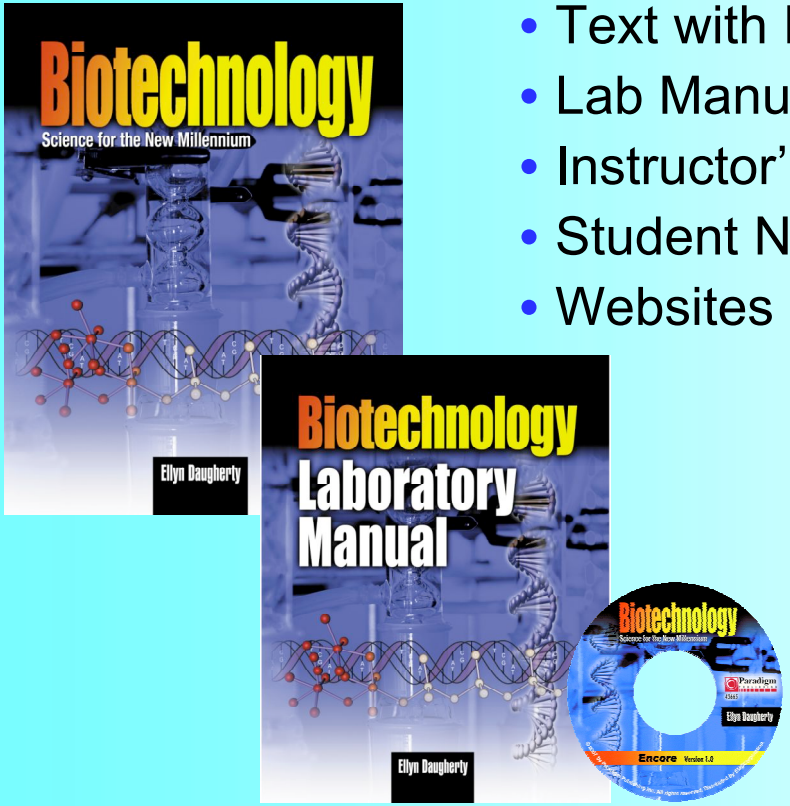
A tour through

# Biotechnology:

## Science for the New Millennium



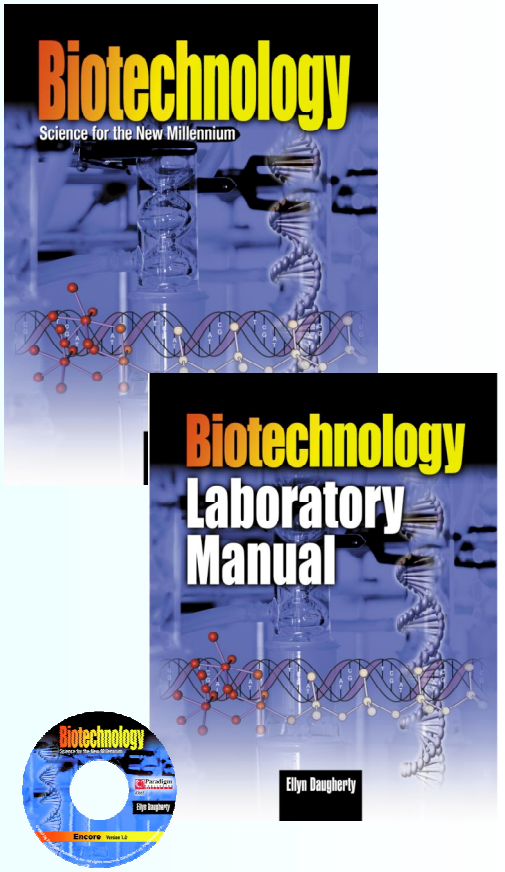

- Text with Encore CD
- Lab Manual
- Instructor's Guides
- Student Notebook
- Websites

Ellyn Daugherty
SM Biotech Career Pathway
**www.BiotechEd.com**
AEEDaugher@aol.com

**www.emcp.com/biotech**

# Curriculum to Support Biotechnology Laboratory Skill Development and Workplace Awareness

- Comprehensive text with concepts and activities that support biotechnology literacy, understanding of scientific processes, bioscience vocabulary development, and biotech workplace awareness
- Lab manual that focuses on the development of basic laboratory skills, confidence, self-directedness, and an appropriate workplace ethic
- Student CD for instruction, reinforcement, and remediation
- Websites with continuing support for both instructors and students

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# *Biotechnology:*

## *Science for the New Millennium*

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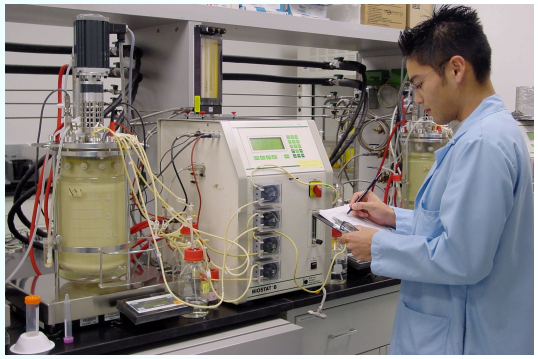

# Features of the Text

- *Biotech Careers*
- Learning Objectives
- Content Sections with Key Terms defined in margins
- *Biotech Online* Activities
- Section Review Questions
- *Speaking Biotech* - List of Key Terms
- *Concept Summary*
- *Lab Practices*
- *Thinking Like a Biotechnician* Questions
- *Biotech Live* Activities
- *Bioethics* (Dilemmas)

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Photo courtesy of Susan Taillant.

## Quality Control Analyst

**Susan Taillant**
**Genentech, Inc, Vacaville, CA**

Susan Taillant works in one of the Genentech, Inc protein-manufacturing facilities. Genentech, Inc uses genetic engineering technology to produce new proteins for medical uses. Working in a large team under the direction of a manufacturing supervisor, Susan is responsible for testing samples at the end of production. She performs general wet chemistry assays (tests) and chromatography (separation) techniques. All testing is performed in compliance with current good manufacturing practices (cGMPs).

The instrument shown in the photo above is a type of high-performance liquid chromatography (HPLC) instrument. It separates molecules based on size, charge, and/or shape, and is used to test the purity of a sample.

Quality control analysts (QCAs) are usually hired after they have earned a Bachelor's degree in biochemistry, chemistry, or molecular biology. Some companies hire QCA candidates with a 1- or 2-year Biotechnician Certificate.

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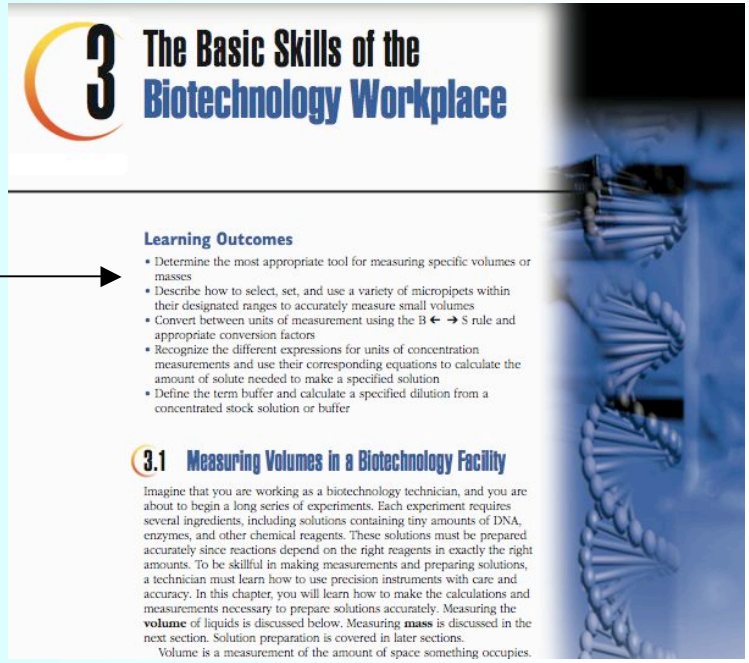

# 3 The Basic Skills of the Biotechnology Workplace

## Learning Outcomes

- Determine the most appropriate tool for measuring specific volumes or masses
- Describe how to select, set, and use a variety of micropipets within their designated ranges to accurately measure small volumes
- Convert between units of measurement using the B ← → S rule and appropriate conversion factors
- Recognize the different expressions for units of concentration measurements and use their corresponding equations to calculate the amount of solute needed to make a specified solution
- Define the term buffer and calculate a specified dilution from a concentrated stock solution or buffer

## 3.1 Measuring Volumes in a Biotechnology Facility

Imagine that you are working as a biotechnology technician, and you are about to begin a long series of experiments. Each experiment requires several ingredients, including solutions containing tiny amounts of DNA, enzymes, and other chemical reagents. These solutions must be prepared accurately since reactions depend on the right reagents in exactly the right amounts. To be skillful in making measurements and preparing solutions, a technician must learn how to use precision instruments with care and accuracy. In this chapter, you will learn how to make the calculations and measurements necessary to prepare solutions accurately. Measuring the **volume** of liquids is discussed below. Measuring **mass** is discussed in the next section. Solution preparation is covered in later sections.

Volume is a measurement of the amount of space something occupies.

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Figure 3.1. **Quart Milk Carton and 1-Liter Carton.** A liter contains 29.12 ounces, while a quart contains 32 ounces.

Figure 3.2. **Graduated cylinders are used to measure volumes between 10 mL and 2 L.**
Photo by author.

**volume (vol•ume)** a measurement of the amount of space something occupies

**mass (mass)** amount of matter (atoms and molecules) an object contains

**liter (lē•ter)** abbreviated "L"; a unit of measurement for volume, approximately equal to a quart

**milliliter (mill•i•lē•ter)** abbreviated "mL"; a unit measure for volume; one one-thousandth of a liter (0.001 L) or about equal to one-half teaspoon

**microliter (mi•cro•lē•ter)** abbreviated "µL"; a unit measure for volume; equivalent to one-thousandth of a milliliter or about the size of the tiniest teardrop

**graduated cylinder (grad•u•at•ed cyl•in•der)** a plastic or glass tube with marks (or graduations) equally spaced to show volumes; measurements are made at the bottom of the meniscus, the lowest part of the concave surface of the liquid in the cylinder

**pipet (pi•pet)** an instrument usually used to measure volumes between 0.1 mL and 50 mL

**micropipet (mi•cro•pi•pet)** an instrument used to measure very tiny volumes, usually less than a milliliter

**unit of measurement (un•it of mea•sure•ment)** the form in which something is measured (g, mg, µg, L, mL, µL, km, cm, etc)

Depending on the volume to be measured, three different types of tools or instruments are used: **graduated cylinders** (see Figure 3.2), **pipets** (see Figure 3.3a, b), and **micropipets** (see Figure 3.4). A technician must be able to select the right instrument, use it properly, and report the appropriate units of measurement for each.

### Converting Units

Often, volumes are measured in one **unit of measurement** and reported in another. To do this, you must be able to convert between larger and smaller units of measurement. For example, if 0.75 mL of an enzyme is needed for a reaction in a tiny tube, a micropipet that measures in microliters may be the best instrument to use. If so, a technician must be able to quickly convert from milliliters to microliters.

It is easy to convert between metric units because they are all larger or smaller than each other by powers of 10. For example, 1 mL is 0.001 L. So, to convert between milliliters and liters, just remember that a milliliter is 1/10 × 1/10 × 1/10, which is 1/1000 (3 decimal places or 3 powers of 10) smaller than a liter; thus move the decimal point to the right three places. The direction the decimal is moved depends on which way you are converting, bigger to smaller units or smaller to bigger units.

Use the B ← → S Rule to know which way to move the decimal. The B ← → S Rule shows how to move the decimal point in the value to be converted: to the right (multiplying) if converting from big units to small units, or to the left (dividing) if converting from small units to larger ones (see Figure 3.5).

For example, let us say a measurement of 1.25 L of solution is required, but the instrument to be used measures only in milliliters. You must convert from liters to milliliters. Since liters are bigger than milliliters, and there are 1000 mL in a liter, move the decimal to the right three places (for the 3 zeroes in 1000). Thus, 1.25 L = 1250 mL.

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## Section 3.1 Review Questions

1. What instrument would you use to measure and dispense the following volumes? Pick the instrument that is likely to give the least error for each measurement.

   23.5 µL  6.5 mL  125 mL  7 µL  2.87 mL  555 µL

2. Convert the following units to the requested unit:

   1.7 L = _____ mL  235.1 µL = _____mL  2.37 mL = _____ µL

3. What numbers should be dialed into the P-10 display if a volume of 3.7 µL is to be measured?
4. What instrument should be used if a technician wants to fill 40 sets of 16 tubes all with identical volumes?

## Biotech Online

Photo by author.

### Positive Displacement Micropipets

A **positive displacement micropipet** is another type of micropipet commonly used in biotechnology laboratories. Find a Web site that describes how a positive displacement micropipet works and lists some of its uses. Print the page, with the Web address, and highlight the informative parts.

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# Chapter

## Speaking Biotech

Page numbers indicate where terms are first cited and defined.

