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ABSTRACT

How can science be made more meaningful to all students? This paper approaches this question through an analysis of gender. It begins with a brief exploration of the fundamental mismatch between women and science as described by statistics on the success, interest, and participation of women in science; feminist critiques of science; and studies of gender in science textbooks. A gender analysis of three different editions of the textbook "Modern Biology" are presented; explaining what it tells students about themselves, the nature of science, and the purposes of science education. It shows how the format, content, and message of this text has changed over time; how these changes can be linked to larger trends in science education, science and society; and how these changes have failed to eliminate barriers to women's participation in science. Finally, today's reform efforts in science education and their potential to help solve problems of gender in science are explained. (PR)

# THE HIGH SCHOOL BIOLOGY TEXTBOOK: A CHANGING MOSAIC OF GENDER, SCIENCE, AND PURPOSE

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## The High School Biology Textbook: A Changing Mosaic of Gender, Science and Purpose

Science education should help all students to obtain a meaningful understanding of science, to see science as both a coherent body of knowledge and a useful activity. Unfortunately, science education for most students results not in understanding but in alienation.

> Science as represented in most textbooks seems to be pretty dull and disconnected stuff, certainly not something that most children would want to find out about in their spare time. Even more troubling, the culture of most classrooms where those textbooks are used has little in common with the culture of adult science. Most adult scientists, for example, spend relatively little time copying facts and definitions out of books, yet that is the primary activity of many students in science classrooms (Anderson, 1989, p. 10).

For many women, the study of science is even more problematic. Science textbooks, for example, often cater to male audiences: most illustrations of humans, examples from real life, and discussions of scientists are of, for and about men (Heikkinen, 1978; Warren, 1988). In addition, women are rarely expected to excel in science: they are told by peers, family, school and society that an aversion to science is natural, that mastery of science's tools and discourse is difficult, and that the pool of potential women scientists is small (Brush, 1991; Kahle, 1990). Moreover, the mythology of science--the tales of science as a solitary, competitive and rational activity--makes it more inviting to men than to women. Those characteristics traditionally identified with science have been associated with and socialized into men; the obverse of these characteristics have been attributed to women (Harding, 1991; Keller, 1989; Longino, 1989).

How can we make science more meaningful to all students? In this paper, I approach this question through an analysis of gender. I begin with a brief exploration of the fundamental mismatch between women and science as described by statistics on the success, interest and participation of women in science; feminist critiques of science; and studies of gender in science textbooks. Next, I present a gender analysis of three different editions of *Modern Biology*, the most popular high school biology text in the last fifty years. I explain what it tells students about themselves, the nature of science, and the purpose of science education. I show how the format, content and message of this text has changed over time, how these changes can be linked to larger trends in science education, science and society, and, most importantly, how these changes have failed to eliminate barriers to women's participation in science. Finally, I turn to current reform efforts in science education, reforms that are trying to improve the state of science education for all students by focusing on the needs of minority women, white women and minority men. I attempt to explain how today's reforms have the potential to help solve problems of gender in science.

To state my thesis clearly, women have and continue to be excluded from science education and scientific practice. The three *Modern Biology* textbooks discussed below represent three different attempts by science educators to make science understandable to students. None of these attempts adequately addressed problems of gender. None directly encouraged the achievement and participation of women in science. These textbooks highlight the need for science educators to take seriously the mismatch between science and women, to explore the intersection of science, gender, diversity and power in the classroom, and to devise specific strategies to make science more meaningful to those traditionally marginalized from its practice. As this small study suggests, the problem of gender in science education will not simply fade away.

## Is Science Education Gendered?

New ideas continually flood the field of education. Before demanding science education be changed to better suit the needs of all students, it is important to provide reasons that such change is needed. Studies of the achievement and participation of women in science offer evidence for the existence of a gender problem. Studies of the nature of science and of gender in science textbooks attempt to explain why science education promotes the differential success of men and women.

### Achievement and Participation in Science

National and international studies document differences between men and women in achievement, interest and participation in science. First, girls do not perform as well as boys on national and international assessments. The National Association of Educational Progress (NAEP) has conducted four science assessments since 1977. In each, the average girl scored significantly below the average boy at both 8th and 12th grades (ETS, 1990; 1992). The 1991 International Assessment of Educational Progress (as cited in *U.S. Nine-Year-Olds*, 1992) also reported nine-year-old and thirteen-year-old boys significantly outperformed their female counterparts in most nations studied.

Second, girls do not find science as interesting as boys. In the 1990 NAEP in science, students were asked to respond to the question: Do you like science? At grade four, there was no significant difference between boys and girls. However, at grade eight, 64 percent of females versus 72 percent of males reported liking science. At grade twelve, the gap became even larger: 57 percent of females to 74 percent of males. Third, women do not select careers in science and engineering as often as men. According to *Women and Minorities in Science and Engineering* (1990), few women participate in precollege science and mathematics courses, and in undergraduate or graduate science and engineering programs. Women also continue to be underrepresented in science and engineering fields, encounter higher unemployment rates, and earn lower annual salaries than men. In 1988, for example, women accounted for 16 percent of scientists and engineers yet comprised 45 percent of the workforce. Moreover, women favored the life and social sciences; only 1 in 25 engineers was a woman.

The Nature of Science

Feminist historians, philosophers and sociologists of science suggest several reasons most women find it difficult to excel in science. According to Keller (1989), language serves to systematically exclude women from scientific practice. The language of gender, she explains, has been used to define both science and masculinity: to name science as masculine; to repudiate the resources of intuition, feeling and connectedness as feminine; indeed, to construct the feminine and scientific in opposition to each other. "It is precisely in the interpenetration of our language of gender and our language of science that the multi-dimensional terrains of nature, of culture, and of power have been transformed into one dimensional contests" (p. 44). Within this one dimension, women are powerless to effect change within science and society; women scientists must disavow difference, must strive for equality as sameness or be excluded from practice; and both women and men scientists are artificially constrained in their ability to engage and succeed in science.

How can we end discrimination against women in science? The key, claims Keller, is to create a new language that breaks the intersection between nature, science, sex and gender. A new language would prevent scientists from collapsing sex, gender and science into a problem of gender and science.

It would eliminate the definition of "feminine" ways of knowing as antithetical to scientific method. And, it would encourage scientists to use a wider variety of methods in exploring phenomena, to celebrate rather than ignore difference. Ultimately, a new language would make science less oppressive to women, more objective and more accurate. It would not, however, make women scientists obsolete. Sex, after all, never goes away. Men and women have different political agendas; they will always need to champion their own concerns within the domain of science.

Longino (1989) attacks the myth of science as impersonal, objective and value-free as harmful to the goals and practices of feminist scientists. According to Longino, the myth of value-free science rests on the very definition of values in science. Traditionally, science is seen as shaped by two kinds of values: constitutive, or internal, values are the source of rules determining practice or method; contextual, or external, values determine group or individual preferences about what ought to be. Moreover, only constitutive values are believed to influence the inner workings of scientific inquiry, observation and reasoning. The definitions of constitutive and contextual values necessitate the understanding of scientists as passive onlookers engaged in the process of discovering fixed relations, and, of good science, as free of both personal and cultural commitments. They also make science that ignores or denigrates women an example of bad science. Women can correct the errors of misogynist, or bad, science to reveal the truth hidden behind, a truth that has no bias, a truth that has no sex. However, they can in no way affect the inevitable progression of scientific knowledge.

