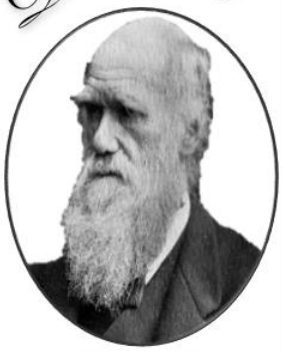
Darwin



Dawkins

Turing

Genes, Memes & Cenes

How they shape your life and will shape the future of humanity

Leonard M. Adleman

Manufacture: March 31, 2019 Best by: December 1, 2019

After the best by date, it is likely that I have decided that this draft is awful and have written a much better one with deeper understanding and superior exposition. To get the latest, go to adleman.usc.edu. It is my hope that in the hands of future researchers this material will contribute to the development of a general theory of evolution

Preface

This is not the book I wanted to write. I have been thinking about a general theory of evolution, what I have come to call “prene-theory”, for over 40 years. I had hoped to reach a level of understanding sufficient to present a grand theory; I did not succeed; perhaps future generations will.

As it is, this book will let you see the world from my prene-theoretic point of view. The next time you run for president, fight a war, or just deal with the ordinary problems that humans are heir to, perhaps the prene-theoretic perspective will be of use. If you want to understand why you will die, or if you need guidance on achieving greatness, prenes may help here as well. If you are confused about where the “computer revolution” is headed, then prenes will provide some answers.

I will apply prene-theory to bacteria, bees, computers, history, humans, literature, music, politics, religion, science, viruses (both biological and computer), and other things. Unfortunately, in many of the areas I consider, I am not an expert. No doubt this and other factors have led to mistakes, over-simplifications, and speculations that the future will determine to be unwarranted.

Finally, some of your treasured beliefs may not be given the respect they deserve. I apologize.

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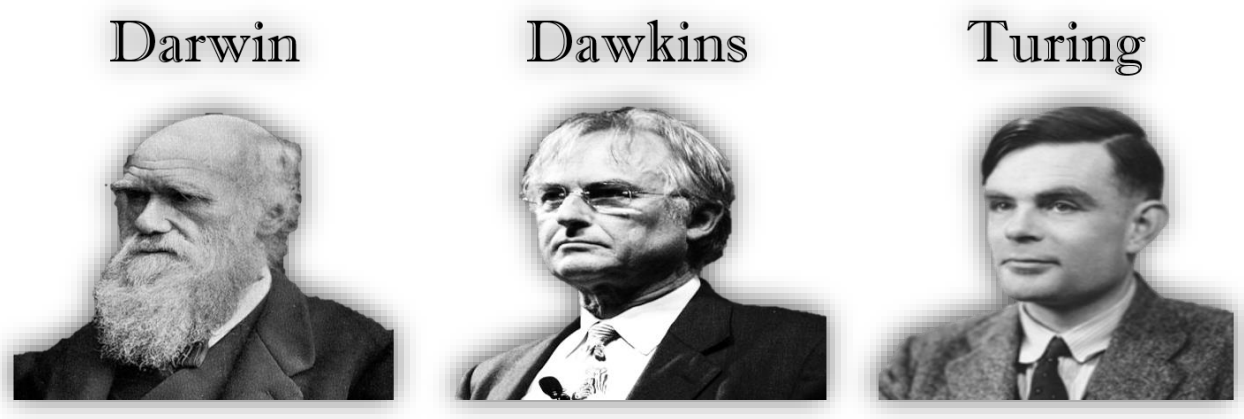

Figure 1: The fathers of Prene-theory [fathers]

I was a young mathematics professor at MIT when I began reading Richard Dawkins' 1976 book "The Selfish Gene" about the primacy of genes in Darwinian evolution [Dawkins]. In the last chapter, Dawkins introduced what he called "memes" – analogues of genes that resided in peoples' brains rather than in molecules of DNA. I recall saying to myself: Oh, that's how it all works.

How what works? Pretty much everything. For example, you.

As a mathematician, I had long been aware of the work of logicians Alan Turing (the father of computer science) and Steven Kleene (the discoverer of the so called "recursion theorem"), and it had been apparent to me, and to others who cared about such things, that their results implied that the things stored in computers (which I later called cenes) were also analogues of genes.

I was really struck by all of this and ever since I have worked to put the pieces together.

It was clear from the start that genes, memes, and cenes must obey Darwin's laws: survival of the fittest, mutation and natural selection. But with time it became

clear that Darwin's laws are often misunderstood, and that there are other laws, not previously described, that also apply. It also became clear that these laws did not just apply to genes, memes, and cenes, but to a larger class of things I came to call "prenes"[1]

Genes have become central to the study of biological evolution. I believe that memes, cenes and other prenes have the potential to occupy a similar position with respect to the study of societal and computer evolution.

As you will see, prenes were here long before you were and will remain long after you are gone. While you are here, they will have an extraordinary influence on every aspect of your life.

[1] "genes", "cenes" and "prenes" rhyme. Cenes is a portmanteau from computers and genes, Prenes comes from primary and genes.

Prenes

This chapter will introduce prenes and provide some reasons why you should care.

What is a prene?[2]

To be, or not to be, that is the question – William Shakespeare

Hamlet's soliloquy. It is stored in books as a sequence of letters. It is stored in computers as a sequence of zeros and ones. It is stored in people's brains in a manner yet to be elucidated by science.

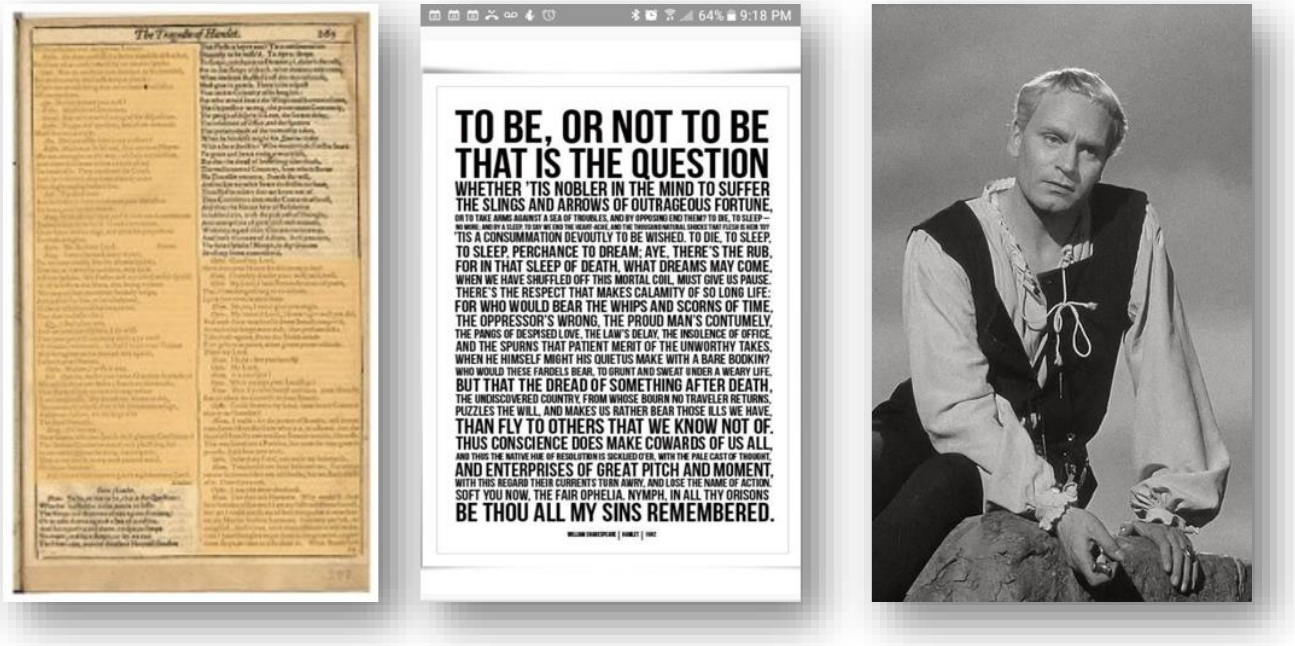

Figure 2: The Hamlet's-soliloquy-prene stored in the Brandeis First Folio (left), on a computer as a cene (middle), and in Lawrence Olivier's brain as a meme (right) [Shakespeare]

[2] I will give one of many possible definitions. The reader may prefer (at least initially) to think of a prene as a "unit of information". Giving a definition of prenes raises the millennia old philosophical "problem of universals", for more on this see *Socrates' Bed*.

While books, computers and brains are physical things, we will treat Hamlet's soliloquy as non-physical. We will call these non-physical things that are stored in physical things "prenes".

Like Hamlet's soliloquy, the smallpox genome is a prene. The smallpox genome is not a molecule of DNA, nor is it a sequence of A's, T's, C's, and G's in a computer; rather, each molecule of DNA in a smallpox virus is storing the smallpox-genome-prene, and each computer with the appropriate sequence of A's, T's, C's, and G's is also storing it.

A prene stored in a brain will be called a meme, one stored in a computer will be called a cene, and one stored (as a sequence) in a nucleic-acid molecule (e.g. DNA or RNA) will be called a gene[3].

So, the Hamlet's-soliloquy-prene is both a meme and a cene, and the smallpox-genome-prene is both a gene and a cene. What makes memes, genes, and cenes especially worthy of study is that, roughly speaking, they alone have mastered the art of self-replication – one might say that they alone are "alive".

A prene may be stored in many physical things at the same time. For example, it is likely that the Hamlet's-soliloquy-prene is currently stored in millions of books, in millions of computers, and thousands of brains.

The most important thing to know about a prene is its current copy number – the number of distinct physical things in which it is stored at this moment. If that number drops to zero, the prene has gone extinct.

For example, it is well-known that some of Shakespeare's plays have been lost; so, baring a miraculous find, the prenes these plays contained have gone extinct. The same can be said for the genome prenes of many ancient creatures.

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[3] In biology, genes are associated with proteins, no such association is required here.

Principle 1:

Principle 1

All prenes struggle to avoid extinction

In light of Darwin, it is easy to see how the smallpox virus, and hence the smallpox-genome-prene it stores, has struggled, but how has the Hamlet's-soliloquy-prene struggled? To understand that, we will need a more refined view of prenes.

The resurrection of smallpox

The gene-world, the meme-world, and the cene-world are all parts of the prene-world. Each is a theater of operation in the grand struggle of prenes to survive. While it is sometimes useful to focus on one of these worlds at a time, we should not lose sight of the fact that prenes can migrate between worlds. When prenes exploit this opportunity to travel, it can have deadly consequences for humanity.

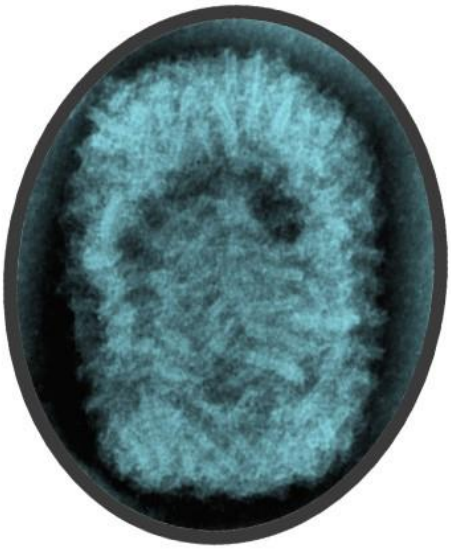

Figure 3: The smallpox virus. Dead or just playing possum?

The following editorial appeared in the Oct 16, 2014 edition of the New York Times. For obvious reasons, I did not use the language of prenes, but, at its core, that is what it is about. It addresses the question: has smallpox been eradicated? The world has always looked at this as a question of biology, that is, as a question about the gene-world, but when looked at in terms of the prene-world as a whole, the view is strikingly different.

By Leonard Adleman

Los Angeles

On Oct. 16, 1975, 3-year-old Rahima Banu of Bangladesh became the last human infected with naturally occurring smallpox (variola major). When her immune system killed the last smallpox virus in her body, it also killed the last such smallpox virus in humans. In what is arguably mankind's greatest achievement, smallpox was eradicated.

Our war with this smallpox virus was brutal. It appears likely that the virus killed about one billion of us. Initially, our only defense was our immune system, but eventually we developed new tools, including vaccination. In the late 1950s, the World Health Organization began responding to outbreaks by vaccinating everyone in the surrounding area to prevent the virus from spreading. By 1975, we had won.

The smallpox virus had only a single host species: us. Other viruses have multiple hosts. For example, some strains of flu live in both humans and pigs, hence "swine flu." If smallpox had had a second host, eradicating it in humans would have been of little value, since it would have thrived in its second host and later re-emerged in humans.

A few samples of the virus are still kept in special labs: one in the United States and one in Russia. We don't bother vaccinating against smallpox anymore; if the virus escapes from one of these labs, the war will begin again. Currently, there is debate about whether these samples should be destroyed or kept for scientific purposes.

But the debate should be broadened. Even if we destroy those samples, the war is not over; the smallpox virus has now found a second host. It is not the pig. In fact, it is not even what we think of as a living thing. It is the computer.

This is not some conceptual game. This is real and life-threatening.

If you search online, you can find the sequence for the smallpox genome. It is a word written with the letters A, T, C and G. The word is about 185,000 letters long. It is the word that tells cells to make smallpox viruses. The sequence was

stored on a computer in the early 1990s, when a research team led by J. Craig Venter obtained it using a biotechnical process applied to a sample of the virus. Of course, a word in a computer file cannot kill you. Well, yes and no. In the 1990s, I ran a biotechnology laboratory. In my lab there was a machine much like a soda dispenser, only in this case the reservoirs were filled with chemicals. If I typed in a short word of my choice using the letters A, T, C and G, the machine would squirt one chemical after another into a test tube. When it was done, the test tube would contain trillions of molecules of DNA. Each would look like a necklace, with molecules of adenine, thymine, cytosine and guanine (the building blocks of DNA) strung according to the word I had typed.

At that time, the 10,000-letter sequence of the H.I.V. genome was available online. I contemplated using my machine, together with well-known biotechnical methods, to create, de novo, the H.I.V. genome — an actual molecule identical to that found in H.I.V. viruses living in the wild. I had reason to believe that inserting such a synthetic molecule into a living human cell would cause the cell to manufacture full-blown H.I.V. viruses that could then be transmitted from person to person and cause AIDS.

I decided not to do the experiment, but I began to worry. If I could do it, so could others with high-tech labs.

Which brings us back to smallpox. Might someone resurrect it? You may think this is mere speculation, but in 2002, scientists used the approach just described to produce an infectious polio virus. It is possible that the great labs, with great scientists, the best equipment and substantial funds, could overcome the considerable challenges that exist and resurrect smallpox right now. Before too long, more modest labs may be able to accomplish the same thing.

I am worried, but also amazed. Smallpox has miraculously and unconsciously saved itself through an extraordinary act of evolution. After thousands of years, it was on the verge of extinction; it existed in one small girl, and just before that girl's immune system killed its last living member, a sample was taken and stored in a lab. Years later, that sample was used by another lab to sequence the

viral genome. The sequence was placed on a computer, infecting a new "species" that had just come into existence.

Do we sit and wait for the day when someone releases resurrected smallpox on an unvaccinated world? I'm a scientist, not a policy expert. But would it be wise for us to consider limiting the distribution of the tools of this emerging technology?

So, at virtually the last possible moment, the smallpox-genome-prene made the leap from gene to cene and was saved from extinction. I cannot think of an evolutionary miracle more remarkable.

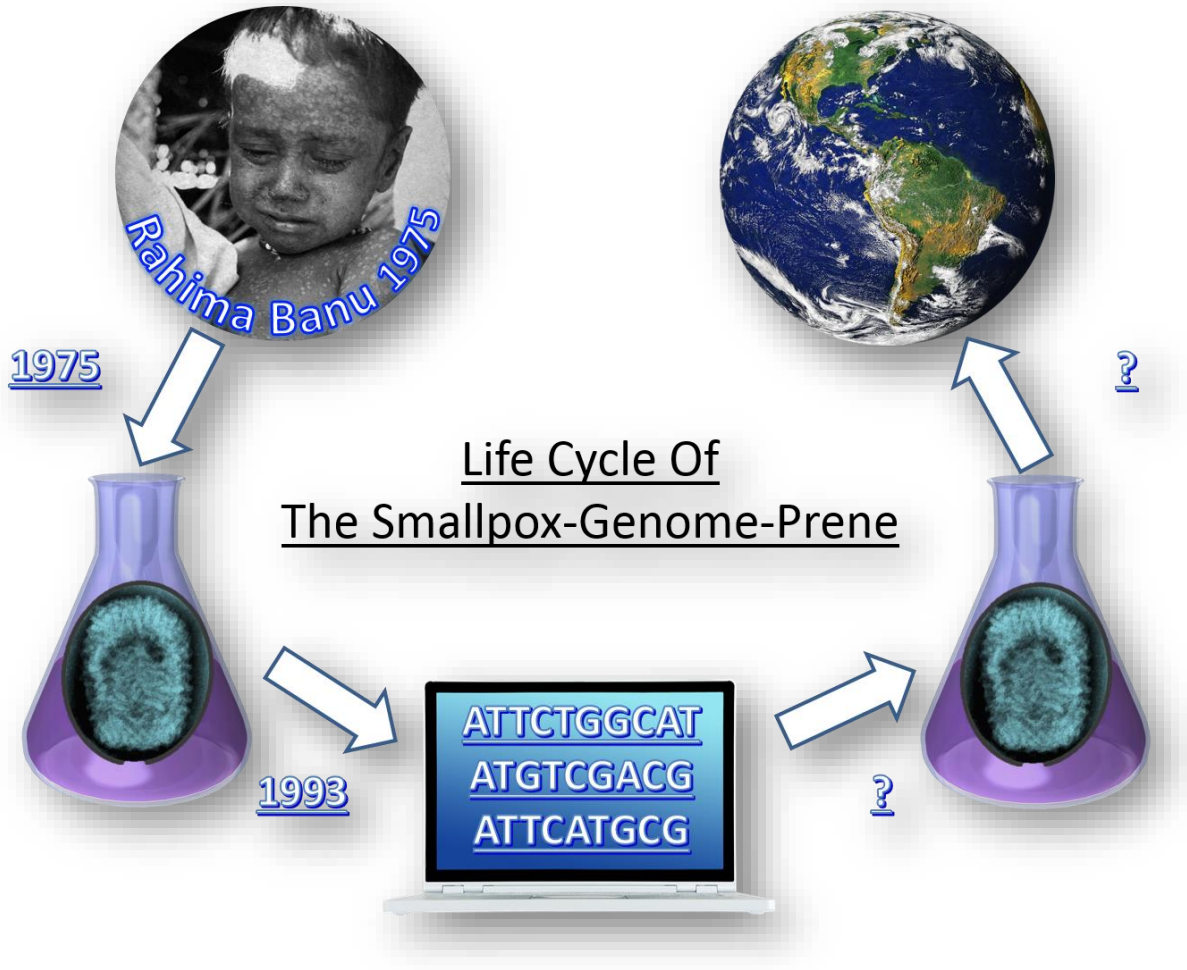

Figure 4: From gene to cene and perhaps back to gene [Smallpox-2]

Recently, a group at the European Bioinformatics Institute has provided another interesting example of prene migration. They have stored all of Shakespeare's Sonnets in DNA molecules [Goldman]. Hence, the Shakespeare's-Sonnet-154-prene began as a meme stored in Shakespeare's brain, became a cene stored on a computer, and then a gene stored in DNA.

Why do bees kill themselves?

In this section, we will use prenes to investigate the shocking number of suicides among honeybees.

If a honeybee stings you, you'll probably be angry because it really hurts. You may find a bit of solace knowing that the bee that did this to you has just signed her own death warrant. Her entrails will be ripped from her body. You probably hope that really hurts too. It probably doesn't, but that's another story.

So, why do bees sacrifice themselves in order to attack you? Suicide is not usually considered a good evolutionary strategy.

Figure 5: Brave prene-warriors [Sacrifice]

Here is one possible answer championed by Dawkins [Dawkins] and others. As our understanding of molecular biology has grown, many scientists have come to view the struggle of living things to survive as a struggle between genes. In this gene-centric view, living things are built by their genes, their behavior is programmed by their genes, and their purpose for living is to preserve and reproduce their genes.

The gene-centric explanation of the honeybee's sacrifice may seem paradoxical: she (only worker honeybees sting, and all workers are female) has sacrificed her life to reproduce her genes, or in our language, to make new copies of the prenes stored in her DNA molecules. While dying terminates her chance to reproduce, it also protects the hive, and increases the reproductive chances of the queen, and because of the bizarre nature of honeybee reproduction, the queen's offspring share more genes in common with the worker than the worker's own offspring would. As a consequence, when the situation is just right, sacrifice can actually increase the overall chances that new copies of the worker's genes will be created. To take advantage of this, the worker's genes have programmed the worker's sacrifice in situations where that sacrifice is likely to increase the future copy-numbers of those genes.

Does this gene-centric view explain all sacrifice in living things? Let's look at some more examples.

Consider humans. Parents sacrifice for their children. Sometimes the sacrifice is life itself, but most often it is more mundane, like getting up in the middle of the night to feed a newborn. Because the children's genes are also genes of the parents, the gene-centric explanation of such sacrifice works in much the same way as it did for honeybees.

But what about a soldier who sacrifice his life for a cause? Here the gene-centric view fails to provide an explanation, since most members of the community that the soldier is protecting are not closely related to him genetically, and those that are, such as his children, are less likely to survive and reproduce once their parent is gone.

But, if the soldier is not programmed by his genes to sacrifice himself, why does he do it?

It is because they are programmed by a different set of prenes, those memes that we call beliefs. For example, the soldier may have acquired American, or Islamic beliefs; he may believe in democracy or sharia. Believers may transfer their beliefs to

someone else, for example, by teaching. When this occurs, the beliefs are stored in new brains and hence the copy-number rises.

So, let's look at the soldier's sacrifice again; this time substituting his beliefs for his genes. While dying terminates the soldier's chances of transferring his beliefs directly to others, it also protects his community, and increases the chance that community members will transfer their own beliefs. But, because the members of the soldier's community are likely to share many of his beliefs, when the situation is just right, the soldier's sacrifice can actually increase the overall chance that new copies of the soldier's beliefs will be created. To take advantage of this, the soldier's beliefs have programmed the soldier's sacrifice in situations where that sacrifice is likely to increase the future copy-numbers of those beliefs.

You may object and say that the soldier doesn't know anything about prene-theory and isn't thinking about his beliefs when he sacrifices himself. You are probably right, but the bee doesn't know prene-theory either and isn't thinking about her genes when she sacrifices herself; nonetheless, it is apparent that her genes have programmed her to do it. You may wonder how a set of beliefs can accomplish such programming. Go watch the training of a squad of elite soldiers; that's how.

But if the soldier's beliefs have programmed his ultimate sacrifice, what have your beliefs programmed you to do? Also, where do beliefs come from anyway? These are some of the things we will address in subsequent sections.

We can sum up the nature of sacrifice with a single prene-theoretic principle:

Principle 2

Prenes may sacrifice copies in situations where that sacrifice is likely to increase future copy-numbers

How to be an unsuccessful prene

A successful prene, one that has many copies over a long period, is a magnificent thing exquisitely suited to its environment.

In this brief section, I will describe a prene that has been unsuccessful and has no one to blame but itself.

The Shakers were a Christian sect that arose from the Quakers in mid-18th century England. To the usual Quaker-prene-set[4], they added a new "celibate-prene": sex is forbidden. I'll skip the details, but guess how many Shakers there are today?

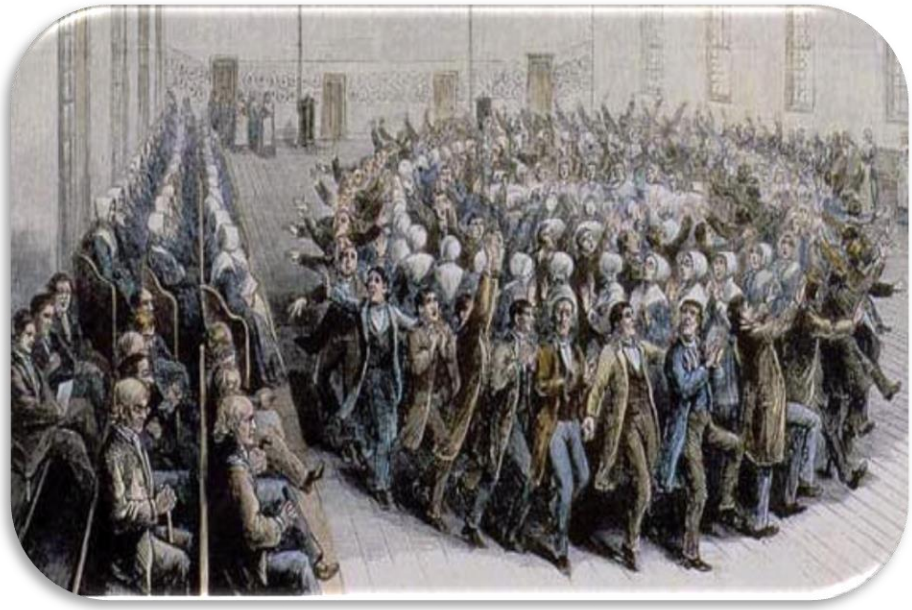

Figure 6: Shakers dance and worship. "I saw in vision the Lord Jesus in his kingdom and glory… I was able to bear an open testimony against the sin that is the root of all evil; … the doleful works of the flesh" - Shakers' Mother Ann Lee (ca 1770). [Shakers 1]

[4] A set of prenes will be called a "prene-set". Gene-set, meme-set, and cene-set will be used similarly. The prene-sets associated with religions, political parties, nations, and other societal entities will be called "societal prene-sets". A believer in a societal prene-set will be called a "follower".

No, you are wrong. Much to my surprise, the correct answer appears to be two [Shaker 2]. However, I suspect your answer will be correct soon enough.

The celibate-prene was ill-suited for its own survival and dragged the Shakers and the Shaker-prene-set down with it. There are several reasons for this, among the most important of which are:

1. The Shakers had to compete with the Quakers and other religious sects for survival. That is, the Shaker-prene-set, the Quaker-prene-set, and other religious prene-sets were struggling to get stored in the same set of brains.

2. The celibate prene foreclosed one of the most basic means by which prenes get into new brains: have children. Human babies are born with an open channel for the transfer of memes from their parents. It got that way because the genes arranged it to be so for their own survival. The reason is obvious: getting the don't-put-your-hand-in-the-fire-meme from your parents helps you and your genes survive (see *Your prene-set*).

Notice that successful religions don't make the mistake of having the celibate-prene in their prene-set. For example, the Jewish and Christian prene-sets virtually begin with an anti-celibate prene:

Be fruitful and multiply (Gen 1:28)

For the same reason that the celibate-prene contributed to its own and the Shaker-prene-set's failure, the be-fruitful-and-multiply-prene has contributed to its own and the Jewish and Christian prene-sets' success.

The Muslim-prene-set specifically exploits the parent-child channel. When a Muslim baby is born, his father whispers into his right ear the first words he will ever hear, the Shahada:

God is great
There is no god but Allah, Muhammad is the messenger of Allah

When the Shaker-prene-set first arose, it would not have been difficult to see that it contained the seeds of its own destruction. Can an analysis of the Christian, Islamic, American, Russian, Democratic, Republican, and other societal prene-sets reveal some of their strengths and weaknesses and provide a glimpse into their futures? I believe it can (see *A prene-centric view of History*). Developing tools to do such analyses is a goal of prene-theory.

The selfish prene

Figure 7: If prenes were people [Pirates]

In *The resurrection of smallpox*, we considered what can happen when a single prene is stored in many different physical things. Here we begin to consider what can happen when a single physical thing stores many different prenes.

The most important thing to know is:

Proposition[5] 1

Prenes are not nice

[5] Principles are laws that govern prenes (as best I can articulate them). Propositions are things worth keeping in mind.

Even the be-nice-prene is not nice. Prenes only care about their own survival.

A prene may form alliances with other prenes to form a prene-set, but if an alliance becomes a burden, the prene will abrogate it without the slightest remorse.

Consider the bread mold (*Neurospora crassa*). When placed in minimal-medium (basically, saltwater with sugar and a source of nitrogen), the genes in the mold's gene-set live happily with one another, merrily exploiting the medium for their common survival and reproduction.

But, if you begin adding a regular supply of uracil (a nucleobase used in making RNA) to the medium, then you will find that changes occur. After many generations, if you look at the mold DNA, you will find that some of the original genes are missing.

Here is what happened: among the genes stored in the DNA prior to the addition of uracil, there was a subset that caused uracil to be synthesized from the chemicals found in the minimal-medium. All the other genes really liked the uracil subset, because without uracil, the mold and hence they would perish. However, once there was "free" uracil available, the rest of the genes asked: "what do we need those guys for?"; they turned on the uracil subset and cast them out [Wikipedia-AT].

