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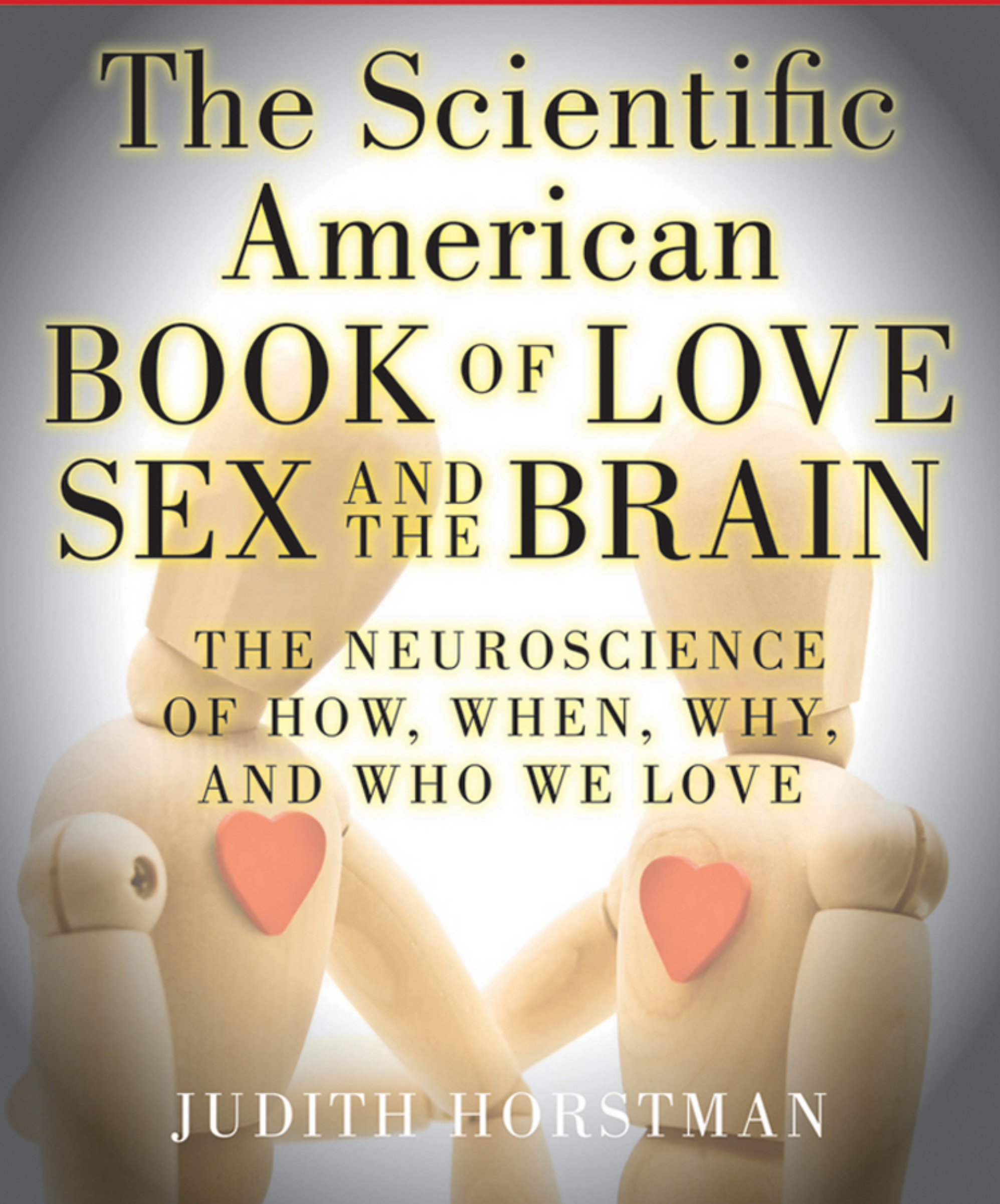
The Scientific American BOOK OF LOVE SEX AND THE BRAIN

THE NEUROSCIENCE OF HOW, WHEN, WHY, AND WHO WE LOVE



JUDITH HORSTMAN

The SCIENTIFIC AMERICAN BOOK OF LOVE, SEX, AND THE BRAIN

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The SCIENTIFIC AMERICAN BOOK OF LOVE, SEX, AND THE BRAIN

The Neuroscience of How, When, Why, and Who We Love

Judith Horstman

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CONTENTS

To my family, my friends, and my Tribe,
who taught me the meaning of love

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PREFACE: WHO DO YOU LOVE?

