Evolution is Simple and Fundamental

Preface

The controversy over teaching "evolution" is about far more than a particular biological process. It's about the search for meaning and, perhaps, comfort. It's about whether science is a well-defined process of discovering (or revealing?) the "one truth" or is it simply the willingness to testing our ideas to find their limits.

It's unfortunate that the teaching of evolution is locked into an educational system that seems to be regressing into teaching testable facts as if they are mantras to be memorized rather than educating people so they can be effective contributors in a constantly changing and thus evolving society.

We see the same problem in geometry classes that require students memorize "facts" like how many degrees the angles of a triangle as it were important. The real lesson should be how to do proofs and how to think logically and critically.

Science is typically taught as a six step process but even as a student I realized that was wrong. Science is really about being willing to test ideas and accept that our understanding is always tentative.

More subtle is that the notion of "proof" in mathematics doesn't really apply to science because the results are always tentative. Even a simple notion like how long is the coast of North American doesn't have a "true" answer – it depends on the purpose and how tightly we follow the coast.

Evolution itself is a basic process that occurs when we have a system that can regenerate what works and discard what doesn't and has a mechanism to provide some perturbation (mutations) that act as a source of diverse potential solutions. I call this digital at scale.

When we teach evolution in biology we lose this simplicity because biological systems are so complex and our own biology is fraught with emotion.

Rather than imparting an understanding of how systems work and giving students the tools to apply their understanding to new situations we turn out citizens who do well on tests. It's harder to recognize what they lack because that can't be easily measured.

It's not about "Intelligent Design" vs evolution – it's about understanding how systems work. It's about public policies that can tolerate risk rather than impose uniformity. It's about challenging accepted wisdom to discover new possibilities and judging others wanting. It's about tolerating a diversity of approaches because there isn't one true answer.

While I'm excited about looking ahead and explaining how systems work I can't do it all in a single essay. My own understanding of the ideas and explanations evolve.

Since I'm not going to get it right the first time I'm going to post a series I'm going to try to write a series of incomplete, imperfect and, ideally, shorter essays.

This is my first attempt …

It Just Evolves

Evolution is fundamental and pervasive. Before we look at complex biological systems we should look for simple and less controversial examples.

The Internet is very simple and wonderful. It seems to have been designed so well.

In fact, the Internet works because it wasn't designed for today's applications. The Web was a surprise and the ability to use the Internet instead of the phone network "just happened" when enough capacity available. The Internet has evolved from very simple design principles. When we write TCP/IP the "/" is a separation of the meaning at the application layer (TCP – the application protocol) and IP (the Internet Packet transport protocol). It's the "End-to-End" principle. The end points have a relationship that is independent of whatever is between them.

End-to-End is often confused with "womb-to-tomb" which requires someone take responsibility for every step along the way. If I send the number 33 over the Internet you can't tell if that stands for 33 degrees or the letter A or the color dark green. P2P (or Peer to Peer) is just another term for End-to-End as people work around the limitations of the current Internet.

The other important principle is that the Internet is digital – if a good idea works we can share it and it can be-

come a standard. These standards are really suggestions and not requirements. You can reinterpret or violate standards as you wish. In fact, there is no difference between a misinterpretation and an intentional violation. The only consequence would be a decreased ability to communicate with others. Very often the new interpretation works much better than the old approach and it becomes a new standard. Those ideas that don't work are discarded. Here too there is no sharp distinction between a failure and simply not working as well as other approaches.

The key point is that the Internet acts like a marketplace that takes advantage of opportunities rather than requiring the Internet be anything in particular.

Today we have VoIP (Voice over IP) replacing the older phone network. Even if you don't subscribe to a VoIP service you are probably still using the protocols because they simply work better than protocols specially designed for telephony. This seems like a paradox – how can the Internet work better than the phone network for carrying phone calls? It does so precisely because the Internet is opportunistic and people discover what works well and that feeds a process that creates more capacity. It turned out that at some point this process created enough capacity that we could use those packets to carry voice. This approach may be less "efficient" than the phone network by traditional measures but that doesn't matter when we have abundance and thus a new measure of efficiency. It's like the difference between trying to live on expensive caviar rather than bread.

The Internet has evolved precisely because there was no designer to prejudge what was important. Had there been we wouldn't have had the opportunity for the web "to happen". The web itself was designed but it too has evolved far beyond the original vision of sharing academic writings.

The Internet has created opportunity rather than just narrow solutions. This is an important lesson for those who are very concerned about making the one right thing happen.

This is the essence of evolutionary processes – taking advantage of opportunity rather than looking for solutions to predefined problems.

