The Great Myths of Human Evolution Part 1

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50 Great Myths of Evolution and Human Evolution

- This lecture is based on:
- 50 Great Myths of Human Evolution By John H. Relethford, 2017
- Some material from Michael Le Page, 2008
- 20 other myths as well from CJV

Evolution

- Understanding misconceptions about human evolution
- Evolution is one of the cornerstones of the life sciences.
- It has been demonstrated countless times in different ways, and it is supported by multiple items of evidence.

Great Myths about Evolution

- Still, some people take issue with evolution for all sorts of non-scientific reasons and present faulty arguments against it.

- Advocates of the pseudo-scientific “Intelligent Design” theory go as far as claiming that features in forms of life on earth were designed by an intelligent being and were created as we find them today.

- Most of the arguments derive from basic misunderstandings of evolutionary theory or other scientific principles.

50 Great Myths of Human Evolution, Understanding About Our Origins – John H. Relethford, 2017

- His definition of "myth" that is closer to the second definition given in the Oxford English Dictionary: "A widespread but untrue or erroneous story or belief; a widely held misconception; a misrepresentation of the truth."

- At its core, science is a way of knowing, specifically a way of knowing about the natural world (including human behavior).

- Science is most importantly a process that enables us to learn more about the physical world.

50 Great Myths of Human Evolution

- Science is a process of making observations, developing possible explanations for what we see (hypotheses), and testing them in some manner.

- Scientific evidence changes over time because this is a dynamic process as we ultimately discard hypotheses that have been rejected.

- In the general sense, a hypothesis is simply a proposed explanation. To be a scientific hypothesis, we have to propose an explanation that is rooted in natural processes and is subject to testing, and falsifiability.

Falsifiability of hypotheses

- A key feature of the scientific method is openness to being proven wrong.
- In the scientific method, we do not prove hypotheses so much as we fail to reject them (sort of like assuming someone is innocent until proven guilty).
- When a hypothesis is rejected in science, we throw it out and move on, coming up with a new explanation or modifying an old one.
- A warning, however, is that given the dynamic nature of science, it is quite likely that new evidence will shed further light on many of the topics covered in this book.

Relethford

- Relethford: picked 50 “myths” about human evolution that he found useful, particularly in teaching about human origins and evolution.

- Each myth is designed to address a broader issue of science and of paleoanthropology

I - Ideas about Evolution

- In order to explore the myths of human evolution, we need to start with a brief review of how evolution works.

- It turns out that many of the myths of human evolution are related to misconceptions about the process of evolution in a general sense, starting with what is likely the biggest one of all—that evolution is "just a theory."

- This section examines some common misconceptions of the process of evolution.

Evolution

- At root, human evolutionary theory consists of two propositions:
  - (1) that the human species is descended from other similar species and
  - (2) that natural selection has been the primary agency of biological adaptation.

- Pretty much everything else is subject to some degree of debate.

Darwin and evolution

- Charles Darwin published On the Origin of Species in 1859, arguably the most important book on biology ever written. In it, Darwin outlined an idea that many still find shocking – that all life on Earth, including human life, evolved through natural selection.
- Darwin presented compelling evidence for evolution and, since his time, the case has become overwhelming.
- Countless fossil discoveries allow us to trace the evolution of today's organisms from earlier forms.
- DNA sequencing has confirmed beyond any doubt that all living creatures share a common origin.

Darwin

- Innumerable examples of evolution in action can be seen all around us, from the pollution-matching peppered moth to fast-changing viruses such as HIV and the Corvid 19 virus.

- Evolution is as firmly established a scientific fact as the roundness of the Earth or gravity

- One does not believe in evolution. One accepts the evidence for evolution

- Evolution must be the best-known yet worst-understood of all scientific theories.

Darwin

- Darwin was one of those who sought an explanation for change over time. Darwin made two very important contributions.

- First, he collected data confirming the fact of evolution as revealed from field studies of living organisms, the fossil record, and the comparative anatomy of different species, among other sources of evidence.

- His result was a convincing argument that all living species were related through a process of what he termed "descent with modification."


EVOLUTION
IS A
THEORY
KYLE BAKER

Darwin

- The mechanism that Darwin proposed (natural selection) will be dealt with in later myths, but here we just focus on the fact that natural selection was a hypothesis relying on natural phenomena that explained the observed facts.
- As with all scientific hypotheses, Darwin's idea has been tested repeatedly.
- Because it has survived without refutation, the concept of natural selection has been elevated to the status of a scientific theory.
- Once more, keep in mind that the word "theory" has a very specific meaning here and does not mean something that may or may not exist.

Myth 1 - Evolution is a theory, not a fact

- Evolution is both a fact and a theory.
- Arguing that something has to be one or the other is a misuse of the scientific method.
- In science, we understand a “theory” to be a body of thoroughly tested and verified explanations for a set of observations of the natural world. i.e. theory of the atom, of gravity, of relativity; each which describes understood facts about the world.

Theory in science

- According to the scientific method, a “theory” is an explanation grounded in a large amount of evidence. We are talking about a hypothesis that has been tested repeatedly and has stood the test of time without being rejected.

- Among scientists, evolution is considered a very solid, well-trusted idea, and one of the most fundamental laws of nature.

- In fact, evolution is a theory just like thermodynamics and gravity.

- They are all falsifiable, but so far no credible evidence has been offered to disprove any of them, including evolution.

Evolution is a highly verified theory

- Many people confuse the word “theory” with “hypothesis”(an educated guess), which still needs to be tested, experimentally or otherwise.

- In contrast, a “theory” in common vernacular is a word meaning a guess or suggested explanation. This meaning is more akin to the scientific concept of “hypothesis.”

- When critics of evolution say it is “just a theory,” they are implying that there is little evidence supporting it and that it is still in the process of rigorous testing. That it is just one opinion. This is a mischaracterization.

- A fact is a verifiable truth—something we can all observe and agree on. The key feature here is that facts must be capable of being verified. Science requires verification even with basic facts.

