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Author: Haury, David L.
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Teaching about the Life and Health of Cells. ERIC Digest.

The cell is "the ultimate irreducible form of every living element, and...from it emanate all the activities of life both in health and in sickness." Rudolph Ludwig Carl Virchow (1858, translated 1860)

We've learned a lot about living cells since Robert Hooke (1665) viewed cork through a crude microscope and likened the hollow chambers to the cells of a monastery. Now we

know that living cells are dynamic micro-environments, complete with microtubule transport networks and protein motors (see http://www.hhmi.org/news/vale.html). With the development of cell theory in 1839 (Mazzarello, 1999), Biology became a theoretical science, and with the publication of "Die Cellularpathologie" (Virchow, 1858), modern clinical medicine gained a scientific foundation. Since then, good health came to be viewed as an outward expression of healthy cells, with disease arising from the cells of a tissue. Now, modern biotechnology is moving us along previously unimagined avenues to health that involve the use of undifferentiated cells (stem cells) in developing cell therapies, replacing diseased or dysfunctional cells with new, functioning cells. Biologists' understanding of cells has been greatly enriched in recent decades (Flannery, 1999). Though a long established field of study, cell biology has been transformed from the study of microscopic curiosities to a theory-based study of life itself, and now to a powerful new tool for creating health by marshalling the body's own life forces. It seems time for the study of cells in school biology to become transformed as well.

STUDYING CELLS

Study of organisms and cells in biology has been eclipsed in recent years by attention to the rapidly developing fields of molecular and population genetics, with older domains of biology serving primarily foundational and contextual roles. Indeed, the "National Science Education Standards" (National Research Council, 1996) limit attention to cell biology to such general ideas as structure and function of cells, the cell cycle, meiotic cell division, membrane physiology, cell differentiation, and examination of cellular structures and processes associated with energy production, transport, synthesis, waste disposal, and genetic storage. These are important areas of foundational knowledge in biology, but has the content in this area become frozen in time?
No; there is an important new role for cell biology at the precollege level, and it relates to biotechnology and the enhancement of human well-being. Cancer, HIV, and other significant threats to human health operate at the cellular level, and it is time to address such topics systematically and directly. The "National Science Education Standards" do promote attention to understandings about science and technology, understandings about personal and community health, and understandings about the historical perspectives of science. Cell biology is central to some of the most important topics and understandings in these areas. For biology teachers, study of cells offers the opportunity both to examine long-understood phenomena related to the structure and function of living beings, and to explore quickly emerging ideas and technologies related to the use of cells to enhance health. While not neglecting foundational content in cell biology, particularly areas where students are known to have conceptual difficulties, biology teachers are beginning to enrich the study of cells and biotechnology with attention to their roles both in causing disease and enhancing health.

Conceptual Difficulties

As long-standing as some foundational concepts in cell biology may be, they continue to cause cognitive dissonance among students. Some of the most widely studied misconceptions in cell biology relate to the concepts of diffusion and osmosis (Odom, 1995; Zuckerman, 1998; and others--see suggestions below for searching the ERIC database). While studying conceptual difficulties, Friedler, Amir, & Tamir (1987) found that use of textbook definitions, teleological language, and other issues related to use of language and textbooks may contribute to misconceptions. Indeed, some textbooks in the past were found to contain errors and misconceptions (Storey, 1992a, 1992b) relating to cell physiology and energetics.

In more recent years, researchers have focused on ways to address conceptual difficulties related to diffusion and osmosis within the classroom. Promising practices include use of discussion groups in constructivist-informed classrooms (Christianson & Fisher, 1999), use of concept mapping and the learning cycle (Odom & Kelly, 2001), and computer animations (Sanger, Brecheisen, & Hynek, 2001). Recent research has also focused on ways to help students better understand concepts related to meiosis (Harrell, 2001; Wynne, Stewart, & Passmore, 2001).

Cells and Disease

The "National Science Education Standards" (NRC, 1996) and Virchow's work (1858) have some elements in common: Both emphasize the importance of inquiry and experimentation; both link science and technology; and both emphasize the central role of science in personal and social perspectives, at least in the context of health and disease. Following are examples of instructional approaches and materials that present cell biology concepts in the context of diseases.

* Cell Biology And Cancer. The National Cancer Institute (1999) has produced a supplemental curriculum guide that brings the latest medical discoveries to classrooms. This inquiry-oriented module uses case studies and data analysis to help students understand basic scientific principles related to cancer as a cellular phenomenon, experience the processes of inquiry and learn more about the methods of science, and recognize the role of science in society and the relationship between science and personal and public health. This module includes five major sections: (1) Understanding Cancer, (2) Implementing Module, (3) Student Activities, (4) Additional Resources for Teachers, and (5) a glossary and references section. A CD-ROM is also included, as well as linkages between the module and both the "National Science Education Standards" and the contents of major biology textbooks.

