Revisualizing the Menstrual Cycle: 
Incorporating Social Factors and Contexts into 
Biological Education

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“Models are abstractions. They are like the anthropologist’s ideal types, which do not exist in nature. They are attempts at representation, inventions used to sort and categorize a multitude of observations and the supposed connections among them.”

Introduction:

The menstrual cycle is visualized and interpreted in a multitude of representations. Static diagrams, videos, models, and textual descriptions are all common ways through which we learn and internalize this information. But how do those depictions shape how we think of menstruation? What information do they provide? Biological cycles are presented in upper-level education as “objective” processes, denying historical, social, and cultural contributions to these biological processes. Through the example of the menstrual cycle, I will argue that there needs to be a paradigm shift from presenting "objective" biological processes to incorporating social contexts and factors into science educational models.

Background:

When I entered Brown University in 2007 I planned on studying biology to prepare for a career in medicine. What I loved most about biology was its objectivity. I thought that it was a black and white science, an area in which there were clear causal relationships. If X then Y. If a person drinks cholera-contaminated water, he/she contracts cholera. If a person share needles with an HIV-infected person, she/he contract HIV. Beyond those “truths” I was disinterested.

In my second year of college, I snuck my way into the senior seminar, AIDS in International Perspective, taught by Professor Patricia Symonds. This class explored HIV/AIDS in the context of medical anthropology, drawing heavily Paul Farmer’s notion of structural

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violence. This class opened many doors to my future education. In many ways, focusing on the HIV/AIDS epidemic as caused by a lentivirus that decreases CD4 count and results in AIDS is incomplete. AIDS does not kill millions of people every year because of the sheer strength of HIV. Transmittance of HIV involves more than merely the structure of the virus. As Farmer describes, systems of structural violence perpetuate socio-economic situations in which HIV can replicate and spread more rapidly. Some theorists have attempted to attribute HIV’s imbalanced global presence to genetic differences between peoples of different geographical, ethnic or racial difference. These claims work both to obscure and justify global hegemonic relationships.

Following AIDS in International Perspective, it was hard to return to my previous curricular path of “objective” science classes. I no longer understood how it was possible to look at biology without taking into consideration the very societal factors that were the foundation of what we considered to be “objective truths.” Topics such as Emerging Microbial Diseases and Genetics were taught as if diseases were unrelated to their social contexts. Yet it is particular social formations that shape the possibilities for microbes to replicate and be transmitted from organism to organism, or for genes to become inherited and expressed. For example, how can we understand cholera without acknowledging that the disease is manifest and spread to different extents depending on social factors, like water sources, water quality, or population density?

Cholera is a bacterial infection caused by Vibrio Cholerae. The majority of cholera cases are found in developing countries as a result of contaminated water supplies. Developed countries rarely see cases of cholera because of the advanced public sanitation available to the population. Access to clean water, technology to decontaminate water sources, and health care are all privileges that should be human rights but are enjoyed by only a small percentage of the global population.

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population. Cholera cannot be fully understood without the consideration of these social conditions of its manifestation.

In many ways I felt that my science education suffered by failing to recognize the contributing factors to scientific knowledge development. In my junior year I chose to change concentration paths and take classes in Science and Society to better understand why and how we understand science as we do today. Now I was seeking to “de-objectify” science, a major contrast from my original academic plan entering Brown. I was highly influenced by work from Donna Haraway. Haraway sought to “reveal the limits and impossibility of (science’s) ‘objectivity’.”\(^3\) Put more simply, science comes closer to objectivity the more we acknowledge its partiality and positionality in our teaching and educational models. In the example of the menstrual cycle, “situated knowledges” would mean acknowledging that biological understanding of menstruation developed within a historical period where women were being actively discouraged to leave household “duties” for work or education. A major justification for this discouragement was the “inherent” weakness and inability of menstruating women. The theory of “situated knowledge” is especially useful in discussions of gendered science. I will discuss Haraway’s theories in more depth later in this thesis to explore how we understand and view reproductive processes.

With my coursework in Science and Society, I became increasingly interested in how science is presented in upper-level education. I became a teaching assistant for Biology 0200: Foundation of Living Systems, hoping to understand more about the educational process from the perspective of an educator. Throughout the semester, I learned two major lessons from speaking and teaching students in laboratory sections. The first lesson was how providing

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animated depictions of otherwise statically presented concepts facilitated the students’ understanding of the material. Many of the biological cycles taught in Biology 0200, especially oxidative phosphorylation, the electron transport chain and photosynthesis can be difficult for introductory students to conceptualize with the traditional visualizations seen in textbooks. (See Appendix A for Figures 1-3)

Mid-semester I conducted a survey with fifteen students to determine the efficacy of the available protein-synthesis animations. (See Appendix D for survey and results) I presented students with textbook diagrams of protein synthesis and subsequently presented them with a protein synthesis animation from BioFlix. The animation begins with a female student eating a doughnut. It continues by following the sugar into her bloodstream, it then presents the cellular synthesis of insulin. All fifteen students reported that the animation was extremely effective in promoting a greater understanding of the material. Many students reported that the animation helped with their visualization of which organelles participated in each step, whereas textbook depictions such as those in Figure 4 failed to provide sufficient visual context. One student reported that the animation was effective because it presented the audience with a subject (the student eating the doughnut) within which a biological process was occurring, helping to contextualize the material. This contextualization helped the student relate these processes to human subjects, enabling him to not only view the steps in protein synthesis, but also to internalize that the production of insulin occurs within cells, within animals, in response to the presence of glucose. In the example of the menstrual cycle, common visualizations lack representations of subjects within which the cycle is occurring.

