Technologies, ed. Elaine Hoffman Baruch, Amadeo F. D'Adamo, and Joni Seager (New York: Haworth Press, 1988); Marsha Saxton and Florence Howe, eds., *With Wings: An Anthology by and about Women with Disabilities* (New York: Feminist Press, 1987).

6. To my knowledge, Anne Finger was the first disability activist to raise this issue in the U.S. women's literature. In her book *Past Due: Disability, Pregnancy, and Birth* (Seattle: Seal Press, 1990), which includes references to her earlier writings, Finger describes a small conference where feminists and disability activists discussed this topic. German and British disability activists and feminists pioneered this issue.
7. Ruth Hubbard, *The Politics of Women's Biology* (New Brunswick, N.J.: Rutgers University Press, 1990), 197.
8. This view must be reevaluated in the era of in vitro fertilization (IVF), where the embryo or a genetically prescreened embryo (following "pre-implantation diagnosis") can be fertilized outside the woman's body and frozen or can be implanted in another woman. Such a fetus has come to have legal status apart from the mother's body: for example, in divorce cases where the fate of these fetuses is decided by the courts.
9. Many "pro-life" groups support abortion for "defective fetuses." Most state laws, even conservative ones, allow later-stage abortions when the fetus is "defective."
10. Rayna Rapp, "Accounting for Amniocentesis," in *Knowledge, Power, and Practice: The Anthropology of Medicine in Everyday Life*, ed. Shirley Lindenbaum and Margaret Lock (Berkeley: University of California Press, 1993).
11. Suneri Thobani, "From Reproduction to Mal[e] Production: Women and Sex Selection Technology," in *Misconceptions: The Social Construction of Choice and the New Reproductive Technologies*, vol. I, ed. Gwynne Basen, Margaret Eichler, and Abby Lippman (Quebec: Voyager Publishing, 1994).
12. Dorothy C. Wertz and John C. Fletcher, "A Critique of Some Feminist Challenges to Prenatal Diagnosis," *Journal of Women's Health* 2 (1993).

Emily Martin

THE EGG AND THE SPERM

How Science Has Constructed a Romance Based on Stereotypical Male–Female Roles

DISCUSSION QUESTIONS

1. The author notes that the wording in many scientific textbooks "stresses the fragility and dependency of the egg." How does this correspond with our ideas of femaleness/femininity in humans?
2. Can you think of other instances in the field of science (or other disciplines) in which concepts seem to be "gendered" to fit our ideas of male/female and/or masculine/feminine?

Emily Martin, "The Egg and the Sperm: How Science Has Constructed a Romance Based on Stereotypical Male–Female Roles" from *Signs: Journal of Women in Culture and Society* Vol. 16 (1991): 485–501.

3. How do these "gendered" depictions of ova and sperm correspond to our ideas of male/female roles in heterosexual intercourse? How do they reinforce heterosexuality as an institution?

> The theory of the human body is always a part of a world-picture....
> The theory of the human body is always a part of a *fantasy*.
>
> —James Hillman, *The Myth of Analysis*[1]

As an anthropologist, I am intrigued by the possibility that culture shapes how biological scientists describe what they discover about the natural world. If this were so, we would be learning about more than the natural world in high school biology class; we would be learning about cultural beliefs and practices as if they were part of nature. In the course of my research I realized that the picture of egg and sperm drawn in popular as well as scientific accounts of reproductive biology relies on stereotypes central to our cultural definitions of male and female. The stereotypes imply not only that female biological processes are less worthy than their male counterparts but also that women are less worthy than men. Part of my goal in writing this article is to shine a bright light on the gender stereotypes hidden within the scientific language of biology. Exposed in such a light, I hope they will lose much of their power to harm us.

