

Persistent Fallacies* in the Teaching of Evolution

(*that have nothing to do with intelligent design)

First and Foremost

- “evolution,” is science.
- Intelligent design is not.
- 99% of scientists (in a discipline that is RELEVANT to the subject matter) agree
- The supreme court of These UNITED STATES OF AMERICA has made the decision.
- End of story.
- That is not what this talk is about.



Reality
(No unicorn :))



Nobody cares what a surgeon thinks about the origin of life. Ask a biologist.

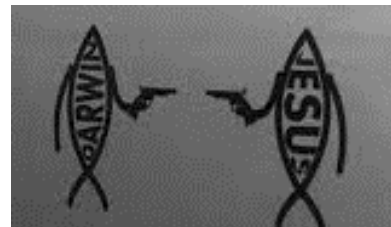
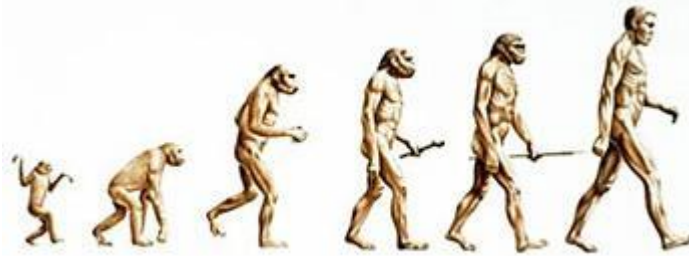
Outline: misconceptions within and outside of academia

Misconceptions and Fallacies in the teaching of Evolution

1. What is Darwinian Evolution?
2. Evolution is directional
3. Organisms are “highly evolved”
4. Living fossils
5. How speciation happens
6. What punctuated equilibrium is

What is Darwinian Evolution?

- We came from monkeys
- Life started from the random interactions of simple molecules in a primordial puddle of goo
- Not sure, but it's against the Bible, and I don't like it.



- It might surprise you to hear that none of these were tenants of the *Origin of Species*.



How life on Earth really got its start.

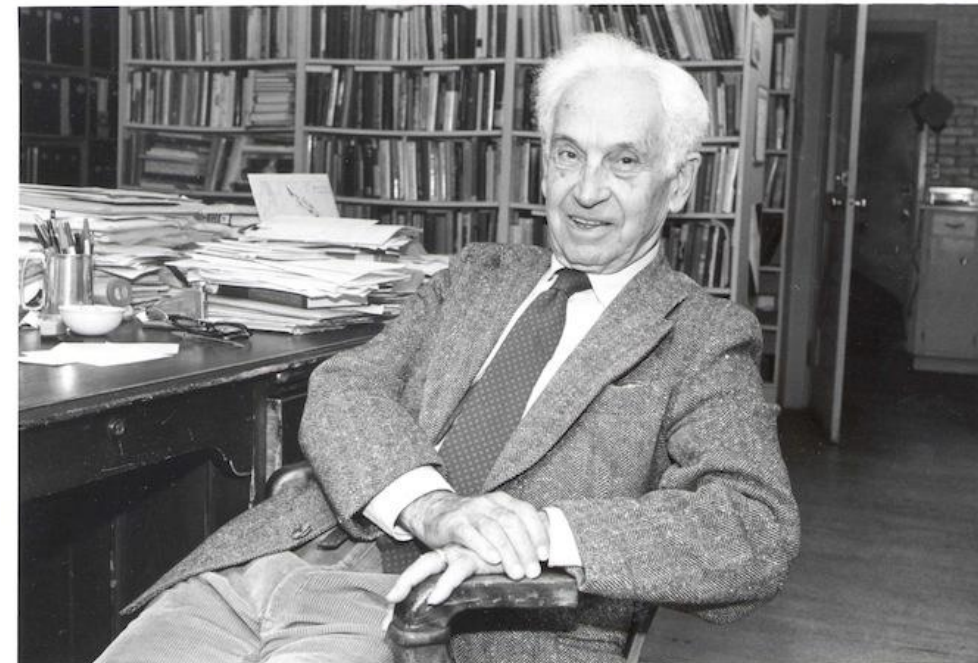
An Evolutionist is someone who believes that they came from scum.

1. What is Darwinian Evolution?

The Five Components of Darwinian Evolution (Mayr 1985)

1. Populations of species changes the average state of various characters through time. AKA, things change; AKA “evolution as such”
2. Common Descent
3. Multiplication of species
4. Gradualism
5. Natural selection happens

700 scientific papers and 25 books. He published his first article at 19 years old, and his last at 100



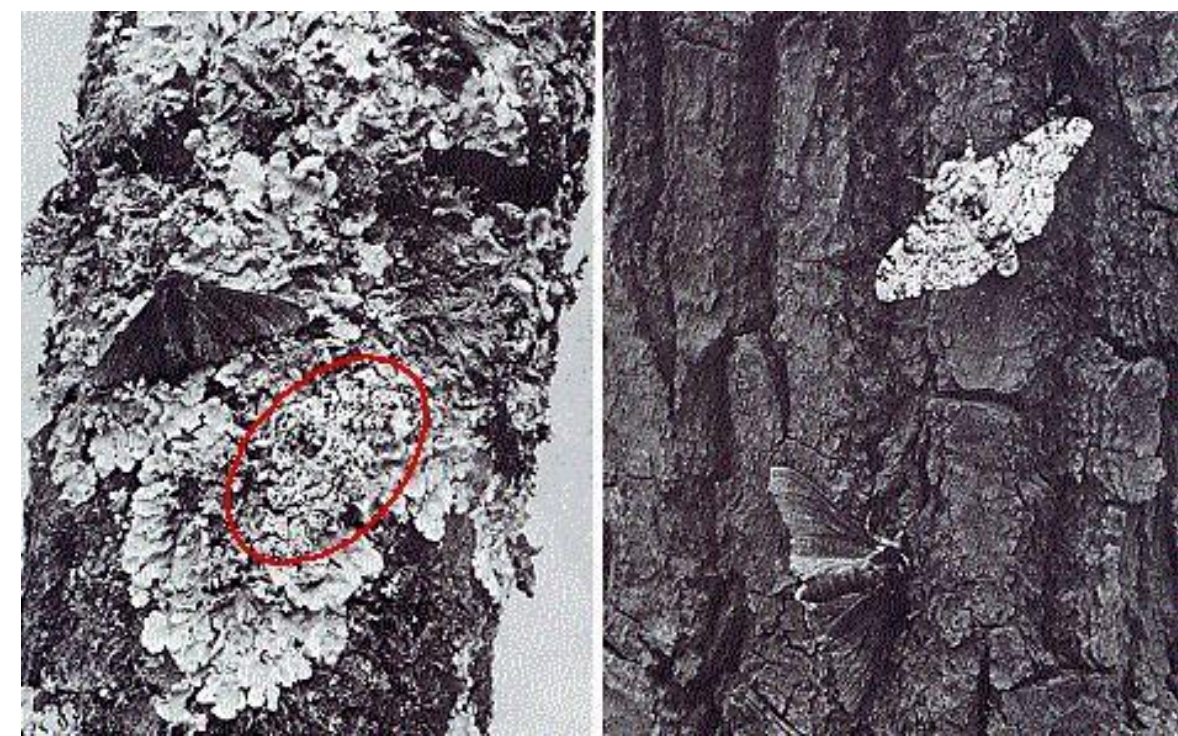
1. What is Darwinian Evolution?



1st: Evolution as such – Populations change through time

- This idea was noncontroversial when it was proposed, and as long as you don't use the word "evolution," it remains non-controversial today.

(Sort of like how people like having healthcare as long as you don't call it Obamacare.)

