Organumics
An Epigenetic Reframing of Consciousness, Life, and Evolution

"Each living creature must be looked at as a microcosm—a little universe, formed of a host of self-propagating organisms, inconceivably minute and as numerous as the stars in heaven."

—Charles Darwin, *The Variation of Animals and Plants Under Domestication*

Introduction

"So, naturalists observe, a flea
Has smaller fleas that on him prey;
And these have smaller still to bite 'em,
And so proceed ad infinitum."

—Jonathan Swift

This Book

To simplify and compartmentalize, this book is split into two parts. The first part is my best attempt at a light, easily understandable, and meaningful overview of the basic biological concepts that lead up to epigenetics for a general audience. The idea is to give non-scientists a grasp of the mechanisms constantly operating within our bodies while simultaneously providing enough interesting factoids and trivia to entertain those with some background in biology. Part one will compile evidence that a view of evolution solely focused on genes is wholly incapable of explaining heredity and natural selection.

Part two will build on the scientific knowledge from part one to both explain epigenetics and to explore the implications of epigenetics that are more philosophical and speculative rather than scientific and realistic.

Part two will continue the pattern of part one, with a mix of interesting science and important facts related to epigenetics and evolution. This includes discussions of how memory and behavior seem to be heritable across generations (Chapters 8 and 9) and the idea that identity itself is likely inherited to some degree as well (Chapter 10). The concept of *Levels of Description* (LoDs) will be introduced to describe the embedded and seemingly infinite dimensions of reality that we use to describe the perceptually inaccessible layers of the universe which will lead into a discussion of consciousness and its relation to biological evolution (Chapter 11). Finally, the term *organum* (Chapter 12) will be coined as a self-directed, self-contained unit of replication subject to natural selection.

Organumics, Life, and Consciousness

This book is in part a response to the current tension between molecular biology and our human Level of Description (LoD). Neo-Darwinian theorists proclaim that the gene is the main substrate and primary unit of natural selection. However, from the human perspective *we* play this role. As this book will discuss, NASA defines a living organism as a self-contained system that undergoes natural selection. And yet, according to the modern synthesis, we do not directly undergo natural selection, the genes that compose us do. Organumics attempts to resolve this tension by expanding the definition of life from organism to organum—an extension that takes into account the collective and stratified nature of life. Individualism is still a vital component of this theory, but only within the context of an infinitely connected and inseparable universe of collaboration—a single organum always exists within a group which composes a larger organum, and all organa are themselves composed of groups of smaller organa.

The seemingly infinite number of organa in the universe occupy overlapping and hierarchically embedded LoDs. Indeed, the word "organum" literally means a medieval polyphonic plainsong made up of multiple voices chanting harmoniously, and this is exactly the idea that organumics intends to portray about biology—that all life is a harmonic composition of interdependent units occupying the same space and time, but on different levels. The course of this book will describe how this framework implies that there is an arbitrary, but explanatory line to be drawn between the first living things and the first conscious things. Epigenetics creates a path to see that life (organum) arose when consciousness began the process of self-replication. But before all of that, we need to start at the beginning with the history of evolutionary theory, molecular biology, and the genetic revolution. We can't see where we're going until we know where we are and how we got here. So let's begin.

Chapter 1: A Brief History of Evolution

"Today the theory of evolution is about as much open to doubt as the theory that the earth goes round the sun."

