Louann Brizendine – The Female Brain

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ANTERIOR CINGULATE CORTEX (ACC): Weights options, makes decision. It's the worry-wort center, and it's larger in women than in men.

PREFRONTAL CORTEX (PFC): The queen that rules the emotions and keeps them from going wild. It puts the brakes on the amygdala. Larger in women, and matures faster in teen girls than in boys by one to two years.

INSULA: The center that processes gut feelings. Larger and more active in women.

HYPOTHALAMUS: The conductor of the hormonal symphony; kicks the gonads into gear. Starts pumping earlier at puberty in females.

AMYGDALA: The wild beast within; the instinctual core, tamed only by the PFC. Larger in men.

PITUITARY GLANDS: Produces hormones of fertility, milk production, and nurturing behavior. Helps turn on the mommy brain.

HIPPOCAMPUS: The elephant that never forgets a fight, a romantic encounter, or a tender moment – and won't let you forget it, either. Larger and more active in women.

ESTROGEN – the queen: powerful, in control, all-consuming; sometimes all business, sometimes an aggressive seductress; friend of dopamine, serotonin, oxytocn, acetylcholine, and norepinephrine (the feel-good brain chemicals).

PROGESTERONE – in the background but a powerful sister to estrogen; intermittently appears and sometimes is a storm cloud reversing the effects of estrogen; other times is a mellowing agent; mother of all allopregnenolone (the brain's Valium, i.e., chill pill).

TESTOSTERONE – fast, assertive, focused, all-consuming, masculine; forceful seducer; aggressive, unfeeling; has no time for cuddling.

OXYTOCIN – fluffy, purring kitty; cuddly, nurturing, earth mother; the good witch Glinda in *The Wizard of Oz*; finds pleasure in helping and serving; sister to vasopressin (the male socializing hormone), sister to estrogen, friend of dopamine (another feel-good brain chemical). [bonding chemical]

CORTIXOL – frizzled, frazzled, stressed out; highly sensitive, physically and emotionally.

VASOPRESSIN – secretive, in the background, subtle aggressive male energies; brother to testosterone, brother to oxytocin (makes you want to connect in an active, male way, as does oxytocin).

DHEA – reservoir of all the hormones; omnipresent, pervasive, sustaining mist of life; energizing; father and mother of testosterone and estrogen, nicknamed "the mother

hormone," the Zeus and Hera of hormones; robustly present in youth, wanes to nothing in old age.

ANDROSTENEDIONE – the mother of testosterone in the ovaries; supply of sassiness; high-spirited in youth, wanes at menopause, dies with the ovaries.

ALLOPREGNENOLONE – the luxurious, soothing, mellowing daughter of progesterone; without her, we are crabby; she is sedating, calming, easing; neutralizes any stress, but as soon as she leaves, all is irritable withdrawal; her sudden departure is the central story of PMS, the three or four days before a woman's period starts.

[DOPAMINE – exciting pleasure chemical of the reward system] (XIII-XVI)

INTRODUCTION

More than 99 percent of male and female genetic code is exactly the same. Out of the thirty thousand genes in the human genome, the less than one percent variation between the sexes is small. […] To the observing eye, the brains of females and males are not the same. Male brains are larger by about 9 percent, even after correcting for body size. […] Women and men, however, have the same number of brain cells. (1)

[… there is] a two-to-one ratio of depression in women compared to men. (2)

[…] male versus female depression rates [don't] start to diverge until females turn twelve or thirteen – the age girls begin menstruating. (2)

Because of the fluctuations that begin as early as three months old and last until after menopause, a woman's neurological reality is not as constant as a man's. his is like a mountain that is worn away imperceptibly over the millennia by glaciers, weather, and the deep tectonic movements of the earth. Hers is more like the weather itself – constantly changing and hard to predict. (4)

[…] men and women have different brain sensitivities to stress and conflict. They use different brain areas and circuits to solve problems, process language, experience and store the same strong emotions. (4)

In a German study, researchers conducted brain scans of men and women while they mentally rotated abstract, three-dimensional shapes. There were no performance differences between the men and women, but there were significant, sex-specific differences in the brain circuits they activated to complete the task. Women triggered brain pathways linked to visual identification and spent more time than men picturing the objects in their minds. (5)

In the brain centers for language and hearing, for example, women have 11 percent more neurons than men. The principal hub of both emotion and memory formation – the hippocampus – is also larger in the female brain, as is the brain circuitry for language and observing emotions in others. This means that women are, on average, better at expressing emotions and remembering the details of emotional events. Men, by contrast, have two and a half times the brain space devoted to sexual drive as well as larger brain centers for action and aggression. (5)

Men also have larger processors in the core of the most primitive area of the brain, which registers fear and triggers aggression – the amygdala. This is why some men can go from zero to a fistfighting in a matter of seconds, while many women will try anything to defuse conflict. But the psychological stress of conflict registers more deeply in areas of the female brain. (5-6)

