

Teacher Guide for Illuminating Catalysts

Class time: 30-50 minutes

Purpose: Testing different catalysts and conditions for the light-producing luminol reaction.

Notes to the teacher: This Teacher Guide is intended to provide an outline of an experiment. You can adapt this activity depending on the level of the students, the amount of available class time and the resources available. For this activity, it is easiest to buy several Cool Blue Light Experiment Kits, ideally one for each group of students working together during the experiment. Each kit contains 5 grams of luminol, 5 grams of perborate, 2 grams of copper sulfate, a small scoop for measuring out the chemicals and a few other accessories. You can also buy the chemicals separately and use common lab equipment.

Luminol and perborate will react in water to produce luminescence, but that reaction is greatly aided by a catalyst. Depending on your preference, students can test different catalysts or they can use the same catalyst but vary other conditions to optimize the reaction.

Students will need light to set up experiments, but dark to see how well the experiments work. Plan to do a lot of flipping of the light switch or have two adjacent rooms, one light and one dark.

Materials:

- [Cool Blue Light Experiment Kit at Home Science Tools](#) (currently \$9.95) or the chemicals included in the kit: luminol mixture, perborate mixture and copper sulfate
- Disposable clear plastic cups or small beaker (about 150 ml)
- Camera without a flash (cell phone cameras will work well)
- Thermometers for each group
- Hot and cold water
- Colorimetric pH indicator strips
- Household acids and bases such as vinegar, lemon juice, ammonia, water with baking soda or laboratory acids and bases with varying pH
- A sheet of instructions outlining the experimental design of your choosing
- Gloves

Directions:

1. Each student lab group should get one Cool Blue Light Experiment Kit (or related chemicals); additional small clear cups or beakers; and various catalysts (see Step 4 below) or other conditions to test such as amount of catalyst used for a specific amount of reactants, temperature of reactants or the effect of pH on reaction rate (see Step 5 and Step 6 below).

2. Students can set up several small clear cups, each with one small scoop of luminol, one small scoop of perborate and a half-filled small cup of water. If your students are taking a more quantitative route to this experiment, have them measure and record the mass of the reactants.
3. Decide on a general procedure that students should use to determine the effect of a catalyst, or help your students determine a sound experimental technique of their own. They need to mix and stir all materials with a catalyst and determine the catalyst's effect. For example, students can use their cell phones to take photos (without the flash) of the luminescent reactions in the dark so they can compare the relative brightness of the reactions afterward. Be sure to use the same exposure settings for each photo with the phone camera and do not auto-adjust the cameras to the brightness.
4. If you would like students to test different catalysts, provide them with a number of options, such as:
 - Copper sulfate crystals
 - Shiny copper (pennies)
 - Corroded copper (pennies left in water for a day in advance)
 - Shiny iron or steel (paperclips, bolts, etc.)
 - Rusted iron
 - Blood from raw meat or chicken (the iron ions act as a catalyst)
 - Zinc (zinc washers, etc.)
 - Aluminum (foil)
 - Magnesium sulfate (Epsom salts)
 - Other metals or chemical solutions that contain metal ions
5. If you would like students to test the effects of different temperatures on the catalytic reaction, they can use the same small number or mass of copper sulfate crystals for each cup, but different water temperatures. Provide sinks or other sources of hot and cold water, as well as thermometers. (Generally the hotter the water is, the faster the reaction will proceed.)
6. If you would like students to test the effects of different pH on the catalytic reaction, they can use the same small number of copper sulfate crystals for each cup but use a variety of solutions ranging from acid to neutral to alkaline instead of using water. Provide colorimetric pH indicator strips and chemical solutions or household acids and bases such as vinegar, lemon juice, ammonia, water with baking soda or laboratory acids and bases with varying pH. (An alkaline solution with a pH around 11 should work best, and acidic solutions should suppress the reaction.) Have students measure the pH of each solution before beginning their experiment.

Teacher Guide for From Lactose to Glucose

Class time: 30-50 minutes

Purpose: Testing the effects of different conditions on lactase, an enzyme that catalyzes the conversion of lactose (milk sugar) to glucose (simple sugar).

Notes to the teacher: You can adapt this activity depending on the number and the level of the students, as well as the amount of available class time.

Materials:

- URS-1G-100 Teco glucose assay strips from www.testyourselfathome.com (currently \$9.95 for 100 strips)
- Scissors (to cut glucose strips in half lengthwise, so one strip will become two)
- Lactaid or similar generic chewable lactase tablets (available at drug stores and in the pharmacy section of grocery stores, Walmart and Target)
- Pliers (to crunch lactase tablets to powder) or a mortar and pestle
- Milk (any type except Lactaid milk that has already been treated with lactase)
- Test tubes
- Test tube racks
- Beakers or cups
- Thermometers
- Balances
- Weigh paper
- Crackers (if time permits for this part of the experiment)
- Stop watches or timers
- Gloves

Directions:

1. Assign students to lab groups, each with a rack of test tubes, a bottle of glucose test strips and the other supplies.
2. Have milk and water available for the whole class. Milk should ideally be in a beaker so it can be easily poured into test tubes.
3. Let the students conduct the lactase reactions with different conditions. Hand out [Blackline Master 4](#) and have students record their results.
4. Have the students graph their results.