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## Summary

### Concepts

- In a cell, DNA directs protein synthesis and its own replication. Each body cell in an organism has the same DNA and same number of chromosomes as every other body cell in that organism. Sex cells have half the chromosomes (half the DNA) of body cells.
- The number of chromosomes is a defining characteristic of an organism. Bacteria have one chromosome per cell, but all other organisms have two or more chromosomes.
- Chromosomes in humans and other eukaryotes are arranged as 23 homologous pairs. Homologues have the same genes in the same order on the chromosome.
- Chromosomes are visible in cells when they thicken and shorten during cell division. Identification of chromosomes and matching them with their homologues is called karyotyping.
- As a result of mitosis, each daughter cell gets an exact copy of the chromosomes of the parent cell. This is possible because DNA is replicated prior to cell division.
- In cells, five enzymes control DNA replication. The enzymes unzip the complementary strands of the DNA double helix (helicase), attach a primer molecule (RNA primase), synthesize a complementary strand to each template (DNA polymerase), remove primer (RNase H), and seal adjacent DNA replication sites (DNA ligase).
- DNA replication can be performed in the lab by technicians. *In vitro* DNA synthesis is done to produce primers, probes, and genes of interest for research. In a test tube, a template molecule is necessary from which a complementary strand is built. Then, all the other essential ingredients for DNA synthesis, including buffer, primer, dNTPs, DNA polymerase, DTT, and magnesium chloride, are added to the tube.
- Using an automated DNA synthesizer, technicians build DNA strands by coupling nucleotides in a specific order to resin beads in a column.
- Synthesis products can be run on a gel and blotted to a membrane for visualization.
- DNA synthesis to make probes is an important application. Hybridization to probe arrays is used to screen samples of DNA for evidence of gene expression. Using microarray technology means hundreds of samples can be probed at the same time.

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# Review

- For ease of use and higher-sensitivity assays, DNA fragments are often transferred to membranes or paper. This is called Southern blotting. To prevent DNA samples from being washed off blots, samples are cross-linked to the membrane by UV light exposure.
- DNA synthesizers also make primers for use in PCR and DNA sequencing. Primers have to recognize specific sequences, so appropriate primer design is critical. Primers should be of a certain length and nucleotide composition.
- PCR is a method used to recognize certain sequences of DNA, and replicate them enough times to have sufficient sample to test or use in research.
- During PCR amplification, DNA is heated until the strands separate (denature). When the sample has cooled, primer is added to each strand, and Taq polymerase synthesizes the rest of each strand. Commonly, the denaturation step occurs at about 95°C, the annealing is at about 60°C, and the extension of the strands is at about 72°C. A complete cycle takes under 5 minutes.
- For each DNA strand in a sample, one strand becomes two, two become four, four become eight, and so on, exponentially, until there are a billion or more copies in the sample.
- The PCR reactions are run in thermal cyclers that control the temperature of the PCR reaction automatically.
- A PCR product is run on a gel to confirm its presence, concentration, and purity.
- PCR protocols take months to optimize. To produce the best PCR product, the reactant volume and concentration are tested, as well as the cycling time, temperature, and cycle number.
- Once a PCR reaction is optimized, it can be scaled-up for large sample numbers and high-throughput screening.
- PCR is used in many applications, including forensics, missing-persons cases, paternity cases, medical diagnostics, drug design, medical research, evolutionary studies, and endangered species study and protection.
- In recent years, VNTR PCR has become the main method of DNA fingerprinting. A VNTR is an allele that is present in a species in many forms due to mutations in the length of the region. Performing a PCR on VNTRs can determine a person's genotype for the alleles. The pattern of VNTRs on a gel is called a DNA fingerprint.
- Forensics is the science of data collection for the purpose of solving a crime. Many methods of data collection and analysis are used in forensics, including DNA fingerprinting.

## Lab Practices

- Oligonucleotides can be made in a test tube using a template and a primer that recognizes the 3′ end of the template. To get good annealing of the primer to the template, technicians mix the primer and template together, and heat them to a temperature that is high enough to separate them completely. Slow cooling allows accurate complementary annealing.
- DNA synthesis (in a test tube) proceeds to completion if all the required reagents are in the proper volume and concentration, including DNA polymerase, dNTPs, reaction buffer, $MgCl_2$, and DTT.
- DNA polymerase has maximum activity at approximately 37°C and is incubated with reactants for approximately 4 minutes at that temperature.
- DNA synthesis fragments are run on a TRIS/boric acid/urea (TBU)-PAGE gel in TRIS/boric acid/EDTA (TBE) buffer with DNA sizing standards. Before loading, they are heated, and the gel is prerun to keep the system at close to 90°C. This helps ensure that the primer-synthesis product and template do not reanneal.
- For DNA samples in low concentration, Southern-blot visualization methods are more sensitive than staining a gel with ethidium bromide (EtBr).
- In a Southern blot, a moistened membrane or nitrocellulose paper is laid on a gel with DNA samples. Paper is laid on top, and a heavy weight is placed on top of the paper. Capillary action draws the samples from the gel to the membrane.

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## Thinking Like a Biotechnician

1. What color is light of the following wavelengths: 600 nm, 525 nm, and 475 nm?
2. A colorless protein is purified from a cell extract. What kind of spectrophotometer should be used to detect its presence and concentration?
3. In moles/liter, what is the concentration of $H^+$ in a solution that has a pH of 6.0? In moles/liter, what is the concentration of $OH^-$ in a solution that has a pH of 6.0?
4. If a solution has a pH of 5.5, how can it be brought to a pH of 7.1?
5. Describe how to prepare 5 L of a 0.25 *M* TRIS buffer at pH 7.4.
6. Describe how to prepare 250 mL of 0.01 *M* sodium monophosphate monobasic buffer at pH 5.5.
7. Describe how to prepare 600 mL of 50 m*M* sodium monophosphate monobasic buffer at pH 6.5.
8. The enzyme, amylase, requires a small amount of $CaCl_2$ as a cofactor for activity. Thus, $CaCl_2$ is added to amylase buffers. Describe how to prepare 100 mL of 0.5 *M* TRIS, 0.05 *M* $CaCl_2$ buffer at pH 7.2.
9. A molecule has a lambda$_{max}$ of 475 nm. What wavelengths would probably not be good to use for testing samples for the presence of the molecule?
10. A set of standards is prepared by diluting a stock sample in a 1:2 ratio. If the stock solution has an absorbance of 1.2 au, and the 1:2 dilution has an absorbance of 0.6 au, what would be the expected amount absorbance of the 1:4, 1:8, and 1:16 dilutions? If the absorbance of the dilutions is not as expected, what might be the reason?

## Biotech Live

Activity 7.1

### Visual Spectrophotometry Virtually

TO DO **Go to http://web.umr.edu/~gbert/color/AAcolor.html to learn how to use the Spec 20 D.**

1. Access the Virtual Spectophotometry Tutorial by Gary L. Bertrand at the University of Missouri, Rolla. Click on the links to "Background," "Operation," "Experiment," and "Check Results" to understand how the spectrophotometer works.
2. Do the "Suggested Experiments." Print data tables and graphs generated for the virtual experiments.

Activity 7.2

### "Phun" at Home with pH

Many of the beverages, condiments, and cooking ingredients found in a kitchen are acids and bases. A solution with a pH of less than 7 has more $H^+$ ions than $OH^-$ ions and is, therefore, an acid. Acid solutions have certain characteristics, including, depending on the strength, a sour taste, and the ability to burn. A solution with a pH higher than 7 has more $OH^-$ ions than $H^+$ ions and is considered a base. Basic solutions may also have a sour taste, feel slippery, and cause burns.

TO DO **Determine the pH of solutions in the kitchen.**

1. Arrange to take home a box of wide-range pH paper.
2. Determine the pH of at least 10 solutions or liquid mixtures in your kitchen. Be creative. Almost anything liquid or sitting in liquid can be tested. **Caution: Read all labels before testing a solution to ensure that the solution is safe.**
3. Make a data table to record the name of each item tested, its pH, whether it is an acid, a base, or a neutral solution.
4. Which of the samples has the additional characteristics of an acid or a base?

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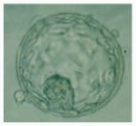
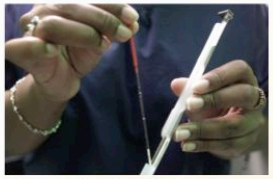
## Bioethics

### STOP ! You cannot use THOSE cells.

Stem cells have been in the news a lot lately. Many people feel strongly that we should be able to use embryonic stem cells for any medical purpose. Others believe that there is no good reason to ever use embryonic stem cells. Still others believe that embryonic stem cells are suitable for some medical applications and not others. Stem cells are so controversial that President George W. Bush created a federal policy for their use in research funded by the US government.



A 6-day-old human embryo (also called a blastocyst). Stem cells are obtained by growing out the inner cell mass of the blastocyst. The inner cell mass is clearly visible in this picture (it is the clump of cells at about the 6-o'clock position within the embryo).
Photo courtesy of Joe Conaghan, PhD



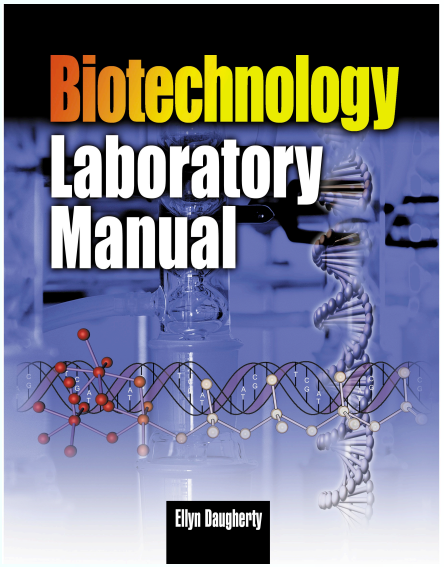
An embryologist takes up frozen embryos from a cane (white item) in which they have been stored in liquid nitrogen. Fertility clinics must store or destroy extra unused embryos after *in vitro* fertilization. What do you think should be done with extra embryos?
© Carlos Avila Gonzalez/San Francisco Chronicle/Corbis.

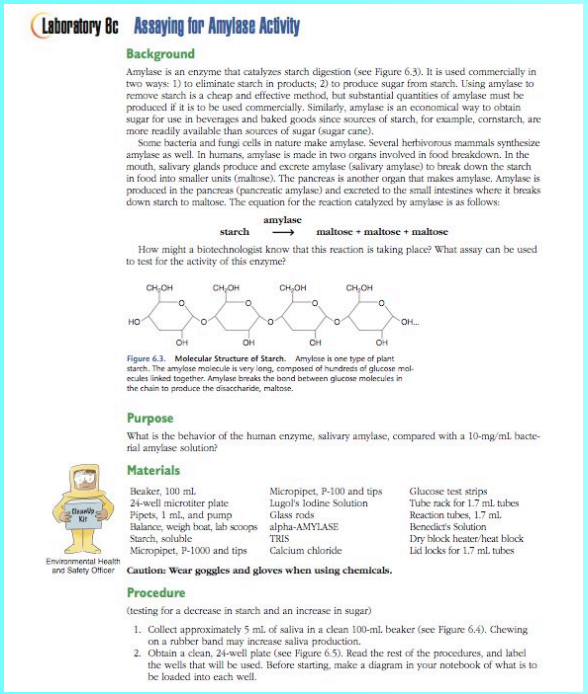
TO DO **Conduct research to examine the use of embryonic stem cells in research and in the development of medical therapies. Evaluate the benefits and risks of using embryonic stem cells, and present a balanced review of a controversial issue.**

1. Using the Internet, find information to answer the following questions. Record all of the bibliographic information, including Web site addresses, for the documents you use as references.
   a. What are embryonic stem cells?
   b. How do scientists produce, harvest, and use embryonic stem cells?
   c. What is the value in using stem cells?
   d. What are the risks of and arguments against using stem cells?
2. Describe three reasons to use embryonic stem cells in research and manufacturing. Give three reasons to not use them. Consider legal, financial, medical, personal, social, and environmental aspects.
3. Create a poster that accurately explains what embryonic stem cells are and why their use is controversial. Include the pros and cons of their use from item 2. Include numbers, data, and photos to make your poster more informative and convincing. Try to avoid your personal view, and give a thorough presentation of both sides of the issue.

# Features of the Lab Manual

- Lab Chapter Prelude/Introduction
- Laboratory Activities
  - Background
  - Purpose
  - Materials List
  - Procedures (in short easy to follow steps)
  - Data Analysis/Conclusion
  - *Thinking Like a Biotechnician* Questions



**Laboratory 8c** **Assaying for Amylase Activity**

**Background**

Amylase is an enzyme that catalyzes starch digestion (see Figure 6.3). It is used commercially in two ways: 1) to eliminate starch in products; 2) to produce sugar from starch. Using amylase to remove starch is a cheap and effective method, but substantial quantities of amylase must be produced if it is to be used commercially. Similarly, amylase is an economical way to obtain sugar for use in beverages and baked goods since sources of starch, for example, cornstarch, are more readily available than sources of sugar (sugar cane).

Some bacteria and fungi cells in nature make amylase. Several herbivorous mammals synthesize amylase as well. In humans, amylase is made in two organs involved in food breakdown. In the mouth, salivary glands produce and excrete amylase (salivary amylase) to break down the starch in food into smaller units (maltose). The pancreas is another organ that makes amylase. Amylase is produced in the pancreas (pancreatic amylase) and excreted to the small intestines where it breaks down starch to maltose. The equation for the reaction catalyzed by amylase is as follows:

$$\text{starch} \xrightarrow{\text{amylase}} \text{maltose} + \text{maltose} + \text{maltose}$$

How might a biotechnologist know that this reaction is taking place? What assay can be used to test for the activity of this enzyme?



