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PART II. ARTICULATIONS OF RACE AND GENDER

INTRODUCTION

SUSANNE LETTOW

In recent decades, the formation of the concept of race in the late eighteenth and early nineteenth centuries has attracted much scholarly interest particularly in the history of science, philosophy, and literary studies. At the same time, the naturalization of gender differences, which went hand in hand with the emerging life sciences, has been widely studied and criticized. However, the concept of race and the naturalized, scientific understanding of gender have rarely been studied in relation to each other, although their co-emergence is not just a question of simultaneity. At the end of the eighteenth century, the two ideas play a central role in the process of the temporalization of nature and the emergence of the life sciences. In particular, scientific understandings of race and gender are constituted and disputed within the debates on procreation, generation, and heredity that take place during the period. *Race* and *gender*[1] are thus closely connected to the new focus on diachronic processes of propagation and on long-term successions of individuals, which—in the second half of the eighteenth century—came to be articulated by the neologism *reproduction*.[2] However, the fact that concepts of race and gender co-emerged within the "procreation discourse" (Jocelyn Holland) of the late eighteenth century does not mean that they did so in parallel or homologous ways. On the contrary, connections between *race*, *gender*, and *reproduction*, which were of central importance for population politics later in the nineteenth century, were dispersed and unstable during the period.

The aim of this volume is to inquire into processes of the co-emergence of the concepts of race, gender, and reproduction in the decades around 1800—a period when all these concepts were in the making. To explore both continuities and discontinuities with subsequent biopolitical discourses,

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Organic Molecules, Parasites, *Urthiere*

The Controversial Nature of Spermatic Animals, 1749–1841

FLORENCE VIENNE
TRANSLATED BY KATE STURGE

The closing years of the eighteenth century have often been described as a phase of transition from a descriptive and classifying "natural history" to a "science of life" that sought general laws of organic development.[1] This chapter approaches that period of transformation through contemporary investigations of the microscopic animals of semen. In 1677, Antoni van Leeuwenhoek (1632–1723) became one of the first to observe and describe these animalcules. His discoveries led him to propose that sperm contained the preformed embryo.[2] Leeuwenhoek's hypothesis found several adherents, but by the second half of the eighteenth century no naturalist continued to defend the view that the germs, which God had put into the world at the moment of Creation, were preexistent—"encased" within the spermatic animalcule.[3] However, if the animalcules were not the preexisting germs or embryos of future organisms, what was the *raison d'être* of these peculiar inhabitants of the semen? Were they even animals or living beings at all? From the mid-eighteenth century on, such questions occupied not only the proponents of preexistence theory, but also its adversaries. These opponents are the focus of this chapter. More precisely, I discuss the theories of generation formulated by the naturalist Georges-Louis Leclerc, Comte de Buffon (1708–1788), the physiologist Johann Friedrich Blumenbach (1752–1840), and the physician

and Naturphilosoph Lorenz Oken (1779–1851). All three were seeking to explain the generation of new life in ways that no longer rested on God's act of creation, but their answers led them to fundamentally divergent views of the nature and function of spermatic animals. Buffon regarded these as initial combinations of "organic molecules"; Blumenbach as parasites of the semen; and Oken as primordial animals or *Urthiere*. By comparing these positions, I trace the emergence of different visions of organic nature that were associated with different concepts of gender relations. In addition, I discuss exemplary cases from the development of cell biology that demonstrate to what extent these conflicting views continued to inform the science of life through the nineteenth and well into the twentieth century.

THINKING THE ORGANIC WORLD AS A UNITY: BUFFON AND BLUMENBACH

The second volume of Buffon's natural history, *Histoire naturelle, générale et particulière*, first published in 1749, is dedicated to the issues of reproduction and generation. It includes a report on extensive microscopic investigations of the seminal fluid of human cadavers and of various animals, both male and female. Buffon explains that he only undertook these studies after having formulated his theory of generation,[4] a crucial aspect of which was the notion that nature consisted of an infinite number of organic "particles" or "molecules." When acted on by a force—which Buffon likened to gravity—these "organic particles" united to form both elementary and more complex organized bodies.[5] It was precisely in the hope of "recognizing," as he puts it, these "living organic particles" that he took up his investigations of seminal fluid.[6] Little wonder, then, that what Buffon "saw" when looking at the semen through the microscope deviated critically from the engravings prepared by Leeuwenhoek. For example, he notes that Leeuwenhoek's depictions of the so-called spermatic animals generally made them too thick and too long.[7] Neither did they move on their own momentum, as Leeuwenhoek had assumed—rather, this movement was a product of the experimental practices (such as the hand trembling) and the liquids in which they were suspended.[8] Above all, however, Buffon was interested in the animalcules' thread-like appendages, which Leeuwenhoek (erroneously in Buffon's view) had described as "tails." For Buffon, this "tail" could not be the body part of an animal. When he placed the seminal fluid of human cadavers under the microscope one to fourteen hours after extraction, he saw that the thread became shorter and shorter. It

increasingly separated from the small moving body and finally disappeared entirely.[9] Buffon observed that the moving bodies' bulk diminished between the tenth and eleventh hour outside the organism. They became little globules, which joined with one another to form a net resembling the "web of a spider besprinkled with drops of dew," with the dew as an enormous number of small globules.[10] Buffon repeated his observations with the seminal fluid of a living dog, "emitted in the natural manner," and with the semen of dissected dogs, rabbits, and rams, taken from the testicles. In all cases he found small moving bodies similar in form and size to those in human seminal fluid. The processes that occurred when Buffon examined the semen microscopically at different intervals were also the same: the detachment of the so-called tail, its transformation into small globules and finally the associations into which those globules entered.[11] What the naturalists had hitherto considered to be animals and living beings, therefore, Buffon reinterpreted as "the first union or assemblages" of "organic particles."[12]

