BASIC BOOKS
A MEMBER OF THE PERSEUS BOOKS GROUP

SEXING THE BODY

GENDER POLITICS *and the* CONSTRUCTION *of* SEXUALITY

ANNE FAUSTO-STERLING

and methods." Many of these men attributed "partner sexual satisfaction and the stability of their relationships to their need to make extra effort including non-penetrating techniques."[102]

My vision is utopian, but I believe in its possibility. All of the elements needed to make it come true already exist, at least in embryonic form. Necessary legal reforms are in reach, spurred forward by what one might call the "gender lobby": political organizations that work for women's rights, gay rights, and the rights of transgendered people. Medical practice has begun to change as a result of pressure from intersexual patients and their supporters. Public discussion about gender and homosexuality continues unabated with a general trend toward greater tolerance for gender multiplicity and ambiguity. The road will be bumpy, but the possibility of a more diverse and equitable future is ours if we choose to make it happen.

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SEXING THE BRAIN:

HOW BIOLOGISTS MAKE A DIFFERENCE

The Callosum Colossus

SUPPOSE MY UTOPIAN VISION, AS DESCRIBED IN THE LAST CHAPTER, came to pass. Would all gender differences disappear? Would we award jobs, status, income, and social roles based only on individual differences in physique, intellect, and inclination? Perhaps. But some would argue that no matter how widely we opened the door, ineluctable differences between groups would remain. Scientists, such naysayers would argue, have proven that in addition to our genitalia, key anatomical differences between the male and female brain make gender an important marker of ability. To drive home their point, they might cite well-publicized claims that, compared to men's, the corpus callosum—the bundle of nerve fibers connecting the left and right brain hemispheres—in women's brains is larger or more bulbous. And *that,* they would exclaim, will limit forever the degree to which most women can become highly skilled mathematicians, engineers, and scientists. But not everybody believes in this difference in brain anatomy.

External anatomy seems simple. Does the baby's hand have five or six fingers? Just count them. Do boys have penises and girls vaginas (intersexuals notwithstanding)? Just look. Who could disagree about body parts? Scientists use the rhetoric of visibility to talk about gender differences in the brain, but moving from easily examined external structures to the anatomy of the interior is tricky. Relationships among gender, brain function, and anatomy are both hard to interpret and difficult to see, so scientists go to great lengths to convince each other and the general public that gender differences in brain anatomy are both visible and meaningful.[1] Some such claims provoke battles that can last for hundreds of years.[2] In coming to understand how and why these battles can last so long, I continue to insist that scientists do not simply read nature to find truths to apply in the social world. Instead, they use truths taken from our social relationships to structure, read, and interpret the natural.[3]

Medical "solutions" to intersexuality developed as scientific innovations, ranging from new methods of classification to new skills in microscopy, interacted with the preconception that there are only two genders. Scientific unanimity reigned in part because the social beliefs about male and female were not in dispute. But when the social arena forms a battleground, scientists have a hard time developing a consensus. In this chapter, I show how, as they move from difference on the body's surface to interior differences, scientists use their tools to debate about masculinity and femininity. For what professions are those with "masculine" or "feminine" brains most suited? Should special efforts be made to encourage women to become engineers? Is it "natural" for boys to have trouble learning to read? Are gay men more suited to feminine professions such as hairdressing or flower arranging because of a more feminine corpus callosum? These interlocking social questions sustain the debate about the anatomy of the corpus callosum.[4]

The winter of 1992 was a hard one. There was nothing to do but sit around and contemplate our collective corpus callosums. Or so it seemed; what else would explain the sudden spate of news articles about this large bundle of nerve fibers connecting the left and right brain hemispheres? *Newsweek* and *Time* magazines started the trend by running feature stories about gender differences and the brain.[5] Women, a *Time* illustration informed its readers, often had wider corpus callosums than men. This difference, suggested a caption to one of the glossy illustrations, could "possibly [provide] the basis for woman's intuition." The text of the article concedes that not all neurobiologists believe in this alleged brain difference. Meme Black, writing for *Elle*, was less cautious: that women have larger corpus callosums, she wrote, could explain why "girls are less apt than boys to gravitate toward fields like physics and engineering."[6]

Others agreed. A *Boston Globe* article about gender difference and the corpus callosum quoted Dr. Edith Kaplan, a psychiatrist and neurologist: "throughout life men's and women's brains are anatomically different, with women having a thicker corpus callosum. . . . Because of these interconnections," she suggests, women have stronger verbal skills and men stronger visuo-spatial ones.[7] Not to be outdone, *The New York Times* science editor Nicholas Wade wrote that definitive research that revealed callosal sex differences discredited "some feminist ideologues" who "assert that all minds are created equal and women would be just as good at math if they weren't discouraged in school." [8] (Imagine!)

Nor did the intrigue stop with questions about whether women's brains

made them unsuitable for science careers. Rather, the media seemed prepared to believe that all physiological and social differences could ultimately be traced to differences in the form of one part of the brain. Follow the logic of a 1995 *Newsweek* cover story entitled "Why Men and Women Think Differently," suggesting that brain differences in the corpus callosum might explain why women think holistically (assuming they do), while men's right brains don't know what their left is doing (if that is, indeed, the case). "Women have better intuition," the author stated, "perhaps because they are in touch with the left brain's rationality and the right's emotions simultaneously."[9] To support this theory the article cited studies that found CAH girls to be more male-like than other girls in both play patterns and cognitive strengths, and suggested—in a stunning piece of circular reasoning—that such studies might indicate that sex hormones are responsible for differences in CC size.[10]

As if this sort of argument were not far-fetched enough, some pushed the CC determinism even further. In 1992, for instance, the psychologist Sandra Witelson mixed a different seasoning into the stew, publishing an article in which she argued that just as men and women differ in cognitive abilities and CC structure, so too did gay and straight men. (As usual, lesbians were nowhere to be found.) "It is as if, in some cognitive respects, [gay men] are neurologically a third sex," she wrote, adding that the brain differences may eventually help account for "the apparently greater prevalence and ability of homosexual men compared to heterosexual men in some professions."[11] She didn't elaborate on just which professions she meant, but by arguing that the form of the corpus callosum helps determine handedness, gender identity, cognitive patterns, and sexual preference, she effectively suggested that this one area of the brain plays a role in regulating almost every aspect of human behavior.[12]

These newspaper and magazine stories show us the corpus callosum hard at work, its sleeves rolled up, sweat pouring down its face, as it strives to provide researchers with a single anatomical control center, a physical origin for an array of physiological and social variations. Why does the CC have to work so hard? Why don't the facts just speak for themselves? In the late 1800s anatomists, who had previously always drawn male skeletons, suddenly developed an interest in female bone structure. Because the skeleton was seen to be the fundamental structure—the material essence of the body—finding sex differences would make clear that sexual identity penetrated "every muscle, vein and organ attached to and molded by the skeleton."[13] A controversy arose. One scientist—a woman—drew females with skulls proportionately smaller than those of males, while another—a male—painted women whose skulls were larger relative to the rest of their bodies than were those of males.

At first everyone favored the former drawings, but—after much back and forth—scientists conceded the accuracy of the latter. Nevertheless, scientists clung to the fact that women's brains were smaller in absolute size, thus proving that women were less intelligent.[14] Today we turn to the brain rather than the skeleton to locate the most fundamental sources of sexual difference.[15] But, despite the many recent insights of brain research, this organ remains a vast unknown, a perfect medium on which to project, even unwittingly, assumptions about gender.

