skillet in the air. This is the classic French method for very thin crepes. Injera is not supposed to be paper thin, so you should use a bit more batter than you would for crepes but less than you would for a flapjack.
4. Cook briefly, until holes form in the injera and the edges lift from the pan. Remove and let cool.

Yield: 10 to 12 injeras

wanted to plant it as an ornamental grass (the company's delightful name and address, Garden Magic of Zephyr Cove, Nevada, matched teff's vernacular English name, "love grass," a direct translation of its Greek-derived genus).

My idea was for the Department of Agriculture to use the Nevada seeds to jump-start a commercial crop of teff. In short order, I argued, there would be a large enough supply of the grain to blackmail Mengistu into concessions on human rights. He could have our teff if he cleaned up his act.

Ronald Reagan's Department of Agriculture paid no attention to me. Eventually, it didn't matter. Mengistu fell anyway. And at least one American grower went ahead and raised teff in serious quantity as a cash crop: Wayne Carlson of Caldwell, Idaho. You can find his teff for sale today in many health food stores.

Nutrition-minded Americans have turned to teff as a source of calcium, fiber, and protein. It is also an alternative grain for people allergic to the gluten in wheat. It has an appealing, sweet, molasses-like flavor. And it boils up into a gelatinous porridge.

So, no doubt unwittingly, Mr. Carlson has made my dream come true in a small way. His teff crop makes it possible for exiled Ethiopians to make injera in this country. Indeed, the largest Ethiopian community in America, in the Washington metropolitan area, has its own injera bakery as well as Ethiopian groceries that sell authentic teff injera in plastic packages.

This is an obvious boon for Ethiopian immigrants, who have also found ways of providing themselves with other crucial elements of their unique cuisine, from honey beer to false banana (Ensete edule). But for non-Ethiopian cooks, one of the unforeseen advantages of a ready supply of teff is that it offers an alternative route for the investigation of one of the mysteries of the kitchen, sourdough baking.

Injera is, among other things, a first cousin of the sourdough breads that have made specialty bakers in San Francisco, Paris, and lately New York—famous and even revered. In the food press, much ink has been spilled over the essential mystery of sourdough—how to start it, how to feed it, how to keep it from getting too sour or from losing its fermentational oomph.

Part of the attraction of this subject is that no one really understands it. No one can say for sure

YESUFF FITFIT

Sunflower water mixed with Injera

(Adapted from Exotic Ethiopian Cooking, by Daniel J. Mesfin, Ethiopian Cookbook Enterprise, 1987)

2 cups sunflower seeds
2 cups green (raw) jalapeño chilies, seeded and chopped
1/2 teaspoon onion, chopped
1/4 teaspoon ginger, chopped
1/4 teaspoon garlic, chopped
salt
4 to 6 slices injera

1. Boil sunflower seeds in 6 cups of water for 15 minutes. Remove from heat, and drain off liquid.
2. Grind seeds in a blender to a paste.
3. Combine paste in a bowl, and add 4 cups water.
4. Mix and then strain liquid into a bowl. Discard paste.
5. Stir in jalapenos, onion, ginger, and salt to the strained liquid.
6. Break injera into small pieces and combine with liquid mixture. Refrigerate, and serve cold in a bowl.

Yield: 4 to 6 servings.

what the sources of the souring are that make the dough and the bread baked from it so delicious. Aficionados do, however, agree on one thing: They don't use commercial yeast. For people like John Thorne, publisher of the quarterly food letter "Simple Cooking" and author of the gastronomic essay collection Outlaw Cook (Farrar, Straus and Giroux, 1992), and Jeffrey Steingarten, food columnist for Vogue, superior sourdough bread rises because of the symbiotic action of "wild" yeasts and naturally occurring lactobacilli.

This is an exceedingly complicated subject, to which I intend to return. But the basic idea is that the best bread is made by duplicating the conditions of the first yeast-risen bread.

Clearly, the first bakers of prehistory could not buy packaged yeast. They invented leavened bread by baking moistened flour that had begun fermenting spontaneously. The carbon dioxide produced as a byproduct of the normal activity of a yeast culture present in the air or in the wheat itself bubbled inside the moistened flour (dough) and made it double in bulk.

Wheat flour, which contains elastic gluten, rose especially well and, if treated properly in an oven, would retain the expanded cell structure produced by the gas even after the gas escaped during the baking process. Voila! leavened bread, hallmark of civilization at least as far back as the exodus of the Jews from Egypt. You will recall that they fled so quickly they didn't have time to wait for their bread to rise. So they ate flat bread, or matzo, remembered now at Passover meals as the bread of affliction.

So the Bible tells us two things about normal bread in ancient days: it was yeast risen and the rising was time-consuming. It also seems likely that bakers back then operated the way aficionados do today saving some of their active dough as starter or "chef" for future dough batches. In this way they would have preserved at successful yeast/bacteria symbiosis that was functional, produced a pleasant-tasting loaf, and resisted infiltration from other, noxious microorganisms.

The custom of saving a piece of dough is still a symbolic part of the Jewish ritual of baking Sabbath bread. Originally, an olive-sized piece of moistened dough was separated from the rest, before baking, and given away, presumably as a sacrifice of something valuable, to the priests. Pious Jewish women today burn the dough as a sign that it is not theirs any longer.

Jewish ritual also recognizes the omnipresence of wild yeast. In an effort to give a precise defini-

tion to the idea of unleavened bread, rabbinical law goes beyond merely proscribing the addition of yeast to moistened flour. Bakers of proper matzo must put the dough in the oven within eighteen minutes of moistening the flour, to prevent leavening through the onset of the fermentation of naturally occurring yeasts. In order to insure that no improper or premature moistening takes place, the orthodox begin supervising matzo flour when it is threshed. This specially-watched matzo, called "shmura matzo," is always handmade. It is the polar opposite of the handmade loaves of the neo-Talmudic sourdough aficionados.

When I originally heard about the Jewish strictures on grain-moistening at Passover, I dismissed them as, well, pharisaical, but that was before I had read John Thorne on the subject of wild yeasts and heirloom sourdough starters handed down for generations because of their estimable qualities. Thorne and the other aficionados are almost as obsessional about other aspects of breadbaking: rising baskets, woodburning ovens, bread cloches. But the notion of spontaneously fermenting sourdough is at the center of their preoccupations (their quasi-scientific experimentations recall Pasteur's revolutionary investigation of the misconception known in his day as spontaneous generation, which led him to unlock the mystery of the chemistry of fermentation in an experiment that inaugurated the science of bacteriology).

Thorne and company, all eloquent proselytizers for wild yeast sourdoughs, seem to have overlooked a large group of potential co-conspirators among injera bakers in Ethiopia and the world over. Perhaps this is because most published recipes for injera obscure its historic identity as a true self-fermenting sourdough. Modern recipes written in this country usually specify the addition of yeast or the use of self-rising flour (which contains commercial yeast). But even these adaptations to life in exile in America call for a classic sourdough waiting period of two to three days while the dough for teff injera ferments and sours.

I am in no position to make sophisticated aesthetic distinctions between naturally fermented teff-batters and those made with commercial American yeasts, but it does seem obvious that the no-yeast recipe collected by Steve Raichlen and published in the Washington Post, which I have adapted here, must reflect traditional practice in the ancient kingdom of the Queen of Sheba before her descendants learned new tricks in our midst. ❖