CHAPTER ONE

THE BIRTH OF THE FEMALE BRAIN

We, meaning doctors and scientists, used to think that gender was culturally created for humans but not for animals. (13)

[The brain's] sex-specific circuits happen during the first eighteen weeks of pregnancy. Until eight weeks old, every fetal brain looks female – female is nature's default gender setting. If you were to watch a female and a male brain developing via time-lapse photography, you would see their circuit diagrams being laid down according to the blueprint drafted by both genes and sex hormones. A huge testosterone surge beginning in the eighth week will turn this unisex brain male by killing off some cells in the communication centers and growing more cells in the sex and aggression centers. If the testosterone surge doesn't happen, the female brain continues to grow unperturbed. The fetal girl's brain cells sprout more connections in the communication centers and areas that process emotion. (14)

Over the first three months of life, a baby girl's skills in eye contact and mutual facial gazing will increase by over 400 percent, whereas facial gazing skills in a boy during this time will not increase at all. (15)

[…] girls can hear a broader range of emotional tones in the human voice than can boys. (17)

[…] disorders that inhibit people from picking up on social nuance – called autism spectrum disorders and Asperger's syndrome – are eight times more common in boys. (23)

Studies of nonhuman female primates […] provide clues that […] sex differences are innate and require the right hormone-priming actions. When researchers block estrogen in young female primates during infantile puberty, the females don't develop their usual interest in infants. Moreover, when researchers inject female primate fetuses with testosterone, the injected females end up liking more rough-and-tumble play than do average females. (25)

[…] the male and female brains' wiring for social connection is significantly affected no just by genes but by the amount of testosterone that gets in to the fetal brain. (26)

Nature certainly has the strongest hand in launching sex-specific behaviors, but experience, practice, and interaction with others can modify neurons and brain wiring. If you want to learn to play the piano you must practice. Every time you practice, your brain assigns more neurons to that activity, until finally you have laid new circuits

between these neurons so that, when you sit down at the bench, playing is second nature. (26-27)

Girls may have, on average, better social skills, empathy, and emotional intelligence than boys – but don't be fooled. This doesn't' mean that girls' brains aren't wired to use everything in their power to get what they want, and they can turn into little tyrants to accomplish their goals. (28-29)

CHAPTER TWO

TEEN GIRL BRAIN

The teen girl's brain is sprouting, reorganizing and pruning neuronal circuits that drive the way she thinks, feels, and acts – and obsessed over her looks. Her brain is unfolding ancient instructions on how to be a woman. During puberty, a girl's entire biological raison d'etre is to become sexually desirable. (31)

This brain state is created by the surge of new hormones [estrogen and progesterone] on top of the ancient female genetic blueprint. (32)

All of this drama is because the girlhood or juvenile pause has ended, and their daughter's pituitary gland has sprung to life as the chemical brakes are taken off her pulsing hypothalamic cells, which have been held in check since toddlerhood. This cellular release sparks the hypothalamic-pituitary-ovarian system into action. (33)

[…] it is the first time that her brain will experience estrogen-progesterone surges [varying on daily and weekly basis] that come in repeated monthly waves from her ovaries. (33)

We know that many parts of the female brain – including an important seat of memory and learning (the hippocampus), the main center for control of the body's organs (the hypothalamus), and the master center of emotions (the amygdala) are particularly affected by this new estrogen and progesterone fuel. It sharpens critical thinking and fine tunes emotional responsivity. (34)

[At puberty g]irls begin to react more to relationship stresses and boys to challenges to their authority. (34)

The first two weeks of the cycle, when estrogen is high, a girl is more likely to be socially interested and relaxed with others. In the last two weeks of the cycle, when progesterone is high and estrogen is lower, she is more likely to react with increased irritability and will want to be left alone. (35)

[…] some verbal areas of the brain are larger in women that in men and that women, on average, talk and listen a lot more than men. […] on average girls speak two to three times more words per day than boys. […] girls speak earlier and by the age of twenty months have double or triple the number of words in their vocabularies than do boys. Boys eventually catch up in their vocabulary but not in speed or overlapping speech. […] In Colonial America, women were put in the town stocks with wooden clips on their tongues or tortured by the "dunking stool," held underwater and almost drowned […] for

the crime of "talking too much." […] Female rhesus monkeys, for instance, learn to vocalize much earlier than do males and use every one of the seventeen vocal tones of their species all day long, every day, to communicate with one another. Male rhesus monkeys, by contrast, learn only three to six tones, and once they're adults, they'll go for days or even weeks without vocalizing at all. (36)

