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Excerpt
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CHAPTER ONE

The Power of Physics Envy

"As I have told you, I was sent to show
the way his soul must take for its salvation;
and there is none but this by which I go.

I have shown him the guilty people. Now I mean
to lead him through the spirits in your keeping,
to show him those whose suffering makes them clean."

-*Canto I*, The Purgatorio

How's this for a battlefield cure?

> Obtain a half pound of grease from a wild boar and a tame one and the same quantity of bear fat. Gather a goodly portion of earthworms, place everything into a pot, seal it and cook lightly. Take a quantity of moss which has grown from the skull of a hanged man and press it into the shape of four walnuts. Add a little wine and mix all. You have created Unguentum Armarium, the ointment of war.

Sound tasty? This quote is from a medieval text on the preferred treatment of battlefield wounds that are caused by weapons of war, such as swords. In medieval days, it could be very difficult to tell which was worse, the wound or cures such as these. The placement of such an ointment directly on a laceration probably would have created a life-threatening situation even if none had existed! Surprisingly, the reality is that this rather eclectic mixture of elements probably did little harm to a medieval warrior. The reason comes from the further directions in the text: the ointment was not to be placed onto the wound but rather onto the weapon that made the wound. When that occurred, the patient was guaranteed to experience the wondrous healing powers of the *Unguentum Armarium.*

From a modern-day perspective, the last two paragraphs seem like a medical nightmare; there is so much wrong physiologically that it is difficult to know where to begin labeling the errors. The most obvious sin here is oversimplification, based on inadequate data, in turn based on faulty assumptions. There might be a certain logic to thinking that the wound-causing weapon might also contain the source of healing (the idea is *very* much in vogue in modern psychiatry: the therapist might tell you to confront a person who is the source of all your troubles in order to initiate healing, for example). But the ointment of war doesn't necessarily make biological sense to groups of wounded cells, inflammatory responses or immune systems. To correctly treat a laceration, one would need a background in the physiology of human wound response, and a working knowledge of germ theory. As of this writing, the majority of these data aren't even one hundred years old.

In this introduction, I want to explore this idea that a solid background is necessary to keep us from oversimplifying important biological processes. I don't bring this up to satirize old medieval texts, but to address some current misperceptions about genes and human behaviors. I don't know how many times I've thrown down a newspaper after reading things like, "scientists have isolated the genes responsible for adultery" or an article describing the, "DNA behind the desire to eat chocolate", or that there are actually chromosomes responsible for the predilection to vote Republican. The attitude that, "if you have the gene, then you have the tendency" occurs with such frequency that many of us who wear lab coats have quit reading the popular press. From a researcher's perspective, most of these headlines carry no more scientific integrity than an ointment made from a hanged man's skull-garden.

The problem is a dearth of background, and the temptation to simplify because of the honest desire both to understand and to avoid complicated issues. I want to talk about both of these desires in this chapter, and, to accomplish this, the chapter is divided into three parts. We will first consider how to scientifically study aspects of human behavior, some pitfalls, some unproductive assumptions, even a few controversies. Then we will proceed to the biology itself, describing some of the brain, neural and genetic interactions necessary to understand the data described in the rest of this book. Finally, we will talk a bit more about Dante and his *Divine Comedy*, contrasting how he organized human behavior with what modern biologists observe.

Let's begin our discussion not with biology but with a far older scientific discipline, physics, and the elegant math that undergirds it. We start with physics and not biology for reasons of simplicity. Physics of any kind has powerful appeal. Certain branches of the discipline possess some very straightforward explanations of our natural world, taming complex phenomena into predictive formulae, even postulating the existence of one grand physical truth that goes by the telling name The Unified Field Theorem.

Physics derives some of its attraction from the fact that human beings enjoy straightforward explanations. The reductionist tendencies of physics have produced some extremely impressive results, and for many centuries people have admired the accomplishments of the discipline. But that just shows the power of the forthright explanation. Even for the medieval soldier, obtaining the recipe for the ointment of war might have initially been popular because it was so much like branches of physics, linear and predictable. Do this, do that, and you get the results you want. A lot of biologists call such simplicity "physics envy".

Now just why do we biologists use the word, "envy"? – because biological scientists do not live in the cut-and-dried world of the physicist. And we'd *love* to, creating a professional jealousy, and also creating the term. The problem with elementary explanations applied to biological systems is that, to put it mildly, the explanations are fraught with variables.