EGG AND SPERM: A SCIENTIFIC FAIRY TALE

At a fundamental level, all major scientific textbooks depict male and female reproductive organs as systems for the production of valuable substances, such as eggs and sperm.[2] In the case of women, the monthly cycle is described as being designed to produce eggs and prepare a suitable place for them to be fertilized and grown—all to the end of making babies. But the enthusiasm ends there. By extolling the female cycle as a productive enterprise, menstruation must necessarily be viewed as a failure. Medical texts describe menstruation as the "debris" of the uterine lining, the result of necrosis, or death of tissue. The descriptions imply that a system has gone awry, making products of no use, not to specification, unsalable, wasted, scrap. An illustration in a widely used medical text shows menstruation as a chaotic disintegration of form, complementing the many texts that describe it as "ceasing," "dying," "losing," "denuding," "expelling."[3]

Male reproductive physiology is evaluated quite differently. One of the texts that sees menstruation as failed production employs a sort of breathless prose when it describes the maturation of sperm: "The mechanisms which guide the remarkable cellular transformation from spermatid to mature sperm remain uncertain.... Perhaps the most amazing characteristic of spermatogenesis is its sheer magnitude: the normal human male may manufacture several hundred million sperm per day."[4] In the classic text *Medical Physiology*, edited by Vernon Mountcastle, the male/female, productive/destructive comparison is more explicit: "Whereas the female *sheds* only a single gamete each month, the seminiferous tubules *produce* hundreds of millions of sperm each day" (emphasis mine).[5] The female author of another text marvels at the length of the microscopic seminiferous tubules, which, if uncoiled and placed end to end, "would span almost one-third of a mile!" She writes, "In an adult male these structures produce millions of sperm cells each day." Later she asks, "How is this feat accomplished?"[6] None of these texts expresses such intense enthusiasm for any female processes. It is surely no accident that the "remarkable" process of making sperm involves

precisely what, in the medical view, menstruation does not: production of something deemed valuable.[7]

One could argue that menstruation and spermatogenesis are not analogous processes and, therefore, should not be expected to elicit the same kind of response. The proper female analogy to spermatogenesis, biologically, is ovulation. Yet ovulation does not merit enthusiasm in these texts either. Textbook descriptions stress that all of the ovarian follicles containing ova are already present at birth. Far from being *produced,* as sperm are, they merely sit on the shelf, slowly degenerating and aging like overstocked inventory: "At birth, normal human ovaries contain an estimated one million follicles [each], and *no new* ones appear after birth. Thus, in marked contrast to the male, the newborn female already has all the germ cells she will ever have. Only a few, perhaps 400, are destined to reach full maturity during her active productive life. All the others degenerate at some point in their development so that few, if any, remain by the time she reaches menopause at approximately 50 years of age."[8] Note the "marked contrast" that this description sets up between male and female: the male, who continuously produces fresh germ cells, and the female, who has stockpiled germ cells by birth and is faced with their degeneration.

Nor are the female organs spared such vivid descriptions. One scientist writes in a newspaper article that a woman's ovaries become old and worn out from ripening eggs every month, even though the woman herself is still relatively young: "When you look through a laparoscope . . . at an ovary that has been through hundreds of cycles, even in a superbly healthy American female, you see a scarred, battered organ."[9]

To avoid the negative connotations that some people associate with the female reproductive system, scientists could begin to describe male and female processes as homologous. They might credit females with "producing" mature ova one at a time, as they're needed each month, and describe males as having to face problems of degenerating germ cells. This degeneration would occur throughout life among spermatogonia, the undifferentiated germ cells in the testes that are the long-lived, dormant precursors of sperm.

But the texts have an almost dogged insistence on casting female processes in a negative light. The texts celebrate sperm production because *it is* continuous from puberty to senescence, while they portray egg production as inferior because it is finished at birth. This makes the female seem unproductive, but some texts will also insist that it is she who is wasteful.[10] In a section heading for *Molecular Biology of the Cell,* a best-selling text, we are told that "oogenesis is wasteful." The text goes on to emphasize that of the seven million oogonia, or egg germ cells, in the female embryo, most degenerate in the ovary. Of those that do go on to become oocytes, or eggs, many also degenerate, so that at birth only two million eggs remain in the ovaries. Degeneration continues throughout a woman's life: by puberty 300,000 eggs remain, and only a few are present by menopause. "During the 40 or so years of a woman's reproductive life, only 400 to 500 eggs will have been released," the authors write. "All the rest will have degenerated. It is still a mystery why so many eggs are formed only to die in the ovaries."[11]

The real mystery is why the male's vast production of sperm is not seen as wasteful.[12] Assuming that a man "produces" 100 million (10^8) sperm per day (a conservative estimate) during an average reproductive life of sixty years, he would produce well over two trillion sperm in his lifetime. Assuming that a woman "ripens" one egg per lunar month, or thirteen per year, over the course of her forty-year reproductive life, she would total five hundred eggs in her lifetime. But the word "waste" implies an excess, too much produced. Assuming two or three offspring, for every baby a woman produces, she wastes only around two hundred eggs. For every baby a man produces, he wastes more than one trillion (10^{12}) sperm.

