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Competing Views of Embryos for the Twenty-First Century: Textbooks and Society

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Abstract It might seem that an embryo is an embryo, and that there would be a fact of the matter. That seems especially true with respect to the way embryos are presented in textbooks, including high school biology textbooks. This paper looks at three co-existing, competing, and often conflicting views of embryos. Then with a close study of twentieth century high school biology textbooks, it explores suggestions about the ways those books have influenced public impressions of embryos.

1 Introduction

Nicole Winfield reported in a much-circulated Associated Press release on Saturday 27 November (2010) that Pope Benedict XVI had issued a call for politicians, world leaders, and the media to "show more respect for human life at its earliest stages, that embryos aren't just biological material but dynamic, autonomous individuals". Benedict made the call at the beginning of Advent, and he urged "bishops around the world to make the service a vigil for 'nascent human life". The story reached many newspaper and television audiences. Its message involves something that seems to be thought of as more than "just biological material".

Meanwhile, *Wikipedia* on the same date gave a second view of embryos. The entry explained that "An embryo (irregularly from Greek: *ἔμβρυον*, plural *ἔμβρυα*, lit. 'that which grows,' from en- 'in' + bryein 'to swell, be full'; the proper Latinate form would be *embryum*) is a multicellular diploid eukaryote in its earliest stage of development, from the time of first cell division until birth, hatching, or germination. In humans, it is called an embryo until about 8 weeks after fertilization (i.e. 10 weeks LMP), and from then it is instead called a fetus." This definition has persisted essentially unchanged from the first *Encyclopedia Britannica* in 1771 and is a decidedly materialistic view. This second view is consistent with advanced biology textbooks and researchers who study embryos and

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explain very clearly that the early embryonic stages are just that—early stages in a developmental process, with little to no gene expression, and little to no differentiation or growth in the earliest stages, including the stages that involve embryonic stem cells.

Furthermore, we are learning quickly about how malleable embryos are. Using a set of engineering procedures that may seem more like science fiction than research underway in labs today, researchers can take pieces of embryos apart and then put them back together in different ways, constructing new embryos and even engineering them genetically. This suggests a third view of early embryos as more nearly raw materials molded not just by the conditions of development and heredity but through human intervention as well.

What does it mean that these seemingly inconsistent views of embryos co-exist? How many and which ones are "true" or "best"? Are embryos really "dynamic, autonomous individuals" that are more than material, or are they "just" unformed, undifferentiated biological material and how far can humans intervene in engineering embryos? Then how can we make sense of the competing views, with their underlying values and epistemologies that sometimes (though not necessarily and certainly not always) come into conflict? Where do such different ideas come from, and what interests do they serve? Given that nations and states around the world are busily passing legislation and deciding judicial cases that involve definitions of "embryos," whose understanding is being used in each case? And on what grounds?

We do not claim here to resolve what are sometimes heated debates. Nor do we see the discussion as a matter of conflict between science and religion as such. The first, metaphysical, view tends to be philosophically based and is more often intertwined with values assumptions, including religious assumptions at times. The second and third views are grounded in materialistic science, but not necessarily in conflict with religious views, since we are discussing definitions rather than values claims. Again, the focus here remains on different interpretations of what embryos are.

What we do is provide perspective, including an outline of the three dominant competing views of embryos introduced above. We begin by asking how these views have come to co-exist and by exploring how we can make sense of the differences. Maienschein's research focuses on the biological understanding of embryos in historical context, and Wellner's exploration of high school textbooks in the United States provides clues to both the motivations for promoting and the reasons for the co-existence of divergent views. While views of embryos often lump different species together, the special attention here is on human embryos. What follows is a brief historical background with an introduction to the three dominant views, then a report on Wellner's study of textbooks, followed by suggestive conclusions and a call for further study.

2 Historical Views: Epigenesis and Preformationism

First came a widely-shared view embraced by those few naturalists who looked at embryos, including Aristotle, and by early religious leaders who came to largely the same view of embryos. Called epigenesis, this idea emphasized that form emerges only gradually and over time out of initially unformed material. Aristotle gave a material account of development based on his observations of chicks and some other embryos, starting with the blending of fluids from the mother and father through sexual reproduction. For Aristotle, the steps that followed involved a gradual epigenetic development of form from the initially unformed material. His final and formal causes helped shape the result, as the efficient and material causes provided the process and material. The early stages of an

individual's development are obviously vastly different from what comes later–even just looking shows that. The early stages are not yet organized, and not visibly an individual organism at all. Organization of the individual organism comes only gradually on this view, and it seemed that some special vital (as in living) organizing principle helps guide development so that it will come out right–meaning the right type of thing, with the right form and function.