Who do we love? Who loves us? And why? Why does some love die while other love lasts? Is it really a mystery—or can science (specifically neuroscience) shed some light on how, why, and who our brains love? Probably it can.

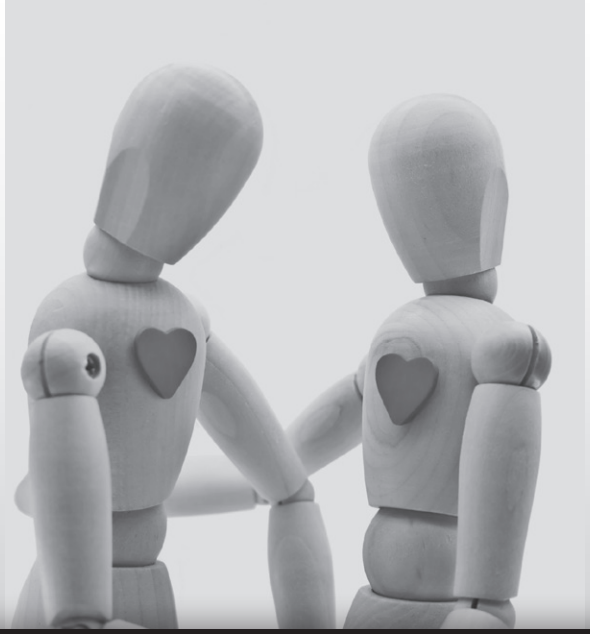
We've been learning more about sex every day, especially since Alfred Kinsey began asking Americans exactly what we were doing sexually, where, and with whom, and since William H. Masters and Virginia E. Johnson began scrutinizing and categorizing what our genitals were doing while our brains were having sex.

Recently researchers have been studying what in our brains makes our hearts go pitter-patter with lust and with lasting love—with the whole smorgasbord of emotions, including the love of parent and child, the affectionate love of companionship, the role that the love of animals can play in our lives, and the love of God.

Scientists have learned that the brain in love and sex uses an entire pharmacy of chemicals and chemical actions and reactions, calling forth a tsunami of neurotransmitters and hormones. And now we are able to actually look at a brain that's in love, lust, or both. New imaging technology allows scientists to peer inside our brains, our

primary sex and love organ, to see what's happening in there. Brain scans, especially the functional magnetic resonance imaging scans, allow scientists to see brain activity in real time in a live, thinking, feeling, loving (or sexually excited) brain. They allow scientists to watch as our brain experiences romance, sex, love, and loss, and several emotions in between.

This book is structured around the way your brain encounters and experiences various kinds of love, beginning with prenatal influences and continuing through parental love, friendship, sex, romance, marriage, religious love, and beyond. It is based on the indisputable evidence that we are hardwired to connect to one another. Love is who we are.



Introduction: What Is This Thing Called Love?

Much is written of the mysteries of love, but there is no mystery about our need for it. We crave the comfort of others, especially those who have become special to us. People will kill, die, starve, and commit crimes for love. They have faced torture and prison, defending their rights to love the god or person of their choice. Children and spouses cling to abusers out of the need for their love. People go mad in solitary confinement, or even, studies show, die of loneliness or the emotional blow of a "broken heart."