Connecting through talking activates the pleasure centers in a girls' brain. Sharing secrets that have romantic and sexual implications activates those centers even more. We're not talking about a small amount of pleasure. This is huge. It's a major dopamine and oxytocin rush, which is the biggest, fattest neurological reward you can get outside of an orgasm. Dopamine is a neurochemical that stimulates the motivation and pleasure circuits in the brain. Estrogen at puberty increases dopamine and oxytocin production in girls. Oxytocin is a neurohormone that triggers and is triggered by intimacy. When estrogen is on the rise, a teen girl's brain is pushed to make even more oxytocin – and to get even more reinforcement for social bonding. At midcycle, during peak estrogen production, the girl's dopamine and oxytocin level is likely at its highest, too. Not only her verbal output is at its maximum but her urge for intimacy is also peaking. Intimacy releases more oxytocin, which reinforces the desire to connect, and connecting then brings a sense of pleasure and well-being. (37)

Testosterone has been shown to decrease talking as well as interest in socializing – except when it involves sports or sexual pursuit. (39)

Men often enjoy interpersonal conflict and competition; they even get a positive boost from it. In women, conflict is more likely to set in motion a cascade of negative chemical reactions, creating feelings of stress, upset, and fear. (40)

Estrogen affects practically everything that a teen girl experiences, including responsivity to light and the daily light-dark cycle. Estrogen receptors get activated in the brain's twenty-four-hour clock cells in the suprachiasmatic nucleus. These clusters of cells orchestrate the daily, monthly, and annual rhythms of the body, such as those of hormones, body temperature, sleep, and mood. Estrogen even directly influences the brain cells that control breathing. It turns on the uniquely female sleep cycle as well as her growth hormone. (43)

Estrogen acts as a fertilizer on cells – exciting her brain as well as making a girl more socially relaxed during the first two weeks. There's a 25 percent growth of connections in the hippocampus during weeks one and two (the estrogen phase), and that makes the brain a little bit sharper. […] During the last two weeks of the cycle, progesterone causes the brain to become first more sedated and gradually more irritable, less focused, and then a little slower. […] The extra connections built during the weeks that estrogen is on the rise are being reversed by progesterone in the last two weeks. In the last few days of the menstrual cycle, when progesterone collapses, this calming effect in abruptly withdrawn, leaving the brain momentarily upset, stressed, and irritable. (45)

One of the most estrogen-sensitive parts of the brain – the hippocampus – is a major relay station for processing memories for words. This may be one biological reason behind women's increased verbal performance during the highest estrogen week – week two – of their cycles. (46)

Females whose ovaries make the most estrogen and progesterone are more resistant to stress because they have more serotonin (a chemical that makes you feel at ease) cells in their brains. […] Hormone and serotonin changes can result in a malfunction in the brain's seat of judgment (the prefrontal cortex), and dramatic, uncontrolled emotions can push through more easily from the primitive parts of the brain. (47)

Her brain's emotion- and impulse-control system – the prefrontal cortex – has sprouted many more cells by the age of twelve but the connections are still think and immature. As a result, a teenage girl's mood changes, resulting in part from the increased emotional impulses blasting in from the amygdala, are more rapid and dramatic. Her prefrontal cortex is like an old dial-up model receiving signals from broadband. It can't handle the increased traffic from the amygdala, and it often becomes overwhelmed. Teenagers, therefore, often cling to an idea and run with it, not stopping to consider the consequences. They become resentful of any authority that wants to head off their impulses. (50)

As a parent of teens, you have the job of ignoring much of what they say. Don't take any impulsive or emotional tirades seriously. Stay calm. Teens state their intentions – and feel them – with such passion – that you can be persuaded in spite of yourself. Just remember, your teen […] impulse-control circuits can't handle the input. Like it or not, you must provide the control while [their] brain cannot. (52)

Boys and girls have the same risk of depression, before the hormones of puberty. But by age fifteen, girls are twice as likely to suffer from depression. Genetics may also play a role in female depression. In certain families with high depression rates, for example, researchers have found a mutation in a gene called CREB-1 that puts teenage females – but not males – at higher risk for clinical depression. (53)

When females are competing with other females, they often use more subtle tools, such as spreading rumors to undermine a rival. This way, they can cover their tracks – "I wasn't trying to be mean. I'm sorry." Such tactics lessen the risk of destroying the bond that the teen girl brain sees as essential to survival. But also essential to survival is sexual competition. (54)

The hormones usually associated with aggression in both males and females are androgens. They begin to rise early in puberty and continue until they peak at age nineteen in females and twenty-one in males. The three main androgens that women make are testosterone, DHEA, and androstenedione (andro-steen-DIE-own). In a study at the University of Utah, the most in-your-face aggressive teenage girls were found to have high levels of the androgen androstenedione. Acne is a good clue that your teen's androgen levels are high. Girls with high levels of testosterone and DHEA also tend to have sexual intercourse earlier. (54)

Teens talking oral contraceptives have reduced aggression and sex drive because the contraceptive suppresses the ovaries, so they make less androgen. Although both men and women make testosterone, men make more than ten times as much – meaning that their sex drive is much greater than women's scientists know that it is probably not just androgens that increase aggressive spirit and ambition in women but estrogen, too. In the same study at the University of Utah, women who were the most outspoken and had the highest self-regard also had the highest levels of estrogen, testosterone, and

androstenedione. They also ranked themselves above how their peers ranked them. And these young women were routinely rated by others as the most boastful. (55)