Figure 6.3. **Molecular Structure of Starch.** Amylose is one type of plant starch. The amylose molecule is very long, composed of hundreds of glucose molecules linked together. Amylase breaks the bond between glucose molecules in the chain to produce the disaccharide, maltose.

**Purpose**

What is the behavior of the human enzyme, salivary amylase, compared with a 10-mg/mL bacterial amylase solution?

**Materials**



Environmental Health and Safety Officer

| | | |
|---|---|---|
| Beaker, 100 mL | Micropipet, P-100 and tips | Glucose test strips |
| 24-well microtiter plate | Lugol's Iodine Solution | Tube rack for 1.7 mL tubes |
| Pipets, 1 mL, and pump | Glass rods | Reaction tubes, 1.7 mL |
| Balance, weigh boat, lab scoops | alpha-AMYLASE | Benedict's Solution |
| Starch, soluble | TRIS | Dry block heater/heat block |
| Micropipet, P-1000 and tips | Calcium chloride | Lid locks for 1.7 mL tubes |

**Caution: Wear goggles and gloves when using chemicals.**

**Procedure**

(testing for a decrease in starch and an increase in sugar)

1. Collect approximately 5 mL of saliva in a clean 100-mL beaker (see Figure 6.4). Chewing on a rubber band may increase saliva production.
2. Obtain a clean, 24-well plate (see Figure 6.5). Read the rest of the procedures, and label the wells that will be used. Before starting, make a diagram in your notebook of what is to be loaded into each well.

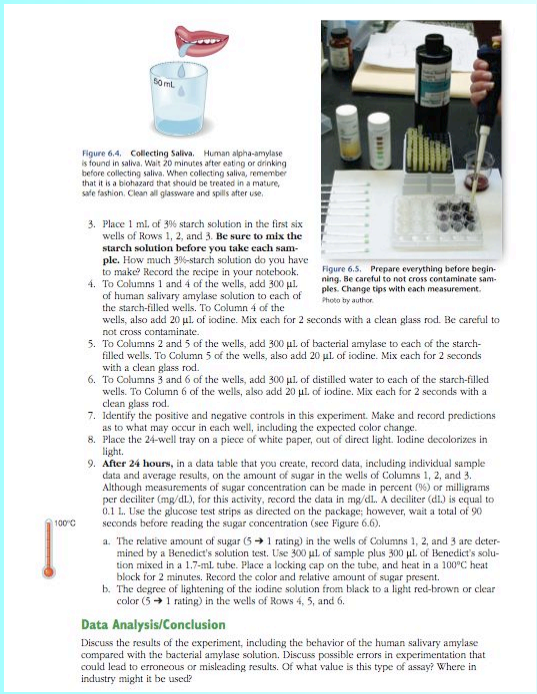





Figure 6.4. **Collecting Saliva.** Human alpha-amylase is found in saliva. Wait 20 minutes after eating or drinking before collecting saliva. When collecting saliva, remember that it is a biohazard that should be treated in a mature, safe fashion. Clean all glassware and spills after use.



Figure 6.5. **Prepare everything before beginning. Be careful to not cross contaminate samples. Change tips with each measurement.** Photo by author.

3. Place 1 mL of 3% starch solution in the first six wells of Rows 1, 2, and 3. **Be sure to mix the starch solution before you take each sample.** How much 3%-starch solution do you have to make? Record the recipe in your notebook.
4. To Columns 1 and 4 of the wells, add 300 µL of human salivary amylase solution to each of the starch-filled wells. To Column 4 of the wells, also add 20 µL of iodine. Mix each for 2 seconds with a clean glass rod. Be careful to not cross contaminate.
5. To Columns 2 and 5 of the wells, add 300 µL of bacterial amylase to each of the starch-filled wells. To Column 5 of the wells, also add 20 µL of iodine. Mix each for 2 seconds with a clean glass rod.
6. To Columns 3 and 6 of the wells, add 300 µL of distilled water to each of the starch-filled wells. To Column 6 of the wells, also add 20 µL of iodine. Mix each for 2 seconds with a clean glass rod.
7. Identify the positive and negative controls in this experiment. Make and record predictions as to what may occur in each well, including the expected color change.
8. Place the 24-well tray on a piece of white paper, out of direct light. Iodine decolorizes in light.
9. **After 24 hours,** in a data table that you create, record data, including individual sample data and average results, on the amount of sugar in the wells of Columns 1, 2, and 3. Although measurements of sugar concentration can be made in percent (%) or milligrams per deciliter (mg/dL), for this activity, record the data in mg/dL. A deciliter (dL) is equal to 0.1 L. Use the glucose test strips as directed on the package; however, wait a total of 90 seconds before reading the sugar concentration (see Figure 6.6).




   a. The relative amount of sugar (5 → 1 rating) in the wells of Columns 1, 2, and 3 are determined by a Benedict's solution test. Use 300 µL of sample plus 300 µL of Benedict's solution mixed in a 1.7-mL tube. Place a locking cap on the tube, and heat in a 100°C heat block for 2 minutes. Record the color and relative amount of sugar present.
   b. The degree of lightening of the iodine solution from black to a light red-brown or clear color (5 → 1 rating) in the wells of Rows 4, 5, and 6.

**Data Analysis/Conclusion**

Discuss the results of the experiment, including the behavior of the human salivary amylase compared with the bacterial amylase solution. Discuss possible errors in experimentation that could lead to erroneous or misleading results. Of what value is this type of assay? Where in industry might it be used?

Lab Page 113-115

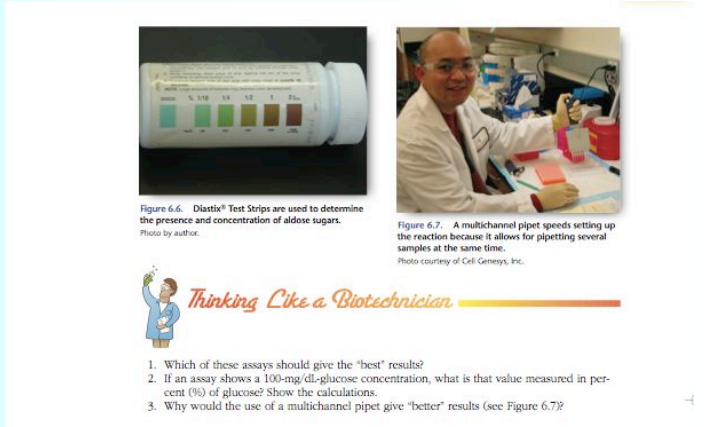




Figure 6.6. **Diastix® Test Strips are used to determine the presence and concentration of aldose sugars.** Photo by author.



Figure 6.7. **A multichannel pipet speeds setting up the reaction because it allows for pipetting several samples at the same time.** Photo courtesy of Cell Genesys, Inc.



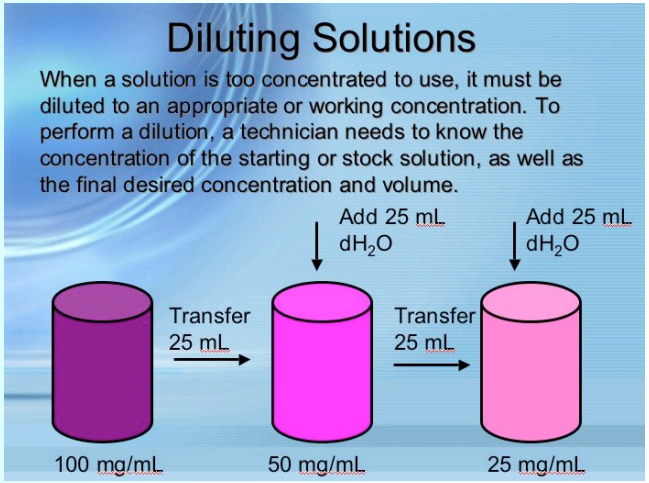
*Thinking Like a Biotechnician*

1. Which of these assays should give the "best" results?
2. If an assay shows a 100-mg/dL-glucose concentration, what is that value measured in percent (%) of glucose? Show the calculations.
3. Why would the use of a multichannel pipet give "better" results (see Figure 6.7)?

# Encore CD

## PACKAGED with TEXT and LAB MANUAL


- Lab Tutor (25 lab skills presentations)
- Glossary and Image Bank
- Flash Cards
- Crossword Puzzles
- Quizzes
- Link to Internet Resource Center




See Intro to Media Prep tutorial

# Features of the Instructor's Guides

Part 1 How to Start and Implement a Program

- Program Overview
- Starting a Biotechnology Program
- Authentic Assessment
- Feedback to the Author
- Additional Student Resources
  - Safety
  - Metrics Review
  - Excel Data Tables Tutorial
  - Excel Graphs Tutorial
  - Writing Conclusions
  - Internet Tutorial
  - Glossary of Key Terms

Part 2 Course Planner (Lesson Plans)

# Examples of Course Outlines in the IG

**Two-term Skill Development Lab-based, Concept-Supported Course Plan**

**Suggested Lesson Planning Guide**
**32 weeks, 5-6 hours of lab and lecture/discussion meetings/week**
Activities may require adjustment to meet the time limitations of a particular course.

| Week | Lab(s) | Lab Lesson Focus | Text Section Support and Lecture Discussion Focus | Key Lab Skill Objectives Students will: |
|---|---|---|---|---|
| 1 | 1a<br>1b | Scientific Notebook<br>Laboratory Safety | 1.1 Defining Biotechnology<br>1.2 Biotechnology Products<br>1.3 Selecting Potential Products | - Start and maintain a legal scientific notebook<br>- Learn emergency procedures and the location of safety hazards and emergency equipment |
| 2 | 1c | Cheese Production | 1.4 Scientific Methodology<br>1.5 Biotech Careers<br>1.6 Bioethics | - Conduct a controlled experiment, analyze and report data |
| 3 | 2b<br>2c | Model Organisms<br>Microscopy | 2.1 Organisms and their Parts<br>2.2 Cellular Organization | - Grow, maintain, and monitor bacteria and fungi<br>- Learn microscope use for prepared and wet mount slides |
| 4 | 2d<br>2e | Microscopic Measurement<br>Properties of Carbohydrates | 2.2 Cellular Organization<br>2.3 Molecules of Cells | - Learn to estimate the size of microscopic specimen.<br>- Study the structure and characteristics of different carbohydrates |
| 5 | 3a<br>3b | Pipeting<br>Micropipeting | 3.1 Measuring Volumes | - Demonstrate skill using pipets and pipet pumps<br>- Demonstrate skill using micropipets |
| 6 | 3c<br>3e | Mass Measurement<br>Mass/Volume Solutions | 3.2 Making Solutions<br>3.3 Mass/Volume Solutions | - Demonstrate skill using balances<br>- Prepare various mass/volume solutions |
| 7 | 3f<br>3g | Percent Mass/ Volume Solutions<br>Molar Solutions | 3.4 Percent Mass/ Volume Solutions<br>3.5 Molar Solutions | - Prepare various percent mass/volume solutions<br>- Prepare various molar solutions |
| 8 | 3h<br>4a<br>4b | Dilutions<br>DNA Isolation Solutions<br>DNA Spooling | 3.6 Dilutions<br>4.1 DNA Structure and Function | - Prepare dilutions of solutions<br>- Prepare buffers and reagents for DNA isolation<br>- Conduct alcohol precipitation of pure DNA sample |
| 9 | 4e | Media Prep | 4.2 Sources of DNA | - Prepare LB agar and LB broth |

# Examples of Course Outlines in the IG

| | | | | |
|---|---|---|---|---|
| 9 | 4e<br>4f | Media Prep<br>Sterile Technique | 4.2 Sources of DNA | - Prepare LB agar and LB broth<br>- Pour sterile LB agar Petri plates |
| 10 | 4g<br>4h | Bacteria Cell Culture<br>Bacteria DNA Extraction | 4.2 Sources of DNA<br>4.3 Isolating and Manipulating DNA | - Streak isolated colonies and start broth cultures<br>- Isolate genomic DNA from bacteria |
| 11 | 4i<br>4j | Agarose Gel Prep<br>Agarose Gel Electrophoresis | 2.4 The "New" Biotechnology<br>4.4 Gel Electrophoresis | - Prepare an agarose gel<br>- Load, run, stain and analyze DNA on a gel |
| 12 | 13e | Lambda PCR | 13.1 Making DNA | - Perform a PCR reaction |
| 13 | 13f<br>13g | Human DNA Extraction<br>Alu PCR Genotyping | 13.3 Polymerase Chain Reaction<br>13.4 Applications of PCR Technology | - Isolate DNA from cheek cells for PCR<br>- Use PCR to test DNA for a specific genotype. |
| 14 | 5a<br>5b | Antibody Function<br>Enzyme Function | 5.1 Structure and Function of Proteins<br>5.3 Enzymes: Protein Catalysts | - Simulate antibody-antigen testing<br>- Test enzyme activity at different concentrations |
| 15 | 5f | PAGE | 5.4 Studying Proteins | - Prepare protein samples and load, run, stain and characterize proteins on a PAGE gel |
| 16 | 5g | Identifying Proteins | 5.5 Applications of Protein Analysis | - Prepare animal muscle tissue samples and run gels to study differences in protein composition |
| 17 | 6b<br>6c | Starch and Sugar Assays<br>Amylase Assay | 6.1 Sources of Potential Products<br>6.2 The Use of Assays | - Conduct aldose and starch indicator tests<br>- Test saliva for alpha-amylase activity |
| 18 | 14a | ELISA | 14.3 Advanced Protein Studies | - Conduct a qualitative ELISA (antibody assay) |
| 19 | 6d | Testing Plants Substances | 6.3 Products from Nature<br>6.4 Plant Proteins as Products | - Extract compounds from plants and test the extracts' antimicrobial activity on the growth of *E. coli* |
| 20 | 6e<br>7a | Searching for Native Amylase<br>Using the Spectrophotometer | 6.5 Producing Recombinant DNA Protein Products<br>7.1 Using the Spectrophotometer | - Predict where amylase-producing bacteria might be found in nature and attempt to isolate colonies<br>- Learn how to operate a spectrophotometer and how light corresponds to colors of the visible spectrum |
| 21 | 7b<br>7c | Using the Spec to Study Molecules<br>Measuring pH | 7.1 Using the Spectrophotometer<br>7.2 Introduction to pH | - Use a VIS-spec to determine the absorption spectra and $\lambda_{max}$ for three colored solutions<br>- Learn to use pH paper and a pH meter |

