

A3.1

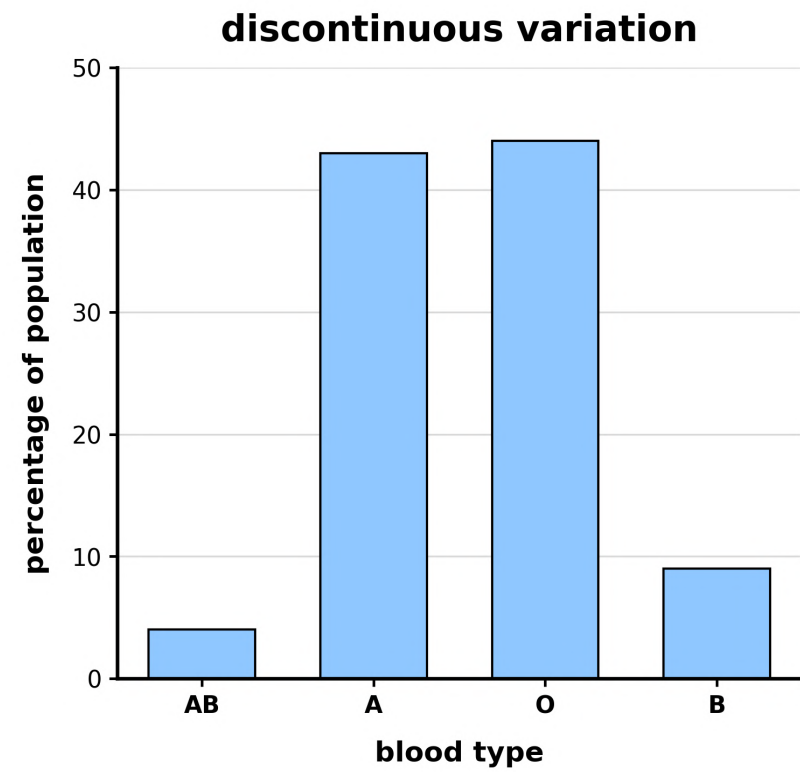
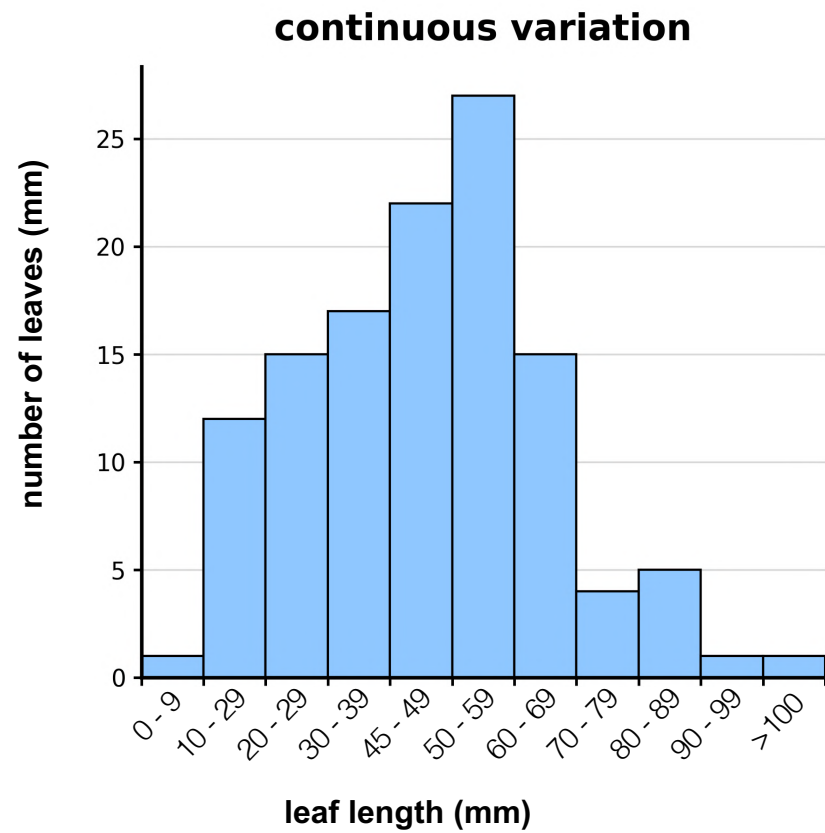
Diversity of Organisms

What is a species?

What patterns are seen in the diversity of genomes within and between species?



No two individuals in a population are identical in their traits.





There is amazing diversity.



Guarini



Leon Woods



Issara Tass



NSWNP



Kelly Abram



D.Gordon F. Robertson



Crimson Worm (*Hermes ilicis*)

Bernard Dupont

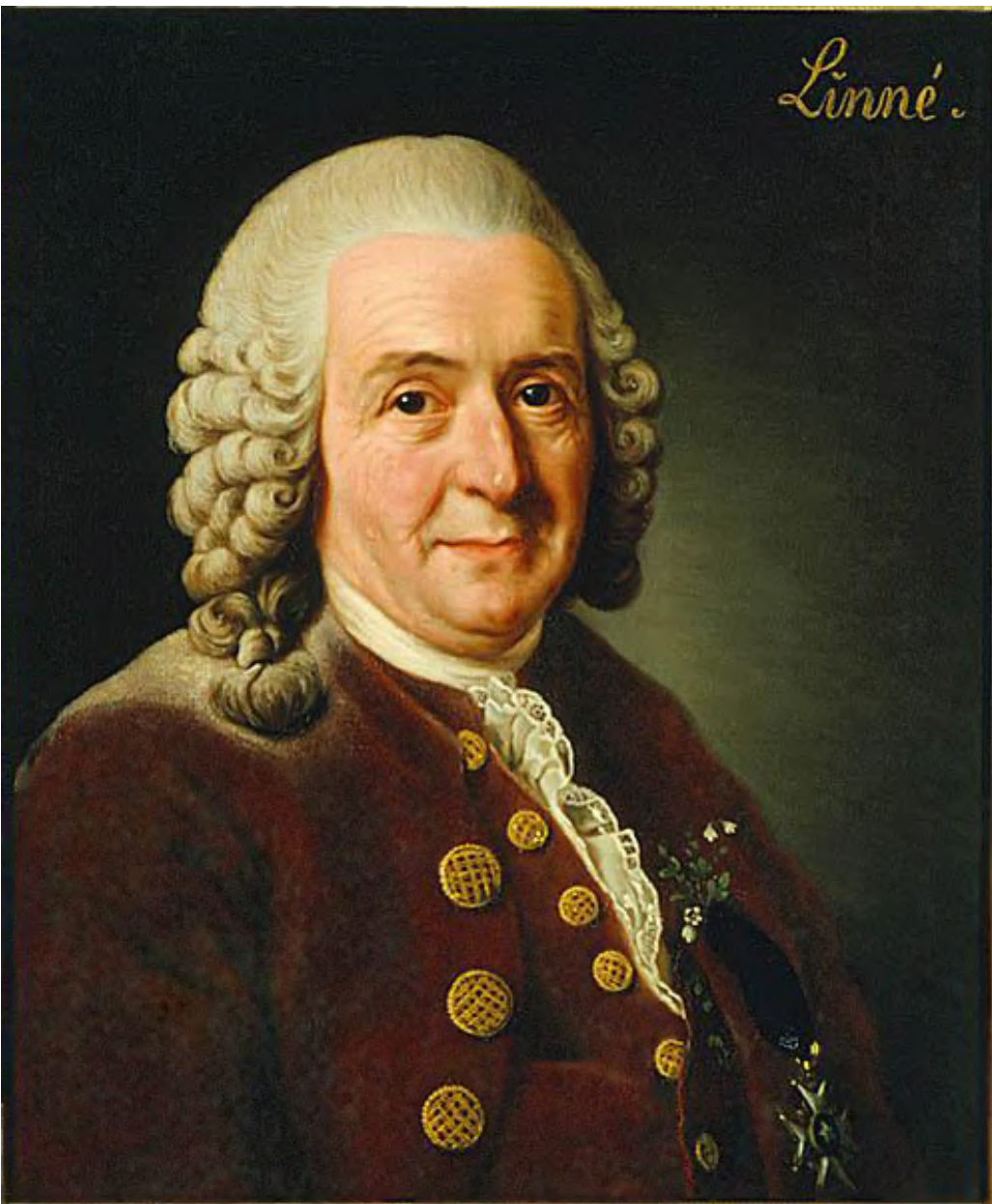


Tom D'Arby



mscra

Picasso moth (*Baorisa hieroglyphica*)



[Wikimedia](#)

Carl Linnaeus



[Perennial](#)



[Sylvia L. Insturatsky](#)

Twinflower *Linnaea borealis*



Strawberry (Fragaria) (1930) by Louis Charles Christopher Krieger. Original from U.S. Department of Agriculture Pomological Watercolor Collection. Rare and Special Collections, National Agricultural Library. Digitally enhanced by rawpixel.

Strawberry early description: *Fragaria foliis hirsutis, fructu parvo rubro*
Translation: strawberry with hairy leaves and small red fruit



[Wikimedia](#)

John Ray 1627 – 1705
Father of Natural History

John Ray was the first person to produce a biological definition of [species](#), in his 1686 History of Plants:

... no surer criterion for determining species has occurred to me than the distinguishing features that perpetuate themselves in propagation from seed. Thus, no matter what variations occur in the individuals or the species, if they spring from the seed of one and the same plant, they are accidental variations and not such as to distinguish a species... Animals likewise that differ specifically preserve their distinct species permanently; one species never springs from the seed of another nor vice versa.

