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Humanity Rising: Why Evolutionary Developmentalism Will Inherit the Future

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Abstract

The main paradigm we presently use to understand our universe is theoretical physics. It has helped us understand much about space, time, energy, and matter, but does not presently explain or predict the emergence of information, computation, life and mind. In biological systems, the discipline of evo-devo biology studies how *evolutionary development* (“evo-devo”) guides the production of ordered, complex, adaptive, and intelligent structures. In living systems we can distinguish *evolutionary processes* which are stochastic, variety-creating, divergent, and contingently adaptive and *developmental processes* which produce convergent and systemically statistically predictable structures and trajectories in a hierarchical replication cycle, from seed, to adult, to reproduction, aging, and death. If our universe is also a cycling, evolutionary developmental system, that moves from seed, to adult, to reproduction and death, as several scientists and philosophers now suspect, it must also exhibit both unpredictable evolutionary creativity over its lifespan, and also many predictable and constraining developmental constraints, function, and futures, as it grows up, reproduces, and dies. If we live in an evo devo universe, our finely-tuned fundamental physical constants, physical laws, and boundary conditions must have *self-organized* their present values, through many prior cycles in the multiverse, to maximize the multilocal production of unique adaptive intelligence, in an ultimately simulation-testable model. As science learns to see our universe and its intelligences as not only as evolutionary but also as *developmental* systems, we’ll move beyond the currently popular “random accident”, “purposeless” and “null hypothesis” views of universal change and its relationship to intelligence, and recognize that a subset of future intelligence processes and destinations are statistically implicit in our physics, waiting patiently to emerge as civilization complexifies. As our understanding of evolutionary developmentalism grows, our *foresight* will greatly improve, and we will gain *new moral responsibilities,* both to predict and help developmental processes unfold, and at the same time to increase our evolutionary free choice and diversity of paths.

Keywords

95/5 Rule, Acceleration Studies, Accidental Universe, Astrosociology, Complexity, Computation, Convergent Evolution, Cosmological Natural Selection, Cultural Evo Devo (Memes), Developmental Immunity, Dinosauroid Hypothesis, Evolutionary Development, Fine-Tuned Universe, Foresight, Humanoid Form, Information, Intelligence, Language, Machine Intelligence, Multilocal Complexity, Null Hypothesis, Postbiological Life, Prediction, Self-Organization, Simulation, Technological Evo Devo (Temes), Technological Singularity, Teleology, Universal Purpose

Bio

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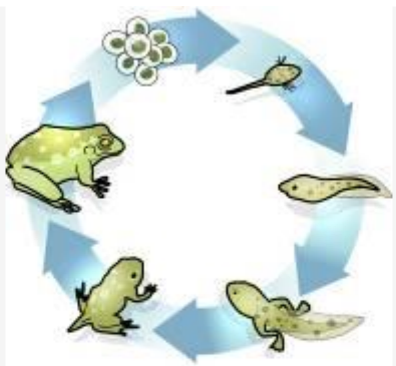
Article

What is evolutionary development ("evo devo")?

It is a minority view of change in science, business, policy, foresight, and philosophy today, a *simultaneous application* of both evolutionary and developmental thinking to the universe and its replicating subsystems. It is derived from evo-devo biology, a view of biological change that is redefining our thinking about evolution and development. As a big picture perspective on complex systems, I think evo devo models will be critical to understanding our past, present, and future. We will use the hyphenated term "evo-devo" when discussing the discipline of evo-devo biology, and the unhyphenated phrase "evo devo" when discussing the paradigm of evolutionary development, which we may apply to all replicating systems within the universe. The seventy-some scholars at Evo Devo Universe, an interdisciplinary community I co-founded with philosopher Clement Vidal in 2008, are interested in arguing, critiquing and testing evolutionary and developmental models of the universe and its subsystems, and exploring their variations and implications.

Whatever else our universe is, and allowing that there are physical mysteries, like dark matter, dark energy, the substructure of quarks, and the nature of black holes still to be uncovered, reasonable analysis suggests that it is both evolutionary and developmental, or "evo devo". Like a living organism, it undergoes both experimental, stochastic, divergent, and unpredictable change, a process we can call **evolution**, and at the same time, programmed, convergent, conservative, and predictable change, a process we can call **development**. Evo devo thinking is practiced by any who realize that parts of our future are unpredictable and creative, while other parts are predictable and conservative, and that in the universe, as in life, both processes are always operating at the same time. To understand the interaction between evolution and development, *think of a river,* which flows to a predictable developmental destination when we look at the system from the big picture, top-down view, but when we look at the system up close and bottom up, the evolutionary path of any individual water molecule on the way to that destination is random, contingent, and unpredictable.



Like living organisms, our universe may have a developmental life cycle.

Consider how our universe likely builds intelligence in every galaxy and solar system in a predictable developmental hierarchy as it unfolds, from physics, to chemistry, to biology, to biominds, to postbiological intelligence. As physicists like Lee Smolin (*The Life of the Cosmos*, 1999) have argued, our universe may also be chained to a developmental life cycle, like a living organism. Since almost every interesting complex adaptive system we know of *within* the universe, from solar systems to cells, undergoes some form of Replication, Variation, Inheritance, Selection, and Convergence on further replication to build its complexity (in shorthand, an RVISC cycle), it is parsimonious (conceptually the simplest model) to suspect this is how the universe built its complexity as well, within a still poorly understood environment that physicists call the multiverse.

In an evo devo universe, any physical system that has both evolutionary (variation, inheritance, selection) and developmental (replication, convergence) features, and that operates in a selective environment, will self-organize its own adaptive complexity as its replication proceeds through many cycles. We see both evolutionary and developmental features in geophysical systems, as in how replicating stars have advanced from the primitive Population III stars to the far more complex Population I systems, like our Sun and its planets, over galactic time. Replicating evo devo chemicals also built up their complexity to eventually create cells, over billions of years. Replicating evo devo cells eventually created multicellular life with nervous systems, again over billions of years. Replicating evo devo nervous systems produced hominids, over roughly 500 million years. Replicating languages, ideas, and behaviors in hominid brains birthed nonbiological computing systems, over something like 5 million years. Now our global computing and robotics systems, whose replication is presently aided by human culture, are soon (within the next few decades, it seems) going to be able to replicate, evolve, and develop autonomously.

