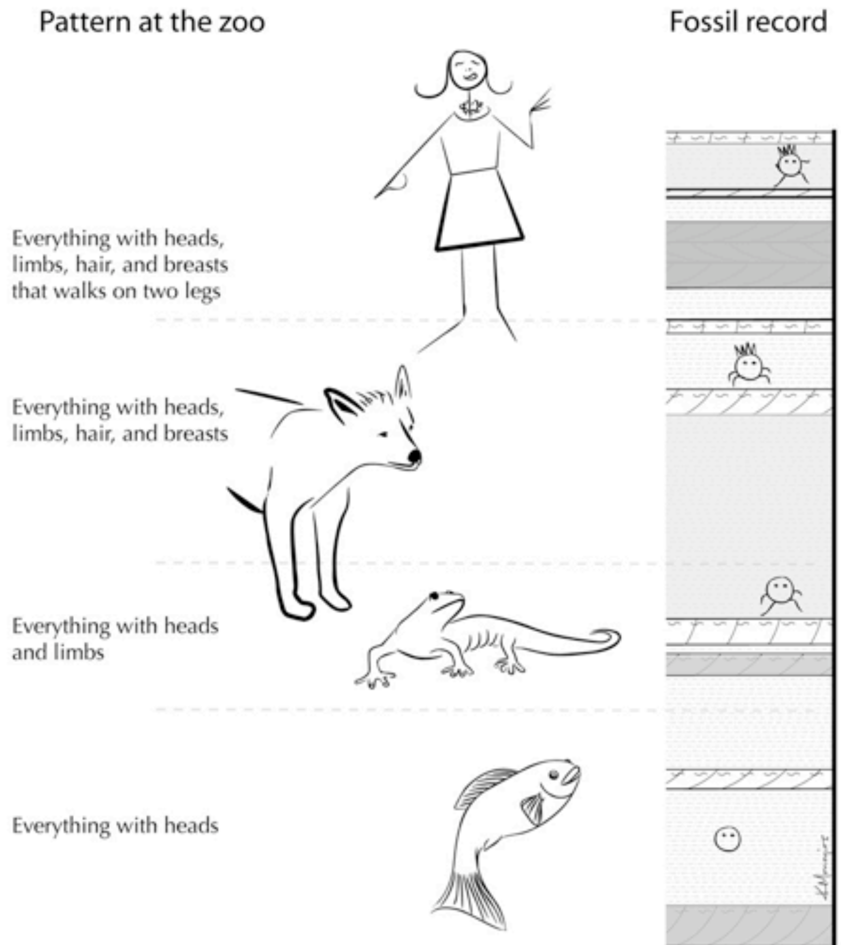
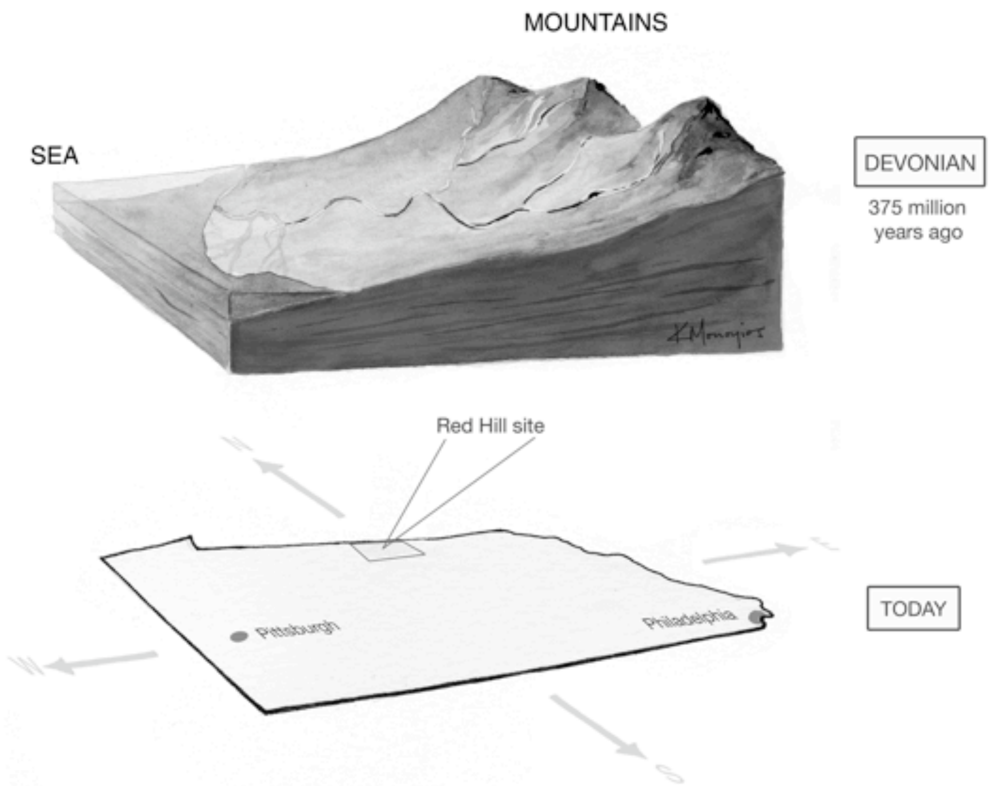
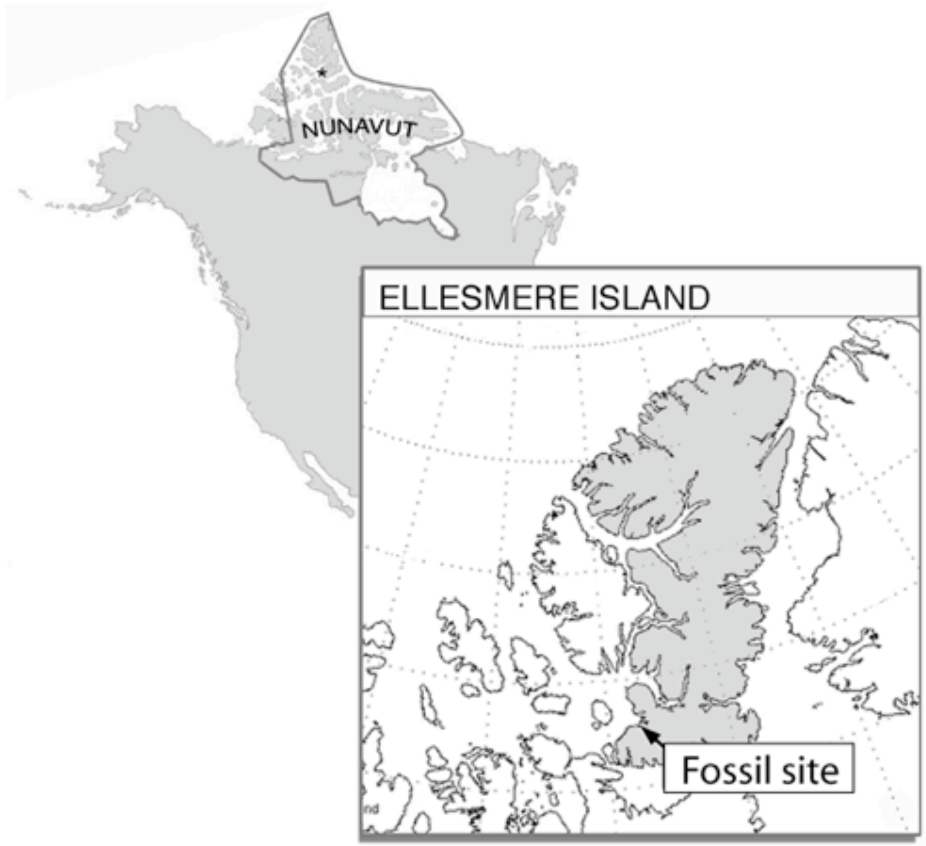



What we discover on our walk through the zoo mirrors how fossils are laid out in the rocks of the world.




Along the roads in Pennsylvania, we were looking at an ancient river delta, much like the Amazon today. The state of Pennsylvania (bottom) with the Devonian topography mapped above it.

Our camp (top) looks tiny in the vastness of the landscape. My summer home (bottom) is a small tent, usually surrounded by piles of rocks to protect it from fifty-mile-per-hour winds.




This is where we work: southern Ellesmere Island, in Nunavut Territory, Canada, 1,000 miles from the North Pole.

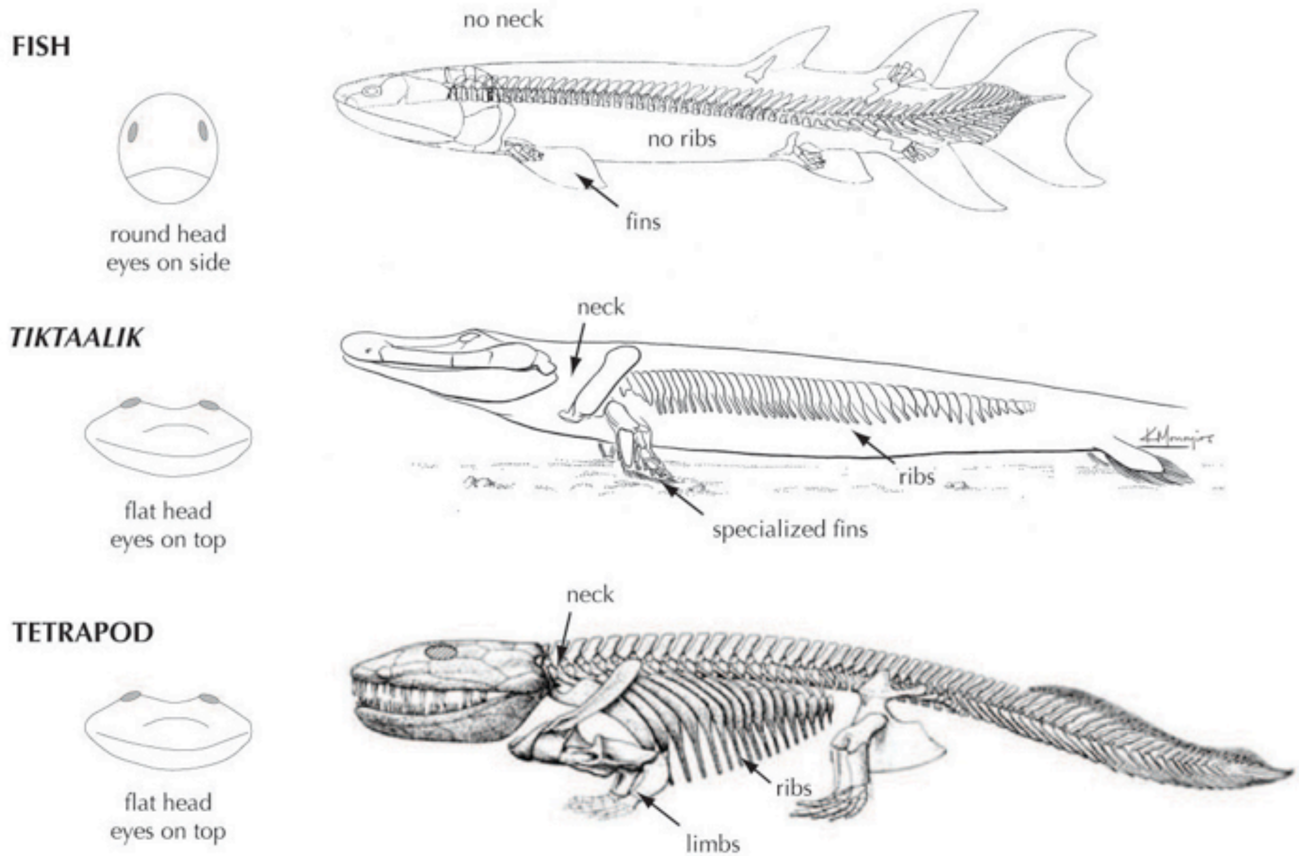
from Neil Shubin's

# *Your Inner Fish*

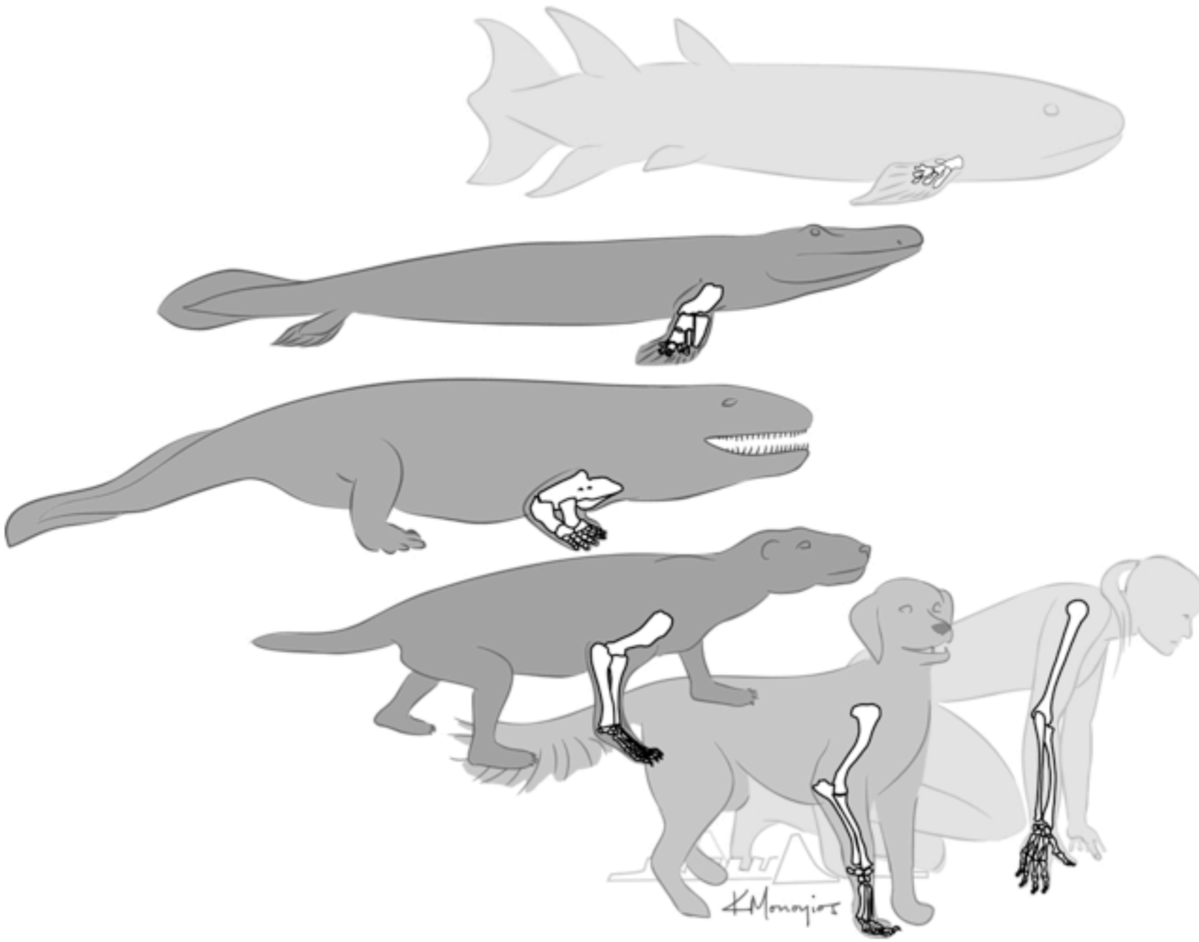
## *A Journey into the 3.5-Billion-Year History of the Human Body*


The process of finding fossils begins with a mass in a rock that is gradually removed over time. Here I show a fossil as it travels from the field to the lab and is carefully prepared as a specimen: the skeleton of the new animal.

