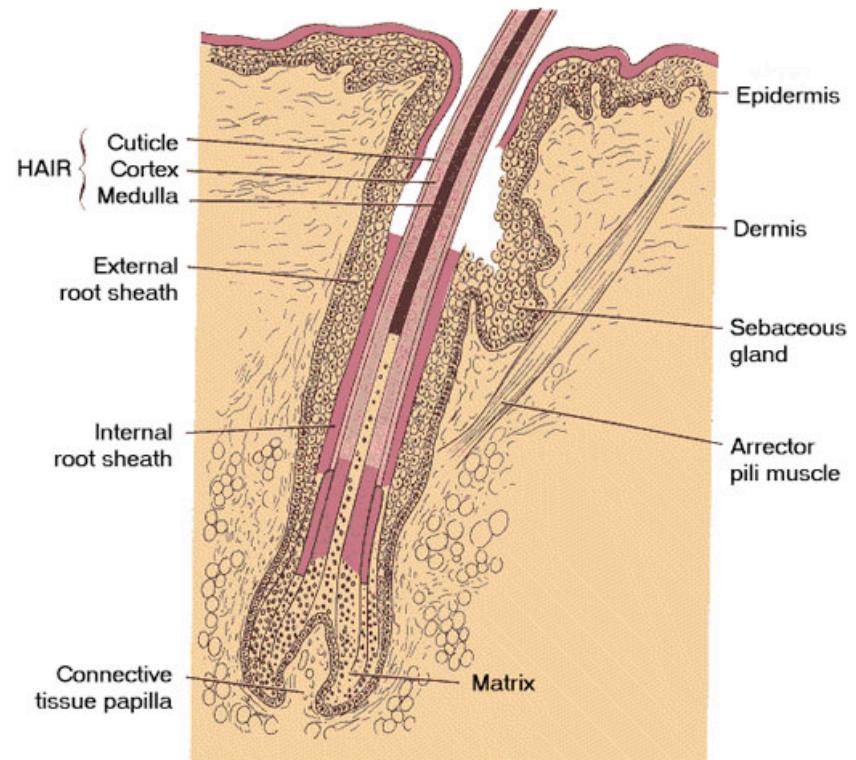


EVOLUTION & ADAPTATION (EEB214S) 2012

Lecture 4: Evidence for Evolution

Remnants: embryos, vestiges and bad design



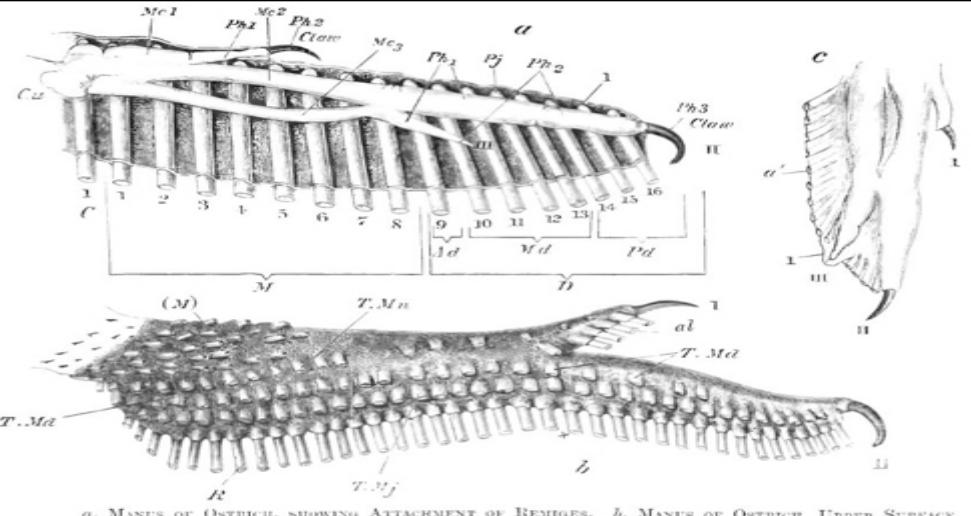


How can we explain the existence of ear wiggling and goose-bumping?

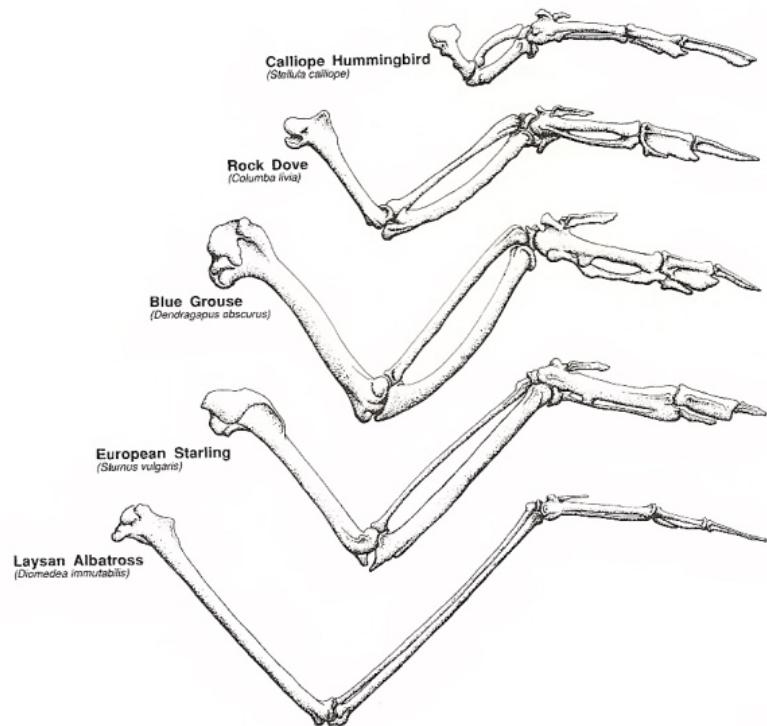
“Nothing in biology makes sense except in the light of evolution”
--Theodosius Dobzhansky

A trait is **vestigial** not because it is functionless, but because it no longer performs the function for which it originally evolved

e.g. the wings of an ostrich have a function, but they originally evolved for flight. Look at the bones in the wing, they are the same as those in the wings of birds that fly.



a. MANUS OF OSTRICH, SHOWING ATTACHMENT OF REMIGES. b. MANUS OF OSTRICH, UPPER SURFACE, SHOWING REMIGES AND COVERTS. c. DIGITS OF EMBRYO, SHOWING REMIGES AND COVERTS. (AFTER WRAY.)
Mc1-3, metacarpals; Ph_n, phalanges; I-III, digits; C, carpal remex; M, metacarpal remiges; D, digital remiges; Al, albuligitals; al, alula spuria; a', tectrices majores.



Darwin noted: “an organ rendered, during changed habits of life, useless or injurious for one purpose, might easily be modified and used for another purpose”

Vestigial traits demand us to ask:

- Why did it lose its function? (Hint: Islands)
- Why hasn't it disappeared completely? Co-opted?



New Zealand Kiwi



Could natural selection favour winglessness?

