



YALE NATIONAL INITIATIVE

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Curriculum Units by Fellows of the National Initiative
2017 Volume VI: Engineering of Global Health

Introduction

by W. Mark Saltzman, Professor of Chemical and Biomedical Engineering

This seminar focused on several related questions: What does it mean to be healthy? How does health differ among the nations of the world? What are the major barriers to health, and can engineering be used to surmount these barriers?

To address these questions, we focused on the physiological functions that lead to a state of health in an individual and a population. We considered health at the cellular and molecular level by focusing on four important determinants of health:

- Genetic variability and its relation to human disease,
- The role of the immune system in protecting health,
- The interaction of microorganisms with humans,
- And the cellular basis of cancer.

Throughout the seminar, two major themes were explored: 1) the relationship between health and biological/physiological mechanisms (e.g. the molecular basis of inheritance, cellular interactions in the immune systems, microbial interactions with hosts, and lung mechanics); and 2) engineering of technologies that enhance health (e.g. vaccines, contraceptives, insulin therapy) and technologies that harm it (e.g. tobacco, power generation by fossil fuels). The discussions in the seminar were enhanced by our reading from: *Biomedical Engineering*, W. Mark Saltzman, Cambridge University Press (2015).

The Fellows prepared curriculum units that covered a breadth of information on global health and engineering. The material presented in the units assembled in this volume span an impressive range and are designed for use in classrooms from elementary through high school.

Several of the curriculum units were prepared for high school teachers. Kwame Adu-Wusu prepared a unit titled *Gene Therapy and Muscular Dystrophy: Structure, Function, and Dysfunction of the Muscular System*. This unit introduces the basic processes of biological transcription and translation in producing proteins, but focuses on the potential effects of mutations in genomic DNA. To illustrate how mutations in a gene can lead to health problems, Kwame describes one kind of gene mutation that produces muscular dystrophy. Monica Cohen prepared a unit titled *A Cell's Story - From Growth to Mitosis*, which provides an introduction to the biology of human cells, putting the biological processes of protein synthesis, DNA replication, regulation, and cellular reproduction into a logical framework. Her unit provides classroom activities that will help high school students make connections between these concepts that underlie human health. Michael A. Doody wrote a unit on *Economics and Community Health - The Wealth-Health Paradigm*. In this unit, Michael describes the differences the health of populations living in different regions of the world, and relates these differences to

local economics. His work provides a framework for students to develop skills in analyzing and interpreting data, while enhancing their understanding of the basis of health and how it differs among nations.

Other units were prepared for teachers at the middle school level. Patricia Moncrief prepared a unit titled *Water... "Good To The Last Drop"*. Here, Patricia focuses on the health effects of water, outlining the problems that can develop when the body has too little water (dehydration). The problems develop because of changes in water availability to cells, and are used to illustrate some important basic physical phenomena, such as diffusion and osmosis. Patricia's unit also describes a service learning project related to water purification. Alexa Freshour prepared a unit titled *Cure for the Common Cold: Fantasy or Reality?*. Alexa's unit focuses on viral diseases of the upper respiratory system, which cause highly impactful world-wide health problems. In the unit, Alexa discusses the respiratory systems, life cycle of viruses, the lymphatic and immune systems, and the elements of vaccines, as she illustrates the difficulty in making a vaccine for the common cold. Nancy Ibarra wrote a unit titled *HeLa Cells, Cervical Cancer, and the HPV Vaccine*. The unit connects important concepts from cell biology and virology and immunology, by focusing on the power of viruses to transform normal cells into cancer cells, and the role of vaccines in preventing viral infections and, therefore, cancer. Nancy uses the example of human papilloma virus, which can cause cervical cancer, and describes how the HPV vaccine is reducing the incidence of this deadly disease.

Beth Valentine Pellegrini wrote a unit titled *Micro Life in a Macro World: Understanding Life at the Microscopic Scale and the Spread of Disease*. In her unit, Beth describes the basic states of matter and, by increasing the scale and level of complexity, builds descriptions of living systems, including bacteria and human cells. These descriptions of living and non-living materials are used to illustrate some of the ways that the human body protects itself from disease. Jessica Johnson prepared a unit of kindergarten teachers titled *Germs Attack!*, which will help to introduce important basic concepts of germs and personal hygiene to young students. Jessica connects her unit to the study of the five senses—which is a common subject of study in many lower elementary classrooms—and describes new ways to improve understanding of the role of bacteria and viruses in human health to even the youngest students.

Mark Saltzman

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