Longino proposes that this notion of science as value-free be replaced with one that includes political motivations as guiding scientific theories and methods. She argues that contextual values do play a role in science, that there is no a priori way to eliminate assumptions from evidential reasoning generally, and, hence, no formal basis for arguing that an inference mediated by value-laden assumptions is bad science. In other words, Longino contends, there is no such thing as good value-free science or bad value-laden science, there is only good and bad science. The adoption of this new description of science, she continues, would legitimate the deliberate and active choice of an interpretive model based on political considerations, would allow women scientists to consciously integrate political commitments into their theoretical work, and would give women the power to affect the course of scientific knowledge production. Ultimately, this redefinition of values would help transform a science predominantly devoted to the concerns and desires of men--to the making of money and the waging of war--into one more sensitive to the needs of both women and men.

## Gender in Science Textbooks

Studies of gender in science textbooks also attempt to explain the differential success of women and men in science education. Textbooks tell a great deal of the story of science education. They have been and remain "both the medium and the message" in elementary and secondary science. Indeed, in the late 1970s, "more than 90 percent of 12,000 science teachers surveyed said that these texts were the heart of their teaching 90 to 95 percent of the time" (Hurd, 1981, p. 25).

Studies of physics, chemistry and biology textbooks indicate that science texts support the stereotype of the natural sciences as exclusively masculine in nature (Warren, 1988). Heikkinen (1978) conducted the most comprehensive study of those found. He examined 17 high school chemistry textbooks--three from the 1940s, five from the 1960s, and nine from the 1970s--for gender bias. He found the following patterns in the texts' illustrations: (1) male figures dominate all textbooks reviewed; (2) male-female ratios have changed little, if at all, over time; and (3) males are portrayed in a broad range of activities, with a focus on "doing," while female figures tend to "pose," engage in passive behavior, or play more limited roles. Heikkinen also examined verbal analogies and examples presented in two of the nine contemporary texts. He found the two most common images in these texts to be automobiles and space travel, areas traditionally considered male interests. Overall, one text provided a reasonable balance between verbal images that appealed to males and those that appealed to females; the other did not.

## Modern Biology

To repeat, science textbooks are often both the medium and message of science classes. As such, they offer important insight into the content of science education over time. Unfortunately, many studies of gender in science texts fail to carefully sift through the wealth of information they provide. Indeed, the study by Heikkinen cited above was one of only a handful found to examine more than illustrations. (Examples of studies of illustrations include Warren, 1988; Mitchell and Rhyne, 1989; Bazler and Simonis, 1990). In response to this perceived void, I present my own gender analysis of science texts. I examine three editions of one high school biology textbook--the 1956, 1965 and 1989 editions of *Modern Biology*--and focus on the unit or units dealing with human biology. I selected *Modern Biology* because it has been and remains the most widely used high school biology text in this country (Hurd, 1981); it traces its origins back to *Biology for Beginners* written by Truman J. Moon and published by Henry Holt and Company in 1921 (Bennetta, 1986). I decided to examine the units on human biology for a simple reason: they most directly address issues of gender. Moreover, I chose to analyze the 1956, 1965 and 1989 editions in order to compare the three different organizational formats used by *Modern Biology* over the last 36 years.

In the following pages, then, I discuss three different versions of human biology as presented by the textbook *Modern Biology*. Each discussion includes an orientation to the text, a study of the presentation of women and men, an examination of the nature of science, a description of the human biology unit's purpose, and a brief overview of concurrent events in science education, science and society. These discussions are bound by a singular purpose: to attempt to propose how science textbooks have contributed to the continued underrepresentation of women in science.

## The 1956 Edition

### *Discussion of Text*

This study begins with the earliest edition of *Modern Biology* found, the 1956 edition. Who wrote and edited this volume? The 1956 edition of *Modern Biology* was created by a handful of contributors, most of them high school teachers, most of them men. Three high school biology teachers wrote the text: Truman Moon, the original author, Paul Mann and James Otto. Eight colleagues reviewed it: six men and two women of whom five were high school teachers, one a botanist, one a zoologist and one a specialist in vaccines. Six high school teachers--five men and one woman--submitted helpful comments and ideas. Also, Otto's wife, Eloise, helped type the manuscript and read the proof.

How is this text organized? The 1956 edition of *Modern Biology* contains 757 pages divided into 10 units. The cover sets the tone for the rest of the text: It is a color drawing of plants and animals in a cross-section of pond in June; it depicts everything from microscopic protozoan colonies growing on a snail to water lilies to a mallard duck. The first unit is "Biology - The Scientific Study of Living Things." It includes chapters on the nature of biology, the physical and functional bases of life (cell biology), and the chemical basis of life (biochemistry). The next five units are devoted to botany and zoology. They form the core of the text, the foundation needed to then cover man,[1] disease, heredity and conservation. As the Preface explains:

> **MODERN BIOLOGY** combines the best features of the type, systematic, and principles course. In the study of type organisms, the beginner has an opportunity to study a complete plant or animal and the interrelation of all its organs and life activities. Such an approach emphasizes the unity of life. On the other hand, the systematic study of plant and animal groups shows the relations of all living things, the development of life through various stages of complexity, and the wide variety of organisms which compose our living world. Finally, the study of principles is accomplished largely by the inductive approach . . . (p. v).

The topic of human biology covers two units. Unit 7 is "a practical study of human biology" entitled "How Biology Applies to Ourselves" (p. v); Unit 8, an examination of "Biology and the Problems of Disease." The focus of both units is on the student and his health. The introduction to Unit 7 makes this emphasis clear. At the top of the page, two students--a boy and girl--smile. (See Figure 1.)

Figure 1. Opening illustration for Unit 7 in 1956 edition of *Modern Biology* (p. 450).

Below is printed:

> Good health is a priceless possession. It reflects in our personalities, our success, and in the enjoyment we get out of living. Still, we often take good health for granted and assume that

[1]The word man is deliberate. During my discussion of each text, I attempt to replicate some of the language used--to give the reader a better feeling for that particular edition.

> we will always have it. It is normal to be healthy, but we have sufficient intelligence and choice in the things we do to abuse our health -- or to safeguard it. Science has given us a wonderful opportunity to be healthy. We can expect to live longer than has any generation before us. And, we expect to live this long life without worry about many of the health problems which plagued our ancestors. What better reason could there be for finding out more about the marvels of your own body? Our study of plant and animal life has led to the climax of biology study -- a more perfect machine than man will ever assemble -- your own body. (p. 450)

The above quote serves to illustrate the overall purpose of these two units as well as to lend support to the following analysis. First, what do these units tell students about being a man or woman? Implicitly, the text explains woman as less important than man. According to the illustrations, the male form suitably represents the bodies of both men and women. It is used in all diagrams of human organ systems. According to the language, man and human are equivalent; the pronoun he refers both to men and women. Indeed, according to the content, women need only be remembered when a distinct difference exists between them and men. For example, both boys and girls experience puberty. Thus, the text provides three examples of how puberty affects male animals--"the large comb of the rooster, the bright plumage of most male birds, and the horns of the deer" (p. 517)--and no examples of how puberty affects female animals. However, men and women have different optimal caloric intakes and perform different activities. The Daily Calorie Table, then, provides information for both sexes. The table (Table 1) is reproduced below with boldface added. Note that only women do not work. Note also that such women's caloric intake is equal to that of preteen children.

