FIVE

Zoophoria

Getting High and Getting Clean

Against the wall of the lab where I perform heart-imaging procedures stands a beige metal box about the size of an office photocopier. It's got a computer screen on the front and, below that, a keyboard. To the right is a little trapdoor that can spit out receipts, like an ATM. Near the keyboard is a dime-sized, glowing red oval—a fingerprint reader. Once you've pressed your thumb and confirmed your identity, you must enter a series of numerical codes before the box will open. And even then only a small sector will be exposed; you can never gain access to all its contents at once.

This mute machine guards the entrance to a kingdom of euphoria. Locked inside are stacked drawers, each containing an array of highly addictive drugs. There are carousels of morphine vials. Pockets of Vicodin pills. Mini-bins stocked with Percoset and Oxycontin. Clear ampoules of fentanyl.

All sit waiting but out of reach in the dark cabinet, unlit and unsparkling, like diamonds on black velvet trays deep in a Cartier safe.

The narcotics contained in this Pyxis MedStation 3500 drug-dispensing apparatus are essential for relaxing patients during medical procedures and for relieving their pain afterward. But the box is there to deter a clever group of highly intelligent and crafty dope fiends: drug-seeking doctors and nurses. Hospitals have learned the hard way that easy on-the-job access can lead to addiction in their personnel. Brilliant colleagues, inventors of life-saving medical devices who rarely fail at anything, would find themselves red-faced, empty-handed, and referred into a career-salvaging "diversion program" if they tried to breach the machine to retrieve an unauthorized Vicodin. The lockbox—and the hospital has dozens of them—protects them from themselves.

That's fine for a white-walled clinical suite where Vicodin tablets don't grow on trees and fentanyl vials don't dangle from vines. But the painkillers and sedatives in that machine are derived from natural opiates that do grow wild—in the *Papaver somniferum* poppy. Imagine the security system you'd need to protect several thousand square miles of poppy fields.

For opium-growing regions, this is a real issue. In Tasmania, a leading producer of medical opium, users sometimes sneak into the fields. Ignoring security cameras, they hop fences and gorge on poppy straw and sap. Dosed on the drug, they flail around in circles, damaging crops. Sometimes they pass out in the fields and have to be carried away in the morning. And there's no way to prosecute these trespassing scofflaws, no rehab to send them to. Because these freeloading opium eaters are wallabies.

I have to admit that the thought of stoned wallabies made me smile. Even the mug shot that accompanied the article in which I read about it was so "wrong": a sweet-faced, gray-brown mini-kangaroo squints before an exotic backdrop of emerald-green poppy stalks. The tableau would be as lovable and cheeky as Peter Rabbit sneaking into Mr. McGregor's garden . . . were it not for the animal's zoned-out eyes and the fact that repeat offenders apparently have a serious drug problem.

Often, what's endearing in animals is detestable in humans. So while we may chuckle at the intoxicated Tasmanian wallabies, we'd be justly horrified if they were Tasmanian children with a heroin habit. And if they were human adults, compulsively eating opium day after day, putting not just their own well-being but that of their families at risk, our horror might turn to disgust.

Indeed, this reaction points to one of the most frustrating, painful, and puzzling aspects of drug addiction. Genetics, vulnerable brain chemistry, and environmental triggers play dominant roles in this illness. But ultimately, on the receiving end of the syringe, joint, or martini glass is a person making the choice, at least in the initial stages of substance use, to shoot up, smoke, or swallow.

To nonaddicts, that choice can be utterly perplexing. Users hemorrhage money, destroy careers, lose homes, and demolish relationships—all in pursuit of a high. Confoundingly, addicts who are parents sometimes make decisions that orphan their children. I've even seen patients stricken off the heart-transplant list—a literal death sentence for them—because they continued to use.

Despite advances in imaging and genetics that clearly characterize addiction as a brain illness, it remains uniquely bewildering. Why *is* it so hard for addicts to "just say no"? Is "can't stop" really just an excuse for "won't stop"? Whether we like it or not, confusion about how we should think about and classify addiction pervades our legal systems, schools, governments—and, frankly, even the field of medicine.* Addicts belong to a set of patients that society, even doctors, judges harshly. So well do addicts know this medical prejudice that they may hide their substance-use histories when they go to a doctor's office or the ER, lest the level of care and compassion decline or disappear entirely. As one doctor I interviewed confided to me, "No one likes an addict."

But nearly everyone likes a cute animal. And so it can be surprising to learn that animals, too—even if they must risk losing their children or, sometimes, their lives—plunder nature's pharmacopoeia. With its vicious war between mind and body, addiction can seem distinctly human. But it turns out that our *Homo sapiens* bodies are not unique in the ways they react to intoxicating substances.

Understanding what drives animals to ingest drugs might help us separate what is inevitable from what is optional about this perplexing disease. The brain chemicals and structures that lead many millions of the world's population to snort, shoot up, or chug are pervasive and powerful. As we'll see, the urge to use has stayed in the gene pool for millions of years and for a paradoxical reason. Although addiction can destroy, its existence may have promoted *survival.*

No one issued Flying While Intoxicated citations to the eighty cedar waxwing birds in Southern California who crashed into a reflective glass wall one February day. Drunk on fermented

*The U.S. medical community's negative attitude toward addiction can be traced back to the 1914 Harrison Narcotics Act, which criminalized opium use and the doctors who prescribed it. This early legislation defined addiction as a crime, as opposed to an illness, and initiated nearly a century of derision and punishment for the addicted.