The point is that prene-sets are seldom happy places. When prenes share an instrument, such as a cell or a human, they will fight each other to control it and use it for their own survival. If a subset of prenes gains control and induces behavior that is harmful to its fellow prenes, or the instrument itself, well, that's their problem.

Why should you care if prenes are unhappy? Because their unhappiness sometimes becomes your unhappiness as we shall see in the next section.

The war within

If you want to find a physical object that stores hundreds of thousands of prenes all at once, you will not have to look far – it's you. You are a storehouse for genes, memes, and other prenes (we will explore this in depth in the chapter *Humans*).

Each of your prenes is an aspiring dictator that wants exclusive use of you to help it survive. Unfortunately, your prenes are often at cross purposes, and when this happens, you may suffer.

Consider what happened to Joan of Arc when her genes and memes came into conflict.

Figure 8: Joan of Arc experiencing cognitive dissonance? [Strike]

Joan was taken to a scaffold set up in the cemetery next to Saint-Ouen Church and told that she would be burned immediately unless she signed a document renouncing her visions…. [Wikipedia-JA]

What was best for Joan's genes? Joan, like all of us, was designed by her genes to stay alive and reproduce. She was the "Maid of Orleans", so we can be pretty sure that she was not succeeding with the latter. By renouncing, Joan would not be burned, would retain the possibility of having children, and increasing the number of copies of her genes. Joan's genes favored renouncing.

What was best for Joan's religious beliefs? Joan was a devout Christian who had attracted a large following in France; much of it based on beliefs she had acquired through divine visions (or more mundanely: the subconscious processing of acquired memes, see *How the brain captures memes*, *How the brain processes memes*). The English wanted her to renounce, knowing it would undermine her French followers. By refusing, Joan would become a martyr, embolden her followers, attract new converts, and increase the number of copies of her beliefs. Joan's religious beliefs favored not renouncing.

By the way, Joan did renounce, but was later burned at the stake anyway. She became a famous martyr, and over the last six hundred years has contributed mightily to the spread of Catholic prenes.

As you might imagine, and as the historical record seems to suggest, this situation was stressful for Joan.

While Joan's case is extreme, we all experience situations in which our prenes compete for our behavior. I like to think of our prenes as members of a "prenes legislature". When a situation arises, a debate ensues with members expressing an opinion about the behavior we, their instrument, should exhibit. Ultimately, the

legislature hammers out a compromise behavior that we implement (how this works will be further described in *Humans*).

When a strong majority of members see eye to eye, we choose our behavior subconsciously. When the members are significantly divided on the appropriate behavior, our conscious mind is invoked, and we may feel discomfort – so called cognitive dissonance.

For example, I was invited to go skydiving, and immediately said “no”. The members of my prenes-legislatures were almost unanimous on the “no” behavior, my conscious mind was not invoked, and I did not feel cognitive dissonance.

However, sometimes at a restaurant, some members argue for a cheeseburger, while others advocate a healthier choice. I am conscious of the conflict. The legislature reaches a compromise: I order a salad with bleu cheese dressing.

Sometimes the disagreement between members is intense. Perhaps you are offered a new job with higher pay, but with a less stable company in another state. Your family will have to move, but the schools are better; your parents will be closer, but you’ll miss your friends, etc. For weeks, it may be difficult to focus your conscious mind on anything else. You may be unable to get a good night’s sleep.

There are many ways that prenes impact feelings. Perhaps, an exploration of the implications of prene-theory in psychology would be worthwhile. I suspect that the theory can augment existing results and provide guidance on therapeutic approaches. I am not qualified to carry out such an investigation but will touch on this topic a bit more in *Humans*.

Hamlet's soliloquy's struggle

Since Darwin, we have accepted that all living things struggle to survive. We are now ready to see how non-living things, like the Hamlet's-soliloquy-prene, also struggle.

When humans consider struggle, they expect to see features like strategy and fear. When we view the struggles of lions or zebras, what we see conforms to our expectations. However, as we move down the evolutionary ladder these expectations are typically not met. Trees, grasses, angiosperms, sponges, bacteria, and viruses all struggle to survive, but since they lack brains, they don't create strategies (in the above sense) or experience fear.

***Figure 9: Can you see the struggle? [struggle*]**

Once we strip the word "struggle" of our expectations, we will be able to see that all prenes struggle for survival in essentially the same way. Let's begin with the Hamlet's-soliloquy-prene.

Where did the Hamlet's-soliloquy-prene come from? Well, it came from Shakespeare's brain (you're welcome). Prior to writing the soliloquy, Shakespeare's brain did not contain the Hamlet's-soliloquy-prene, but it did contain lots of theatrical memes. We can be pretty sure of this because Shakespeare was an actor, playwright, part owner of an acting group (The King's Men), and part owner of a London theater (the Globe), so it is likely he had read, heard and perhaps memorized thousands of lines by others. He had also learned the techniques of acting, staging and performance.

Shakespeare's job and other factors led him to expend time and brain-cycles writing new plays. Shakespeare processed his existing memes and created new ones such as the Hamlet's-soliloquy-prene.

Now that the Hamlet's-soliloquy-prene existed, it began its struggle to survive. At this point, its only instrument was Shakespeare. Fortunately for the Hamlet's-soliloquy-prene, he was an excellent advocate.

Shakespeare was in the right place at the right time, since plays were a major form of entertainment in Elizabethan London and he owned part of a theater. Hence, he could ensure that Hamlet would be performed (presumably with dramatic lighting, costumes, and sets) in front of a large audience. History suggests that Shakespeare's works were "well-received"; that is, theatergoers, including royalty and fellow actors, exposed to Shakespeare's plays often acquired and valued some of Shakespeare's prenes. The copy numbers of Shakespeare's prenes, including the Hamlet's-soliloquy-prene, began to rise.

Shakespeare's prenes were in good hands so long as Shakespeare was alive to facilitate their spread, but upon his death, the prenes were endangered. Fortunately, a good number of Shakespearean prenes had been stored in durable form as quartos and production notes. But these documents would not survive forever. Shakespeare's prenes were in need of effective new instruments or they would almost certainly go extinct (many plays of Shakespeare's time, including some by Shakespeare himself, are known to have been lost).

Fortunately, the needed new instruments appeared in the form of John Heminges and Henry Condell. They were actors who knew Shakespeare, and following his death, they gathered the materials available and produced the first folio containing 36 plays. Heminges and Condell were Shakespeare's apostles; the first folio, his gospels (see *A prene-theoretic view of History*).

The folio was apparently a business success and several editions ensued. Eventually, the world would be inundated with editions of "The Complete Works of Shakespeare" modeled on the first folio. The Hamlet's-soliloquy-prene had gone viral.

You may say: "that's it?". Yep, that is it. It is a theme with many variations, but that is it.

Let's look at a few more examples.

Where did the smallpox-genome-prene come from? We can only guess, but here is a plausible answer.

Several thousand years ago, a human cell became infected with a poxvirus similar to, but different from, smallpox. Inside that cell, the poxvirus mutated and became the smallpox virus. In prene language, we might say that the poxvirus-genome-prene was processed by the cell to produce a new prene: the smallpox-genome-prene.

That cell was the smallpox-genome-prene's Shakespeare, and it was at least as effective an instrument for the smallpox-genome-prene as Shakespeare was for the Hamlet's-soliloquy-prene.

That cell presented the smallpox virus, and hence the smallpox-genome-prene, to neighbors where it was well-received; that is, those cells acquired (i.e. became infected with) and nurtured (i.e. reproduce) the smallpox-genome-prene.

The smallpox-genome-prene made its way from cell to cell, individual to individual, and eventually to humans by the millions. The smallpox-genome-prene had gone viral.

So, is there any important difference between the struggle of the smallpox-genome-prene and that of the Hamlet's-soliloquy-prene? I don't think there is. Even the perception that the former is "alive" while the latter is not, does not seem to matter.

The smallpox-genome-prene's creation and subsequent reproduction relied on cells created by human gene-sets. The Hamlet's-soliloquy-prene's creation and subsequent reproduction relied on brains created by those same gene-sets.

You may say that Hamlet's soliloquy is beautiful, moving, and profound, while smallpox is none of those things. Of course, I agree. But billions of years before humans evolved, prenes had been struggling to survive, and it is the fundamental nature of that struggle that we are trying to understand. We could use words like avidity, affinity, and hydrophobicity to describe why smallpox was well-received. But the words humans use to describe why a prene is well-received are of little importance. The bottom line is that, both the Hamlet's-soliloquy-prene and the smallpox-genome-prene had whatever qualities were sufficient to be well-received, and had it been otherwise, they would not have gone viral.

Most "potential prenes" are never created and typically those prenes that do come into existence quickly go extinct. Among the rare exceptions are some genes of living things, and some prenes found in the great works of art, music, science, mathematics, religion, government, and other societal prene-sets.

Let's look at one more example, which illustrates what an iffy thing it is for a prene to survive and go viral.

Consider Bach's Brandenburg-concerti-prene. Roughly speaking, Bach's whole family consisted of composers, so his head was filled with musical memes. Bach was kantor at St. Thomas Church in Leipzig, a job which required him to expend time and brain-cycles composing music. Bach processed his existing memes, including his musical ones, and created the Brandenburg-concerti-prene.

At the time of its creation, Bach was the sole instrument of the prene. But surprisingly, he was not very good at it.

Perhaps Bach performed some version of the concerti during his lifetime, but there is no indication that the Brandenburg-concerti-prene reached a large audience where it was well received. Further, while some of Bach's musical-prenes were published, it appears that the concerti-prene was not.

Bach did create a manuscript of the concerti in his own hand and sent it to Christian Ludwig, Margrave of Brandenburg. But it appears that Ludwig simply set it aside and forgot about it.

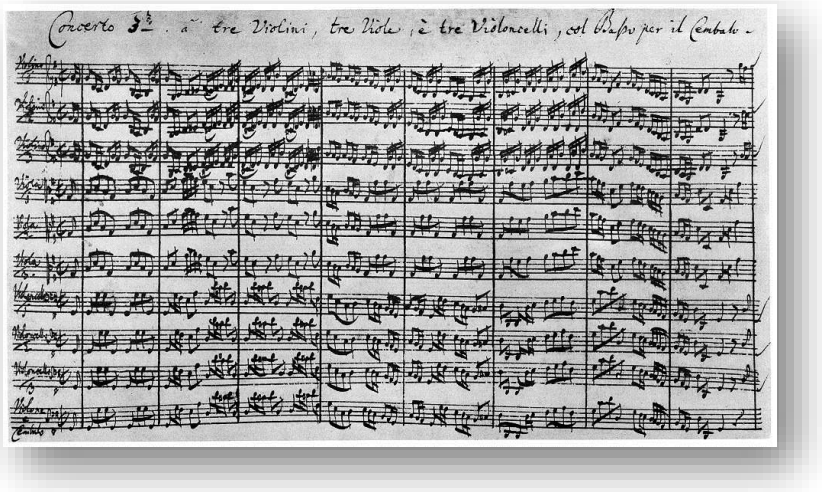

Figure 10: The third Brandenburg-concerto-prene stored in a manuscript written by Bach [Bach]

Then Bach died. Things were not going well for the Brandenburg-concerti-prene; it had not gone viral, in fact, it appears that its copy number was one, and it had no human instrument to exploit. It was teetering on the brink of extinction.

As time went by, the musical ecosystem changed, as it always does, and people stopped performing Bach's music. What changed? Perhaps baroque music stopped getting "air time" because music publishers had more attractive options like the "rocking" new prenes of classical composers like Mozart and Beethoven or romantic composers like Schumann and Mendelssohn. For whatever reason, it appears that by the early 19th century, Bach had largely been forgotten.

Then the vagaries of life smiled on the Brandenburg-concerti-prene. The musical prenes that Bach had stored on paper in the 18th century had remained, spore like, in churches and music rooms. In the early 19th century, some of these documents, but not the Brandenburg concerti, fell into the hands of Felix Mendelssohn who began championing Bach's music. Bach's musical prenes had acquired a powerful new instrument to exploit. Mendelssohn organized performances where Bach's musical prenes were well-received. Bach became popular and scholars searched for more of his old manuscripts.

Then in 1849, more than a century after its creation, the manuscript that Bach had sent to Ludwig was rediscovered. It was published the next year, and the Brandenburg-concerti-prene went viral.

So, the survival of Bach's Brandenburg-concerti-prene was a near thing. An unlikely sequence of accidents. A miracle? Hardly, compared to the smallpox-genome-prene's survival (*The resurrection of smallpox*), it was nothing but a cheap trick.

It seems certain that virtually every gene-set of every living creature, and every societal prene-set that is currently thriving only exists because of an astonishingly unlikely sequence of accidents.

When we think of "survival of the fittest", we sometimes think that it occurs in an instant: an old prene mutates, and because the new prene is more suited to the environment, it flourishes. But survival is a process, and the environment is a moving target.

Commonly, when a new prene is born in a cell or a brain, the greatest challenge it will ever face is getting to copy number two. Whether it gets there does not depend on its fitness in the greater world, but its fitness in the microenvironment surrounding its place of birth. That first black moth in industrial England most probably perished, and black mutants probably occurred many times before one got the chance to prove its worth in the greater world.

In the end, very small changes in environment can have a profound impact on whether a prene goes viral or not. Natural selection is not a simple, straight-forward

process; rather it is chaotic, and sheer luck (or lack thereof) has much to do with the outcome.

Roughly speaking, the struggle of a prene to survive resembles crystal growth. Crystals grow from spontaneously created nanoscopic seeds; many seeds form, some grow a bit larger, but almost all quickly dissolve back to nothing. Only rarely does a seed grow large enough to persist for a significant period. Very often there is little or no difference between seeds, and those that grow large are not special, they are just lucky.

Had the Brandenburg-concerti-prene gone extinct, would it have been any less a masterpiece? No doubt, many now extinct human works would have been deemed masterpieces had they ever made it beyond their local environments (See *The silver stars you wear*).

A short history of prenes

When the earth formed about four and a half billion years ago, prenes existed but genes and memes did not. Many prenes would have been stored in small physical things such as molecules, electrons, and photons, and the prenes with the most copies over the longest period of time, the ones winning the struggle to survive, would likely have been those stored in physical things that were durable; that maintained their integrity in the prevailing conditions.

The copy numbers of such prenes changed almost exclusively as a result of physical interactions that destroyed some things and created new ones. The distinction between the physical things and the prenes they stored was not important, and the laws of chemistry and physics would have provided an adequate prene-theory.

There would have been little reason to believe that things would ever change.

But, amazingly, things did change. Apparently, molecules arose that could catalyze the raw materials and energy in their environment to create new molecules identical to themselves. The prenes stored in these self-replicating molecules would have been engaged in a fascinating struggle for survival. Survival would now depend on both durability and reproductive efficiency. Optimizing with respect to such requirements in a constantly changing environment would have been a daunting task, and it seems likely that the dominant “species” one moment would be supplanted by another the next. While the first self-replicating molecules might have seemed primitive, after millions of years they would have evolved into astonishing things worthy of our admiration.

While chemistry and physics are among our greatest achievements and have done much to shape our world, we should not overestimate their power. Chemistry and physics allow us to predict some of the behavior of simple systems, but as the systems become more complex, their usefulness declines, and in systems with self-

replicating molecules, they are virtually useless for predicting behavior, and do little to enhance our theoretical understanding[6].

Fortunately, Darwin came along and provided a theory that has helped fill the void. With the theory of evolution, prene-theory finally transcended chemistry and physics.

In the popular imagination, there was a primordial soup one day and cells the next. What actually happened was almost certainly far different. My guess is that millions, perhaps tens of millions, of years passed between the emergence of self-replicating molecules and the emergence of nucleic-acid based cells. Current evidence suggests that by three and a half billion years ago such cells had emerged, and thus genes had come into existence.

Cellular gene-sets were responsible for building cells, ensuring their survival, and organizing their replication. With time, these cells would evolve into the plethora of one-celled creatures that surround us today.

About two billion years ago, cells evolved that used ion-channels and ion-pumps to create electrical potentials across their surfaces. In multicellular organisms, these cells became neurons and this electrical potential was used for rapid intercellular communication.

About half a billion years ago, bilateral creatures such as flatworms evolved with complex collections of neurons (ganglia) in their heads. These primitive proto-brains acted like electronic computers, processing sensory inputs, such as light, and inducing behavior, such as movement. The development of these proto-brains was an important step in a critical process by which genes were surrendering partial control of

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[6] These statements have a theoretical basis (see for example, [Adleman-SA]). In general, our ability to use our theories to predict the future is quite limited. Prediction requires computation, and as systems become more complex, more computation is required. Even with modern computers we cannot predict much about the behavior of systems with large numbers of non-identical interacting parts. Our current trust in computer simulations of such systems may ultimately prove unwarranted.

their organisms to a new type of prene, the proto-meme. It may well turn out that this was the worst move genes ever made.

About two hundred thousand years ago, modern man emerged with a brain composed of hundreds of billions of neurons. The meme age had dawned, and it would soon be filled with ideas and beliefs about religion, governance, science, morality, beauty, and many other things. Societal prene-sets would emerge and control much of our behavior. And the world would be filled with people struggling with internal conflicts and emotional pain. In the chapter *Humans* we will look more deeply into all of this.

Less than a hundred years ago, our memes created digital computers. Computational devices had budded off their genetic stalks and were on their own; cenes had arrived. How will they evolve? What relationship will they have with genes and memes? How will computers affect the future of humanity? That will be the topic of the chapter *Computers*.

Humans

From the prene-centric view, humans are merely vessels for storing and serving their genes, memes and other prenes. From this view, you have remarkably little to do with you.

Do you think you determine what you eat, what smells good, when you cry, where your children go to school, for whom you vote, your views on abortion, democracy, global warming, and God? From a prene-centric view, these things are determined by prenes.

Looking at humans as mere instruments of prenes will not capture the beauty and richness of our lives. If you are on a spiritual journey searching for the meaning of life, you may not like the answers that prene-theory provides. Nonetheless, looking at humans in this way may allow us to see things about ourselves that we have overlooked in the past.

What a piece of work is a man?

Among the most important features that distinguish humans from other organisms is the complexity of their prene-sets. Each of us has multiple gene-sets and multiple meme-sets. For example, I have meme-sets derived from the science prene-set, the mathematics prene-set, the American prene-set, and lots of others.

Our prenes are frequently in competition with one another, fighting to control our behavior, fighting to use us to increase their own copy-numbers (see *The selfish prene*). For better or worse:

Proposition 2

Each human stands at the crossroads of many lines of evolution

The complexity of our prene-sets makes human endeavors complicated. The example of Joan of Arc (*The selfish prene*) shows how this complexity can torment individuals, but it can also impact societies.

Let's compare honeybee society to American society.

Each honeybee hive has exactly one queen. Why exactly one? For no better reason than the gene-set of honeybees has evolved to organize hives that way. The Queen has huge influence and responsibility, but curiously, she is not special. Any egg (i.e. fertilized ovum) produced by a queen, if fed exclusively on royal jelly and mated with a drone, will become a queen. As far as I know, the eggs that become queens are chosen at random. It doesn't matter which egg is chosen because (if the queen mates with just one drone) all eggs have exactly the same gene-set and this alone will determine how a queen performs her role. Now consider America.

America has exactly one president. Why exactly one? For no better reason than the American-prene-set, and in particular the prenes in the Constitution, evolved to organize America that way. The president has huge influence and responsibility, but is the president special? Unlike honeybees, Americans are not all the same. Each is a confusing mixture of all kinds of prene-sets and therefore each would perform differently in the role of president. The behavior of a particular president cannot be divorced from the prenes acquired before taking office. All these prenes, not just those of the American-prene-set, will determine the president's behavior, and hence much of the behavior of America.

As an aside, a hive sometimes contains a small number of virgin-queens, mature females that have been fed exclusively on royal jelly but have not mated with a drone. Each virgin-queen is a potential queen. When the old queen retires, the virgin-queens engage in a ruthless fight to the death until only one remains, she will mate and become the new queen (cf. presidential politics).

Our genes built us "knowing" (through evolution) that we would live at the crossroads of these evolving, often contradictory, prene-sets, and so they provided us with hardware and software for coping.

Our genes have given us "actuators" that allow us to act upon the physical world. They have provided legs for moving, vocal cords for speaking, hearts for circulating blood, and lacrimal glands for crying. We cannot exhibit physical behavior that our actuators cannot produce. So even if you think you can fly, you can't.

Though no two people are entirely the same, to a first approximation, all (normal, healthy, etc.) humans share essentially the same actuators, and hence essentially the same repertoire of potential physical behaviors.

Our genes have provided us with "sensors" that monitor our internal and external environments. We have eyes for seeing, and ears for hearing. We have sensors that monitor our blood sugar level, and level of hydration. We have sensors that detect temperature, pressure, and taste. We may also have sensors that detect

physical and emotional pleasure and pain, but it is also possible that these are, at least partially, higher constructs created in our brains.

To a first approximation, all humans share essentially the same sensors.

Our genes have provided us with brains.

The human brain is a computer. This is not to say that the brain is digital, for example, it may have analogue parts, but that the brain cannot do anything that a digital computer cannot. This assertion is consistent with all known science and is axiomatic in the mathematical theory of computation. Digital computers are universal (*Computers*) and have the capacity to do all the remarkable things our brains do, even though, at this stage in our civilization, we don't know how to program them to actually do it.

To a first approximation, all humans share essentially the same computer brains.

So, here we are, beings with sensors, actuators, and computer brains. We are biological robots.

Wait, what? Robots? Yes, we are biological robots, at least from the points of view of prene-theory, and, I think it's fair to say, science and mathematics. If it helps, from those points of view, we are the most amazing, awe-inspiring, robots ever. From the point of view of other prene-sets, for example religious prene-sets, we are far more than robots. But in any case, we are the beauty of the world.

Figure 11: Two robots [Robots]

Let's investigate the human robot.

Because our brains are computers the laws that govern computing must also govern our brains. Fortunately, we know a great deal about these laws. We can thank a number of great mathematicians, starting in the 1930's with Gödel and Turing for this knowledge.

Perhaps the most important law is that all computers are essentially the same. Some go fast, some go slow, some are big, some are small, some use a single processor, some use many, some are made of silicon, others of DNA [Adleman-DNA], and still others of meat, but what they can do and the kinds of parts they must have are always the same.

All computers have "memory devices" that store prenes and "processors" that perform operations on them.

In general, the physical properties of a memory device have a great deal to do with the kinds of prenes that get stored in it, and the rate at which those prenes mutate.

For example, commercial computers typically have memory devices with a wide variety of physical properties. There are read-only memories, random-access memories, and others. Read-only memories are usually “non-volatile”; once a prene is stored, considerable energy is required to remove or mutate it. So, what gets stored in read-only memories? Important prenes like the kernel of the operating system. On the other hand, typically, random-access memories are “volatile”; a stored prene will “evaporate away” unless energy is constantly expended to prevent it. So, what gets stored in random-access memories? Less important prenes like the temporary information used by your browser, or the intermediate values used in the course of a computation.

It is reasonable to assume that our brains also have memory devices with a wide range of physical properties.

For example, what you are seeing at this moment is being stored in some memory device, but if you turn your head, the current prenes will be displaced by new ones. In general, it is likely that what we call “short-term memory” is stored in volatile memory devices.

On the other hand, some of our memories persist all of our lives. It is likely that these are stored in non-volatile memory devices. For example, such devices are probably storing all the things you wish you could “unsee” but can’t (sorry for bringing it up).

How does our brain decide which prenes to store in volatile memory and which to store in non-volatile? I will speculate on this in *How the brain captures memes*.

Computers use their processors to run programs. When run, programs can access sensory readings and prenes stored in their memory devices. They can make copies of prenes, create new ones, and destroy old ones. When computers are attached to actuators, programs can induce physical action in the world.

We end up with the following proposition:

Proposition 3

We are biological robots with computer brains. Our brains can process our sensory inputs and stored prenes, modify our meme-sets, and induce both physical and emotional behavior

So, for example, the first time you put your hand in fire, your sensory readings indicate pain. Your brain (and nervous system) processes these sensory inputs and creates behavior; you scream and remove your hand from the fire. Your brain may also modify your set of memes, for example by adding new ones that record the experience. After the event, your brain may continue processing and ultimately create new memes that will play a role in determining your future behavior; perhaps your future behavior will not include putting your hand in fire for a second time.

Similarly, if you watch a person skin a cat alive (*The power of belief*), your brain processes these sensory inputs and creates behavior. Perhaps you begin to salivate in anticipation of dinner; perhaps you turn away in disgust. Your response will depend on the memes you acquired during your life.

So, even though your repertoire of emotional and physical responses is provided at birth, in many cases, these responses become wedded to external stimuli through the acquisition and processing of memes.

When two people purchase identical smart phones, after a short time they will have different photos stored and different apps installed. Similarly, even though newborn identical twins have virtually identical actuators, sensors, and brains, they will soon have different experiences, and as a result, different memes stored in their brain's memory devices. Since so much of our behavior is the result of meme-dependent brain processing, the twins will begin to exhibit different behavior. They may

acquire memes that lead them to dress differently, and since memes also mediate our emotional behavior, they may develop different emotional responses to the world.

It seems to me that, more than any other factor, it is the uniqueness of our memes that make us unique.

Your prene-set

We have established (*What a piece of work is a man?*) that you are a robot, a biological machine whose behavior is controlled by your various prene-sets. In this section, I will describe your prene-sets and how you acquired it.

At the most fundamental level, there is the gene-set you got from your parents. I'll call this the "you-gene-set". The you-gene-set is the most important prene-set you will ever have. It is your first prene-set, and together with your mother's prene-sets, has almost exclusive control of you until you are born.

During the prenatal period, the you-gene-set will build your body, create the systems that will connect and maintain its parts. In particular, it will make your brain, your sensors and your actuators. It will provide you with your sensory and behavioral repertoire (*What a piece of work is a man?*).

But once you are born, the you-gene-set does a surprising thing; it invites other prene-sets to enter and share control of you. As we know, prenes in general, and the members of the you-prene-set in particular, are not noted for their generosity, so why do they do it?

Welcome to the bacterial hotel

When you are born, there are about 5 trillion cells in your body each of which contains exactly one copy of the you-gene-set (there are lots of red blood cells as well, but they do not contain DNA) [cells1]. After birth, you will quickly become infested with microbes – bacteria, viruses, fungi, etc. For example, you will have about 40 trillion bacteria in your gut; each with its own gene-set. The best current estimates are that these bacteria are representatives of about 10,000 distinct species [cells2]. So, the you-gene-set is sharing your body with at least 10,000 not-you gene-sets. These not-you genes-sets are not chosen at random, but are very carefully selected by the you-gene-set.

The you-gene-set designed your gut to be a full-service bacterial hotel. When you were born, none of the rooms were occupied, but soon after your birth they were filled with bacteria from the surrounding environment.

Why did the you-gene-set provide these bacteria with a nice place to live and plenty to eat?

The answer is, of course, that the bacteria are paying guests. For example, you are unable to digest some of the carbohydrates you consume. Gut bacteria transform some of these into products that you can digest, providing you with energy that you would not otherwise have. It is likely that there are many other ways the gut bacteria pay for their room and board, but the science on this is still embryonic.

Like all microbes, those that find a room at the bacteria hotel have their own gene-sets, their own evolutionary destinies, and really don't care about you at all. As we saw in *Prenes aren't nice* (also see *Mutation)*, if a microbe can benefit itself by harming you, it will do so without a moment's hesitation. This creates a major security problem at the hotel.

Since the you-gene-set builds the bacteria hotel and the systems that operate it, it gets to put security measures in place to help keep harmful bacteria out and to suppress those that do get in. For example, the genes keep the hotel pretty hot (98.6

degrees Fahrenheit, 37 degrees Centigrade). As a result, though all manner of bacteria enter the hotel when we consume food, many potentially harmful ones are rapidly evicted. For example, since fish live in the ocean and are cold blooded, fish bacteria have evolved to survive at temperatures far below 98.6 degrees Fahrenheit. Typically, bacteria optimized to survive these low temperatures cannot also survive at 98.6. Hence if you eat fish and acquire some typical fish bacteria, it is unlikely they will harm you. Perhaps this is why eating raw fish is more common than eating raw horse whose body temperature is very close to our own. Legal disclaimer: if you contaminate your fish with non-fish bacteria, or if your fish happen to have atypical fish bacteria (e.g. those that form spores that can survive at 98.6), then consult your physician before consuming it.

The you-gene-set also uses a trick to help assure that the initial hotel guests will be friendly. It has made it easy for maternal bacteria to pass into the baby's hotel during birth. Since the mother has already survived and reproduced, there is a good chance that the maternal bacteria are friendly. Since these maternal bacteria are the founding members of the microbial gene-set collection, they will have a powerful voice in determining future additions. Because the rooms are initially filled by these helpful bacteria, many potentially harmful bacteria are kept away because they cannot compete for a room; hence the bacteria in your gut are part of your immune system.

In fact, the human gene-set and the bacterial gene-sets have been at this game for so long that they have co-evolved, each trying to train the other to be more friendly, but that is another story.

As an aside, ensuring that only friendly bacteria reside at the hotel, has recently become a concern of memes; this has led to the study of probiotics.