Table 1: Daily Calorie Requirements of Children, Women and Men (p. 465)

| TABLE 1<br>DAILY CALORIE NEEDS (APPROXIMATELY) | |
|---|---|
| 1. For child under 2 years | 1,000 Calories |
| 2. For child from 2 to 5 years | 1,300 " |
| 3. For child from 6 to 9 years | 1,700 " |
| 4. For child from 10 to 12 years, **woman (not working)** | 2,000 " |
| 5. For girl from 12 to 14 years, woman (light work) | 2,200 " |
| 6. For boy (12-14), girl (15-16), **man (sedentary)** | 2,600 " |
| 7. For boy (15-20), man (light work) | 3,000 " |
| 8. For **man (moderately active)** | 3,200 " |
| 9. For farmer (busy season) | 3,500 to 4,500 " |
| 10. For excavator, hard laborer, etc. | 4,500 to 5,000 " |
| 11. For **lumberman (winter)** | 5,000 to 8,000 " |

*Modern Biology* also teaches students that men and women hold separate roles in society. Men, it explains, are expected to be virile, active and career-oriented. In the discussion of sexual maturation, boys are told they have or will experience a deepening of voice, growth of beard, increase in body hair, broadening and deepening of chest, and rapid growth. In the pictures, they are featured as track stars, weight lifters, conscientious students, first aid instructors, pilots, policemen, narcotic agents, and surgeons. And, in both pictures and text, they comprise all examples of adult biologists, scientists and doctors. Girls, in contrast, are expected to be nurturing and supportive. In the same discussion of sexual maturation, girls learn the presence of estrogen is linked to the mothering instinct. They also are told their body contours will soften, breasts enlarge, hips broaden, and menstruation begin--all characteristics associated with reproduction. It seems girls neither experience increase in body hair nor rapid growth. In the photographs and pictures of women--a mere fourteen in these two units--women appear three times as mothers, three times as lab assistants, and once as a nurse. We will return to this theme of text as conveyor of societal norms later in this discussion.

Second, how do the 1956 human biology units describe science? The answer to this question already has been suggested: in these two units, science is described as the activity of white men. Who writes about science? As noted above, this text's authors and majority of contributors are men. Who performs science? In the photographs, men are the doers of science; women, mere assistants, nurses or lab technicians. In the written text, only male scientists--nineteen male scientists--are discussed. The explanation of infectious diseases alone includes the works of Hippocrates, the father of medicine; Galen; Louis Pasteur, the father of bacteriology; Robert Koch, the father of bacteriological technique; and Dr. H. T. Richetts. One is left to wonder if there were ever mothers of science, if women too gave birth to important scientific discoveries. Moreover, who should consider becoming scientists? For the third time, the answer is men. Most of the metaphors used to convey scientific ideas and processes refer to interests or experiences more closely associated with boys than with girls. In Unit 7, the majority of metaphors refer to the economy and to machines: good health is considered a priceless possession; cells are remarkable factories; the digestive system is an assembly line in reverse; plants manufacture their own food from raw materials; muscles build up an oxygen debt during exercise to be paid in full later; the human body is a perfect machine; the endocrine system is like the balance wheel of a watch; the nervous system is a telephone exchange; and the cerebellum's action is "a little like picking up a weak radio or television signal and amplifying it before broadcasting it" (p. 531). In Unit 8, the primary metaphor is that of war. The body is a fort with three lines of defense to keep out or destroy invading microbes. "The skin is the outer wall. Mucous membranes and other first-line defenses guard the entrances. If microbes break through these defenses, white corpuscles rush to the attack and engage the invaders in local battle. If the battle grows and becomes a general war, the reserves are called out in the form of antibodies in your blood stream" (p. 580). Fortunately, the doctor is a powerful ally with a well-stocked arsenal of defensive weapons. He "knows how to mobilize defenses against some diseases before they strike. He can send reserves into the blood stream to aid the body's natural defenses . . ." (p. 572).

Finally, what is the purpose of these human biology units? One purpose is to socialize students, to transform young adults into productive and responsible citizens, to create new enforcers of the status quo, to sell them the American dream. Students receive the message that proper appearance brings popularity and success. "Personal cleanliness [--they are told--] is a vital part of being acceptable" (p. 524). Smoking is discouraged not because it is unhealthy[2] but because it is unsightly. "Teeth may become stained and discolored. Breath can become strong and objectionable. Certainly no one's appearance is improved by a cigar or cigarette hanging from the mouth. And good appearance is worth a great deal" (p. 557). Bad posture should be avoided: it can lead to unemployment and unhappiness. After all, "what is your impression of a person who stands with his back bent, his shoulders drooping, and his head hanging forward? If you were an employer, would you hire him to fill a job requiring initiative and leadership? . . . The emotional state of an individual exerts a powerful influence on posture. A dejected unhappy person usually maintains a slumped posture and the poor posture adds to the dejection" (p. 461).

Students are also encouraged to become members of a team--both the school team and the American team. Participation in school sports is desirable. "Competitive athletics is a valuable experience for at least two reasons. In the first place, it requires gradual but regular attainment of a physical peak under a trained coach. In addition, it trains participants in the cooperation of team play

[2]According to the text, smoking was not yet considered a serious health risk.

and provides situations in which one must be a good loser and a graceful winner" (p. 461). Moreover, participation in mainstream American society is vital. True, the text admits, the world is becoming more and more complex. Hustle and bustle, hurry and worry are the signs of the time. However, "you [--the student--] have every reason to look forward to many years of health and happiness . . . Your opportunities for success are almost unlimited today if you have the desire, the drive, the ability and the good health to claim your place" (p. 557). Alcohol, they are told, "is a dangerous detour which leads only to misery and failure" (p. 557). Not only does an alcoholic ruin his life, "his family and all society pay a price for his short-sightedness" (p. 552). Mental illness is equally dangerous and easily avoided. "Most cases of mental illness could be avoided if the individual understood something about the cause of these disorders . . . Study the following list carefully. Then see if you are tending toward any of the attitudes which may possibly lead to trouble in later life." The list includes such helpful advice as: "Avoid thinking too much about yourself . . . Strive to get satisfaction from your work . . . If possible, engage in sports and other outdoor activities which tend to tire you physically . . . [And, above all,] be conscientious in what you do, but don't worry excessively" (pp. 608 - 9).

A second purpose is to convince students that science is necessary and good, that they should readily use the fruits of scientists' labor and avidly support scientific research. To do so, the text describes the scientific enterprise as a heroic endeavor. The introduction to the unit on diseases, for example, attempts to awe students: "You have been spared the dread of smallpox because an English country doctor made a great discovery and dared to defend his idea in the face of ridicule. We have waged a successful war against the microbe world because a French chemist discovered bacteria and a German doctor devoted his life to the study of germ diseases" (p. 560). The text also characterizes science as inevitably progressive. It recounts how, time after time, new discoveries are made which supplant ignorance with knowledge, pain and discomfort with bliss. Because of science, students are reminded, humans "have every reasons to look forward to many years of health and happiness" (p. 557). They can eat a well-balanced diet, feel refreshed in an air-conditioned building, pick up a telephone and talk to people worldwide, watch a World Series game in their own living room, have their vision restored by means of glasses, and live without fear of the scourge of smallpox. Science, in short, has contributed mightily to the improvement of the human condition. It has every reason to be thanked and respected.

At first glance, this discussion of the units' purpose seems superfluous to an analysis of gender: Both boys and girls are subject to the forces of socialization; both are encouraged to cherish and support science. However, when tied to the descriptions of men, women and science, it serves to make clear--to bring to the fore--a point hinted at all along. *Modern Biology*'s message to students is gendered in that it defines success, and thus the way to achieve happiness, differently for boys and girls. To be successful, boys must be able to earn a respectable living, to support a family, to contribute to rather than burden society. They have their choice of careers: pilot, policeman, doctor, scientist. Science is a reasonable choice; after all, it has been and remains the domain of men. In contrast, girls have few opportunities for success: they can become mothers (women that do not work) or, if they must, assistants to men. There is no need to encourage women to take an active interest in science, to provide examples of what women can do as scientists, to inspire them to break down barriers to participation in science--women do not and should not become scientists. In sum, *Modern Biology* has no intention of sparking a revolution in science education. It means only to indoctrinate a new group of recruits into the established order, to convince students that they should become successful members of mainstream society.