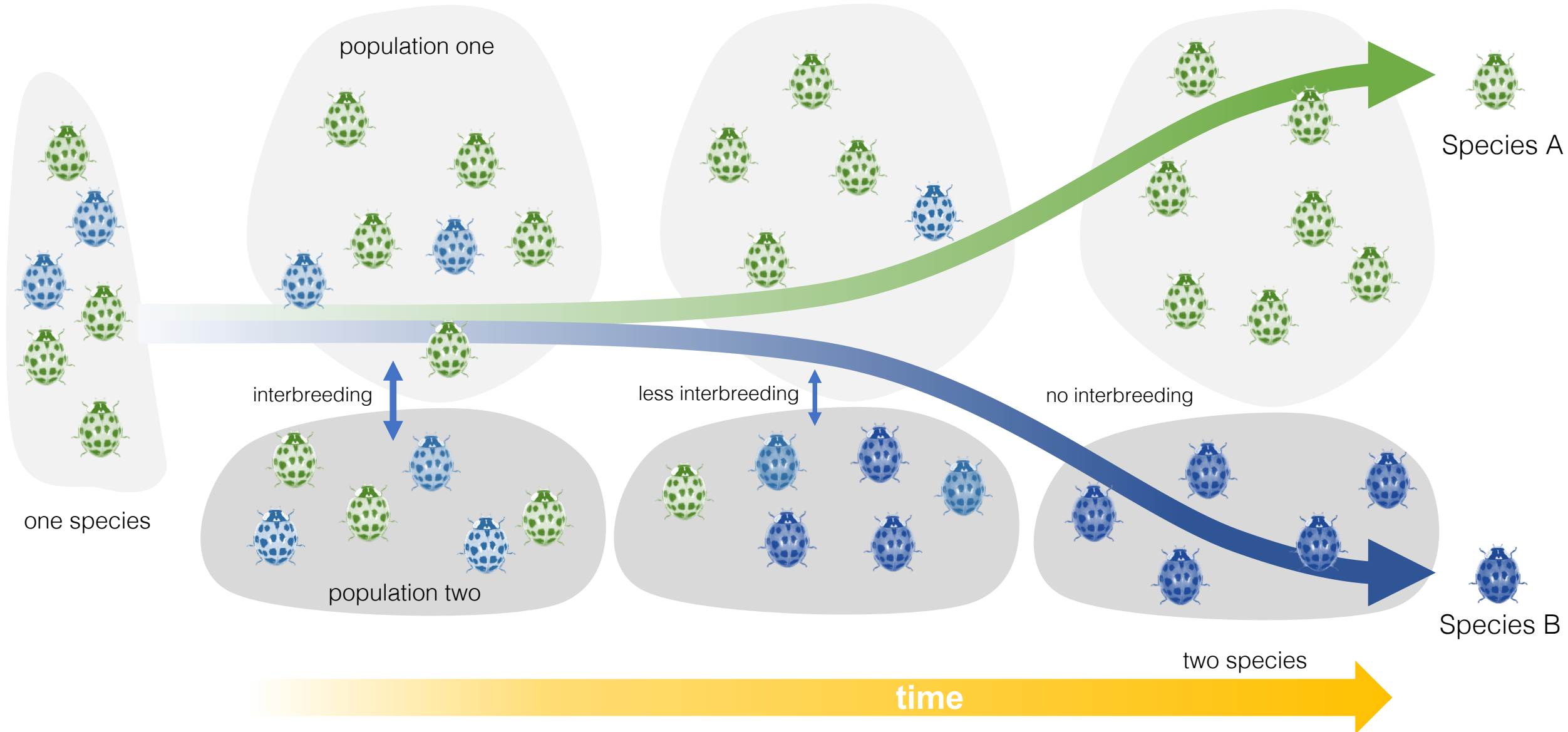
Today his species concept would fit the genus or family level of classification.

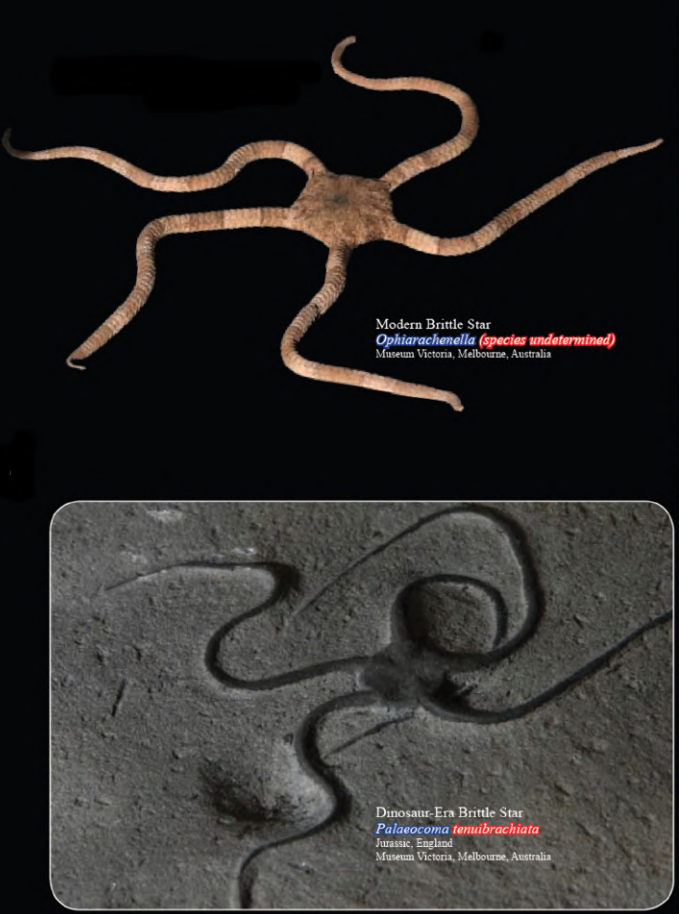
A **parson-naturalist** was a cleric, who often saw the study of natural science as an extension of his religious work. The philosophy entailed the belief that God, as the creator of all things, wanted humans to understand the created order and therefore to study them by collecting and classifying organisms and other natural phenomena.

*“Creator of elephants and atoms,
of whales and the living water dots!
I am amazed by the infinite diversity of designs your wisdom used to shape
every body of the animal, the bird, the fish, the insect, and the worm in a
different way!”*

Pastor Johann August Ephraim Goeze 1773

When does one population become a different species?





Modern Brittle Star
Ophiarachnella (species undetermined)
Museum Victoria, Melbourne, Australia

Dinosaur-Era Brittle Star
Palaeocomma tenuibrachyata
Jurassic, England
Museum Victoria, Melbourne, Australia

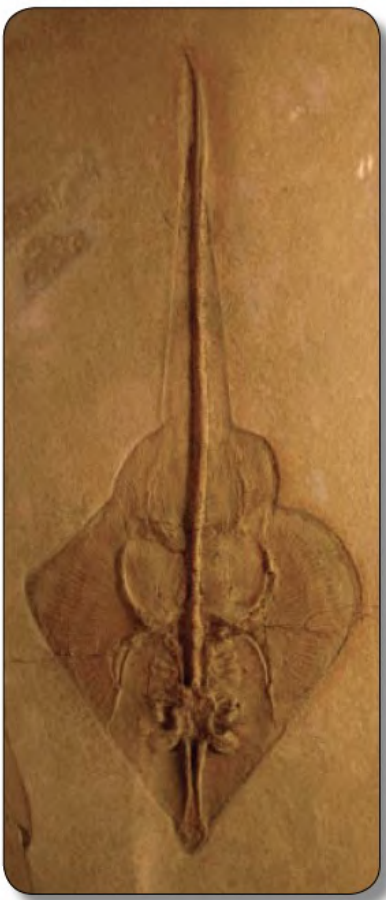


Fork-tailed Bush Katydid
Scudderia furcata
Missouri, USA²



"Extinct" Dinosaur-Era Insect
Pycnophlebia speciosa
Jurassic, Solnhofen, Germany
Jura Natural History Museum, Germany

Dinosaur-Era Ray
Belemnobatis sismondae
Jurassic, Solnhofen, Germany
Carnegie Museum of Natural History, USA

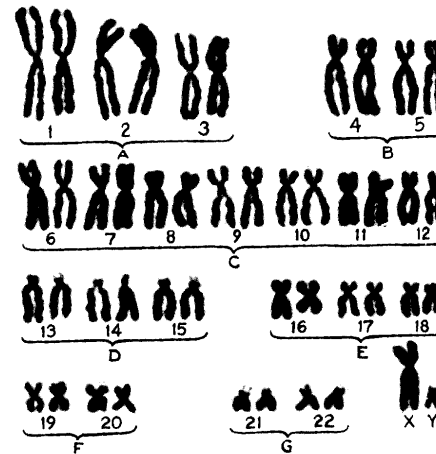
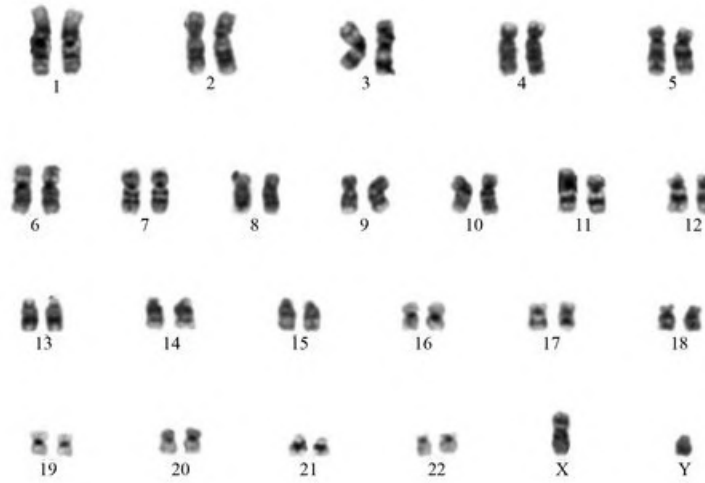