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5 Appendix D Survey Results and comments
The second lesson I learned was how students rarely considered the development of the material that they were memorizing. Despite having experienced this myself, I had not considered how ubiquitous this inconsideration was within my peers. An integral part of the Foundational Biology curriculum is in the molecular and mechanic structure of DNA, specifically the sugar-phosphate backbone and the double-stranded, helical structure assumed by DNA strands. Professor Kenneth Miller assigns *The Double Helix* by James Watson to complement lectures on DNA structures. *The Double Helix* is an autobiographical account of the discovery of the DNA structure by James Watson and Francis Crick. The book provides evidence of the controversial sexist hierarchy in the scientific world. Watson describes how he and Crick took a DNA X-ray diffraction from Rosalind Franklin, a female X-ray crystallographer who was primarily acknowledged in the book – not for the brilliance in her X-ray crystallography that directly led to the discovery of DNA’s helical structure – but, rather, for her lack of femininity. Watson and Crick used Franklin’s work without her permission to further personal research, an abuse of intellectual property that was unfortunately not an uncommon experience for women working in science in the mid-20th century.

The unanimous reaction of students to this book was shock that “objective” science was subject to sexism, classism, and egotism. Students had never considered that something so fundamental in biology, both educationally and personally, such as the structure of DNA, could be entrenched in social relationships. It is not uncommon for students to believe that the science education they receive is devoid of social influence. Discussing social construction of molecular mechanisms in an upper-level organic chemistry class would be a rare occurrence. I am not

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8 Article P. Miller gave
arguing that contemporary science education is wrong, but rather, incomplete. By excluding historical background and social movements that contributed to the development of our understanding of biology, educators are presenting incomplete images of the sciences. Science education has become so fixated on propagating objectivity that we’ve forgotten that biological processes occur within human bodies, and that humans are necessarily social subjects.

The examples of HIV/AIDS, Cholera, Protein Synthesis animation, and the origins of the helical structure of DNA are comparable because each example is commonly represented incompletely. There is an opportunity to incorporate interdisciplinary knowledge, such as history, anthropology, and sociology, in science education. This inclusion could do two things; facilitate a relationship between disciplines and instill in students a more complex, complete, understanding of biological processes.

With this thesis I hope to explore the presentation of biological cycles and how our educational model is ineffective in both presenting the biological processes and presenting a comprehensive picture of how social and biological factors are inseparable. I am going to explore this idea through the lens of the menstrual cycle – how it is variously experienced as a bodily phenomenon, perceived as a social sign of instability and irrationality, and how its current representations in science texts reflect, but do not acknowledge, its historical development.

**Historical and Contemporary Depictions of the Menstrual Cycle**

The menstrual cycle is heavily associated with nervous system pathologies such as depression, emotional instability, and irrationality. One current example of this is the recent popularity of smart phone applications designed for women to chart their menstrual cycles.
Period trackers elicit a number of questions. The first question is the validity of the “28-day cycle,” a common cycle length seen in visual representations of the menstrual cycle. Does the “average” woman experience 28-day cycles? Do women menstruate for the same length of time, in the same intervals, each month? One study (Chiazze et al., 1986) of over 30,000 cycles found the average cycle length was 29.1 days, with a standard deviation of 7.5 days and a prediction interval of 15-45 days. The study included that a “slightly irregular menstrual cycle” constituted an 8-20 day variability. Additionally, this study found that variability fluctuated with age, with highest variability in groups of women under 25 years of age and between 40-49 years of age.11 Period tracking applications are no longer marketed solely towards women. Applications marketed towards men are a new addition to the movement in period charting. One application, Code Red, was designed so that,

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10 Ibid.
"Men no longer need to fear the wrath of menstrual madness. MEDL mobile is pleased—and very relieved—to introduce Code Red: a simple but powerful menstrual calendar for men to keep track of—and survive—their girlfriend’s/fiancé’s/wife’s monthly cycle."

-MEDL Mobile Application Description

Images of this application demonize women and attempt to predict the mood of the woman subject from a standardized model of ovulation and menstruation that are not, in fact, so standard.

What do these depictions suggest about how we understand and publicize the menstrual cycle? Phrases such as, "time to prepare for storm ahead," "hyperemotional," "Compliment her outfit...Love is in the details," "fear the wrath of menstrual madness" all present negative associations with the menstrual cycle. These warnings present women as emotionally unstable, as unable to control behavior/emotions, and as irrational, delicate beings.

Associations between nervous systems and menstrual fluctuations have historical precedents. In late 19th century America menstruation was used as an argument against women

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13 Ibid.
14 Ibid.
joining the workforce. The nineteenth century shift towards the inclusion of women in the public work sector coincided with a heightened interest in understanding the biology of the menstrual cycle. Not unlike theories of humeral balance prevalent in the 18th and 17th centuries, medical practice in the late 19th century was guided by a theory of bodily energy. This theory stated that each body had a set amount of energy that was consumed by whichever physiological processes were most used. Opponents of the inclusion of women in the workforce used biological differences in women as evidence for their exclusion. Many exploited the menstrual cycle to support theories of gendered mental and physical differences. Advocates for the theory of bodily energy argued that women could not be educated or included in the workforce because both reproductive and neural activities would compete for energy, resulting in either a deficiency in mental or reproductive capacity. Edward Clarke, a member of the Massachusetts Medical Society and leading proponent of this idea, wrote *Sex in Education*, a book addressing biological inhibitions for females in education.