CHAPTER THREE

LOVE AND TRUST

For men and women, the initial calculations about romance are unconscious, and they're very different. In short-term couplings, for example, men are chasers and women are choosers. That's not sex stereotyping. It's our inheritance from ancestors who learned, over millions of years, how to propagate their genes. As Darwin noted, males of all species are made for wooing females, and females typically choose among their suitors. This is the brain architecture of love, engineered by the reproductive winners in evolution. Even the shapes, faces, smells, and ages of the mates we choose are influenced by patterns set millennia ago. (59)

[…] in every culture, women are less concerned with a potential husband's visual appeal and more interested in his material resources and social status. (61)

Women […] also look for mates who are, on average, at least four inches taller and three and a half years older. (61)

Worldwide, men prefer physically attractive wives, between ages twenty and forty, who are an average of two and a half years younger than they are. They also want potential long-term mates to have clear skin, bright eyes, full lips, shiny hair, and curvy, hourglass figures. The fact that these mate preferences hold true in every culture indicates that they're part of men's hardwired inheritance from their ancient forefathers. (63)

[…] one study found that young college males admitted to depicting themselves as kinder, more sincere, and more trustworthy than they really are. Some anthropologists speculate that natural selection favored men who were good at deceiving women and getting them to agree to have sex. Females, as a result, had to get even better at spotting male lies and exaggerations – and the female brain is now well-adapted to this task. A study by the Stanford University psychologist Eleanor Maccoby showed, for example, that girls learn to tell the difference between reality and fairy tales or "just-pretend" play earlier than boys. By adulthood, modern females have fine-tuned their superior ability to read emotional nuance in tone of voice, eye gaze, and facial expressions.

As a result of this extra cautiousness, the typical female brain isn't as ready to admit to being overwhelmed by infatuation or the sheer excitement of sexual behavior as is the male. Women do reach the same or a higher romantic end point, but they're often slow to confess to being in love and more careful than males in the beginning weeks and months of a relationship. Male brains have a different neurological love wiring. Brain-imaging studies of women in love show more activity in many more areas, especially gut feelings, attention, and memory circuits, while men in love show more activity in high-level visual processing areas. These heightened visual connections may also explain why men tend to fall in love "at first sight" more easily than women. (64-65)

Falling in love is one of the most irrational behaviors or brain states imaginable for both

men and women. The brain becomes "illogical" in the throes of new romance, literally blind to the shortcomings of the lover. It is an involuntary state. Passionately being in love or so-called infatuation – love is now a documented brain state. It shares brain circuits with states of obsession, mania, intoxication, thirst, and hunger. It is not an emotion, but it does intensify or decreases other emotions. The being-in-love circuits are primarily a motivation system, which is different from the brain's sex drive area but overlaps with it. This fevered brain activity runs on hormones and neurochemicals such as dopamine, estrogen, oxytocin, and testosterone.
The brain circuits that are activated when we are in love match those of the drug addict desperately craving the next fix. The amygdala – the brain's fear-alert system – and the anterior cingulate cortex – the brain's worrying and critical thinking system – are turned way down when the love circuits are running full blast. Much the same thing happens when people take Ecstasy: the normal wariness humans have toward strangers is switched off and the love circuits are dialed up. So romantic love is a natural Ecstasy high. The classic symptoms of early love are also similar to the initial effects of drugs such as amphetamines, cocaine, and opiates like heroin, morphine, and OxyContin. These narcotics trigger the brain's reward circuit, causing chemical releases and effects similar to those of romance. In fact, there's some truth to the notion that people can become addicted to love. Romantic partners, especially in the first six months, crave the ecstatic feeling of being together and may feel helplessly dependent on each other. Studies of passionate love show this brain state lasts for roughly six to eight months. This is such an intense state that the beloved's best interest, well-being, and survival become as important as or more important than one's own. (66-67)

Touching, gazing, positive emotional interaction, kissing, and sexual orgasm […] release oxytocin in the female brain. (68)

Brain development in utero, the amount of nurturing one receives in infancy, and emotional experiences all determine variations in the brain circuits for loving and trusting others. (69)

Many people […] think the loss of the romantic high of early love is a sign that a couple's relationship is going south. In reality, however, the pair may be just moving into an, important, longer-term phase of the relationship, driven by additional neurological circuits. Scientists argue that the "attachment network" is a separate brain system – one that replaces the giddy intensity of romance with a more lasting sense of peace, calm, and connection. Now in addition to the exciting pleasure chemicals of the reward system, such as dopamine, the attachment and pair-bonding system regularly triggers the release of more of the bonding chemical oxytocin, keeping partners seeking the pleasure of each other's company. These brain circuits for long-term commitment and bond maintenance become more active. (70)

