

What is evolution?

What's the evidence for it,
and why should I care?

Evolution

- Change through time
 - Over generations
 - If within an individual, it's not evolution- it's "development"
- **One** cause of evolution is natural selection.
 - NOT the only one!



Classic example: Peppered moth

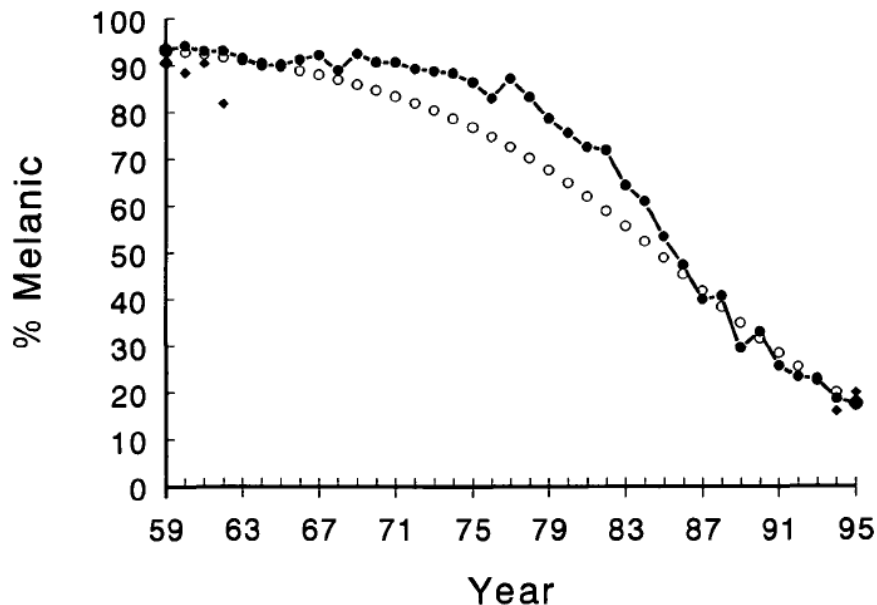
- All moths observed were “peppered” -1848
- Industrial revolution pollution
 - Trees blackened, lichens killed
- By 1895, 98% of moths “black”
 - “Industrial melanism”



Classic example: Peppered moth



- By 1895, 98% of moths “black”
 - “Industrial melanism”
- Air pollution continued- Great Smog of 1952
- Clean Air acts passed in 1956 and 1968



Is evolution by natural selection “just a theory”?

- Let's imagine that you're working with a population of squirrels.

Type A: run randomly Type B: fear asphalt

Average: 1 offspring 2 offspring

Start: A: 100 B: 100 50% B

Gen 1:

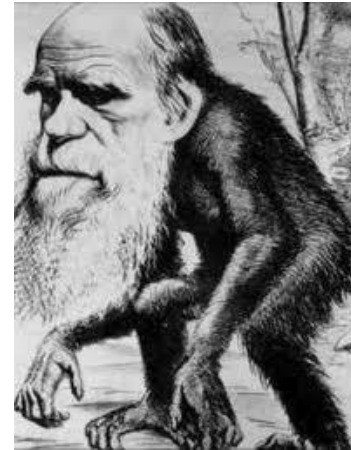
Gen 2:

Gen 3:



Why is this contentious to the general public?

- Are there flaws with the concept of evolution?
- Are there “holes” in the evidence?
- Are there contradictions with respect to facts you know from elsewhere?



History has a tendency to repeat itself...

1925

EVOLUTION TRIAL OPENED BY PRAYER; JUDGE HAS A BIBLE

PERSONNEL OF EVOLUTION CASE

Bird's Eye View of Men, Etc., in
Famous Trial Opening To-
day in Tenn.

J. T. RAWLSTON THE JUDGE

The defendant—John T. Scopes,
24, formerly science teacher in the
Rhea county, Tenn., public schools,
his first position after being gradu-

*Bryan Gets a Round
of Applause Upon
Entering the
Room.*

**DARROW IS IN
SHIRT, SLEEVES**

*Courtroom is Crowded
With People, Who
Overflow Steps and
Corridors.*



PARTLY CLOUDY

32°

19°

BACK PAGE

PENNSYLVANIA NEWSPAPER OF THE YEAR

The Patriot-News

WEDNESDAY
December 21, 2005

50 cents

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HARRISBURG, PA. PENNLIVE.COM FINAL EDITION

JUDGE JONES ON THE DOVER SCHOOL BOARD: "The students, parents, and teachers of the Dover Area School District deserved better than to be dragged into this legal maelstrom, with its resulting utter waste of monetary and personal resources."

THE DECISION: U.S. District Judge John E. Jones III, right, struck down Dover's intelligent design policy, saying the school board's real purpose was to promote religion.



JUDGE JONES ON INTELLIGENT DESIGN: "We have addressed the seminal question of whether ID is science. We have concluded that it is not, and moreover that ID cannot uncouple itself from its creationist, and thus religious, antecedents."

JUDGE RULES INTELLIGENT DESIGN IS 'NOT SCIENCE'

Area schools walk a fine line over religion

BY DIANA FISHLOCK
Of The Patriot-News

Religion still has a place in public schools, a fact in evidence during the holidays, but districts face a delicate balance in studying faith without promoting it or alienating students.

This time of year, midstate schools take different approaches. While some of the more religiously diverse communities revel in Christmas, Hanukkah and Kwanzaa, others avoid religious holidays altogether.

Religion can't be avoided when studying American history and culture, some area school officials say.

Derry Twp. teachers talk about traditions, including Christmas, Hanukkah and Kwanzaa, said Troy Portser, a school district spokesman.

FROM THE RULING:

"The citizens of the Dover area were poorly served by the members of the Board who voted for the [intelligent design] Policy. It is ironic that several of these individuals, who so staunchly and proudly touted their religious convictions in public, would time and again lie to cover their tracks and disguise the real purpose behind the ID Policy."



Historic ruling orders Dover to rescind policy

BY BILL SULON
Of The Patriot-News

In a sweeping and potentially landmark ruling, a federal judge yesterday said that the Dover Area School District's policy on intelligent design is unconstitutional and that the concept of intelligent design is unscientific and religious.

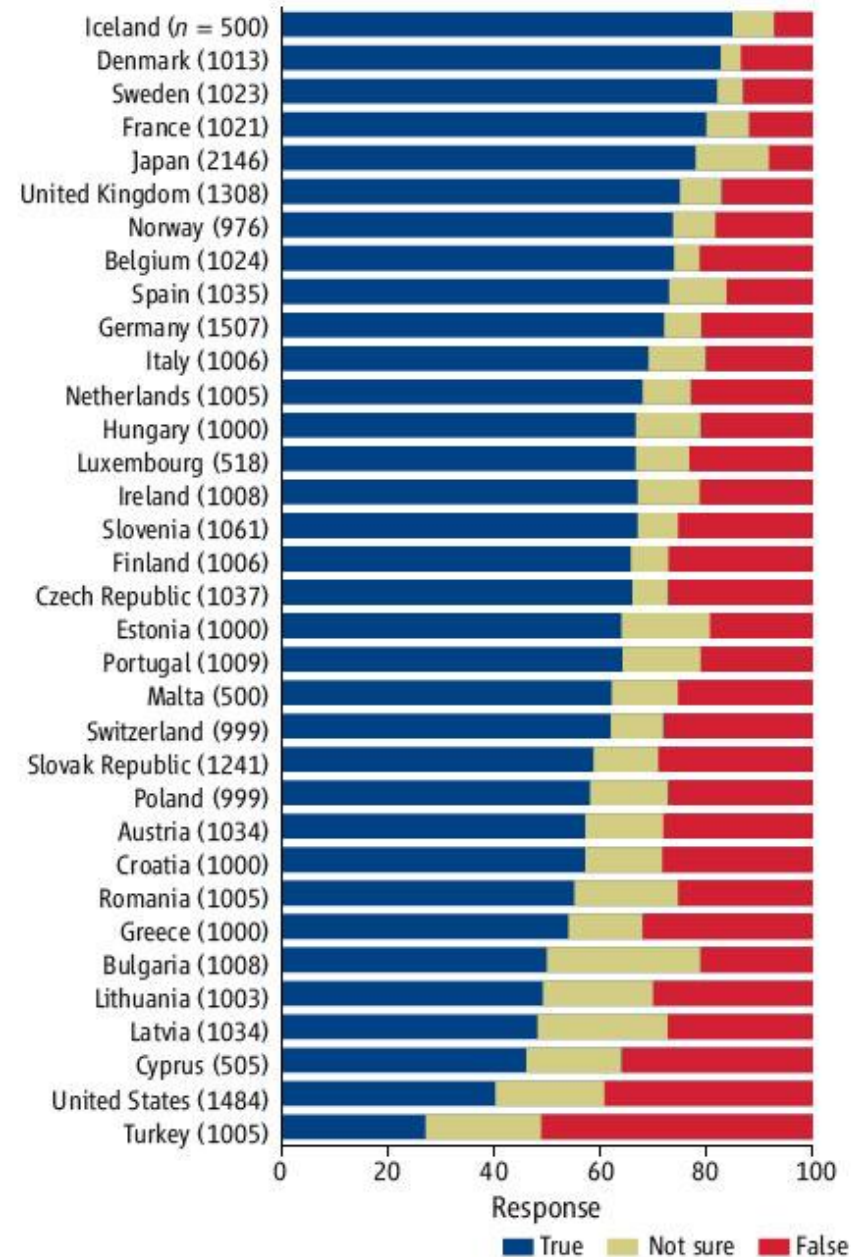
And in an unusually scathing rebuke, he called several former school board members who supported the policy liars.

