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SEXING THE BODY

GENDER POLITICS *and the* CONSTRUCTION *of* SEXUALITY

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7

DO SEX HORMONES REALLY EXIST? (GENDER BECOMES CHEMICAL)

Getting Ready for the Deluge

CARL MOORE'S AND DOROTHY PRICE'S WORK DID NOT END CONFUSION about the biological nature of masculinity and femininity, nor about the hormones themselves. During the decade preceding World War I, scientific insights accumulated slowly, but in the postwar era a new phase of research on hormones—later called the "endocrinological gold rush" and the "golden age of endocrinology"[1]—was made possible by interlocking networks of new scientific and political institutions in the United States and England. Once again, the social worlds that provided the context for scientific work are an essential part of the story; in particular, understanding the social context helps us see how our gendered notions about hormones have come to be.

World War I badly disrupted European science. Furthermore, physiologists and biochemists were immersed in the study of proteins. The chemicals used to extract and test proteins, however, did not work on gonadal hormones, which, as events would have it, belonged to a class of molecules called steroids—derivatives of cholesterol—(see figure 7.1). It was not until 1914 that organic chemists identified steroids and found ways to extract them from biological material (although biochemists had hit upon lipid extraction of gonad factors a couple of years earlier).[2] Gonadal hormones had been defined as chemical messengers, but before 1914 nobody knew how to study them as isolated chemical compounds. Instead, as we've seen, their presence could be surmised only through a complex combination of surgery and implantation. One skeptical scientist wrote that researchers in this early period relied on the testing of "ill-defined extracts on hysterical women and cachexic girls." By the end of World War I, "The social and scientific hopes of a medical endocrinology of human sex function and dysfunction had not been fulfilled."[3]

Despite the slow accumulation of scientific information about hormones,

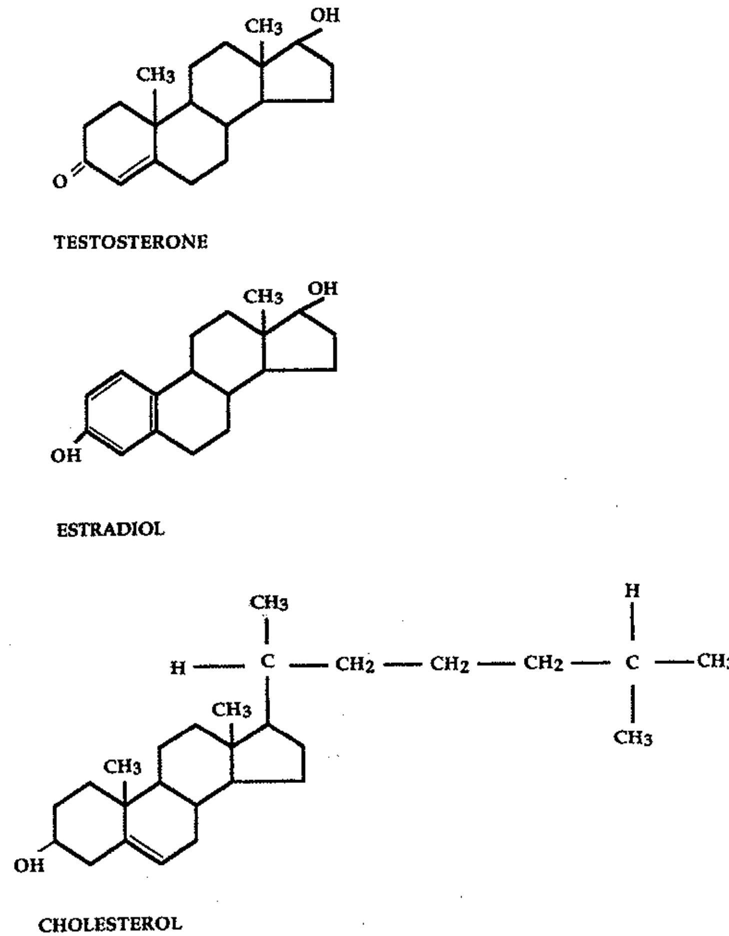

FIGURE 7.1: The chemical structure of testosterone, estradiol, and cholesterol. (Source: Alyce Santoro, for the author)

important changes were afoot. Alliances, intrigue, and melodrama began to link the work of biologists such as Frank Lillie with that of psychologists such as Robert Yerkes, philanthropists such as John D. Rockefeller, Jr., and several stripes of social reformer. These included women who sported the newly minted moniker "feminist,"[4] and (with some double casting) eugenicists, sexologists, and physicians. Hormones, represented on paper as neutral chemical formulae, became major players in modern gender politics.

The early twentieth century was an era of profound crossover between social and scientific knowledge, research and application. The new business managerial class looked to scientific wisdom to help make its workers and complex industrial production processes as efficient as possible;[5] social reformers looked to scientific studies for guidance in managing a host of social ills. Indeed, this was the era in which the social sciences—psychology, sociology, and economics—came into their own, applying scientific techniques to the human condition. Practitioners of the so-called hard sciences, meanwhile, also saw themselves as experts with something to say about social matters, devising scientific solutions for problems ranging from prostitution, divorce, and homosexuality to poverty, inequality, and crime.[6]

The intertwining biographies of the era's most passionate social reformers with those of its most prominent scientific researchers point to the complex connections between social and scientific agendas. Consider, for instance, the role that science and scientists played in the lives of some early-twentieth-century feminists and as they formulated their ideas about gender.[7] As a young woman, Olive Schreiner, the South African feminist and novelist, had a love affair with Havelock Ellis, one of sexology's founding fathers. His influence can be found in her well-known 1911 treatise, *Women and Labor,* in which Schreiner argued that economic freedom for women would lead to greater heterosexual attraction and intimacy.[8] Nor was Schreiner the only feminist Ellis affected. From 1913 to 1915 the birth control activist Margaret Sanger sought him out and became his lover, after traveling to Europe to avoid U.S. prosecution for sending birth control literature through the mail, and for defending an attempt to blow up the Rockefeller estate in Tarrytown, New York.[9] Like Schreiner, and like anarchists and free-love advocates such as Emma Goldman, Sanger promoted birth control by openly linking sexual and economic oppression. And like Goldman, Sanger risked imprisonment by defying the U.S. Comstock Laws that banned as obscene the distribution of birth control information and devices.[10]

Birth control, especially, was a cornerstone of feminist politics. One activist of the period wrote: "Birth control is an elementary essential in all aspects of feminism. Whether we are the special followers of Alice Paul, or Ruth Law or Ellen Key, or Olive Schreiner, we must all be followers of Margaret Sanger."[11] And Margaret Sanger strove mightily to influence the research paths of hormone biologists, hoping that their science could provide salvation for the millions of women forced to give birth too many times under terrible circumstances. Indeed, over the years she secured more than a little institutional funding for scientists willing to take on aspects of her research agenda. Part of the story of sex hormones developed in this chapter involves a struggle