Biological systems are not simple, even if you are looking at seemingly uncomplicated organisms like those uncooked earthworms. The armies that used *Unguentum Armarium* soon found that they did not get the results they wanted, and had to cook up some other crazy explanations. It was another six hundred years before a useful treatment for battle wounds became available.

A good lesson learned

Six hundred *years*? That's the delay between this recipe and the revelation that germs cause disease. Why did it take so long? The answer is that it took a long time for medical types to learn from our physicist colleagues. In order to make the same kinds of advances, those conducting biological research had to apply an intellectual rigor known almost solely to Isaac Newton and his friends. In the case of medicine, this meant starting over. Though a mortally wounded medieval warrior might not have been interested in how the metal, dirt and human flesh interacted, the great contribution of twentieth century science to medicine was to show that this interaction does matter. Biological systems were found to obey the laws of physics and chemistry. If you wanted to cure something, you would have to understand how those rules were played out in the systems under study. It's astonishing to see how recent this idea really is. It wasn't until the last fifty years of the twentieth century that you stood a better chance of getting better if you went to the doctor than if you stayed at home and just waited out what ailed you!

There is some understanding to be had in our six-hundred-year wait. When we began looking under the hood of biological organisms, we were instantly amazed and profoundly discouraged. Biological systems possess some of the most complicated, exquisitely designed mechanisms ever encountered by science. Just the source code – the genetic information inside human cells – has such a volume of detail that if you lined up all the DNA inside a single human being, you would create an unbroken queue stretching to the Sun and back one hundred and fifty times. There are around one hundred thousand genes inside just one of those cells, and we have isolated only a tiny percentage of them. In other words, there is a lot of stuff inside us which we don't know very much about. And that previous sentence describes the *present* condition, not the comparatively meager knowledge of past decades.

When you begin to talk about molecules and behavior, you pile such a level of complexity upon this already staggeringly difficult genetic reality that the task almost defies comprehension. That's because you are necessarily forced to work with the most convoluted and talented groups of cells in the known universe, the human brain. And by examining behavior, you are looking at one of the brain's most sophisticated functions. Consider just the numbers: there may be as many as a million million cells in the human brain, packed so tightly that a pea-sized chunk of tissue contains almost two miles of them. We call these cells neurons, and figuring out how the brain uses them would seem an impossible task even if they were just lined up end to end like snippets of wires, each associated by a single connection in a nice physics-kind of way. Unfortunately, the design specs are not that simple. A single neuron can have connections to literally thousands of other cells. Moreover, we are finding that these connections are exquisitely organized. Most form associations with immediately neighboring cells, creating local area networks of neurons (with infrequent associations with more distant areas farther away). The record is a cell type known as the Purkinje cell, located deep within the brain, possessing more than one hundred thousand different connections to various local groups.

To make matters worse, we are also finding that there are many different kinds of associations, some turning certain specific connections on, others turning things off. We are also learning that individual neurons can read these on/off patterns in aggregate ways, making intelligent decisions based on the shifting patterns being detected. This means that a single neuron acts less like a wire and more like a computer. If you can imagine one million million computers all connected in parallel, capable of talking to each other at around nine hundred meters or three thousand feet per second, you have an idea of the enormous firepower that lies just below our scalps. And when you understand that we have never isolated even one tiny active human neural circuit in a lab dish, let alone delineated how huge battalions of neurons work together, you have an idea of just how ignorant we are.

That's an important point, for even if we knew precisely how every gene worked in every cell of the brain, we still wouldn't know about the connections. Since in the brain connections are everything, we don't even know much about *obvious* behaviors, like fight-or-flight responses, let alone subtle ones, such as pair-bonding and divorce. The state of the research effort can be put this way: we have a working knowledge of a tiny fraction of human genes, and we have an even smaller working knowledge of the computing power embedded in the neurons that use these genes. No wonder biologists have physics envy!

So what does this have to do with behavior?

Given this paucity of knowledge, you may at this point be wondering what the rest of this book is going to be about. That's a fair question, but I bring up this idea of complexity to underscore a single point about human behavior, and to tell you why I get so mad at the headlines. Let me give an example, which takes the form a transcript of a radio interview I did awhile back. The subject was the impact of genetic engineering, involving a half-hour interview with call-ins. A woman's voice came on the line:

WIFE: My husband said that its okay for him to see other women. He read there is a gene that makes men want to . . .