Buffon's proof that the semen did not contain living animals but living organic molecules was of prime importance in confirming his theory of generation. At stake was not only a critique of the animalculist version of preexistence theory. Perhaps to an even greater extent, the objective of his microscopic studies was to refute the theory's ovist version. For this reason, his discussion of reproduction challenged not only the work of Leeuwenhoek and his disciples, but also that of William Harvey (1578–1657) and of his student Reinier de Graaf (1641–1673). Both had emphasized the importance of the ovum in generation.[13] Buffon's aim was to refute Harvey's view that human beings and animals came from eggs; the egg was, he argued, neither the place where the chick was formed, nor did it function as an agent of generation. It could not be understood as an active and essential unit of generation but served solely to nourish the embryo.[14] Indeed, for Buffon the vesicle that de Graaf had described as an *ovum*—due to its resemblance to the *ova* found in the ovaries of hens—was not an egg at all. It was wrong to assume that mammals possessed eggs, and this error had, according to Buffon, led Harvey and de Graaf to the incorrect view that only one sex played a role in generation.[15] He cast doubt not only on this view but, more generally, on all those theories of generation that assumed an asymmetrical contribution to generation by the two sexes. Such theories included the Aristotelian dichotomy between form and matter, according to which the man represented the sole generative force, or efficient principle, whereas the woman supplied matter in the shape of menstrual blood. Buffon gave little credence to Aristotle's notion that seminal fluid contributed no matter but worked like a sculptor

forming a piece of marble, and he equally disregarded all other attempts to locate the origin of life exclusively in one of the two sexes.[16] In his opinion, the existence of hybrids (for example, the offspring of a donkey and a horse), and especially the fact that children resemble both their mother and their father, put beyond doubt the fact that "both parents have contributed to the formation of the child."[17]

In search of a different theory based on an equivalence of both sexes' contribution to generation, Buffon postulated the existence of a generative material, common to both the male and the female organism. He adopted the view of Hippocrates and Galen that the female sex was endowed with a seminal fluid analogous to that of the male.[18] Taking his cue from Pierre-Louis Moreau de Maupertuis (1698–1759), he assumed that the two seminal fluids had to mix for generation to take place.[19] Once he had carried out his microscopic studies of semen, Buffon needed to extend his investigations to female animals to confirm his theory of generation. In line with his belief that females possessed not ovaries but testes, he dissected a female dog, found the organ in question—with ease, as he stresses in his description of the experiment—and removed a fluid from it. Examining this fluid under the microscope, he "had the satisfaction of perceiving, at the first glance," that it, too, contained small moving bodies. These were "exactly similar" to the bodies he had found in the seminal fluid of the male dog.[20] Buffon repeated his observations with the seminal fluids of other female dogs; he even mixed them with the semen of a male dog. The moving bodies he had observed under the microscope were so similar as to be indistinguishable.[21] From freshly slaughtered cows, as well, it was possible without difficulty to extract the seminal fluid from the testes, and in this fluid Buffon again and again found active, mobile bodies.[22] He had thus established that the female semen contained the same moving, living organic particles.[23] The two seminal fluids—and this was Buffon's main finding—represented two "equally active" materials.[24]

However, if the generative matter of one sex possessed all the necessary preconditions for reproduction, the objection inevitably arose that the other sex was superfluous. To counter that objection, Buffon offered a series of explanations aiming to demonstrate the necessity of both sexes for generation in humans and animals. The molecules contained in the generative matter of the two sexes came from different parts of the parental organisms and were miniature images of individual parts of the body. It was only through the "assemblage" of the organic molecules of the father and the mother that complete organs and full embryos could be formed—some of them female and others male.[25] In another passage, Buffon proposed that the molecules

of one individual could only unfold their full activity through the force or resistance of the molecules of the other. I do not pursue Buffon's thinking on the interplay of the organic molecules of the two sexes any further here.[26] His assumptions regarding the complementary roles of the sexes in reproduction did not lead him to postulate a fundamental distinction or hierarchy between them. On the contrary, Buffon's research aimed to rigorously eliminate all differences between the reproductive bodies and materials. Comparing this with later theories of generation, it is striking that Buffon extends his principle of symmetry to the constitutive elements of both generative materials. The organic molecules of women's and men's seminal fluid were not all identical, because they represented different parts of the body, but they were mutually dependent in their interaction, and in their primary function as life-constituting units they were equally efficient. For Buffon, there were no female and male organic molecules, just as there were no sex-specific generative materials.

In fact, more generally, the presence of the seminal fluid—its production and its function—were not bound up with the body's sexual organs, whether that body was male or female. An important aspect of Buffon's theory of generation was that he saw the seminal fluid as being produced by an excess of nutriment (because women were smaller and took less food, their seminal fluid was present in smaller quantities).[27] Buffon also emphasized that the organic molecules he observed and described in semen did not differ significantly in their strength and effect from those that were present in other plant and animal substances.[28] The difference was merely that semen contained them in more abundance.[29] The organic particles that Buffon identified through his microscopic studies of seminal fluid were, then, not those of a specific substance but those of organic matter in general. In his view, nature comprised only one kind of organic matter—a kind of matter that was common to all organisms, whether animals or plants, and that served not only reproduction but also nutrition and development.[30] That being the case, he described this matter as a "universally prolific substance" or "universal semen."[31] The proof that female animals also possessed this seminal fluid, furnished with the same organic molecules, was crucial to his understanding. By considering Buffon's concept of "universal" organic matter, it becomes possible to grasp the full import of his microscopic studies of the semen. What Buffon observed under the microscope were not living beings, but the first steps in a process of generating life. The initial assemblages of organic molecules that he described in the seminal fluid of both male and female animals illustrated nothing less than the first stage in the reproduction of life—a process that was occurring constantly and everywhere in the whole of the organic world.