- Evolution - simply means that a species undergoes heritable change over time.
- Natural Selection - if individuals within a species differ from one another, and some of differences affect an individual's ability to survive and reproduce, then they will leave more descendants, and ultimately increase in frequency in the population.
- Gradualism - it takes many generations to produce substantial evolutionary change, true some are quick (think drug resistance), but the really big changes (think the emergence of birds from reptiles), well, it takes some time.
- Common Ancestry - if we look back in time we (say using the fossil record) we will find that the animals and plants at the tips -- the descendants lineage -- fuse at their ancestors
- Speciation - a splitting process in which a new species is formed from an initial one.

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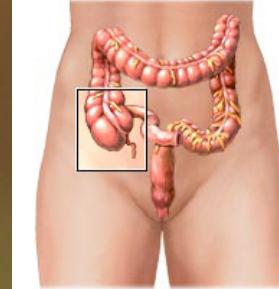
New Zealand Kiwi



Other examples?

Other examples:

Firefly



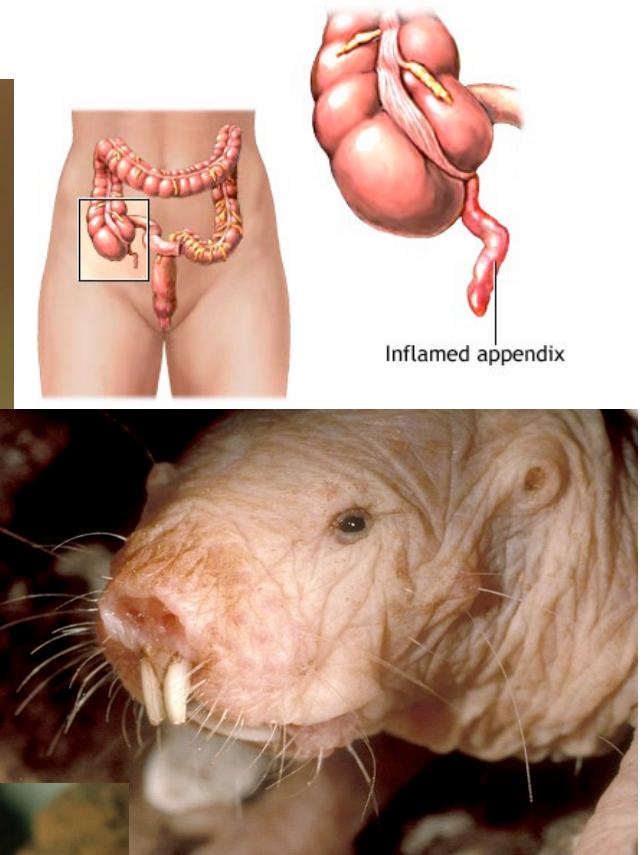
Inflamed appendix



Mole rats

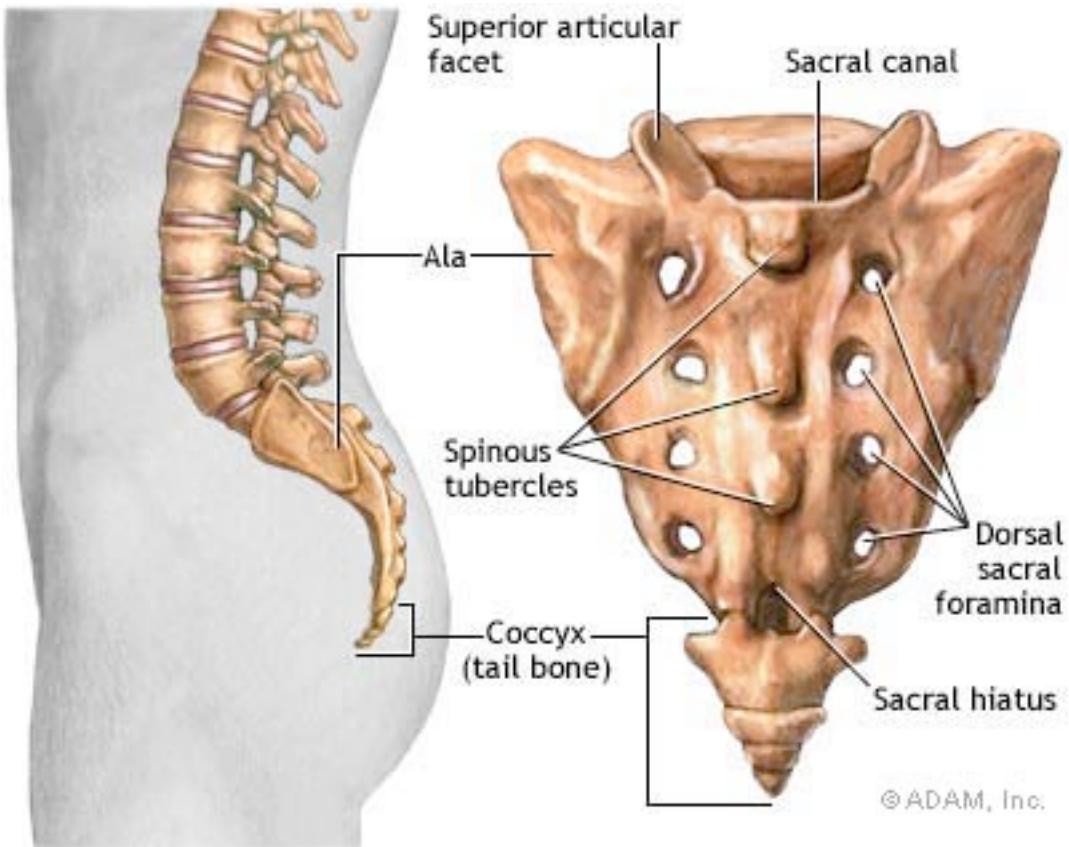
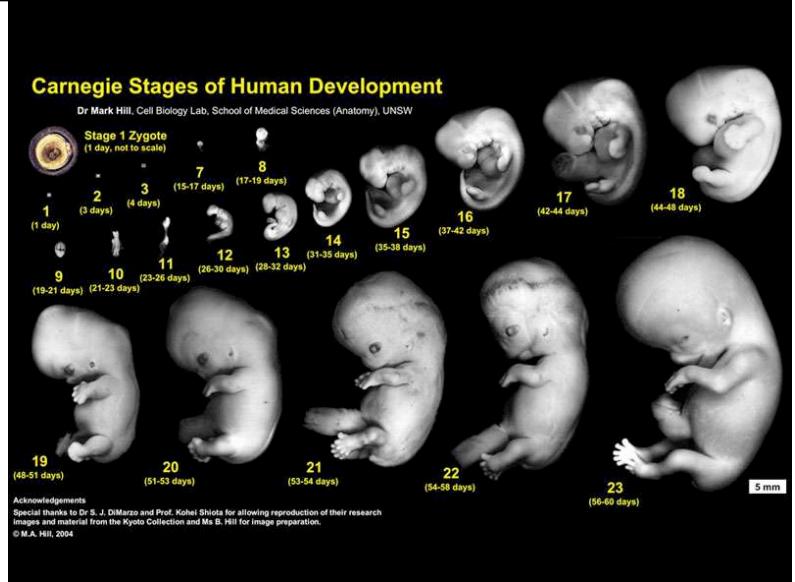
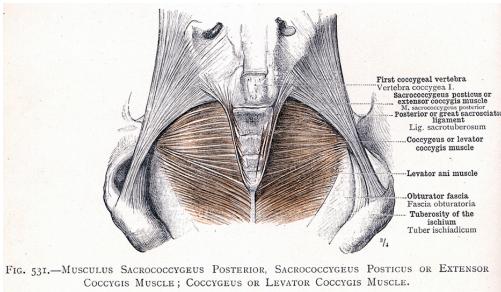
- Why did it lose its function?
- Why hasn't it disappeared completely?