Brazilian pepper tree berries, they all died of spinal fractures and internal bleeding, some of them still clutching the mind-altering fruit in their beaks. The Bohemian waxwings in Scandinavia that sometimes gorge on naturally alcoholic rowan berries and then fall into the snow and freeze to death have no irreverent nickname—unlike Russia's *podsnezhniki*, or "snowdrops," the human drunks who are discovered, dead, in thawing snowbanks every spring. When a horse named Fat Boy nearly drowned in a neighbor's swimming pool after getting sauced on ethanolized apples in a small English village, he made the evening news but didn't have to apologize to the local fire brigade that pulled him out.

These animal encounters with intoxicants, however surprising and even amusing, were probably accidental. But others are not. Some animals show what seems to be more deliberate and chronic drug-seeking behaviors. Bighorn sheep in the Canadian Rockies are reported to scale cliffs to get their fix of a psychoactive lichen and grind their teeth down to the gums scraping it off rocks. In opium-producing regions of Asia, water buffalo (like Tasmania's wallabies) are known to sample a daily dose of the bitter poppies and then show signs of withdrawal at the end of the flower-growing season. The pen-tailed tree shrew that lives deep in the Segari Melintang rain forest in West Malaysia prefers the fermented nectar of the Bertram palm to all other food. The yeasty brew has an alcohol concentration comparable to that of beer (3.8 percent).

When cattle and horses that graze in the chaparral of the western United States lose their sense of direction, go weak in the legs, withdraw from other animals, or suddenly become violent, ranchers immediately suspect locoweed. Several varieties of this legume grow freely throughout the West; the numerous types can be identified by their blue, yellow, purple, or white blossoms that resemble small sweet peas. If the intoxicated livestock don't die from walking off a cliff or blundering up to a predator, "locoed" animals can eventually starve or suffer severe, irreversible brain damage. Despite these dire consequences, some animals actually prefer the plant over their regular foraging options—and, tellingly, one taste of it makes them more likely to try it again. In addition to misadventure and death, locoweed produces another nasty problem that annoys ranchers. Like the cool-kid druggie in homeroom, one locoweed-eating animal can influence others to start. Handlers must be assiduous about removing locoed animals from the herd so the weed-seeking behavior doesn't spread. And locoweed affects wild animals, too. Elk, deer, and antelope have been seen staring dully and pacing nervously after a few nibbles.

A friendly cocker spaniel in Texas once sent her owners' lives into a tailspin when she turned her attention to toad licking. Lady had been the perfect pet, until one day she got a taste of the hallucinogenic toxin on the skin of a cane toad. Soon she was obsessed with the back door, always begging to get out. She'd beeline to the pond in the backyard and sniff out the toads. Once she found them, she mouthed them so vigorously she sucked the pigment right out of their skin. According to her owners, after these amphibian benders Lady would be "disoriented and withdrawn, soporific and glassy-eyed." Soon the neighbors' dogs weren't allowed to come over to play, for fear that they'd pick up Lady's bad habit. Lady's family dreaded the raised eyebrows when they hosted parties and PTA meetings and so started withdrawing from their social obligations because of the dog's new inclination. As amusingly recounted in a story on National Public Radio, one night the dog's human mistress found herself in the backyard at four in the morning, desperately searching for a toad to give to Lady—literally enabling the addiction so

the dog would finally come inside and the family could get some sleep.*

Giving alcohol to animals—or watching them imbibe on their own—has entertained humans for centuries. In colonial New England, hogs that got tipsy after eating pomace (the pulpy by-product of cider production) may have provided the sounds that gave rise to a term popular in the day: "hog-whimpering drunk."

Aristotle described Greek pigs becoming intoxicated when "they were filled with the husks of pressed grapes." According to the author and alcohol historian Iain Gately, Aristotle also recorded a way to trap wild monkeys by enticing them with alcohol. The technique involved strategically laying out jugs of palm wine for the simians to sample and then simply plucking them up after they got drunk and passed out. Apparently the trick worked just as well in the nineteenth century: Darwin described the same procedure in *The Descent of Man*.†

You can see modern-day drunken monkeys in a BBC video shot on the Caribbean island of St. Kitts. The Curious George look-alikes, with their bright, rounded faces, dart among bikini-clad hotel guests. Like teens at a wedding, they wait until no one's looking, then run off with half-drunk daiquiris and mai tais. What comes next is enhanced by the video's quick-cut editing but mirrors what happens to other animals, too, from squirrels drunk on fermented pumpkins

*In Australia's Northern Territory, vets have also treated dogs who lick cane toads. After getting "a smile on their face and look[ing] like they're going to wander off into the sunset," many dogs go back "to have a second go. . . . They go on to do it again and again," said one vet.

