

Post - Biomechanics

Difference and Gender in Margulis and Sagan's *What Is Sex?*

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- 1 The cover illustration of *What Is Sex?* features what is in this culture an instantly recognizable image.¹ Moonlike, an ovum hangs in the center against a black background. Off to the lower left a single sperm, its curved tail suggesting movement, points its head toward the egg. This image depicts a moment of anticipation, just before the merger of egg and sperm. As part of the cover illustration this image seems to function as the answer to the question posed by the title. The juxtaposition of the title and this image implies a definition of “sex” that is necessarily linked to reproduction and a fixed dual-gender system. This image of egg and sperm, which stands in for human females and males, suggests that when it comes to answering the question “what is sex?” human beings are central to the discussion.
- 2 Lynn Margulis, a biologist, and Dorion Sagan, a science writer (and her son), have written a scientific narrative that is instructive on how to read this image of egg and sperm ironically. Margulis and Sagan’s work is grounded in the Gaia hypothesis and in a view of evolution that emphasizes symbiosis, interconnectedness, and cooperation rather than natural selection, individuality, and competition. In their work, which explains the origins of sexuality from the perspective of a particular evolutionary theory, sex and reproduction are not automatically linked together. Neither does sex or sexual reproduction require two “opposite” genders. As it turns out, “male” and “female” are only “useful approximations.” Furthermore this scientific narrative is not so narrow in its scope, for its perspective on evolution and sexuality is nonzoocentric. In other words, human beings are not that significant in the larger scheme of things, and there is no hierarchy that positions different forms of life as higher or lower. The merger of egg and sperm is not the moment we’ve all been waiting for, and male and female are not a starting point for defining “sex.”
- 3 Feminist critiques of science have pointed out that the image of egg and sperm is linked to narratives, both popular and scientific, of romance, entrepreneurship and warfare.² Narratives about egg and sperm reinforce gender hierarchies and stereotypes; sperm are active, eggs are passive; sperm are athletic little soldiers on a mission to

conquer the egg; the egg is either a femme fatale or waits as patiently as Pauline to be rescued. These and other scientific narratives about sperm and egg are thus implicated in binary oppositions: male/female, active/passive, self/other, culture/nature (to name but a few). Donna Haraway explains how technoscience is involved in producing these dualisms:

From the eighteenth to the twentieth centuries, the great historical constructions of gender, race and class were embedded in the organically marked bodies of women, the colonized or enslaved, and the worker. Those inhabiting these marked bodies have been symbolically other to the fictive rational self of universal, and so unmarked, species man, a coherent subject. The marked organic body has been a critical locus of cultural and political contestation, crucial both to the language of the liberatory politics of identity and to systems of domination drawing on widely shared languages of nature as a resource for the appropriations of culture.³

- 4 In this spirit, Margulis and Sagan have written a powerful counternarrative that calls into question the very idea of the coherent subject and radically reconceptualizes gender in terms of multiplicity rather than binary oppositions. In their work, Margulis and Sagan provide an explanation of a new perspective on evolution and sex that is grounded in the following ideas: a taxonomy that is inclusive of all forms of life, including microbial life, and a view of evolution that emphasizes symbiosis over adaptation and cooperation over competition. At the same time, the authors provide a critique of the dominant perspective in evolutionary theory generally known as neo-Darwinianism. As I shall show in this essay, the shift from neo-Darwinism to the “new biology” has a potentially transformative effect on evolutionary narratives both in terms of their scope and in terms of the way they imagine relationships between actors, both human and non-human. In my view, an understanding of this shift is crucial for understanding the implications of Margulis and Sagan’s work. Throughout I will discuss examples that make appearances in the authors’ work, such as gene-trading bacteria, tiny creatures that live in the hindguts of termites, exclusively female whiptail lizards, and androgynous hyenas. Through a neo-Darwinian lens, these examples might be considered mere curiosities; it might be tempting to believe that they have little to do with human beings. From a Gaian perspective, however, with its potentially destabilizing narrative, the same examples are mobilized into a radical revision of gender and the

self.

The Ground is Stirring Under Our Feet⁴

- 5 In the opening pages of *What Is Sex?* the authors ask, “Why is sex so misunderstood? Is it because no one knows its history?” To characterize the book as a history of sex is useful, for it does progress chronologically and explains the origins of sexual activity and the ways in which sexual systems have evolved. However, in contrast to some neo-Darwinian accounts, *What Is Sex?* does not chronicle progress toward standard metazoosexuality, but omnidirectional transformations. Furthermore the history of sex begins with bacteria. This is an unusual move, but as Sagan explains, “four fifths of the history of life on Earth has solely been a bacterial phenomenon. Moreover, all plants, animals and fungi and the miscellaneous eukaryotic kingdom known as protocists are bacterial in nature.”⁵ Indeed Margulis and Sagan are fond of pointing out that “bacteria are biochemically and metabolically far more diverse than all plants and animals put together. Their natural history is so bizarre that they would have excited huge interest were they discovered in outer space rather than beneath our feet.”⁶
- 6 The authors’ nonzoocentric perspective widens the scope of traditional evolutionary narratives and transforms relationships between actors, both human and non-human. In particular their narrative is informed by two theoretical developments: a new taxonomy for the classification of life; and the Gaia hypothesis, which emphasizes interconnectedness over autonomy and cooperation over competition. In this section, I will explain these developments and the ways in which they transform scientific narratives about evolution and sex.
- 7 Margulis and Sagan’s nonzoocentric perspective is informed by a taxonomy that posits five kingdoms. In the book *Five Kingdoms: An Illustrated Guide to the Phyla of Life on Earth*, co-authored by Lynn Margulis and Karlene Schwartz, the authors explain that from the time of Aristotle until around the mid-twentieth century, the dominant system for classifying forms of life involved only two kingdoms, plant and animal.⁷ More recently, biologists have shifted to new taxonomies that are able to account for life forms that were not easily classifiable in the old schema, such as bacteria, fungi, and slime molds. Margulis is a proponent of a system of five kingdoms: kingdom bacteria, kingdom protocista, kingdom fungi, kingdom animalia, and kingdom plantae. There are also two “superkingdoms.” Prokaryotes, or bacteria, do not have nucleated cells. Eukaryotes, the superkingdom that encompasses all other forms of life on earth, have nucleated cells. The “lack” of the

nucleus in bacterial cells should not be taken as a disadvantage, and neither should cells with nuclei be understood as a progression from more “primitive” forms. An important feature of the five kingdom taxonomy is that it is not merely additive. In other words, it does not simply account for *more* forms of life while at the same time preserving a hierarchical view of “higher” and “lower” forms of life. That there are no “higher” or “lower” forms of life has implications for human beings who are accustomed to thinking of themselves at the apex of a great chain of being.⁸ As we shall see, bacteria with non-nucleated cells have been powerful agents of change, and without them life as we know it wouldn't exist. The shift in perspective involved in this new taxonomy is important in the authors' reconceptualization of gender and the self.