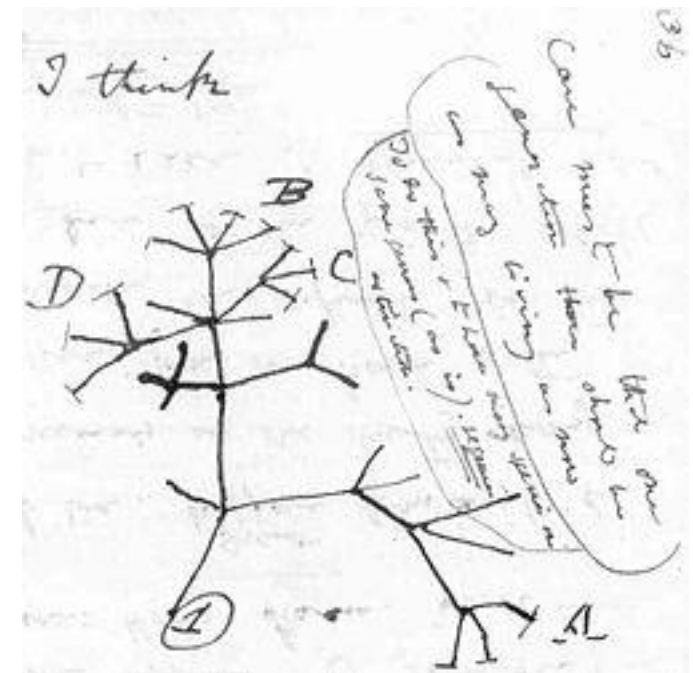


- Height
 - 183 cm 40K YBP
 - 162.5 cm 10K YBP
 - 165 cm 600 YBP
 - 175 cm today
- Smaller Brains
 - 1500 cc 100K YBP
 - 1450 cc 12K YBP
 - 1350 cc today
- Smaller Teeth and Jaws

1. What is Darwinian Evolution?

2nd: Common Descent

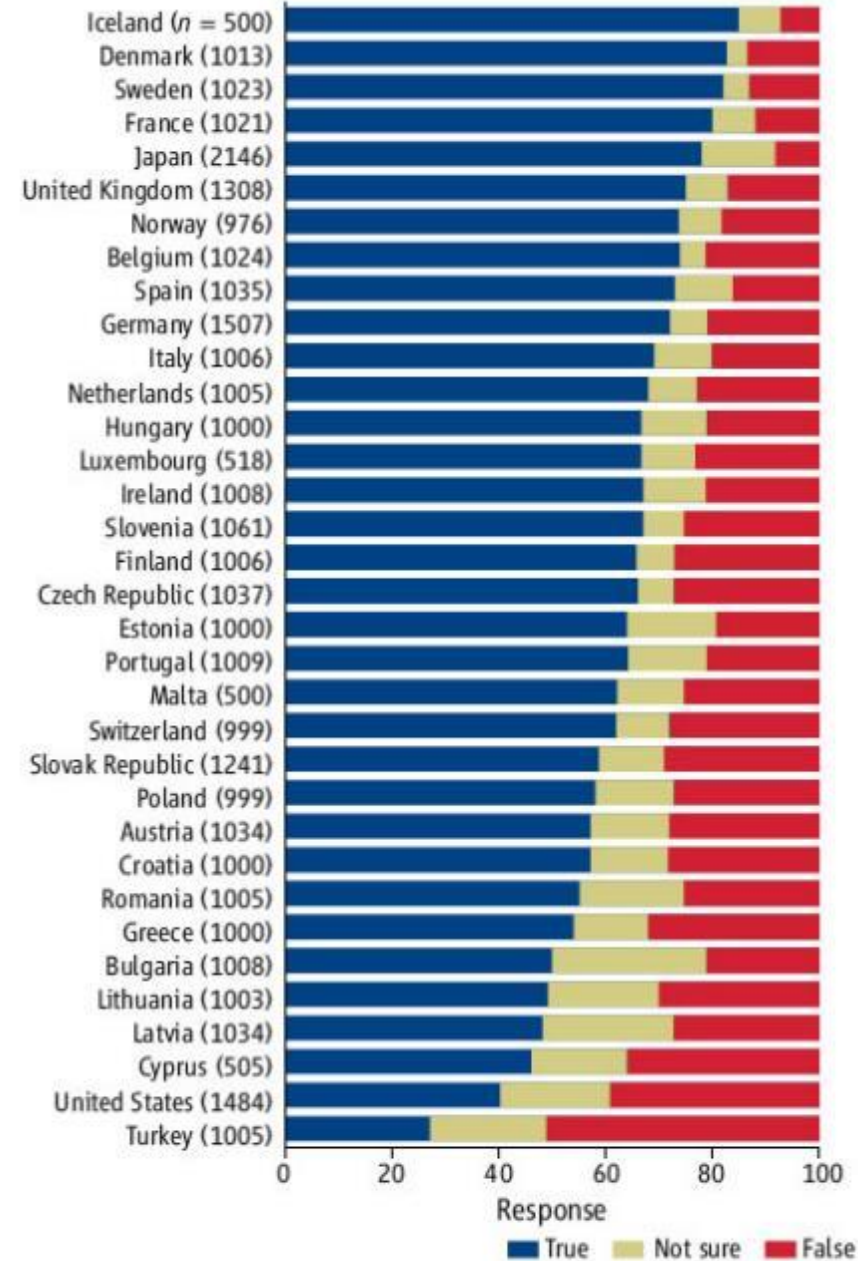
- Darwin wrote that his examinations of organisms of THOUSANDS of different species revealed similar traits, or what we call homologies, that appear to have been modified within each species to fit its environment. He viewed these similarities as reflecting descent from a common ancestor, but even Darwin wrote that this ancestor was something into which “life was first breathed,” which sounds more biblical than the primordial ooze scenario



1. What is Darwinian Evolution

3rd: Multiplication of Species

- Life is best viewed as a tree.
- Rather than all existing species having been created at one instance and remaining immutable forever after, evidence suggests that groups of closely related, but different species, have “derived” from a single, ancestral species. One species can become two. Darwin’s point was not surprising, anyone who spent time outside knew this, and thus Darwin focused on how this happens (natural selection), paying little attention to gathering evidence that it does happen. In the US, but not most of the educated world, we are still hung up on the notion that it doesn’t happen.

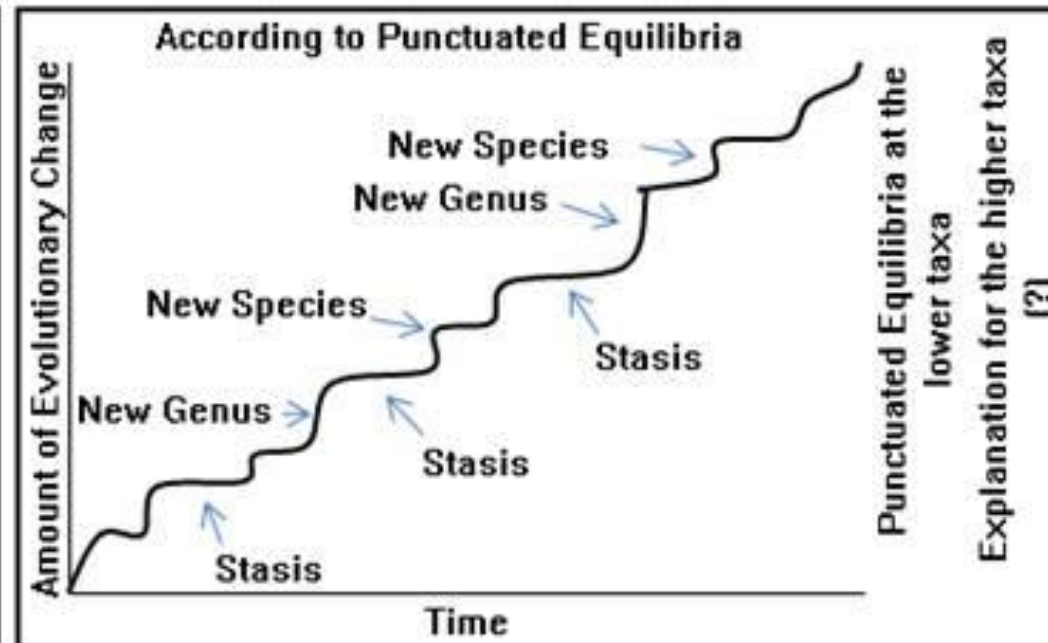
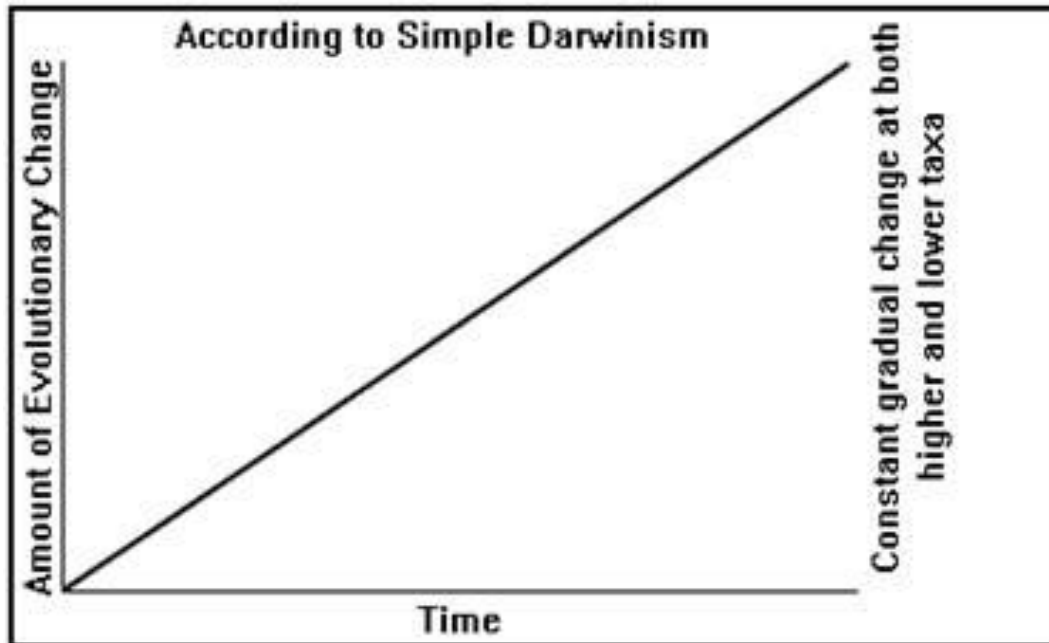
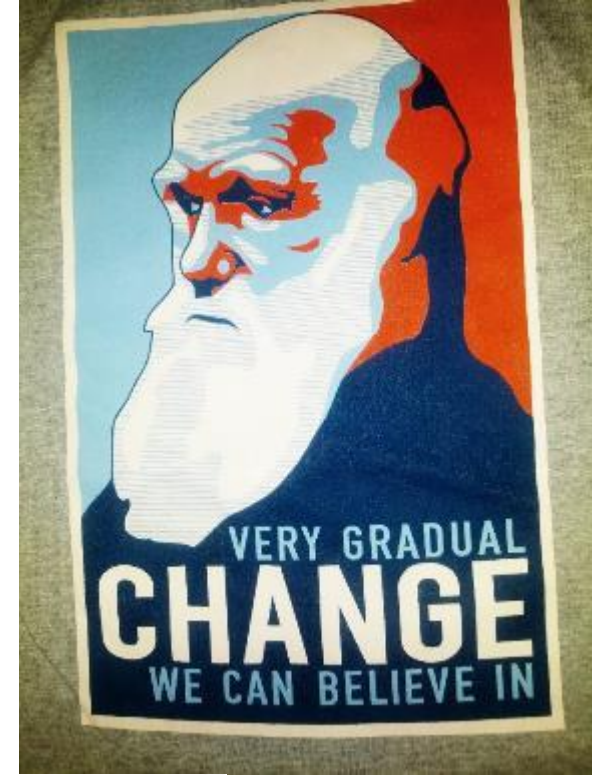