The search for a universal principle underlying the generation of life was also pursued by the physician Johann Friedrich Blumenbach in his influential essay *Über den Bildungstrieb und das Zeugungsgeschäfte* (On the formative drive and the business of procreation, 1781).[32] Blumenbach derived his concept of the *Bildungstrieb* (formative drive) from his observations of the regeneration of amputated freshwater polyps and his work on wound healing. Working from these phenomena, he assumed that in "all living creatures, from man to maggot and from cedar to mould," a drive or force was at work that directed not only the process of generation, but also that of reproduction (in the sense of the regeneration of amputated body parts) and nutrition.[33] For Blumenbach, an important feature of the formative drive was its universality: it formed all "organized bodies" to an equal extent, regardless of their length, size and other such physical attributes.[34] In the second edition from 1789, he also emphasized that the formative principle was one of the "forces of life" but that it differed distinctly from all the other forces at work in organized bodies. He regarded the formative drive, in analogy to Newtonian gravity, as being a constantly active power. How the formative drive actually exerted its effect, and the causes (and reasons) of that effect, could not be determined more precisely according to Blumenbach. It was a mysterious force, a *qualitas occulta*.[35]

For Blumenbach generation was one of the three processes subject to this superordinated and generally effective force. Not unlike Buffon, he assumed that the generative matter of both parents, including the "paternal semen," contributed to the generation of a new organism.[36] During fertilization, the "paternal and maternal liquors destined for generation" united and mixed. However, in Blumenbach's view this act and these generative materials were not capable of bringing forth new life on their own. It was only later, when the *Bildungstrieb* took effect, that the hitherto unformed matter began to take form.[37] In other words, Blumenbach's view of generation was characterized by a dichotomy between an immaterial "vital force" and a material devoid of any of the qualities of life. In this respect, Blumenbach's theory of generation differed quite fundamentally from that of Buffon who assumed the existence of vital elements in the material itself. The difference becomes particularly clear in Blumenbach's approach to the spermatic animals. He found equally nonsensical both the idea that spermatic animals were preformed germs of future beings and the attempt to deny their vitality completely: "I cannot conceive how some professed philosophers and natural historians have been led to deny life and voluntary motion of the spermatic animals."[38] The microscopic formations to be found in semen were, in Blumenbach's view, undoubtedly

animals, though animals that had no relationship to the actual generative matter. They were located in this physical substance by mere coincidence; he called them "foreign guests of the male semen."[39]

The dualism between an immaterial vital force and unformed material that underlay Blumenbach's theory of generation made it superfluous for him to analyze the organic material more closely, using a microscope to search, as Buffon had, for active material entities that could generate life. In his essay on the formative drive, Blumenbach referred to the parents' "generative substances" or "liquors." For his theory, it was irrelevant to define those substances and the organs that produced them in more detail, since from Blumenbach's perspective, all the formative processes were steered by an immaterial vital force and were not laid down in self-organized organic matter. Yet despite all the differences between Buffon and Blumenbach, their theories share some important common ground. Both conceive of the organic world in its unity and seek to explain the generation of life in ways that can apply across every distinction to all human beings, animals and plants.

ORDERING THE WORLD THROUGH GENDER HIERARCHY: OKEN

About twenty years after the first edition of Blumenbach's theory of the formative drive, Lorenz Oken remarked that the book was to be found "in the hands of every physician and every naturalist."[40] In Oken's view, the extensive and positive reception of Blumenbach's theory was well-deserved. Oken and Blumenbach gave the same reasons for rejecting preexistence theory, especially in its most recent, ovist variant: they both noted that bastards, monsters, and, more generally, resemblances between fathers and their children could not be explained by preexistence theory.[41] Neither Oken nor Blumenbach were in any doubt that "all formation" occurs through epigenesis.[42] Despite this agreement with Blumenbach, Oken's essay *Die Zeugung* (Generation) undertook what he called an "audacious" attempt to write "in a new way" about the origin and generation of life.[43] Oken proposed a theory of generation that separated him not only from Blumenbach but also from Buffon. What was the nature of his innovation?

Oken's criticism was directed at the fact that Blumenbach, while claiming that a confluence of "certain liquors" occurred in generation, failed to address the issue of how to specify this substance and its components more precisely.[44] At the same time, he criticized Buffon's definition of both sexes' generative substance as consisting of fundamentally identical materials. For Oken there

was no female semen: "the liquor emitted by the female genitals during intercourse" was, he argued, no generative material and must not be confused with the "real semen." Rather, it was a mucus to lubricate the vagina; "a result of the opening uterine orifice."[45] The woman's contribution to generation was, in Oken's understanding, clearly "the female vesicle." The man, in contrast, contributed a truly generative substance: semen that was uniquely male. Only the male semen contained spermatic animals, which Oken—in contrast to Blumenbach's view—did not consider parasites but rather "essential, indeed the essential element of the entire business of generation."[46] Unlike Buffon, who had fully separated the production of organic molecules from the sexed body, Oken thought that spermatic animals were developed exclusively in the testicles of the male organism.[47] Oken's theory of generation, however, involved a further innovation. As he himself stressed, he contested the views of "most recent physiologists," who considered the female vesicle to be the "central point of epigenesis."[48] According to him, the egg in fact supplied neither "a germ nor elementary organic particles nor anything else material, but merely the form."[49]