*Link to Science Education, Science and Society*

What influenced the form and message of this text? Some aspects are easier to explain than others. First, the authors, as male high school teachers living in the 1950s, shaped the organization, style and content of the text to suit their values, ideas and culture. Second, the state of science education had an effect. The 1950s marked the beginning of attempts by the federal government and scientific organizations to fill the perceived need for a scientifically-literate populace and a larger science workforce. As part of this effort, the federal government established the National Science Foundation (NSF) in 1950 to fund scientific research and science education. NSF was to counteract the public's mistrust of science and technology, to soothe their dissatisfaction with the mechanization of industry and subsequent loss of jobs (Hurd, December 2, 1991, personal communication), and to promote science as "a large and very important component of our national culture, economy, and defense" (Levin, 1954, p. 19). Third, the testament to the power and goodness of science no doubt stemmed from the then recent advances in the prevention and cure of disease: Penicillin, for example, had been discovered in 1929 and a vaccine for polio, in 1954. Finally, the 1950s culture played a part in the message and content of the text. The 1950s were a time of economic prosperity, suburbia, the cult of motherhood and the beginning of the second wave of American feminism, an explosion in the use of technology, McCarthy politics, and the Korean War.

## The 1965 Edition

### *Discussion of Text*

By the early 1960s, science educators, scientists and the federal government grew convinced that extensive and immediate repair of science education was in order. They called for a new purpose in science education: both to create a scientifically literate public and to recruit a large number of scientists. They also recommended textbooks like the 1956 edition of *Modern Biology* be replaced with ones versed in the most modern advances in science. In response to these concerns, the 1965 edition of *Modern Biology*, the next in this study, presents a radically different structure, content and message.

Who wrote and edited the 1965 volume? For the first time since 1921, Truman Moon did not help in the revision. Rather, James Otto and Albert Towle, a newcomer, are named as authors. Again, both authors are men; both, high school biology teachers. In addition, each unit was reviewed by a high school biology teacher and a specialist in that particular field of biology. Four high school biology teachers and seven university scientists are acknowledged--all men. Two women are also thanked for their contributions: one, a biology teacher who assisted in the preparation of units two and six,[3] and the second, a high school science librarian who provided the bibliographies at the end of each unit. All told, in comparing the 1956 and 1965 editions, the ratio of women to men contributors

[3]This biology teacher, Mrs. Elizabeth Crider, taught with James Otto at George Washington High School in Indianapolis. She is listed as co-author with Otto and Towle on supplementary materials to the text: the teacher's guide and the laboratory manual. Unfortunately, because of lack of time, space and resources, these additional pieces of the *Modern Biology* curriculum are not examined in this paper.

decreased, the number of reviewers increased from eight to thirteen, and the percentage of scientists involved more than doubled. Reasons for these changes will be offered in a later section.

How is this text organized? This text provides a radical departure from the style and organization used in editions published in 1956, 1960 and 1963; it places a much heavier emphasis on molecular and cellular biology. The pictures on the cover and opening page of each unit set the new tone. The cover shows mitosis in a prepared slice of onion root tip. The photographs on the cover page of each unit include a model of DNA, Drosophila chromosomes, protozoans, Spongin fibers, a cross section of bone, and a drop of pond water. The names and organization of the units highlight this new focus as well: the chapter on "The Chemical Basis of Life" has grown from 14 to 22 pages; cell biology has expanded from three to five chapters; the word cell is now prominently displayed in the title of four chapters; units once called "Flowerless Plants" and "The Biology of Plant Life" have been renamed "Microbiology" and "Multicellular Plants;" the unit on genetics/evolution has been modernized, expanded and moved from second-to-last to second place; and the topics of ecology and conservation have been combined and moved to the end of the text. The Preface provides reasons for this change in emphasis from systematics--botany and zoology--to the microscopic:

> Biology today is vastly different from biology ten years ago. In the field of cellular biology, the electron microscope has yielded discoveries long suspected but incapable of positive proof. Improved techniques in biochemistry have revealed new vistas at the molecular level. Man's understanding of genetics, microbiology, and ecology has reached new heights . . . The book begins with molecular and cellular biology from which it logically moves into reproduction and genetics. From there it moves to evolution and hence into classification, thus building a basic structure of biological principles on which to build further concepts and facts--as much as circumstances, interest, and curricula requirements permit . . . The greatly expanded, thoroughly modern unit on genetics is a feature of this revision. Also modern in scope is the unit on molecular and cellular biology which includes now the treatment of cell reproduction formerly discussed much later in the text. (pp. 5 - 6)

The topic of human biology is covered in one unit: "The Biology of Man." The fifty-two page unit on "Biology and the Problems of Disease" has shrunk to a sixteen-page chapter entitled "Infectious Disease" and placed in the unit on microbiology; as a result, it will not be included in this analysis. The authors deliberately reduced the scope of the disease unit "to produce a pattern more consistent with current trends in the various science curricula . . . [It is a topic now] generally covered in the elementary and junior high school science programs"(p. v). Again, the opening page of "The

Biology of Man" encapsulates the unit's mood and message. This page presents a green and black circular picture of human blood with *Trypanosoma cambiens*. (See Figure 2.)

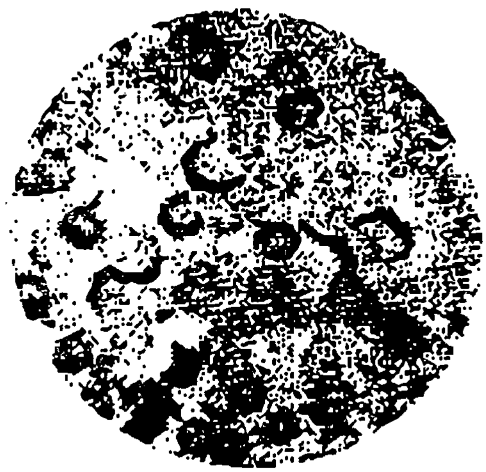

Figure 2. Opening illustration of human blood with parasites for Unit 7 in 1965 edition (p..541).

It states:

> Having followed the development of organs and organ systems through increasing levels of advancement and efficiency in the vertebrate classes, it is fitting that our study of anatomy, physiology, and body chemistry concern the mammal. What better example to use than the human body? Man, the most advanced living organism, dominates the living world. Intelligence, ingenuity, and creative ability have made him the master of every environment on the earth and in space beyond. (p. 541)

In this human biology unit, there is little new regarding the portrayal of men and women. The words man and human continue to be used interchangeably; the pronoun he, to represent both men and women. The illustrations still picture men much more often than women: There are eighteen illustrations of men, two of both men and women, and a mere three of women. The descriptions of puberty and secondary sexual characteristics described above remain the same. Even the new discussion of fertilization gives men greater attention and credit: "When the sperm penetrates the ovum at the time of fertilization, the tail separates. The head and connecting piece enter the ovum and the zygote is formed" (p. 649 - 650). Indeed, women have made only two noticeable advances. The female form is now used in the drawings of the endocrine and autonomic nervous systems. And, a woman scientist is mentioned. Mrs. L. S. B. Leakey and her husband, the "eminent British anthropologist" Dr. Leakey, is credited with spending nearly 35 years excavating and studying fossils (p. 544). Unfortunately, Mrs. Leakey does not have her Ph.D. as well.