The contemporary CC debate began in 1982 when the prestigious journal *Science* published a brief article by two physical anthropologists. The paper received instant notoriety when the talk-show host Phil Donahue inaccurately credited the authors with describing "an extra bundle of neurons that was missing in male brains."[16] The *Science* article reported that certain regions of the corpus callosum were larger in females than in males. Although admittedly preliminary (the study used nine males and five females), the authors boldly related their results to "possible gender differences in the degree of lateralization for visuospatial functions."[17]Here's the lay translation: some psychologists (but not all[18]) believe that men and women use their brains differently. Men, supposedly, make almost exclusive use of the left hemisphere when processing visuo-spatial information, while women allegedly use both hemispheres. In psycho-jargon, men are more lateralized for visuo-spatial tasks. Layered on top of this claim is another (also disputed), that greater lateralization implies greater skill capacity. Men often perform better on standardized spatial tasks, and many believe that this also explains their better performance in mathematics and science. If one buys this story *and* if one believes that the posited functional differences are inborn (resulting, for example, from anatomical differences, perhaps induced by hormones during fetal development), then one can argue that it makes no sense to develop a social policy calling for equal representation of men and women in fields such as engineering and physics. You can't, after all, squeeze blood out of a stone.

The psychologist Julian Stanley, who heads a national program for mathematically talented youth, recently reported that male twelfth graders got higher scores on Advanced Placement tests in physics. He believes the test scores imply that "few females will be found to reason as well mechanically as most males do. This could be a serious handicap in fields such as electrical engineering and mechanics. . . . Such discrepancies would . . . make it inadvisable to assert that there *should* be as many female as male electrical engineers." "It doesn't make sense," he continued, "to suppose that parity is a feasible goal until we find ways to increase such abilities among females."[19] Meanwhile, Stanley's colleague, Dr. Camilla Benbow, suggests with very little

evidence[20] that sex differences in mathematics may emanate, at least in part, from inborn differences in brain lateralization.[21]

We see the corpus callosum employed here as part of what Donna Haraway calls "the technoscientific body." It is a node from which emanate "sticky threads" that traverse our gendered world, trapping bits and pieces like newly hung flypaper.[22] Callosal narratives become colossal, linking the underrepresentation of women in science with hormones, patterns of cognition, how best to educate boys and girls,[23] homosexuality, left versus righthandedness, and women's intuition.[24] The sticky threads do not restrict themselves to gender narratives, but glue themselves as well to stories about race and nationality. In the nineteenth and early twentieth centuries the CC itself was racially implicated. In the late twentieth century, styles of thinking (thought by many to be indirectly mediated by the CC[25]) are often racialized. Instead of learning that "Negroes" have smaller CC's than Caucasians,[26] we now hear that Native Americans or Asians (of every stripe) think more holistically than do Europeans. In discussions of the corpus callosum and its role in connecting left and right brain hemispheres, the slippery dualisms that Val Plumwood warned us against (see chapter 1) abound (table 5.1). The CC does not easily bear such weight, and therein lies the heart of this chapter. How have scientists turned the corpus callosum into an object of knowledge? Given this techno-scientific object's recalcitrance, what are the scientific weapons deployed in the battle to make the corpus callosum do gender's bidding?

Taming the Wild CC

Most claims about what the corpus callosum does are based on data about its size and shape. But how in the world can scientists produce accurate measurements of a structure as complex and irregularly shaped as the corpus callosum? Looked at from above, the CC resembles a raised topographical map (figure 5.1). A pair of ridges run oddly parallel for some distance, but diverge to the south. Flanking one ridge to the west and the other to the east lie plateaus, while a vast valley runs between the ridges. East-west striations traverse the entire territory. These striations—which represent millions of nerve fibers—constitute the corpus callosum.[27]As the ridges and valleys suggest, these fibers don't run along a flat, two-dimensional surface; instead they rise and fall. Moreover, as the edges of the map indicate, the fibers are not wholly separate from other parts of the brain, but instead connect to and entangle with them. As one pair of researchers writes: "the corpus callosum is shaped much like a bird with complicated wing formation. Further these wings co-mingle with the ascending white matter tracts . . . making the lat-

TABLE 5.1 *Nineteenth- and Twentieth-Century Left/Right Brain Dichotomies*[a]

19TH CENTURY		20TH CENTURY	
LEFT	RIGHT	LEFT	RIGHT
Anterior	Posterior	Verbal	Visuo-spatial/ nonverbal
Humanness	Animality	Temporal	Simultaneous
Motor activity	Sensory activity	Digital	Analogic
Intelligence	Emotion/sensibility	Rational	Intuitive
White superiority	Nonwhite inferiority	Western thought	Eastern thought
Reason	Madness	Abstract	Concrete
Male	Female	Female	Male
Objective	Subjective	Objective	Subjective
Waking self	Subliminal self	Realistic	Impulsive
Life of relations	The organic life	Intellectual	Sensuous

a. Taken from Harrington 1985.

eral portion of the corpus callosum essentially impossible to define with certainty.[28]

Or one could imagine the CC as a bunch of transatlantic telephone cables. In the middle of the Atlantic (the valley on the map, which joins the left and right cerebral hemispheres), the cables are bundled. Sometimes the bundles bunch up into ridges; but as the cables splay out to homes and offices in North America and Europe, they lose their distinct form. Smaller bunches of wire veer off toward Scandinavia or the Low Countries, Italy or the Iberian Peninsula. These in turn subdivide, going to separate cities and ultimately to particular phone connections. At its connecting ends, the corpus callosum loses its structural definition, merging into the architecture of the cerebrum itself.

The "real" corpus callosum, then, is a structure that is difficult to separate from the rest of the brain, and so complex in its irregular three dimensions as to be unmeasurable. Thus, the neuroscientist who wants to study the CC must

FIGURE 5.1: A three-dimensional rendering of the entire corpus callosum cleanly dissected from the rest of the brain. (Source: Alyce Santoro, for the author)

first tame it—turn it into a tractable, observable, discrete laboratory object. This challenge itself is nothing new. Pasteur had to bring his microbes into the laboratory before he could study them;[29] Morgan had to domesticate the fruit fly before he could create modern Mendelian genetics.[30] But it is crucial to remember that this process fundamentally alters the object of study. Does the alteration render the research invalid? Not necessarily. But the processes researchers use to gain access to their objects of study—processes often ignored in popular reporting of scientific studies—reveal a great deal about the assumptions behind the research.[31]

Scientists began to tame the CC before the turn of the century. Then, great hopes were pinned on using it to understand racial differences (with a little gender thrown in to boot). In 1906 Robert Bennet Bean, working in the anatomical laboratory at Johns Hopkins University, published a paper entitled "Some Racial Peculiarities of the Negro Brain."[32] Bean's methods seemed unassailable. He carefully divided the CC into subsections, paid careful attention to specimen preparation, provided the reader with large numbers of CC tracings,[33] made extensive use of charts and tables, and acquired a large study sample (103 American Negroes and 49 American Caucasians). So useful were his results that some of the participants in the late-twentieth-century debate not only refer to his work but have reanalyzed his data.[34] Indeed, despite some modernist flourishes (like the use of sophisticated statistics and computers), the methods used to measure the size and shape of the corpus callosum in cadavers has not changed during the ninety odd years since the publication of Bean's account. I do not want to tar modern scientists with the brush of earlier research that most now find racist. My point is that, once freed from the body and domesticated for laboratory observation, the CC can serve different masters. In a period of preoccupation with racial difference, the CC, for a time, was thought to hold the key to racial difference. Now, the very same structure serves at gender's beck and call.[35]

Bean's initial measurements confirmed earlier studies purporting to show that Negroes* have smaller frontal lobes but larger parietal lobes than Caucasians. Furthermore, he found that Negroes had larger left frontal but smaller left parietal lobes, while the left/right asymmetry was reversed for Caucasians. These differences he felt to be completely consistent with knowledge about racial characteristics. That the posterior portion of the Negro brain was large and the anterior small, Bean felt, seemed to explain the self-evident truth that Negroes exhibited "an undeveloped artistic power and taste . . . an instability of character incident to lack of self-control, especially in connection with the sexual relation." This of course contrasted with Caucasians who were clearly "dominant . . . and possessed primarily with determination, will power, self-control, self-government . . . and with a high development of the ethical and aesthetic faculties." Bean continues: "The one is subjective, the other objective; the one frontal, the other occipital or parietal; the one a great reasoner, the other emotional; the one domineering but having great self-control, the other meek and submissive, but violent and lacking self-control."[36] He found also that the anterior (*genu*) and posterior (*splenium*) ends of the corpus callosum were larger in men than in women. Nevertheless, he focused primarily on race. He reasoned that the middle portions (called the *body* and the *isthmus*) contained fibers responsible for motor activity, which he thought to be more similar between the races than other brain regions.[37]

* I use the word Negro because it is used in Bean's paper.