- 8 While this new taxonomy repositions human beings in Margulis and Sagan's scientific narrative about sex and evolution, the Gaia hypothesis also emphasizes cooperative and interconnected relationships among all forms of life, human beings included. The Gaia hypothesis was developed by James Lovelock and named by the novelist William Golding. Despite its poetic name and the figure of a maternal Earth, the Gaia hypothesis is most decidedly a scientific theory.⁹ From a Gaian perspective, the Earth and all living organisms are “autopoietic.” Autopoiesis is a fundamental principle of the Gaia hypothesis and a replacement for “neo-Darwinian mechanics.”¹⁰ Autopoietic systems are self-bounded, self-maintaining, and self-perpetuating, unlike mechanistic systems that do not create and maintain their own boundaries. As the authors explain it, the Earth's atmosphere is analogous to a circulatory system, which was created and continues to be maintained by life, especially microbial life. Contrary to a neo-Darwinian perspective, the Earth is not just an inert scene to which living beings adapt and find their niche.¹¹ Instead the activity of living beings constitutes the very context in which evolution occurs. Furthermore, from the perspective of the new biology, the more important and interesting evolutionary changes occur not through selection or adaptation but through symbiosis, a “prolonged physical association between two or more different organisms belonging to different species.”¹² While neo-Darwinian narratives imagine living beings engaged in competition for scarce resources, Gaian narratives imagine them working in concert to maintain the autopoietic system that is the Earth. Instead of privileging autonomous individuality, the Gaia hypothesis emphasizes interconnected relationships.
- 9 In the Gaian scene, human beings are not very important. This is not just a question of sheer numbers, or of an assumption that bacteria are more interesting and bizarre than we are. It has to do with our

relatively late arrival and the relatively unimportant role we play in creating and maintaining the Earth as an autopoietic system. Bacteria were here first, and “from a Gaian point of view animals, all of which are covered with and invaded by gas-exchanging microbes, may simply be a convenient way to distribute these microbes more numerous and evenly over the surface of the globe.”¹³ Human beings consume the Earth’s resources in the form of food and air as well as oil and silicon, and produce waste as individuals and as communities. However, our impact on the environment is slight in comparison to that of bacteria. As the authors explain, without bacteria “we would have no air to breathe, no nitrogen in our food, no soil in which to grow crops.”¹⁴ Human beings do not have the same capacity to create the conditions necessary for life. Although the activities of human beings are destructive to other forms of life, we do not have the capacity to destroy life itself.¹⁵ Bacteria were here long before us, and certainly will survive us.

Why Must Our Bodies End at the Skin?¹⁶

- 10 As if it weren’t enough that humans have been ousted from their position at the center and endpoint of evolutionary narratives, Margulis and Sagan also call into question the very idea of the autonomous, self-bounded individual. As Sagan puts it, the “zoological ‘I’” is open to radical revision.¹⁷ That is because of the new biology’s focus on symbiosis rather than adaptation. Because of the multiple symbiotic relationships in which all living creatures are involved, it is difficult to determine where one individual leaves off and another begins. In the case of bacteria, it may be problematic even to think of them as individuals, or even species, and it has been proposed that bacteria constitute a superorganism that spans the entire earth.¹⁸
- 11 Humans and animals might be unwitting vehicles for gas-exchanging microbes, but the relationships created through symbiosis are much more intimate than that. One example cited often in Margulis and Sagan’s work is *Mixotricha paradoxa*, a protocist that lives in the hindgut of a south Australian termite. The termite depends on the protocist for survival because without *M. paradoxa*, the termite would not be able to digest wood. In turn, this protocist depends on spirochete bacteria for survival. In great numbers, the bacteria attach themselves to the protocist and continuously propel it forward, literally keeping the protocist from falling out of the termite. Although the bacteria, protocist, and termite all maintain reproductive independence, they exist in a permanent cooperative relationship with each other.¹⁹

- 12 In a narrative that does not advocate hierarchies of life forms, *Mixotricha paradoxa* cannot be dismissed as a curiosity, or “lower” form of life that is not like us. In any case, termites are not the only organisms involved in prolonged, mutually beneficial relationships with other living creatures. According to Margulis, symbiotic relationships that developed long ago may have played a crucial role in the development of human bodies. The same fast-swimming spirochete bacteria that keep *Mixotricha paradoxa* from falling out of the termite may also have played a role, for example, in the development of motility in human sperm cells, when long ago symbiotic mergers between the bacteria and the sperm cells created the tail that propels the sperm through the reproductive tract.²¹ Margulis and Sagan even speculate that scientists can find the origins of human consciousness itself in bacteria. In the context of Margulis and Sagan's work, the story is a familiar one. “I hypothesize that all these phenomena of mind, from perception to consciousness, originated from the unholy microscopic alliance between hungry killer bacteria and their potential archaeobacterial victims.”²¹ Fast-swimming, active spirochetes invaded the slower-moving archaeobacteria, who fought off the infection by absorbing their potential killers. Neither type of bacteria died; instead both survived in a symbiotic relationship for some one thousand million years. Margulis argues that our nerve cells are the product of such mergers. The movements of our nerve cells, the connections they make when we exercise our memory, suggest the movements of spirochetal remnants.
- 13 Although the Gaia hypothesis and its associated evolutionary theory have the effect of redrawing the boundaries of the individual, the self-bounded individual has not been dissolved entirely. In the discourses that imagine an autonomous body with clearly demarcated boundaries (such as neo-Darwinian evolutionary theory), these boundaries are often imagined to be epidermal. To use Margaret Morse's phrase, human beings have a “skin ego,” or “envelope of identity and self.”²² The idea of a skin ego often is linked with the idea that the presence of bacteria in the body is a sign of infection and a transgression of the body's boundaries. This is not the case in Margulis and Sagan's work. Often what begins as an invasion of “predatory bacteria” is transformed into a necessary, beneficial, and permanent symbiotic relationship. In this context, the boundaries of the body become more permeable. Furthermore the boundaries of living beings always are changing. “Through their membranes, skins and orifices they connect with their surroundings and each other . . . Organisms are far less independent individuals than modern neo-Darwinian biology has assumed.”²³

