Science and Society

Genetics and Evolution

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Genetics and Evolution

All living organisms contain and require proteins

All plants contain the protein called *RuBisCO*

All mammals contain the protein *Profilin*

All living organisms except viruses contain *ribosomal RNA*

Why is there is such widespread commonality?

Are some species more related than others?

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Automated methods for reading the sequence of nucleotides (GCAT) now allow the complete cataloging of the genetic information in an organism

It has been done for hundreds of species already

Eventually it will be done for every individual and stored as part of that person's medical data

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Chimpanzees and humans are built a lot alike, and they have many similar behaviors

Is there any genetic evidence that they evolved from a common ancestor?

(Neither evolved from the other)

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Chromosomes

Humans have 23 chromosomes
Chimps have 24 chromosomes

Uh oh!

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Chromosomes

The DNA sequence of humans and chimps is 98% the same

Hmmmmmmm?

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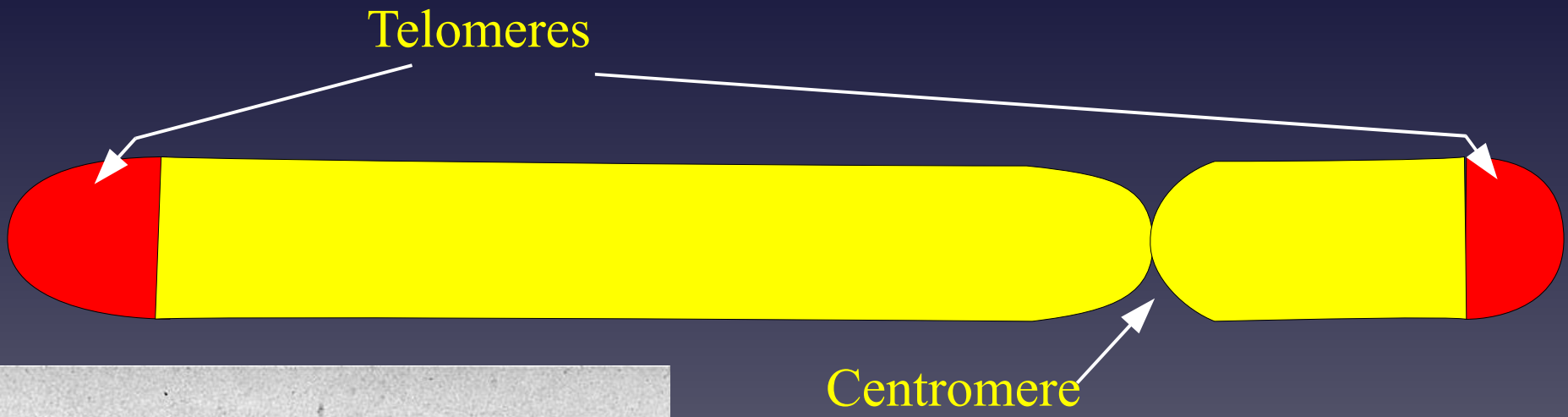
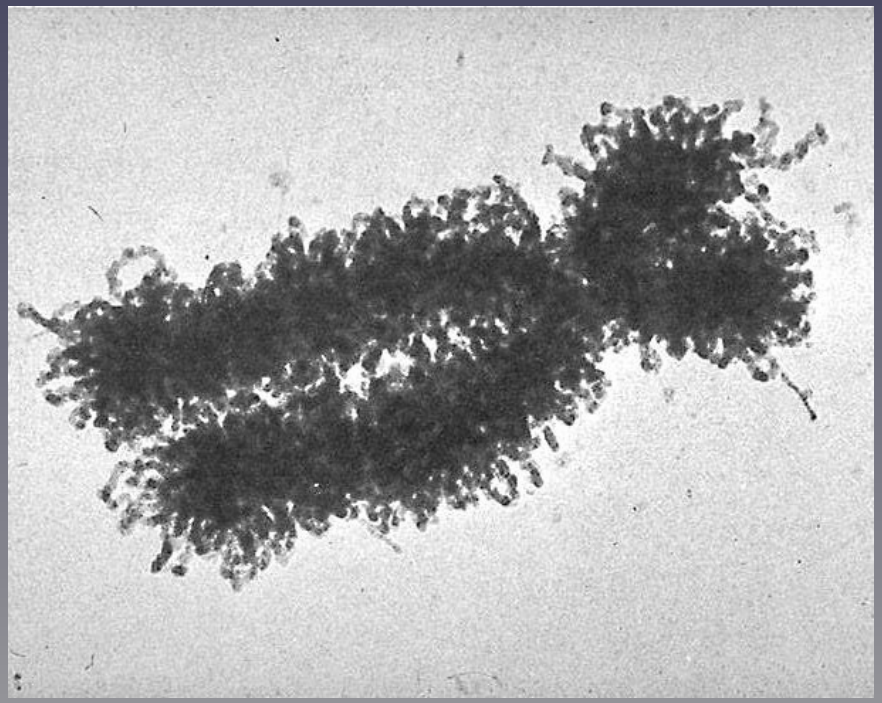
Chromosomes