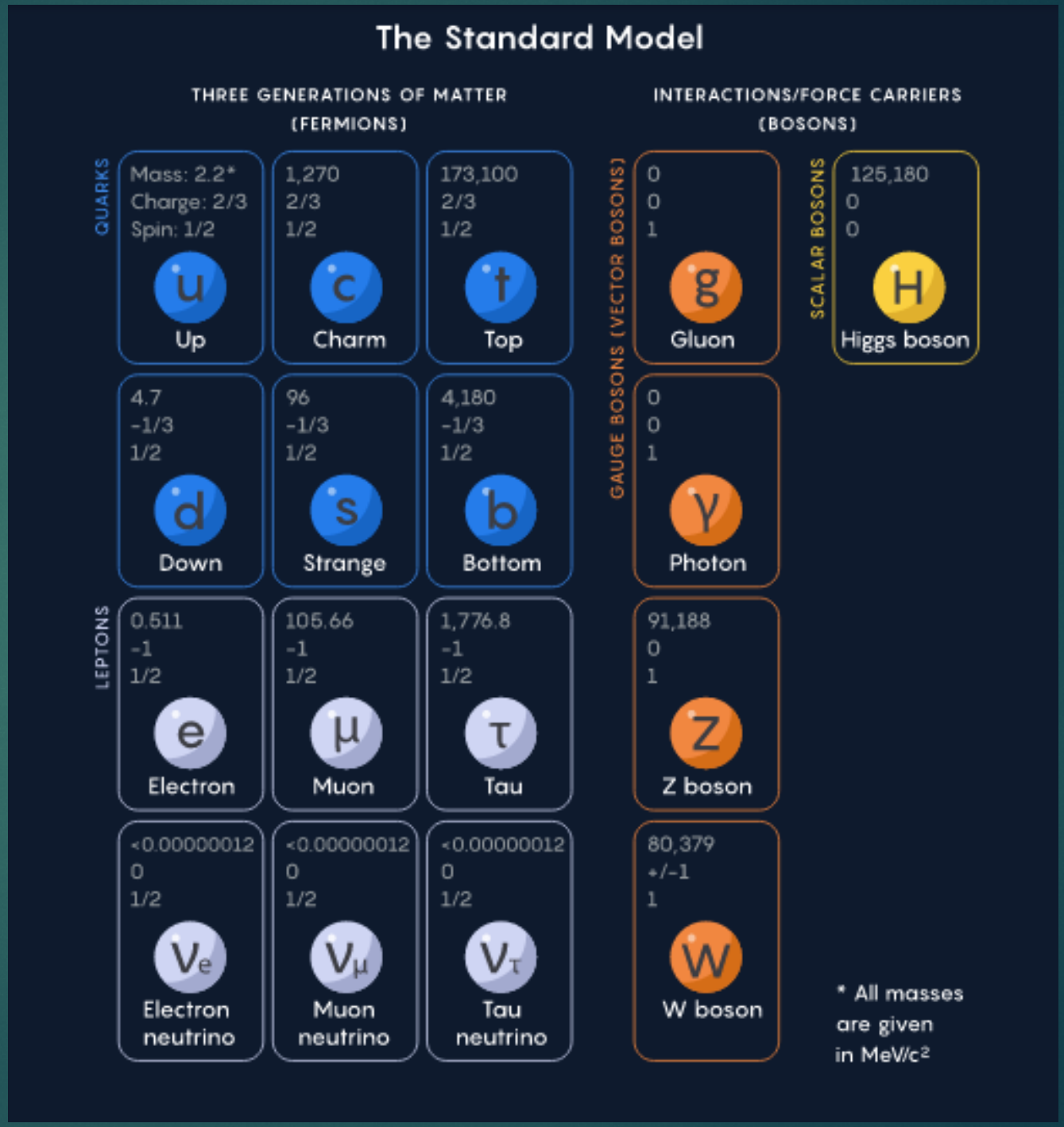
Hypothesis vs theory

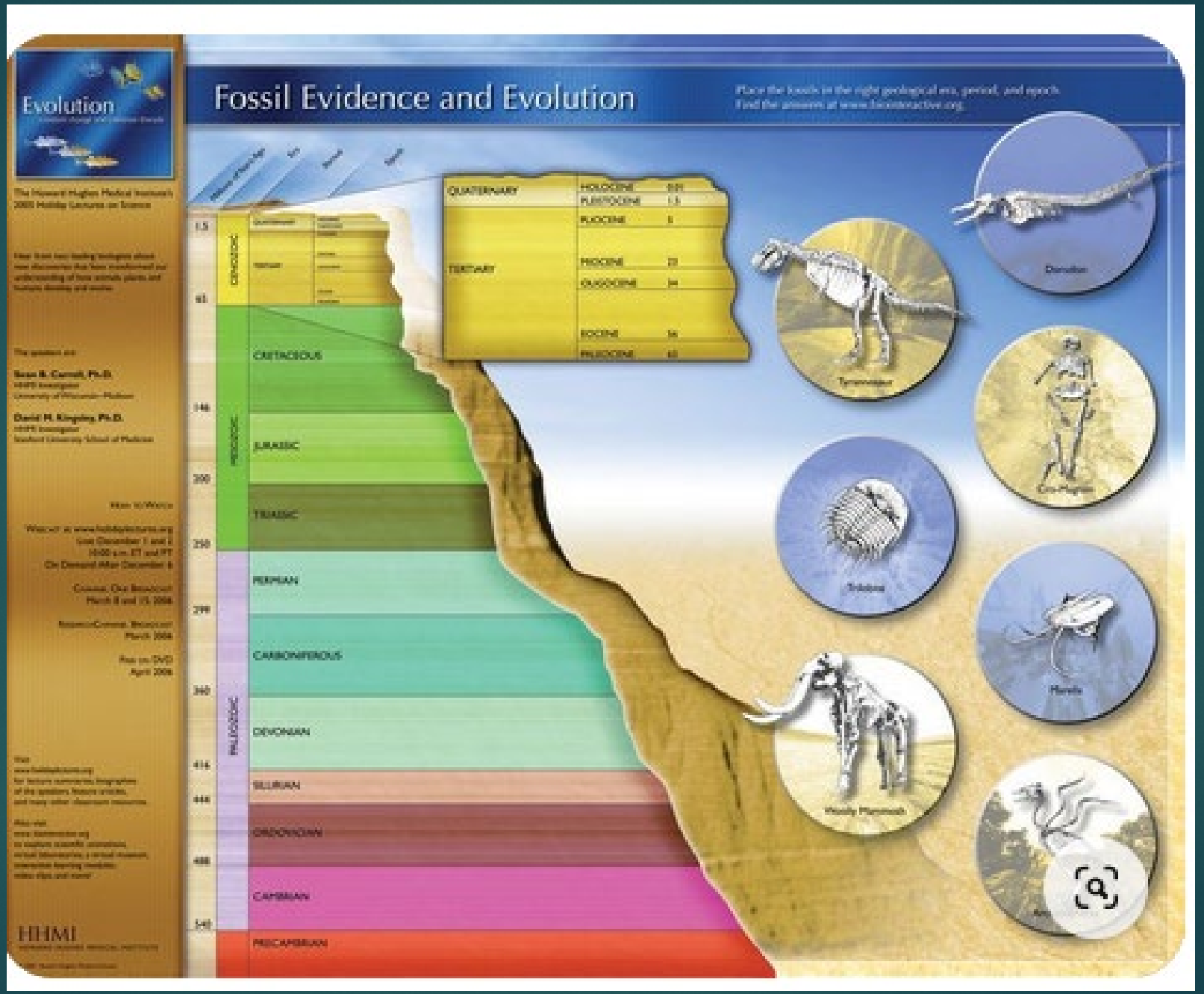
- Each time we develop a hypothesis we try to determine some way to test it. Science is continually involved with the testing and retesting of hypotheses, looking for hypotheses that have stood the test of time.

- In the natural sciences, we use the word "theory" to indicate a hypothesis, or set of hypotheses, that has been tested repeatedly and has not been rejected. We might continue to refine the theory, but the basic elements are widely agreed upon and unlikely to change.

- Evolution is the only scientifically valid and accepted theory that accounts for our observations of the variation in the biological world

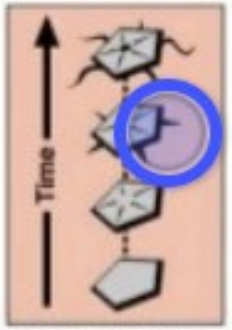
Proven facts/evidence of the Standard Model of physics



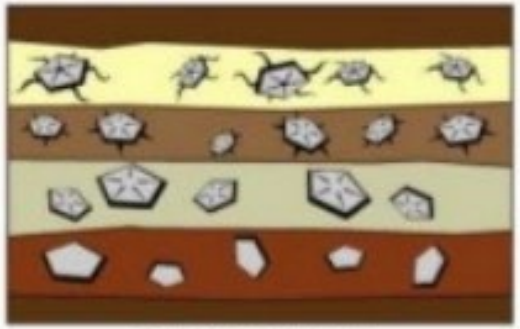

Evolution
Fossil Evidence and Evolution
QUATERNARY
HOLOCENE
PLEISTOCENE
TERTIARY
PLIOCENE
MIOCENE
OLIGOCENE
EOCENE
PALEOCENE
CENOZOIC
MESOZOIC
PALEOZOIC
CRETACEOUS
JURASSIC
TRIASSIC
PERMIAN
CARBONIFEROUS
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN
PRECAMBRIAN
HHMI

Evidence for Evolution

Fossil record

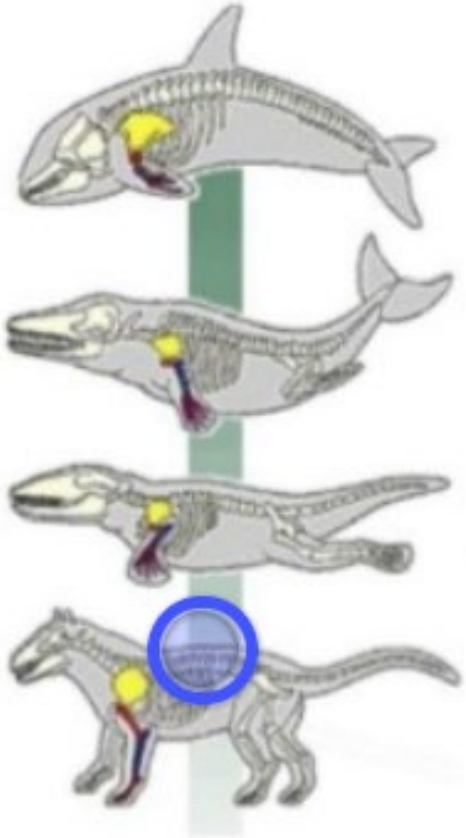


Gradual lineage evolution



Rock strata with fossils

Homologous structures



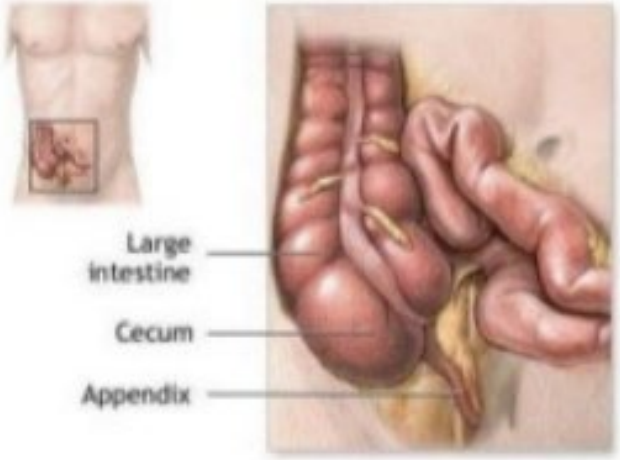
http://evolution.berkeley.edu/evosite/evo101/VIIAPacecevolution.shtml

