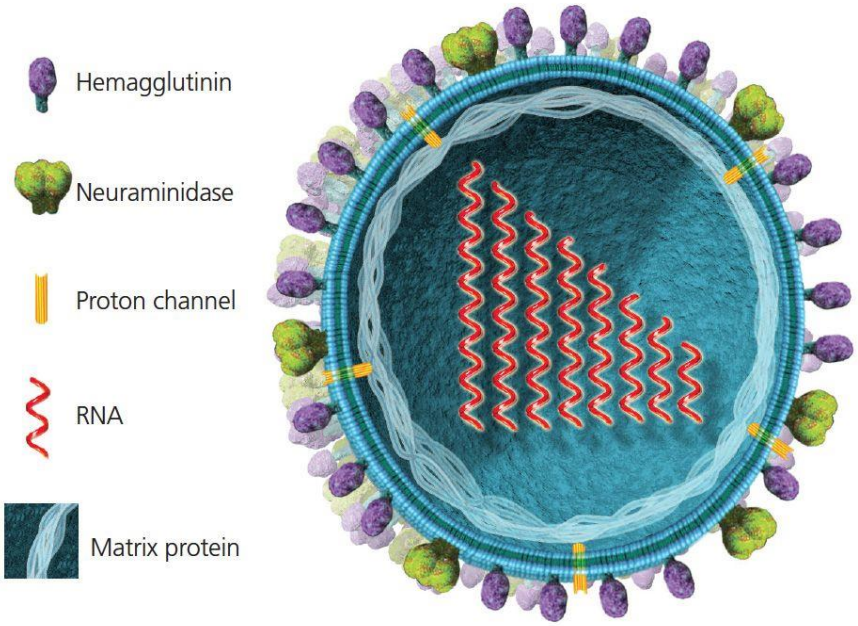
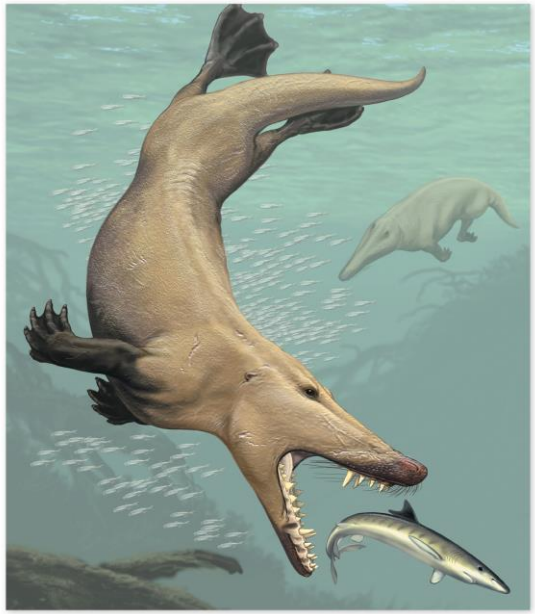
# Evolution explains the diversity of life

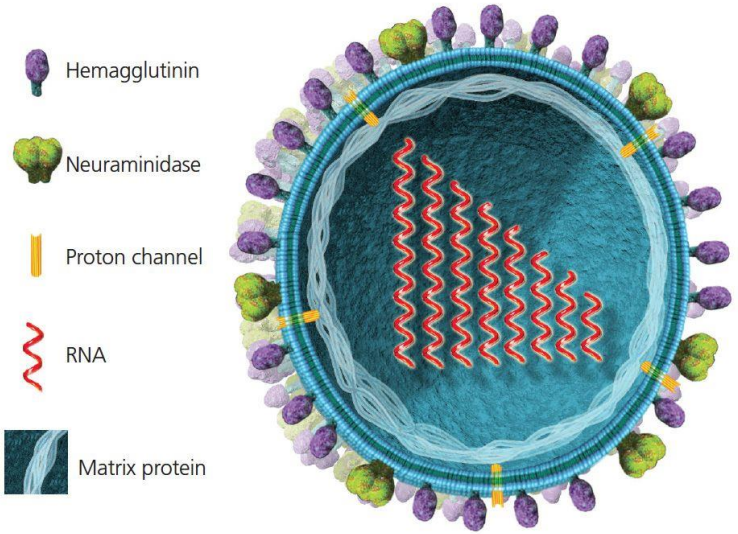


Chapter 1 Evolution case studies

- Whales: mammals gone to sea
- Viruses: the deadly escape artists

**Q1. Why choose whales and viruses to focus on? What kinds of organisms are whales and viruses? What do you know about them?**





**Q2. How are whales different from sharks?**

What major group do sharks belong to?