In humans […] male love circuits get an extra kick when stress levels are high. […] Women, by contrast, will rebuff advances or expressions of affection and desire when under stress. The reason may be that the stress hormone cortisol blocks oxytocin's action in the female brain, abruptly shutting off a woman's desire for sex and physical touch. (72)

As far as researchers know, human males represent behaviors on a spectrum from totally polygamist to totally monogamous. Scientists speculate that different genes and

hormones may account for this variability there is a gene that codes for a particular type of vasopressin receptor in the brain. […] Males how [have] a longer version of the vasopressin receptor gene show greater monogamy. […] The human gene comes in at least seventeen lengths. So the current joke among women scientists is that we should care more about the length of the vasopressin gene in our mates than about the length of anything else. (73)

Male monogamy may […] be somewhat predetermined for each individual and passed down genetically to the next generation. It may be that devoted fathers and faithful partners are born, not made or shaped by a father's example.
Our two closest primate cousins – chimpanzees and bonobos – also have different lengths of this gene, which match their social behaviors. Chimpanzees, who have the shorter gene, live in territorially based societies controlled by males who make frequent, fatal war raids on neighboring troops. Bonobos are run by female hierarchies and seal every social interaction with a bit of sexual rubbing. They are exceptionally social and have the long version of the gene. The human version of the gene is more like the bonobo gene. It would seem that these with the longer gene are more socially responsive. For example, this gene is shorter in humans with autism – a condition of profound social deficit. Differences in partner commitment behavior may therefore be related to our individual differences in the length of this gene and in hormones. (74)

CHAPTER FOUR

SEX: THE BRAIN BELOW THE BELT

Female sexual turn-on begins, ironically, with a brain turn-off. The impulses can rush to the pleasure centers and trigger an orgasm only if the amygdala – the fear and anxiety center of the brain – has been deactivated. Before the amygdala has been turned off, any last-minute worry – about work, about the kids, about schedules, about getting dinner on the table – can interrupt the march toward orgasm. (77)

Research has shown that the biological reason for males coming more quickly is that females who orgasm after the male has ejaculated are more likely to conceive.

It's a delicate system, but the connection to the brain is about as direct as it gets. Nerves in the tip of the clitoris communicate straight to the sexual pleasure center of the female brain. When those nerves are stimulated, they boost electrochemical activity until it hits a threshold, triggers a burst of impulses, and releases bonding, feel-good neurochemicals such as dopamine, oxytocin, and endorphins. Ah, climax! It stimulation of the clitoris is cut off too soon, if the clitoral nerves aren't sensitive enough, or if fear, stress, or guilt interfere with stimulation, the clitoris is stopped dead in its tracks. (78)

As the orgasm subsides, waves of oxytocin cause a woman's chest and face to flush because the blood vessels expand. (79)

Many sex therapists say that, for women, foreplay is everything that happens in the twenty-four hours preceding penile insertion. For men, it's everything that happens there minutes before. (82)

Women do not necessarily need to experience orgasm in order to conceive, though it helps.

Despite some scientists' belief that there is no purpose in female orgasm, it actually works to keep a woman lying down after sex, passively retaining sperm and increasing her probability of conception. Not to mention that orgasm is intense pleasure, and anything that feels good makes you want to do it again and again – just what Mother Nature had in mind. Others have suggested that female orgasm evolved to create a stronger partnership between lovers, inspiring in women feelings of intimacy and trust towards mates. An orgasm communicates a woman's sexual satisfaction with and devotion to a lover.

Many evolutionary psychologists have also come to view the female orgasm as a sophisticated adaptation that allows women to manipulate – even without their own awareness – which of their lovers will be allowed to fertilize her eggs. The quickened breath, moaning, racing heart, muscular contractions and spasms, and nearly hallucinatory states of pleasure that orgasm inspires may constitute a complex biological event with a functional design. Scientists believe orgasm may function as a "sperm competition," through which women's bodies and brains choose a winner.

The muscular contractions and uterine suction associated with women's orgasm have long been known to pull the sperm through the cervical mucus barrier. In one published account of the strength of the orgasmic suction into the cervix, a doctor reported that a patient's uterine and vaginal contractions during sex with a sailor had pulled off his condom. Upon inspection, the condom was found inside the tiny cervical canal. (83-84)

Using the body odor of men and the noses of women, Jan Havlicek of Charles University in Prague has hatched a controversial theory about pheromones and the female brain. He found that ovulating women who already have partners preferred the smell of other more dominant men but that single women showed no such preference. Havlicek argues that his findings support the theory that single women want nurturing men who will help raise a family. But once the home is secured, they have the biological urge to sneak around with men who have the best genes. Studies of mating patterns in species of birds once thought to partner for life showed that up to 30 percent of the baby birds were sired by males other than the ones taking care of them and living with their mothers.