Selective breeding

http://www.bbc.co.uk/schools/ks3bitesize/science/images/bio_dogs.gif

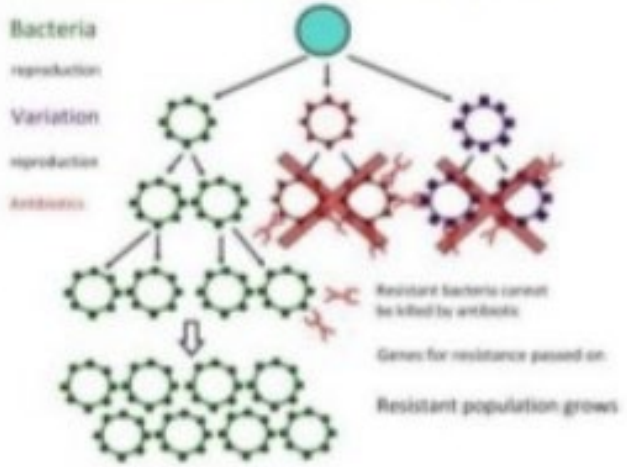
Comparative DNA

Vestigial structures

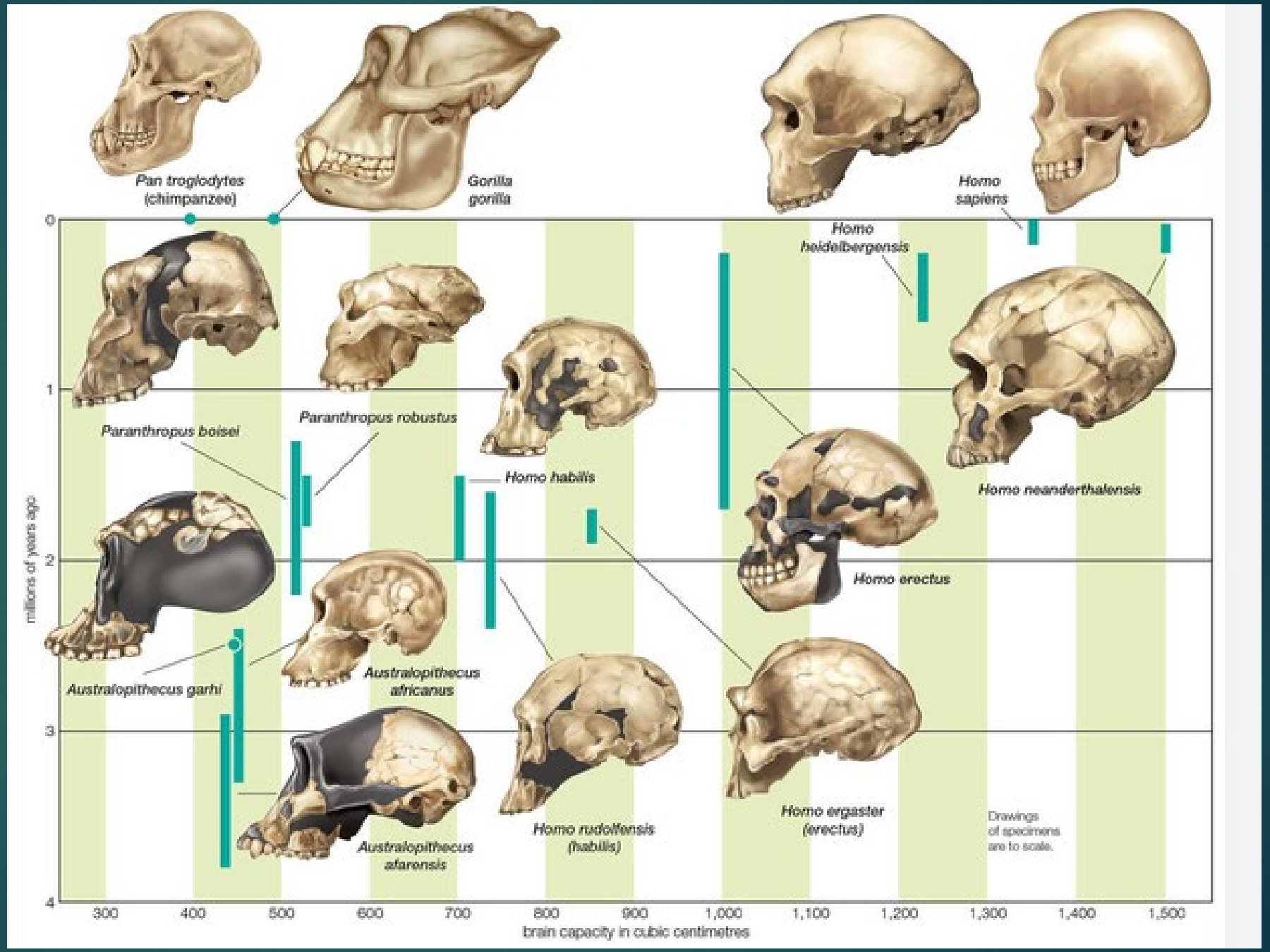


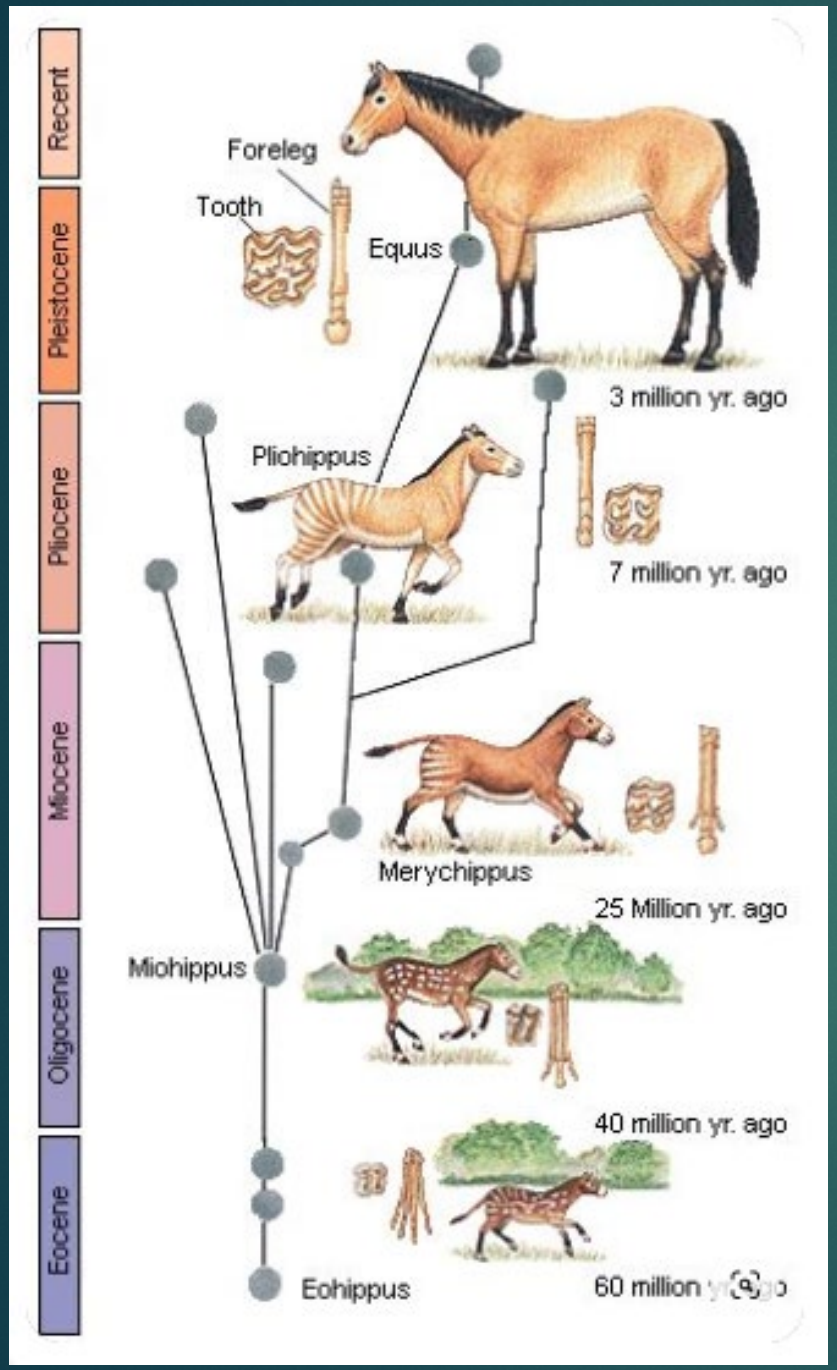
http://www.nlm.nih.gov/MEDLINEPLUS/ency/imagepages/1128.htm