However, *Modern Biology*'s description of science has changed. Science is now best described as consisting of two faces. (The idea of science as two faces is borrowed from Latour's (1987) work on the sociology of science.) The first chapter in the human biology unit, a chapter on the evolution of man, presents the first face of science: science in the making. It describes the history of the understanding of human evolution as a story with actors, methods and missing pieces. It carefully explains the discipline of anthropology, two processes used to date fossils, and the work of prominent scientists. Moreover, the text repeatedly reminds the reader that the nature of this information is tentative. It explains that Charles Darwin first created his theory of the descent of man without physical proof. "Since then, hundreds of bones have been unearthed . . . [However,] this evidence still does not provide us with a complete picture of man's development, but the fossils serve as clues from which hypotheses can be formed" (p. 543). It also highlights a current point of disagreement: "The bones of Zinjanthropus and Australopithecus are similar and look like those of modern apes . . . Anthropologists are not agreed as to whether these forms should be placed in the ape family or in the family that includes man" (p. 544).[4]

The remaining chapters of the human biology unit provide a stark contrast. They present the second face of science: science as a static body of truths, or ready made science. Ready made science is confident in its importance, utility and validity. It takes credit for making man master of every environment on earth and beyond. Ready made science is anonymous: the chapter on the history of man names four scientists; the other eight chapters mention a total of one. Ready made science also consists of declarative statements free of subjectivity and of context. In describing what happens after a blood vessel is cut, the text states:

> Clotting results from chemical and physical changes in the blood. When blood leaves a vessel, the platelets disintegrate and release thromboplastin. This substance reacts with prothrombin and with calcium to form thrombin. The thrombin changes fibrinogen, a blood

[4]Donna Haraway (1989), in her discussion of primatology, describes how the commonly told story of human evolution is inherently sexist: it marks paternity as the key to humanity. However, in *Modern Biology's* account of human evolution, the words are sexist but the actual story is not. The text only mentions the formation of family groups once--in reference to Neanderthal man--and never discusses the loss of estrus or the rise of paternity. If anything, *Modern Biology's* story is racist: it states that the facial features of the aborigines are similar to the Australoids, the predecessors of man, and thus suggests a relationship between them.

protein, to fibrin. The fibrin is a network of tiny threads that trap blood cells, thus forming a clot, and prevents further escape of blood. (p. 586)

Who discovered how blood clots? When? How? Why? What is their evidence? Who disputes their findings? As with all of ready made science, these questions are neither raised nor answered.

Before moving on, it is important to note that one could argue the 1956 edition presents the two faces of science as well. The unit on diseases could be considered an example of science in the making; the unit on anatomy and physiology, ready made science. However, both 1956 units describe the work of scientists, highlight areas of remaining ignorance and take time to explain how experimental pieces of equipment work. The differences between the two 1956 units, then, are less distinct than within the one 1965 unit.

*Modern Biology* has also changed its message to students. In the 1965 human biology unit, students are told that they should learn science for its own sake--science as understood by scientists. At the organization level, the unit has lost its place of importance in the biology course. The study of man is no longer considered to represent the climax of biology; rather, it can be used to extend the basic structure of biological principles presented in the units on biochemistry and genetics. The unit has also lost its emphasis on health: the title has been changed from "How Biology Applies to Ourselves" to "The Biology of Man," and the purpose, from health to the study of "anatomy, physiology and body chemistry" (p. 541). At the content level, the study of humans has been buried beneath detailed descriptions of microscopic processes, organs, and organ systems. Discussions of good posture, teeth hygiene, care of skin, care of eyes and ears, tension fatigue, and a balanced diet have been eliminated to make room for complex descriptions of muscle contraction, kidney filtration, hormonal feedback, and lymph circulation. Even the illustrations highlight this move away from the whole human: there are fewer pictures of people (13 in 1965 versus 34 in 1956) and more of cellular phenomenon (34 in 1965 versus 18 in 1956).[5] At the level of the student, his interests and needs no longer form an integral thread of the text. In 1956, "each chapter opens with a short introduction which directs the thinking of the student to the chapter content" (p. vi). In 1965, there are no introductions. There are also fewer metaphors, references to familiar expressions, sentences directly

[5]In making these two comparisons, only Unit 7-- "The Biology of Man" or "How Biology Applies to Ourselves"--was used; Unit 8 in the 1956 edition is not included here.

addressed to students, discussions of common misperceptions, attempts to connect science to everyday experience, and references to students' life, like athletics, or students' concerns, like acne.

Is this human biology unit gendered? It is obvious that the portrayal of men and women is androcentric; however, it is less clear that the descriptions of science and of purpose can be explained as such. One could argue that, like the 1956 edition, this text fails to see its women readers as potential scientists. It neither explains the virtual absence of women in science nor encourages girls to consider scientific careers. Still, because conformity to social norms is no longer heavily emphasized, this argument is less persuasive in this context.

One could also argue that the text's description of science as dehumanized activity, as domination over nature is androcentric. According to Ruth Ginzberg (1989), women possess a deep reverence for nature, a capacity for union with that which is to be known, a sort of holism of approach that is ignored in Western science. Rather than trying to control and delineate every aspect of the planet, women seek to form interconnections "through their careful attention to the dynamics of living systems as pieces of a larger and more awesome natural world which is constantly responding to, and responsive to, itself" (p. 71). However, Ginzberg's argument is not without its own problems. Both Longino (1989) and Keller (1989) think it dangerous to define certain characteristics as distinctively masculine or feminine. Such labeling ignores the fact that women are constructed by society to occupy positions of subordination. Such labeling attempts to define all women as one and thereby ignores diversity among them. More importantly, such labeling perpetuates the stereotype of women as incapable of succeeding in science.

Finally, to take an extreme stance, one could argue that the heavy emphasis on the molecular basis of life and on the certainty of scientific information is androcentric. Drawing from what she calls the old psychoanalysis tradition, Keller (1990) explains the discovery of DNA by Watson and Crick as beginning "the transformation of biology from a science in which the language of mystery had a place not only legitimate but highly functional, to a different kind of science--a science more like physics, predicated on the conviction that the mysteries of life were there to be unraveled, a science that tolerates no secrets" (p. 179). This new biology of secrets, she continues, required that these secrets be explainable, that the secrets of life be found. Historically, the secret of life had been considered the secret of women and, by association, of nature--a secret kept from men. The quest for the biological basis of life, then, is best understood as a man's quest: "the illumination of a female interior, or the tearing of nature's veil . . . an inversion of surface and interior, an interchange between visible and invisible, that effectively routs the last vestiges of archaic, subterranean female power" (p. 178). Once the mechanism of genetic replication had been found, the biological sciences proclaimed that even the darkest recesses of nature's interior had been illuminated, began to represent life as the molecular mechanics of DNA, and declared living organisms outside the proper subjects of discussion. Life and women became equally absented, discounted, and by implication, devalued in biological research. However, once again, this argument for the continuing--indeed growing--separation of women and biology has both strengths and weaknesses. As Keller (1992) herself explains:

> Even though I have found it strategically impossible to proceed with psychodynamic explorations of scientific postures, I stand by that earlier work [of secrets]; I continue to believe in the value, and perhaps even in the ultimate indispensability, of psychodynamic approaches to the study of science, notwithstanding the ill favor with which they are currently received. For both good and bad reasons, most historians, philosophers, and sociologists of science have come to regard psychoanalysis, and even the very idea of the individual subject on which it depends, as something of an embarrassment. However . . . the "subject" on which at least traditional psychoanalysis depends is in no sense either independent of or an alternative to other forms of social structure . . . Psychoanalysis, despite its problems and deficiencies, continues to provide some of our only tools for thinking about both individual and collective subjectivities. (pp. 8 - 9)