How is it that positive images are denied to the bodies of women? A look at language—in this case, scientific language—provides the first clue. Take the egg and the sperm.[13] It is remarkable how "femininely" the egg behaves and how "masculinely" the sperm.[14] The egg is seen as large and passive.[15] It does not *move* or journey, but passively "is transported," "is swept,"[16] or even "drifts"[17] along the fallopian tube. In utter contrast, sperm are small, "streamlined,"[18] and invariably active. They "deliver" their genes to

the egg, "activate the developmental program of the egg,"[19] and have a "velocity" that is often remarked upon.[20] Their tails are "strong" and efficiently powered.[21] Together with the forces of ejaculation, they can "propel the semen into the deepest recesses of the vagina."[22] For this they need "energy," "fuel,"[23] so that with a "whiplashlike motion and strong lurches"[24] they can "burrow through the egg coat"[25] and "penetrate" it.[26]

At its extreme, the age-old relationship of the egg and the sperm takes on a royal or religious patina. The egg coat, its protective barrier, is sometimes called its "vestments," a term usually reserved for sacred, religious dress. The egg is said to have a "corona,"[27] a crown, and to be accompanied by "attendant cells."[28] It is holy, set apart and above, the queen to the sperm's king. The egg is also passive, which means it must depend on sperm for rescue. Gerald Schatten and Helen Schatten liken the egg's role to that of Sleeping Beauty: "a dormant bride awaiting her mate's magic kiss, which instills the spirit that brings her to life."[29] Sperm, by contrast, have a "mission,"[30] which is to "move through the female genital tract in quest of the ovum."[31] One popular account has it that the sperm carry out a "perilous journey" into the "warm darkness," where some fall away "exhausted." "Survivors" "assault" the egg, the successful candidates "surrounding the prize."[32] Part of the urgency of this journey, in more scientific terms, is that "once released from the supportive environment of the ovary, an egg will die within hours unless rescued by a sperm."[33] The wording stresses the fragility and dependency of the egg, even though the same text acknowledges elsewhere that sperm also live for only a few hours.[34]

In 1948, in a book remarkable for its early insights into these matters, Ruth Herschberger argued that female reproductive organs are seen as biologically interdependent, while male organs are viewed as autonomous, operating independently and in isolation:

> At present the functional is stressed only in connection with women: it is in them that ovaries, tubes, uterus, and vagina have endless interdependence. In the male, reproduction would seem to involve "organs" only.
>
> Yet the sperm, just as much as the egg, is dependent on a great many related processes. There are secretions which mitigate the urine in the urethra before ejaculation, to protect the sperm. There is the reflex shutting off of the bladder connection, the provision of prostatic secretions, and various types of muscular propulsion. The sperm is no more independent of its milieu than the egg, and yet from a wish that it were, biologists have lent their support to the notion that the human female, beginning with the egg, is congenitally more dependent than the male.[35]

Bringing out another aspect of the sperm's autonomy, an article in the journal *Cell* has the sperm making an "existential decision" to penetrate the egg: "Sperm are cells with a limited behavioral repertoire, one that is directed toward fertilizing eggs. To execute the decision to abandon the haploid state, sperm swim to an egg and there acquire the ability to effect membrane fusion."[36] Is this a corporate manager's version of the sperm's activities—"executing decisions" while fraught with dismay over difficult options that bring with them very high risk?

There is another way that sperm, despite their small size, can be made to loom in importance over the egg. In a collection of scientific papers, an electron micrograph of an enormous egg and tiny sperm is titled "A Portrait of the Sperm."[37] This is a little like showing a photo of a dog and calling it a picture of the fleas. Granted, microscopic sperm are harder to photograph than eggs, which are just large enough to see with the naked eye. But surely the use of the term "portrait," a word associated with the powerful and wealthy, is significant. Eggs have only micrographs or pictures, not portraits.