Love is so vital to the human condition that it is beyond mere emotion. Indeed, many researchers have described love as a drive, an urge, and even a hunger. A multistudy analysis confirms that the powerful rush we feel when we are madly, deeply, passionately in love is not really an emotion. It's a reward produced by ancient brain

pathways that similarly motivate our most basic needs such as those for food or sleep.

And that's not just sexual love. Consider the results of a 2010 meta analysis of 148 studies of how and why people die and the causes. Loneliness ranks right up there on the top. The study found that a lack of relationships can be as deadly as well-established risk factors for death such as smoking and alcohol, and it is even greater than other risk factors such as obesity. Shunning, abandonment, and forced solitary confinement are among the worst punishments, considered to be cruel and excessive, or even torture, and the rejected brain is a very wretched brain.

So What Is Love?

Everyone in every culture knows what love is, in all its many guises, as both a noun and a verb. It is tender, sweet, protective, passionate, lustful, jealous, trustful, and sometimes mad. But just try to get a good, clear, take-to-the-bank definition, and you will be stymied. Google alone yields 6,730,000,000 hits for the simple word *love*.

The poets say it in verse, as Shakespeare did in his Sonnet 116:

> Love is not love
> Which alters when it alteration finds,
> Or Bends with the remover to remove.
> O, no! It is an ever-fixed mark,
> That looks on tempests and is never shaken.
> —WILLIAM SHAKESPEARE

Kahlil Gibran in *The Prophet* describes love thus:

> Love has no desire but to fulfill itself. To melt and be like a running brook that sings its melody to the night. . . . To wake at dawn with a winged heart and give thanks for another day of loving.

The New Testament offers the well-quoted passage from 1 Corinthians 13:47:

> Love is patient, love is kind. It does not envy, it does not boast, it is not proud. It is not rude, it is not self-seeking, it is not easily angered, it keeps no record of wrongs. Love does not delight in evil but rejoices with the truth. It always protects, always trusts, always hopes, always perseveres.

And, of course (and anonymously), "God is love."

Philosophers don't sound very philosophical when it comes to love. Sophocles wrote, "One word frees us of all the weight and pain of life: That word is love." Plato wrote, "At the touch of love everyone becomes a poet," and later added, "Love is a serious mental disease."

Scientists reduce love to its basics, exemplified by these definitions from Stephanie Ortigue and associates:

> Love is the existence of a complex rewarding emotional state involving chemical, cognitive, and goal-directed behavioral components.

> Romantic love is a mammalian brain system for mate choice.

And this basic truth is from the twentieth-century psychoanalyst Eric Fromm:

> Love is the only sane and satisfactory answer to the problem of human existence.

Even fictional characters have an opinion. The character Hawkeye from the TV show *M*A*S*H** said on one episode in 1973, "Without love, what are we worth? Eighty-nine cents! Eighty-nine cents worth of chemicals walking around lonely."

We all have our own definitions when it comes to being in love, but most of us would agree, "I know it when I see it" (which just happens to also be the way Supreme Court Justice Potter Stewart famously defined pornography).

Love Is a Many Splendored Thing—and the Greeks Had a Word for All of the Types

There are as many types of love and ways to express love as there are cultures, languages, and perhaps even people: puppy love, friendship love, affectionate love, courtly love, parental love, passionate love, sexual love, baby love, unconditional love, possessive love, and love for a pastime, a pet, a purchase, an object, or a pleasure. *Love,* as used in the English language (and a few others), can range from a mild liking to a passionate obsession. It has also been described, and not humorously, as a form of obsessive compulsive disorder.

But when we talk about love, we can generally describe it in five ways, based on words from the ancient Greeks. While the meanings of the Greek words have shifted and changed over millennia and been adopted and adapted by newcomer cultures, the basic concepts remain pretty accurate.

So how do I love thee? Let us count the ways:

Agape. In ancient Greece, it meant loving in general. It then became used widely in Christianity to describe what is considered the highest form of love: unconditional love, divine love, or even sacrificial love. In Greece today, it's often used to say, "I love you," but it implies a deeper, truer love—more than just eros.