Applying biology's evo-devo model to the universe provides an intuitive, life-analogous, and conceptually parsimonious explanation for several nagging and otherwise improbable phenomena, including the fine-tuned universe problem, the presumed great fecundity of terrestrial planets and life, when an evolution-only framework would lead us to predict a Rare Earth universe, the Gaia hypothesis, the surprisingly life-protective and geohomeostatic nature of Earth's environment, the unreasonably smooth, redundant and resilient nature of accelerating change and leading-edge complexification on Earth, and other curiosities. If we live in an evo devo universe, our finely-tuned fundamental physical constants, physical laws, and boundary conditions must have *self-organized* their present values, through many prior cycles in the multiverse, to maximize the multilocal production of unique adaptive intelligence, in an ultimately simulation testable model. The evo devo universe offers a rejoinder to theologian William Paley's watchmaker argument, that only a God could have designed our planet's breathtaking complexity, with the awe-inspiring counterexample of replicative evo devo self-organization of complexity, a phenomenon seen in a great variety of dissipative systems on multiple scales in our universe, and one we will increasingly understand, model, and test in coming years.

As much as some might find comfort in believing in a God who designed our universe, it is perhaps even more comforting and useful to believe, tentatively and conditionally, in a Universe with such incredible self-improving and self-protecting features, as evidenced in the amazing history and abilities of evolutionary and developmental processes in living systems themselves. Evo devo processes have apparently created both matter and mind, and have been astonishingly resilient to generating complexity and intelligence at ever-accelerating rates. Big History, the science story of the universe so far, is sufficiently awe-inspiring, humbling, useful, and hopeful to give us guidance, once we place it in an evo devo frame.

Furthermore, as science learns to see our universe and its intelligences as not only as evolutionary but also as *developmental* systems, we'll move beyond the "random accident", "purposeless" views of universal change offered by many current scholars (see for example Alan Lightman's Sydney award winning essay, "The Accidental Universe," *Harpers* 2011). We'll also move beyond our sterile "null hypothesis" perspective on the likely relation between the laws of our physical universe and its accelerating intelligences. We'll admit that a subset of future intelligence processes and destinations are always statistically implicit in universal physics, waiting patiently to emerge as complexity scales. We'll recognize our universe has self-organized to protect and accelerate the emergence of an astronomically large number of multilocal intelligences, making it the most massively parallel computational system in, well … the Universe. We'll understand intelligence always plays a nonrandom role in the survival and structure of the universe that generates it, just as it does in replicating evo-devo biology.

If Earth-like civilizations and technologies *develop*, not just evolve within our universe, all of their developmental features must be as isomorphic (the same in various systems) and predictable as, for example the features of galactic, stellar, and biological development are assumed to be today, even though humanity's current math and physics are not yet good enough to model many of these predictable processes. But if you've seen one acorn develop into an acorn tree, you don't need math and physics to know what kind of tree the next acorn will produce. You just need to have seen it once, and know the process is developmental.

Scientists and evolutionary theorists often use the null hypothesis of there being no relationship between observed phenomena, and the implicit assumption of randomness in system interactions as *starting points* in developing our statistical models and inferences. But randomness is a good model only for many evolutionary processes. The more closely we look, the more we see that intelligence is also developing, not just evolving. As we'll suggest, we now know enough about evolution and development at the universal scale to begin relating these processes to our own lives, and to ask how to make our local and personal values and goals more consistent with universal processes.

As our universe grows islands of accelerating local order and intelligence in a sea of ever-increasing entropy, physics tells us this process cannot continue forever. The universe's "body" is aging, and will end in either heat death, or a big rip, or both. If our universe is indeed a replicating complex adaptive system that engages in both evolution and development, as it grows older it must package its intelligence into some kind of reproductive system, so it's complexity can survive its death and begin again. Developmental models thus argue that intelligent civilizations throughout the universe are *part* of that reproductive system – protecting our complexity and ultimately reproducing the universe and further improving the intelligence it contains. In other words, growing, protecting, and reproducing personal, family, social, and universal intelligence may be the evolutionary and developmental purpose of all intelligent beings, to the greatest extent that they are able.

Charles Darwin, *On the Origin of Species,* 1859

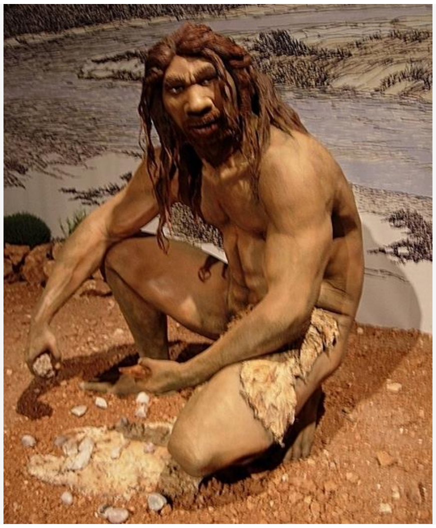
http://vermillionpubliclibrary.org/wp-content/uploads/2014/02/Darwin-young.jpg

Beginning in 1859, **Charles Darwin** helped us to clearly see evolutionism in living systems, for the first time. Discovering that humanity was an incremental, experimental product of the natural world was a revolutionary advance over our humanocentric and antirational religious beliefs. But until we also understand and accept *developmentalism*, recognizing that the universe not only evolves but also develops, the purpose and values of the universe, and our place in it will remain mysteries about which science has little of interest to say. Our science will remain infantile, descriptive without also being prescriptive, and unable to deeply inform our morality and politics. That must and will change in coming decades.

As an example of where we are today, let me recommend a Discovery Channel program on evolution, *Mankind Rising,* available for $1.99 at YouTube. It is Season 2, Episode 8 of *Curiosity*, a five-year, multi-million dollar initiative to educate the public on fundamental questions and mysteries of science, technology, and society, in sixty episodes. There is also a commendable Curiosity initiative in American K-12 schools, to use the show to increase our children's engagement in STEM education.

Mankind Rising considers the question "How did we get here?" It tells the journey of humanity from the cooling of life's nursery, Earth, 4 billion years ago, and the emergence of the first cell 3.8 billion years ago, to *Homo erectus*, anatomically modern humans, 1.8 million years ago. It does this in one 43 minute time-lapsed computer animation, the first time life's history has received such a treatment, as far as I know. The animation is primitive, but it holds your interest enough to follow the story. And what an amazing story it is.