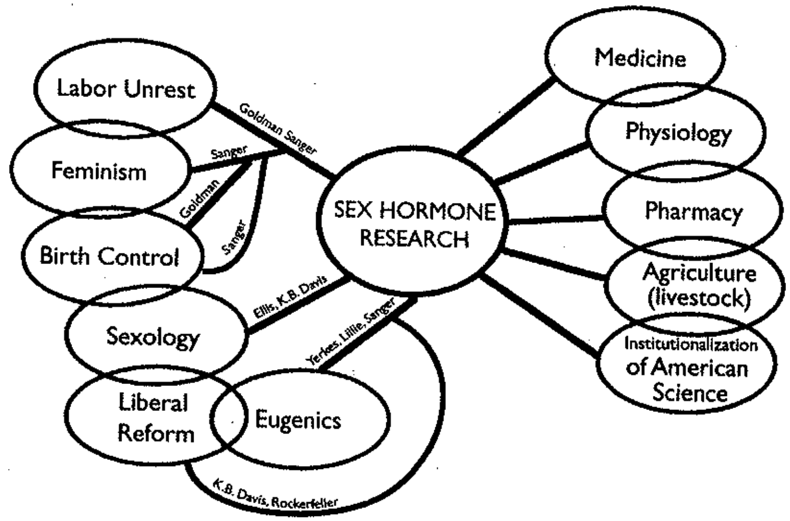

FIGURE 7.2: Personal and institutional social worlds. (Source: Alyce Santoro, for the author)

between scientists and political activists to secure one another's help while holding on to their specific goals—either promoting birth control or furthering "pure" knowledge about sex hormones.

But even more than the personal channels between activists and scientists, unprecedented partnerships between philanthropist social reformers, social scientists, and government-fostered institutions made possible the development of new scientific knowledge about gender and hormones (see figure 7.2). In 1910, John D. Rockefeller, Jr., served as a member of a New York City grand jury investigating the "white slave trade."[12] Deeply affected by the deliberations, he organized and privately funded the Bureau of Social Hygiene (BSH). Over the following thirty years the BSH gave nearly six million dollars for the "study, amelioration, and prevention of those social conditions, crimes and diseases which adversely affect the well-being of society, with special reference to prostitution and the evils associated therewith."[13] Among the many enterprises supported under the bureau's aegis was the Laboratory of Social Hygiene for the study of female offenders, designed and run by the feminist penologist and social worker Katherine Bement Davis (1860–1935).[14]

Davis had received a Ph.D. in political science from the University of Chicago. Her sociology professors there included Thorstein Veblen and George Vincent, who himself later headed the Rockefeller Foundation.[15] In 1901 she became Superintendent for Women at the newly opened Bedford Hills Reformatory for Women in New York State. There her pioneering work on female sex offenders drew Rockefeller's attention. In 1912 he bought land next to the reformatory and established the Laboratory of Social Hygiene. He called Davis "the cleverest woman I have ever met."[16] By 1917 she had become general secretary and a member of the board of directors of the Bureau of Social Hygiene. Her interests extended beyond the problems of criminality, and she used her influence to extend the BSH's work to include "normal" people, public health and hygiene, and a great deal of basic biological research into the physiology and function of sex hormones.[17]

But still, the scaffolding that supported the explosion of hormone research during the 1920s was not quite in place. In 1920 the psychologist Earl F. Zinn, a staff member for Dr. Davis's Bureau of Social Hygiene, proposed an extraordinary new effort to understand human sexuality.[18] His request for financial support to the National Research Council—the new research arm of the National Academy of Sciences—came directly to the attention of pioneer psychologist Robert M. Yerkes.[19] In October 1921, Yerkes convened a group of distinguished anthropologists, embryologists, physiologists, and psychologists, who encouraged the NRC to undertake a broad program in sex research. Attendees noted that "the impulses and activities associated with sex behavior and reproduction are fundamentally important for the welfare of the individual, the family, the community, the race."[20] With this urging and complete outside funding from the Bureau of Social Hygiene, the NRC's Committee for Research in Problems of Sex (CRPS) came into existence.

The new committee's scientific advisory committee contained Yerkes, the physiologist Walter B. Cannon, Frank R. Lillie, Katherine B. Davis, and a psychiatrist named Thomas W. Salmon. They were "a little group of earnest people . . . facing a vast realm of ignorance and half-knowledge, scarcely knowing even where or how to begin."[21] Their initial mission was to "understand sex in its many phases." The strategy was to launch "a systematic attack from the angles of all related sciences."[22] Within a year, however, Lillie had hijacked the committee, turning it away from a multidisciplinary approach and toward the study of basic biology.[23] Lillie listed the following topics for study, in order of importance: genetic aspects of sex determination, the physiology of sex and reproduction, the psychobiology of sex in animals, and, finally, human sexuality, including individual, anthropological, and psychosocial aspects. During its first twenty-five years, CRPS funded much of the major research in hormone biology, the anthropology of sexual behavior, animal psychology, and, later, the famed Kinsey studies. Yerkes chaired the committee for its entire time, while Lillie remained a member until 1937.

Lillie and Yerkes turned CRPS toward the support of research on hormone biology, arguing that basic biology was fundamental to the understanding of the complex problems that had originally stimulated Rockefeller to fund the BSH and CRPS. These two scientists, however, were no ivory tower nerds, unaware of or uninfluenced by the major social trends of their time. Indeed, they both shaped and were shaped by prevailing concerns about sexual politics and human sexuality. As head of the Marine Biological Laboratory in Woods Hole, Massachusetts, and Chairman of the Department of Zoology at the University of Chicago (from 1910 to 1931), Lillie was already a major player in the development of American biology. His work on freemartins placed him in the center of the emerging field of reproductive biology, and he planned to organize biological research at the University Chicago around the fields of embryology and sex research. Lillie intended to unify the various disciplinary strands in his department under a tent of social utility.

In particular, he strongly supported the eugenics movement, which he believed provided a scientific approach to the management of human social ills. Eugenicists warned that the nation's "racial stock" was endangered by the vast influx of Eastern European immigrants and by the continued presence in the population of former slaves and their descendants. To limit the burden placed on the white middle class by poverty and crime, believed to result from the "weak heredity" of immigrants and darker-skinned peoples, eugenicists advocated controlling the reproduction of the so-called unfit and promoted child-bearing among those thought to represent strong racial stock. A member of the Eugenics Education Society of Chicago, the general committee of the Second International Eugenics Congress (1923), and the advisory council of the Eugenics Committee of the United States, Lillie explained his views to the University of Chicago student newspaper: if "our civilization is not to go the way of historical civilizations, a halt must be called to the social conditions that place biological success, the leaving of descendants, in conflict with economic success, which invites the best intellects and extinguishes their families." In his plans to build an Institute of Genetic Biology Lillie elaborated on this theme: "We are at a turning point in the history of human society . . . the populations press on their borders everywhere, and also, unfortunately, the best stock biologically is not everywhere the most rapidly breeding stock. The political and social problems involved are fundamentally problems of genetic biology."[24]