TABLE 5.2 *Bean's Results*

CAUCASIAN MALE > CAUCASIAN FEMALE > NEGRO MALE > NEGRO FEMALE	CAUCASIAN MALE > CAUCASIAN FEMALE > NEGRO MALE = NEGRO FEMALE	NEGRO MALE > NEGRO FEMALE > CAUCASIAN MALE > CAUCASIAN FEMALE	NEGRO MALE > NEGRO FEMALE = CAUCASIAN MALE > CAUCASIAN FEMALE
Total callosal area	Anterior/posterior half (ratio)	Splenium	Body/isthmus (ratio)
Area of anterior half			
Area of genu			
Area of isthmus			
Area of body			
Genu/splenium (ratio)			

Indeed, he found the greatest racial differences outside the motor areas. Prevailing beliefs about race led Bean to expect the splenium, which presumably contained fibers linking more posterior parts of the left and right brain halves—areas thought to be more responsible for the governance of primitive functions—to be larger in nonwhites than whites. And the measurements confirmed it. Similarly, he predicted that the genu, connecting the more anterior parts of the brain, would be larger in Caucasians, a prediction again confirmed by his numbers.[38]

Then, as now, such work stimulated both scientific and public challenges. In 1909 Dr. Franklin P. Mall, Chairman of the Anatomy Department at Johns Hopkins, disputed Bean's findings of racial and sexual differences in the brain.[39] Mall's objections have a familiar ring: extensive individual variation swamped group differences. No differences were great enough to be obvious on casual inspection, and Bean and others did not normalize their results by taking into account differences in brain weight. Furthermore, Mall thought his own measurements were more accurate because he used a better instrument, and he did his studies blind in order to eliminate "my own personal equation."[40] In conclusion, he wrote: "Arguments for difference due to race, sex and genius will henceforward need to be based upon new data, really scientifically treated and not on the older statements."[41] At the same time that

Mall engaged Bean in the scientific arena, Bean and the anthropologist Franz Boas tangoed in the popular media.[42] The social context may change, but the weapons of scientific battle can be transferred from one era to the next.

DEFINING THE CORPUS CALLOSUM

Scientists don't measure, divide, probe, dispute, and ogle the corpus callosum per se, but rather a slice taken at its center (figure 5.2). This is a two-dimensional representation of a mid-saggital section of the corpus callosum.[43] This being a bit of a mouthful, let's just call it CC. (From here on, I'll refer to the three-dimensional structure—that "bird with complicated wing formation"—as the 3-D CC.) There are several advantages to studying the two-dimensional version of the CC. First, the actual brain dissection is much easier. Instead of spending hours painstakingly dissecting the cerebral cortex and other brain tissues connected to the 3-D CC, researchers can obtain a whole brain, take a bead on the space separating left and right hemispheres, and make a cut. (It's rather like slicing a whole walnut down the middle and then measuring the cut surface.) The resulting half brain can be photographed at one of the cut faces. Then researchers can trace an outline of the cut CC surface onto paper and measure this outline by hand or computer. Second, because tissue preparation is easier, the object can be more handily standardized, thus assuring that when different laboratory groups compare results, they are talking about the same thing. Third, a two-dimensional object is far easier to measure than a three-dimensional one.[44]

But methodological questions remain about this postmortem (PM) technique. For example, to prepare the brains, one must pickle them (a process of preservation called fixation). Different laboratories use different fixation methods, and all methods result in some shape distortion and shrinkage. Thus, some doubt always exists about the relationship between living, functioning structure and the dead, preserved brain matter actually studied. (For example, one could imagine that a size difference between two groups could result from different quantities of connective tissue that might show different shrinkage responses to fixation.)[45]

Although researchers disagree about which techniques for obtaining brain samples cause the least distortion, they rarely acknowledge that their data, based on two-dimensional cross sections, might not apply to brains as they actually exist: three-dimensionally in people's heads. In part, this may be because researchers are more interested in the relative merits of the postmortem technique and techniques made possible by a new machine, the Magnetic Resonance Imager (MRI). Some hope that this advanced technology will allow a unified account of the CC to emerge.[46]

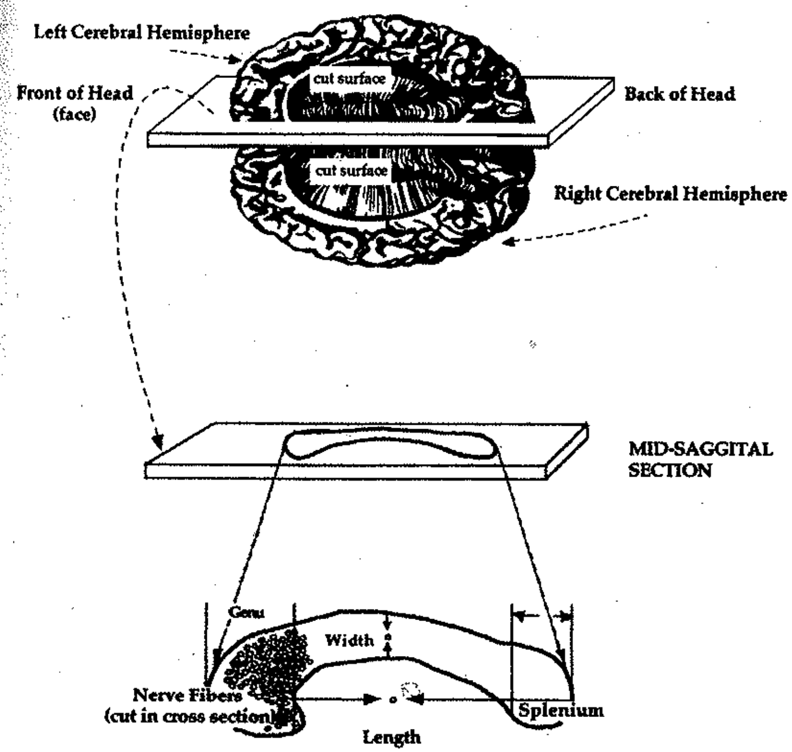

FIGURE 5.2: The transformation of the 3-D corpus callosum to a version represented in only two dimensions. (Source: Alyce Santoro, for the author)

MRI's (figure 5.3) offer two major advantages. First, they come from living, healthy individuals; second, living, healthy individuals are more available than autopsied brains.[47] Hence larger samples, better matched for possibly confounding factors such as age and handedness, can be used. But there is no free lunch. The neuroscientists Sandra Witelson and Charles Goldsmith point out that the boundaries between the CC and adjacent structures appear less clearly in MRI's than PM's. Furthermore, the scans have a more limited spatial resolution, and the optical slices taken are often much thicker than the manual slices taken from postmortems.[48] Jeffrey Clarke and his colleagues note that "the contours of the CC's were less sharp in the MRI graphs than in the postmortem" while others cite difficulties in deciding just which of the many optical slices was the true mid-saggital slice.[49] Finally, studies using MRI's are