DNA is a digital representation and proceeds along the same principles. Mammals "happened" when the ecology changed and dinosaurs no longer rules.

Once we get beyond the egocentrism that requires we be special we can start to understand the process and understand what simply emerges rather than assuming everything happens by intent. That's what makes the future so exciting – the many new possibilities. It also means that we are participants. We can't predict the future but we can suffer the consequences of short-sighted decisions.

The "Evolution" essays

The audience for this is those who believe that in Darwin's essential idea – that evolution is a natural process that does not require, nor even tolerate, divine guidance. It may also appeal to those who are curious and trying to understand the issues. In listening to the debate I've been concerned with the inability to articulate why the issues are important and to lift the debate beyond the limited scope of the details of biological evolution.

"Nor even tolerate" is a strong statement and one can indeed define divine guidance in such a way as to make it moot. After all, it is just a phrase and we can make it mean what we want. In this context I'm using it to emphasize that evolutionary processes are not directed and that there is just a path and no destination.

I've been struggling to write about a set of interrelated issues. For now I'm going to try to write overlapping essays addressing these topics from different points of view. In writing about these topics my own ideas have evolved – the best way to learn is to try to explain ideas to others. Of course, if you have read my writings you may see some familiar themes and examples as per my essay: "Pardon me if I repeat myself".

I'm directly addressing the fears that make people hostile to the idea of godless evolution. The idea that the universe operates with utter indifference to our existence is fundamentally at odds with the belief that we are special and will live forever under the protection of a personal God who sees each of us as favorite.

By teaching evolution in biology class we force this confrontation because it is about us. The actual mechanisms are fundamental to all systems. We can look at simple examples like the Internet as laboratory studies without confronting or forcing teachers to confront the real issue behind the proxy debate about teaching "the theory of evolution". It's as if we are debating the theory of addition.

Why We Must Understand Evolution

In itself, it doesn't really matter whether we "descended from apes" or somehow appeared on Earth one day. Unfortunately all-too-often we find that people are being forced to memorize these "facts" and that misses the real point of learning about evolution.

Darwin's insight was in recognizing the mechanisms of evolution. People already knew that the earth had been changing but ascribed it to a mysterious process directed by a deity. Darwin provided an explanation of how the process could proceed without a designer.

Just as Copernicus displaced us from the center of the universe Darwin denied us specialness. We are just the result of an indifferent process.

It is this insight that is at the center of public policy controversies today. After all, why should we worry about the ecology if it's only purpose is to server our needs.

If we are not that special than if we must take responsibility for the consequences of our actions and that can lead to very unpopular political consequences. In countries that accept responsibility these political measures are accepted as the price we must pay to assure that we will continue to reap the benefits of our world rather than discovering ourselves impoverished.

Perhaps it is the prosperity that we in the United States have experienced that has allowed ourselves to continue to believe we are special and exempt from the consequences of our actions.

The complexities of biological evolution make it too easy to dismiss it as just another story. We tend to teach evolution as an arbitrary fact to be memories. We also teach science as a six step process as if it were just another formalism or religion. No wonder so many people dismiss science as just another competing explanation.

Science is simply about constantly testing our understanding. We learn when we find out we are wrong and we adjust our models.

Evolution too is a simple mechanism. Biological evolution is just a special case. We get evolution whenever we have a system that regenerates what works and discards what fails. We can consider this a property of "digital" systems. It's a little more than that as I point out below but that's the essential and simple idea.

Our understanding of digital systems is a result of our experience with computing systems that can operate autonomously. We can look at the Internet and see how this process operates in complete detail. Attempts to govern the system, akin to adaptionism in evolutionary theories, actually make the system behave worse.

The system operates only in the absence of a designer!

We must liberate evolution from the confines of biology and recognizing that it is the process by which all systems change and survive.

The so-called complex systems are those for which we don't have simple models but the mechanisms are the same. They are not magic. Though we cannot make detailed predictions we can characterize the systems and make intelligent decisions about how to co-exist with each other and the world in which we find ourselves.

As Jared Diamond has shown in *Collapse!* we can't afford ignorance. "Just so" stories may be comforting but the price is far too high.

Those who insist on denying biological evolution put us all at risk. This is not a battle over religion; it is a battle over understanding the world so that we may have a future.

"Explanations" without insight

Everything around us is constantly changing. That's obvious. What is less obvious is why things seem to work so well. Surely this can't be by chance. This is an interesting philosophical question but when we apply this to ourselves as a product of slow change over time it becomes a very loaded question. The question is no longer why things work but WHY are we here. The goal is not "understanding" in the sense of insight. It's just an attempt to satisfy a much deeper need and yearning for comforting certainty. Yet the result is a universe that is perverse and seeming malevolent.