Lillie's eugenics concerns allied him directly with two other activists in the eugenics movement, Margaret Sanger and Robert Yerkes. By the late teens, Sanger had traded in her radical feminist persona for a more conservative image. Sanger's (and the birth control movement's) waning interest in women's rights paralleled their increased rhetoric touting the value of birth control for lowering the birthrate among those seen to be of lesser social value. "More children from the fit, less from the unfit—that is the chief issue of birth control," Sanger wrote in 1919. Eugenicists wrote regularly for the American Birth Control League's magazine, the *Birth Control Review*, while during the 1920s only 4.9 percent of its articles focused on feminist issues.[25]

Like Lillie, Yerkes was a trained scientist. He had received his Ph.D. in psychology from Harvard in 1902, and for the next ten to fifteen years worked on organisms ranging from invertebrates such as earthworms and fiddler crabs to creatures with warm blood and backbones—including mice, monkeys, and humans. At Harvard, Yerkes crossed paths with Hugo Munsterberg, one of the early founders of industrial psychology, who promoted the idea of a natural hierarchy of merit. In a democracy such as the United States, this meant that social differences must come from inherent biological ones. Yerkes wrote: "in the United States of America, *within limits set by age, sex, and race*, persons are equal under the law and may claim their rights as citizens."[26]

In this early period of his work, Yerkes concentrated on measuring those limits. The future of mankind, he felt, "rests in no small measure upon the development of the various biological and social sciences . . . . We must learn to measure skillfully every form and aspect of behavior."[27] In the early twentieth century, when psychology was struggling for scientific respectability, Yerkes worked hard to demonstrate what the emerging discipline could offer.[28] When World War I came along, he seized the opportunity, convincing the army that it needed psychologists to rank the abilities of all soldiers for further sorting and task assignment. With Lewis M. Terman[29] and H. H. Goddard, two other proponents of mental testing, Yerkes turned the IQ test into an instrument that could be applied en masse, even to the many illiterate army recruits. By war's end, Yerkes had amassed IQ data on 1.75 million men and shown that the tests could be applied to large institutions. In 1919 the Rockefeller Foundation awarded him a grant to develop a standard National Intelligence Test. It sold five hundred thousand copies in its first year.[30]

CRPS, led by Lillie and Yerkes, was not the only organization focusing attention and money on the problems of hormone biology. Starting in the 1920s, Margaret Sanger and other birth control advocates actively began to recruit research scientists to their cause, in the hope that they could create a technological solution to the personal and social misery brought on by unwanted pregnancies.[31] Sanger enrolled her scientific supporters through the Birth Control Clinical Research Bureau (which she founded in 1923). Among the members of her professional advisory board were Leon J. Cole, a professor of genetics at the University of Wisconsin, who had close associations with

Lillie because of their mutual interest in freemartin research. The freemartin connection also extended to the British researcher F. A. E. Crew, whom Sanger had enlisted to try to develop a safe, effective spermicide.[32] Because the mailing of contraceptive information in the United States was illegal, the spermicide research went on in England, but not without the support of yet another private American agency—the Committee on Maternal Health, which obtained funds from the Bureau of Social Hygiene and funneled them to Crew.[33] From time to time, Sanger also directly received Rockefeller money for specific projects and conferences.

Thus the personal, institutional, research, financial, and ultimately political interests of the actors promoting and carrying out research in hormone biology overlapped in intricate ways. During the 1920s, with the backing of this strengthened research apparatus, scientists finally brought the elusive gonadal secretions under their control. Chemists used abstract notation to describe them as steroid molecules (see figure 7.1). They could classify them as alcohols, ketones, or acids. Yet as it became clearer that hormones played multiple roles in all human bodies, theories linking sex and hormones became more confusing, because the assumptions that hormones were "gendered" were already deeply ingrained. Today, it seems hard to see how asocial chemicals contain gender. But if we follow the hormone story from the 1920s until 1940, we can watch as gender became incorporated into these powerful chemicals that daily work their physiological wonders within our bodies.

As this high-powered, well-funded research infrastructure fell into place, the optimism became palpable. "The future belongs to the physiologist," wrote one physician. Endocrinology opened the door to "the chemistry of the soul."[34] Indeed, between 1920 and 1940 hormone researchers enjoyed a heyday. They learned how to distill active factors from testes and ovaries. They devised ways to measure the biological activity of the extracted chemicals, and ultimately, produced pure crystals of steroid hormones and gave them names reflecting their structures and biological functions. Meanwhile, biochemists deduced precise chemical structures and formulae to describe the crystallized hormone molecules. As hormone researchers took each step toward isolation, measurement, and naming, they made scientific decisions that continue to affect our ideas about male and female bodies. Those judgments, understood as "the biological truth about chemical sex," were, however, based on preexisting cultural ideas about gender. But the process of arriving at these decisions was neither obvious nor free from conflict. Indeed, by looking at how scientists struggled to reconcile experimental data with what they felt certain to be true about gender difference, we can learn more about how hormones acquired sex.

In 1939 CRPS supported the publication of the second edition of a book entitled *Sex and Internal Secretions.*[35] The volume represented much of what had been accomplished since the National Research Council, with Rockefeller support, began funding hormone research in 1923. True to Frank Lillie's program, most of this scientific book of 1,000-plus pages covered findings on the chemistry and biology of hormones, describing magnificent feats of discovery.

The collective efforts of hormone researchers seemed potentially to offer some radical ways to think about human sex. Lillie recognized as much.[36] "There is," he wrote in his introductory comments, "no such biological entity as sex. What exists in nature is a dimorphism . . . into male and female individuals . . . in any given species we recognize a male form and a female form, whether these characters be classed as of biological, or psychological or social orders. *Sex is not a force that produces these contrasts.* It is merely a name for our total impression of the differences." Sounding like today's social constructionists, Lillie reflected: "It is difficult to divest ourselves of the pre-scientific anthropomorphism . . . and we have been particularly slow in the field of the scientific study of sex-characteristics in divesting ourselves not only of the terminology but also of the influence of such ideas."[37]

Lillie, however, could not follow his own advice. Ultimately he and his colleagues proved unable to abandon the notion that hormones are linked essentially to maleness and femaleness. Even as he noted that every individual contained the "rudiments of all sex characters, whether male or female" and reiterated Moore's arguments against the concept of hormone antagonism, Lillie wrote of unique male and female hormones: "As there are two sets of sex characters, so there are two sex hormones, the male hormone . . . and the female."[38] Chapter after chapter in the 1939 edition of *Sex and Internal Secretions* discusses the surprising findings of "male" hormones in female bodies and vice versa, but Lillie never saw this hormonal cross-dressing as a challenge to his underlying notion of a biologically distinct male and female.

Today we still contend with the legacy of what Lillie called "pre-scientific anthropomorphism." When I searched a computer database of major newspapers from February 1998 to February 1999, I found 300 articles mentioning estrogen and 693 discussing testosterone.[39] Even more astonishing than the number of articles was the diversity of topics. Articles on estrogen covered subjects ranging from heart disease, Alzheimer's, nutrition, pain tolerance, immunity, and birth control to bone growth and cancer. Articles on testosterone covered behaviors such as asking directions (will he or won't he?), cooperation, aggression, hugging, and "female road rage," as well as a diverse range of medical topics including cancer, bone growth, heart disease, female impotence, contraception, and fertility. A quick perusal of recent scientific publications shows that, in addition to my newspaper list, researchers have learned that testosterone and estrogen affect brain, blood cell formation, the circulatory system, the liver, lipid and carbohydrate metabolism, gastrointestinal function, and gall bladder, muscle, and kidney activities.[40] Yet despite the fact that both hormones seem to pop up in all types of bodies, producing all sorts of different effects, many reporters and researchers continue to consider estrogen the female hormone and testosterone the male hormone.