U.S. Middle District Judge John E. Jones III, who presided over a six-week trial in Harrisburg, ruled that the intelligent design policy promotes religion and violates the U.S. and Pennsylvania constitutions. The First Amendment's Establishment Clause bars government from

2005

Evolution 2005

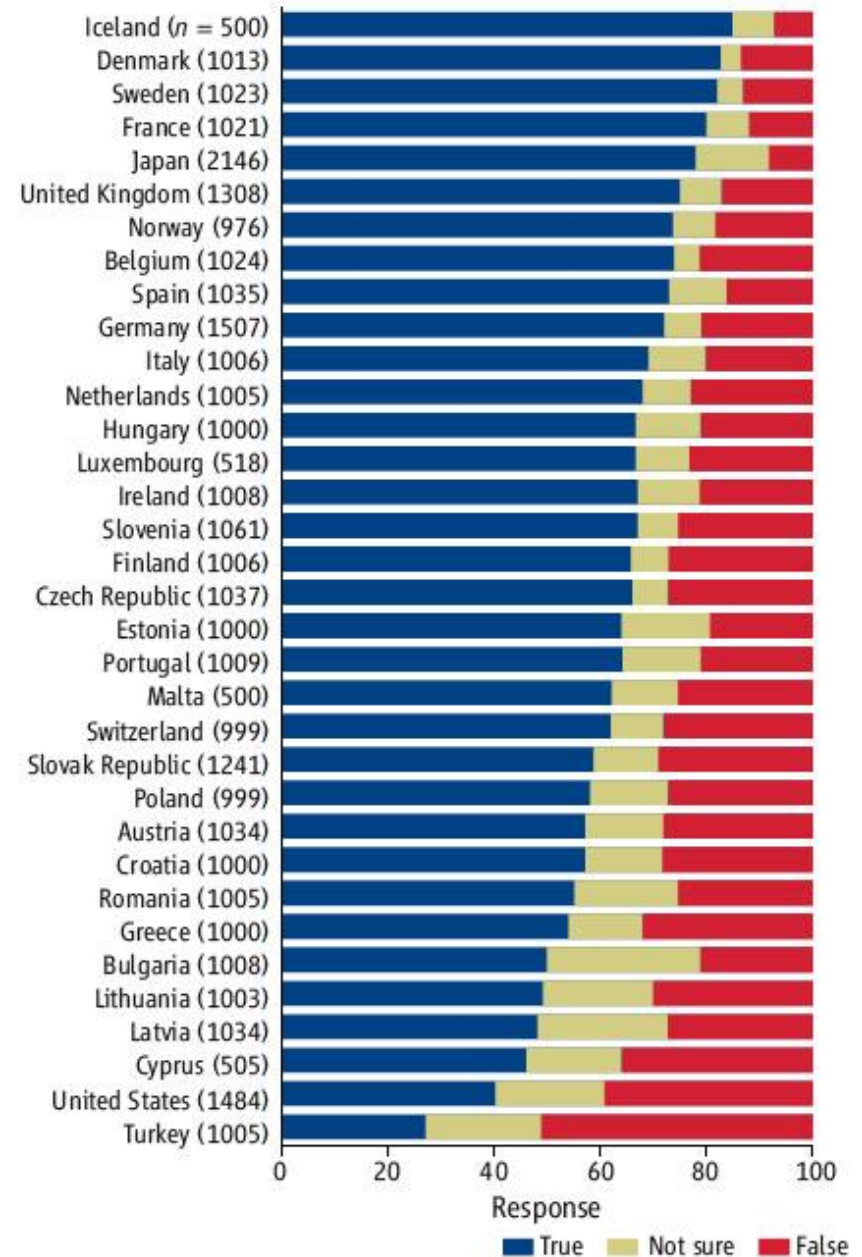
- USA shows one of the highest rates of “disbelief” in evolution
- USA shows one of the lowest rates of “belief” that evolution has occurred



Public acceptance of evolution in 34 countries, 2005.

Evolution 2005

- USA shows one of the highest rates of “disbelief” in evolution
- USA shows one of the lowest rates of “belief” that evolution has occurred



2009: USA- 35% Public acceptance of evolution in 34 countries, 2005.

Why are we still talking about this?

- **FACT:** Within the scientific community, there is no debate about the truth of evolution.
 - Also true among those that are devout Christians
 - There is no “controversy” to teach
 - Debates are only about relative importance of different forces
- **FACT:** Evolution is a theory and a fact.

Scientific “theory” vs “Theory” In General Parlance?

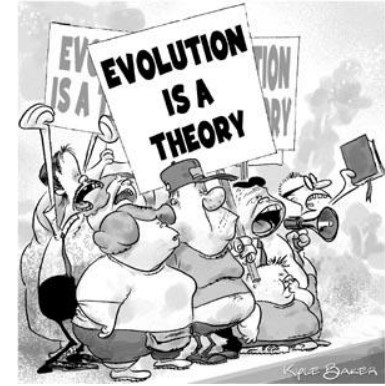
A theory is what one or more hypotheses become once they have been verified and accepted to be true.

A theory is an explanation of a set of related observations or events based upon proven hypotheses and verified multiple times by detached groups of researchers.

“Gravity is ‘just a theory’”

“Atoms- haven’t seen ‘em!”

“Germs- bah, humbug!”

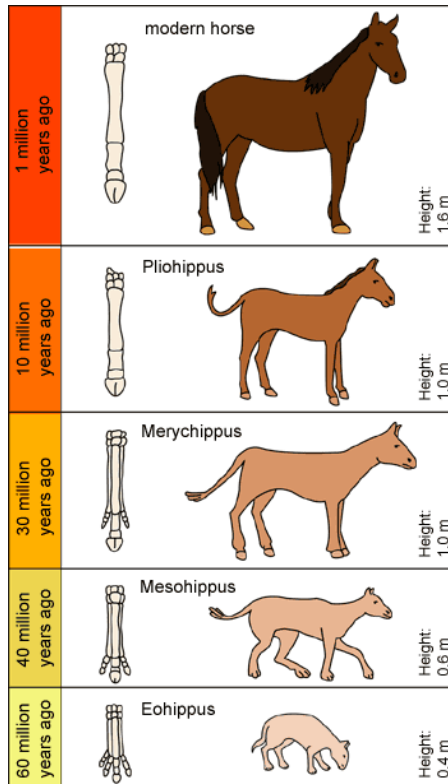


EVOLUTION has two fundamental processes

- Change within a lineage
- Formation of new lineages (associated with split of existing lineage)

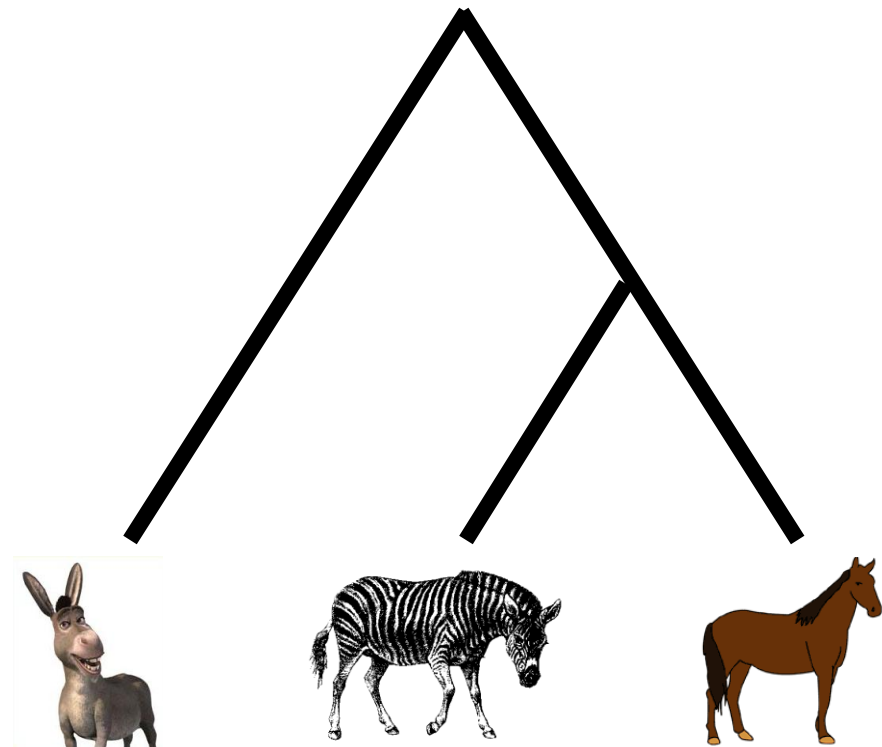
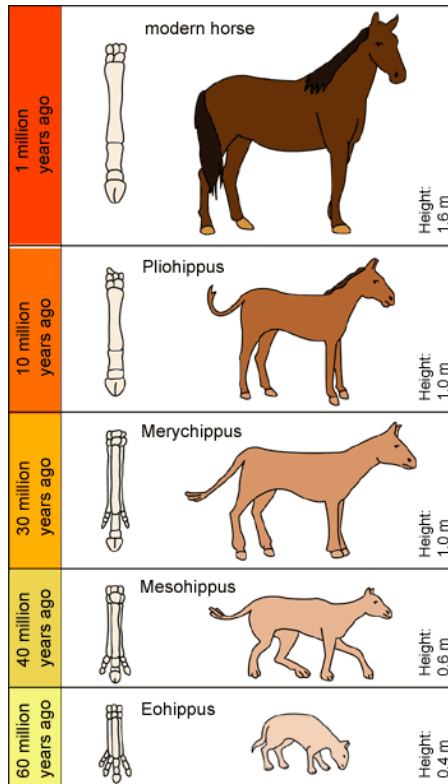
EVOLUTION has two fundamental processes

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- Formation of new lineages (associated with split of existing lineage)



EVOLUTION has two fundamental processes

- Change within a lineage
- Formation of new lineages (associated with split of existing lineage)



Species “seem intricately and almost ***perfectly designed*** for living their lives.”

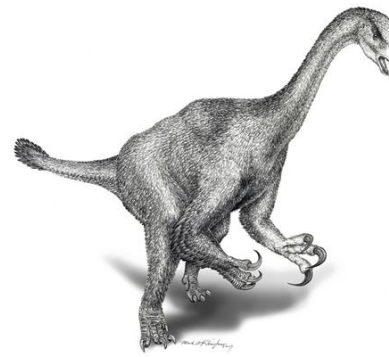
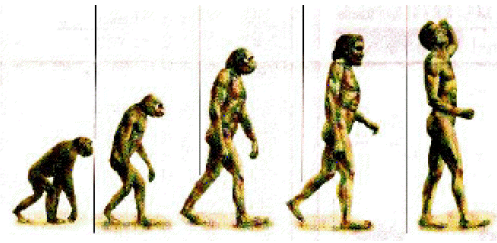
(Coyne “Why Evolution Is True”, Chapter 1, 1st sentence)



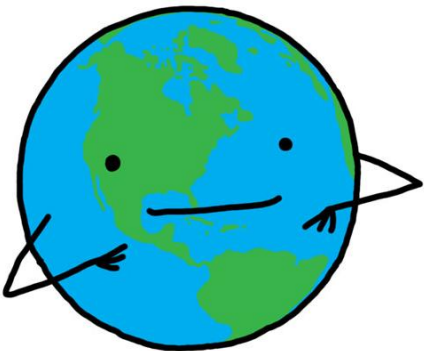
- Appearance of “design” throws people off
- Some adaptations evolved in response to the physical environment
- Other adaptations evolved in response to interactions with other species.