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Although the extent of gender bias in *Modern Biology*'s 1965 edition is open to debate, it is clear that the text's radical changes in structure, content and message were not motivated by the desire to improve the status of women in science. Rather, the text's changes reflect the perceived need for more scientists and the hardening of biology into a predictive science. First, the text incorporates recommendations made by the science education reform movement of the 1960s. This reform movement was initiated by scientists and the federal government; it rose in response to the Cold War, the increasing impact of science on society, and the changing nature of science. As described above, the federal government first became interested in science education in the late 1940s. Then, in October of 1957, the Soviet Union shot Sputnik I into space. As Mayer (1986) explains, Sputnik did not originate science educational reform; however, it did launch science education into the federal spotlight and shower it with federal dollars. That same year, NSF began considering proposals for innovative science curriculum projects at the precollege level (Hurd, 1982). The following January, "the U.S. Congress began hearings 'to learn, in the light of recent Russian scientific and educational achievements, what action America must take to strengthen our education' " (Hurd, 1982, p. 3). Moreover, in September of 1958, President Eisenhower signed into law the National Defense Education Act to provide funds for the modernization of schools (Hurd, 1961).

The scientists took the lead in this reform effort. In November of 1956, the year before Sputnik, Jerrold Zacharias, a physicist at M. I. T., received an NSF grant to form the Physical Science Study Committee, or PSSC. PSSC developed a high school physics textbook and film series (Jackson, 1983). In later years, other groups of scientists developed curricula for high school biology, chemistry, earth science and social science courses as well as for elementary and junior high school science (Mayer, 1986). These scientists organized and filled their texts with what they, as mostly white male insiders, thought important. They were eager to explain to students why science was crucial to the well-being of people and to the prosperity of the nation. They hoped that by giving students a strong basis in the latest scientific knowledge and processes, students would be able to understand and do science. By the early 1970s, scientists had created over two dozen NSF-funded curricula (Kyle et al, 1982).

*Modern Biology* was not a direct product of the 1960s science reform effort; however, it was dramatically affected by the movement. "One study reports that from 1965 on, close to 70 percent of the changes made in *Modern Biology* . . . were made to conform with the model offered by materials emanating from the BSCS (Biology Science Curriculum Study) team, the federally funded project in biology" (Quick, 1977 as cited in Jackson, 1983, p. 149). More specifically, Mayer (1986) credits BSCS with encouraging biology texts like *Modern Biology* to include material about sex and human reproduction, de-emphasize classical morphology and systematics, and make room for newer material on genetics, biochemistry, cellular physiology, ecology and behavior. These statements are supported by the changes in content and organization noted above.

Second, the form and content of the 1965 edition of *Modern Biology* reflect changes in the actual discipline of biology. By the early 1960s, biology was no longer considered "simply a grouping of phenomena for the sake of description, classification and correlation" (BSCS, 1967, p. 67); it had become a sophisticated, predictive and powerful science. To effect this transformation, biology modeled itself after physics: it adopted the conviction that mysteries can be solved (Keller, 1990). This new formulation of the biological sciences helps to explain the 1965 edition's organization of units according to specialties, increased prominence of molecular and cellular phenomena, and emphasis on science as ready made.

## The 1989 Edition

### *Discussion of Text*

The organization and content of *Modern Biology* remained relatively constant for over twenty years. It did not undergo another radical revision until 1989--again, in response to a call for science education reform. Who wrote and edited the 1989 edition? Albert Towle is now sole author; however, the number of contributors, reviewers and consultants has dramatically increased. The text boasts 14 contributors: approximately half men and half women; or three biologists, three high school teachers and seven others. Thirty-four reviewers and consultants are also listed: 20 men and 14 women; or 20 teachers, 8 biologists and 6 others. Moreover, the development process is overseen by 14 members of *Modern Biology*'s National Advisory Panel, a panel consisting of nine men and five women. Compared to 1956, the 1989 edition has eight times the number of participants and a much larger percentage of women involved in its revision.

The 1989 edition has grown into a massive volume of almost 900 pages. A quick flip through the text brings to light two trends. The first trend is the continued and increased reliance on the microscopic, the reduction of every organism or organ system to the minute. In the human biology unit alone, there are discussions of arthroscopic surgery and in vitro fertilization; detailed explanations of how muscle cells contract, nerve cells stimulate and lymphocytes attack; and diagrams of the immune response, the transmission of a nerve impulse and hormone-induced changes within the cell. There are also far more photographs of the microscopic than of people: 30 as compared to 13. The second trend is the overwhelming array of pictures and information. The text brings to mind a child's encyclopedia with colorful photos, easy-to-read headings for a quick search, and easy-to-digest information bites for a quick read. Every chapter in this edition includes an introduction, a chapter outline, a chapter concept, section objectives, end-of-section review questions, one laboratory investigation, end-of-chapter review questions, end-of-chapter critical thinking questions, a vocabulary review, and extension ideas; every unit, one of more inserts of "Biology in Process," one or more inserts of "Biotechnology," one "Writing About Biology" written by a scientist, and one "Intra-Science" focus on current issues. Ironically, the one feature missing in both chapter and unit is a summary. For once, the cover seems to belie the bewildering amount of information hidden inside. The cover is simple, subtle and pleasant: on the front is a great horned owl against a dark green background; on the back, otter point in Acadia National Park, Maine.

As with the textbook, the unit on human biology has expanded in length and scope. It is now 127 pages long and includes a "new" chapter on infectious diseases and the immune system. For the third time, the unit cover pages--this time, there are two--summarize the character and purpose of the chapters to follow. The pictures on these cover pages are shown below. (See Figure 3.)