Do all of these different organ systems deserve to be seen as sex characters by virtue of the fact that they are affected by chemicals that we have labeled sex hormones? Would it not make as much sense to follow the lead of one current research group, which suggests that these are "not simply sex steroid[s]?"[41] Why not redefine these molecules as the ubiquitous and powerful growth hormones they are? Indeed, why were these hormones not seen in this light from the very beginning? By 1939, scientists knew of the myriad effects of steroid hormones. But the scientists who first learned how to measure and name the testis and ovarian factors entwined gender so intricately into their conceptual framework that we still have not managed to pull them apart.

Purifying

In 1920, the male hormone turned boys into men, and the female hormone made women out of the girls. Feminists had won a major political victory in gaining the right to vote, and America had rid her shores of many foreign radicals. But out of this apparent calm, a new unrest soon broke loose. While feminism struggled to maintain its newfound identity, women's roles continued to change and sex hormones started to multiply.[42]

Three interrelated scientific questions took center-stage in the new research centers established in the 1920s. Which cells in the ovary or testis produced the substance or substances responsible for the sorts of effects Steinach, Moore, and others had observed? How could one chemically extract active hormones from these tissues? And finally, once one produced an active extract, could it be purified? In 1923, the biologists Edgar Allen and Edward A. Doisy, working at the Washington University Medical School in Saint Louis, announced the localization, extraction, and partial purification of an ovarian hormone.[43] Just six years earlier Charles Stockard and George Papanicolaou (for whom the Pap smear is named) had developed an easy method to monitor the estrus cycle of the rodent.[44] Allen and Doisy now used the technique to assess the potency of extracts obtained from ovarian follicle fluid removed from hog ovaries.[45] By injecting their extracts into spayed animals, they could try to induce changes in vaginal cells typical of rodents in estrus.

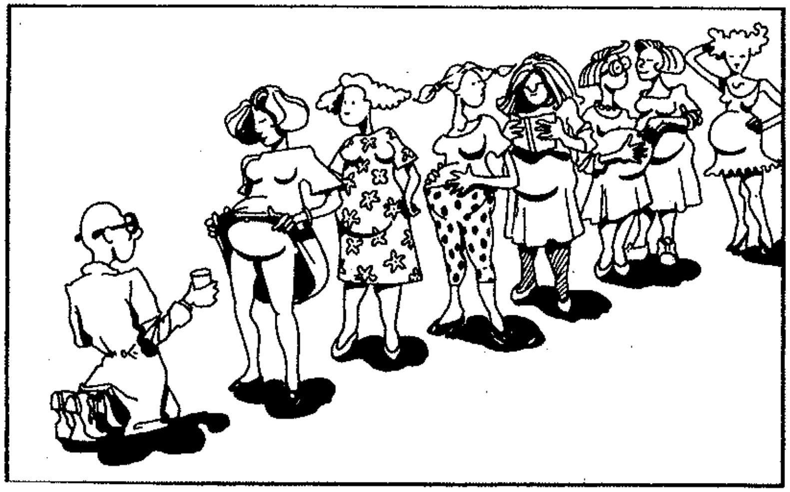

FIGURE 7.3: Pregnant women's urine has high concentrations of female hormone. (Source: Alyce Santoro, for the author)

First they showed that only substances from the fluid surrounding the oocyte in the ovary (called the follicular fluid) affected the estrus cycle. Not only did the spayed animals exhibit a change on the cellular level; they also changed behaviorally. Allen and Doisy noted that the animals displayed "typical mating instincts, the spayed females taking the initiative in courtship." Having established a reliable method to test for hormone activity—called a bioassay, because the test relies on the measurable response of a living organism—Allen and Doisy also tested extracts marketed by pharmaceutical companies. These turned out to have no bio-activity, justifying what they called a "well-founded skepticism concerning commercial preparations."[46]

Allen and Doisy had made a great start. They had a reliable bioassay. They had shown that the ovarian factor came from the liquid that filled the ovarian follicles (rather than, for example, the corpus luteum—another visible structure in the ovary). But purification was another story. Progress was slow at first because the raw material was available in only limited quantities and at "staggering" costs. About 1,000 hog ovaries yielded 100 cubic centimeters (about a fifth of a pint) of follicular fluid, at the cost of approximately $1.00 per milligram of hormone.[47] Then, in 1927, two German gynecologists discovered that urine from pregnant women has extremely high concentrations of the female hormone,[48] and the race was on, first to gain access to enough of that suddenly valuable commodity (figure 7.3) and then to isolate and purify

FIGURE 7.4: Men's urine has high concentrations of male hormone. (Source: Alyce Santoro, for the author)

the hormone. By 1929, two groups (Doisy's in St. Louis and Butenandt's in Göttingen)[49] had succeeded in crystallizing the urinary hormone and analyzing its chemical structure. But was it really the same as the hormone made in the ovaries? The final proof came in 1936, when Doisy and his colleagues used four tons of sow ovaries to produce a few crystallized milligrams of chemically identical molecules.[50] The urinary hormone and the ovarian factor were one and the same.

The isolation of the male hormone followed a similar track. First, scientists developed a method of assaying an extract's strength—the number of centimeters of regrowth over a specified time period of a cockscomb after castration (expressed in International Capon Units—ICU's for short). Then they had to search for an inexpensive hormone source. Again, they found it in cheap and ubiquitous pee. In 1931, Butenandt isolated 50 milligrams of male hormone from 25,000 liters of men's urine collected from Berlin's police barracks (figure 7.4).

Scientists had found male hormones in testes and men's urine, and female hormones in ovaries and the urine of pregnant women. So far so good; everything seemed to be where it belonged. But at the same time, other research was threatening to unravel Steinach's (and Lillie's) formulation that each hormone belonged to and acted in its respective sex, defining it biologically and psychologically. To begin with, it turned out that the male and female hormones came in several molecular varieties. There wasn't a single substance, but a family of chemically related compounds with similar, but not identical, biological properties. The two hormones became many.[51] Even more bewildering, there were scattered reports of female sex hormones isolated from males. In 1928, nine such reports appeared. The gynecologist Robert Frank wrote that he found this news "disconcerting" and "anomalous,"[52] while an editorial in the *Journal of the American Medical Association* called the report of female hormone bioactivity in "the testes and urine of normal men" "somewhat disquieting."[53] So convinced was the editorial writer of the unlikelihood of such a finding that he (I presume the pronoun is correct) questioned the validity of vaginal smear tests, which had become the standard of measurement in most of the laboratories working in female hormone purification.[54]