# Examples of Course Outlines in the IG

| | | | | |
|---|---|---|---|---|
| 22 | 7d<br>7e | Making Buffer<br>Demonstrating Buffer Efficacy | 7.3 Buffers | - Prepare a buffer to use in making a protein solution<br>- Prepare buffers and test their ability to resist changes in pH |
| 23 | 7f<br>7g | Spec Amylase Study<br>Determining Amylase Concentration | 7.4 Determining Protein Concentration | - Determine the absorbance spectrum for amylase-Bradford reagent to learn $Lambda_{max}$<br>- Use a best-fit standard curve to determine the concentrations of unknown amylase solutions |
| 24 | 7i<br><br>8b | UV Spec to Study Proteins<br>Restriction Digestion of pAmylase | 7.4 Determining Protein Concentration<br>8.1 Overview of Genetic Engineering | - Use a UV-VIS spec to determine the $Lambda_{max}$ for a sample of colorless protein<br>- Conduct a restriction digestion of the pAmylase to confirm prior to transformation of *E. coli* cells |
| 25 | 8c | Transformation | 8.2 Transforming Cells | - Transfer plasmids into *E. coli* and select transformants |
| 26 | 8e | Scaling-up Transformed Cells | 8.3 After Transformation<br>8.4 Fermentation, Manufacturing, and GMP | - Select colonies and scale them up from a selection plate to selection broth media. |
| 27 | 9a<br><br>9b | Harvesting Amylase<br><br>Dialysis of Protein Buffers | 9.1 Harvesting a Protein Product<br>9.2 Using Chromatography to Study and Separate Molecules | - Separate transformed cells from broth and test the broth for amylase activity<br>- Use dialysis tubing to conduct a buffer exchange prior to column chromatography |
| 28 | 9c | Using Ion-Exchange Chromatography | 9.3 Column Chromatography | - Separate lysozyme from albumin on an ion-exchange column |
| 29 | 9d | Ion-Exchange Purification of Amylase | 9.4 Product Quality Control<br>9.5 Marketing and Sales | - Use an ion-exchange column to determine the overall charge of amylase at pH7.2 and isolate amylase from a broth culture. |
| 30 | 12a<br><br>12b | Using the UV Spec to Study Caffeine<br>MSDS to Recognize Compounds | 12.1 Drug Discovery | - Use the UV spectrophotometer to characterize, a colorless organic compound, caffeine<br>- Access MSDS data to learn the characteristics of compounds |
| 31 | 12c | Synthesis of Aspirin | 12.2 Creating Pharmaceuticals by Combinatorial Chemistry | - Synthesize acetylsalicylic acid through combinatorial chemistry |
| 32 | 12d | Melting Point Determinations for Quality Control | 12.3 Creating Pharmaceuticals by Peptide and DNA synthesis<br>12.4 Pharmaceuticals by Protein | - Conduct melting point determinations the product of their acetylsalicylic acid production |

# Course Planner - Lab Skill Development Program

**Lab 3e Making Solutions of Differing Mass/Volume Concentrations**

**Objective:** Students demonstrate how to calculate and then prepare solutions of differing mass/volume concentrations.

**Timing:**
Per-lab = one 50-minute period for practice calculations.
Laboratory = one 50-minute period to prepare solutions.
Optional extension = one 50-minute period to check the accuracy of the solutions using the spectrophotometer.

**Student Groups:** Student Pairs

**Materials:**

**Safety Issues and Tips:**
- Just as with any chemical, copper sulfate pentahydrate should be measured out wearing goggles and gloves.

**Text Support:**
Section 3.3 of the text has an extensive discussion on reporting concentration in mass/volume units and how to preparing solutions of mass/volume concentrations.

**Anticipatory Set:**
Display a can of frozen. Stand staring at it for a long time. Then turn to the class and say, "Well it says, "*Concentrate*." Hopefully, students recognize the multiple meaning of concentrate. Ask them why the frozen orange juice is called a concentrate. It is in a more dense or stronger form than in which it is used. To drink it, it must be diluted in water. 3 cans water to one can frozen concentrate. This is a one in four parts dilution (1:4). In this activity, concentration units are introduced and solutions are prepared that are reported in mass/volume units.

**Instruction:**
Use the Background section at the beginning of the lab activity to define the terms: solution, solute, and solvent. Solutions are prepared with some amount of solute (usually a dry chemical weighed on a balance) dissolved in some volume of solvent (usually deionized water).

In this activity, students prepare solutions of different mass/volumes. Review the mass volumes listed in the Background. Of these: g/mL, g/L. mg/mL, µg/mL and µg/µL are commonly used in biotechnology laboratories. Protein, DNA and RNA solutions are often reported in these concentration units.

Demonstrate how to use the Mass/Volume Concentration Equation to calculate the mass needed to make a specific volume of a specific concentration of solution.

**Volume desired (mL) X Concentration desired (g/mL) = _____g**

# Course Planner - Lab Skill Development Program

The units can be any of the acceptable mass/volume concentration units as long as the volumes cancel out in during multiplication. The mass must be in grams (or converted to grams) since most lab balances measure in grams.

Use an example, such as: A technician needs 200 mL of a 1.55 mg/mL solution of salmon sperm DNA (in sterile, distilled water). How is this solution made from freeze-dried DNA ordered from a biological supply house? Hold up a bottle of dehydrated crystalline DNA.

Remind students that when calculating how to prepare a mass/volume solution, remember that "of" is the same as saying "multiply by."

So, **Volume desired (mL) X Concentration desired (g/mL) = _____g**

**200 mL X 1.55 mg/mL = 300 mg = 0.3 g**

Notice that 300 mg is converted to 0.3 g.

Therefore, 0.3 g of salmon sperm DNA should be weighed out and placed in a volumetric (one with graduations) bottle and sterile, distilled water is slowly added, stirring to suspend the solute, until the final volume reaches 200 mL. The resulting solution has a concentration of 1.55 mg/mL.

Assign procedure steps 1-3 and have each student produce the tubes specified in Table 3.9. Students should evaluate their weighing technique, volume measurement, and solution preparation skills as directed in the procedures.

Before assigning procedure step 4, using the following demonstration, teach students a little about the spectrophotometer and how it can "see" the difference in molecules. This is not meant to be a long, detailed spectrophotometry lesson (which is presented in Chapter 7).

Let several Spec 20D+ spectrophotometers heat up. Calibrate a spec to a wavelwngth of 610 nm. Turn the wavelength knob until 610 shows in the wavlength display. Turn the 0% transmittance knob, with nothing in the sample holder, until the diplay shows 0% transmittance. Then, place 4 mL of water in a 13x100 mm cuvette in to the sample holder, close the lid, and set the 100% transmittance knob by turning it until the transmittance display reads "100."

Now, change the mode to "absorbance" and without touching any knobs, first place a cuvette with 4 mL of blue food coloring in the sample holder. Record the absorbance. Next, place a cuvette with 4 mL of green food coloring in the sample holder. Record the absorbance. Next, place a cuvette with 4 mL of red food coloring in the sample holder. Record the absorbance.

The differences in absorbance values shows that the spec is detecting them differently, a lot of absorbance for the blue sample, less for the green and very little for the red. You may discuss spectrophotometry more (See Chapter 7 activities) or the students can go ahead and complete procedure #4 by following the "Using the Spectrophotometer to Check Copper Sulfate Samples."

Assign the rest of the procedures and have students complete a data table similar to table 3.11.

**Things to Stress with Students:**

- When making a solution, the solute is measured out first and the solvent is mixed into the solute.
- Since the mass of the solute takes up some amount of space, solutions are always prepared by raising the solvent to the final volume. For example, when making 100mL of 0.1g/mL solution measure out 10g of copper sulfate, place it in a beaker, and add deionized water up to the 100mL mark.
- When setting up the equations for calculation make sure all units are shown and in a form where they can cancel out. Sometimes units will have to be converted so they can cancel, such as from grams to milligrams or liters to milliliters.
- Most balances only measure in grams so if calculations result in milligram answers, the milligrams must be converted to grams to measure on the balance.
- In procedure number one, each solution is half the concentration of the one before, this should be evident in the amount of blue color each one has. Half the concentration means half the copper sulfate molecules per unit volume, therefore half the blueness.
- In procedure number four, the concentration of all the tubes change when their volumes were made the same.

**Tips, Tricks, and Hints:**

- Take time between procedure number three and four to observe the color of the first set of tubes. Hold the tubes up in a peg rack to see effects of a serial dilution on the color of the solutions.
- Use the spectrophotometer to quantify the results after step three. If a solution has half the concentration, it should have half the absorbance.
- A good strategy for setting up and doing these equations is to write out **the Mass/Volume Concentration Equation** and then above each term place the correct numbers and units for the problem. This helps students visualize what goes where, and that the units will cancel out.

**Other Teaching Tools:**

Show the student Encore® CD PowerPoint® clips demonstrating how to prepare solutions of varying mass/volume concentrations.

**Checking for Understanding:**

Assign the Data Analysis/Conclusion section, found at the end of the activity.

Assign students the *Thinking Like a Biotechnician* questions at the end of Lab 3e.

1. Most solutions used in a biotechnology facility are colorless. How can the concentration of a colorless solution be checked?
   Answers will vary but one method might include using an indicator solution that changes color due to the presence and concentration of a sample (i.e. Benedict's, iodine, phenol red, Biuret reagent, etc.
2. A technician needs to read the absorbance of several samples on a spectrophotometer. But, after calibrating the spectrophotometer for reading the samples, he or she finds that all of the

# Course Planner - Lab Skill Development Program

values are over the upper limit of 2.0 au. Why are all of the absorbance readings so high? What might the technician do to be able to use the spectrophotometer to check the samples? Answer: Solution concentrations are probably all too high. All the light the spectrophotometer is shining on the samples is being absorbed because there are just too many molecules in every sample. Dilute all the samples, with the same amount of solvent, until they have absorbance values within the range of the spectrophotometer (0.02-2.0 a.u.).

3. Complete the Making Solutions Review Sheet No. 1.

**Making Solutions Review Sheet No. 1**

Convert the values as indicated. Specify the appropriate instrument with which the final measurements should be made. For items 10 through 17, show the calculation (equation and units) for the preparation of each solution. Then, draw a diagram of how to make the solution in an appropriate container.

**Instrument Choices**

| | | | | |
|---|---|---|---|---|
| graduated cylinder | 10-mL pipet | 5-mL pipet | 2-mL pipet | 1-mL pipet |
| tabletop balance | P-1000 | P-200 | P-100 | P-20 |
| analytical balance | P-10 | | | |

| | | |
|---|---|---|
| 1. 3.4 mL = _____ µL | 4. 73.12 µg = _____ mg | 7. 10.5 µL = _____ mL |
| 2. 43.9 mL = _____ L | 5. 5.39 g = _____ mg | 8. 7.503 mL = _____ µL |
| 3. 0.17 mL = _____ µL | 6. 30.6 g = _____ mg | 9. 33 µg = _____ mg |

| **Solution To Be Prepared** | **Diagram of How To Prepare It** |
|---|---|
| 10. 25 mL of 2.5 g/mL NaCl solution | 11. |
| 12. 10 mL of 50 mg/mL $CuSO_4$ solution | 13. |
| 14. 2 L of 0.5 g/mL dextrose solution | 15. |
| 16. 100 mL of 0.005 g/mL NaOH solution | 17. |

3. Answers:

1. 3, 400 µL, 5 mL pipet
2. 0.0439 L, graduated cylinder (or 50 mL pipet)
3. 170 µL, P-200 micropipet
4. 0.07312 mg, analytical balance
5. 5,390 mg, tabletop balance
6. 30,600 mg, tabletop balance
7. 0.0105 mL, P-20 micropipet
8. 7,503 µL, 10 mL pipet
9. 0.033 mg, analytical balance
10. 25 mL x2.5 g/mL = 62.5 grams NaCl in solvent ($dH_20$) up to 25 mL
11. In a 50 mL tube
12. 10 mL X 50 mg/mL = 500 mg = 0.5 grams $CuSO_4$ in solvent ($dH_20$) up to 10 mL.
13. In a 15 mL tube
14. Convert 2 L to 2,000 mL then, 2000 mL X 0.5 g/mL = 1000 g of dextrose in solvent ($dH_20$) up to 2 L.
15. In a 2 L flask or bottle
16. 100 mL X 0.005 g/mL = 0.5 grams of NaOH in solvent ($dH_20$) up to 100 mL.
17. In a 125 mL flask or bottle

**Extensions:**

Have students find articles on the Internet about how concentration determinations of various substances are important in other applications such as environmental studies (such as dissolved oxygen concentration in ponds), health (i.e. lead or mercury concentration taken into the body) and medicine, or food and agriculture (such as salt concentrations in soil). The students can print the article and website and explain the significance of the concentration determinations to their lab partners.