Example: Lampsilis Mussel (video)

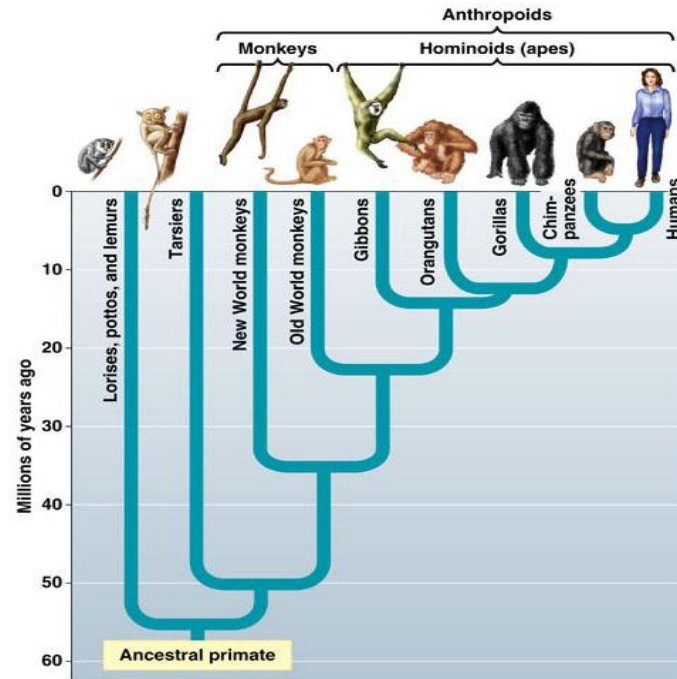




What are basic principles of evolution, and what is the evidence?



2 important principles of evolution



1. All species share *common ancestry* (as a result of splitting of lineages from one ancestral life form)
2. Much of the evolutionary change was caused by **natural selection**, which is the sole process producing *adaptation* (the appearance of design).

Prediction

If life originated on Earth in the distant past and then evolved, we should see:

That the first detectable traces of life on Earth would be simple forms

. . . and only later would more complex and more “modern” forms appear

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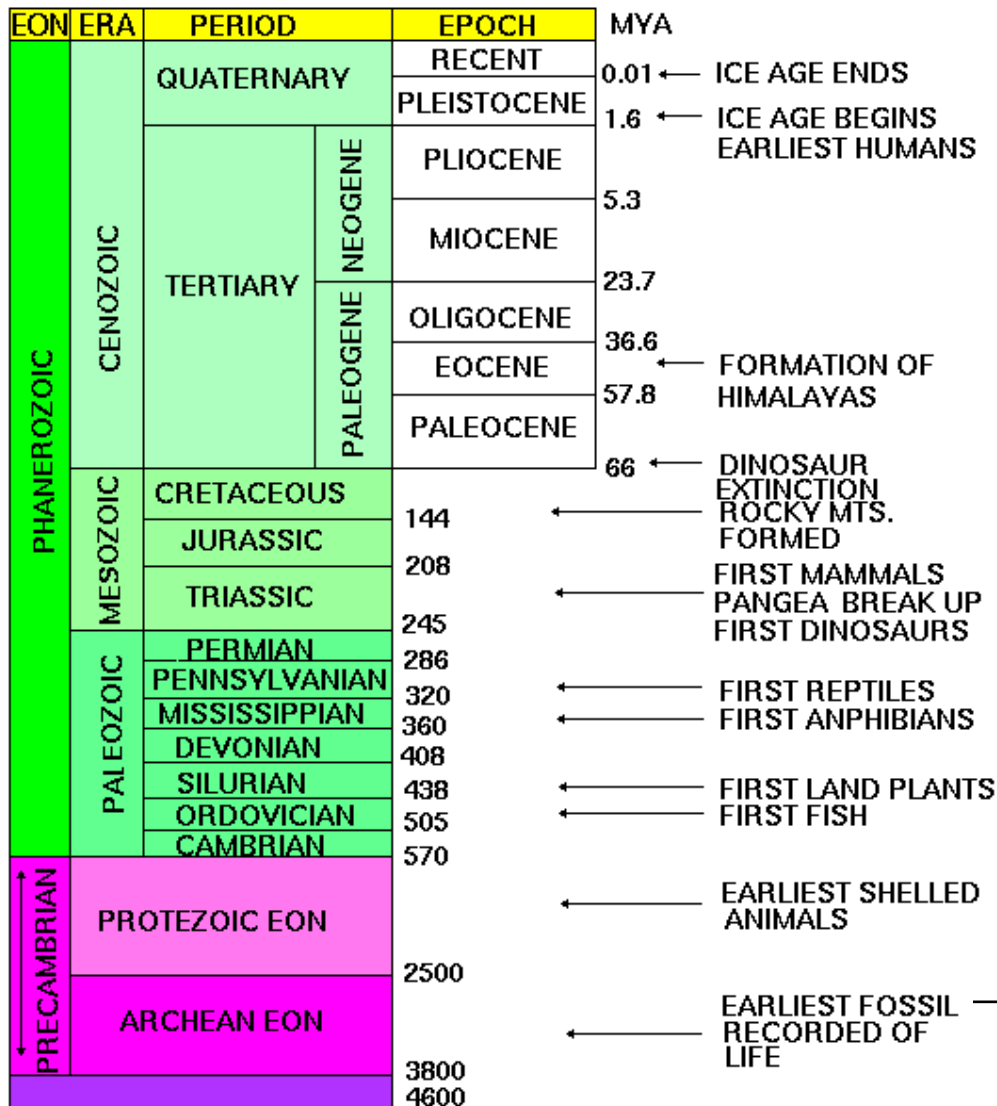
That the first detectable traces of life on Earth would be simple forms

. . . and only later would more complex and more “modern” forms appear

No “fossil rabbits in the Precambrian era”...



Fossil evidence: early life simplest

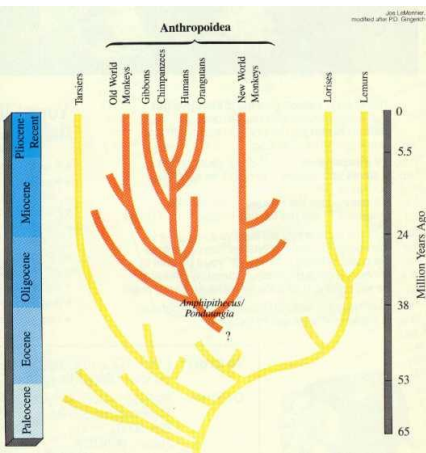


Prediction

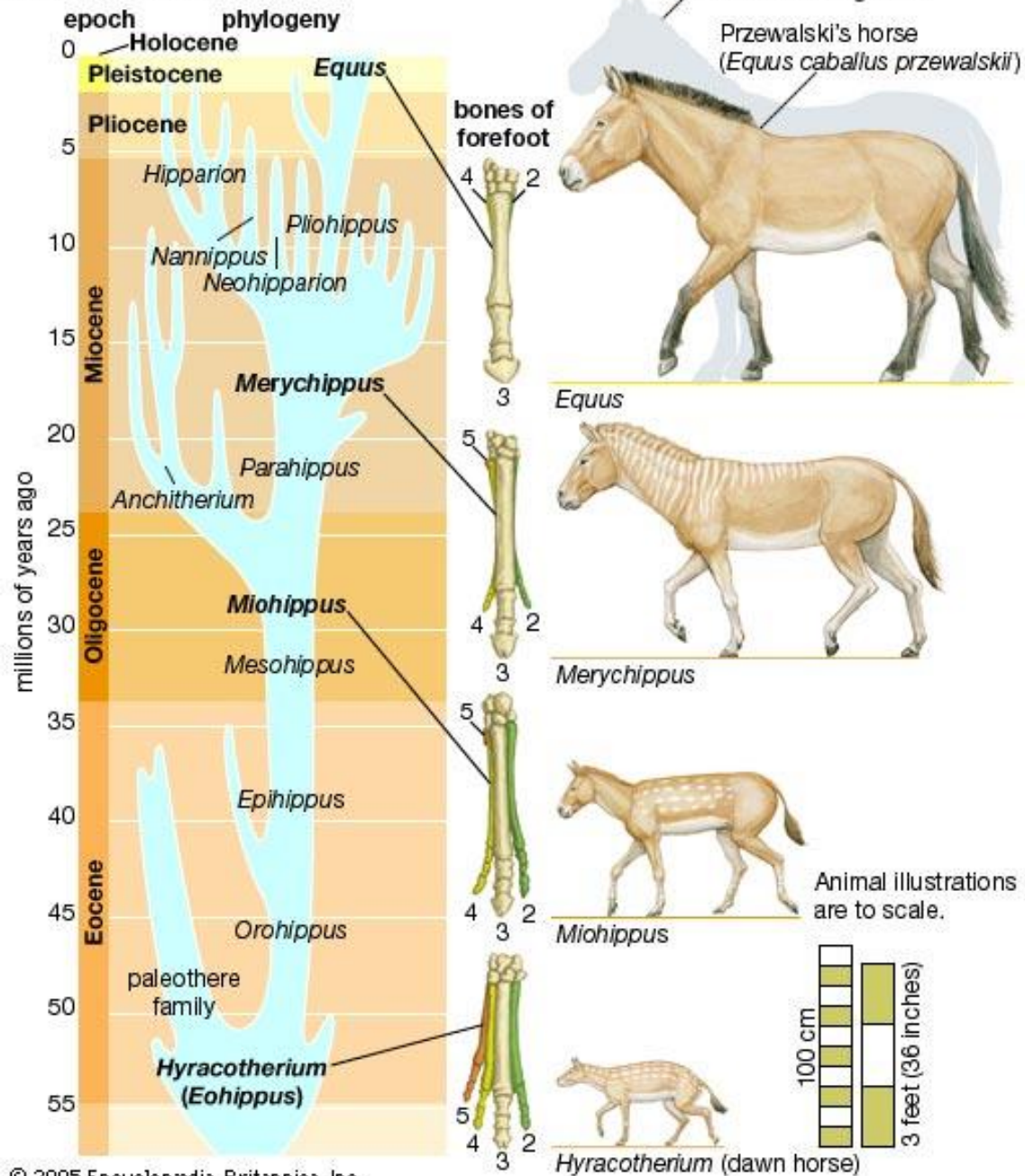
If evolution occurred within lineages, and those lineages sometimes split:

Then we should be able to find examples of traits and species gradually changing in the fossil record

And we should sometimes see one lineage dividing into two or more in the fossil record



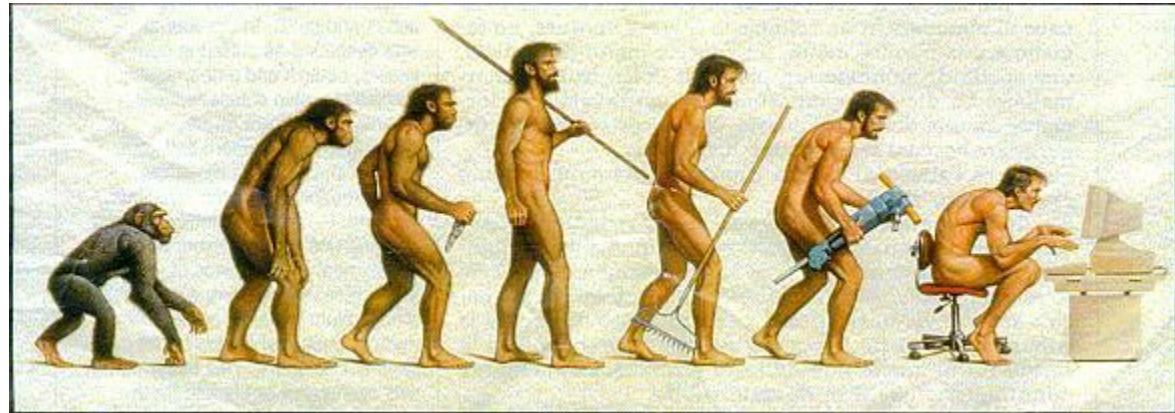
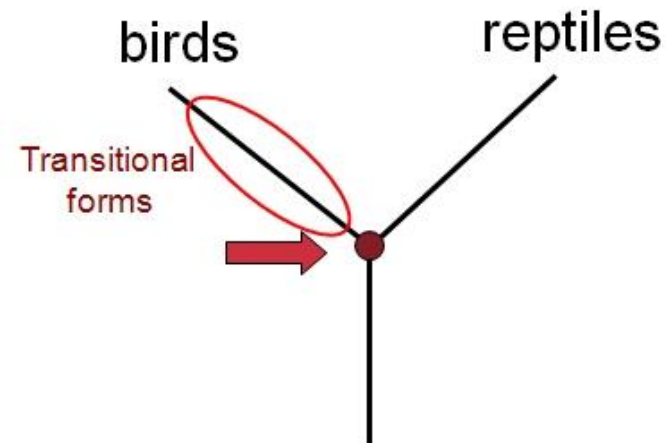
Evolution of the horse



Prediction

If all creatures share a common ancestor:

We should find transitional fossils that connect modern groups to their common ancestor



FEATHERED DINOSAUR!!!!



*Sinornithosaurus
milleni*

FEATHERED DINOSAUR!!!!



Also appears
at the right
time in the
fossil record

*Sinornithosaurus
millenni*

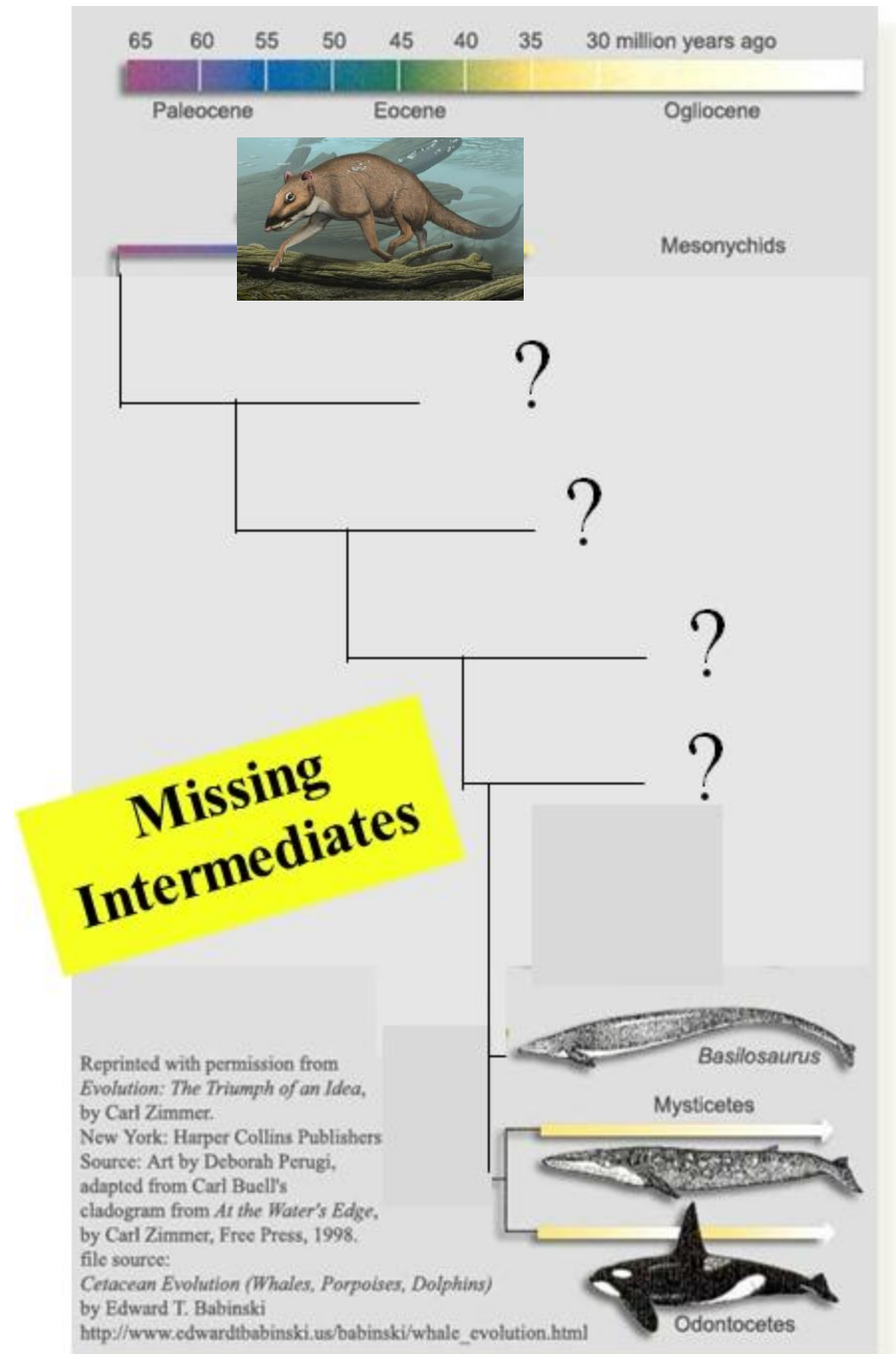
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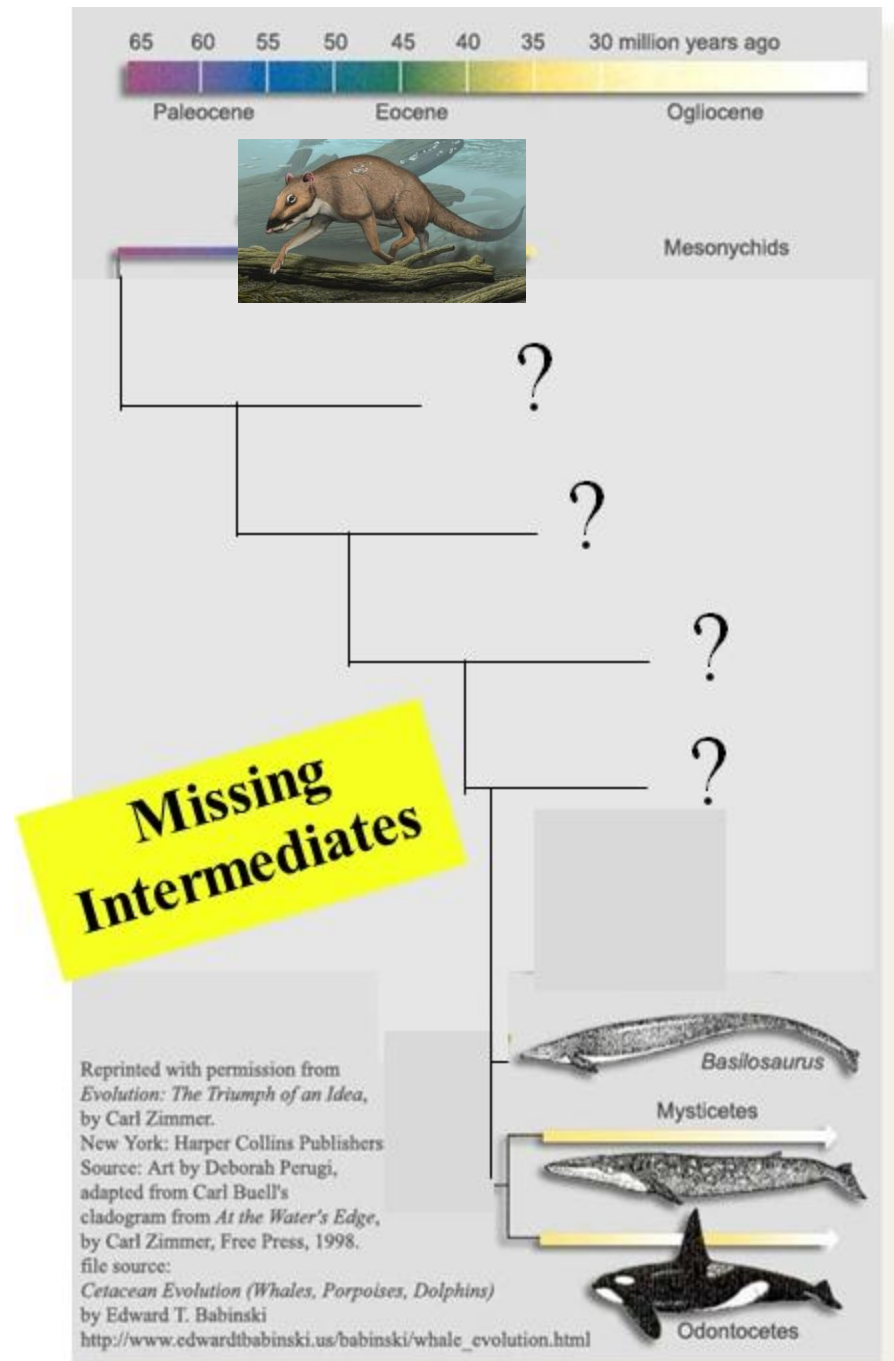
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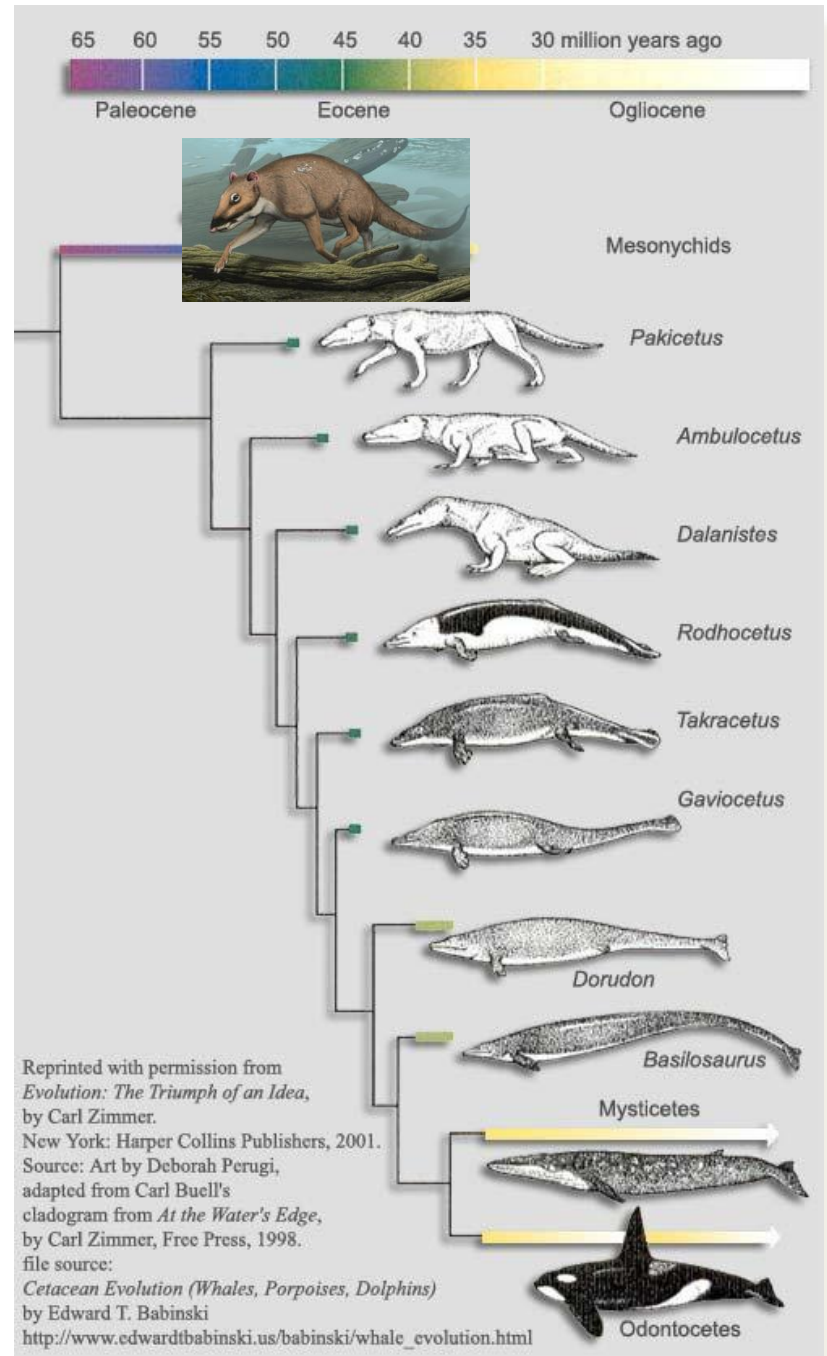
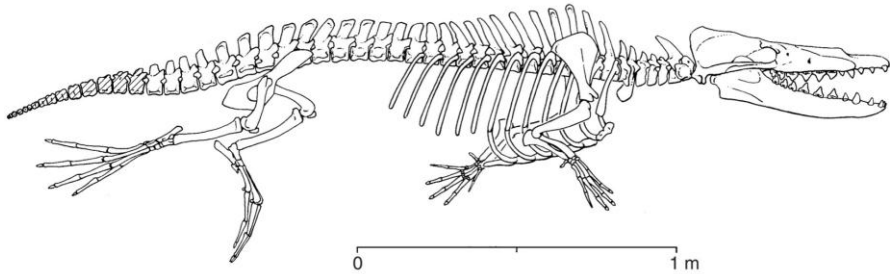
Missing Links?