Modern Era Ray
Rhinobatos productus
Malibu, California, USA



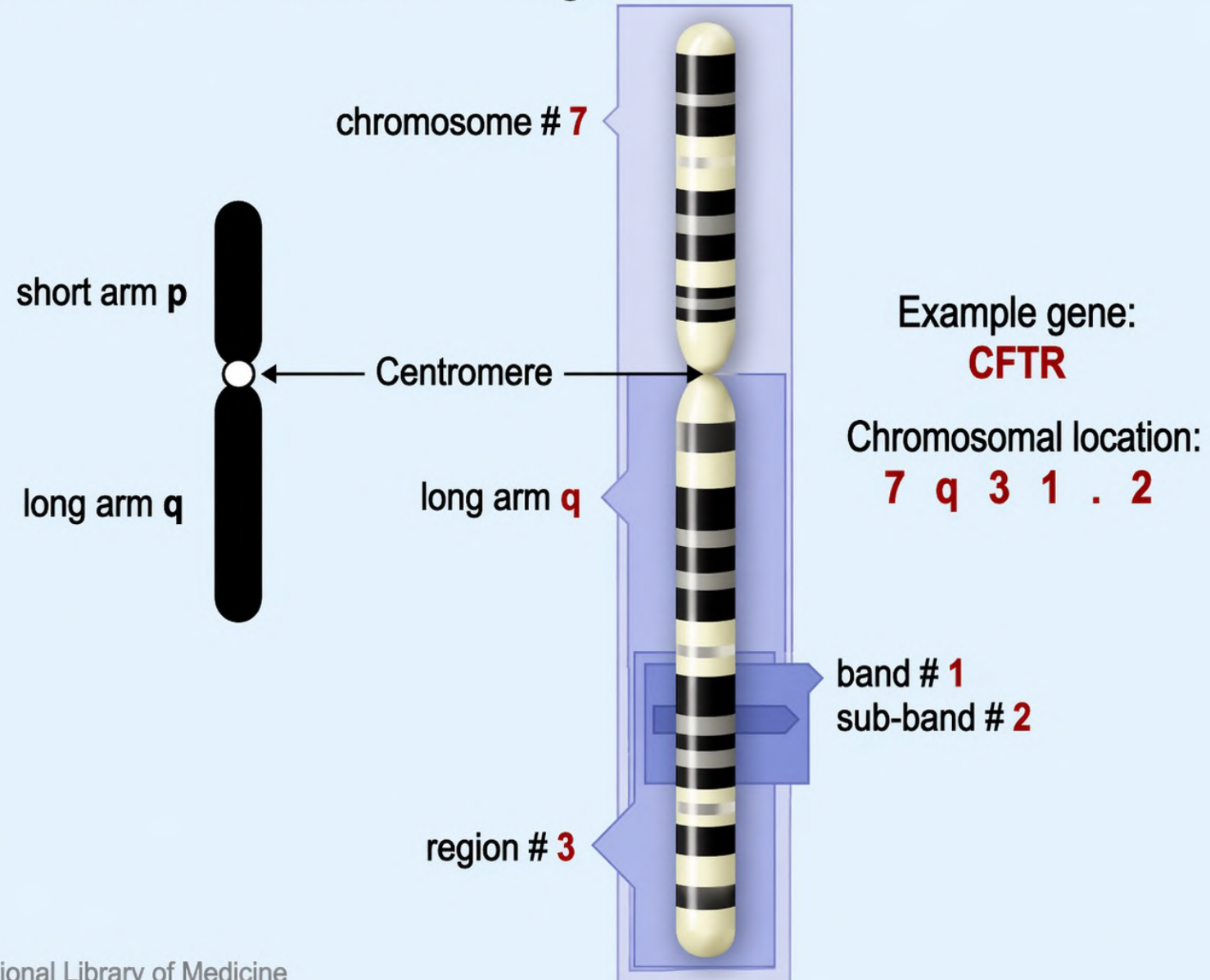
Werner 2009

Should each of these fossils be in a different *genus* from matching species alive today?
If they are separated by millions of years it is often assumed that they must be very different species.

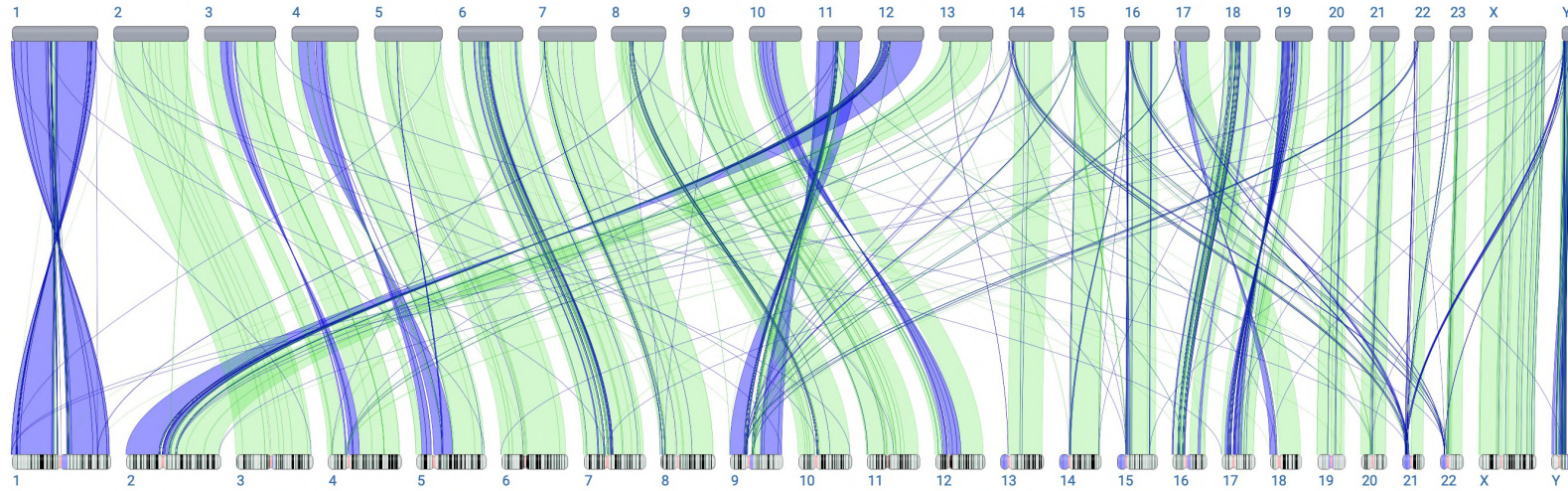


Although chromosomes may appear 'one armed' in their condensed state - they actually consist of two chromatids which separate at anaphase.

Chromosomal location of a gene



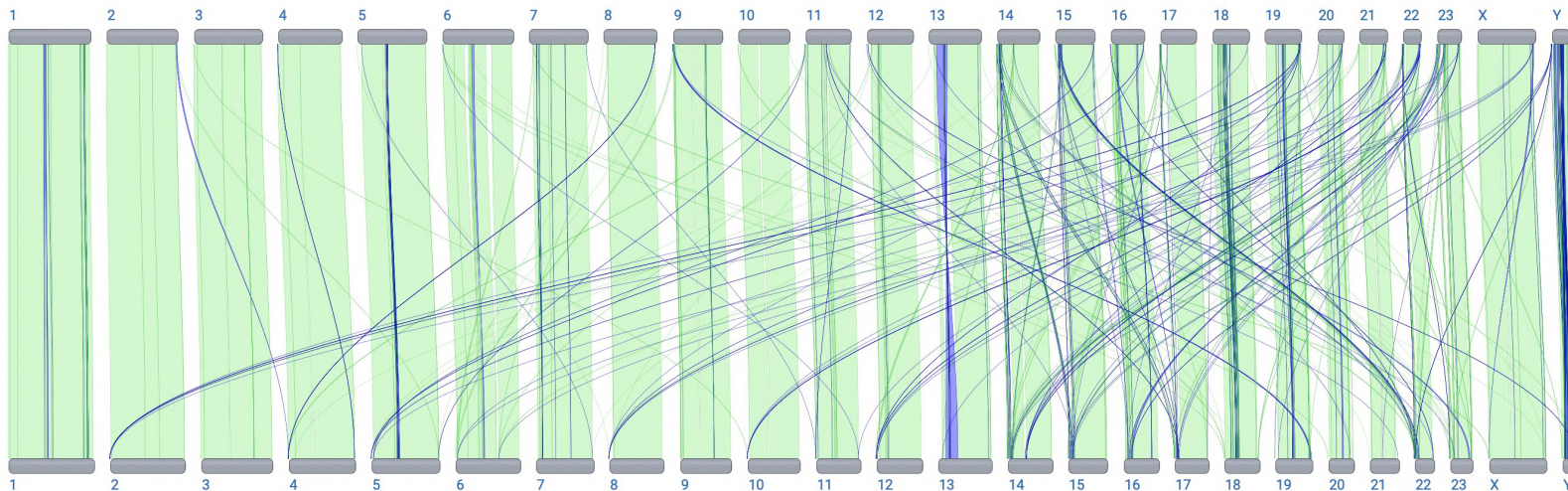
Pan troglodytes NHGRI_mPanTro3-v2.0_pri ([GCF_028858775.2](#))



Homo sapiens GRCh38.p14 ([GCF_000001405.40](#))



Pan paniscus NHGRI_mPanPan1-v2.0_pri ([GCF_029289425.2](#))



Pan troglodytes NHGRI_mPanTro3-v2.0_pri ([GCF_028858775.2](#))



Genome Alignment Comparison

Chimpanzee
to
Human

Most protein coding genes are in common and most are found in the same location. Note chromosomes 12 and 13 map well to human chromosome 2.

