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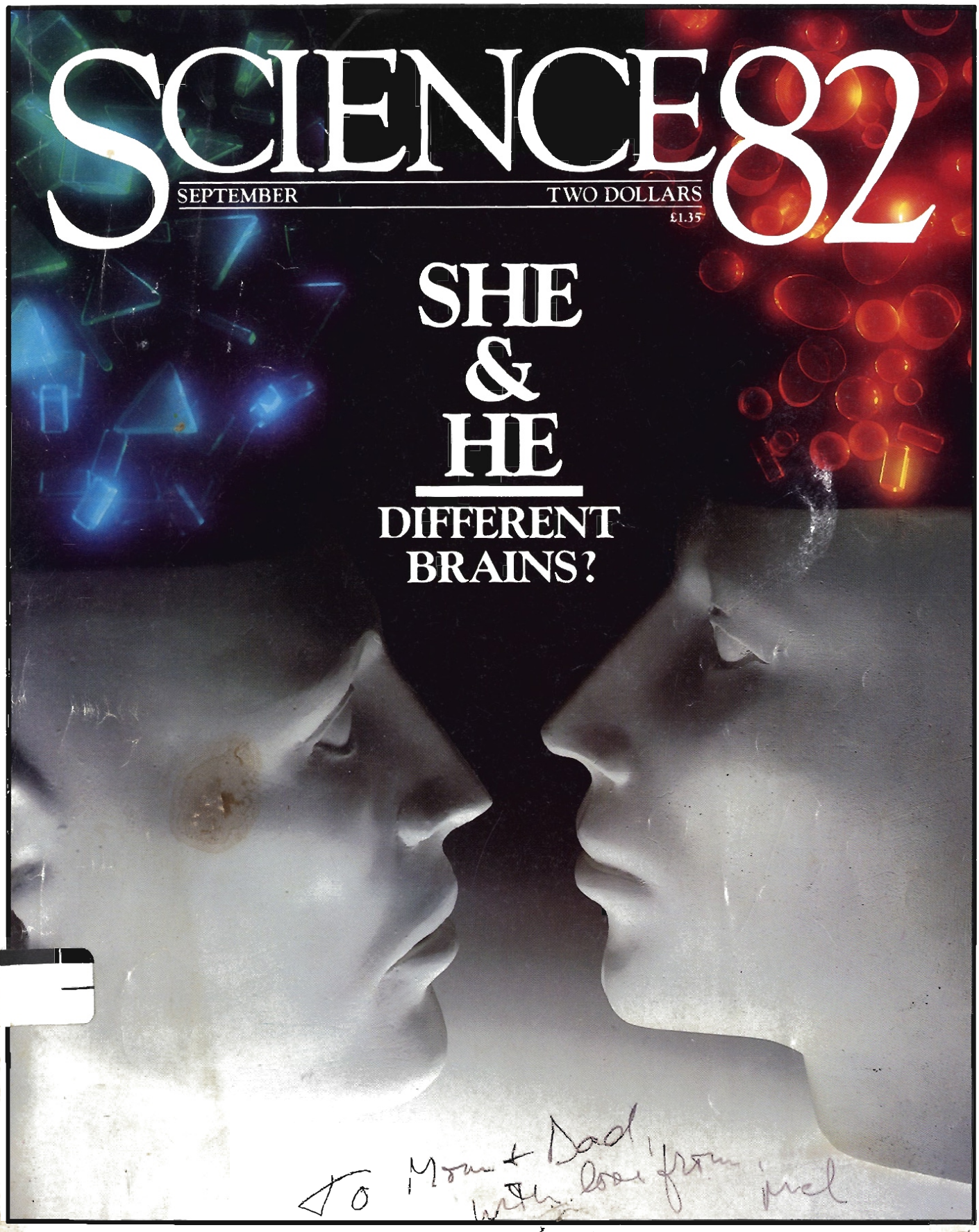