14 Moreover our bodies are characterized as “open thermodynamic systems.” The authors explain:

individual organisms are open to both energy and materials flowing through them. Indeed the most basic parts of living – eating, breathing, excreting, sex – attest to our status as open thermodynamic systems. It is probably no coincidence that the most natural pleasures – such as thrusting, coming, sneezing, drinking, eating, defecating, urinating, sunbathing, sweating and perhaps even music and vision as the aesthetic delights of sound entering the ear or light waves dancing through the back holes of our pupils to create visual impressions at the back of our retinas – tend to involve orifices and flows.²⁴

The authors, however, go considerably farther when they assert that the self-bounded individual is an *illusion* defined by informational closure. Names, identifying numbers, and titles distinguish us as individuals, and this “closure is exacerbated by the American ethos of individualism.”²⁵ For Margulis and Sagan, individuality is defined in terms of the cybernetic concept of autopoiesis and thus the idea of the “skin ego” has not disappeared entirely but has been redefined. Moreover Margulis and Sagan’s view of the body is affirmative in the sense that it is imagined in terms of its abilities to make connections and undergo transformations.

Three Sexual Systems

15 This affirmative view of the body is connected to a view of sex that involves three sexual systems, and one in which reproduction is not the only result of sexual activity. Accordingly I will discuss three sexual systems, their relationship to the revision of the “zoological ‘I’” and the beginnings of the destabilization of a dual-gendered system. It turns out that the answer to the question “What is sex?” is much more complicated than the cover illustration suggests. When Margulis and Sagan define sex, they do not begin with either reproduction or gender, but with “gene transfer.” There are three distinct kinds of sexual systems:

The first to evolve was the unidirectional type of bacterial sex that led to survival of a finely tuned global bacterial ecological network. Then, a highly specific form of symbiotic hypersex helped form our

nucleated ancestors, the protocists. Most recently in protocist ancestors to fungi, plants and animals the most familiar form of sex evolved: meiotic and fertilization sex involving cell fusion. These were all necessary preludes to gendered bodies, such as ourselves.²⁶

- 16 Transgenic sex in bacteria developed as a shortcut to survival. Under stressful conditions, bacteria trade genes. “Bacterial sex allowed them to change, not only by accumulating mutations, but by receiving genes from their separately evolved, transgenic neighbors.”²⁷ Transgenic bacterial sex reveals a bizarre natural history. Bacteria trade their genes often and easily and do not confine themselves to their own species. The authors use numerous analogies to illustrate how remarkable is transgenic bacterial sex: “If eukaryotes could trade genes as fluidly as do bacteria, it would be a small matter for dandelions to sprout butterfly wings, collide with a bee, exchange genes again and soon be seeing with compound insect eyes.”²⁸ There are many kinds of bacterial gene transfer, but the important thing to keep in mind is that life itself depends on transgenic sex, as transgenic sex in bacteria transformed the planet “from a sterile, hostile place into one rich with a variety of abundant life.”²⁹ Transgenic sex is not just a curiosity and does not only affect the bacteria that engage in it.
- 17 The second sexual system, hypersex, also ignores the human taboo of interspecies sex. Hypersex, unlike other forms of sex, is not a temporary encounter, but a “permanent merging through symbiosis to make organisms with genes from more than a single source.”³⁰ Transgenic sex is only a bacterial phenomenon; hypersex is not. The authors explain:

Bacterial unions are the foundation of each animal cell in your body and in each of the cells of plants. Your constituent cells are hypersex hybrids . . . Cells contain tiny organelles called mitochondria which produce energy for the cell by metabolizing oxygen. These microscopic mitochondria were once free living, oxygen-breathing bacteria. In the early days before any animals, plants or fungi had evolved, small predatory bacteria, adept at breathing oxygen, probably forced their way into larger fermenting cells (protocists) with no such capability. With time the

invading agents became mitochondria. They permanently “mated.”³¹

The merger of spirochete bacteria and human cells, which may have resulted in sperm motility and human consciousness, were acts of hypersex. Again hypersex is not just a curiosity but also has been crucial to our own evolution and survival.

- 18 The third sexual system, fertilization or “fusion” sex, is the most familiar system to us, since this is how human beings and many other animals reproduce. Our bodily cells are normally diploid, with two sets of chromosomes. Sperm and egg cells are haploid, with only one set of chromosomes. The process of creating the haploid sperm and egg from diploid cells called spermatocytes and oocytes is called meiosis. “In animals sperm and eggs that eventually find each other, fuse, and form fertilized eggs that form embryos. Haploidy, ending in fertilization, and diploidy, ending in meiosis, form the central cycle of the life history of animals.”³²
- 19 Just as the zoological “I” is open to radical revision, so too is the human dual-gender system. The same scientific narratives that destabilize the self-bounded individual radically destabilize the idea of two genders. Our unimportance and late arrival to the Gaian scene puts things in perspective, as gender is not necessary for sex to occur. Bacteria, which have long engaged in acts of transgenic sex and hypersex, are not gendered.³³ Even the third sexual system, fusion sex, does not require two genders. Whiptail lizards, for example, which are exclusively female, manage to reproduce through the fusion of female haploid cells.³⁴
- 20 The authors go on to speculate that our system of reproductive sex, which depends on a dual-gender system, could very well change in the future. Margulis and Sagan imagine a future in which even human males might not be needed for reproduction. Perhaps the human dual-gendered system might reverse or disappear entirely over the course of evolution. Or it might be that in the future, only a small percentage of the population will reproduce: “Sexual intercourse now prerequisite to reproduction may be co-opted for other roles in future human collectives.”³⁵ Although in the present the link between sex and reproduction is imagined to be fairly strong, over the course of evolution the link could weaken.³⁶
- 21 Margulis and Sagan look to the past as well as the future to destabilize what is thought to be a fixed and necessary two-gender system. As it turns out, two genders, male and female, are effects

of evolution, and not so tightly linked to fusion sex that one is not possible without the other. Fusion sex long preceded humans and other animals. Two billion years ago, in times of stress, single-celled protocists merged in order to survive. The haploid protocists survived in a doubled or even tripled state. Sometimes the mergers weren't successful and the protocists died. At first, there were no significant differences between the mating protocists, but over time, differences evolved. In other words:

Protocists, whose males (or other mates) look the same as females (or other mates), detect each other by very subtle cues. In the beginning, with cells as their only bodies, no specialized genitals or swimming propagules existed. Early mates looked just like each other. Over time, and separately and in many lineages, equal single cells became distinct and unequal. Ultimately, anisogamy appeared in the form of small sperm and large eggs. With time different sorts of mating bodies evolved.³⁷

Gender itself evolved, and over time the gender systems we know might change. A dual gender system is only one of many possibilities. In the next section, I will consider both the possibilities and limitations of Margulis and Sagan's reconceptualization of gender.

The Specter Of Neo-Darwinianism

- 22 “Strange Attractions: Sex and Perception” is the penultimate chapter of *What Is Sex?* Its focus is decidedly zoocentric, with discussion of examples including various species of birds and apes, damselfly, and human beings. Absent from this chapter is the focus on microbial life, symbiosis, and cooperative relationships that characterizes the rest of the book. The point here is not to criticize the authors for this absence, but rather to illustrate the ways in which the tensions between neo-Darwinian and Gaian perspectives manifest themselves in this particular chapter. Here the focus tends to shift more towards neo-Darwinian perspectives, and representations of gender and the self are the most problematic.
- 23 In “Strange Attractions,” Margulis and Sagan “explore the wider context of meiotic [reproductive] sex, then move on to traits, including those of our own species, which have arisen in the wake

of sexual reproduction.”³⁸ This chapter explains, from the perspective of evolutionary theory, how animals (humans included) have developed characteristics that members of their own species find sexually attractive. In other words, when it comes to sexual attraction, appearances do count. The authors explain that perception plays an important role in the selection of prospective mates because, although it is advantageous for individuals to choose the best mate, they can’t detect genotypes, or “DNA making up the genes in the chromosomes of a prospective mate.” Instead we must rely on phenotypes, “or how genes are expressed to make the whole animal.”³⁹ Humans and other animals read outward appearances in each other as signs of fitness to reproduce and to be effective parents. This is so because the development of desirable traits evolved in a context in which relationships between animals of the same species are competitive rather than cooperative. When Margulis and Sagan set up the chapter, accordingly, they begin with an explanation of sperm competition theory, which posits that over the course of evolution males of a given species develop strategies as they compete with each other to fertilize the females.⁴⁰ As evolutionary biologist Robin Baker puts it, sperm competition is the “process by which sperm from different males duke it out inside the female to win the right to fertilize the egg.”⁴¹ According to sperm competition theory, “reproductive success” is the goal of sex, which for males means siring as many offspring as possible and for females selecting the mate who will be the best provider.

- 24 Oddly the critique of neo-Darwinian perspectives that is so prominent elsewhere in Margulis and Sagan’s writing is absent from their discussion of sperm competition, sex, and perception. Sperm competition theory is heavily implicated in the idea of the autonomous individual with clearly demarcated boundaries, cost/benefit analyses of various types of sexual acts and behaviors, the selfish protection of genetic investments, and defines bodies through extended metaphors of capitalism and warfare. Yet in “Strange Attractions,” sperm competition theory is reiterated as a scientific theory that accounts for the relationship between sex and perception.
- 25 In their further discussion of human beings and attraction, in fact, the authors reinforce some fairly traditional ideas. For example, they argue that both “the Renaissance ideal of healthy plumpness [in women]” and the “slim supermodel” are “examples of features favored by sexual selection.” They continue, “Perhaps, in times of relatively limited resources, the bodies of wide-hipped plump

women indicate a potentially greater ability to bear and nurse infants. Alternately in modern, more densely populated urban cultures, slimness may indicate women who are easier and less expensive to support.”⁴² This example naturalizes what are arbitrary and hierarchical social arrangements: whether in the Renaissance or in contemporary society, men are responsible for supporting women financially, while women primarily are responsible for bearing children and caring for them. In the example about pelicans that follows, it is the male pelican that is judged in terms of his appearance. However, this is not a reversal; even in the animal kingdom the male is the breadwinner as the male pelican is judged in terms of how well he appears to be able to catch fish. All of this could readily be found in the most masculinist neo-Darwinian exercise in sociobiology.

Sexual Dimorphism and Reversing Genders

- 26 In spite of examples such as “slim supermodels,” the chapter does question the idea of a fixed, dual gender system through a discussion about sexual dimorphism, though not entirely successfully. Sexual dimorphism is defined in this book as “body size and form, behavior and/or metabolic differences in males and females belonging to the same species.”⁴³ Margulis and Sagan are certainly not the first within the sciences to turn their attention to the question of sexual dimorphism. As Donna Haraway comments, “There is no region of the body, living or dead, soft tissue or bony, that has not been interrogated for the secrets of sex and sexual difference. The construction of organic sexual difference has been a major discursive production.”⁴⁴ Feminists are interested in the problem of sexual dimorphism because the idea has been mobilized to justify hierarchical gendered social relations and because it reinscribes the dichotomous, culturally constructed categories “masculine” and “feminine.”⁴⁵ The authors’ discussion of hyenas and human beings is particularly relevant on this point.
- 27 The final example discussed in “Strange Attractions” is the hyena, whose apparent lack of sexual dimorphism is, from a human perspective at the least, puzzling, and at the worst monstrous. Interestingly, although the topic in question still is “sex and perception,” the point of view has shifted. In the case of hyenas, the authors do not talk about the selection of desirable traits in hyenas from the hyena’s point of view.⁴⁶ Instead hyenas are discussed from the point of view of anxious humans confronted