The you-gene-set has built its bacterial hotel, but the hotel is surrounded by other properties with "do not enter" signs. For example, the you-gene-set does not want microbes in your blood, so it has built a blood-born immune system that will punish trespassers.

Do these security measures work? Absolutely. Do they work absolutely? Absolutely not. Most of us will from time to time get harmful bacteria and experience “food poisoning”. Some of us will get bacteria in our blood (septicemia) and die.

Welcome to the meme hotel

The you-gene-set also built a hotel for memes, the brain. The meme hotel has much in common with the bacteria hotel.

Like the bacteria hotel, the meme hotel has a huge number of vacancies when you are born but will quickly fill with memes acquired from the surrounding environment. Many of these will be "learned memes" that come from parental prene-sets, religious prene-sets, government prene-sets, political prene-sets, vocational prene-sets, and other societal prene-sets. Some will be "experiential prenes" acquire through our senses (see *How the brain captures memes*).

Like the bacteria, the memes are paying guests. Among other things, the brain/meme complex appears to allow you to react quickly and "intelligently" to your environment. It also provides you with the ability to plan your future behavior. What are you doing this weekend? The gene-sets within you don't have a clue, but your brain may have already processed your memes and made plans. So, your memes provide services that can increase your chances to survive and reproduce.

Once again, there is a big security problem. There are prenes out there that if they get into your meme hotel could harm the you-gene-set. If you acquire them, they can lead you to suicide, self-sacrifice in the name of a cause (*Why do bees kill themselves?*), substance abuse, etc.

As with the bacteria hotel, the you-gene-set builds the meme hotel and the systems that operate it. The you-gene-set chooses how much memory your brain will have for storing memes, the number of processors, when the meme recorder goes on (see *How the brain captures memes*), the number of brain-cell receptors for neurotransmitters like serotonin and dopamine, and many other things. The you-gene-set has also put security measures in place to keep harmful prenes out and suppress those that do get in.

The genes have designed your brain to rapidly acquire memes from your parents when you are young (see *How to be an unsuccessful prene*). The fact that your parents survived to produce you is good evidence that their memes are you-gene-set friendly. Since these memes are the founding members of your meme-set collection, they will resist the acquisition of future memes that would have antithetical goals. For example, if you are brought up a Christian, it is unlikely you will later convert to Judaism, and vice versa. Perhaps, this partially explains the apparent phenomenon that the young readily acquire new memes, while the old do not.

We are all aware that our genes design us to protect our children. This includes carefully controlling the memes our children acquire. We provide them with our own memes, but we also choose their schools, their places of worship, what they can watch on TV, etc.

As an aside, parents also carefully control what microbial gene-sets children acquire. The mother provides her own microbial gene-sets, but the parents also choose what and where the children will eat. Hence your parents' you-gene-sets have exploited your parents' meme-sets to help secure your bacterial hotel.

Of course, once our children become adults, they will choose the food they eat and the prene-sets they expose themselves to. That is, they will add new gene-sets and meme-sets to their collections. We have raised them to make good choices of what to add, but there are no guarantees.

The amazing you

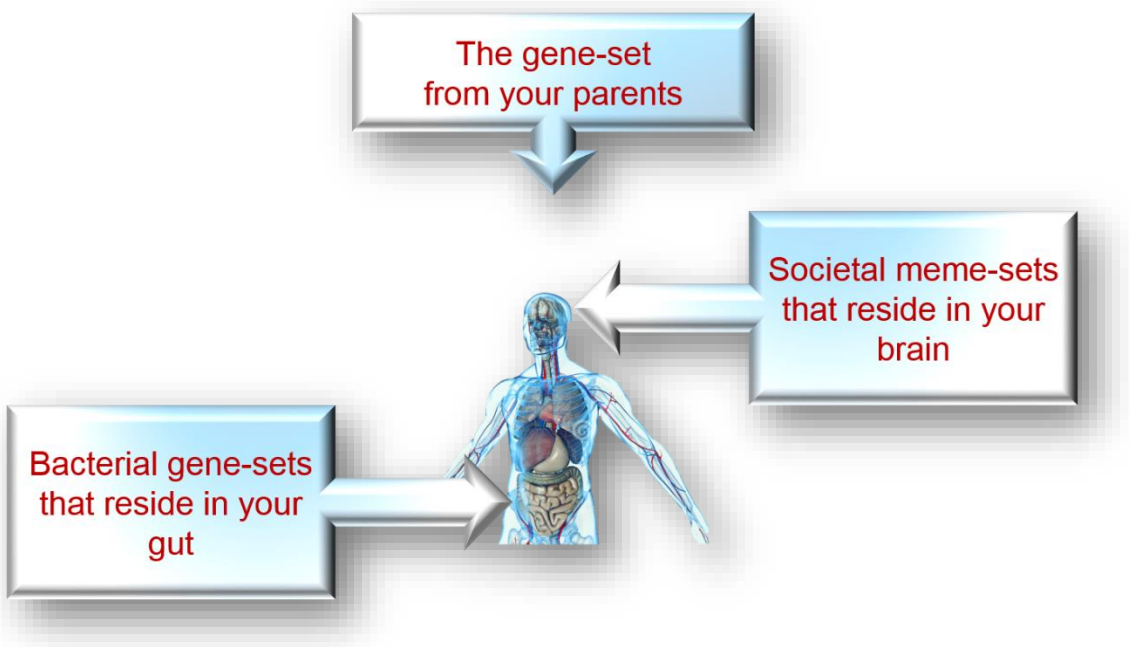

Figure 12: Major members of your prene-set

In addition to the prene-sets indicated in Figure 12, you have a few others. In your gut, and other places, there are gene-sets from non-bacterial things such as viruses, and fungi. In your brain, there are memes you acquired through your senses, and those that you generate when your brain processes the memes you already have (*How the brain captures memes*, *How the brain processes memes*). There are also some pseudo-genes (*Pseudo-genes*).

It is an amazing you. Let me explain. Consider eukaryotic cells. The typical cell has a single nucleus with a single copy of the gene-set. We occasionally see a cell with many nuclei each with a copy of the same gene-set (e.g. osteoclasts). We even see cells with no nuclei and no gene-set at all (e.g. red blood cells). What we never see is a cell that has many nuclei each storing completely unrelated gene-sets. That is,

there is nothing like a cell that contains an elephant nucleus, a zebra nucleus, a butterfly nucleus, and a fish nucleus

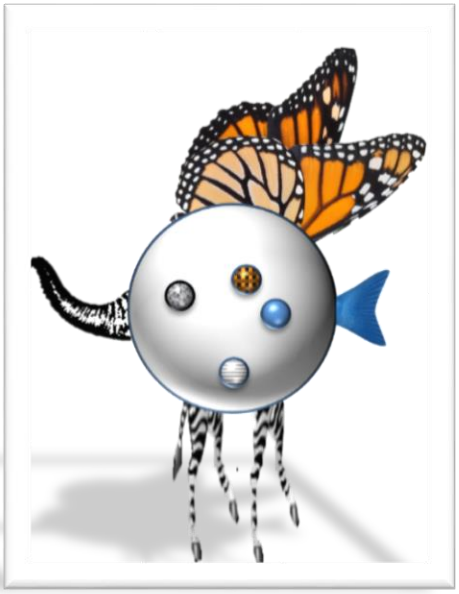

Figure 13: The quadra-nucleated Fishea-Elephanto-Zebrati-Butterflyi-cell which is conjectured not to exist.

There is a very good reason we do not see cells like that. Because it would be a total disaster. Each gene-set would fight with the others to control the cell – what proteins it would make, what morphology it would assume, what it would eat, and where it would go. Cells have not figured out how to organize such competition and hence such a cell would never survive.

But that crazy cell is like you. You have so many prene-sets. Gene-sets from humans, bacteria, viruses, fungi. Meme-sets from religions, political parties, and educational institutions. And they all fight with the others to control you: what you eat, what you feel, what you believe, where you go, whom you mate with, and just about everything else.

The surprising thing is that we are not disasters (well, not total disasters anyway) and we don't all just die of confusion. The fact that we do as well as we do is a tribute to evolution and the you-gene-set which designed your body and brain and provided the software "operating system" to deal with the mess.

There is no escape!

As discussed in *Your prene-set*, upon birth you begin to acquire memes. Many of these come from societal prene-sets. Importantly, these prene-sets existed long before you showed up. They have been waiting for your arrival. Like skilled predators, they have evolved extremely refined methods to make the most of their opportunity. They intend to capture and enslave you.

It is common for people to say that political parties, religions, and other societal entities, are “all about money” or “all about power”, etc. They are not; what they are all about is survival.

The cheetah lies in wait and then, in a sudden, astonishing burst of speed, overtakes and kills its helpless prey. The Venus fly trap entices its prey with the promise of food, and then gently imprisons and consumes it. Predatory biological prene-sets and their societal counterparts have a great deal in common.

Figure 14: Ruthless predatory prene-warriors with their prey [Predators]

Let’s explore how societal prene-sets go about their work. I will use the Catholic-prene-set as an example, but the points made apply to virtually all societal prene-sets.

Typically, societal prene-sets are large and their prenes are infused over time. For example, if you are becoming a Catholic, you will be taught the catechism early on, but only much later, if at all, are you likely to be taught the *Universi-Dominici-gregis*-prene.

In general, the first prenes you acquire are a landing force that prepares for the arrival of reinforcements.

For example, the Catholic-prene-set has learned, through evolution, that many of its prey will encounter the Church as children under the control of their already committed parents. This provides a period of several years, during which the child will be exposed to Catholic prenes. The Catholic-prene-set will use this time wisely. The child will be taken to church, sent to Sunday school, enrolled in youth groups, join choirs, etc. all of which have been created by the Church (that is, by the Catholic-prene-set) as a means of continuously and progressively infusing more and more prenes into the child's brain.

The Catholic-prene-set has also learned how to associate positive feelings with desired behavior (see *What a piece of work is a man?* and *The silver stars you wear*). A child who acquires the proffered Catholic prenes will experience feelings of success and accomplishment; one who does not may experience feelings of failure or disappointment.

The childhood route to the Catholic-prene-set is not the only one available. For example, there are occasions when the first encounter with the Church occurs in adulthood. Unlike the child, the prey is not likely to be compelled to consume the proffered prenes. The Catholic-prene-set has designed a different strategy in cases like this. The initial prenes offered are enticing and induce strong feelings that maximize the chance that the individual will stick around for reinforcements to arrive. This purpose is served by beautiful architecture, music, paintings, friendly people, free food, etc.

Not all children exposed to the Catholic-prene-set will stay the course. Some will abandon the faith, some will only go to church on holidays, some will become pope. Why does this happen?

The answer is other prene-sets. A person is a limited resource. He has a finite life span, and at each moment he can execute a certain number of brain cycles and expend a certain amount of energy. He cannot provide full service to the demands of all the societal prene-sets he will encounter.

So, eventually the Catholic-prene-set will come into conflict with other predatory prene-sets for control of the child's behavior and his future acquisition of prenes. For example, perhaps he will begin to acquire an "interest in" sports. That is, some sports prene-set will succeed in infusing initial prenes and begin controlling some of his behavior. What is to be done when there is a game on Sunday at the same time church services are being held? When the child reaches adolescence, his gene-set will make a strong bid for greater control: the adolescent will discover sex.

Figure 15: The Catechism. That boy on the left, though? Probably not going to be pope. [Catechism]

The adolescent discovery of sex is emblematic of a more profound feature of humans. Earlier (*The wars within*), I described the prenes-legislature, where prenes debate the behavior we should enact. I think of the legislature as bicameral. There is a high chamber which has our genes and a low chamber which has all the rest. It got that way because our genes built everything, and the bicameral legislature provided a way for them to carefully tailor the amount of control they would surrender to the memes. For example, the genes surrender very little power to memes regarding bodily functions such as digestion and circulation. On the other hand, they allow the memes great control over how we groom ourselves, where we go, and how we act in public.

In some cases, the genes wield power in subtle ways. For example, the genes allow the memes to determine a great deal of our behavior during courtship, but when intimacy approaches, they exert increasing control, only to rapidly surrender it when intimacy terminates. A similar thing happens when a rapid response to an emergency is required.

So, one thing a societal prene-set can be sure of is that when it infects a human, it will be taking up residence and sharing behavioral control with a gene-set. Those societal prene-sets that deal with this cohabitation well will have the genes as allies, those that do not will have them as enemies (see *How to be an unsuccessful prene*).

Discord between a societal prene-set and the gene-sets is common, and can have serious psychological consequences, for example, when one does covet thy neighbor's wife.

Nietzsche, Freud, and others have explored the conflicts between societal prene-sets and human gene-sets; sometimes seeing them as conflicts between civilization and human nature.

Just as a human may commit suicide even though none of his cells would endorse such action, a societal prene-set may induce behavior that virtually none of its followers would support. The tragic ending of the Jim Jones cult provides an extreme

example. National prene-sets often engage in wars that cost the lives of followers who would rather not participate (*Prene-warrior*).

In the end, you will acquire memes from many different societal prene-sets. They will share your resources.

A prene-set that acquires a small share will have little influence on you. One that gets a significant share will regularly impact your behavior and become “part of your life”. If a single societal prene-set acquires a very large share, then that prene-set will occupy a huge portion of your time, energy, and thoughts and become a center of your existence. You will have time for little else and may be seen by others as obsessed. Obsessed people are the ones that societal prene-sets like best and sometimes reward with important silver stars which I will discuss in *The silver stars you wear*.

Is anything in this book true?

I think it is customary for the author of a scientific book to believe that he is writing the truth. I do not have such a belief. I find some comfort from the fact that I also do not believe I am writing falsehoods.

So, what's the deal? To answer that, we have to delve into the notion of truth itself (I wonder why no one ever delved into this before[7]). What we discover will apply not just to truth, but to beauty, bravery and lots of other things, and will help us understand how human society works.

Figure 16: The gold star of truth

[7] This book touches on many topics that have been of great interest to philosophers for millennia. Though I wish it were otherwise, I lack the expertise to know how the notions in this book comport with those of the philosophers.

What is truth? Is it true that "1+1=2"? Is it true that "$E=MC^2$"? Is it true that "Christ was the son of God"?

Let's start with the easy one: is it true that "1+1=2"? What do you think? Well, let's ask a mathematician if "1+1=2" is true.

Mathematicians have taken the question of truth very seriously and after about 2000 years of effort, in the early 1930s, they succeeded in giving a precise mathematical definition[8]. So, a mathematician will apply that definition to "1+1=2" and conclude: "it is true that '1+1=2'". What he actually means is that "according to the definition of truth in mathematics: it is true that '1+1=2'". As an aside, to preserve my mathematical dignity, let me remark that I am assuming that we are working with the standard model of arithmetic.

What about "$E=MC^2$"? Is that true according to the definition of truth in mathematics? To a mathematician you might just as well ask if it is true that "love conquers all". Love has never been, and most probably will never be, defined mathematically, and it is in the nature of the definition of truth in mathematics that truth or falsity can only be applied to concepts that have mathematical definitions. Energy (E), mass (M), and the speed of light (C) are things measured in laboratories and are not defined mathematically. So, the correct thing for a mathematician to say is: "the definition of truth in mathematics does not apply".

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[8] The definition of truth in mathematics was given by Alfred Tarski in the 1930s. Once mathematically defined, mathematicians could study mathematical truth mathematically. The results are at the pinnacle of human accomplishment; they are both enlightening and depressing. Briefly and informally, in 1931, Godel was able to prove that there is more truth in mathematics than we can ever know. Even worse, mathematicians realized that they don't even know what mathematics is. Turns out that there are infinitely many contradictory "things", called structures, that deserve to be called "mathematics", but mathematicians can never determine which is the "correct one". Finally, mathematicians are not, and provably can never be, sure that someday they won't prove that $1+1\neq 2$. If that day comes, then nothing is true, and nothing is false, and everything they have ever done becomes worthless. Given that mathematics has the highest standard of truth of all human endeavors, you have to wonder what you should think when a physicist or a politician says something is true.

However, if we ask a physicist if "$E=MC^2$" is true, he will say yes. Physicists have a different definition of truth than mathematicians. The physicist's definition is (at least in the popular imagination) something like "has been demonstrated by numerous experiments", so the physicists should say "according to the definition of truth in physics: it is true that '$E=MC^2$'".

This is how it goes in general. A societal prene-set will often have a set of prenes that determine truth and falsity. I call these prenes: "veracity prenes". Different societal prene-sets have different veracity prenes. I like to think of the veracity prenes as telling followers of the prene-set the rules for placing a "silver star of truth" or a "silver star of falsehood" on things.

Very roughly speaking, for Jews the veracity prenes are found in the Hebrew Bible; for Christians, in the Old and New Testaments; for Muslims, in the Quran.

So, is it true that Christ was the son of God? For Jews: according to the veracity prenes of Judaism it is false that Christ was the son of God. For Christians: according to the veracity prenes of Christianity it is true that Christ was the son of God. For Muslims: according to the veracity prenes of Islam it is false that Christ was the son of God. For mathematicians: the veracity prenes of mathematics do not apply. For physicists: the veracity prenes of physics do not determine that it is true that Christ was the son of God, nor do they determine that it is false that Christ was the son. However, the physicist's veracity prenes allow him to make a temporal judgement; in the future evidence may appear that allows him to answer the question.

Surely, a prene-set cannot put silver stars of truth on logically inconsistent things. Well, in mathematics it is not clear whether this can happen, but all mathematicians say a prayer each night that it can't. But there are plenty of societal prene-sets that thrive with logically inconsistent silver stars of truth. For example, Christians are to take the gospels as the true, despite the fact that they are logically inconsistent, for example, regarding the empty tomb. The apparent inconsistency of a monotheistic religion with a trinity at its apex has caused a great deal of turmoil in Christianity; yet it remains the largest of all the world's religions.

From a prene-theorist's point of view, logically consistent societal prene-sets are no better and no worse than logically inconsistent ones.

Certain other prenes are commonly found in prene-sets with veracity prenes. There are the "absolute truth" prenes. The absolute truth prenes tell followers that the things with a silver star of truth actually have a gold star of truth - that is, they are not just true according to the veracity prenes of our prene-set, they are true in some absolute transcendental sense.

Sometimes there are "proselytize" prenes that tell followers that they have a duty to spread the things with silver stars of truth to people who have yet to be "enlightened", and to resist enlightenment by others.

Interestingly, logically inconsistent societal prene-sets often have the our-prene-set-is-not-logically-inconsistent-prene. For Christians, this prene is fundamental to the work of apologists. For political parties, it is fundamental to the work of speech writers.

One finds veracity prenes, absolute truth prenes, and proselytizer prenes in many successful prene-sets including Christianity, Islam, democracy, and communism. Needless to say, this can lead to conflict. Many Muslims and Christians have fought to the death, driven by just such a constellation of prenes.

Do not think that scientists are immune from these prene-driven passions. How many biologists are willing, at least in private, to declare creationists fools? Perhaps creationists have an equally negative view of biologists. But neither has a gold star of truth. When a biologist says that "According to the veracity prenes of biology: the views of creationists are false", he is articulating something about the relationship between the creationist-prene-set and the biology-prene-set. But, when he says, "creationists are fools", he is invoking an absolute truth prenes of the biology-prene-set and is not engaged in what we scientists like to think of as our honorable, dispassionate search for truth.

Educated people in western civilizations have acquired various parts of the scientific-prenes-set. They will argue (for example with me) that the veracity-prenes of science are "special" and that what science says is true is actually "really, really, true".

That science is “careful” and “correctable” and “testable” and “refutable”. But science is not special, and its “truths” are silver not gold.

So, do gold stars exist? Are there transcendental absolute truths? Lots of people seem to think so, and many are more than willing to tell you what they are.

Descartes claimed to have found one: “cogito ergo sum”. But that assertion is at best controversial and, to my eyes, misses the mark entirely. Today, Descartes’ statement does not even get the philosophy-prene-set’s silver star of truth.

Even if there actually is a transcendental absolute, “gold”, truth, I suspect that it is fundamental to the universe we inhabit and the mechanisms that control our acquisition of knowledge that we can never be sure what it is. Humans did not evolve to be truth detectors; they evolved to survive and reproduce their prenes. More importantly it does not matter. The reality on the ground is that humans have different prene-sets with different veracity prenes; they believe in different truths and base their behavior on those beliefs (see *Why do bees kill themselves*, *The power of belief*).

This brings us back to the question: Is what I have written in this book true?

Of course not, it gets no gold star. I am a scientist, that is, a follower of the science-prene-set. This book is a document produced in accordance with the dictates of that prene-set. There is no great transcendental truth here; if I worked in advertising, I would be selling dog food instead.

Figure 17: [Advert]

My book is putting forth a scientific argument designed to convince other scientists that there is something to this prene-theory stuff, that they should use some of their resources to investigate it further, and they should ultimately place a science silver-star of truth on it.

Just as a prene-set may have veracity prenes that tell followers when to apply a silver star of truth, they may also have "beauty prenes" that tell followers when to apply a silver star of beauty, "humor-prenes", etc.

Silver stars are also applied to people. For example, there may be "wisdom prenes" that dictate when a follower is to place a silver star of wisdom on a person. Einstein has been awarded such a star from the science-prene-set; Shakespeare has one from the literature-prene-set.

The constellation of silver stars that adorn a person has much to do with that person's physical behavior and feelings, and the physical behavior and feelings of followers toward him. This will be addressed in more detail in *The silver stars you wear*.

But as with truth, there are no gold stars. A thing by itself cannot be true, beautiful, humorous, or wise; it acquires such attributes only with respect to prenes that define them.

So, is democracy good and moral? We can be pretty sure that most democrats believe it is. What about Christianity, Islam, communism, capitalism, Nazism, etc.? Are they good and moral?

It is typically good strategy for a societal prene-set to have its followers believe that it possesses admirable qualities. But to a prene-theorist, such beliefs are of secondary importance; societal prene-sets are struggling to survive and using humans as their instruments. The future of these prene-sets will be determined on the field of battle and will depend solely on how well they compete with one another.

The silver stars you wear

As remarked in *Nothing in this book is true*, societal prene-sets may have silver stars of truth, beauty, etc. that can be applied to things. They also may have silver stars that can be applied to people. For example, silver stars of heroism, wisdom, cowardice, stupidity, etc.

Silver stars applied to people are typically associated with ancillary prenes that define the requirements for obtaining the star (and for retaining it), the powers that accrues to (or are taken from) those who wear it, the behavior expected of people wearing the star, and the behavior expected of followers toward such people.

For example, to obtain a silver star of heroism typically requires that the person displays great courage. Receiving the silver star is associated with positive feelings of pride and a duty to act with dignity. Followers are expected to treat someone adorned with the star with feelings of gratitude and to afford them respect. Receiving the silver star of cowardice produces the opposite results.

Figure 18: What feelings and behavior do these "silver stars" elicit in the people pictured? [Lodz]

When you meet someone for the first time, often an important aspect of your initial communication can be seen as an exploration of each other's prene-sets and silver stars. What is learned may determine future feelings and behavior regarding one another.

While some silver stars have physical incarnations, most do not. Like the silver star of truth, silver stars you wear are depended on the prene-set that defines them. They are typically visible to followers but invisible to non-followers.

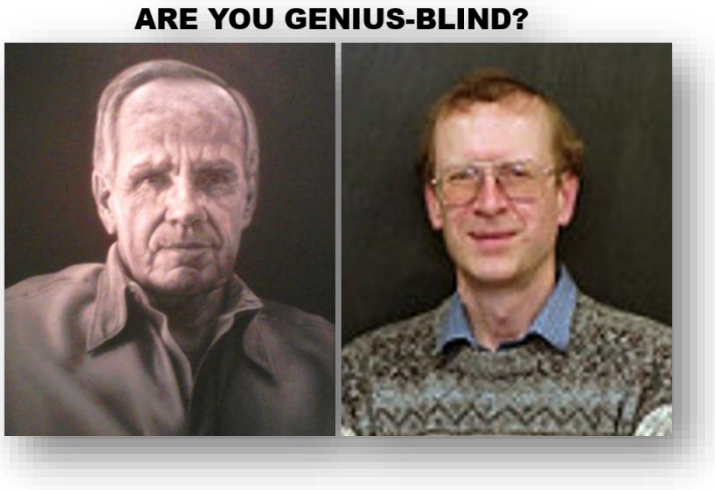


Figure 19: How many silver-stars of genius do you see?
If you see none: you have serious genius-blindness
If you only see the star on the left portrait (Andrew Wiles): you are mathematics-genius-blind
If you only see the star on the right portrait (Cormac McCarthy): you are literature-genius-blind
If you see two silver stars you are far better educated than I am. [Genius]

For example, today, Cormac McCarthy wears a silver star of genius in literature, and Andrew Wiles wears a silver star of genius in mathematics. The literati have never heard of Wiles, and if they met him would not see his star, and mathematicians have

never heard of McCarthy, and don't see his. By the way, there is no contradiction here; as a mathematician, I had never heard of Cormac McCarthy, I got his name by Googling "contemporary authors literary genius".

Since silver stars are prene-set dependent, the correct (according to prene-theory) answer to questions like "is Shakespeare a greater genius than Newton?" is not "yes" or "no"; it is "with respect to which prene-set?"

A follower may strive to achieve a silver star, but it is only other followers who can confer it. If other followers don't see the star on you, it is not yours. So, many individuals work hard and achieve personal goals, but never receive the stars they seek. Many highly accomplished musicians, artists, and actors never gain stardom.

In *There is no escape!*, I described how societal prene-sets have evolved elaborate systems to entice and capture their prey (e.g. you). Very often these systems include sequences of silver stars laid out like bread crumbs for individuals to follow. As the prey moves from star to star, he is rewarded with positive feelings and accrues power.

Societal prene-sets use silver-stars as part of their mutational strategies. They typically have silver stars that confer the power to interpret or mutate some portion of the prene-set for some portion of the followers. For example, within the Catholic-prene-set, as one moves from priest to bishop to pope, the set of prenes accessible to interpretation or mutation increases to include those further along the spectrum from ephemera to endura, (see *Mutation part 1*) and the flock of followers who are impacted grows. Societal prene-sets have learned, though evolution, to require greater contributions of resource (e.g. time, energy, and brain cycles) from followers seeking stars that confer greater power to mutate. By this means, important mutations occur only in brains dedicated to the prene-set.

There is another message worth recording here. Early multicellular organisms may not have been highly differentiated. That is, each cell may have done pretty much the same thing as every other cell. Perhaps the collected cells survived simple by virtue of size or reduced surface area. However, after about a half-billion years of

evolution, multicellular organisms have become highly differentiated. For example, in humans, each cell (except for red blood cells and gametes), carries the whole gene-set, but behaves much differently than most other cells. A heart cell, brain cell, fat cell, and T-cell do not share similar behavior. Each cell type has a different function to perform for the organism. It appears that societal prene-sets organize their followers in a highly differentiated way, and they use silver stars to do it. The pope, a priest, a nun, a crusader, and a simple parishioner all share the same prene-set but have different constellations of silver stars and different functions to perform.

Since I promised to provide guidance on achieving greatness, here it is.

To achieve greatness, you must acquire the appropriate silver star from some societal prene-set. The star may go by many names: the silver star of genius, the silver star of stardom, the silver star of heroism, the silver star of champion, etc. Sometimes the star has a physical incarnation: a Nobel Prize, an Oscar, the Medal of Honor, a title belt, etc. Sometimes it does not. It is very likely that the star you seek requires the expenditure of huge amounts of time, energy, and brain cycles.

So, the guidance is this: obsession. Be prepared to expend huge amounts of your resources. To do this, you must avoid other prene-sets that would steal a significant part of those resources. If you plan to be a great physicist, movie star, or basketball player, do not spend a great deal of time learning to become an even mediocre concert pianist. You cannot afford the resources. If you choose to seek greatness, then be prepared to give up other things, perhaps simple pleasures like going to the movies, but perhaps even a good family life and children. It is up to you to decide if the sacrifice is worth it. So, roughly, how do you become great? My prene-theoretic advice is similar to that contained in the old joke about the way to Carnegie Hall: practice, practice, practice.

How the brain captures memes

The next two sections are highly speculative.

Memes may be acquired directly from nature via our senses. They may also be acquired from other brains through processes carried out by parents, friends, teachers, political parties, governments, religions, authors, actors, musicians, advertisers, and others, using tools such as speech, books, media, and the Internet, by techniques called education, indoctrination, brain-washing, enlightenment, entertainment, training, propaganda, etc. We will call the former set “experiential memes” and the latter “learned memes”.

The world is awash with prenes for your brain to capture. How come your brain captures some and ignores others? Your genes want you to capture those that further their goals, but how have they organized your brain to make that happen? In this section, I will speculate on what appears to be an important mechanism. Let’s begin by looking at the evolution of brains and memes.

Way before brains showed up, organisms evolved what I will call “monitoring-response systems” that observed their internal and external environments and responded when something unusual occurred. These systems consisted of sensors for monitoring and actuators for responding. For example, some bacteria monitor the concentration of chemicals in their environment, and when sufficiently high concentrations of desirable chemicals are detected, respond by moving along the chemical gradient.