## SHE & HE
## DIFFERENT BRAINS?

To Mom + Dad
With love from Jael

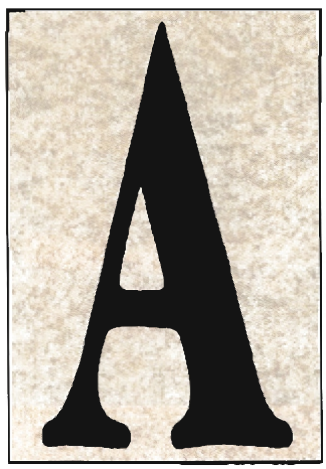
Sept 7, 1982

CANCER GENES
NIGHT OF THE SPADEFOOT TOAD
THE DOOMSDAY LETTERS

# SHE & HE

## The differences start in the genes, trigger the hormones, shape the brain, and direct behavior.

*by Melvin Konner*



nke Ehrhardt, Patricia Goldman, Sarah Blaffer Hrdy, Corinne Hutt, Julianne Imperato-McGinley, Carol Nagy Jacklin, Annelise Korner, Eleanor Emmons Maccoby, Alice Rossi, Beatrice Blyth Whiting. These are the names of some distinguished women scientists who devote their lives to the study of brain, hormones, or behavior, human and animal. They range from the world famous to the merely well known. Each, within her discipline, has a reputation for tough-mindedness. All have in common that they have given considerable attention (most of them many years) to the question of

Illustrations by Dean Willia

## After sexism is stripped away, there will still be something different—something grounded in biology.

whether the sex differences in behavior each has observed—in the field, in the clinic, and in the laboratory—have a basis that is in part biological.

Without exception, they have answered this question in the affirmative. One cannot imagine that they did so without difficulty. Each has suffered, personally and professionally, from the ubiquitous discrimination against women that is common outside the academy and within it. Each has worked with some man who envisioned her—in his heart of hearts—barefoot, meek, pregnant, and in the kitchen. Each has sacrificed more than the average brilliant man to get in a position to work on a problem that troubles her intellectually, and the payment of that sort of price makes the truth more compelling. Nevertheless, each is wise enough to know that over the long course of time, the very sorts of oppression she has experienced are bulwarked and bastioned by theories of "natural" gender differences.

These women are doing a balancing act of formidable proportions. They continue to struggle, in private and in public, for equal rights and equal treatment for people of both sexes; at the same time, they uncover and report evidence that the sexes are irremediably different—that after sexism is wholly stripped away, after differences in training have gone the way of the whalebone corset, there will still be *something* different, something that is grounded in biology.

Like many stories in modern behavioral science, this one begins with Margaret Mead. She was one of the greatest of all social scientists. In a world in which all odds were against it, she established a concept of human differences as more flexible, more malleable, more buffeted by the winds of life experience—as delivered by our very different cultures—than anybody had then thought possible. And this concept has stood the test of time.

No question so engaged her interest as that of the role of gender in behavior. In trip after stubborn trip to the South Seas, she gathered information impossible to come by otherwise. Among headhunters and fishermen, medicine men and exotic dancers, in steamy jungles, on mountaintops, on vivid white beaches, in bamboo huts, in meeting houses on stilts high above water, in shaky-looking seagoing bark canoes, she took out her ubiquitous notebook and recorded the behavior and beliefs of men and women who had never heard of American sex roles. By 1949, when *Male and Female* was published, she had done so in seven remote societies.

In all her cultures there was homicidal violence, and in all, that violence occurred at the hands of men. Tchambuli men may have been effeminate in relation to certain American conventions, but they were still very devoted to taking victims—and, more traditionally, hunting heads. Mundugumor men were unthreatened by having their women provide for them. But that was because it freed them to plot and fight.

This may be traced in a like manner through all the world's thousands of different cultures. In every culture there is at least some homicide, in the context of war or ritual or in the context of daily life, and in every culture men are mainly responsible for it. There are, of course, individual exceptions, but there is no society in the ethnographic or historical record in which men do nearly as much baby and child care as women. This is not to say anything, yet, about capacity; it is merely a statement of plain, observable fact. Men are more violent than women, and women are more nurturant, at least toward infants and children, than men.

Even in dreams the distinction holds. In a study of dreams in 75 tribal societies around the world, men were more likely to dream of coitus, wife, weapon, animal, red, while women were more likely to dream of husband, mother, father, child, cry.

Of course, this is ethnographic fact, and that raises some eyebrows. Although cross-cultural surveys are quantitative in nature, they are based on individual studies consisting mainly of mere description. As such, they are the victims of "hard science" snobbery. That snobbery is most ill-founded. Ethnology is in its earliest phase as a science. Just as "mere" description of the look of a newly delineated brain region or a type of liver cancer as they appear under the microscope is a first step on a new path in science, so, equally, is the description of a society—description using the human eye, ear, and mind without computers.