Missing Links?



Missing Links?





EVOLUTION RETRODICTIONS???

Things we wouldn't necessary predict ahead of time but support the idea.

Retrodictions: vestigial organs



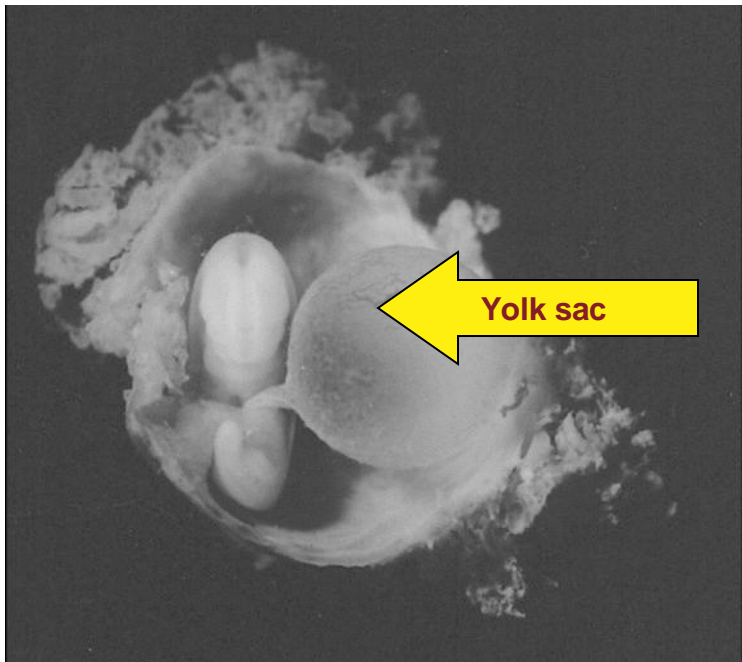
Vestigial hind limbs of gray whale

Predictions: vestigial (dead) *genes*

Genes for making yolk proteins

Genes for making vitamin C

Olfactory receptor genes proteins



Retrodictions: biogeography

Many native birds and insects, but
lack of *native* mammals, amphibians,
and freshwater fish on oceanic islands



The animals that ate Hawaii



**INDIAN
MONGOOSE**



CANE TOAD

Retrodictions: biogeography

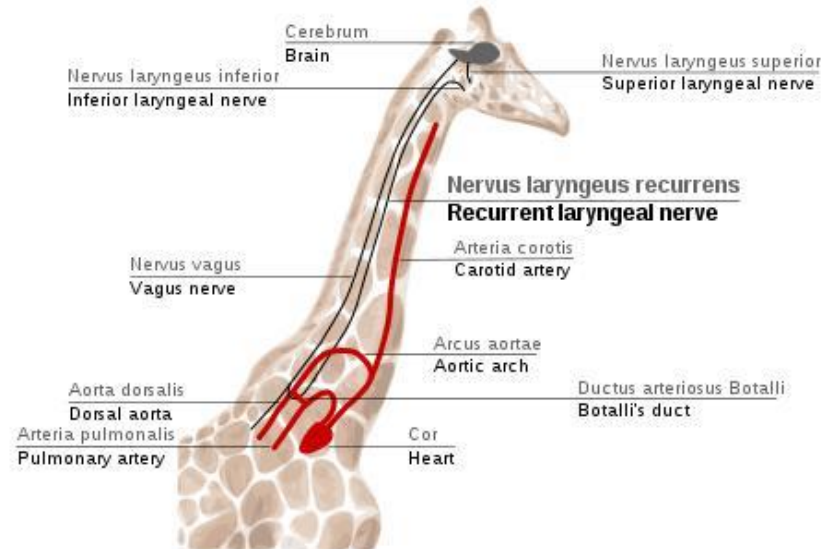
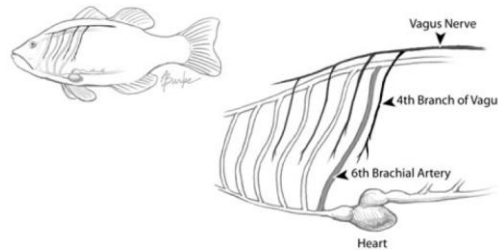
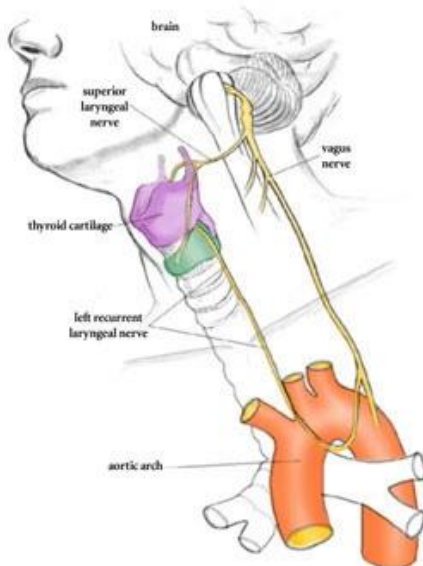
Most similar species to those on oceanic islands are usually found on the nearest mainland



Retrodictions: inefficient design

Loop of laryngeal nerve around aorta works fine for ancestral fish-like form, but **very inefficient** for humans and especially giraffe

Evolution worked with materials available- couldn't produce "more efficient design"



Examples of natural selection
in “real time”

Fossil record

Vestigial organs

Vestigial genes

Biogeography

Inefficient design

TRUE!!!