Why haven't vestigial traits disappeared completely?



Mole rats

The coccyx



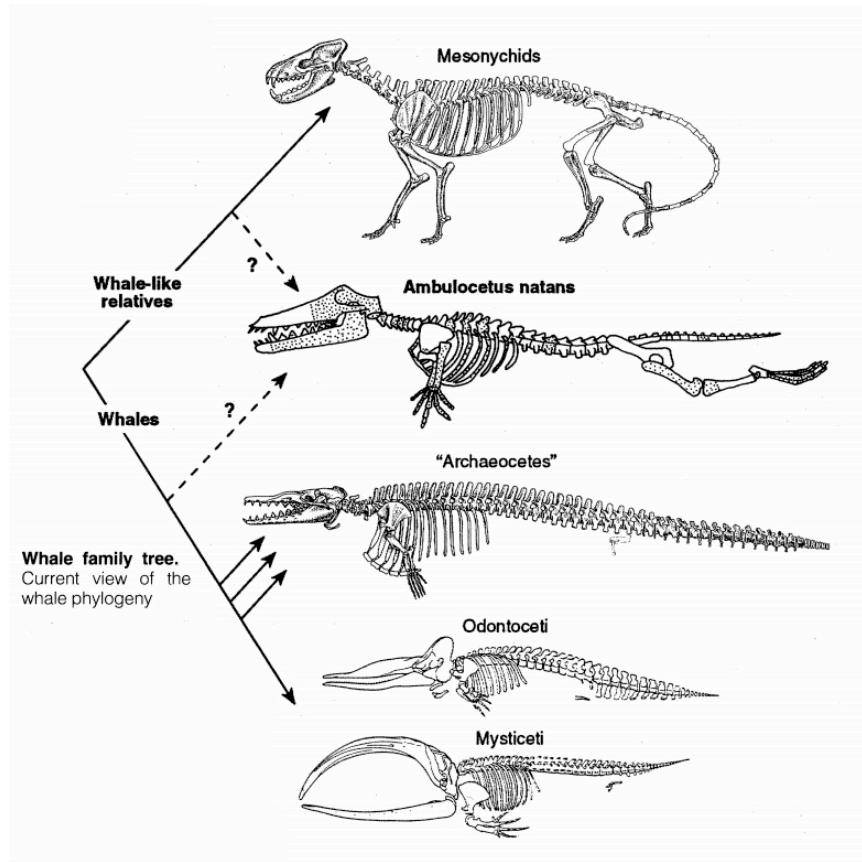
(Atavism) Coccyeal projection



What do these animals have in common?