Buffon, too, had cast fundamental doubt on the importance of the egg for generation. But whereas Buffon's concern was to formulate a theory based on a symmetrical contribution to generation by both sexes, Oken reintroduced an asymmetry. He again made reference to the Aristotelian dualism between form and matter, but imbued it with a different meaning: instead of contrasting female matter with male immaterial formative power, he postulated the existence of only one material unit—the spermatic animals—that assigned the leading role in generation to the man for two reasons. First, it was the spermatic animals "entering" the "female vesicle" that supplied the raw material for the future embryo. Second, these animals were the driving force of the entire process of generation.[50]

However, in Oken's *Die Zeugung* the significance of the spermatic animals is not exhausted by these two functions. Tellingly, Oken usually referred to the spermatic animals as "infusorians."[51] The term embraced both the microscopic entities observed in the human body and all of the entities that appeared in the course of fermentation, the putrefaction of organic substances, or infusions. Whereas eighteenth-century research into these infusorians attempted to prove the animal nature of the microscopic creatures or to substantiate the hypothesis of spontaneous generation, Oken's objective was a different one.[52] For him, the infusorians were neither animals nor could their emergence be described as the creation of animals that did not exist previously. Instead, he attributed their existence to a process of "coming

apart," which referred to the decomposition of a composite organization into its "constituent animals."[53] By inverse inference (as he put it), he proposed the hypothesis that all "higher animals" consist of infusorians or "constituent animals." He called them constituent animals or *Urthiere*—"primordial animals"—because they had, like earth, air, and water, come into being at Creation. An additional reason for Oken to consider them primordial animals was that he believed they represented *Urstoffe* or "primordial substances" of the organic "elements in the organic world."[54] The concept of the infusorians as *Urthiere* was, therefore, connected with the view that they were not merely the fertilizing component of a specifically male generative substance but had a far more comprehensive function: they were, quite simply, the primary units constituting life and generating life.

Although Oken did not use the word *cell* in his 1805 text (at least not with reference to elementary organic forms), historians of biology have often considered his concept of infusorians to anticipate cell theory.[55] Attempting to identify crucial conceptual developments that led to the emergence of the cell theory during the nineteenth century, François Jacob has highlighted the distinctions between Buffon's organic molecules and Oken's infusorians. Both scholars proceeded from the assumption that living bodies consist of elementary units. But, according to Jacob, whereas Buffon's concept of "organic molecules" was influenced by Newtonian mechanics, the breach with the eighteenth-century's mechanical thinking embodied by Oken was a pivotal move toward the cell theory. At the beginning of the nineteenth century, a living body:

> [C]ould no longer be imagined as a mere association of elements as Maupertuis and Buffon envisaged. Even when Oken again brought up the idea that beings were composed of elements, he did not contemplate autonomous units bracketed together, but units amalgamated in the wholeness of the complete organism. Oken's new idea, from which the cell theory was gradually to emerge, was to consider the bodies of large animals in relation to microscopic beings and to visualize the latter as elements of the former—in short, to imagine the complex living organism as an association of simple living organisms.[56]

Oken's conceptualization of the common basic unit of the organic world in analogy to the smallest living beings was thus, in Jacob's view, a decisive innovation. In contrast to earlier understandings, this unit "could no longer be a

simple molecule, an inert element or a portion of matter. It was itself a living body, a complex formation, able to move, feed, and reproduce, a body, in fact, endowed with the principal attributes of life."[57]

I would like to contest Jacob's interpretation by pointing out that even if Buffon did not conceive of his organic molecules as living beings, he certainly did consider them to be mobile, active, and living entities. In Buffon's description of the fundamental unit of the organic world, the term *activity* is of no lesser importance than in Oken. Thus, one of Buffon's conclusions reads: "The life of an animal or vegetable seems to be nothing else than a result of all the particular [activities, all the particular] *lives* (if the expression be admissible) of each of these active particles, whose life is primitive, and perhaps indestructible."[58] A major difference between Buffon and Oken is that Oken reinterpreted this activity, as an exclusively male characteristic. Thus, Oken equates the "active" with the infusorian and the "man," and opposes it to the passive plant or the "woman."[59] The dichotomy of active and passive—in combination with the dichotomy of male and female—however, is not only a key motif in Oken's text, but also appears in the work of other Romantic philosophers of nature, such as Friedrich Joseph Wilhelm Schelling, whose writings had a particularly strong influence on Oken.[60]

This gendered understanding of the "infusoria" is completely left out by Jacob and also by Georges Canguilhem in his essay on the history of the cell theory. Both fail to analyze Oken's book as a whole and focus only on one short quotation from one of the few passages in which gender is not thematized.[61] For Canguilhem, Buffon's and Oken's concepts differ in so far as the latter conceived elementary units of life, which relinquish their individuality to subordinate themselves to a higher unity. Oken's vision of the organism, in Canguilhem's view, results from a rejection of the ideas of the French Revolution and the political philosophy of the Enlightenment: "Oken conceived the organism in the image of society—not society as an association of individuals, as per the political philosophy of the *Aufklärung*, but as the community conceived by Romantic political philosophy."[62] Canguilhem concludes that the history of the cell concept is inextricably entwined with the history of the concept of the individual. In his analysis of vitalism in the Enlightenment era, Peter Hanns Reill likewise locates Oken's theory of generation within the political context of the late eighteenth century. Oken's formative years, Reill reminds us, were dominated by the French Revolution and its consequences. One of Reill's propositions is that in reaction to these political upheavals, which meant chaos and uncertainty for Oken's generation, and especially in opposition to the new ideas of the Enlightenment, Oken and the *Naturphilosophen* affirmed a renewal of hierarchies, order, and clarity. However, for Reill, unlike for Canguilhem, Oken's critique of the Enlightenment did not only imply the individual's subordination to the well-being and continuity of society, but also a redefinition of gender relations.[63]