From the very first edition of the *Encyclopedia Britannica* in 1771, natural philosophers (as scientists were called then) made official this view that the embryo remains largely unformed until the eight-week stage in humans. At that point, it is called a fetus and has the basic organ parts and structural systems, though they are not yet functioning. Religious interpretations also focused on "forty days" as the critical point when an individual's life begins. This was taken to be the time of "quickening," accepted by traditional Jewish, Muslim, and Catholic theologians.

Epigenetic understanding of development remained the primary view for natural philosophers and theologians, who saw and reasoned as Aristotle did that it took time for the form to begin to emerge. By the eighteenth century, though, as historian Shirley Roe has discussed, an alternative view emerged based on different underlying assumptions. (Roe 1981, see p. 176 n1 for definitions; Maienschein 2003) This was the idea of preformationism, with the assumption that form must somehow be there from the very earliest stages even when it is not yet visible. Preformationists held that organisms were really formed from the beginning, at least in broad strokes, but we just cannot see them at the beginning. What had changed that led some to this interpretation?

Preformationists in the eighteenth century were metaphysical materialists, namely those who started with the assumption that what exists in the world is material. They rejected the idea of special invisible vital forces or entities. But this caused a problem, because these materialists did not see how form could arise on its own, largely because they could not imagine a materialist explanation by which form could arise from unformed material. They were not all happy with the conclusions, but felt compelled to take a preformationist or at least a predeterminist view of life.

Preformationism remained a minority view until geneticists placed predeterminism on new foundations in the mid-twentieth century, but historically what this new view did was to create competition. Embryos could be interpreted as essentially preformed, with their fate laid out from their very beginning—presumably at fertilization when the contributions from the parents came together. Or, alternatively, embryos could be seen as largely self-organizing in response to environmental conditions. Empiricism favored this latter view, while metaphysical materialism pointed toward the first. These two views began to co-exist, and each developed into a tradition with its own evolution and advocates. By the end of the nineteenth century, observation moved these closer together, with a materialistic view of embryos in which the main biological question was how much genetic inheritance or cytoplasmic structure of the egg pre-organized or informed development.

3 Three Competing Contemporary Views of Embryos

3.1 Biological Materialistic View

In the twenty-first century, we have three competing views of embryos, with the third as a recent addition. One view (the second mentioned above) is the *empirically based biological view*. According to this view, from fertilization onward, the embryo is alive in the

sense that it carries out the biological processes of growth and development. And it is an individual organism in the sense that it is bounded and defined, though at first only very roughly. In the early stages, however, it is not differentiated or formed or organized until gradually, over time, developmental processes (which today we understand in terms of a combination of inherited genetic factors interacting with environmental conditions to yield developmental change) bring differentiation and eventually function as a living organized organism.

Biologically, all the developmental stages are on a continuum from fertilization to death, and arguably they really even continue back to the formation of the parental egg and sperm and extend beyond the individual's death through offspring. Nonetheless, it seems reasonable to define an individual as existing from fertilization to death. The important question is how to understand the different stages of development since fertilization does very little biologically, and the later stages, during which form emerges, are increasingly very different. The fully developed individual after birth is undeniably radically different biologically from the single fertilized initial cell.

By the late nineteenth century, biologists had begun to work out details of these stages and their differences. In humans, this happened especially at the Carnegie Institution Department of Embryology. Led by Franklin Paine Mall, building on the embryo collections of Wilhelm His, the department worked out the developmental stages for humans. In the first decade of the department, they focused on capturing what was empirically visible. Then they added research into how development occurs, through processes and structural and functional changes (Maienschein et al. 2005).

What became clear by the early twentieth century is that there are, in fact, different biologically significant stages. It therefore made good biological sense to distinguish them, rather than to lump them all together as the same kind of thing. Biologists at the Carnegie department, along with embryologists and developmental biologists elsewhere, were showing the differences and that the early stages are definitely not the same kind of thing as later stages (UNSW 2010).

