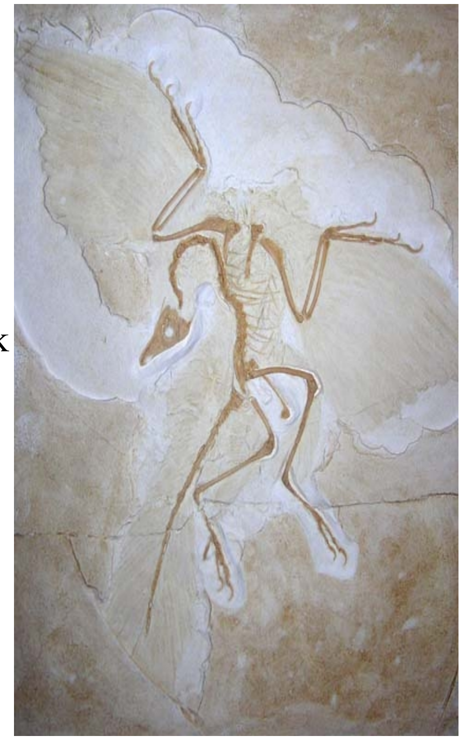
Evolution Notes

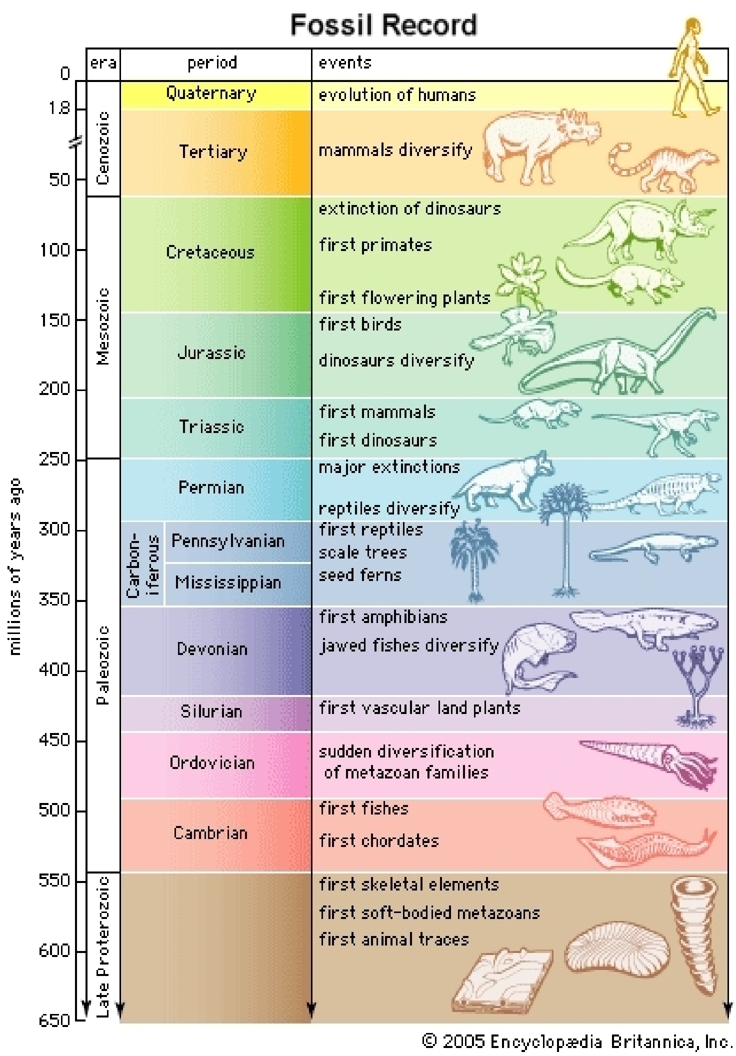
Evidence for Evolution



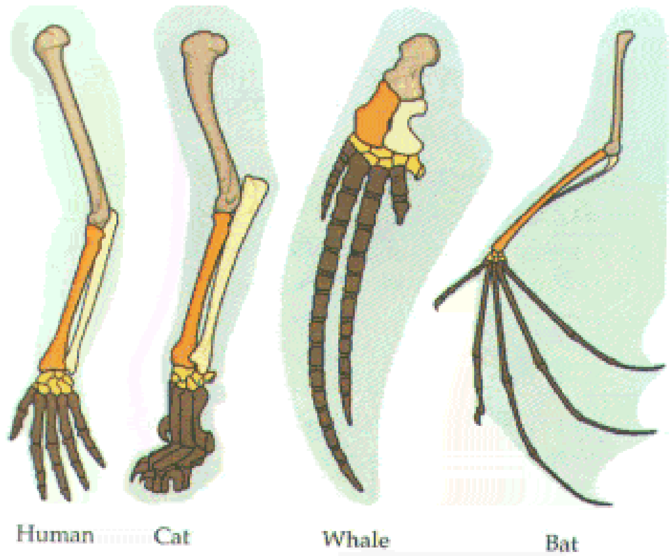
1. **Fossils** – Rock with imprint of ancient organism
Dead organism gets trapped in sand & turns to rock
Only hard structures fossilize (bone, teeth, shells, wood)
Fossils show gradual change over millions of years
Fossil record will never be complete
Relative Age: if it is deeper it is older
The fossil record shows gradual change over time. In the deepest layers of rock we find fossilized cells, above that: fish, above that: amphibians, then reptiles, mammals, dinosaurs, and birds. We don't find rabbits down in the deepest layers, and we don't find dinosaurs in the most recent layer.

Archaeopteryx
A dinosaur with feathers

We can see amphibians changing as we move up the layers, the same for fish, reptiles, mammals, dinosaurs, etc. The fossil record shows us that species change over time.



2. **Atomic physics**
Atomic dating of fossils shows change over large spans of time
Absolute Age: use radioactive isotopes such as carbon 14 (14C) or Potassium-Argon
Radioactive isotopes decay over time