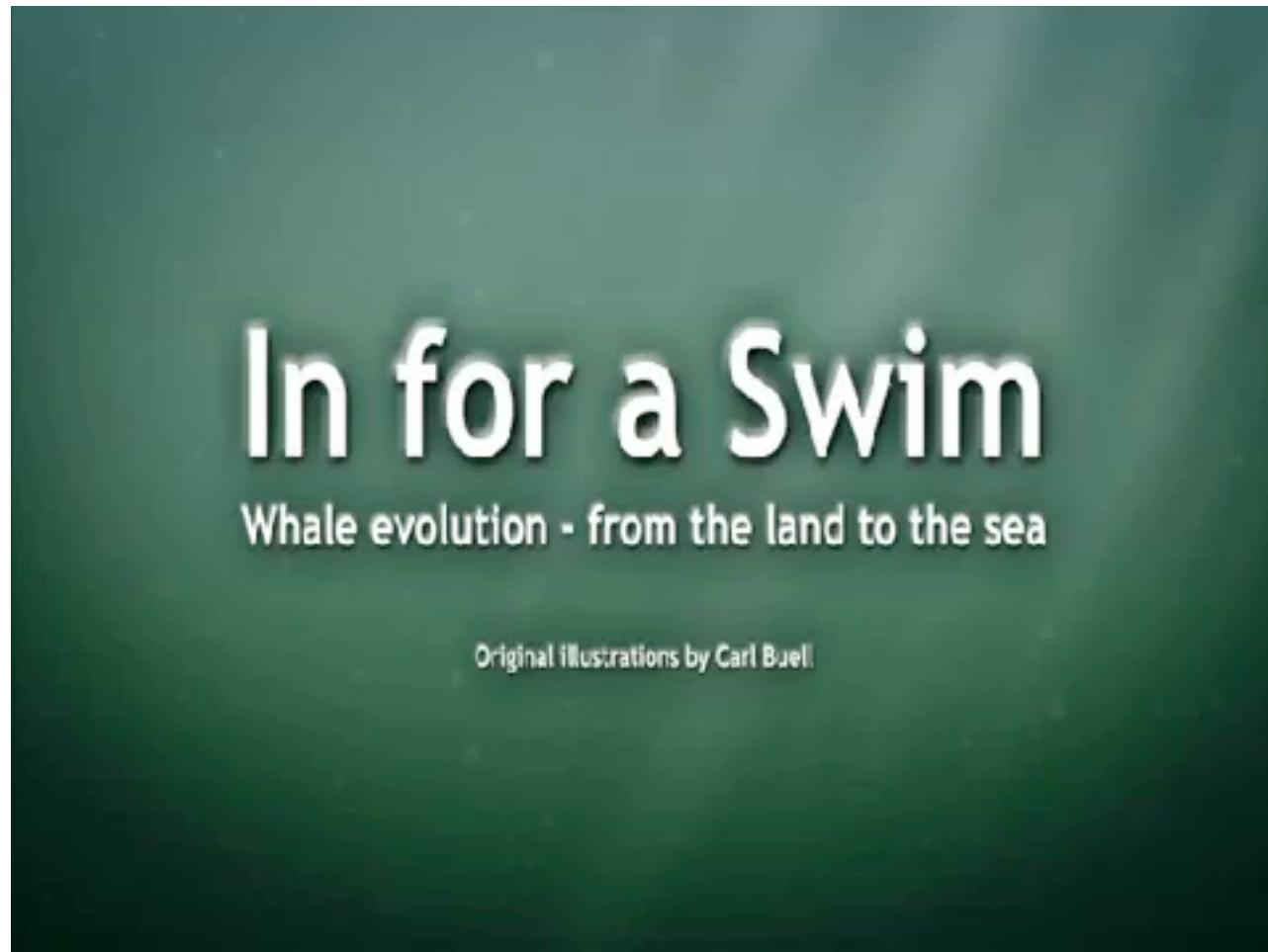


Whales' vestigial hindlimbs



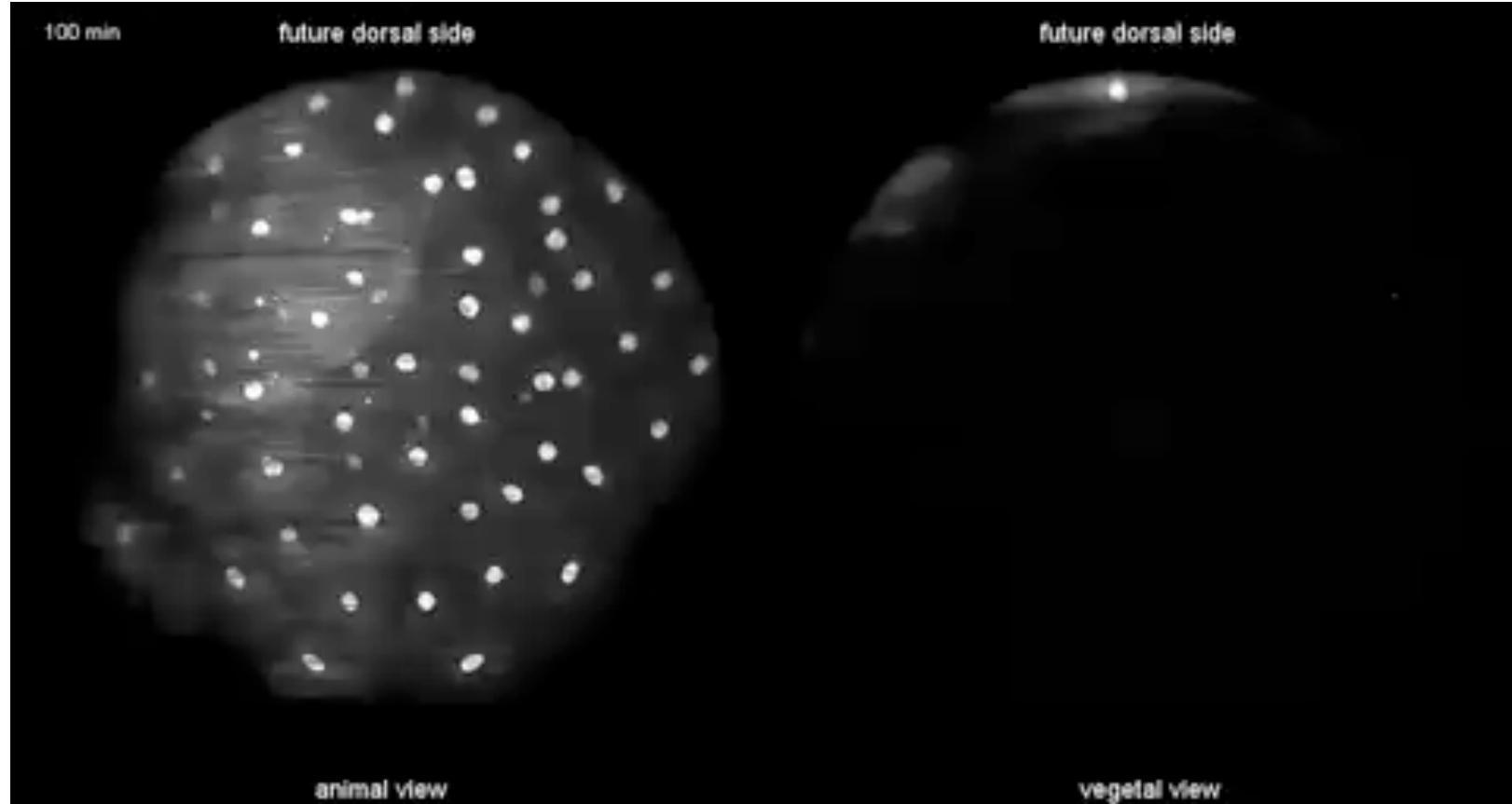
- Whales likely evolved from a wolf-sized creature called *Pakicetus*, that lived around 52 million years ago.
- We know *Pakicetus* was aquatic because its bones were denser to stop it bobbing around in water.
- Very quickly (by 50 mya) *Ambulocetus* ("walking-whale") appeared.
- The *Rodhocetus* whose nostrils had moved backwards to help it breath in water.
- **All in all the evolution of whales from land to being fully aquatic took only 10 million years**

What do these animals have in common?
They are all cousins

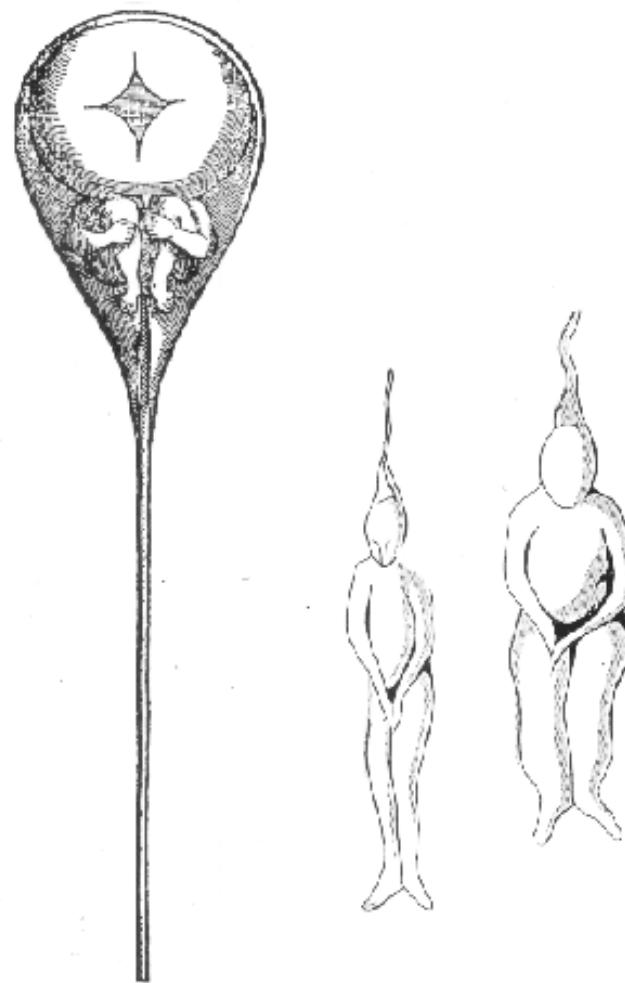




Notice the wires



We don't begin life as tiny humans, as previously thought.