Observable changes



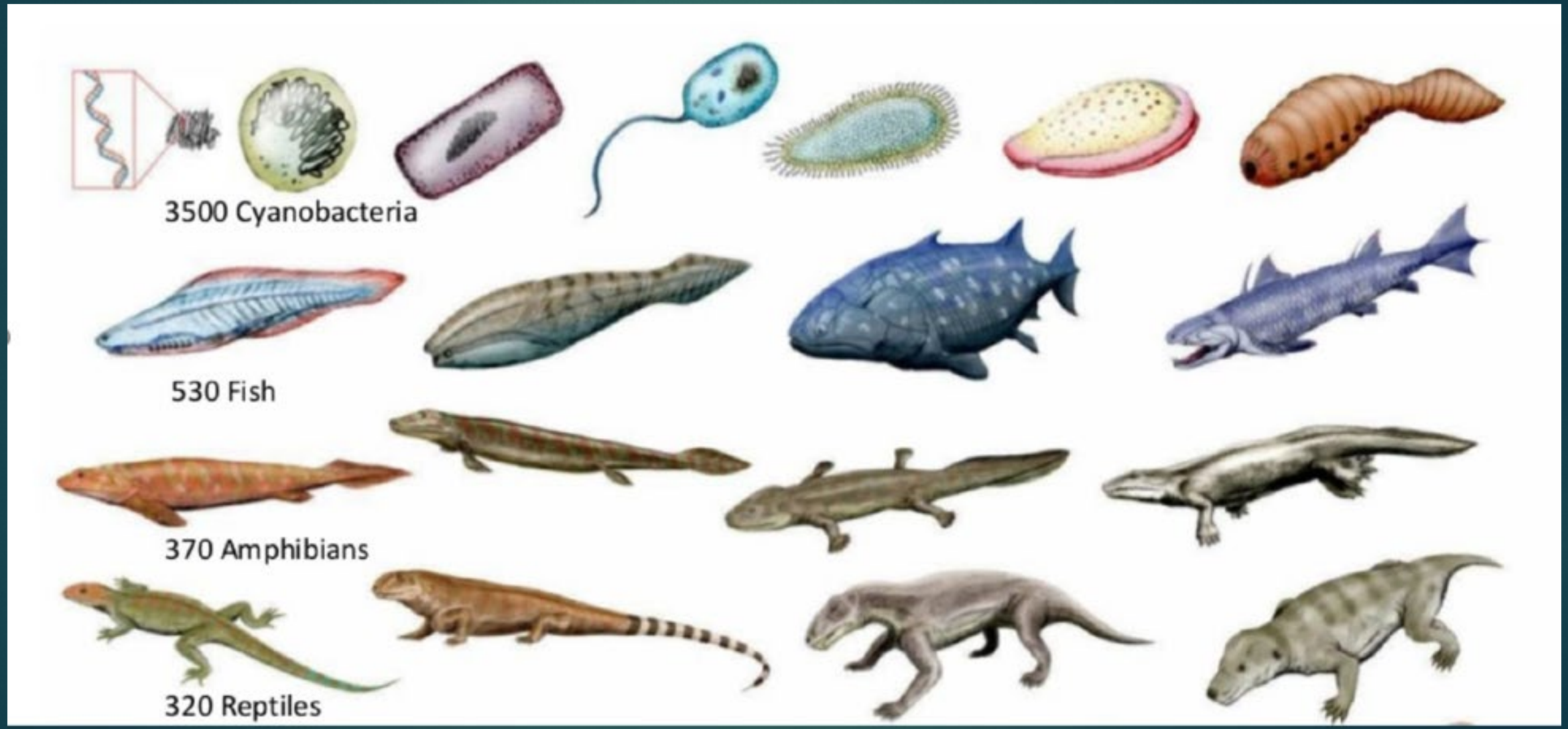
Anatomical Evidence of Evolution




Recent
Pleistocene
Pliocene
Miocene
Oligocene
Eocene
Foreleg
Tooth
Equus
3 million yr. ago
Pliohippus
7 million yr. ago
Merychippus
25 Million yr. ago
Miohippus
40 million yr. ago
Eohippus
60 million

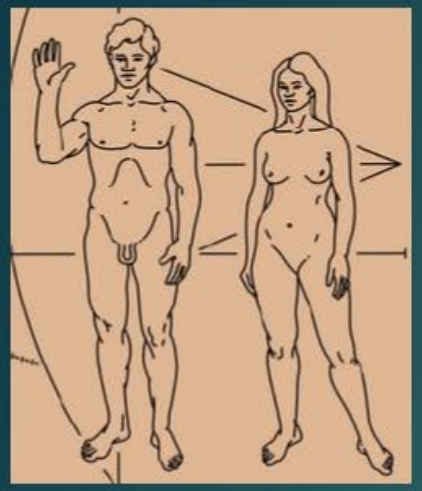

Origin of life

4.5 billion-year history of our evolution – cellular until 560 Ma



N. Tamura, 2010

How Much of Your DNA You Share with:



99.9%

Neandertals 99.7%

98.4%

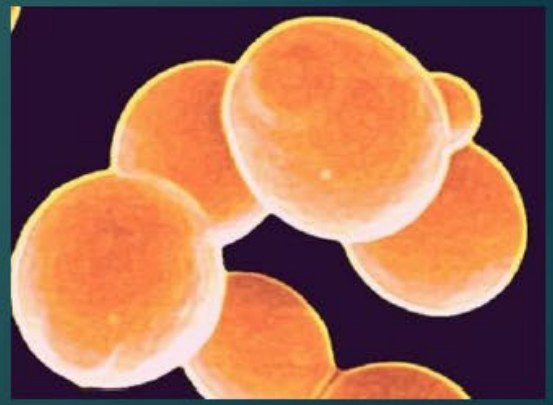
92%

70%

50%

60%

You are related to every living creature on earth



Yeast = 26%

Myth: Evolution explains the origin of life

- Evolution does not explain the origin of life. It does explain how it developed after life appeared on earth.

- The scientific definition of evolution is “a change in the allele distribution in a gene pool”, where “allele distribution” is how often a trait appears and “gene pool” refers to the collective genetic material of a reproducing population of a life form.

- In other words, to have evolution there needs to be a pre-existing gene pool, meaning life already must exist. There has to be pre-existing variation.

- Most of evolutionary biology deals with how life changed *after* its origin. Regardless of how life started, afterwards it branched and diversified, and most studies of evolution are focused on those processes.

Michael Le Page, 2008

Myth 2 - Evolution is completely random

- This is a myth because it implies that evolution is a chance event.
- Although some aspects of evolution (such as mutation) have a random element, other aspects, such as natural selection, are not random.
- Whether an individual survives and reproduces or not depends on their evolutionary fitness (success at surviving and reproducing) relative to their local environment.
- Like many natural processes, evolution has both nonrandom and random components.

A common misconception of the evolutionary process is that it is random; that is, due to chance.

- Part of the confusion may lie with the fact that some parts of the evolutionary process are random. However, having some randomness in parts of a process is not the same as an entire process being random.

- To be more specific, the origin of initial genetic variation is random, but the outcome is not.

- Variation is all around us in the natural world; an observation that Darwin was able to tie to environmental differences.

Animal domestication

- Darwin tied together the observation of differential survival with the observation of variation.
- Given variation within a species, in a specific environment some individuals will be more likely to survive and reproduce than others.
- The principles of natural selection are often best understood by analogy to the process of animal domestication.
- Farmers breed for the characteristic of interest and it will become more common over time, be it the size of pigs, speed of a horse, disposition of a dog, or many other traits.

Animal domestication

- Larger pigs will produce larger offspring. This is not a perfect correlation, but it is strong enough that people have relied on this principle of selective breeding to feed themselves in the last 12,000 years. This selection is not random.

- Darwin recognized how this process of selection could lead to evolution, where the change over time was due to the farmer selecting who lived to reproduce and who did not.

- He also recognized that the same process could happen in nature, but where the selection was not the product of conscious manipulation by a human being, but was instead due to interaction with the environment.

Natural selection

- Those organisms that are better adapted to a given environment are more likely to survive and reproduce and will then pass on their characteristics in greater numbers to the next generation.

- Darwin tied together the observation of differential survival with the observation of variation.

- Given variation within a species, in a specific environment some individuals will be more likely to survive and reproduce than others. Unlike the artificial selection that occurs due to the intervention of the farmer, this selection occurs in nature and is therefore termed natural selection.