Half-life = time it takes for half of the isotope to decay
14C decays to 12C in 5700 yrs
Half of Uranium decays to Thorium in 80,000 yrs
Carbon dating is used for dating items less than 50,000 years old, other elements are used for more distant timespans.



3. **Homologous Structures** - Variations of one design. Body parts with similar structure and pattern have different uses based on different habitats
Mammals, birds, reptiles, and amphibians have the same skeleton, but the bones are in different proportions.
Analogous Structures look similar, not due to common ancestry but because they evolved in similar environments. Example: Whale fins and shark fins look similar even though whales and sharks are not closely related.

4. **Vestigial Organs**
Structures that are reduced in size & have an altered or absent use or function
Ex: whales' pelvis left over from an ancestor that walked on land, moles with remnants of eyes, goosebumps and back hair on humans

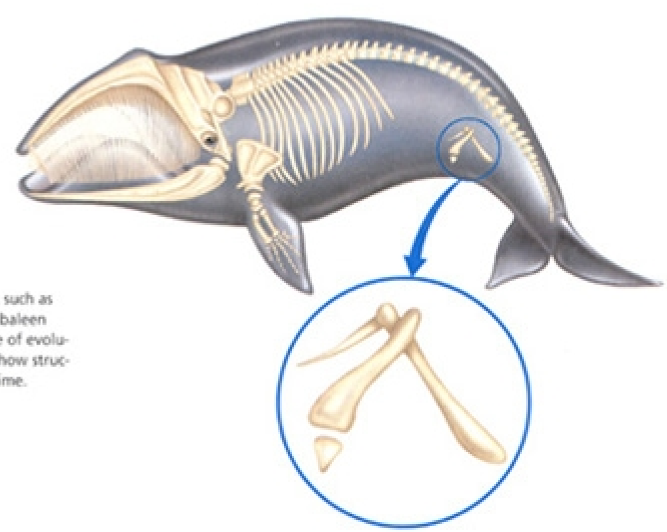


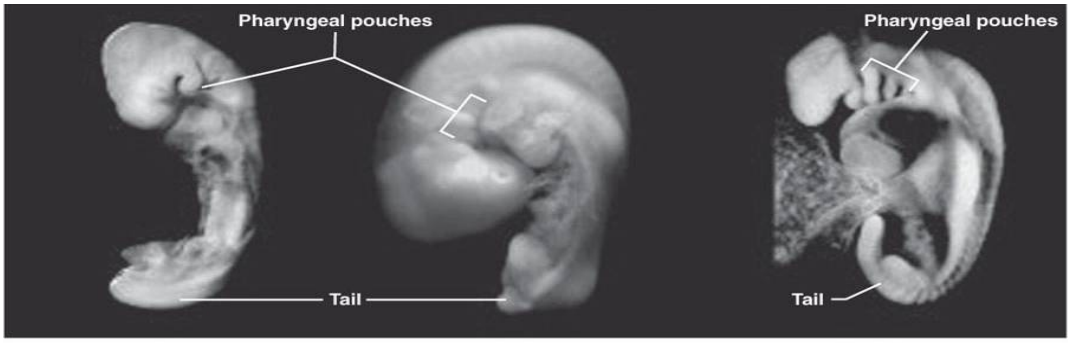
Figure 15.8
Vestigial structures, such as pelvic bones in the baleen whale, are evidence of evolution because they show structural change over time.