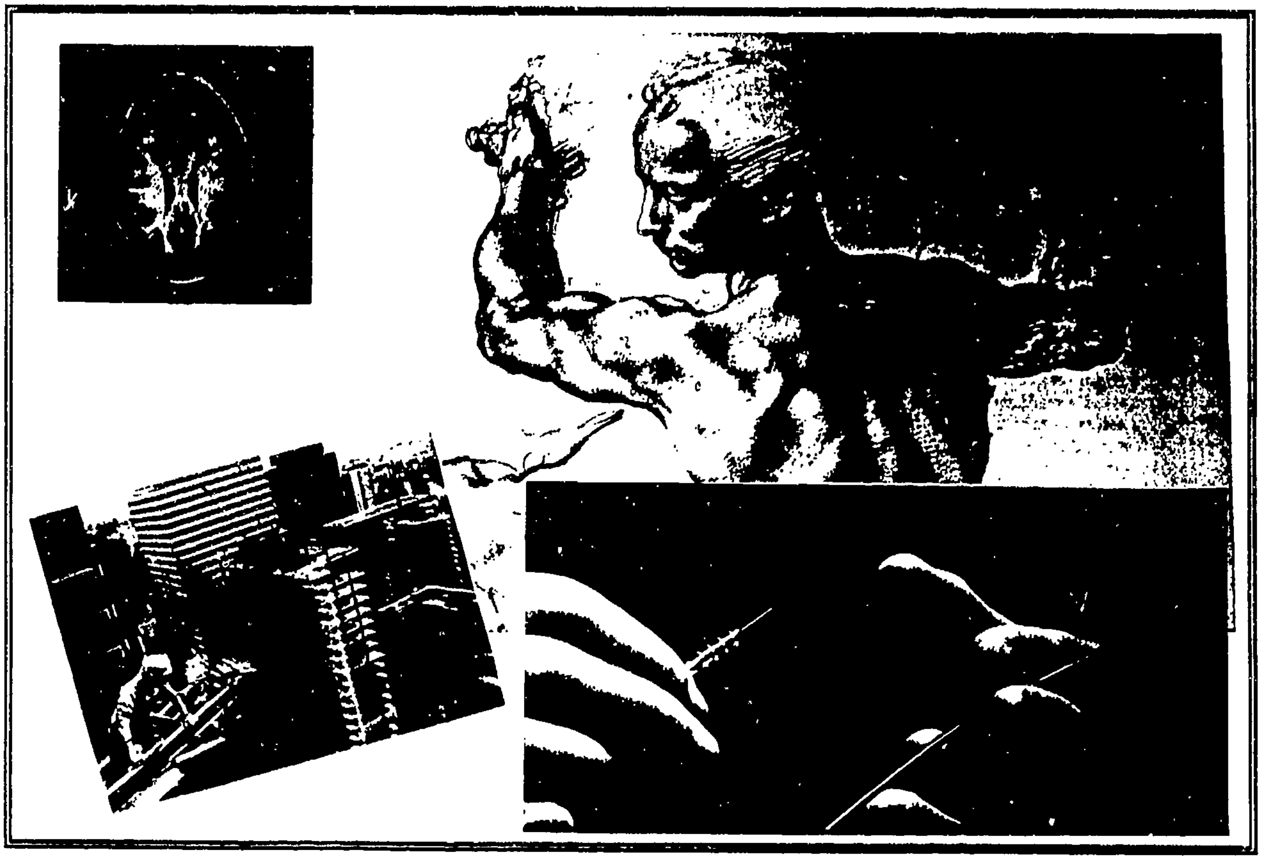

Figure 3. Opening illustration of anatomical drawing by Michelangelo, MIR of human brain, surgeon's hands and construction worker in Unit 9 of 1989 edition (pp. 634 - 35).

The introduction underscores the importance of scientific applications, the integral relationship between science and technology:

> "I sing the body electric." Walt Whitman. The images . . . [of man and brain] represent two contrasting views of parts of the human body--one medieval and artistic, the other modern and technological. However, the highly developed brain shown in the magnetic resonance image is a uniquely human characteristic that underlies all human achievement, including both art and technology. In this unit you will learn many details about the structure and function of the human body. You will also develop a deeper appreciation for such distinctively human characteristics as upright posture, opposable thumbs, stereoscopic vision--and, of course, the human brain. In what ways are these characteristics important to the construction worker and surgeon shown?

First, are there any noticeable changes in how the 1989 human biology unit portrays women? From the perspective of gender, the unit on human biology is, in some ways, better than earlier editions. First, and most obviously, the word man is no longer used; the study of "The Biology of Man" has finally become "Human Biology." Second, women are seen performing a wider range of activities: they are shown as a jogger, a doctor working on in vitro fertilization, and an instructor of aerobics. Third, the text gives the egg--often considered to represent women--a more active role in fertilization. At one point, it describes how the sperm "penetrates the surface" of the egg; at a second, how "the egg membrane engulfs the head of a single sperm" (p. 739). Fourth, the pregnant mother has become a more integral part of fetal development. The text describes what women normally experience during pregnancy and provides examples of desirable health practices. As expected, however, women have yet to reach full equality with men. For example, in this unit, illustrations of men or of the male form outnumber those of women or the female form 3 to 1; discussions of famous male scientists outnumber those of famous women 9 to 0; and, in the end-of-unit section on careers related to science, a long list of promising professions is accompanied by a picture of a woman teaching aerobics. Is teaching physical education truly the closest a woman can come to a science-related career? Is that the best she can be?

Second, how does the 1989 edition define science? A careful reading of the human biology unit shows science to be a powerful way of knowing, a way that promises control over nature and attainment of the good life. In descriptions of scientists' accomplishments, science is presented as an effective tool to increase our store of knowledge, as in the cases of William Harvey and Lennart Nilsson, or to improve the quality of human life, as in the cases of Jonas Salk and Robert Koch. Features on biotechnology underscore the varied ways science-as-tied-to-technology enhances our lives: arthroscopic surgery saves athletes' precious careers; in vitro fertilization offers infertile couples the opportunity to bear children; and use of the double-blind experiment ensures the effectiveness of drugs placed on the open market. Critical thinking and extension questions also reinforce this tie between sc, ıce, technology and a better life: they ask students to research artificial hearts and valves, prescription drugs manufactured by drug companies, vaccines, treatment for allergies, treatment for infertility, anesthetics, dialysis machines, use of steroids to overcome illness, and use of methadone to treat heroin addiction.

Third, what is this text's message to students? The 1989 human biology unit attempts to convince students that science and technology are integral threads in the fabric of our society, that being a scientist is an important and interesting career. To do so, the unit focuses much of its attention on examples of scientific applications in medicine: arthroscopic surgery, artificial hearts, blood transfusions, prescription drugs, magnetic resonance imaging, computer tomography scanning, in vitro fertilization, and ultrasound. It uses high-tech illustrations--often in color, often high-resolution photographs of the microscopic--to showcase complex scientific information. It also describes a variety scientific careers: surgeon, medical and biological photographer, research scientist, physician, chemist, member of the Food and Drug Administration and dietician.

Interestingly, the 1989 edition does not appear concerned with facilitating students' use of science in their everyday lives. There are few attempts to make the language of science more understandable to students. In contrast to 1956, there are few metaphors, few references to common misconceptions and few attempts to illustrate the connections between science and students' experiences. Moreover, there is no concerted attempt to encourage students to use science outside the classroom. True, a plethora of information is given about health-related issues: AIDS, cholesterol, alcohol and recreational drugs, smoking and fad diets. And, as mentioned above, students are often given topics related to health and medicine to research in the extension section of each chapter. Unfortunately, students are neither told how to use this information in their own lives nor specifically encouraged to do so.

Is the 1989 version of human biology gendered? In language and illustrations, the text has made some effort to eliminate gender bias. As explained above, the word man is no longer used, great pains are taken to avoid the pronoun he, and photographs of two women doctors are included. Indeed, one could argue that the text attempts to address a non-gendered reader: it rarely uses gendered pronouns, and frequently pictures scientists with cap and mask to obscure their sex. However, in terms of content, the text has much room for improvement. First, the text does not treat men and women equally: there are more pictures of men than of women; more of men scientists than of women scientists. Second, it fails to explain the virtual absence of women from the history of science. Why are the works of nine male scientists discussed in the human biology unit while no women scientists are even mentioned? Did women contribute nothing to the study of human biology? What barriers prevented many women from entering scientific careers in the past? What barriers remain today? Third, the text focuses, for the most part, on the benefits of science to society. It does not explore misuses and abuses of science--misuses and abuses that more often harmed women than men. Why have women been systematically excluded from most studies of human physiology? How has gender bias--differential access to the tools and power of science--influenced the aims and products of science, who benefited, and who was ignored? Would a science conducted largely by women study different things, use different methods and produce different findings? Ironically, the text plants the seed for this very kind of analysis. Twice, it mentions the harm caused to developing fetuses when pregnant women took what was thought to be a safe tranquilizer called thalidomide. Unfortunately, it fails to use these opportunities to explore the intersection of science, gender and power. In sum, the gender bias present in the 1989 edition can be understood as more pernicious than in past editions: on the one hand, it has eliminated those features that are most obviously androcentric; on the other, it continues to deny that a problem between women and science exists.