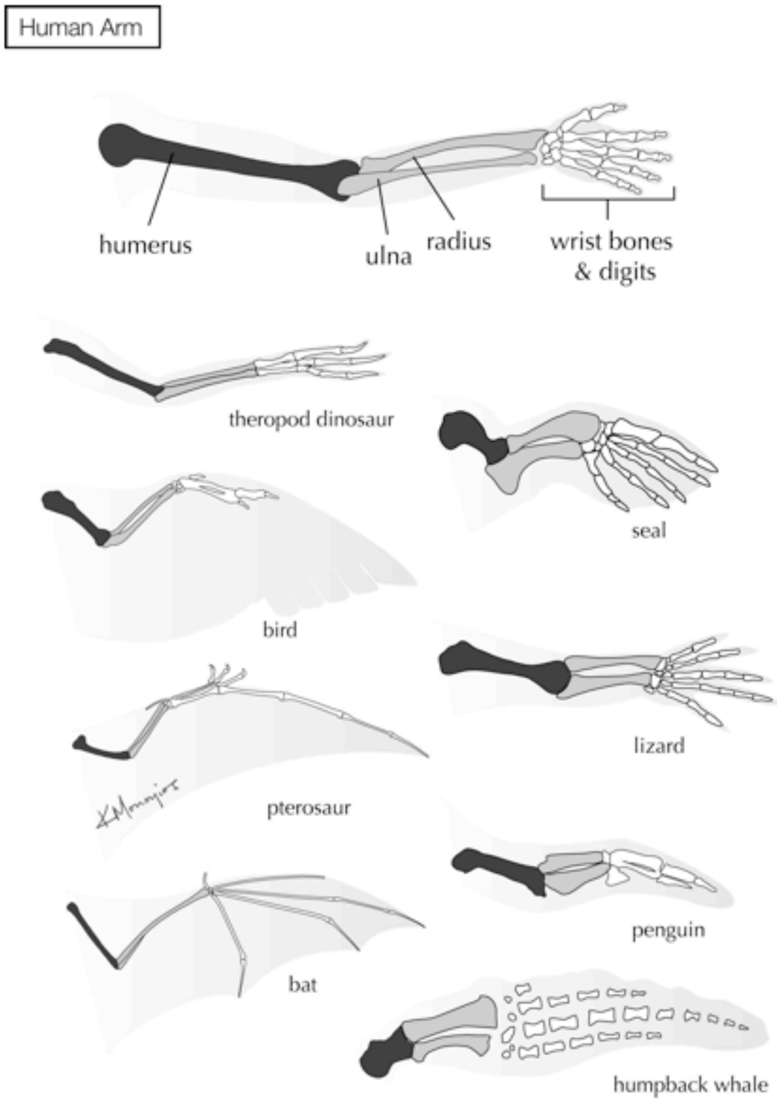
Photograph in upper left by N. Shubin; other photographs courtesy of Ted Daeschler, Academy of Natural Sciences of Philadelphia.



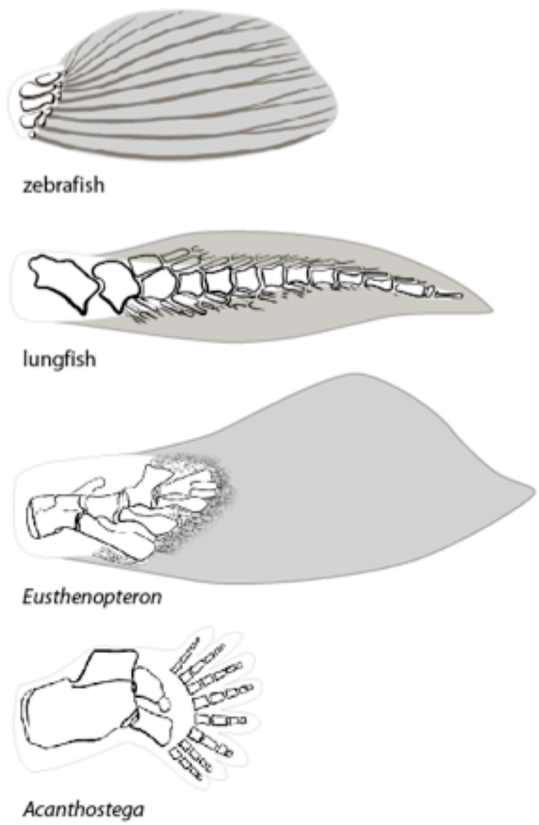

This figure says it all. *Tiktaalik* is intermediate between fish and primitive land-living animal.




Tracing arm bones from fish to humans.



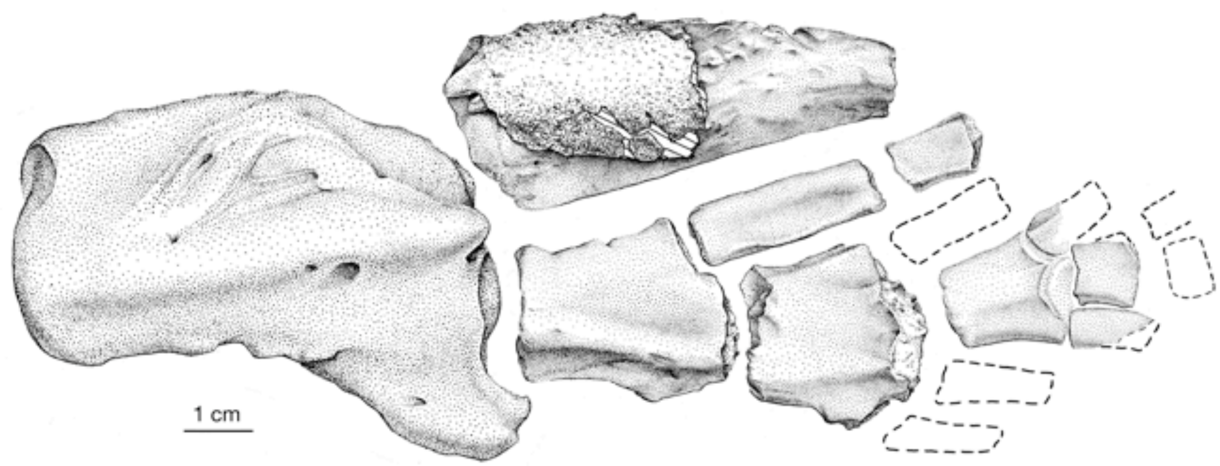

The common plan for all limbs: one bone, followed by two bones, then little blobs, then fingers or toes.



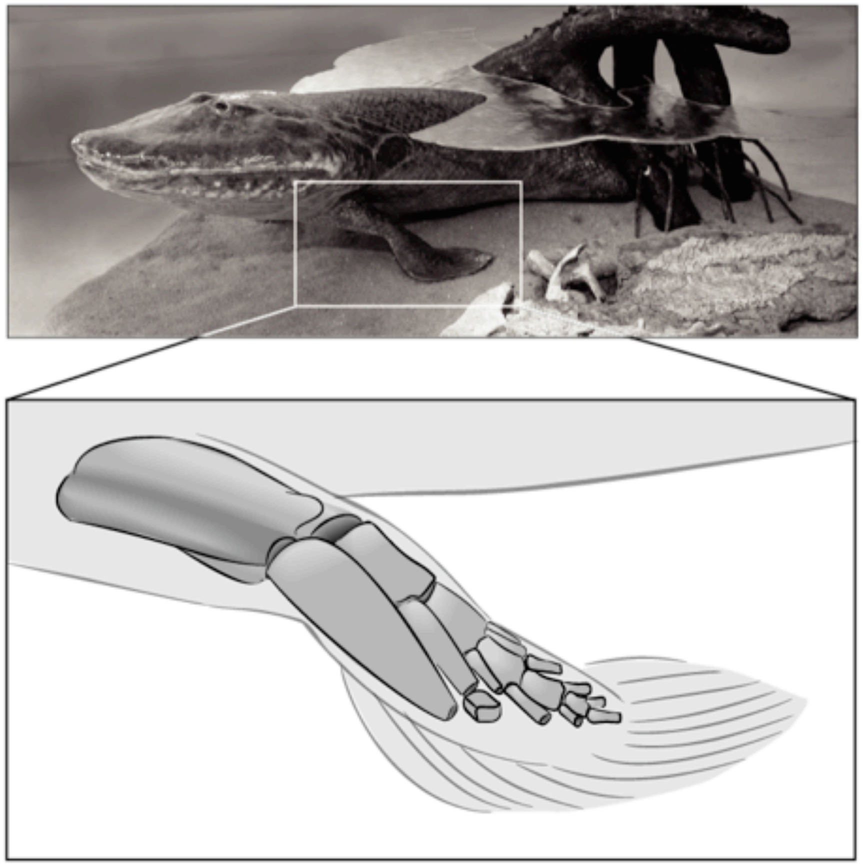

The fins of most fish - for example, a zebrafish (top) - have large amounts of fin webbing and many bones at the base. Lungfish captured people's interest because like us they have a single bone at the base of the appendage. *Eusthenopteron* (middle) showed how fossils begin to fill the gap; it has bones that compare to our upper arm and forearm. *Acanthostega* (bottom) shares *Eusthenopteron*'s pattern of arm bones with the addition of fully formed digits.

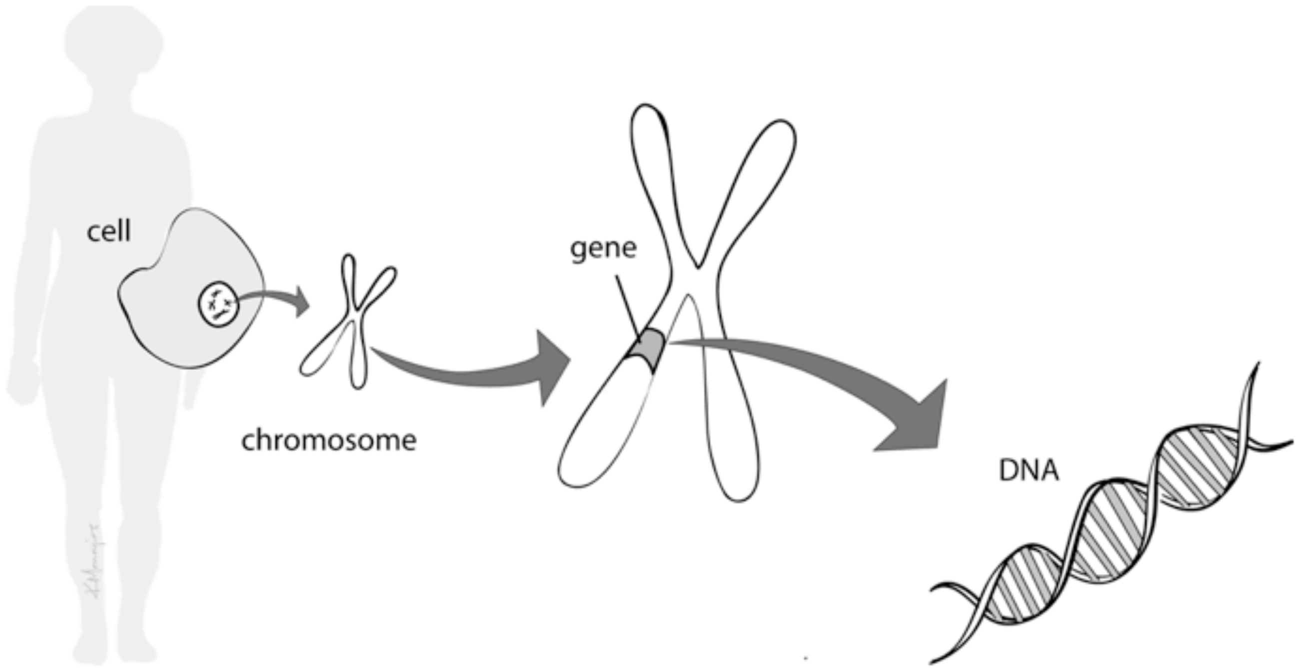
Our tantalizing fin. Sadly, we found only this isolated specimen.