For example, we get to see the rise of the first tool users, *Homo habilis,* 4 million years ago, in a dramatic sequence where an early human strikes one rock against another and is fascinated to discover a sharp rock in his hands. *H. habilis'* ability to hold sharp rocks and clubs in their hands, and use them imitatively in groups to defend against other animals was perhaps the original human event. The best definition of humanity, in my opinion, is any species that gains the ability to use technology creatively and socially to continually turn themselves into something more than their biological selves. We inevitably become a species with both greater mind (rationality, intellect) and greater heart (emotion, empathy, love), two core kinds of intelligence. I would predict the *first* collaborative rock-users on any Earth-like planet must soon thereafter become its dominant species, as there are so many paths to further adaptiveness from the powerful developmental duo of creative tool use and socially imitative behavior.



Homo habilis, the first human tool users.

https://upload.wikimedia.org/wikipedia/commons/7/71/Homo_heidelbergensis_(10233446).jpg

One clever thing that the first socially-adept rock- and club-holding animals on any Earth-like planet gain access to is pack hunting, and if good at sweating, a form of pack hunting called persistence hunting. Learning both how to pack hunt and how to tame fire, as described in Richard Wrangham's *Catching Fire: How Cooking Made Us Human* (Basic Books, 2009), may have doubled our brain size by giving us our first reliable access to meat, a very high-energy fuel source.

We may have begun with pack hunting by ambush, which chimpanzees do today, and then graduated to persistence hunting, or running down our prey, sometimes in combination with setting fires to flush out our prey. We primates sweat across our entire bodies, not just through our mouths like other mammals. Humans have developed our sweating and cooling ability the best of all primates by far. As a result, two or three of us working together can actually run to heat exhaustion any animals that can't sweat, if we hunt them in the mid-day sun. Some peoples persistence hunt even today, as seen in this amazing seven minute *Life on Earth* clip of San Bushmen running down a Kudu antelope in the Kalahari desert.

Mankind Rising ends with *Homo erectus* ("human upright"), possibly the first language-using humans, 1.8 million years ago. We don't yet have fossil evidence that their larynx was anatomically modern, but there are indirect arguments. Language, both a form of socially imitative behavior and a fundamental tool for information encoding and processing, was very likely the final technology needed to push our species from the animal to the human level.

Unfortunately, there are serious shortcomings to *Mankind Rising* as an educational device. The show's narrative, and the theory it represents, are the standard one-sided, dogmatically-presented story of life's evolution, with no hint of life's development. As a result, it treats humanity's history as one big series of unpredictable accidents. This is the perspective of universal evolutionism, also called "Universal Darwinism" ", which considers random selection to be the only process in universal change, ignoring the possibility of universal development. In evolutionism, all the great emergence events are told as happening randomly and contingently. The show even makes the extreme claim that life itself emerged "against the laws of probability." The emergence of humanlike animals is also presented as a stroke of blind luck, because the K-T meteorite wiped out our predators, the dinosaurs. All of this is true in part, only from one set of perspectives, that of the *individual, organism, or individual event.* In other words this story, and evolutionism in general, is a dangerously incomplete half-truth. When we look at the same events from the perspective of the universal system, the environment, or distributions of events over time, many particular forms and functions appear physically predetermined to emerge, just the opposite of the story evolutionists tell us.

In Evolutionism, the Universe is Simply a Massive Set of Random Events, Randomly Interacting.
https://upload.wikimedia.org/wikipedia/commons/e/e5/Dice_(typical_role_playing_game_dice).jpg

Let's look to evo devo for a different universe story. Consider two genetically identical biological twins, or two snowflakes. Either example will work well. Most of what happens to these systems up close, at the molecular scale, is randomly, contingently, unpredictably different. The microstructure of all the twin's organs, including their brain, fingerprints, and many other molecular features are as different as the designs of two snowflakes. But look at both of these systems from across the room, taking a *system* or *environmental* perspective, and you see that they achieve many of the same developmental endpoints over time. The twins have the same body and facial structure and many of the same personality traits, constrained by the organism's developmental genes and the shared environment. The snowflake's hexagonal structure is developmentally predetermined, constrained by the way water forms hydrogen bonds as it freezes.

The better we understand development in any complex system, the more often we find self-similarity in how developmental processes occur in many different types of complex systems. For example, cosmologists have recently shown that the same density fluctuation models and math used to explain power law mass scaling (Zipf's law) in galactic development can be used to explain power law population scaling in city development. Many developing complex systems share other spatial scaling laws and frequency distributions (such as the normal and log-normal distributions).

In universal development, just as in biological development, the convergence on standard and future-predictable forms and functions occurs because of the special initial conditions (physical laws, or "genes") of our universe, the time constancy and environmental sameness (isotropy) of that physical law throughout the universe's internal environment, and perhaps also due to invariant features of its external environment, which for universes is a place physicists call the multiverse.

Examples of developmental processes and structures are easy to propose. We can see developmental physics in the motions of the planets, which are highly future-predictable, as Isaac Newton discovered. Other physical processes, such as the production of black holes in general relativity, the acceleration of entropy production, and of complexification in special locations, also appear highly predictable and universal. Other physics by contrast, such as quantum physics, looks highly evolutionary and unpredictable. As we move up the complexity hierarchy from physics to chemistry to biology, to society, our list of potential evolutionary and developmental forms and processes rapidly grows.

Other commonly proposed examples of inevitable, ubiquitous developments in our universe appear to include *organic chemistry* as the only easy path to complex replicating autocatalytic molecular species. *Earth-like planets* with lots of liquid water, carbon and nitrogen cycles, plate tectonics, nucleic acids, lipid membranes, amino acids, and proteins as the only easy path to cells. Earth-like planets in turn are expected by some developmentally-minded astrobiologists to be common in complex galaxies like ours, a proposal for a life-fecund universe that may be backed up by observational evidence in the next generation.