Public acceptance of evolution in 34 countries, 2005.

1. What is Darwinian Evolution

4th: Gradualism

- Evolution occurs in a gradual, steady process. There are no “leaps” in evolution
- The vast majority of biologists have rejected this explanation.



1. What is Darwinian Evolution

5th: Natural Selection

- This is what we attribute to Darwin most often, right after the part where he said we came from monkeys.
- Darwin did not argue that natural selection was the main agent of change, or of speciation, he just argued that it was a process by which change could happen. You've got to have three things,
 - Variation among individuals
 - Heritability of variation
 - Differential survival of offspring based on that heritable variation
- There are thousands of well-recorded instances of natural selection causing change in populations. If you don't accept this, I have nothing else to say to you (because logic and evidence clearly are not the currency of your mode of understanding)

1. What is Darwinian Evolution

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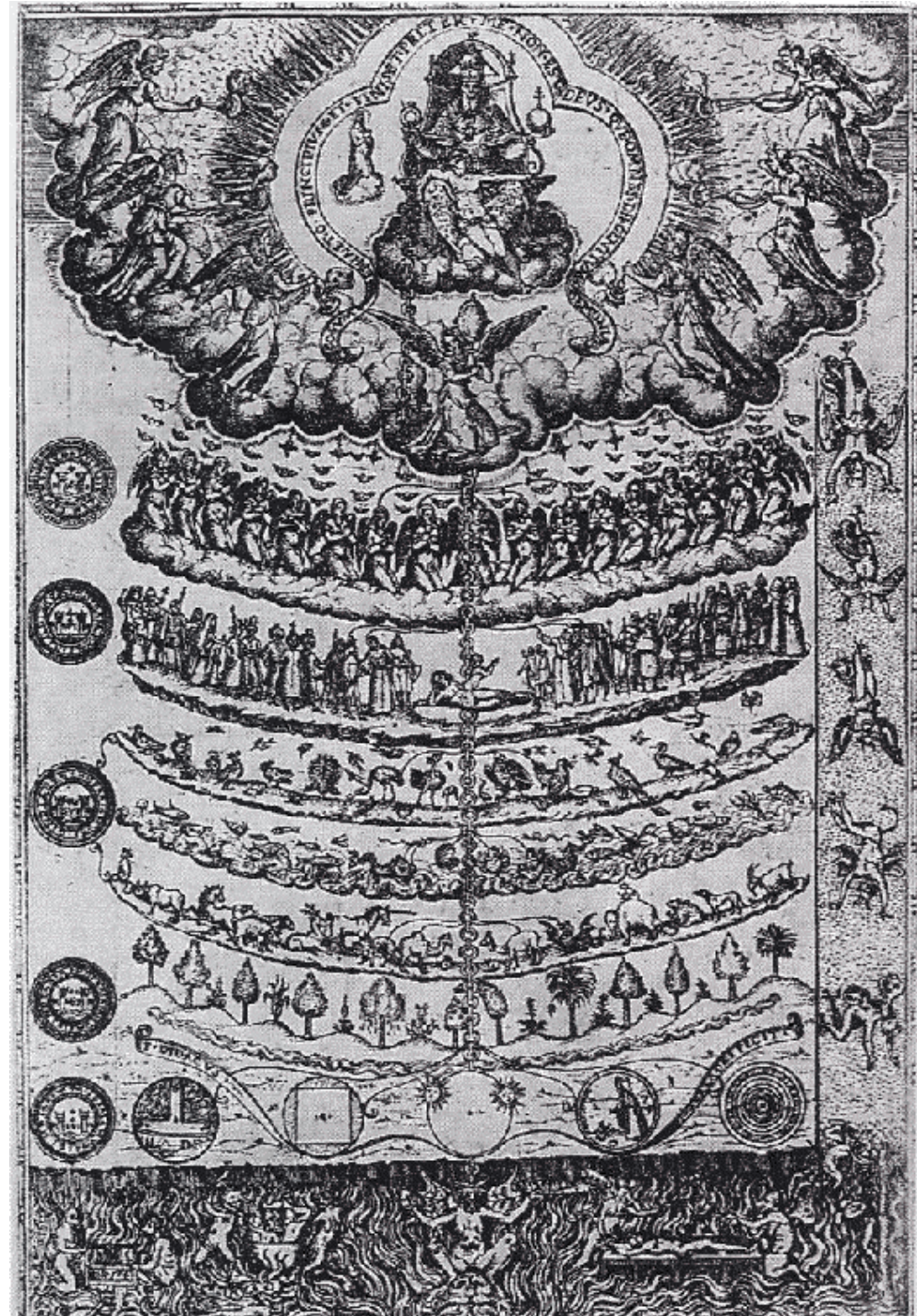
Note that one of these has been rejected by evolutionary biologists. The rest of pretty non-controversial. None of them mention how life started, and none of them even mention the word “monkey”

2. Evolution is Directional

- “Oh my god, he *evolved*.....”
- She is “the next step in human evolution.....”
- First problem: Individuals cannot evolve. Evolution is the change in the mean state or frequency of a character through time. Means are calculated from groups called populations. An individual cannot have a mean trait frequency, only a population can have a mean trait frequency. Individuals cannot evolve, or be the “next step” in evolution.

Teleology and *Scala Naturae*

- God
- Angels
- Demons
- Stars/moon
- Kings/nobles
- Common men (the white European ones)
- Wild animals
- Domesticated animals
- Trees/plants
- rocks