Genome Alignment Comparison

Bonobo
to
Chimpanzee

Green lines are genes found at the same locus.

Purple lines are genes in common but found in a different locus.

Low Confidence

1. Can't be repeated
2. Nobody witnessed actual event
3. Retrospective study
4. Clear opportunities for bias
5. Many assumptions are required
6. Overstated claims

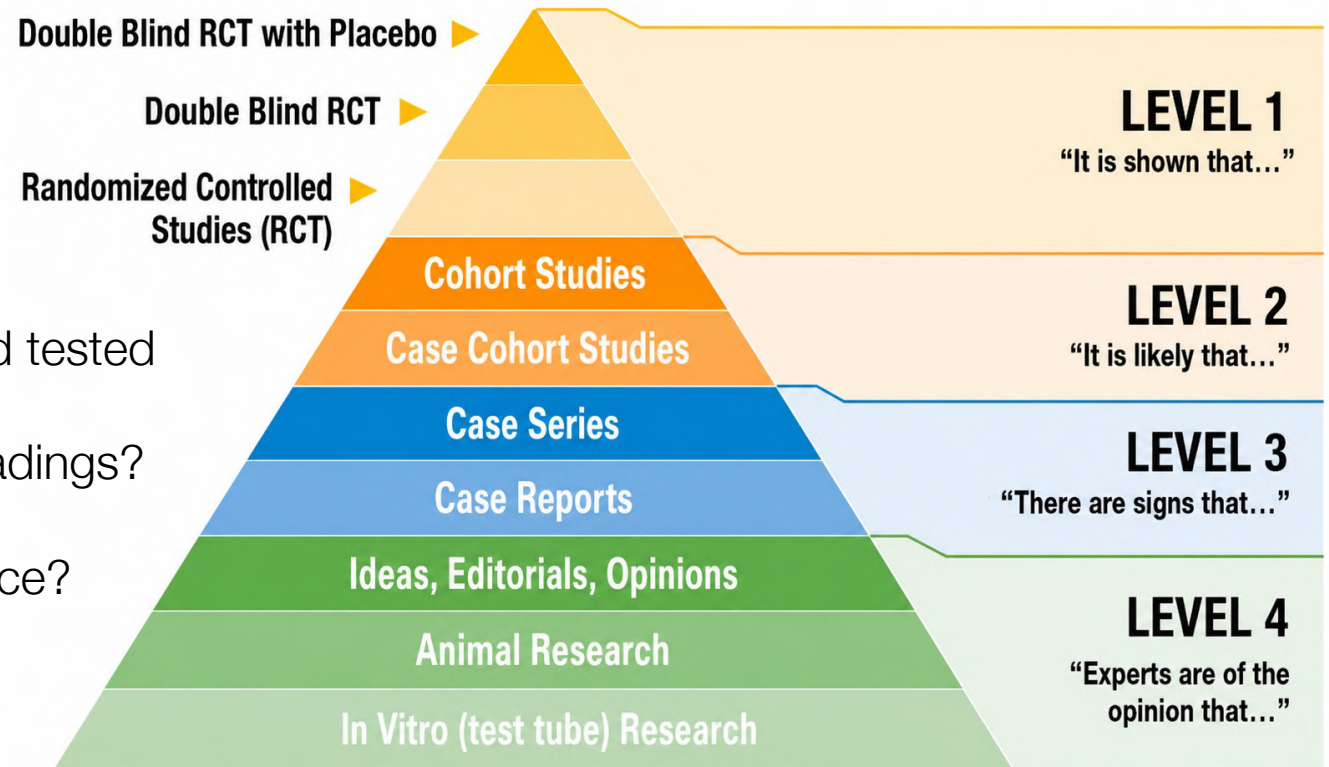
High Confidence

1. Repeatable
2. Directly observable
3. Prospective study
4. Careful to avoid bias
5. Careful to avoid assumptions
6. Reasonable claims

Evaluation of Evidence

Questions to consider:

- is the quantity of evidence sufficient?
- replication - has the method been repeated and tested by other researchers to confirm results?
- is the method reliable – size of error bars on readings?
- is there any valid conflicting evidence?
- is there a logical explanation or is it a coincidence?
- what money, fame, or worldviews are involved?





[Masao et al 2016](#)

Who or what made these bipedal tracks at Laetoli Site S?

The foot prints fall within the variation made by human foot prints with a clear heel strike, arch foot and big toe in line with the foot for a big toe push off.

NOS Testable Fossil Evidence

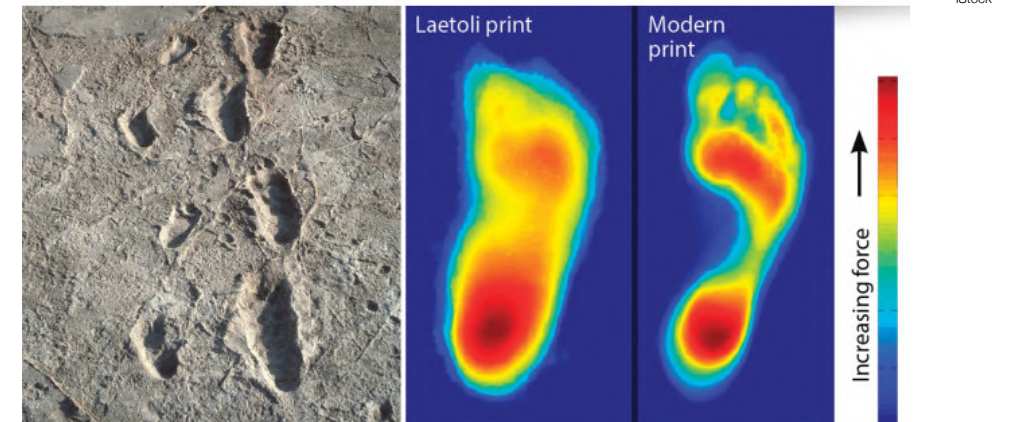
The hominid fossil called Lucy (*Australopithecus afarensis*) was found in Ethiopia in 1974. The name Lucy is sometimes used to refer to all *A. afarensis* skeletons. No complete *A. afarensis* skeletons have been found – allowing much room for speculation. Hominids are bipedal. Lucy has an interesting mix of features for tree climbing and walking upright on two legs. Bones can be tested to see if they are male or female, juvenile or adult and for brain size. Teeth can indicate diet. Behaviour, creativity and language are more difficult to test for this species.

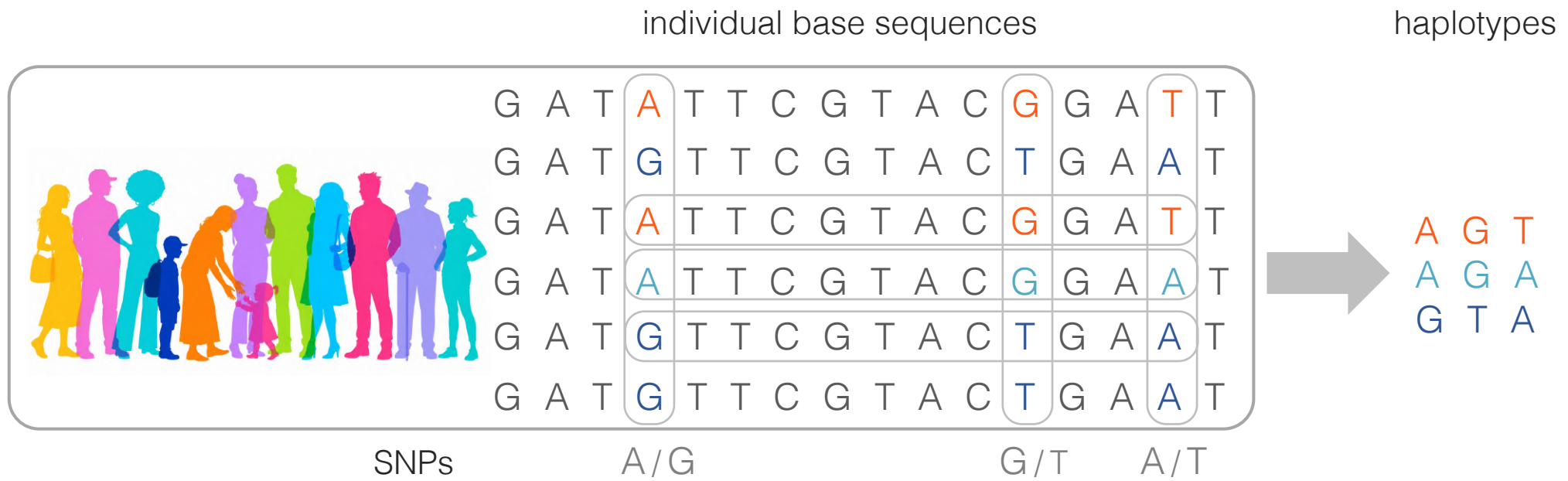
Lucy had:

- o long arms and a wrist that could lock in place for knuckle walking
- o balancing organs of the ear are aligned for climbing and partly bipedal
- o curved finger bones and shoulders made for swinging in the trees
- o femur slanted in towards the knee suggests an upright stance
- o long and curved toe bones for grasping trees – debate remains over big toe alignment
- o an isolated foot bone unattached to any skeleton reveals an arched foot?
- o a hyoid bone of the larynx indicates a voice box similar to an ape
- o a brain the same size and shape as a chimpanzee
- o a nose and muzzle like an ape, no chin, a sagittal crest in males
- o dental microwear reveal a diet of soft foods like fruit, leaves, insects
- o broken ribs suggest Lucy's particular skeleton may have died from a fall

Some believe that *A. afarensis* made the Laetoli footprints 3.6MYA. If assumptions behind dating methods are correct then habitual up-right walking evolved unexpectedly early.