But the shock of finding female hormone in the testes and urine of "normal men" paled in comparison to another finding, published in 1934. In an article variously described by other scientists as "surprising," "anomalous," "curious," "unexpected," and "paradoxical,"[55] the German scientist Bernhard Zondek described his discovery of the "mass excretion of oestrogenic hormone in the urine of the stallion"—that cherished mythic symbol of virility.[56] In short order, others found female hormones where they ought not to be. In 1935, thirty-five such scientific reports appeared, followed the next year by another forty-four. The first report of male hormones in females appeared in 1931, and by 1939 had been confirmed by at least fourteen additional publications.[57]

Actually, the first report of cross-sex hormone action had appeared as early as 1921, when Zellner reported that testes transplanted into castrated female rabbits could cause uterine growth. But the full import of such work became apparent only when the hormones of one sex turned up in the bodies of the other. Not only did contrary sex hormones appear unexpectedly in the wrong sex: they also seemed able to affect tissue development in their opposite number! By the mid-1930s it was clear that male hormones could affect female development and vice versa. The anatomists Warren Nelson and Charles Merckel, for example, noted the "amazing effect" of an androgen in females. Administration of this "male" hormone stimulated mammary growth, enlargement of the uterus, "a striking enlargement of the clitoris," and "periods of prolonged estrus."[58]

At first, scientists tried to fit their findings into the old dualistic scheme. For a while they referred to the cross-sex hormones as heterosexual hormones. What did heterosexual hormones do? Nothing, some suggested. They're just nutritional by-products with no connection to the gonads. (So suggested Robert T. Frank, who claimed that "all ordinary foodstuffs contain female sex hormone. An average-sized potato contains at least 2 M. U. [mouse units].")[59] The further discovery that the adrenal glands could make heterosexual hormones provided brief relief for those who found their existence anxiety-provoking. At least the gonads themselves still functioned along strict gender lines, since cross-sex hormones did not originate with them![60] As an alternative to the nutritional hypothesis, Frank found the presence of female hormone in the bile "of great theoretical interest and is of importance in explaining the occurrence of [*sic*] female sex hormone reaction in the blood of males and in the urines [*sic*] of males."[61]

Finally, some argued that the heterosexual hormones indicated a diseased state. Although the men from whom estrogen was extracted appeared to be normal, they might, perhaps, be "latent hermaphrodites."[62] But given how widespread the findings were, that position was hard to maintain. All of which led to a crisis of definition: if hormones could not be defined as male and female by virtue of their unique presence in either a male or a female body, then how could scientists define them in a manner that would prove translatable among different research laboratories as well as the pharmaceutical companies that wished to develop new medicines from these powerful biochemicals?

Measuring

Traditionally, scientists address such crises, which often plague new and rapidly expanding fields, by agreeing to standardize. If only everyone used the same method of measurement, if only everyone quantified their products in the same manner, and if only all could agree on what to call these proliferating substances that had somehow escaped the boundaries of the bodies to which they were supposed to belong—then finally, scientists hoped, they could straighten out what had become a messy situation. In the 1930s, standardization became central to the agenda of sex hormone experts.

During the first three decades of the twentieth century, scientists had used a bewildering variety of methods to test for the presence of female hormones. Generally speaking, they removed the ovaries from test animals and then injected or implanted test substances or tissue parts and looked for the restoration of some missing function. But what missing function were they to look for, and how accurately could it be measured? Gynecologists focused on the organ dearest to their hearts—the uterus— measuring the impact of test substances on the increase in uterine weight in test animals following ovariectomy. Laboratory scientists, however, used a much wider variety of tests. They measured muscular activity, basal metabolism, blood levels of calcium and sugar, the feather coloration of domestic fowl, and the growth of mammary glands and the vulva.[63] Not to be outdone, psychologists used a variety of behaviors to assess the presence of hormonal activity: maternal nest building, sexual vigor and drive, and maternal behavior toward newborn pups.[64]

The question of how to measure and standardize the presence and strength of the female hormone was not merely academic. Many of the early research reports on measurement and standardization explicitly addressed the question of pharmaceutical preparations.[65] Drug companies, leaping on the opportunities presented by the advances in hormone research, began hawking preparations made from male or female sex glands. Especially popular was the idea that testicular hormones could slow or even reverse the aging process. One report on the extraction and measurement of testicular hormones attacked the use of preparations in humans, writing: "Thus far there is no indication that this product can be of any value in restoring 'vigor' to the aged or neurasthenic. However, if there is an indication for its use and if the dosage in man is comparable to that found in the capon, the daily injection equivalent for a 150 pound man would have to be an amount equivalent to at least 5 pounds of bulls' testes tissue or 2 gallons of normal male urine."[66]

This initial scientific skepticism had little impact on the hormone market. As late as 1939, companies such as Squibb, Hoffman-LaRoche, Parke-Davis, Ciba, and Bayer were marketing approximately sixty different ovarian preparations of doubtful activity.[67] Mindful of the debacle in 1889, in which the scientist Edouard Brown-Séquard (see chapter 6) had insisted that testicular extracts made him feel younger and more vigorous, only to withdraw his claims a few years later, gynecologists wanted to make sure such preparations had genuine therapeutic value.[68] So too did the pharmaceutical companies that funded basic research aimed at standardizing hormone preparations.[69] Finally, in 1932, an international group of gynecologists and physiologists met under the auspices of the Health Organization of the League of Nations to develop a standard measure and definition of the female sex hormone.

As one of the participants, A. S. Parkes, later noted, "the proceedings were unexpectedly smooth."[70] Participants in the First Conference on Standardization of Sex Hormones, held in London, agreed, for instance, that the term "specific oestrus-producing activity" is to be understood as the power of producing, in the adult female animal completely deprived of its ovaries, an accurately recognizable degree of the changes characteristic of normal oestrus. For the present, the only such change regarded by the Conference as providing a suitable basis for quantitative determination of activity in comparison with the standard preparation is the series of changes in the cellular contents of the vaginal secretion of the rat or mouse.[71] Amusingly, the tradition

of using mice in America and rats in Europe led to two standard units: the M.U.(mouse unit) and the R.U. (rat unit).

Despite this agreement, the standardization conference did not satisfy everyone. By narrowing the definition of the female hormone to its actions in the estrus cycle, conference members had rendered less visible the hormone's other physiological effects. Dutch scientists, who had played a key role in the processes of identification and hormone purification, criticized what they called the "unitary school" of sex endocrinology.[72] A 1938 publication by Korenchevsky and Hall at the Lister Institute of London underscored their point. Estrogens could stunt growth, produce fat depositions, accelerate the degeneration of the thymus gland, and decrease kidney weight, the authors pointed out. These were, then, "not merely sex hormones, but . . . hormones also possessing manifold important effects on non-sexual organs."[73] Was it biologically correct to define the female hormone solely in terms of the mammalian estrus cycle? Didn't that divert attention from the many nonsexual roles in the body? Indeed, given that "sex hormones are not sex specific,"[74] could they legitimately continue to call these hormones sex hormones? Did sex hormones really exist?