Observations that would falsify evolution



Fossils in the wrong place (e.g. mammals in the Devonian)

Adaptations in one species good only for a second species

General lack of genetic variation in species

Adaptations that could not have evolved by a step-by-step process of ever-increasing fitness

Evolved altruistic behavior among non-relatives in non-social animals

Unexplained discordance between phylogenies based on morphology/fossils and on DNA

Other common criticisms

- Too much change for evolution to explain
 - Man from a bacteria??? Yeah right...
- Can't explain the complexity we see
 - Half an eye doesn't work.
- Why isn't it still happening?
 - “Why aren't monkeys still evolving into humans?”
- Doesn't explain life's origin- denies existence of God

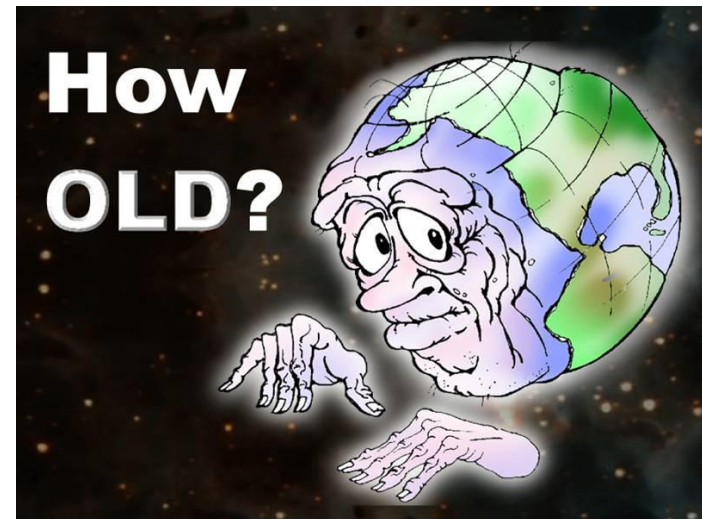
Too much change...

- **Dogs**- domesticated a few thousand years ago.
 - Breeds we see are only a few hundred years old.
 - Striking diversity



Too much change...

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- **Life on Earth**- estimated 3.5 billion years old
 - Hard to relate to this number...



Too much change...

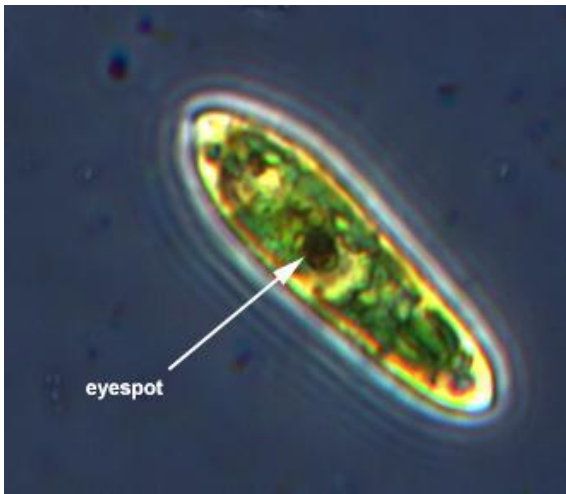
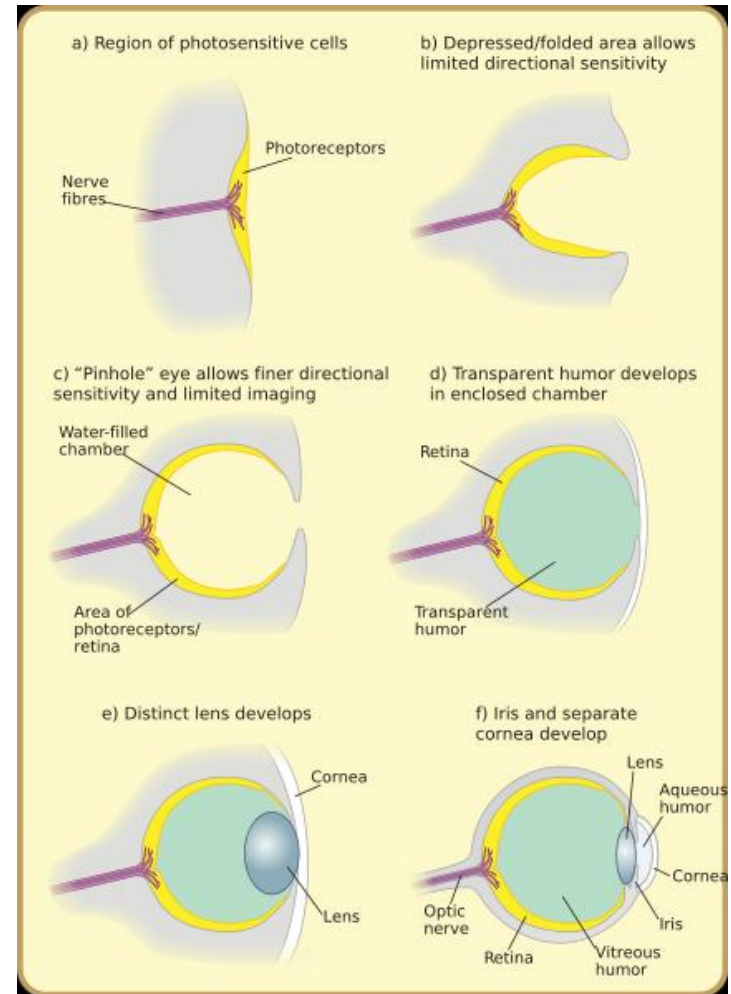
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 - If 1000 years were a millimeter...

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 - Hard to relate to this number...
- **Difference**- how many times over could dog breeds have been done?
 - If 1000 years were a millimeter...
 - 3.5 billion would be 3.5 kilometers!

Too much complexity

- Intermediates DO exist, even in extant species
- Even single-celled *Euglena* has the eyespot photoreceptor



Why isn't still happening?

- Many incorrect assumptions with argument
 - Formation of new species means demise of old
 - Presumed “directionality” of evolution

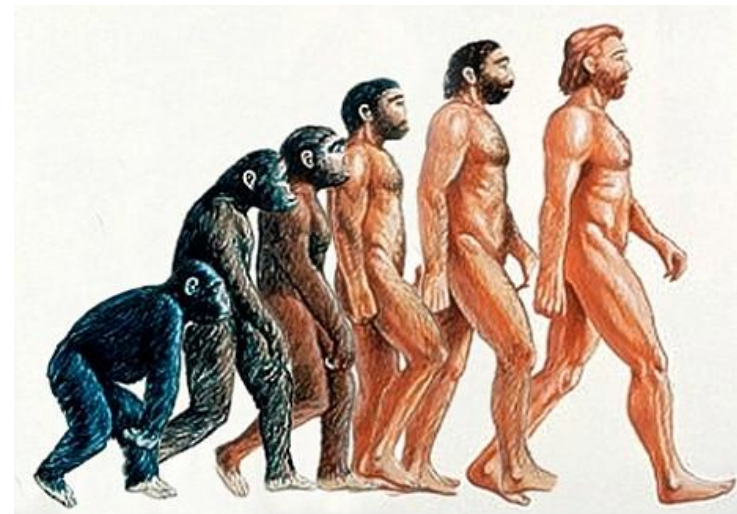
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Why isn't still happening?

- Many incorrect assumptions with argument
 - Formation of new species means demise of old
 - Presumed “directionality” of evolution
- New forms may be advantageous because exploit different resources
- No “direction” of evolution
 - History may not repeat itself



COMMON MISCONCEPTION:

- Humans did not evolve from amoebae or chimpanzees or anything else that is currently alive.
- Humans and all these other species “share a common ancestor”
- All species (including humans) have changed relative to the ancestral forms.
 - No “higher beings”: Even single-celled animals have evolved over time!



wrong



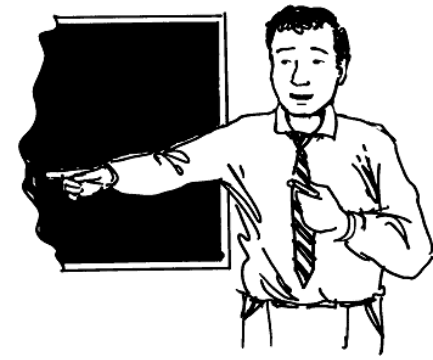
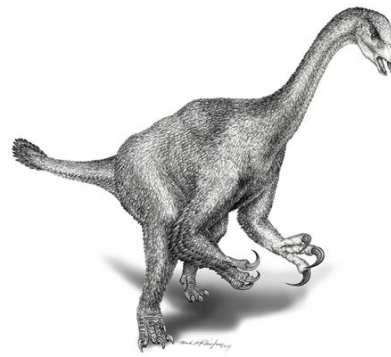
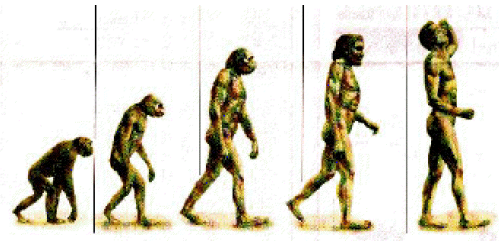
right



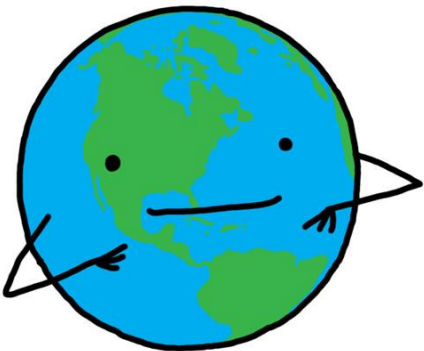
Doesn't explain life's origin- denies existence of God



- **First part true:** Most evolutionary theory does not attempt to address why or how life arose
- **Second part untrue:** There's no intrinsic theism or atheism in what we've discussed
 - Some biologists who support evolution are also devout in faith (e.g., Francis Collins, NIH director)
 - Some are devout atheists (e.g., Richard Dawkins)



How does studying evolution help humanity?



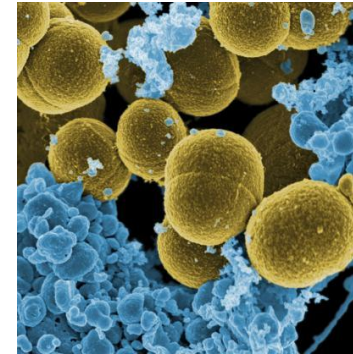
Quantitative genetics

- Similarities between parents/ offspring well known for millenia
 - Some traits “more” heritable than others
- Similarity applied in selective breeding
 - Crops
 - Livestock
 - Pets



Antibiotic resistance

- Penicillin mass-produced in 1943



Thanks to **PENICILLIN**
...He Will Come Home!