# Course Planner - Concept Support for Lab Skills

Lesson Plan for Sections 3.1 and 3.2

**Anticipatory Set**

Project photos of some critically important biotechnology measuring devices on a monitor or screen. Include graduated cylinders, pipets, micropipets, balances (scales), meterstick (rulers), and pH meters. Ask them to identify their function.

**Instruction**

Have the students create a Metric Measurement Instrument Chart, like the one below.

Briefly demonstrate the use of each instrument as you discuss what can be measured and in what units of measurement. Start out with the first column and fill in the rest as you lecture/discuss. Students will fill in their versions.

| Instrument | Measures What? | Units of Measurement | Additional Notes |
|---|---|---|---|
| Graduated cylinder | Volume | L or mL | For 10 mL or more |
| Pipet | Volume | mL | Must use a pipet aid |
| Micropipet | Volume | µL | Must use a tip |
| Balance (scale) | Mass/weight | g (or kg, mg, or µg) | Must use weigh boat or weigh paper |
| Ruler (metric) | Length | km, m, cm, mm, µm | |
| pH meter (discussed in the next lesson) | H+ concentration | | H+ concentration determines the acid or base level of a solution |

When appropriate, introduce the B←→S rule to show conversion between units, such as between L and m, or g and kg, mg, or µg.

Now, demonstrate how a solution is prepared, showing how some amount of solute is mixed with solvent until a specific final volume is reached.

Briefly discuss the three main ways to report concentrations of solutions:

- Mass/volume solutions (reported as mg/mL, g/L, µg/mL, or µg/µL)
- % mass/volume solutions (reported as % g/mL)
- Molar solutions (reported as *M*, mM, or µ*M*

Show an example of how a solution of each type is prepared.

For example, show how to make 100 mL of 1 mg/mL rennin solution by drawing a 250 mL beaker, drawing a small pile of 0.1 gram (100 mg) of rennin, and then draw deionized water filling up the beaker to 100 mL.

Show how to make 50 mL of 2% glucose solution by drawing a 100 mL beaker, drawing a small pile of 1 gram of glucose, and then draw deionized water filling up the beaker to 50 mL.

Show how to make 10 mL of 0.2 *M* NaCl (salt) solution by drawing a 15 mL test tube, drawing a adding 0.12 g* of NaCl, and then draw deionized water filling up the tube to 10 mL.

* 0.01L X 0.2 mol/L X 58.4 g/mol = 0.12 g (rounded)

**Additional Activities/Resources**

Assign the *Biotech Online* "Bet You Can't Hit a 150 meter Homer!"

Read through the Biotech Career focus at the beginning of Chapter 3. Ask students what kinds of materials do they think a Materials manager manages? Answer: She manages all of the ordering and distribution of chemicals, biologics, plastics, glassware, instruments, and equipment.

Show one or more of the student Encore® CD PowerPoint® clips demonstrating how to use a pipet, micropipet, or balance.

Show one or more of the student Encore® CD PowerPoint® clips demonstrating how to prepare a solution of a specified concentration.

Assign the *Biotech Live* Activity 3.4, "Finding the Molecular Weight of the Solutes Used in Common Solutions."

**Checking for Understanding/Applications**

After reading 3.1, have students answer the Section 3.1 Review Questions.

1. What instrument would you use to measure and dispense the following volumes? Pick the instrument that is likely to give the least error for each measurement.
   23.5 µL 6.5 mL 125 mL 7 µL 2.87 mL 555 µL
   Answer:
   23.5 µL = P-100
   6.5 mL = 10 mL pipet
   125 mL = 250 mL graduated cylinder
   7 µL = P-10
   2.87 mL = 5 mL pipet
   555 µL = P-1000
2. Convert the following units to the requested unit:
   1.7 L = _____ mL 235.1 µL = _____mL 2.37 mL = _____ µL
   Answer:
   1.7 L = 1,700 mL 235.1 µL = 0.2351 mL 2.37 mL = 2,370 µL
3. What numbers should be dialed into the P-10 display if a volume of 3.7 µL is to be measured?

# Course Planner - Concept Support for Lab Skills

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4. What instrument should be used if a technician wants to fill four sets of 16 tubes all with identical volumes?
   Answer:
   A multi-channel pipet should be used if a technician wants to fill four sets of 16 tubes all with identical volumes.

After reading Section 3.2, have students answer the Section 3.2 Review Questions.

1. What instrument should be used to measure and dispense the following solutes? Choose the instrument that is likely to give the least error for each measurement.
   3.5 g of salt  6.5 mg of DNA  12.5 g of gelatin
   Answer:
   The instrument that should be used to measure and dispense the following solutes, are:
   3.5 grams of salt = electronic tabletop balance
   6.5 milligrams of DNA = analytical balance
   12.5 grams of gelatin = electronic tabletop balance
2. What is the relation of solute to solvent as a solution becomes more concentrated?
   Answer: The amount of solute increases in relation to the amount of solvent as a solution becomes more concentrated.
3. Which of the following are concentration units? mi/hr  g/mL  m*M*  °F/°C
   Answer: g/mL and m*M* are each units of concentration measurement.
4. Describe how glassware should be prepared before using it to prepare or store solutions.
   Answer: When preparing glassware for solution preparation, wash the vessel with laboratory soap and water until clean. Rinse with tap water until no evidence of soap remains. Then rinse five more times with tap water and do a final rinse with deionized water, if available.

Ask the students to answer # 1-3 in the end of the chapter "*Thinking Like a Biotechnican*" questions.

1. What is the best instrument to use to measure these volumes: 12.5 mL, 25 µL, 8.3 µL, 250 mL, and 571 µL?
   Answer:
   The best instrument to use to measure:
   12.5 mL = 25 mL graduated cylinder or 25 mL pipet
   25 µL = P-100 micropipet
   8.3 µL = P-10 micropipet
   250 mL = a 250 mL graduated cylinder
   571 µL = P-1000 micropipet
2. Convert the following values:
   a. 12.5 µL = ___ mL
   b. 3.05 mL = ___ µL
   c. 0.45 L = ___ mL
   d. 1.25 g = ___ mg
   e. 989 µg = ___ mg

Answer:
a. 12.5 µL = 0.0125 mL
b. 3.05 mL = 3,050 µL
c. 0.45 L = 450 mL
d. 1.25 g = 1, 250 mg
e. 989 µg = 0.989 mg

3. What numbers will be displayed on a P-20 if it is set to measure and dispense 14.8 µL?
   Answer:
   The number displayed on a P-20 if it is set to measure and dispense 14.8 µL is

| |
|---|
| 1 |
| 4 |
| 8 |

Lesson Plan for Sections 7.2 and 7.3

**Anticipatory Set**

What is acid indigestion? What causes it? What can you take to counter the unpleasant effects of acid indigestion?

Acid indigestion is the burning feeling that occurs when excess HCl acid from the stomach bubbles up into the esophagus. Since it is behind the heart some people call it "heartburn." By ingesting an antacid (a "basic" substance – the opposite of an acid) the acid is neutralized to a non-irritating pH.

The topic for this lesson is acids, bases, pH, and buffers.

**Instruction**

Have on hand some solutions to test, pH paper, and a pH meter. The easiest way to explain pH is to show how solutions have different ones.

Prepare a pH 7 buffer to show "neutral". Even though deionized water is supposed to be pH 7.0 it never is due to carbon dioxide from the air mixing into it. Show the pH 7.0 reading on pH paper.

Prepare a pH 4 and a pH 10 buffer to show acid and basic pHs, respectively. Show the pH of these buffers with pH paper.

Using pH paper, determine the pH of some common solutions, such as milk, apple juice, lemon juice, 7up®, and Alka-Seltzer® in water. Test the pH of 1*M* HCl and 1*M* NaOH.

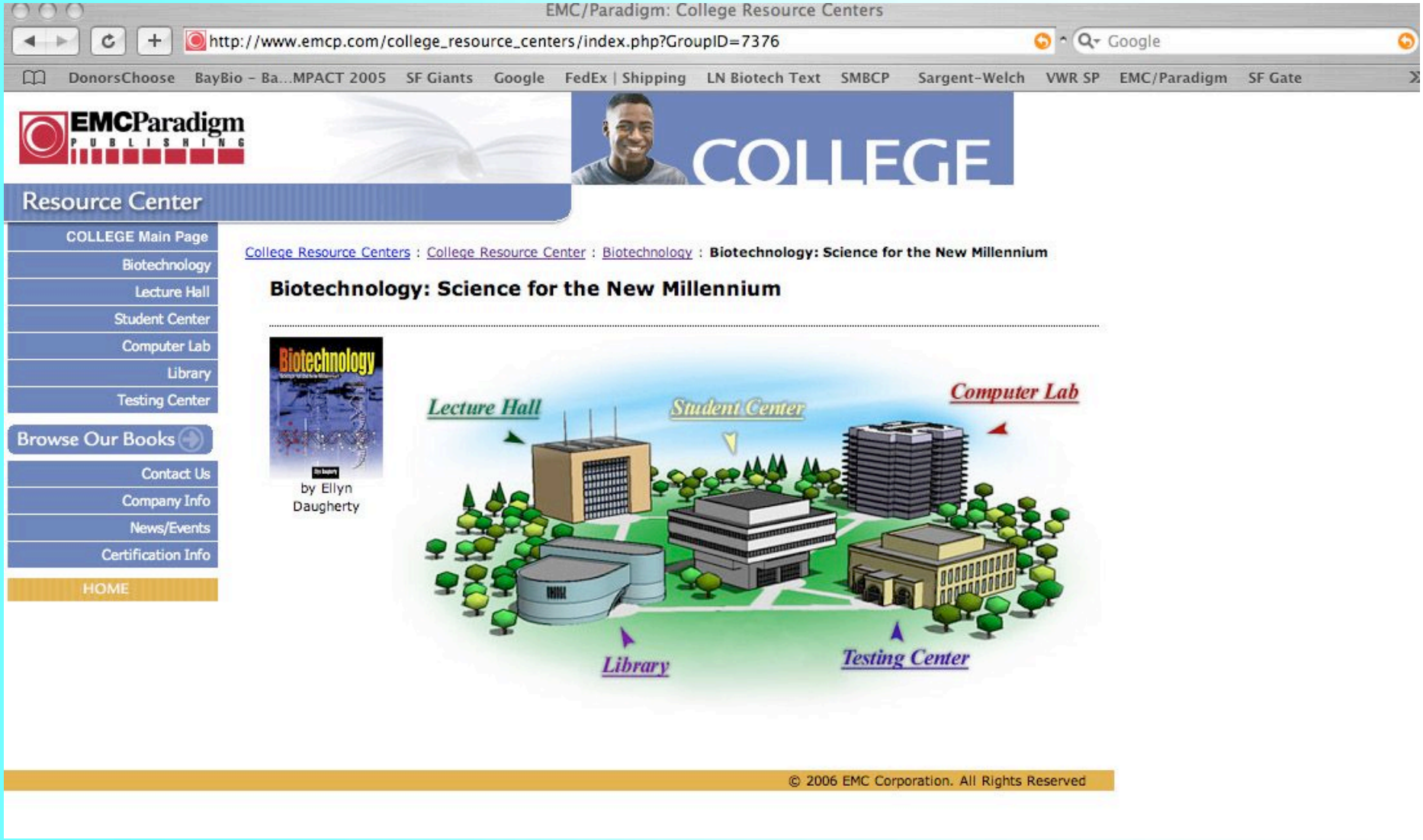
Now define pH, acids, bases, and neutral solutions. Identify which of the items tested is an acid, base, or neutral solution.