* Cell Biology and HIV. DiSpezio (1997) has developed a curriculum package (book and video) that brings research on the HIV virus into science classrooms. Instructional activities, readings, model design, guided discussions, and examples of research in action are used to bring the science behind this infection into focus. Fundamental areas of biology and health education covered include cell biology, general virus and HIV structure, immune system function and HIV infection, drug therapeutics, and infection prevention. The video features animations of concepts contained within the book, interviews with leading scientists and health care workers, compelling stories of adolescents living with HIV, and prevention strategies.

* Cell Biology and the Common Cold. Gillen and Mayor (1995) describe activities and problem-solving exercises related to cell biology, rhino viruses, and new trends in treatment of the common cold.

Stem Cells

This is an area of cell biology where instructional leadership and curriculum development are needed. This is topic of great pubic interest, it represents the cutting edge of research, and there are many issues related to science, technology, personal health, and social perspectives. But there are few published resources offering background information and instructional guidance for school science teachers. Following are selected resources on the Web that point the way:

"Stem Cells: A Primer"

National Institutes of Health

http://www.nih.gov/news/stemcell/primer.htm

"Stem Cells: Scientific Progress and Future Research Directions"

- National Institutes of Health
- http://www.nih.gov/news/stemcell/scireport.htm
- "The Stem Cell Debate"
- Time.Com
- http://www.time.com/time/2001/stemcells/
- "Stem Cell Research Lesson Plan"
- PBS Newshour Online
- http://www.pbs.org/newshour/extra/teachers/lessonplans/august01/ stemcells/
- "Learning How Stem Cells Can Repair the Body"
- New York Times Learning Network
- http://www.nytimes.com/learning/teachers/lessons/20001107tuesday.h tml? searchpv=learning_lessons

"Stem Cell Research"

CNNfyi.com Lesson Plan

http://www.cnn.com/2001/fyi/lesson.plans/07/12/stem.cell/index.htm l

"The Bionic Body Teaching Guide"

Scientific American New Frontiers

http://www.pbs.org/saf/1107/teaching/teaching2.htm

"Stem Cells and the Future of Regenerative Medicine"

The National Academies Press (Read the book online)

http://www.nap.edu/catalog/10195.html

GENERAL WEB RESOURCES

"Cells and Cell Structure"

Biology4Kids

http://www.biology4kids.com/files/cell_mai n.html

"Cells Alive!"

http://www.cellsalive.com/index.htm

"Cell Form and Function: Lesson Plans and Ideas"

http://www.win.co.nz/bioweb/cell.html

"Cell Biology Chapter"

MIT Hypertextbook

http://web.mit.edu/esgbio/www/cb/cbdir.html

"Studyin g the Cell"

Lubey's BioHELP!

http://www.borg.com/~lubehawk/cell.htm

RESOURCES IN THE ERIC DATABASE

There are many records in the ERIC Database pertaining to cell biology that have not been included here, but it takes a little searching to find them. The term cell biology is not used to index records in ERIC, so it is best to search using cytology as a Descriptor, combined with other relevant Descriptors, Identifiers, or keywords. Related Descriptors include: "diseases", "diffusion", "misconceptions", "cancer", "acquired immune deficiency syndrome", "protozoa", or "microscopes". Related Identifiers include: "osmosis", "mitosis", "meiosis", "organelles", "cells (biology)", "cloning", and "stem cells". You can narrow your search by combining these terms with one or more of the following Descriptors: "science activities", "science curriculum", "science instruction", "laboratory experiments", "science laboratories", "concept formation", "scientific concepts", or similar terms. You can further narrow your search by using education level Descriptors, such as "elementary education", "middle schools", "intermediate grades", "junior high schools", "secondary education", or individual grade levels. You can search the database on the Web at http://ericir.syr.edu/Eric/adv_search.shtml.

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Odom, A. L. (1995, October). Secondary & college biology students' misconceptions about diffusion & osmosis. "American Biology Teacher", 57 (7), 409-15. [EJ 518 917]

Odom, A. L., & Kelly, P. V. (2001, November). Integrating concept mapping and the learning cycle to teach diffusion and osmosis concepts to high school biology students. "Science Education", 85 (6), 615-635. [EJ 643 870]

Sanger, M.J., Brecheisen, D. M., & Hynek, B. M. (2001, February). Can computer animations affect college biology students' conceptions about diffusion and osmosis? "American Biology Teacher", 63 (2), 104-109. [EJ 625 569]

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