The establishment of a standard measure and definition of the male sex hormone followed a similar pattern. Again, a wide variety of effects from substances injected after castration presented themselves as potential standards for the male sex hormone. The growth of the cockscomb as the standard unit of measure emerged victorious over other contenders—changes in the weight of the prostate, seminal vesicle, and penis to the size of the comb of the fowl, the horns of the stag, the crest of the male salamander, or the production of mating plumage in certain birds. The Second International Conference on Standardization of Sex Hormones, which took place in London in 1935, recognized the need for a mammalian assay, but concluded that an acceptable one did not exist. It was therefore "agreed that the International Standard for the male hormone activity should consist of crystalline androsterone and the unit of activity was defined as 0.1 mgm [*sic*]. This weight is approximately the daily dose required to give an easily measurable response in the comb of the capon after 5 days."[75] As with the female hormone, "all functions and processes that were unrelated to sexual characteristics and reproduction were dropped."[76]

Defining the female hormone in terms of the physiology of the estrus cycle, and the male hormone in terms of a secondary sex characteristic less central to the drama of reproduction, did not necessarily represent what we might call today "the best science." For both the male and the female hormones, more than one potentially accurate, easy-to-use assay contended for the role of standard-bearer. For example, the male Brown Leghorn chicken has black, round-tipped breast feathers, while its saddle feathers are orange, long, and pointed. The female Leghorn has salmon, round-tipped breast feathers and round-tipped, brown saddle feathers. Injecting female hormone into plucked capons produced the growth of new salmon-colored breast or brown saddle feathers. The experiments on this dimorphism "suggest that the production of brown pigments in the breast feather of the Brown Leghorn capon might be used as an indicator for the female hormone."[77] The test was easy, did not involve killing any of the test animals, and took only three days. In apparent contrast, the rat estrus assay required great care because of individual variability—a fact noted at the time it was chosen as the standard measure.[78]

In the case of the male hormone, a test based on prostate and seminal vesicle growth in castrated rats stood out as an alternative to the comb growth test. Korenchevsky and his colleagues distrusted the comb growth test for a number of reasons. They were especially disturbed that the urine of both pregnant and "normal" women stimulated comb growth to the same degree as did urine from men. "The specificity of the comb test, therefore, becomes doubtful" and should be "replaced by a test on the sexual and other organs of mammals."[79] On the other hand, Thomas F. Gallagher and Fred Koch, who developed the comb test, thought the mammalian assays had not proven their mettle. "We know of no studies," they wrote, "in which animal variability has been established by means of mammalian tests. Our opinion is that the mammalian tests thus far devised will be found to be either more time-consuming or less accurate or both."[80]

Thus, the choice of a measurement that distanced animal masculinity from reproduction, linked animal femininity directly to the cycle of generation, and made less visible the effects of these hormones on nonreproductive organs in both males and females was not inevitable. Nature did not *require* that these particular tests become the standard of measurement. Choices for particular measures were probably not made because of the gender views—either conscious or subconscious—of the main players. That would be far too simplistic an explanation. Being present at the conference may have carried a big advantage. Neither Korenchevsky nor Gustavson were present at either of the international standardization conferences, while Doisy and Koch, whose assay systems were chosen, were conference participants. At any rate, the hypothesis that gender ideology *caused* the particular assay choices would require more in-depth research to confirm or deny. Nevertheless, the choices made, for whatever reasons—rivalries, publication priority, convenience—have profoundly influenced our understanding of the biological nature of masculinity

and femininity. These decisions shaped the sexing of the sex hormones. The normal processes of science—the drive to standardize, analyze, and accurately measure—gave us particular sex hormones at the same time that they proscribed the possible truths about how the body works, about how the body *does* gender.

From the moment the process of measuring male or female hormones was standardized, a set of molecules of a known chemical composition and structure officially became sex hormones. From that time on, any physiological activity those hormones had were, by definition, sexual, even though the "male" or "female" hormones affected tissues such as bones, nerves, blood, liver, kidneys, and heart (all of which was known at the time). That hormones had such wide-reaching effects didn't change the association of hormones with sex. Instead, these non-reproductive tissues became sexual by virtue of their interaction with sex hormones. The scientific definitions of standard mouse, rat, and comb units seemed to echo on a molecular level the notion of human makeup that Sigmund Freud had insisted on: sex was at the very center of our beings.

Naming

If choosing how to standardize hormonal measurements was crucial in consolidating their identities as sexual substances, so too was choosing what to call them. It was no random act of scientific purity to name male hormones "androgens," female hormones "estrogens," the hormone isolated first from urine collected in a police barracks (but later identified as the culprit found in the testes) "testosterone" (chemically speaking—a ketone steroid from the testis), and the hormone first crystallized from the urine of pregnant women (and later shown to exist in hog ovaries) "estrogen" or, more rarely, estrone (chemically speaking, a ketone related to estrus). Rather, these names became the standards only after considerable debate. They both reflected and shaped ideas about the biology of gender in the twentieth century.

During the early days of sex hormone research, investigators showed remarkable restraint. They did not name or define. Referring only to the "male hormone" and the "female hormone," or occasionally their tissue of origin (as in the "ovarian hormone"), they patiently awaited further clarification.[81] By 1929, a number of contender names for the female hormone had been floated. The words *ovarin, oophorin, biovar, protovar, folliculin, feminin, gynacin,* and *luteovar* all referred to site of origin. In contrast, *sistomensin* (making the menses subside), *agomensin* (stimulating the menses), *estrous hormone*, and *menoformon* (causing the menses) all referred to proposed or demonstrated biolog-

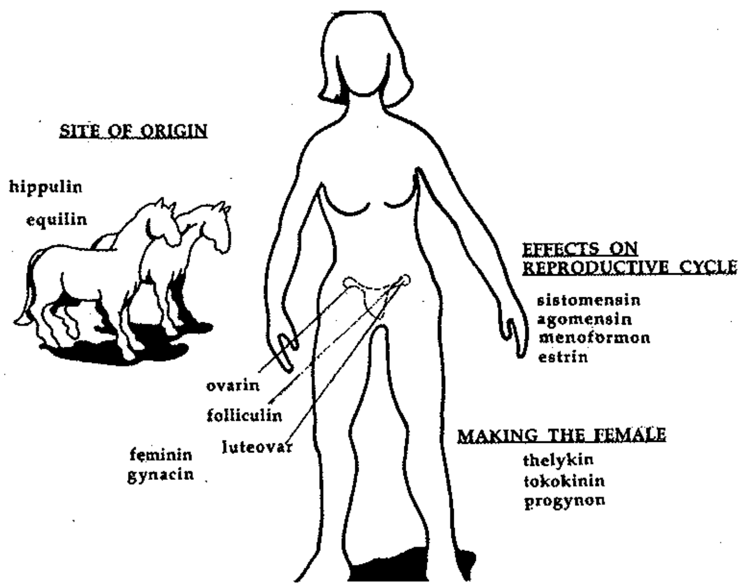

FIGURE 7.5: Naming the female hormone. (Source: Alyce Santoro, for the author)

ical actions. Some researchers preferred Greek constructs, hence the words *thelykin* (thelys = the feminine: kineo = I set going), *theelin, theeol,* and for the male hormone, *androkynin. Tokokinins* signified "the procreative hormone (Zeugungshormon) applicable to both male and female" (see figure 7.5). But the definitive moment had not arrived. Frank, for example, felt that "the term female sex hormone covers all needs until we know more about the substance itself. The term is applicable to any substance which either increases or actually establishes feminine characteristics and feminineness."[82]

In the early 1930s the terms male and female hormone began to loosen their grip. In 1931, the author of a research paper referred to an "ambosexual" hormone (one having actions in both sexes); in 1933, a researcher noted the "*so-called* female sex hormone." In 1937, the *Quarterly Cumulative Index Medicus* introduced the terms *androgens* (to build a man) and *estrogens* (to create estrus) to its subject index, and within a few years these words had taken hold.[83] But not without some jockeying and debate. Two interrelated problems emerged: what to call the male and female hormones (of which it was then known there were clearly several), and how to refer to their contrary locations and actions (female hormones in stallion urine).