Philia (or *Phileo*). Brotherly love, generous love, affection. Philadelphia is the city of brotherly love, and *philanthropy* refers to the unselfish concern and efforts of goodwill to better or benefit others.

Storge. Affection and family love, especially the love of parents for children and children for parents, but also love for other family members.

Platonic. From the dialogues of the philosopher Plato and his descriptions of a chaste, nonsexual, but passionate love between two people, usually of the same sex (Plato liked young men). The term actually came about in the Renaissance and continues to mean a

WHAT NEUROSCIENCE KNOWS ABOUT YOUR BRAIN IN LOVE

Much fascinating information about our brains and the many kinds of human love is coming from curious scientists and new imaging technologies that allow a look inside our living, loving brain—our primary sex and love organ—to see what's happening in there.

Among some of the findings are:

- Our brains are hardwired to seek the love and the companionship of others. In fact, social isolation is so bad for your brain that solitary confinement could be considered torture.
- Sex, love, and orgasm are good for your brain, contribute to your health, and may even help lower your risk of developing dementia—and loss of a mate may increase your risk of death.
- Your genes contribute to your love life, from your gender choice in sex partners, to how easily your brain reaches orgasm, to how likely you are to dabble in one-night stands—but your life experiences may trump those tendencies.
- Love lives in your brain, and many of the same parts involved in sexual and romantic love are activated by drugs, music, and even religious ecstasy.
- Parenthood actually causes the brain to grow in both moms and dads and your friendships may be (next to your mother) the most important loving relationships in your life.
- As the body ages, the brain is still more than willing to engage in sex. Studies show some of us are having sex and desiring sex well into very old age, health permitting (and with or without partners).

strong (or even passionate) but nonsexual relationship between persons of any gender or sexual preference.

Eros. Passionate love, sensual desire, romantic love, and usually (but not always) sexual love. In ancient Greece, the god Eros was the

spirit of love that arose from chaos. Later, Eros was depicted as a mischievous little god of love, and in Roman mythology, he became Cupid or Amor.

The Basics of Your Brain in Love and Sex

The chapters that follow detail which parts of your brain are doing what while your body is having sex, thinking about having sex, thinking about being in love, being in love, loving children, loving parents, losing love, and more. The inescapable observation is that a very large proportion of our brain's real estate is dedicated to love and sex. And the question is: Why?

Social scientists and evolutionary psychologists have plenty of theories about why social behaviors (or what we call love) are so important. They say our need for other people goes back to primitive cultures of the past (and remote cultures today) when isolation and exile often meant death. Being banished from friends and family and the community campfire meant literally being thrown to the wolves or other predators of the night—a fate as bad as (or in fact resulting in) death. They speculate that social behaviors, including sex, not only help humans survive as individuals, they ensure cooperation, reproduction, and care for offspring and thus the survival of the species.

Psychologists, philosophers, poets, and neuroscientists have also given this a lot of thought. Among their conclusions are these:

- The brain evolved to protect the body (and mind, presumably). Therefore, the brain tells us what to do that will improve our chances of surviving and passing on our genes so that our species survives.
- Choice of sexual partners is driven in men by the evolutionary-fueled drive to spread their sperm, and love by a man's urge to know any offspring are his own.

- A female's sex urge is also spurred by reproductive desire, and her love by a need to keep a male partner to help improve survival of the offspring.
- Parental love for a child is essential for survival of the species. Unlike most other mammals, humans are not only born helpless but remain in need of intensive adult attention and care for years.

Based on these theories, it's no surprise that sex and love are highly pleasurable—so much so that many neuroscientists posit they are basic needs. That may be so, because we crave the company of each other: it just makes us feel good. The experience of loving is intimately connected to a biochemical reward circuit in our brains not very different from, and as powerful as, any addiction, including heroin.

I've Got You Under My Skull: Love in Your Brain

It's still not possible to say exactly how love works in your brain, but we are beginning to get a good idea of the brain activities and anatomy involved.