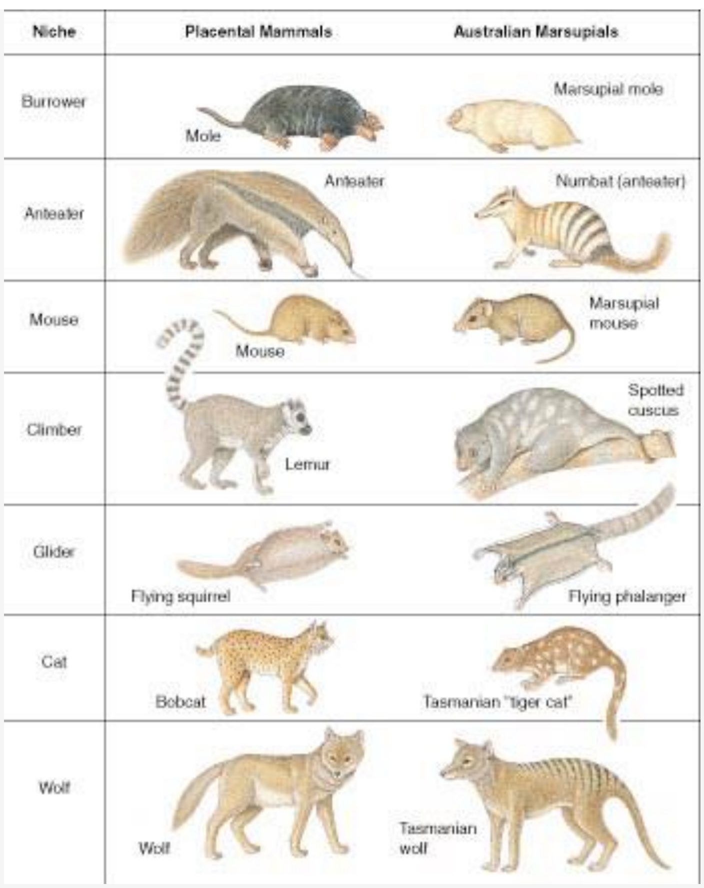
Oxidative phosphorylation redox chemistry is suspected by some chemists to be the only easy developmental pathway to high-energy chemical life. *Multicellular organisms, bilateral symmetry, eyes, skeletons, jointed limbs, land colonization, prehensile appendages, opposable thumbs, social brains, gestural and vocal language, and imitative behavior* may be the only easy path to runaway technology (tool use). The better our ability to simulate physical, chemical, and biological evolution in computers becomes, the more simulation testable all of these hypotheses become. In the meantime, we can use logic, argument, and cases of comparative and convergent evolution here on Earth to test several of our developmental hypotheses.

Consider the hydraulic empire hypothesis. Earth's first large-scale civilizations, including Mesopotamia, Egypt, Somalia, China, and Sri Lanka, Mexico, and Peru all developed around the large-scale control of river water for agriculture. Several of these empires emerged independent of each other, in geographically isolated locations, as in Asia vs. the Americas. But all hydraulic empires had common features including extensive irrigation engineering, flood control, taxation of surplus produce, bureaucracy, castes, and military defenses. If this model holds up to future simulation, the first empires arising in large river deltas or river plains with farmable soil is a developmental bottleneck we should expect on *all* Earth-like planets. It is a universal portal pathway to a higher level of civilization complexity.

Consider also the unique developmental advantages of written language, math, science, and various technology archetypes, from sharp rocks and clubs to levers, wheels, electricity, and computers. Such potentially universal forms and functions may be destined to emerge, because of the particular initial conditions and laws of this universe, in which evolution is occurring. Each of these universal forms and functions are destined to become optimal or dominant, for a time, in all Earth-like environments in which accelerating complexification and intelligence growth are occurring.

On Earth, we have seen a number of these forms, such as eyes, emerge and persist independently in various separate evolutionary lineages and environments. Independent emergence, convergence, and optimization or dominance of developmental forms and processes is one good way to separate them from the much larger set of ongoing evolutionary experiments. Developmental forms and functions are those that will be more adaptive at each particular stage of environmental complexity, in more contexts and species. Think of two eyes for a predator, over three or one eye. Or four wheels for a car, over three or more than four wheels.

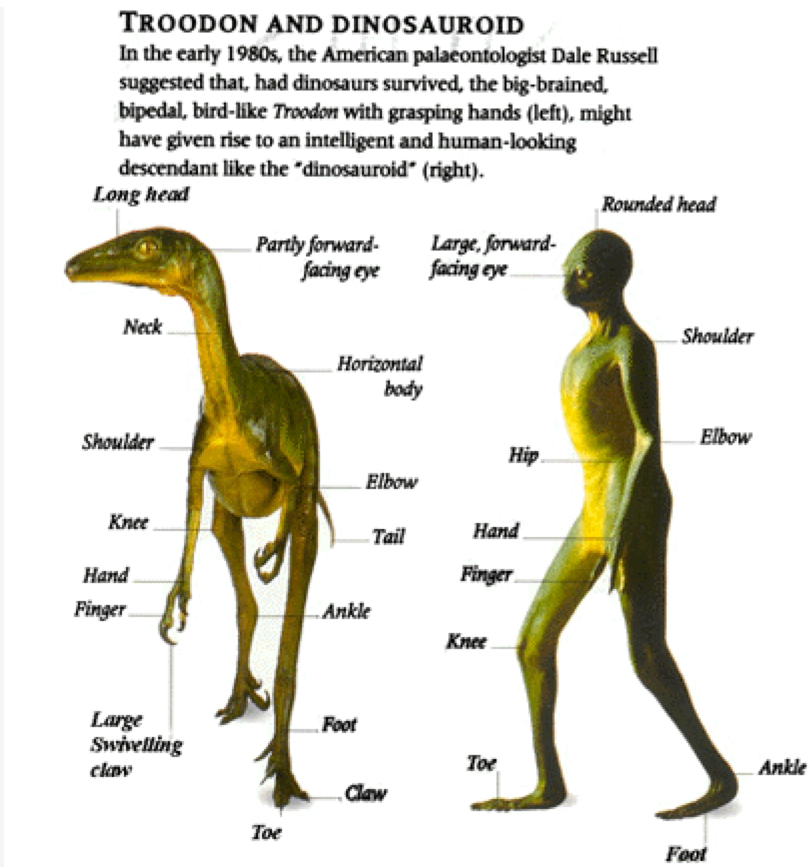
Think also of all the body form and function types that have converged in placental and marsupial mammals. Australia separated early from the other continents, yet produced many similar mammal types via marsupials, plus a few new ones, like the kangaroo. This is a classic example of convergent evolution, or more accurately, convergent evolutionary *development,* when we consider biological change not from the species perspective but instead from the planet's or universe's perspective. Evolution seems destined to randomly, contingently, and creatively discover these optimum forms and functions. But once discovered, they stay dominant for their time and place, and they eventually lead inevitably to the next portal pathway.



