I hope that this excerpt gets you interested in this book. It helps to understand the neuroscience of addiction. Chapter 2 is about drug addiction, Chapter 3 about food, Chapter 4 - sex, Chapter 5 – gambling, Chapter 6 – Virtuous Pleasures (and a little pain) is about addiction to exercise, healthy and moral behavior as they affect the pleasure circuit.

**Source**: Linden, David J. (2011-04-14). The Compass of Pleasure: How Our Brains Make Fatty Foods, Orgasm, Exercise, Marijuana, Generosity, Vodka, Learning, and Gambling Feel So Good (Kindle Locations 148-209). Penguin Group. Kindle Edition.

**CHAPTER ONE: MASHING THE PLEASURE BUTTON**

Montréal, 1953. Fortunately, Peter Milner and James Olds didn’t have perfect aim. While postdoctoral fellows at McGill University, under the direction of the renowned psychologist Donald Hebb, Olds and Milner were conducting experiments that involved implanting electrodes deep in the brains of rats. The implanting surgery, conducted while the animals were anesthetized, involved cementing a pair of electrodes half a millimeter apart to their skulls. After a few days of recovery from the surgery, the rats were fine. Long, flexible wires were then attached to the electrodes at one end and to an electrical stimulator at the other, to allow for activation of the specific brain region where the tips of the electrodes had come to rest.

One fall day Olds and Milner were testing a rat in which they had attempted to target a structure called the midbrain reticular system. Located at the midline of the brain, at the point where its base tapers to form the brain stem, this region had previously been shown by another lab to control sleeping and waking cycles. In this particular surgery, however, the electrodes had gone astray and come to rest still at the midline, but at a somewhat more forward position in the brain, in a region called the septum.

The rat in question was placed in a large rectangular box with corners labeled A, B, C, and D and was allowed to explore freely. Whenever the rat went to corner A, Olds pressed a button that delivered a brief, mild electrical shock through the implanted electrodes. (Unlike the rest of the body, brain tissue does not have the receptors that allow for pain detection, so such shocks don’t produce a painful sensation within the skull.) After a few jolts, the rat kept returning to corner A and finally fell asleep in a different location. The next day, however, the rat seemed even more interested in corner A than the others. Olds and Milner were excited: They believed that they had found a brain region that, when stimulated, provoked general curiosity. However, further experiments on this same rat soon proved that not to be the case. By this time, the rat had acquired a habit of returning often to corner A to be stimulated. The researchers then tried to coax the rat away from corner A by administering a shock every time the rat made a step in the direction of corner B. This worked all too well—within five minutes, the rat relocated to corner B. Further investigation revealed that this rat could be directed to any location within the box with well-timed brain shocks—brief ones to guide the rat to the target location and then more sustained ones once it arrived there.

Many years earlier the psychologist B. F. Skinner had devised the operant conditioning chamber, or “Skinner box,” in which a lever press by an animal triggered either a reinforcing stimulus, such as delivery of food or water, or a punishing stimulus, such as a painful foot shock. Rats placed in a Skinner box will rapidly learn to press a lever for a food reward and to avoid pressing a lever that delivers the shock. Olds and Milner now modified the chamber so that a lever press would deliver direct brain stimulation through the implanted electrodes. What resulted was perhaps the most dramatic experiment in the history of behavioral neuroscience: Rats would press the lever as many as seven thousand times per hour to stimulate their brains. They weren’t stimulating a “curiosity center” at all—this was a pleasure center, a reward circuit, the activation of which was much more powerful than any natural stimulus. A series of subsequent experiments revealed that rats preferred pleasure circuit stimulation to food (even when they were hungry) and water (even when they were thirsty). Self-stimulating male rats would ignore a female in heat and would repeatedly cross foot-shock-delivering floor grids to reach the lever. Female rats would abandon their newborn nursing pups to continually press the lever. Some rats would self-stimulate as often as two thousand times per hour for twenty-four hours, to the exclusion of all other activities. They had to be unhooked from the apparatus to prevent death by self-starvation. Pressing that lever became their entire world.

Further work was done to systematically vary the placement of the electrode tips and thereby map the reward circuits of the brain. These experiments revealed that stimulation of the outer (and upper) surface of the brain, the neocortex, where sensory and motor processing mostly reside, produced no reward—the rats continued to press the lever at chance levels. However, deep in the brain, there was not just a single discrete location underlying reward. Rather, a group of interconnected structures, all located near the base of the brain and distributed along the midline, constituted the reward circuit. These included the ventral tegmental area, the nucleus accumbens, the medial forebrain bundle, and the septum, as well as portions of the thalamus and hypothalamus (more on these various regions later). Not all these areas were equally rewarding. Stimulation in some parts of this medial forebrain pleasure circuit could support self-stimulation rates of seven thousand lever presses per hour, while others elicited only two hundred per hour.

It’s hard to imagine now, but in 1953 the notion that motivational or pleasure/reward mechanisms could be localized to certain brain regions or circuits was highly controversial. The dominant theory, which had held sway for many years, was that excitation of the brain was always punishing and that learning and the development of behavior could be explained solely by punishment avoidance. This was called the drive-reduction hypothesis. In Olds’s characterization of the theory, “pain supplies the push and learning based on pain reduction supplies the direction.” There was no need for reward or pleasure: This model was all stick, no carrot. The pioneering experiments of Olds and Milner clearly demolished the punishment-only model in favor of a more comprehensive, hedonistic view that “behavior is pulled forward by pleasure as well as pushed forward by pain.”1

I know what you’re thinking: What does it feel like for a human to have his or her medial forebrain reward circuitry stimulated with an electrode? Does it produce a crazy pleasure that’s better than food or sex or sleep or even Seinfeld reruns? We do in fact know the answer to that question. The bad news is that that answer comes, in part, from some deeply unethical experiments.

Dr. Robert Galbraith Heath was the founder and chairman of the Department of Psychiatry and Neurology at Tulane University in New Orleans. He served from 1949 to 1980, and during that time the major focus of his work involved stimulation of the brains of institutionalized psychiatric patients, often African Americans, using surgically implanted electrodes. His main goal—to use brain stimulation to relieve the symptoms of psychiatric disorders such as major depression and schizophrenia—was laudable. However, he did not obtain proper informed consent from his patients and took decisions in experimental design that would never be approved by modern human-subjects ethical review boards.