†Darwin also detailed a simian hangover: "On the following morning they were very cross and dismal; they held their aching heads with both hands and wore a most pitiable expression: when beer or wine was offered them, they turned away with disgust, but relished the juice of lemons."

to goats sauced on spoiled plums. The monkeys weave. They stagger. They list. They tip over. They try to stand up. They pass out.*

Of course, comparing drug use in animals and in humans has limitations. The superpotent, rapidly addicting, Ph.D.-designed forms of opioids, marijuana, and cocaine peddled to and used by today's human addicts differ significantly from naturally found plant sources of these psychoactive agents. The alcohol available to human consumers is much more refined and intense than what Mother Nature can make on her own. Furthermore, for scientists it's frustrating that most examples of wild animal substance use and its effects are based on observation and anecdote. Indeed, the few papers that do examine wild animal models of intoxication bemoan this fact and call for more stringent field studies. But controlled conditions do occur more frequently in the lab, and animal drug use and abuse have been widely studied in that setting.

Rats, the most examined animal in substance abuse research, have revealed many crossover aspects of intoxication. Like us, in order to start using a substance, they first must overcome an initial aversion. They lose neuromuscular control when under the influence of certain drugs. They seek out and self-administer doses—sometimes to the point of death—of various drugs, from nicotine and caffeine to cocaine and heroin. Once addicted (researchers sometimes say "habituated"), they may forgo sex, food, and even water to get their drug of choice. Like us, they also use more when they're stressed by pain, overcrowding, or subordinate social position. Some ignore their offspring. (Conversely, drug seeking can decrease in lactating female rats.) But rats, although they've become the most popular models for addiction in mammals, are not the only lab animals to be tempted by inebriating substances.

*You could argue that the St. Kitts monkeys "choose" to steal drinks. But the Internet abounds with examples of animals being given intoxicants on purpose, for human amusement, a practice that is ethically questionable and in some cases frankly abusive.

Bees "dance" more vigorously when they're dosed with cocaine. Immature zebrafish hang out on the side of the tank where they were once given morphine. Methamphetamine juices snail memory and performance the way Ritalin might boost a sophomore's PSAT scores. Spiders on a range of drugs from marijuana to Benzedrine spin webs that are overly intricate or nonfunctional, depending on the drug.

Alcohol can make male fruit flies hypersexual and pursue more same-sex matings, perhaps because the ethanol interferes with their reproductive signaling mechanisms. Even humble *Caenorhabditis elegans*, a tiny worm, moves more slowly when exposed to levels of alcohol similar to the ones that make mammals intoxicated. And the females lay fewer eggs when drunk.

Drug seeking. Raised tolerance. Attempts to get stronger and more frequent doses. Begging or jonesing for a drug. If human beings were the only creatures who showed these classic addiction behaviors, then we could say the disease is uniquely human. But clearly we aren't alone. Across the animal kingdom—not just in mammals with highly developed brains—animals react to drugs in comparable, although of course not totally identical, ways.

That we can see parallel effects from intoxicants, whether the organism is a rodent, a reptile, a firefly, or a firefighter, strongly suggests two things. First, animal and human bodies and brains have evolved designated doorways for some of nature's most potent drugs. Called receptors, these doorways are specialized channels on the outsides of cells that allow chemical molecules to enter. Receptors for opiates, for example, have been found in some of Earth's oldest types of fish as well as in humans, and even in amphibians and insects. Receptors for cannabinoids (the intoxicant found in marijuana) have been identified in birds, amphibians, fish, and mammals as well as mussels, leeches, and sea urchins. This introduces the biological likelihood that opiates and cannabinoids—plus many more psychoactive substances—play key roles in maintaining the health and safety of animals. Indeed, these drug-response systems may have evolved and endured because they actually *increase* an animal's survival chances, or "fitness." More on that in a moment.

These animal examples also challenge anyone who would stigmatize addicts or moralize about the disease. What you might see as a personal failing in your no-account uncle who ruins every Thanksgiving with his drunken antics is not a uniquely human impulse. Uncle Bill is not alone in the animal kingdom in seeking and responding to chemical rewards. Maybe knowing that won't make the annual get-together any more pleasant—or his life any easier. But the fact remains that driving his addiction is a chemical reward system shared by other animals, from worms to primates, which has been in existence for millions of years. True, Uncle Bill can choose between a trip to the liquor store and a trip to his AA meeting. But if a fruit fly had the same option, it, too, might sometimes take a rain check on sour coffee in a Styrofoam cup in favor of a warm, soothing hit of ethanol.

Jaak Panksepp never expected to make his name by tickling rats. He'd planned to be an architect or an electrical engineer or, at one point, inspired by his University of Pittsburgh freshman classmate John Irving, a writer. But an internship at a mental hospital when he was an undergraduate set him

on a different path. Seeing how the patients there required a wide range of treatments, from short-term stays to padded cells, made him want to understand, he says, "how the human mind, especially emotions, could become so imbalanced as to wreak seemingly endless havoc upon one's ability to live a happy life." And so he became a psychologist and, later, a neuroscientist. He now holds a position that gives him a unique vantage point on how the brains of many species work. As the Baily Endowed Chair of Animal Well-Being Science in Washington State University's College of Veterinary Medicine, Panksepp brings his expertise in human emotional systems to a department devoted to the health of nonhuman animals.

Panksepp specializes in what goes on chemically and electrically in the brains of mammals when they play, mate, and fight, or separate and reconnect. And he is convinced that human addictive behaviors stem from ancient parts of our brains that are shared across species.