Her way of work was sustained and continuous, and out of harmony with the rhythmical periodicity of the female organization. The stream of vital and constructive force evolved within her was turned steadily to the brain, and away from the ovaries and their accessories. The result of this sort of education was, that these last-mentioned organs, deprived of sufficient opportunity and nutriment, first began to perform their functions with pain, a warning of error that was unheeded; then, to cease to grow; next, to set up once a month a grumbling torture that made life miserable; and, lastly, the brain and the whole nervous system, disturbed, in obedience to the law, that, if one member suffers, all the members suffer, became neuralgic and hysterical.

Associations between menstruation and inherent weakness in women may have originated in workforce debates but worked as a foundation for the development of generalized connotations between the menstrual cycle and female inability.

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17 Ibid. p 48
18 Ibid. p 56
Following the American Civil War, a number of job opportunities in the industrial workforce became available to women. Poor working environments, little pay and long hours lead to occupational hazards for both men and women. Although occupational health was a relatively new field, a number of articles were published in the late 19th century discussing the implications of having women work in stressful and unsanitary environments. Many of these articles argued that women were inherently weaker than men and could not work under the same conditions.\(^{20}\) Despite having the pretense of examining the occupational hazards of the industrial workforce, the majority of these publications focused on gendered differences, such as menstruation-induced weakness, to discuss women in the workforce, rather than the hot, unsanitary, and toxic environments within which women worked;\(^ {21}\) menstruation was used to obfuscate poor working conditions. One such author was Dr. Azel Ames, a Special Commissioner of Investigation to the Massachusetts Bureau of Labor Statistics. Although Ames noted the dismal working conditions in 19th century workspaces, his examination focused heavily on “innate” inabilities of women.\(^ {22}\)

By the late 19th century, the rate at which women were leaving home and attending college or joining the workforce began to disrupt the traditional hierarchical society enjoyed by white men.\(^ {23}\) As a consequence of this shift, age at marriage increased and rate of reproduction decreased. “As educational and professional opportunities expanded in the late nineteenth century, these women found more to life than marriage and motherhood, and they restricted procreation accordingly.”(Kline, p 12) Ideas that working affected and was affected by the menstrual cycle were derived from fears of an abandonment by women of their reproductive

\(^{21}\) Ibid, p 41.
“duties” to society.  

Women were valued as “makers of men.” Educated, working, white women threatened this role. While understanding of the menstrual cycle was still relatively undeveloped, theories that women’s inclusion in the workforce could biologically, if not mentally, impede reproduction elicited strong negative responses. “If, however, the working-girl is destroyed by her labors, the commonwealth loses both herself as a present integer in the maintenance of society, and her creative possibilities and powers for the future of the race.”

Many saw reproduction as a duty towards society. Some white women who chose not to have children were accused of being “race criminals.”

The development of the early 20th century eugenics movement reflected preexisting race relations in the United States. Insecurity in white male identity paralleled an increase in corporate capitalism. Self-employment decreased from 67 to 37 percent, creating an economic depression and a fear of the “authority loss” of white, middle-class men.

“While the white middle class appeared to be fading away, the strength and numbers not only of African Americans but also of the working class and immigrants seemed to increase…Also threatening the authority of white middle-class manhood in the late nineteenth century was the ‘woman question.’ Turn-of-the-century social observers frequently commented on two new class-based figures in American culture: the ‘woman adrift’ and the ‘new woman.’ Both figures called into question the sanctity of nineteenth-century gender roles and signaled the end of the Victorian era.”

Changes in the traditional white male hierarchical American society fueled the eugenics movement and emphasized responsibility in promoting racial superiority. “This millennial vision of progress, coupled with the desire to regulate fertility and stem the tide of ‘race suicide,’ exemplifies the new social concerns of the Progressive era.”

25 Ibid. p 20
26 Ibid. p 10
27 Ibid. p 12
While debates over the inclusion of women in the workforce morphed and developed at the turn of the century, negative associations with the menstrual cycle remained in public consciousness. An article written by W.P. Graves in the 1913 edition of The New England Journal of Medicine discussed the “relationship between the female genital organs and the nervous system.” Late 19th century opinions of menstruation-induced weakness and emotionality were clearly highlighted throughout the text.

“On the psychic and nervous side of perfectly healthy women the menstrual curve is still more plainly demonstrated. There is at that time a greater sensitiveness and impressionability. The individual is far more irritable and subject to the outbursts of ill-temper and to unreasonable caprices. There is markedly less self-control and an invariable tendency to depression.”

At the turn of the 20th century research on the menstrual cycle and its affects on women in everyday life increased. This article is a good example of common attitudes towards menstruation. The article sites research showing that a disproportional amount of women with “criminal or suicidal tendencies” were menstruating during “that time.” Additionally, Graves discusses the “influence of menstruation on pathological mental and nervous conditions.” “The nervous disturbance may be expressed only by severe periodic headaches. Hysteria, hysteroepilepsy, epilepsy, erotomania, dipsomania, kleptomania, and melancholia frequently appear chiefly or solely at the menstrual period.” By associating the menstruation with this list of conditions the author is presenting women as inherently unstable. Publications such as Clarke’s *Sex in Education* and Grave’s article in NEJM argue that the “facts” of biology cause social difference in gender roles; however, I’d like to argue the opposite – that social views of

29 Ibid. p 558.
32 Ibid. 559
gender roles have produced these negative interpretations/representations of biology. I do not wish to debate the role menstruation plays in eliciting neurological responses. Instead, I’d like to argue that the negative menstruation-nervous system relationship propagated by academics in the early 20th century was influenced by existing gender role tensions and developed contemporary perceptions of menstruation.