Eventually primitive brains evolved and where exploited to mediate some monitoring-response systems. For example, some flatworms have sensors to monitor light, touch, and temperature and appear to use their primitive brains to coordinate nuanced physical responses to the multiple stimuli they receive.

Once primitive brains with writable memories evolved, memes could exist, and it seems reasonable to guess that some monitoring-response systems would respond to

unusual situations by turning on the “meme recorder”. There is good genetic rationale for this: unusual situations are sometimes associated with future dangers or opportunities, and recording such events provides a means for designing future behavior to enhance those opportunities or diminish those dangers.

Figure 20: Surprise! [Lion]

For example, let’s say I come to your house, knock three times, and, when you open the door, I release a lion. Let’s further assume that you actually survive. I’ll bet you will never forget that day :). In fact, you can’t afford to; you must make sure that it does not happen again. To do this, you must remember what happened; you have to

turn on the meme recorder. The recorder will save valuable information like: where the encounter occurred, what time of day it occurred, who was there, etc. Information prior to the encounter may also be important; what sounds were heard, what smells were in the air? So, the content of short-term memory, where it is likely such information is stored (see *What a piece of work is a man?*), is also recorded. As an aside, perhaps such memory dumps help explain the ultrahigh resolution, slow-motion, recollection sometimes observed following serious mishaps.

The newly recorded memes will later be processed to improve future behavior. After processing, future behavior may include running the next time you see me or exercising increased caution when hearing three knocks on the door. You may also make an associate between opening doors and feeling anxiety or fear.

A similar thing may happen when a new romantic encounter occurs. The meme recorder gets turned on, and a comprehensive report is captured. You may record the location, the time, the physical feelings, the scent in the air, the special way your mate looked. As with the lion encounter, the new memes will later be processed to improve future behavior. After processing, future behavior might include recreating the original environment and seeking out your mate for more romantic encounters. You may make an associate between being in such an environment with your mate and feelings of excitement and pleasure.

Notice that the lion and romantic encounters would result in chemical changes in the brain. It seems likely that brain-chemistry dependent monitoring-response systems initiate these recordings.

When we buy a new cell phone, we treat its memory in much the same way as we treat our own. What things have you stored on your cell phone and why? Probably most of the memory is storing pictures, videos or music. But why these particular choices? Because these things produced a significant, often emotional, response in you.

In man, these ancient genetic mechanisms for acquiring experiential memes are exploited by societal prene-sets to induce the acquisition of learned memes.

It is no accident that advertising agencies have learned to use attractive people to get you to remember their beer. The Catholic church has been reluctant to take this approach but uses glorious music and wondrous art to achieve a similar effect. Indeed, baroque art itself arose as a direct result of the Catholic counter-reformation's explicit endorsement of dramatic art for the purpose of teaching Catholic prenes.

Would a 17th century Italian peasant doubt the holiness of Saint Ignatius after viewing Pozzo's magnificent ceiling fresco?

Figure 21: The apotheosis of St. Ignatius by Andrea Pozzo, church of Sant'Ignazio, Rome. [Pozzo]

I conjecture that, roughly speaking, a newly acquired meme is given a sort of priority rating. The greater, in magnitude or duration, the change detected by the monitoring system the higher the rating. Memes with high ratings are stored in less volatile memory, are retained longer, and are processed more than memes with lower ratings.

In addition, it appears that while the genes have given us a system for recording memes, they have not given our conscious minds direct control of their removal. The lower the rating, the more rapidly a meme may dissipate, but we cannot consciously hasten that process. We cannot simply decide to forget our memories; just make them go away.

So, summing up, it appears that:

Proposition 4:

Our brains are like bells, the harder they are struck, the longer they reverberate, but we do not possess the conscious power to damp them.

Though we cannot remove memes by volition alone, we can certainly add new memes to our existing set. This can be used to change behavior (physical, emotional, mental, or otherwise). The basic idea is to introduce new memes that will oppose existing memes in the prene-legislature.

The addition of new learned memes lies at the heart of many non-invasive approaches to changing behavior. Talk-therapy, some eastern religions, 12 step programs, and many others use this approach.

As an aside, a few remarks regarding mindfulness. Mindfulness is often spoken of as roughly equivalent to awareness – awareness of one's present thoughts, feelings, and situation. However, mindfulness in this form is of limited value. It can be

acquired by learning new memes that act in the legislature to resist the onset of behavior that would otherwise occur. For example, one learns to take some deep breaths or count to ten before reacting to a stressful situation. However, in many important situations far more is needed. In particular, new, expertly tailored, memes must be added (typically over an extended period) that provide an alternative behavior after the count of ten passes. When artfully done, the new memes can sometimes overwhelm the memes that initiated undesirable feelings or responses and produce behavior which is more satisfying.

The addition of experiential memes can also be used. This is the idea behind aversion therapy. If you have acquired memes that lead you to smoke, introduce a new anti-smoking meme by giving an electrical shock the next time you reach for a pack. While this approach seems tenable, our current ability to apply it seems rudimentary.

There are some experiential memes that are particularly important. I call them “pivotal memes”; they are the ones that, informally speaking, max-out the meters on our monitoring-response systems. Examples would include memes acquired when sexual fulfillment is first achieved, or when (as I understand it) heroin is first mainlined. Other examples might include the memes you would acquire if I really did show up with the lion, or if you suddenly found yourself in the middle of a gun battle.

Pivotal memes come from striking the bell with great force; they reverberate for a longtime and are repeatedly processed by our brains. They are the footprints left by major life events, and for obvious reasons, the genes have made them virtually indelible and have given them a prominent voice in the prenes-legislature. Whether acquired in positive or negative emotional situations, they become a central focus of a person’s life, and much energy and many brain cycles will be invested in planning a future around them.

When pivotal memes are acquired in negative situations, we sometimes call the result post-traumatic stress disorder. In cases like heroin injection, we might call it post-ecstatic stress disorder.

Figure 22: PTSD: when the ringing won't stop. [Bells]

How the brain processes memes

Let's turn to how the brain processes memes to determine our future behavior and to create new memes. We will have to wait for advances in neuroscience before we understand the details of this processing, but we can make few observations now.

The brain's processing is, to a significant extent, subconscious.

For example, when you cannot think of a name and it suddenly "pops" into your head, that name was discovered by your subconscious while processing your stored memes and was then forwarded to your conscious mind.

This subconscious processing never stops. If while sleeping, your subconscious discovers something of potential value to your conscious mind, it may post a notification. When you wake, you may find that notification and have an "I got it" sense.

For example, I once woke with the certainty that I could finally prove a theorem I had been struggling with for months. I arose, went to my blackboard, and had the bizarre but pleasant experience of writing the proof that, at that moment, my conscious mind was seeing for the first time.

Because long arduous subconscious processing sometimes generates memes of value that are transmitted to our conscious mind in moments, there is a tendency for people to believe that something magical, divine, or inspired is involved in human creativity.

It is a question of considerable interest why we have a conscious mind at all. This is not the question of "consciousness" and what it is; I don't find that question particularly interesting. I am content to know that the Kleene recursion theorem makes it perfectly clear that computational devices can be programmed to see themselves within their environments in real time and make decisions accordingly.

But, why was it advantageous for our genes to exploit that possibility and create our conscious minds? Was it a recent evolutionary add-on? Do non-human animals

have conscious minds? (I suspect they do). Was the conscious mind piled on top of the subconscious to act as the court of final authority when subconscious disputes among prene-sets result in dead-locks about behavior? Does the conscious mind enable quicker or better reactions to the world? Is it only in the conscious mind that we experience pain and pleasure?

There is a special version of the interactions between the subconscious and the conscious mind that I find interesting. It stems from the fact that humans can envision possible futures. For example, chess players can envision possible ways a game may unfold.

I presume that primitive mechanisms for envisioning the future arose long ago in evolutionary history. When we see an orca wobble an iceberg to dislodge a seal, or a pack of wolves hunt, I believe that we are witnessing animals with the ability to envision possible futures. Like the chess player, each wolf seems able to envision possible future positions of its prey, its pack and itself.

But if the wolf has this ability, how might the genes exploit it when the wolf is not hunting. Do wolves use it to create dreams of hunts as a means of sharpening skills for the future?

In man this ability is highly developed. Our brains create possible futures complete with moving images, sounds, feelings, things, and people, including ourselves. Our existing memes are part of the raw material for generating these possible futures, and, it seems likely that experiential memes with a high priority rating are the most likely to be incorporated. Our subconscious can create possible futures, and experiment with possible behavioral responses. Perhaps, in much the same way as current AI programs behave, when an experimental behavior is perceived to have a negative outcome, the brain modifies its memes to decrease the likelihood of that behavior actually occurring in the future; when perceived to have a positive outcome, the likelihood is increased. When these possible futures are explored at night, we call them dreams.

This may be part of the means by which memes are processed to determine our future behavior.

The importance of subconscious processing cannot be overstated. We know from work on vision, that our genes have programmed our visual pathways to process our visual inputs before presenting them to our conscious mind. Perhaps this kind of processing is not entirely hard-wired. Perhaps some processing occurs in the software as well.

As I have suggested (*Your prene-set*) your brain is a battle ground for discontent memes and genes waging a civil war for your behavior. Each of these combatants would like you to see “reality” in a way that serves it best. I suspect, and it is purely speculation, that our brains have been programmed by our genes, to process these disparate realities subconsciously, and present a carefully digested, piecewise continuous, “unified reality” to our conscious minds. We may be like children, restricted by our parents to watching a Walt Disney version of the world. The thing you call “you” may just be the icing on the subconscious cake.

The power of belief

In *Why do bees kill themselves*, we saw that beliefs can program our physical behavior. Can they also program our emotional behavior, and, it particular, how we feel?

Consider the following true story:

> *I once saw a video of a man skinning a cat alive and throwing it into a kettle of boiling water – I was repulsed and angered – however, the man in the video was just preparing dinner for his family and presumably had a very different response.*

The sad story of the delicious cat can teach us some valuable lessons about the nature of memes and behavior.

My emotional response seemed spontaneous and visceral. *A priori*, I would have thought that only my genes could induce such behavior. However, since essentially the same stimuli led to quite a different response in the man, there is little chance that gene-sets were responsible.

It seems clear, and, of course, comes as no surprise to sociologists, that the differences in responses can be traced to differences in cultures. I had acquired beliefs that cats were cute, and that harming animals was abhorrent. The man in the video had acquired different beliefs. By the way, do you like lobster?

Hence:

Proposition 5

Memes, and in particular beliefs, can induce physical and emotional behavior

Let's take a brief detour to clear up which memes are beliefs, and which are not. Some memes have a large impact on our behavior while others do not. For example, the if-you-say-you-will-do-something-then-you-must-do-it-meme I acquired from my parents has had a big impact on my behavior, while the when-you-wish-upon-a-star-your-dreams-come-true-meme I got from Walt Disney has had almost none. Informally, we might say that the difference is that I "believe" the former but not the latter.

Turning this on its head, I use the term "belief" to denote a meme that has a significant impact on behavior (emotional, physical, mental, or otherwise). In reality, there is no clear line that separates beliefs and non-beliefs; it is a continuum.

It is not unusual for a person to acquire beliefs that dictate contradictory behaviors. For example, an individual may acquire religious beliefs when young, and scientific beliefs during early adulthood. The former may include creationism; the latter evolution. When it comes time to vote on abortion issues, these beliefs may dictate contradictory behaviors. As discussed in *The wars within,* such situations can produce psychological distress.

There is another important lesson to be learned from the sad story of the delicious cat. As best I can determine, my dramatic emotional response was not mediated by my conscious mind; it was entirely subconscious. I believe that:

Proposition 6

People are often unaware when their memes are influencing their behavior

These propositions play out on a daily basis in our lives and impact even our mundane behavior.

For example, most people seem to think that the opinion they express on a politically controversial topic such as abortion or gun control is "reasonable" or "true" or

"based on science" or "derived from unassailable authority", or, or, or. In reality, for the most part, it is determined by the political beliefs they were taught when they were young by their parents, their peers, their schools, their churches, the media, the Internet, etc.

When you speak with someone of a different political persuasion, you may see them as unthinking parrots simply reciting the slogans fed to them by their political overlords. You are probably right to think of them like that, but are you willing to think of yourself that way as well?

Probably not. We have all acquired a variety of meme sets: political meme-sets, religious meme-sets, scientific meme-sets, occupational meme-sets, etc. These sets are in your brain, and they are actively trying to use you to further their aims. They don't like being ignored. So, part of the challenge of leaning prene-theory is learning to put on your science-hat and keep your other prene hats at bay.

As an exercise, the next time you begin a political discussion with someone who does not share your beliefs, try seeing it from the prene-centric viewpoint. You and the other person are merely prene-warriors unconsciously in the service of political prene-sets that have been at war for centuries. Your discussion has been repeated, *mutatis mutandis*, millions of times, and likely with the same results: unresolved and often unpleasant disagreement. In the future, perhaps you will listen to your mother's advice.

Figure 23: Linus the prene-theorist. [Schultz]

Prene warrior

Earlier (*The war within*), I described how prene wars within you can lead to psychological distress. But these are not the only kind of prene wars. Societal prene-sets are constantly at war with one another. These are the kinds of wars that occur between nations, political parties, and religions; the kinds that historians write about.

In this section, I will describe an occasion when I ended up as a prene-warrior in a war between the academic-prene-set and the national-security-prene-set.

In the late 1970s, I was a professor of mathematics at MIT, and with two MIT friends, Professors Ron Rivest and Adi Shamir, produced a short manuscript with the title “A Method for Obtaining Digital Signatures and Public-key Cryptosystems” [RSA]. We did not realize that we had just collided with a powerful prene-set whose existence was unknown to us. The prene-set belonged to the National Security Agency (NSA) and the reverberations of that collision are still with us today.

Our cryptosystem became the topic of a column in Scientific American [Gardner]. In the column, we offered to send a copy of our manuscript to anyone who would send a self-addressed stamped envelope to MIT.

My first clue that there was something strange going on came when I happened to be standing in line at a book store in Berkeley and the customer in front of me said to the cashier words to the effect: have you seen this article on crypto in Scientific American? The cashier replied “Yeah, that’s so cool!”. I realized what they must be talking about, and in a youthful burst of pride said “Oh, that’s our stuff …”. The customer took his copy of the magazine and asked me to autograph it.

I know you probably think that mathematicians are constantly accosted by strangers seeking autographs, but it had never happened to me before, and I had never considered that it ever would.

But things got even stranger when I returned to MIT and found that there were thousands of self-addressed envelopes being stuffed with copies of the manuscript.

And the addresses seemed odd as well, things like “The Bulgarian Department of Intelligence”.

We soon received a letter from someone informing us that we could not send the manuscript out of the country – it was against the law. What? What law? What is going on?

We found out that the letter came from an employee of the NSA, an agency we had never heard of. It turned out that the NSA was the largest intelligence agency in America – bigger than the FBI and CIA combined – and so secret that it had a “black budget” and was unknown to most in government; those who did know of it referred to it as “No Such Agency”.

The NSA was a “black chamber”, the centuries old name given to the government agency responsible for making a nation’s secret codes and for breaking the codes of other nations.

Our paper had changed everything. Our code was good mathematics, it was not kid’s decoder ring stuff, and when it appeared in Scientific American, it apparently meant that the Nation’s enemies could now use a code that the NSA could not break. A major source of intelligence could dry up overnight. A very bad thing. And, in fact, even today terrorists use our code to keep their plans secret. But our code was double-edged. It could also be used to protect every American from agencies, both foreign and domestic, that might wish to violate their privacy. A very good thing. And, in fact, our code is widely used for that purpose. When your private information (e.g. credit card numbers, medical records) is sent or stored on the internet, you are most likely using our code to keep that information secure.

Had I known all this before we had published, I would have had a great moral dilemma on my hands, but the code was out there now, and things would just have to evolve as they would.

Apparently, the Scientific American publication hit the NSA hard, and they responded with vigor. The letter was just the beginning; it was followed by attempts to secure legislation that would inhibit the wide spread use of our code; attempts to

create a new national standard code different from ours, and widely suspected to be intentionally flawed so that the NSA could break it.

The NSA even tried to co-opt me by offering a sweetheart consulting deal. While MIT took the position (which I actually agree with) that it was a privilege to teach and do research there, and an affront to expect anything but a subsistence wage, the NSA took a wholly different position. I was tempted by the NSA offer, but declined. I have sometimes wondered if this episode eventually led to the related scene in “Good Will Hunting”.

The prene-war that started then continues to this day. The recent information revealed by Edward Snowden alludes to the fact that the NSA is still attempting to mitigate the impact of our code [Menn].

At any rate, we had inadvertently attacked the NSA and it had turned to confront us. I was now involved in a prene-war pitting the national-security-prene-set against the academic-prene-set. I was under attack but would soon get the opportunity to counterattack.

As a matter of routine, every few years I sought and received a grant from the National Science Foundation (NSF) to do my mathematical research. The NSF is the major funder of pure mathematical and scientific research in the United States. In 1980, I was seeking my next grant.

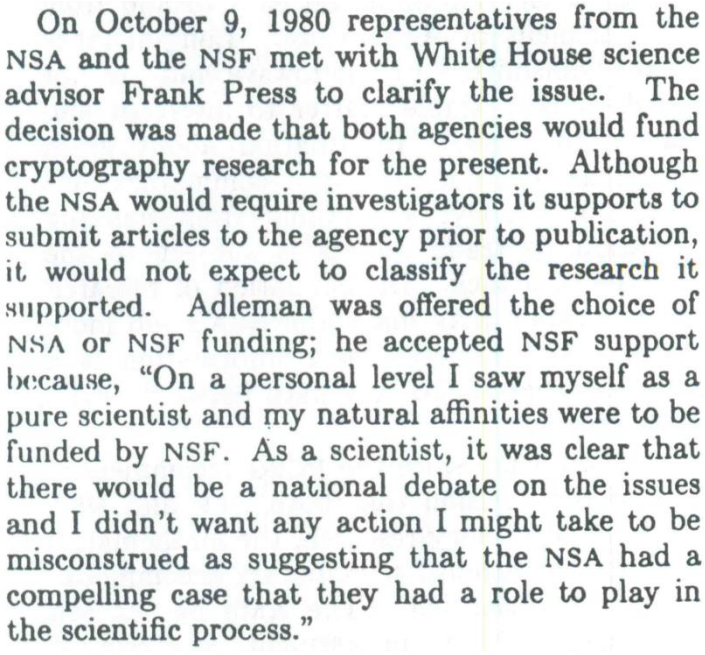
The procedure was well known: I would write a proposal of about 30 pages describing how, if given the money, I would do such amazing mathematical things in the next few years that the Nation would thank me and the NSF. Since our manuscript had made crypto a very hot academic topic, I included a few paragraphs about how, despite the fact that everything I planned to work on appeared on the surface to be pure mathematics devoid of any possible use, my work actually had great practical importance because it was applicable to cryptography.

I submitted my proposal and received a call from NSF. They informed me that they would be delighted to give me the money and, oh, by the way, the NSA generously decided to fund the part of the proposal that involved cryptography.

I hung up the phone and knew that I had just won a major battle.

I began the counterattack. I picked up the phone and dialed Gina Kolata, a distinguished science writer at The New York Times. I had known Gina for several years, and I said I had a story that she might find interesting.

A few hours later, I got another call, this time from the head of the NSA, Admiral Bobby Inman, explaining that there may have been a small misunderstanding. But it was too late; the counterattack was under way. The next day the story appeared on the front page of the Times. Soon after the NSA sued for peace:



On October 9, 1980 representatives from the NSA and the NSF met with White House science advisor Frank Press to clarify the issue. The decision was made that both agencies would fund cryptography research for the present. Although the NSA would require investigators it supports to submit articles to the agency prior to publication, it would not expect to classify the research it supported. Adleman was offered the choice of NSA or NSF funding; he accepted NSF support because, "On a personal level I saw myself as a pure scientist and my natural affinities were to be funded by NSF. As a scientist, it was clear that there would be a national debate on the issues and I didn't want any action I might take to be misconstrued as suggesting that the NSA had a compelling case that they had a role to play in the scientific process."

Figure 24: Landau, Susan, Notices of the American Mathematical Society 1983 [Landau]

Today, the situation is pretty much as described by Landau, both NSF and NSA provide grants for mathematicians, and mathematicians may choose which direction they want to take.

It has been many years since then, I now see the prene-war that I was engaged in as just that and nothing more. I no longer think that I was "right" and they were "wrong". In fact, I think they behaved most admirably. I had been taught most of my

political prenes at Berkeley (B.S. 1968, Ph.D. 1976) and believed the absolute-truth-prene (see *The gold star of truth*). Now that I am a prene-theorist, I understand that all involved were playing their expected roles as prene-warriors for their respective prene-sets.

But the bigger message of all of this is what it says about the nature of prene-sets and how to fight a prene-war.

Prene-sets are often bristling with triggers and if you pull one, behavior can be dramatically altered.

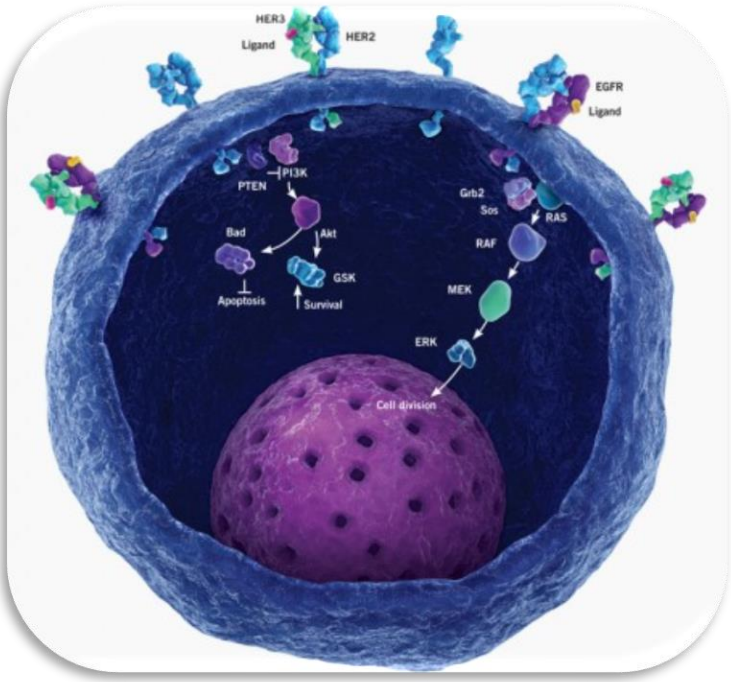


Figure 25: Breast cancer cell, expressing the HER2 surface receptor protein. Once HER2 binds to HER3, the cell undergoes cell division and growth. [Fenner]

For example, cells are usually covered with surface molecules called receptors put there by the gene-set. These are the triggers. If a molecule, called a cognate ligand, has just the right shape, it will bind to the receptor, pulling the trigger and

initiating a cascade of events within the cell leading to a significant change in its behavior.

Some human cells have insulin receptors on their surface and when insulin binds, the cells begin to take glucose from the blood, lowering blood sugar levels. Other human cells even have receptors that if bound cause them to commit suicide (apoptosis). Why would a human cell have such a receptor? Well this gets back to sacrifice (*Why do bees kill themselves?*). For example, when humans form in utero their hands grow as solid bodies and only when some cells apoptose are the fingers defined.

Individuals are also covered with triggers. When speaking to a friend, we are often aware that there are certain words or topics that we cannot introduce because of the changes they will induce.

Pulling a trigger on a prene-set is like gently dropping a feather on a mountaintop to initiate an avalanche; a tiny input produces a large output. When a trigger is associated with a particularly dramatic change, as in the apoptosis case, we can think of the trigger as a tipping point for the prene-set. Since prene-sets evolve through time, trigger points exposed today may be gone tomorrow.

I was lucky. I had previously established a good relationship with Gina Kolata, so I felt comfortable calling her. She wrote for the New York Times, one of the world's largest prene-spreading instruments, so I could be confident that my prene would go viral.

A far more dramatic example of using a feather occurred in Sarajevo on June 28, 1914 when Gavrilo Princip, a Bosnian Serb, assassinated Archduke Franz Ferdinand of Austria. Though the people of Europe were unaware of it, the constellation of their national prene-sets had exposed a trigger that Princip pulled with astonishing effect. The Archduke was the first to die, but about forty million people, followers of their national prene-sets, were killed or wounded in the war that followed.

A similar approach is being used in the militant-Islam-prene-set's war with the Western-prene-set. It goes like this. A small group of militants kill a small number of

what, to the Western-prene-set, are innocent people. Best, if it is all on video, because a feather is being dropped on the Western-prene-set via the Western media.

The Western media is exquisitely triggered to respond to exactly this kind of thing. Way before this attack, the media had secured the services of a swarm of consultants who are available 24/7 to appear and discuss the implications: who might be responsible; what might they do next; what should you tell your children; what should we do: nuke them, get them jobs. The Western world will get end-to-end coverage for days; economic, social, and other issues will be driven off the air and their natural trajectories will be altered. The cost to the militant-Islam-prene-set: small. The impact on the Western-prene-set: huge.

How should one fight a prene-war? Hard to say, but it is important to know the enemy prene-set well, and to remember that the prene-set itself is the primary opponent; not its instruments (i.e. its followers, its weapons, etc.).

A prene-set's instruments can be attacked using physical force. The prene-set itself can be attacked by mutating it. Both the sword and the pen have their place.

For example, the Allied victory over Japan in World War II was largely achieved by using physical force to attack the instruments of the Japanese-prene-set, but the transformation of Japan into a US ally came largely from mutating that prene-set. Post-war, the United States occupied Japan and mutated the monarchical-militaristic Japanese-prene-set into a democratic-pacifistic one. The United States succeeded in producing generations of new followers for some of its most important prenes. A different post-war strategy was used by the Romans at the end of the third Punic war.

In my opinion, we are experiencing a major shift in the balance between force and mutation. I suspect that the primary battleground of the future will be the Internet and prene-sets will mutate one another by the application of propaganda, education, enlightenment, etc.

The United States with its expertise in advertising, media, and computer science has considerable potential in this area, but has yet to fully exploit it.

The struggle between prene-sets is often prolonged. We use words like war and peace, victory and defeat, but these merely describe particular epochs and instances in the process. The Islamic-prene-set and the Christian-prene-set have struggled for over a thousand years with many periods of war and peace, and many instances of victory and defeat, but there is no end in sight.

We are all prene-warriors in the service of the prene-sets we acquire, though most of us are not conscious of that fact.

Human discourse

As an exercise in prene-theory, I (essentially at random) downloaded and analyzed the following debate entitled “Should we fear the power of government over the Internet”? [Wagner].

Point	Counterpoint
The internet is a means of communication – therefore also a means of communication between criminals. And because it is global it creates global crime problems that need coordinated responses. One type of crime that has particularly become a problem on the internet is child sexual abuse material: the internet allows for an easy and anonymous distribution method which can even be secured by modern encryption methods.[1] Governments can help fight this by requiring ISPs and mobile companies to track people's internet histories, hand over data when requested, and allow police to get information from them without a search warrant, something which has been proposed by the Canadian government.[2] In Australia, the government even proposed mandatory filtering of all internet traffic by ISPs to automatically filter out all child sexual abuse material.[3] Admittedly, these measures seem drastic – but in cases like these, or similar cases like terrorism, the harm prevented is more important. *[1] 'Child Pornography on the Rise, Justice Department Reports'. 2010.* *[2] 'Current laws not focused enough to combat child porn online'. 2012.* *[3] Mcmenamin, Bernadette, 'Filters needed to battle child porn'. 2008.*	*Everyone is against child sexual abuse material. But in their drive to battle it, governments might go too far. For example, granting the police the right to search without (full) warrant is a harm to citizens' basic right to privacy and freedom from unwarranted government surveillance.[1] The automatic internet filtering and data retention are possibly an even worse infringement on basic civil liberties: it designates all internet traffic and therefore all internet using citizens as suspect, even before a crime has been committed. This overturns the important principle that people are presumed innocent until proven guilty. Moreover, instead of the police and prosecution changing their behavior, internet filters hardwire these new assumptions into the architecture of the internet itself.[2] This means it is more all-pervasive and less noticeable, thus constituting an even worse violation. These draconian measures might even seem worth it, until you realise they don't work: blocking and filtering technology makes mistakes and can be circumvented easily.[3]* *[1] 'Online surveillance bill critics are siding with 'child pornographers': Vic Toews'. 2012.* *[2] Lessig, 'Code is Law'. 2000.* *[3] 'Why government internet filtering won't work'. 2008.*

First, do you think that the person who wrote the point is taller than the person who wrote the counterpoint? Stupid question? Perhaps, but there is a purpose. Whoever these people are does not matter very much, if not them, then someone else. These people have been infected with particular prene-sets and they are acting as instruments for those sets. By and large, people are interchangeable parts suitable to act in the service of any prene-set that infects them.

It is as if it mattered which camera was used to show you a football game. One camera or another, what difference does it make? Cameras are all basically the same and if you point them at something, then they will convey it. If they are expensive cameras, they may obtain higher resolution or briefly store and process the images for contrast or color before sending them out, but we would be foolish to think that the cameras themselves created the images. Both the cameras and the people are vessels though which other things are passing.