One depiction of sperm as weak and timid, instead of strong and powerful—the only such representation in western civilization, so far as I know—occurs in Woody Allen's movie *Everything You Always Wanted To Know About Sex**But Were Afraid to Ask.* Allen, playing the part of an apprehensive sperm inside a man's testicles, is scared of

the man's approaching orgasm. He is reluctant to launch himself into the darkness, afraid of contraceptive devices, afraid of winding up on the ceiling if the man masturbates.

The more common picture—egg as damsel in distress, shielded only by her sacred garments; sperm as heroic warrior to the rescue—cannot be proved to be dictated by the biology of these events. While the "facts" of biology may not *always* be constructed in cultural terms, I would argue that in this case they are. The degree of metaphorical content in these descriptions, the extent to which differences between egg and sperm are emphasized, and the parallels between cultural stereotypes of male and female behavior and the character of egg and sperm all point to this conclusion.

NEW RESEARCH, OLD IMAGERY

As new understandings of egg and sperm emerge, textbook gender imagery is being revised. But the new research, far from escaping the stereotypical representations of egg and sperm, simply replicates elements of textbook gender imagery in a different form. The persistence of this imagery calls to mind what Ludwik Fleck termed "the self-contained" nature of scientific thought. As he described it, "the interaction between what is already known, what remains to be learned, and those who are to apprehend it, go to ensure harmony within the system. But at the same time they also preserve the harmony of illusions, which is quite secure within the confines of a given thought style."[38] We need to understand the way in which the cultural content in scientific descriptions changes as biological discoveries unfold, and whether that cultural content is solidly entrenched or easily changed.

In all of the texts quoted above, sperm are described as penetrating the egg, and specific substances on a sperm's head are described as binding to the egg. Recently, this description of events was rewritten in a biophysics lab at Johns Hopkins University—transforming the egg from the passive to the active party.[39]

Prior to this research, it was thought that the zona, the inner vestments of the egg, formed an impenetrable barrier. Sperm overcame the barrier by mechanically burrowing through, thrashing their tails and slowly working their way along. Later research showed that the sperm released digestive enzymes that chemically broke down the zona; thus, scientists presumed that the sperm used mechanical *and* chemical means to get through to the egg.

In this recent investigation, the researchers began to ask questions about the mechanical force of the sperm's tail. (The lab's goal was to develop a contraceptive that worked topically on sperm.) They discovered, to their great surprise, that the forward thrust of sperm is extremely weak, which contradicts the assumption that sperm are forceful penetrators.[40] Rather than thrusting forward, the sperm's head was now seen to move mostly back and forth. The sideways motion of the sperm's tail makes the head move sideways with a force that is ten times stronger than its forward movement. So even if the overall force of the sperm were strong enough to mechanically break the zona, most of its force would be directed sideways rather than forward. In fact, its strongest tendency, by tenfold, is to escape by attempting to pry itself off the egg. Sperm, then, must be exceptionally efficient at *escaping* from any cell surface they contact. And the surface of the egg must be designed to trap the sperm and prevent their escape. Otherwise, few if any sperm would reach the egg.

The researchers at Johns Hopkins concluded that the sperm and egg stick together because of adhesive molecules on the surfaces of each. The egg traps the sperm and adheres to it so tightly that the sperm's head is forced to lie flat against the surface of the zona, a little bit, they told me, "like Br'er Rabbit getting more and more stuck to tar baby the more he wriggles." The trapped sperm continues to wiggle ineffectually side to side. The mechanical force of its tail is so weak that a sperm cannot break even one chemical bond. This is where the digestive enzymes released by the sperm come in. If they start to soften the zona just at the tip of the sperm and the sides remain stuck, then the weak, flailing

sperm can get oriented in the right direction and make it through the zona—provided that its bonds to the zona dissolve as it moves in.