RADIO HOST: To have their cake and eat it too?

WIFE: No. He just said that it was natural for guys to go out with other women, 'cos there's something about spreading their genes, making babies, or whatever.

HUSBAND (comes on the line!): That's not what I said! There's this article in the newspaper and all it said was that males have this natural urge to be with lots of women. It sort of said it was in our genes. Isn't that right, Dr Medina? Isn't there some kind of natural gene for this kind of thing?

ME: No. There is no gene for promiscuity. Some people are trying to explain why women have menopause and men do not, but that's not a . . .

WIFE: See! It's not your genes, its just because you don't have any . . .

HUSBAND: Have any what?

ME: Oh dear.

RADIO HOST: I think we need to take another caller.

Do you see what I mean? This interview shows how easy it is for even well-meaning articles to be misinterpreted. When we first began to understand that gene activation could contribute deeply to human behavior, a lot of people began to go overboard with the nature side of the famous nature/nurture debates. Every emotional outburst, every violent behavior, every sexual peccadillo became explainable by our DNA, and the perception of behaviors and motivations began their slow slide into oversimplification. With this sad ignorance came all the inaccurate baggage of an *Unguentum Armarium*; and great predictions were made about our future ability to design our moods and understand why people eat chocolate, as well as the imminent extinction of mental illness. Because we knew a few things, we projected that we knew many things, and the dangerous assumption that everything could be explained biologically came into vogue. The enthusiasm completely ignores how little we know about the physical side of the products of our brains, and many have begun overinterpreting even the smallest stride in the field.

There is another reason why I wish to bring up this complexity. Since so much of the biology of human behavior is not understood, there is great controversy concerning exactly what it is. This controversy started with the people in the position to know best, the professionals who study behavior for a living. Here's one example.

All but one of The Seven Deadly Sins mentioned in this book have emotional content and, indeed, much of this book's pages try to explain the involvement of genes in emotion. But that's not an easy task from the start; there are many experts out there who completely disagree on the nature of emotion. There is even one professional who believes emotions don't exist. Consider the following quotes, the first from Dr Joseph LeDoux, author of the insightful book *The Emotional Brain*, and a recognized expert in the neurobiology of human emotion.

> I view emotions as biological functions of the nervous system. I believe that figuring out how emotions are represented in the brain can help us understand them. This approach contrasts sharply with the more typical one in which emotions are studied as psychological states, independent of the underlying brain mechanisms
>
> *(LeDoux, 1996)*

He then goes on to state what he thinks an emotion is.

> My idea about the nature of conscious emotional experiences, emotional feelings, is incredibly simple: it is that a subjective emotional experience, like the feeling of being afraid, results when we become consciously aware that an emotion system of the brain, like the defense system, is active.
>
> *(LeDoux, 1996)*

Implicit in these quotes is the idea that emotions exist in such a form that they can be studied scientifically; that there are actual brain mechanisms for emotions just waiting for the keen experimental insights of researchers to uncover. Nothing wrong with that, except that this enthusiasm is not universally shared. Consider this quote, taken from another academic professional, Paul E. Griffiths, author of an equally fine book *What Emotions Really Are*.

> (The general concept of emotion) needs to be replaced by at least two more specific concepts. This does not necessarily imply that the emotion concept will disappear from every day thought . . . Concepts like "spirituality" have no role in psychology but play an important role in other human social activities. But as far as understanding ourselves is concerned, the concept of emotion, like the concept of spirituality, can only be a hindrance.
>
> *(Griffiths, 1997)*

Can you sense the conceptual discrepancy between these two important individuals? Is there enough evidence that emotions exist for them to be studied by a neurologist? Alternatively, are they just an out-dated idea so badly in need of a conceptual tune-up that the notion should be erased before we go trotting off to the lab bench? Further reading of both men's ideas shows that they agree on many important points. However, they disagree on so many other issues that one is left either scratching one's head or nodding in agreement with the fact that they disagree for the precise reason that we must be cautious: we know so little about any part of brains and behaviors that we are still asking basic, what-is-it-really, type questions. Without a responsible framework, there's no way to ascribe individual genes to individual behaviors and hope to relay an important truth. And that, precisely, is the point I am trying to make.