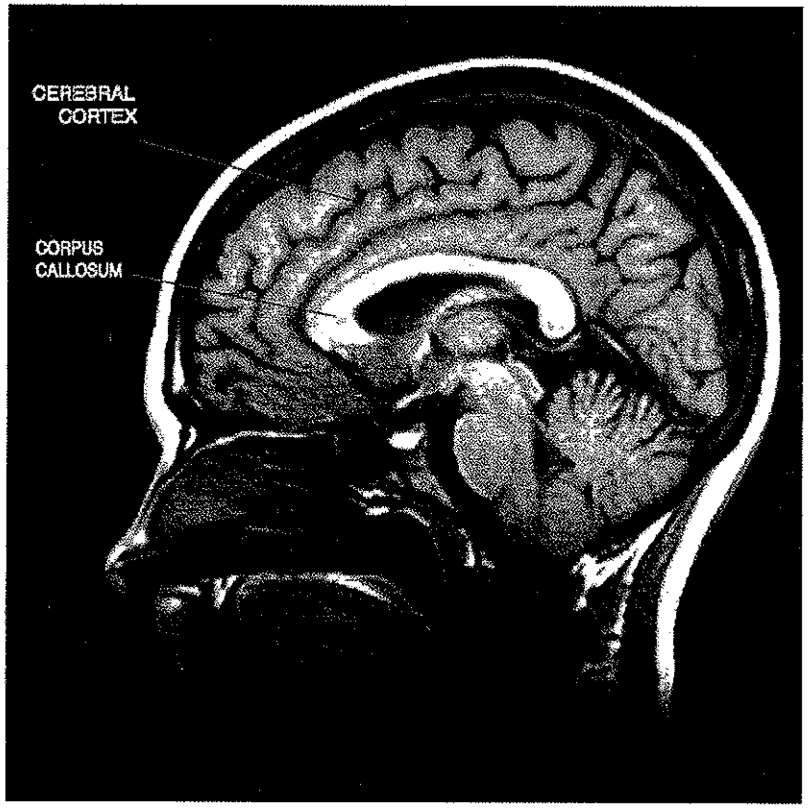

FIGURE 5.3: An MRI image of a mid-saggital section of a human head. The convolutions of the cerebral cortex and the corpus callosum are clearly visible. (Courtesy of Isabel Gautier)

hard to standardize with respect to brain weight or size. Thus, because, MRI's, like PM's, represent certain brain features, researchers using either technique study the brain at an interpretive remove.

TAMING BY MEASURING

Can scientists succeed in making measurements of the CC on which they all agree? Can they use their CC data to find differences between men and women or concur that there are none to be found? It would appear not. Here I look at thirty-four scientific papers, written between 1982 and 1997.[50] The authors use the latest techniques—computerized measurements, complex statistics, MRI's, and more—but still they disagree. In their efforts to convince one

another (and the outside world) that the CC is or is not significant for questions of gender, these scientists work hard to come up with the right techniques, the best measurement, the approach so perfect as to make their claims unassailable.

Looking at table 5.3, one sees that almost nobody thought there were absolute size differences in the entire CC. Instead, scientists subdivided the two-dimensional CC (see figure 5.4). Researchers chose different segmentation methods and constructed different numbers of subdivisions. Most symbolized the arbitrary nature of the CC subsections by labeling them with letters or numbers. Others used names coined in an earlier time. Almost everyone, for example, defined the splenium as the CC's posterior one-fifth, but a few divided the CC into six[51] or seven parts[52] calling the most posterior segment the splenium. Each approach to subdividing the CC represented an attempt to tame it—to make it produce measurements the authors hoped would be objective and open to replication by others. Labeling choices gave the methods different valences. By labeling the subdivisions with only letters or numbers, some made visible the arbitrary nature of the method. Others assigned traditional anatomical names, leaving one with a feeling of reality—that there might be visible substructure to the CC (just as the pistons are visibly distinct within the gasoline engine).

To succeed in extracting information about the brain's workings, scientists *must* domesticate their object of study, and we see in table 5.3 and figure 5.4 the variety of approaches used to accomplish this end. Indeed, this aspect of making a difference is so deeply built into the daily laboratory routine that most lab workers lose sight of it. Once extracted and named, the splenium, isthmus, midbodies, genu, and rostrum all become biological things, structures seen as real, rather than the arbitrary subdivisions they actually are. Simplifying body parts in order to layer some conceptual order onto the daunting complexity of the living body is the daily bread of the working scientist. But there are consequences. When neuroanatomists transform a 3-D CC into a splenium or genu, they provide "public access to new structures rescued out of obscurity or chaos." The sociologist Michael Lynch calls such creations "hybrid object(s) that (are) demonstrably mathematical, natural and literary."[53] They are mathematical because they now appear in measurable form.[54] They are natural because they are, after all, derived from a natural object—the 3-D CC. But the corpus callosum, splenium, genu, isthmus, rostrum, and anterior and posterior midbodies, *as represented in the scientific paper,* are literary fictions.

There is nothing inherently wrong with this process. The difficulty arises when the transformed object—Lynch's tripartite hybrid—ends up being

TABLE 5.3 *Absolute Sex Differences in the Corpus Callosum: A Summary*

	# OF STUDIES FINDING					
	ADULT FEMALE LARGER	ADULT MALE LARGER	ADULTS DON'T DIFFER	MALE CHILD LARGER[b]	CHILDREN DON'T DIFFER	NO FETAL DIFFERENCE[c]
Measurement taken (see figure 5.4)						
Callosal area	0	1[a]	16[a]	1	2	2
Maximum splenial width	3	0	11	0	1	2
Callosal length	0	0	7	1	0	0
Area: division 1	0	1	7	0	1	0
Area: division 2	0	0	8	0	1	0
Area: division 3	0	2	7	0	1	0
Area: division 4	1	0	9[g]	0	1	0
Area: division 5 (splenium)	0[f]	0	17[g]	1[d]	2	0
Width 1	0	0	2	0	0	0
Width 2	0	0	2	0	0	0
Width 3	0	0	2	0	0	0
Width 4 (minimal splenial)	0	1	3[e]	0	0	1
Minimal callosal width	2	2	0	0	0	0
Maximum body width	0	0	2	0	0	0
Area of anterior 4/5ths	0	0	2	0	0	0

a. One of the findings showed a difference with one statistical test (ANOVA) but not with another (MANOVA).
b. There were no cases in which female children had larger parts.
c. In one case an absolute difference favoring female fetuses was found in splenial width but not area.
d. Depends on which statistical test is used.
e. Difference appeared in postmortem but not MRI's.
f. De Lacoste-Utamsing and Holloway (1982) say there is a difference, but then cite a statistical probability of $p = 0.08$, which is usually considered statistically insignificant.
g. Based on dividing the CC into 7 parts (the isthmus being the 6th and the splenium the 7th).

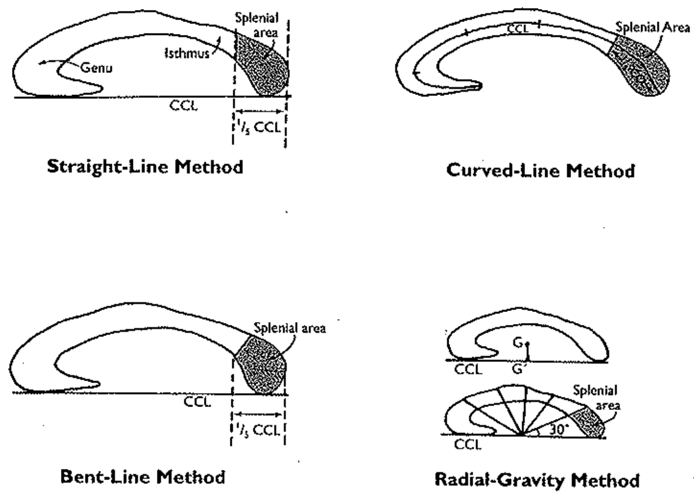

FIGURE 5.4: A sampling of methods used to subdivide the corpus callosum. (Source: Alyce Santoro, for the author)

mistaken for the original. Once a scientist finds a difference, he or she tries to interpret its meaning. In the debate at hand, all of the interpretations have proceeded as if the measured object *was* the corpus callosum. Instead, interpretation ought to try to work by reversing the abstraction process; here, though, one runs into trouble. Far too little is known about the detailed anatomy of the intact, three-dimensional corpus callosum to accomplish such a task. One is left to assign meaning to a fictionalized abstraction,[55] and the space opened up for mischief becomes enormous.

