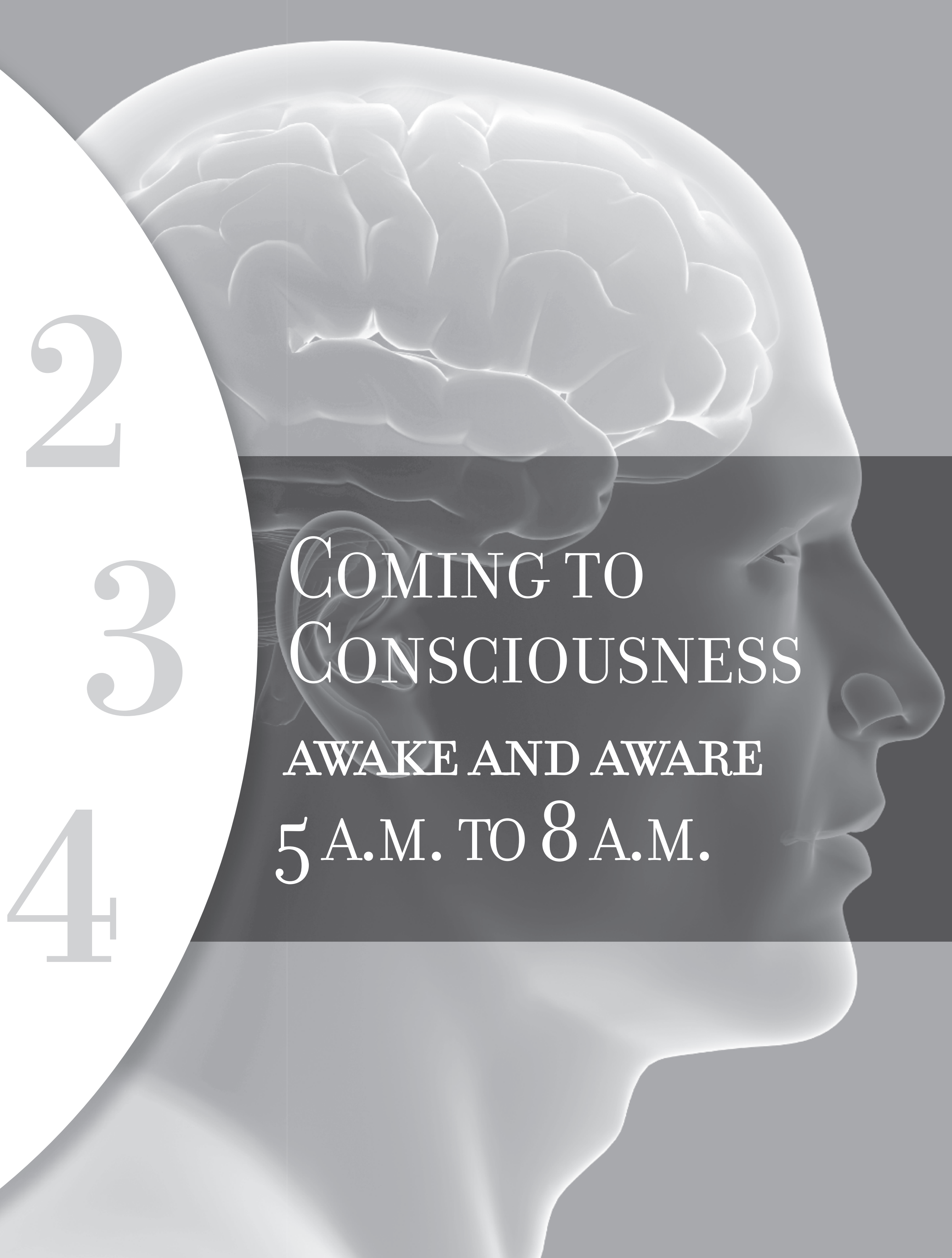
Part 1



Coming to Consciousness

Awake and Aware

5 A.M. to 8 A.M.

5 a.m.

Waking to the World

One minute, you're dead to the world. In dreamland. Incommunicado. The next second, or so it seems, you and your brain are being dragged into the waking world.