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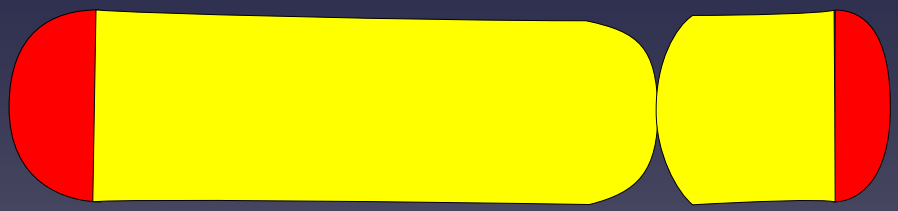
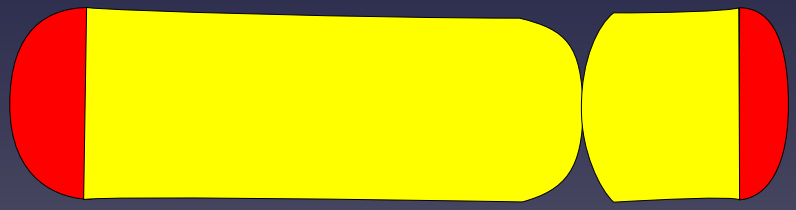
Chromosomes

Chimp chromosome 2A



Chimp chromosome 2B



Human chromosome 2

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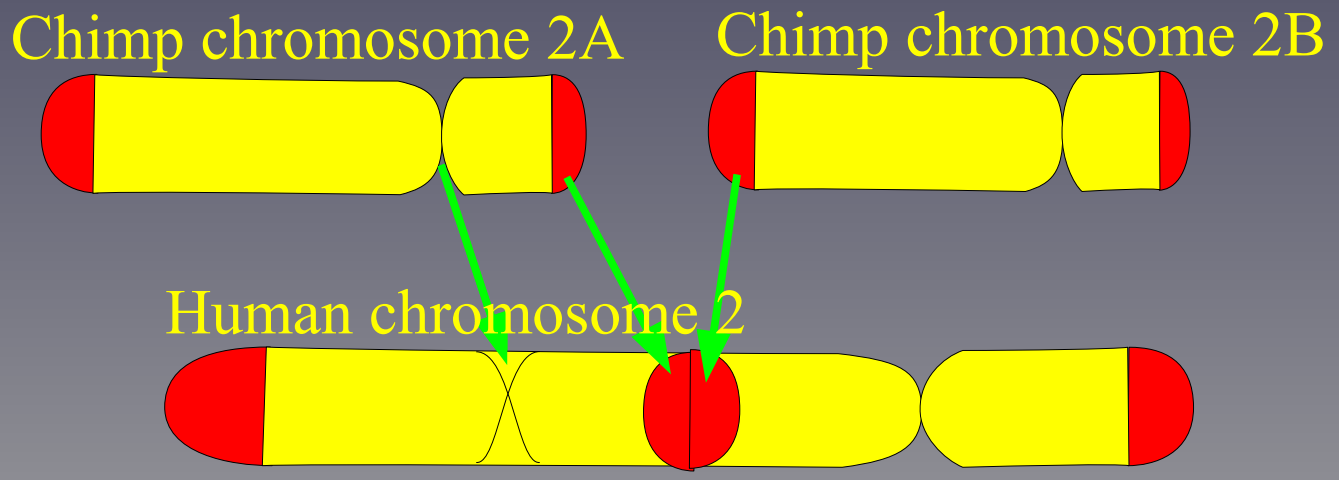
Chimp/Human Chromosomes