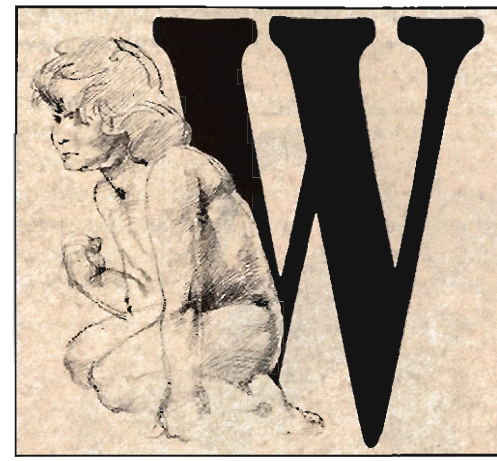
Nevertheless, we recognize quantification as necessary, and, at least

until recently, such quantification was more usual in the work of psychologists than of anthropologists. For many years now, psychologists in the Western world have studied gender differences, and they have done so with an exactitude very difficult to match in the tropical jungle. Eleanor Maccoby, an elder stateswoman of American psychology, and Carol Jacklin, a young scientist trained in part by Maccoby, have, after years of work on the problem, written a major book, *The Psychology of Sex Differences.* It not only summarizes their own work but, more important, systematically reviews and tabulates hundreds of carefully described and annotated studies by other investigators. They review studies of sex differences on scores of different dimensions—tactile sensitivity, vision, discrimination learning, social memory, general intellectual abilities, achievement striving, self-esteem, crying, fear and timidity, helping behavior, competition, conformity and imitation, to name only a few.

For most of these dimensions it may be emphatically stated that there is no consistent pattern of gender difference. For almost all there are at least some studies that find a gender difference in either direction—usually both—and many studies that find no difference. Indeed, the main thrust of the book is to demolish cliché after cliché about the difference between boys and girls, men and women. There is no evidence that girls and women are more social, more suggestible, have lower self-esteem or less achievement motivation than boys and men, or that boys and men are more analytic. In the realms of tactile sensitivity and fear and timidity there is weak evidence of a gender difference —girls show more of these. There is also weak evidence that girls are more compliant than boys and less involved in assertions of dominance. In the realm of cognitive abilities, there is good evidence for superiority of girls and women in verbal ability and of boys and men in spatial and quantitative ability.

But the strongest case for gender difference is made in the realm of aggressive behavior. Out of 94 comparisons in 67 different quantitative studies, 57 comparisons showed statistically significant sex differences. Fifty-two of the 57 studies that showed differences showed boys to be more aggressive than girls.

Maccoby and Jacklin do not report on studies of nurturance per se, but in an earlier book, published in 1966, Maccoby summarized 52 studies in a category called "nurturance and affiliation"; in 45 studies, girls and women showed more of it than boys and men, while in only two did males score higher, with five showing no difference.



While it is difficult to get accurate information in nonindustrial cultures on such measures as verbal and spatial ability, a number of excellent studies have been done on child behavior, using techniques of measurement and analysis that live up to a high standard of rigor. Beatrice Whiting has been a leader in this field, originating techniques of study and sending students out to remote corners of the Earth (as well as making field trips herself) to bring back accurate knowledge about behavior. She is one of the most quantitatively oriented of anthropologists and may be said to have built an edifice of exactitude on the foundation that was laid by Margaret Mead. She has been at it for about 40 years.

In a series of investigations that came to be known as the Six Cultures study, Whiting, together with John Whiting and other colleagues, studied children's behavior through direct, detailed observations, in standard settings, distributed throughout the day. These observations were made by teams in a New England town called Orchard Town—its identity is still a mystery—and in five farming and herding villages throughout the world. In Mexico, Kenya, India, Japan, and the Philippines, as well as in New England, hundreds of hours of observations were made.

In all six cultures, boys differed from girls in the direction of greater egoism and/or greater aggressiveness, usually both. The difference varies greatly from culture to culture, presumably in response to different degrees of inculcation of gender role. Even more interesting, the girls in one culture may be more aggressive than the boys in another. But the direction of the difference within any culture is always the same. In other words, studies of children who are not fully socialized to their cultures underscore gender differences in the areas of aggressiveness and nurturance.

It may be argued that the children in Whiting's stud-

ies had nevertheless been trained; they ranged in age from three to 12. Furthermore, all of the six cultures may well be sexist.

till, we can go younger. Annelise Korner has spent many years studying newborn infants, and one of her central interests has been sex differences. She, as well as other investigators, has found that at birth boys show more muscle strength—greater head lift in the prone position, for example—while girls show greater skin sensitivity, more reflex smiles, more taste sensitivity, more searching movements with their mouths, and faster response to a flash of light.