3.2 Metaphysical View

Meanwhile, a second interpretation of *embryos as metaphysical* had emerged in the middle of the nineteenth century that led to a tradition in direct conflict with the biological interpretation. This became highly visible in 1869 with Pope Pius IX, though it is not restricted to religious leaders. Pius IX was embarked on reforms known as "Vatican 1," which involved a conservative move to tighten Church control, including control of women and their reproduction. He ruled that life begins at "conception," which was generally interpreted to mean at fertilization (since the discovery of the biological process of fertilization of egg and sperm cells took place about the same time). With his decree, Pius insisted that the individual human life and its individuality as a "person" begin not at 40 days or some later point, but from conception. Thereafter, abortion or attempts to prevent development were religiously illicit and punishable by the Church. Pius IX's actions meant that for followers, an embryo is not only "alive" in the biological sense but also carries the individual "life" and soul in an important spiritual and metaphysical sense (Lopez 2010). It is more than "just" material. In this case, evidence came from faith rather than empirical observation.

Again, this is not a matter of religious interpretation in conflict with secular views. Philosophers might also have a metaphysical conviction that the embryo is more than material. And one well-known biologist turned to this view when he felt that materialism

alone could not explain how form emerges from non-form. Hans Driesch studied the earliest embryonic stages, when the fertilized egg cell divides into two cells, then four, and so on. He discovered that if he shook apart the first two cells in sea urchin eggs (which were easy to get and easy to study), each cell responded by developing normally, only a little smaller. This suggested to him that each cell had a tremendous capacity to self-regulate, and that the fertilization process itself did not determine very much, if anything important. It was the process and some internal force or process, what he called some "harmonious equipotential system" that drives development, Driesch concluded. Implicit in Driesch's view is that biological stages differ but the "entelechy" is always at work. In some ways, Pope Pius IX (and Pope Benedict today) also held that the embryo is essentially the same kind of thing at all stages and that we should treat it the same, a view implicit in Benedict's call for respecting and protecting embryos as "nascent human life." Yet Driesch emphasized the biological nature and the importance of regulation of the whole in a material way (Maienschein 1991).

3.3 Constructed View

But there is also an emerging third view of embryos that challenges the underlying assumptions of both. This is a view of embryos as the product of engineering forces, or the idea of the *embryo as constructed*. In "natural" situations, the embryo starts with sperm fertilizing an egg and cell division from one cell into two, into four, into eight, and so on. It is the inherited genetic and cytoplasmic factors that interact with the cell environment to construct the resulting embryo, which gives rise in due time to a fetus, then eventually to a baby, and even later to an adult.

Since 1978, however, human fertilizations need not take place in "natural" conditions. And later studies have also shown that what is "natural" in most cases may actually vary quite a lot. A large number of embryos today start out "in glass," that is in a laboratory dish through in vitro fertilization (IVF). IVF began to help infertile couples produce their own embryos.(Edwards and Steptoe 1980) Then donor sperm, donor eggs, even donor embryos added more options. Since the 1990s, various forms of preimplantation genetic diagnosis (PGD) have made it possible to remove one of the cells up to the 8-cell stage in order to test for genetic disease. (Handyside 2010) In fact, protocol allows removing two of the cells from the eight-cell stage, and experiments with mice show that it is possible to remove even seven of the eight cells. The rest of the cells seem to compensate and the result is assumed to be the same as it would have been. The technologies of reproduction have continued to evolve with demand and discovery.

But that's not all. Beatrice Mintz showed in the 1960s with mice that she could mix cells from different individuals, and even from different varieties. Taking cells from different donors and adding them together produced chimeras, with very clear results in the form of striped mice. (Mintz 1965) showed that embryos are actually highly adaptive, or regulatory; they are able to respond to changing conditions as needed.