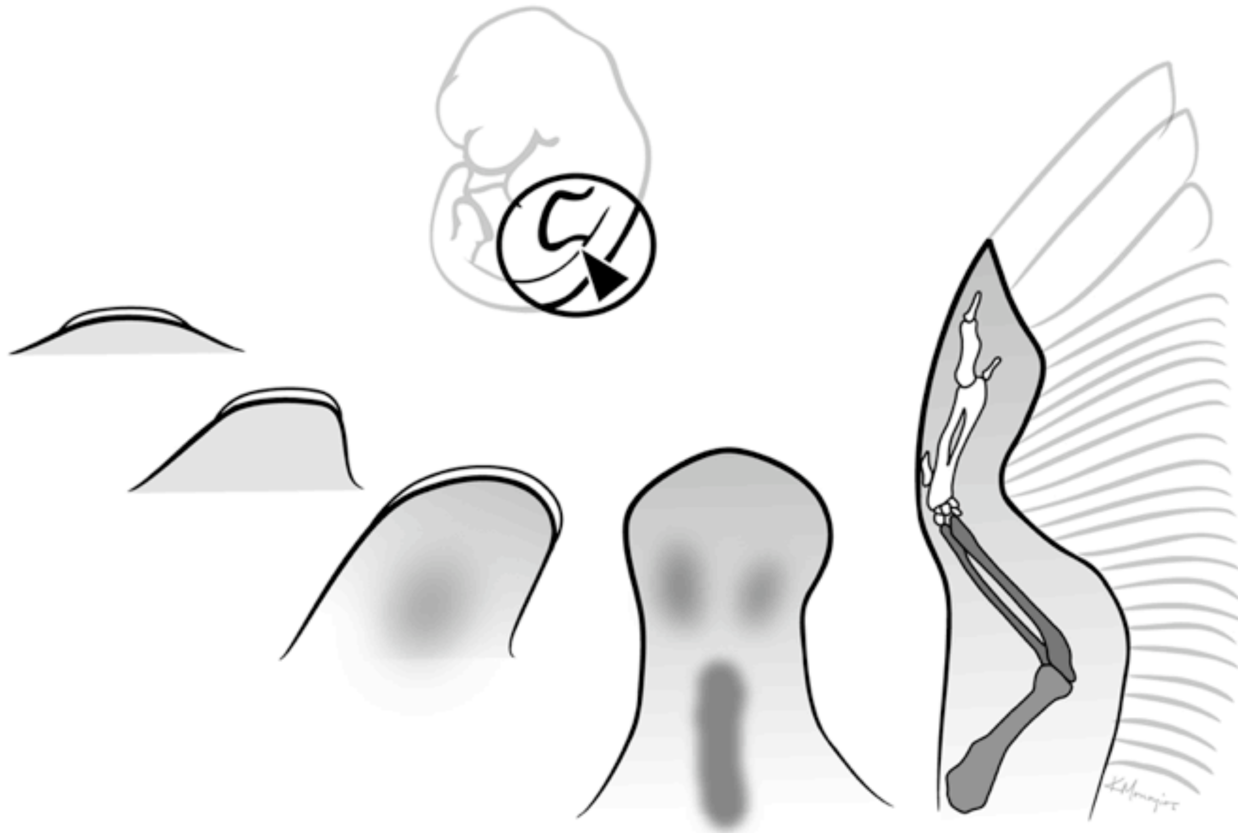

The bones of the front fin of *Tiktaalik* - a fish with a wrist.



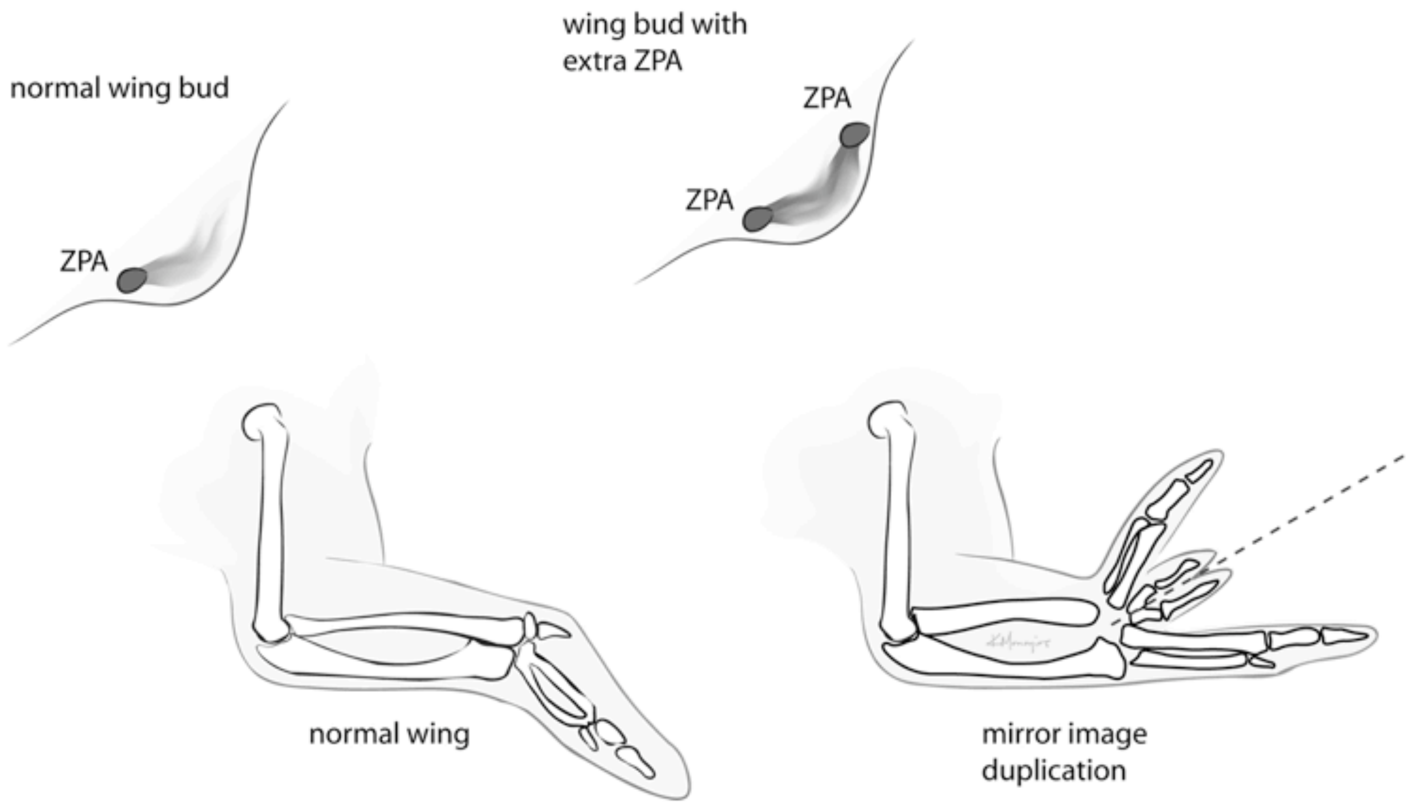
A full-scale model of *Tiktaalik*'s body (top) and a drawing of its fin (bottom). This is a fin in which the shoulder, elbow, and proto-wrist were capable of performing a type of push-up.




Genes are stretches of DNA contained in every cell of our bodies.

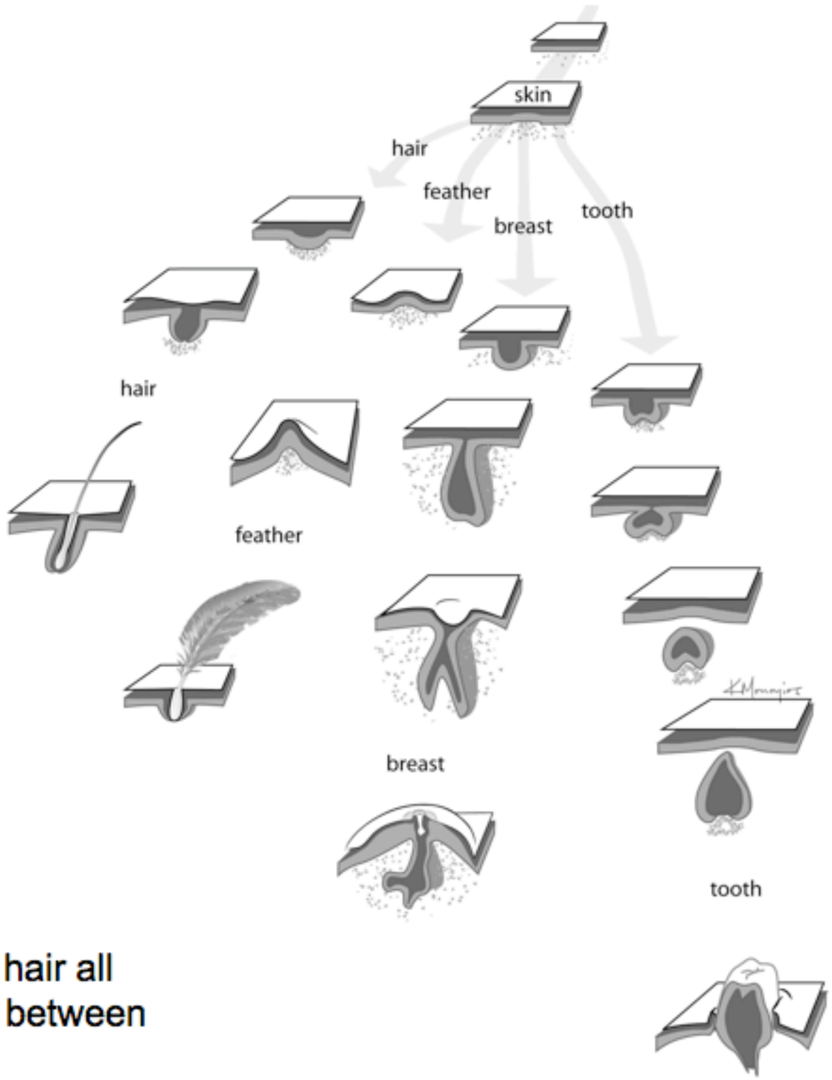


The development of a limb, in this case a chicken wing. All of the key stages in the development of a wing skeleton happen inside the egg.

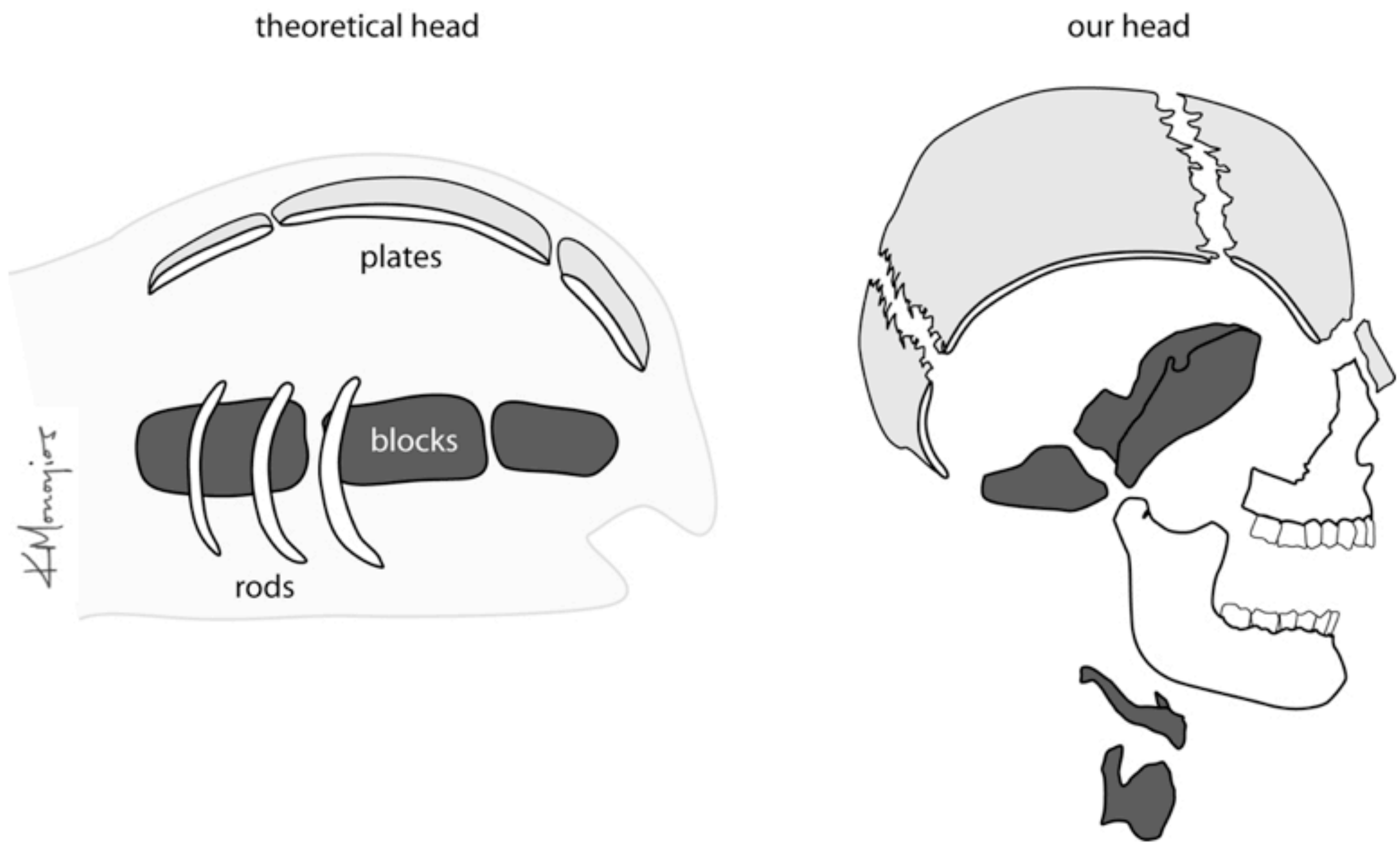



Moving a little patch of tissue called the ZPA causes the fingers to be duplicated.