Using the word *estrus* (meaning "gadfly," "crazy," "wild," "insane") as the root on which biochemists built female hormone names happened over drinks

"in a place of refreshment near University College," when the endocrinologist A. S. Parkes and friends coined the term *estrin.*[84] One of the participants in this brainstorming session found the choice "a happy thought which gave us a satisfactory general term and a philologically manageable stem upon which to base all the new nouns and adjectives that physiologists and organic chemists soon needed."[85] In 1935, the Sex Hormone Committee of the Health Organization of the League Nations chose the name "estradiol" for the substance isolated from sow ovaries, thus linking the concept of estrus with the terminology of the organic chemist.

By 1936, scientists had crystallized at least seven estrogenic molecules. The Council on Pharmacy and Chemistry of the American Medical Association wrestled with what to call them. With Doisy on the committee, there was a lot of sympathy for calling the female hormone *theelin*, the word he had coined. But it turned out that Parke, Davis and Company had already marketed their purified estrin under the "theelin" trademark, thus making the word unavailable for general use. That made using the root *estrus* the next best choice. Unfortunately, Parke, Davis and Company had also trademarked the word *estrogen*, but on request from the Council on Pharmacy and Chemistry, the company gave up its proprietary rights to the name, and the Council adopted the word as a generic term.[86] The Council accepted the common names *estrone, estriol, estradiol, equilin*, and *equilenin* (the latter two being chemicals found in mare's urine). They also retained the names *theelin, theeol*, and *dihydrotheelin* as synonyms for *estrone, estriol,* and *estradiol.*[87]

The die had been cast, although for a few more years people would continue to suggest modifications. Parkes, for instance, with an ever-growing awareness of the diverse biological effects of the female hormone complex, proposed a new term, which would make the naming system for male and female hormones parallel. "One hesitates to advocate the use of new words," he wrote, "but obvious anomalies are becoming evident in the description of certain activities of the sex hormones." The terms *androgenic* and *estrogenic*, he remarked, had been introduced to "promote clear thinking and precision of expression . . . but it is now evident that [the terms] are inadequate." The word *estrogenic*, he argued, should apply only and literally to substances that produce changes in the estrus cycle. Noting that the ability of estrogen to feminize bird plumage, for example, could hardly be called estrogenic, in the literal meaning of the word, Parkes proposed that *gynoecogenic* be "used as a general term to describe activity which results in the production of the attributes of femaleness."[88] But his proposal came too late. The nonparallel nomenclature—*androgens* for the male hormone group, *estrogens* for the collection of female hormones—took hold. Eventually, terms with the root *thelys*, which denoted not the reproductive cycle but the more general concept of the feminine, dropped from common usage, and thus the ideal of female hormones became inextricably linked to the idea of female reproduction.

Naming the male hormone group, meanwhile, had been fairly simple. A review of androgen biochemistry did not even note the naming question, although the companion article on the biochemistry of estrogenic compounds devoted four pages to nomenclature.[89] With only one exception, the male hormone name simply combined the Greek root for *man* ("andrus") with the technical naming systems of the biochemist. Only for the molecule we now call testosterone (and its derivatives) did the more specific term, *testis*, provide the etymological building block.

By the mid-1930s then, scientists had crystallized the hormones, agreed on the best way to measure them, and named them. Only one problem remained. If androgens made men and estrogens produced a distinctly female mating frenzy, then how ought these hormones to be categorized when they not only showed up in the wrong body but seemed to have physiological effects as well? Korenchevsky and co-workers referred to such hormones as "bisexual" and proposed to group both androgens and estrogens according to this property. Only one hormone (progesterone—from the corpus luteum) could they envision as purely male or female. They designated a second group as "partially bisexual," some with chiefly male properties, others with predominantly female ones. Finally, they proposed the existence of "true bisexual hormones," ones that cause a return to "the normal condition of all the atrophied sex organs . . . to the same degree in both male and female rats."[90] Testosterone belonged to this group.

In 1938 Parkes suggested a different tack. He disliked the term *bisexual* because it implied "having sexual feeling for both sexes" and proposed instead the term *ambisexual*, which could, he felt, "be applied with perfect propriety to substances . . . which exhibit activities pertaining to both sexes."[91] These fine distinctions never took hold. Even today the classification question dogs the steps of biologists, especially those interested in correlating hormones with particular sexual behaviors.

Gender Meanings

We can see from this story of hormone discovery that the interchanges between social and scientific gender are complex and usually indirect. Scientists struggled with nomenclature, classification, and measurement for a variety of reasons. In scientific culture, accuracy and precision have high moral status, and as good scientists, using the highest standards of their trade, endocrinologists wanted to get it right. Yet in terms of nomenclature, only Parkes seems to have come up with the "correct" proposal, and his views fell by the wayside. One reason for this (but not the only one) is that in the struggle to get it right, "it" was a loaded term—denoting a variety of social understandings of what it meant in the years 1920 to 1940 to be male or female.

Whatever "it" was defined both biological and social normality. For example, Eugen Steinach proposed that hormones kept underlying bisexual potentials from appearing, abnormally, in the wrong body.[92] Males made only male hormones that antagonized or suppressed female development even in the presence of female hormone. Females made female hormones that antagonized or suppressed male development even in the presence of male hormones. Each sex normally had its own sphere. Steinach's views influenced more than a decade of hormone researchers, including Lillie. But as it became clear that the body regulates hormones through complex and balanced cycles that involve feedback with the pituitary gland,[93] the notion of direct hormone antagonism gave way, even though scientists such as Lillie held on to the notion of separate spheres.[94]

Because of their loyalty to a two-gender system, some scientists resisted the implications of new experiments that produced increasingly contradictory evidence about the uniqueness of male and female hormones. Frank, for example, puzzling at his ability to isolate female hormone from "the bodies of males whose masculine characteristics and ability to impregnate females is unquestioned," finally decided that the answer lay in contrary hormones found in the bile.[95] Others suggested that the finding of adrenal sex hormones could "save" the hypothesis of separate sex-hormonal spheres. In a retrospective piece, one of the Dutch biochemists wrote: "By proposing the hypothesis of an extra-gonadal source to explain the presence of female sex hormones in male bodies, scientists could avoid the necessity to attribute secretion of male sex hormones to the ovary."[96]

But scientists are a diverse lot, and not everyone responded to the new results by trying to fit them into the dominant gender system. Parkes, for example, acknowledged the finding of androgen and estrogen production by the adrenal glands as "a final blow to any clear-cut idea of sexuality."[97] Others wondered about the very concept of sex. In a review of the 1932 edition of *Sex and Internal Secretions* (which summarized the first ten years of advances funded by the Committee for Research in Problems of Sex), the British endocrinologist F. A. E. Crew went even further, asking "Is sex imaginary? . . . . It is the case," he wrote, "that the philosophical basis of modern sex research has always been extraordinarily poor, and it can be said that the American workers have done more than the rest of us in destroying the faith in the existence of the very thing that we attempt to analyze." Nevertheless, Crew believed that science would ultimately define sex, "the object of its searchings," instead of vice versa. "If in a decade so much has been disclosed," he wrote, "what shall we not know after a century of intelligent and industrious work?"[98] Despite growing scientific evidence to the contrary, sex *must* exist.