Cells from the eight-cell stage can be separated to produce separate octuplets in mice, and occasionally in humans. As far as we know, however, nobody has considered it desirable to intervene and carry out this experiment in humans. Those who hold that an individual life begins with fertilization and that the resulting embryo is an autonomous individual with a "soul," have long had to deal with the fact that that "individual" can split to give rise to identical twins—each of which somehow becomes its own autonomous and individually ensouled self. So far they have offered additional (and some would say ad hoc)

metaphysical assumptions about the nature of ensoulment and of individuality to compensate for the lack of empirical evidence. Yet the increasing capacities for artificially producing multiples "in the dish" as with separating the eight cells, adds new levels of complexity to old questions as well as introducing new issues.

Further questions arise with genetic engineering. Again, in mice and other organisms considered as models for humans, researchers have been able to insert genes, enhance or multiply the effects of genes, or "knock-out" genes to modify the inherited genetic composition of the embryos. This raises questions about the metaphysically presumed integrity of the whole. If we can remove cells and even within cells can replace genes, then what about embryos is so special that they deserve to be labeled as "dynamic, autonomous individuals" that is more than just material? What does individuality mean? And what, really, is an embryo?

Now researchers can go farther and extract somatic (or body) cells from a person and culture them. (Landecker 2007) With the right mix of genetic factors, the cells can be reprogrammed to function like other kinds of cells, including germ cells or embryonic cells. Once again in mice, such cells have shown the capacity to act as an egg and a sperm and to undergo fertilization and subsequent differentiation. Other researchers have been working to synthesize cells and other organic processes, leading to the popularity of "synthetic biology." Yet all this was "artificially" constructed, starting from a person's body cell. Where is the autonomy here? Where is the individuality? What do we mean by an embryo in this case? This third understanding of embryos, growing out of the capacities from new technologies, challenges the underlying assumptions of both the earlier biological and metaphysical views of embryos. The biological and constructed views can be made compatible, with further interpretation, and so perhaps can the metaphysical view. Yet the possibilities of construction do require rethinking the way we have understood embryos as natural objects.

4 Co-existence and Conflicts

We note that society will be best served with an open, honest, and robust discussion about the full range of interpretations of what embryos are thought to be. It will help to promote understanding and informed assessment of the underlying metaphysical and epistemological assumptions involved. Only then can we begin to move toward reasoned and responsible humane responses within a context of respectful debate.

We will return to this point, and the political context in which the debate is currently occurring in the conclusion. Next, however, it is useful to look at some of the reasons we have reached this point where society embraces these sometimes dissonant views of embryos. In fact, Wellner's study of high school textbooks (2010) through the twentieth century suggests some factors influencing how confusions may have arisen and been enforced, even within the education community and perhaps unintentionally. Her study focuses on the United States, though comparisons elsewhere could be quite instructive, and indeed we welcome additional research and discussion. And her survey helps demonstrate and illuminate public understanding of embryos.

5 High School Biology Textbooks Through the Twentieth Century

Wellner's study of high school biology textbooks published during the 1900s reveals inconsistent messages that changed, often, by decade. The changing messages and

implications suggest that different generations of those who were exposed to these courses, whether directly or indirectly through friends or family members, may well have reinforced different views of embryos in ways that are worth exploring further.

Looking at a single high school biology textbook, even in multiple editions, might suggest that science is static and that embryology is somehow loaded with vocabulary that has not changed much over the years. But a chronological, decade-by-decade examination of many textbooks begins to reveal how the study of development has been influenced by the mix of evolving societal views of the embryo, changes in science education pedagogy, textbook publishing, and changes in scientific technology and embryological research. The changing messages and implications suggest that different generations have been exposed to different views through evolving textbook messages– both explicit and implicit.

Coupled with an increasingly evident reverence for embryos and ethical concerns surrounding them, embryos carry an underlying social burden, one that students are not overtly made aware of. In a study of over 120 commercially developed high school biology textbooks (1907–1999), Wellner examined how development, and in particular human development, has been treated over the course of the twentieth century.

To help focus on what has been written about embryos, she coded textbook paragraphs and visual representations and placed them into one of four categories: descriptive, investigative, nature of science, and technology and society. These categories were based on the four major themes of scientific literacy established by Chiapetta et al. (1993) in their textbook analyses. They also correlated with recommendations established in *Benchmarks for Scientific Literacy*, published in 1993 by the AAAS, and the *National Science Education Standards* published in 1996.