—Richard Dawkins, *The Selfish Gene*

We start chapter one with a very brief overview of evolution, from Lamarck to Darwin to the modern synthesis of biology. The course of this book will show that epigenetics not only brings back Lamarck's ideas, but also uncovers a deeply held resistance to anything resembling "Lamarckism." Despite this, Lamarck is just as much to thank (or blame) as Darwin for the current views on evolution. There is so much unnecessary resistance to Lamarckism, especially considering that his ideas weren't all that different from Darwin's. In this chapter we will see that Lamarck is remembered for ideas that could easily be ascribed to many other theorists, including Darwin. Instead of the shortcomings of his theories, Lamarck would have wanted to be remembered for the emphasis he placed on behavior in the process of evolution. Even Darwin understood that behavior had to play some role in natural selection, as he described through the concept of artificial selection, otherwise known as domestication. The current view of evolution (including genes, memetics, and epigenetic inheritance, concepts that will be discussed in future chapters) supports a combination of Lamarckian and Darwinian theories. The way scientific education frames evolutionary thought as a fight between Darwin and Lamarck is disturbing, unnecessary, and ultimately false. At some level, the way Lamarck is framed as a failure in the education of evolutionary history is a distraction from the implications of a novel field of study: epigenetics.

Chapter 2: Your Genome and You

After the brief discussion of evolution in Chapter 1, I introduce below the concepts of genes and the genome. Genetics has become an immensely popular topic, but the average person cannot define what a gene is with any real detail. Even scientists have a hard time coming up with a specific definition of a gene. But this is unfortunate, because genes and genetics are vitally important for medicine and health—they are relevant to every living thing on the planet (or so it seems). A gene is an ambiguous stretch of nucleotides, which is a type of molecule that composes DNA; DNA is a nearly ubiquitous aspect of cellular physiology that is essentially the "brain" of the cell; the totality of genes within an individual is known as a genome, which is essentially, but not entirely, a set of instructions for how to create all the RNA and proteins within that individual. Each cell in your body stores a copy of your genome within an organelle called the nucleus. There are two exceptions though: red blood cells, which have no nucleus—a physiology that allows them to carry more oxygen—and mitochondria, which are technically tiny bacteria that live within your cells and have their own DNA and genomes. Genomes are very powerful and effective means of storing hereditary information that can be passed on to offspring—a type of cellular memory. While DNA is a universal feature of life, it was almost certainly not an aspect of the original type of life.

Chapter 3: Genome to Gene Expression

In this chapter we will see that the main role of the genome is not just to store intergenerational memories, but to act as a set of instructions—templates for the creation of life. Cells use these instructions to create the massive variety of molecules in your body, known as RNA and proteins. Since DNA was likely not a part of the original lifeforms, RNA and proteins have been suggested to be the original replicators. It is hard to say if RNA or proteins came first; RNA is more self-sufficient and flexible, but proteins are sturdier and functional. Either way, at some point in our evolutionary past these two self-replicating systems joined forces. Together, RNA and proteins created a system of computing (analogous to human computers) that allows them to read and write an instruction manual in the form of DNA—a genetic book of life as it were. This lets RNA and proteins create and maintain massive conglomerations of themselves. The phrase "gene expression" refers to the process of RNA and proteins creating more RNA and proteins. It is logical to consider transcription (the process of creating RNA from DNA) and translation (the process of creating protein from RNA) as a form of molecular reproduction, analogous to the way that living things make copies of themselves. Gene expression is a powerful determinant of cellular behavior, and by extension, human behavior. But every human has a very similar genome, and all the cells in a given individual have the same copy of their genome, so how can cells and humans all act so differently?

Chapter 4: Evolution and Development

All our cells (and all of us) have nearly identical genetics. Even beyond the comparison from cell to cell or human to human, every single living thing is related to every other living thing. This is because we all share a common ancestor—a preposterously old organism that spawned all generational lineages, which has led to everything that is currently alive. For this reason—and probably other reasons too—all living things look, act, and develop in very similar ways. This is clearly visible in the arm bones of mammals or in the developmental process of vertebrate embryos. It is possible to use this similarity to argue for "intelligent design," but it is more reasonable to see this as a function of the relative "blindness" of evolution. Charles Darwin saw the homology of embryos as being the greatest piece of evidence for natural selection and speciation. The reason that organisms can all look so different and have a variety of different types of cells within them is because of stem cells. These potent cells have the capacity to replicate and turn into any other type of cell in your body, be it a skin cell, a heart cell, or a brain cell. The process of a stem cell becoming another type of cell and losing its replicative capacity is known as differentiation. It is a process highly dependent on when and where a cell is within its developmental and organismal environment, and there are entire scientific fields dedicated to the study of these concepts.