I would like to take up Reill's point and argue that it is perfectly possible to find notions of gender ambiguity and complementarity in the work of Blumenbach and Buffon. For both scholars, however, the ultimate goal was to formulate explanations for the generation of new life that transcended such ambiguities. What characterized Buffon's organic molecules and Blumenbach's formative force was, as I have shown, their status as universal principles: they were equally present and equally effective in all living beings, plants, and animals, regardless of sex and size. In contrast, Oken wanted to validate an order of life that would secure supremacy for one sex—the male. The principle closing Oken's 1805 treatise is "Nullum vivum ex ovo! Omne vivum e vivo." In studies of the history of the cell theory, this principle has been interpreted as a rejection of spontaneous generation and an anticipation of Virchow's famous formula "Omnis cellula a cellula" of 1855.[64] If we read this against the background of Oken's deliberations on gender relations, it becomes clear that, especially with his notion of the *Urthiere*, Oken aimed to disengage the "origin and reproduction of life" completely from the female body.[65]

COMBINING ANTAGONISTIC VISIONS OF THE ORGANIC WORLD

As I have shown in the previous section, Canguilhem and Jacob did not reflect on the central role of dualistic and hierarchical ideas of gender relations in Oken's *Die Zeugung* or on their implications for his notion of organic elementary units. This omission is characteristic for the prevailing view on the history of cell theory. Although numerous studies have discussed the political analogies and metaphors that shaped this theory, it has so far not been analyzed from a gender perspective. In the concluding part of this chapter, I therefore want to pursue my argument by pointing to a few exemplary cases from nineteenth-century sperm and cell research. The first case is Theodor Schwann (1810–1882), who is widely regarded as the "founding father" of cell theory in the late 1830s. Canguilhem and Jacob have related his cell theory to Oken's notion of organic elementary units. Arguing that both Oken and Schwann conceived these elementary units, respectively "cells," in analogy to living beings, Jacob postulates a historical continuity between their concepts.[66] This

view disregards an important difference. Whereas Oken understood this unit as a male animal, Schwann explicitly defined the cell in gender-neutral terms as an "individual, an autonomous whole."[67] For Schwann, each cell possessed "an autonomous life" as well as an ability and force to induce organic developmental processes.[68] Whereas for Oken the existence of the organism presupposed the subordination and even the destruction of the individual "infusorians," Schwann regarded the organic whole as the result of the interaction and union of autonomous units. So, if any historical parallel can be drawn, it is between Buffon and Schwann.[69] As I mentioned earlier, Buffon regarded the life of an animal or vegetable as the sum of active particles "whose life is primitive and perhaps indestructible."[70] Both Buffon and Schwann searched for a universal law of organic development, a principle that was not only common for animals and plants, but which could also explain all physiological processes, especially the formation of new organisms. In this context, both proposed a new definition of the egg. Whereas Buffon negated the existence of the egg altogether, Schwann equated the structure and development of the egg to that of other organic tissues.[71] As a result, he did not draw a distinction between the formation of the embryo and other cellular processes in living tissues. Like Buffon, Schwann located the origin of life in a unit that transcended the differences of male and female reproductive substances and bodies. In great similarity to Buffon's theory of reproduction, Schwann's cell theory proposed a vision of the organic world that abstracted from differences between the sexes.

My second example refers to the impact of cell theory for the physiology of reproduction. Historians of biology usually assume that the cell concept was immediately applied to the reproductive process.[72] Yet, the nature and function of the male semen remained a matter of controversy well into the second half of the nineteenth century. An understanding of spermatic animals as parasites largely prevailed until the 1840s,[73] and it was not before the 1850s and 1860s that physiologists began to describe sperms as cells and fertilization as a cellular process.[74] I would like to explain briefly the late arrival of this development by presenting the example of Albert Kölliker (1817–1905). In 1841 Kölliker published a lengthy study on the cellular formation of sperm. Here he compared sperms with other "organic elementary particles," especially blood corpuscles and eggs.[75] At the same time, however, he emphasized the peculiar nature of sperms. Although he did not consider them to be animals, and especially not animals "that come in from outside," he did still see them as having one property reminiscent of their animal nature: their motility. For

Kölliker, this was a feature that fundamentally distinguished sperm from egg. Whereas the "principle of repose" inhered in the egg, the "principle of movement," and therefore a "higher life," was present in the sperm. The union of these two complementary principles was necessary for generation, but as a result of their specific characteristics, Kölliker credited the sperms with the role of initiating the fertilization process.[76] The case of Kölliker represents a hegemonic branch of nineteenth-century physiology of reproduction that was permeated by the gender-dualism of Romantic *Naturphilosophie*. The identification of sperms as a specific form of organic elements that was essentially different from eggs and other cells can be attributed to a dichotomic understanding of gender difference.[77]