Our understanding of the menstrual cycle developed within a 19th century dialogue of gender delineation. Although this dialogue may not have affected the physical processes of menstruation, it continues to affect how the public perceives and treats menstruating women, therefore disregard this historical context would be to disregard an integral part of a comprehensive understanding of the menstrual cycle.

**How Do We Visualize the Menstrual Cycle?**

The majority of menstrual cycle visualizations fall into two categories. These categories are linear representations and circular representations (See Figure 4 and 5 in Appendix A). Linear diagrams depict hormonal changes that fluctuate throughout the menstrual cycle while circular diagrams depict calendar representations. Linear diagrams are found most commonly in biology textbooks while circular diagrams are more likely to be found in informational pamphlets and websites. 33

**Linear Representations**

Linear representations of the menstrual cycle illustrate hormonal fluctuations that occur throughout the represented 28-day cycle.

Most models begin with the shedding of the uterine lining and unfertilized ovum. This phase is known as the follicular phase, characterized by a spike in follicle stimulating hormone (FSH). During the first week of menstruation, follicles, hollow shells containing cells and an immature ovum, begin to grow. The growing follicles secrete estrogen hormones into the blood. After the first seven days of growth, each follicle begins to degenerate except for one. The remaining follicle provides nutrients for the ovum contained within. Around day twelve, the follicle secretes a large amount of estrogen. The estrogen travels through the bloodstream to the hypothalamus, and triggers the release of Luteinizing Hormone (LH). One-two days following the secretion of LH, the growing follicle releases the ovum in a process known as ovulation. The follicle from which the ovum was released will form a corpus luteum, releasing large levels of progesterone into the blood and causing the uterus to prepare for the possible fertilization of the released ovum. If the ovum is not fertilized following ovulation, the corpus luteum will be shed.

34 Appendix B, Figure 4.
with the uterine lining during menstruation.\textsuperscript{35} If the ovum is fertilized, the implanted blastocyst develops three layers, the ectoderm, mesoderm, and endoderm, and gastrulation ensues.\textsuperscript{36}

Linear diagrams are commonly used in textbook and educational depictions. They are not used in lay-literature, as understanding behind hormonal fluctuations is uncommon in non-scientific communities.

\textit{Circular Representations}

Circular representations of the menstrual cycle are models that depict the calendar format of the “average” 28-day menstruation cycle.

The calendar model is typically characterized by averaged day-estimates of menstrual cycle phases. For example, Figure 5 depicts five phases. Days 1-7 are menstruation, days 8-11 the uterine lining thickens in preparation for pregnancy, between days 11-18 (around day 14) ovulation occurs, days 18-25 the corpus luteum fades away if there is no fertilization, and days


\textsuperscript{36} Ibid.

\textsuperscript{37} Appendix B, Figure 5
26-28 the uterine lining detaches and menstruation begins. Calendar representations are used most commonly in health care offices and on informational websites to give a basic understanding of “normal” patterns of menstruation. Circular representations can be used to give a sense of fertility but health care providers warn against using this chart as a birth control method as every woman’s menstrual cycle is different. While linear representations are seen in textbooks and upper-level courses on reproduction, circular representations are more commonly seen in middle and high school sexual education courses, courses designed to be accessible to a variety of educational backgrounds.

Circular representations encourage charting of one’s menstrual cycle and the comparison to a reported average. In many cases, young women are encouraged to use these representations to understand the relative normalcy of their menstrual cycles. Circular representations have also been used to predict times at which fertility is highest. Pamphlets with calendar models of menstrual cycles are commonly disseminated through sexual education classes and health services.

Linear and Circular representations of the menstrual cycle are the most widely distributed visualizations. One question I want to explore with this thesis is whether either of these models adequately captures the complexities of the bio-social phenomenon of menstruation. Both visualizations are used in educational models yet neither incorporates historical contributions, social factors, or human subjects/experience. In the mid-20th century, science education was accused of failing to incorporate experiential science into public school curricula.

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Where do we see these visualizations? Attitude towards sex education

Outside of upper-level courses in reproduction, menstrual cycles are discussed primarily in sexual education in pre-pubescent and adolescents. Subject matter in sexual education in U.S. public schools has varied widely within the past four decades. In the latter half of the 20th century, with the rise in sexually transmitted diseases and unwanted pregnancies, public schools began implementing sexual education classes for ages 10-15 years. By 1975, 55% of large school districts had some sort of sexual education.40 Advocates for public sexual education debated design and purpose of these courses. The debate was centered on two viewpoints, the first being that sexual education should teach the biology behind menstruation, puberty, and reproduction, the other being that the experience of sexuality should be the focal point.