with the apparent sexual ambiguity of hyenas. As the authors explain, the differences between male and female hyenas are quite subtle; both male and female hyenas appear to have a penis. So subtle are these differences, in fact, that the problem of sexual difference in hyenas was not resolved by scientists until the early 1990s. The authors do not discuss whether puzzled scientists studied hyenas closely in order to determine sexual difference based on other characteristics such as brain size, bone structure, hormone levels, or gendered divisions of labor. They do, however, mention that the female hyenas are vicious hunters. I wonder whether scientific anxiety about hyenas is actually a reaction to the apparent masculinization of the female hyena. As it turns out, the female of the species does not really have a penis; she has a large clitoris and lacks a vagina. Nevertheless hyenas manage to reproduce and perpetuate their species. In what must be a painful process, female hyenas give birth along the length of the urethra and through the clitoris. The authors close the example, and the chapter, with the assertion that although hyenas might seem strange to humans, for their species they are “perfectly normal.”

- 28 From the point of view of a feminist critic, I have mixed reactions to this chapter on sex and perception, in particular to the discussion of sexual dimorphism. On one hand, Margulis and Sagan's assertion that “genders evolve and maybe even ‘reverse’ over time” problematizes what have been essentialist and deterministic views elsewhere in evolutionary theory and biology.⁴⁷ The authors themselves hint at the problem that has occupied many feminist critics: science's tendencies to read cultural constructions of gender onto human and animal bodies. As they explain it, the problem is not the hyenas themselves, but a limited human perspective that finds it difficult to imagine possibilities much beyond “our straight and narrow view.” On the other hand, while Margulis and Sagan problematize the idea of a fixed, dual gender system, they have a tendency here to reinscribe and naturalize the dualistic cultural categories “masculine” and “feminine.”
- 29 The hyena is not just an odd case of gender reversal or ambiguity. Margulis and Sagan argue that perhaps gender reversal will occur in humans, at least in terms of sexually dimorphic characteristics. As the authors explain it, successful human males currently display the same “dominant dimorphic characteristics” as silverback gorillas: “large size, solid musculature useful in jealous combat, male pattern baldness, coarse hair, dark hair and/or skin, low voice, gruff manner, beard, mustache, side burns and

patterned streaks of gray hair.”⁴⁸ The authors also assert, however, that as social arrangements change, displaying the characteristics of the “alpha male” becomes less important and it becomes more and more advantageous for men to “soften” their appearance. The problem is that these characteristics of the “new male” are characterized as “signs of youth and childlike femininity.”⁴⁹ As this example implies, male humans become either more masculine or more feminine. There is little room for ambiguity, or for imagining something else entirely. Genders might reverse, but the dichotomous categories “masculine” and “feminine” remain intact and uninterrogated.

Fifty Thousand Genders

- 30 Nonetheless the book as a whole, with its nonzoocentric perspective, suggests further possibilities for rethinking gender. For example, the definition of gender that appears in the glossary destabilizes the male/female binary and the idea of a fixed system of “opposite” sexes:

Differences between any two complementary organisms that render them capable of mating. Organisms of different gender potentially mate while those of the same gender cannot mate to form fertile offspring. Many species include healthy organisms of hundreds, even thousands of genders. In some, gender (mating type) differences are determined by tiny changes; specific genes and proteins on the surface of mushroom threads (hyphae) give over 50,000 genders in the common fungus, *Schizophyllum*. The bewildering series of genders in ciliates that depend on tiny chemical genetic differences in undulipodial surface proteins (ciliary antigens) give rise to genders that may change in a daily cycle. Maleness and femaleness commonly associated with fertilization by anisogamy where male individuals produce many small, swimming gametes (i.e., sperm) while females produce fewer, larger food-storing gametes (i.e., eggs) is just one of many natural systems.⁵⁰

There are a number of points worth emphasizing here, the first of which is that this nonzoocentric definition of gender does not begin with a binary opposition between male and female. This

definition reinforces the authors' use of the term "gender" with its connotations of contingency as opposed to a fixed system. Margulis and Sagan's definition of gender is akin to Elizabeth Grosz' discussion of gender and difference: "a difference capable of being understood outside the dominance or regime of the One, the self-same, the imaginary play of mirrors and doubles, the structure of binary pairs in which what is different can be understood only as a variation or negation of identity."⁵¹

- 31 Since Margulis and Sagan's definition of gender does not begin with the male/female binary, "male" can no longer function as a stable point of reference, and "female" no longer is constituted as "symbolically other to the fictive self of universal and so unmarked, species man, a coherent subject."⁵² In this system, there are not just two genders, or even a third "intermediate" gender, but multiple genders that in some forms of life number in the hundreds, or tens of thousands. What is remarkable about this definition of gender is not simply that there are so many possible genders, but the ways in which the authors talk about difference. And again a more affirmative view of the body emerges, one that is grounded in multiplicity. As Grosz further explains, multiplicity does not merely mean "many" or "plural," but identities that are defined in terms of their potential to make connections and undergo transformations rather than maintain their sameness over time.
- 32 Margulis and Sagan's history of sex, with its affirmative view of the body and its radical reconceptualization of gender, can be mobilized to address the problem of biological determinism. Biological determinism is a "form of reductionism in that it explains the behaviors and characteristics of societies in terms of biology."⁵³ For feminists, biodeterministic claims are problematic because they naturalize socially constituted hierarchies of gender and race. The weight of biodeterministic claims depends in part on the considerable cultural authority of biological discourse. The power of biodeterministic claims that justify gendered social relations depends on the idea that underneath culturally constituted gender, there is a fixed system of two "biological" sexes. The term commonly used, "biological sex," with its conflation of the terms "biology" and "nature," attests to the authority of biological discourse. Feminist theorists, both inside and outside of the sciences, have written extensively about the problem of biological determinism. Margulis and Sagan's work presents the opportunity for a fresh approach to this problem. The authors (particularly Margulis, who is a working scientist) do not

give up biology's considerable cultural authority. Instead, they call into question the idea of a fixed system of two “biological” sexes. In addition to the assertion that genders might change or reverse over time, their use of language reinforces the idea that gender is contingent. Consistently throughout the book, the term “gender” *always* refers to “difference” while the term “sex” *always* refers to “gene transfer.” The binary sex/gender has been severed, and in this story about evolution and sex it is no longer possible to posit a deterministic relationship between “biological sex” and “culturally constituted gender.” Therefore Margulis and Sagan’s narrative about evolution and sex makes biodeterministic claims about hierarchical gendered social relations less tenable. Admittedly it might be a very long time before genders in human beings reverse or change.⁵⁴ But this scientific narrative, with its nonzoocentric perspective, argues that our current gender system is only one of many existing and viable alternatives.