The wakeup call can be the relentless shrilling of an alarm clock, a baby's cry, or the grind and beep of a garbage truck. Other senses—the smell and sound of brewing coffee, a shake or a splash of cold water, hunger, thirst, or an urge to urinate—can nudge you toward wakefulness. And with the first light, our body clocks chip in as well, setting off an ebb and flow of hormones and neurotransmitters to stimulate us to awareness.

The process of arousal actually takes several minutes and a literal brainstorm of neural activity with a complex combination of cues, neurochemicals, and body clocks to get you up and keep you awake.

Your Inner Alarm Clocks

A sentry system in your basic brain is set to arouse you when it detects change, such as that annoying alarm clock. Called the reticular activating system (RAS), it's a part of your brain left over from the prehistoric era when you had to be able to detect danger immediately and wake abruptly.

The RAS acts as a gatekeeper for incoming stimulation and sensations, perking up when it detects something new and helping your brain wake up and stay alert and awake all day long. It connects your brainstem to your cortex, sensory organs, and limbic system to help process and regulate activity and consciousness in your thinking brain.

The RAS does this through fibers that project widely throughout your brain, many through the thalamus, considered to be the doorway between sensory input and the cerebral cortex. *Reticular* means "little net." Like a net, the fibers of the RAS "catch" signals from the sensory systems about what's happening in the body or its local environment.

A part of the RAS called the locus coeruleus is particularly attuned to respond to new, abrupt, or loud stimulation and is your brain's major factory for norepinephrine, a neurotransmitter released in response to stress or other stimulation. As soon as the system detects a significant change, such as a snarling sabre-toothed tiger, a splash of cold water, or that ringing alarm clock, it pops out some strong chemicals to increase your state of alertness.

Meanwhile, as night turns to day, another alarm clock starts to "ring." It's the built-in light-dark alarm system of your body clock called the suprachiasmatic nucleus (SCN): two tiny bundles of ten thousand neurons, each no bigger than a letter on this page, nestled deep in your brain, very near the optic nerves.

As the morning light strikes your retina, photoreceptor cells there signal to the neurons in the SCN to begin firing. The SCN toggles a biological switch setting off a process that tells the pineal gland to shut off the flow of melatonin, start the waking process, and keep you awake all day.

Your Brain Chemicals

While you were sleeping, levels of adenosine, a neurochemical with a powerful effect on your sleep-wake cycle, were dwindling. Your entire metabolism slowed, bottoming out to its lowest rate about an hour ago, at 4:00 A.M. or so. Now, as you come to consciousness, a brew of chemical messengers from your brain is telling your metabolism to get up and go.

The neurotransmitter acetylcholine helps pass information to the rest of your brain's sentry system for interpretation. As the amygdala detects a possible survival challenge (*There's an alarm!*), your hippocampus helps decide how much focused attention and memory formation the stimulus warrants (it's a wake-up alarm, not a fire alarm) and helps it get processed by your thinking brain where goal setting and decisions are made (if you ignore that alarm and are late again, you can lose your job, so you better get up *now*).

Other neurotransmitters jump in, including serotonin (necessary for mood regulation and involuntary movement) and dopamine (needed for voluntary movement and attentiveness). A hefty shot of cortisol jump-starts everything. Your body temperature, blood pressure, and respiration begin to rise. And these arousal systems don't stop after they wake you. An active RAS is vital for ongoing awareness. In fact, if your brain's RAS stops firing signals, you may fall asleep again, and damage to your RAS can cause coma. Many general anesthetics and some tranquilizers work on this part of your brain.

The SCN will also stay active most of the day, helping you stay awake until evening when the process reverses, and the rising levels of sleep-promoting chemicals such as melatonin and adenosine make you sleepy all over again.

Larks and Owls

The trip from sleep to consciousness seems longer for some people than others. Some of us seem to wake up instantly: as soon as our eyes pop open, we appear to be fully awake and often upright. Others struggle toward consciousness, moving and sometimes speaking but not fully connected for a half-hour or more, responding to a body clock set a bit later.

Some of us are morning people; some of us are not. Scientists don't know why yet, but all of us know which is which. In case you don't know which you are (or are not sure about someone else) here's a list of characteristics that makes it clear that larks and owls march to different body clocks.

The numbers in brackets are points you scored for each answer. You'll find out how to use them at the end of the questionnaire.