Convergent form and function in placental and marsupial mammals,
an example of convergent evolution (aka convergent evolutionary *development*).

http://www.txtwriter.com/Backgrounders/Evolution/EVpage14.html

Another fascinating example of developmentalism ignored by *Mankind Rising* is the longstanding hypothesis, first popularized by Dale Russell and Ron Séguin in 1982, that our “humanoid form”, a bilaterally symmetric bipedal tetrapod with two eyes, four prehensile appendages (arms and legs), and two opposable thumbs on the dominant appendages (arms), may be a likely outcome for *all* biological intelligences that first achieve our level of sophistication on Earth-like planets. These authors argued that if the K-T meteorite hadn’t hit Earth and caused mass extinction of large animals 65 million years ago, dinosaurs would likely have inevitably discovered the adaptive value of humanoid form, rocks, language, and tools. In fact, the most successful dinosaurs were already trending in that direction long before the K-T extinction event, as we’ll now see.



Would raptors have led inevitably to dinosaur humanoids
if the K-T meteorite hadn’t struck Earth 65 million years ago?

http://vignette3.wikia.nocookie.net/dino/images/9/9c/Troodondinosauroid.gif/revision/latest?cb=20110123035914

If you have seen the movie *Jurassic Park,* you know that raptors like *Troodon,* had semi-opposable digits on their two arms and hunted in packs, both by day and night. It is easy to bet that the first raptor descendants that *also* learned how to hold sharp rocks and clubs in their hands in close-quarters combat would have been able to claim the role of top biological species. It would be game over, and competitive exclusion, for all other species that wanted that niche. Once you are manipulating tools in your hands, and speaking with your larynx, your body will be forced upright, and you'll be engaged in runaway complexification of your social and technical intelligence. In other words, you've become human, with all the creativity and capability that entails.

The hand of *Troodon inequalis*, with a partly opposable digit.

Note the closeup of the hand of *Stenonychosaurus (*now called *Troodon) inequalis,* from Russell's paper, "Reconstructions of the small cretaceous theropod *Stenonychosauris inequalis* and a hypothetical dinosauroid," Dale A. Russell and Ron Séguin, *Syllogeus,*37, 1982. The authors state that the structure of the carpal block on *Troodon's* hands argues that one of the three fingers partially opposed the other two as shown. The shape of the ulna also suggests that its forearms rotated. It probably used its hands to snatch small prey, and to grab hold of larger dinosaurs while ripping into them with the raptorial claw on the inside of each of its feet.

Troodon was a member of a very successful and diverse clade of small bipedal, binocular vision dinosaurs with one free claw on their feet, the *Deinonychosaurs* ("fearsome claw lizards"). These animals lived over the last 100 million years of the 165 million years of dinosaur existence, and were among the smartest and most agile dinosaurs known, with the highest brain-to-body ratios of any animals in the Mesozoic era. Most *Deinonychosaurs* had arms that were a useful combination of small wings and crude hands consisting of these three claws. *Troodon* was in a special subfamily that had lost the wings but retained the three long digits on each hand. According to Russell, *Troodon's* brain-to-body ratio was the highest known for dinosaurs at the time. Because of their special abilities, I'd argue that *Deinonychosaurs* were not only members of an evolutionarily successful niche, they also occupied an inevitably successful developmental niche as well.

One assumption I make, also made by a handful of anthropologists and evolutionary scholars over the years, is that *trees* are a key niche, the "developmental bottleneck," through which the first rock-throwing and club-wielding imitative hominids will very likely pass, on a typical Earth-like planet. Swinging from limb to limb requires very dextrous hands, and a cerebellum and forebrain that can *predict* where the body will go in space. With their manipulative hands, with or without wings, their big, strong legs and multipurpose feet, and their small size, *Deinonychosaurs* would have been tree climbers, able to escape rapidly up and drop down from considerable heights. If they were the largest and strongest animals physically capable of doing so, which seems likely, this argues that they would have permanently occupied the special niche that primates would later inhabit, the niche they used to become fully human.

Can you envision primates getting into the all-important tree niche, with *Deinonychosaurs* running about? Not a chance! *Deinonychosaurs* would have achieved "competitive exclusion", the ability to permanently deny other species access to the critical transitional niche that may be the fastest developmental gateway leading to the top tool-using vertebrate on Earth. So if tree climbing and swinging is the fastest and best way to build grasping hands and predictive brains good at simulating complex trajectories (a claim that should be testable by future simulation) and eventually, modeling and imitating the mental states of others in their pack so they could do imitative tool use (also eventually testable by simulation), then if diverse variants of *Deinonychosaurs* came to dominate that niche, we can expect a *Deinonychosaur* descendant to be the first to make the jump to tool use. *Troodon* couldn't swing in the trees, but he would have been very agile among them, able to use them for escape and evasion. He had two manipulative hands that would have been very useful both in killing and in avoiding being killed. This looks to me like a promising case for competitive exclusion.

One might ask, couldn't tool use under water grow to reach competitive exclusion first? Like trees versus the ground for complex tool use, is land vs. water likely to be the dominant developmental gateway for the first emergence of species that use built structures, on any Earth-like planet? Apparently so. Unlike air, water is a very dense and forceful fluid relative to the muscles of species that operate within it, gravity doesn't hold down aqueous structures or animals very well, and language may not allow for the same degree of phonetic articulation underwater as well as it does in air (human vocal structures have access to roughly 100 phonemes, and our dominant languages use 30-50 of these, allowing complex and compressed acoustic communication).

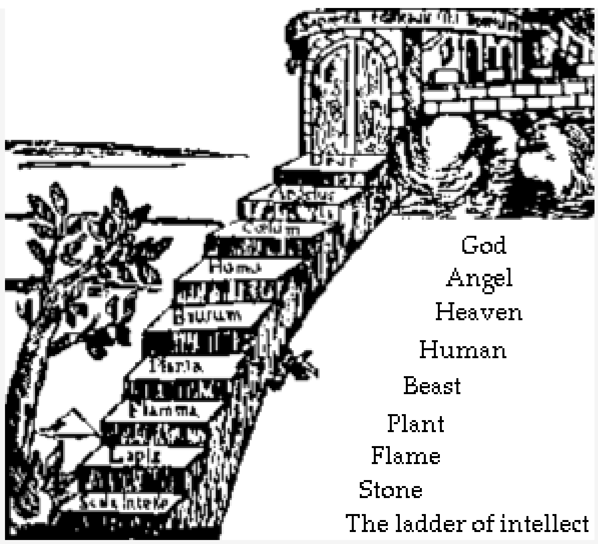
Underwater tool using collectives do exist. Dolphins use sponges in collectives, and Jacques Cousteau discovered in the 1980s that octopi used rocks as tools, and in a great case of developmental convergence, even built rock huts near each other in small "villages", as socially imitative groups. Also, like their eyes and brains, *two* of their eight appendages are prehensile with bilateral symmetry, meaning they are neurologically wired to *oppose* each other in grasping and wielding objects, just like human arms and hands (grasping with two appendages is a plausible universal developmental convergence for dominant vertebrates on all Earth-like planets). But the collective rock use of octopi could not make them the dominant species under water, due to its harsher physics compared to air. Critically, under water, you can't use your prehensile limbs and opposable thumbs to collectively throw rocks at *ninety miles an hour through the air* toward an opposing predator, as baseball players (excellently) and chimpanzees (poorly) can do today, and as *Homo habilis* presumably did very well on Earth, likely immediately making him the dominant animal on the savannah, versus the jaguars that regularly dined on his *australopithecine* ancestors any time they came down out of the trees. You also can't wield clubs lethally as a group in close quarters combat, if the jaguar ignores your warning. So it seems land, air, and imitative use of such tools as rocks and clubs are clear developmental portals to further civilization complexity. Yet precious few evolutionists, even today, are willing to state this proposition in such obviously predictive terms.