Those three pounds of flesh, nerves, and fluid that make up your brain contain 1 billion or so specialized cells called neurons that communicate and form and dissolve networks through chemicals (especially those called neurotransmitters) and minuscule electrical charges that pass over the tiny gaps, or synapses, between them. Each neuron can communicate with hundreds of thousands of other neurons and can (and does) change its connections and networks all the time, a process called neuroplasticity. Some of these will be temporary and fleeting, rather like a one-night stand, while others will become more established with repeated use, into a lasting marriage of sorts.

The brain and its functions can be described in three parts, from bottom to top, in the order in which it evolved: the primitive brain, the emotional brain, and the thinking brain.

The primitive brain—the brain stem or hindbrain—sits at the top of the spine and takes care of the automated basics, such as breathing, heartbeat, digestion, reflexive actions, sleeping, and arousal. It includes the spinal cord, which sends messages to and from the brain to the rest of the body, including to and from your sex organs, and the cerebellum, which coordinates balance and rote motions, such as dancing and making love.

Above this is your emotional brain, tucked deep inside the bulk of the midbrain. It acts as the gatekeeper between the spinal cord below and the thinking brain in the cerebrum above. The major players for love, both sexual attraction and deep bonding, most likely originate here in what's also called the limbic system. This regulates survival mechanisms such as sex hormones, sleep cycles, hunger, emotions, and, most important, fear, sensory input, and pleasure.

The ever-alert amygdala resides here, ready to sound the fight-or-flight alarm. It helps decide whether an experience is pleasurable or bad, and whether it should be repeated or avoided. It sends that message along to the hypothalamus, which produces and releases chemicals that spur your body to action, and to the hippocampus, your gateway to short-term memory that helps record memories of the event, including where and when and with whom it happened so you can do that good thing again and reject the bad thing (or person) next time around.

You Make Me Feel So Good: The Pleasure Center

Now this is important for understanding love: the so-called pleasure center, or reward circuit, is also based in the limbic system, involving the nucleus accumbens, ventral tegmental area (VTA), and the caudate nucleus—midbrain reward/motivation systems that are connected with pleasure and addiction. So while you are experiencing something you like very much, such as sex or cuddling with your newborn, a

pathway (called the VTA-accumbens pathway) evaluates how good the experience is and sends that rating along to other parts of your reward circuit, including your amygdala and prefrontal cortex. There they file it away: the more rewarding the experience, the more likely your brain is to want to repeat it.

And flooding your system with the neurohormone dopamine is what makes sex feel so good and keeps us coming back for more: it's no figure of speech to say love is addictive. Just as all drugs of potential abuse prompt a veritable tsunami of dopamine, so love and lust can also overwhelm, capture, and change the pleasure circuit, leaving us craving more and more. Oxytocin, the neurohormone of trust and attachment, also gets involved, contributing to bonding and lasting love. It can help convert and dampen that insane lust reflex into lasting affection.

The Very Thought of You

More than attraction and addiction are involved in love. Studies show that your thinking brain also chimes in for lasting love (even sexual love). The thinking brain—the wrinkly and crevassed cerebrum, the part we usually see when we picture a brain—sits like a crown on the very top of your brain, covered with the nickel-thin layer of the cerebral cortex (or neocortex).

This is the most recently evolved part of the brain—the part, some say, that makes us human. Its four major sections, or lobes, control thoughts, language, planning, and imagination and process all of the sensations of being in love. The frontal lobes take care of emotions and reasoning, the occipital lobes in the back process what you see, and the temporal lobes (above your ears) are responsible for what you hear and for understanding speech, appreciating music (and perhaps thinking of a supreme being). The parietal lobes running across the top and sides of the brain are the primary sensory areas, taking in information about taste, touch, and movement.

Eventually your thinking brain will coordinate and process all the important information it is receiving from your limbic and reward systems. Over time, it will decide how you actually feel about love and your love objects and experiences. But at first, your emotional brain is in charge—and it wants what it wants, and it's going to get it. There are many more connections running from the amygdala to the cerebral cortex than the other way around, so your emotional brain will rule in any tug of war between feeling and thinking—something that all of us already know.