**FROM ORDINARY MOLD—
the Greatest Healing Agent of this War!**

On the green, green and yellow mold above, called *Penicillium notatum* in the laboratory, grows the mysterious substance first discovered by Professor Alexander Fleming in 1928. Named penicillin by its discoverer, it is the most powerful weapon ever developed against many of the deadliest infectious bacteria in man. Intensive research on molds was already a part of Schenley's research. Schenley Laboratories were well able to meet the problem of large scale production of penicillin, when the great need for it arose.

When the darkened pages of this war have subsided to pages of silver print in a history book, the greatest news story of World War II may well be the discovery and development — not of some exotic secret weapon that destroys — but of a weapon that saves lives. That weapon, of course, is penicillin.

Every day, penicillin is performing some unbelievable act of healing on some far battlefield. Thousands of men will return home who otherwise would not have had a chance. Never will more and more of this precious drug, so now available for civilian use — to save the lives of patients of every age.

A year ago, production of penicillin was difficult, costly. Today, due to specially devised methods of mass-production, in use by Schenley Laboratories, Inc. and the 29 other firms designated by the government to make penicillin, it is available in even increasing quantity, at progressively lower cost.

Given to "THE DOCTOR NEARBY" according to National Institute of Health, U.S. Department of Health, Education and Welfare, U.S.A. Use your doctor for dose and method.

SCHENLEY LABORATORIES, INC.

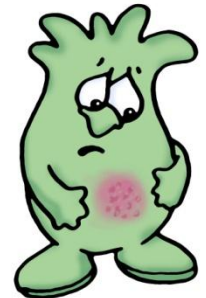
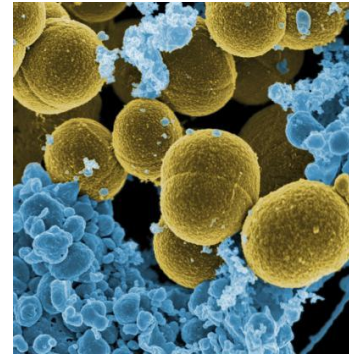
Producers of **PENICILLIN-Schenley**



Antibiotic resistance

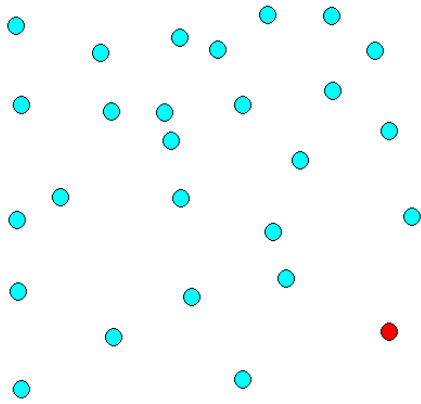
- Penicillin mass-produced in 1943
- First resistant staph strain found 1947
- 1950: 40% of staph isolates resistant
- 1960: 80% of staph isolates resistant

- How did this happen???



Very basic evolutionary principle of **natural selection**

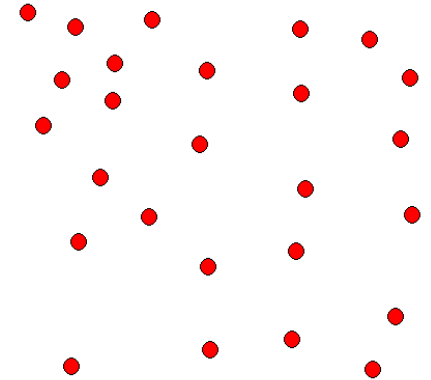
Original population



Antibiotic applied
(no competition for resistant strain)

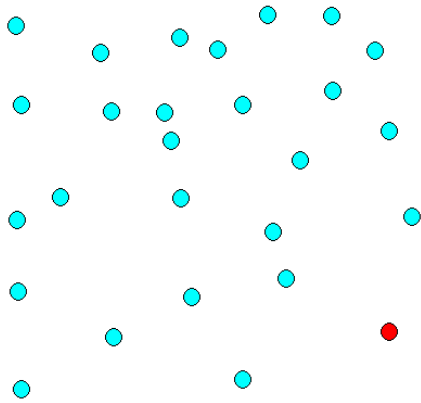


Resistant strain multiplied



Very basic evolutionary principle of **natural selection**

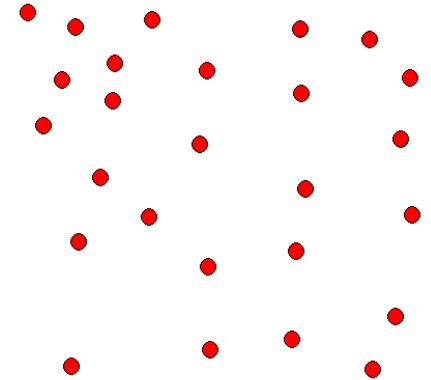
Original population



Antibiotic applied
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Resistant strain multiplied



Lesson: antibiotics were (and often still are) overprescribed...

Coadaptation with “good” microbes

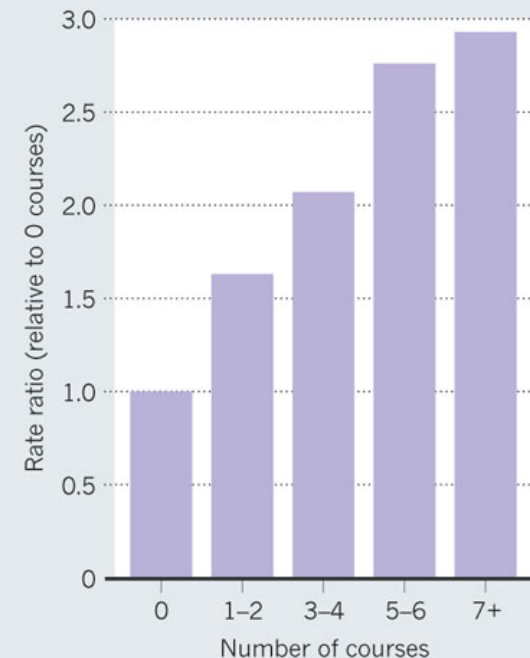
- Humans have co-evolved with many bacteria
 - Synthesize our required vitamin K
 - Help us to resist invading organisms
 - Affects regulation of stomach hormones
- Antibiotics kill “the good stuff” too!



2011 study:

TRUUBLING CORRELATION

The risk of inflammatory bowel diseases in children rises with the number of courses of antibiotics taken.



Some vignettes...

- Control of mosquito spread of dengue using intracellular bacteria
- Understanding human evolution of lactose “tolerance” (lactase persistence)



Pest/ disease control

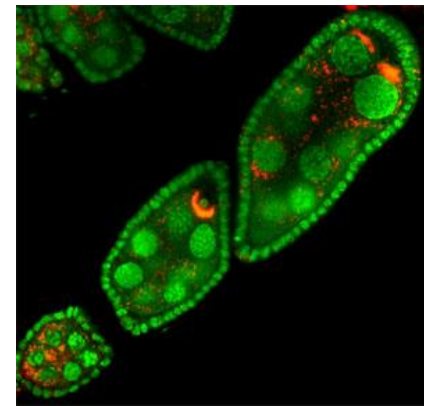
- Dengue fever virus spread by mosquitoes
- Leading cause of child death in SE Asia
- 40% of world at risk of infection
- Some epidemics, including Americas, through 2009
- Control:
 - Kill / avoid mosquitoes?
 - No available vaccine yet



Research on Wolbachia bacteria

- Intracellular parasite
- Common across insects
- Passed through eggs
- No offspring from mating of *infected males* and *uninfected females*
- All other pairings yield offspring

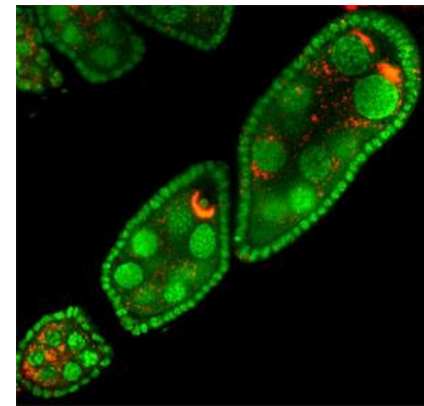
	♀	I	U
♂			⊘

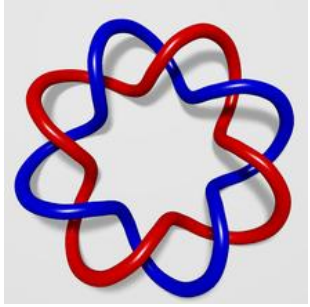


Wolbachia facilitates its spread

- Look at chart
 - Focus on columns
 - Imagine population where some males (I)nfected, some males (U)ninfected
 - For female, is it better to be
 - (I)nfected?
 - (U)ninfected?
 - Which would give more offspring?