ARE YOU AN OWL OR A LARK?

1. Breakfast: How's your appetite in the first half-hour after you wake up in the morning?
   a. Very poor [1]
   b. Fairly poor [2]
   c. Fairly good [3]
   d. Very good [4]
2. For the first half-hour after you wake up in the morning, how do you feel?
   a. Very tired [1]
   b. Fairly tired [2]
   c. Fairly refreshed [3]
   d. Very refreshed [4]
3. When you have no commitments the next day, at what time do you go to bed compared to your usual bedtime?
   a. Seldom or never later [4]
   b. Less than one hour later [3]
   c. One to two hours later [2]
   d. More than two hours later [1]
4. You are starting a new fitness regime. A friend suggests joining his fitness class between 7:00 A.M. and 8:00 A.M. How do you think you'd perform?
   a. Would be in good form [4]
   b. Would be in reasonable form [3]
   c. Would find it difficult [2]
   d. Would find it very difficult [1]
5. At what time in the evening do you feel tired and in need of sleep?
   a. 8:00 P.M. to 9:00 P.M. [5]
   b. 9:00 P.M. to 10:15 P.M. [4]
   c. 1:15 A.M. to 1:45 A.M. [3]
   d. 1:45 A.M. to 2:00 A.M. [2]
   e. 2:00 A.M. to 3:00 A.M. [1]

continues on next page

6. If you went to bed at 11:00 P.M., how tired would you be?
   a. Not at all tired [0]
   b. A little tired [2]
   c. Fairly tired [3]
   d. Very tired [5]
7. One night you have to remain awake between 4:00 A.M. and 6:00 A.M. You have no commitments the next day. Which suits you best?
   a. Not to go to bed until 6:00 A.M. [1]
   b. Nap before 4:00 A.M. and sleep after 6:00 A.M. [2]
   c. Sleep before 4:00 A.M. and nap after 6:00 A.M. [3]
   d. Sleep before 4 A.M. and remain awake after 6:00 A.M. [4]
8. Suppose that you can choose your own work hours but have to work five hours in the day. When would you like to start your workday?
   a. Midnight to 5:00 A.M. [1]
   b. 3:00 A.M. to 8:00 A.M. [5]
   c. 8:00 A.M. to 10:00 A.M. [4]
   d. 10:00 A.M. to 2:00 P.M. [3]
   e. 2:00 P.M. to 4:00 P.M. [2]
   f. 4:00 P.M. to midnight [1]
9. At what time of day do you feel your best?
   a. Midnight to 5:00 A.M. [1]
   b. 5:00 A.M. to 9:00 A.M. [5]
   c. 9:00 A.M. to 11:00 A.M. [4]
   d. 11:00 A.M. to 1:00 P.M. [3]
   e. 5:00 P.M. to 10:00 P.M. [2]
   f. 10:00 P.M. to midnight [1]
10. Do you think of yourself as a morning or evening person?
    a. Morning type [6]
    b. More morning than evening [4]
    c. More evening than morning [2]
    d. Evening type [0]

Scoring: Add up the points you scored for each answer. The maximum score for these questions is 46. The minimum is 8. The higher your score, the more of a morning person you are. The lower the score, the more you're a night owl.

Coming to Our Senses

As you swing out of bed and start your morning ritual, your senses wake up to guide you through the day. Taking your morning shower, brushing your teeth, tying your shoes: you probably don't give any of

WHY DO MEN AWAKE WITH ERECTIONS?

Waking up with an erection is fairly common for a healthy male. In fact, an erect penis may be the default state. (Women also have nighttime erections. But more about that later. See "10:00 P.M.")

Nocturnal erections don't (usually) have much to do with sexy dreams or the need to urinate. Men have three to five cycles of nocturnal penile tumescence through the night during phrases of rapid eye movement (REM) sleep. Women go through the same cycle, with an engorgement of the labia, vagina, and clitoris.

These erections don't usually wake us up, and researchers still don't know exactly why they happen. Some speculate this ebb and flow over the long hours of sleep is part of nature's way of keeping a blood supply to the sex organs.

Others think an erect organ may be the default state. Most of the time, the sympathetic nervous system puts the brakes on many functions, including erections, and it's known that the sympathetic neurons in the locus coeruleus that connect to the spinal cord are turned off during REM sleep. This may allow nocturnal erections to occur.