As expected, every decade of textbooks was dominated by descriptive paragraphs of terminology, life cycles, and scientific knowledge about embryos and fetuses to be learned by the reader. Content has always been at the heart of science education and textbooks have always served as repositories for content. Not surprisingly, these types of paragraphs represent essentially the empirical biological interpretation of embryos.

Wellner found that early twentieth century texts presented understanding of embryos, and biology generally, as highly static—as if there were nothing more to discover. Anyone who was a high school biology student prior to the mid-1940s would have understood that all mammals go through developmental stages in utero, but it was not always clear that humans do too. This changed during the late 1940s and through the entire decade of biology textbooks in the 1950s. After World War II, textbooks shifted attention from the familiar frog and chick eggs to include human prenatal care and do's and don'ts for pregnant women.

During the 1950s, new technologies emerged and so did society's views on women and childbirth. Around 1940, 55% of America's births were taking place in hospitals, by 1950 it was 88%, and by 1960 most children of suburban and urban mothers were born in hospitals (Leavitt 1986, p. 171). As human pregnancy became more hospitalized, it was commonplace for doctors to use obstetric technologies, including X-rays and blood tests. This increased the visibility of the fetus (Hopwood 2009) and led to the view that obstetricians now had two patients on their hands, the pregnant mother and the fetus. It was here, in the 1950s, where textbooks presented fetuses as "patients." This view would increase dramatically in texts published in the 1980s, and it would be worth exploring why. On the face of it, this shift seems to move from a more empirical biological to a more metaphysical view of embryos. This is not the place for a full social analysis, which calls for much more study, but it is worth noting the broad shifts.

Textbooks published in the late 1940s and through the 1950s show recognition of early versions of the third, constructed, view of embryos. Granted, the human embryo had not yet been fertilized in vitro, but the post WWII period brought increasing conviction that the in vivo environment of the embryo's fertilization and gestation mattered. Healthy children would grow from optimal environments, which could be scientifically understood and "constructed." This meant frequent explicit promotion of visits to the obstetrician, and avoiding things like horseback riding, venereal diseases, radiation, and drugs. Students during this era, especially girls, saw that extra vigilance and attention to the unborn would result in a "remarkable," "unbelievable," "miraculous," and "amazing" baby. Such superlative adjectives were never applied to the birth of frogs or opossums, suggesting to the post War generation that human embryos were not just predetermined biological material, but that careful nurturing would make a difference. Of course, from a biological standpoint, human births that occur every minute of the day are simply a normal part of the biological processes of life. Yet as social historian Donna Haraway (1991) claims, our inability to look at the human embryo biologically leads many of us to see embryos as indeed "miracles."

With new textbooks arriving on the scene in the 1960s, especially BSCS materials, the biological view of embryos gained precedence, and the metaphysical and social emphases faded away. In particular, the theme of motherhood and pregnancy that had come to dominate the post War period of the 1950s literally disappeared. Teratogens such as thalidomide and measles appeared in textbooks because of their biological effects, giving the impression that embryos are not highly adapted and that they do not respond well to change. Chapters on human reproduction still appeared, but the information focused on updating the curriculum with timetables of embryonic development, fetal circulation, menstruation, male and female reproductive systems, and the role of hormones in pregnancy and childbirth.

Outside the empirical biological classroom there was growing concern about the sexual revolution sweeping the United States, and in 1960 the FDA approved Searle's sale of birth control pills. This focused attention on the early stages of life and what causes (or prevents) them. Then, in 1965, *Life* magazine published several of Lennart Nilsson's color photographs of human embryos and fetuses and helped make these stages visible (http://www.lennartnilsson.com/). The public was captivated by the detailed images of human life that they had never seen before, and this helped lead the embryo from the laboratory to the living room in the form of coffee table books. What was increasingly empirical and biological presentation in the high school textbooks was increasingly socially visible as well.

The impact of Nilsson's photos did not stop with public presentations, however. Beginning with Stanley Weinberg's 1971 *An Inquiry into the Nature of Life*, Nilsson's embryos became highly publicized in high school biology textbooks. Although there had been pictures of human embryos in textbooks prior to this, they were usually small snapshots of black and white Carnegie preserved stages. Nilsson's pictures were published in color and were often quite large, sometimes taking up the entire page of the textbook. Anthropologist Lynn Morgan (2009) argues that when fetal pictures are oversized, they magnify and exaggerate the amount of space that embryos or fetuses take up, especially if no scale is given. She also claims that Nilsson's photographs are one example of how fetal imagery proliferated to the point that solitary apparently autonomous developing forms (often called "embryos" but which were really almost always "fetuses") came to function as icons of life, and even as objects of worship.