Today, sperms and eggs are defined as cells. Yet, fertilization is regarded as a process in which the sperm cell—still referred to by the term *spermatozoon*[78]—"penetrates" the egg. Sperms continue to be described as animals with a "head" and a "tail." Their motility or nonmotility, which—along with their number and shape—is regarded as an indicator of male fertility or infertility and is equated with "vitality" or "death." Buffon's reinterpretation of sperms as initial associations of organic molecules completely overthrew the notion of spermatic animals as living beings. The modern understanding of reproduction seems to owe more to Kölliker's and Oken's views, which highlighted the opposition between the male/active and the female/passive parts.[79] In fact, our perspective on reproduction combines two opposing visions of the organic world. One is based on the principles of universality, individual autonomy, and the functional equality of all organic elements, and one is centered on a hierarchical view of gender difference. In contrast to the former, the latter attributes to the male sex a specific, primary role in the formation of life. The studies and debates discussed in this chapter show how far the thinking about the organic world in the eighteenth and nineteenth centuries was shaped by these two perspectives and the antagonism between them. Moreover, it demonstrates that a gender-based approach allows for a reassessment of well-established narratives in the history of biology.

NOTES

1. See Michel Foucault, *The Order of Things: An Archaeology of the Human Sciences* (New York: Vintage, 1994); François Jacob, *The Logic of Life: A History of Heredity*, trans. Betty E. Spillmann (Princeton: Princeton

University Press, 1993); Wolf Lepenies, *Das Ende der Naturgeschichte: Wandel kultureller Selbstvertsändlichkeiten in den Wissenschaften des 18. und 19. Jahrhunderts* (München: Hanser, 1976).

2. This discovery is well known and has often been discussed, see Jean Rostand, *La formation de l'être: Histoire et idées sur la génération* (Paris: Hachette, 1930), 79–88; Jacques Roger, *Les sciences de la vie dans la pensée française du XVIIIe siècle* (Paris: Albin Michel, 1993), 293–322; Jörg Jantzen, "Theorien der Reproduktion und Regeneration," in Friedrich Wilhelm Joseph Schelling, *Ergänzungsband zu Werke Band 5 bis 9: Wissenschaftshistorischer Bericht zu Schellings naturphilosophischen Schriften 1797–1800* (Stuttgart: Frommann und Holzboog, 1994), 588–595; Carlo Castellani, "Spermatozoa Biology from Leeuwenhoek to Spallanzani," *Journal of the History of Biology* 6 (1973):37–68; John Farley, *Gametes & Spores: Ideas about Sexual Reproduction* (Baltimore: Johns Hopkins University Press, 1982), 17–23; *Antoni van Leeuwenhoek 1632–172: Studies On the Life and Work of the Delft Scientist Commemorating the 350th Anniversary of His Birthday*, ed. L. C. Palm and H. A. M. Snelders (Amsterdam: Rodopi, 1982); Edward Ruestow, "Images and Ideas: Leeuwenhoek's Perception of the Spermatozoa," *Journal of the History of Biology* 16 (1983):185–224; Carla Pinto-Correia, *The Ovary of Eve: Egg and Sperm and Preformation* (Chicago: University of Chicago Press, 1997).
3. On the formation and diffusion of the preformation theory in the seventeenth and eighteenth century, see Roger, *Les Sciences*, 324–439; Shirley A. Roe, *Matter, Life, and Generation. Eighteenth-Century Embryology and the Haller-Wolff Debate* (Cambridge: Cambridge University Press, 1981); Pinto-Correia, *The Ovary of Eve*.
4. See Georges-Louis Leclerc, Comte de Buffon, *Histoire naturelle, générale et particulière* (Paris: Imprimerie Royale, 1749–1788), vol. 2:168. The translation of the following quotations by Buffon partly follows the English edition: Georges-Louis Leclerc de Buffon, *Natural History, General and Particular*, trans. William Smellie, vol. 2 (London: Strahan and Cardell, 1781).
5. Buffon, *Histoire naturelle*, vol. 2:54.
6. Ibid., 168. On Buffon's concept of organic molecules, see Roger, *Les Sciences*, 542–558; Peter Hanns Reill, *Vitalizing Nature in the Enlightenment* (Berkeley: University of California Press, 2005), 33–70.
7. Buffon, *Histoire Naturelle*, vol. 2:172.
8. Ibid., 73–174.
9. Ibid., 178–185 and 241–254.

10. Ibid., 186.
11. Ibid., 189 and 189–201.
12. Ibid., 169.
13. On Harvey and de Graaf, see Jantzen, "Theorien der Reproduktion," 566–573; Pinto-Correia, *The Ovary of Eve*, 42–45; Thomas Laqueur, *Making Sex: Body and Gender from the Greeks to Freud* (Cambridge, MA: Harvard University Press, 1990), 142–148, 182.
14. See Buffon, *Histoire Naturelle*, vol. 2:99 and 288–292.
15. Ibid., 130, 133, 288, and 292–297.
16. Ibid., 86–90. On Aristoteles' notion of semen and generation, see Gianna Pomata, "Vollkommen oder verdorben? Der männliche Samen im frühzeitlichen Europa," *L'Homme* 6 (1995):59–85.
17. Buffon, *Histoire Naturelle*, vol. 2:77–68 and 158.
18. Ibid., 92–97. On Galen's two-seed theory, see Pomata, "Vollkommen," 166–170.
19. On Maupertuis and his influence on Buffon, see Roselyne Rey, "Génération et Hérédité au 18e siècle," in *L'Ordre des Caractères: Aspects de L'hérédité dans L'histoire des Sciences de L'homme*, ed. Jean-Louis Fischer and Claude Bénichou (Paris: Sciences en Situation, 1989), 7–41; Rostand, *La Formation*, 103–107.
20. Buffon, *Histoire Naturelle*, vol. 2:202–203.
21. Ibid., 208.
22. Ibid., 210–221.
23. Ibid., 169–170.
24. Ibid., 329.
25. Ibid., 330–331. He assumed that the "assemblage" of an embryo from organic molecules occurred according to a formative principle called "internal mould": "c'est de la réunion de ces parties organiques, renvoyées de toutes les parties du corps de l'animal ou du végétal, que se fait la reproduction, toujours semblable à l'animal ou au végétal dans lequel elle s'opère, parce que la réunion de ces parties organiques ne peut se faire qu'au moyen du moule intérieur, c'est-à-dire, dans l'ordre que produit la forme du corps de l'animal ou du végétal, & c'est en quoi consiste l'essence de l'unité & la continuité des espèces." Buffon, *Histoire Naturelle*, vol. 2:258. On Buffon's generation theory, see Roger, *Les Sciences*, 542–558; Jantzen, "Theorien der Reproduktion," 606–609; Rostand, *La Formation*, 112–117 and Susanne Lettow in this volume.
26. See Buffon, *Histoire Naturelle*, vol. 2:336–337.
27. Ibid., 72.