THERE IS MEASURE IN ALL THINGS (CALLOSAL)

With all the subdivisions agreed upon, finally, students of the corpus callosum are in business. Now they can make dozens of measurements. From the undivided CC come dimensions of the total surface area, length, width, and any of these divided by brain volume or weight. From the subdivided CC come named or numbered parts: the anterior one-fifth becomes the genu, the posterior one-fifth the splenium, a narrower portion in the center the isthmus. Once researchers have created a measurable object out of the CC, what do they find?

The results summarized in tables 5.3, 5.4, and 5.5 reveal the following: no matter how they carve up the shape, only a few researchers find absolute

sex differences in CC area. A small number report that males and females have differently shaped corpus callosums (females have a more bulb-shaped splenium, making the CC wider, according to these authors), even though the shape does not translate into a size (area or volume) difference. The few studies of fetuses and young children came up with no measurable sex differences; these results suggest that, if there is a gender difference in adult CC's, it appears only with age.[56] Finally, reports about sex differences in corpus callosum size during old age conflict, permitting no firm conclusions about gender differences in the elderly.[57]

Some researchers have suggested that, if there is a gender difference in the CC, it may be the opposite of what scientists have commonly assumed it would be. Men generally have larger brains and bodies than women. If it turns out that women and men have similar-sized CC's but women have smaller brains, then on a relative per volume or per weight basis, do women have *larger* CC's?[58] Following this logic, many researchers have compared the relative size of the whole and/or parts of the male and female corpus callosum. Table 5.4 summarizes these relative measures, and the decision is split: about half report a difference, while half do not.

Although most investigators interested in gender differences focus on the splenium—the more (or less) bulbous-shaped posterior end of the corpus callosum—others have turned their attention to a different segment of the CC named the isthmus (see figure 5.4). While those who measure the splenium have tended to look only for differences between men and women, those examining the isthmus believe this part of the brain is linked to several characteristics—not only gender, but also left- or right-handedness and sexual orientation. Some find that the area of the isthmus is smaller in right-handed than in non-right-handed males, but that women show no such difference.[59] I've tabulated these results in table 5.5. Here, too, there is little consensus. Some find a structural difference related to handedness in males but not females; some find no handedness-related differences; one paper even reports that one of the CC regions is larger in right-handed than in left-handed women, but smaller in left-handed than in right-handed men.[60]

What do scientists do with such diverse findings? One approach uses a special form of statistics called meta-analysis, which pools the data from many small studies to create a sample that behaves, mathematically, as if it were one large study. Katherine Bishop and Douglas Wahlsten, two psychologists, have published what seem to be the unequivocal results of such a meta-analysis. Their study of forty-nine different data sets found that men have slightly larger CC's than women (which they presume is because men are larger), but no significant gender differences in either absolute or relative size or shape of

TABLE 5.4 *Relative Sex Differences in the corpus Callosum: A Summary*

	# OF STUDIES FINDING					
	ADULT FEMALE LARGER	ADULT MALE LARGER	ADULTS DON'T DIFFER	MALE CHILD LARGER	CHILDREN DON'T DIFFER	NO FETAL DIFFERENCE
Measurement taken (see figure 5.4)						
Callosal area/brain weight or volume	7		8		2	
Area: division 1/brain weight or volume		1	2			
Area: division 2/brain weight or volume			2			
Area: division 3/brain weight or volume		1	1			
Area: division 4/brain weight or volume	1		2			
Splenial width or area/brain weight, volume, or length	3		5[c]			
Splenial area/callosal area or length	3		4			
Slenderness index (CC length/ideal thickness)[b]	2[d]		1[d]			1[d]
Bulbosity coefficient (average splenial width/average width of the adjacent region of the corpus callosum)[a]	2[d]					
Bulbosity coefficient/total callosal area			1			
Minimal width/total callosal area	1					
Area 6 (of 7 ÷'s)/total callosal area	1					

a. I've nicknamed this the "turkey-baster" coefficient, or TBC, because it is based on the idea that a bulbous splenium growing out of a narrow-necked CC gives a turkey-baster shape to the overall structure. See Allen, Richey et al. 1991.
b. Clarke et al. (1989) define the ideal thickness as the corpus callosum area divided by the length of the median line (calculated to bisect the mid-sagittal corpus callosum area).
c. I calculated one of these results from the data presented by Emory et al. 1991; 1 of the 5 is based on subdividing the CC into 4 parts.
d. Find a difference for postmortems but not MRI.

TABLE 5.5 *Hand Preference, Sex, and Corpus Callosum Size: A Summary*

	# OF STUDIES FINDING					
	MALES ONLY: RIGHT < LEFT-HANDED[a]	MALES ONLY: RIGHT = LEFT-HANDED[a]	FEMALES ONLY: RIGHT = LEFT-HANDED[a]	FEMALES ONLY: RIGHT > LEFT-HANDED[a]	MALES & FEMALES COMBINED: RIGHT < LEFT-HANDED[a]	MALES & FEMALES COMBINED: RIGHT = LEFT-HANDED[a]
Measurement taken (see figure 5.4)						
Total callosal area	2	3	6	0	1	4
Isthmus: area[b]	3	1	3	0	2[c]	1
Isthmus/total callosal area	1					
Anterior half[b]	1	1	2	0	1	1
Posterior half[b]	1	1	2	0	1	1
Region 2[b]	2	1	1	1	1	1
CC/brain						1
Splenium/brain						1

a. The definitions of handedness actually used are both more complex and subtler than just left vs. right. b. For regionalization of CC in handedness studies, see figure 5.4. c. LH males > females.

the CC as a whole or of the splenium. Bishop and Wahlsten recalculated the statistical significance of a finding of an absolute sex difference in splenial area each time they added a new study to their data base. When only a small number of studies with a cumulatively small sample size existed, the results suggested the existence of a sex difference in splenial area. As additional data (from newer studies) accumulated in the literature, however, the sex differences diminished. By the time ten studies had appeared, the absolute splenial sex difference had disappeared and nobody has successfully resurrected it.[61]

Researchers, however, continue to debate the existence of relative differences in CC structure. Bishop and Wahlsten found none, but when a different research team performed a second meta-analysis, they found not only that men have slightly larger brains and CC's than women, but that relative to overall brain size, women's CC's were bigger. This study did not contain enough data, however, to conclude that relative size of male and female spleniums differed.[62]

But these meta-analyses run into the same methodological issues experienced by individual studies. Is there a legitimate way to establish a relative difference? What factor should we divide by: brain weight, brain volume, total CC size? One research team has called the practice of simply dividing an area by total brain size "pseudostatistics."[63] (Them's fightin' words!) Another researcher countered that it is no wonder colleagues will attack the methodology behind any study that discovers gender differences, given that "one end of the political spectrum is invested in the conclusion that there are no differences."[64] We are left with no consensus.[65]

DOING BATTLE WITH NUMBERS

To the outsider coming to the dispute for the first time, the flurry of numbers and measures is bewildering. In displaying and analyzing their measurements, scientists call on two distinct intellectual traditions, both often labeled with the word *statistics*.[66] The first tradition—the amassing of numbers in large quantity to assess or measure a social problem—has its roots (still visible today) in eighteenth- and nineteenth-century practices of census takers and the building of actuarial tables by insurance companies.[67] This heritage has slowly mutated into the more recent methodology of significance testing, aimed at establishing differences between groups, even when individuals within a group show considerable variation. Most people assume that, because they are highly mathematical and involve complex ideas about probability, the statistical technologies of difference are socially neutral. Today's statistical tests, however, evolved from efforts to differentiate elements of human society, to make plain the differences between various social groups (rich and poor; the law-abiding and the criminal; the Caucasian and the Negro; male and female; the English and the Irish; the heterosexual and the homosexual—to name but a few).[68]