Researchers are interested in morning erections as a clue to solving erection problems. If a man who has erectile dysfunction is getting morning erections, the cause could be psychological rather than physical. There hasn't been much interest among researchers in women's nocturnal turn-ons.

this much thought, and you don't need to. Your brain is directing these actions on a subconscious level. (See "Your Brain Prefers Autopilot," page 24.)

But no matter how simple (or unconscious) the action, each involves a multiplicity of complex memory, sensory, and muscle functions that, not surprisingly, involve many regions of the brain and frequently overlap with incoming data from other senses.

Take the simple act of getting a cup of coffee. You smell the coffee: it triggers a memory that you like and want coffee. You look around and see the coffee pot, hear it perking and bubbling, and get up and walk across the room and pour a cup. In just the milliseconds that your frontal lobes decide to get that cup of coffee, a tidal wave of neural signals sweeps across a multitude of brain regions.

An Orchestra of Sensory Harmony

Each step in the act of getting your coffee draws on a different combination of senses and brain regions to receive and interpret these incoming data. Your brain has to coordinate vision and sound with balance, touch, smell, and spatial awareness. It has to decide which muscles to activate to move you across the room and how much pressure to use when you pick up the cup and coffee pot, when to tip the pot and when to stop pouring coffee, whether the brew tastes strong enough for you, if it needs sugar or milk, if it's too hot or too cool.

Smell pulled you toward the brew. It's our most intense and ancient sense, profoundly connected to memory, sex, and survival. Even bacteria "smell" poisons or nutrients, danger or safety. Smell helps us select our sex mates and remember the good and bad. Many animals rely on smell to know the sex, social rank, territories, and reproductive status of others and to identity their own mates or offspring.

Smell is profoundly linked with memory. Just think how suddenly a familiar scent can whisk you into the past, even many decades ago. Proust surely did: he wrote thirty-two hundred pages featuring the power of memory, spurred by the remembered taste and smell of a small French cake, the madeleine.

Research shows he was right: smell can help the brain encode memories. Volunteers in one study memorized the locations of several objects while smelling a rose scent; then some of them were exposed to the same scent while they slept. Those with perfumed sleep remembered the locations of the objects much better than their fragrance-free peers did, because the scent probably reactivated memories stored temporarily in the hippocampus.

And no wonder. While human sense of smell is relatively weak compared to that of other mammals, we nevertheless have 347 different types of sensory neurons in the olfactory layer for smell inside the nose. Each one detects a different type of odor, and all the varied aromas and stenches we know result from mixtures of responses of these 347 types of receptor cells. By comparison with sight, for example,

THE VERY SMELL OF COFFEE MAY HELP THE RAT RACE

As you inhale that coffee aroma, the very smell intensifies alertness, partly because our brain remembers it as the scent of waking.

There may be a scientific basis for that coffee high. It seems that the aroma of coffee alone could be helpful to the stressed-out brain—in rats, at least, according to a report in the *Journal of Agricultural and Food Chemistry.*

Scientists had laboratory rats, including some that were sleep deprived, inhale the aroma of roasted coffee beans. They found the smell activated seventeen different genes in their brains, and thirteen of them produced proteins known to protect nerve cells from the damaging effects of stress. The experiment hasn't been tried on humans yet (the rat brains were dissected for the study), but it's known that caffeine also offsets the effects of adenosine, a sleep-promoting hormone.

You can conduct your own nonscientific study without shelling out four dollars for that latte. Just walk by the counter instead, inhaling deeply. The smell alone might be enough to kick-start your day.

every color we see results from signal combinations of only three types of sensory neurons in the retina (red-, green-, or blue-sensitive cones).

Vision shows you where to go as information streams in through your retina, moving through the optic nerve to the thalamus and then to the occipital cortex. There your brain has to make various adjustments to "see" the coffee pot. Since light was criss-crossed when it passed through the lens, it was received upside down. And since the optic nerves partially cross over at the optic chasm, each hemisphere of the brain receives slightly different input from both eyes. Your brain combines the data for a three-dimensional effect and then neatly turns the image right-side-up. Finally, the parietal and temporal lobes interpret what the brain is "seeing."