But before we resort to this indirect accounting, it behooves us to consider another category of evidence: the sort of evidence that comes from studies of hormones, behavior, and the brain.

The idea that humoral factors secreted by reproductive organs influence gender differences in behavior is very old; castration has long been used in attempts to reduce aggressiveness in animals and men, and systematic experimental work demonstrating that this works has been available since 1849. The question is no longer whether hormones secreted by the testes promote or enable aggressive behavior, but *how*, and also: What else goes on in a like manner?

The principal male gonadal hormone in mammals is testosterone. It belongs to a chemical class known as steroids. The steroid class includes the two principal female reproductive hormones: estradiol—the key estrogen in humans—and progesterone, the gestation-promoting substance secreted in massive quantities by the placenta, and in lesser quantities, in the nonpregnant woman, by the ovaries. Estradiol and progesterone, together with the pituitary hormones that regulate them, participate in the determination of the monthly cycle. Although nothing so fabulous as that exists in males, there is much in common between testosterone's mode of action and that of the two female sex steroids.

The brain is the main regulatory organ of behavior, and behavior is that organ's major output; for a molecule to affect behavior it must generally first affect the brain, or at least the peripheral nerves. Sex steroids are no exception. Giving a rat a systemic injection of estradiol (radioactively labeled for tracing) will produce a high concentration of this hormone in certain brain cells—specifically, in their nuclei—within two hours. Twenty-two hours after that there will be a correspondingly massive increase in the tendency of the rat—if female—to respond to stimulation with sexual posturing. What happens in those 22 hours will tell a tale that may very well change the way we look at cell biology, but the tale cannot be told without at least a few more years of research.

Meanwhile, we know, as children like to say, *for sure*, that sex steroid hormones affect behavior, and we know they get around quite well in the brain. Using radioactive labeling, it has been very easy to show not only that they pass from blood to brain, but they concentrate selectively in certain brain regions. That is, concentrations occur in brain regions that play an important role in courtship, sex, maternal behavior, and violence—just the behaviors in which the sexes most differ and the ones most subject to influence by testosterone, estradiol, and progesterone.

Although the way the system works is scarcely understood, there are clues. For instance, injection of testosterone lowers the threshold for firing of nerve fibers in the pathway that leads to the hypothalamus, and as such in all likelihood mediates an excitatory influence on sexual and aggressive behavior. This finding gives substance to the action of testosterone on behavior. It is one thing to say that this hormone probably influences sex and aggression by acting on the brain; it is quite another to find a major nerve bundle deep in the brain, likely to be involved in sex and aggression, that can fire more easily when testosterone acts on it than when it does not. A key link in the story has been formed.

But we don't even need to reach so deeply into the brain. Peripheral nerves have now been shown in several experiments to concentrate these hormones. In songbirds in which the male of the pair is the singer, testosterone is concentrated in the motor nerves to the syrinx—the bird's voice box—and this is almost certainly part of the reason testosterone promotes song, which is a male courtship pattern. In female rats, injec-

Among male prison inmates, the higher the adult testosterone level, the earlier the age of the first arrest.

tion of estradiol increase the size of the region of sensitivity of the nerve to the pelvic region, even when that nerve is detached from the brain; this is presumably part of the mechanism that makes the female susceptible—some of the time, anyway—to male advances.

Such is the view of the physiologist, which is, not surprisingly, pretty unrelenting. What is a bit surprising is that someone like Alice Rossi has accepted it. Rossi is a family sociologist. After years of distinction in her field, she became dissatisfied with 19th-century sociologist Emile Durkheim's dictum that only social facts can explain social facts and began to take seriously the notion that at least some social facts might be explained by biological ones. She has become adept in reading the biological literature, and when she reviews it for her sociologist colleagues, she does not attempt to conceal from them her belief that some of the observed gender difference in social behavior—for example, in parenting—is attributable to causes in endocrinology.

In reviewing the well-known sex difference in nurturing behavior—obvious particularly within the family, and in all cultures—Rossi has accepted the possibility that it may have its roots partly in hormonal differences. She has defended this viewpoint in several recent articles, in the scholarly as well as semipopular literature.

From a hormonal perspective, nurturance has not been as well studied as aggressiveness, in some ways the antithesis of nurturance. In many studies of humans and other animals, testosterone at least clearly enables and perhaps directly increases aggressiveness. While no one with any experience in this field thinks that there is a simple relationship between testosterone and aggression, most people now accept that some such relationship does exist.