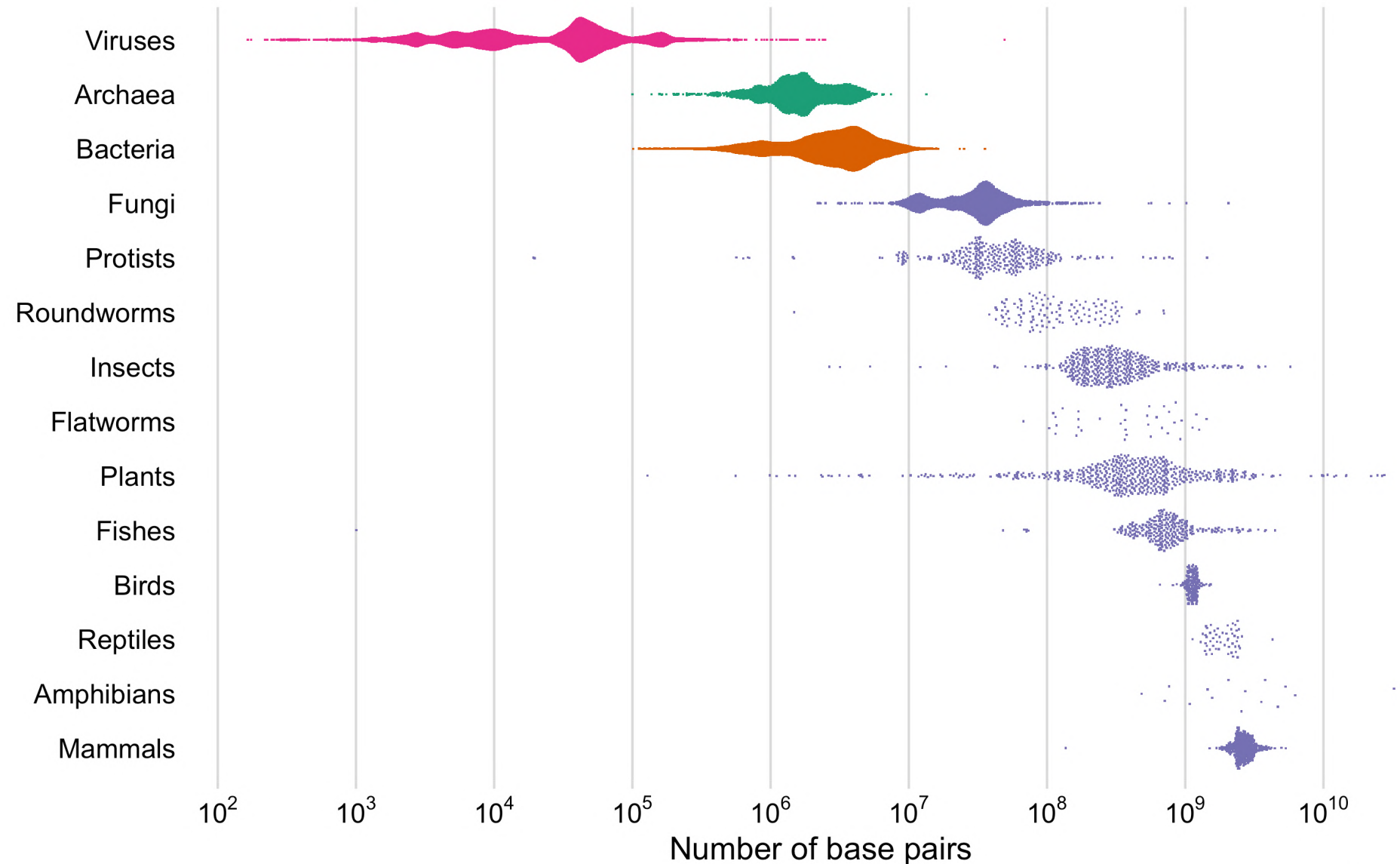
The field of human evolution has attracted more funding, fame and interest than other fossils types. Since Darwin's time more than 200 species of ape-human intermediates have been overturned.





adapted from IDT

Genome size



Data source: National Center for Biotechnology Information

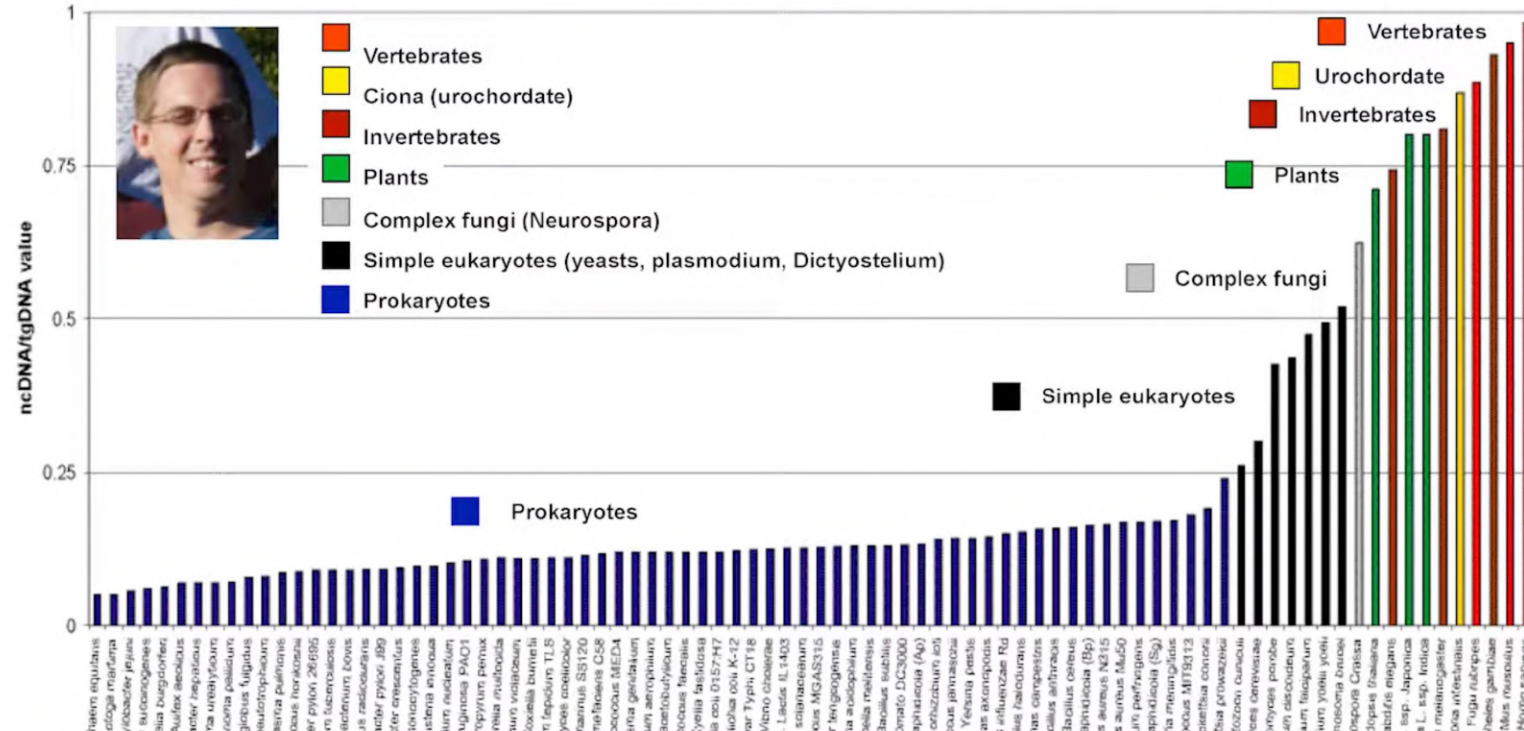
[Tom White](#)

Eukaryotes are shown in purple.

This visualization uses a bee-swarm plot, which shows each data point separately, as well as indicating the distribution.

An amphibian the axolotl has one of the largest genomes by size.