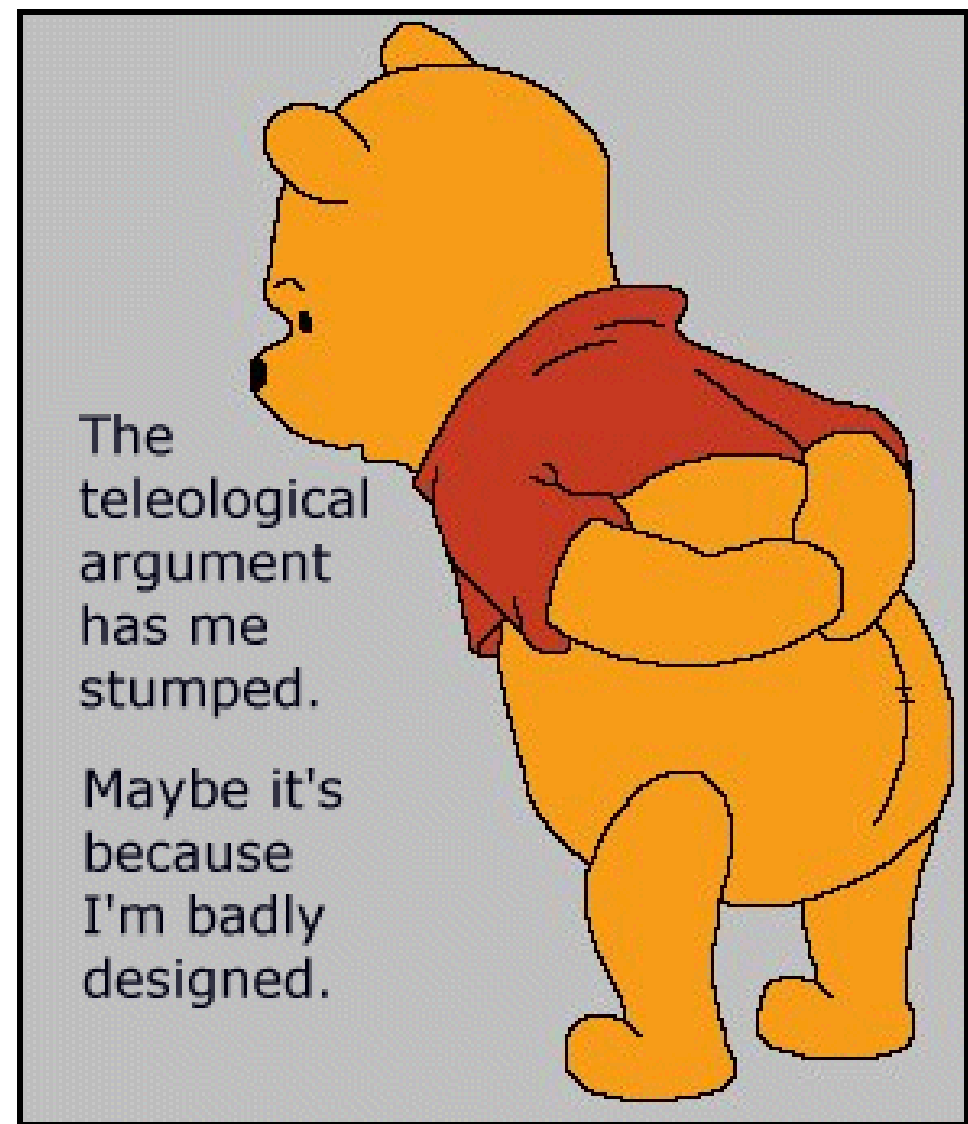


Teleology and *Scala Naturae*

- Teleology is the idea that evolution has some predestined endpoint
- Evolution is change through time (changes in the trait frequencies of populations, not individuals). That's it. Change. Not getting better, not getting more adapted, not becoming more complex, not becoming more diverse, just changing. Teleology has a direction. Evolution has no long-term direction.

Think of evolution as somewhere between habitat matching and random changes





This idea is as old as the flat earth paradigm (both of which were vigorously defended by Christianity), and while most people have accepted that the earth is round, we still cling to

Scala Naturae

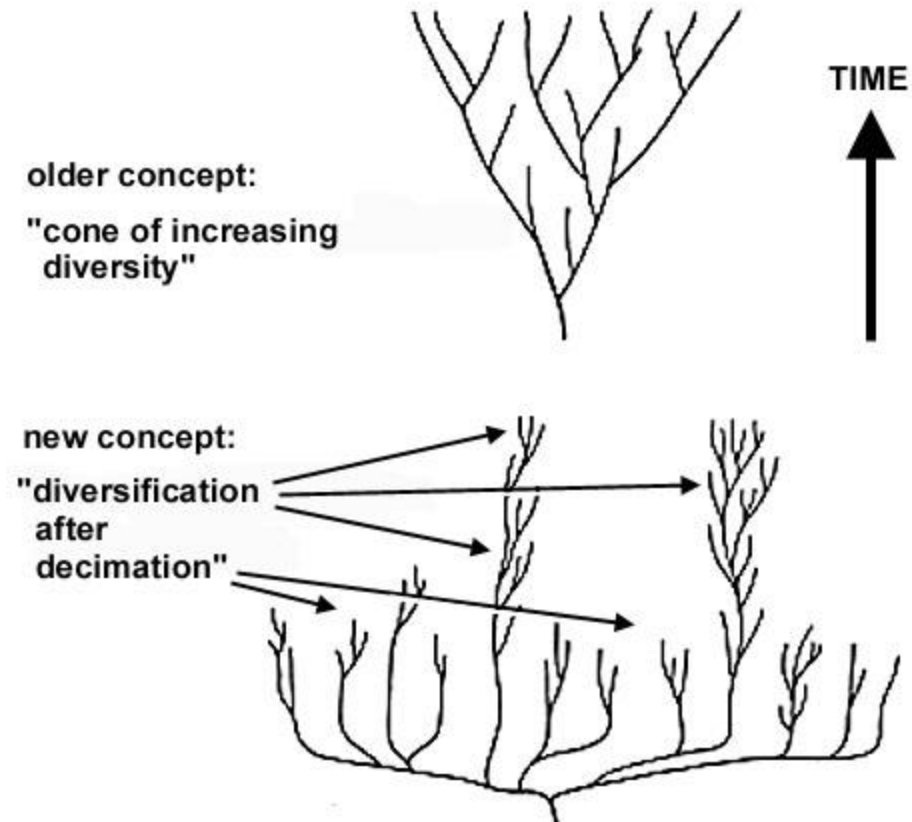
2. Evolution is Directional

Teleology is largely held on to by the public, probably because it's comforting to imagine (as is the existence of unicorns). But, even biologists make three common mistakes in teaching evolution

- Evolution steadily and forever increases diversity through time (no.)
- Evolution increases complexity through time (yes, but only as an artifact)
- Natural selection is what shapes the world (no, chance shapes the world)

Isn't evolution directional?

- Evolution increases diversity through time
 - Specifically, we mean phenotypic diversity. Life is more diverse now than it was 100 million years ago, right?
 - NO. Seriously, NO, it isn't! not even more than 500 million years ago! (Briggs and Fortey 2005)
 - "Fallacy of the cone of increasing diversity"
 - Burgess Shale