How are whales different from fish like tuna?
What major group of fish do tuna belong to?

Cetaceans are mammals!

So they…

- Develop in uterus with a placenta and drink milk from Mammary glands
- Movement of body (tail flukes)
- Hair (in developing embryos)
- Bones of inner ear are unique!

Whales share **synapomorphies** with mammals
Similarities with fish arose through **convergent evolution**

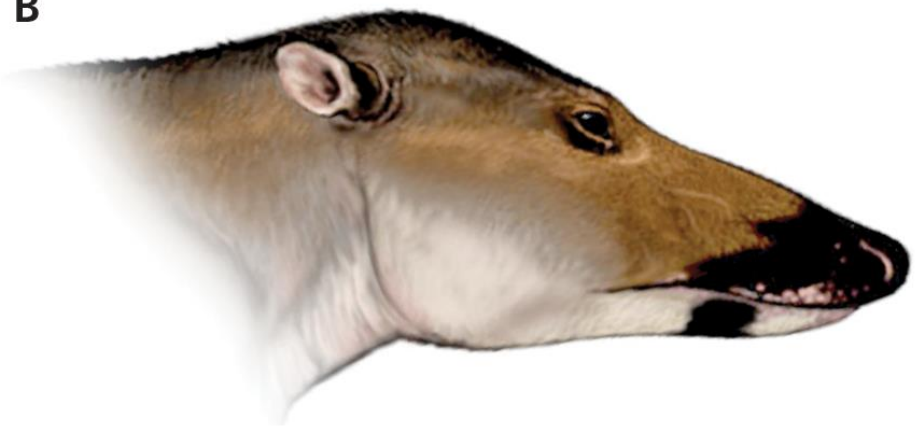
**Q3. What are the two main extant (still living) lineages of Cetaceans and how do their feeding styles and teeth differ?** (Fig 1.2)

**Odontocetes**
toothed whales (porpoise or “killer” whale and dolphin)
**Mysticetes**
baleen-it is keratin! (genes for building teeth disabled)

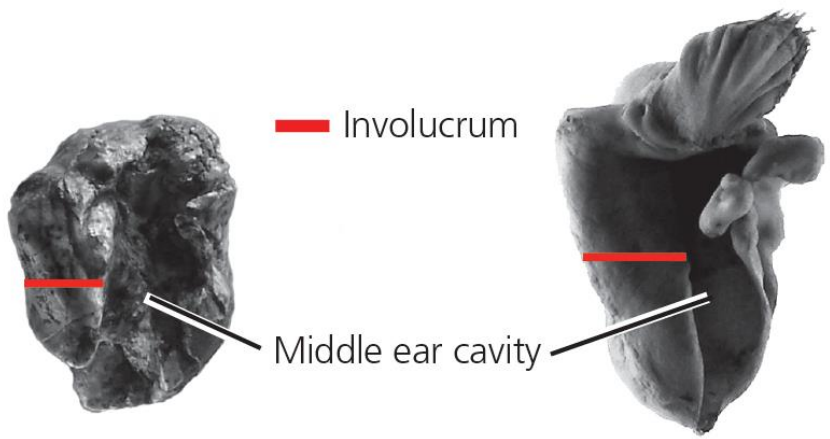
What other traits differ between these lineages? (Fig 1.8)


A

B



C




Fossil *Pakicetus* Dolphin *Lagenorhynchus*

**Q4. If you looked at Fig. 1.5A and 1.5B you might imagine this whale ancestor shared a recent common ancestor with what group?**

(In other words what kind of an animal does it remind you of and why?)

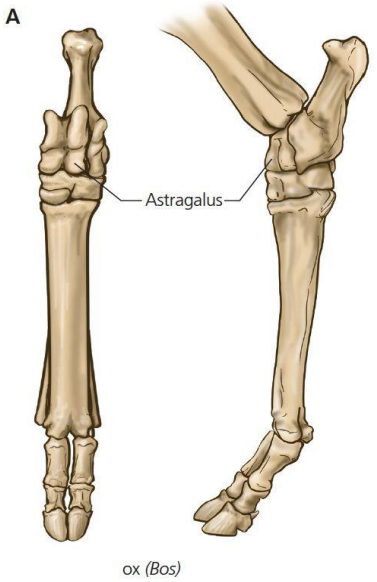
Q5. What is the astragalus and what was its role in understanding whale evolution? (Fig 1.7)