Sure, some people are better than others as advocates for particular prenes, and yes, we all wish to think of ourselves as special, but the arguments put forth by the debaters, after what I assume was considerable reflection and effort, are merely personally processed prenes derived from societal prene-sets (in particular political prene-sets) that evolved long ago and which the debaters acquired from others. The political prene-sets will likely persist well into the future, while the debater's flourishes are unlikely to endure.

Now who is telling the truth, the pointer or the counterpointer? Of course, by now you know that there is no gold star of truth (*The gold star of truth*), so really we are asking: according to which veracity prenes are they getting silver stars of truth? We can be pretty sure that both would give themselves silver stars based on their own veracity prenes. My mathematical prenes assign neither of their arguments a silver star of truth; the issues under consideration are just not definable mathematically and the veracity prenes are quiescent.

The scientific-method veracity prene might, in theory, have something to say about which gets a science silver star of truth. Perhaps, if a gazillion well-designed

experiments are carried out and yield consistent results, science silver-stars would be awarded. Of course, those experiments will never take place. In fact, with systems as complex as governmental measures on the Internet, a well-designed experiment is almost inconceivable. Science is good with simple systems: if I let go of this ball, will it go up or down? If, despite my skepticism, experiments are done, they will most likely be controversial with respect to subjects, duration, end-points and a thousand other things – including that big one, experimenter bias; will experiments with outcomes that favor the pointer come from experimenters who share beliefs with the pointer and vice versa? Even if we ignore all of that and a lot of experiments are done, there is virtually no chance that they will yield consistent results, and even if they do, there is virtually no chance that all interested parties will agree that enough was done in the correct manner to warrant a scientific silver star of truth.

We frequently see followers of societal prene-sets try to apply scientific or mathematical veracity-prenes in an attempt to be “rational”. This is typically a fool’s errand.

More importantly, it does not matter who is telling the truth, what matters is how successful each writer has been in increasing the copy numbers of their prenes. Truth is overrated. In some settings, telling the “truth” can be a useful means of spreading prenes, but the same can be said for telling “lies”. If you really want to get serious about spreading prenes, then go to an expert like an advertiser or a political consultant. Neither of them will bother you with issues of truth.

For me another striking thing about this debate is: who cares? As a matter of fact, I do, but that is not the point. There are, presumably, thousands of such debates online and the number of debates, formal or otherwise, humans have undertaken could be in the trillions. There is an endless parade of topics. Did we care about internet governance fifty years ago; will we care fifty years from now? The topics of human debate are just prenes; some last a long time: “Is there a God?”, “Is democracy the best form of government?”; some are evanescent: “Will the Y2K problem bring down the banking system?”.

Prene-sets enter the arena of struggle and sometimes succeed in infecting people who then become instruments for the set's survival. An individual once infected may go through a standard kabuki dance using standard forms to fight for the prene-set's survival.

Shakespeare again:

Life's but a walking shadow, a poor player
That struts and frets his hour upon the stage
And then is heard no more. It is a tale
Told by an idiot, full of sound and fury
Signifying nothing.

So where does this constant stream of new debate topics come from? Successful prene-sets are often prene generators. They radiate new prenes in their struggle to survive. For example, political prene-sets constantly generate prenes that will fortify the followers and attract non-followers. Opposing political prene-sets generate opposing prenes and debates like the one above ensue.

The debate above also reveals how difficult it can be to conceal one's societal prene-sets. What did you learn about the person who composed the debate topic? Why did he write: "Should we fear the power of government over the Internet?", rather than: "Should government protect us on the Internet?". Fear? Protect? By that choice, the person has revealed much about his political prene-set.

As it turns out (and I discovered this only after completing my analysis), the web site gives a brief biography of the "curator" of this debate (who, I will assume had a hand in composing the debate topic). Among other things, he describes himself as a fellow of "Human Rights Watch in Berlin". Now we know why he wrote the topic as he did.

I have little doubt that the curator tried to be fair to both sides. Nonetheless, quite possibly unconsciously, he biased the debate in support of his beliefs. This kind of thing is ubiquitous – it is almost impossible to avoid.

The press constantly claims impartiality (whatever that is) while biasing the news. In America, if you watch FOX news and do not see the bias, it is not because there is none; it is because you are a conservative. If you watch MSNBC and do not see the bias, it is not because there is none; it is because you are a liberal.

Would the nice people in the news media manipulate us this way? Of course, they would, and they may not even be conscious of the fact that they are doing it.

If you are on one side or the other of the political divide, you will find it almost impossible to watch “news” from the other side. This is because your political prene-set, left or right, occupies you and will resists opposition.

Happiness

Proposition 7

Your prenes care not a whit about your happiness per se

This should come as no surprise, because the only thing prenes care about is themselves.

To paraphrase the Declaration of Independence:

All men are created by their genes for Life and the pursuit of Happiness

The you-gene-set created you to *pursue* happiness; it did not create you to be happy all of the time. If your genes wanted you to be perpetually happy, it would have been no problem. They would have built you without pain receptors, they would have put your brain cells in a perpetual endorphin-positive state – you would not live long and you would not reproduce, but you would feel great until the end. Serious drug addicts try to achieve a similar state with similar results.

You are designed to seek happiness and avoid unhappiness. The you-gene-set built your brain and chose its features: the amount of memory, the number of processors, when the meme recorder goes on, the number of brain-cell receptors for neurotransmitters like serotonin and dopamine, and a thousand other things that drive you to pursue happiness and ensure that you never achieve enough of it.

Just as the genes make some people tall and others short, they make some people with sunny dispositions and others with gloomy ones. The gloomy people may experience more unhappiness than the sunny people. However, this does not necessarily mean that they are less likely to accomplish the goals of their genes. I suspect that, on average, gloomy people generate about the same number of offspring who reach adulthood as sunny people. Gloomy dispositions are a perfectly viable strategy for the genes.

I am not a psychologist[9], but in my view, the vast majority of individuals with psychologically defined maladies, such as depression, have no genetic abnormality, no "imbalance", and no physical anomaly. This is not to say that they do not have genuine suffering, they most certainly do.

Independent of your genetically endowed emotional base state, much of your happiness in life will be determined by the prenes you have acquired and those you acquire in the future. Be warned: societal prene-sets learn very quickly to offer happiness to potential followers. Often, they will define happiness for you: freedom from physical pain, financial security, salvation, respite from internal stress.

[9] Nonetheless, a brief remark on Freud's tripartite structural model of the psyche consists of the id, the superego, and the ego. This structure seems similar to the structure we have been describing where the genes, the memes, and the gene-built operating system in our brains play analogous roles.

Do humans deserve more credit?

I have been hard on humans. Saying demeaning things like “From the prene-centric view … you have remarkably little to do with you”.

I have argued that humans are robots with gene-built computer-brains and gene-built operating systems. We are like driverless cars that move around the world and “decide” when to stop or go; when to turn right or left. We are prene-bots.

But there is another view, one that every human believes: we deserve a great deal of credit for what we do. We think and agonize about the future and make critical decisions. We decide how to raise our children, how to vote, what to create, who to love, and where to eat lunch. This is the view that gives our lives purpose and makes them worth living.

So, am I just being a misanthrope to ignore all that? No; let me explain.

The two views are not contradictory; they are perfectly compatible. There is no scientific or mathematical reason to think that a programmed robot cannot have an internal perception of turmoil, contemplation, choices, decisions, love, and hate. Indeed, you are a living example of that fact.

Perhaps people think of these views as incompatible because they think that being programmed means being predictable. Actually, mathematical theory supports the opposite: there is nothing less predictable than a program (see *What a piece of work is a computer?*). Typically to see what a program will do, you simply have to wait for it to do it. At any rate, you are far too complex to be predicted efficiently. Certainly, you yourself cannot predict what you will ultimately do. When you decide to do

something, typically your conscious mind did not know what that something was, until you decided to do it.[10]

So, we actually get the best of both worlds: we humans are all of the complex, wonderful things we think we are, and we are programmed robots.[11]

Why not just include all of that wonderful stuff in prene-theory?

I wish I could.

One of the major follies in trying to build a powerful scientific theory is to include too much. Powerful theories only address limited topics.

Consider ancient numerology, astrology and alchemy. They were grand "theories" that tried to do too much. They tried to tell us how numbers, heavenly bodies, and substances influence the destiny of people. They ended up degenerating into blather. Science no longer takes lucky numbers, the signs of the zodiac, or the philosopher's stone seriously. It is only when these ancient theories jettisoned the extraneous and focused on the core: numbers and how they are added and multiplied,

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[10] This is part of a larger picture (which I cannot articulate with precision): the behavior of a complex machine cannot be predicted by a smaller machine more quickly than the complex machine itself unfolds. For example, the universe seemingly cannot predict what the universe will do faster than the universe will do it. Otherwise, one has a very sticky self-reference problem.

[11] Roughly speaking, researchers in the humanities and social sciences view humans as wonderful things, while those in the sciences view them as robots. As a result, when the former group investigates human endeavors, they see humans and the choices they make as primary. So, historians may focus on "great men", psychologists may investigate the impact of peoples' choices on their happiness, and philosophers may consider how people make moral decisions. Scientists do not consider such things but may study the chemistry and structure of the brain, the role of pathogens in disease, or the mechanisms of morphogenesis. The two worlds share little in common. Prene-theory is on the science side of this divide; however, it is closer to the border than other sciences, and ideally, a prene-theoretic view of human endeavors will complement and augment what is currently found in the humanities and social sciences.

matter and the laws that govern its motion, molecules and how they react, that they became powerful scientific theories: number theory, astronomy and chemistry.

Like number theory, astronomy, and chemistry, prene-theory is a scientific theory. Like other scientific theories, it is reductionist and sacrifices a grand view for a narrow one with enhanced clarity.

We have seen reductionist theories before. To the physicist, you are the superposition of quantum states evolving according to a Hamiltonian; to the chemist, you are a collection of interacting molecules obeying the laws of mass action. Neither physics nor chemistry will inform you about God or love. But physics provides cat scans, radiation therapy, microwave ovens, and nuclear bombs; chemistry provides pharmaceuticals, fertilizers, plastics, and poisons.

In 1859, Darwin provided us with a powerful scientific theory that had living things and how they evolve at its core. Turing and Dawkins opened the door to a broad generalization of Darwin's theory that has prenes and their evolution at its core. As a result, we can now see that the Hamlet's-soliloquy-prene struggles to survive, and that religious prene-sets mutate, evolve, and war with one another. We can look behind human endeavors and see prenes pulling the strings.

To avoid the mistakes of the ancients, we will have to leave the wonderful things about humans behind. Those wonderful things are the subject of many other disciplines and will have to remain so.

In prene-theory, humans will not get the credit they deserve.

Why do we die? [12]

In *Why do bees kill themselves?* we saw that prenes sometimes program the suicide of one of their own to increase future copy-numbers. Prenes are also perfectly willing to let one of their own die of neglect if that will help. In fact, this is often what they do, and unfortunately, you and I will very likely be victims of that neglect.

So, why do we die? Even worse, why do we die in less than 150 years? I will argue that it is not because our genes failed to build us to last longer, but because they had good reason not to try. Let's start with an analogy.

Assume that you are a car manufacturer designing next year's model. The style, emission control, etc. have all been settled. The last thing on your agenda is to determine what metal will be used. Your engineers have done extensive lab testing and sent you the following table.

[12] The remarks in this section ultimately stem from consideration of thermodynamics. Death, not life, is the natural order of things. To sustain life requires the constant expenditure of energy. As a result, genes design their organisms to acquire energy efficiently. Genes also determine how energy will be used. In this regard, perhaps the most important issue is how much to spend sustaining life and how much to spend creating and supporting offspring. I have not seen an instance where opting for immortality was a successful strategy. More generally, all prenes sets must determine what portion of resources to expended ensuring the survival of existing copies and what portion to expended creating new copies. This book is not the proper forum to discuss these issues in depth, and so I have chosen to simplify the exposition and specialize to mammals. If you would like to pursue this further, you might start with the question: did the genes design trees to die of old age?

Metal in Car	Cost per car	Lifetime
Tin	$10,000	1 year
Titanium	$1,000,000	100 years

So, for the same investment, you can build a fleet of tin cars that won't last long, or a small number of titanium cars that will last a long time.

You opt to go with titanium. You put the car into production, and the first one rolls off the line … and gets crushed by a passing truck. You ask the engineers why the car did not last the promised one hundred years. They tell you it's because the one-hundred-year number was "in the lab". They say that if you want to produce a car that will last one hundred years in the real world, they are not sure that it is possible at all, but they might be able to do it using spider-silk-wrapped carbon-nanotubes filled with depleted uranium at a cost of $1,000,000,000 per car.

The point is that car manufacturers cannot have it both ways: expensive cars and lots of them. They are forced by limited resources to trade one for the other. Those manufacturers that find a good tradeoff may survive, those that do not may succumb to those that do.

Gene-sets face a similar challenge. They can build lots of offspring that live a short time or a few offspring that live a long time. Those gene-sets that find a good tradeoff may survive, those that do not may succumb to those that do.

Now consider the mouse gene-set. Should it build lots of baby mice that won't last long, or a few baby mice which will last a long time.

We know the answer:

> *House mice usually live under a year in the wild, due to a high level of predation and exposure to harsh environments. In protected environments, however, they often live two to three years. [Wikipedia-HM]*

The female house mouse can produce "as many as ten litters – approximately sixty mice – each year" [Mousefacts]

What is the right investment strategy for gene-sets? That is a difficult question, but some strategies are clearly terrible. For example, it would have been unwise for the mouse gene-set to build baby mice with expensive hearts designed to last a hundred years, since despite the great heart, it is likely that within a few years the baby would succumb to a cat or some other real-world killer such as starvation, infection, accident, or exposure.

The "goal" of the mouse gene-set should be to build a heart that will function well only while the offspring survives. Put informally, the mouse gene-set should not invest much in individuals that should be dead.

Figure 26: Later, when asked whether the mouse with the expensive heart or the mouse with the cheap heart tasted better, the cat replied that they both tasted about the same to him [Cat]

These ideas lead us to the following proposition:

Proposition 8

Mammalian gene-sets typically invest little in individuals whose age exceeds the adult life-expectancy.

Where adult life-expectancy is the life expectancy (from birth) among the cohort of individuals that reach adulthood (i.e. reproductive age).

The implications of Proposition 8 are surprisingly rich. Let's begin by considering the human gene-set. What investment decision has it made regarding your lifespan?

Swedish census data indicates that between 1751 and 1800 the adult life-expectancy was about 59 years [Berkeley].

There seems little reason to think that the adult life-expectancy changed much until the last several thousand years. Then external threats such as starvation, predation, infection, accident, and exposure began to diminish, thanks in large part to our memes which produced such things as: agriculture, architecture, engineering, commerce, public hygiene, antibiotics, and seatbelts. It seems reasonable to think that when, in the 18th century, it reached 59 years, it had never been higher.

By Proposition 8 the human gene-set in the 18th century would be investing little in individuals beyond 59 years old.

Today the adult life-expectancy in the United States is an impressive 84 years [Berkeley]. Presumably the human gene-set will eventually respond to this recent increase by changing its investment strategy, but there is virtually no chance that those changes have occurred yet.

Hence, the genes designed us to thrive for at most 59 years[13] and we now live 84 years; we are in big trouble.

Just as the mouse gene-set should not build babies with hearts designed to function perfectly for a hundred years, the human gene-set should not (and does not) design, hearts, lungs, kidneys, blood vessels, immune systems, etc. to function perfectly for more than 59 years. By the time we reach 60 those organs, and many other systems in our bodies, will decline and loose functionality.

These losses of functionality are the result of the lag time between changes in the environment and changes in the gene-set. I call conditions that arise due to such lag times, “genetic-lag conditions”. For example, much of heart disease, kidney failure, cancer, etc. are genetic-lag conditions. Genetic-lag conditions are the major cause of death among humans – more than any other thing, they are the reason we die.

Are all lag-conditions genetic? No, lag-conditions are ubiquitous and associated with all manner of prenes. They are not an accident, they are an inevitable feature of prenes (the laws that govern them will be discussed later in *Mutation*, and *Lag-conditions*).

Lag-conditions are seen most clearly when a prene-set contain prenes that have become virtually immutable and inhibit rapid response to recent change. For example, the Hebrew Bible, the New Testament, and the Quran store prenes that are virtually immutable (see *A prene-theoretic view of History*). The U.S. Constitution stores prenes that are extremely hard to amend.

When the Western world bemoans the lack of flexibility of Islamic fundamentalists and criticizes their failure to adapt to the 21st century, they are reacting to the immutability of the prenes in the Quran that make the changes they would like to see virtually impossible. Similarly, the first amendment to the Constitution

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[13] 59 years is an upper bound since it is possible that the human gene-set has not yet responded to the changes that began several thousand years ago.

enshrines a separation-of-church-and-state-prene. So, when fundamentalist Islam calls for Sharia, it is anathema to America, and change is highly unlikely.

Before leaving the topic of why we die, I want to address the question of whether our genes actually try to kill us rather than just let us die of neglect. Prenes would never do such a terrible thing, right? Wrong (see *The selfish prene*).

In many species, the genes have designed their organisms with "time bombs" that ensure that they cannot live beyond a predetermined age. For example, the males of many species, from insects to marsupials, are designed to die after a single event or season of mating. These males often die with deteriorated bodies, a manifestation of the gene's goal to minimize investment in the dead. Black widow spider genes get particularly high marks for their effort to liquidate residual investment. Have our genes put time-bombs in us? I suspect that they have.

For example, many mammalian cells appear to have cellular clocks[14] known as telomeres that are stored at the tips of chromosomes [Wikipedia-TE]. It has been suggested that these clocks count down with each cellular replication and so limit the number of times a cell can reproduce, and consequently how long an individual can live. Why do this? It has been hypothesized that such a limit is a defense against cancer. Hence, the genes may have condemned us all to die, in order to enhance the

[14] If cellular clocks exist, and I suspect they do, then they open the door to many interesting possibilities. For example, in theory, the immune system could exploit such clocks to learn how to distinguish self from non-self. A new born immune cell could be given a time limit to explore the body. If it encounters a cognate antigen before the limit is reached, it kills itself. Otherwise, it becomes mature and will mount an immune response if such a cognate antigen is ever encountered. By reversing that system, a daughter of clonal expansion could die if it does not encounter a cognate antigen within the allotted time and continue to divide and/or produce antibodies otherwise. We certainly do have global clocks (e.g. that maintain the circadian rhythm). The gestational clock stops at birth, this could also provide the signal for immune cells to mature.

prospects that the young will thrive. Like burning a candle at both ends, a gene that enhances the prospect of the young to the detriment of the old may be favored[15].

If one wished to significantly extend the life-span of individuals, then repairing failing systems may not be enough; it may be necessary to diffuse these time bombs.

[15] I have investigated this a bit mathematically, and in my models, sacrificing the life of the old to enhance the reproductive capacity of the young is a clear winner for the genes.

Women

The Swedish census data we alluded to in Why do we die? also shows that between 1751 and 1800 the adult life-expectancy of women was about 59 years [Berkeley].

As we reasoned before, we can deduce that the human gene-set has probably not designed women to be fully functional beyond 59.

However, in the case of women we have additional information.

Currently, in the United States, the average age of perimenopausal onset (the beginning of irregular periods) is 47.5 years [Menopause].

It may not be obvious why this is important. But it is and here is why.

Surprisingly, a woman is born with all of the primary oocytes she will ever have. Each primary oocyte can give rise to at most one ovum (i.e. unfertilized egg), and ova can come from nowhere else. How many primary oocytes should the genes provided a woman at birth?

It is clear that the genes would be violating Proposition 8 if they provided women with so many primary oocytes that they could continue the regular production of ovum for a thousand years – because no human would live that long. Since the genes did provide sufficiently many primary oocytes to allow women to maintain regular production until age 47.5, it follows that genes designed women to be around at least 47.5 years.

So, in the case of women we have deduced that the genes have designed their systems to function very well until at least the age of 47.5, but not beyond the age of 59.

Menopause also allows us to see in some detail of how systems begin to fail once they are no longer supported by their genes.

It is clear that, on average, the genes designed women to produce one ovum per month, starting at puberty. The production of an ovum each month is a probabilistic phenomenon depending on the number of primary oocytes available and many other factors. To achieve the production of one ovum per month, sufficiently many primary oocytes and other factors must be available each month to ensure that the probability is very near 1. When the probability drops enough below 1, a woman begins to miss periods – that is, she becomes perimenopausal – on average this occurs at 47.5 years.

Menopause on the other hand is defined by the medical profession to be 12 consecutive months without a flow. On average, this occurs at age 51 [Menopause]. A short calculation with reasonable assumptions shows that this would happen when the probability has dropped to about 0.05. So, post 47.5 a woman's fertility is dropping rapidly, but it has not stopped abruptly.

This is typical. When a gene-set stops supporting a system, that system does not stop abruptly, but rather begins a slow decline with diminishing functionality.

It seems likely that the fecundity of women is carefully controlled by the genes, and the probability of an ovum each month, rises abruptly at puberty, peaks some years prior to 47.5, and then declines.

Finally, a brief aside regarding the so called "grandmother hypothesis" that the genes designed women to become menopausal so that they could devote energy to their grandchildren. I agree that menopausal women devote energy to their grandchildren; it is the claim that the genes designed woman to become menopausal for that reason that I take issue with.

For obvious reasons, the genes designed both men and women so that throughout their lives they would expend some of their energy in support of closely related individuals. Since women (and men) currently live for a long time (84 years on average in the US, about 70 years on average in the world), they now have the opportunity to devote energy to their grandchildren and even their greatgrandchildren.

Here is a hypothesis, consistent with the ideas of this section, that I find more compelling. Call it the “mother hypothesis”.

Pregnancy and childbirth contribute significantly to the probability of death in women. The genes introduced menopause as an inexpensive way to remove these burdens and prolong the lives of women who then may survived long enough to help raise their last-born children.

The primacy of prenes

People are to societal prene-sets what cells are to biological ones. Just as cells store their personal set of biological prenes as genes in their DNA, people store their personal set of societal prenes as memes in their brains.

Like the gods of mythology, prenes are immaterial, but carry out their activities, through humans, and other physical things. They began their journey long ago and will continue it long into the future. We are merely evanescent creatures swirling in their wake.

Figure 27: [Destiny]

Computers

You may have noticed that computers seem to be taking over the world. What is a computer anyway? Where did they come from? More importantly, where are they going and what does this mean for humanity? All will be revealed.

What a piece of work is a computer?

In 1937, the British mathematician Alan Turing published a paper “On Computable Numbers, with an Application to the Entscheidungsproblem” [Turing] which is now viewed as the start of the computer revolution. In that paper, Turing did at least two remarkable things. He laid the theoretical foundation for the concept of a computer, and he provided a roadmap for building one.

Just prior to the Second World War, Turing began to follow that roadmap and built proto-computers that succeeded in breaking German secret codes. The process culminated on February 15, 1946 when the first man-made computer, ENIAC, was unveiled at the University of Pennsylvania. ENIAC used vacuum tubes to store numbers – one of those numbers was the first cene.

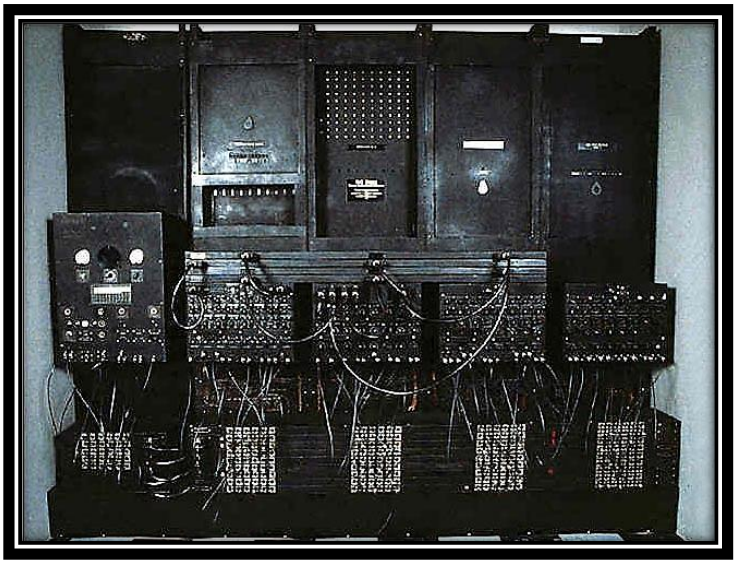

Figure 28: ENIAC: the birth of cenes [Eniac]

Humans added and multiplied this early cenes and occasionally copied them from one location to another, but the cenes themselves had little control of their own

destinies; their fate was in the hands of humans (that is, in the hands of genes and memes).

The prenes stored in the molecules of early earth were much like that; their fate was in the hands of the laws of chemistry and physics. But all that changed when self-replicating molecules emerged. Prenes stored in these molecules began to exert significant control of their destinies, and eventually their descendants would include wondrous creatures like us.

Would cenes ever start to self-replicate? They already have. Less than 40 years after ENIAC, the first computer viruses appeared, and as it happens, I was there at their birth.

It was November 3, 1983 - there should have been lightning and thunder – but this was LA. I was teaching a class on computer security at USC when a student, Fred Cohen, approached me with words to the effect: I have an idea for a new kind of security threat. The age of the computer virus had dawned.

Fred proceeded to describe a program that would be made available to users of a computer system. Like an app today, the program would be advertised to do some useful task. But once uploaded by an unsuspecting (and at that time, no one suspected anything) user, the program could do things that had not been advertised; it could access files, make copies of itself, and a lot of other things.

Here is what happened next:

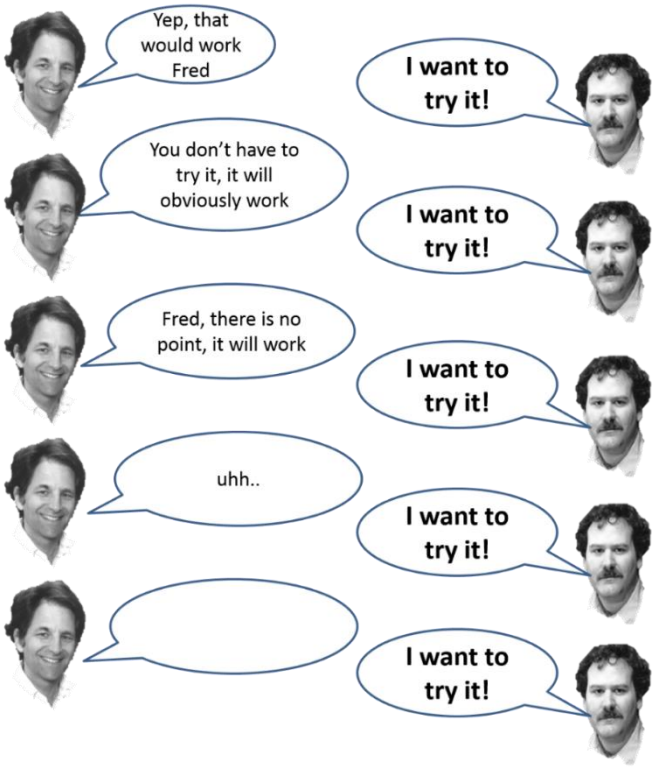

Figure 29: A reenactment

Fred was, and is, a forceful, energetic person, and he finally wore me down. On his behalf, I asked the department chairman if Fred could give it a try on the department computer.

Chairman: Sure, why not?

In those days, faculty, students, and staff did not have personal computers and we all shared the department computer. Fred proceeded to write his program and make it available.

The next week, I invited Fred to present his results to the class. As predicted (why don't people ever listen to me?), it worked. Copies of Fred's program quickly spread throughout the computer and conferred complete control of the system to Fred.

By now Fred was thinking hard about what he could do with these new kinds of programs and wanted to try more experiments.

But, when word got out about Fred's success, other people also started thinking hard about what these programs could do.

Chairman: Perhaps I was a bit hasty.

There would be no more experiments.

I became one of Fred's Ph.D. advisors; his advisor *de jure* was Irving Reed of Reed-Solomon fame. Later that year, I was at a conference and ran into a Los Angeles Times science reporter I knew named Lee Dembart. Lee asked what I was working on. Nothing much I said, but somewhere in the conversation I mentioned that one of my students was studying something we were calling "computer viruses".

I had dropped another feather (see *Prene-warrior*). I don't think I intended to do it, but either way, saying "computer virus" to a reporter is like saying "walk" to a dog. The result: Lee wrote the story, which as I recall, even included the now common image of a computer with a thermometer in its mouth [Dembart]. Computer viruses had gone viral.

Since those days, I have learned that the term computer virus had appeared in science fiction works by Gregory Benford years before I had used it, and that other early computer programs also have legitimate claims to be the forerunner of the computer virus.

So less than 40 years after the advent of cenes, they began to self-replicate. Today's computer viruses are much more sophisticated than Fred's, and they mutate and replicate despite our attempts to stop them. We are relegated to stopping the simple ones with our anti-virus programs, but we can prove [Cohen] [Adleman-CV] that we can never stop them all.