Biological evolution has become the flashpoint in a cultural war because the stakes are so high – it's about us and the meaning of our existence. The focus on biological evolution compounds the problem because it is very hard to do science in biology because there are so many interacting processes. Like clouds, the complexity allows us to see things that aren't there. We start of by asking the wrong question because our egos do insist that we are special. Humans are very complex and utterly im-

probable so it is "obvious" to many that we need to explain the particulars of our existence.

Against this we have a deep cultural divide. The search for revealed truth is very old. Even the early Greek philosophers assumed that there was a natural order that they could discover. The big idea of the renaissance was that you can and should ask questions rather than just accepting "explanations" you were given. I put explanations in quotes because they weren't explanations in an operational sense as much as stories that felt like explanations. It's as if we accepted Aesop's fable of the sour grapes to understand why inaccessible grapes are sour – we might very well explain a phenomenon that doesn't even exist!

Such ignorance can be very dangerous. In Collapse!, Jared Diamond attempts to understand how and why some civilizations have survived and others prospered. David Landes asks a different question in The Wealth and Poverty of Nations. The common theme in both books is that societies pay a high price for seeking satisfying "explanations" rather than accepting disquieting uncertainty.

When someone walks out on thin ice and drowns we ask why as if the obvious reason isn't enough – we are seeking comfort in the guise of an explanation.

There is tragic irony in this because they are seeking false certainty as a refuge from a world they see as impossibly confusing and dangerous. We can see this in the idea of crossing the street. It must be terrifying with all the traffic going to and fro. It satisfying to know that God is looking after you and will assure you make it across safely. How else can you explain the phenomenon? What's there to explain? We created the streets – why would we create streets that weren't safe to cross? We could say that streets evolved or we co-evolved with them but that's an observation rather than an explanation. Well, I guess you could call it an explanation but that's part of the problem – our language is a very flexible tool. But its flexibility allows us to use words without really understanding them and for us to think we've communicated with others without actually sharing the same concepts – just the same words.

This is the point that George Lakoff makes in *Moral Politics*. We all cross streets but it's not obvious that some do so with the confidence that they are being protected by an intelligent being and others just rely on their ability to look for cars before proceeding. The difference become obvious when we shift to different venues and apply the same explanations to other situations. Imagine designing a new highway system leaving the safety considerations to God. We don't usually have to worry about that because the fallacy becomes pretty obvious and we do have engineering principles to guide us. Drivers, on the other hand, have different risk profiles. Putting aside teenagers who seem to assume their own immortality I'd rather be on the road with a driver who takes responsibility for his actions than relying on God as his co-pilot. Of course, even those drivers do tend to be cautious but seem unwilling to take the credit for their good driving – it is only good if it meets the approval of their deity.

What does crossing the street have to do with evolution? Everything! We don't just cross the street, we await an opportunity when there are no cars and it's safe. Sometimes we wait and sometimes we walk on one side and then take advantage of the opportunity when it presents itself. Often we decide where to shop based on the street pattern – it's an iterative and interactive process. There isn't a mathematic equation that tells us how to cross the street though we could step back far enough and observe statistic properties. We can, however, give a recipe or algorithm for crossing the street.

Computers have given us a new vocabulary for describing such a process. It is this vocabulary that allows us to describe dynamic systems. It's more than just a vocabulary. We can create operational models and see how they work and tease them apart. We can create systems and watch how they operate given a set of rules. Some have compared this with playing god – we give birth to systems that operate autonomously. It's an interesting metaphor, especially as we discover the intrinsic limits of such control.

Perhaps the most disturbing result comes from Claude Shannon's work on information theory. If you look at the letters in a book they have no meaning in themselves. It's not until someone puts enough of them together that the reader can find an interpretation. Even then, two readers might not agree on the meaning of the word. It is ambiguity, not meaning that is fundamental. Do those genes encode a gill or an ear? It depends on the context not the particular genes themselves.

Computers have given us the Internet. The key to the Internet's success is the end-to-end principle which means that the network itself transports bits but doesn't define their meaning. The meaning is defined at the edge. 61 may be a number or may represent the letter "a". We can't tell if we just look at the traffic on the net. It depends on how the reader may interpret the value.

Meaning is not intrinsic and the same evolutionary mechanisms apply to any system that changes.

It means we aren't very special and that's part of the problem. It was very hard to accept Copernicus mathematical transformation because it came at the price of displacing us from the center of the universe. Galileo was disturbing because the notion that the planets were full-fledged entities in their own right didn't fit into a model in which everything had a purpose and that purpose was part of God's plan for us.