How are they applied to the problem of gender differences in the CC? The CC studies use both approaches. On the one hand, morphometrists make many measurements and arrange them in tables and graphs. On the other, they use statistical tests to correlate measurements with variables such as sex, sexual preference, handedness, and spatial and verbal abilities. Sophisticated statistical tools serve both rhetorical and analytical functions. Each CC study amasses hundreds of individual measurements. To make sense of what the philosopher Ian Hacking calls this "avalanche of numbers,"[69] biologists categorize and display them in readable fashion.[70] Only then can investigators "squeeze" information out of them. Does a structure change size with age or differ in people suffering from a particular disease? Do men and women or people of different races differ? The specialized research article, which presents numbers and extracts meaning from them, is really a defense of a particular interpretation of results. As part of his or her rhetorical strategy, the writer cites previous work (thus gathering allies), explains why his or her choice of method is more appropriate than that used by another lab with different outcome, and uses tables, graphs, and drawings to show the reader a particular result.[71]

But statistical tests are not just rhetorical flourishes. They are also powerful analytic tools used to interpret results that are not obvious from casual observation. There are two approaches to the statistical analysis of difference.[72] Sometimes distinctions between groups are obvious, and what is more interesting is the variation within a group. If, for example, we were to examine a group of 100 adult Saint Bernard dogs and 100 adult Chihuahuas, two things might strike us. First, all the Saint Bernards would be larger than all the Chihuahuas. A statistician might represent them as two nonoverlapping bell curves (figure 5.5A). We would have no trouble concluding that one breed of dog is larger and heavier than the other (that is, there is a group difference). Second, we might notice that not all Bernards are the same height and weight, and the Chihuahuas vary among themselves as well. We would place such Bernard or Chihuahua variants in different parts of their separate bell curves. We might pick one out of the lineup and want to know whether it was small for a Saint Bernard or large for a Chihuahua. To answer that question we would turn to statistical analyses to learn more about individual variation within each breed.

Sometimes, however, researchers turn to statistics when the distinction between groups is not so clear. Imagine a different exercise: the analysis of

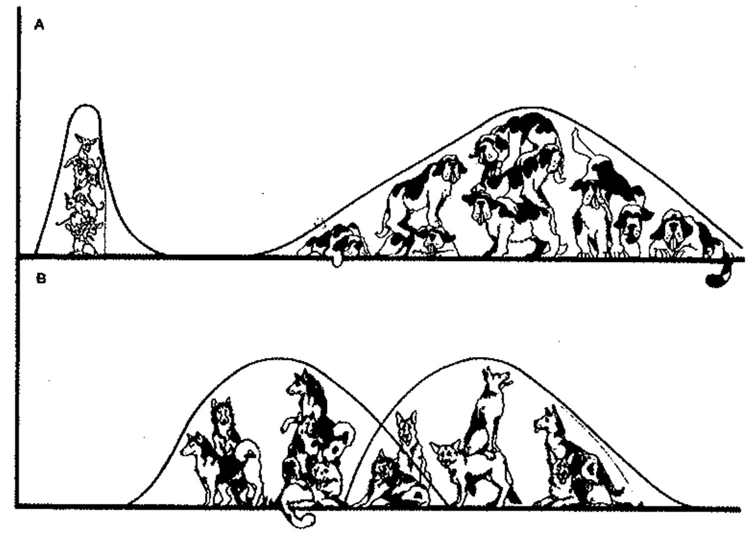

FIGURE 5.5: *A*: Comparing Chihuahuas to Saint Bernards. *B*: Comparing huskies to German shepherds. (Source: Alyce Santoro, for the author)

100 huskies and 100 German shepherds. Is one breed larger than the other? Their bell curves overlap considerably, although the average height and weight differ somewhat (figure 5.5B). To solve this problem of "true difference," modern researchers usually employ one of two tactics. The first applies a fairly simple arithmetical test, now automated in computer programs. The test takes three factors into account: the size of the sample, the mean for each population, and the degree of variation around that mean. For example, if the mean weight for shepherds is 50 pounds, are most of the dogs close to that weight or do they range widely—say, from 30 to 80 pounds? This range of variation is called the standard deviation (SD). If there is a large SD, then the population varies a great deal.[73] Finally, the test calculates the probability that the two population means (that of the huskies and that of the shepherds) differ by chance.

Researchers don't have to group their data under separate bell curves to establish differences between populations. They can instead group all the data together, calculate how variable it is, and then analyze the causes of that variability. This process is called the analysis of variance (ANOVA). In our doggie example, researchers interested in the weight of huskies and German shepherds would pool the weights of all 200 dogs, and then calculate the total variability, from the smallest husky to the largest German shepherd.[74] Then they would use an ANOVA to partition the variation—a certain percent accounted for by breed difference, a certain percentage by age or brand of dog chow, and a certain percentage unaccounted for.

Tests for mean differences allow us to compare different groups. Is the difference in IQ between Asians and Caucasians real? Are males better at math than females? Alas, when it comes to socially applied decision making, the clarity of the Chihuahua versus the Saint Bernard is rare. Many of the CC studies use ANOVA. They calculate the variability of a population and then ask what percentage of that variability can, for example, be attributed to gender or handedness or age. With the widespread use of ANOVA's then, a new object of study has crept in. Now, rather than actually looking at CC size, we are analyzing the contributions of gender and other factors to the *variation* of CC size around an arithmetical mean. As scientists use statistics to tame the CC, they distance it yet further from its feral original.[75]

Convincing others of a difference in CC size would be easiest if the objects simply looked different. Indeed, in the CC dispute a first line of attack is to claim that the difference in shape between the splenia of male and female CC's is so great that it is obvious to the casual observer. To test this claim, researchers draw an outline of each of the 2-D CC's in their sample. They then give a mixture of the drawings, each labeled only with a code, to neutral observers, who sort the drawings into bulbous and slender categories. Finally, they decode the sorted drawings and see whether all or most of the bulbous file turn out to have come from women and the slenders from men. This approach does not yield a very impressive box score. Two groups claim a visually obvious sex difference; a third group also claims a sex difference, but males and females overlap so much that the researchers can only detect it using a statistical test for significant difference.[76] In contrast, five other research groups tried visual separation of male from female CC's but failed in the attempt.

When direct vision fails to separate male from female, the next step is to bring on the statistical tests. In addition to those who attempted to visually differentiate male from female CC's, nine other groups attempted only a statistical analysis of difference.[77] Two of these reported a sex difference in splenial shape, while seven found no statistical difference. This brings the box score for a sex difference in splenial shape to 5 for, 13 against. Even statistics can't discipline the object of study into neatly sorted categories. As Mall found in 1908, the CC seems to vary so much from one individual to the next that assigning meaningful differences to large groups is just not possible.

In 1991, after the CC debate had been raging for nine years, a neurobiologist colleague told me that a new publication had definitively settled the matter. And the news accounts—both in the popular and the scientific press—

suggested he was right. When I began to read the article by Laura Allen and her colleagues I was indeed impressed.[78] They used a large sample size (122 adults and 24 children), they controlled for possible age-related changes, and they used two different methods to subdivide the corpus callosum: the straight-line and the curved-line methods (see figure 5.4). Furthermore, the paper is packed with data. There are eight graphs and figures interspersed with three number-packed, subdivided tables, all of which attest to the thoroughness of their enterprise.[79] Presenting their data in such detail demonstrates their fearlessness. Readers need not trust the authors; they can look at their numbers for themselves, recalculating them in any fashion they wish. And what do the authors conclude about gender differences? "While we observed a dramatic sex difference in the *shape* of the corpus callosum, there was no conclusive evidence of sexual dimorphism in the area of the corpus callosum or its subdivisions."[80]

But despite their emphatic certainty, the study, I realized as I reread it, was less conclusive than it seemed. Let's look at it step by step. They used both visual inspection and direct measurement. From their visual (which they call subjective) data, they reach the following conclusion.