5. **Embryological Evidence**

Found in vertebrates

In early stages of development organisms look very similar

The same body plan is tweaked to produce different species



Reptile Bird Human

6. **Genetic similarity**

DNA and proteins are common to all organisms

If two organisms have more DNA sequences in common then they are more commonly related

This is the gene that is the most different between humans and chimpanzees. Every other gene is more similar. It is 118 base pairs long, and differs by 18 nucleotides. It is called HAR1, which stands for "Human accelerated region 1."

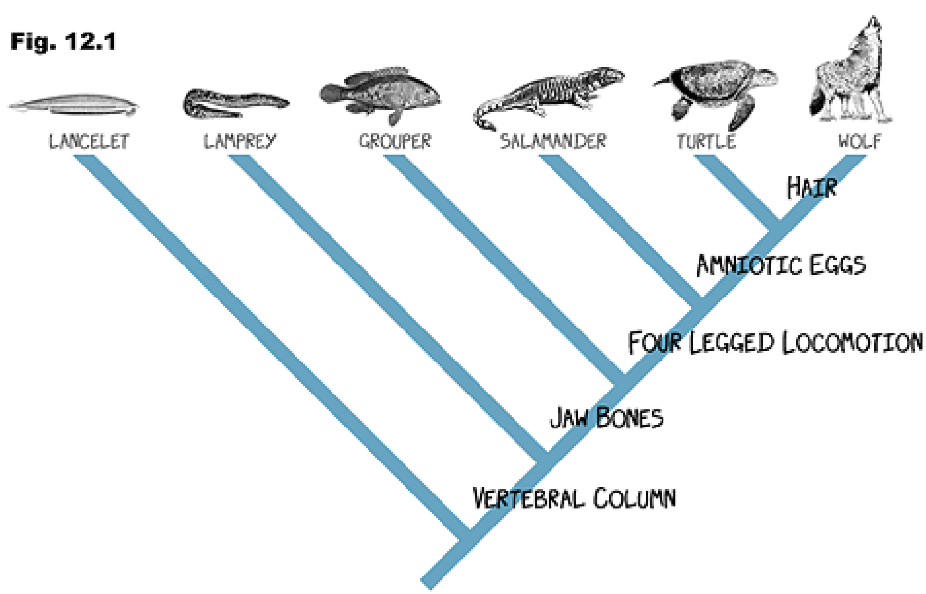
T	G	A	A	A	**C**	G	G	A	G	G	A	G	A	**C**	**G**	T	T	A	C
A	G	C	A	A	**C**	**G**	T	**G**	T	C	A	**G**	C	T	G	A	A	A	T
G	A	T	**G**	G	G	**C**	G	T	A	G	A	C	**G**	C	A	**C**	G	T	C
A	G	C	**G**	G	**C**	G	G	A	A	A	T	**G**	G	T	T	T	C	T	A
T	C	A	A	A	A	T	**G**	A	A	A	G	T	**G**	T	T	T	A	G	A
G	A	T	T	T	T	C	C	T	C	A	A	**G**	T	T	T	C	A		

Changes in human sequence relative to that of the chimp

T	G	A	A	A	T	G	G	A	G	G	A	G	A	A	A	T	T	A	C
A	G	C	A	A	T	T	T	A	T	C	A	A	C	T	G	A	A	A	T
T	A	T	A	G	G	T	G	T	A	G	A	C	A	C	A	T	G	T	C
A	G	C	A	G	T	**G**	G	A	A	A	**T**	A	G	T	T	T	C	T	A
T	C	A	A	A	A	T	T	A	A	A	G	T	A	T	T	T	A	G	A
G	A	T	T	T	T	C	C	T	C	A	A	A	T	T	T	C	A		

Cladogram – A diagram showing evolutionary relationships among a group of organisms. Genetic differences form a nested tree that is perfectly explained by common ancestors.

Fig. 12.1



7. **Pseudogenes** (broken genes)

Our DNA is like a history book, and we can read the letters in it to learn about the past. Humans need to consume vitamin C or we will develop scurvy. Dogs and cows don't have to consume vitamin C. They have a gene (called GULO) that produces a protein that synthesizes vitamin C. We have a broken version of that gene in our DNA. The gene is broken in the same way in Humans, Chimpanzees, and other apes. This makes sense in the light of evolution. A common ancestor had a mutation that broke the gene, and it passed on that broken gene to all of us.