5. If you have the time, allow your students to experiment with their own saliva (and make sure that they dispose of it properly when finished). Saliva contains amylase, an enzyme that breaks down starch into glucose. Have them crumble a cracker in water in a cup. Then they should chew another cracker for 30 seconds, spit it into a second cup and test both cups for glucose. Even the test strips rely on the enzymes glucose oxidase and peroxidase.

Student Guide for From Lactose to Glucose

Enzymes are catalysts that do certain jobs inside you. Your body can easily use simple sugars like glucose as energy sources. However, milk mainly contains lactose, two simple sugars (glucose and galactose) bonded together. Therefore, your body (especially when you are young) makes the enzyme lactase, which breaks lactose into its two parts. If people don't have enough lactase, milk can upset their stomachs. But there's a solution: Lactase tablets provide the enzyme, and Lactaid milk comes with all the lactose already broken down.

1. Cut the glucose test strips in half lengthwise so you can do two tests with one strip.
2. Fill three test tubes approximately half full with milk.
3. Briefly dip a glucose test strip into each tube of milk, then let the strip dry on the table for a minute or two. Compare the color of the strip with the color code on the side of the bottle of test strips. How much glucose is in the milk? Record your data on the accompanying sheets.
4. According to the thermometer, what is room temperature?
5. Fill a beaker most of the way with hot water. Record the water temperature.
6. Fill a beaker most of the way with cold water. Record the water temperature.
7. Use pliers or a mortar and pestle to crunch a Lactaid (lactase enzyme) tablet into powder. Put the powder on weigh paper on the scale. Record the mass of the powder.
8. Add the lactase powder to the test tubes of milk ($\frac{1}{3}$ tablet of powder per tube). Mix each tube by putting your gloved thumb over the top and shaking gently (or use a stopper if provided).
9. Set or hold one milk tube in the beaker of hot water, one in the beaker of cold water and one at room temperature (in no water).
10. After 1 minute, test the milk in each tube with new glucose test strips. How much glucose is in the milk? Record your data on the accompanying data table.
11. After 2 minutes, test the milk in each tube with new glucose test strips. Record your data.
12. Repeat the testing and recording procedure on each minute until you test and record the amount at 7 minutes.
13. Graph your data for the cold temperature on the accompanying sheets (add appropriate units to the axes).
14. Graph your data for room temperature on the accompanying sheets (add appropriate units to the axes).

15. Graph your data for the hot temperature on the accompanying sheets (add appropriate units to the axes).
16. Pick one length of time (for example, 4 minutes) and graph the results for temperature versus glucose (add appropriate units to the axes). Mix hot and cold water to create two water baths with new, unique temperatures. For the length of time previously chosen (for example, 4 minutes), repeat steps 7 through 9 for the two new water baths. Make sure you use the same mass of lactase as you did in the first three test tubes, and make sure that the lactase is crushed to the same degree. Plot your results on the same temperature versus glucose graph.
17. Test and graph the results for different amounts of milk per tube (measure and record the amount of milk in each tube with a graduated cylinder or ask your teacher for specific instructions), with the same length of time, same temperature and same lactase mass for all tubes. Add appropriate units to the axes.
18. Test and graph the results for different masses of lactase per tube, with the same amount of time, same temperature and same milk amount for all tubes.
19. Once you have collected all of your data, answer the following questions. Explain your answers by using specific evidence from your graphs.
 - How does time affect the amount of glucose produced at a specific temperature? Explain.
 - How does temperature affect the amount of glucose produced after a specific amount of time? Explain.
 - What temperature gives the most glucose? What might happen to the lactase enzyme at high temperatures? Explain.
 - How does the amount of milk affect the amount of glucose produced by the reaction in a specific amount of time? Because glucose is a product, what does this tell you about how the amount of milk affects the rate of the chemical reaction? Is there a maximum or minimum amount of milk above which or below which this relationship no longer exists? If so, why might this “amount of milk limit” exist?
 - What is the relationship between the amount of lactase used and the amount of glucose produced for a given amount of time and a specific temperature? What does this tell you about how the amount of lactase affects the rate of the chemical reaction? Based on your knowledge of catalysts, explain why this might be the case.

Lab: Lactase Enzyme Activity

Name: _____

Cold water bath temperature:	Room temperature:	Hot water bath temperature:
Time: 0 Glucose:	Time: 0 Glucose:	Time: 0 Glucose:
Time: Glucose:	Time: Glucose:	Time: Glucose:
Time: Glucose:	Time: Glucose:	Time: Glucose:
Time: Glucose:	Time: Glucose:	Time: Glucose:
Time: Glucose:	Time: Glucose:	Time: Glucose:
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