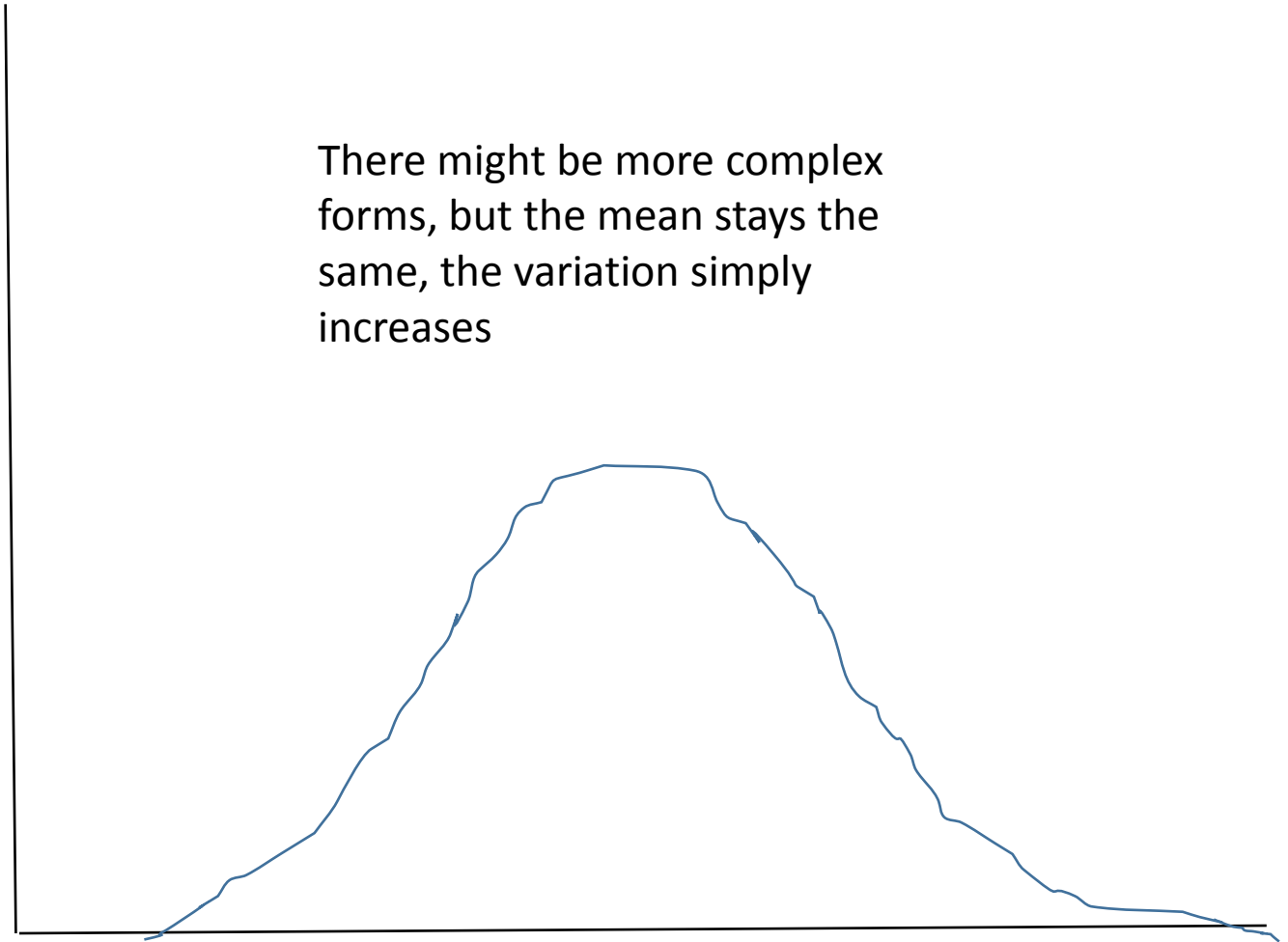
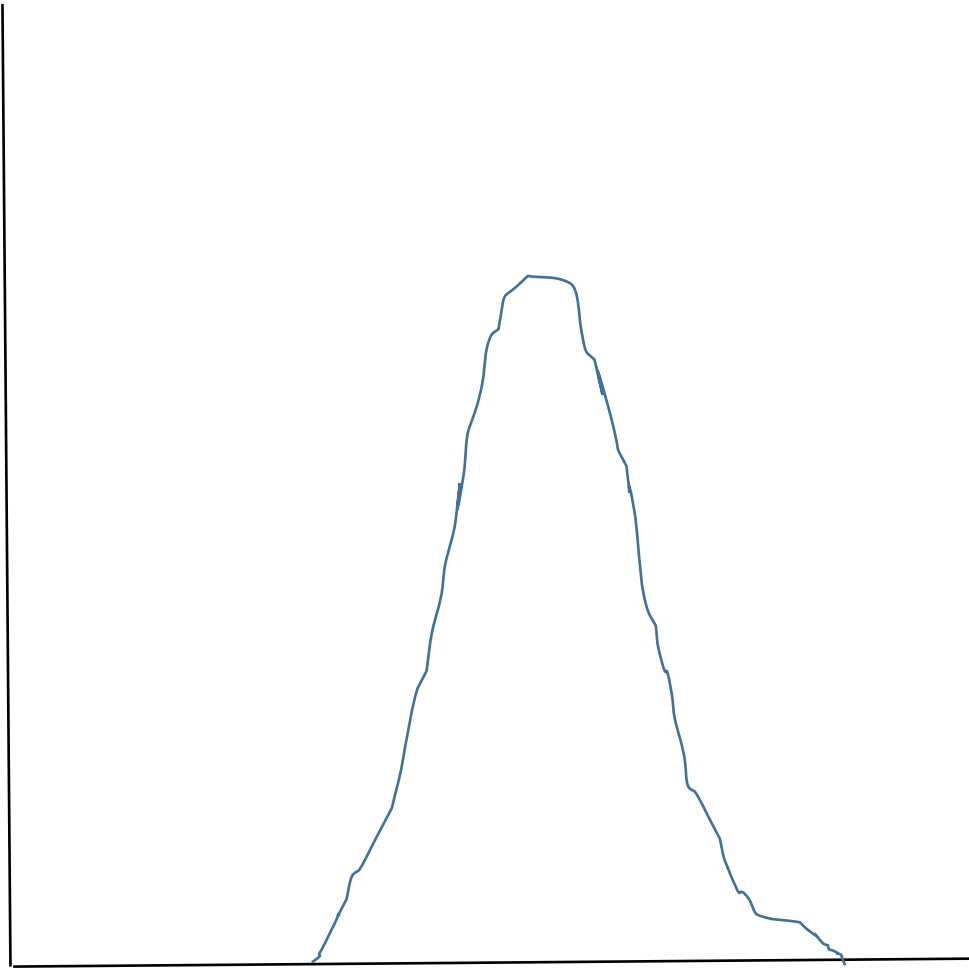
“Apparently, evolution settled upon just a few themes or ground plans for arthropods and then stuck with them through the greatest story of diversification in the entire animal kingdom. The story of the Burgess Shale ranks as perhaps the most amazing in the history of life largely in relation to this phenomenon of later restriction in arthropod ground plans- for in addition to early representatives of all four later groups, the Burgess Shale, one quarry in British Columbia, contains fossils of more than twenty additional basic arthropod designs. How could such disparity originate so quickly? Why did only four basic designs survive?”



In the early 1980s, when home computers first became affordable, there were about a dozen manufacturers, and a number of unique, fairly terrible operating systems (most developed in the 1960s and 1970s). Today, we have ~4 major manufacturers and they operate on Windows or Mac's OSX (and a few of us dorks still use Linux). We have less diversity today than we did 50 years ago. We have more computers today, but these are variations on the same theme. Overall diversity has decreased (that's what natural selection does, decrease diversity).

But evolution still has some predictable directionality, life started simple, now it is complex

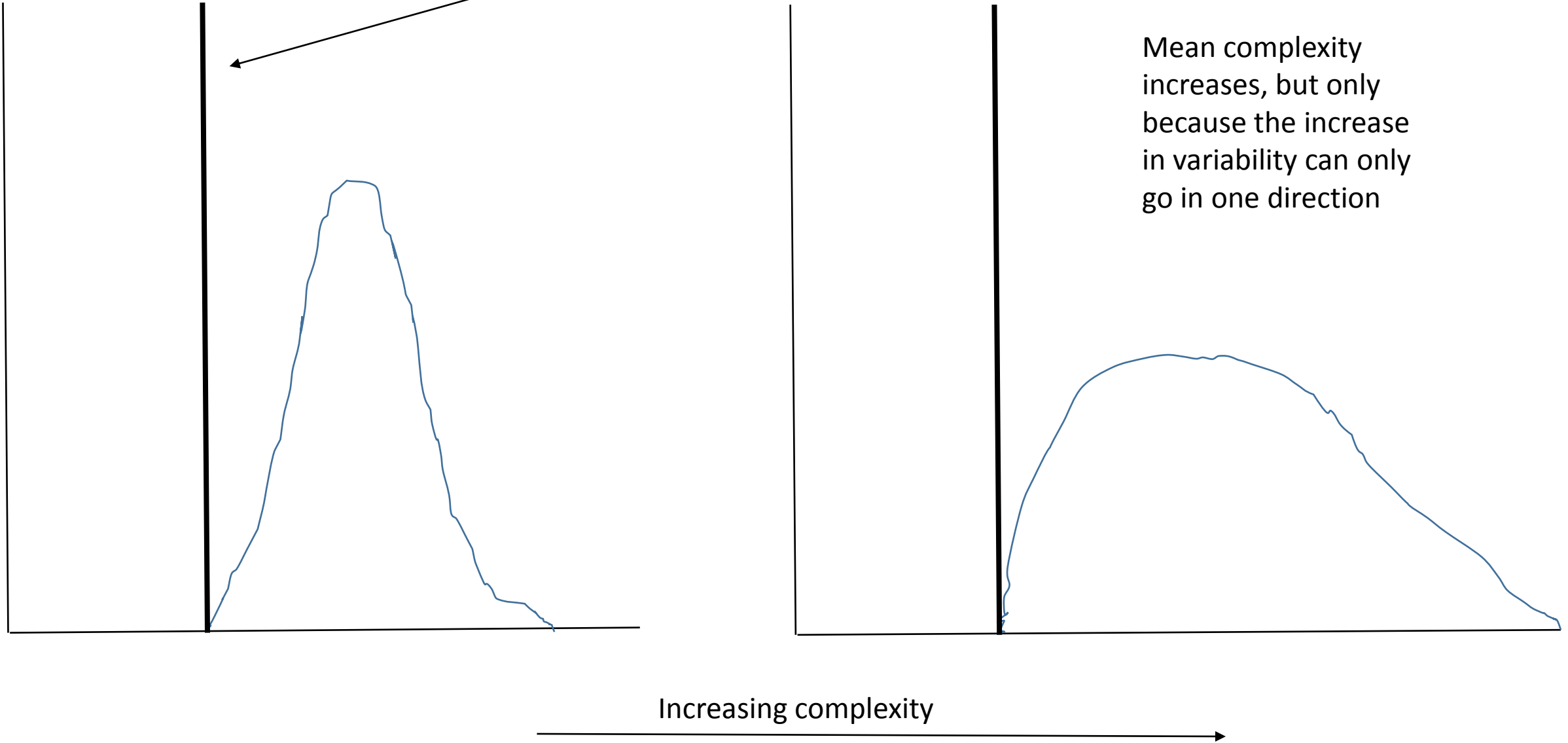
- Evolution increases complexity through time
 - Well, sort of, but that isn't a direct product of evolution.
 - *The Bell Curve*, by Stephen Jay Gould
 - When you start simple, as simple as life could possibly be, then the only way to change is towards increasing complexity. There are two ways to do that, directionally, whereby you get rid of simple stuff and replace it with complex stuff, or, passively, whereby you make more simple stuff and more complex stuff, so on average, complexity increases, because it can't possibly decrease (you can't get simpler than a single-celled organism)
 - So which is it? How do you we know? It's passive! So yea, evolution increases complexity, but only in the way that eating makes you older. Eating permits you to live, and since you can't live without getting older, you get older.