28. Ibid., 301.
29. Ibid., 422 and 280.
30. Ibid., 420.
31. Ibid., 306, 304, and 425.
32. On Blumenbach's theory of the *Bildungstrieb* and its influence on Kant and the naturalists and physiologists of the late eighteenth and early nineteenth century, see Robert J. Richards, *The Romantic Conception of Life: Science and Philosophy in the Age of Goethe* (Chicago: University of Chicago Press, 2002), 207–237; Reill, *Vitalizing Nature*, 166–171; Jantzen, "Theorien der Reproduktion," 636–668; Timothy Lenoir, "Kant, Blumenbach, and Vital Materialism in German Biology," *Isis* 71 (1980):77–108; Timothy Lenoir, *The Strategy of Life: Teleology and Mechanics in Nineteenth-Century German Biology* (Chicago: University of Chicago Press, 1982).
33. Johann Friedrich Blumenbach, *Über den Bildungstrieb und das Zeugungsgeschäfte* (Stuttgart: Fischer, 1971), 9–13. The following quotations by Blumenbach partly follow the translation by Alexander Crichton, J. F. Blumenbach, *An Essay on Generation* (London: Cadell, 1792).
34. Blumenbach, *Über den Bildungstrieb und das Zeugungsgeschäfte*, 55 and 85.
35. Johann Friedrich Blumenbach, *Über den Bildungstrieb* (Göttingen: Dietrich 1789), 25–26.
36. Blumenbach, *Über den Bildungstrieb und das Zeugungsgeschäfte*, 20. Blumenbach had already pointed to the role of semen in his *Handbuch der Naturgeschichte* (1779); see Lenoir, "Kant, Blumenbach, and Vital Materialism," 82; Richards, "Kant and Blumenbach," 17. In this context he referred to the plant hybridization experiments of Joseph Gottlieb Koelreuter (1733–1806), see Staffan Müller-Wille, Vitezslav Orel, "From Linnean Species to Mendelian Factors: Elements of Hybridism, 1751–1870," *Annals of Science* 64 (2007):171–215, 182–191.
37. Blumenbach, *Über den Bildungstrieb und das Zeugungsgeschäfte*, 42 and 46.
38. Ibid., 32.
39. Ibid.
40. Lorenz Oken, *Die Zeugung* (Würzburg: Goebhardt, 1805), 102.
41. Ibid., 37–57.
42. Ibid., 107
43. Ibid., iii.
44. Ibid., 108.

45. Ibid., 98.
46. Ibid., 101 and 102.
47. Ibid., 61.
48. Ibid., 101.
49. Ibid., 103.
50. Ibid.
51. The term "infusorians" was introduced by Martin Frobenius Ledermüller in 1763. See *Geschichte der Biologie: Theorien, Methoden, Institutionen, Kurzbiographien*, ed. Ilse Jahn (Jena: Fischer, 1998), 267. It referred to all microscopic animals that were up to than subsumed under the Latin notion "animalculae." The study of infusorians started in the late seventeenth century; see Marc J. Ratcliff, *The Quest for the Invisible: Microscopy in the Enlightenment* (Farnham: Ashgate, 2009), 177–215.
52. On the history of spontaneous generation, see John Farley, *The Spontaneous Generation Controversy from Descartes to Oparin* (Baltimore: Johns Hopkins University Press, 1977).
53. Oken, *Die Zeugung*, 21.
54. Ibid., 22.
55. See Georges Canguilhem, *Knowledge of Life*, trans. Paola Marrati and Todd Meyers (Fordham University Press 2008), 39–40; Jacob, *The Logic of Life*, 114–116; William Colemann *Biology in the Nineteenth Century: Problems of Form, Function, and Transformation* (New York: Wiley, 1971), 25–26; Henry Harris, *The Cells of the Body: A History of Somatic Cell Genetics* (Cold Spring Harbor: Laboratory Press, 1995), 1–3; Jahn, *Geschichte der Biologie*, 290–292. Ilse Jahn points out that Oken used the term *cell* as early as 1809, see p. 292.
56. François Jacob, *The Logic of Life*, 114–115.
57. Ibid., 116.
58. Buffon, *Histoire Naturelle*, vol. 2:340.
59. Oken, *Die Zeugung*, 116 and 150.
60. On gender dichotomies in Schelling's philosophy see Lettow and Alison Stone in this volume, and Claudia Honegger, *Die Ordnung der Geschlechter: Die Wissenschaften vom Menschen und das Weib* (Frankfurt am Main: Campus, 1991), 182–190. Oken himself referred to Schelling's influence on his thinking, see Oken, *Die Zeugung*, iv. On the general importance of gender differences in the late eighteenth century, see Ute Frevert, *Mann und Weib, und Weib und Mann: Geschlechter-Differenzen in der Moderne* (München: Beck, 1995); Honegger, *Die Ordnung*; Laqueur, *Making Sex*.
61. "Die Verbindung der Urthiere im Fleische ist nicht zu denken, als etwa