In a laboratory, to ensure appropriate structure and function, most DNA, RNA, and protein solutions must be maintained within a certain pH range. Using a pH meter, a solution is prepared

# Internet Resource Center: Student

- Lecture Hall
  - Text Learning Outcomes
  - Text Chapter Summaries
  - Text Chapter Glossaries
- Student Center
  - Using the Encore CD
  - Troubleshooting Your PC
  - Tips for Communicating Online
  - Tips for Course Success
- Biotech Lab
  - Lab Manual Chapter Objectives
  - Lab Manual Glossary
  - Tutorials
  - Metric Measurements
- Library
  - Biotechnology Web Links
  - Biotechnology Acronyms
  - Building a Web Page
  - Successful Web Searching
  - The Greek Alphabet
- Testing Center
  - Tips for Taking Tests
  - Lab Manual Quizzes

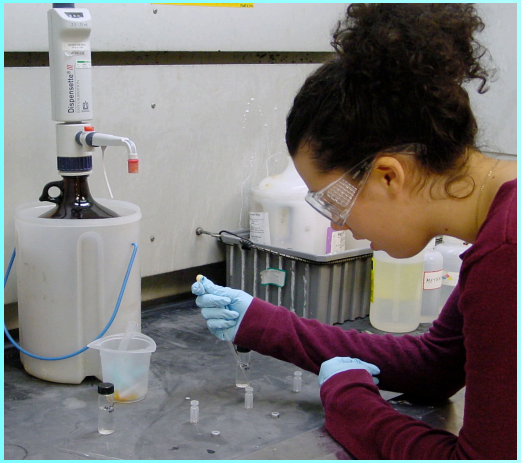
# Internet Resource Center: Student



# Internet Resource Center: Instructor

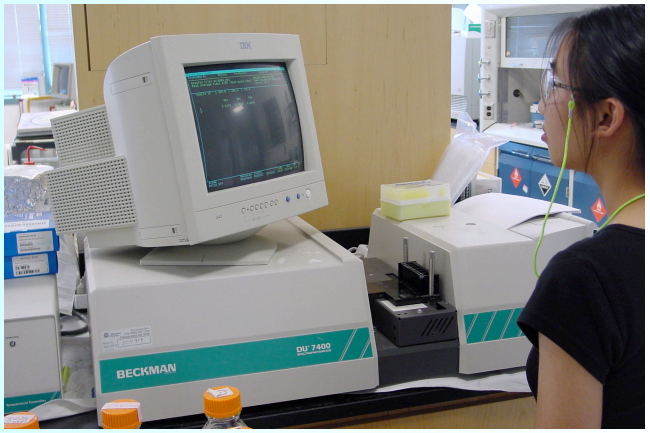
- Site Map
  - Instructor Side
  - Student Side

- Course Planning Tools
  - Product Components
  - Course Plans (Concepts, Concepts & Lab, Lab)
  - Text Features
  - Lab Manual Features
  - Lesson Plans (Text)
  - Lesson Plans (Lab Manual)

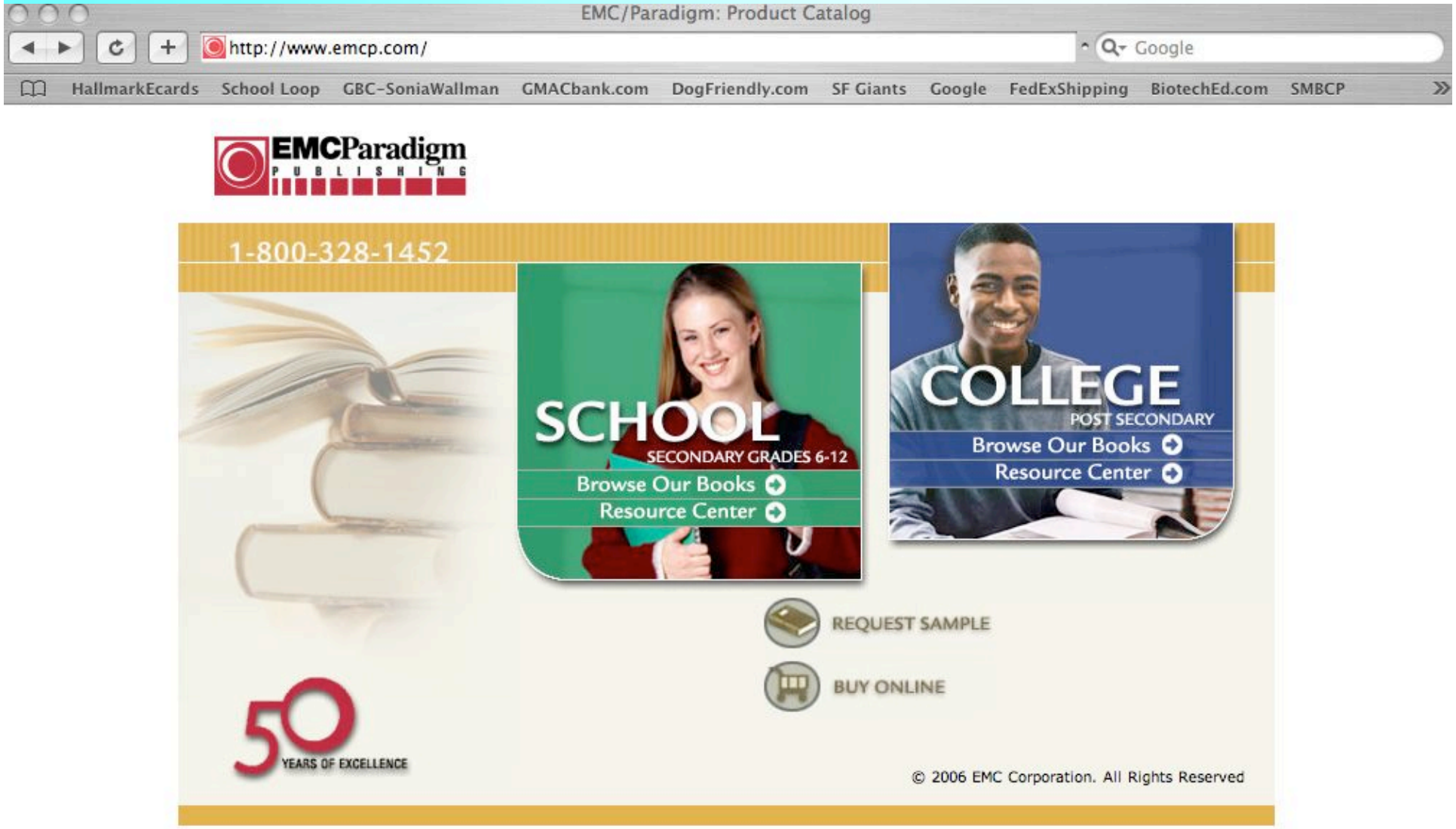


- Course Presentation Tools
  - PowerPoint Presentations
  - Image Bank (illustrations)
  - Getting to Know Text
  - Resources from Text/Lab Manual

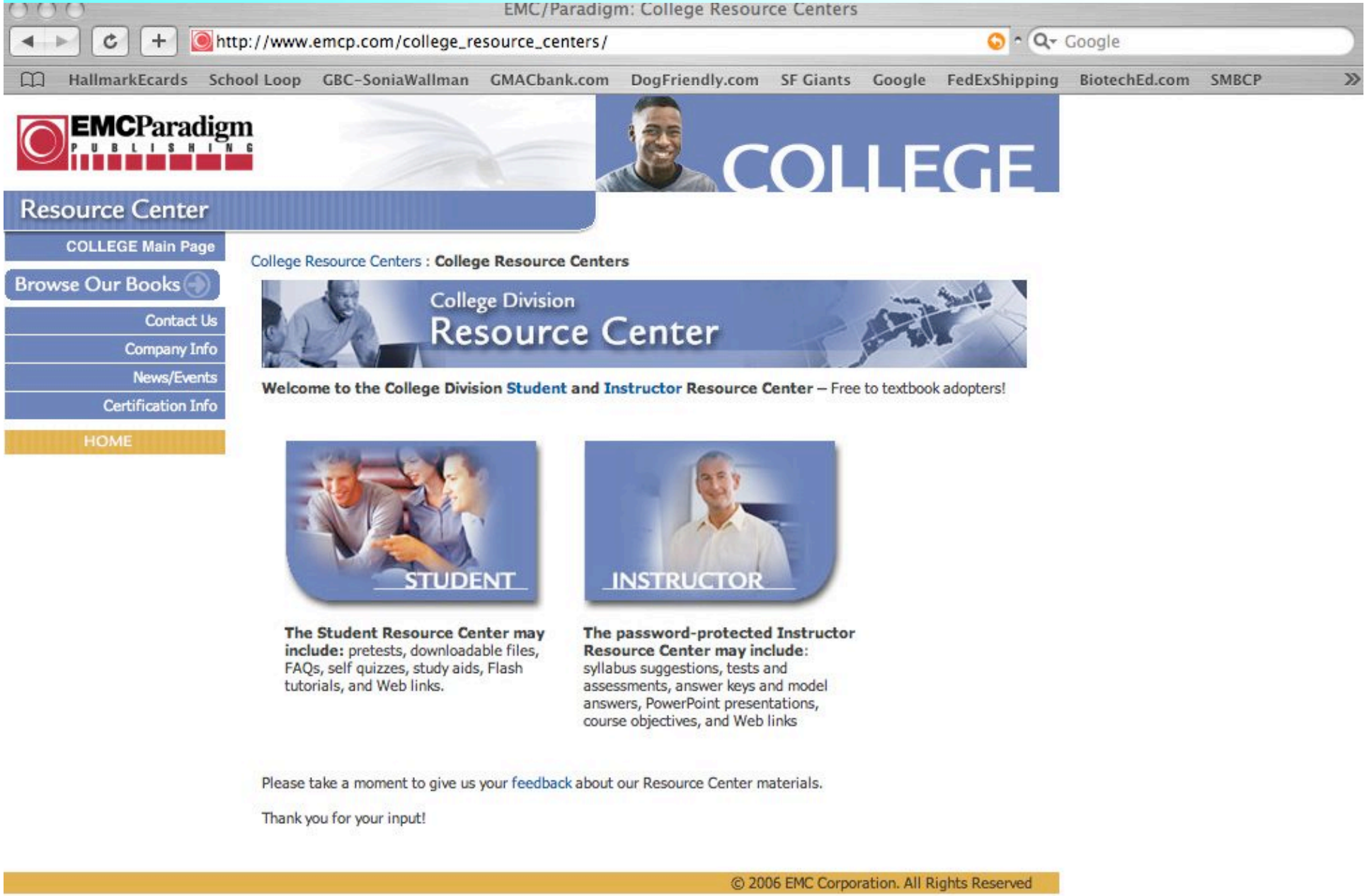
- Course Evaluation Tools
  - Guidelines for Authentic Assessment
  - Chapter Exercise Answers
  - Unit Tests and Answers
  - User's Guide for ExamView Test Generator



# Internet Resource Center: Instructor



# Internet Resource Center: Instructor



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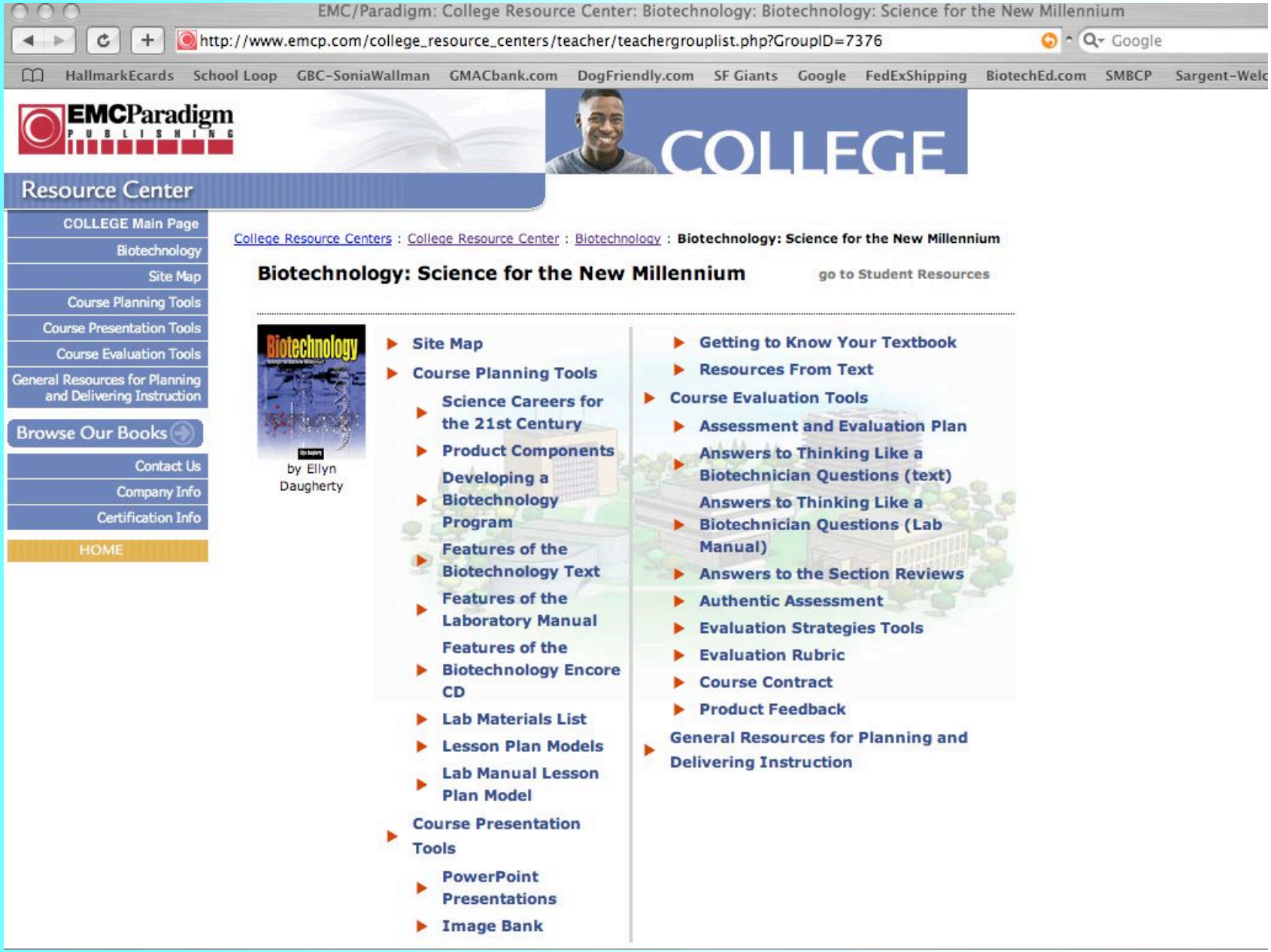