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The 1989 edition's emphasis on the utility of science, on science's ties to medicine and technology has its roots in the second wave of science education reform begun in the early 1980s. This time, the science educators and business community initiated the movement. Science educators claimed that the science reform efforts of the 1960s had effected little change, that American students were falling further and further behind the students of other nations in mathematics and science, and that the economic future of America rested on producing more scientifically literate citizens. Mary Budd Rowe (December 1991, personal communication), a participant in the formulation of national education policy, suggests science educators pushed for reform in an attempt to get more government dollars for science education. The fact that federal funding of science education hit its all time low shortly before 1983, she claims, is no accident. The business community also helped to instigate science reform: it complained loudly about the schools, about a workforce with poor job skills and about economic competition. Together, the science educators and business community convinced the federal government that science education was the key to winning America's new war, an economic war against Japanese and European competitors. In 1983 alone, the government produced several reports bemoaning the state of science education. *A Nation at Risk* (1983) was the first to broadcast this new agenda:

> Our Nation is at risk. Our once unchallenged preeminence in commerce, industry, science and technological innovation is being overtaken by competitors throughout the world . . . If an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war. As it stands, we have allowed this to happen to ourselves. We have even squandered the gains in student achievement made in the wake of the Sputnik challenge . . . History is not kind to idlers. The time is long past when America's destiny was assured simply by an abundance of natural resources and inexhaustible human enthusiasm, and by our relative isolation from the malignant problems of older civilizations. The world is indeed one global village. We live among determined, well-educated, and strongly motivated competitors. We compete with them for international standing and markets, not only with products but also with the ideas of our laboratories and neighborhood workshops. America's position in the world may once have been reasonably secure with only a few exceptionally well-trained men and women. It is no longer. (pp. 5 - 6)

It is important to note that the slogan of the new reform movement was "science for all students." This new slogan sprang from the realization that science education, as practiced since the 1960s, had reached only elite students, that women and minority men were becoming an increasingly significant proportion of the workforce, and that America's continued economic competitiveness rested on its ability to produce superior scientific and technological products. Indeed, as early as 1978, appeals for the education of all students in science could be heard. However, it remains unclear to what extent these initial calls for science for all students produced the tools needed for real, systemic change; to what extent they address more than superficial barriers to the participation of women and minority men in science; to what extent they were motivated by more than economic imperatives.

Other factors influenced the 1989 edition of *Modern Biology's* as well. First, the publishers contributed to the massive and chaotic collection of information present in the text. During the 1970s and 1980s, publishing grew into a big business dominated by a dozen large companies each trying to capture the textbook market. Moreover, large numbers of people became involved in the production of each text. A textbook was no longer written; it was developed. And, as with any consumer product, publishers attempted to satisfy as many customers with as few textbooks as possible (Bennetta, 1986). Second, the biological sciences contributed to the increased size and fragmentation of the text; it too grew larger, more fragmented and more specialized. Third, the civil rights and women's movements of the 1960s also affected change. *Modern Biology* first included a picture of a black student in 1969; it first eliminated the use of the word man to mean human in 1977.

### What About Today?

Are we closer to equalizing the achievement and participation of men and women in science today? Today, efforts to implement reform in science education--to refine those ideas first proposed in the early 1980s--continue. Two national projects--Project 2061 by the American Association for the Advancement of Science, and Scope, Sequence and Coordination by the National Science Teachers' Association--are spearheading this effort. Both attempt to address the needs of women and minorities; both attempt to make science meaningful for all students. Project 2061 thinks the best way to achieve this objective is through depth in content, practical applications and hands-on instruction. It also advocates the teaching of science by themes, the incorporation of the history of science, and the integration of science with technology and mathematics (American Association for the Advancement of Science [AAAS], 1989). Scope, Sequence and Coordination agrees that depth, applications and student-centered learning are important. However, it includes recommendations for the elimination of tracking, the institution of six years of science, and the integration of physics, chemistry, biology and earth/space science with computers and technology at each grade level (NSTA, 1990).

Obviously, recommendations such as the elimination of structural barriers to the participation of marginalized groups in science--barriers like tracking, science course offerings and science course requirements--will help more women and minority men learn about science. However, it is less clear that proposed changes in course content and methods of instruction will help make science more understandable to all students. Will the teaching of science by themes or the integration of natural sciences with technology make science more interesting to women? Will hands-on activities alone offer students from marginalized groups greater access to scientific information? Would efforts be better spent explaining science within the larger societal context, examining science across cultures, and exploring how science can both help and oppress different groups of people?

In step with these national reform movements are efforts to improve the quality of science textbooks. As one of twenty-two states to conduct state-wide review and adoption of educational materials, California is a leader in this effort. The California *Science Framework* (1990) makes twelve recommendations to textbook publishers in the areas of content, presentation and pedagogy. Several of these criteria are directed at narrowing the gap between women and minority groups, and mainstream science education. These recommendations include: (1) explanations should embroider the accumulation of knowledge with a detailed description of how it is we come to know these facts and why this information is important; (2) language must be made accessible to students; (3) science should not be represented as an enterprise operating in isolation from society, technology and other fields of knowledge; and (4) instructional materials must recognize diversity and reflect strategies that have shown to be successful in meeting the needs of all students.

These recommendations in California's *Science Framework* more closely reflect recommendations by feminist critics on how to generate a gender-free science. It seems that, in order for women to truly feel welcomed in science, science education needs to include the work of a larger number of women scientists, scientists such as Barbara McClintock, Rosalind Franklin and Adrienne Zihlmann. It needs to explain why science has been and remains largely the domain of white men; to explore science within its larger historical, social, cultural and economic context; to examine examples of how science has excluded certain groups from practice, how it has oppressed some groups to benefit others, and how it reflects and helps shape the larger political economy. Most importantly, the language, instructional methods and content used to teach science need to allow for and celebrate differences among students.

## Conclusion

Before closing, three points must be emphasized. First, the pace and degree of change in *Modern Biology* varies from topic to topic, item to item. In examining only three texts spaced almost 40 years apart, it is easy to think that all change is quantum, that new trends emerged full blown. In truth, some of the changes mentioned were gradual; some, quantum; and many, incomplete. Second, the organization, form and content of a biology text is influenced by a large number of forces: authors, science educators, the nature of science, politics and society. The links I made between changes in *Modern Biology* and its larger context vary in terms of strength and validity. Moreover, many other connections, some undoubtedly important, have been missed. Third, the usefulness of this analysis rests on the assumption that textbooks have some influence over what science teachers teach and how students learn. If this assumption is not valid, an explanation of how textbooks shape science education is of little worth.

Despite its flaws and inaccuracies, the preceding discussion demonstrates how gender can be used as a starting point for a critical examination of science instruction. More importantly, it shows that science education must go beyond the elimination of obvious gender bias, must devise new strategies for reaching marginalized groups like women if it ever hopes to create a science education for all students. As Carolyn Carter (1990) explains:

> It is critical to remember that most individuals in our society are alienated from science as a way of knowing. The statistics and cries of crisis which inform the public view of science education reinforce what science teachers already know, that few students are developing a knowledge of science which they can own. Rarely do our students develop from science courses a knowledge which they can actually use as [a] conceptual lens for viewing the world. Instead they learn that science is something not of their world. Perhaps by examining the "woman problem" . . . we may develop a more powerful framework for thinking about science instruction for everyone. (p. 131)

Let us hope that both boys and girls find science equally interesting and meaningful in the near future.

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