Rat tickling came in the mid-1990s, after Panksepp had spent several decades studying play urges in rodents. Using an audio device that measured the ultrasonic vocalizations of bats, Panksepp had discovered that rats make two very different sounds when they're playing. Happily engaged rats emit abundant high-pitched chirps at about fifty kilohertz—much higher than we can hear with the naked ear. To Panksepp it sounded happy, a bit like childhood giggling and laughter. He wondered if the animals would make this sound under other circumstances. One morning, he took a rat accustomed to being held by humans, gently rolled it onto its back, and tickled its belly and armpits. Instantly he heard it: fifty kilohertz vocalizing. He tried another rat. Same thing. Rat after rat, eventually over many years and in many different labs, vocalized at fifty kilohertz when they were tickled in this way.

Panksepp and others found that rats make this "happy" sound in several other specific situations. When they're copulating. When they're about to get food. When a lactating mother is reunited with her offspring. But most especially when two friendly rats are playing with each other.

Their other major vocalization registers at a much lower—but still inaudible to human ears—twenty-two kilohertz. Rats make this very different sound when they're alarmed, anticipating a scary situation, when they're fighting, and especially when they've been defeated in a skirmish. Although not a measure of physical pain, it apparently does reflect psychological distress or psychic pain. Baby rats make a version of it when they're abandoned by or isolated from the warmth of their mothers.

Panksepp says that when you run these sounds through a machine that translates them to a frequency we can hear, the high-pitched notes are roughly analogous to human laughter. The low-pitched calls sound like human moaning. He's found rats make the higher, chirping sound when they're anticipating receiving drugs they desire. They utter the lower, moaning sound when deprived of the drugs and experiencing withdrawal.

Panksepp thinks it's no accident that rats emit the same sound when they're in psychic pain and when they're denied a drug they crave. "*Pain*" is a word that came up again and again in my interviews with human addicts and the doctors who treat them. Overwhelmingly, addicts report that they need their substances to "dull the pain," "make the pain go away," or "make the suffering disappear."

Rarely do they mean literal, physical pain (although many addictions, especially to opioids, begin with a prescription for relief of bodily pain). The pain that addicts describe is more of an ineffable internal ache—an emotional throbbing or social tenderness.

Panksepp is not the first to wonder whether other animals experience life in a way that could be called "emotionally" painful. This fundamental question has puzzled thinkers for generations: Do animals feel things the way we do?

Charles Darwin tackled the issue in his 1872 book *The Expression of the Emotions in Man and Animals.* Trying to extend his principles of evolution beyond anatomy, he argued that natural selection could be applied to emotion and behavior. The idea didn't catch on. Darwin was up against two centuries of René Descartes's insistence on a dichotomy between body and soul. For Cartesians, only humans—specifically, men—possessed a soul, which was also the seat of intelligence. Having neither soul nor emotions, animals existed in a purely physical realm. Instead of "I think, therefore I am," Cartesians believed that for animals it was more like "I can't think, therefore I can't feel."

Without the tools to track—or even define—emotions in nonhuman species, the behaviorists of the early twentieth century, like J. B. Watson and B. F. Skinner, were obliged to infer what an animal might be experiencing solely by observing its behavior. Here the differences between animals and humans really did get in the way. The facial muscles of most animals don't react in ways that clearly communicate pain to a human observer. Most animals don't vocalize when they're hurt (at least not at frequencies we can hear)—possibly as a self-protective strategy against attracting predators. Many withdraw instead of seeking help. So different are these responses that they supported the behaviorists' idea that animals don't, or can't, perceive physical pain.

Because they couldn't see what was going on inside the cranium, the behaviorists concluded that animal conduct occurred without awareness. If a creature didn't "know" it was in pain, then it couldn't possibly feel pain. Only human brains (and perhaps some other highly developed simian brains), they believed, functioned at a level of cognition high enough to process the unpleasant sensations of pain. Although the behaviorists were trying to reconcile body and mind, they succeeded only in further splitting them. Animals went from being soulless physical entities to boring biological machines. Remarkably, the notion that human consciousness was a prerequisite for feeling pain persisted into the last part of the twentieth century.*

And in some cases tragically, this belief was applied to another group of beings who can't use words to describe their experiences: human infants. The conventional medical wisdom *until the mid-1980s* held that newborns' neurological networks were immature and thus subfunctional. The prevailing doctrine was that babies "couldn't feel" pain the way older humans do.†

Although this view persisted for an uncomfortably long time, pain management is now a priority in both veterinary medicine and human medicine—including, thank goodness, pediatrics.

Advanced brain imaging and other technologies are emerging that allow us to directly study the brain's emotional systems. The techniques are providing evidence for Darwin's view that emotions, like physical structures, have evolved. They are subject to natural selection based on their fitness benefit to individuals. And the reason is pretty simple. What we call "feelings" or "emotions" are not airy, intangible thought-vapors that emanate, auralike, from our brains. Emotions have a biological basis. They arise from the interplay of nerves and chemicals in the brain. And like other biological traits, they can be retained or rejected by natural selection.

Of course, how an animal experiences the world cannot be fully known to a human being. Some scientists, including Joseph LeDoux, an author and neuroscientist at New York University, object to using the word "emotion" when describing the interior world of animals. LeDoux coined the term "survival circuits" to describe the hardwired brain systems that drive animals to defend themselves and promote their well-being.