Although this new version of the saga of the egg and the sperm broke through cultural expectations, the researchers who made the discovery continued to write papers and abstracts as if the sperm were the active party who attacks, binds, penetrates, and enters the egg. The only difference was that sperm were now seen as performing these actions weakly.[41] Not until August 1987, more than three years after the findings described above, did these researchers reconceptualize the process to give the egg a more active role. They began to describe the zona as an aggressive sperm catcher, covered with adhesive molecules that can capture a sperm with a single bond and clasp it to the zona's surface.[42] In the words of their published account: "The innermost vestment, the *zona pellucida,* is a glycoprotein shell, which captures and tethers the sperm before they penetrate it. . . . The sperm is captured at the initial contact between the sperm tip and the *zona.* . . . Since the thrust [of the sperm] is much smaller than the force needed to break a single affinity bond, the first bond made upon the tip-first meeting of the sperm and *zona* can result in the capture of the sperm."[43]

Experiments in another lab reveal similar patterns of data interpretation. Gerald Schatten and Helen Schatten set out to show that, contrary to conventional wisdom, the "egg is not merely a large, yolk-filled sphere into which the sperm burrows to endow new life. Rather, recent research suggests the almost heretical view that sperm and egg are mutually active partners."[44] This sounds like a departure from the stereotypical textbook view, but further reading reveals Schatten and Schatten's conformity to the aggressive-sperm metaphor. They describe how "the sperm and egg first touch when, from the tip of the sperm's triangular head, a long, thin filament shoots out and harpoons the egg." Then we learn that "remarkably, the harpoon is not so much fired as assembled at great speed, molecule by molecule, from a pool of protein stored in a specialized region called the aerosome. The filament may grow as much as twenty times longer than the sperm head itself before its tip reaches the egg and sticks."[45] Why not call this "making a bridge" or "throwing out a line" rather than firing a harpoon? Harpoons pierce prey and injure or kill them, while this filament only sticks. And why not focus, as the Hopkins lab did, on the stickiness of the egg, rather than the stickiness of the sperm?[46] Later in the article, the Schattens replicate the common view of the sperm's perilous journey into the warm darkness of the vagina, this time for the purpose of explaining its journey into the egg itself: "[The sperm] still has an arduous journey ahead. It must penetrate farther into the egg's huge sphere of cytoplasm and somehow locate the nucleus, so that the two cells' chromosomes can fuse. The sperm dives down into the cytoplasm, its tail beating. But it is soon interrupted by the sudden and swift migration of the egg nucleus, which rushes toward the sperm with a velocity triple that of the movement of chromosomes during cell division, crossing the entire egg in about a minute."[47]

Like Schatten and Schatten and the biophysicists at Johns Hopkins, another researcher has recently made discoveries that seem to point to a more interactive view of the relationship of egg and sperm. This work, which Paul Wassarman conducted on the sperm and eggs of mice, focuses on identifying the specific molecules in the egg coat (the zona pellucida) that are involved in egg–sperm interaction. At first glance, his descriptions seem to fit the model of an egalitarian relationship. Male and female gametes "recognize one another," and "interactions . . . take place between sperm and egg."[48] But the article in *Scientific American* in which those descriptions appear begins with a vignette that presages the dominant motif of their presentation: "It has been more than a century since Hermann Fol, a Swiss zoologist, peered into his microscope and became the first person to see a sperm penetrate an egg, fertilize it and form the first cell of a new embryo."[49] This portrayal of the sperm as the active party—the one that *penetrates* and *fertilizes* the egg and *produces* the embryo—is not cited as an example of an earlier, now outmoded view. In fact, the author reiterates the point later in the article: "Many sperm can bind

to and penetr
an unfertilize
eventually fu
rounding the
egg and givi

The imag
larly startlin
reported is i
egg coat that
Wassarman's
ture. He cal
ZP3, a "sper
waiting role
describe the
it all happen
sperm first a
to receptors
coat, the zo
large numbe
binds to mar
cifically, a si
fits a comple
as a key fits
as the "key"
which one a
this imagery
lock) wait u
we speak o
regard the
ates the fert

NOTES

1. James H
Northw
2. The text
in classe
or medic
library f
Johns H
at other
3. Arthur
(Philade
4. Arthur
S. Lucia

to and penetrate the zona pellucida, or outer coat, of an unfertilized mouse egg, but only one sperm will eventually fuse with the thin plasma membrane surrounding the egg proper (*inner sphere*), fertilizing the egg and giving rise to a new embryo."[50]