> Subjective classification of the posterior CC of all subjects by sex based on a more bulbous-shaped female splenium and a more tubular-shaped male splenium revealed a significant correlation between the observers' sex rating based on shape and the actual gender of the subject ($\chi^2 = 13.2603$; 1 df; contingency coefficient = 0.289; $p<0.003$). Specifically, 80 out of 122 (66 percent) of the adult's CC ($\chi^2 = 10.123$; 1 df; contingency coefficient = 0.283; $p<0.0011$) were correctly identified.[81]

First, we can extract the actual numbers: using splenial shape, their blind classifiers could correctly categorize as male or female 80 out of 122 tracings of adult 2-D CC's. Was that good enough to claim a visual difference, or might we expect the 80 out of 122 to occur by chance? To find out, the authors employ a chi-squared test (symbolized by the Greek letter χ^2). The well-known founder of modern statistics, Karl Pearson (and others) developed this test to analyze situations in which there was no unit of measurement (for example, inches or pounds). In this case the question is: Is the correlation between bulbous and female or slender and male good enough to warrant the conclusion of a visual difference? The take-home is in the figure $p<0.0011$. This means that the probability of 80 of 122 correct identifications happening solely by chance is one-tenth of 1 percent, well below the cutoff point of 5 percent ($p<0.05$) used in standard scientific practice.[82]

Well, 66 percent of the time observers could separate male from female CC's just by eyeballing their shape. And the χ^2 test tells us how significant this differentiation process is. Statistics don't lie. They do, however, divert our attention from the study design. In this case, Allen et al. gave their CC tracings to three different observers, who had no knowledge of the sex of the individual whose brain had generated the drawing. These blind operators divided the drawings into two piles—bulbous or tubular, on the assumption that if the difference were obvious, the pile of tubular shapes should mostly turn out to have come from men and the bulbous from women. So far so good. Now here comes the trick. The authors designated a subject's gender as correctly classified if two out of the three blind observers did it right.

How does this work out numerically? The complex statistical passage quoted above says that 66 percent of the time the observers got it right. This could actually mean several things. There were 122 drawings of the corpus callosum. Since three different observers looked at each drawing, that means that there were 366 individual observations. In the best case (from the authors' point of view), all three observers always agreed about any individual CC. This would mean that 244/366 (66 percent) of their individual observations accurately divined sex on the basis of shape. In the worst case, however, for those measures that they counted as successful separations, only two out of the 3 observers *ever* agreed about an individual brain. This would mean that only 160/366 (44 percent) of the individual observations successfully separated the CC drawings on the basis of sex. Allen et al. do not provide the reader with the complete data, so their actual success remains uncertain. But using a chi-squared test on their refined data convinces many that they have finally found an answer that all can accept.

The data do not speak for themselves. The reader is presented with tables, graphs, and drawings and are pushed through rigorous statistical trials, but no clear answer emerges. The data still need more support, and for this scientists try next to interpret their results plausibly. They support their interpretations by linking them to previously constructed knowledge. Only when their data are woven into this broader web of meaning can scientists finally force the CC to speak clearly. Only then can "facts" about the corpus callosum emerge.[83]

WHEN IS A FACT A FACT?

Like all scholarship, Allen and her colleagues' study is necessarily embedded in the context of an ongoing conversation about the broader subject matter it explores—in this case, the corpus callosum. They must rely heavily on preexisting work to establish the validity of their own. Allen and her colleagues note, for example, that even though the CC has a million or more nerve fibers running through it, this enormous number still represents only 2 percent of all the neurons in the cerebral cortex. They note evidence that fibers in the splenium may help transfer visual information from one brain hemisphere to the other. Another region—the isthmus—for which they find no sex difference (but for which others find a complex of differences between gay and straight and left- and right-handed men), carries fibers connecting left and right cortical regions involved with language function.

Allen and colleagues need to keep their discussion pithy. After all, they want to examine their findings, not review all that is known about the structure and function of the corpus callosum. Let's imagine this aspect of the production of facts about the corpus callosum as a macramé weaving. Here an artist uses knots as links in the creation of intricate, webbed patterns. The connecting threads secure individual knots within the larger structure, even though a single knot in the web may not be all that strong. My drawing of the CC weaving (figure 5.6) includes only contemporary disputes. But each knot also contains a fourth dimension—its social history.[84] To locate the knot labeled "corpus callosum gender differences," Allen et al. have spun out a thread and secured it to a second knot, labeled "structure and function of the corpus callosum." That tangle is, in turn, secured by a second web of research.

Speculation abounds about the CC's structure and function. Perhaps more nerve fibers permit faster information flow between left and right brain hemispheres; perhaps faster flow improves spatial or verbal function (or vice versa). Or perhaps larger (or smaller) CC segments slow the flow of electricity between brain halves, thus improving spatial or verbal abilities (or vice versa). But what, exactly, does the CC in general and the splenium in particular do? What kinds of cells course through the CC, where do they go, and how do they function?[85] The function/structure knot contains hundreds of papers produced by overlapping research communities, only some of which are interested in sex differences. One team of sociologists calls such groups "persuasive communities,"[86] whose language choices or use of techniques such as sophisticated statistics may condition how its members envision a problem.[87] Work on the structure and function of the corpus callosum links several persuasive communities. One locale, for example, compares the numbers of large and small neurons, some with an insulating coat of myelin, others lying naked in different regions of the CC. These cells perform different functions and thus provide clues to CC function.[88]

The structure/function node is dense.[89] An issue of the journal *Behavioural Brain Research* devoted entirely to work on the function of the corpus callosum illustrates the point. Some papers in the volume addressed findings and con-

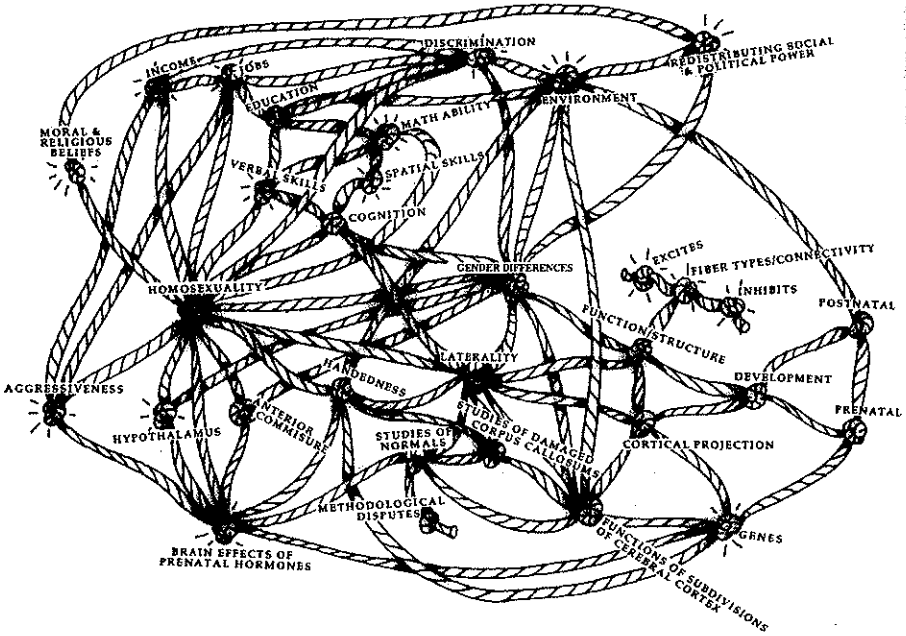

FIGURE 5.6: A macramé weaving of knots of knowledge in which the corpus callosum debate is embedded. (Source: Alyce Santoro, for the author)

troversies on hemispheric lateralization, speaking directly to the implications for CC function.[90] The laterality work in turn connects to studies of handedness, sex differences, and brain function.[91] These also interconnect with a literature that debates the interpretation of studies on humans with damaged CC's and compares results to studies that try to infer CC function from intact subjects.[92] One well-known aspect of lateralization is handedness—how shall we define it, what causes it (genes, environment, birth position?), what does it mean for brain functions, how does it affect CC structure (and how does CC structure affect handedness?), are there sex differences, and do homosexuals and heterosexuals differ? Handedness is a busy knot.[93]