Yet another blow to the myth of female fidelity is the dirty little secret in human genetic studies – up to 10 percent of the supposed fathers researchers have tested are not genetically related to the children these men feel certain they fathered. (87-88)

Another study found that women who have lovers on the side start to fake orgasm more often with their stable partners. Faking orgasm with their steady partners was more common even among women who reported only flirting with other men. Men are biologically geared to look for cues of sexual satisfaction for a reason – such satisfaction is reassurance about women's fidelity. Faking orgasm may function to distract a woman's primary partner from her infidelity. (88)

Researchers have shown that when women do engage in extramarital sex, they retain fewer sperm from their main partners (their husbands, in many cases) and experience more copulatory orgasms during their trysts, retaining more semen from their secret lovers. (88)

Women are no more built for monogamy than men are. They are designed to keep their options open, and they fake orgasm to divert a partner's attention from their infidelities. (88)

The sexual desire trigger for both genders is the androgen testosterone, the chemical that is mistakenly called, by some, the "male hormone." It's actually a sex and aggression hormone, and both men and women have lots of it. Men produce it in their testes and adrenal glands, while women make it in their ovaries and adrenal glands. In both males and females, testosterone is the chemical fuel that gets the brains' sexual engine going. When there's enough fuel, testosterone revs the hypothalamus, igniting erotic feelings and arousing sexual fantasies and physical sensations in the erogenous zones. The process works the same way in men and women, but there's a huge sex difference in the amount of testosterone that's available to "turn on" the brain. Men have on average ten to one hundred times more testosterone than women. (89)

Between the ages of eight and fourteen, a girl's estrogen level increases ten to twenty times, but her testosterone level rises only about five times. A boy's testosterone level increases twenty-five-fold between ages nine and fifteen. (89)

The sex-related centers in the male brain are actually about two times larger than parallel structures in the female brain. (91)

[…] sex [is] as important to a man as communication [is] to a woman. (93)

CHAPTER FIVE

THE MOMMY BRAIN

The sweet smell of an infant's head carries pheromones that stimulate the female brain to produce the potent love potion oxytocin – creating a chemical reaction that induces baby lust. (97)

Between six months and the end of pregnancy, fMRI brain scans have shown that a pregnant woman's brain is actually shrinking. This may be because some parts of her brain get larger as others get smaller – a state that gradually returns to normal by six months after giving birth. (100)

When a baby lamb passes through its mother's birth canal, oxytocin pulses rewire the ewe's brain in minutes, making it exquisitely sensitive to its baby's smell. For five minutes or less, just after birth, she's able to imprint the odor of her newborn. After that, she'll permit only her own lamb to nurse, rejecting others, which have unfamiliar smells. If she doesn't get to smell her own baby in those first five minutes, she will not recognize it and thus reject it, too. […] For the human mother, the lovely smells of her newborn's head, skin, poop, spit up breast milk, and other bodily fluids that have washed over her during the first few days will become chemically imprinted on her brain – and she will be able to pick out her own baby's smell above all others with about 90 percent accuracy. This goes for her baby's cry and body movements, too. (101-102)

Mothers may have better spatial memory than females who haven't given birth, and they may be more flexible, adaptive, and courageous. […] Female rats, for example, that have had at least one litter are bolder, have less activity in the fear centers of their brains, do better on maze tests because they are better at remembering, and are up to five times more efficient in catching pray. (103)

Expectant dads go through hormonal and brain changes that roughly parallel those of their pregnant mates. (103)

In the weeks before birth, researchers have found, fathers have a 20 percent rise in their level of prolactin, the nurturing and lactation hormone. At the same time, their level of the stress hormone cortisol doubles, increasing sensitivity and alertness. Then, in the first weeks after birth, men's testosterone plummets by a third, while their estrogen level climbs higher than usual. These hormone changes prime their brains for emotionally bonding with their helpless little offspring. Men with lower testosterone levels actually hear the cries of babies better. They don't hear quite as well as moms, however, when babies whimper, for example, fathers are slower than mothers to respond, although they tend to react just as quickly when a baby screams. Men's lower testosterone levels also decrease their sex drive during this time. (104)

Researchers hooked new mothers up to brain-monitoring equipment and showed them photographs of their own children, then pictures of their romantic partners. The scans revealed that the same oxytocin-activated regions of the brain lit up in response to both photos. (105)

In one study, mother rats were given the opportunity to press a bar and get a squirt of cocaine or press a bar and get a rat pup to suck their nipples. Which do you think they preferred? Those oxytocin squirts in the brain outscored a snort of cocaine every time. […] When a [human] baby grasps its mother's breast with tiny hands and suckles on her nipple, it triggers explosive bursts of oxytocin, dopamine, and prolactin in the mother's brain. (106)

[…] how well you mother your daughter will determine how well she mothers your grandchildren. (110)

Scientists have also shown that high nurturing – from any loving, trust-inducting adult – may make babies smarter, healthier, and better able to deal with stress. These are qualities they will carry throughout their lives and into the lives of their own children. Children with less maternal care, by contrast, end up more easily stressed, hyperreactive, inattentive, sick, and fearful as adults. (111)