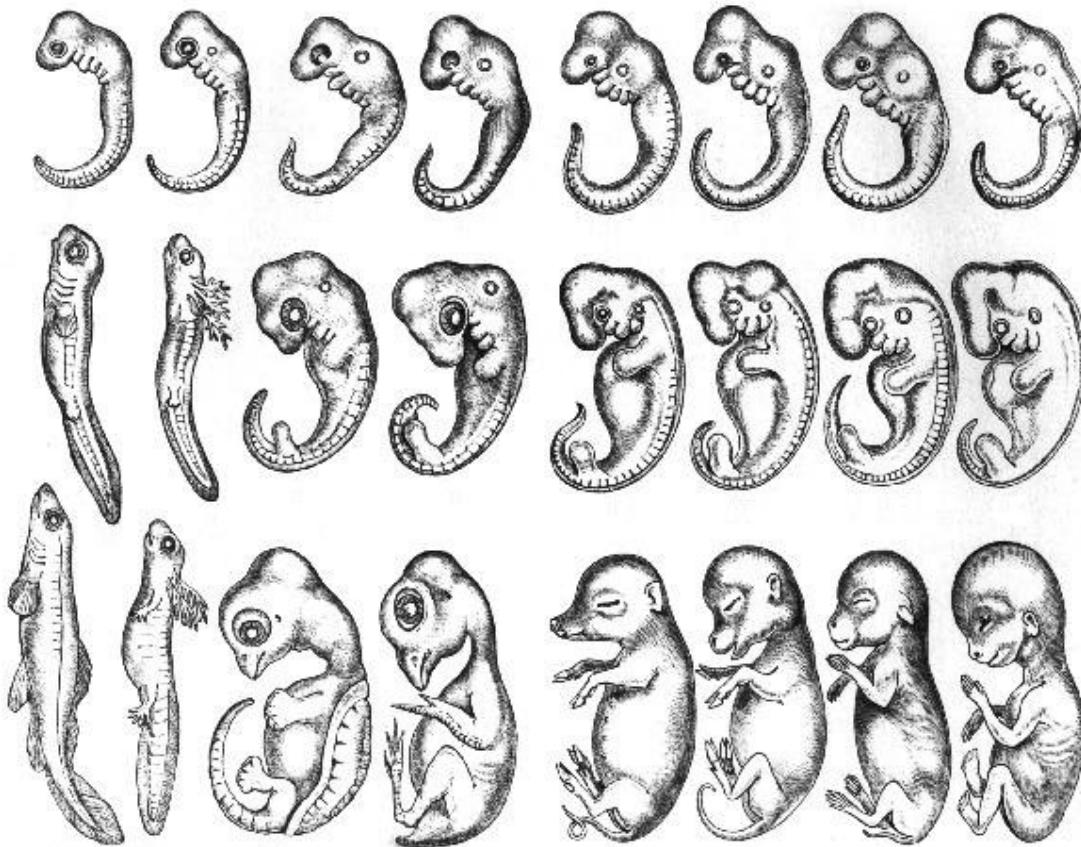
17th century biologists believe that sperm contained a miniature copy of a man -

Karl Ernst von Baer



“I have two small embryos preserved in alcohol,
that I forgot to label. At present I am unable
to determine the genus to which they belong.
They may be lizards, small birds, or even
mammals.”

Karl Ernst von Baer



- von Baer studied baby chicks and compared them with the embryos of other vertebrates, he found that they looked very alike.

Von Baer's principles

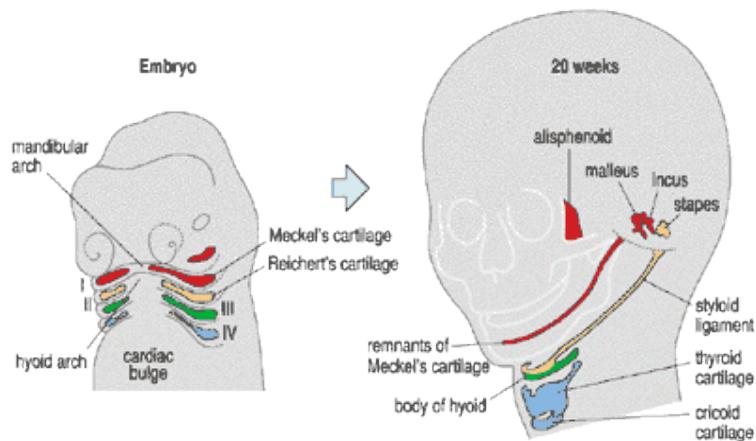
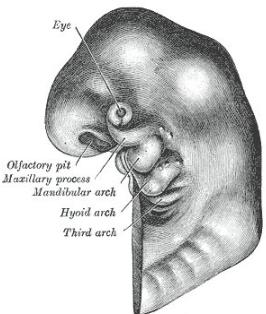
From his studies he came up with a few ideas...

- The **general features** of a large group of animals **appear earlier** in development than do the specialised features of a smaller group.
- **Less general characters develop from the more general**, until finally the most specialised appear.
- **Higher animals** (we would interpret this as animals who have evolved more specialised traits) **go through what looks like earlier stages of other lower animals**, but the “lower fish” stick with these simply slits and convert them to gills.

“Nothing in biology makes sense except in the light of evolution”
--Theodosius Dobzhansky

Do von Baer's ideas make sense in the light of evolution?

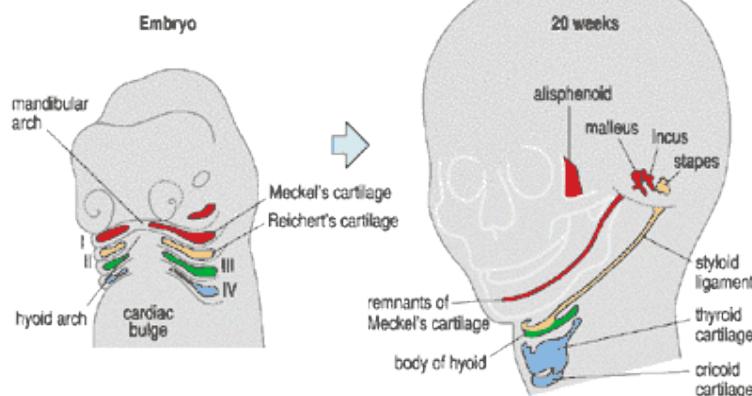
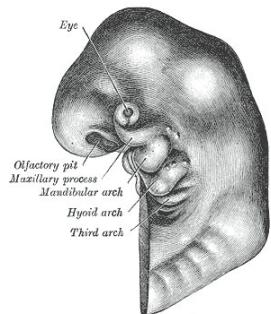
- In sharks (which are fish) the branchial slits become the jaw and gills simply by enlarging.



Here's a diagram of a 5-week-old embryo on the left, with the arches color-coded, and an infant on the right, showing what connective tissues develop from each arch.



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- In sharks (which are fish) the branchial slits become the jaw and gills simply by enlarging.
- In humans the branchial slits become our inner ear, jaw and throat (tonsils, larynx, nerves).