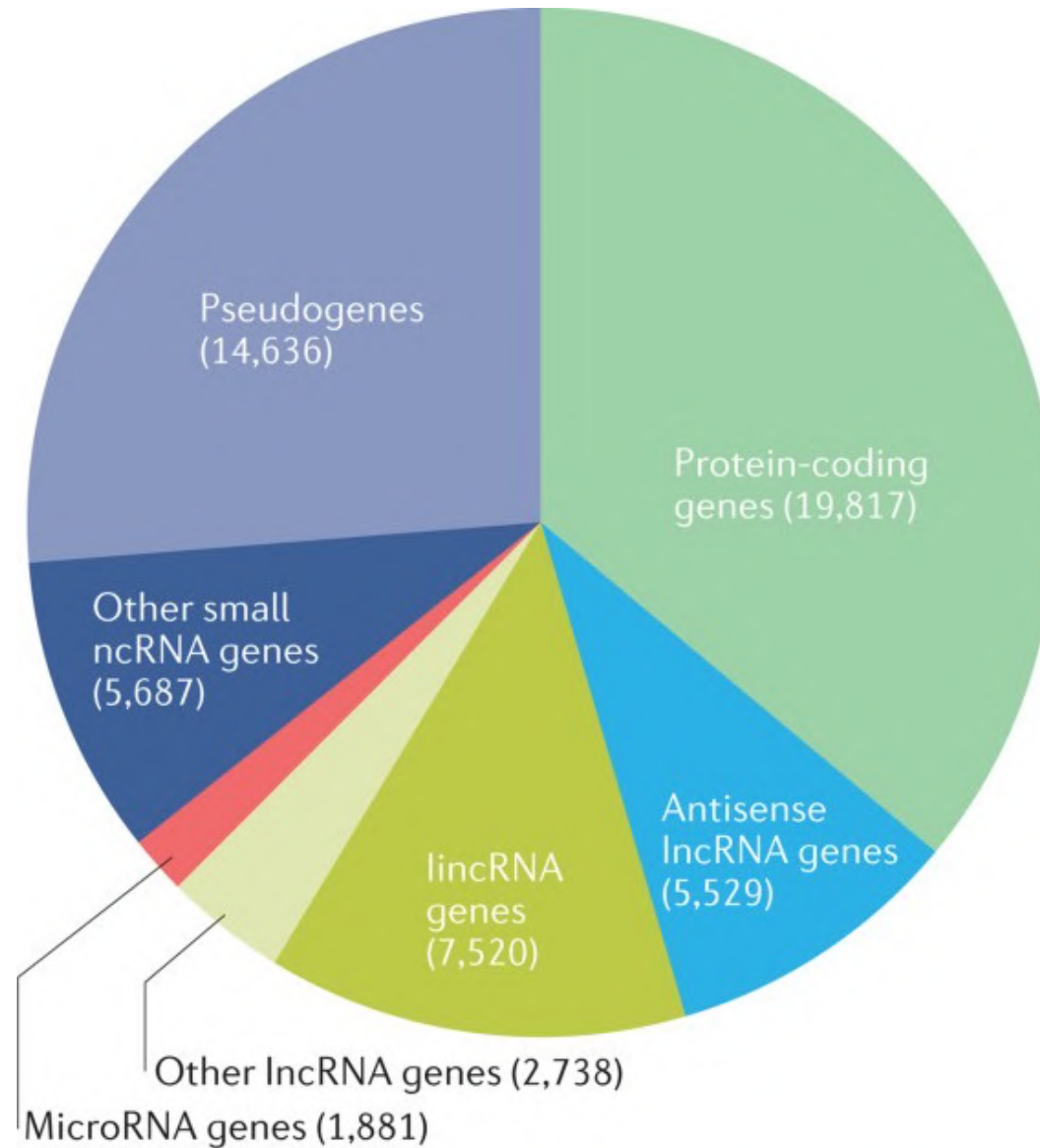
The proportion of noncoding DNA increases with developmental complexity



Irrespective of the extent of non-coding sequences, the vast majority of the genomes of complex organisms is dynamically and differentially transcribed in different cells and tissues at different developmental stages.

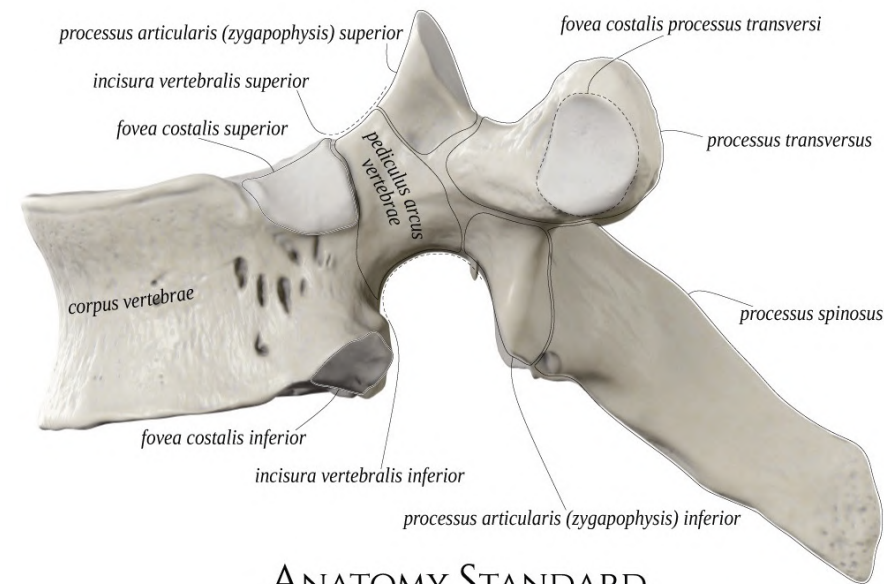
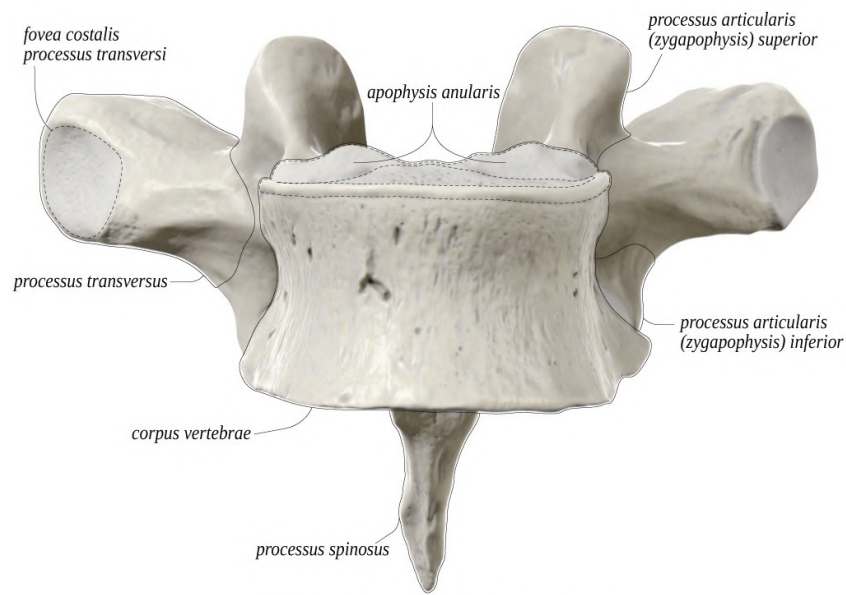
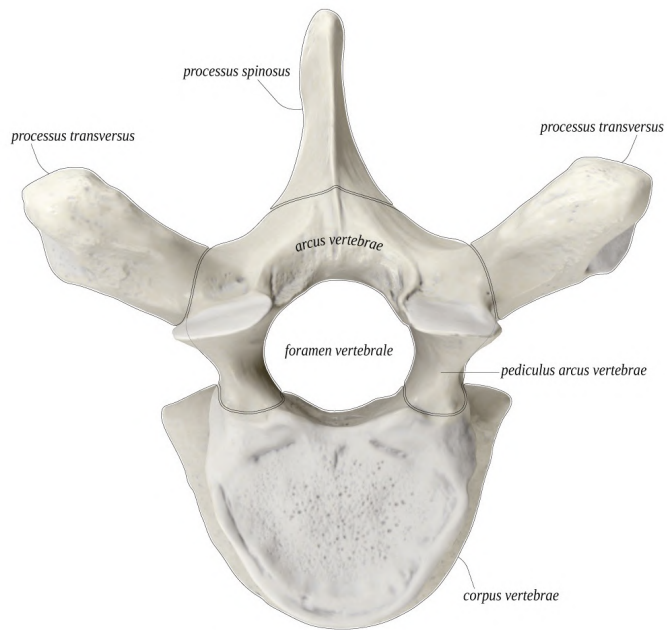
Either there is an enormous amount of useless transcription or there is another layer of genetic information transacted by RNA, which expands in complex organisms.

[via John Mattick presentation](#)



It is now realized that non-coding regions have an important regulatory role to play in the genome.

[Salta and Strooper 2017](#)

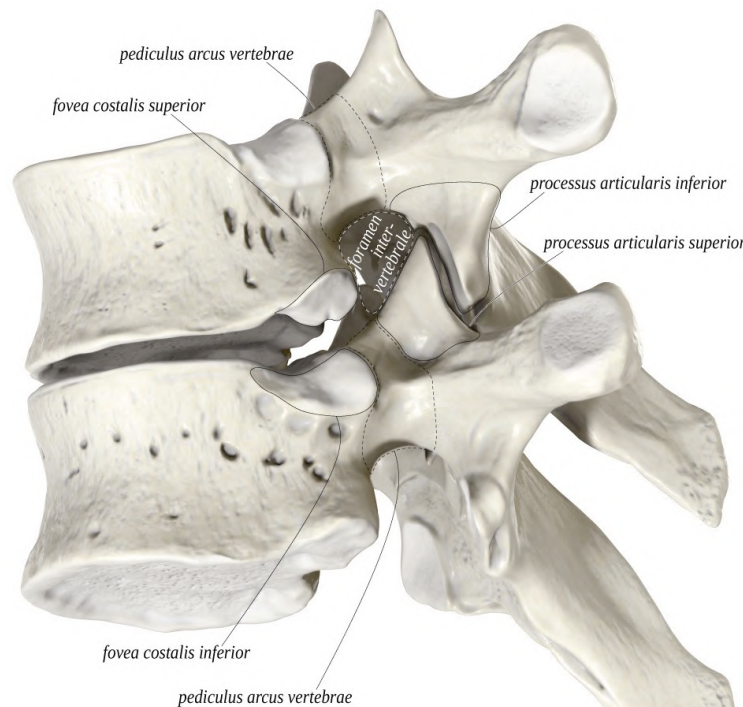


ANATOMY STANDARD

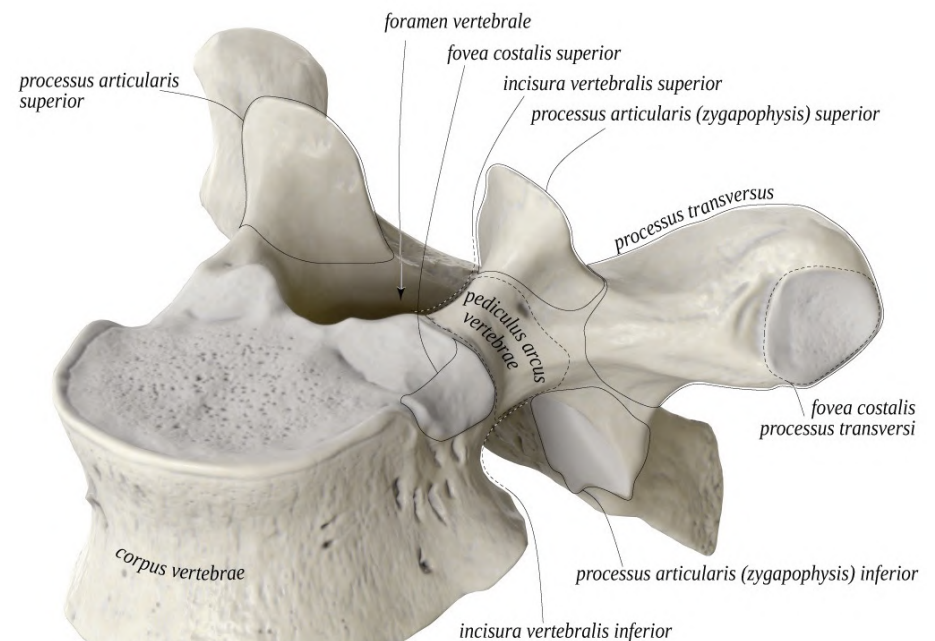
From a zygote to 30 trillion adult body cells.