To take an example, although repeated studies of aggression and testosterone in prison inmates have produced a confused picture, one intriguing discovery stands out: Among male prison inmates, in one very good study, the higher the adult testosterone level, the earlier the age of the first arrest. That is, the men who had the highest levels had been arrested youngest, in early adolescence. In another study, the level of testosterone in male juvenile delinquents was correlated with their level of observed aggressive behavior.

This finding brings us to one of the most central facts about the gonadal hormones: They rise very dramatically at adolescence. From very low levels during early and middle childhood, testosterone (especially but not exclusively in males) and estradiol and progesterone (both especially but not exclusively in females) all rise to adult levels over the course of a few years, and the female monthly cycle is instituted. Few studies have measured hormones and behavior in the same individuals, but it is likely that adolescent behavior—and its gender differentiation—is influenced by these massive hormonal changes. Gender differences in fat, muscle mass, and the pitch of the voice, all of which contribute to gender-specific behavior, are determined in large part by the teenage boy's rise in testosterone.

One could conceivably leave the picture here, stress the similarity between the sexes in neurobehavioral plan, and suggest that evolution made a single beast with a single twist: an infusion of different hormones, coming from the gonads, just at the moment of reproductive maturity, just when we would expect the genders to begin to be really different.

The difficulty with this neat picture is that we have overwhelming evidence that the sexes differ in their behavior long before puberty, when previously we had thought that there were not enough circulating sex steroids to make the difference.

There is increasing evidence that the accounting may lie deep in the brain. In 1973 it was shown for the first time that male and female brains differed structurally. In the most forward portion of the hypothalamus, male and female rats differed in the density of synaptic connections among local neurons. Furthermore, castration of males just after birth would leave them with the female brain pattern, and injection of testosterone into females—likewise just after birth—would give them the male pattern.

To say that this study by Geoffrey Raisman and Pauline Field "rocked the neuroscience community" seems an extreme statement, yet I believe it to be accurate.

# Scientists concluded that the basic plan of mammals is female—unless told to be otherwise.

There are several reasons. For one thing, it was the first demonstration that the brains of the sexes differ, in any animal. For another, the difference was in a region where it should have been—a region concerned with the brain's regulation of the very gonadal hormones we have been looking at. But most impressive of all, to those who knew the field, was the demonstration that sex hormones, circulating *at birth*, could change the brain. One of the most interesting experiments of the kind produced "pseudo-hermaphrodite" monkeys by administering male gonadal hormones to female fetuses before birth. As they grew, these females showed neither the characteristic low female level of aggressive play nor the characteristic high male level but something roughly in between.

For these reasons, investigators had, before 1973, already begun to talk about a change in the brain by male sex hormones around the time of birth; to put it crudely, a masculinization of the brain. But the involvement of the brain was only speculative until the report of Raisman and Field, which then gave the phrase its first genuine meaning.

That, as it now appears, was only the beginning of the story. A few years later, Dominique Toran-Allerand did a tissue-culture experiment—with brain slices in petri dishes—in which she watched the process in action. She made thin slices of the hypothalamus of newborn mice—of both sexes—and kept them alive long enough to treat them with gonadal steroid hormones, including testosterone. Her brief paper, published in *Brain Research*, shows the stunning results in photomicrographs. The cells in the slices treated with testosterone show more and faster growing neural processes than with the testosterone-free solution. In effect, she was able to watch as testosterone changed the newborn brain. Her work did not imply that the faster, more florid growth made the testosterone-treated hypothalamus *better*—only different.

For these and a variety of other reasons, the community of scientists working in this field concluded that the basic plan of the mammalian organism is female and stays that way unless told to be otherwise by masculine hormones. That this was not a necessary arrangement was shown by the sexual differentiation of birds, in which the opposite seems to be true; the basic plan is male, and the female course of development is the result of female hormones. But the mammal story was becoming clear: The genetic signal for masculinity, from the Y chromosome, did its work on a female structural plan, through masculine hormones.