First possibility: If chimps and humans came from a common ancestor and two chromosomes fused after the split, we should find remnants of the extra telomeres and centromere



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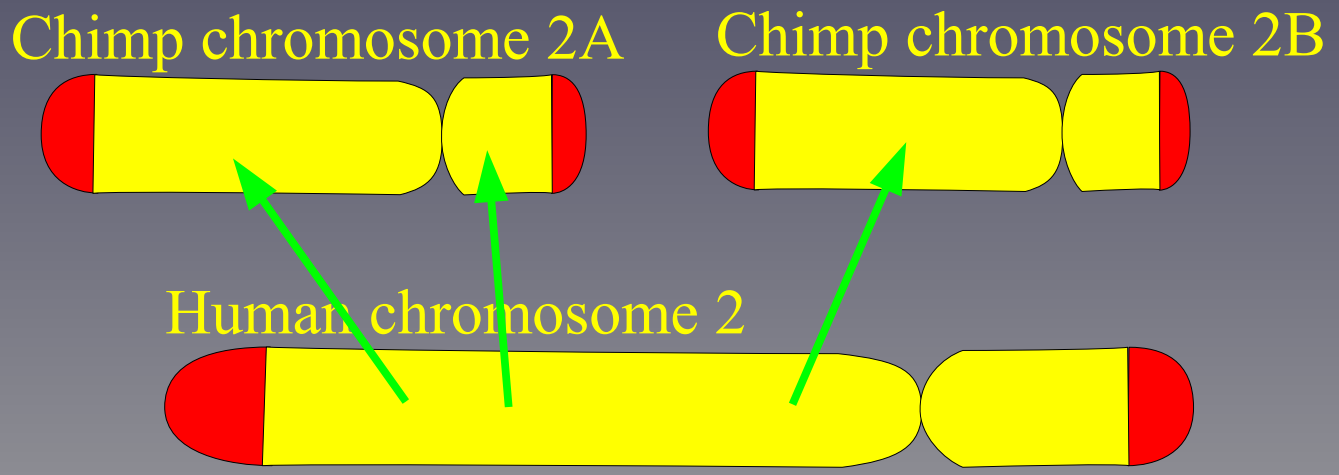
Chimp/Human Chromosomes

Second possibility: If humans and chimps came from a common ancestor and one chromosome split in two, we should find a new centromere and telomeres inserted somewhere



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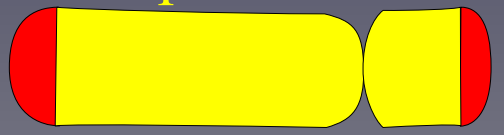
Chimp/Human Chromosomes

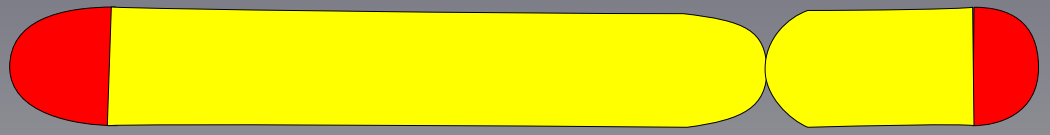
Third possibility: If humans and chimps never had a common ancestor, we should find nonspecific differences in the chromosome structures

Chimp chromosome 2A

Chimp chromosome 2B



Human chromosome 2



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Chimp/Human Chromosomes

A telomere consists of many repeats of the sequence

```
....TTAGGG|TTAGGG....
....AATCCC|AATCCC....
```

repeated 50 to 100 times

Protects the ends of the chromosome during replication

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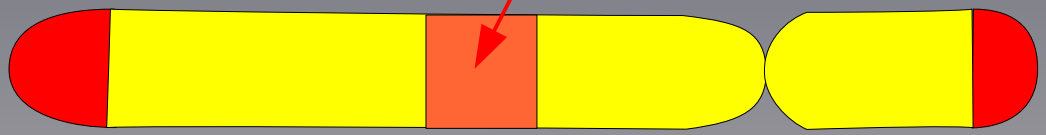
Chimp/Human Chromosomes

In the human chromosome, researchers found the sequence

....TTAGGGG|TTAGGG|TTAG|CTAA|CCCTAA|CCCTAA....
....AATCCCC|AATCCC|AATC|GATT|GGGATT|GGGATT....