If we look at our laboratory model we can observe how a system with no one in charge becomes a stable system. Not just that but it challenges systems designed for stability by becoming more stable and less expensive! And it does that because it is simple. Complexity is an illusion – we call systems complex when we fail to see the simplicity.

The key idea is that of digital systems. Digital systems have a very important defining property – there is a sharp distinction between the states. If you make a copy you are regenerating the original! It gets more interesting when we observe that we only regenerate what we care to regenerate and we ignore the rest. You can think of this as natural selection but it's a local decision that composites into coherent behavior! Here is a subtle twist when we define success as what is regenerated. It seems tautological but not really. It's just an operational definition!

Of course if we really did just perfect reproductions of what we already had it would be difficult to get change. We can get new properties by combining elements in novel ways. The combinations themselves are digital entities and so are the component entities. Digital itself is a simple concept but if we try to explain all the recombinations it seems complex. But the complexity emerges and is not intrinsic. When we look at a web page built out of many elements it is again simple.

What is fascinating is how the properties disappear when we look very closely and only appear when we see a whole. This is no different from what we see in statistics – we refer to some properties as statistical when we can't see them in individuals. I argue that the so-called wave/particle duality in physics is similar. The problem with such phenomena is that they seem to demand explanation when there needn't be any – it's a matter of observation and interpretation. We should keep our egos in check – this interpretation needn't involve us at all. If a tree falls in the forest the sound waves will be the same whether or not we are there to listen.

There is another key element in the process – scale. That table does seem very solid but that's only because of the constant motion of atoms and molecules filling the gaps and clinging to each other. They are in constant motion and constantly recombining and changing.

We're familiar with shaking a bowl of sand or pebbles to smooth it out. This is a all evolution does – the constant chaos at a small scale allows the system to appear smooth and stable at a larger scale. You don't choose the exact grains – you keep shaking until some just happen to fall into place but you don't know which or how soon.

This is a fundamental process. When you hit a dead end it's too late to try to find a solution – it's much better to choose among solutions already available. If you can't predict the future then you better have a rich set of alternatives already available and that's what diversity and disorder give us. There's no guarantee there isn't a solution. That's a dead end that doesn't get regenerated. Here too we need scale. If the weather changes you might find yourself in the wrong pond and can't find any way out. Or you may have a wonderful protocol on the Internet that stops working when new machines no longer need your compression algorithm.

Once we start thinking about digital systems and these processes we see them everywhere. Imagine if you didn't have distinct atoms or minerals – it would all be just a formless mush. I almost typed, "formless void" to quote a biblical phrase. That's a problem in that so much of the vocabulary comes from literature including the bible. Phrenology which is the study of bumps on the head has long been discredited but has given us "low brow" and "highbrow". Same for Freudian terminology such as "anal". The bible has given has a useful vocabulary. If we assume that there is order in the world we might refer to it as "god" because we just need a term. This doesn't mean an anthropomorphic but some will interpret the phrase that way and will use it to "prove" their case as if their interpretation is intrinsic. As Lakoff points out, it comes with the belief in an absolute ordered universe.

It's harder to embrace ambiguity and the idea that evolution is about reinterpreting what we find. We reinterpret a gill as an ear. This is the same terminology we use in computers where we create abstractions and interpretations. We might create something we call a "quacker". We don't' care if whether it is a duck, just whether it quacks like a duck. We can call it a duck but that doesn't make it a duck. But then "duck" is just a word so then if

we call it a duck it is a duck. What we are not saying is that it acts like the kind of duck we see in the water. Sure, it's wordplay but it's important wordplay because it gives us an understanding of science.

We can have a theory of ducks and then later realize we've been using the same word or theory for two different creatures and have to adjust our theory when we find that the consequences of calling both a duck demonstrates the need to refine our understanding. Being humans we might still use the word "duck" in a loose sense while being aware that when we look closer we need to make a distinction. For those who don't see past the wordplay this can be problematic.

After all, if we call evolution a "theory" then it's just an idle conjecture so why not posit another "explanation"? I quote explanation just like I did above. What do we mean by a theory of evolution? The idea that things change is not new, so the theory posits a particular mechanism. At a generic level all it says is things change and what works gets regenerated. That's pretty close to saying that 2+2 is 4. That too is a theory because 2+2 can also be 11 if we use base 3 notation. The "theory" part is in the details of the mechanism – not in whether evolution occurs. Intelligent design might be a counter-theory were it testable but it isn't – is an alternative to having an explanation!

