Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
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Introduction

The practice of medicine has changed dramatically since you were born. Consider a few of these changes, some of which have undoubtedly affected your own life: couples can test for pregnancy in their homes, a new vaccine is available for chicken pox, ultrasound imaging is available to follow the progress of pregnancy, and small reliable pumps can administer insulin continuously for diabetics. For your parents, the changes have been even more sweeping. Overall life expectancy (that is, the span of years that people born in a given year are expected to live) increased from 50 in 1900 to almost 80 by 2000. You can expect to live 30 years longer than your great-grandparents; you can also expect to be healthier and more active during all the years of your life.

How has this happened? One answer is obvious. People are living longer because they are not dying in situations that were previously fatal, such as childbirth and bacterial infections. The growth of biomedical engineering is a major factor in this extension of life and improvement of health. Biomedical engineers have contributed to every field of medicine -- from radiology to obstetrics to cancer treatment to emergency medicine. In this seminar, we investigated some of the biomedical engineering innovations that have improved patient care. We looked at the science underlying these innovations, the design of medical devices, and (in some cases) the mathematics that governs the principles of their operations.

Our work in this seminar followed a syllabus that allowed us to examine many of the activities that encompass modern biomedical engineering. The first part of the seminar focused on technologies that have enabled biomedical engineering to enter the modern era: recombinant DNA technology, cell culture technology, and antibody technology. These topics led naturally to a discussion on vaccine development. We spent two weeks discussing drug delivery systems, starting with the conventional forms of drug delivery, such as injections and pills, before expanding to consider new systems, such as drug-eluting stents and transdermal patches. With this information on drug delivery as background, we discussed the role of engineering in cancer treatment including imaging, radiation therapy, and chemotherapy. The final weeks of the seminar covered dialysis and other blood treatments, artificial organs, and biomedical imaging.

The discussions were supplemented with drafts of chapters from a book in progress, *Biomedical Engineering: Bridging Medicine and Technology* , by myself and Veronique Tran. The textbook is scheduled for publication in 2007.

The Fellows prepared curriculum units that covered the breadth of biomedical engineering, although the collection focused primarily on the chemical and medicinal aspects of biomedical engineering.

Karen Beitler prepared a unit on "Launch Biotechnology in Your Classroom" for high school science students.

Karen's unit explores fundamental principles that are important in biotechnology and biomedical engineering, focusing primarily on diffusion and its consequences in drug delivery. Her unit contains a wealth of background information on drug delivery systems that depend on diffusion for their operation. The lesson plans that Karen has designed will allow teachers and students to get hands-on experience with these concepts. She emphasizes activities that will help students develop an intuitive understanding of the role of physical phenomena, such as diffusion, in biotechnology applications.

Chrissy Bieler prepared a unit on "Dietary Supplements and the Chemistry of Life" for high school chemistry students. Her unit provides background information on the major components of the human diet and an introduction to metabolism. The unit focuses on the dietary supplements, particularly those that are marketed for use in weight reduction. This unit should be of great interest to high school students, who may be tempted to use these supplements and will benefit from Chrissy's clear description of the potential problems with these products. The unit has lessons that describe metabolism, dietary and energy needs for children and young adults, and analysis of dietary supplements.

Raymond Brooks prepared a unit on "Biomedical Engineering and Quality of Life Improvements" for students in grades six through eight interested in science fair projects. In his unit, Ray provides an example of a natural experiment, which students can perform using existing information that is available in textbooks and Internet sources to test their own hypotheses about the role of technology on disease progression. Ray illustrates his approach with the example of treatments for prostrate cancer. His unit progresses systematically from study of the cell and cell components through cancer and its treatment.

Matthew Cacopardo prepared a unit "Hold Off on the Headphones" for high school science students. Matt's project uses the auditory system as a platform to blend material from the physical and biological sciences into a coordinated unit. His unit progresses systematically from a description of waves and their properties, to sound and its measurement, to the biology of hearing loss. The unit should appeal to students, because it involves a subject of interest to many of them -- sound and the experience of music. Matt incorporates creative hands-on activities to provide tangible experience upon which to build a conceptual understanding of far-reaching concepts in physics.

Judith Dixon prepared a unit on "A Child's Journey through Medicine" for fifth grade students. Judy's project focuses on human physiology, highlighting the respiratory and cardiovascular systems and the problems that occur in children with asthma. Her unit blends science background with practical knowledge that students should find interesting: many will have experience with asthma, or friends and classmates with asthma, and the unit provides an excellent connection for students between a problem they can see and the workings of their bodies. The unit introduces concepts of drug delivery, using medication for asthma as an example. The lesson plan is a balanced mixture of activities, which are hands-on and participatory.

Carolyn Kinder prepared a unit on "Biomedical Engineering and Diabetes" for fifth to eighth grade science students. Carolyn's unit provides background on diabetes, focusing on the physiology of the disease, its effect on people who suffer from diabetes, and the tools that are available for treating it. Her unit is prepared for students who are at an age at which they will be recognizing diseases such as diabetes in friends and family; this unit provides teachers with tools for using that curiosity about disease to draw students into the underlying biology and the technology for treatment. There is an excellent section on vocabulary, a pre-test for assessing students' prior knowledge, and activities that can be used to draw students into discussions and learning about the disease and its treatment.

Marcela Oliveira-Antunovich prepared a unit on "Interdisciplinary Applications of Chemistry through

Engineering: CSI New Haven" for high school chemistry students. Marcy recognizes the great interest of students in forensic science, and uses that interest to introduce chemical and engineering techniques important in that area. Her unit describes some of the chemical techniques that are routinely now in forensic science including chromatography, spectroscopy, pH determination, and DNA analysis. She develops a case study of an accident scene as the basis for lesson activities, which will allow students to get hands-on experience with chemical determinations.

Hermine Smikle prepared a unit on "Mathematics in Biomedical Engineering" for grade 11 and 12 mathematics students. Hermine recognizes the central role of mathematics in engineering, and introduces some of the techniques that can be used to understand biomedical engineering. Students often react more positively to mathematics that is connected to applications, and biomedical engineering provides a wealth of interesting examples. Hermine's examples are drawn from diverse areas, including cancer cell growth and drug delivery.

Chris Willems prepared a unit on "The Challenge to Deliver Insulin" for high school biology and chemistry students. Chris's unit, like Carolyn's, focuses on diabetes, but his unit concentrates on the chemistry of insulin, the methods of its production by the body, and the techniques that have been used to produce it for use as a drug. Because insulin is a protein, this provides Chris with an opportunity to explore the biochemistry of proteins and the molecular biology of insulin manufacture. Chris provides diverse connections -- on insulin research, molecular evolution, and others -- that teachers can follow in their classroom studies. His lesson plans also span a range from molecular models to planning for a healthy lifestyle.

W. Mark Saltzman