	♀	I	U
♂			⊘



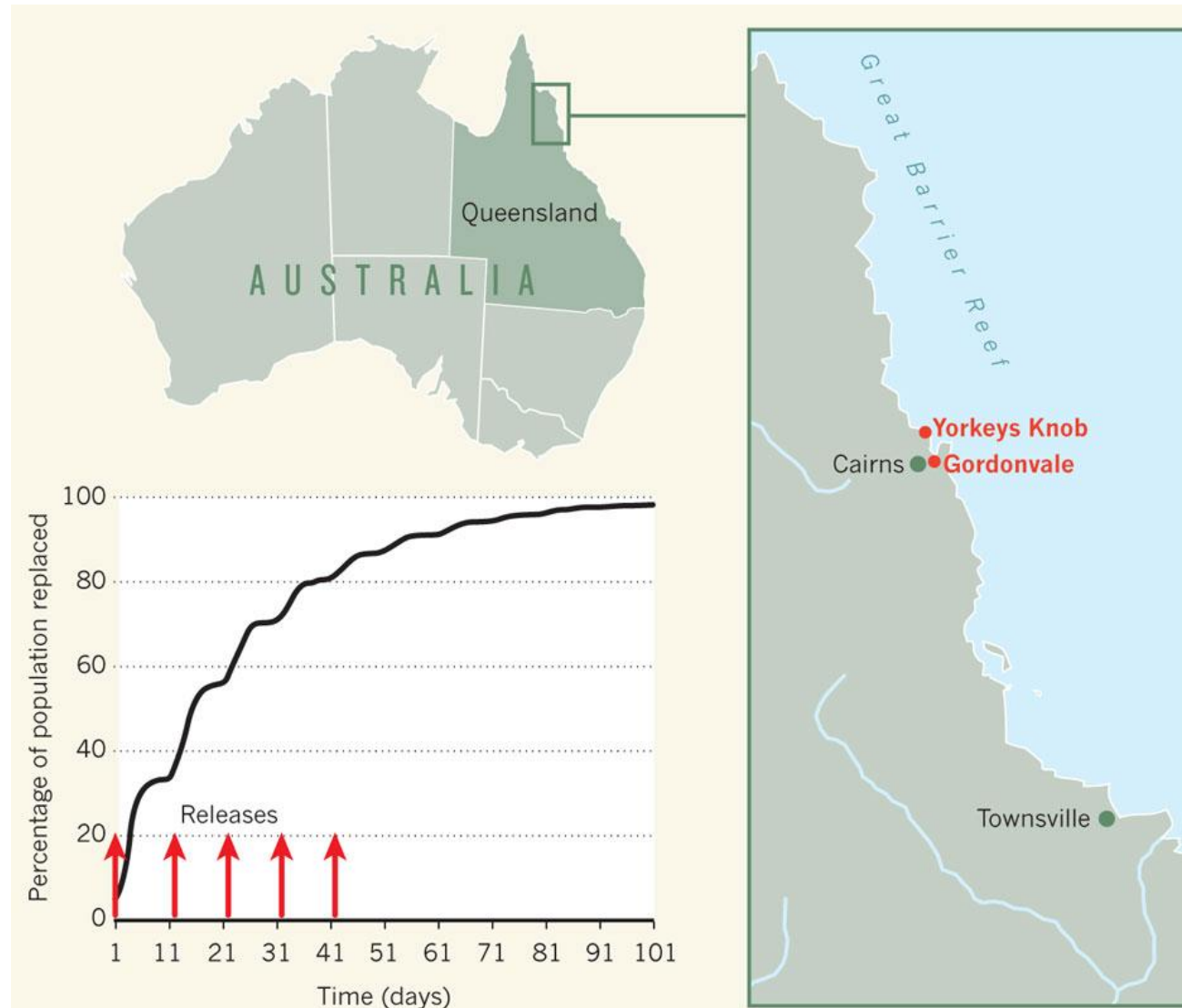


Linking the two...

- 2009: Paper published showed could introduce slightly life-shortening Wolbachia into mosquitoes
- 2009: Another study showed Wolbachia directly inhibits other viruses from infecting host
- Wolbachia infection spreads because of female-advantage

Controlled Wolbachia-infected mosquito releases in Australia, 2011

Very rapid spread of Wolbachia infection in local populations...



Evolutionary study may reduce/ eliminate dengue!!!

- Leveraging evolution research on Wolbachia
- Outcome may affect 40% of the world's population!!!



Some vignettes...

- Control of mosquito spread of dengue using intracellular bacteria
- **Understanding human evolution of lactose “tolerance” (lactase persistence)**



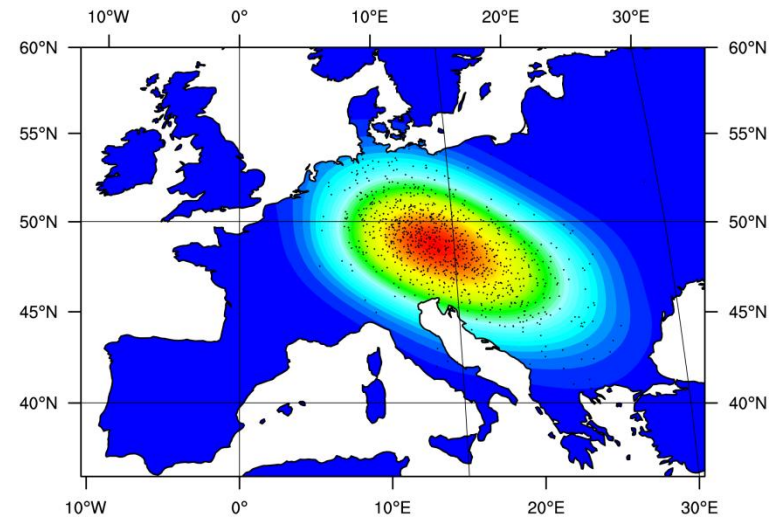
Lactose intolerance

- Extreme, painful gas produced when consume milk products *for people >5 years old*.
- Ancestral condition is **intolerance!**
 - “Mutant” condition is tolerance!
- Today, varies in incidence worldwide
 - 1 % Dutch
 - 12 % European Americans
 - 45 % African Americans
 - 98 % Southeast Asians



What happened?

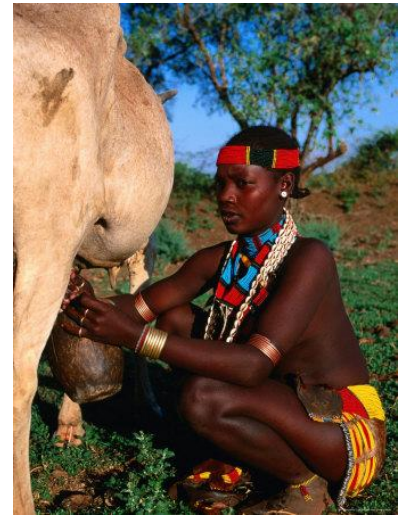
- In **EUROPE**, ~7500 years ago, mutation occurred allowing production of lactase enzyme in adults (digestion of lactose)
 - Coincides with onset of dairy usage in Europe
 - Advantageous: spread!
- Earlier European fossils do not have this mutation



Multiple mutations!



- In **AFRICA**, had a *different* mutation ~5000 years ago allowing adult lactase production!
 - Estimate survival/ reproductive advantage of ~5%
 - Later date coincides with later cattle domestication in East Africa than Europe



Multiple mutations!

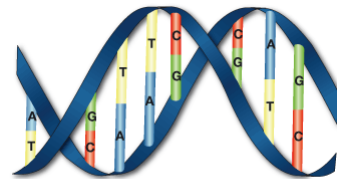
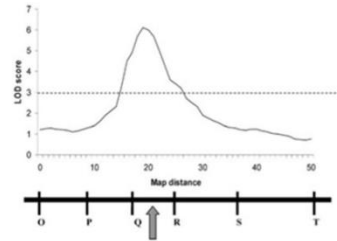
- YET ANOTHER origin in Middle East, effect of two mutations together
 - Evidence that it may have been in response to camel milk consumption
- **Likely others, too...**





Evolutionary genetic studies of lactase persistence in humans

- Associated with “medical” condition
- Genetic mapping done to isolate “cause” alleles
 - Identified multiple, independent origins
- Evolutionary analysis identified *strength* of selection
- Coupled genetic data with evolutionary analysis to *date* the new mutation
 - Inferred cause from anthropological data

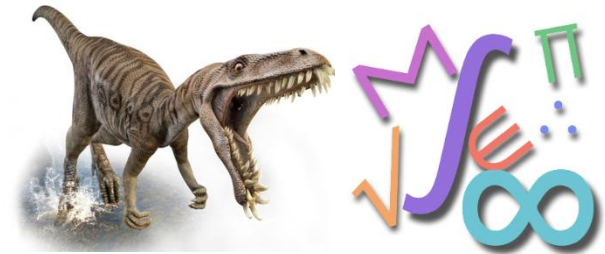


Thymine (Yellow) = T Guanine (Green) = G
Adenine (Blue) = A Cytosine (Red) = C



How are evolutionary insights applied to aid/ understand humanity?

- “It ain’t all math & dinosaurs...”



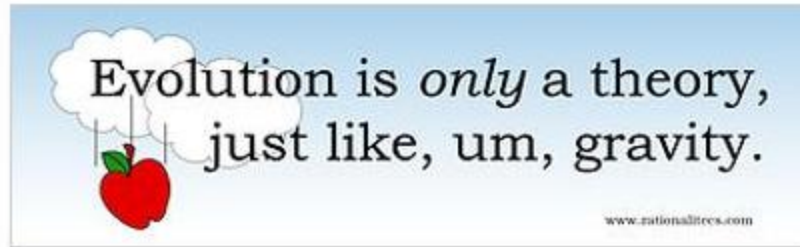
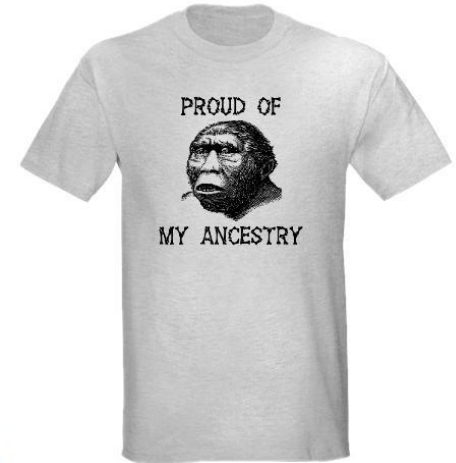
- Quantitative genetics (huge)
- Selection & microbes
- Two “vignettes”
- ... and many, many more

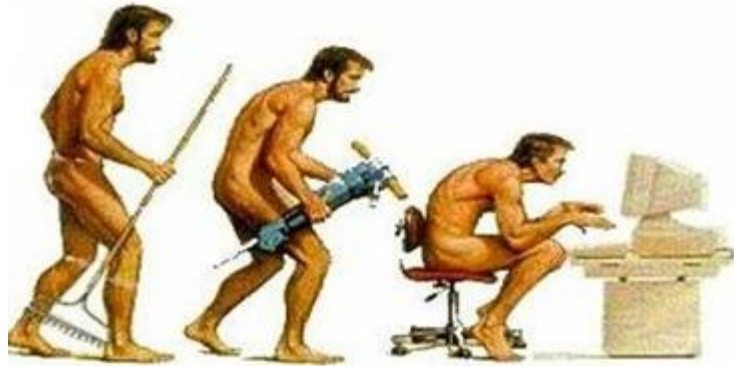




Evolution is cool!

Check out the merchandise!





Thanks for having me!



PHOTO: JIM WALLACE/DUKE UNIVERSITY