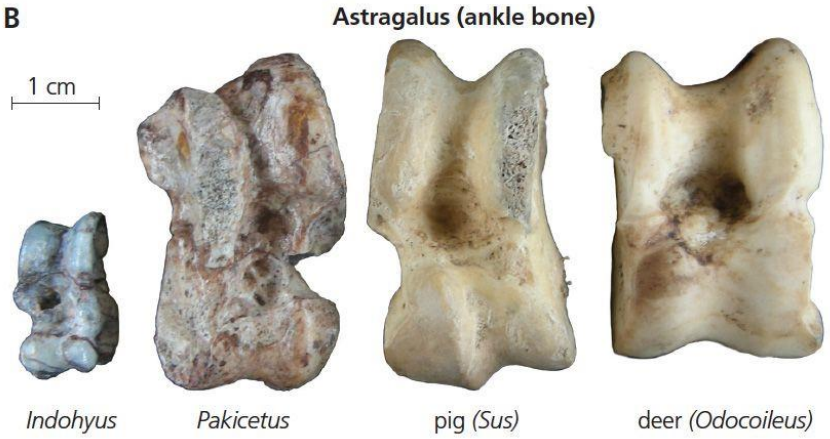
Q6. Would you call the astragalus a synapomorphy? Why? Why not?

Q7. Who are the Arteriodactyls?

Q8. Why don't whales and dolphins have an astragalus?

Q9. Who are the Perissodactyls? (horses, tapirs and rhinos)