It is only natural to doubt whether such generalizations are applicable to that most puzzling of all mammals, the one that does research on its own nature. My own doubts in the matter—formidable at the time—were largely dispelled by the investigations of Anke Ehrhardt and her colleagues, first at the Johns Hopkins School of Medicine, later at the Columbia College of Physicians and Surgeons. Ehrhardt has spent years studying the condition and clinical treatment of certain unfortunate "experiments in nature"—anomalies of sexual and psychosexual development. In one such set of anomalies, known as the adrenogenital syndrome, a genetic defect produces abnormally large quantities of the sex steroid testosterone. For girls with the syndrome, masculine levels of the hormone are floating around in the blood throughout gestation, until the time of birth. Shortly after birth the condition can be corrected, so that it is presumably only in the prenatal period that the hormone can have its effects.

At age 10 these girls are psychologically different from their sisters and from unrelated controls. They are described by themselves and by their mothers as doing less doll play, being more "tomboyish," and expressing less desire to marry and have children when they grow up. Whatever value judgment we choose to place on these phenomena—I am inclined, for the moment, to place none—they seem to be real. They have been repeated by different investigators with different samples and even with different syndromes that amount, hormonally, to much the same thing. Taken together with the increasing animal evidence, these findings suggested to Ehrhardt and her colleagues—and to many others as well—that humans too could experience psychosexual differentiation, affecting both behavior and the brain, as a result of masculinizing hormones acting near or before birth.

his possibility received stunning confirmation in a series of discoveries made by endocrinologist Julianne Imperato-McGinley of the New York Hospital-Cornell Medical Center. These had to do principally with the analysis of a new syndrome of abnormal sexual differentiation that defied all previous rules. It was confined to three intermarrying rural villages in the southwestern Dominican Republic and, over a period of four generations, afflicted 38 known individuals from 23 interrelated families. It is clearly genetic but has arisen only recently due to mutation and intermarriage.

Nineteen of the subjects appeared at birth to be unambiguously female and were viewed and reared that way. At puberty they first failed to develop breasts and then underwent a completely masculine pubertal transformation, including growth of a phallus, descent of the testes, deepening of the voice, and the development of a muscular masculine physique. Physically and psychologically they became men.

The physiological analysis undertaken by Imperato-McGinley and her colleagues revealed that these individuals are genetically male—they have one X and one Y chromosome—but lack a single enzyme of male sex-hormone synthesis, due to a defective gene. The enzyme, 5-alpha-reductase, changes testosterone into another male sex hormone, dihydrotestosterone. Although they lack dihydrotestosterone almost completely, they have normal levels of testosterone itself. Evidently these two hormones are respectively responsible for the promotion of male external sex characteristics at birth and at puberty. The lack of "dihydro" makes for a female-looking newborn and prepubertal child. The presence of testosterone makes for a more or less normal masculine puberty.

But for present purposes, the most extraordinary thing about these people is that they become men of their culture in every sense of the word. After 12 or more years of rearing as girls, they are able to completely transform themselves into almost typical examples of the masculine gender—with family, sexual, vocational, and avocational roles. Of the 18 subjects for which data were available, 17 made this transformation completely, the other retaining a female role and gender identity. The 17 did not make the transformation with ease. Imperato-McGinley reports that it cost some of them years of confusion and psychological anguish. But they made it, without special training or therapeutic intervention. Imperato-McGinley and her colleagues reason that the testosterone circulating during the course of growth in these men has a masculinizing effect on their brains.

What are we to make of these extraordinary facts? For the immediate future, at least as far as I am concerned, nothing. It is simply too soon. Given present knowledge, for instance, it is not beyond the realm of possibility that the observed differences between the brains of the two genders serve only physiological functions. The brains must be different to exert different control over different reproductive systems, having nothing at all to do with behavioral subtleties. But I think this unlikely. If not now, then in the very near future, it will be extremely difficult for an informed, objective observer to discard the hypothesis that the genders differ in their degree of violent behavior for reasons that are in part physiological. [See Currents, p. 14, of first evidence of differences in human brains.]

If the community of scientists whose work and knowledge are relevant should come to agreement on this point, then it seems to me that one policy implication is plausible: Serious disarmament may ultimately necessitate an increase of women in government. Some women are as violent as almost any man. But speaking of averages there is little doubt that we would all be safer if the world's weapon systems were controlled by average women instead of by average men.

I think it appropriate to end where we began, contemplating the women who have helped unearth these facts. Visualize them in their offices and laboratories, trying to sort out what it all means; how do they handle the dissonance their findings must engender? I suspect that they do it by making a reconciliation—not a compromise—but a complex difficult reconciliation between the idea of human difference and the ideal of human equality. It is one that we must all make soon.

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*Melvin Konner, a Harvard biological anthropologist, will become chairman of anthropology at Emory University this fall.*