Right here the use of C and G switches. It is the exact point where the two chromosomes fused together

Human chromosome 2



....TTAGGG|TTAGGG....
....AATCCC|AATCCC....

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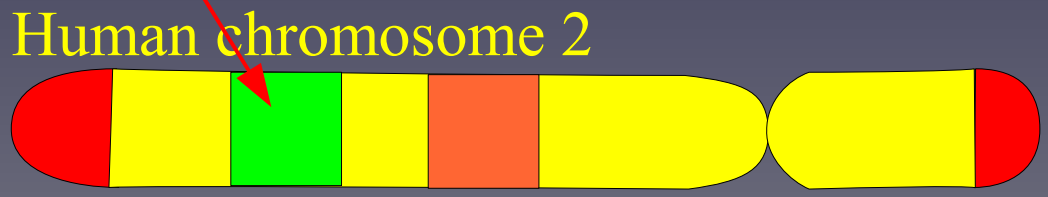
Chimp/Human Chromosomes

Furthermore, the sequence of a centromere is well known, and a copy of a mutated centromere was found here



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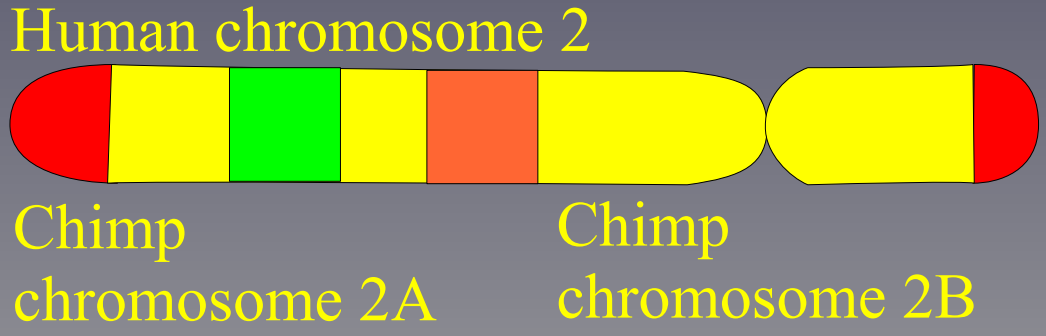
Chimp/Human Chromosomes

The position of the genes on human chromosome 2 line up now with the positions of 2A and 2B after fusion

This is what we would expect if chimps and humans have a common ancestor



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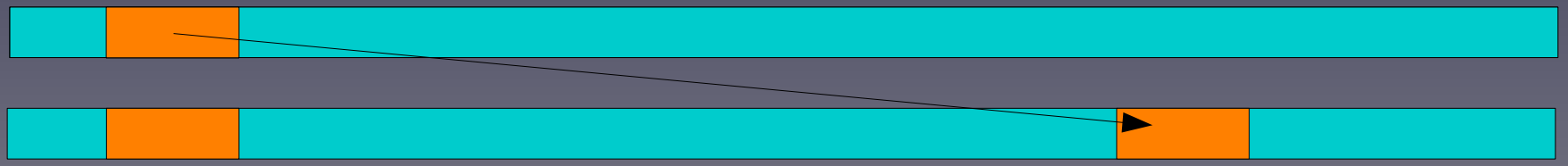
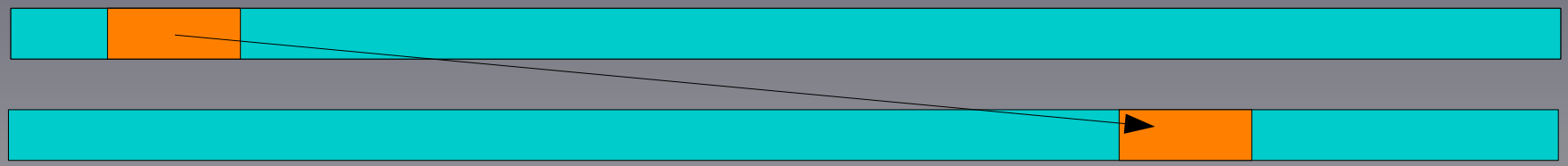
All higher organisms' DNA contains *transposons*: segments of DNA that can move from one place to another in the DNA