Despite the available scientific information about development, generations of students in biology classrooms during the 1970s and 1980s saw Nilsson's pictures in their textbooks as well. They might well have been led to agree with Pope Benedict XVI's view of embryos as dynamic and autonomous individuals. With the mother always left out of the picture, the take-away message was that embryos and fetuses could function on their own. Viewers could well see them as looking beautiful and somewhat "miraculous."

Several texts used Nilsson's photographs besides Weinberg's three texts published in 1971, 1974, and 1977. These included *Modern Biology* (Otto and Towle 1977), *BSCS Green Version* (1973, 1978) and *Biology* (Smallwood and Green 1977). It is important to note that the use of these photographs marks the beginning of the public's transition to accepting public viewing of human embryos and fetuses and to acknowledge that they had a place in both public and scientific spheres (Morgan 2009).

Unlike the Carnegie embryo pictures in which no claim was ever made that the specimens were living when photographed (http://www.hps.com.ac.uk/visibleembryhos/s6_2.html), Nilsson's fetuses took on the appearance of being alive when their pictures were snapped, but this was not the case for most of them. They were actually quite dead. (Matthews and Wexler 2000) As the abortion debates continued, Nilsson's pictures seemed to touch a chord with everyone, but especially with anti-abortion advocates.

Meanwhile, in the 1960s laboratory, biologists were carrying out nuclear transplantation studies and in vitro research that was beginning to develop the capacity to construct embryos. (Maienschein and Robert 2010) Very few texts in the 1960s, however, described the implications of this research or any social issues related to embryology. This remained relatively unchanged even during the 1970s, with the 1973 U.S. Supreme Court ruling that legalized abortion and a 1975 moratorium on federally supported research on in vitro fertilization. (Culliton 1978). Up until the 1970s, textbook attention to the interaction of human embryos, technology and society (HETS) was nearly non-existent. A cursory glance at the percentage of HETS paragraphs in the 1970s reveals a paltry 2% of the total. However, this value actually represented a small shift that rapidly expanded into the 1980s and 1990s.

Most 1970s textbooks talked about experiments and remained focused on the biological research, but John Kimball's *Biology* (1974, 1978) brought up ethical questions about reproductive engineering. Kimball wrote that "The rapid advances that have been made in the understanding of human reproductive physiology raise the prospect of manipulating the process in ways not hitherto possible" (1974, p. 447). In *Biology,* students were introduced to several technological advances: the ability to freeze and store human sperm for future use; the possibility of using surrogate mothers to incubate embryos; in vitro sex determination; amniocentesis and genetic screening; and tetra parental offspring. Engineering life by controlling development was definitely taking on a new role in biology textbooks.

Several of Kimball's examples had only been tried in laboratory animals at the time his texts were published in the 1970s, including the chimera research reported by Beatrice Mintz (and discussed earlier). In a case of foreshadowing, Kimball declared that all of these manipulations raised ethical and legal questions that needed to be dealt with before the need to do so became critical. Like the embryos in the laboratory dish, the textbook embryo had become a future-directed enterprise that would have societal consequences. Kimball began to see new questions raised by the ability to construct embryos in different ways.

Biology textbooks published during the 1980s appeared against the backdrop of tremendous change in the world of the embryo. The research embryo was now spending time having its DNA rearranged, recombined, or replaced, while most people saw ethical

questions in traditional terms, still inspired by the impressions from Nilsson's beautiful color photographs. Only gradually did some textbooks begin to raise new questions about such issues as embryo exploitation through cloning, in vitro fertilization, and abortion. The embryo during the 1980s was beginning to be seen as highly adaptable and capable of being manipulated in different ways—a clearly different view from the earlier presentations that made embryos and their development seems programmed, predictable, and largely static.