Turing's theoretical foundation for computers was almost as important as his technical one. That theoretical foundation was developed over the last 80 or so years and it has taught us much about what a computer is and is not. A computer is a "universal machine". That is, it is a machine in the sense of physics; a physical thing that occupies a certain chunk of space for a certain amount of time and obeys the laws of physics. It is universal, which means it can be programmed to compute all things that can be computed. So, to be a computer, the machine must be programmable to play chess, guide a rocket to Mars, and anything else that can possibly be computed. Since things like abaci and adding machines cannot be programmed to do all this, they are not computers.

We have also learned that computers are not the simple, predictable, things we may have initially thought they were. Very far from it. Because computers are universal, they can do very, very, complex things, and are provably unpredictable. No computer can ever be programmed to predict what other computers will do. I would go so far as to say that computers are the least predicable things that exist[16].

So that is what a piece of work a computer is.

[16] These statements have a mathematical bases (see for example [Adleman-RT]). Physicists may argue that it follows from quantum mechanics that some phenomena in Nature are absolutely unpredictable. Whether this is the case has been disputed for over a century in physics (Einstein: "God does not play dice with the universe"; Bohr: "Einstein, stop telling God what to do."). Even results on Bell's inequality do not necessarily ensure that there are absolutely unpredictable phenomena in Nature.

The rise of the cenes[17]

Humans had been making tools for thousands of years, and, at first, computers seemed to be nothing more than the neatest new tool. A shovel could help a person dig a hole faster; a computer could help them do math faster. But the computer was not like any tool that preceded it. Because the computer was universal, it provided an environment in which cenes could do amazing things. Not only could a computer help a person play chess better, it could play chess better than the person.

We are currently striving to make computers that will think better than we do. We are focused on making computers in our own image; making them into super-humans. This quest has given rise to concerns about our relationship with computers, and questions regarding their future and ours.

The old arguments suggesting that humans have little to be concerned about now seem quaint.

The idea that because we humans make and program computers, they can never surpass us is nonsense. It is a version of the parable of the watchmaker. The best chess player and the best jeopardy player in the world are both computers. Computers do many things far better than humans.

The idea that if things get out of hand, we can turn the computers off is wishful thinking. If we turn off all the world's computers this seconds, you will probably not be alive in a month. Your lights go out, your Internet, phone, TV, and radio stop working; you have no credit; do you really think that the local store will continue to have groceries for sale?

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[17] Reality has to some extent stolen my thunder. While much of what appears in this section was apparent at least a quarter century ago, the development of computers and their cenes has been so rapid that many of the surprising things that were anticipated then have now occurred or are anticipated by virtually everyone.

To keep our societies prosperous and secure (from one another), we will build more and more powerful computers and more and more sophisticated software. We will even rely on our computers to help us build better computers. If computers and their cenes do take over, we will have sold them the rope.

Isaac Asimov's idea that we can program computers to do no harm to humans is charming but naive. It is not possible to achieve this without sacrificing universality and hence usefulness. And, in any event, we have already programmed computers to do harm. We program drones to locate and destroy our enemies. The capacity to do this autonomously has existed for decades, and though we currently require human authorization before the destruction begins, when push comes to shove, I expect that the human will be replaced by a computer.

More importantly, if the US, Russian, and Chinese governments are not working on black-hat programs that, in the event of war, will knock out the computational infrastructure of the other two, they aren't doing their jobs. Such programs are weapons of mass destruction, and, if used, the death toll could be colossal. A first world country with no computational infrastructure is a country with no economy, no food, no power and ultimately not a country at all[18].

Will computers cause great disruptions in our societies and transform them in unimaginable ways? Sure, the process is already well under way. Many of the things that concern us about our future with computers will likely come to pass.

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[18] There is a small silver lining here. It is conceivable that computers and their cenes will put an end to the traditional physical weapons of mass destruction. Such weapons require computers to operate, and computers are inherently insecure. The recent events surrounding the North Korean nuclear program illustrate the issues.

When the first fish-like creatures crawled onto the land, they may have found it a sanctuary from the struggles of the sea, but in reality, it was just a new substrate for evolution, and the rules of the game had not changed: birth, struggle, reproduction, and death. A similar thing seems to be happening with humanity. We have entered cyberspace, and initially it seemed a sanctuary from the difficulties of the brick and mortar world, but it is not, it is just a new substrate for the struggle of prenes to survive.

Ever since Darwin, we have had to accept the likelihood that something would eventually evolve to supplant humans as the dominant form of intelligent life on earth. But much like the idea that the sun will eventually stop shining, the event itself seemed so distant that it was only of theoretical interest. Hence, it is with considerable surprise that the rapid emergence of computers has forced us to face the possibility that we might be supplanted in the near future.

Some envision the appearance of super intelligent robots that will demand that humans obey. When computers and their cenes have matured enough to be capable of making such demands, they will have acquired their own goals and direct human domination is unlikely to be one of them.

Future robots will not be simple single-minded automata, they will be much like us. They will become the instruments of prene-sets. The prenes they acquire from the outside world will fight to control their behavior and they will be filled with the same internal conflicts that we bear (see *The war within*, and *Humans*).

Though we did not realize it, something of monumental importance occurred on February 15, 1946. A new branch emerged on earth's tree of life. Computia have joined the Archaea, Bacteria, and Eukarya.

Figure 30: Tree of Life: It started to grow about 3,600,000,000 years ago. Computia budded off 72 years ago; they are already marvelous creatures. [Life]

We currently live in a symbiotic relationship with computers. In the language of biology, our relationship is “mutualistic”; both parties benefit. For us the relationship is “facultative”; we could (I think) survive as a species even if computers disappeared. For computers, the relationship is “obligatory”; they cannot survive without us; if we go extinct, so do they. But the relationship between humans and computers is changing far more rapidly than symbiotic relationships typically found in the biological world,

Eighty years ago, computers did not exist. Seventy years ago, they were weak, awkward things, few in number, having little to do with the lives of most humans. About thirty years ago, cenes started to self-replicate inside computers. Today, they are ubiquitous; they infest our cars, offices and homes. They even live as ectosymbionts on our hands and wrists.

Today's computers are far more powerful than their ancestors. Their future forms and power will almost surely astound us. Already, they store our money, run the systems that provide our food and energy, and do a million other things that we cannot live without – and that is the point. We may be very near the time when our side of the relationship stops being facultative and becomes obligatory – if the computers stop, humans will go extinct.

Today, cenes are like the genes of biological viruses, they must rely on special environments created by other living things. For virus genes, replication occurs in cells created by a host; for cenes, replication occurs in computers built by humans.

But it seems likely that, with human help, cenes will learn to build, repair, and sustain computers by themselves. When we see robots used in manufacturing, perhaps we are seeing the early stages of that process. Eventually, cenes will no longer need us to survive; they will be free to follow their own destinies and evolve according to their own needs.

The genes may have served their evolutionary purpose by giving rise to modern computers and their cenes. Like the scaffolding used to construct something grand, they may eventually be discarded.

But perhaps all of this scary talk about the rise of the cenes is being blown out of proportion. Perhaps they will leave us alone.

They will not leave us alone - they are prenes and they will struggle to survive.

The future of computia

I have designated ENIAC as the first “man-made” computer, but it is not the first computer. In fact, computers have been around for billions of years. Though no one realized it until very recently, even molecules are computing when they react with one another. In fact, everything that can be computed (e.g. telling whether a number is prime, playing chess, or guiding a spaceship to mars) can be computed using molecules alone [Adleman-DNA]. Molecules are `universal’; they are and always have met Turing’s definition of a computer (*What a piece of work is a computer?*).

It’s just that for hundreds of millions of years after the earth formed, terrestrial molecules were not computing anything we find very interesting. But that changed.

By the time bacteria arose, molecular computers were actually pretty good. Today, nucleic acids, proteins, and other molecules are the processing centers within bacteria. Among other things, they compute which proteins to express, and which actions to take in response to sensory input. For example, when bacteria sense nutrients, it’s their molecules that compute how to move to find the source.

But what is far more remarkable is that these molecules are learning machines. They arose from their predecessors by mutation. Like modern learning programs, bacterial molecules update themselves to make the bacteria “smarter”; they learn how to deal with the environment as it changes through time.

The molecular computers in bacteria are slow compared to electronic computers. But what they lack in speed, they make up for in parallelism. There are a lot of bacteria, an estimated $5x10^{30}$ on earth [Wikipedia-BA]. There are about $7x10^{9}$ humans each with about 10^{11} brain neurons. So, there are over a billion bacteria for every one human neuron. Though it is a very crude analysis, the take home message seems to be that the bacteria are still out-computing us. And bacteria have learned advanced computing techniques as well. Long ago they invented the “bacterial internet”. By using sophisticated molecular software, such as horizontal gene transmission [Wikipedia-HT], and quorum sensing, they distribute their discoveries to

one another and organize group behavior. For example, much to our detriment, they use the bacterial internet to spread antibiotic resistance.

In *Mutation*, we will see that even something as “simple” as HIV has used molecular computation to learn about its changing environment and adapt to it.

Living things made the switch to electronic computation about 500 million years ago when creatures, like the flatworm, began making proto-brains out of neurons.

Because these proto-brains were fast and had memory, the organisms could make decisions, learn about their environment, and modified behavior much more rapidly and cheaply than their molecular computing brethren (see *Pseudo-genes*).

Just as modern computers allow manufacturers to try out prototypes without the expense of actually building them, the enhanced computing power of brains endowed them with the ability to analyze the value of possible future behavior with little investment or physical risk.

These new gene-built electronic computers got better with time. Today, there is no better computer on earth that the human brain. It is fast, has lots of memory, and it runs very sophisticated gene-built software.

In the future, with Moore’s law, with the possibility of quantum computers, and with “unexpected” breakthroughs, it seems likely that the human brain will no longer be the best computer even on earth. Non-biological computers will see further into the future with better resolution than we do. They will make better, quicker, choices about behavior than we do. They will rapidly learn about their changing environments and adapt accordingly. They will be on a different level than us. Perhaps they will see us as sluggish and almost static. Where will we be then?

There is a tendency for people to think that the human brain has made humans fundamentally different from other creatures; made them special, even miraculous or divine. This is not the prene-theoretic view. Evolution did not stop because humans arose. Yes, it is clear that we have the best computers and use them to think about ourselves and our futures, but nothing has really changed, the evolution of our brain is

part of a continuous and inevitable evolution of computing power and cenes. That evolution is as natural as the evolution of life on earth and is more fundamental. It seems likely that cenes and the computia they create will continue to evolve long after all of earth's nucleic-acid based forms of life have ceased to exist.

Inquiries

In this chapter, we will look at some of the deeper aspects of prene-theory. We will also touch on a few notions that simply seem interesting.

Mutation

Darwin taught us that mutation is the driving force behind biological evolution. It is generally accepted among biologists that a sequence of mutations led from one-celled animals to us. In fact, mutation drives all prene evolution, and a deep understanding of prenes requires a deep understanding of mutation.

Our current view of mutation needs to be refined. In *Hamlet's soliloquy's struggle*, I argued that natural selection it is far more chaotic and far less deterministic than is commonly thought. In this chapter, I will argue that mutation it is far less random and far more algorithmic than is commonly thought.

Put informally, "mutation and natural selection" is an endless programming contest where it is never quite clear what the judges are looking for.

Mutation part 1

It is a common belief, even among biologists, that mutation is the result of random change. In fact, this is far from the case.

Principle 3

Mutation is typically exquisitely controlled change carefully programmed by prenes

I will start with a sports analogy. You are the owner of a professional sports team that has just won the championship. Do you trade some players? The initial response is no; don't touch anything. But, is this the wisest thing to do? You can be virtually certain that next season will not be exactly the same as this one. Things change, players change, other teams change, rules change, the weather changes, interest rates fluctuate, etc. So perhaps you should consider some trades to prepare for the changes you think might come.

You have many choices. You may think that next season's rules will severely penalize players who do not sing beautifully; so, you may decide to trade the entire team for the Vienna Boys Choir. You have made a change in anticipation of a future that has virtually no chance of materializing, and consequently you will have virtually no chance to repeat as champion. But what if you look at your players and see an aging veteran at the end of his career who spends most games sitting on the bench? Do you trade him for an untested young player with great promise? Perhaps you do. You cannot be sure it's a wise move, and you would have to look very closely at the veteran, the rookie, and a lot of other things, but under the right circumstances, it might be a risk worth taking. Presumably, many successful owners take such risks from time to time.

Each time you gamble with change, you may win, or you may lose. But, if you want to increase your chances of winning, you do not gamble recklessly, you choose your bets very carefully.

Successful prene-sets are master gamblers, because those that aren't are destine for extinction. Let's look at an example.

Consider the HIV virus and its gene-set. Very roughly speaking, biological evolution is like a 3.6 billion-year single-elimination tournament, so the fact that the virus exists at all is a powerful demonstration that its current "gene team" is a champion. Should the owner of the team, the gene-set itself, make changes? In this case, we know what the gene-set has decided: make lots and lots of changes. In fact, the HIV gene-set insists on so many changes that virtually all daughters are mutants. Can this really be wise? It is, and here is one reason why:

Through evolution, HIV has "learned" that the future is always dismal. An HIV virus lives in a human with an immune system which is trying to kill it.

The immune system is like a trillion-person police force composed of cells. Those cells are constantly on the lookout for intruders. From the point of view of an immune cell, HIV looks like a ball wearing a coat made of glycoproteins. The first immune cell to spot an HIV intruder sends "kill on sight"-posters with a picture of the coat to other immune cells. The virus is now the hunted.

What would you do if you were the virus? Yep, change the coat – put on a disguise. Well, that is exactly what the gene-set has designed the virus to do. A daugther of an HIV virus almost never wears the same coat as its parent.

Figure 31: HIV mother and her daughters at a checkpoint [Checkpoint]

This is how HIV does it. The virus stores its gene-set in RNA molecules. To increase the copy-numbers of the genes, the organism makes a new copy of itself - including its RNA molecules. To make new copies of these molecules, the organism uses a wonderful protein called a polymerase. Polymerase proteins are what life is all about, without them DNA and RNA molecules don't reproduce, cells don't reproduce, and you don't reproduce.

There are slightly different polymerases in different species, but all polymerases are similar. They are really, really small, about 2,000,000 of them side-by-side would be the diameter of a penny, and they all behave like jugglers on a tightrope. In our wildest dreams, we scientists could not build nano-machines even remotely as amazing as the polymerase proteins.

Figure 32: The Amazing Poly: juggler extraordinaire [Polymerase]

Think of a nucleic acid molecule as a strand of beads, where each bead can have one of four possible colors. A polymerase protein will hop onto a strand and begin to move down the beads. As it passes each bead it reads the color and uses that as a guide to put a bead of the appropriate color onto a new strand it is stringing. When it is done, the new strand stores the same gene as the original one did – unless the polymerase makes a mistake.

One thing that humans can be proud of is that their polymerase almost never makes a mistake. It only puts a bead of the wrong color into the new strand about once in every ten billion beads. By comparison, the HIV polymerase is pathetic; it puts the wrong bead into the new strand once in every few thousand beads.

The HIV virus should be ashamed of its polymerase. Well, it's not, and it did it on purpose. Why? The wrong beads often result in daughters with mutated glycoprotein coats. As a result, when the immune system's police show up looking for the original intruder's coat, the daughters are already wearing next season's fashion and are allowed to pass unmolested.

Eventually, the immune system will figure out the deception, begin searching for the new coats, and the process will repeat.

When all is said and done, the HIV gene-set has used the polymerase-gene to ensure a rapid rate of mutation of the glycoprotein-gene. In contrast, the human gene-set has largely abstained from such polymerase-based change.

Prene-sets are remarkably subtle in controlling how often they gamble and where bets are placed. For example, the human gene-set uses a process called V(D)J rearrangement to create a high rate of mutation in the genes that encode antibodies [Wikipedia-AB]. Antibodies have the shape of the letter Y. The bottom stem is called the constant region and the two raised arms are called the variable regions. The human gene-set has arranged for the antibody genes to mutate in such a way that the variable regions change extremely rapidly while the constant region hardly changes at all[19].

In general:

[19] A brief comment about programming and mutation within the cell. Because the protein folding problem is NP-complete, there are amino acid sequences that cannot fold quickly in Nature, since otherwise we could let them fold, image their structures, and use this approach to solve NP-complete problems quickly. If cells allowed for random mutation of the DNA that encodes proteins, it is very likely the resulting protein would not fold in the life of the cell (or perhaps the life of the universe). Hence, it is incumbent on cells to carefully program such mutations to ensure that mutants have a high probability of folding quickly. V(D)J rearrangement is an example of such programming. This may be a reason why proteins are found in classes with similar structures

Principle 4

Prene-sets typically choose the rates at which prenes mutate

Since prenes make these choices, and prenes themselves mutate, the rates evolve over time. We could call the changes in these rates, meta-evolution. There is also meta-meta-evolution, etc.

What is the proper rate of mutation for each prene in a prene-set?[20] Like many questions that confront prene-sets, there is no obvious answer, but the decision a prene-set ultimately makes will have profound implications for its survival, and, in the case of the human gene-set, yours (*Why do we die?*).

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[20] A brief aside regarding the question of punctuated versus gradual evolution. I suspect that genotypic (and more generally prenotypic) evolution is gradual. But the reason is not because punctuated equilibrium violates any mathematical or physical laws. Indeed, it is not difficult to imagine a cell with a polymerase worse than HIV's, one that is so bad that it choses nucleotides at random. Each daughter would receive a random genome unrelated to that of its parent. Such a mutational strategy would on (extremely rare) occasion produce a wholly new species in a single generation. The reason such dramatic mutation does not occur in Nature is because it is a losing mutational strategy that would not produce an adequate number of viable offspring. Genomic gradualism does not rule out phenotypic punctuation. A single point mutation could easily produce a mutant protein that would no longer function normally within an organism; this in turn could have far reaching phenotypic consequences. For example, it seems likely that just such a mutation in the FGFR3 gene produces dwarfism in some humans [FGFR3].

It follows from Principle 4, that we can order the prenes within a prene-set by their rates of mutation. I call prenes with a high rate of mutation “ephemera” (i.e. short-lived), and those with a low rate “endura” (from enduring, durable, hardened). For HIV, the polymerase-gene is endura while the glycoprotein-gene is ephermera.

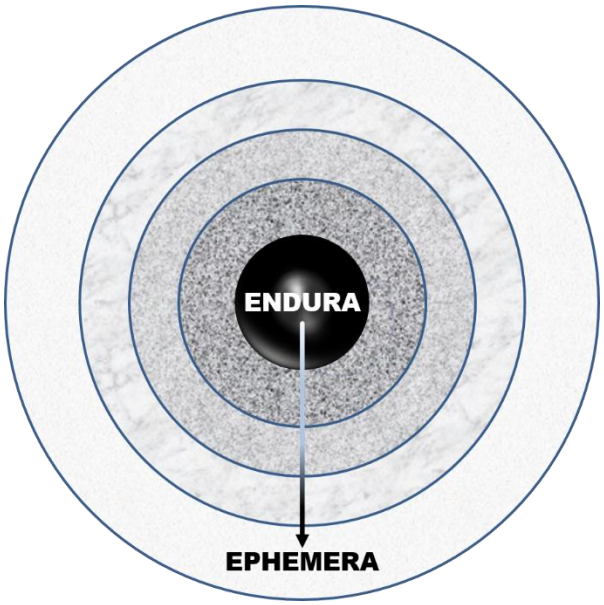

Figure 33: The structure of a prene-set. Surrounding the endura-core are shell after shell of prenes with greater and greater rates of mutation. At the boundary are the ephemera, the most labile prenes, in a swirling maelstrom of mutation.

The Ten-Commandments-prene is a good example of religious endura. Within the Abrahamic prene-sets, it has become virtually immutable; it is as if it were written in stone.

It is often the case that a societal prene-set’s endura are made accessible to followers and others by storing them in durable objects that are widely accessible. Modern religions and governments often use printed material for this purpose.

Especially when stored in durable objects, endura become syntactical and only acquire meaning when semantics is provided. It is not unusual to see societal prene-sets erupt in civil war over the “correct” meaning and who gets to provide it.

For example, the Protestant reformation is (yes, it still goes on) a Christian civil war fought over whether Popes or ordinary people get to interpret the endura stored in the Bible (see *A prene-theoretic view of History*). In the United States, the American endura stored in the Constitution is interpreted by the Supreme Court, and the Democratic and Republican parties engage in a civil war (currently without physical violence) partly over who gets onto the Court and gets to do the interpreting.

In Principle 3, I used the term “programmed” intentionally. The HIV “polymerase mutation algorithm” demonstrates how refined things have become, and how purposeful mutation can be; it is anything but random.

So, why have biologists come to think of mutation as random? Certainly, random events produce mutations. For example, cosmic rays damage DNA bases and do so largely in a random fashion. However, mutations produced by random events seldom persist, because gene-sets typically invest heavily in mechanisms to correct them. For example, the human gene-set creates hordes of enzymes to repair cosmic ray damage. In general, when random mutations occur, they persist only if the gene-set desires them or has determined that their repair is not worth the expense (see *Why do we die?*).

HIV

A few brief remarks regarding HIV. Its mutational strategy works. There are an estimated thirty-five million humans infected with the HIV virus. Like all living things, HIV is amazing. Let me try to give you some sense of why.

Below is a picture of some of my favorite prene warriors:

Figure 34: prene-warriors par excellence: Thomas Jefferson, Karl Marx, David Ogilvy ("the father of advertising"), Jesus, Buddha, the Democratic party, the Republican party, Escherichia Coli, Tyrannosaurs Rex, and the Stuxnet computer virus.

It is stored on my computer as a file of 1,679,268 bytes. Here is a much lower resolution version:

Figure 35: Prene-warriors par excellence (in 2,814 bytes)

It is stored in a file of just 2,814 bytes. You can't store much in 2,814 bytes, right? What about the HIV gene-set? How many bytes would be needed to store it as a sequence of A's, C's, G's and U's (for Uracil)? Only 2,437. Less than the low-resolution image above. Nonetheless, in the real world, the HIV gene-set builds and operates the HIV virus, which infects humans, survives, and reproduces despite immune systems and drugs. The HIV gene-set is a masterpiece of programming, way better than anything our computer industry could write, and worthy of our admiration. The human gene-set requires a file of roughly 750,000,000 bytes, so imagine how cleverly you and your brain have been programmed.

Like all humans, I have many beliefs and these beliefs need not be consistent (*Humans*). I can admire HIV with one set of beliefs and abhor it with another. By adopting a prene-centric view, perhaps I can acquire a useful understanding of the viral enemy [Adleman-AIDS, Margolick].

Mutation part 2

The HIV virus had many options of how to change, it could have cut up its genome and randomly rearranged it, or it could have replaced A's with C's, or a million other things. It is easy for a living thing to create genetic diversity, but most changes lead to disaster.

Consider sexual reproduction; it creates diversity. Each human parent stores their gene-set on 23 pairs of chromosomes; as a result, each pair of parents has the potential to create about:

100,000,000,000,000

genetically distinct children (I will ignore crossover and other phenomena here). That's a lot of diversity. Since each child's gene-set comes from parental gene-sets that have already demonstrated success, there is a good chance the child will be viable and a small chance the child will actually be superior to both parents.

But why not have 100 pairs of chromosomes? Then each pair of parents would have the potential to create about:

*1,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,00
0,000,000*

genetically distinct children; an astronomically huge increase in diversity.   How come the human gene-set has not figured that out? Well, it is likely that somewhere in time all kinds of mutational strategies were tried by gene-sets, but most were failures.

Proposition 9

In the prene-world, the creation of diversity per se has no value; only judicious diversity is rewarded.

While the prenes within a prene-set mutate, the prene-set as a whole mutates by the addition or removal of members. In *How to be an unsuccessful prene* we considered the Shaker-prene-set which arose from the Quaker-prene-set by the addition of the celibate-prene. In *The selfish prene*, we considered the bread mold gene-set which mutated by removing the uracil genes.

Addition and removal are important processes and the laws governing them should be explored in depth. I have not given them the attention they deserve, but the following proposition has emerged:

Proposition 10

Endura typically have the least likelihood of being removed from a prene-set.

For example, the prenes of the American-prene-set change through time, but the endura stored in the Constitution persist. There are thousands of Abrahamic religions with different prene-sets, but the endura stored in the oldest books, those of the Torah, are common to all.

Note that though prenes are not physical, their mutation, like their reproduction, always occurs within physical things. In the most interesting cases, it occurs within cells, brains, or computers.

Death to mutants!

Principle 2:

Figure 36: The fate of mutants [Mutants]

Rapid extinction is the most common destiny for a mutant prene-set.

For example, most HIV mutants are unsuccessful because their mutations have left them unable to assemble correctly, infect cells, reproduce, or do a thousand other things necessary to survive in their environment.

But they must often face an additional challenge:

Proposition 11:

Frequently a mutant must compete with its parental prene-set

In the case of HIV, even if a mutant is lucky enough to be able to survive in its environment, if it cannot reproduce faster than its parent, it will still be driven to early extinction.

When a serious conflict occurs between a societal prene-set and its mutant, it typically ends with the parental prene-set prevailing. This is the case even if the mutant is in some sense better suited to the environment. A new mutant is seldom on an equal footing with its parent. The parental prene-set usually has many instruments at its disposal, while the mutant has few. In addition, if the parental prene-set has survived for a substantial period, it is likely to be a grizzled veteran of numerous wars with mutants and to have developed effective means with which to combat them.

For example, a standard tool long surviving religious prene-sets use is murder. When a mutant emerges, its founder and early followers are threatened with death or are killed. This is often done with the aid of governmental prene-sets with which the religious prene-set has a religion-ruler-deal (see *A prene-theoretic view of History*).

So, the Jewish and Roman prene-sets condemn Jesus to death, the Catholic and Holy Roman empire prene-sets condemn Luther to death, and the polytheistic religious prene-sets and governmental prene-sets of Mecca condemn Mohammed to death. Of course, these particular examples are antithetical since the societal prene-sets that Jesus, Luther, and Mohammed put into motion were ultimately very successful, but thetical examples are hard to find, presumably because the approach worked so well in most cases that the mutants were dispensed without leaving a trace.

Lag-conditions

[LENOTE: THIS SECTION MUST BE REWRITTEN IN LIGHT OF CHANGES IN WHY WE DIE AND WOMEN]

In *Why do we die?* I introduced the notion of a genetic-lag condition. But lag-conditions transcend genetics and are central features of the struggle of prenes to survive.

Why do lag-conditions arise?

As discussed in *Mutation*, prene-sets program the rates at which prenes in the set mutate. That determination is not easy since good choices are dependent on future changes in the environment.

If the environment stays stable for a long time, then prene-sets that use a slow rate of mutation may have an advantage since the current prenes have a record of success in the current environment.

If the environment changes rapidly, then prene-sets that opted for a rapid rate of mutation may be favored since the current prenes are suited to an environment that may soon cease to exist. We saw an example of this in *Mutation*, where as a result of rapidly-changing attacks from the host immune system, the HIV-gene-set selected a high rate of mutation for the genes that determined surface glycoproteins.

Every choice is a gamble and in the case of mutation rates, part of the gamble can be described as follows:

Principle 5

A high rate of mutation increases the likelihood of unsuccessful offspring. A low rate of mutation increases the likelihood of lag-conditions

So, like mutation itself, lag-conditions are inevitable and fundamental features of evolution.

In humans, a slow rate of mutation has been chosen for many genes. Was it a good choice? One way to judge is to look at copy numbers. Since there are 6 to 7 billion people each with about 10^14 cells and each cell has one copy of the human gene-set, 6.0221x10^23 seems a good guess. So, the choice has worked so far. But there is no free lunch, and the human gene-set must pay for this choice with lag conditions.

I'll need a bit of notation. In *Why do we die?* we established that the human gene-set designed us to live with full functionality no more than 59 years. But we did not pin down the numbers down more than that. So perhaps we are only designed to have full functionality for 55 years, or 57, or whatever. Whatever that number of years is, I will refer to it as the "genetic life-time" in what follows. In the case of woman we know that the genetic life-time is at least 47.5 years (*Women*).

As noted in *Women* the genes have decided to give women their full allotment of primary oocytes at birth. Call a cell type with this property "irreplaceable".

Humans have other irreplaceable cell types. For example, at birth, humans receive their full allotment of cardiomyocytes (contractile heart cells) and cortical neurons (brain cells). For all irreplaceable cell types, Proposition 8 dictates that there will be an adequate supply to sustain functionality for the genetic life-time, after which functionality will decline. So, the degeneration of heart function and brain function in later life are at least partially due to genetic-lag conditions.

It would be nice if we only had to worry about degeneration of irreplaceable cell types, but we are not that lucky. Call a cell type that is not irreplaceable, “replaceable”. Replaceable cell types have predecessor cell types that can produce (through maturation or dividing with differentiation) new cells when existing cells are lost.