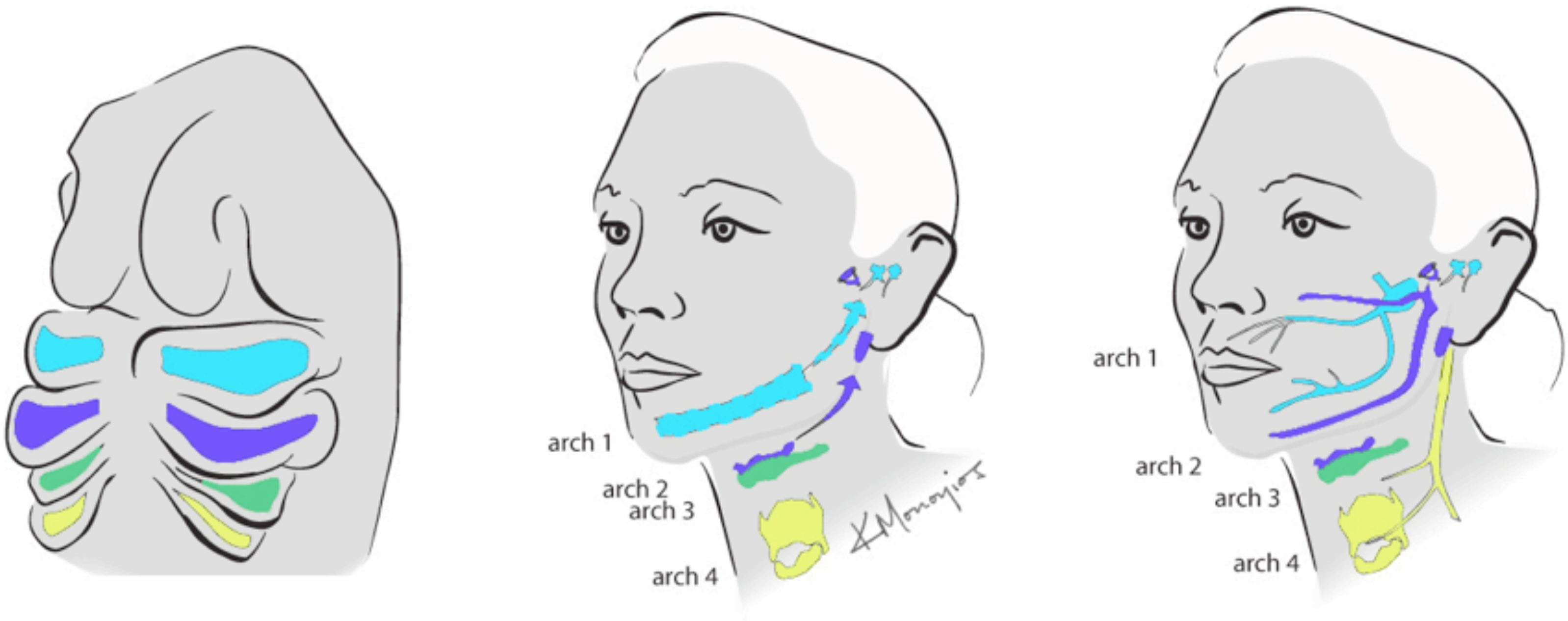
Paul Olsen finding footprints in the tidal flats of Nova Scotia. At high tide, the water would come all the way to the cliffs at left. The arrowhead points to a spot where, if we timed our trip wrong, we would be stuck on the cliffs for hours at a time.




Teeth, breasts, feathers, and hair all develop from the interactions between layers of skin.

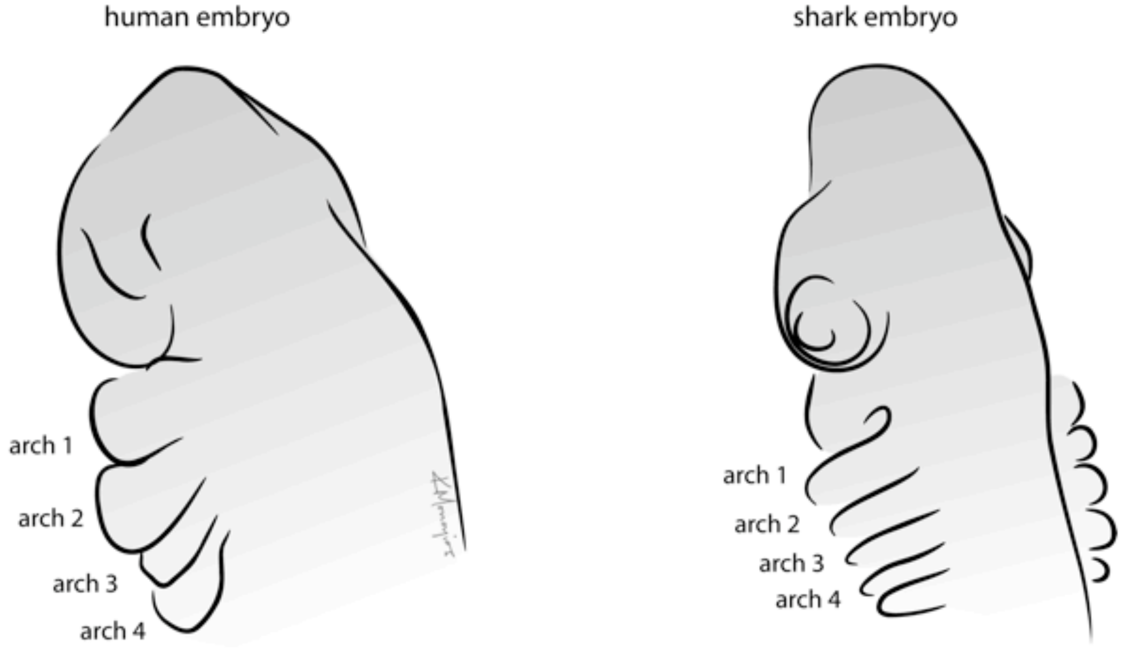



Plates, blocks, and rods: the theme for skulls. Every bone in our head can be traced to one of these things.

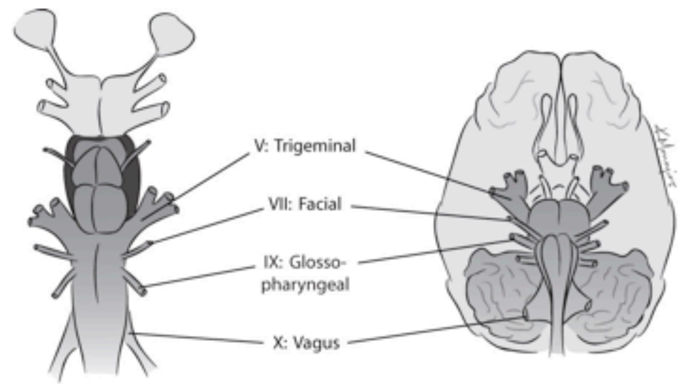


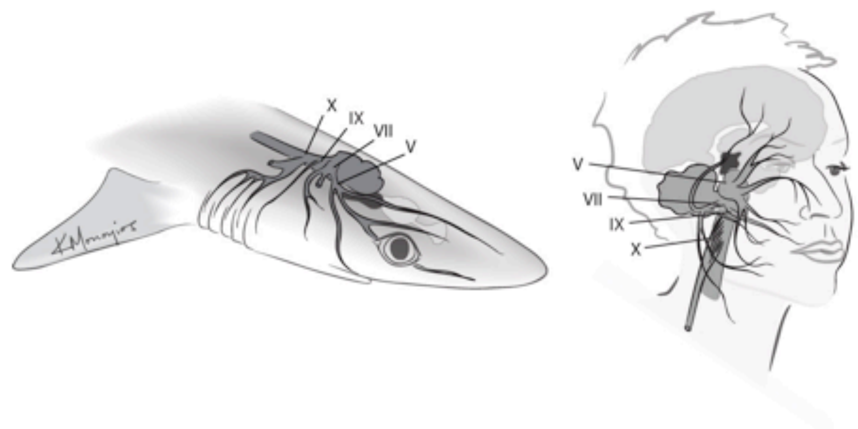

If we follow the gill arches from an embryo to an adult, we can trace the origins of jaws, ears, larynx, and throat. Bones, muscles, nerves, and arteries all develop inside these gill arches.

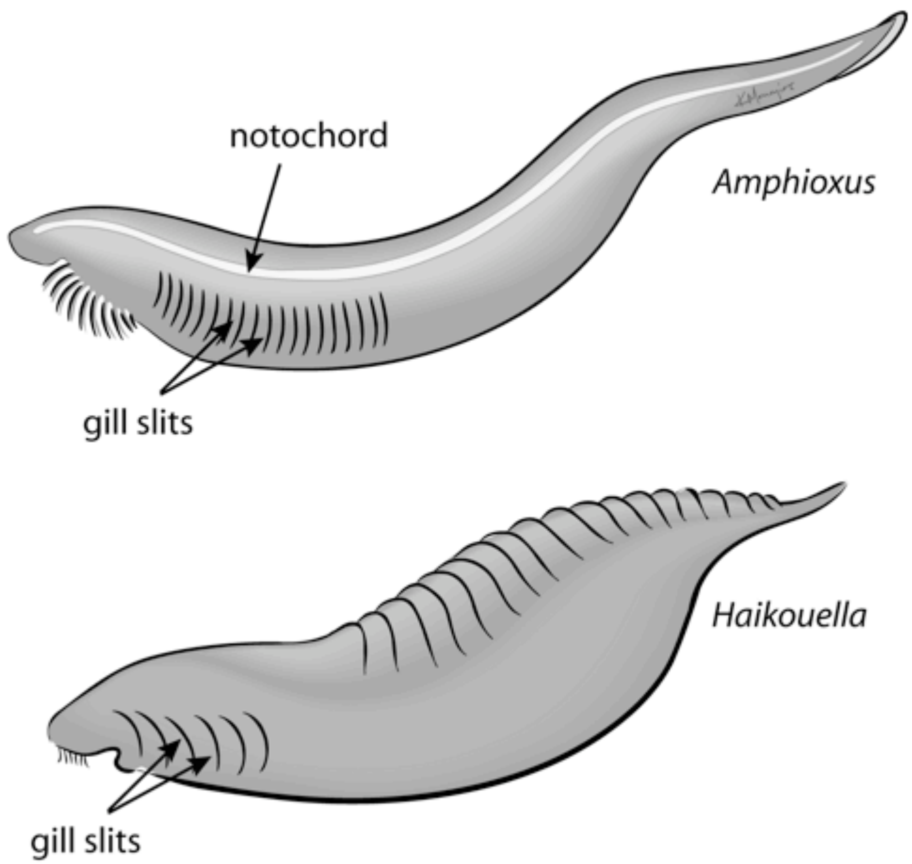



The gill region of a developing human and a developing shark look the same early on.