Ultrasound procedures soon joined the mix. On a personal basis, a parent's first visual contact with his or her child now occurred while the fetus was hidden in the womb, rather than at birth. The fetal pictures became part of the routine prenatal care package, and ultrasound images were placed in biology textbooks during the late 1980s. These images were also accompanied by pictures from fetal surgery, chorionic villi sampling (CVS), in vitro fertilization, and amniocentesis. These pictures of new reproductive technologies helped portray to students the enlarged clinicians' control over reproductive processes and showed treatments that seemed to include the doctor and the fetus, only. Much as with Nilsson's photographs, the fetus in these images was seen as autonomous, while the mother remained invisible and depersonalized.

A comparison of 1950s and 1980s textbooks shows how societal norms influenced what was acceptable for students to learn about babies (or at least what society would tolerate). In the 1950s, Caucasian babies were shown sleeping in incubators and attended to by nurses (but not their mothers); in the 1980s, dead embryos and fetuses are shown in glass dishes. In the 1950s, all embryos and fetuses appeared to have been planned for. In the 1980s, a few books discussed abortion and *BSCS Green Version* (1987) texts told students that while nature aborted many fetuses before birth, there was also voluntary termination. Voluntary termination was not always done just because a fetus had a major chromosomal or genetic abnormality, but sometimes because unmarried, and even married women, might want to terminate a pregnancy when they were not able to support and properly raise the child that would result. It was now apparent to BSCS users that not everyone loved embryos!

In *Biology for Living* (1987), authors Bruce Wallace and George M. Simmons discussed abortion in a chapter titled "Personal Biology." Unlike the *BSCS Green Version*, this text discussed abortion only in the context of genetic diseases and prenatal accidents: "it is for fear of abnormal births that physicians often recommend abortions when the embryo has been exposed to a known damaging agent" (p. 48). The authors also discussed spontaneous abortions and interjected that "despite terminology that has become commonplace in recent years, there are few, if any pro-abortionists in this world. There are really only 'anti-abortionists' and 'anti-anti-abortionists'" (p. 49). The authors stated that abortion laws in the United States had been liberalized but they identified abortion as having only one purpose: to remove damaged embryos from the womb. There was no acknowledgement of the fact that abortions might be performed on healthy fetuses for any number of reasons.

One thing that Wallace, who had served on the BSCS board for several years, and Simmons did with their text was to present students with a series of scenarios to clarify their thoughts on matters of abortion. The first scenario gave the students background on fetal physiology: the human embryo does not need a brain in utero since oxygen and nutrients are delivered by the mother's circulation system. If the fetus can be kept alive this way, should a fetus diagnosed with anencephaly be aborted? The second statement concerned the fertilized egg: the fertilized, diploid egg is given moral value, whereas before fertilization, haploid eggs and sperm are considered worthless and discarded. Students

were left to ponder this discrepancy. They were invited to think metaphysically and not just biologically, even though these textbooks were designed for biology classes.

The last scenario addressed the idea that the developing organism was an individual person from the fertilized egg stage onward. This raised such questions as whether the loss of an embryo or fetus, for any reason, warrant an official investigation to assess blame. And what were students to think of embryo transplants where "stand by" embryos were destroyed? With such questions, the 1980s marked the time when the shifting views of the embryo began showing up in a lot of places: the laboratory, the pregnant mother, the ultrasound video camera, and even the courtroom.

Although not all texts during this decade addressed concerns with embryological research and technology, enough of them did to raise questions about changes in how embryos were being perceived. The most obvious change dealt with embryos and pregnancy. In the late 1940s and 1950s texts, pregnancy looked as if it was rather foolproof—if, that is, the expectant mother avoided lifting heavy things, saw and followed her obstetrician's orders, and had a compassionate husband. Pregnancy in the 1980s was different. A developing embryo was now known not to be fully protected by the uterus and placenta and this led to a heightened sense of urgency that the embryo be monitored, checked, and tested before being allowed to grow up. Pregnant mothers no longer had the luxury of sitting all day in a chair with their feet propped up; in addition to avoiding anything that could harm the embryo, they now had to make appointments for genetic screening, amniocentesis and CVS to detect abnormalities, ultrasounds to detect for more abnormalities, blood work for hormonal tests, and numerous checkup visits with their obstetricians. The message to students was that not following all of these recommendations would simply be inviting trouble for the fetus.