There is another reason to be cautious. There is an area of the brain called the cortex, a skin-like covering of our brains where most of our sophisticated "human" functions are processed. The cortex helps us in our ability to generate and process language, and allows us to think about how to manipulate our environment using our useful opposable thumb. It also gave us a remarkable characteristic: it enabled us to create a social organization that could manipulate its environment. This organization was so unique to individual people groups that the concept of culture was born. The ability to use our hands with our talented brains gave us physical art, types of houses, specific religions, and discrete behavioral protocols. These protocols became so powerful that their mores and customs could reconfigure the very organ that started them (we will talk more about this phenomenon, often called neural plasticity, in the last chapter). In other words, culture plays an enormous role in the shaping, even in the origins, of our behaviors. Moreover, except in the broadest sense, there is nothing *genetic* about it.

A complete explanation of emotion and behavior cannot omit this enormously important social input. Since this book focuses on biology, we will not be addressing this critical role for culture, and hence our discussion is imperfect. I mention it here, however, simply because it adds another layer of complexity to an already convoluted task. Also, we need to understand that the subject *is* this complicated as we attempt to address phenomena such as sexual arousal and anger, for example. In fact, most biologists shy away from the social inputs, not because we believe they are unimportant, but simply because the task is too overwhelming to try to integrate the inputs successfully in a test tube. I will remind us of the importance of social forces in shaping behavior in the next chapter.

So what are we going to do?

It probably sounds fairly radical to say that there is no such thing as emotions, or that behaviors are so plastic that social forces can actually alter their contours, if not change them outright. We are so familiar with our own behaviors, and are so depend upon their presence, that life would seem impossible to live without them. And because emotions are so deeply rooted in us, our tendency is to quickly ascribe their origins to genetic roots. We even get these feelings at an early age, a fact brought home to me one fine morning when my son was about four months old. To understand the following story, you must know that my son was born with red hair, and lots of it (he actually had to endure three haircuts before his first birthday).

One rainy morning in Joshua's first autumn, my son began to discover this tangled mop of protein squatting on his forehead. He seemed to be asleep, and at first he just touched his hair softly, patting it drowsily here and there when he could get his arms under control (no mean feat for this four month old). But on this rainy fall morning, I watched him touch his hair as usual, make a fist, and then pull at it with all his might. This of course hurt, and at first he looked wild-eyed, as if he were afraid, and then he howled in pain, clenching both fists, crying at the top of his lungs. This clenching included the hand holding the hair, strengthening his grip, causing him to scream even louder, which caused him to clench even tighter and . . . you get the picture. Poor Joshua was caught in a vicious loop of emotional reactions, and I distinctly remember when he realized it – the quality of his cry changing from pain to what can only be described as anger. It took many minutes for Daddy to gently pry the source of his consternation away from his head. And when he let go, I saw him smile, relax his little hands and fall back to sleep on his pillow.

How intriguing to watch fear and pain and wrath and relief and happiness come into focus in my son's brain, like some biological film slowly being developed. Psychologists – as well as zoologists – tell us that this emotional development (or *whatever* development we should call it) is very important for a baby's overall growth, and has powerful reasons for coming into existence. A human's ability to feel fear, for example, is a critically important survival skill. Joshua will never develop the teeth of a jaguar, the physical strength of a grizzly bear, or the sharp talons of an eagle. These unfortunate facts mean one thing: if Joshua were forced to survive in the wild, he would have to become something of a coward, doing lots of avoiding, learning to become afraid of life-threatening situations, becoming angry when his environment is disorganized, happiness when life settles down, all in the hope that he can make it through the next day. In this view, the ability of the brain to conjure up specific motivations is a talent meant to keep it alive, pure and simple.

The previous sentence makes a powerful judgment. It says that one of the chief job descriptions of the brain is to act as a survival organ, and that the organ's ability to motivate is nothing more than another powerful tool designed to help us pass on genes. The fact that we are capable of complex behaviors simply means that we have chosen to grow fangs not in our mouths, but in our cortexes, that our physical strength is developed not in our muscles but in our neurons, and that it is our IQs, rather than our fingernails, that give us the intellectual talons sharp enough to claw out a place in this world. This evolutionary view, which I believe to be the proper one, reveals to us some real hope for understanding behaviors. We obtain a clue as how to write about the genes of motivation, even if we don't really know what they are.

How we will look at emotions and behaviors

One reason why this evolutionary context is an important perspective is that it allows us to make several predictions. Many researchers believe that our emotions and behaviors evolved to give us a fighting chance against the saber-toothed tigers. If our brains really did develop specific types of