Scientists struggled to understand the role of hormones in constructing sex difference, in a cultural milieu awash with changes in the meaning and structure of gender systems. In 1926, Gertrude Ederle stunned the world by becoming the first woman to swim the English Channel, besting the preexisting men's record in the process. Two years later, Amelia Earhart became the first woman to fly across the Atlantic. While the symbols were dramatic, far-reaching changes proceeded a bit more doggedly. From 1900 to 1930, gainful employment of married women outside the home doubled, but only to about 12 percent, and in the decade following the passage of the 19th Amendment, feminist efforts to infiltrate all corners of the labor market remained an uphill struggle.

But while resistance to complete economic equality persisted, during the period from 1920 to 1940, a major reconceptualization of the family, gender, and human sexuality took place. For example, in Kinsey's famous survey, only 14 percent of women born before 1900 admitted to premarital intercourse before the age of twenty-five; for those born in the first decade of the twentieth century, the percentage rose to 36.[99] Feminism, the growing popularity of Freudian psychology, the new field of sexology, and the increasing knowledge about sex hormones and internal secretions all "swelled a tide of scorn for 'Victorian' sexual morality."[100]

Diversity in scientific voices paralleled diversity within feminism itself. For example, some feminists argued that women could labor in any field on a par with men; others thought that their special reproductive differences made them deserving of protective legislation governing their hours and the degrees of danger in which their jobs might place them.[101] By the end of the 1930s feminists faced a dilemma of their own rhetorical making (one, I might add, with which contemporary feminism also struggles): if women and men were complete equals, then organizing as members of one or the other sex made little sense. If, on the other hand, they were truly different, then just how far might one push the demand for equality? In 1940, Eleanor Roosevelt summed up the problem with precision: "women must become more conscious of themselves as women and of their ability to function as a group. At the same time they must try to wipe from men's consciousness the need to consider them as a group or as women in their everyday activities, especially as workers in industry or the professions."[102]

Amid such gender turmoil, it was never possible to resolve the identity of the sex hormones. In 1936, John Freud, a Dutch biochemist working on hormone structure, suggested abandoning the entire concept of sex hormones. Estrogen and its relatives acted as "growth-promoters to the smooth muscle, stratified epithelium and some glandular epithelia of ectodermal origin."[103] Envisioning hormones as catalysts would make it "easier to imagine the manifold activities of each hormonal substance." He imagined that "the empirical concept of sex hormones will disappear and a part of biology will definitely pass into the property of biochemistry."[104]

While we should honor (albeit with some feminist hindsight) the intellectual heritage of hormone research, starting with Berthold's experiments on gonad implants in capons, the time has come to jettison both the organizing metaphor of the sex hormone and the specific terms *androgen* and *estrogen*. What could we put in their stead? Our bodies make several dozen different, but closely related and chemically interconvertible, molecules belonging to the chemical group we call steroids. Often, these molecules reach their destination via the circulatory system, but sometimes cells make them right at the site of use. Hence, it is usually appropriate to call them hormones (given the definition that a hormone is a substance that travels through the bloodstream to interact with an organ some distance from its place of origin). So, for starters, let's agree to call them *steroid hormones* and nothing else. (I'm willing to keep their technical biochemical designations, provided we remember the etymological limits of the naming system.)

A variety of organs can synthesize steroid hormones, and an even wider variety can respond to their presence. Under the right circumstances these hormones can dramatically affect sexual development at both the anatomical and the behavioral level. They are present in different quantities and often affect the same tissues differently in conventional males and females. At the cellular level, however, they can best be conceptualized as hormones that govern the processes of cell growth, cell differentiation, cell physiology, and programmed cell death. They are, in short, powerful growth hormones affecting most, if not all, of the body's organ systems.

Retraining ourselves to conceptualize steroid hormones in these terms provides us with important opportunities. The theoretical near-unity achieved by hormone biologists at the end of the 1930s is dead. If any possibility exists for obtaining a meaningful, all-encompassing theory of action and physiological effect of these cholesterol-based molecules, we must leave the sex paradigm behind. Second, if we are to understand the physiological components of sexual development, and of mating-related animal behaviors, we must be willing to break out of the sex hormone straitjacket, looking at the steroids as one of a number of components important to the creation of male, female, masculinity, and femininity. Not only will we then start to see non-steroid, physiological constituents of such development, but we will become able to conceptualize the ways in which environment, experience, anatomy, and physiology result in the behavior patterns that we find interesting or important to study.

One of the lessons of this chapter is that social belief systems weave themselves into the daily practice of science in ways that are often invisible to the working scientist. To the extent that scientists proceed without seeing the social components of their work, they labor with partial sight. In the case of sex hormones, I suggest that widening our scientific vision would change our understanding of gender. But of course, such changes can occur only as our social systems of gender change. Gender and science form a system that operates as a single unit—for better and for worse.

8

THE RODENT'S TALE

Using Hormones to Sex the Brain

BY THE 1940S, HORMONE BIOLOGISTS, BIOCHEMISTS, AND REPRODUCTIVE endocrinologists had identified, crystallized, named, and classified a host of new hormones. They had also outlined the roles of hormones—both gonadal and pituitary—in the control of the reproductive cycle, leaving researchers poised to look more seriously at the possibility that hormones regulated human behavior. The study of the chemical physiology of behavior came into its own, beginning in the late 1930s, as the old institutional and funding coalitions that had facilitated and directed the blossoming of hormone biology experienced a sea change.[1]

Until 1933, the Rockefeller Foundation had funneled its support of sex research through the social service-oriented Bureau of Social Hygiene, but then the Foundation took over direct funding of the Committee for Research in Problems of Sex (CRPS).[2] The transfer marked a transition from the development of national science in direct service to social change to one in which the scientists themselves developed research agenda, which appeared, at least on the surface, to be motivated solely by the ideal of knowledge for knowledge's sake.[3] As early as 1928, CRPS had signaled this change in its new five-year plan. "Modern science," CRPS committee members had written, "particularly experimental medicine, has shown that the greatest benefits to mankind have come from fundamental researches, the implications of which could not be foreseen. . . . Pressing social and medical problems" would most likely only be solved by first obtaining a scientific understanding of human sexuality.[4]

The Rockefeller Foundation took over the Committee for Research in Problems of Sex just as the conservative engineer Warren Weaver became the full-time director of Rockefeller's Division of Natural Sciences. Weaver