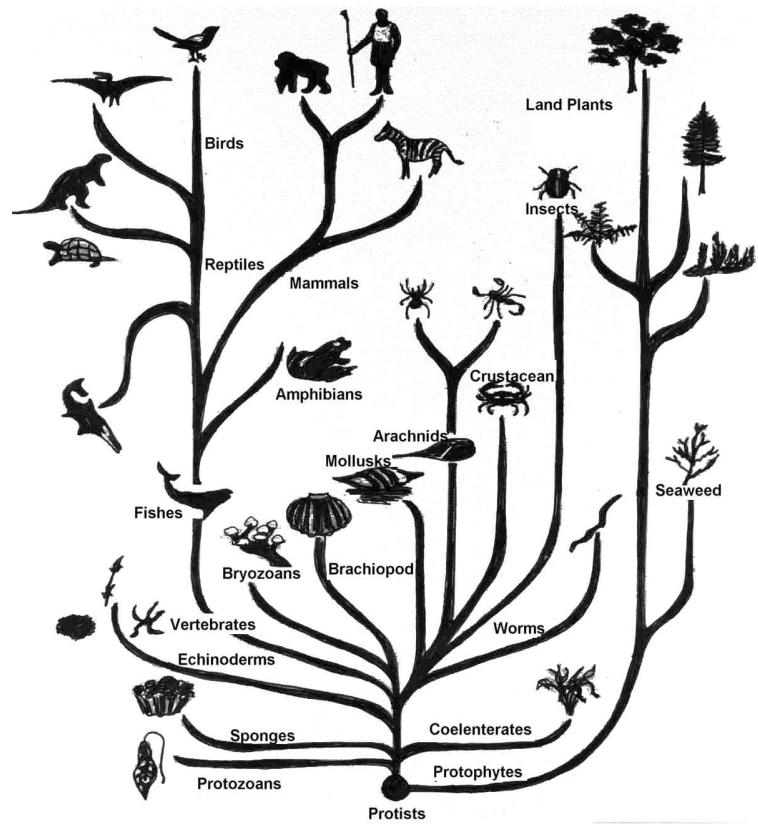
- Both fish and mammals have a salt problem, fish resolve it with gills, we resolve it with the parathyroid gland.
- The gills and parathyroid gland are derived from the same tissues, the branchial slits..

- Why do different vertebrates, which end up looking very different from each other, all begin development looking like fish embryo?
- Why do mammals form their heads and faces from the same embryonic structures that become fish gills?
- Why does the sequence of development mimic the order of our ancestors (fish to amphibian to reptile to mammal)?

Darwin recognised that it wasn't from a shared experience:

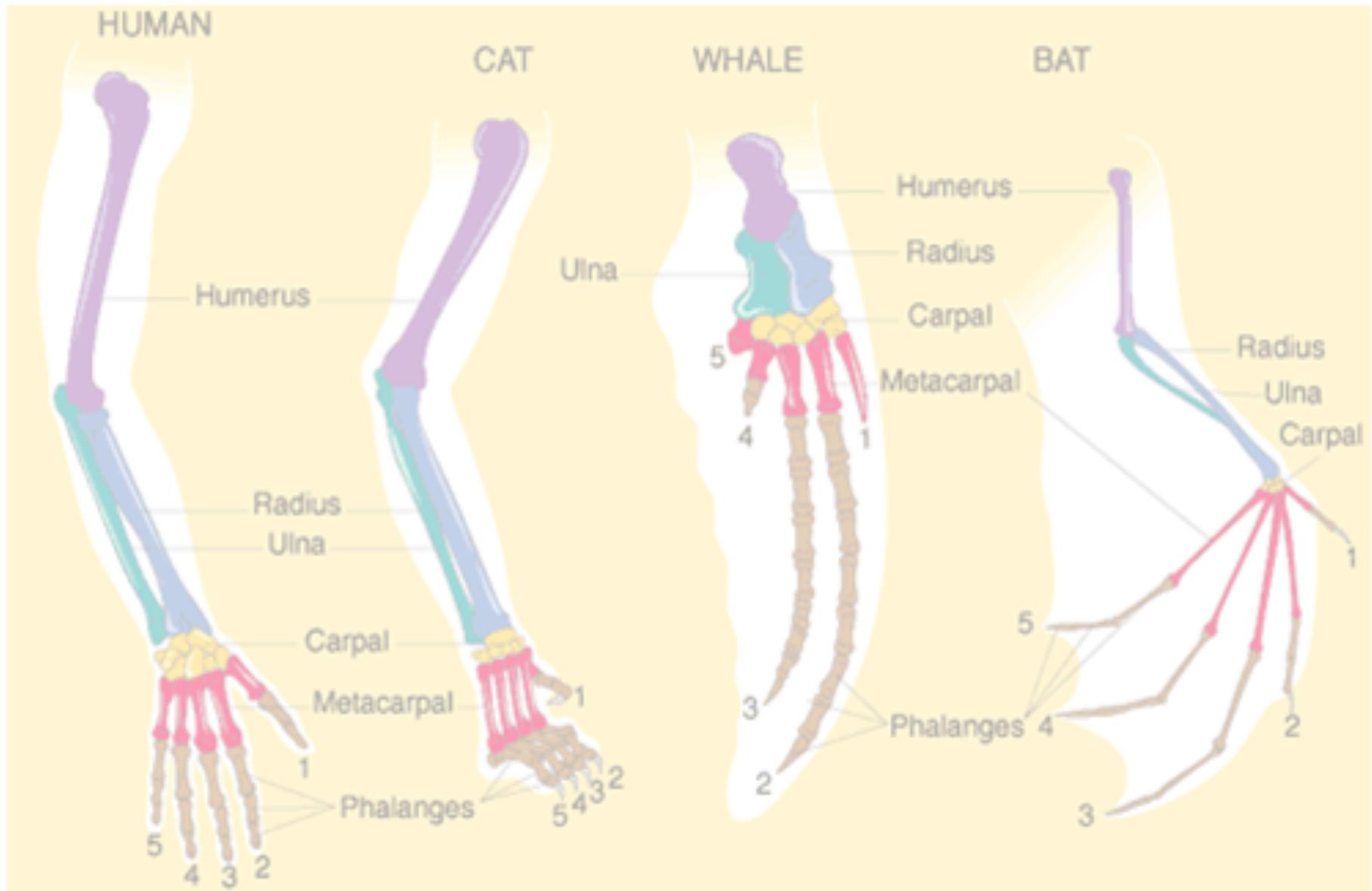
“The points of structure, in which the embryos of widely different animals of the same class resemble each other, often have no direct relation to their conditions of existence. We cannot, for instance, suppose that in the embryos of the vertebrata the peculiar loop-like course of the arteries near the branchial slits are related to similar conditions, in the young mammal which is nourished in the womb of its mother, in the egg of the bird which is hatched in a nest, and in the spawn of a frog under water.”





Understanding this requires that we recognise that one species evolves from another.

For example, all tetrapods (four-footed) - including those that have since stood on two - have evolved from fish.



If we all evolved from a common ancestor then it is not surprising that we all have a similar body plan.

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...because we have inherited our developmental programme from our ancestors.

Changes to this developmental plan (as new structure evolve) are best done later in development because those done early are more likely to have major effects, which will probably have negative consequences for the animal.