Gerbils also have a broken GULO gene, but it is broken in a different way. This also makes sense in terms of evolution. Gerbils have a different evolutionary history, and they happened to have a mutation that broke it in a different way than in great apes.

Human	ACCCTGAGGT	GGTGTCCCAC	TACCTGGTGG	GGGTACGCTT	CACCTG-GAG
Chimpanzee	ACCCCGAGGT	GGTGTCCCAC	TACCTGGTGG	GGCTACGCTT	CACCTG-GAG
Orangutan	ACCCTGAGGT	GGTGTCCCAC	TACCCGGTGG	GGGTGCGCTT	CACCCA-GAG
Cow	GCCCCAAGGT	AGTGGCCCAC	TACCCCGTGG	AGGTACGCTT	CACTCGCGGG
Dog	ACCCCAAGAT	GGTGGCCCAC	TTCCCTGTGG	AGGTCCGCTT	CACCCGCGGG
Rat	ACCCCAAAGT	GGTAGCCCAC	TACCCCGTAG	AGGTGCGCTT	CACCCGAGGG

Homo sapiens	Human
Pan troglodytes	Chimpanzee
Pongo pygmaeus	Orangutan
Bos taurus	Cow
Canis lupus	Dog/Wolf
Rattus norvegicus	Rat

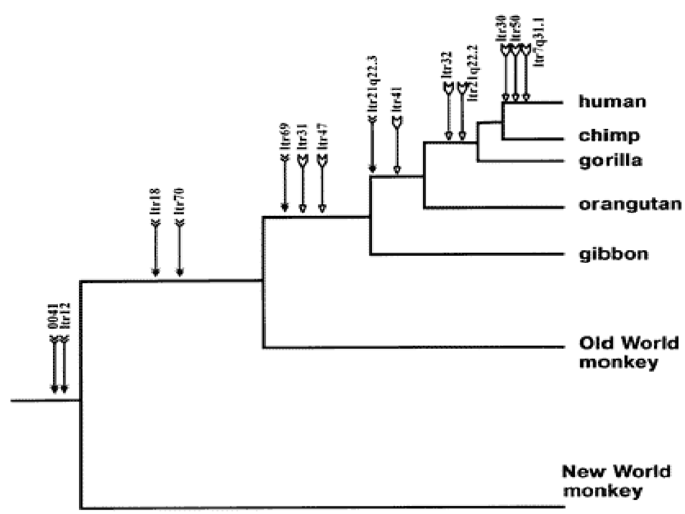
Functional GULO sequences from cow, dog, and rat compared to nonfunctional sequences in several primates. A portion of exon 12 is shown. Differences from the human sequence are shown in black. Primates share a single nucleotide deletion (highlighted in yellow) in common in this region.

We have thousands of pseudogenes, and share most with chimpanzees. Some we share with distantly related mammals, such as a gene for producing a reptile egg yolk. A reptilian ancestor passed it on to all mammals.

8. **Endogenous Retroviruses**

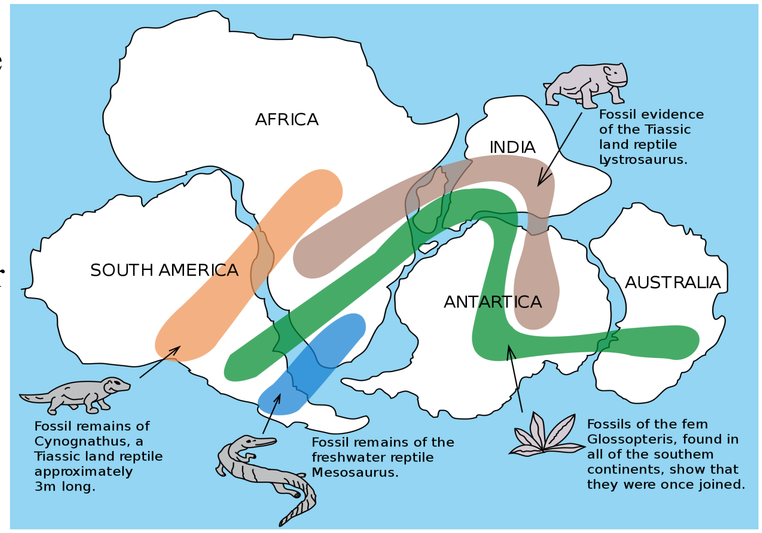
(Old broken viruses)

When a virus infects a cell it will insert its DNA into the host cell's DNA. Old viruses can be passed down from parent to child. Around 8% of the human genome is remnants of old broken viruses. We share most endogenous retroviruses with chimpanzees. They are located in the same places in our DNA. This is evidence of common ancestors that had the viruses and passed them on to both of us.