In 1987 the American School Health Association differentiated between sexual education and sexual information, “Sex education is to be distinguished from sex information and can best be described as character education…and attitude development and guidance related to associations between the sexes.”41 This differentiation was used by advocates on both sides to defend which course of sexual education was most important to prepare children to enter puberty. Proponents of anatomy and physiology based sexual education believed that teaching children about contraception and sexuality would encourage adolescents to become sexually active. One study suggested that teaching sexual information rather than sexuality education would be more detrimental than beneficial to students because it would dehumanize sex. “Teaching anatomy and physiology is imparting the mere plumbing of sexuality and may even be dehumanizing. Understanding sexuality requires values clarification or something akin to it- a confrontation with diversity in which participants choose from among alternatives and cherish,

publicly affirm, and act on their choices.” 42 By stripping sexual education of sexuality and experience, advocates for physiology based sexual education threatened the personal development seen in more personalized models of sexual health courses. 43

By 2002, 75% of U.S. public schools had some form of sexual education. 44 Programs varied widely due to both the lack of a centralized system for sex education and the lack of a clear paradigm for effective sexual education curriculum. Sexual health is designed and implemented at state-levels, and in some cases states allow school districts to format individual curricula. Two models for sexual education are taught in the United States, abstinence only programs and abstinence plus programs. 45 One study found that the most common material seen in U.S. sexual education courses is consequences of teen pregnancy, puberty, HIV, STIs and abstinence. 46 In a study conducted in 2007, 43% of teachers felt pressured to teach material they felt wasn’t as relevant as other subjects not as commonly taught such as sexual abuse, sexual orientation, abortion, birth control, and condom use for STD prevention. 47

In the past forty years, sexual education has shifted from programs focused on contraception and responsibility to abstinence and reproductive facts. Between 1988 and 1999, abstinence education doubled from 24% to 48%, where as contraception education was quartered from 4.8% to 1.5%, both cases representing significant changes with p < .01. (see Appendix C, Table 1) The debate over the efficacy of abstinence-only programs on decreased teenage pregnancy and sexual activity remains a matter of nationwide controversy. Many argue that it is

44 Ibid. p 690
hypocritical to promote abstinence at younger ages only to then provide a more comprehensive sexual education at older ages.

Science Education Past, Present, and Future

“One cannot ‘be’ either a cell or molecule-or a woman, colonized person, laborer, and so on – if one intends to see and see from these positions critically”

Science Education – roots and revolutions in 20th century America

Science education, while still contemporarily criticized, has been greatly debated in 20th century America. Driving global competitions have heavily influenced science education. Nowhere is this more apparent than in the case of Congress’ response to the Soviet Union’s launching of Sputnik in 1957. Due to the publicity garnered by Sputnik, the U.S. congress passed the National Defense Education Act, issuing $887 million towards science education, a large percentage of which went towards the National Science Foundation. In the mid-20th century, students were educated to progress science rather than to achieve any understanding of their development through the material. The investment in science education was considered an investment in the next generation of scientists. Lessons were static and reflected a set paradigm, and courses relied heavily on textbooks as the authority on science curriculum. The congress had spent nearly $900 million dollars on educational development to encourage students to study sciences and consequently join those professions. Curricula focused heavily on the saturation of facts and failed to offer an understanding of how science could be contextualized in everyday life. One can see reflections of this policy ineffectivity in the example of menstrual cycle

visualizations. Upper-level courses on the menstrual cycle focus on the memorization of facts rather than an understanding of the material as it pertains to the individual.

In 1969, the National Assessment of Educational Progress was created to test the knowledge of science held by American students. The heavy focus on fact-collection and global progress proved to be an ineffective strategy. By 1978, the enthusiasm driving science education reform had diminished. Congress withdrew financial support from science programs in primary and secondary schools. The National Science Foundation funded the University of Colorado to conduct Project Synthesis, a study on the level/depth of contemporary science education curricula. Project Synthesis determined that science education was ineffective both in the motives of educating children in the sciences and the manner in which they were taught. Additionally, case studies estimated that “90-95% of the 12,000 teachers surveyed used textbooks 90% of the time as the major curriculum material.” The project concluded by issuing four goals for science education in addition to goals for primary and secondary school curricula. Below is a table with the recommendations issued by Project Synthesis. Emphasis has been added.

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<thead>
<tr>
<th>Elementary Science Recommendations</th>
<th>Middle School Science Recommendations</th>
<th>High School Science Recommendations</th>
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<tbody>
<tr>
<td>Elementary personnel and parents must realize that science is basic</td>
<td>Primary goal at this level should be general educational programs, not academic preparation.</td>
<td><strong>Biological concepts should be presented in a personal and societal context.</strong></td>
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<tr>
<td>Elementary school science should</td>
<td>MS Science should address issues &amp;topics relating to individual, societal &amp; career awareness.</td>
<td>Emphases should be placed on the results on the human endeavor on the world, human dependence on the environment and the responsibility for preserving the world.</td>
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<td>o Excite children’s natural curiosity</td>
<td>Increased emphasis on problem-solving &amp; decision-making skills</td>
<td>Advanced (college prep) science courses would still be offered in high school, but</td>
</tr>
<tr>
<td>o Foster an interest in the student’s world &amp; in themselves</td>
<td>Lab emphasis should change</td>
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<td>o Provide opportunities to engage in scientific methodology</td>
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<td>Content knowledge should broadly</td>
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53 Ibid. p 53
Elementary science should develop the processes of science from rediscovering concepts & principle to investigating implications of scientific knowledge & technological development on problems faced by individuals and society. Science concepts would be selected in relation to all 4 goals, not because of their prerequisites for high school science knowledge.

New courses would be developed for applications of physical & earth science to attract all students. These courses would be science/technology courses emphasizing personal, societal and academic goals.