Peppered moth

Peppered moth: classic example of natural selection

Peppered moth: example of industrial melanism (more black)

- A classic example of natural selection acting upon variation is found in studies of the coloration of the peppered moth in England.
- At one time, most of the moths of this species were light-colored, but a very small number were dark in color. The light color was more common because it was adaptive; the light color acted as camouflage when the moths rested on the light-colored tree trunks. Because these moths blended in, they were less likely to be seen by birds, unlike the dark-colored moths that were more visible and thus more likely to be eaten.
- Here, selection acted to maintain the light color over time and most dark-colored moths were selected out of the gene pool. Whether a moth was eaten or not was not random.

Camouflage-predation explanation for industrial melanism in peppered moths

- However, scientists also noted what happened when the environment changed because of industrial pollution killing off lichen on the trees, exposing the underlying dark color.
- At this point, the selective balance shifted and light-colored moths were then at a disadvantage and dark-colored moths were at an advantage.
- Each generation the proportion of dark-colored moths increased until they were the most common form as the population became better adapted to the environment.

Source of variation: Mutation

- Darwin's model of natural selection leaves out one important question—where does variation come from in the first place?
- Darwin did not know about genes/mutations.
- Natural selection acts upon mutations. If a mutation is harmful to the organism that inherits it, hindering survival or reproduction, it can be eliminated through natural selection. Selection thus acts to weed out harmful effects.

Mutations

- On the other hand, if a mutation leads to an advantage, it can be selected for and increase in frequency over time.

- Putting mutation and natural selection together, we get a picture of mutations generating variation that is then filtered by natural selection, leading to the reduction in frequency of harmful mutations and the increase in frequency of helpful mutations.

Initial Mutation = random

- Mutation is a random process. Mutations do not appear when they are needed.
- Does this mean that evolution is random and everything we see around us resulted merely from a series of chance events?
- Absolutely not.
- “Mutation is random” simply means that the initial generation of variation is random, not the outcome.
- Remember, natural selection is not a random process.

Not totally random

- Whether an organism will survive and reproduce or not is a function of its adaptive value (what we call “fitness”) in a given environment.

- When environments change, the difference between survival and extinction is not a matter of chance, but instead is a direct outcome of organisms differences in fitness (trait that helps them to survive & reproduce).

- Although the direction of evolutionary change may change as the environment changes; this is not a random change.

- Although evolution does have a random component (mutation), the direction of evolutionary change due to natural selection is not a random outcome.

So, is evolution random?

- *No and yes.* Natural selection is a rigorous testing process that filters out what works from what doesn't, driving organisms to evolve in particular directions. However, chance events play a big role too.

- Evolution by natural selection is a two-step process, and only the first step is random: mutations are chance events, but their survival is often anything but.

- Natural selection favors mutations that provide some advantage and the physical world imposes very strict limits on what works and what doesn't. The result is that organisms evolve in particular directions.

Natural selection

- All fast-swimming creatures evolve a streamlined shape, as we see in animals as diverse as squid, sharks and dolphins. It might look like the result of design, but it shows instead the power of natural selection, which can be thought of as a rigorous real-world testing process for evaluating the effect of different mutations.

- Natural selection – the testing process – is what moves evolution in particular directions.

- One consequence of this is that evolution tends to produce similar “designs” to meet similar problems, a phenomenon known as convergence.

- There are countless examples. Pterosaurs, birds and bats all evolved similar ways of flying. Tuna and some sharks use similar mechanisms to keep their swimming muscles warmer than the surrounding water.

Myth 3 - All evolutionary changes are adaptive

- This is a myth that results from equating the entire evolutionary process with natural selection acting upon mutations.
- Not all evolutionary changes reflect adaptation.
- There is also random fluctuation over time, known as genetic drift (change in frequency of an existing gene variant in the population due to random chance).
- Evolutionary biologists all agree that both selection and drift are important, although there is debate over the relative influence of each.

Adaptive vs nonadaptive evolution

- Variation in skin color can be explained by adaptation through natural selection to ultraviolet radiation. This dark and light skin patterns correlate with the global distribution of ultraviolet radiation.

- Natural selection may not be the only factor contributing to variation. There are also cases where natural selection does not explain anything about the variations that we see.

- Can some variation be explained by nonadaptive evolutionary change? The answer is yes.

The 4 Evolutionary Forces

- Genetic change within a population (defined as a change in the frequency of different genetic variants) can be explained through the action of four mechanisms, termed evolutionary forces.
- 1 – Mutation
- 2 - Natural selection
- 3 - Gene flow (movement of genetic material from one population to another).
  - Let's say that you leave your hometown and move somewhere else, marry someone who is living there, and then have a child with your spouse. Gene flow has occurred because you have mated with someone in a different population and thus have connected two populations genetically.

Gene flow

- Gene flow can affect the genetic makeup of a population in two ways.
  - First, new genetic variants can be introduced into the population from somewhere else. This process allows new mutations to be spread throughout a species.
  - Second, gene flow acts to make populations more similar to each other over time.

Genetic drift

- 4 - Genetic drift*: random* fluctuation in the frequency of a genetic variant over time.
- Under genetic drift, it is possible for a genetic frequency to change by chance. This is an example of nonadaptive evolution—there has been a change, but not due to natural selection.
- Genetic drift is an example of what we call sampling error (a statistical error that occurs when an analyst does not select a sample that represents the entire population of data).
- Genetic drift works in a similar manner; this means that the frequency of an allele in the offspring generation can be different from the frequency in the parental generation because of chance.

Genetic drift = effect of chance

Not all change is adaptive.

- The take-home lesson is that not all evolution has to be adaptive.
- Some traits have evolved because of adaptation via natural selection and others are likely to reflect the balance between mutation and drift.
- In any specific case, such as the traits we will examine for human evolution, we need to examine all available clues to determine if the evolutionary change we see is primarily adaptive or nonadaptive in nature.

Genetic drift can have major effects in small populations.

- Genetic drift has a larger effect on small populations, but the process occurs in all populations. Genetic drift occurs because, due to chance, the individuals that reproduce may not exactly represent the genetic makeup of the whole population.
- For example, in one generation of a population of captive mice, brown-furred individuals may reproduce more than white-furred individuals, causing the gene version that codes for brown fur to increase in the population — not because it improves survival, but just because of chance.
- The same process occurs in large populations: some individuals may get lucky and leave many copies of their genes in the next generation, while others may be unlucky and leave few copies.

Myth 4 – In evolution, bigger is always better

- Herbert Spencer: natural selection is "survival of the fittest." Is this phrase accurate?

- In a popular application of the idea of "survival of the fittest," we tend to equate larger size as having the greater chance of evolutionary success because we assume biggest is the most fit.

- Although there are indeed many cases where larger individuals have a greater chance at survival and reproduction, there are also cases where being smaller gives one an evolutionary advantage. It all depends on the specific environmental circumstances.

Bigger is better?

- The answer depends on the exact use of the word “fittest.”
- Often, the word conjures up an image of traits related to physical fitness, such as size, strength, and speed.
- Thus, when we say “survival of the fittest,” we may picture a situation where the largest, strongest, and fastest individuals are the most likely to survive and reproduce because their physical attributes make them better competitors for mates and food and better able to defend themselves.

A balance between benefits and costs

- Natural selection operates to lead to a balance between the benefits and costs to maximize fitness.

- Here, the word fitness is used in the more precise evolutionary context as the probability of survival and reproduction. This probability reflects the net balance between benefits and costs.

- Natural selection can be thought of in a similar manner. Body size, for example, can be related to both benefits and costs, which in turn affects overall fitness. If the benefits of larger body size outweigh the disadvantages of larger body size, then natural selection will favor larger size. The same goes for smaller body size.