These transposons appear to have come from viral infections of very early organisms

Class I transposon (retrotransposon)



Class II transposon



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Freedom to evolve

The duplicated DNA usually contains one or more genes

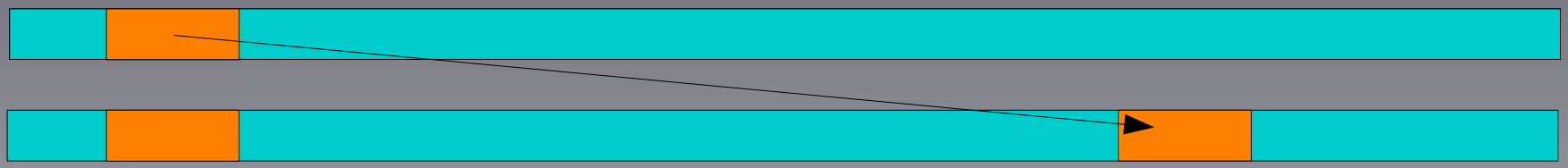
The second copy is not needed by the organism

It is free to mutate without harm to the organism

If it mutates into something useful to the organism, it may gain a new function

After enough copying and mutation has occurred, we have a new species

Class I transposon (retrotransposon)



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Chimp/Human Chromosomes

What do transposons tell us about Chimp/Human genetics?

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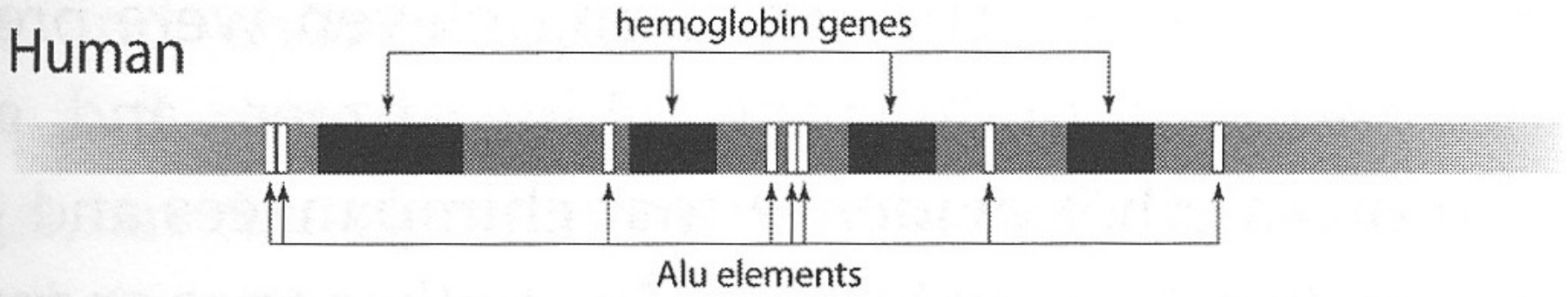
Chimp/Human Chromosomes

All primates have many copies of a transposon called ALU
The genes for hemoglobin in chimps and humans are common to both



All the transposons are the same except for point mutations

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Chimp/Human Chromosomes

The transposons are 98.9 to 94.7 percent the same in chimps and humans
This is what we would expect if chimps and humans have a common ancestor
The differences have accumulated over the time since the species diverged

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Chimp/Human Chromosomes

All primates have a transposon called HERV-K
How similar are fourteen different human HERV-K transposons in different primates?