Our universe, from an evo devo perspective, seems developmentally fated to use the first language-capable tool-using species on land to start selection for smarter and more social brains and ideas, in a new complexity space of cultural evo devo, using Richard Dawkin's concept of the *meme* as an elemental mentally replicating behavior or idea. Humans in turn may be fated to culturally select for increasingly complex and self-aware *technologies*, in a process of technological evo devo, using Susan Blackmore's concept of the *teme* as an elemental socially replicating technological form or algorithm. Once these important new replicators emerge, biological evo devo (genetic change) becomes so slow and modest by comparison that its further changes relative to memes and temes is also increasingly *future irrelevant.* Today, memetic change (replicating ideas) in concert with temetic change (replicating technological algorithms) drive the future on all human-populated planets. Genetic change, by contrast, remains so slow and so limited in its ability to complexify further that only its *heritage*, its collected complexity and wisdom to date, is likely to be important to our future.

In the years since Russell's indecent proposal, hundreds of other scientists, including the paleontologist Simon Conway Morris (*Life's Solution*, Cambridge U. Press, 2001, and *The Deep Structure of Biology*, Templeton Press, 2008) have proposed that humanity's most advanced features, including our morality, emotions, and tool use, have all been independently discovered, to varying degrees, in other vertebrate and invertebrate species on Earth. According to Conway Morris, if something catastrophic happened to *Homo sapiens* on Earth, it is highly probable that another species would quickly emerge to become the dominant "human" tool-users in our place. In other words, local runaway complexification seems well protected by the universe. In evo devo language, we can say there appears to be a *developmental immune system* operating, to ensure that humanoid emergence, and re-emergence if catastrophes like the K-T meteorite occur, will be both a very highly probable and an accelerating universal event, on any Earth-like planet.

If complexity acceleration is statistically so well protected by Earth's special environment, it seems very likely that only the *quality* of our present transition to postbiological status seems evolutionary, based on the morality and wisdom of our actions. Our pathway to and our subtype of humanity may thus be special and unique, but our humanity itself, in many of its key features, seems to be a product of the universe, far more than a product of our own free choice. Learning to see, accept, and better manage all this hidden universal development, and in the process bringing our personal ego, fears, and illusions of control back down to fit historical reality, are among the greatest challenges humans face in understanding the true nature of the universe and our place in it.

Fortunately, these and other developmentalist hypotheses can increasingly be tested by computer simulation, as our computing technology, historical data, and scientific theory get progressively better. Run the universe simulation multiple times, and anything that appears environmentally dominant time and again, and any immunity that we see (statistical protection of accelerating complexity), is developmental. The rest, of course, is creative and evolutionary. To recap our earlier example, hexagonal snowflake structure will be developmental on all Earth-like planets with snow. But the pattern of each snowflake will be evolutionary, and unpredictably unique, both on Earth and everywhere else. Nature always uses both types of processes to build intelligence.



In Evolutionary Development, the Universe is not just a Ladder of Nature (Developmentalism), or a Random Experiment (Evolutionism), but *some useful combination of the two simpler models.*

Image from Shakespeare's Life and Times. Permission to republish for academic use.

Let me stress here that evolutionary development is no return to the Aristotelian *scala naturae* (Ladder of Nature, Great Chain of Being), where all important matter and process are predestined into some strict hierarchy of emergence. Only the *developmental framework* of universal complexification is statistically predetermined to emerge in evo devo models, not the evolutionary *painting* itself, which is the bulk of the work of art. Remember the all-important differences in tissue microarchitecture and mental processes and life choices between two genetically (developmentally) identical twins.

Nor is an evo devo universe a Newtonian or Laplacian "clockwork universe" model, which proposes total physical predetermination, though it is a model with some statistically *clockwork-like features,* including the timing of various hierarchical emergences over the universe's lifespan and death, just as we see in biological development. Neither the Aristotelian nor Laplacian models of the universe are developmental (positing statistically predetermined emergence and lifecycles) but rather caricatures of it, one-sided models that allow no room or role for evolution.

Nor is an evo devo universe the random, deaf-and-dumb Blind Tinkerer that universal evolutionists like Richard Dawkins (*The Blind Watchmaker*, Norton, 1986) or the writers of *Mankind Rising* portray. Blind Tinkerer models misunderstand convergent evolution, and are as incomplete in describing universal change as neo-Darwinian theory is in describing biological change today.

It appears that our universe is significantly more complex, intelligent, resilient, and interesting than any of these models suppose – it is predictable in certain critical parts that are necessary for its function and replication, and it is intrinsically unpredictable and creative in all the rest of its parts. Furthermore, unpredictable evolution and predictable development may be constrained to work together in ways that *maximize intelligence and adaptation,* both for leading-edge systems, and for the universe as a system.

Evo-devo biology is an academic community of several thousand theoretical and applied evolutionary and developmental biologists who seek to improve standard evolutionary theory by more rigorously modeling the way evolutionary and developmental processes interact in living systems to produce biological modules, morphologies, species, and ecosystems. Books like *From Embryology to Evo-Devo,* ed. Manfred B. Laubichler and Jane Maienschein (MIT Press, 2009), and *Convergent Evolution: Limited Forms Most Beautiful*, George R. McGhee (MIT Press, 2011), are great intros to this emerging field. I expect most evolutionary developmental biologists would agree with the statement that evolution and development are in many ways opposite and equally fundamental processes in complex living systems, and that neither can be properly understood without reference to its interaction with the other.