[It is better to tinker than do a total redesign]

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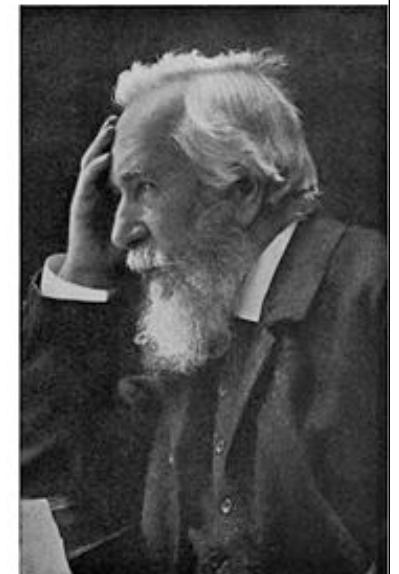
“Ontogeny recapitulates phylogeny”

This idea was jumped on by Ernst Haeckel, biologist and Darwin contemporary, who reformulated it as “Ontogeny recapitulates phylogeny”.

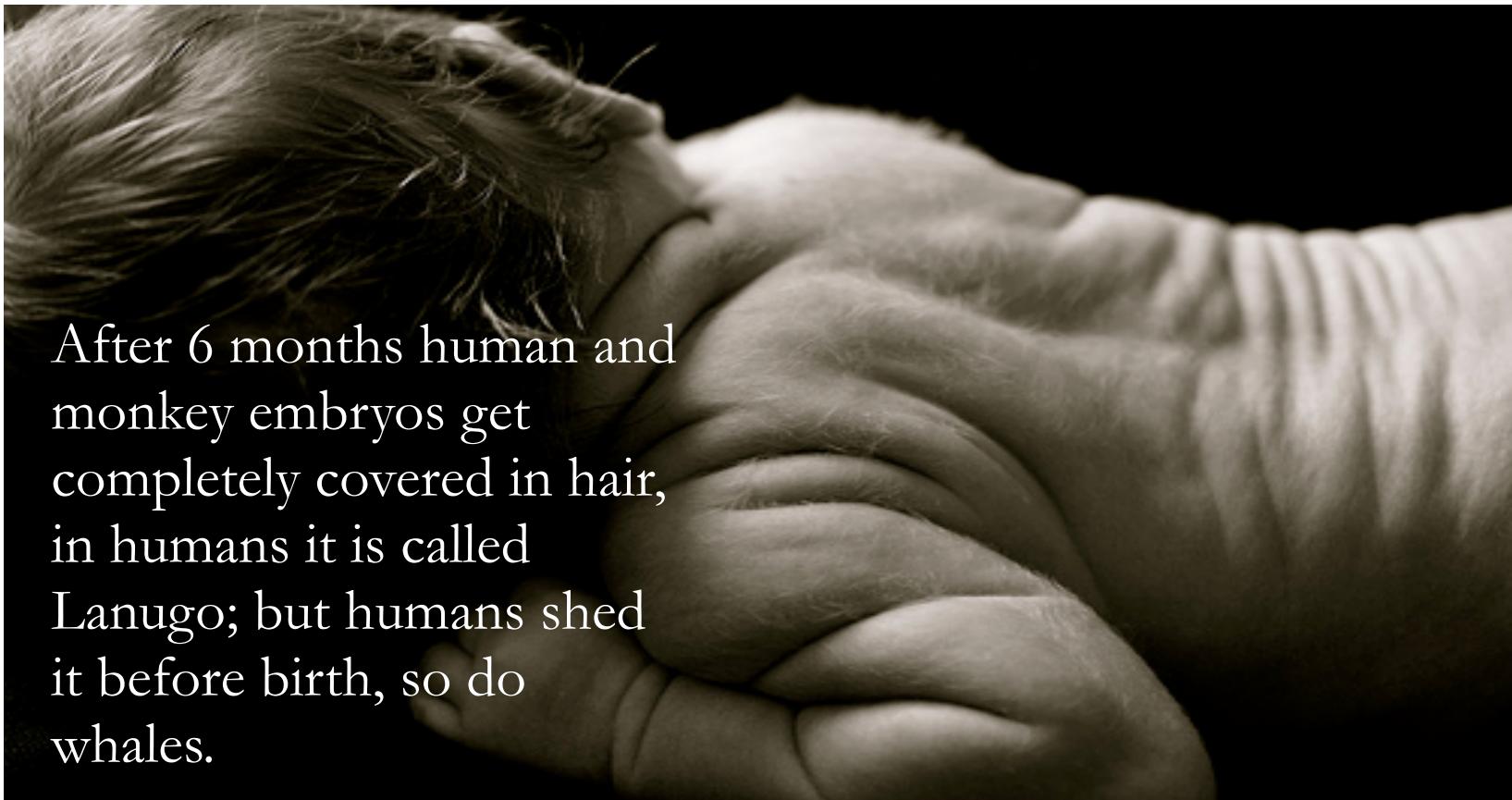
However, this idea has its problems:

- Claimed embryonic stages look like adults of their ancestors, they don't they look like the embryos of their ancestors
- Not every feature of the ancestor appears in the embryonic stage
- There is variation in how much embryos of different species resemble their ancestors
- Haeckel adjusted his drawings to make embryos look more similar than they really were

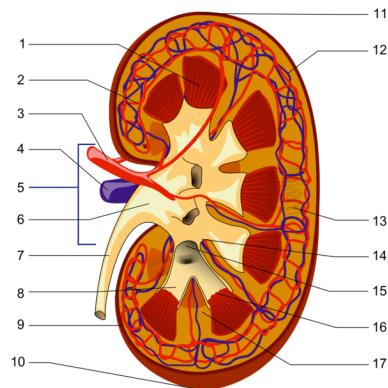
But just because he massaged his data a little doesn't mean that the concept is totally wrong.



Other examples...



After 6 months human and monkey embryos get completely covered in hair, in humans it is called Lanugo; but humans shed it before birth, so do whales.



Human kidneys go through 3 different forms and first two are discarded, and look like jawless fish and reptiles.