Randolph Nesse, a University of Michigan psychiatrist and a leader of the growing field of evolutionary medicine, put it this way in a paper in *Science*: "Emotions . . . shaped by natural selection . . . adjust physiological and behavioral responses to take advantage of opportunities and to cope with threats that have recurred over the course of evolution. . . . Emotions influence behavior and, ultimately, fitness." Nesse's view echoes that of E. O. Wilson, who wrote, controversially at the time, "Love joins hate; aggression, fear; expansiveness, withdrawal . . . in blends designed not to promote the happiness of the individual but to favor the maximum transmission of the controlling genes."

Whether or not we use the word "emotion" to describe it, animals seem to be rewarded with pleasurable, positive sensations for important life-sustaining undertakings. These are

*See the work of Marc Bekoff, Jeffrey Masson, Temple Grandin, and others in the field of animal welfare research for the scientific and compassionate arguments that moved this debate into the twenty-first century.

†In the early 1900s, exploration of whether infants could feel pain led to horrifying experiments in some of the most prominent hospitals in the country. Repetitive pricking of needles into newborns' skin or running their limbs under very cold or hot water to record responses are a few examples. So certain were experts that neonates felt no pain that through the mid-1980s major surgeries on newborn babies were sometimes performed *without anesthesia*. These included major cardiovascular procedures requiring prying open rib cages, puncturing lungs, and tying off major arteries. Though provided with no pharmacologic agents to blunt the pain that cracking ribs or cutting through the sternum might have induced, babies were given powerful agents to induce paralysis—ensuring an immobile (and undoubtedly terrified) patient on whom to operate.

activities such as finding food, approaching mates, escaping to a hideout, outrunning a predator, and interacting with its kin and peers. The joyful pleasure a young human or animal feels upon reuniting with a caretaking parent encourages bonding, for example. Pleasure rewards behaviors that help us survive.

Conversely, depression, fear, grief, and isolation, among other negative sensations, indicate to an animal that it's in a survival-threatening situation. Anxiety makes us careful. Fear keeps us out of harm's way. Imagine the trouble you'd be in if you didn't feel anxious and fearful when encountering a rattlesnake on a hiking trail or a masked gunman at an ATM.

And there is one thing that creates, controls, and shapes these extremely important feelings: tiny hits of addictive chemicals stashed in microscopic pouches (called vesicles) in our brains.

It's as though we're all born with an internal Pyxis 3500 machine that opens specific drawers in response to our unique genetic "thumbprints" and behavioral "codes." Our personal chemical-dispensing apparatus is stocked with tiny capsules of natural narcotics: time-melting opioids, reality-revving dopamine, boundary-softening oxytocin, appetite-enhancing cannabinoids, and many more—some of which haven't even yet been identified.

Gaining access to one's personal, intracranial lockbox may be one of the most potent motivators in animals, including us. But instead of entering a number, an animal must perform a behavior to release the substances. Behaviors are the codes. Do something that evolution has favored, and you get a hit. Don't do it, and you don't get your fix.

Foraging. Stalking prey. Hoarding food. Searching for and finding a desirable mate. Nest building. These are all examples of activities that greatly enhance an animal's chances of survival, or what biologists call fitness. Pleasant sensations of

anticipation and excitement—born in the brain's neural circuitry and chemistry—encourage initiative, risk, curiosity, and discovery in animals.

We humans have a similar suite of life-sustaining activities. We just call them by different names: Shopping. Accumulating wealth. Dating. House hunting. Interior decorating. Cooking.

Indeed, when these activities have been studied in humans and other animals, they are associated with rises in the release of certain chemicals, mostly dopamine and other similar stimulating compounds. Nesse notes that "from slugs to primates," dopamine mediates the search for and consumption of food. Ancient dopaminergic systems have been found in fruit flies and honeybees, suggesting that similar reward experiences may be at play in their behavior. Bees have increased levels of octopamine (their version of dopamine) when they are foraging. Tellingly, their drive to find food appears to come not from personal hunger but rather from a desire for the reward.

Finding safety can also trigger these chemical rewards. Imagine the tremendous relief you felt when the biopsy came back benign, or when the creepy person behind you on the sidewalk turned down another street. That flood of relief is actually a chemical dump within your brain.

Opioid receptors and pathways (the same pathways used by heroin, morphine, and other narcotics) have been found in jawed vertebrates that lived 450 million years ago—well before mammals came on the scene. That means that, from barracudas to wallabies, Seeing Eye dogs to homeless heroin addicts, animals have an ancient and intimate response to opiates.

Researchers working with Panksepp have found that opiates regulate separation and distress calls in dogs, guinea pigs, and domestic chicks. His colleagues have also found that when dogs wag their tails and lick each other's or their owners' faces, that behavior, too, is modulated by opioids. Opioids play a role in early suckling behavior in rats. And the proximity of offspring has been shown to trigger a hit of pleasurable chemical reward in the brains of rat mothers.

Besides opiates and dopamine, many other chemicals work constantly in our bodies and brains. Cannabinoids, oxytocin, and glutamate, among others, create a complex system of simultaneous positive and negative sensations. This cacophonous chemical conversation (what Panksepp calls the "neurochemical jungle of the human brain") is the basis of emotion—emotion that creates motivation and drives behavior.