The best of this work realizes there are two key forms of selection and fitness landscapes operating in natural selection – evolutionary selection, which is divergent and treelike, with chaotic attractors, and developmental selection, which is convergent and funnel-like, with standard attractors. Thus evolutionary developmentalism is an attempt to generalize the evo-devo biological perspective to nonliving replicating complex adaptive systems as well, including solar systems, prebiological chemistry, ideas, technology, and in particular, to the universe as a system.

Let's close this overview with one revealing example of the interaction of evolution and development that we can glean from evo-devo biology. In living systems, the vast majority of our genes, roughly 95% of them, are evolutionary, meaning they change randomly and unpredictably over macroscopic time, continually recombining and varying as species reproduce. Yet only about 3-5% of our genes (a percentage that varies by species, but is always very small) control our developmental processes, and those highly conserved genes, our "developmental genetic toolkit", direct predictable changes in the organism as it traces a life cycle in its environment. As I've argued before, roughly 95% of the processes or events in a wide variety of complex adaptive systems, including organizations, societies, species, and even the universe itself may turn out to be creative bottom-up and evolutionary, and only 5% predictable top-down, and developmental**,** though this evo devo ratio must surely vary by system to some degree.

The generic value of a 95/5 Rule in building and maintaining intelligent systems, if one exists, would explain why the vast majority of universal change appears to be bottom-up driven, evolutionary and unpredictable in complex systems, what systems theorist Kevin Kelly described as “out of control” in his prescient work *Out of Control* (Basic Books, 1994). Yet a critical subset of events and processes in these systems also appears to be top-down/systemically directed, developmental, and intrinsically predictable, if you have the right theory, computational resources, and data. Discovering that developmental subset, and differentiating it from the much larger evolutionary subset, will make our world vastly more understandable, and show how it is constrained to certain future destinies, even as creativity and experimentation keep growing within all the evolutionary domains.

So what do we gain from conditionally holding and exploring the hypothesis of universal evolutionary development? Quite a lot, I think:

First, **we regain an open mind.** Rather than telling humanity’s history from a dogmatic and one-sided perspective, and assuming that our past existence in the universe is predominantly a “random accident,” we remember that there are many highly predictable things about our universe, such as classical mechanics, the laws of thermodynamics, and accelerating change. This allows us to present life’s story as a mystery: What parts of its emergence are highly probable, or statistically predetermined, and what parts are improbable accidents? We also lose our blind faith that neo-Darwinism explains all of life or the universe, and realize that there appears to be a balance between evolutionary experiment and developmental predetermination in all things in the universe, and in life.

Second, **we regain our humility**. We no longer see ourselves as either miraculous creations or extremely improbable accidents. We recognize that there are likely vast numbers of human communities in the universe, which has self-organized to produce complex systems like us, and our postbiological descendants. It is commonly suggested that we are incredibly unique in the universe, and that we emerged “against astronomical odds.” On the contrary, developmentalists suspect that many or all of the things we hold most dear about humanity, including our brains, language, emotions, love, morality, consciousness, tools, technology, and scientific curiosity, are all highly likely or even inevitable developments on Earth-like planets all across the universe. This kind of thinking, looking for our universals as well as our uniquenesses, moves us from a Western exceptionalist frame of mind to one that also includes an Eastern or Buddhist perspective. We may not only be unique and individual experiments, we may also be members of a type that is as common as sand grains on a beach, instruments of a larger cycle of universal development and replication.

Third, **we lose our unjustified fear of and pessimism about the future**, and replace it with courage and practical optimism. The evolutionary accident story of humanity teaches us to be ever vigilant for things that could end our species at any moment. Vigilance is adaptive, but fear is usually not. We are constantly reminded by evolutionists that 99% of all species that ever lived are extinct (yes, but they were all necessary experiments, and their useful information lives on), and we live in a random, hostile and purposeless universe (no, we don't). Evolutionists conveniently forget that the patterns of intelligence in those species that died are almost all highly redundantly backed up in the other surviving organisms on the planet. Life is very, very good at preserving relevant pattern, information, and complexity, and now with science and technology, it is getting far better still at protecting complexity and resilience.

When we study how complexity has emerged in life's history, we gain a new appreciation for the *smoothness* of the rise of complexity and intelligence on Earth. Every catastrophe we can point to appears to have primarily *catalyzed* further immediate jumps in life's accelerating intelligence and adaptiveness at the leading edge. Life apparently *needs* regular catastrophe to make it stronger, and it is resilient and what Nick Taleb calls antifragile (see *Antifragile*, Random House, 2014) beyond all expectation. What causes this antifragility? Apparently a combination of evolutionary diversity and developmental immune systems. We undervalue the former, and remain mostly ignorant of the latter, for the time being at least.

If the universe is developmental, we can expect it has some kind of immune systems protecting its development, just as living systems do. The more we are willing to consider the idea that the universe may be both evolving and developing, the more we can open our eyes to hidden processes that are protecting and driving us toward a particular, predetermined future, even as each individual and civilization on Earth and in the universe will take its own partly unpredictable and creative evolutionary paths to that developmental future. Then we can get busy helping those systems get stronger, intelligently "vaccinating" them and building their capacities, rather than randomly, wastefully, and far too fearfully responding to life's catastrophes.

Fourth, **we gain an understanding of universal purpose.** Talk of purpose legitimately scares most scientists, who are so recently free of state-controlled religion interfering with their work. They claim they don't want to return to a faith-based view of the world, but we all must have, and should constantly revise and keep parsimonious, our own personal set of faiths. For example, our scientific axioms are all useful faiths about how the world works. Human reason and intuition, no matter how powerful they become, will always be computationally incomplete. Unexamined faiths are of course the most dangerous kind. Evolutionists put a lot of unexamined and unrecognized faith in their purposeless universe model, and it blinds them to the value of admitting uncertainty on this question. Many scientists attack hypotheses of universal teleology wherever they find them – even as they live in a world that they clearly know is predictable in part. We must call that stance hypocrisy, as predictability is a basic form of teleology, or purpose.

Evolutionary and behavioral psychologists are now proposing biologically-inspired scientific theories of human values. [See Sam Harris's *The Moral Landscape*, Free Press, 2010, for one]. But most of this work still is not deeply biologically-inspired, as it remains focused on evolution, ignoring development. We must recognize that a better understanding of universal evolution and development must help science derive more useful and more universal evolutionary and developmental values. I believe it is both the best definition and the purpose of humanity to use technology to continually reshape us, individually and collectively, into something more than our biological selves, and to do this in as deliberate and ethical a way as possible, using both evolutionary and developmental means. We can further realize what appears to be our universal purpose to think, feel, act, and build in ways that maximize our intellectual and emotional intelligence, advancing our minds and our hearts.