It might be filling but not at all nutritious. It has no operational value and if we try to build on the theory we find ourselves in a trap that we only escape by ignoring the contradictions. At least if we posited that evolution was controlled by LGMs (Little Green Men) on Mars we could test it and act on it. Of course if we get to Mars those who subscribe to the LGM theory are likely to give a "reason" why they were ring – perhaps the LGMs are on Jupiter. This is what has happened to those who give a date for the end of the world – they just try again with a new date.

The real problem is that there isn't necessarily anything to explain. Things change. What is less obvious is that things that work persist but the definition can change. "Works" depends on context and is intrinsically unpredictable because all elements of the system are changing and the very fact that something works is a reason for something else not to. Imagine if there were a formula for predicting the outcome of a horse race – that alone would cause it to fail.

What we are up against is the observer effect. If you got 7 baseball predictions in the mail and they were all right how much would you bet on the next one? It's a great con – there are probably 127 other people who saw at least one wrong prediction. The tendency to think of ourselves as special leads us to assume it's all about us. Everything is in probably but something has to happen so it does. If you walk down a road flipping a coin at each fork you'll arrive somewhere but there's nothing special about that destination.

If you do think that it's special then you are liable to make disastrous extrapolations of the kind Jared Diamond cited in *Collapse!*

The selection process has another interesting implication – it means the world is relatively safe because there is constant and extensive testing. If a disease kills people too swiftly it can't survive. We tend to ignore failures and prefer to think that people have made great predictions when they are constantly making midcourse corrections. Congress is constantly patching over old laws and relying on individuals to make reasonable interpretations. When they try to "solve" problems by removing the ability of judges to, well, judge, then we get horrendous results that fill our prisons and turn them into training camps for crime.

It also makes people unwilling to accept the idea that abortion reduces crime by not regenerating people who are not wanted. The fixation on sex found in some religions is another topic with horrible consequences.

The desire for "explanation" makes us blind. Everything is in constant change. Evolution is just a synonym for change. It's a very simple process yet we manage to confuse ourselves by confusing emergent properties with real phenomena which we then try to explain. We confuse our failure to recognize simplicity with inexplicable complexity.

We depend upon accidental properties. We wouldn't have ears if we didn't have gills to build upon. Of course we can't explain ears without knowing that history. We could avoid having to think about the history by simply declaring it inexplicable and then saying the only possible explanation is an intelligent being. Sir Arthur Canon Doyle made this mistake with Sherlock Holmes. The stories were premised on the idea that the improbable explanations must be correct. No wonder he believed in fairies based on faked photographs. Those who seek "explanations" are, by their nature, gullible.

It leads to very disastrous public policies by pandering to an egotistic need to believe we are special. If we can use

our military might to impose our specialness then there is no limit to the self-delusion. No limit, that, is until it is possibly too late.

The concept of "explanation" is important in everyday life. Recently the Powerball® Lottery had 110 winners – something that is very improbably if not impossible. Could there be a mystical explanation? It turned out to be very mundane – the numbers came from fortune cookies which all had the same numbers.

Ignorance may seem comforting but it's far scarier to live in a universe which seems perverse than one that is simply indifferent.

What to do?

I will be writing about this in far more detail in future essays.

A start is to recognize that evolutionary processes are fundamental and pervasive. They occur all around us and are actually very simple. We can teach the process in elementary school if not earlier. We also need to teach the wonder of not having to explain everything and create a taste for wanting to learn more.

That's really what science is about – a willingness to accept that what we know is always tentative. For us, it means that we learn most when we are wrong and gain new insights rather than simply confirming what we already new. If we don't understand something then we're not stupid, we just need to debug our understanding – that is, to learn.

We can't simply say that science doesn't answer the question "why". In fact it does! The problem is in what we mean by "why". Science will give operation explanations that do answer why.

We need to be explicit in recognizing that there is another meaning of "why" which is the comforting "just so" story. It is that sense of "why" which science doesn't address because balm for those who find it too hard to come to terms with the unfathomable.

While we can, and should, help them come to terms with their fears the priority is in limiting the consequences when they go beyond clinging to the illusion of certainty and translate them into public policy of the kind that led the Easter Islanders chop down the last trees even as their society collapsed around them.

Readings

I've started to collect a list of recommended books. I hope to add to it over time and back fill with a listing of authors. I haven't (yet) included Stephen Gould's books. He does a superb job of explaining "evolution" though within the context of biology.

Robert Laughlin's *A Different Universe* is almost at the opposite extreme since it has no references to the biological mechanism but he does a superb job in giving an understanding of science beyond the simplistic view that there is a single truth even at the most basic levels of physics.