- Three are found only in humans
- Eleven are found in humans, chimps, and gorillas
- Nine are found in orangutans
- Seven are found in gibbons
- Old World monkeys have four
- New World monkeys have two

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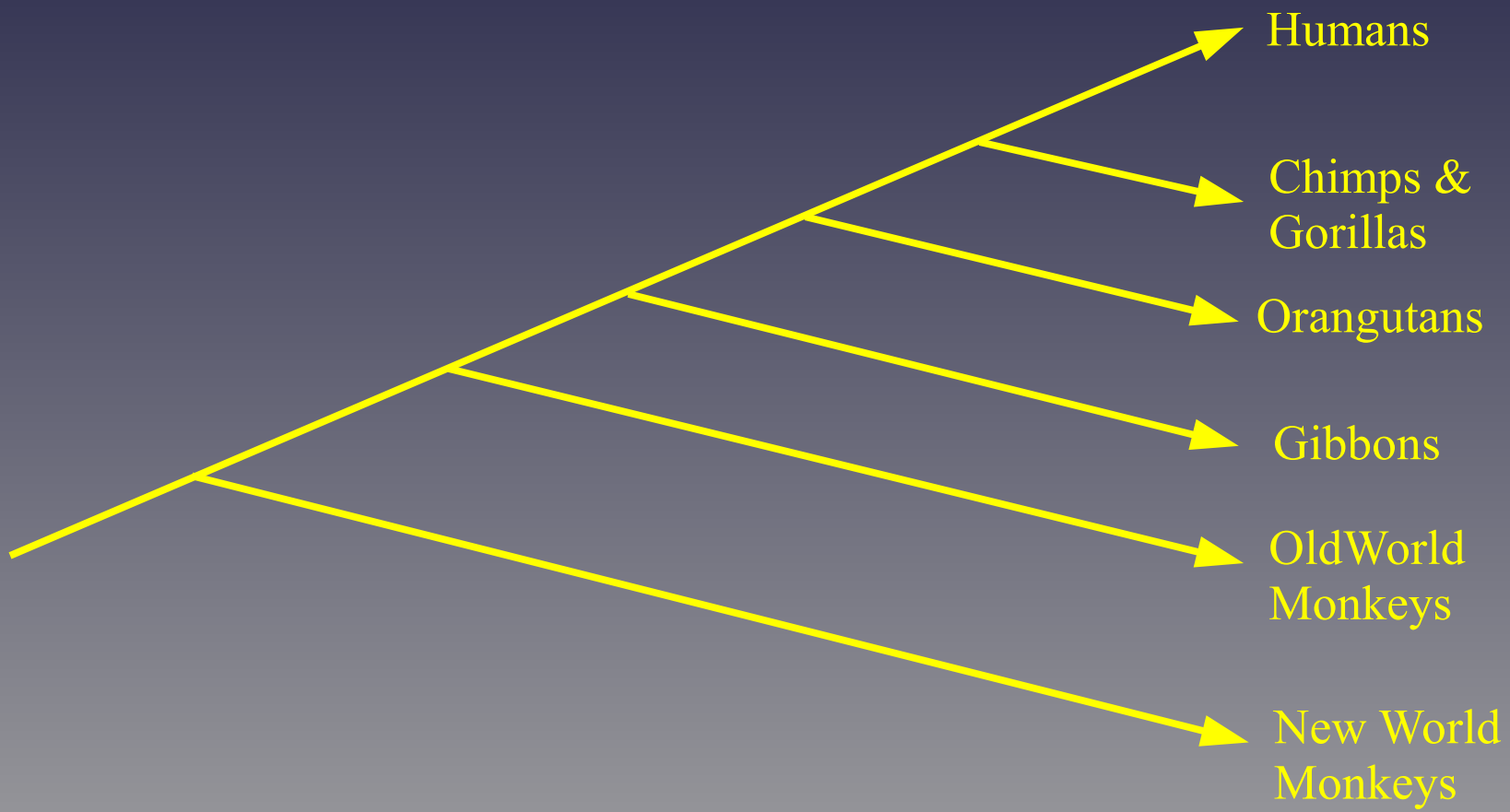
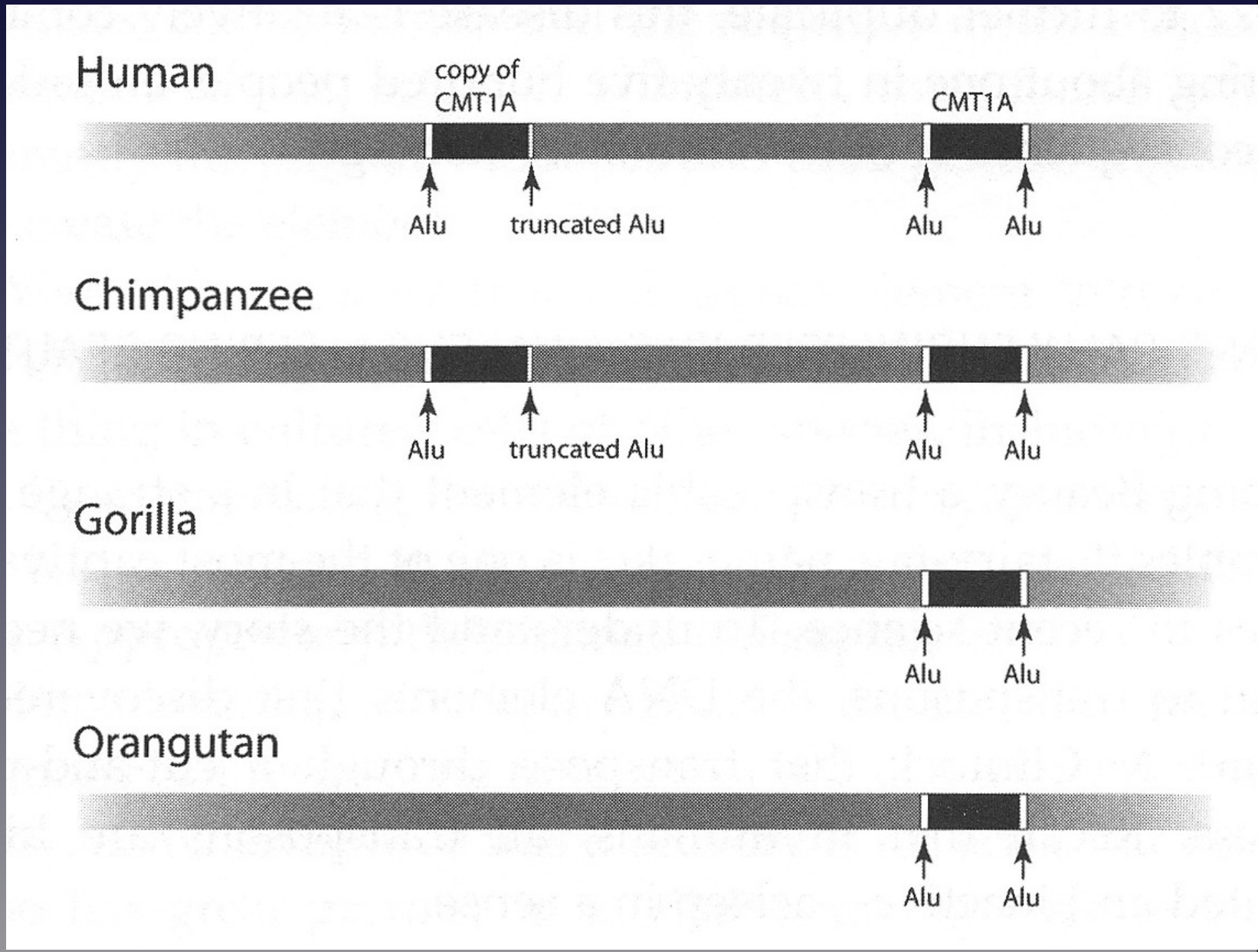
Chimp/Human Chromosomes

The HERV-K family tree
It is the same relationship discovered from other data before the HERV-K work was done



Another duplicated segment of DNA is CMT1A



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Many studies of transposable elements in primates show the relations expected if the present-day species followed a particular history of separation

Other genetic similarities and differences confirm those discussed here

Genetic studies of other species also show the expected relationships

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Is evolution a scientific fact?

We have discussed how fossils, chronological changes in the fossil record, physiologic similarities of species, genetics, geographic disposition, observable change, selection mechanisms, isolation mechanisms, human-controlled breeding, development of new species in lab conditions, and observation of change in species during the modern era are observations that point to evolution of living organisms

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Is evolution a scientific fact?

- Origin of all living species from one or a few original organisms is explained by the theory of evolution
- The many lines of evidence we have discussed and many others support the theory of evolution
- No well-established observation contradicts the theory
- Other theories do not explain the observations
- The Theory of Evolution is a Scientific Fact