The project stated that there needed to be an incorporation of both personal and societal awareness for each level of education. The four tenets on which Project Synthesis formed its report were:

- **Goal 1: Personal Needs.** Science education should prepare individuals to utilize science for improving their own lives and for coping with an increasingly technological world.
- **Goal 2: Societal Issues.** Science education should produce informed citizens prepared to deal responsibly with science-related societal issues.
- **Goal 3: Career Awareness.** Science education should give all students an awareness of the nature and scope of a wide variety of science and technology-related careers open to students of varying aptitudes and interests.
- **Goal 4: Academic Preparation.** Science education should allow students who are likely to pursue science academically as well as professionally to acquire the academic knowledge appropriate for their needs. 

Contemporary science education lacked an understanding of science past what a textbook could offer, despite the historical and social importance of the development of science. As Yager (2000) stated, “The question is: ‘Can we shift our goals, programs and practice from the current overwhelming emphasis on academic preparation for science careers for a few students to an emphasis on preparing all students to grapple successfully with science and technology in their own, everyday lives, as well as to participate knowledgeable in the important science-related decisions our country will have to make in the future?’”

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56 Ibid.
By 1983, the National Commission on Excellence in Education declared that the nation was “at risk” due to its poor performance in education, specifically in the sciences.\(^5\) In the 26 years since Sputnik had been launched, “average achievement of high school students on most standardized tests” had lowered. The proportion of students demonstrating “superior achievement” on the SATs had decreased while illiteracy in adolescents had increased dramatically.\(^6\) Ultimately, the political context within which science educational reform occurred mid-century developed an understanding of science that failed to incorporate any part of the human experience. Additionally, the dogmatic methods of science education prevented multiple generations of students from questioning the authority of “science” leading to an educational environment where students are not only disconnected to the material, but also unaware of the limits and the questionable validity of many of the science programs. Ultimately, science should be used to instill “skills which allow them to become active, responsible citizens by responding to issues which impact their lives,”\(^7\) rather than to promote a generation of scientists able to represent the United States in a global competition for progress.

Based off of data from the National Science Foundation and the United States Congress, the current science educational model needs to be modified. As stated before, it is not that I believe that the current paradigm for science education is incorrect, but rather, incomplete. As Project Synthesis reported, science curricula lack “personal and social context,” essentially distancing students from material- for example, biology, chemistry, and physics- that could be incorporated into everyday ideology.

Considering the historical development of science education is beneficial in a current examination of educational representations of the menstrual cycle. Specifically, the Project

\(^6\) Ibid.
Synthesis emphasis on developing a “personal and social context” of science material would be beneficial in the development of a more experiential-based learning of menstruation.

*How does biological language reflect social attitudes toward the menstrual cycle?*

In an era of postmodernism, it is easy to examine 19th century interpretations of the menstrual cycle and see the role that social expectations and beliefs played in the construction of biological understanding of the menstrual cycle. By the end of the 19th century, the menstrual cycle was considered pathological both in how it affected women and in the physiological process of menstruation. In *Women in the Body*, Emily Martin references Walter Heape, a 19th century reproductive biologist who wrote that in menstruation the epithelium was ripped away, “leaving behind a ragged wreck of tissue, torn glands, ruptured vessels, jagged edges of stroma, and masses of blood corpuscles, which it would seem hardly possible to heal satisfactorily without the aid of surgical treatment.” This language elicits violent, gory, images, ultimately acting to pathologize menstruation. Heape’s pathological imagery was common in biological texts at the turn of the 20th century, and it developed an understanding of menstruation as an unnatural consequence of failed fertilization, even though in her lifetime, a woman will menstruate many more times than conceive a child.

Late 19th century biologists argued that the biological value of a woman was her reproductive ability. A woman’s role in society was to produce offspring. Menstruation was a process that occurred when women failed to fulfill this responsibility. Biological texts

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presenting pathological descriptions of menstruation are not unique to the late 19th century (emphasis added): “The damaged tissue probably liberates an anticoagulant. The spiral arteries then dilate one at a time, and their necrotic walls rupture, producing hemorrhage, sloughing, and menstrual flow.” This passage is taken from A Review of Medical Physiology, 11th ed. Published in 1983. Language such as “damaged,” “necrotic,” “hemorrhage,” and “sloughing,” all elicit visualizations of death and violence, presenting a “pathological” menstruation, similar to the late 19th century description of Heape.

Biology textbooks that use language such as A Review of Medical Physiology represent menstruation in opposition to fertilization. “When fertilization fails to occur, the endometrium is shed, and a new cycle starts. This is why it used to be taught that ‘menstruation is the uterus crying for lack of a baby.’” It is important to take into consideration the origin and development of this language. Reproductive biology, as discussed above, developed in a socio-political movement against women’s departure from traditional household roles. Women who chose to work, attend college, or use birth control threatened historical roles of women’s economic dependence on men. Additionally, at the beginning of 20th century a eugenics movement took hold of the United States. Eugenicists exploited the Congress’ fear of societal degeneration by advocating for both positive and negative eugenics. Positive eugenics was the encouragement of “fit” women to reproduce, whereas negative eugenics was the prevention of “unfit” women from reproducing as well as the prevention of millions of immigrants from entering the United States. A large emphasis was placed on the importance of “fit” classes reproducing; making any deviation from this goal a crime against society. In this way, language surrounding menstruation reflected fears of a woman neglecting her role as reproducer.

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67 Ibid. p 356
The language used in current textbooks reflects attitudes towards menstruation that have existed for multiple decades. While many proponents of scientific objectivity claim that science should be taught without associated social context, I would argue that “objective” representations of the menstrual cycle are not truly “objective,” and therefore educators should be cautious in these claims. As Donna Haraway discussed in *Situated Knowledges*, “we need the power of modern critical theories of how meanings and bodies get made, not in order to deny meanings and bodies, but in order to build meanings and bodies that have a chance for life.”68 By attempting to strip away social understanding and development of the menstrual cycle we are failing to acknowledge a multifaceted history, an acknowledgement that I believe is essential for a full comprehension of the material.