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Biotechnology : Biotechnology: Science for the New Millennium : Course Presentation Tools : **PowerPoint Presentations**


by Ellyn Daugherty

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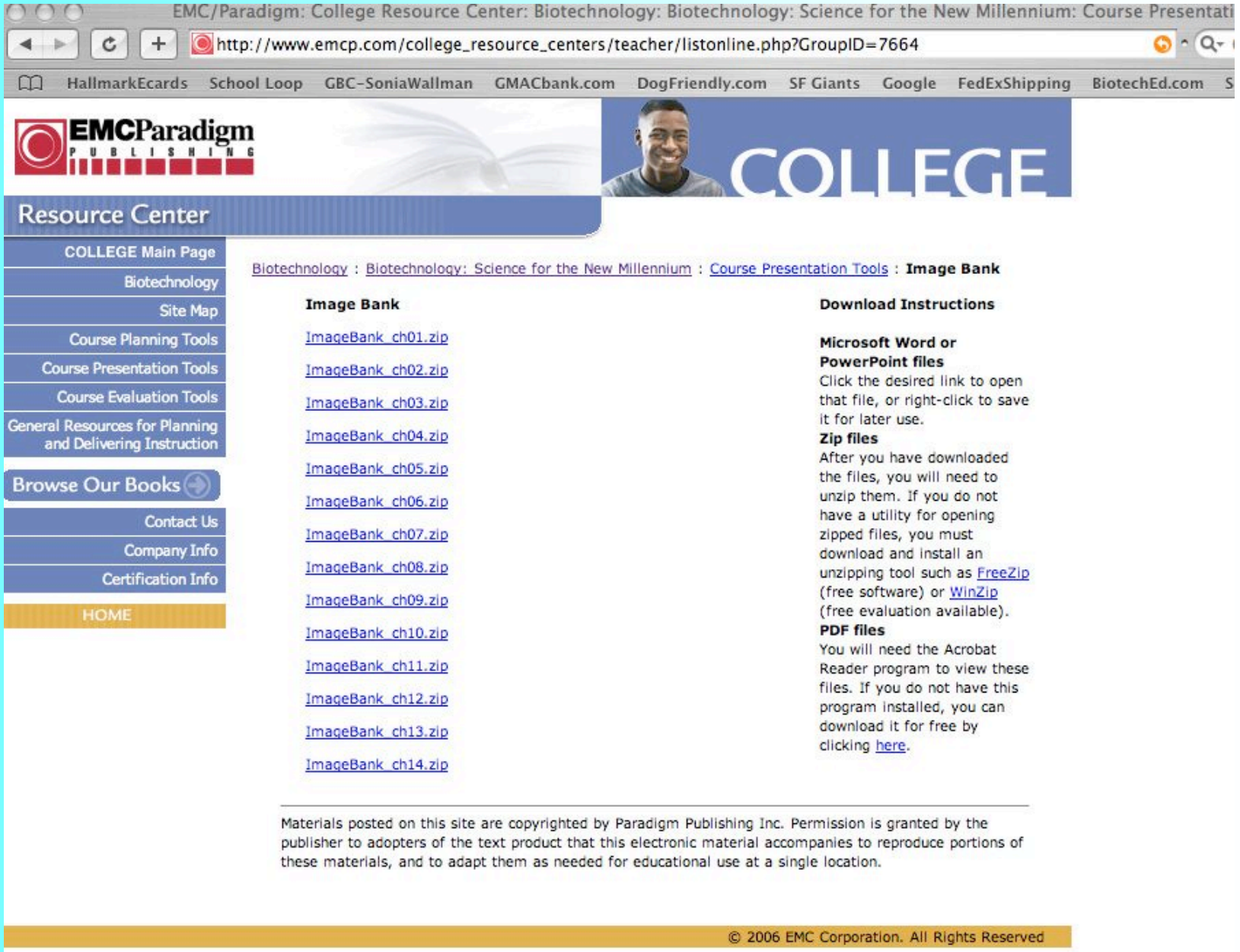

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Biotechnology : Biotechnology: Science for the New Millennium : Course Presentation Tools : **Resources From Text**


by Ellyn Daugherty

## Resources From Text

Choose a Book

- Biotechnology Text
- Biotechnology Lab Manual

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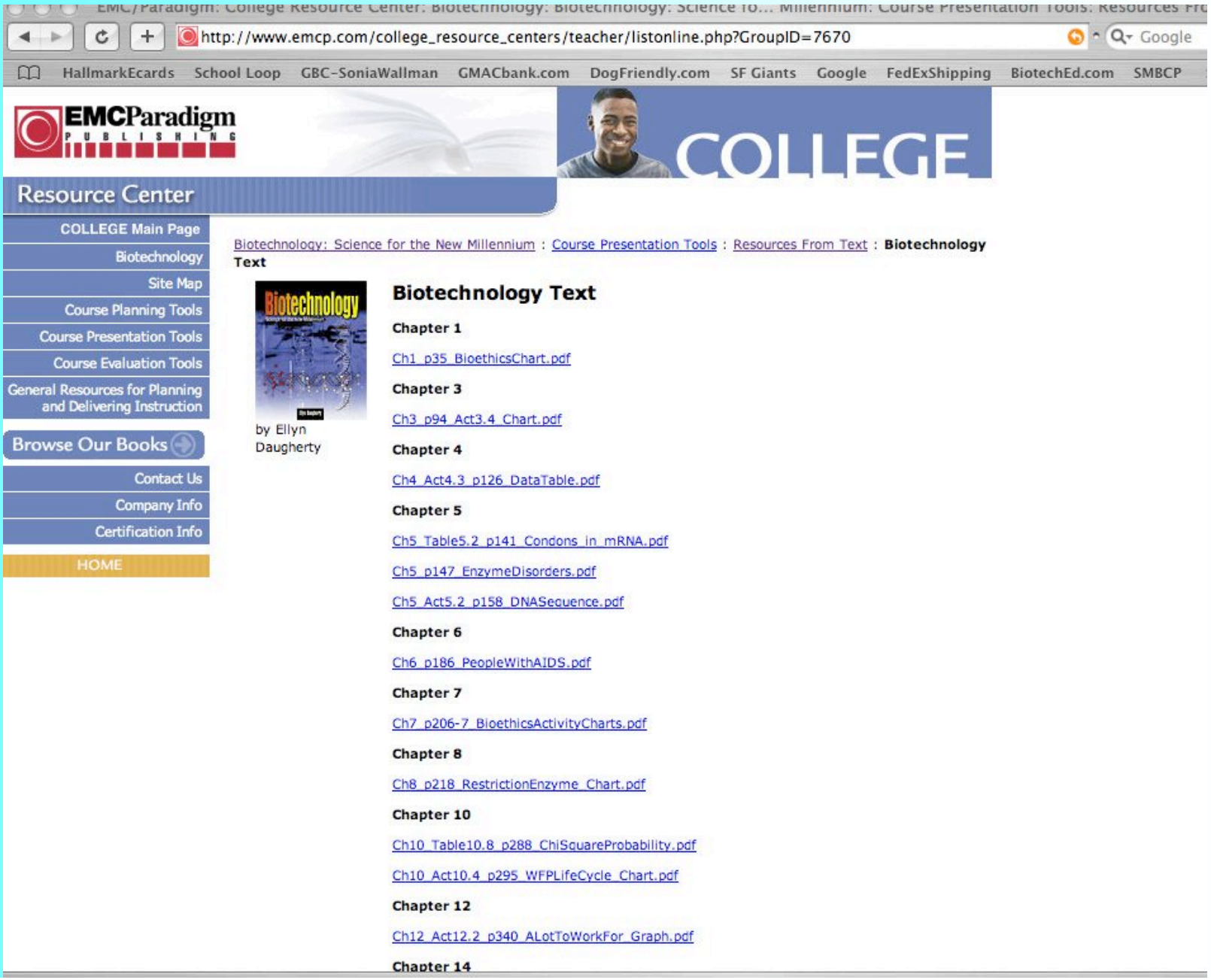

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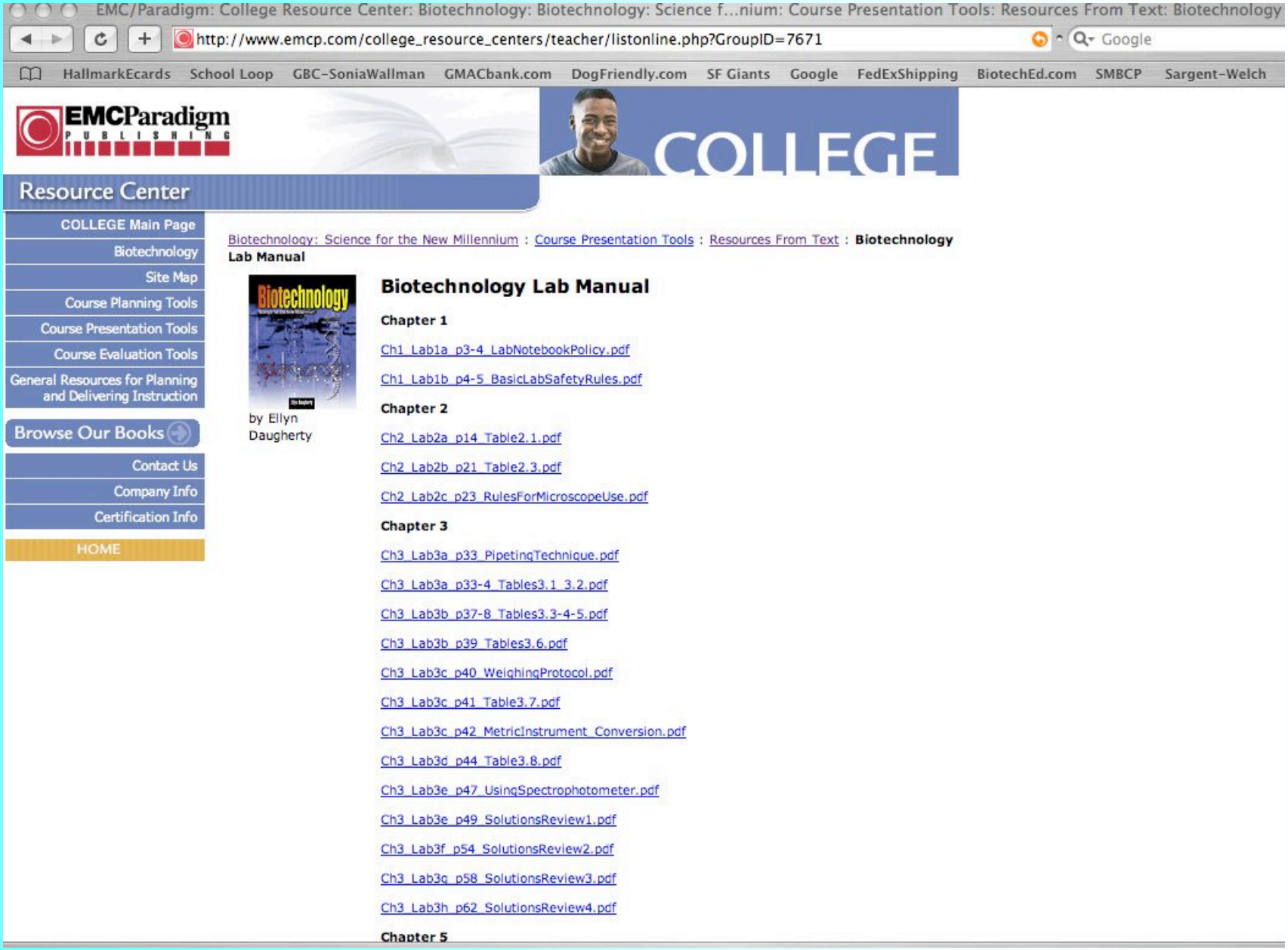

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## *BIOTECHNOLOGY: Science for the New Millennium*

**by Ellyn Daugherty**

## ~ Biotechnology Education Program Support ~

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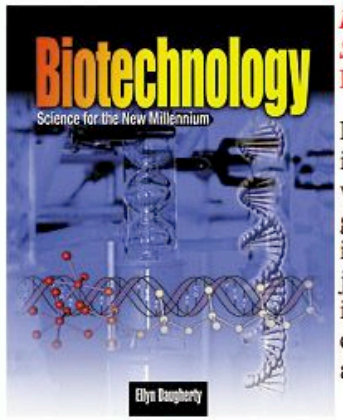


***Biotechnology:***
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**Biotechnology** is one of the fastest growing industries in the nation, with a high demand for entry-level workers and two-year and four-year college graduates. In the last 25 years, the US biotechnology industry has created more than 198,000 high-quality jobs, at over 1,400 pharmaceutical, agricultural, industrial, and instrumentation biotechnology companies , plus more at academic and government agencies (see statistics).

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Chapter 2 The Raw Materials of Biotechnology
Chapter 3 Basic Skills of the Biotechnology Workplace
Chapter 4 Introduction to the Study of DNA Molecules

**Your Students In Biotechnology**

***Biotechnology: Science for the New Millennium*** is a comprehensive program that prepares adults and teenagers for a variety of post-secondary options including community or career college biotechnology certificate programs, four-year biotechnology degree programs, and industry workplaces. The vast text and laboratory curriculum was development and improved with input from an industry advisory committee composed of laboratory internship mentors. Biotechnology: Science for the New Millennium allows students to increase conceptual background as they build lab proficiencies. Science-bound and business-bound students benefit from the extensive skill development, science methods, and career exploration that permeate the curriculum.

