Cellular Respiration in Yeast -- Teacher Preparation Notes

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Equipment and Supplies needed per group

Test tubes that hold at least 50 ml (4)
Test tube rack (1)
Method for labeling test tubes (1)
Baker's yeast (2 tsp)
Water balloons (4)
Ruler (1)
Warm sucrose solution, 1%, 5%, (~25 mL of each concentration), 10% (~125 mL)
    To make sucrose solution:
        1%: add 1 g of sugar to every 99 mL of water
        5%: add 5 g of sugar to every 95 mL of water
        10%: add 10 g of sugar to every 90 mL of water
    Warm tap water (~50 mL)

Needed for Part II (The exact quantities needed vary depending on students' questions)
Salt
Oil
Egg substitute
Flavoring and additives such as cinnamon and raisins
Cold, room temp, warm, and hot water

Needed to make bread
    Flour (4 Tbsp)
    Bowl to mix bread in (1)
    Something to mix bread with (plastic knife, spoon, etc.)
    Tin baking cup (1)

The **flow of this activity** is as follows:
1. Students learn basic information about aerobic and anaerobic cellular respiration.
2. Students design an experiment to test whether sucrose concentration affects the rate of cellular respiration in yeast.
3. Students design an experiment to test the effects of other bread ingredients or temperature on the rate of cellular respiration in yeast. Instead of water as their control, they will use the 10% sucrose solution without the test ingredient or at the temperature used in the original experiment.
4. The students can then use the yeast solution from the treatment with the most CO_2 bubbles to make a roll of bread.

Cellular respiration will be measured with carbon dioxide production. This can be measured by measuring the depth of the layer of bubbles trapped in the foam on top of the yeast solution and also by observing balloons capping the test tubes, which catch the carbon dioxide produced and get bigger.

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[1] These teacher preparation notes and the related student handout are available at http://serendip.brynmawr.edu/sci_edu/waldron/.

After their second experiment the students can use the yeast solution in one of their treatment test tubes to produce a small loaf of **bread**. For the students to be able to eat their bread after they bake it, it will be necessary to make sure the test tubes and containers that hold the sugar etc. are clean and that students wash their hands and work areas before they start the experiment. To make bread they will 1) put 3 Tbsp of flour and 2 Tbsp of warm water into a bowl. 2) Add the chosen yeast solution to the bowl. 3) Mix the contents. 4) Knead the dough on a paper plate or a piece of paper, using extra flour as needed. 5) Form a ball and place in a labeled tin muffin cup. 6) Cover with a warm paper towel.

Allow at least an hour for the dough to rise before you bake the bread. If you need to leave the bread overnight without baking you should store it in the refrigerator so it doesn't rise too much and collapse. You can bake the cups in a **preheated** toaster oven in your room or collect all the muffin cups on a large cookie sheet and ask the lunch ladies to bake them all at once at 360 F until golden brown. The students can then taste their bread the next day.

See http://busycooks.about.com/library/archive/blyeastingred.htm for a discussion of what the different ingredients of bread are used for.

Discussion of Metabolism

The yeast which is used to make bread is *Saccharomyces cerevisiae.* This yeast is a facultative anaerobe, which means that when oxygen levels are low or glucose levels are high, sugar is metabolized without using oxygen, resulting in the production of a small amount of ATP, as well as carbon dioxide and ethanol. As the bread bakes, the ethanol evaporates. Bubbles which contained carbon dioxide provide the fluffy texture of bread. *Saccharomyces cerevisiae* and other members of the same genus are used in making wine and beer, where, obviously, the production of alcohol is a major goal.

Teaching Points

- If sugar is available but oxygen is not, the yeast uses alcoholic fermentation to metabolize the sugar, resulting in the production of carbon dioxide bubbles.
- When more sugar is available, the rate of respiration in the yeast is faster.
- Experimental method

Related Activities

One alternative activity, "Is Yeast Alive?", uses yeast metabolism as one way of testing whether the little brown grains of yeast are alive (available on this website). Another activity, "Taste Test: Can microbes tell the difference?", uses gas production as a measure of rate of yeast metabolism with different foods such as artificial sweeteners and different beverages (available at http://www.asm.org/Education/index.asp?bid=35292). Another activity, "Yeast on the Rise", tests the rate of rising in bread doughs that differ in the concentrations of sugar or other ingredients (available at http://www.microbeworld.org/resources/experiment/pgs62-65.pdf).