With the successful 1978 IVF-assisted birth of Louise Brown in England, and the first American IVF baby in 1981, how long would it take for this information to be found in biology textbooks? Surprisingly, quite a while—no texts published in the 1980s discussed in vitro fertilization. By 1987, with at least 5000 IVF babies born worldwide, and 1000 of them born in the U.S. (United States 1987), the American public had apparently become more comfortable with the thought of a new human being conceived in a glass dish. This allowed several authors in the 1990s to begin discussion about IVF and other reproductive technologies in their textbooks.

Some of these 1990s texts presented HETS material such as IVF quite descriptively, with no mention of bioethical or social issues. For example, fetal surgery was discussed in two texts (McLaren et al. 1991; Schraer and Stoltze 1990), but the procedure was presented more from a heroic medicine standpoint than as a possible life-threatening issue. Both texts declared that fetal surgery presented a significant advance in medical science, but only McLaren et al. wrote that any treatment of the fetus could be risky for both the mother and the fetus.

A photograph accompanying this text showed a fairly large fetus being pulled out of a sliced-open uterus. The bloody surgical gloves and numerous hemostasis clamps are testament to the extent that surgeons and society would go to make an unhealthy fetus healthy again. The use of this popular image helped portray fetuses as viable objects that needed to be saved from death, and imparted values on embryos and fetuses that were much different from the embryo of past decades. In effect, the message came across that all unborn can—and should—live! In reality though, the majority of embryos and fetuses pictured in textbooks were not alive when their pictures were taken.

Several texts mentioned abortion in the 1990s, including the 1990 *BSCS BlueVersion*. Unlike previous editions, which avoided the term abortion, the *Blue Version* presented

abortion as an option given to parents by a genetic counselor. The 1998 *BSCS Green Version* included abortion in its discussion about birth control. Whereas students using other texts were led to believe that abortion was only done as a last resort because the mother was carrying an unhealthy fetus, this text stated that "many abortions are undertaken because contraception failed" (p. 135) and that the issue of planned abortions was complex and emotionally charged.

Other controversies brought up by John Kimball (1994) included discussions about birth control techniques, cloning, and IVF. In the case of in vitro procedures, Kimball was the only author to note how expensive and relatively unsuccessful IVF had turned out to be. He also raised ethical concerns about egg storage. If the prospective parents separated or one or both died, what would happen to the frozen embryos? As in his 1970s texts, Kimball again told students that advances in biological technology threatened to outstrip our ability to cope with the new and complex ethical and legal issues that they created (p. 408).

6 Conclusions

This historical co-existence of first two and then three views of embryos to which the public was exposed provide the context in which textbooks did their work. Just as the public discussion failed to choose only one view, so the textbooks embraced differences. They did so without explicitly acknowledging that fact, and perhaps without even realizing it.

Study of textbooks suggests that the inclusion of court cases, birth control, images of "miraculous" babies, and future embryo scenarios indicated several things: (a) these Science-Technology-Society topics were encouraged by science educators; (b) the public still saw the interface between science and society as an acceptable target to help students understand science; and (c) as the twenty-first century approached, embryos had become part of an unsettled ethical, legal, and social debate. More than any other decade, high school biology students in the 1990s were seeing that biological advances had societal consequences.

The examination of twentieth-century textbooks shows that perceptions of the stability, organization, and relative emphasis on embryos have changed through the years along with educational, political, and social forces. The differences in textbooks from different periods at least raises the question whether different generations were reinforced in their particular views of embryos by the changing textbooks. It would be instructive to discover how much difference the textbooks make—given that high school may be the most exposure that many people have to any understanding of biology. Sources such as the National Science Foundation's *Science and Engineering Indicators* chapters on public understanding of science have repeatedly shown that only a small portion of the U.S. public reads technical books, studies the science section in the *New York Times*, or regularly explores NIH or other technical websites, for example.

If information and impressions come from textbooks, then it is worth studying in more detail the results of the past. It also behooves us to look closely at the messages given by textbooks today, and to ask whether the result is what we intended—or rather, what we should have intended for high school biology courses. Surely the challenges brought by constructed embryos demand more thoughtful and reflective discussion of embryos in textbooks of the future. History helps put such discussion in perspective.

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