*Alternative Models:*

In reflection of the previous discussion on historical and societal contributions to how we interpret and visualize the menstrual cycle I am offering an alternative model to contemporary biological educational models. For this model I sought a medium that could present biological processes within a social context. I sought to be able to include subjects within the understanding of how and where processes such as the menstrual cycle take place. I sought to find a medium in which educators could acknowledge the positionality of the production of scientific knowledge. Additionally, I hoped that this medium could be used to present material in a more comprehensive and effective manner than previous educational models.

*Animated Models in Biological Education:*

Ultimately, I chose animation because I believe it to be one the most versatile of educational media. Animated models provide versatility in subject matter, setting, user-control, and visual contextualization. In Appendix A, Figures 1-4 show four static models of fluid biological processes. Since the invention of the printed book, stationary diagrams have been used to present scientific information. With the development of computer design technology, the utilization of computer graphics to present scientific models has increased. The shift from static diagrams to animated models has been slow considering the available technology. Initial studies on the efficacy of animated models disappointed many advocates for this educational archetype. One study conducted by Tversky Morrison and Betancourt (2002) showed no difference between the efficacy of traditional static diagrams and computer animated models of scientific material. The animations used in these initial studies have been criticized for poor design. Despite these criticisms, these studies demonstrated that even with imperfect design animated models are as effective as static diagrams in science education.

Recent animated visualizations have been found to be very effective in teaching molecular science. One study conducted by Carl-Johan Rundgren and Lena Tibell showed that static molecular models caused students to believe that the cell transport systems they were studying were static as well. Appendix A, Figures 1-4 are good examples of complex biological cycles presented in completely static manners. Figure 4 shows a static visualization of protein synthesis. In comparison, I looked at the aforementioned animation on cellular insulin synthesis. In addition to providing the context of a subject consuming glucose, the animation

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successfully maneuvers through the blood stream into the nucleus to provide a dynamic visual understanding of the sequence of steps in protein synthesis.\textsuperscript{73}

One of the biggest criticisms of initial educational animations was the absence of any focus on individual needs. Interestingly, this weakness is developing into one of the most noteworthy strengths of the area. Program designers have begun to focus on speed, concurrency and complexity of presented material. Because of this focus, animated models are now “user-controlled” such that students can control the speed and area of focus. Many critics of the current educational system have long awaited the movement towards the de-centralization of education to accommodate a variety of educational needs.

Animated models can be used to acknowledge social-biological interactions, enhance student comprehension of molecular models, and provide a medium through which a variety of situations can be presented (similar to comics, cartoons, and graphic essays).

\textit{Adopting the Problem-Based Learning Model for Menstrual Cycle Visualizations}\textsuperscript{74}

Problem-based learned is an instructional method that became popularized in Canadian Medical Schools in the 1970’s.\textsuperscript{74} The concept of teaching through situational analysis have much older historical roots, however, the incorporation of the model into the contemporary educational paradigm is much more recent. The foundation of this educational model is centered on the belief that effective mastery of a material starts with an understanding of the context and situation in which the material develops. Since the 1970’s, a number of medical schools have


adopted the PBL model because of its proven efficacy in student performance and information retention.

Many consider the theories of John Dewey as the precursor for contemporary PBL. Dewey argued that learning was a social progression and that students should interact with their education and integrate social understanding and knowledge into their coursework.\textsuperscript{75} Dewey believed that material should be presented in such a way that students would be able to incorporate their personal experiences so as to attain a more contextualized view of the subject.\textsuperscript{76}

PBL is primarily used in medical school to present situational knowledge for patient-based care. Students form groups and receive “problems” to explore and discuss. Historically, medical school focused on the presentation of material through lectures, providing a static representation of information without context. PBL, however, aims to do the opposite by presenting material dynamically in specific situations.

Proponents of PBL argue that information should be taught within social contexts, not “stripped” of them, as so many science curricula attempt to demonstrate. It is counterintuitive to present material outside of social contextualizations, especially in a profession, such as medical care, that is centered on human experience.

While Medical Schools are adapting quickly to incorporate PBL into curricula, science education elsewhere is not following suit. Research on PBL clearly demonstrates the benefits in both critical thinking and comprehension. PBL is considered a useful tool in Medical School because of the social aspect of the material.

I would like to argue that a similar strategy should be applied to upper-level science education. Using animation, the menstrual cycle could be represented not in static linear and

\textsuperscript{75} Louttit, C. M. "Child Development and the Curriculum." Journal of Educational Psychology 38.6 (1947): 382-83.
\textsuperscript{76} Ibid. p 382
circular diagrams but through models that incorporated specific situations, backgrounds, and examples that promote a dynamic understanding of the complexities of the cycle. Each representation of the cycle would not be standardized, taking into consideration a multitude of experiences with menstruation.