Human feelings powerful enough to launch a thousand ships, build the Taj Mahal, or ignite pleasurable melancholy at Mimì and Rodolfo's parting in act IV of *La Bohème* have emerged from "survival circuits" (to use LeDoux's term) that we share with other animals. In other words, our emotions exist as they do today because their building blocks helped our animal ancestors survive and reproduce.

And this is precisely why drugs can so brutally derail lives. Ingesting, inhaling, or injecting intoxicants—in doses and concentrations far higher than our bodies were designed to reward us with—overwhelms a system carefully calibrated over millions of years. These substances hijack or ignore altogether our internal Pyxis 3500 mechanisms, removing the need for the animal to input a code, in this case, a behavior, before receiving a chemical dose. Nesse writes, "Drugs of abuse create a signal in the brain that indicates, falsely, the arrival of a huge fitness benefit." In other words, pharmaceuticals and street drugs offer a faux fast track to reward—a shortcut to the sensation that we're doing something beneficial.

This is a critical nuance for understanding addiction. With access to external substances, the animal isn't required to

"work" first—to forage, flee, socialize, or protect. Instead, he goes straight to reward. The chemicals provide a false signal to the animal's brain that his fitness has improved, although it has not actually changed at all.

Why spend an afternoon in the dangerous and time-consuming task of foraging for a hundred acorns (or bringing in a hundred new clients) when you could achieve a far more intense reward state with one snort of cocaine? Or, to be less extreme, why go through a half hour of awkward small talk at an office party when a martini or two can trick your brain into thinking you've already done some social bonding?

The excessive, seemingly inexplicable behavior of those addicts who forgo the important, life-preserving chores of daily life becomes clearer when viewed this way. Drugs tell users' brains that they've just done an important, fitness-enhancing task—even though they haven't. Their brain receptors don't know whether that opioid molecule came from a hash pipe or from having a conversation with a trusted friend. They don't know whether the dopamine molecule came from a crack spoon or from the rush of getting five phone numbers at a bar or finishing a tough assignment on deadline. The rewarding feelings signal that they *have* gained resources, found mates, and elevated their social status. The awful irony is that these substances so potently imitate these feelings that their users may cease doing the real work of life. Their brains are telling them they already did.

We can condemn addicts and their poor self-control as much as we wish. Ultimately, however, the powerful urge to use and reuse is provided courtesy of honed and inherited brain biology that evolved to maximize an individual's shot at survival. Seen this way, we're all born addicts. That's what "motivates" creatures to do important things.

And that's why Pyxis 3500 machines stand sentry throughout my hospital. They restrict access. As David Sack, the CEO of the drug-rehab program Promises, told me, "You can't become addicted to a drug you don't have access to."

Putting synthetic and plant-derived drugs into our bodies circumvents the personal lockboxes in our brains. But the stashes of natural drugs are still in there. And, as we've seen, the codes to releasing them are elemental behaviors. This reveals an interesting possibility. Even if an animal doesn't have access to external sources of drugs, there may be another way to hack into the internal stores: by punching in code after code . . . of unnecessary but reward-producing behaviors. Maybe addiction can be activated by things we *do*, almost as effectively as the substances we *take*.

As a cardiologist, I mostly encounter substance addictions as they relate to a patient's heart health. But in the late 1980s, I was training to become a psychiatrist and began treating a patient for depression and anxiety. He was handsome and a meticulous dresser. At our weekly sessions he was unfailingly polite and charming, which I interpreted as an openness to the therapeutic process.

At our first meeting I learned the main reason for his anxiety: he was cheating on his wife. Soon I learned that he was cheating on the mistress, too—with her best friend. While maintaining regular relationships with all three women, he was also having frequent one-night stands. As he described the stress and anxiety of juggling each week's sexual appointments, he explained his utter inability to stop doing it. I could sense his excitement about what he was doing—the danger of sleeping around, of hiding it from his family, the thrill of getting away with it. As his psychiatrist, I thought it all just sounded dangerous. He was risking his marriage, his relationship with his child, and his career (the mistress was a subordinate at work). After several months, he quit coming to therapy; he continued his risky behavior and eventually lost his job and his wife.

At that time, psychiatry had a primary approach to treatment: psychodynamic psychotherapy. The basic premise of this method is that our adult selves are formed in large part by our childhood experiences. The entire time I was treating this patient, my professional assumption was that his inability to have a stable sexual relationship with his wife stemmed primarily and perhaps exclusively from attachment issues connected to early childhood traumas. My supervisors confirmed the diagnosis and supported my treatment plan, so I spent many sessions probing his early years, looking for reasons to explain his promiscuous and risky behavior.

Thinking about it twenty-five years later, I realize that my understanding of his reckless sexual behavior was incomplete. The field has now advanced to recognize that early experiences do actively shape genes and the brain, laying the groundwork for susceptibility to addiction later in life. But what I had missed then was the fact that my patient was addicted to the neurochemicals provided to him through his sexual pattern: the spike of thrill-danger-novelty dopamine and perhaps also the feel-good payoff of sex itself. Nowadays he would probably be referred to a sex-addiction program. But that never occurred to me then. The brain-disease theory of alcoholism was only just emerging at the time. That behaviors like sex or shopping or overeating could be put in the same category as a substance addiction wasn't part of the medical vocabulary. Even today, addictions to the things a person does, instead of the substances he takes, are not completely understood. The debate over whether or not they're "real" addictions divides doctors within and outside the addiction field.