Chapter 5: Expression in Space and Time

"It turns out that even micro-organisms are highly complex and intelligent, not simple and mechanical…cells appear to be units of will, purposeful agents."

—Andreas Weber, *The Biology of Wonder*

In this chapter we will discuss how cells have many, many ways of determining "when" and "where" they are. The various means by which they perform these feats are known collectively as cell signaling. One of the ways that cellular signaling works is through concentration gradients, which rely on diffusive forces to spread molecules from areas of high concentration to areas of low concentration (imagine introverts moving away from the group at a party). One type of molecule that signals through concentration gradients are transcription factors (TFs). TFs are proteins that bind to DNA to affect gene expression. They are very important for all aspects of cellular function and can be a powerful signal of where a cell is spatially. TFs can operate in cyclical feedback loops that act like the mechanisms of a clock or an hourglass to keep track of time, or "where" a cell is temporally. These rhythmic cycles of gene expression are one piece of a complex system of timekeeping known as circadian rhythms. Rhythmic physiology is a universal feature of life that controls almost every aspect of our being. But even red blood cells and things that don't have genes or DNA can operate in a rhythmic fashion. Non-genetic rhythms provide a powerful example of how life can hypothetically operate in the absence of gene expression, even though there aren't really any processes that are completely independent from DNA.

Chapter 6: The Heritability of Experience

This chapter will describe genes and DNA as an amazing system of heritable memory. The genome is a sort of written record that can be inherited and, therefore, exist long past the death of any individual RNA, protein, cell, or human. It is truly magnificent that great thinkers such as Darwin or Mendel were able to produce detailed descriptions of evolution and heritability without any idea that DNA or genomes existed. It actually makes quite a bit of sense when we consider that the gene-centric view of evolution is not nearly the full story. Humans and other organisms cannot exist in their current forms without DNA, but it is important to focus on the interplay between genes, the organism, and the environment to get a complete picture of heritability and evolution. This becomes very clear when we consider the zombified proteins called prions. Prion diseases can be genetic, but often they are simply the spread of a protein folding configuration—essentially the inheritance of a structure, a shape, an idea. The heritability of ideas is a well-established science known as memetics—the study of ideas as individual, but ambiguous, units known as memes. Viruses show us that the line between living things and pure information, or memes, is a lot fuzzier than we often think. Viruses are a clear example of a DNA sequence that can produce a transient body in order to infect other organisms. The infection of a new organism creates a dormant piece of pure information within a new genome. Perhaps it is for this reason—that viruses can exist somewhat independently of a body—that many scientists and philosophers have a hard time accepting viruses as living things. The confusion surrounding the division between pure information and life is a perfect place to begin the dive into epigenetics.

Chapter 7: Epigenetics

Here we will finally broach the subject of epigenetics—a phrase that literally means "on top of genetics." This topic is the perfect interface between genetics, heritability, and phenotype. Epigenetics is a means for the environment to change the genetic expression of an organism in a way that its offspring can inherit. Epigenetics can also be literally translated as "in addition to genetics," in which case it describes types of completely non-genetic heritability—specifically, the memory of events that happened in the past. But, this chapter will use the stricter definition of epigenetics as "mechanisms that operate by altering the structure of chromosomes," chromosomes being the combination of DNA and the proteins that it wraps around ("on top of" rather than "in addition to"). These changes can physically block genetic sequences to prevent their expression. But this definition is a bit too strict, because there are clear examples of epigenetic processes like RNAi (RNA interference) that aren't directly related to chromatin. It is possible that all these epigenetic mechanisms arose to control transposable elements (TEs)—essentially, sequences of DNA that literally jump in and out of the genome. The extreme ambiguity and variety of epigenetic mechanisms allow them to perform amazing feats that were thought to be biologically impossible. Indeed, a third way to translate epigenetics is "above genetics," which is suggestive of the miraculous implications of the concept and the way the word will be used for the remainder of the book (after this chapter).

