



Introduction

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Humans eat, drink, and breathe to bring into their bodies the raw materials for growth, and the generation of energy necessary for life and the actions that bring pleasure to life. Most of us also, at one time or another, swallow, inject, or inhale drugs to improve our health or prevent sickness. In taking a drug, we are hoping to activate a specific set of events that lead to healing or avoidance of disease. Unlike the foods that we eat, which are complex mixtures, most drugs are highly purified and chemically defined. Drugs – refined and manufactured and formulated into prescription and over-the-counter medicines, vaccines, supplements, vitamins, alcohol and illicit agents – are created to encourage specific chemical processes in the body.

Our seminar focused on how drugs work. The seminar began with descriptions of the biological basis of drug action, using examples of drugs that are used to treat common conditions such as heart disease, infections, pain, and cancer. This discussion led to a description of the chemical basis of drug specificity: why do drugs affect one condition (or one set of cells in the body) and not all others? Drug specificity is never perfect, so the seminar discussed side-effects, which is the most important limitation in our ability to design drugs. The seminar used mathematics to describe the duration of drug action: what determines the frequency with which drugs must be taken? Finally, the seminar considered a remarkable feature of modern medicine: drug discovery is now accomplished using high-throughput techniques, in which thousands of prospective "drugs" are screened to identify compounds with the right biological and chemical activity. Because of the high frequency of chronic diseases among children – such as asthma, diabetes, allergy, and attention disorders – almost every classroom in the U.S. is impacted by drugs. The seminar focused on biology, chemistry, health, and mathematics, which can be made relevant to students at all levels: accordingly, there were fellows teaching at all grade levels in the seminar group.

Specifically, the seminar covered the following topics:

1. How are drugs administered?
2. How do drugs work?
3. Natural medicines
4. Drugs of addiction
5. New methods for drug discovery (with a visit to Yale's West Campus, Center for Molecular Discovery)
6. Fighting infection

7. Cardiovascular drugs

8. Drugs for treating cancer

9. Non-invasive imaging to examine drug function (with a visit to Yale's PET Imaging Center)

The discussions in the seminar were enhanced by our reading from: *Magic Molecules: How Drugs Work*, Susan Aldridge, Cambridge University Press (1998); and *Biomedical Engineering*, W. Mark Saltzman, Cambridge University Press (2009).

The Fellows prepared curriculum units that covered a breadth of information on drugs and the mechanisms of drug action. 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.

Many of the units focused on material that is appropriate for high school students. Marlene Gutierrez wrote a unit called "Can You Pill It? Demystifying Painkillers" for high school chemistry students. In her unit, Marlene describes the chemistry of over-the-counter pain medications – ibuprofen, aspirin, and acetaminophen. Using the chemistry of pain medicines as an example, she is able to illustrate one way that chemistry impacts the lives of people. Deborah Smithey prepared a unit called "Cardiovascular Medications, Beta-Blockers, and Their Effect on Cells" that describes the role of beta-adrenergic receptor activity in cardiovascular disease, and the role of beta-blockers in promoting health. Vanessa Vitug prepared a unit titled "Antibacterial Gone Viral – Understanding Immune Responses in Bacterial and Viral Infectious Diseases." Vanessa's unit describes the mechanisms for bacterial and viral infections, and the role of antimicrobial products in protecting against these pathogens. Stephen Lewia wrote a unit called "The Down Low on High Blood Pressure," which describes both the biological basis of high blood pressure and the many types of medications that can be used to control blood pressure. While written for high school classrooms, all of these units can be adapted for use in middle school classrooms, as well.

Two units focused on material specifically designed for middle school students. Aimée MacSween prepared a unit called "A, C, E Detective: calculating percentages." Aimée's unit uses real information about vitamins A, C, and E – and how these vitamins work in our bodies – as background material to present the concepts of percentages and graphing and number sense. John Miklaszewski wrote a unit called "Toxic Effects of Mercury, Alcohol, and Cannabis on Human Cellular Function." John's unit describes the general operation of human cells, and the mechanisms by which they are adversely affected by three different common toxins.

Finally, four of the units are aimed at elementary classrooms. Valerie Schwarz wrote a unit called "Caution! Drug Diffusion Underway: Using inquiry to understand how drugs and the body interact. Her unit, designed for the fourth-grade classroom, describes how drugs move in the body, emphasizing the processes of diffusion that control drug distribution. Valerie's unit is rich in hands on activities to engage young people with these concepts. Tracy Lewis designed a unit for second- and third-grade students called "What's Going On Inside My Body? An Introduction to the Central Nervous System and the Digestive System," which introduces two essential organ systems, and relates the function of each to the molecules that we consume in our meals. Two of these units discuss medicines in the context of the traditional healing in the Diné Nation. Jolene Smith prepared a unit aimed at fifth- and sixth-grade students. The unit – called "Medicine between Two Worlds" – describes herbs, and their methods of preparation, and compares their healing effects to Western medicines. Marilyn Dempsey wrote a unit called "Diné Be' azee': Diné Traditional Medicine." Marilyn's unit, designed for fifth- through eighth-grade students, also introduces students to traditional methods for healing, but by emphasizing three special sources of medicines: sage brush, juniper, and piñon trees.

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