Sperm and Egg Reconsidered

- 33 In light of the evolutionary narrative produced from the perspective of the new biology, the cover illustration of *What Is Sex?* invites a different reading. The connection between the image of sperm and egg and narratives of romance, entrepreneurship and warfare is weakened, and this image is positioned in relation to a narrative told from the perspective of the Gaia hypothesis, evolution through symbiosis and cooperative relationships. The same evolutionary narrative that displaces human beings from its center also displaces reproductive sex from its center. Although reproductive sex is important to us and other species, so-called “fusion sex” is only one of three possible sexual systems. Moreover, when it comes to maintaining the autopoietic system that is the Earth, transgenic sex and hypersex have been and will continue to be far more important than reproductive sex. Reproductive sex might serve our own selfish interests, but transgenic sex transformed the Earth itself from a sterile and hostile environment into a living system abundant with life. Hypersex transformed human, animal and plant bodies and created permanent, mutually beneficial relationships that transcend the boundaries between species. From a Gaian point of view, defining “sex” in terms of reproduction seems not only erroneous, but also overly self-interested.
- 34 Moreover this evolutionary narrative presents possibilities for transforming bodies, gender and the self. Sperm and egg, which

synechdochally have stood in for human males and human females, can no longer signify autonomous individuals that cooperate with each other only occasionally with the goal of protecting their genetic investments. For one thing, it is difficult to determine where one individual leaves off and another begins. The sperm in its present form may be the product of an act of hypersex that took place long ago – thanks to fast-moving spirochete bacteria, the sperm can propel itself through the reproductive tract. Similarly human and other bodies have been transformed by other acts of hypersex in some interesting and important ways. According to Margulis and Sagan’s scientific narrative, we are not autonomous, self-bounded individuals and never were. Furthermore the merger of sperm and egg can no longer be read as the merger of opposites. As it turns out, male egg and female sperm are not in a fixed, dualistic relationship, but male and female are “useful approximations.” The anomalous chapter on sex and perception demonstrates the limitations of a dualistic system in which the only possibility for change is to reverse. The larger narrative, however, presents an affirmative view of gender and the body that is more concerned with making connections and undergoing transformations than the reproduction and maintenance of the self.

- 35 The shift from neo-Darwinianism to the “new biology” would have a transformative effect on evolutionary narratives in terms of their scope and the way in which they imagine relationships between actors, both human and non-human. An understanding of a taxonomy involving five kingdoms, the Gaia hypothesis, and their transformative effects on evolutionary narratives is crucial for understanding the implications of Margulis and Sagan’s work. Otherwise the three sexual systems, bodies that are products of symbiotic relationships and genders that reverse over time might seem merely curiosities or anomalies for human beings who are accustomed to imagining themselves in terms of an autonomous body, a fixed, dual-gender system and one sexual system. However, in this story human beings are no longer the point of reference against which all other life is measured. In *What Is Sex?* Lynn Margulis and Dorion Sagan have produced a “mutated” evolutionary narrative that provides a compelling alternative to constraining dualisms and self-centered perspectives.⁵⁵

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Notes

- 1** Lynn Margulis and Dorion Sagan, *What is Sex?* New York, Simon and Schuster, 1997.
- 2** For feminist critiques of sperm and egg narratives see Emily Martin, "The Egg and The Sperm: How Science Has Constructed a Romance Based on Stereotypical Male-Female Roles," *Signs*, 16, 1991, pp. 485-501; and Kirsten Dwight, "Sperm Stories: Romantic, Entrepreneurial and Environmental Narratives About Treating Male Infertility," *Science as Culture*, 27, 1997, pp. 246-276. For an example of scientific narratives about sperm warfare, see Robin Baker, *Sperm Wars: The Science of Sex*, New York, Basic Books, 1996.
- 3** Donna Haraway, "The Biopolitics of Postmodern Bodies," *Simians, Cyborgs and Women: The Reinvention of Nature*, New York, Routledge, 1991, p. 210.
- 4** Foucault remarks of his own work, *The Order of Things*, New York, Random House, 1970, p. xxiv: "In attempting to uncover the deepest strata of Western culture, I am restoring to our silent and apparently immobile soil its rifts, its instability, its flaws; and it is the same ground that is once more stirring under our feet." The work of Margulis and Sagan would seem to evidence this again.
- 5** Dorion Sagan, "Metametazoa: Biology and Multiplicity," *Zone 6: Incorporations*, Jonathan Crary and Sanford Kwinter, eds., New York, Zone Books, 1992, p. 377.
- 6** Sagan, "Metametazoa," p. 377.
- 7** Lynn Margulis and Karlene V. Schwartz, *Five Kingdoms: An Illustrated Guide to the Phyla of Life on Earth*, New York, W.H. Freeman, 1998.
- 8** Lynn Margulis and Dorion Sagan, *Slanted Truths: Essays on Gaia, Symbiosis, and Evolution*, New York, Springer, 1997, p. 78.

⁹ Margulis and Sagan emphasize this point throughout the collection *Slanted Truths*. In terms of its institutional status, however, the Gaia hypothesis has not quite achieved complete legitimacy, as scientists interested in pursuing research from this perspective often have trouble obtaining the necessary funding (p. 301). Donna Haraway also characterizes Gaia as a scientific perspective while situating it in a political and an historical context: “Lovelock’s perception was that of a systems engineer gestated in the space program and the multinational energy industry and fed on a heady brew of cybernetics in the 1950s and 1960s, not, say the intuition of a vegetarian feminist mystic suspicious of the cold war’s military-industrial complex and its patriarchal technology.” See “Cyborgs and Symbionts: Living Together in the New World Order,” *The Cyborg Handbook*, Chris Hables Gray, ed., New York, Routledge, 1995, p. xiii.