All of these knots connect at some point with one labeled cognition.[94] Sometimes tests designed to measure verbal, spatial, or mathematical abilities reveal gender differences.[95] Both the reliability of such differences and their origin provide fodder for unending dispute.[96] Some link a belief in gender differences in cognition to the design of educational programs. One essayist, for example, drew a parallel between teaching mathematics to women and giving flying lessons to tortoises.[97] Elaborate and sometimes completely opposite theories connect cognitive sex differences with callosal structure. One,

for example, suggests that higher mathematical ability derives from differing numbers of excitatory neurons in the CC, while another suggests that the inhibitory nature of the CC neuron is most important.[98]

The effects of hormones on brain development form an especially powerful knot in this macramé weaving (I will have a lot more to say about hormones in the next three chapters). Allen and her colleagues wonder whether sex differences in the corpus callosum might be induced by hormones, some other genetic cause, or the environment. After briefly considering the environmental hypothesis,[99] they write: "However, more striking have been the data indicating that nearly all sexually dimorphic structures examined thus far have been shown to be influenced by perinatal gonadal hormone levels."[100] This brief statement invokes a huge and complex literature about hormones, the brain, and behavior (some of which we have already considered in the context of intersexuality). Standing alone, the corpus callosum research may be weak. But with the vast army of hormone research to back it up, how could claims of a difference possibly fail? Even though there is no convincing evidence to link human corpus callosum development to hormones,[101] invoking the vast animal literature[102] stabilizes the shaky CC knot.[103]

Within each of the persuasive communities represented in figure 5.6 by knots on the macramé weaving, one finds scientists at work. They are devising new methods to test and substantiate their favored hypothesis or to refute a viewpoint they believe in error. They measure, use statistics, or invent new machines, trying to stabilize the fact they pursue. But in the end, few of the facts (excised, unsupported knots) about gender differences are particularly robust[104] (to use a word favored by scientists) and must, therefore, draw significant strength from their links to the weaving. These researchers work primarily on the science side of things, studying genes, development, parts of the brain, hormones, analyses of brain-damaged people, and more (figure 5.7A). This portion of the nexus appears to deal with more objective phenomena, the realm traditionally handed over to science.[105] On the cultural side of the macramé weaving (figure 5.7B) we find that webbed into the sex difference knot are some decidedly political items: cognition, homosexuality, environment, education, social and political power, moral and religious beliefs. Very rapidly we have skated along the strands from science to politics, from scientific disputes to political power struggles.[106]

Talking Heads: Do Facts Speak for Themselves?

Can we ever know whether there is a gender difference in the corpus callosum?[107] Well, it depends a bit on what we mean by *knowing*. The corpus callo-

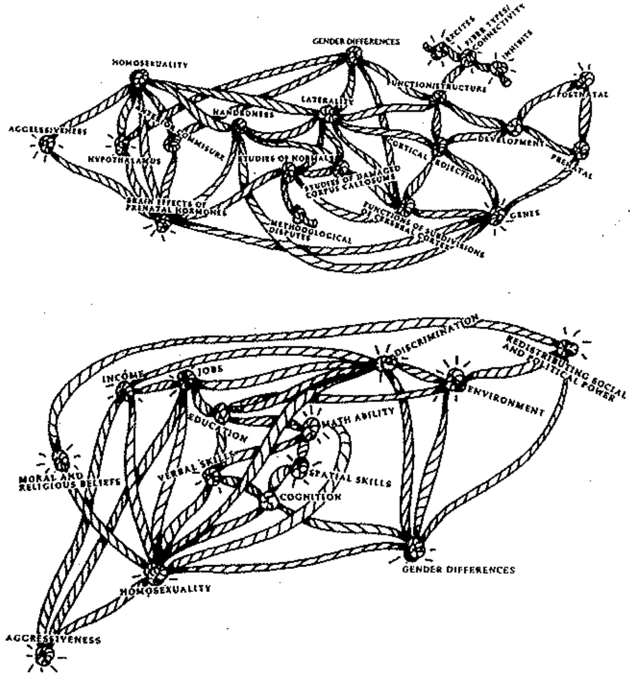

FIGURE 5.7A (*top*): The "science half" of the woven knowledge connections; 5.7B (*bottom*): The "culture half" of the woven knowledge connections. (Source: Alyce Santoro, for the author)

sum is a highly variable bit of anatomy. Scientists go to great lengths to fix it in place for laboratory observation, but despite their efforts it won't hold still. It may or may not change, depending on the experience, handedness, health, age, and sex of the body it inhabits. Knowing, then, means finding a way to approach the CC so that it says the same thing to a wide array of investigators. I think the likelihood of this happening is small. Ultimately, the questions researchers take into their studies, the methodologies they employ, and their decisions about which additional persuasive communities to link their work to, all reflect cultural assumptions about the meanings of the subject under study—in this case, the meanings of masculinity and femininity.

A belief in biologically based difference is often linked to conservative social policy, although the association between political conservatism and biological determinism is by no means absolute.[108] I cannot predict on a priori grounds whether or not in the future we will come to believe in gender differences in the CC, or whether we will simply let the matter fall, unre-

solved, by the wayside. If we were to reach social agreement on the politics of gender in education, however, what we believe about CC structure wouldn't matter. We know now, for example that "training with spatial tasks will lead to improved achievement on spatial tests."[109] Let's further suppose that we could agree that schools "should provide training in spatial ability in order to equalize educational opportunities for boys and girls."[110]

If we were culturally unified around such a meaning of equal opportunity, the CC dispute might follow one of several possible paths. Scientists might decide that, given how little we still know about how the CC works, the question is premature and should be set aside until our approaches to tracing nervous function in the CC improve. Or they might decide that the difference does exist, but is not forever fixed at birth. Their research program might focus on which experiences influence such changes, and the information gained might be of use to educators devising training programs for spatial ability. Feminists would not object to such studies because the idea of inferiority and immutability would have been severed from the assertion of difference, and they could rest secure in our culture's commitment to a particular form of equal educational opportunity. Or we might decide that the data, after all, do not support a consistent anatomical group difference in the CC at any point in the life cycle. We might, instead, ask research questions about the sources of individual variability in CC anatomy. How might genetic variability interact with environmental stimulus to produce anatomical difference? Which stimuli are important for which genotypes? In other words, we might use developmental systems theory to frame our investigations of the corpus callosum. Choosing a scientific path acceptable to most, and littering that path with agreed-upon facts, is only possible once we have achieved social and cultural peace about gender equity. Such a view of fact formation does not deny the existence of a material, verifiable nature; nor does it hold that the material—in this case the brain and its CC—has no say in the matter.[111]

The CC is not voiceless. Scientists, for example, cannot arbitrarily decide that the structure is round rather than oblong. With regard to gender differences, however, let's just say that it mumbles. Scientists have employed their immense talents to try to get rid of background noise, to see if they can more clearly tune in the CC. But the corpus callosum is a pretty uncooperative medium for locating differences. That researchers continue to probe the corpus callosum in search of a definitive gender difference speaks to how entrenched their expectations about biological differences remain. As with intersexuality, however, I would argue that the real excitement of studies on the corpus callosum lies in what we can learn about the vastness of human variation and the ways in which the brain develops as part of a social system.