The imagery of sperm as aggressor is particularly startling in this case: the main discovery being reported is isolation of a particular molecule *on the egg coat* that plays an important role in fertilization! Wassarman's choice of language sustains the picture. He calls the molecule that has been isolated, ZP3, a "sperm receptor." By allocating the passive, waiting role to the egg, Wassarman can continue to describe the sperm as the actor, the one that makes it all happen: "The basic process begins when many sperm first attach loosely and then bind tenaciously to receptors on the surface of the egg's thick outer coat, the zona pellucida. Each sperm, which has a large number of egg-binding proteins on its surface, binds to many sperm receptors on the egg. More specifically, a site on each of the egg-binding proteins fits a complementary site on a sperm receptor, much as a key fits a lock."[51] With the sperm designated as the "key" and the egg the "lock," it is obvious which one acts and which one is acted upon. Could this imagery not be reversed, letting the sperm (the lock) wait until the egg produces the key? Or could we speak of two halves of a locket matching, and regard the matching itself as the action that initiates the fertilization?

NOTES

1. James Hillman, *The Myth of Analysis* (Evanston, Ill.: Northwestern University Press, 1972), 220.
2. The textbooks I consulted are the main ones used in classes for undergraduate premedical students or medical students (or those held on reserve in the library for these classes) during the past few years at Johns Hopkins University. These texts are widely used at other universities in the country as well.
3. Arthur C. Guyton, *Physiology of the Human Body,* 6th ed. (Philadelphia: Saunders College Publishing, 1984), 624.
4. Arthur J. Vander, James H. Sherman, and Dorothy S. Luciano, *Human Physiology: The Mechanisms of Body Function,* 3d ed. (New York: McGraw Hill, 1980). 483–84.
5. Vernon B. Mountcastle, ed., *Medical Physiology,* 14th ed. (London: Mosby, 1980). 2: 1624.
6. Eldra Pearl Solomon, *Human Anatomy and Physiology* (New York: CBS College Publishing, 1983), 678.
7. For elaboration, see Emily Martin, *The Woman in the Body: A Cultural Analysis of Reproduction* (Boston: Beacon, 1987), 27–53.
8. Vander, Sherman, and Luciano, 568.
9. Melvin Konner, "Childbearing and Age," *New York Times Magazine* (December 27, 1987), 22–23, esp. 22.
10. I have found but one exception to the opinion that the female is wasteful: "Smallpox being the nasty disease it is, one might expect nature to have designed antibody molecules with combining sites that specifically recognize the epitopes on smallpox virus. Nature differs from technology, however: it thinks nothing of wastefulness. (For example, rather than improving the chance that a spermatozoon will meet an egg cell, nature finds it easier to produce millions of spermatozoa.)" (Niels Kaj Jerne, "The Immune System," *Scientific American* 229, no. 1 [July 1973]: 53). Thanks to a *Signs* reviewer for bringing this reference to my attention.
11. Bruce Alberts et al., *Molecular Biology of the Cell* (New York: Garland, 1983), 795.
12. In her essay "Have Only Men Evolved?" (in *Discovering Reality: Feminist Perspectives on Epistemology, Metaphysics, Methodology, and Philosophy of Science,* ed. Sandra Harding and Merrill B. Hintikka (Dordrecht: Reidel, 1983), 45–69, esp. 60–61). Ruth Hubbard points out that sociobiologists have said the female invests more energy than the male in the production of her large gametes, claiming that this explains why the female provides parental care. Hubbard questions whether it "really takes more 'energy' to generate the one or relatively few eggs than the large excess of sperms required to achieve fertilization." For further critique of how the greater size of eggs is interpreted in sociobiology, see Donna Haraway, "Investment Strategies for the Evolving Portfolio of Primate Females," in *Body/Politics,* ed. Mary Jacobus, Evelyn Fox Keller, and Sally Shuttleworth (New York: Routledge, 1990), 155–56.
13. The sources I used for this article provide compelling information on interactions among sperm. Lack of space prevents me from taking up this theme here, but the elements include competition, hierarchy, and sacrifice. For a newspaper report, see Malcolm W. Browne, "Some Thoughts on Self Sacrifice," *New York Times* (July 5, 1988), C6. For a literary rendition, see