Sound helps you orient yourself in time and space. It enters the eardrums and travels through several complex processing and filtering centers, including the thalamus, and ends up in the temporal gyrus of our thinking brain where it is interpreted and processed further. Speech, for example, gets shunted to the left hemisphere language centers.

Touch and Movement: Feeling Our Way

If smell is our most ancient sense, touch is our first sense as a newborn. It floods our brain with sensation as we waken and is vital for movement, guiding us as we get up and head for the kitchen. Touch signals are processed in a brain area directly behind the fold called the central sulcus, an area associated with movement. (For more about movement see "7:00 P.M.") Touch tells us when our fingers encounter the coffee cup and have grasped it, and it guides the move toward our lips.

Scientists are still trying to figure out how touch works on a molecular level, because the nerve endings in question are extremely small and there are so very many of them. Our entire bodies are covered with a network of tactile sensors, perhaps 6 million to 10 million in all. Interpreting touch sensation can be tricky, since there's not a lot of detailed information about exactly where these information gatherers are located.

Sensory receptors are not evenly distributed over your body. We have many fewer touch sensors in our internal organs, and the surface of the brain feels nothing at all when touched. But the skin (our largest organ), especially the erogenous zones and the area around the mouth, is rich in receptors. Your lips are hundreds of times more sensitive than, say, the rough soles of your feet.

But you already knew that. In fact, we all know, through painful experience, which areas of our body have the most sensory receptors and receivers.

Varieties of Touch

Touch has the potential for adding pleasure and pain to your world and is essential for protecting your body from damage. Those who cannot feel, including pain, can't retreat from damage. This is why some people with leprosy or diabetes who have lost the nerves for pain perception often end up with extremities so damaged they must be amputated.

The signals and feelings that arise from your body surface—itch, sharp pain, dull pain, burning pain, tickle, soothing touch, heat and cold—go to the insula and anterior cingulate cortex. Sensations from the inside of your body—the invigorating inner feeling when you finally drink that first cup of warm morning coffee—are mapped in your insula.

Researchers make a distinction between passive and active touch information. Passive tactile awareness is accepting external sensations: the sun on your face, the wind in your hair, the warmth of a morning shower, your mother's caress. Active touching is when we explore our surroundings with our hands, feet, or mouth: sipping that coffee, walking barefoot on wet grass, biting into a ripe mango. This form of touch helps our brains develop a comprehensive understanding of objects around us.

Both active and passive touch are vital for early brain development. Babies of many species develop as they actively explore their environment with hands, feet, and mouth.

YOUR BRAIN PREFERS AUTOPILOT: IT SAVES FUEL

As you get up and go about these morning rituals, you probably don't give them much thought—and you don't need to. The many regions of your brain directing these actions operate on a subconscious level. And that's just the way your brain likes it.

Tasks that require practice—like brushing and flossing your teeth properly, playing the piano, or riding a bike—must be learned consciously. Your brain has to concentrate. But once you've mastered them, your brain shuffles them to a lower level of consciousness: you don't "think" about what you're doing. In fact, if you focus too much attention on the details, you can bungle the performance.

Your brain likes this auto-state and is constantly trying to run on autopilot. It wants to remove mental processes from consciousness, so that work can be completed faster, more effectively, and at a lower metabolic cost.

That's because consciousness is slow, subject to error, and expensive. It involves chemical reactions and changes in synaptic connections that take lots of oxygen and glucose. In other words, it takes more energy. But with practice and mastery, the neural networks involved gradually become smaller and get shifted to areas that operate unconsciously, such as the motor cortex, the cerebellum, and the basal ganglia.

Passive touch is vital as well, and therapeutic massage is part of regular health care in many cultures. Many researchers agree that early skin-to-skin contact affects later intelligence, as well as social and emotional growth. In the laboratory, young rats separated from their mother immediately secrete less growth hormone.

Human babies left untouched for too long, as many children have been in orphanages, don't develop normally in many ways. Studies show, for example, that children who spent the first two years of their lives in an orphanage may later produce much lower levels of oxytocin, the hormone of bonding, love, and trust. In fact, therapies for premature babies that include whole-body massage have been shown to reduce stress hormone levels and are correlated with faster weight gain and growth.