Baleen whale embryos produce teeth that are reabsorbed before forming the baleens

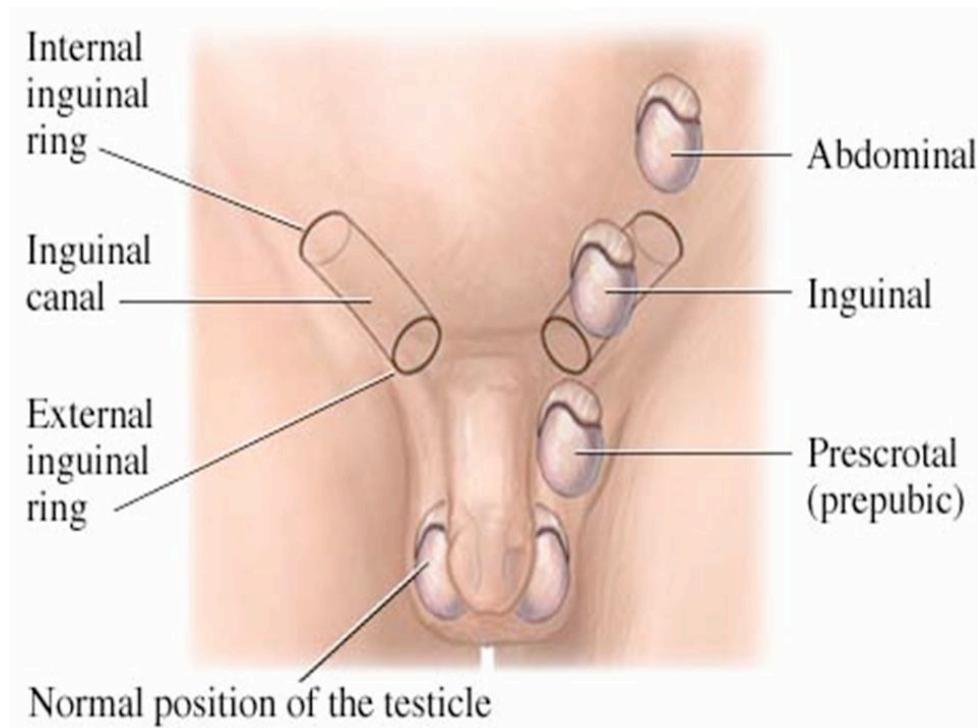


Bad designs

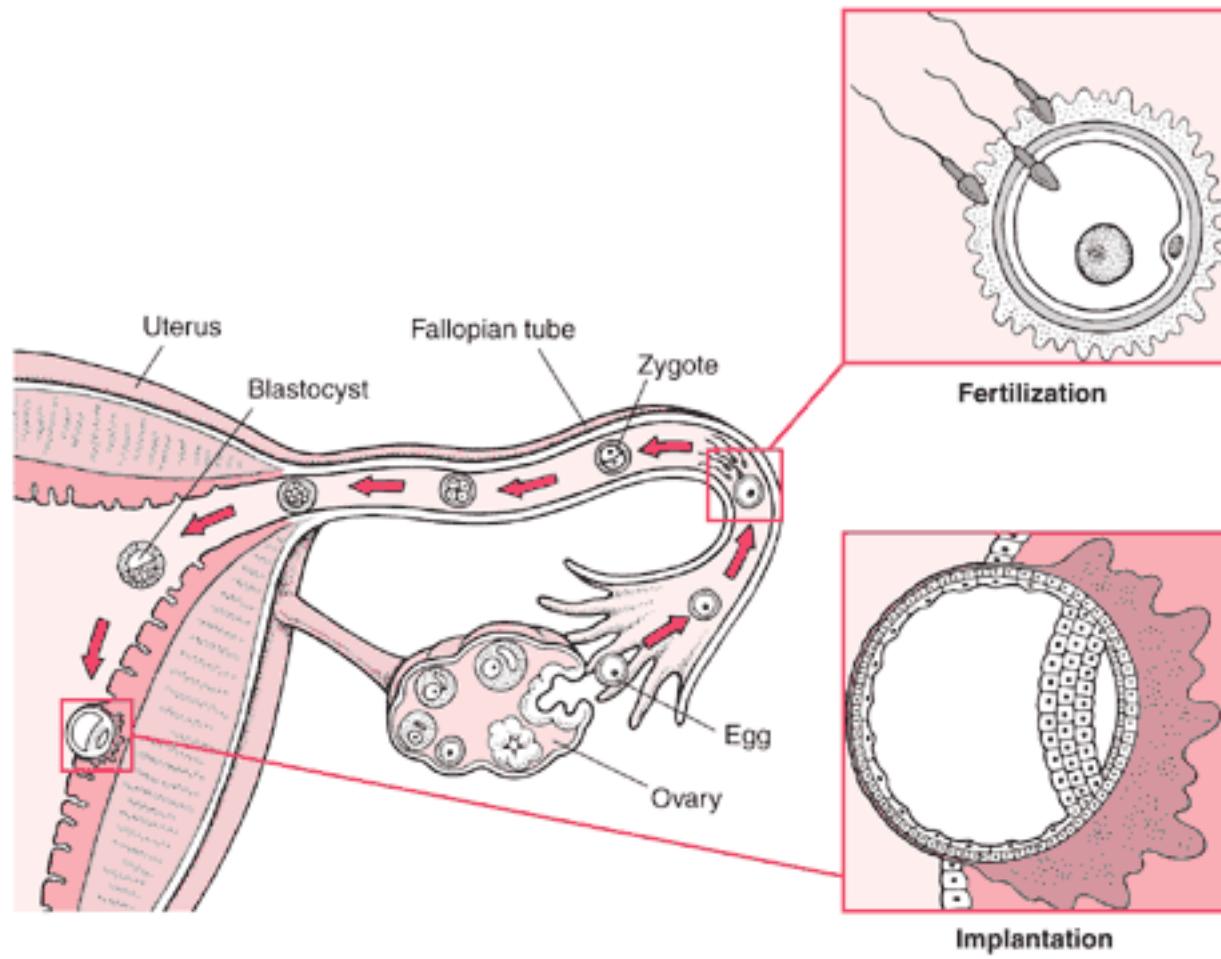
New parts evolve from old ones, and so we should expect compromise

“Look at the human body; is that intelligent? We’ve a waste processing plant next to a recreation area!”

--Robin Williams



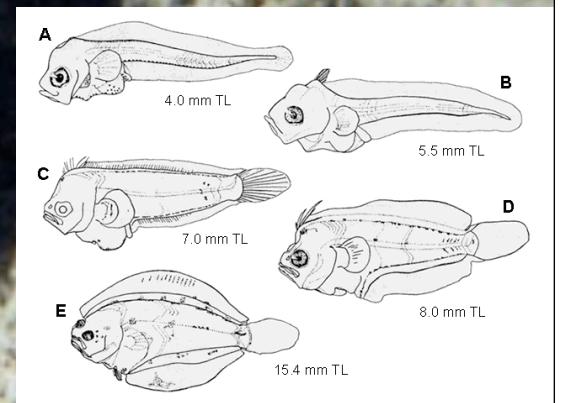
- Testes migrate into the scrotum at 4-6 months old through the inguinal canal, leaving men vulnerable to hernias.
- Testes have evolved from fish gonads, which are internal, descending out of the body was a later adjustment in evolutionary time.



Flounder



Their ugliness
comes from their
evolutionary
heritage



Summary: The evidence for evolution in embryology and developmental biology

- New structures evolve from old ones and give clues to our *shared ancestry* and is evidence for *gradualism*
- Most creatures are far from perfectly evolved, there are many examples of vestigial traits e.g redundant legs and tails, and nefarious appendices
- And many examples of ‘bad designs’, where evolution has tacked on an adjustment

READING: Jack Horner's Plan to Bring Dinosaurs Back to Life

<http://discovermagazine.com/2009/apr/27-jack-horner.s-plan-bring-dinosaurs-back-to-life>