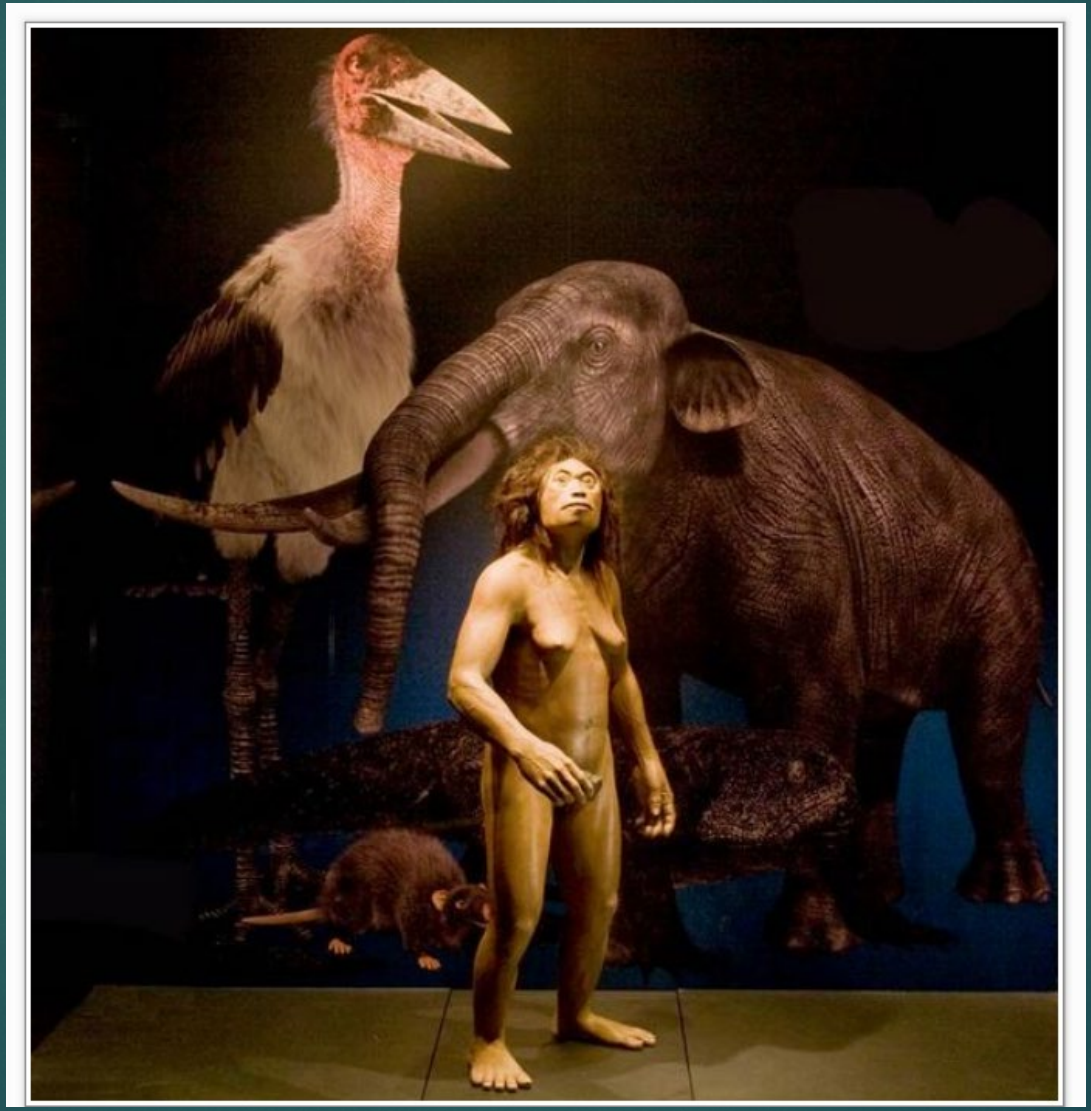
Environment context

- The actual fitness of large or small body-sized organisms thus depends on the specific environmental context and shows that bigger is not always better.

- Brain size in hominins increased from 2 Ma ago, but in Homo sapiens it has actually decreased slightly over the past 35,000 years, in part the result of a similar decline in average body mass.

- But recent study indicates larger brains in US rom 1930 to 1970 due to healthcare and higher education (your environment).

Island dwarfism: Flores – dwarf elephants, H. floresiensis, giant storks



Island dwarfism

- Perhaps one of the best counterexamples to the myth that bigger is always better is a phenomenon known as island dwarfism, named for the finding that a number of large-bodied species trapped on islands or other isolated areas often show a reduction in body size over time.

- One of the more spectacular examples of island dwarfism is the fossil remains of dwarf elephants found on islands around the world, and some of these extinct species are estimated to have weighed as little as 441 pounds. Or H. floresiensis.

- Main lesson here is that the evolutionarily optimal body size will depend on specific conditions and will not always lead to larger body size. But sometimes do.

Malta: 6-foot swans, 3-foot elephants

Myth 5 – Natural selection always works

- One common misconception about evolution is that natural selection always works, and a species will always be able to adapt to changing environmental circumstances.
- This is not true, and the fact that over 99 percent of all past species are now extinct shows that, over the long term, natural selection does not continue to work. Because new species are born at the same time that old species die, the process of life continues, but with new players over time.
- Natural selection is a remarkable process, but it is not perfect. Selection leads to an optimal solution in terms of the differences in survival and reproduction, but this does not mean it will lead to a perfect solution.

Natural selection is not perfect

- Mutation is a random process that is blind to the need for certain mutations to develop when they are needed.

- Even if the necessary mutation is present, it may often take a long time to increase the frequency of a new allele to a level high enough to result in major changes in survival. If environmental conditions change too fast, a species' ability to adapt through natural selection may be compromised. Think of the 5 mass extinctions on earth as examples.

Extinction vs. natural selection

- The historical extinction rate is a good demonstration that over the long term natural selection may not keep pace in a species as the environment changes.

- Extinction happens all the time as species fail to adapt to changing conditions.

- Scientists agree that today's extinction rate is hundreds, or even thousands, of times higher than the natural baseline rate. Judging from the fossil record, the baseline extinction rate is about one species per every one million species per year.

Myth: Natural selection acts for the good of the species.

- We hear about altruism in nature: dolphins spending energy to support a sick individual, or a meerkat calling to warn others of an approaching predator, even though this puts the alarm sounder at extra risk

- It's tempting to think that those behaviors arose through natural selection that favors the survival of the species — that natural selection promotes behaviors that are good for the species as a whole, even if they are risky or detrimental for individuals in the population.

- However, this impression is incorrect.

Natural selection does no act for the good of the species.

- Natural selection has no foresight or intentions.
- In general, natural selection simply selects among individuals in a population.
- It favors traits that enable individuals to survive and reproduce, yielding more copies of those individuals' genes in the next generation.
- Theoretically, in fact, a trait that is advantageous to the individual (e.g., being an efficient predator) could become more and more frequent and wind up driving the whole population to extinction (e.g., if the efficient predation actually wiped out the entire prey population, leaving the predators without a food source).

Individual trait could be disadvantage for the group

- So what's the evolutionary explanation for altruism if it's not for the good of the species?
- There are many ways that such behaviors can evolve.
- For example, if altruistic acts are "repaid" at other times, this sort of behavior may be favored by natural selection.
- Similarly, if altruistic behavior increases the survival and reproduction of an individual's kin (who are also likely to carry altruistic genes), this behavior can spread through a population via natural selection