As a rule, primates, including humans, are fairly practical about their investment in mothering. For example, primates in the wild are very rarely full-time mothers. Many mother monkeys balance infant care with their essential "work" of foraging, feeding activities, and resting. They also pitch in when needed to care for offspring other than their own – this is called alloparenting. In fact, in times of plenty, other moms easily adopt and care for foster children, even those from other communities or species. (113)

CHAPTER SIX

EMOTION: THE FEELING BRAIN

[…] scientists speculate that there may be more mirror neurons in the human female brain than in the human male brain. (118)

Gut feelings are not just free-floating emotional states but actual physical sensations that convey meaning to certain areas in the brain. Some of this increased gut feeling may have to do with the number of cells available in a woman's brain to track body sensations. After puberty, they increase. The estrogen increase means that girls feel gut sensations and physical pain more than boys do. Some scientists speculate that this greater body sensation in women punches up the brain's ability to track and feel painful emotions, too, as they register in the body. The areas of the brain that track gut feelings are larger and more sensitive in the female brain, according to brain scan studies. Therefore, the relationship between a woman's gut feelings and her intuitive hunches is grounded in biology. (120)

[…] brain-imaging studies show that the mere act of observing or imagining another person in a particular emotional state can automatically activate similar brain patterns in the observer – and females are especially good at this kind of emotional mirroring. (122)

In the male brain, most emotions trigger less gut sensation and more rational thought. The typical male brain reaction to an emotion is to avoid at all cost. (123)

For both sexes, the emotional gatekeeper is the amygdala, an almost-shaped structure located deep within the brain. The amygdala is like the brain's Homeland Security Alerting and Coordinating System, switching on the rest of the body systems – the guy, skin, heart, muscles, eyes, face, ears, and adrenal glands – to look out for incoming emotional stimuli. The first relay station for emotion from the amygdala to the body is the hypothalamus. Like the Joint Chiefs, it's responsible for coordinating the launch of systems that raise blood pressure, heart rate, and breathing rate, and stimulate the fight-or-flight reaction after receiving reports from the body. The amygdala also alerts the cortex, the brain's Intelligent Branch, which sizes up the emotional situation, analyzes it, and determines how much attention it deserves. If it senses enough emotional intensity, the cortex cues the amygdala to alert the conscious brain to pay attention. This is the moment when we're flooded with conscious emotional feelings. Before this point, all this brain processing is happening behind the scenes. The brain's decision-making center, or Executive Branch – the prefrontal cortex – can now decide how to respond.

Part of the reason that her memory is better for emotional details is that a woman's amygdala is more easily activated by emotional nuance. The stronger the amygdala response to a stressful situation, such as an accident or threat, or a pleasant event, such as a romantic dinner, the more details the hippocampus will tag for memory storage about the experience. Scientists believe that because women have relatively larger hippocampus, they have better memories for the details of both pleasant and unpleasant emotional experiences – when they happened, who was there, what the weather was like, how the restaurant smelled – in a detailed, three-dimensional, sensory snapshot. (127-128)

The amygdala is the brain center for fear, anger, and aggression, and it's physically larger in man than in women, whereas the anger, fear, and aggression control center – the prefrontal cortex – is relatively larger in women. As a result, it's easier to push a man's anger button. The male amygdala also has many testosterone receptors, which stimulate and heighten its response to anger, especially after the testosterone surges at puberty. That's why men whose testosterone levels are high, which includes younger men, have short anger fuses. Many women who start taking testosterone also notice that

their anger response is suddenly quicker. As men age, their testosterone naturally declines, the amygdala becomes less responsive, the prefrontal cortex gains more control, and they don't get angry as fast. (129)

[…] the brain learns about what is dangerous when its fear pathways are activated and about what is safe when its pleasure-reward circuits fire. Females find it harder than do males to suppress their fear in response to anticipation of danger or pain. (132)

CHAPTER SEVEN

THE MATURE FEMALE BRAIN

A menopausal woman becomes less worried about pleasing others and now wants to please herself. (136)

A constancy in the flow of impulses through [post-menopausal woman's] brain circuits replace[s] the surges and plunges of estrogen and progesterone caused by the menstrual cycle. (136)

Fifty-one and a half years is the average age of menopause, the moment twelve months after a woman's last period; twelve months after the ovaries have stopped producing the hormones that have boosted her communication circuits, emotional circuits, the drive to tend and care, and the urge to avoid conflict at all costs. The circuits are still there, but the fuel for funning the highly responsive Maserati engine for tracking the emotions of others has begun to run dry, and this scarcity causes a major shift in how a woman perceives her reality. With her estrogen down, her oxytocin is down, too. She's less interested in the nuances of emotions; she's less concerned about keeping the peace; and she's getting less of a dopamine rush from the things she did before, even talking with her friends. She's not getting the calming oxytocin reward of tending and caring for her little children, so she's less inclined to be as attentive to others' personal needs. (137)