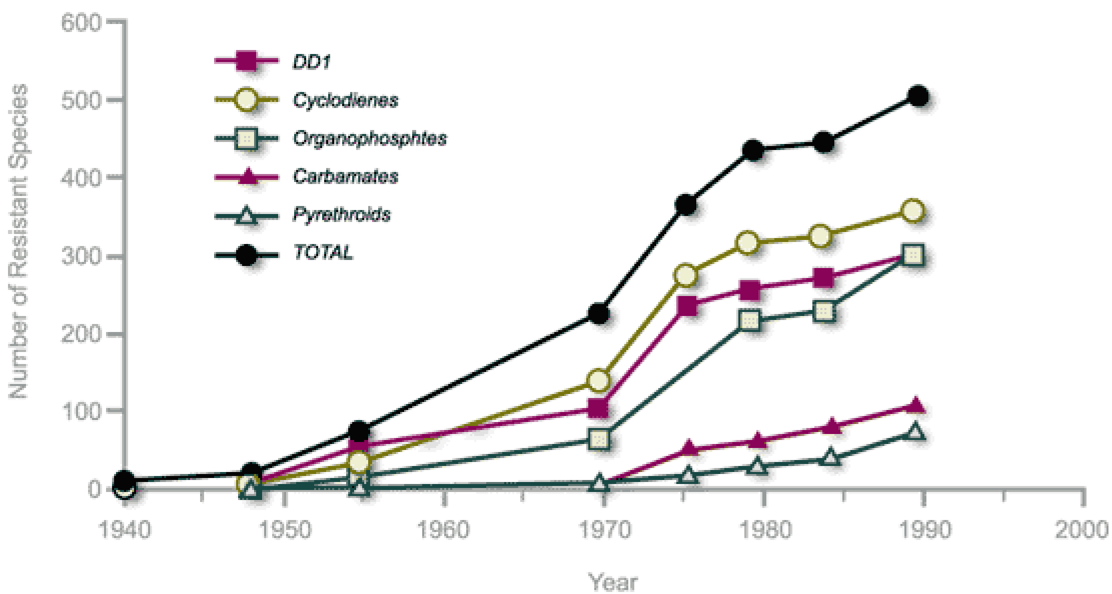
9. **Biogeography**

We find genetically similar species in the same geographic areas. Closely related marsupials are found on Australia, not one in Australia and the other in North America. This makes sense if both species evolved from a common ancestor that lived in Australia. Some mobile species like birds, or seeds that can be transported long distances by birds or water currents may not follow this.



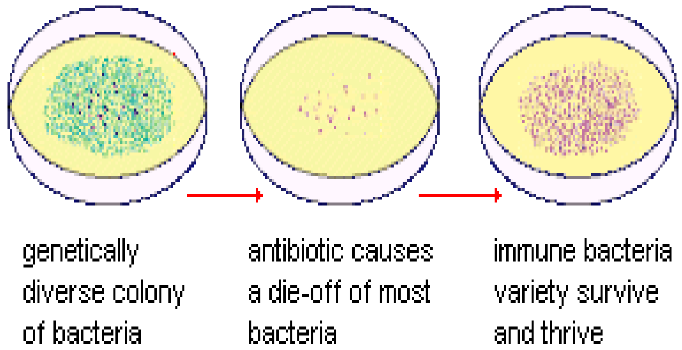
10. **Ecology**

We can see insects evolving to become immune to pesticides. Insects that happen to have a mutation that makes them immune will survive and pass on their immune gene to the next generation. Eventually the entire population will be immune to the pesticide.



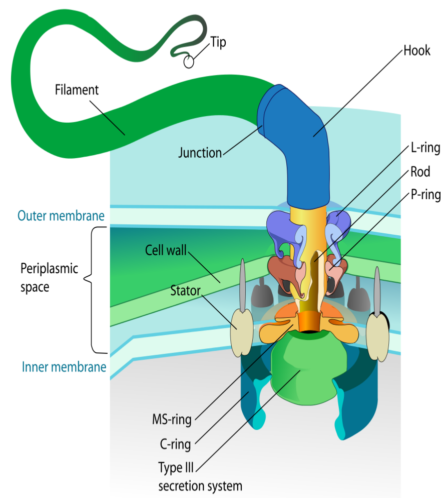
More than 500 insect species have evolved immunity to these five pesticides.