Each cell is directed by non-coding RNA to develop in the right place at the right time into the right cell.

Bone tissue is precisely shaped – and can adapt to local stresses throughout the life of the individual.



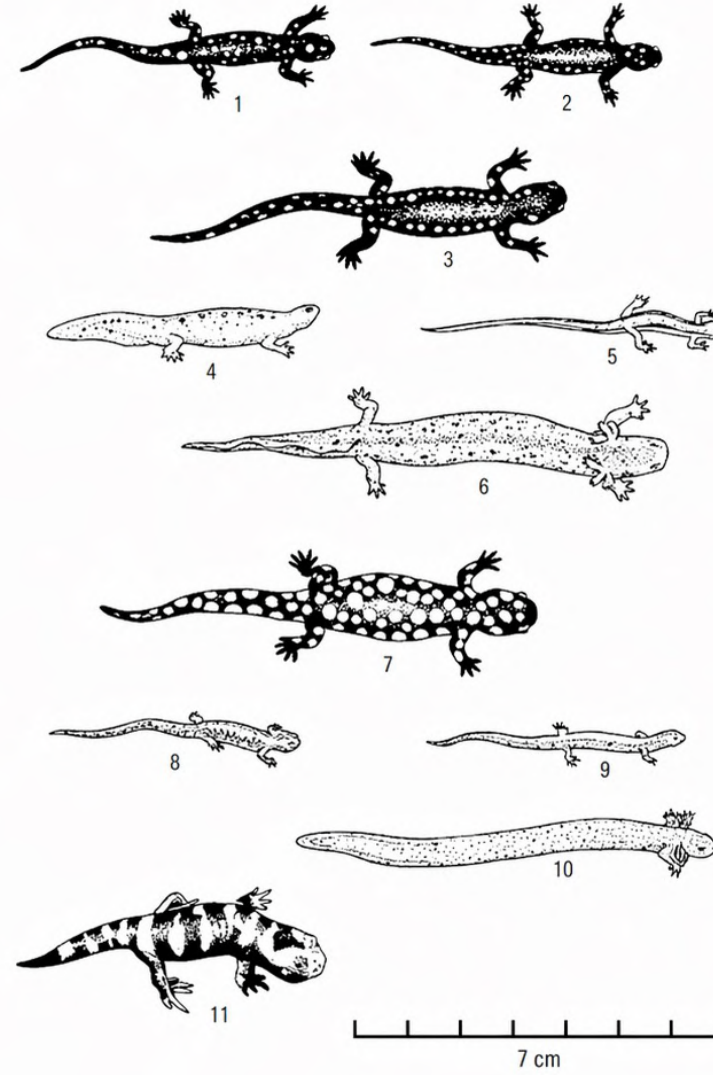
ANATOMY STANDARD



Savlovskis and Raits anatomystandard.com

Salamander Dichotomous Key

- 1 a Hind limbs absent*Siren intermedia*
b Hind limbs presentGo to 2
- 2 a External gills present in adults*Necturus maculosus*
b External gills absent in adultsGo to 3
- 3 a Large size (over 7 cm long in Figure 1)Go to 4
b Small size (under 7 cm long in Figure 1)Go to 5
- 4 a Body background black, large white spots variable in size completely covering body and tail*Ambystoma tigrinum*
b Body background black, small round white spots in a row along each side from eye to tip of tail*Ambystoma maculatum*
- 5 a Body background black with white spotsGo to 6
b Body background light color with dark spots and/or lines on body....Go to 7
- 6 a Small white spots on black background in a row along each side from head to tip of tail*Ambystoma jeffersonianum*
b Small white spots scattered throughout a black background from head to tip of tail*Plethodon glutinosus*
- 7 a Large irregular white spots on a black background extending from head to tip of tail*Ambystoma opacum*
b No large irregular black spots on a light backgroundGo to 8
- 8 a Round spots scattered along back and sides of body, tail flattened like a tadpole*Triturus viridescens*
b Without round spots and tail not flattened like a tadpoleGo to 9
- 9 a Two dark lines bordering a broad light middorsal stripe with a narrow median dark line extending from the head onto the tail...*Eurycea bislineata*
b Without two dark lines running the length of the bodyGo to 10
- 10 a A light stripe running the length of the body and bordered by dark pigment extending downward on the sides*Plethodon cinereus*
b A light stripe extending the length of the body without dark pigment on the sides.....*Hemidactylium scutatum*



Optional Extension (not required for IB exams)



[Petr Gajda](#)

Optional Extension (not required for IB exams)



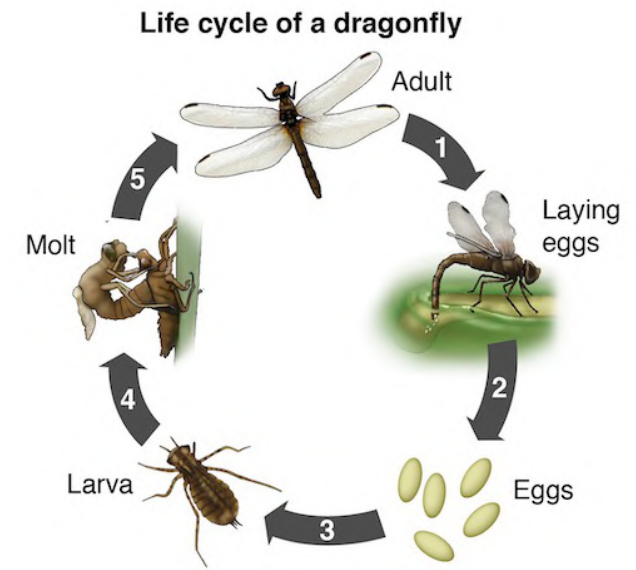
Dragonflies appear suddenly in the fossil record 250-300MYA – many existing species are also found largely unchanged in the fossil record.

[Gunter Bechly](#)

Optional Extension (not required for IB exams)



Natural History Museum London

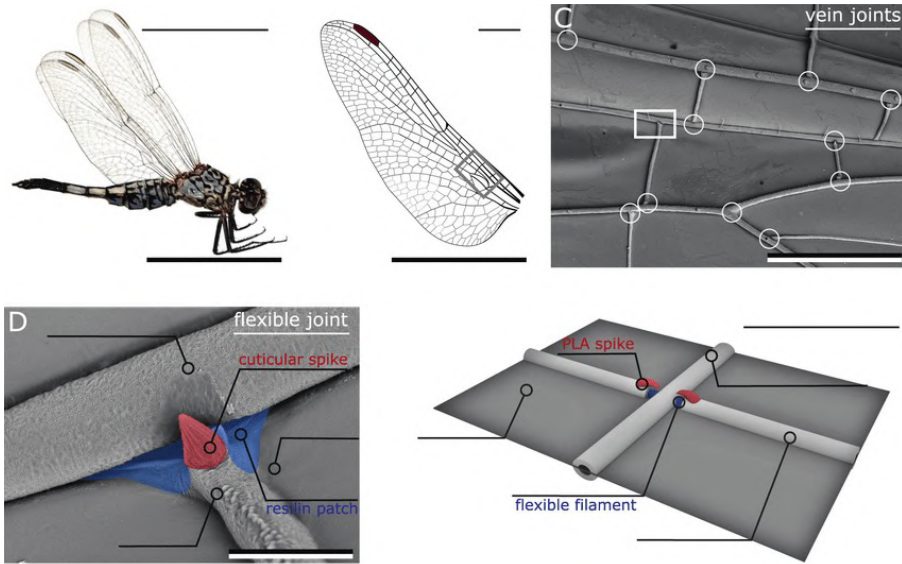


Some insects have gills as larva then after metamorphosis the adult has spiracles. How did this strange jump in lifecycle development evolve gradually?

The pterostigma adds mass to act as a damper to prevent wing vibrations and fluttering.

The wings get lift on the down and up stroke.
The eyes have up to 30 000 individual sections.