Increasing complexity



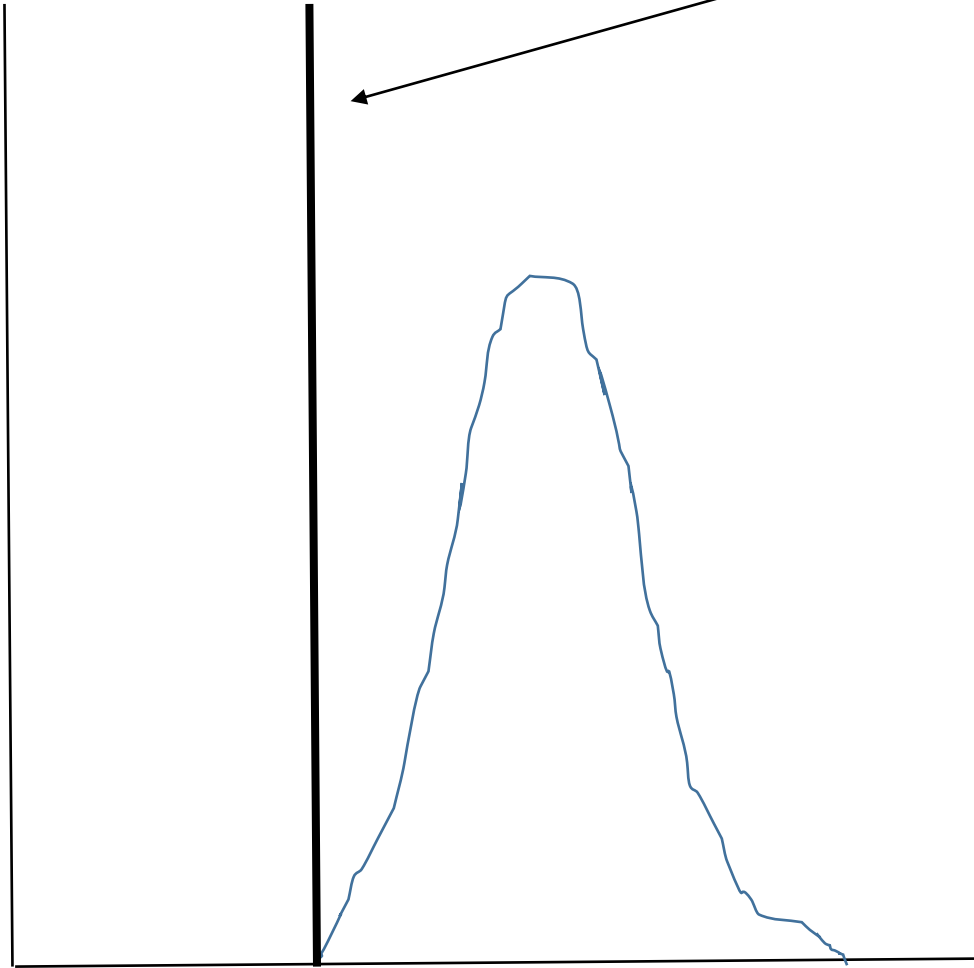
Barrier: e.g., life cannot get more simple than a single-celled organism



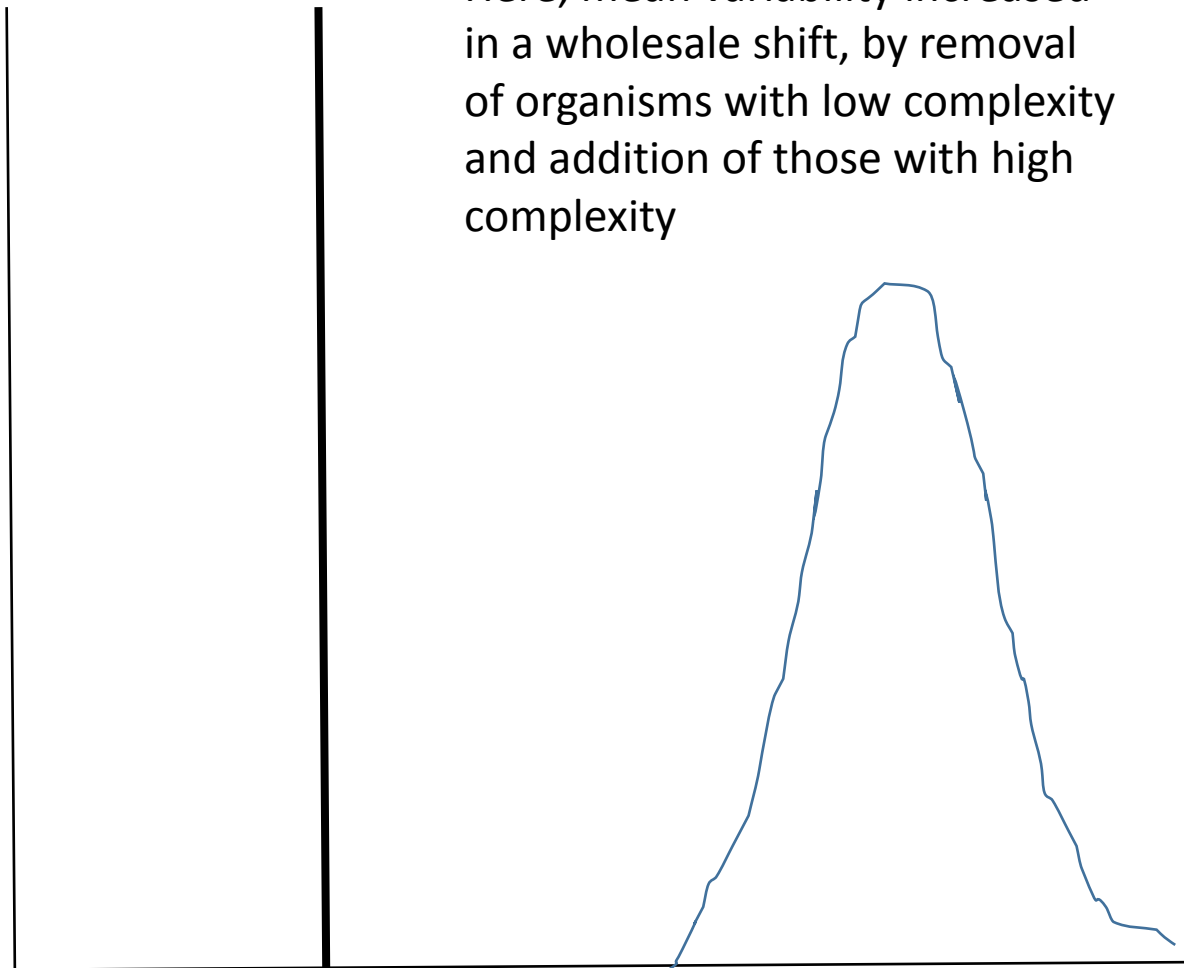
Mean complexity increases, but only because the increase in variability can only go in one direction