¹⁰ Margulis and Sagan, *Slanted Truths*, p. 98.

¹¹ For a similar critique of neo-Darwinianism, see Judith Masters, “Evolutionary Theory: Reinventing our Origin Myths,” *Reinventing Biology: Respect for Life and the Creation of Knowledge*, Lynda Birke and Ruth Hubbard, eds., Bloomington, Indiana University Press, 1995, pp. 173-190. Masters argues that through the lens of neo-Darwinism, there is a sharp dichotomy between organisms and their environment which leads to a “strangely static view of natural organization, whereby the world is seen as having been partitioned into niches which exist prior to the organisms that fill them” (p. 176). Masters also argues that neo-Darwinianism imagines humans’ relationship to nature in terms of a masculinist impulse to achieve mastery and domination.

¹² Margulis and Sagan, *What is Sex?* p. 249.

¹³ Margulis and Sagan, *Slanted Truths*, p. 153.

¹⁴ Margulis and Sagan, *Slanted Truths*, p. 78.

¹⁵ This is not to say that human beings are not capable of tremendous damage. When the authors make the claim that humans cannot destroy “life itself” it should be understood that they mean even if we were to destroy all forms of eukaryotic life, bacteria would survive. Because bacteria are so important for creating the conditions necessary for life, new forms of life could emerge. In the preface to a recent edition of *Microcosmos*, the authors acknowledge that the book was “criticized on several

scores, most vehemently for our cavalier attitude toward our own species. We outraged some with the implication that even nuclear war would not be a total apocalypse, since the hardy bacteria underlying life on a planetary scale would doubtless survive it.” Lynn Margulis and Dorion Sagan, *Microcosmos: Four Billion Years of Evolution*, Berkeley, University of California Press, 1997, p. 15.

¹⁶ Donna Haraway, “A Cyborg Manifesto: Science, Technology and Socialist Feminism in the Late Twentieth Century,” *Simians, Cyborgs and Women: The Reinvention of Nature*, New York, Routledge, 1991, p. 178.

¹⁷ Sagan, “Metametazoa,” p. 379.

¹⁸ Sagan, “Metametazoa,” p. 378.

¹⁹ Margulis and Sagan, *Slanted Truths*, p. 43. *M. paradoxa* makes many appearances in Margulis and Sagan's writing. The authors discuss this protocist in *Microcosmos; What Is Sex? What Is Life?* New York, Simon and Schuster, 1995; and more than once in *Slanted Truths*. Donna Haraway also cites this example in her introduction to *The Cyborg Handbook*. In this essay, she discusses Margulis and Sagan's writing about Gaia, and in particular *M. paradoxa*, as examples of cyborgs that are all “part of the same post-World War II clan” (“Cyborgs and Symbionts,” p. xxi). Haraway explains: “*M. paradoxa*, [is] a mixed-up, paradoxical microscopic bit of ‘hair’ (trichos). This little filamentous creature makes a mockery of the notion of the bounded, defended, singular self out to protect its genetic investments” (p. xvii). I cite this example specifically because it is one point of connection between Margulis and Sagan's work and some postmodern writing. Haraway cites their work in this essay, and in turn they cite Haraway's “Cyborg Manifesto” in *What Is Sex?* An interesting feature of Margulis and Sagan's work is its interdisciplinarity. Sagan's essay “Metametazoa” was published in an interdisciplinary collection of essays about “the problem of life itself.” The citations in Margulis and Sagan's co-authored works also are interdisciplinary and include Plato, Descartes, Foucault, Bataille, and Oscar Wilde (to name a few). However, it is worth noting that, although Margulis and Sagan cite authors who are not scientists and who could be characterized as “postmodern” or “post-structuralist,” they cite such authors for purposes of elaboration or illustration. When it comes to citing evidence to support their claims they always cite scientific authors or scientific

evidence. In my view, the way in which they cite different kinds of writing has the effect of demonstrating an affinity for post-structuralism, while at the same time reinforcing the credibility of their writing as scientific.

20 Margulis and Sagan, *Microcosmos*, p. 147.

21 Margulis and Sagan, *Slanted Truths*, p. 115.

22 Margaret Morse, "What Do Cyborgs Eat?" *Culture on the Brink: Ideologies of Technology*, Gretchen Bender and Timothy Druckery, eds., Seattle, Bay Press, 1994, p. 165.

23 Margulis and Sagan, *What is Sex?* p. 113.

24 *Ibid.*, p. 33.

25 *Ibid.*

26 *Ibid.*, p. 80.

27 *Ibid.*, p. 59.

28 Sagan, "Metametazoa," p. 378.

29 Margulis and Sagan, *What is Sex?* p. 61.

30 *Ibid.*, p. 73.

31 *Ibid.*, p. 74.

32 *Ibid.*, pp. 91-92. Note that Margulis and Sagan tell a more egalitarian story of the meeting of sperm and egg – here they "find each other," and "fuse." Out of the picture (for the moment) are narratives about romance, entrepreneurship, sperm competition, sperm warfare, and the conquest of the female reproductive tract.

33 Some scientists tell a different story. As Bonnie Spanier explains it (in *Im/Partial Science: Gender Ideology in Molecular Biology*, Bloomington, Indiana University Press, 1995), biology textbooks designate gender of E. Coli in terms of "+/-," "plus" being "male" bacteria, "minus" being the female. Bacteria do not engage in sexual reproduction through the merger of haploid cells (egg and sperm) and do not have genitalia. Instead, as Spanier explains, "One form of genetic transfer between two cells is the movement of a tiny circle of DNA, called an F (for 'fertility') plasmid, with the aid of a bridge called a pilus. The pilus is a thin

protuberance that grows out from the surface of a plasmid-containing cell (called F+) and attaches to a cell without a plasmid (called F-)” (p. 56). In other words, “male” bacteria are defined in terms of initiating sexual activity. “Female” bacteria are defined in terms of passivity and the lack of a pilus. Spanier, a molecular biologist, concludes, “the designation of male and female strains of E. Coli is simply incorrect by scientific definition.”

