Got Milk? Do Biochemistry

Bacteria make up approximately 98 percent of the species on Earth and are ideal to study because of their physiological diversity and ecological importance. However, many life science teachers avoid using bacteria because they believe that the bacteria are too hard for students to observe or that the preparation of sterile media is too difficult. Bacteria should not be shunned, however, because they are very useful for introducing students to biochemical processes in the cell, including the hydrolysis of nutrients, the production of waste products, and changes in pH. All of this can be demonstrated to students using simple microbiological media made from a familiar material —milk.

Observing biochemical processes

Microbiologists have been growing bacteria on skim milk media for over a century. Milk contains protein in the form of casein and carbohydrates in the sugar lactose. If a simple pH indicator is added to skim milk, not only does bacteria grow in the media but changes in the media caused by the breakdown of protein and sugar are easily observed. This is the premise behind *litmus milk*, a combination of skim milk and litmus powder that allows biologists to determine what nutrients bacteria can break down and what end products are given off as a result.

The media starts out as an opaque, purple liquid. The litmus powder will change to pink if the media becomes acidic and to blue if the media becomes basic. Depending on the bacteria growing in litmus milk, a number of different things can happen.

- *Fermentation of lactose:* Many different bacteria are capable of fermenting lactose—breaking it down anaerobically to release energy. This process results in the production of lactic acid as a byproduct. Under these conditions, the media will turn pink as the pH drops. If a large amount of acid is produced, the media will also form an *acid clot* or *sour curd*. The media solidifies as proteins in the skim milk are denatured by the change in pH and become insoluble. Occasionally, the fermentation of the lactose also generates some carbon dioxide. This can often be identified by cracks in the acid clot produced as the gas is formed.
- *Hydrolysis of casein:* Not all bacteria can use lactose as an energy source. Some break down the protein casein instead. During this process, bacterial enzymes such as rennin break the weak chemical bonds in the casein, causing it to lose its three-dimensional structure. This process is called *sweet curdling* because little acid is present. Sweet curdling is an essential step in cheese production.
- *Deamination of proteins:* When amino groups are removed from milk proteins as ammonia molecules, the pH of the media goes up. As the media becomes more basic, the color of the litmus milk changes from purple to blue. Also, as large protein molecules are broken into more soluble amino acids, the media begins to lose its opacity and become transparent. This process is known as *peptonization*.
- *Litmus reduction:* Some bacteria can actually use the litmus powder as an electron acceptor during respiration. When this happens, the litmus is reduced and turns white.

All of the biochemical reactions that occur in milk are simple for students to understand metabolically and relate to naturally occurring, familiar processes. Acid-producing bacteria, for instance, create yogurt and make raw milk sour. In fact, milk is pasteurized to remove the organisms that cause it to become sour. Spore-forming bacteria like *Bacillus*—bacteria that are not destroyed by pasteurization—cause the chemical changes and precipitation of protein in pasteurized milk.

Cheese-making is dependent upon the formation of curd using the enzyme rennin. The enzyme was originally isolated from the stomachs of cows and mixed with raw milk to form a curd. Certain bacteria also have this ability.

Litmus milk is easy to use in the intermediate or secondary classroom. The media can be obtained sterilized and in test tubes from a variety of suppliers; a number of harmless strains of bacteria can be used to demonstrate the various chemical reactions. *Lactococcus lactis* is a species of nonpathogenic bacteria that can be used to illustrate the acid reactions, clotting, and litmus milk reduction reac-

tions. In fact, any yogurt that contains "active cultures" will also cause these reactions in the media. Peptonization and deamination are seen in litmus milk inoculated with spore-forming, soil bacteria of the genus *Bacillus*, especially *Bacillus megaterium*. Heating soil samples in an oven (at 100°C for about an hour) and inoculating tubes of litmus milk with the soil can demonstrate these reactions. Heating will kill many soil bacteria and leave the spore-forming *Bacillus* behind.

Most litmus milk reactions will occur at room temperature, so there is no need for special incubators. The reactions occur gradually over a two- to seven-day period, allowing students to see how various reactions progress as different nutrient sources are exhausted and wastes are produced. Used media can be safely and easily disposed of by heating the tubes in a boiling water bath for 30 minutes and then washing the contents down the sink.

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Starting the Year Off Right

As science teachers today are called upon to meet the goals set out by state and national standards and the No Child Left Behind Act, teachers cannot afford to waste classroom time. Efficient classroom management is now more important than ever and the best time to implement classroom management strategies is in the beginning of the year. Teachers who use the summer break to plan effective strategies for the coming year will thank themselves later on!

Classroom management consists of the practices and procedures teachers use to maintain an optimum environment for instruction and learning. If teachers do not structure their classrooms the first week of school, students will structure the classrooms themselves, in ways that may be detrimental to effective teaching and learning.

The key to a successful beginning of the school year is *consistency*. Effective teachers manage their classrooms with procedures and routines that keep the atmosphere consistent throughout the year, while ineffective teachers often are forced to run their classrooms with threats and punishments. Effective teachers set clear expectations for students right from the start and generally have no need for coercive discipline. For example, students should start the year knowing:

- What to do if they are absent or tardy;
- How materials are dispensed and collected at the end of an activity;
- What to do if they finish an activity early; and
- What to do if they have a question.

While these ideas may seem basic, they form the foundation of successful teaching. All of our higher-order goals for students—deep understanding, critical thinking, inquiry and inclusion—have one fundamental prerequisite: a classroom that is managed effectively.

Science teachers can and should borrow successful management strategies from other teachers and modify the techniques to work in their own classrooms. For effective classroom management procedures used by other teachers, visit *www.teachers.net/wong*. Some examples of material available on this website are:

- *The first five minutes are critical.* Four secondary teachers explain how they immediately engage students during the first five minutes of class.
- *Dispensing material in 15 seconds.* A tote tray system can be used to organize, dispense, and collect materials—all in 15 seconds with nothing broken.
- *A first day of school script.* Just like a football coach enters a game with a draft for the first 20 plays, this teacher has a script of procedures created for the first day of school.
- *The problem is not discipline.* Classroom management and discipline are not the same thing; this online article offers tips on how to master classroom management skills.

Procedures are the foundation for student achievement. Students who know the classroom expectations and procedures at the onset of school will be much more successful in their studies, and their teachers—in these well-managed classrooms—will have done their best to insure that no child is left behind.

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