Possible Animation Storyboards for Menstrual Cycle:
- **Female Subject 1**
  - Menstruates eight times a year
  - What does menstruation look like in her body?
- **Female Subject 2**
  - Does not menstruate
  - Attends doctor’s appointments to receive hormonal injections to induce menstruation
  - What do reproductive organs look like in her non-menstruating body?
- **Female Subject 3**
  - Athlete
  - Menstruates once a year
  - What does menstruation look like in her body?
- **Female Subject 4**
  - Postpartum mother
  - Five months after birth, is not menstruating
  - What does menstruation look like in her body?
- **Female Subject 5**
  - 17-yr old
  - Does not menstruate
  - Anxious about lack of menstruation
  - What do reproductive organs look like in her non-menstruating body?
- **Female Subject 6**
  - 22-yr old
  - Does not menstruate
  - Recently lost a considerable amount of weight
  - What do reproductive organs look like in her non-menstruating body?
- **Female Subject 7**
  - 19-yr old
  - Believes she suffers from severe PMS and heavy periods
  - Begins to take birth control to control hormonal levels
  - What does menstruation look like in her body?

In collaboration with writing and researching this thesis, I also experimented with storyboard depictions of a menstruation animation. Specifically, I attempted to capture the sequence of
frames I believe would be effective in illustrating context, subject, and biological details of the menstrual cycle. For example, one such animation would introduce the female subject by presenting information such as age, environment and menstrual cycle history. This would act to subjectify the female. Subsequently, the animation would zoom into the female’s body, and explore the menstrual cycle as it is occurs within her body (although in some of the scenarios, menstruation is not occurring). The storyboard would end by zooming out, depicting the female, rather than her organs, as the subject of the animation.

Conclusion

Ultimately, I am arguing that current standard models for biological education are incomplete. In the example of the menstrual cycle, historical gender attitudes and global competitions developed public interpretation and visualization. Despite the clear social and historical subjectivity of the menstrual cycle, linear and circular representations attempt to present objective visualizations for educational purposes. I believe, however, that forcing objectivity onto a process so heavily affiliated with historical gender debates and prejudices is both incomplete and dishonest in its depictions. “I am arguing for the view from a body, always a complex, contradictory, structuring, and structured body, versus the view from above, from nowhere, from simplicity.”

Thomas Kuhn’s interpretations of scientific objectivity in *The Structure of Scientific Revolutions* revolve around concepts of scientific discovery within paradigms. The biological understanding of the menstrual cycle was developed within a society heavily affected by social, racial, and gender tensions that should be recognized. There should be an educational

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paradigm shift away from objectivity towards models combining both biology and social connotations. To effectively do this, however, there needs to be a medium through which both biology and historical/social interpretations can be represented. Shifting educational models towards animation would provide an enhanced learning environment, recognize social-biological interactions, present biological processes in a "personal and societal context," and remove models from "objective" public understanding.

Bibliography


Appendix A
Biological Cycles Figures

Figure 1 - Oxidative Phosphorylation

http://bbc.mcw.edu/Computation/models/images/TCA/Figure1_TCA1.jpg

Figure 2 - The Electron Transport Change

Figure 3- Photosynthesis\(^81\)

![Diagram of Photosynthesis](http://diogenesii.files.wordpress.com/2009/05/the-biochemistry-of-photosynthesis.jpg)

Figure 4 – Transcription and Translation - Protein Synthesis\(^82\)

![Diagram of Transcription and Translation](http://stemcells.nih.gov/StaticResources/info/scireport/images/figurea6.jpg)

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\(^{81}\) http://diogenesii.files.wordpress.com/2009/05/the-biochemistry-of-photosynthesis.jpg

\(^{82}\) http://stemcells.nih.gov/StaticResources/info/scireport/images/figurea6.jpg
Appendix B
Menstrual Cycle Figures

Figure 4 - Linear Representation of Menstrual Cycle

![Linear Representation of Menstrual Cycle](http://doctorgrasshopper.wordpress.com/2010/05/page/2/)

Figure 5 - Circular Representation of Menstrual Cycle

![Circular Representation of Menstrual Cycle](http://www.maybe-baby.com/_fertility_timing.html)

Figure 6 – Fertility Calendar within Menstrual Cycle

![Fertility Calendar within Menstrual Cycle](http://medippt.files.wordpress.com/2010/05/menstrual-cycle.gif)

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83 http://doctorgrasshopper.wordpress.com/2010/05/page/2/
84 http://www.maybe-baby.com/_fertility_timing.html
85 http://medippt.files.wordpress.com/2010/05/menstrual-cycle.gif
### Appendix C

#### Tables

Table 1. Percentage distribution of sexuality education teachers, by specific topic cited as the most important message they wanted to convey to students

<table>
<thead>
<tr>
<th>Topic</th>
<th>1988</th>
<th>1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstinence</td>
<td>24.8</td>
<td>41.4***</td>
</tr>
<tr>
<td>Responsibility</td>
<td>38.0</td>
<td>20.9***</td>
</tr>
<tr>
<td>Reproductive facts</td>
<td>9.2</td>
<td>13.2***</td>
</tr>
<tr>
<td>STDs/AIDS</td>
<td>11.6</td>
<td>10.0</td>
</tr>
<tr>
<td>Self-Esteem</td>
<td>4.0</td>
<td>3.6</td>
</tr>
<tr>
<td>Change is normal</td>
<td>2.0</td>
<td>2.7</td>
</tr>
<tr>
<td>Contraception</td>
<td>4.8</td>
<td>1.5***</td>
</tr>
<tr>
<td>Puberty</td>
<td>U</td>
<td>1.4</td>
</tr>
<tr>
<td>Other</td>
<td>5.6</td>
<td>5.3</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

*Significantly different from 1988 at p<.05. **Significantly different from 1988 at p<.01. ***Significantly different from 1988 at p<.001. *Note: u=unavailable; question not asked.*