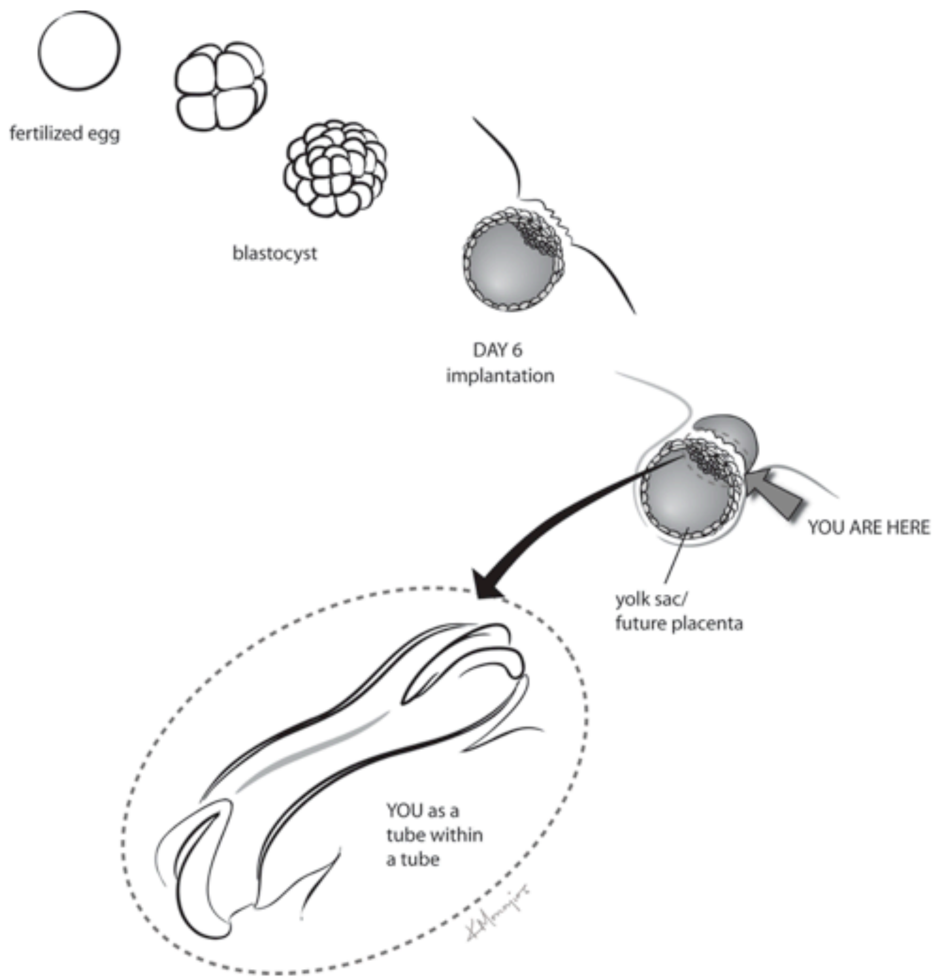


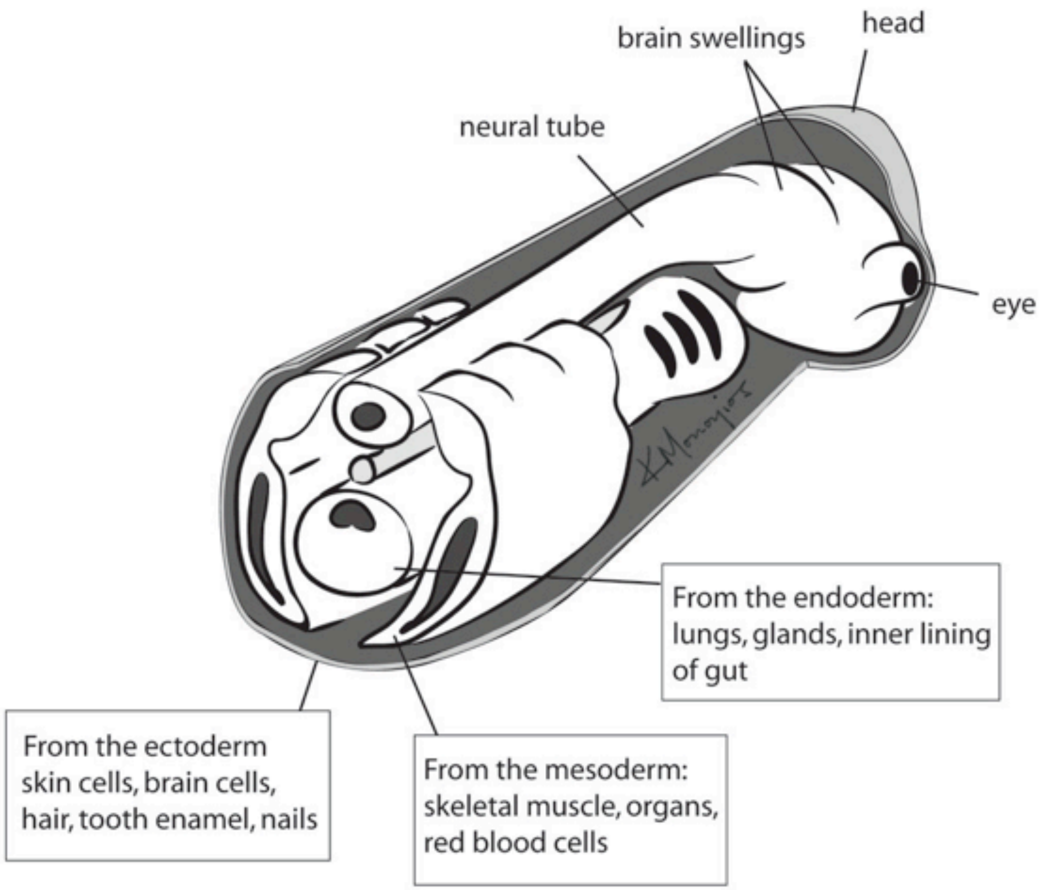

At first glance, our cranial nerves appear different from those of a shark. But look closely and you will find profound similarities. Virtually all of our nerves are present in sharks. The parallels go deeper still: equivalent nerves in sharks and humans supply similar structures, and they even exit the brain in the same order.



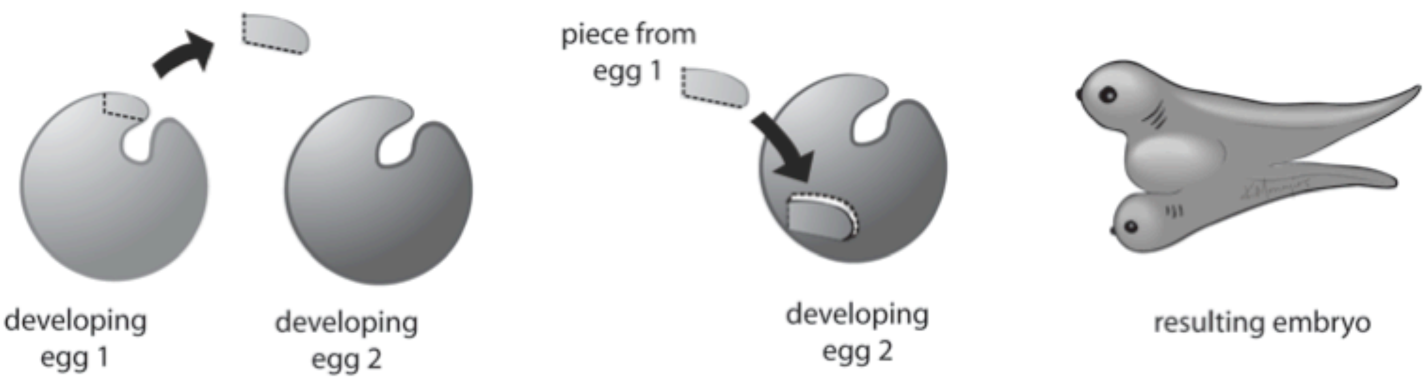

The closest relatives to animals with heads are worms with gill slits. Show are *Amphioxus* and a reconstruction of a fossil worm (*Haikouella*) over 530 million years old. Both worms have a notochord, a nerve cord, and gill slits. The fossil worm is known from over three hundred individual specimens from southern China.



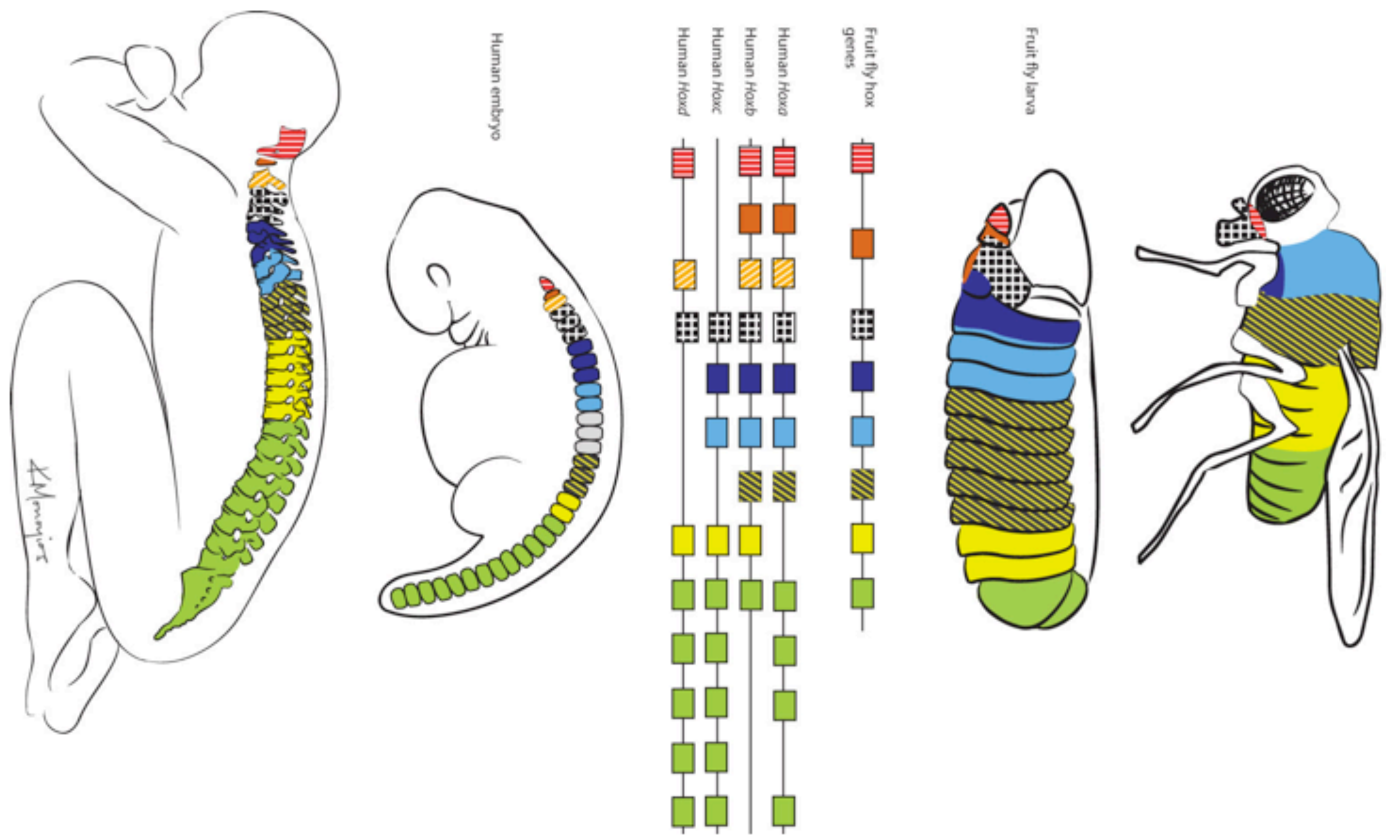

Our early days, the first three weeks after conception. We go from being a single cell to a ball of cells and end up as a tube.



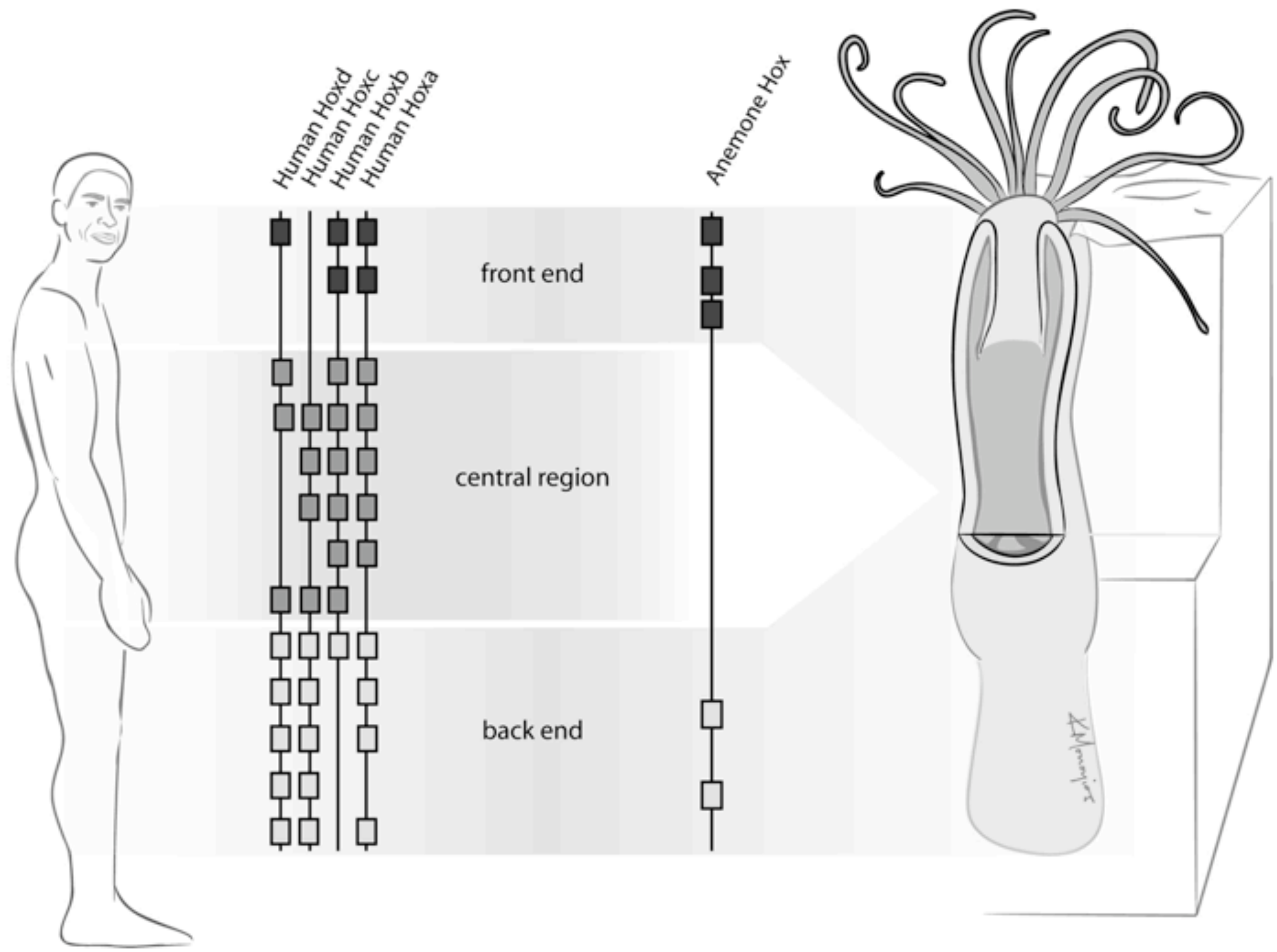

At four weeks after conception, we are a tube within a tube and have the three germ layers that give rise to all our organs.



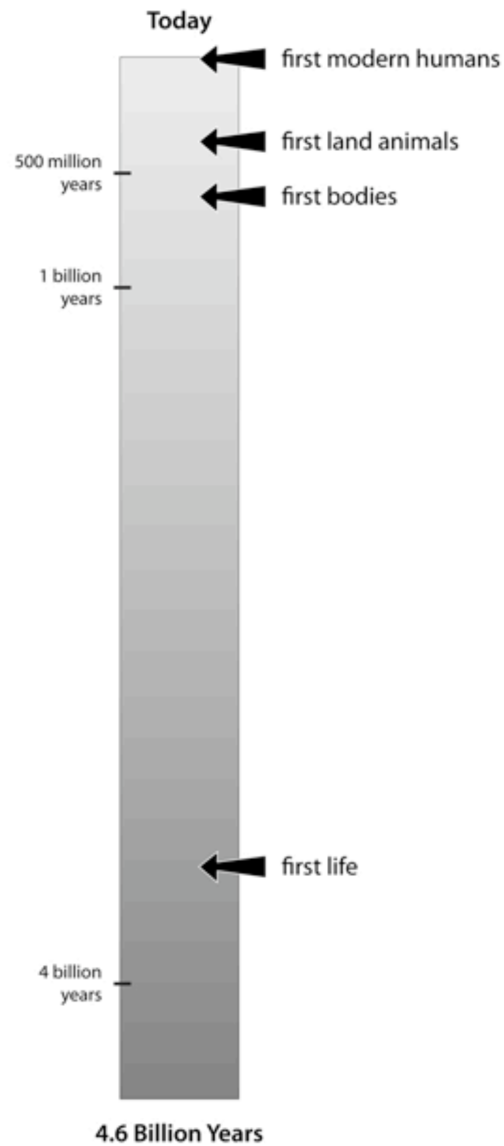

Just by moving a small patch of tissue in the embryo, Mangold produced twins.