34 Margulis and Sagan, *What is Sex?* p. 119.

35 *Ibid.*, p. 216.

36 In his essay, “Michel Foucault” (in *Doom Patrols: A Theoretical Fiction about Postmodernism*, New York, Serpent’s Tail, 1997), Steven Shaviro has appropriated the work of Margulis and Sagan in order to disconnect sexuality from the imperative of procreative heterosexuality. Shaviro argues that in terms of our sexuality we are trapped by culture rather than nature: “Socially enforced norms of human behavior tend to be more rigid and intolerant of change than ‘natural’ constraints ever were” (p. 41). Moreover “overt discourses of liberation are less of a threat to power than is the simple dumb tenacity of the flesh. . . . Bodies stubbornly resists psychological or linguistic categorization. Organs sprout and grow, adapt themselves to new functions, even uproot themselves to new locations. Orifices open and close. Our bodies still retain the marks of the old bacterial freedoms, even when our institutions work busily to suppress them. On the surfaces of the skin, and in the depths of the viscera, we may discover the excesses of an inhuman sexuality” (pp. 42-43). In turn, Margulis and Sagan cite Shaviro in *What Is Sex?* (pp. 218-219).

37 *Ibid.*, p. 96.

38 Margulis and Sagan, *What is Sex?* p. 150. See also Lynn Margulis and Dorion Sagan, *Origins of Sex: Three Billion Years of Genetic Recombination*, New Haven, Yale University Press, 1986.

39 Margulis and Sagan, *What is Sex?* p. 155.

40 *Ibid.*, p. 167.

41 Baker, *Sperm Wars*, p. xiv.

42 Margulis and Sagan, *What is Sex?* p. 162.

43 *Ibid.*, p. 249.

44 Donna Haraway, *Primate Visions: Gender, Race and Nature in the World of Modern Science*, New York, Routledge, 1989, p. 343. Haraway makes this comment in the context of a discussion about feminist interventions within primatology, though as she points out this problem in primatology is only a part of the “extraordinary ‘incitement to discourse’ on sex that has characterized the last two hundred years of the life sciences.” There are numerous examples of feminist scholarship that address this problem. For example, see Londa Schiebinger, “Skeletons in the Closet: The First Illustrations of the Female Skeleton in Eighteenth Century Anatomy,” *The Making of the Modern Body: Sexuality and Society in the Nineteenth Century*, Catherine Gallagher and Thomas Laqueur, eds., Berkeley, University of California Press, 1987. In addition, Bonnie Spanier and Ruth Hubbard discuss the heterosexism in biological concepts of sexual dimorphism. See Bonnie Spanier, *Im/Partial Science*, pp. 21-22; Ruth Hubbard, “Have Only Men Evolved?” *Biological Woman: The Convenient Myth*, Ruth Hubbard, Mary Sue Henifin and Barbara Fried, eds., Cambridge, MA, Schenkman, 1982. For an overview of “failed” scientific attempts to establish or reinforce the idea of sexual dimorphism, see Joyan Sanders and Liss Platt, “Brains on Toast,” *Processed Lives: Gender and Technology in Everyday Life*, Jennifer Terry and Melodie Calvert, eds., New York, Routledge, 1997.

45 Margulis and Sagan, *What is Sex?* p. 249.

46 *Ibid.*, p. 198.

47 *Ibid.*, p. 199.

48 *Ibid.*, p. 187. The comparison of humans and other primates to “solve the problem of human nature” has a long history, as Londa Schiebinger reminds us in her study of eighteenth century science, *Nature’s Body: Gender in the Making of Modern Science*, Boston, Beacon, 1993. Such cross-species comparisons have been mobilized to produce hierarchies of race and gender. As Schiebinger also explains, beards and facial hair have a long history as signs of masculinity and virility. In eighteenth century Europe – during “the great age of classification” – the presence or absence of facial hair signified superiority or inferiority. The absence of facial hair on women indicated a “less than noble character” and there was much discussion amongst naturalists

about the apparent lack of facial hair in Native American men (pp. 120-125). For an account of the production of gender and race in primatology, see Donna Haraway, *Primate Visions: Gender, Race, and Nature in the World of Modern Science*, New York, Routledge, 1989.

49 Margulis and Sagan, *What is Sex?* p. 193.

50 *Ibid.*, pp. 245-246.

51 Elizabeth Grosz, "A Thousand Tiny Sexes," *Gilles Deleuze and the Theater of Philosophy*, Constantin V. Boundas and Dorothea Olkowski, eds., New York, Routledge, 1994, p. 192.

52 Haraway, "Biopolitics," p. 210.

53 Ruth Hubbard, "Human Nature," *Biopolitics: A Feminist and Ecological Reader on Biotechnology*, Vandana Shiva and Ingunn Moser, eds., London, Zed Books, 1995, p. 32.

54 Feminist biologists Anne Fausto Sterling and Ruth Hubbard also problematize the idea of a fixed, dual gender system from a slightly different perspective. Fausto Sterling considers the case of intersexed humans, and argues that such variations are much more common than we might think – people are not normally aware of intersexed humans because medical intervention to fix the "problem" begins immediately after the birth of an intersexed infant. Instead of a dualistic gender system, Fausto Sterling proposes a spectrum of five sexes, ranging from female to male. Ruth Hubbard also writes about natural variations in gender and the flaws of a binary system. In addition, Hubbard points out that in some cultures there exists the idea of "intermediate" genders. See Anne Fausto Sterling, "The Five Sexes: Why Male and Female Are Not Enough," *The Sciences*, March-April, 1993, pp. 20-24; Ruth Hubbard, "Gender and Genitals: Constructions of Social Gender," *Social Text*, Spring-Summer, 1996, pp. 157-166. Also see Gilbert Herdt, "Introduction: Third Sexes and Third Genders," *Third Sex, Third Gender: Beyond Sexual Dimorphism in Culture and History*, Gilbert Herdt, ed., New York, Zone, 1993, pp. 21-81.

55 Haraway, "Cyborgs and Symbionts," p. xix.