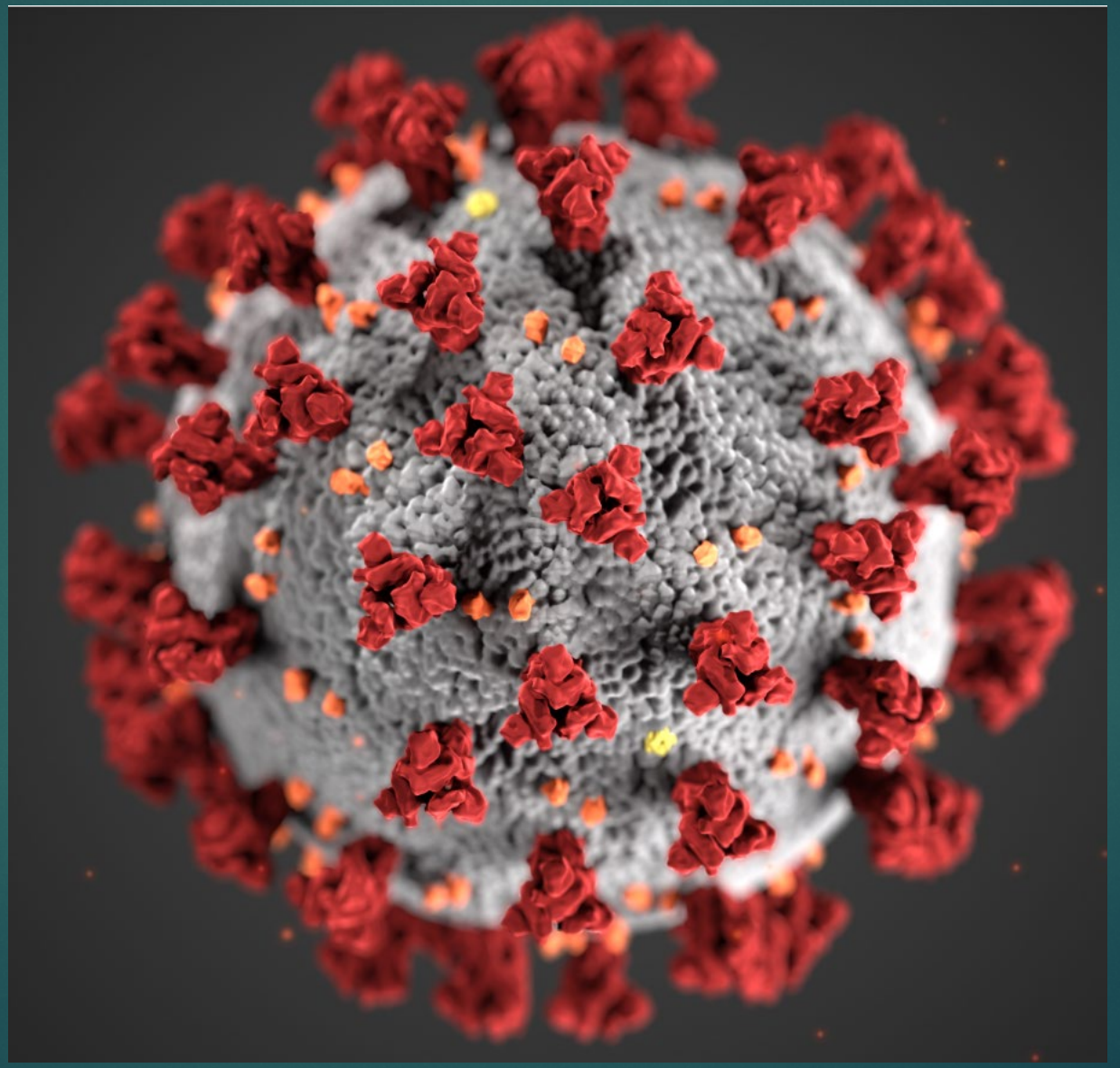
Selection has no foresight

- Selection can act at different levels and that, in some circumstances, species-level or group-level selection may occur.
- However, it's important to remember that, even in this case, selection has no foresight and is not "aiming" at any outcome.
- It is simply favoring the reproducing units that are best at leaving copies of themselves in the next generation.

Myth 6 – Some species are more evolved than are others

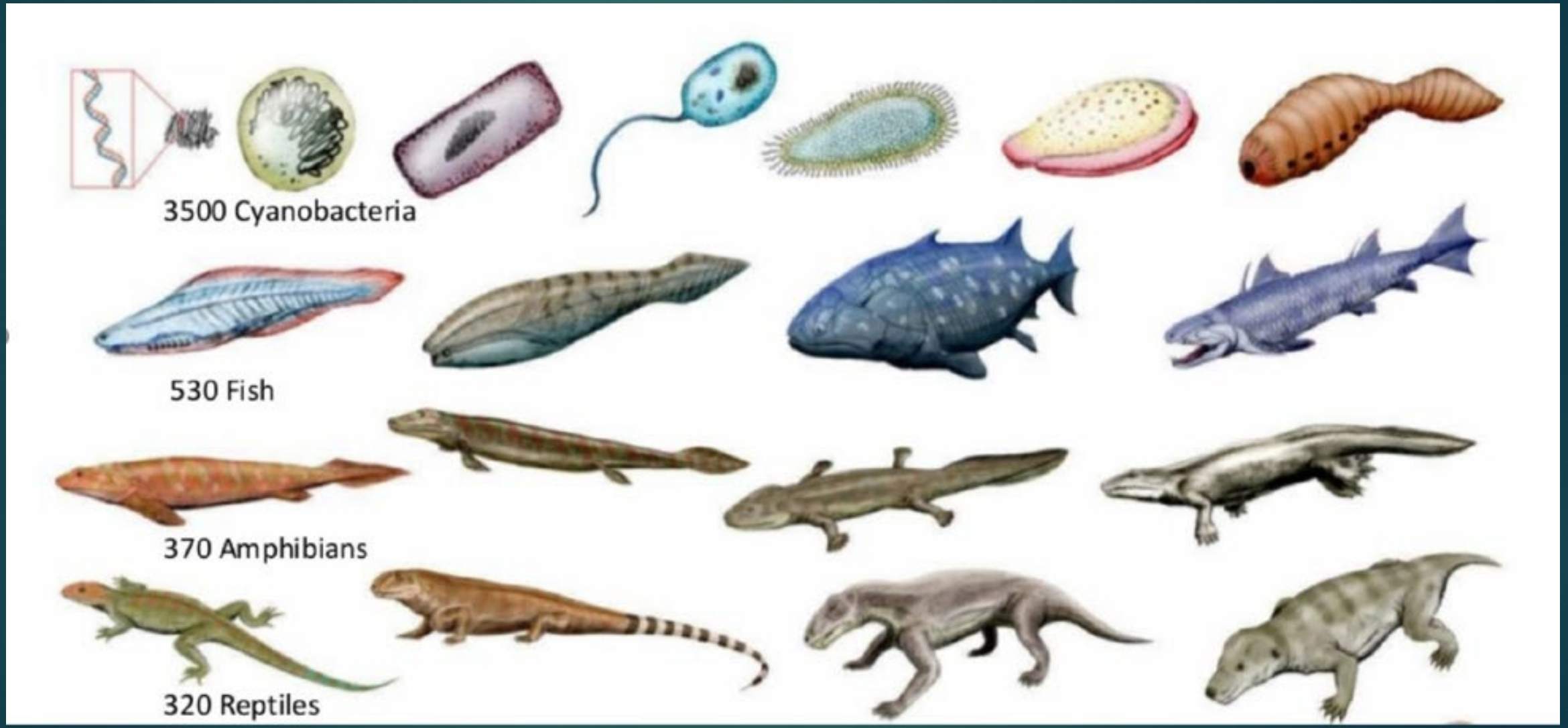
- It is common for people to think of some species as being "more evolved" than others, and to further rank species from less evolved to most evolved, with humans typically placed at the extreme position of most evolved.
- Eugenics and Nazi death camps resulted from this idea.
- However, most definitions of "most evolved" rely on arbitrary characteristics that reflect our own biases of worth and value.

Covid 19 virus: just as evolutionary perfect as humans



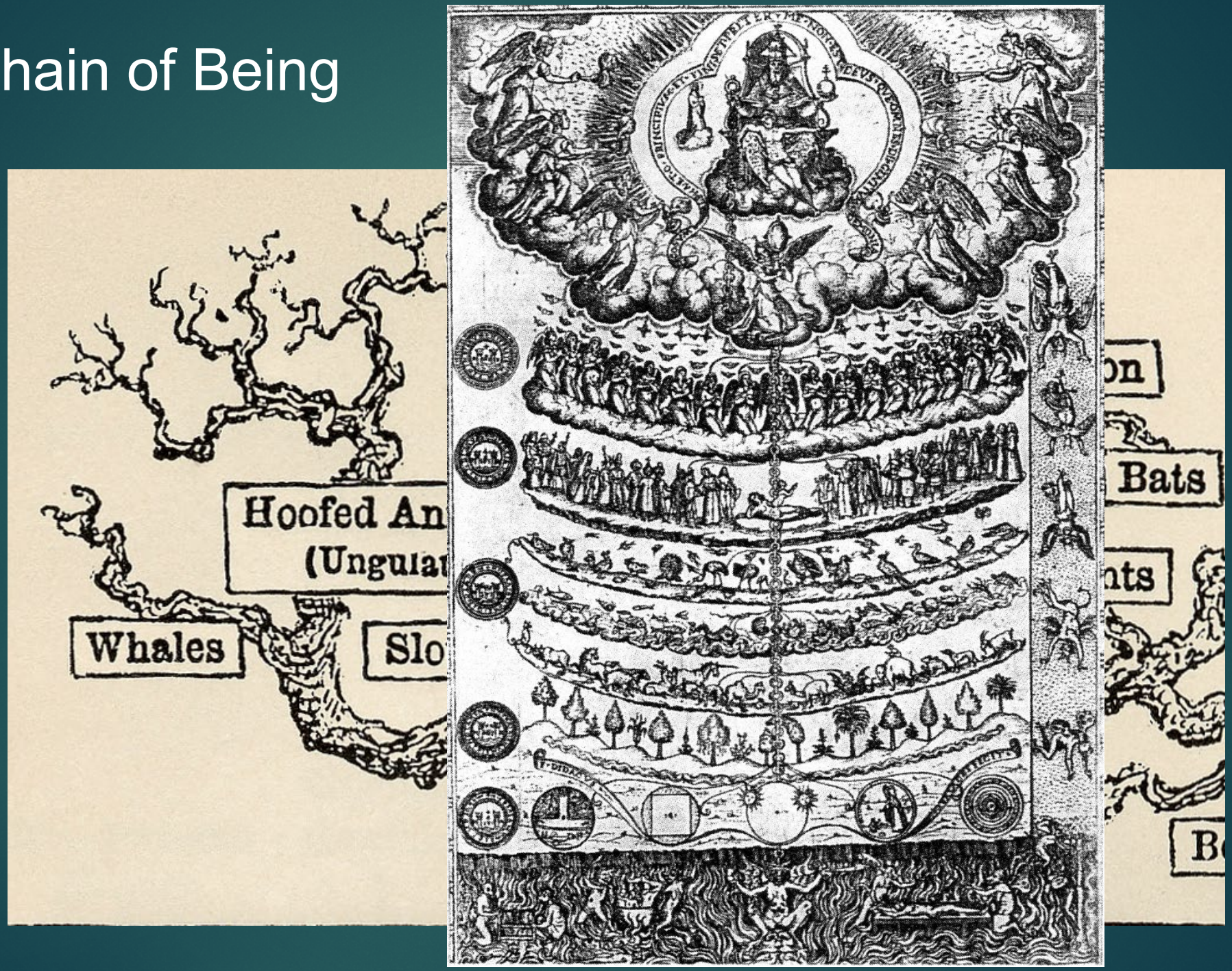
CDC

4.5-billion-year history of our evolution – We were just cellular until 560 Ma



N. Tamura, 2010

Great Chain of Being



Differentially evolved

- Which animal is more evolved—an ant or a chimpanzee?
- Given this choice, I imagine that most people would choose the chimpanzee. If the choice was between an ant and a human, I suspect that virtually everyone would argue that humans are more evolved.
- Goes back to Aristotle's Scala Naturae, or Ladder of Being, with humans at the top,
- From a purely evolutionary sense, all life shares a common origin and all species, by definition of evolutionary time back to a common ancestor, are equally evolved. Not "more evolved." but "differently evolved."