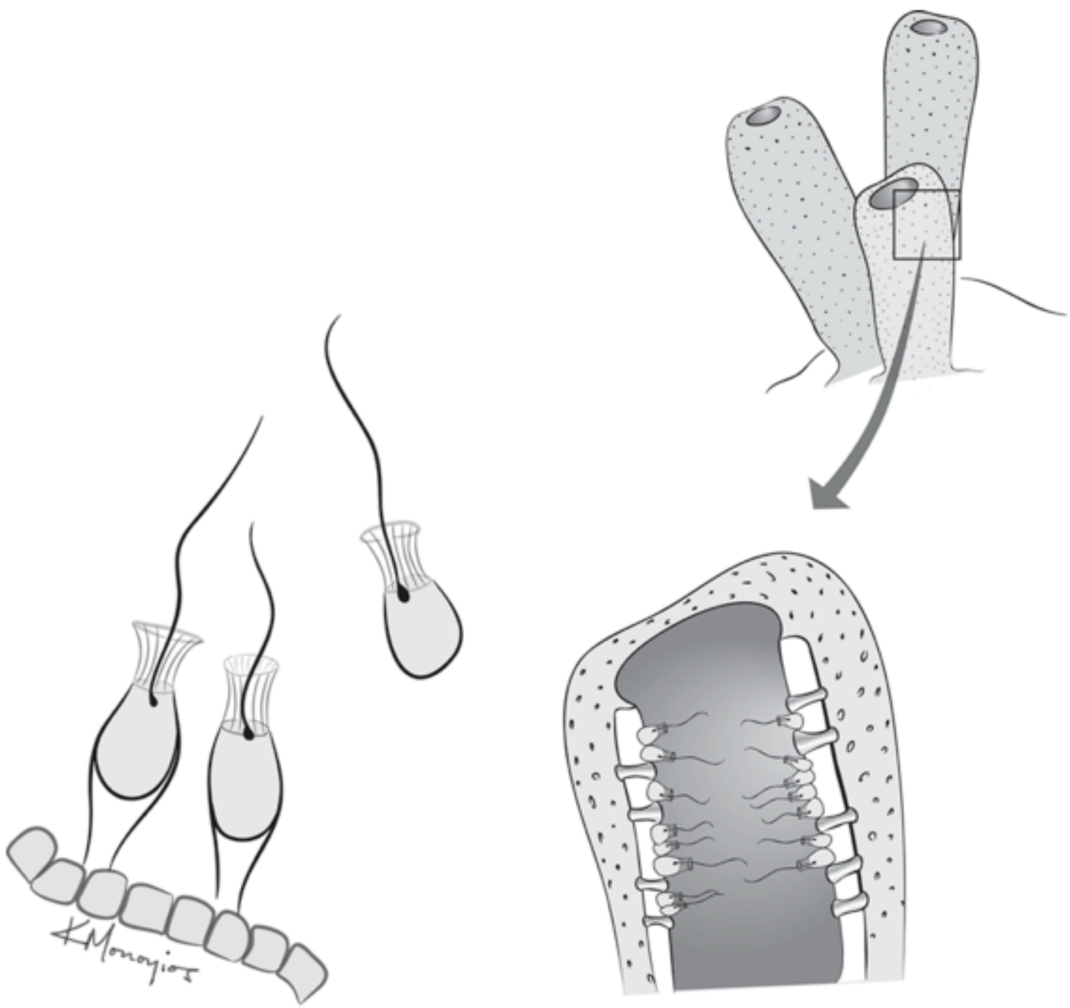



*Hox* genes in flies and people. The head-to-tail organization of the body is under the control of different *Hox* genes. Flies have one set of eight hox genes, each represented as a little box in the diagram. Humans have four set of these genes. In flies and people, the activity of a gene mtches its position on th eDNA: genes active in the head lie at one end, those in the ail at anoher, with genes affecting the middle of the body lying in between.

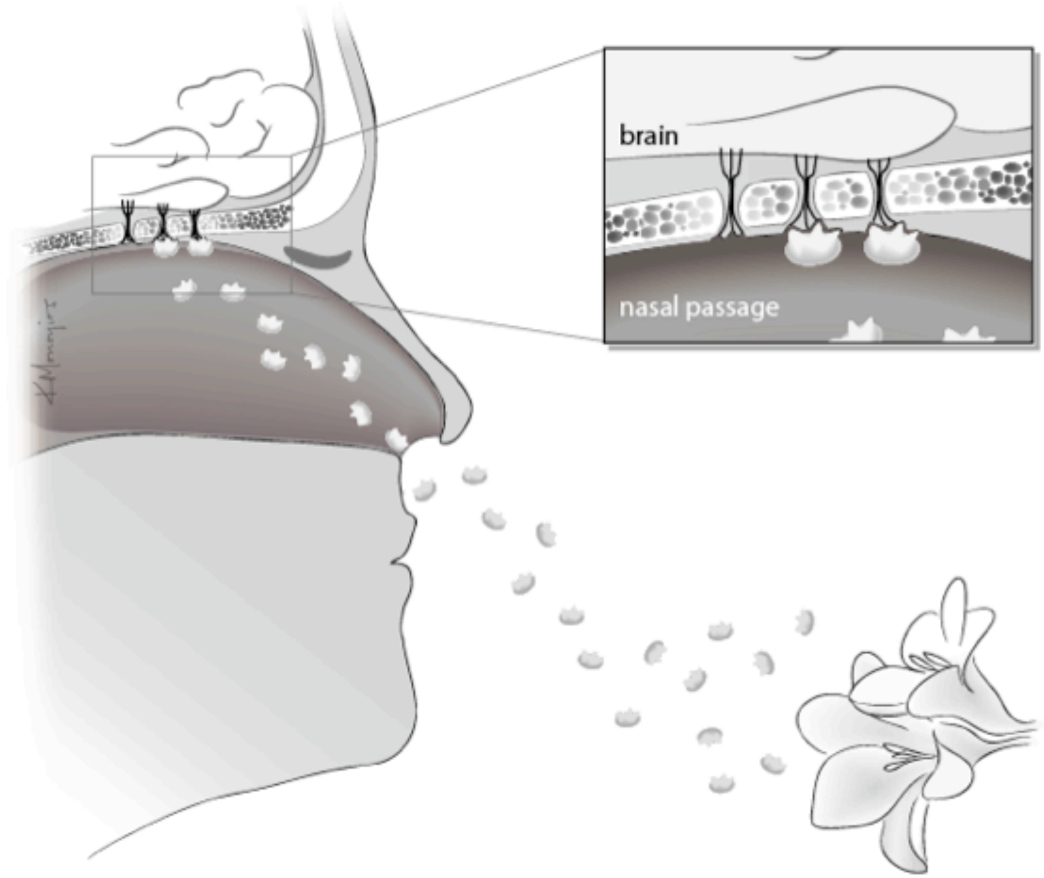



Jellyfish relatives, such as sea anemones, have a front and a back as we do, a body plan set up by versions of the same genes.

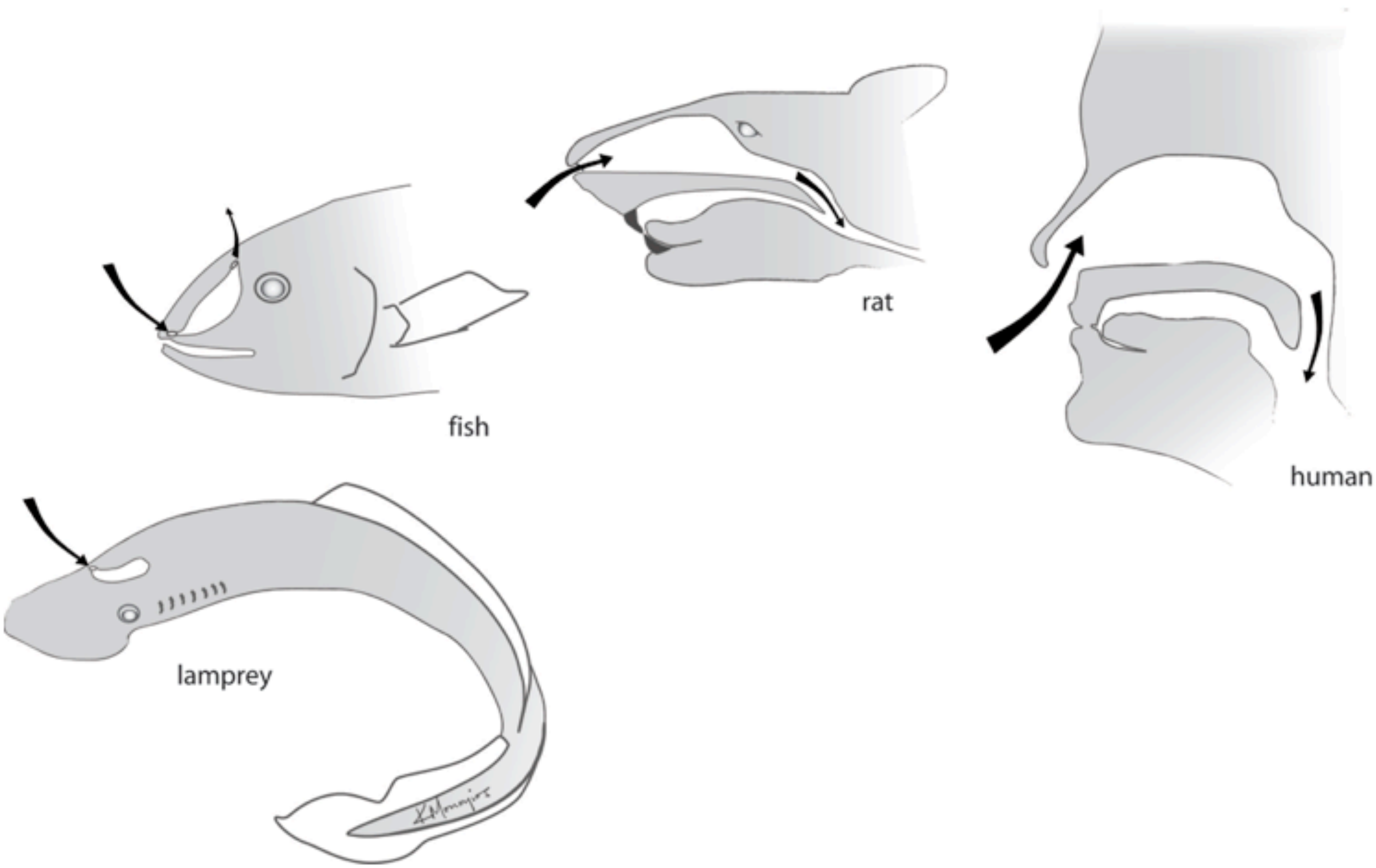

Today
first modern humans
first land animals
500 million years
first bodies
1 billion years
first life
4 billion years
4.6 Billion Years



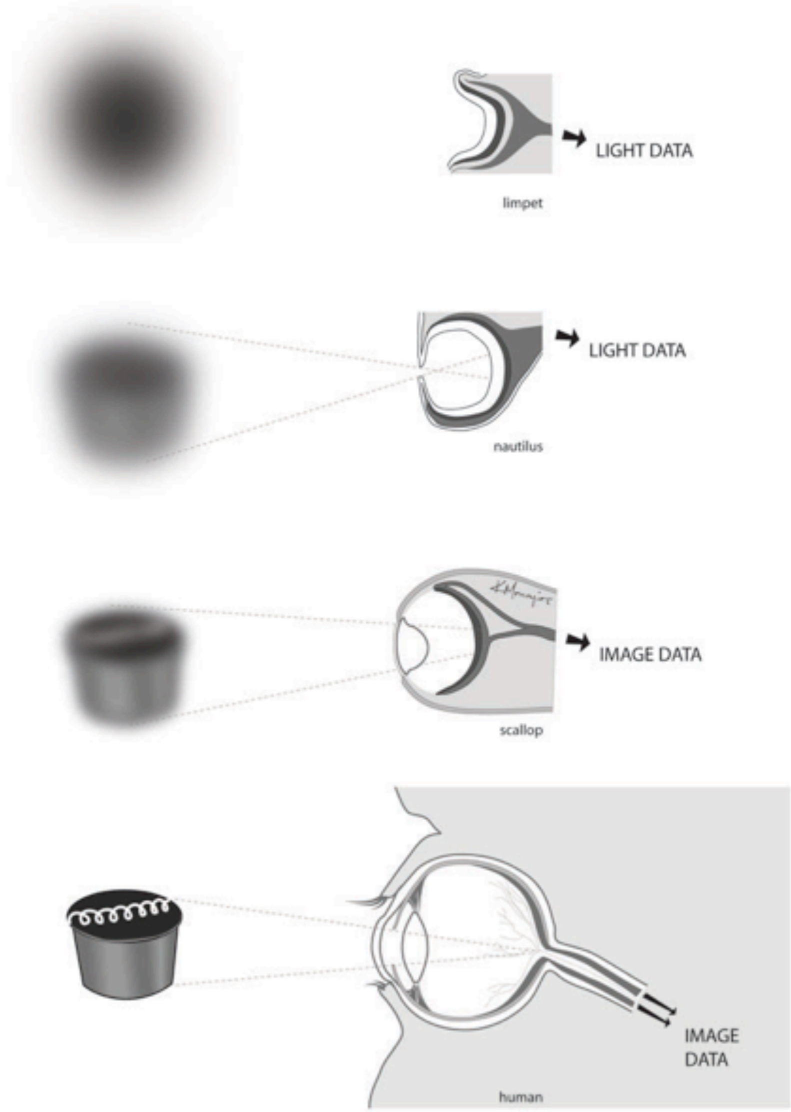

Choanoflagellates (left) and sponges (right).