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| Chapter | 14 | Advanced Biotechnology Techniques |

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**Ellyn Daugherty**

Founder of the San Mateo Biotechnolog Career Pathway (SMBCP) and Author

***Biotechnology: Science for the New Millennium***

*Biotechnology: Science for the New Millennium* has been used in the San Mateo Biotechnology Career Pathway (SMBCP) courses for the past ten years. Started in 1995, SMBCP instructs approximately 175 high school students and 35 adults per year. Annually, 50-70 student interns complete internships with mentors at any of 20 loca [illegible] gh focused on the middle 50% o

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| Upcoming Presentations in 2006 by Ellyn Daugherty | |
|---|---|
| *March 12-14* | *The Monroe County Biotechnology Summit, Tannersville, PA* |
| *April 5-7, 9-12* | *The Biotechnology Institute/BIO, Chicago, IL* |
| *April 7-9* | *The National Science Teacher's Association (NSTA), Anaheim, CA* |
| *April 25-27* | *Northern and Central California ROCP Conference, Kelseyville, CA* |
| *June 3-8* | *BIO-LINK Summer Fellows Forum, Berkeley, CA* |
| *June 12-14* | *The Career College Association (CCA), Las Vegas, NV* |
| *June 14-15* | *2006 Health Science and Technology (HST) Conference, Salt Lake City, UT* |
| **July 24-28** | BIOMAN 2006, Northeast Biomanufacturing Center and Collaborative |

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student interns complete internships with mentors at any of 20 local biotechnology companies. Although focused on the middle 50% of the high school student population, the program has students coming from all socioeconomic and academic levels.

Tested for ten years, *Biotechnology: Science for the New Millennium* contains enough activities for four years of curriculum, with the hope that schools develop programs that match the needs of their students, community, and industry. The text is presented in short sections so students may master the concepts as they build proficiencies in employable lab skills.

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AEEDaugher@aol.com

**Curriculum Vitae / Professional History**

**Ellyn Daugherty receives the First National Biotechnology Teacher-Leader Award**
Press Release | San Mateo Daily Journal Article

Read Examiner.com article on Ellyn's new textbook Biotechnology: Science for the New Millennuim

***Biotechnology: Science for the New Millennium*** text, lab manual, and student Encore® CD were released in January 2006. The Instructor's Guide and Internet Resource Center were released in March 2006. Visit **www.emcp.com/biotech** for a tour through the text and lab manual.

Click here to get more information about ordering the book from the publisher, **EMC-Paradigm Publishing**.

Click here for **Sargent-Welch Equipment and Materials** support.

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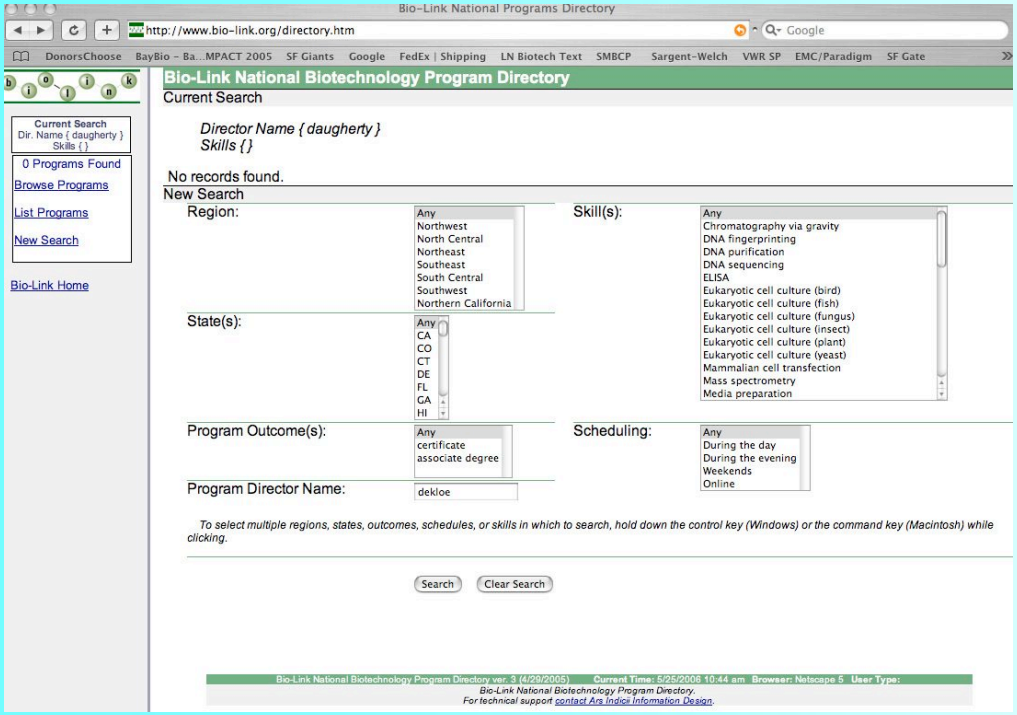
# Other Curricular Support

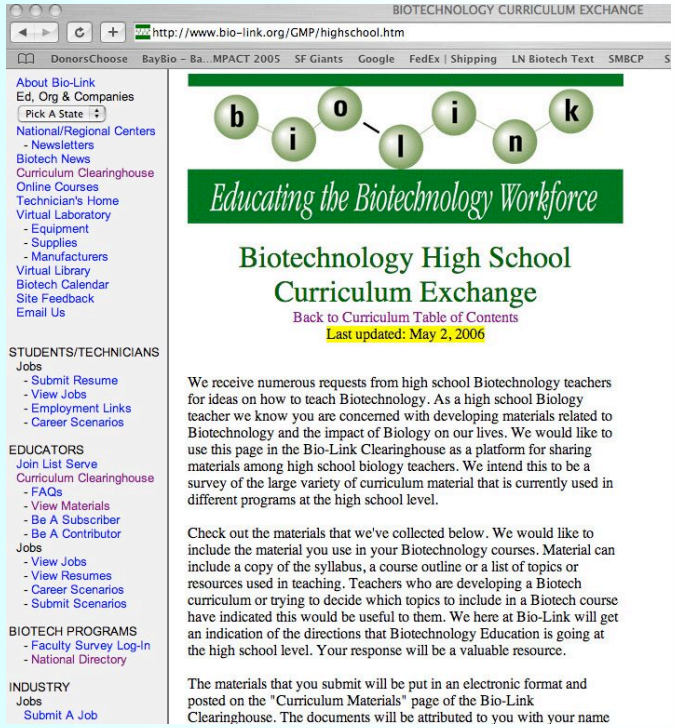
- **Biotech Education Groups (Workshops)**
  - –County (Gene Connection, SCCBEP, EBBEP, SFBase, Probe, etc.)
  - –Regional (**BABEC**, Dolan DNA Learning Center, BayBio, Salk, Scripps, BIOCOM, etc)
  - –CC/University (UC Davis, CSUSD, SDCC, Access Excellence, BIO, **Fralin Center**, etc.)
  - –National (**NSTA**, **NABT**, **Bio-Link**, Access Excellence, BIO, **Biotechnology Institute**, etc.)
  - –My workshops (check **www.BiotechEd.com**)
- **On the Web** www.bio-link.org
  - –My Teacher Support web site(**www.BiotechEd.com**)
  - –www.accessexcellence.org, www.biospace.org, http://www.nal.usda.gov/bic/Education_res/, http://www.public.asu.edu/~langland/lesson-index.html, etc.
  - –Vendor websites and/or workshops (VWR/Sargent Welch, Carolina Biological, Fotodyne, Edvotek, Sigma, Bio-Rad, etc.)
- **My Instructor's Guides (www.emcp.com/biotech)**

# www.bio-link.org

Bio-Link is a wonderful network of college and HS teachers and programs providing a vast amount of resources for biotech educators.

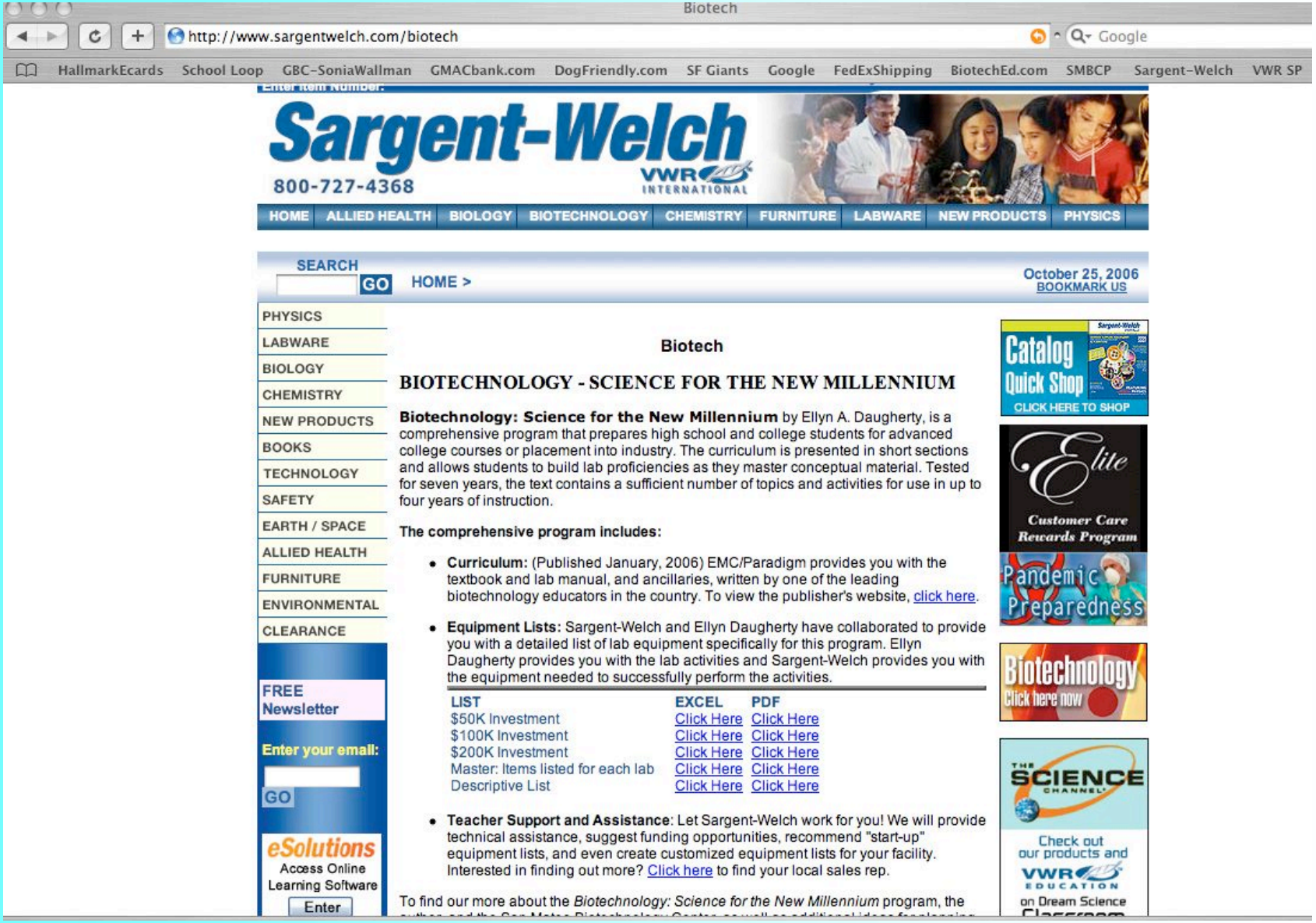






# Materials/Supplies Support

**www.sargentwelch.com/biotech**
- for materials lists and to locate your Sargent Welch sales rep



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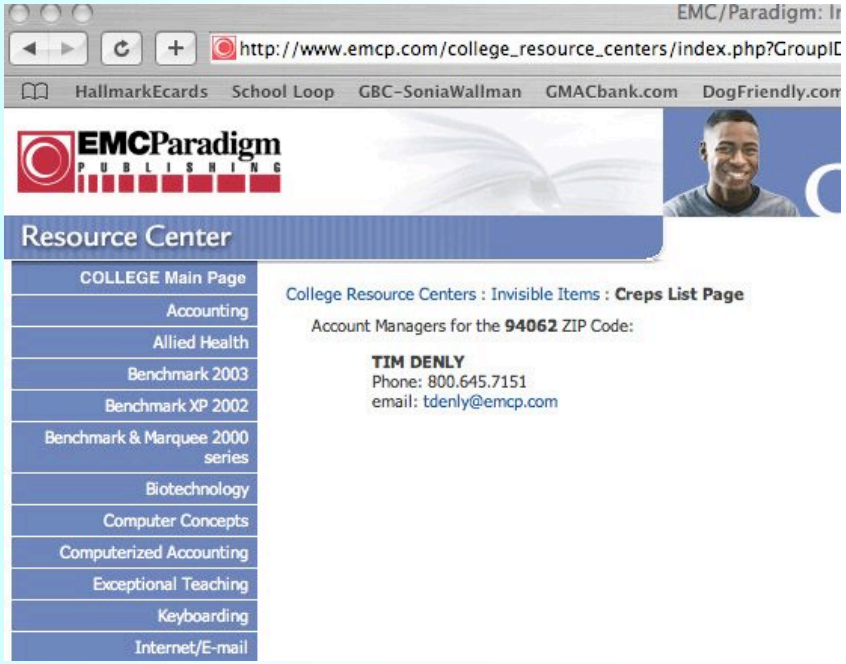


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