By the age of menopause, women have also lost up to 60 percent of the testosterone they had at age twenty. (141)

It is commonly believed that men leave their aging, chubby, post-menopausal wives for fertile, younger, thin women. This couldn't be further from the truth. Statistics show that more than 65 percent of divorces after the age of fifty are initiated by women. (147)

[…] women who had estrogen replacement therapy right after the removal of their ovaries retained the memory function they'd had before, but women who had no estrogen replacement right after their ovaries were removed had declining verbal memory unless they were soon given estrogen. The therapy restored their memory to nearly premenopausal levels – but only if they began it immediately or soon after the operation. There's a brief window, it seems, when estrogen provides maximum protective benefits for the brain. (152)

Men's and women's brains age differently, with men losing more of the cortex sooner than women. (154)

The special, supportive role that grandmothers play may be one of the reasons that evolution engineered women to live for decades after they can no longer bear children. Grandmothers […] may actually be one of the keys to growth and survival in ancient human populations. (154)

Even though the life span in hunter-gathering societies is typically less than forty, about a third of all adult women survive past that age, and many go on to live productively into their sixties and seventies. (155)

APPENDIX ONE

THE FEMALE BRAIN AND HORMONE THERAPY

[…] estrogen promotes brain cell survival, growth, and regeneration. (166)

The following areas were spared the usual age-related shrinking in women taking HT: the prefrontal cortex (an area for decision making and judgment), the parietal cortex (an area for verbal processing and listening skills), and the temporal lobe (an area for some emotional processing). (166)

[…] men's brains shrink faster with age than women's brains. This is especially true in regions such as the hippocampus, the prefrontal white matter, which speeds decision making; and the fusiform gyrus, an area involved in facial recognition. (167)

By age fifty, many women have lost up to 70 percent of their testosterone. […] By age fifty, men have lost half of their adrenal testosterone and 60 percent of the testosterone produced by the testes when they were young. (176)

Millions of [peri- and post-menopausal] women see their sex drive disappear […]. The biological reasons for this decline are profound hormonal changes in the brain. The estrogen, progesterone, and testosterone surges from the ovaries that formerly marinated the brain are now ending. Androgen and testosterone production by the adrenal glands and ovaries, which surged around puberty and remained high into woman's twenties and early thirties, dwindles by about 2 percent per year, until by the age of seventy or eighty [they] have only 5 percent of what [they] had when [they] were twenty. Libido in women decreases with age starting in the third decade of life and is especially prevalent if women have had their ovaries removed. (177)

[…] a quarter of women ages seventy to ninety still masturbate. (177)

[…] by giving testosterone [to women] we can increase a woman's urge to masturbate and shorten her time to orgasm, but not necessarily increase her desire for partner sex. For some women, testosterone can improve sexual interest dramatically, but the hormone may not be the panacea we once thought for improving sexual interest in all women. (179-180)

In addition to its effects on the brain's sexual center, testosterone promotes mental acuity as well as muscle and bone growth. On the downside, it can contribute to thinning hair, acne, body odor, facial hair growth, and a lower voice. But the effects of testosterone on the brain – increased mental focus, better mood, more energy and

sexual interest – are the reason many men and women who take it say they are willing to assume the downside risks. (180)

APPENDIX TWO

THE FEMALE BRAIN AND POSTPARTUM DEPRESSION

One out of ten female brain will become depressed within the first year after giving birth. […] Postpartum psychiatric changes can range from maternity blues to psychosis, but the most common is postpartum depression. (181)

The well-known predictors of depression after giving birth include a previous depression, depression during pregnancy, lack of proper emotional support, and high stress at home. (182)

Some scientists feel that breast feeding may be protective against postpartum depression in certain women. (183)

APPENDIX THREE

THE FEMALE BRAIN AND SEXUAL ORIENTATION

[…] same-sex romantic attraction […] is estimated to occur in five to ten percent of the female population.

The female brain is only half as likely to be wired for same-sex attraction as is the male brain. […] Biologically, genetic variations and hormonal exposure in both male and female brains are thought to lead to same-sex attraction, but the origins in women appear to be different than in men. (185)

Sexual orientation in females occurs along more of a continuum than in males, with females reporting more bisexual interest. Psychosocial studies have also shown that gay women have higher self-esteem and quality of life than do gay men. (186)

[prenatal exposure to an opposite-sex hormonal environment, like testosterone in a genetically female brain, leads the nervous system and brain circuits to develop along more male-typical lines. (186)

Gay versus straight women showed a less sensitive auditory response – a male-typical pattern. […] Gay women showed opposite-sex shifts in their verbal fluency scores – scoring in a range intermediate between males and females. (186)

[…] the wiring of the female brain for sexual orientation occurs during fetal development, following the blueprint of that individual's genes and sex hormones. (187)