I have to confess that, until recently, I, too, was extremely skeptical. You're "addicted" to buying shoes. Really? Can't stop eating candy corn? Feel physical withdrawal pains when separated from your pornography or video game? Uh-huh. The model of substance addiction as a brain disease made sense to me, but until recently, applying the term "addiction" to behaviors seemed sloppy—a "no-fault," feel-good cop-out, a lazy, twentieth-century inability to break bad habits. It's not me, Your Honor. It's my *disease.*

However, spending the past several years trying to understand my human patients through a veterinary perspective has led me to a different view and a surprising hypothesis: substance addiction and behavioral addiction *are* linked. And their common language is in the shared neurocircuitry that rewards fitness-promoting behaviors.

When you look at the most-often-treated behavioral addictions from an evolutionary perspective, they are exceedingly fitness enhancing. Sex. Binge eating. Exercise. Working. It's hard to imagine that "in nature" or when tested by natural selection, those behaviors would produce many downsides, even when taken to extremes.

Gambling and compulsive shopping—although they're human variants—work on the same neural pathways as two extremely beneficial animal activities: foraging and hunting. These involve focused and concerted effort and expenditure of energy with a specific goal of gaining resources, typically food but sometimes shelter or nesting materials. Neurochemical rewards reinforce this positive behavior in animals. As Panksepp puts it, "Every mammal has a system in the brain to look for resources."

By following the neurobiology, we can see that gambling is foraging taken to an extreme, where food has been replaced by a financial payoff. Although food and money are certainly rewards in themselves, the true payoff—the addictive part—is the neurochemical mix associated with seeking and risk-taking. Behavior produces a reward that creates dependence, just as external chemicals do.

Connecting brain-rewarding behaviors to increased survival also allowed me to rethink technological "addictions" like online gaming, texting, and social networking. The executive who jokes that she's addicted to her digital device probably doesn't think she needs a twelve-step program to quell her itchy thumbs. But many of us find the urge to check that little screen irresistible—even during an important meeting or when we're behind the wheel. Our smartphones, Facebook pages, and photo-sharing feeds profoundly combine the things that matter most to animals competing to survive: a social network, access to mates, and information about predatory threats. But like drugs, these devices provide the hit without the work. We get a dopamine squirt without seeking a tangible resource. We may get a lovely opiate flood of feeling part of a herd, without the inconvenience of actual herd mates.

Veterinarians I interviewed were reluctant to apply the word "addiction" to animals. As they pointed out, pets generally do not, on their own accord, get hooked on drugs or alcohol.

But there is one thing they seem to crave: reward. It can be as simple as a pat on the head and a murmured "Good boy." A morsel of frozen liver or mouthful of oats. A tummy rub.

Do a behavior, get a reward. Rewards in the form of food or praise have long been used by animal trainers to produce certain predictable behaviors. As Gary Wilson, a professor and trainer at the Exotic Animal Training and Management Program at Moorpark College in California, told me, external treats in the form of food and congratulatory sounds are in effect bridges to the animal's brain. They pair the feel-good neurochemicals produced by anticipation of nutrients with desired behaviors.*

Seen this way, the unrecognized goal of some animal training may be to create a kind of behavioral addiction, as animals learn to associate the pleasure of reward with new behaviors. David J. Linden, a professor of neuroscience at Johns Hopkins University and author of *The Compass of Pleasure,* connects this pleasure of learning and training in humans to the neurobiology of other addictions.

He notes that learning, along with behaviors such as gambling, shopping, and sex, "evoke neural signals that converge on a small group of interconnected brain areas called the medial forebrain pleasure circuit." Successful dog training creates what we could call a learning addiction, driven by pleasure circuits. Linden notes that these circuits "can also be co-opted by artificial activators like cocaine or nicotine or heroin or alcohol."

Human medicine has only recently started to regard chemical dependency as a physical and chronic illness requiring ongoing (perhaps lifelong) care, rather than a condition (like an infection) that we can treat, cure, and quickly put behind

*A technique called clicker training pairs a metallic *tick-tock!* with a food treat every time the animal performs a desired behavior. Eventually the animal comes to associate the sound of the clicker with the feel-good neurochemical rewards of the food. When the treat is discontinued, the animal will continue doing the behavior, because its brain has been conditioned to anticipate reward and actually releases dopamine to the sound alone. A human version of clicker training is increasingly being used to train gymnasts and other precision-sport athletes and to reinforce positive behaviors in classrooms and special education groups. Called TAG teaching (teaching with acoustical guidance), to avoid the animal overtones of clicker training, it works on the same principles of associating behavior and reward. "Neurologically, clicker training activates the dopamine centers in the amygdala," Wilson said. The clicker "becomes a marker, the internal reinforcement of the dopamine system."

us. Understanding the evolutionary origins of addiction can improve how we care for this disease. It may help us be more compassionate to users and addicts and can help us understand that substance use in animals of all kinds is an attempt to get a little more of what we spend our lives seeking.

If you exposed a hundred people to a carcinogen, they wouldn't all get cancer. It's the same thing with drugs. Expose a hundred animals to a chemical molecule, and they're not all going to get addicted to it. Not all cocker spaniels become toad lickers. Not every monkey steals cocktails or wants to drink one every day. Only some wallabies jump the fence to eat opium poppy sap.