Increasing complexity

Barrier: e.g., life cannot get more simple than a single-celled organism



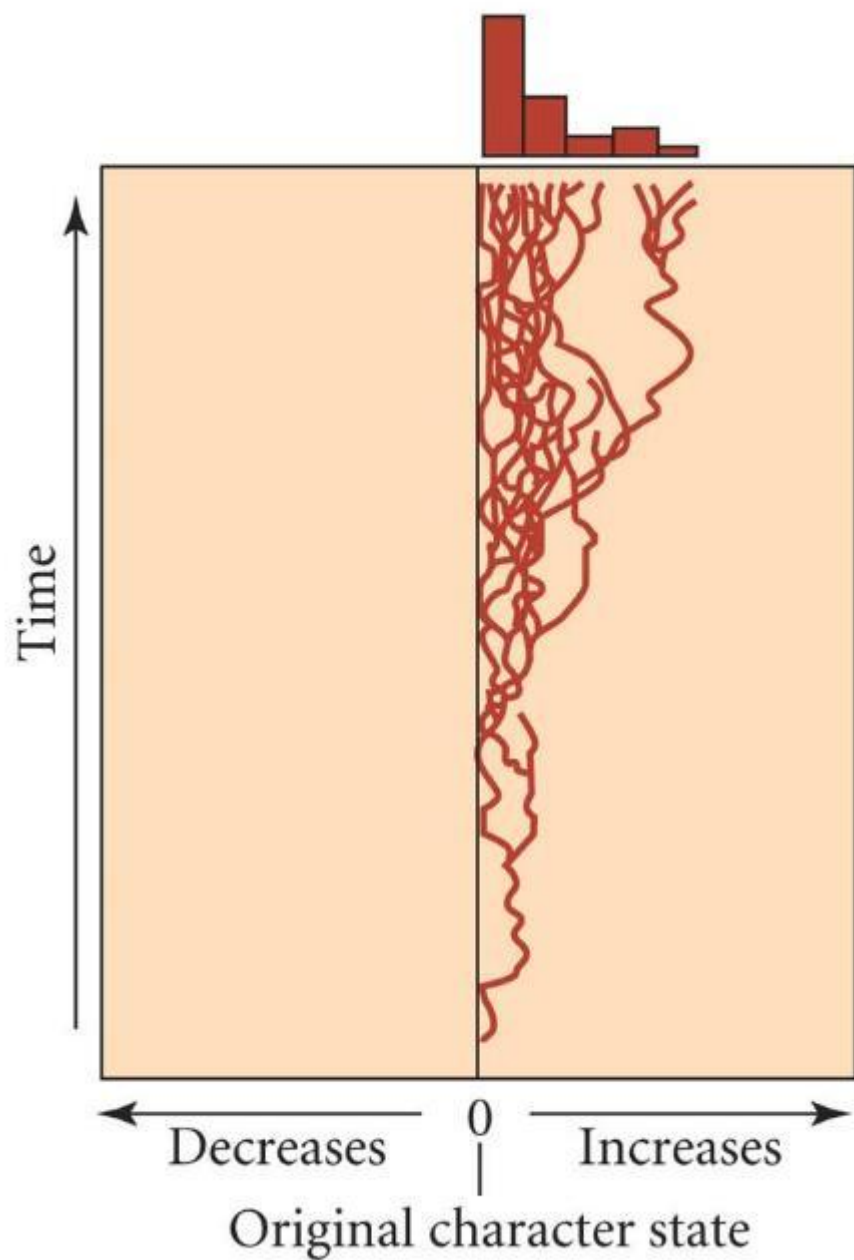
Here, mean variability increased in a wholesale shift, by removal of organisms with low complexity and addition of those with high complexity



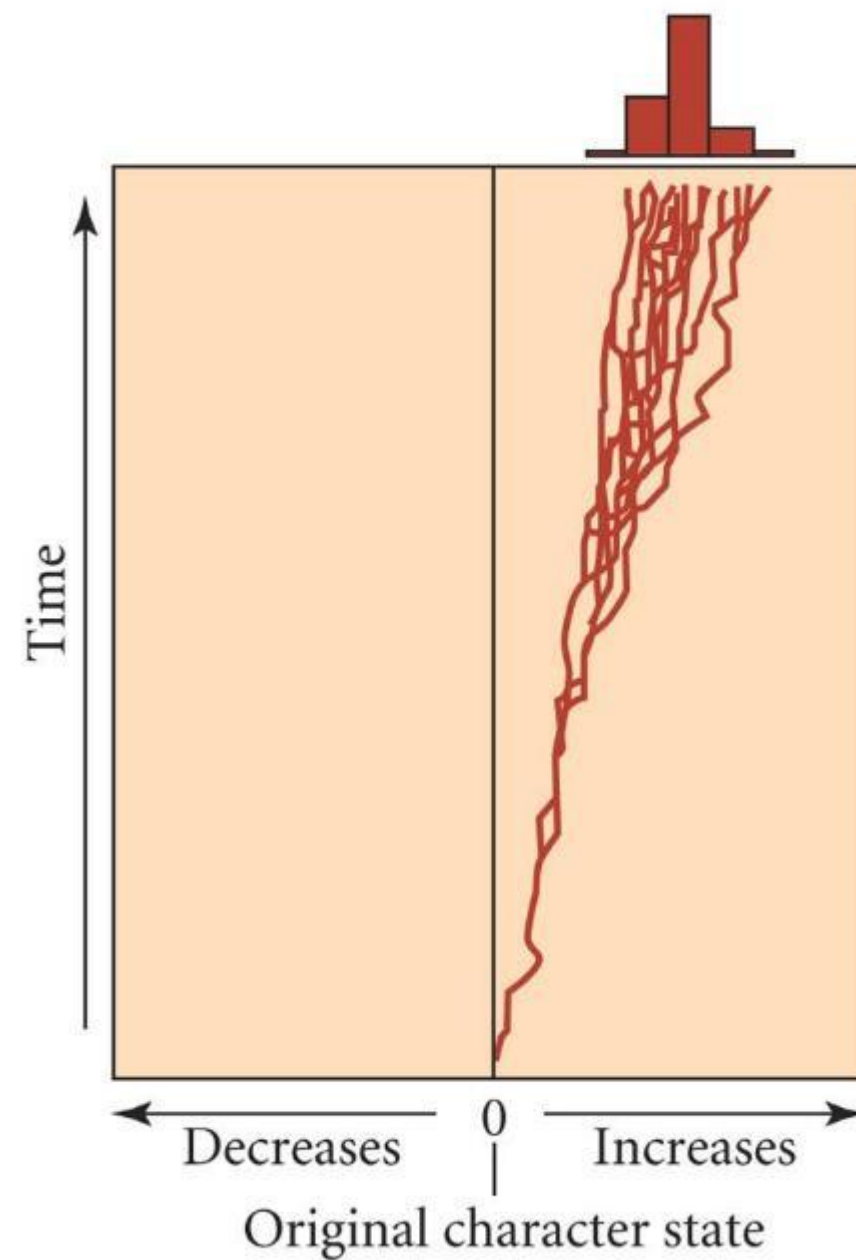
Increasing complexity



(A) Passive



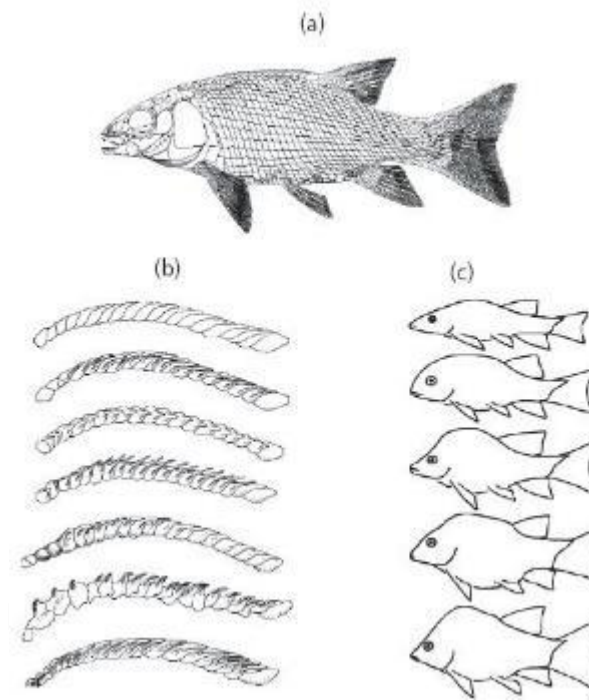
(B) Active



2. Evolution is Directional

Tiers of Selection (Steven Jay Gould)

- **1st Tier:** adaptation on ecological scales (generations)
- **2nd Tier:** “species sorting” over millions of years: which species happen to environmental conditions of the time
- **3rd Tier:** mass extinctions over dozens or hundreds of millions of years- it’s random who persists
 - In many cases, becoming highly adapted over ecological timescales dooms you to extinctions over geological timescales (“reversal of the second tier”)



“man, this really bums me out. All that work to adapt, and for nothing. What a waste. Dr. Reece, this makes me depressed.”

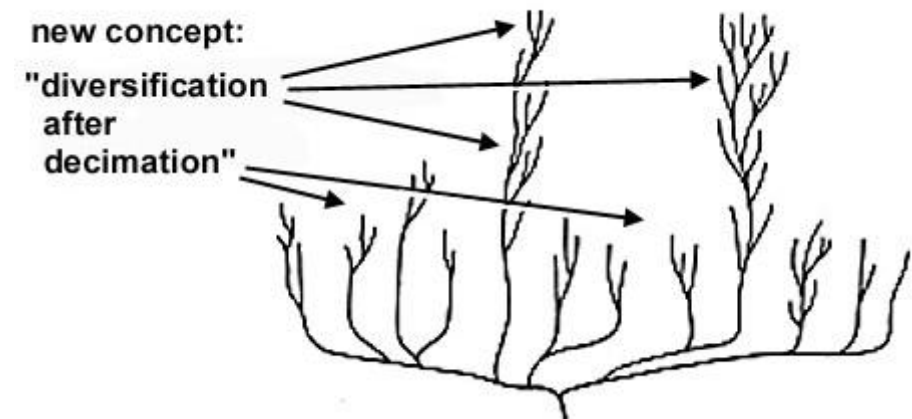


2. Evolution is Directional

- The evolution of life on earth is not the story of adaptation or survival of the fittest. It is a story of contingency and constraint.
- Constraint drives the evolution of diversity as much or more than natural selection (in fact, natural selection, by definition, reduces diversity)
 - Interestingly, it isn't the constraint of brain size versus pelvic width, it's a constraint of metabolism (Dunsworth et al. 2012)



Gould presents the “pageant of evolution as a staggeringly improbably series of events, sensible enough in retrospect and subject to rigorous explanation, but utterly unpredictable and quite unrepeatable. Wind back the tape of life to the early days of the Burgess Shale; let it play again from an identical starting point, and the chance becomes vanishingly small that anything like human intelligence would grace the replay.”