Fifth, **we recognize that very important parts of the future are predictable**. This benefit is the most useful to me as a professional futurist. Increasingly, we find foresight practitioners who accept the likelihood of developmental futures. Consider Pierre Wack at Royal Dutch/Shell's foresight group, who proposed the inevitable TINA (There Is No Alternative) trends in economic liberalization and globalization in the 1980s. Or Ron Inglehart and Christian Welzel, who have charted the inevitable developmental advance (with brief and partial evolutionary reversals) of evidence-based rationalism and personal freedom in all nations over the last 60 years (see WorldValuesSurvey.org).

Some leading recent books arguing for the inevitability of certain kinds of social development are Robert Wright's *Nonzero*, (Pantheon, 1999) on positive-sum rulesets, Steven Pinker's *The Better Angels of Our Nature* (Viking, 2011) on violence reduction, and Ian Morris's, *The Measure of Civilization* (Princeton U Press, 2013) on the predictable dominance of civilizations that are leaders in energy capture, social organization, war-making capacity, and information technology.

There are still far too many professional futurists who confidently and ignorantly claim that the future is entirely evolutionary ("cannot be predicted"). But a growing number of leaders, strategists, and futurists see regionally and globally dominant trends and inevitable convergences, make good predictions, and use increasingly better data and feedback to improve their models. For some good recent books on this, read Nate Silver's *The Signal and the Noise: Why So Many Predictions Fail But Some Don't* (Penguin Group, 2012) and Philip Tetlock's excellent *Superforecasting: The Art and Science of Prediction* (Crown, 2015).

As we learn take an evolutionary developmentalist perspective, at first unconsciously and later consciously, and use powerful new collective and machine intelligence foresight tools and platforms, we will greatly grow our predictive capacity in coming decades. More of us will foresee, accept, and start managing toward the ethical emergence of such inevitable coming technological developments as the conversational interface and big data, deeply biologically-inspired (evo and devo) machine intelligence and robotics, digital twins (intelligent software agents that model and represent us) and the values-mapped web, lifelogs and peak experience summaries, internet television, the wearable web, teacherless education, augmented reality, and many other new platforms for collective intelligence, information-generation, innovation, interdependence, and immunity production.

Professional futurists and forecasters are now developing our first really powerful tools and models that will keep expanding our prediction domains and horizons, and improving the reliability and accuracy of our forecasts. I believe evolutionary developmentalism is a foundational model that all long-range forecasters and strategists will eventually need to embrace. Not only must we realize there are possible and preferable futures ahead of us, but we must be convinced that there are inevitable and highly probable futures as well, futures which can increasingly be uncovered as our intelligence, data, and methods improve. Such an effort, at a species level, is the only way we can map what remains truly unpredictable, at each level of our collective intelligence.

We've got a long way to go before modern science is willing to give the developmentalist perspective the same consideration and intellectual honesty that we presently give the evolutionist perspective. A lot of papers will have to be published. A lot of arguments will have to be made, and evidence marshaled. Courageous scientists will have to build the bridge from the developmentalist aspects of physics, chemistry, and biology to the highest aspects of our humanity, our ethics, consciousness, purpose, and spirituality. Convergent evolution is one of several fields that will win lots of converts to developmentalism as it advances. Astrobiology will likely also play a big role, if it shows us just how common our type of life is in the universe, as many suspect it will.

Fortunately**,** as futurist Alvis Brigis has noted, many of the world's leading companies are already surprisingly developmentalist in their strategy and planning. We can trace this shift back at least to Pierre Wack's strategy group at Royal Dutch/Shell in the 1980's, as discussed in Peter Schwartz's *The Art of the Long View* (Doubleday,1996), a classic in business foresight. Wack realized that in order to do good scenario planning (exploring "what could happen", and the best strategic responses to major uncertainties) one should first *constrain the possibility space* by understanding what is very likely to continue to happen in the larger environment.

To restate this in evo devo language, Wack recommended starting with developmental foresight, finding the apparently "inevitable" macrotrends that he called TINA trends ("There Is No Alternative" to the trend), and then doing evolutionary foresight (exploring alternative futures) within the expanding set of testable developmental constraints and TINA trends. That in turn will make our alternative futuring much more believable and accurate as a result. Treating both evo and devo foresight perspectives seriously is a key challenge for strategy leaders. Many management and foresight consultancies are good at one, but not the other, as it's a lot easier to pick one perspective as your dominant framework than to have to continually figure out how to integrate two opposing processes. Yet both are critical to understanding and managing change.

As a technology foresight consultant, and a student of foresight work at other consultancies, I am convinced that those companies with the best predictions, forecasts, and foresight processes interfacing with their strategic planning groups are winning increasingly large advantages in their markets every year. All the most successful companies realize there are many highly predictable aspects of our future, and collectively our business and government leaders are now betting trillions of dollars annually on their predictions. A few are using good foresight processes, but most are still flying by the seat of their pants.

The executives leading our most successful companies don't see the world as a random accident, like an evolutionist, or some naive and self-absorbed postmodernist who lives off the exponentiating wealth and leisure of the very same science and technology that he argues are "not uniquely privileged perspectives" on the universe. Let's hope that our young scientists in coming years have the courage to be as developmentalist in their research, strategy, and perspective as our leading corporations are today. And as our biologically-inspired intelligent machines, destined to be faster and better at pattern recognition than we are, will be a few decades hence.

Will modern science recognize the evolutionary developmental nature of the universe before human-surpassing machine intelligences (the technological singularity) predictably arrive sometime this century and definitively show it to us? That is hard to say. But I believe we can predict with high probability that as humanity continues its incredible rise, our leaders, planners, and builders must become evolutionary developmentalists if we are to learn to see reality through the universe's eyes, not just our own.

Further Reading

For a more detailed treatment of evolutionary developmentalism, with references, you may enjoy my précis, ***Evo Devo Universe?***, 2008 (57 pp.). For one speculative proposal on where accelerating change may take intelligence, as a universal developmental process, see my paper ***The Transcension Hypothesis***, 2012, (19 pp.).

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Smart, John M. 2011. The Transcension Hypothesis, *Acta Astronautica*, 16 Dec 2011. Online PDF: http://bit.ly/1FLE50K