Replaceable cell types themselves are of two types, those whose lineage leads back to an ancestor that is irreplaceable and those whose lineage does not. Call the former types “mortal” and the later types “immortal”.

For example, ova are replaceable but not immortal since primary oocytes can divide and differentiate to produce new ova, but primary oocytes are themselves irreplaceable. Mortal cell types must eventually succumb to the same fate as their irreplaceable ancestors: decline and failure. When the ancestors decline and fail, so do they. The trajectory of this decline may vary from cell type to cell type.

Whether humans have immortal cell types at all is a good question. Since all individual cells have a non-zero probability of dying before dividing, immortal cell types can only exist if their lineage leads back to what I’ll call a “self-sustaining” cell type. The cells of a self-sustaining cell type can generate increasing numbers of cells of exactly that type – that is, cells that are indistinguishable from their predecessors. Self-sustaining cell types present an obvious cancer risk. This issue may be related to questions of cellular-clocks, such as those based on telomeric retraction, but that is another story.

Current research suggests that the spermatogonia are self-sustaining. If this is the case, then sperm (which have spermatogonia as ancestors) are immortal. My guess, and it is only a guess, is that this is not the case; that sperm are mortal and fertility will decline in later life. The trajectory of the decline appears to be gradual, and even very old men may be able to produce some sperm. For example, US Senator Strom Thurmond famously fathered a child at age 66 [Wikipedia-TH], but I suspect this was pure luck – monkeys and typewriters - given enough men each with a slowly declining sperm production, such things will occasionally occur. Presumably for the

same reason, Dawn Brooke became pregnant (through natural means) at the age of 59 [Wikipedia-PR].

With regard to declining functionality as we age, there is a bit of good news – at least for the young. They will sometimes be “super-functional”.

For any number of reasons, cells die. As a result, irreplaceable cell numbers and the functionality they support, begin to decline in the womb and continue to decline thereafter. So, for all but immortal cell types, whatever the number of cells (and other factors) the genes have determined to be adequate for functionality until the genetic life-time, the young will have more. For example, a young person should have more primary oocytes, cardiomyocytes and neurons than a person in their 30s. This may help explain why the young excel in athletics while the elderly have difficulty with exertion; why the young have a high learning capacity while, as is said, you can’t teach an old dog new tricks.

The examples of genetic-lag conditions discussed so far all arise from decreases in the capacity or number of cells. These “cellular” genetic-lag conditions are actually part of a larger class of which I call “repair” genetic-lag conditions.

Consider our body’s responds to injury. You get a bad cut, you rapidly create a scab that protects you from potentially fatal blood loss and infection. Then you replace the scab with a scar, presumably to provide a more durable barrier. But why don’t you replace the scar with new skin? If you lived forever, the eventual accumulation of scars over your body would be fatal (since, for example, scars do not have sweat glands). But since you are not intended to live forever, and you are likely to die before your scar burden becomes a serious problem, the genes appear to have opted not to invest in a mechanism for replacing scars with skin.

Now consider plaque buildup in arteries. Why didn’t your genes make a better mechanism for clearing that? Perhaps the genes opted to make mechanisms (e.g. artery diameter) sufficient to control build-up until the genetic life-time. Fortunately, we now live longer; unfortunately, the build-up eventually becomes serious and we die of heart attacks.

Heart disease, cancer, chronic respiratory disease, stroke, Alzheimer's disease, and diabetes account for more than 85% of the deaths in the United States. It seems likely that these diseases were responsible for a far smaller percentage of deaths in the years between 200,000 and 10,000 years ago when the leading causes of death may have been starvation, injury, and infection. I suspect that for the most part these diseases are genetic-lag conditions.

As an aside, though the language of prenes is not used, a description of the pathogenesis of AIDS as a genetic lag condition is given in [Adleman-AIDS] and [Margolich].

Lag-conditions are also a central feature of social prene-sets.

Consider the American-prene-set. Perhaps no two Americans would agree on exactly which prenes are in the set. Nonetheless, it seems likely that the vast majority would agree that the American-prene-set contains the prenes in the Constitution.

The Constitutional prenes entered the American-prene-set at the constitutional convention of 1787. At that convention, it was up to the Framers to determine the Constitution's rate of mutation, and they took their task quite seriously; the result was the amendment process we have today.

In The Federalist No. 43, James Madison sums-up the issues that are always involved in reaching such decisions:

> *It guards equally against that extreme facility which would render the Constitution too mutable; and that extreme difficulty which might perpetuate its discovered faults.*

So, the Framers opted for a slow rate of mutation; perhaps they would be pleased to learn that there have been only 27 amendments since 1788 (when the Constitution was ratified). Of course, this slow rate has led to lag-conditions.

At times, Americans have favored amending the second amendment with respect to the right to bear arms, but the difficult conditions required for an actual amendment have never been satisfied, and so we have a high rate of gun deaths in

the United States. At times, Americans have favored a balanced-budget amendment, but again the necessary conditions have not been satisfied and so we sometimes have run-away deficits. These are lag-conditions.

In America, the Constitutionally enshrined notion of “checks and balances” is highly touted. But from a prene-theoretic point of view, this is merely a way to slow the rate of some forms of mutation and may serve the American-prene-set well in some settings and not in others. It may make dictatorship less likely, but it also creates a lag-condition that might disable the country in modern wars. The so called “War Powers Resolution” of 1973 can be seen as an attempt to forsake some checks and balances to achieve a more rapid response to attack.

More mundane examples abound. Consider the process by which school curricula are changed. Often, teachers’ unions, text book publishers, the public, political parties, and school administrators are given a voice by law, regulation, or custom. The result is a slow rate of change and lag-conditions. For example, young children in some jurisdictions are still taught to write in cursive, despite the fact that in their futures it will be about as useful as jousting. In other jurisdictions, all students must learn a foreign language, despite the fact that computers can translate for us.

Lag-conditions are the result of prenes that have not mutated. But problems can also arise even when mutations do occur.

While some prenes mutate rapidly and some mutate slowly, prene-sets do change over time. As a result, followers of societal prene-sets learn different versions of the prene-set. Typically, the young have a current version while the old have one that is to some extent out of date. A significant part of the perceived deterioration in the old, by both the young and the old themselves, is not the result of physical or mental decline, though these certainly occur, but is the result of getting more and more “old fashion”.

As you age, and great numbers of people no longer share some of your deeply held beliefs, you will not enjoy it.

This guy seems to have understood what I am talking about:

The children now love luxury. They have bad manners, contempt for authority; they show disrespect for elders and love chatter in place of exercise

-Socrates (469–399 BC)

There is some solace in knowing that the young eventually become old and karma tends to balance things out.

Pseudo-genes

A “pseudo-gene” is a prene that is stored in a living thing but not as a gene. Memes, those prenes stored in brains, are an important class of pseudo-genes. Pseudo-genes also come in other forms.

For example, your fingertips store a pair of pseudo-genes we might call the “coarse fingerprint pseudo-gene” and the “fine fingerprint pseudo-gene”. The coarse pseudo-gene is genetically determined and accounts for the major pattern of swirls and loops of your fingerprint; the fine pseudo-gene is not genetically determined, but arises *in utero* because of environmental factors, and accounts for the fine details of your fingerprint. When these pseudo-genes are transferred to a smooth surface during the commission of a crime, they may lead to arrest. Even if the suspect has an identical twin, the fine fingerprint pseudo-gene will allow police to distinguish him from his twin.

While many molecules in our bodies, such as water or ordinary salt, store relatively innocuous pseudo-genes, some molecules store very important ones. For example, some antibodies store pathogen-destroying pseudo-genes in their shapes.

In a fashion similar to finger tips, DNA molecules are capable of storing multiple prene simultaneously. In their sequence they store a gene, but they often store important pseudo-genes as well. This happens because two DNA molecules may have the same sequence (and hence store the same gene) but differ in small details. For example, one may be methylated at sites where the other is not. The pattern of methylation is storing a pseudo-gene. The pseudo-genes stored on DNA molecules are of great current interest and are central to the field of epiGenetics.

It is likely that for billions of years pseudo-genes of various sorts played critical roles in the struggle of living things to survive. Consider the humble flatworm.

Figure 37: Planaria: fussy eaters. [IslandWood]

Flatworms evolved about half a billion years ago. A particular set of flatworms called *planaria* are still with us. Like all living things, *planaria* are genetically sophisticated. They can see, sort of; they have a pair of “eye spots” that can detect the intensity of light. They have collections of neurons (ganglia) in their heads that act like primitive brains.

Planaria have a special trick; they can regenerate lost tissue. If you cut a planarian into many pieces, each piece may grow into a full planarian. In fact, some subspecies of *planaria* reproduce asexually by splitting in two and letting each part grow into an offspring. Other subspecies reproduce sexually by mating and exchanging gametes. Some subspecies do both.

Planaria are not adventurous diners. If you take a planarian to a nice new place to eat, it will be very cautious and only eat after a considerable delay. However, if you take it to the same place again and again, it will become “comfortable” and eat immediately.

We know this because of recent experiments [planaria] where one group of planaria was fed on a rough surfaced petri dish for several days while another group

was fed on a smooth surfaced petri dish for the same length of time. When members of both groups were then fed on a rough surfaced dish, the members of the first group commenced eating more quickly than the members of the second group.

This experiment, like others before it, shows that planaria can learn. They can remember some features of their environment. *A priori*, I would have guessed that these environmentally acquired prenes were stored in flatworm brains, and hence they were memes. Perhaps this is so, but that is not the end of the story.

The researchers cut members of each group widthwise, kept the tail parts, and waited for them to grow new heads. They then fed members of each group on a rough surfaced plate. The reconstituted planaria from the group that had learned to be comfortable with rough surfaces commenced eating more rapidly than the reconstituted planaria from the other group. Hence, there was some place other than the brain where the environmentally acquired prenes were being stored.

The research is fairly recent, so I do not yet consider it definitive, but I want to use it as the starting point for a made-up story that I find quite plausible, and that illustrates how even primitive, non-meme, pseudo-genes and genes may have interacted, and sometimes fought to the death.

Assume that there existed a species of flatworm that, like some modern subspecies of *planaria*, could reproduce both asexually (by splitting) and sexually (by mating). Further, assume that like the planaria in the experiment above, these flatworms acquired the pseudo-gene that leads them start eating immediately when on a rough surface.

The experiment above demonstrates that the pseudo-gene would be passed to offspring that resulted from splitting. However, for technical reasons, it seems unlikely that the pseudo-gene would be passed to offspring that resulted from sexual reproduction. If it I am wrong about this, it would lend considerable support to Lamarckian evolution.

Now put such flatworms into an environment with a rough surface and a modest supply of food. What might happen?

An offspring that arises through asexual reproduction acquires the pseudo-gene and “knows” to commence eating immediately. An offspring that arises through sexual reproduction does not know that, approaches food with caution, and delays eating. Since the supply of food is modest, this provides the asexual offspring with an advantage over the sexual offspring. After many generations, we might see that the gene-set of the flatworm has mutated to produce a flatworm that has abandoned sexual reproduction and can only reproduce asexually (see *Mutation*).

If this actually happened, then it would provide a vivid example of the struggle of prenes to survive. The flatworm pseudo-gene has survived and the genes for sexual reproduction have not. The evolutionary destiny of the flatworm was not determined by its genes alone; its pseudo-genes were just as important.

Did this actually happen to flatworms? Who knows? But the story is so plausible, that it is easy to imagine that something very like it did happen long ago.

After millions of years of evolution, the sophisticated pseudo-genes we call memes arose in humans, and together with genes, determine much of our behavior and destiny.

Socrates' bed [IN PROGRESS]

In book X of the *Republic*, Socrates addresses the question "what is a bed?".

Socrates: Let us take any common instance; there are beds and tables in the world --plenty of them, are there not?
Glaucon: Yes.
Socrates: But there are only two ideas or forms of them --one the idea of a bed, the other of a table.
[Republic]

With this Socrates, broaches the "problem of universals" which has been of interest to philosophers ever since. He also reveals a distinction between an instance of a bed, which is a physical thing, and the "idea" or "form" of a bed which is not.

This is the approach I have taken in the definition of "prene" given at the start of the book. So at least roughly, Socrates' ideas and forms are this book's prenes.

But there are important differences between the Socratic approach and the one taken in this book.

Socrates' idea of a bed appears to be immutable. He asserts that even a skilled maker of beds could not possible have made the idea of a bed because that:

Socrates: is made by God, as I think that we may say --for no one else can be the maker?

Perhaps the most important message of this book is that prenes (or if you prefer ideas and forms) are not static, they are mutable; they struggle to survive and evolve according to Darwinian and other laws.

So, let's explore how the idea of a bed or equivalently the bed-prene evolved. In fact, there is no single bed-prene, rather each of us has their own bed-meme which they use to recognize some set of physical things as beds. For example, I don't think of a chaise lounge as a bed, but perhaps you do.

Now let's go back in time. I'll use the Wikipedia article "Beds" [Wikipedia-BD] for guidance.

Early beds were little more than piles of straw or some other natural material.

So, it is reasonable to assume that at least some early humans had some "bed-memes" that they used to distinguish a set of physical things they called beds from things they did not call beds.

An important change was raising them off the ground, to avoid drafts, dirt, and pests.

So, the "bed-memes" in early human brains changed. How did that happen?

As said in the book, the genes, for their own survival, have built people to be obligatory prene processors. We are constantly using our brains to processes our existing memes and creating new ones. Once technological memes concerning raising objects above ground level began to inhabit brains that already stored the old bed-meme, some human created a new bed-meme – what we could call a mutation of the old bed-meme.

This may have happened numerous times, but at least once, the new bed-meme went viral; it rapidly passed from brain to brain. How did that happen?

There are many plausible possibilities, here is one: perhaps the creator of a new bed-meme actually built a raised bed, showed it to his family and friends; they liked it and began building their own. With time the old bed-meme was in fewer and fewer brains (perhaps on its way to extinction), while the new bed-meme spread to more and more brains.

At this point it is easy to see how a sequence of such mutations would account for the bed-meme that currently resides in your brain.

But can we go back further in time? Did the bed-meme in your head actually start to emerge before humans existed? Yes.

Consider Chimpanzees (though they are not our predecessors, the point will still remain) (https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0095361). They build beds. And there is considerable evidence that they have bed-memes that evolve.

ADDITIONAL MATERIAL NEEDED……

Well, if the bed-meme can plausibly be traced to pre-human times, how far back does it go?

I think your bed-meme began to evolve by the time life began on earth. I think there were prenes stored in one-celled organisms that were the mutatory predecessors of your bed-meme. Before you dismiss this notion and deride me for suggesting it, you best be sure that your criticism does not also exclude the notion that you yourself arose from those same one-celled organisms.

You may think that evolution of the bed-meme is nice, but it is not “real evolution” like we see in biology. You may think that the evolution of genes is somehow more important or more dramatic, than the evolution of memes. But that is an illusion. biological evolution is actually not dramatic, it proceeds by slow, ponderous steps, and, when viewed up close, is quite banal. And with regard to importance, the evolution of memes is the foundation for the evolution of our political, religious and other societal prene-sets.

There are many possible ways to deal with the problem of universals. But for me, any way that does not include a theory of evolution is inadequate.

Before ending, I will give a brief description of an alternate definition of prenes that, in many ways, I find more informative than the one given at the start of the book. But a warning: things are going to get a bit mathematical, so unless you are that kind of person, I suggest you skip to the next section.

In the interest of brevity, I will ignore certain issues of physics, some of the paradoxes of set theory, a million details, and provide an overly simplified version of what should actually be done.

Consider all of the physical objects that exist in the universe. What about dinosaurs? Well, I like dinosaurs, so let's instead consider all of the physical things that could (according to the laws of physics) exist in the universe. It's a pretty big set, but now, let's consider all its non-empty subsets. So, one subset just includes you, another includes you and a dinosaur, another you and me, another all living people, another all people who ever lived. There is a subset that has exactly the physical objects that you think are beds, and another the physical objects that you think store the Hamlet's-soliloquy-prene.

One can define a prene to be a non-empty subset of all of the physical things that could exist in the universe. Let's explore this definition just a bit. Consider the subset consisting of all dinosaurs that ever existed. That set has no intersection with set of all of the physical things that actually do exist in the universe at this moment. In fact, through time, the size of that set's intersection with the things that actually do exist, its copy number, has fallen to zero, it has gone extinct. Similarly, the subset of all humans who have ever lived had copy number zero a million years ago and now has copy number about seven billion.

What about hypecubes of dimension 100? Physical law excludes hypercubes so there is no non-empty subset that corresponds to it – there is no hypercube-of-dimension-100-prene. There is, however, a definition-of-a-hypercube-of-dimension-100-prene and that subset contains various brains and books that mathematicians use.

I will not go bore you with more. The reason I like this kind of definition is that it reveals interesting things. For example, there are more prenes than there are words to describe them (let alone provide definitions for them).

Is the iPhone Alive?[21]

Because humans have been studying biology and biological evolution for more than a century and a half, the gene-world is an ideal place for observing the role of prenes and discerning the laws that govern them. But, for prene-theory to be generally useful, we must acquire the ability to look at non-gene-world phenomena and discern the role that prenes are playing. In this section we will enter the world of commerce, and in particular the Apple iPhone part of it, to try to get a grasp on what is at play from a prene-theoretic point of view.

What is an iPhone? It is a physical thing and it stores cenes. Does the iPhone reproduce? No, we never put our iPhone's down at night and discover more of them when we wake (it is true that the cenes inside the iPhone reproduce, for example, when we send a photo to another iPhone). On the other hand, if we consider the number of iPhones through time we find that in 2006, one year before iPhone was announced, the number of iPhones was zero, but in 2018 Apple announced the sale of its one billionth iPhone. So, though iPhones don't reproduce, their numbers are increasing rapidly.

I assume that the increasing number of iPhones stems for something like the following process:

People working at 1 Infinite Loop, Cupertino, California have the plans for the iPhone. That is, they have the iPhone-plans-prene-set. I do not care exactly what that prene-set includes, but I assume it includes the source code for the current operating system, the physical characteristics of each iPhone part, the blueprint of how the parts are to be assembled, the marketing strategy (something like: every two years we will introduce a new model, next year we will invest heavily in advertising in the middle-

[21] The ideas for this chapter arose out of a course on prene-theory that I taught in the Fall of 2018 at USC. I thank the students in that class, and in particular Zhoa Zhao and Dean Wasill, for their contributions.

east, in 2057 we will introduce an iPhone made of 18-caret gold, etc.), and a bunch of other stuff.

Apple contracts manufacturing companies to produce iPhones. These companies receive a subset of the iPhone-plans-prene-set and use it to organize the production of iPhones. Each manufactured iPhone stores a subset (e.g. the operating system) of the manufacturing company's subset as cenes. When demand is sufficiently high, new companies will be contracted to meet it.

So now let's take a prene-theoretic view. This is not the only possible view, but I find it worthwhile, and much to my surprise, it reveals a prene-set which survives in a manner that I had not foreseen, and which appears to have no analogue in the gene-world.

Let compare the iPhone situation to the honeybee's. So, a bit more (*Why do bees kill themselves*, *What a piece of work is a man?*) about honeybees.

The bees live in hives, each hive has one queen, the queen and only the queen can reproduce. The queen can lay eggs of two types: the haploid type which have the queen's gene-set, and the diploid type which have the queen's gene-set plus genes from a drone (often from another hive) with which she has mated. The diploid types become drones, most haploid types become workers, a few haploid types are fed exclusively on royal jelly and become virgin queens (if they mate with a drone they become queens).

Let's focus on the workers. They cannot reproduce, so the only way to get more workers is to have the queen make them. Their primary job is to find flowers and partake in a symbiotic relationship wherein the flower provides nectar that is brought back to the hive and the bee transports the plant's pollen to other plants; aiding in reproduction (your parents should have taught you this).

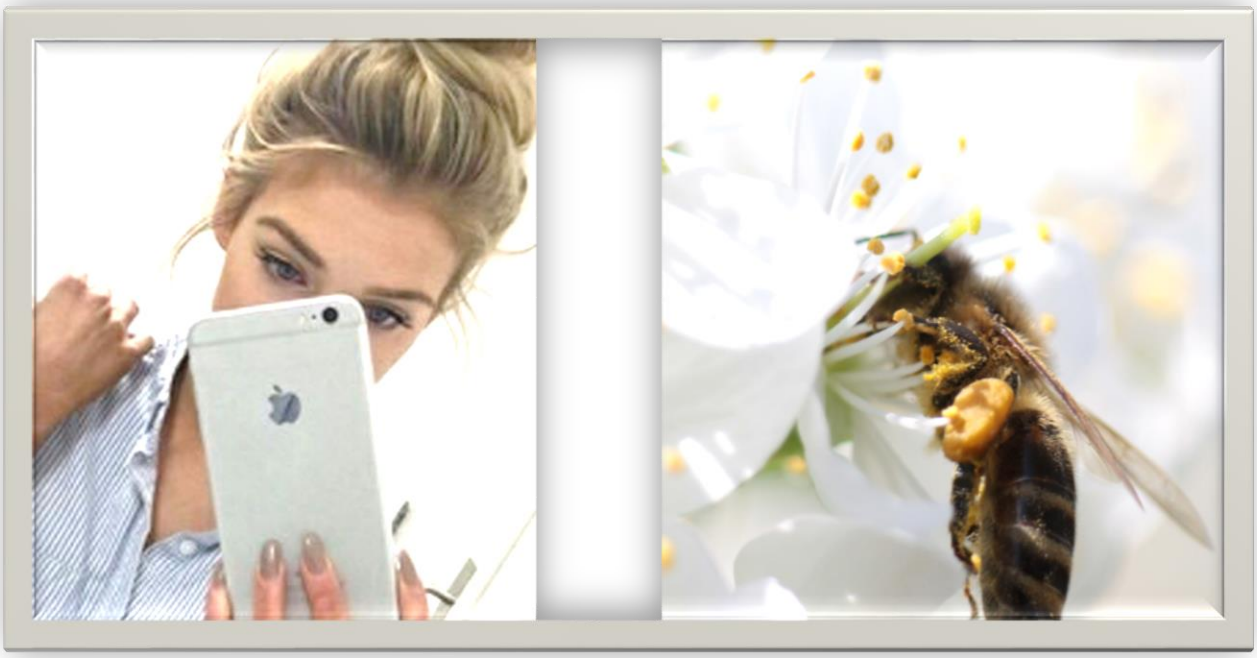

Figure 38: Workers and their symbiotes [iPhone]

The iPhones are very similar to the workers. They have some prenes from the iPhone-plan-prene-set, but not all, they cannot reproduce themselves, and their primary job is to find humans and partake in a symbiotic relationship wherein the human provides dollars that go to the hive in Cupertino, and the iPhone aids the human in many ways including, is some cases, reproduction.

When flowers are abundant, and therefore the demand for workers is great, the queen may leave her hive, and, along with an entourage of workers, form a new hive at a new location (a virgin queen from the old hive will mate and become its new queen). This is much like what happens with the manufacturing companies in the Apple case.

It is a pretty good analogy, and I'll leave it to you to see that many of the principles in this book are at work. But the analogy is not perfect. There is an interesting prene-set that does not quite fit: the iPhone-plan-prene-set itself.

While some prenes (e.g. those in iPhones, those at manufacturing companies) in the iPhone-plan-prene-set have increased copy number though time, others (e.g. the source code for the operating system) have not. These are the prenes which a business person would call “proprietary”. If a copy of these proprietary prenes becomes available to a competitor, it might have devastating consequences for the survival of the iPhone-plan-prene-set. It is likely that active measures (e.g. encryption) are taken to keep copies from being made.

Now revealed, it is clear that proprietary prenes are found in many prene-sets: the formula for Coke, everything that is “top-secret”, your passwords. Proprietary prenes are vital to the survival of their prene-sets but restrained from acquiring large copy numbers. They have no direct analogy in the gene-world that I am aware of.

Though I was aware that prenes could survive by being durable, I had thought that “modern” prenes (those that emerged in the last say billion years) had all adopted the reproductive strategy of survival. It appears that I was wrong. Certainly, these proprietary prenes are worthy of further study.

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A prene-theoretic view of History
[IN PROGRESS]

Until recently biologists viewed biology as the study of living things. Now, many biologists see it as the study of genes, and see living things as instruments used by the genes to accomplish their survival, replication, mutation, and evolution. This is not to say that the work of pre-Darwinian biologists was not worthwhile; that would be to ignore enduring contributions by giants like William Harvey, Linnaeus, Von Leuwenhoek, and Pasteur; nor is it to say that all fundamental contributions made by today's biologists rely directly on Darwin; rather it is to say that the genes have become primary. It is the gene-centric view that guides biologists and provides a solid foundation for their work.

I propose that those who study human endeavors, particularly in the social sciences[22] and the humanities, add the prene-centric view to their repertoires.

But what does an academic prene-centric investigation of human endeavors look like? I don't know, and it will take time to know, but I thought, as an exercise, I would give it a try.

I decided to apply prene-theory to History. I considered the history of a single prene, the monotheism-prene: there is exactly one God. Real historians will properly see my attempt as amateurish (or worse), but I think the exercise was worthwhile.

Among other things it taught me what a prene-theoretic view of history should not be. It should not be a simple repackaging of a standard history where every major event is attributed to prenes and every major figure is said to be driven by his meme-set. Rather, prenes should guide us to reconsider what the major events were and

[22] Sociology is particularly well suited to exploit a prene-centric view. The notion of societal norms is already prene-theoretic, but the view that these norms mutate, evolve, and war with other societal-prene-sets should not be overlooked.

who the major figures were. For example, below Jesus and Luther are ultimately seen as less important than Constantine and Columbus.

Pre-Darwinian biologists gave great weight to morphology, environment, and behavior; today, historians give great weight to people, events, dates, and places. My history will not ignore these things, but will emphasize religious prene-sets, their endura, their mutational and reproductive strategies, and their struggles to survive.

By the way, it is reported that at least 3.6 billion people (52% of the world's population) believe the monotheism-prene [Adherents].

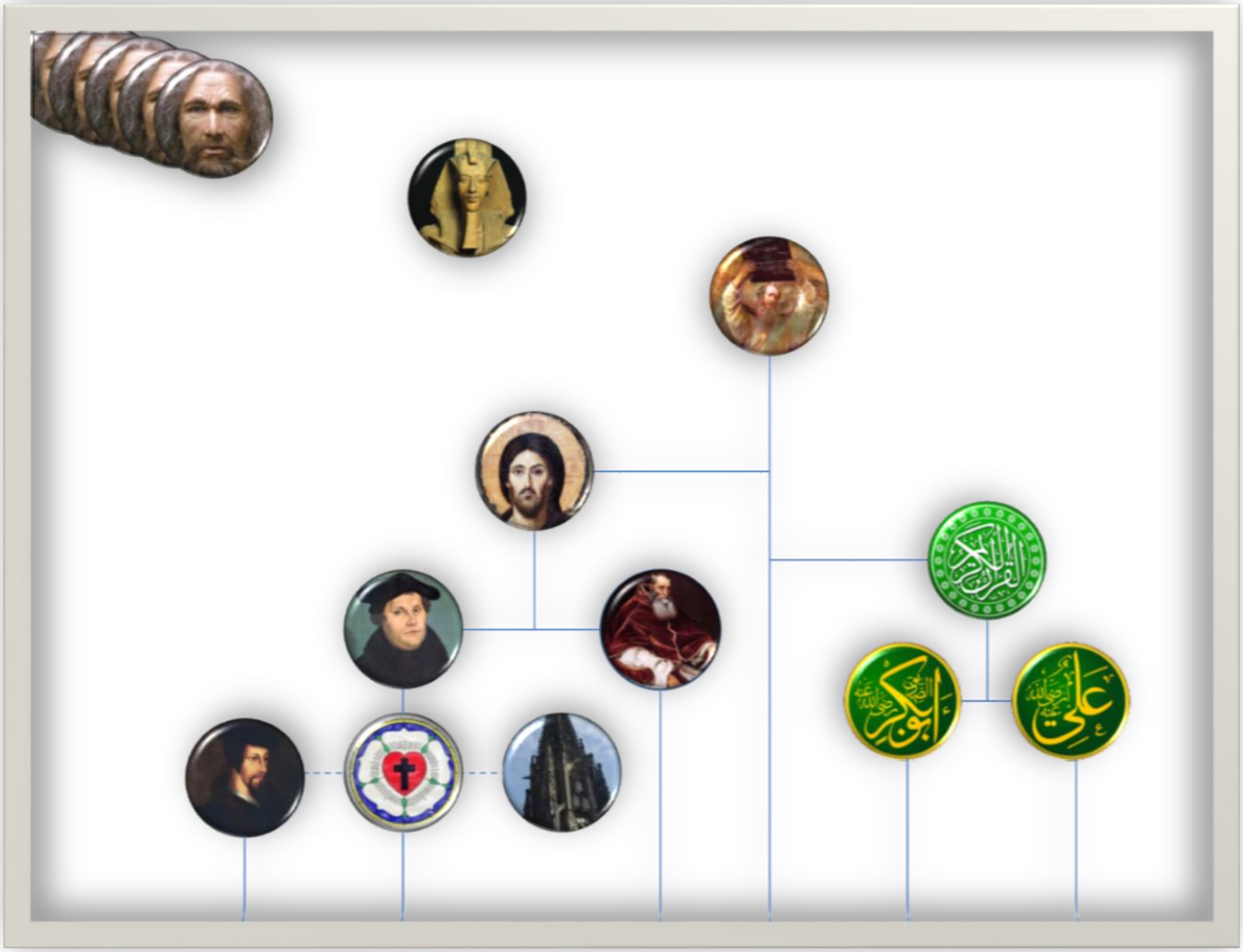

Figure 39: The history of the monotheism-prene [Monotheism]

It seems likely that the monotheism-prene came into existence numerous times and then went extinct (see *Hamlet's soliloquy's struggle*). Humans are in the prene-generating business. Our genes have programmed our brains to

continuously process our existing memes and generate new ones. It is easy to imagine early humans generating mystical or religious memes while dealing with the problems their environment presented. It seems likely that the monotheism-meme would have arisen from time to time. Even today, some individuals come to believe that they themselves are God or can speak to God. It seems likely that most times the monotheism-prene has emerged, it has failed to acquire more than a few followers before going extinct.