The biological term for these differences within populations is "heterogeneity." What heterogeneity means in terms of addiction is that each person, each animal, has a slightly different response to each chemical. An abundance of research backs this up: there's a strong genetic basis for susceptibility to addiction. Recently, families with histories of substance abuse have started educating their children about their particular inborn vulnerabilities. But environmental factors, from the climate in our mother's uterus to the food we eat and the pathogens we encounter, also play key roles in who becomes an addict. It's becoming clearer to scientists that what you eat, where you live, the work you do, and even how you were parented can change how your genes are expressed. The emerging field of epigenetics considers what happens to our personal genetic code when it meets the real world. It explains why nature/nurture is not a divide but, rather, an endless feedback loop.

Genes give an individual high school sophomore a predetermined potential to become addicted to alcohol or drugs.

But when and how he encounters those chemical molecules will create the epigenetic effect. For one teen, a Friday night, postgame first exposure to, say, marijuana can activate neural responses that will make cannabis a gateway drug for future use. For that teen's best friend, that first toke might be just another moment in an ordinary get-together at a friend's house, a teenage dalliance that he'll laugh about in a self-deprecating way later in life. Same party; same drug; two different life outcomes. If either teen had encountered that substance as an older adult or as a younger child, again, the outcome might be different.

Like many humans, some nonhuman animals can enjoy the pleasures of substances without apparent adverse effects. The Malaysian pen-tailed tree shrew imbibes copious volumes of fermented palm nectar without observably diminished reflexes or impaired coordination. Zenyatta, a multilaureled and now retired racehorse, traditionally guzzled a Guinness after every race and went on to win the next one.

Heterogeneity stocks every animal's lockbox with different supplies of drugs. Epigenetics calibrates the codes. Those codes are set and changed throughout our lives. But an important period of code setting occurs in childhood—infancy through adolescence. Human and animal data both suggest that the younger the animal is at first exposure to an external drug, the more likely it is to become addicted and responsive to that drug in the future.

This is a very important point. Our behavioral relationship with potentially addictive neurochemicals begins from the minute we enter the world (and quite possibly before). Suckling has been found to produce an internal opioid hit, a chemical reward for this basic, life-sustaining task. Indeed, Panksepp and others believe the suite of "attachment" neurochemicals are many and powerful, and that some of the codes for releasing them are set in earliest infancy. Various

elements of a child's young life—including physical health, "wiring," but also, significantly, parenting—influence how their personal lockbox will respond to increasingly challenging environments.

Like younger children, adolescents, too, have highly malleable brains. Pouring external sources of powerful reward chemicals into the brain at precisely the point it's trying to calibrate the system can have lifelong effects. It can influence tolerance levels and response sensitivity. Across species, a zoobiquitous look at addiction suggests that delaying the age of first use could have powerful protective effects. Extensive study of the effect of alcohol exposure on adolescent rodents and nonhuman primates has shown alcohol's long-term effects on the adult brains of these young mammalian imbibers. Along with impaired cognitive function, early use in these animals may increase their risk of alcohol addiction later in life.

In the United States, we've tried prohibition and "just say no" campaigns. We've set the drinking age at twenty-one and the illegal drug use age at never. None of these interventions has completely stopped teenagers from going after what they want.

But the evidence suggests it's wise for parents to try harder to delay their children's first exposures and, perhaps, to teach them natural ways of achieving those chemical rewards: through exercise, physical and mental competition, or "safe" risk-taking, such as performing.

In some individuals, whether cedar waxwings or late-night partiers, intoxication can lead to tragedy. In humans it's linked to higher rates of motor vehicle accidents, suicides, homicides, and accidental injury. In the wild, intoxicated animals, too, are at greater risk. They can more easily be picked off by predators, miss out on opportunities to mate, or fly into walls.

But nature provides its own abstinence program. Access to plants, berries, and other food sources in the wild vary with seasonality, weather, competition, and many other factors, including predation. And these variations automatically reduce access to substances that might otherwise lead to addiction. It's like a wild version of having one's coke dealer leave New York for Miami between November and March. This lack of ongoing access to substances, coupled with the increased risk of death to an intoxicated animal in the jungle, desert, or savannah, makes the possibility of humanlike addiction in the wild unlikely.

Recovery from addiction may involve restoring the integrity of the lockbox we're born with. Substance abusers can learn healthy behaviors that provide the same (albeit less potent) good feelings they used to seek from a bottle, a pill, or a needle. In fact, that may be what makes some rehab programs so effective for certain addicts. If you look at the behaviors these programs encourage—socializing, companionship, anticipation, planning, and purpose—they're all part of an ancient, calibrated system that doles out internal neurochemical rewards.

Ironically, one way to fight addiction may be with addiction, replacing a dependence on heavily refined drugs with the hard work that makes life worth living. The endorphin release of physical work and exercise. The adrenaline rush of healthy competition and risk in games or business. The exquisite anticipation of planning, serving, and at last eating a great meal. The opioid rush of being part of an actual flesh-and-blood social network. Or the warming satisfaction of helping others. The term "natural high" may sound as dated as a John Denver song, but it's not a metaphor. It's the ancient reward that motivates and sustains all animals, including us.