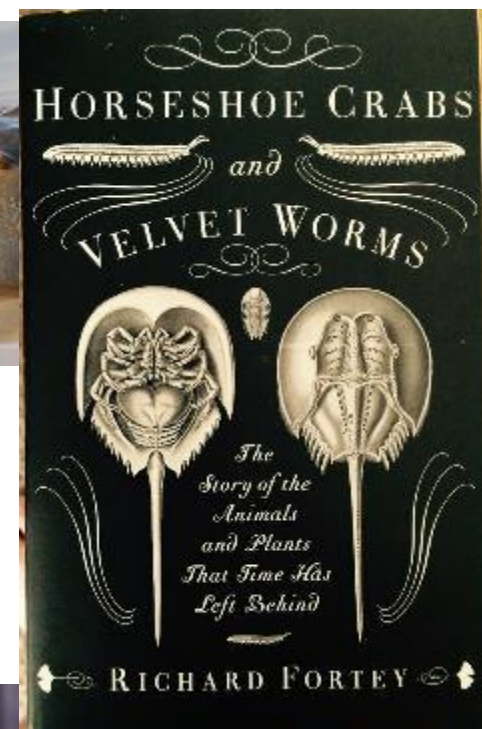
3. Organisms are Highly Evolved

- That doesn't even make sense.
- Exaptations versus Adaptations
 - Spandrels of San Marcos (Gould and Lewontin 1979)
- Most organisms are terribly designed, like really, really terribly designed. In fact, most traits that species have that actually increase fitness, arose for reasons that have nothing to do with that fitness
- Pangloss- legs were made for breeches, and noses to hold up spectacles.



4. Living Fossils

- Horseshoe crabs, Coelocanths- living fossils!
- Horseshoe crabs: “they’ve had millions of years to adapt to dealing with microbes.”
- Guess what, every species on earth has had millions of years to adapt. Every. Single. One. Has had exactly the same amount of time.
- These are examples of the difference between lineages that are cladogenic (branching) and lineages that are anagenetic (non-branching). Both evolve! One speciates and evolves, the other evolves without speciating



5. How Speciation Happens

- Microevolution is what happens within species (gene frequencies changing over time) and macroevolution is what happens between species (speciation)
- One population gets split into two populations, over time, they slowly diverge from one another over time and eventually, become so different that they no longer interbreed with one another. Microevolutionary changes scale up to macroevolutionary changes.
- This was rejected before I was born (Lewin 1980). It's ludicrous that we are still teaching it that way.
- So, how does it happen? Well, it's complicated. But, it involves complex traits, RAPID change, a strong component of geographic isolation (usually), and it is punctuated.
- It was not until well after the Modern Synthesis that we were able to describe the process of speciation (see Pigliucci 2009)

6. What Punctuated Equilibrium Is

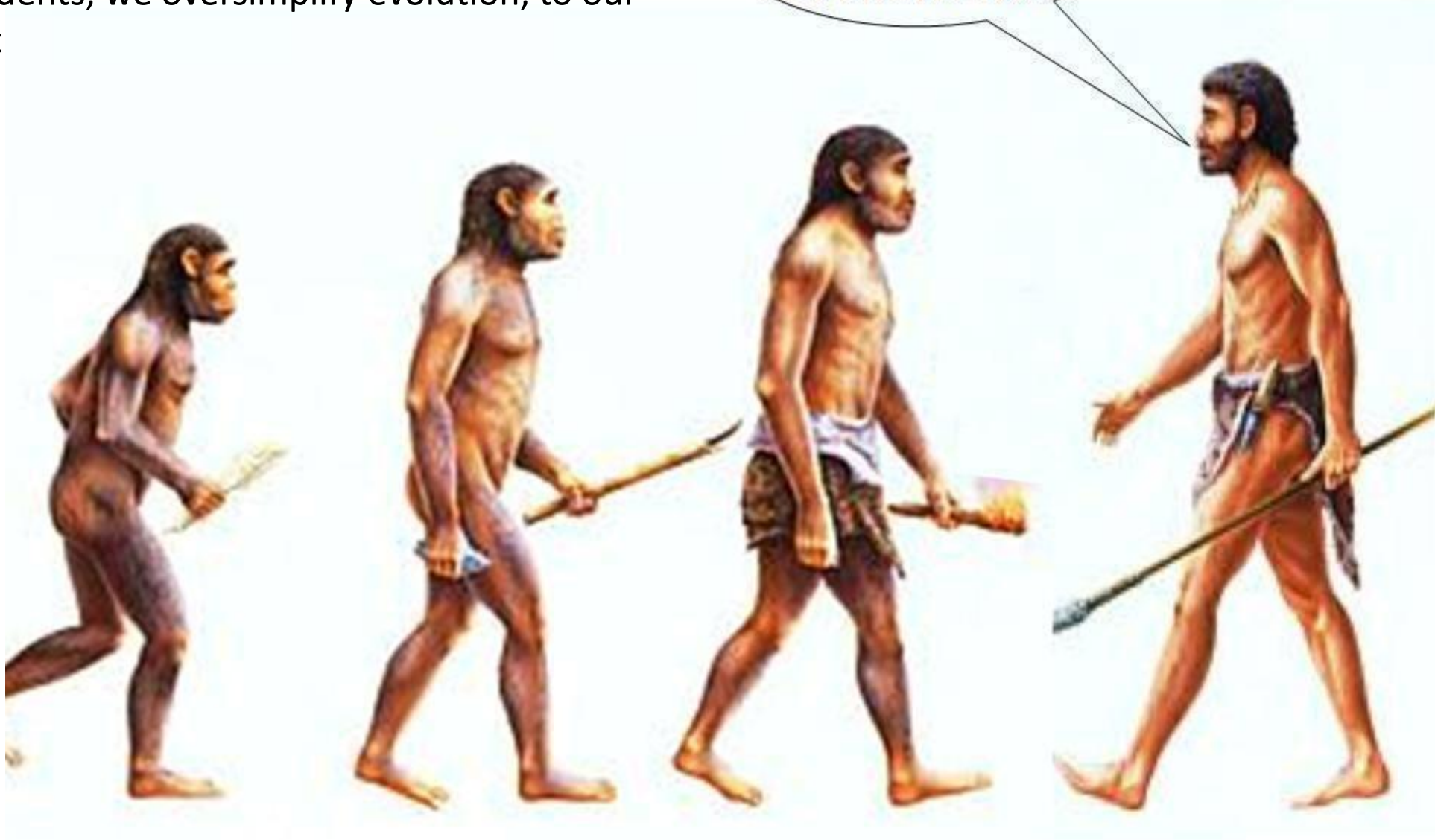
- Most people say that punctuated equilibrium is the idea that stasis is the norm in the fossil record. We have long periods of stasis (no speciation), then brief periods with lots of speciation. These brief periods are when there is a lot of environmental change. That makes sense, why speciate and diversify if the environment isn't changing? Cool.

- NO! Read the paper! That's only half of it. People knew that long, long before Gould and Eldridge came along.
- Punctuated Equilibrium is about two things: speciation and morphological evolution, it does state that there are long periods with no speciation, and brief periods with tons and tons of speciation, and, importantly, virtually all morphological evolution happens during those brief periods of speciation. PE is about the coupling of morphological evolution and speciation, that is its novelty



We won the religion wars: Intelligent Design is not Science
(I didn't say it was dumb, wrong, silly, or evil, I just said not science)
We have made zero ground with public opinion, and even
among our students, we oversimplify evolution, to our
own detriment

**GO BACK.
WE F*CKED UP
EVERYTHING**



So, next time someone asks you if you believe in “evolution,” ask them if they believe in the existence of change. It’s a stupid question.

- Darwinian evolution is not what you thought it was: but now you know.
- Evolution is not directional, there is no goal. In fact, natural selection isn’t even directional over long enough timescales.
- “highly evolved” is a really stupid adjectival phrase
- There is no such thing as a “living fossil” or an “old species”
- Microevolution does not explain most speciation. It’s different.
- Punctuated equilibrium is about the coupling of speciation and morphological evolution in brief time periods, followed by long periods of very little morphological evolution or speciation

Evolution is a wondrously complex body of theory, don't over-simplify it. Just be amazed.



Reality
(No unicorn :))

(unicorns don't exist, sorry.)