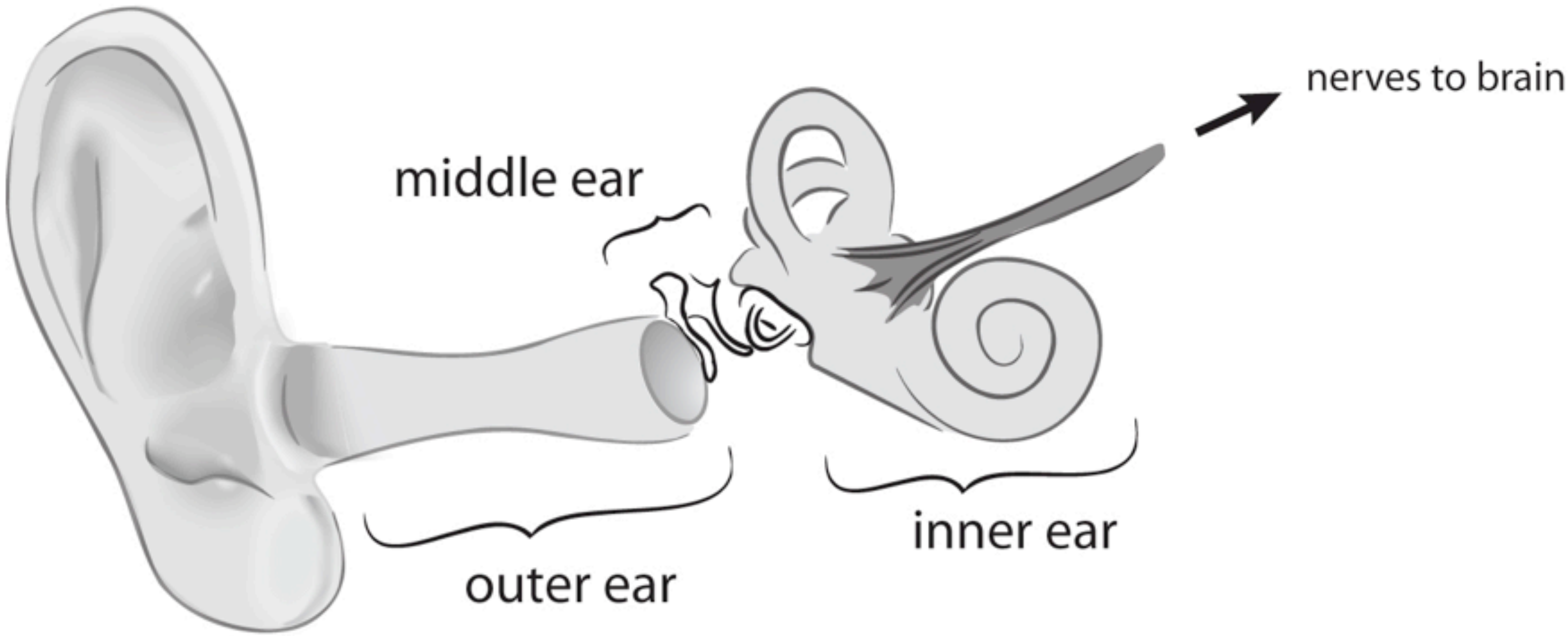

Molecules (enlarged many, many times) from a flower waft through the air. These molecules attach to receptors inside the lining of our nasal cavities. Once the molecules attach, a signal is sent to our brain. Each smell is composed of many different molecules attaching to different receptors. Our brain integrates these signals as we perceive a smell.



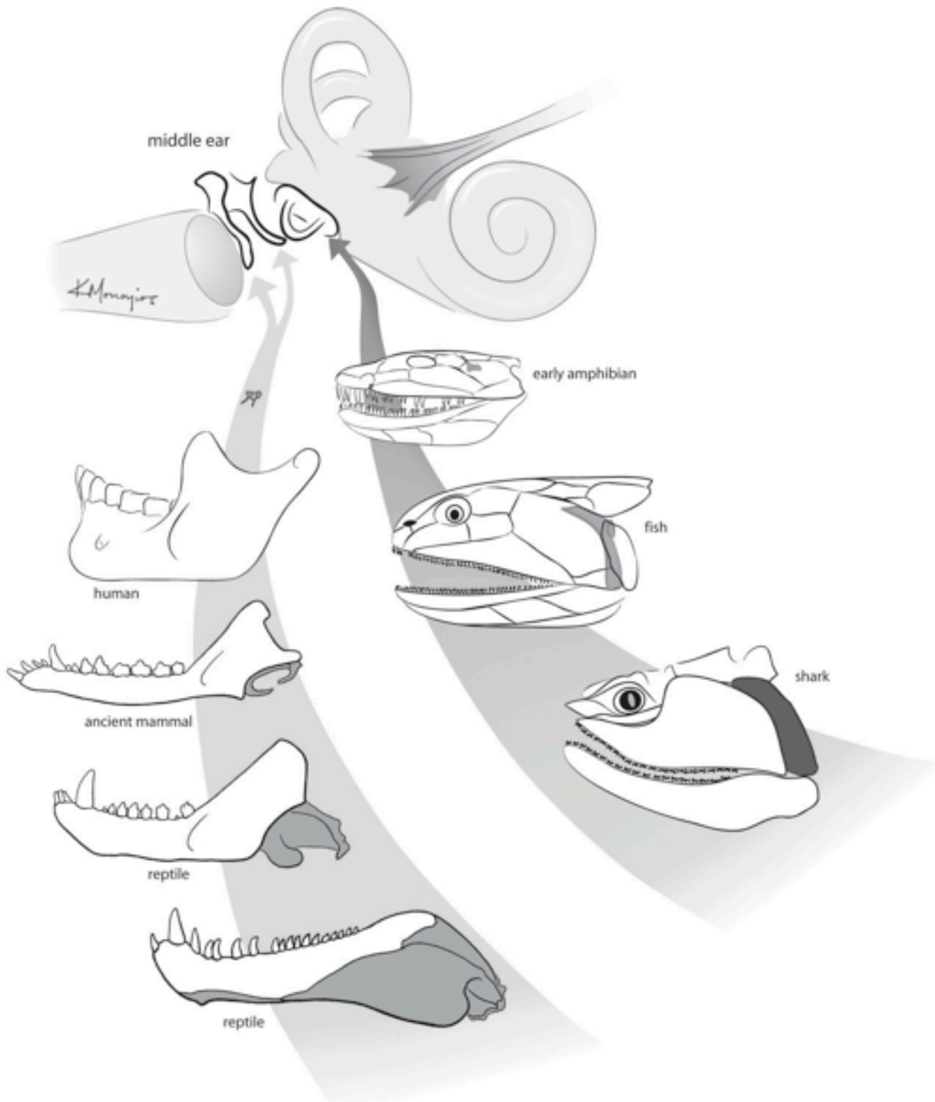

Nasal openings and the flow of odor molecules from jawless fish to man.



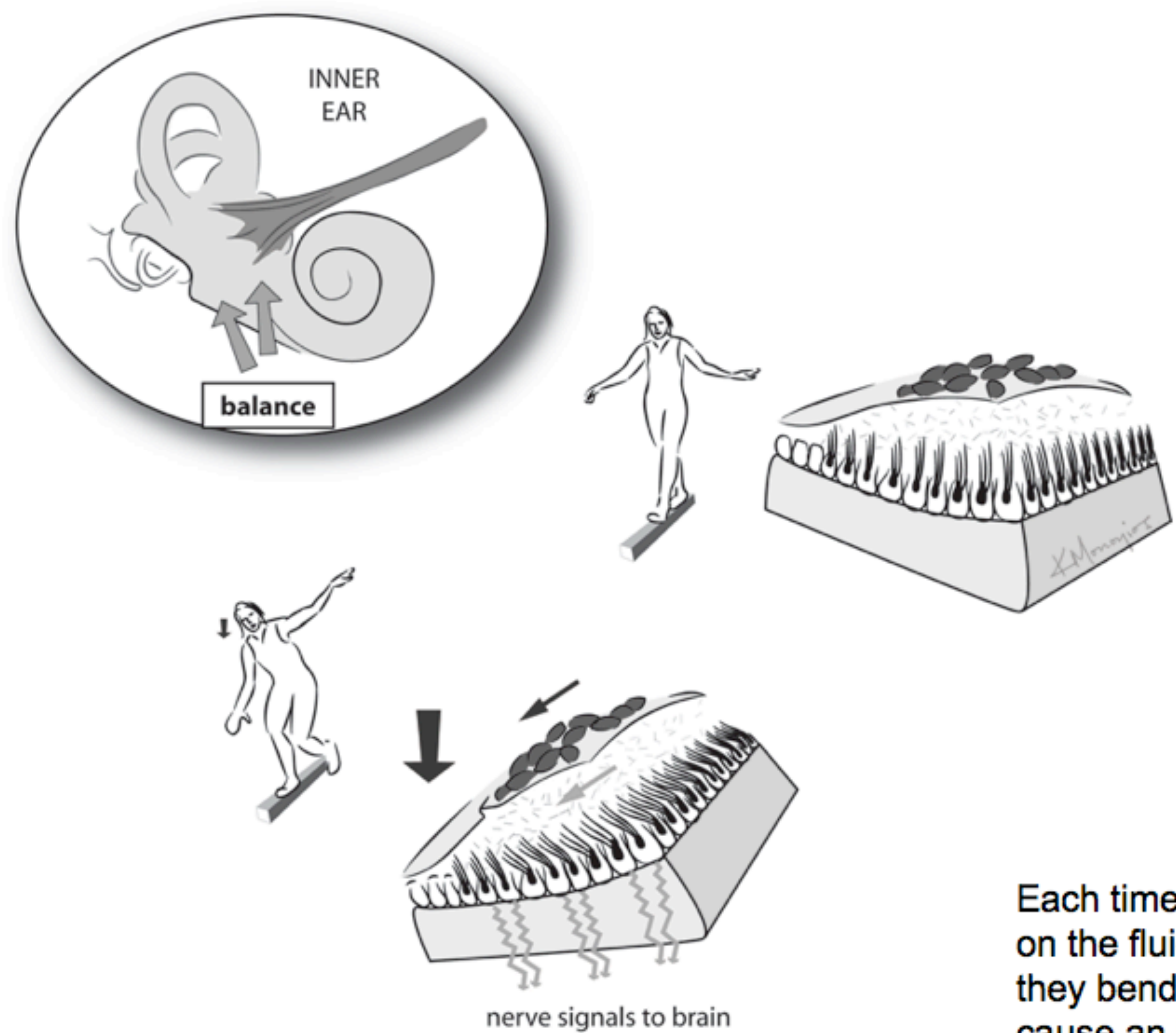

Eyes come into focus: from primitive light-capturing devices in invertebrates to our camera-type eye with a lens. As eyes evolve, visual acuity increases.



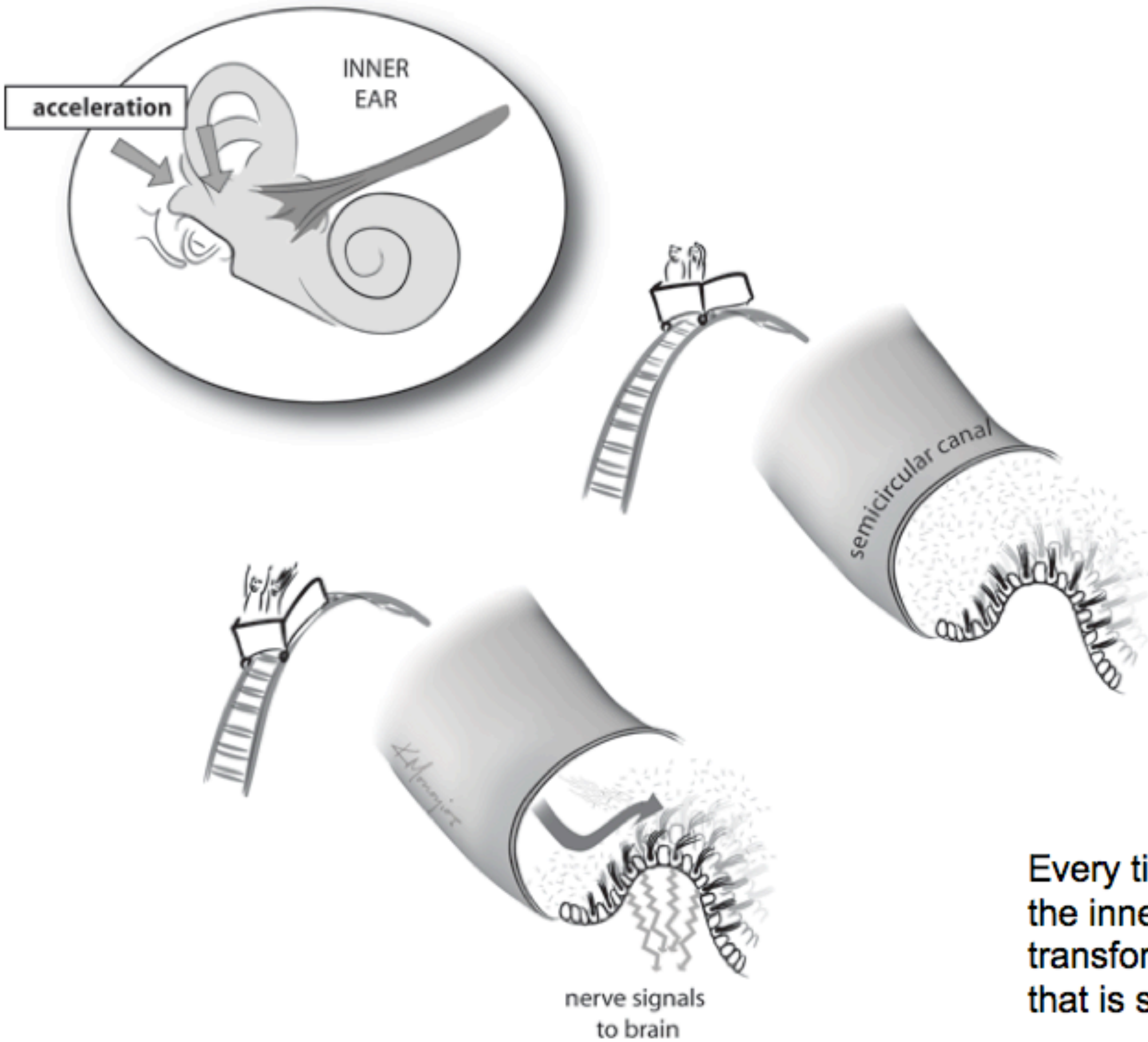

Of the three parts of our ear - the outer, middle, and inner - the inner ear is the most ancient and the part that controls the nerve impulses sent to the brain.