Chapter 8: Collective Memory

"Inheritance must be looked at as merely a form of growth…"

--Charles Darwin, *The Variation of Animals and Plants Under Domestication*

As I mentioned at the beginning of Chapter 7, the rest of the book will no longer be using the word epigenetics in the restricted sense of changes in gene expression through the alteration of chromatin marks. Instead, from now on it will mean *any non-genetic system of memory or heritability*. In this sense of the word, epi- no longer means what physically happens "on top of" genes, but rather, what happens at the levels "above" genes. Epigenetic inheritance is a powerful concept that leads to many hard-to-believe conclusions, because it is easy to overlook that heritability is essentially a form of memory. Memory is a tool that provides an organism with a template for where it has been, so it can best choose where it needs to go in the future—to survive. Even though genetic and epigenetic mechanisms are surely a form of memory or information storage, natural selection is often described as blind. And although there does not seem to be a single designer in or outside of nature, the process of evolution produces designs that are highly reminiscent of the artifactual mechanisms created by humans. For example, non-genetic memory systems like circadian rhythms strongly resemble the mechanisms of a clock or a watch (or do human artefacts resemble evolutionary designs?). There are many examples of non-genetic and epigenetic memory systems within our bodies right now. Some of these systems even seem to store information over the course of a lifetime that can be inherited by one's offspring, which is exemplified by the concepts of inherited fears and traumas. The interplay between our many concurrent levels of memory indicates how evolution progresses and has implications for the role that we as individuals play in the collective future of our species. Let's dive in.

Chapter 9: The Sickness Within Us

This chapter explores the epigenetic relationship between physical and mental health. The heritability of trauma and stress discussed in the last chapter seems to lead to a vicious, intergenerational feedback loop. The stresses that your ancestors endured can cause stresses in your body, which can lead to physiological changes and disorders. For example, PTSD causes changes in the expression of the GR and cortisol, which can lead to heritable decreases in stress resilience. Similarly, addiction has a strong epigenetic component, which leads to extremely high rates of heritable addictive behavior, even though there is no underlying genetic predisposition for these behaviors. Since mental and physical health are intrinsically linked by epigenetically heritable disorders, we must rethink the current definition of sickness. Diseases are often thought to arise from pathogenic invaders, like bacteria, parasites, or viruses. However, our bodies are crawling with microorganismal critters that don't always cause us harm. It makes more sense to think of diseases as imbalances in homeostatic processes—literally dis*order*s. This means that health and healing are nothing more than restoring balance in disrupted biological processes. Trying to fight off invaders rather than restore balance can lead to even more stress and imbalance. To truly find balance, it is vital to have a clear sense of self—after all, how can invaders be recognized if there are no clear boundaries of what is being invaded? This concept leads us directly to the connection between epigenetics, heritability, and identity.

Chapter 10: Who Are You, Really?

"Identity should not be understood as solely subjective, but rather as intersubjective… The gift, the gift of being seen, of being mirrored, is a biological necessity."

--Andreas Weber, *The Biology of Wonder*

In this chapter, we will use the definition of sickness as an imbalance of "normal" bodily processes to reconsider the concept of identity. Even though we often think of illness as a bodily invasion, humans are constantly swarmed with "non-human" microorganisms. We even have a type of bacteria, mitochondria, in nearly every one of our "human" cells. In addition, viruses and transposable elements (TEs) make up a massive portion of our DNA—possibly over 50%. You likely already know that family history and upbringing have powerful influences on our identities, but interpersonal interactions with non-family members also shape who we are and who we can become. Memetic heritability (the transfer of memes, or ideas, from person to person) creates an interconnected web of human consciousness, so, in a very real sense, humans cannot exist in isolation. There is no way to escape the societal and memetic bonds that keep us tethered to our consciousness and the people around us—our identity as individuals is a total illusion. You do not exist as an entity separated from your surroundings or the universe, as you cannot escape reality. Even if you could somehow define yourself as an individual, your body is constantly being recycled and constantly changing in response to the environment. The most personal information, like our perceptions, can be stored and transmitted to future generations through epigenetic mechanisms. If our conscious perceptions are heritable, then our identities are heritable as well. If our identities don't end with our bodies, our consciousness existence needs to be reconsidered in light of epigenetics and evolution.