Myth: Individual organisms can evolve during a single lifespan.

- Evolutionary change is based on changes in the genetic makeup of populations over time. Populations, not individual organisms, evolve.

- Changes in an individual over the course of its lifetime may be developmental (e.g., a male bird growing more colorful plumage as it reaches sexual maturity) or may be caused by how the environment affects an organism (e.g., a bird losing feathers because it is infected with many parasites).

- However, these shifts are not caused by changes in its genes.

Evolution in a lifetime

- While it would be handy if there were a way for environmental changes to cause adaptive changes in our genes — who wouldn't want a gene for malaria resistance to come along with a vacation to Mozambique? — evolution just doesn't work that way.

- New gene variants (i.e., alleles) are produced by random mutation, and over the course of many generations, natural selection may favor advantageous variants, causing them to become more common in the population.

- But what about CRISPR germline editing? $2 Million for sickle cell cure. He Jiankui fiasco – 2 embryos germline edited to change allele to prevent HIV

Individuals Evolve

- Evolution is the change in a population's genetic composition over time, specifically over generations, resulting from differential reproduction of individuals with certain alleles.

- *Populations* evolve not *individuals*. Evolution is just a change in the genetic composition of a population over time, so, since individuals cannot change their genetic composition, they cannot evolve.

Myth: Organisms Evolve on Purpose

- Statements such as "organisms evolve in response to a change in an environment" are quite common, but such statements can lead to two types of misunderstandings.

- First, do not interpret the statement to mean that individual organisms evolve.

- The statement is shorthand for "a population evolves in response to a changing environment."

There is no purpose in evolution

- However, a second misunderstanding may arise by interpreting the statement to mean that the evolution is somehow intentional.

- A changed environment results in some individuals in the population, those with particular phenotypes, benefiting and therefore producing proportionately more offspring than other phenotypes.

- This results in change in the population, if the characteristics are genetically determined.

Antibiotic resistance

- It is also important to understand that the variation that natural selection works on
  - is already in a population and
  - does not arise in response to an environmental change.

- For example, origin of antibiotic resistance:
- applying antibiotics to a population of bacteria will, over time, select a population of bacteria that are resistant to antibiotics.
- The resistance, which a gene causes, did not arise by mutation because of applying the antibiotic.

Antibiotic resistance is already present

- The gene for resistance was already present in the bacteria's gene pool, likely at a low frequency.
- The antibiotic, which kills the bacterial cells without the resistance gene, strongly selects individuals that are already resistant, since these would be the only ones that survived and divided.
- Experiments have demonstrated that mutations for antibiotic resistance do not arise as a result of antibiotic.

Myth: Natural selection gives organisms what they need

- Natural selection has no intentions, predictors, or senses; it cannot sense what a species or an individual “needs.”
- Natural selection acts on the genetic variation in a population
- This genetic variation is generated by random mutation — a process that is unaffected by what organisms in the population need.

Natural selection does not give organisms what they need

- If a population happens to already have genetic variation that allows some individuals to survive a challenge better than others or reproduce more than others, then those individuals will have more offspring in the next generation, and the population will evolve.

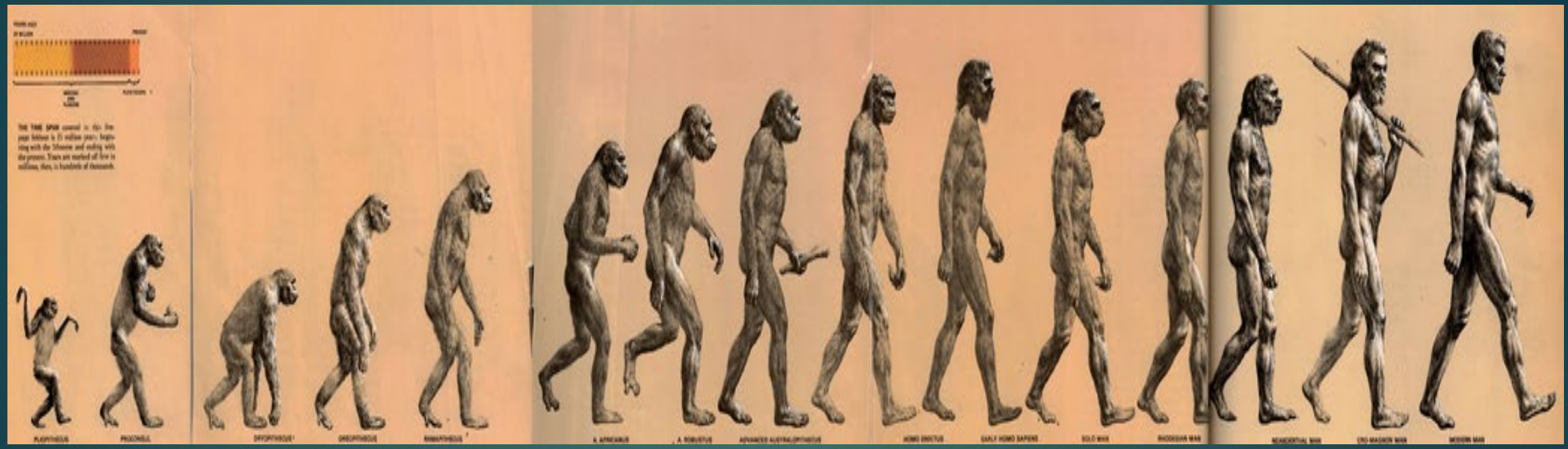
- If that genetic variation is not in the population, the population may survive anyway (but not evolve via natural selection) or it may die out.

- But it will not be granted what it “needs” by natural selection.

Myth: Evolution is linear (anagenetic)

- An earlier group of australopiths becomes a different type of australopiths; Ardi. ramidus becomes A. amanensis becomes A. afarensis via anagenesis
- Anagenesis is the transformation of a particular lineage of organisms to a different state which can be justified as a new species from its ancestral species. It is the constant evolution of a species that continues to exist as an interbreeding population. With no species branching.
- Human evolution is not anagenetic; it is a massive branchy bush often in the same landscape using different resources. Not 1 thing becoming another with prior species dying out.

1965 March of Progress: wrong view of evolution –
Nature does not evolve toward higher complexity = Us



Early Man volume of the *Life Nature Library*, published in 1965, and drawn by the artist Rudolph Zallinger.

Evolution is not directional or goal oriented

- March of Progress image of 1965: Wrong idea of evolution.
- Evolution is fundamentally not goal directed.
- Species do not become “better” over time. They simply track their changing environment with adaptations that maximize their reproduction in a particular environment at a particular time.
- Evolution has no goal of making faster, bigger, more complex, or even smarter species.

Evolution is not directional

- What characteristics evolve in a species are a function of the variation present and the environment, both of which are constantly changing in a nondirectional way.
- A trait that fits in one environment at one time may well be fatal at some point in the future; i.e. Dodo bird's lack of fear of predators
- Being human is not the goal of evolution.

Myth: Evolution is linear. It has a goal.

- Evolution is not linear. It's not a progression from bad to good to better to best.
- Humans are not the pinnacle of evolution, just one of many successful branches.
- Every single organism alive today, is the 'Pinnacle of Evolution", i.e. Covid 19
- Humans are just a side branch of fish evolution. As is ever other mammal.

Natural selection

- Evolution is natural selection based on existing genetic variation.
- Development of a mutation that has a fitness benefit, which will reproduce more frequently and enhance survival.
- No inevitability to being human. Humans are a terminal branch of species that responded to pressures of the African environment.
- Humans have used cultural evolution to evolve significantly. You are not smarter than a Neandertal. It is our cultural sharing of information that has caused ability to create massively complex entities.