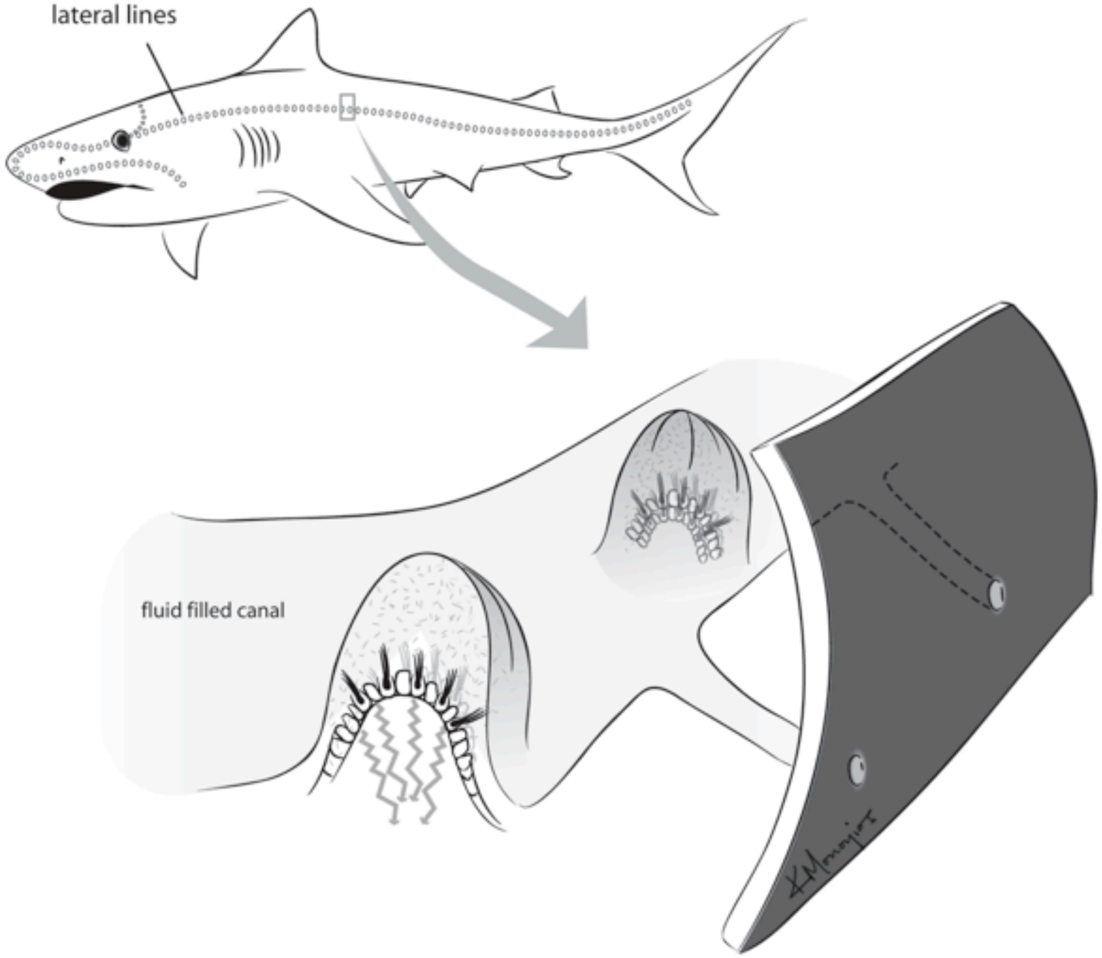

We can trace bones from gill arches to our ears, first during the transition from fish to amphibian (right), and later during the shift from reptile to mammal (left).



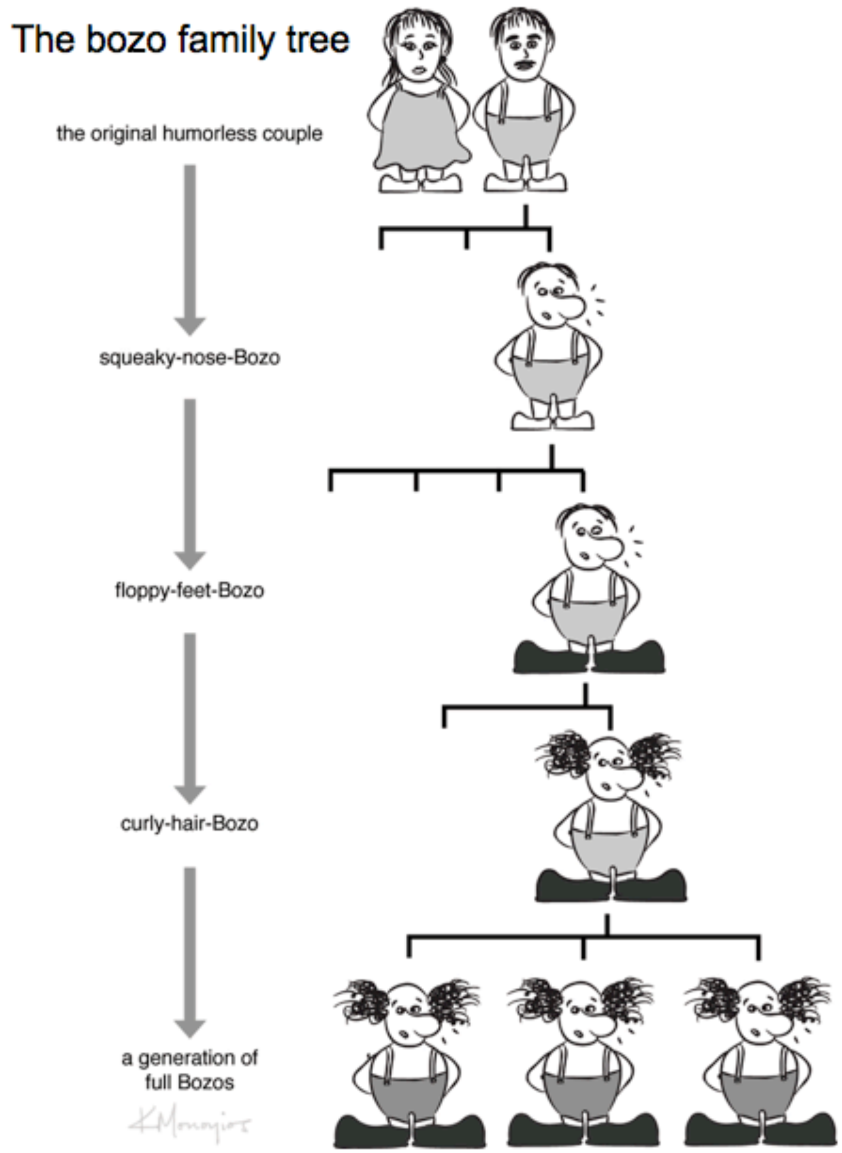

Each time you tilt your head, the tiny rocks on the fluid-filled sacs move. In doing so, they bend nerve endings inside the sacs and cause an impulse to be sent to your brain saying "Your head is tilted."

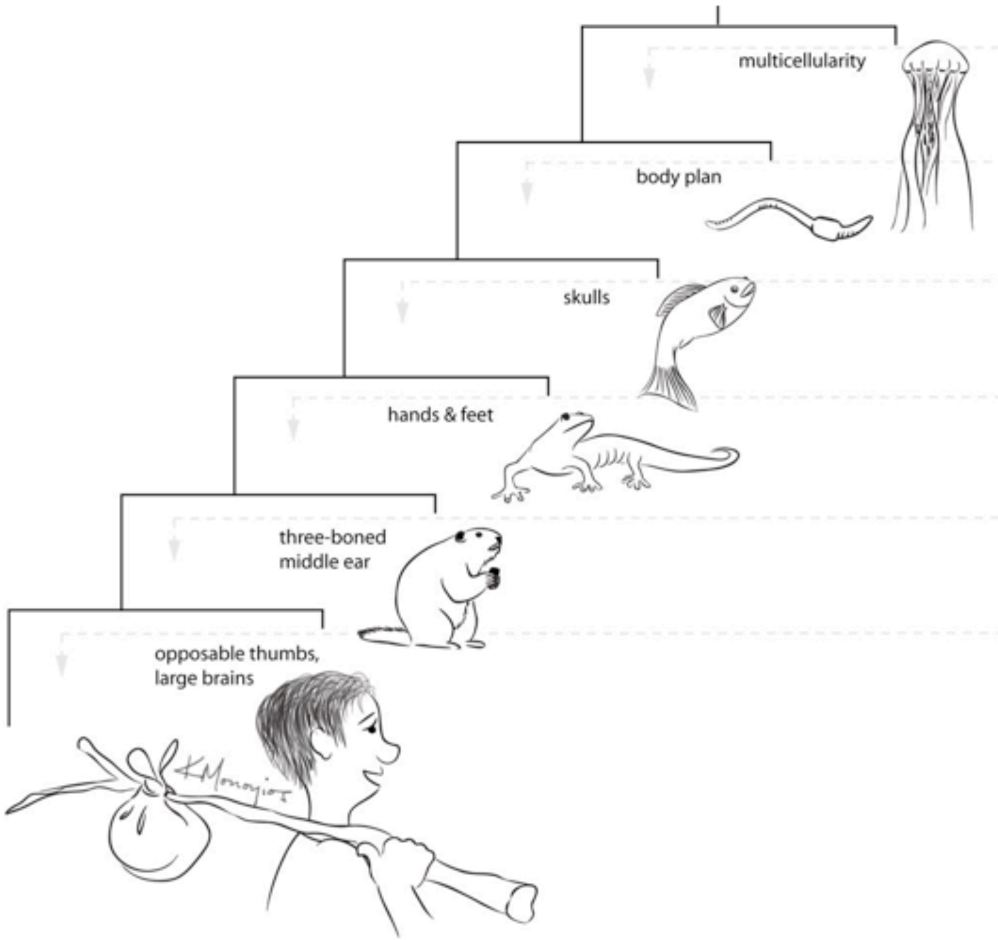



Every time we accelerate, fluid in the inner ear swishes. The swish is transformed into a nerve impulse that is sent to the brain.

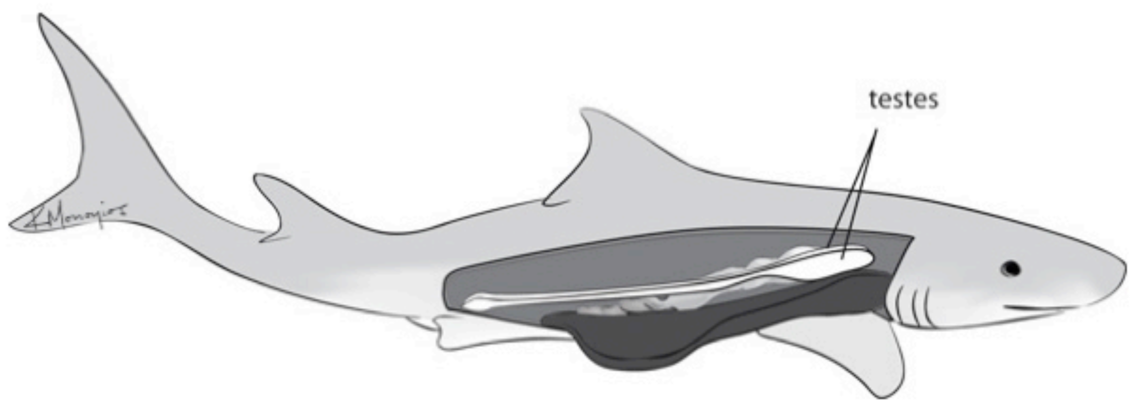



A primitive version of part of our inner ear is embedded in the skin of fish. Small sacs - the neuromasts - are distributed around the body. When they bend, they give the fish information about how the flow of water is changing.


The bozo family tree
the original humorless couple
squeaky-nose-Bozo
floppy-feet-Bozo
curly-hair-Bozo
a generation of full Bozos



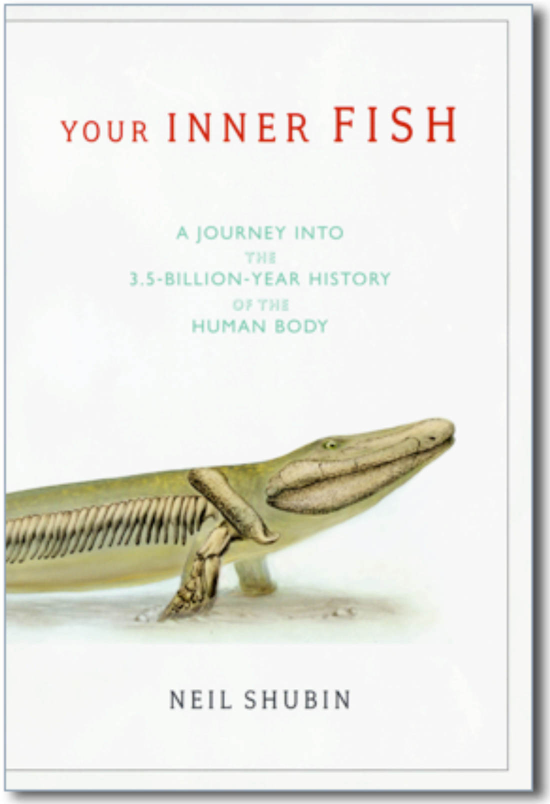

A human family tree, all the way back to jellyfish. It has the same structure as the one for the bozos.




Open a shark and you find a huge liver. Push the liver aside and you see gonads, which extend relatively close to the heart, as they do in other primitive creatures.

The descent of the testes. During growth, the testes descend from the gonads' primitive position high up in the body. They end up lying in the scrotum, which is an outpocket of the body wall. All of this leaves the body wall of human males weak in the groin area.




For more teaching resources, go to:

http://tiktaalik.uchicago.edu/resources.html

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