11. **Pharmacology**
Bacteria populations evolve immunity to antibiotics.
A mutation for immunity is passed on to the next generation.

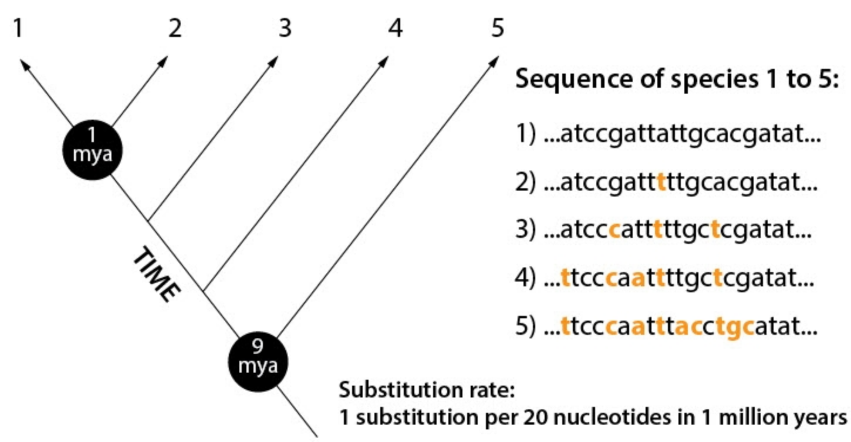


12. **Homologous genes**

Some complex systems evolved by using existing (or slightly mutated) proteins for a new purpose.
Of the 23 proteins involved in the flagellum, 21 are variants of other proteins that perform different jobs.

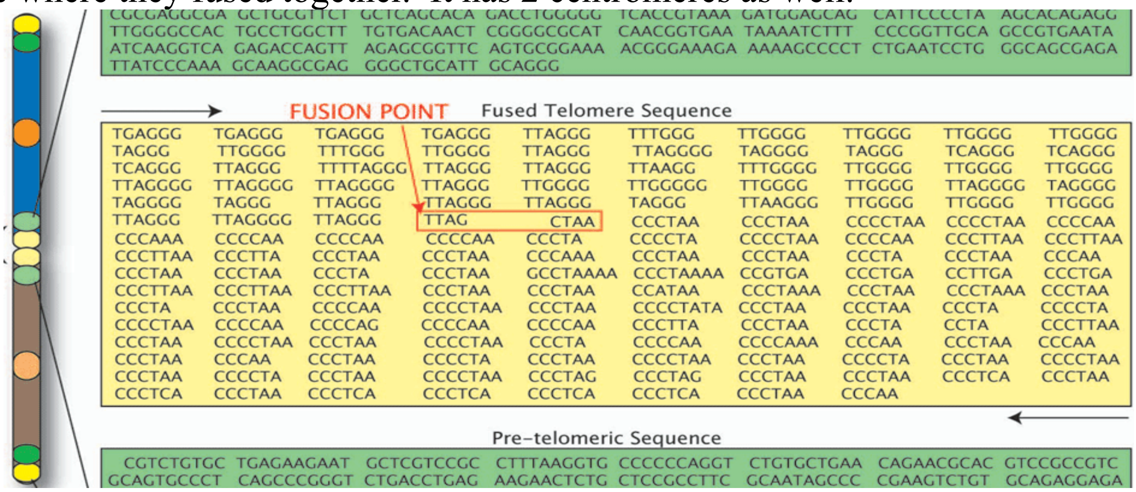


13. **Molecular clock**
We can use mutation rates and mutation differences to calculate when species last had a common ancestor.
Proteins have changed very slowly and are shared by many species.
The molecular clock matches up with the fossil record. DNA and fossils both independently tell us the same story.



14. **Fused chromosomes**

Human chromosome 2 resulted from a fusion of chromosomes 2a and 2b, which are still separate in Chimpanzees, Bonobos, Gorillas, and Orangutans. Human chromosome 2 has telomeres, which are normally found on the ends of chromosomes, embedded in the middle where they fused together. It has 2 centromeres as well.



15. **Mutations always occur**

We can sequence the DNA of parents and children, and see that random mutations occur from one generation to the next. One of the fundamental properties of life is that DNA changes over time.