Chapter 11: Levels of Description

"…everything we do could in principle be described in terms of cells… Most of us accept this in a rather matter-of-fact way… We read about DNA and 'genetic engineering' and sip our coffee. We seem to have reconciled these two inconceivably different pictures of ourselves simply by disconnecting them from each other…Seldom do we have to flip back and forth between these two concepts of ourselves, wondering 'How can these two totally different things be the same me?'"

--Douglas Hofstadter, *Gödel, Escher, Bach*

This chapter will take the epigenetic and non-genetic inheritance systems discussed in previous chapters to suggest that Lamarckian theory was on to something—behavior does seem to influence the process of evolution by natural selection. Since behavior clearly influences survival, it is absurd to suggest that it is distinct from evolution. This behavioral influence on evolution extends into the process of speciation, which, at some level, can only be described as "Lamarckian." In other words, our choices as individuals are intricately linked to our evolution as a species. I will take this concept one step further and argue that behavior and consciousness are inseparable. Unfortunately, consciousness is the most slippery topic imaginable because it is an infinitely recursive and self-referential process of self-awareness. Strangely, any self-referential loop will have this same problem. A descriptive system will never be able to wholly describe itself, because as soon as a complete description is generated there is a new "whole" (the complete description) that needs a new description. Behavior and consciousness are connected by *emotion* and *feeling*, where emotion is a directed response to environmental change and a feeling is internal awareness that occurs in response to these responses. Human consciousness (as well as other forms of "higher" self-awareness) emerges from an infinite and recursive loop of feeling a feeling a feeling ad infinitum. Because of the descriptive slipperiness of this internalized dimension of feeling, I have created an acronym that reframes our descriptions of reality to become more manageable: the LoD, or the Level of Description. LoDs provide reference points for description by making a conceptual anchor out of the dimension or level of the thing that is being described. Even beyond humans, LoDs suggest there are many living things that have the necessary features of evolution and conscious awareness.

Chapter 12: Organum

"...our life is situated inside a nested hierarchy of self-organized systems... Each of these levels are non-equilibrium systems that owe their existence to processes of self-organization... Is there a sense in which the universe as a whole could be a non-equilibrium, self-organized system?"

--Lee Smolin, *The Life of the Cosmos*

This chapter will revisit Neo-Darwinian theory in terms of Levels of Description (LoDs) rather than evolutionary substrates. Within the framework of LoDs it becomes more apparent why it is so absurd to suggest that genes are the sole substrate of natural selection, because the LoD of genetics is just one among a seemingly infinite number of inseparable dimensions that are all interconnected and affected by the processes of evolution and natural selection. The concept of LoDs and the substrate independence of natural selection leads to some startling implications. For example, this new perspective rewrites the history of life and places epigenetics as the precursor to genetics. In addition, this may mean that the stability of physical bodies emerged more recently in the history of evolution than the self-replicative capacity of informational templates. In other words, the *concept* of life existed before the physicality of living things. The traditional definition of life as an organism (i.e., something affected by natural selection) simply isn't clear enough to truly explore the depth of pre-genetic history and the implications of LoDs. Therefore, I have co-opted an old medieval word, *organum*, to describe a new view of life—not just as "things" affected by natural selection, but as cooperative groups of self-directed, self-contained, and self-referential replicators. In this way, the entire universe can be described as infinitely embedded series of organa surviving, multiplying, changing, and interacting. *Organumics*, a word I have coined to mean "the study of organa," aims to reframe the human perspective from the LoD of evolution. After all, "nothing in biology makes sense except in the light of evolution"—and we are nothing but biology.