eine mechanische Aneinanderklebung eines Thierchens an das andere, wie ein Haufen Sand, in dem keine andere Vereinigung stattfindet, als des Beieinanderliegens mehrerer Körnchen—nein! Ähnlich dem Verschwinden des Wasserstoffes und Sauerstoffs im Wasser, des Quecksilbers und Schwefels im Ainober, ist es eine wahre Durchdringung, Verwachsung, ein Einswerden all dieser Thierchen, die von nun an kein eigenes Leben führen, sondern alle, im Dienste des höheren Organismus befangen, zu einer und derselben Funktion hinarbeiten, oder diese Funktion durch ihr Indentischwerden selbst sind. Hier wird keines Individualität geschont, dies geht für sich schlechthin zu Grunde, und aber nur uneigentlich gesprochen, die Individualität aller bilden nur Eine Individualität—jene werden vernichtet, und diese tritt erst aus jener Vernichtung hervor." Oken, *Die Zeugung*, 23.

62. See Canguilhem, *Knowledge of Life*, 39–42.
63. See Reill in this volume and Reill, *Vitalizing Nature*, 220–236. On the issue of gender differences in Oken's theory of generation, see also Dietmar Schmidt, "Klimazonen des Geschlechts: Zeugung um 1800," *Metis* 17 (2000):5–29.
64. See Harris, *The Cells of the Body*, 3.
65. Oken, *Die Zeugung*, iii.
66. See in particular Renato Mazzolini, *Politisch-biologische Analogien im Frühwerk Rudolf Virchows* (Marburg: Basiliken-Presse, 1988); Laura Otis, *Membranes: Metaphors of Invasion in Nineteenth-Century Literature, Science and Politics* (Baltimore: Johns Hopkins University Press, 1999); Eva Johach, *Krebszellen und Zellenstaat: Zur medizinischen und politischen Metaphorik in Rudolf Virchows Zellularpathologie* (Freiburg i. Br. u.a.: Rombach, 2008).
67. Theodor Schwann, *Mikroskopische Untersuchungen über die Übereinstimmung in der Struktur und dem Wachstume der Tiere und Pflanzen* (Leipzig: Engelmann, [1839] 1910), 4.
68. Schwann, *Mikroskopische Untersuchungen*, 189.
69. Buffon's place in the history of the cell theory has often been discussed, but not from a gender perspective, see Canguilhem, *Knowledge of Life*, 33–37; Staffan Müller-Wille, "Cell theory, specificity, and reproduction, 1837–1870," *Studies in History and Philosophy of Biological and Biomedical Sciences* 41 (2010):225–231; Daniel J. Nicholson, "Biological atomism and cell theory," *Studies in History and Philosophy of Biological and Biomedical Sciences* 41 (2010):202–211.
70. See Buffon, *Histoire naturelle*, vol. 2:340.

71. See Schwann, *Mikroskopische Untersuchungen*, 40–60.
72. See, for instance Jacob, *The Logic of Life*, 125.
73. See, for instance, the entry "Vom Samen" in Johannes Müller, *Handbuch der Physiologie des Menschen* (Coblenz: Hölscher, 1840), vol. 2:633–651.
74. See Ferdinand Keber, *Ueber den Eintritt der Samenzellen in das Ei: Ein Beitrag zur Physiologie der Zeugung* (Königsberg: Bornträger 1853); Schweigger-Seidel, "Über die Samenkörperchen und ihre Entwicklung," *Archiv für mikroskopische Anatomie* 1 (1865):309–335; Adolph Lavalette St. George, "Über die Genese der Samenkörper," *Archiv für mikroskopische Anatomie* 1 (1865):403–414.
75. Albert Kölliker, *Beiträge zur Kenntniss der Geschlechterverhältnisse und der Samenflüssikeit wirbelloser Thiere nebst einem Versuch über das Wesen und die Bedeutung der sogenannten Samenthiere* (Berlin: Logier, 1841), 75.
76. Kölliker, *Beiträge zur Kenntniss der Geschlechterverhältnisse*, 74 and 82, see also 83–84.
77. For a longer development of this argument, see Florence Vienne, "Vom Samentier zur Samenzelle: Die Neudeutung der Zeugung im 19. Jahrhundert," *Berichte zur Wissenschaftsgeschichte* 32 (2009):221–229.
78. It was Karl Ernst von Baer (1792–1876), one of the pioneers of modern embryology, who introduced the modern name "spermatozoa" in 1827, yet even he considered these to be parasites and denied them any role in generation. See Karl Ernst von Baer, "Beiträge zur Kenntnis der niederen Tiere," *Verhandlungen der kaiserlichen Leopoldinisch Carolinischen Akademie der Naturforscher* 13 (1827):558–659, p. 640; and the *Die Physiologie als Erfahrungswissenschaft*, ed. Friedrich Burdach (Leipzig: Voss, 1826), vol. 1:90–95.
79. Helga Satzinger shows that this opposition still informed Theodor Boveri's theory of fertilization, see Helga Satzinger, *Differenz und Vererbung: Geschlechterordnungen in der Genetik und Hormonforschung 1890–1950* (Köln: Böhlau, 2009), 83–111.