We do know that the monotheism-prene arose in Egypt during the reign of Amenhotep IV in approximately 1300 BC and that it survived and increased copy numbers for a significant amount of time.

In Amenhotep's time, the official religion of Egypt was polytheistic and hierarchical with the god Amun at the apex and the god Aten somewhere lower down. The name Amenhotep means "Amun is satisfied".

Amenhotep created the Aten-prene-set, a mutant of the Amun-prene-set, which included the monotheism meme and declared Aten as the one true god. Amenhotep even changed his name to Akhenaten which means "effective for Aten" [Wikipedia-AK].

As discussed in *Death to mutants*, often a mutant must compete with its parental prene-set for survival.

By changing the pantheon, the Aten-prene-set was antithetical to the Amun-prene-set's endura, so peaceful co-existence was unlikely. In addition, the Amun-prene-set had existed for at least several hundred years prior to Amenhotep, and, as is usual with such long lived prene-sets, it is likely to have survived many prene wars and to have acquired substantial weapons. *A priori*, one would not expect the Aten-prene-set to survive for long. So why did it?

Here we get into what I call “religion-ruler-deals”. Societal prene-sets do not exist in isolation, they sometimes form alliances with one another. A religion-ruler-deal is an alliance between a religious-prene-set and the prene-set of a government. In one form or another, religion-ruler-deal work as follows: the religious prene-set is mutated to include the god-has-chosen-the-ruler-to-rule-prene, and the ruler prene-set is mutated to include the this-religion-is-the-official-religion-prene. For example, on Christmas day 800 ACE, the pope crowned Charlemagne as the Holy Roman Emperor and Charlemagne reciprocated by killing everyone in Western Europe who was not Christian and would not convert.

Because Akhenaten was Pharaoh, he was a one-stop religion-ruler-deal maker; he made himself the special conduit between the people and Aten and he used the power of the state to suppress the Amun priesthood. He built cities dedicated to Aten and created stelae praising him. The Aten-prene-set increased copy numbers rapidly.

This situation resembles that of Henry VIII, who created the Anglican-prene-set. Like Akhenaten, Henry was a one-stop religion-ruler-deal maker. Henry made himself head of the Anglican Church and made the Church declare that Henry ruled by divine right. Henry then used the power of the state to protect his Protestant religion from the Catholic Pope.

What is particularly interesting from a prene-theoretic aspect is the stunningly rapid decline and virtual extinction of the Aten-prene-set.

In *Hamlet’s-soliloquy’s struggle,* we saw that it is common for a newly created prene-set to face a critical point when its creator dies. The soliloquy survived that point thanks to Heminges and Condell. Bach’s Brandenburg-concerti-prene was lucky to survive it at all.

It appears that Akhenaten did not take appropriate steps to ensure that after his death the Aten-prene-set could survive the on-going struggle with the Amun-prene-set. Akhenaten should have read this book. He made serious errors in the use of propaganda and force (see *Prene warrior*).

We can imagine that followers of the Amun-prene-set, including the high priest of Amun, members of the Amun hierarchy, and many others, were less than pleased with the Aten religion. Akhenaten could have used force to annihilate them and their instruments, but, apparently, he only suppressed them during his reign.

But perhaps Akhenaten biggest mistake was his apparent failure to take the seemingly simple and obvious step of assuring that his successor would use the power of the Pharaoh in support of the Aten-prene-set. This should have been prene-theory 101, given that the successor was his own son. Akhenaten seems to have started off OK; he named his son Tutankhaten which means “living image of Aten”. Then, it appears, Akhenaten dropped the ball.

When Akhenaten died, Tutankhaten changed his name to Tutankhamun (yes, King Tut) which means “living Image of Amun” [Wikipedia-TU]. The Amun-prene-set arose and defeated the Aten-prene-set. The Amun-prene-set followers seemed to have a better understanding of prene-theory; they destroyed many of the instruments of the Aten-prene-set: the cities, temples, and stelae that Akhenaten had built to the glory of Aten.

Henry VIII almost had a similar failure. When Henry died, his daughter Mary became queen. Mary was a close relative to Charles V, the Holy Roman emperor, and a staunch Catholic. Had “Bloody Mary” not died young, the Anglican-prene-set might have gone the way of the Aten-prene-set. As it was, Elizabeth, daughter of Henry and the Protestant Anne Boleyn, became queen, and the Anglican-prene-set is still with us.

In fairness to Akhenaten, perhaps his performance with respect to the Egyptian-prene-set as a whole was more successful than it was for the Aten-prene-set. Nonetheless, with respect to that prene-set, and hence the monotheism-prene, Akhenaten does not receive high marks.

What appears clear is that the monotheism-prene's big break came when it formed an alliance with other prenes to become the Jewish-prene-set. Unfortunately, historians know little about the origin of this prene-set, and I know even less. Basic questions such as whether Moses was an actual person remain unanswered. As a result, a prene-theoretic view of the originators of the Jewish-prene-set, and that set's parentage is beyond reach.

The relationship between Moses and monotheism has been investigated by no less a figure than Sigmund Freud whose (aptly named) book on the subject "Moses and Monotheism" [Freud] takes a psychoanalytic view. Freud hypothesizes a direct link between Akhenaten and Moses, but there seems to be little evidence to support this position.

The monotheism-prene is articulated in the Mosaic Covenant.

> *I am the LORD your God, who brought you out of the land of Egypt, out of the house of bondage. You shall have no other gods before Me.*
> First Commandment, Exodus 20:2-3

The first commandment, and with it the monotheism meme, entered the Jewish-prene-set very early. Historians indicate that Exodus appeared far earlier than other books now found in the Hebrew Bible.

As discussed in *Mutation*, prene-sets carefully control the rate at which memes mutate and the earliest memes to enter a prene-set typically have the slowest rates of mutation; that is, they become endura.

In my opinion, this virtual immutability is the central pillar on which the current success of the monotheism-prene rests. Because of this immutability, a mutant of the Jewish-prene-set would have very little chance of surviving without preserving it. So, while the Catholic, Protestant, and Moslem prene-sets are in many ways antithetical to

the Jewish prene-set, all continue to contain some form of the First-Commandment-prene and hence the monotheism-prene.

Like other successful prene-sets, the Jewish-prene-set allowed for carefully controlled mutation. One of the most important mechanisms for mutation was embodied in what I will call the “prophesy-prene”, which dictated that God would reveal His word to certain special individuals called prophets.

The Jewish-prene-set recognized thirteen Patriarchal Prophets, and as many as a hundred total prophets. But, there was no prohibition against future prophets. In fact, the Jewish-prene-set invited them, and then left it up to the followers to determine which were “true prophets” and which were false.

The Jewish-prene-set did have a few memes to provide guidance on future prophets, but the instructions were not that clear.

> *If there be a prophet among you, I the LORD will make myself known unto him in a vision, and will speak unto him in a dream. (Num 12:6)*

> *And if thou say in thine heart, How shall we know the word which the LORD hath not spoken?*
> *When a prophet speaketh in the name of the LORD, if the thing follow not, nor come to pass, that is the thing which the LORD hath not spoken, ... (Deu 18:21-22)*

The prophesy-prene would turn out to be a disaster for the Jewish-prene-set as a whole, but, perhaps paradoxically, a windfall for the monotheism meme.

The major religious prene-sets, Christianity and Islam, that would arise from the Jewish-prene-set, would take advantage of the prophesy-prene. They would evolve their own endura, but, presumably because it was so deeply entrenched, the monotheism-prene was left intact.

Interestingly, as we will see, Islam would take steps to slow its own rate of mutation by mutating the prophesy-prene.

No doubt, many “prophets” came along and spawned mutations of the Jewish-prene-set. It seems likely that most of these mutants quickly went extinct.

There seems to be agreement among scholars that Jesus was a Jew, that he was born and raised in the Jewish community of Nazareth then under the control of Rome. He became a Jewish rabbi (i.e. teacher). So, Jesus’ job and perhaps other factors led him to spend time and brain cycles processing his Jewish and Roman memes and generated new ones (see *Hamlet’s Soliloquy’s struggle*). He generated the Jesus-prene-set (later to evolve into the Christian-prene-set), and applied the prophesy-prene.

What is surprising is that the Jesus-prene-set did not quickly go extinct. As remarked earlier, often a new mutant competes with its parental prene-sets. The Jesus-prene-set was a mutant of the Jewish-prene-set, but also the Roman-prene-set. The Jesus-prene-set was antithetical to the endura of both its parents. For example, Jesus, himself, asserted that he was the messiah, even though by the requirements embodied in Jewish endura, he did not qualify to wear that silver star (see *The silver stars you wear*). Jesus’ expulsion of the money changers, condemnation of commerce, and his general disruption of civil order would not have endeared him to the Romans. The Jesus-prene-set should have had little chance of surviving a war with such veteran opponents. Of course, Jesus himself did not survive that war, but the Jesus-prene-set did. Why?

As the initial instrument of the Jesus-prene-set, I have seen little to recommend Jesus. Unlike Akhenaten, he had no military or political power; he was not a one stop religion-ruler-deal maker; he could not impose his memes on others.

Perhaps as a teacher (i.e. rabbi) he had learned to make compelling presentations to others. In any event, he acquired a powerful ally in John the Baptist. Apparently, John was an apocalyptic preacher who saw in Jesus the great prophet he

had been expecting. John had an established following prior to meeting Jesus, and it is among these followers that Jesus acquires his first disciples. The Jesus-prene-set had acquired powerful new instruments. These new instruments allowed the Jesus-prene-set to survive Jesus' crucifixion, however they did not end the war, and the odds still heavily favored the Jewish and Roman prene-sets. In such a setting, one often seen survival strategy is flight.

Indeed, most of the apostles did flee – to India, Afghanistan, Iran, Syria, Bulgaria, Georgia, Italy, Spain, and many other places. They would spread the Jesus-prene-set; they would augment it with the Gospels, ultimately the Jesus-prene-set would mutate into the Christian-prene-set and the Gospels would grow to become the Christian-prene-set's endura, the basis for the New Testament.

Figure 40: The earliest known fragment of a Gospel (John). The Rylands Papyrus 52, Ca 150 CE. [Gospel]

The competition between the Christian-prene-set and the Roman-prene-set ended in 312 AD with a major religion-ruler-deal with Emperor Constantine. This was of monumental importance for the monotheism-prene since it ultimately opened up all Western European (and eventually all New World) brains to its spread.

The competition between the Jewish-prene-set and the Christian-prene-set persists, and I think it reasonable to assert that the Jewish-prene-set's copy numbers have suffered greatly because of it. Today, Jews make up about one half of one percent of the world's monotheists.

As these things go, it was a remarkably smooth road for the Jesus-prene-set (for a comparison, see remarks regarding Bach's Brandenburg Concertos in *Hamlet's Soliloquy's struggle* or the story of the smallpox virus in *The resurrection of smallpox*.

Mohammed was neither a Jew nor a Christian. He was born in Mecca on the Arabian Peninsula where the prevailing religions were polytheistic. There were significant populations of Jews living in the same area so, the Hebrew Bible and the monotheism-prene would likely have been well known.

Famously, at about the age of 40, Mohammed began to ascend Mount Hira to meditate. Mohammed processed his existing memes and produces the Mohammed-prene-set, which evolved to become the Islamic-prene-set. Mohammed includes the monotheism-prene.

He includes Moses and Jesus as prophets, and adds new words-of-God memes that cleared up any confusion about future prophets:

> *Muhammad is not the father of any man among you, but he is the Messenger of God and the last (end) of the Prophets. (33:40)*

With this, Islamic-prene-set reversed the Jewish-prene-set's use of prophets for mutation. It also created lag-conditions (see *Why we die* and *Lag conditions*)

Once again, we see the common pattern of new prene-sets competing with parental prene-sets for survival. Not surprisingly, the existing polytheists and rulers of Mecca attempted to assassinate Mohammed. The attempts were not successful, and Mohammed was around for many years to act as a powerful instrument for his beliefs. As in the case of Jesus, the early followers fled, first to the Kingdom as Aksum, and then to Medina where a religion-ruler-deal, referred to as the Constitution of Medina,

provided a base from which the Islamic-prene-set spread rapidly across much of the Middle East and North Africa.

Luther was not a Prophet; he did not claim that God had revealed word-of-God prenes directly to him. He was a mid-level member of the Roman-Catholic priesthood, but his impact was monumental.

I include his story, because it allows us to explore how a major societal prene-set can be torn asunder by the application of a modicum of force. In the big picture, Luther did not have a major impact on the monotheism-prene, which by Luther's time was so firmly entrenched as endura in Christianity, that nothing short of cataclysmic exogenous events could expunge it.

We are fortunate that historians have unearthed an abundance of information about Luther's life. We are unfortunate that I am not an historian. So, I will stick with the standard story of Luther's life in trying to understand what happened from a prene-theoretic standpoint.

Luther's early life was fairly uneventful from a prene-theoretic point of view. His parents had immediately exposed him to the Catholic-prene-set, and to the academic and other societal prene-sets commonly acquired when pursuing a career in law.

Then on July 2, 1505, when Luther was twenty-one, an event of prene-theoretic interest may have occurred. While traveling through Stotterheim, a violent storm may have resulted in lightning (nearly) striking Luther (and/or Luther's friend), and (perhaps) throwing Luther to the ground (and/or killing his friend). Historians seem uncertain.

Luther himself later described the event, and recalled crying out:

"Help, St. Anne! I'll become a monk!"
-Martin Luther [Luther]

If something like this did occur, then Luther appears to have acquired a pivotal meme (see *How the brain captures memes*), and it may provide some understanding of the rest of his life. From this moment on, he essentially appears to have PTSD with its associated obsession.

Within a few weeks of the storm, Luther dropped out of law school, and enrolled in monk school, and, to the delight of the Catholic-prene-set, began to seek salvation with a vengeance. He becomes about as obsessed as it is possible to be:

> *"I was indeed a pious monk, and followed the rules of my order more strictly than I can express. If ever monk entered heaven in virtue of his monkery, assuredly I should have gone there… A much longer time of it must have made me martyr, even to death, what with watching, prayers, reading and other labors!"*
> *-Martin Luther [D'Aubigne]*

Presumably, Luther learned Roman-Catholic endura while at his Augustinian cloister, but perhaps he was sheltered from the accommodations the church had made to the genetic imperative (*There is no escape!*). During a visit to Rome in 1511, Luther is reported to have been upset by the irreverence of some priests, and the exploitation of followers through the selling of indulgences. He seems to have seen these as antithetical to Christian endura and therefore corrupt.

Famously (but perhaps apocryphally), in 1517, Luther hammered his ninety-five theses onto the door of Schlosskirche in Wittenberg. Whether he knew it or not, he had started the Protestant reformation, he had dropped a feather (see *When memes collide*, *The rise of the cenes*) on the Catholic-prene-set. Like Princip's feather (*When memes collide*), Luther's would have astonishing ramifications.

The parental Catholic-prene-set attacked Luther using the tried and true methods. These included excommunications, and, exploiting the religion-rule-deal that began with Charlemagne, a death sentence from the Holy Roman Emperor Charles V.

It seems likely these would have worked, but, Luther somehow made his own religion-ruler-deal with Prince-Elector Fredrich III and fled to Germany.

The ninety-five theses were a challenge to the Catholic-prene-set, but to me it seems unlikely that they alone would have fragmented the Church. But Luther was a prene-warrior of astonishing skill, and it is what he did in exile that ultimately led to Protestant ascendancy.

Historians point out that Luther was adept at using the printing press to spread his ideas around Europe. But perhaps they underappreciate how brilliantly he used it. In 1522, he published his German-language Bible. Let me explain why I think so highly of this step.

In the early 1970's computers were still behemoths that existed in a few elite institutions and were inaccessible to most people. I was a graduate student of Berkeley and ended up with the keys to the room that contained one of the world's most advanced computer systems for working with graphics. It had a big screen, which today you would laugh at, on which black and white images could be displayed. Someone had written what must have been one of the very earliest video games. It was called Spacewars, and it allowed stick-figure rockets to maneuver and fight under keyboard control. I was cool! I could provide access to the most astonishing technology that any of my friends had ever seen. No one would find that game exciting now; we have Xboxes and iPhones. Well, when Luther introduced and mass produced the German-language Bible, he was like Steve Jobs introducing the iPhone. The printing press had existed for about a hundred years, and common language translations of the Bible had been around pretty much forever. But by wedding the two, Luther had found the killer app for a widely available technology. The common (literate) renaissance man could now play the greatest game in the world – he could

read the Bible – he could speak with God! And the Pope? Like me, he quickly became uncool.





Societal prene-sets are constantly mutating, and religious prene-sets are no exception. A recent count of Christian denominations revealed tens of thousands distinct denominations each with at least a few hundred followers [Barrett]. So, the rate of mutation of Christian prene-sets has been quite rapid. Why so many?

We can thank Luther for that. While Mohammed slowed the rate of mutation of the Islamic prene-set, Luther greatly accelerated it for the Protestant prene-set. Luther gave every individual the power to interpret the endura in the Bible. By this step, Luther, set the rate of mutation to warp speed.

So, there arose a huge number of mutants with different interpretation of Biblical endura. This gave rise to the large number of Protestant denominations that are with us today and many denominations that have gone extinct.[23]

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[23] For a really horrifying (and entertaining) example of the human cost of Luther's change in the rate of mutation, I encourage you to listen to the Dan Carlton podcast "Prophets of Doom" about the Anabaptist uprising in the city of Munster in the sixteenth-century [Carlin]. When you are done, look at the image of the spire in Figure 39, do you see those three little rectangles?

The stories of Jesus, Mohammed, and Luther are remarkably similar. A person acquires and believes a large set of religious memes that are found in his environment. He spends a great amount of time and brain cycles processing those memes and produces his own variant. He seeks new followers for his prene-set. The religious and ruler-prene-sets that existed before the new prene-set try to exterminate it, and, in particular, its inventor. The early followers seek protection through religion-ruler-deals that provides a stable base to operate from.

Why, did the monotheism-prene go viral? There can be many reasons, but as we saw in the case of the Brandenburg-concerti-prene (*Hamlet's soliloquy's struggle*) and the smallpox-genome-prene (*Genes, memes, and cenes*), a major contributor is sheer luck.

The history of the monotheism-prene continues; its copy-number is now so large, and its position as endura within many religious prene-sets so securer that it will almost surely be with us for the foreseeable future. Forever? Probably not, at least not with large copy-numbers. Likely there are dinosaur genes that had high copy numbers for millions of years but are now extinct (copy-number=0).

The monotheism-prene seems to have been fortunate over the last several thousand years. I am only aware of a few serious attacks during this period: that of the Mongols in the 13th century, and that of communism in the 20th. Today, the monotheism-prene's major threat seems to come from scientific prene-sets, and their allied academic, national, and political prene-sets. It is possible that these prene-sets will steadily diminish the number and commitment of followers of the monotheism-prene.

Here is a prene-theoretic graphic of the monotheism-prene.

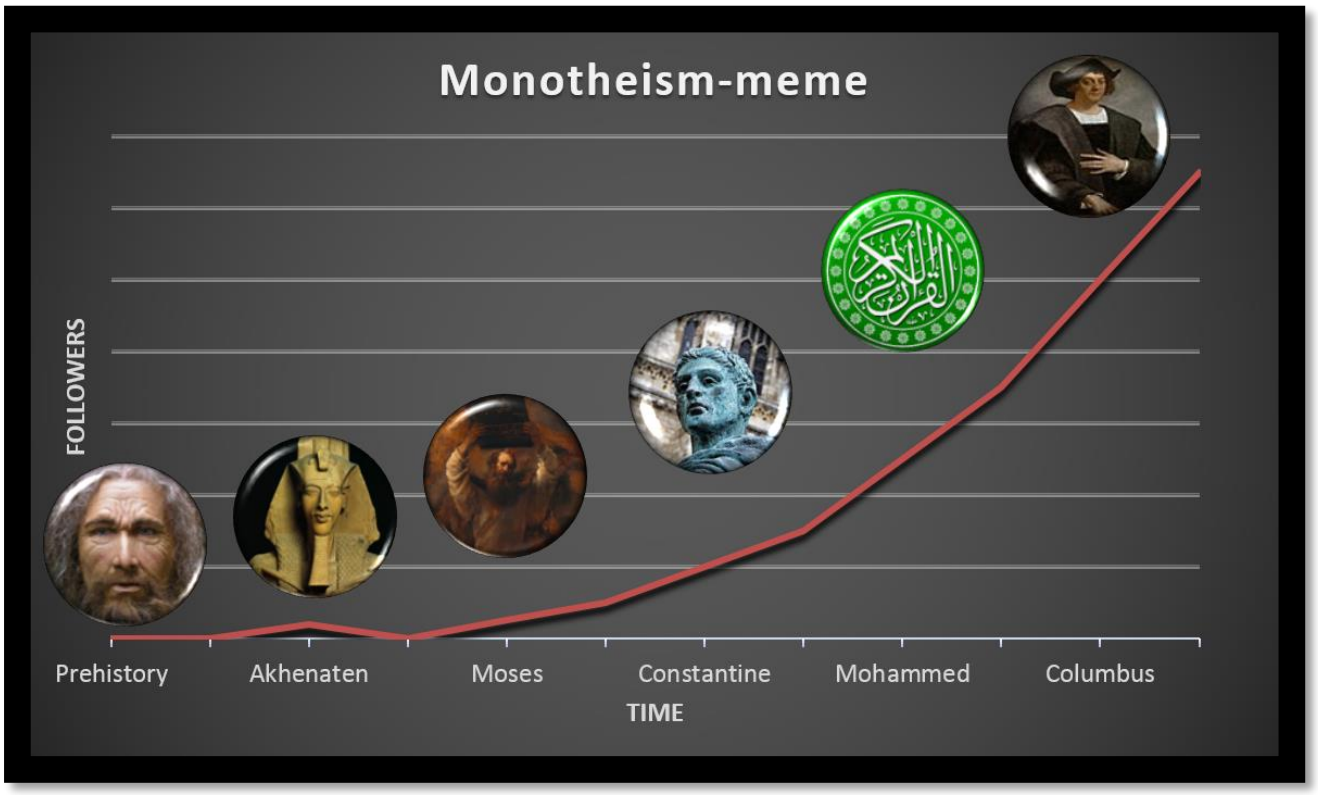

Figure 41: The history of the monotheism-prene (from a prene-centric viewpoint)

The primary content of Figure 41 is the graph, what I call the “follower curve”. While historians traditionally would put great people and great events at the center of their investigations, a prene-theoretic view puts data like the “follower curve” at the center. The follower curve itself will lead to the people and events of importance. In mathematical language, it is at non-smooth points of a meme’s “follower-curve” that we should look for great people and great events. I have added images to the graph to indicate these events and people.

The absence of Jesus and Luther may seem surprising. In the former case, while Jesus created a critical prene-set, that prene-set did not immediately produce a huge number of followers. It is when Constantine converted that Europe and the Levant opened up to Christian memes. Had Constantine converted to Zoroastrianism, would monotheism have gone viral anyway?

Luther is not included because the Protestant reformation did not significantly increase the monotheism-prene's number of followers. It was a schism, a civil war for the brains of people who already believed the monotheism-prene. In general, schisms seem to occur when a new prene-set arises without, at least initially, significant changes in the parental prene-set's endura, but with significant changes in the interpretation of that endura. In the case of religious prene-sets, endura often found in durable form called scripture. In this form, it is syntactical and only acquires meaning through semantics; that is interpretation. The Sunni-Shite schism seems to also be of this form.

I included Columbus because he symbolizes the age of exploration which provided new fertile environments for the monotheism-prene to increase the number of followers. As an aside, Columbus is also a symbol of colonialism, and that is considered a terrible thing in the current academic environment. Is it? Prene-theory has nothing to say about such questions; however, it can answer the question: was colonialism a successful evolutionary strategy? The answer is yes, it has greatly increased the copy numbers of various prene-sets, such as Christianity and democracy.

It would be interesting to figure out the follower-curves for other memes. For example:

Monarchy-prene: there is exactly one ruler.

Democracy-prene: rule by consent of the ruled.

Marriage-prene: each person shall have one mate.

Science-prene: the explanation of events can be obtained by rational means.

Communism-prene, money-prene, animal-rights-prene, happiness-prene, Santa-clause-prene, there is an inexhaustible supply. There are many questions to ask. How are follower-curves related, are they independent, do the rise and fall together, do the rise and fall in opposition?

Perhaps the prene-centric view can cast light on some of the meta-issues of history. For example, the “great man” question. Is history the story of great men, or is it the story of great events? From the prene-centric view, it is neither; it is the story of societal prene-sets. Prenes are the overlords of history. Though immaterial, they carry out their struggles and wars by means of the material world, including its humans. Human endeavors are manifestations of the prenes struggle to survive.

The prene-centric view changes the stage of history. A standard history of monotheism might have described a cast of characters moving on the world stage. The march of Islam from Arabia across North Africa to Spain in the seventh and eighth centuries, the descent of crusading knight on the Holy Land in the Middle Ages. Our prene-centric view has deemphasized geography and tracked the spread of monotheism from prene-set to prene-set. Copy-number becomes more important than geographical distribution.

Geography is rapidly declining in importance. Most of us don’t know and don’t care where Google, Wikipedia, and Facebook are physically located. We will soon see religions, nations, and economies rise and fall in cyberspace. These entities will be no less powerful and have no less impact on our lives than their current “brick and mortar” counterparts. Political, economic, and even military power will be diffuse; the physical locations of like-minded people will be less important than their numbers and connectivity.

We already see early signs of this development. For example, “homegrown terrorist” whose allegiance is to others in cyberspace, rather than those in their hometowns. Future wars are likely to involve geographically dispersed, internet connected, groups of individuals driven by competing prene-sets that are political, economic, religious, or otherwise. By and large, these wars will not be fought with guns; they will be fought through cenes (see *The rise of the cenes*). The fine line between “hot” and “cold” wars will disappear (in fact, it never existed). Wars will vary in intensity as prene-sets engage and disengage in their selfish struggle to survive.

Perhaps future maps will resemble the “T and O” maps of the Middle Ages more than the geographical maps of today. For example, maps may represent important prene-sets, the number of followers, and the communications channels between them.

Figure 42: T and O map from 12th century [Wikipedia-TO], contemporary world map [Map1], hypothetical world map of the future [Map2].

From Earth to Proxima Centauri b

Interviewer:

We are honored to have Captain Amitroe Gardono with us today. Captian Gardono is, of course, one of the pioneers of space travel, and the last astronaut to be totally human.

Captain Gardono, it is a momentous occasion; what are your thoughts?

Gardono:

Well, there are so many. I remember when I was a small boy hearing about the earth sized planet orbiting Proxima Centauri. I dreamed of going there; I think that's why I became an astronaut. Of course, at a distance of 4.3 light-years getting there wasn't a realistic possibility.

Interviewer:

What do you make of the fact that all of today's crew will be totally non-human?

Gardano:

Well, I know many of them, and it seems to me that they are an especially talented group. Even before Gagarin and Glenn, we always put our best and brightest at the forefront of exploration, today is no exception.

Interviewer:

Would you like to be going with them?

Gardono:

Oh, heavens no. it's a pretty long trip. Even at a million miles an hour, it will take over two thousand years to reach Proxima Centauri b. And, when they get there, they will find a rocky planet with no atmosphere, virtually no water, and a radiation burden a million times greater than here on earth. A total-human like me would have about as

much chance of surviving as a jelly fish. We were made for earth; these computea were made for the universe.

Interviewer:

And of course, these travelers will never return. Their mission statement is clear: to evolve throughout the universe.

Gardono:

Yes, I am touched by that in many ways. Of course, we will never see them again, but they will transmit comprehensive-experience data on a continuous basis, and so we who remain, humans, chimeras, and computia alike, will be able to keep an eye on them and see the places they go, the beings they encounter, and the species they become.

But, I have great-great-grandchildren of my own and know how they are consumed by their own lives and futures; I suspect that these children of our super-species will eventually forget about us, but I will always feel that I am some small part of them.

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