New advances in technology are showing us more and more about what happens inside our skulls and are beginning to connect actions, feelings, and even thoughts to activity in specific parts of our brains. The functional magnetic resonance imaging (fMRI) technique, which can show activity inside a living, thinking, and even fornicating brain, has contributed much to our understanding of love and other emotions.

A word of caution: The technology of brain imaging is amazing; however, announcements about how the sources of some emotions and functions have been "mapped" in the brain need to be taken with care. Brain-imaging technology is remarkable and has revolutionized surgery but it is still very new and relatively crude, and it can't prove cause and effect. Although brain scans can indeed show what parts of your brain become active at certain times, scientists say they don't yet know exactly what that activity means or even if they are seeing all the action going on. Brain researchers are still trying to figure out much of what goes on between your ears.

How Scientists Research Love and Sex in Your Brain

You may be wondering how scientists get all this information about what's going on in your brain. They use several research tools to put

together theories about what your brain is thinking (and doing) about love. Sometimes several or all of these investigative techniques are used in one research project. Throughout this book, you'll read about examples of these techniques:

1. *They ask you (interviews).* Surveys and questionnaires tell us what people say they think about sex and love, including choice of partners, frequency of sex, and satisfaction with sex and relationships. Since the information is self-reported, it may not be completely objective but is still useful. For example, recent studies where some elderly men said they have intercourse every week may not be true—but it shows these men are still thinking about sex in old age.
2. *They watch you (observation).* Observing animals and people as they perform or react to situations and stimuli, including sexy images and even sex acts, hints at what is going on in the body and brain and helps to connect the actions with the amount and location of brain activity.
3. *They sample your tissue and fluids (laboratory tests).* Humans and other mammals produce specific neurochemicals and hormones related to fear, stress, pleasure, sexual activity, orgasm, and even love. Measuring these chemicals gives insights into what people are thinking and feeling, as well as what their brains are doing. For example, they found that many who are unable to bond with others have lower levels of oxytocin, the hormone produced along with feelings of love and connection.
4. *They wire you up (electroencephalography).* An older technique, it is still useful to record your brain's electrical activity from outside your skull.
5. *They look inside your brain (brain scans).* A host of imaging techniques and tools show which parts of your brain are active when you are feeling or even experiencing sex or love.

TOOLS FOR LOOKING INSIDE YOUR BRAIN

Today's array of sophisticated imaging technologies has come a long way since the X-ray was discovered in 1895.

Here's what that alphabet soup of acronyms means:

EEG (electroencephalograph). A direct reading of the brain's electrical activity taken from multiple electrodes placed on the scalp is displayed as squiggly lines on a chart. It has been in use since the 1920s and is relatively inexpensive and effective. But it can't detect activity deep inside the brain very well or produce an image.

CAT (computed axial tomography); also CT (computed tomography). Uses special X-ray equipment and computers to create cross-sectional pictures of the body at different angles (*tomography* means imaging by sections). It has been used since the 1970s and has the advantage over X-rays of being able to show body sections behind other parts and in much more detail.

PET (positron emission tomography). A small amount of radioactive material is given and then detected by special cameras in images that allow researchers to observe and measure activity in different parts of the brain by monitoring blood flow and other substances such as oxygen and glucose.

SPECT (single photon emission computed tomography). Uses a small amount of radioactive tracer in a way similar to PET to measure and monitor blood flow in the brain and produce a three-dimensional image.

MRI (magnetic resonance imaging). Uses magnetic fields to generate a computer image of internal structures in the body; particularly good for imaging the brain and soft tissues.

fMRI (functional magnetic resonance imaging). Today's favorite imaging tool: Can measure blood flow and other activity in a living brain in action and in real time, showing abnormalities, mapping functions and anatomy, and showing activity in the brain as it is happening.