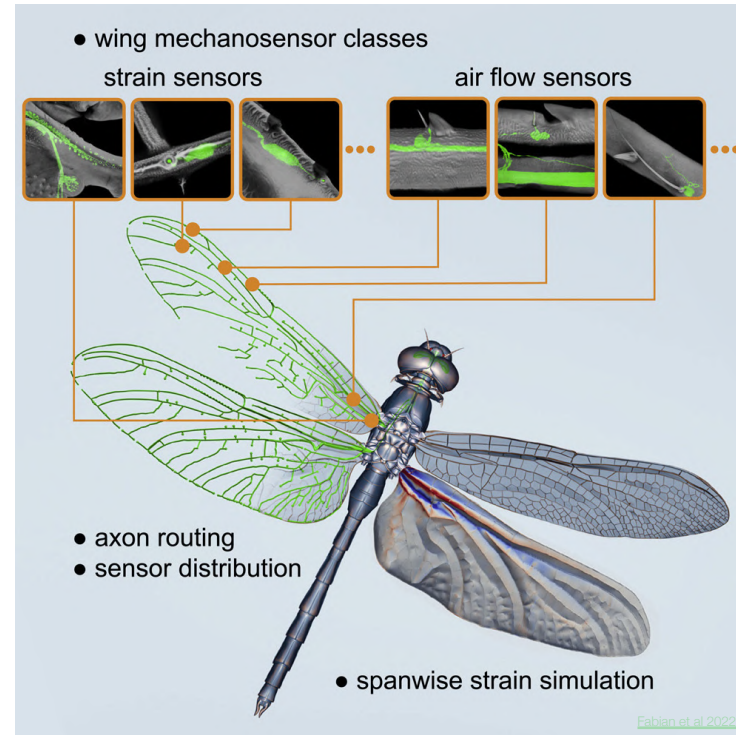
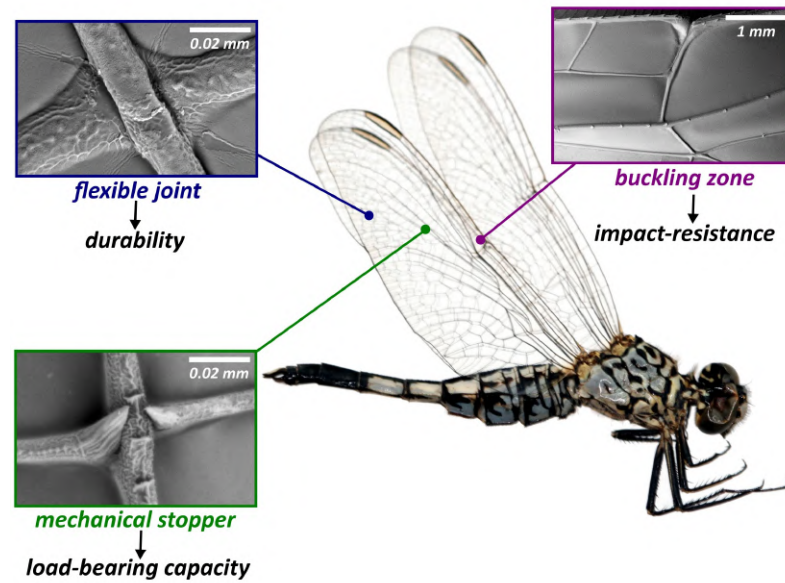
Optional Extension (not required for IB exams)



From inspiration to design.

- (A) An image of the dragonfly *Acisoma panorpoides*.
- (B) Hind wing of the dragonfly. Rectangle shows area in (C).
- (C) A SEM image showing vein joints. Rectangle shows area in (D).
- (D) A SEM image of a flexible joint with a spike and a resilin patch.
- (E) Designed joint consists of flexible filaments at the interval of the reinforcing elements and two stiff spikes on the cross elements.

Scale bars: 15 mm (A), 10 mm (B), 2 mm (C), and 0.05 mm (D)

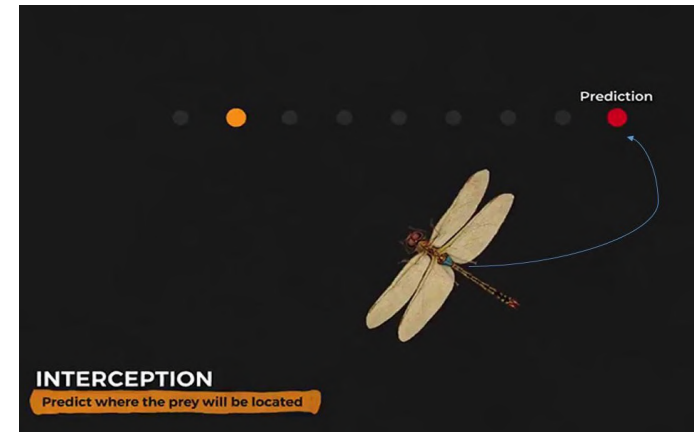


biomimetics - drawing inspiration from nature to invent new technology



iStock

Ocelli (3 smaller eyes) have limited resolution but very high contrast and processing speed to detect the horizon during high speed flight.



Interception in humans is a learned behaviour, in dragonflies however, it's believed that it's hardwired into their nervous system and motor system directly.

Optional Extension (not required for IB exams)



iStock

Optional Extension (not required for IB exams)



[Drawing Tutorial](#)

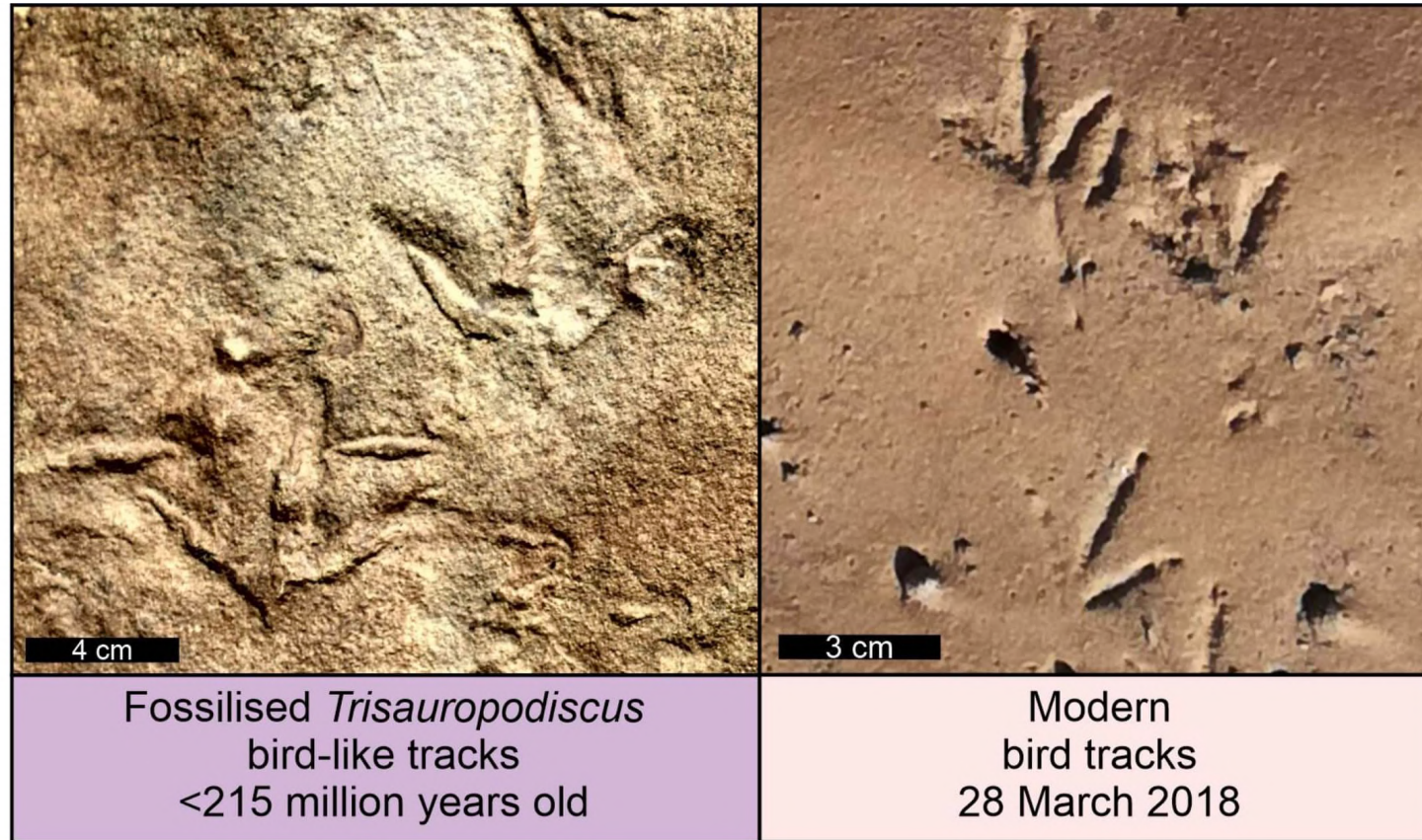
Also see
[Richard Lewington Illustrator](#)

Optional Extension (not required for IB exams)



[Matt Mochlyav Wikimedia](#)

Optional Extension (not required for IB exams)



[Abrahams and Borden 2023 Plos One](#)

The *temporal paradox* identified by bird paleontologist Alan Feduccia is that early fossil birds are older than their assumed theropod dinosaur ancestors. This is explained by a theropod *ghost lineage* – a large span of time where species leave no fossil record. In due course the fossil evidence should be found. However, some bird footprints appear to have been found even earlier in the fossil record than predicted making this paradox worse.

*“These footprints are something of a mystery:
fossils for even the earliest bird ancestors don’t show up for another 60 million years.”*
David Nield [2023](#)

The Lamb – William Blake

*Little Lamb who made thee
Dost thou know who made thee
Gave thee life & bid thee feed,
By the stream & o'er the mead;
Gave thee clothing of delight,
Softest clothing wooly bright;
Gave thee such a tender voice,
Making all the vales rejoice;
Little Lamb who made thee
Dost thou know who made thee*

*Little Lamb I'll tell thee,
Little Lamb I'll tell thee;
He is called by thy name,
For he calls himself a Lamb:
He is meek & he is mild,
He became a little child:
I a child & thou a lamb,
We are called by his name.
Little Lamb God bless thee.
Little Lamb God bless thee.*



[Frauke Rietter](#)