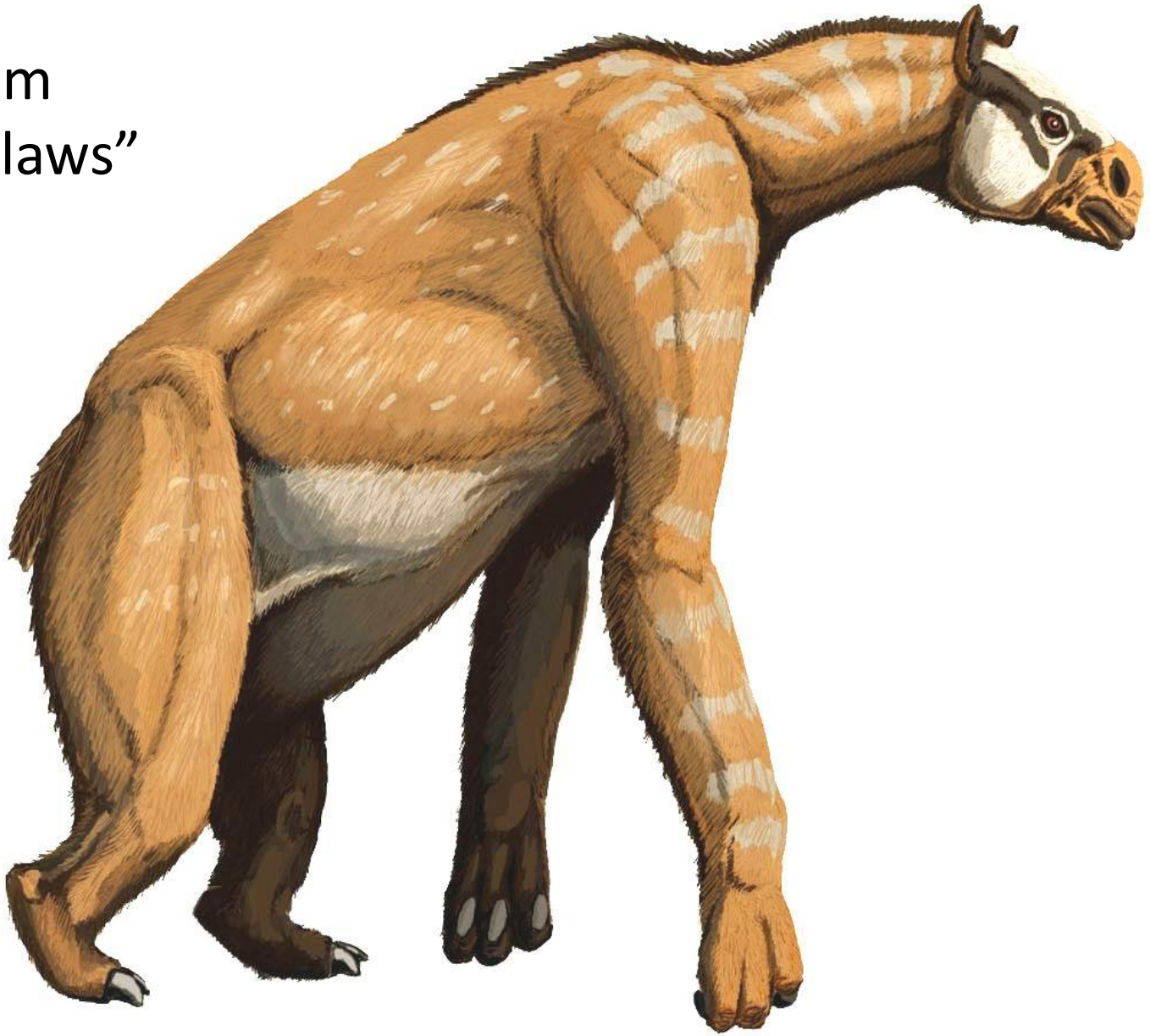



https://twitter.com/PepomintNarwh

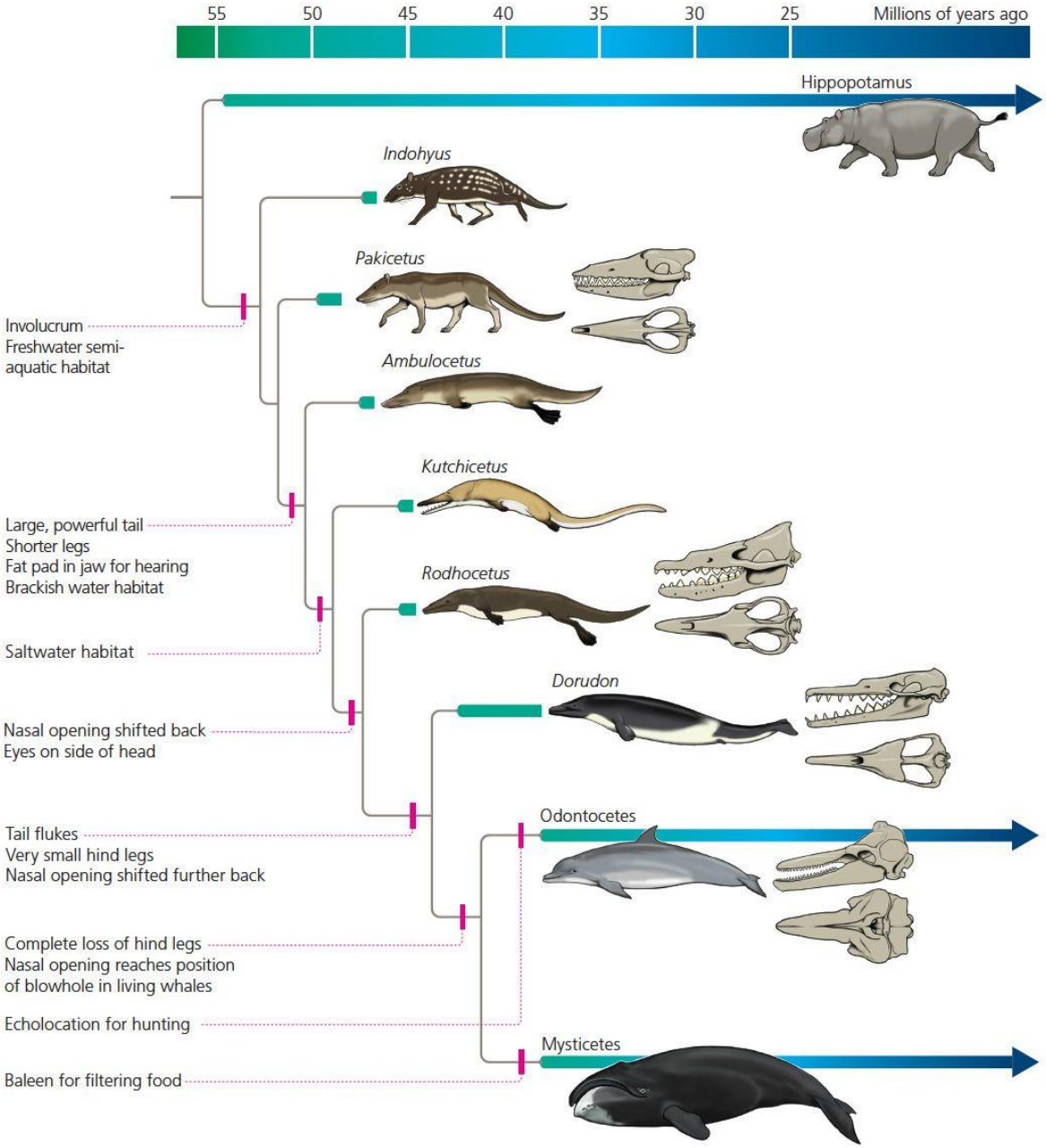
Another cool Perissodactyl…

Chalicotherium
“horse with claws”



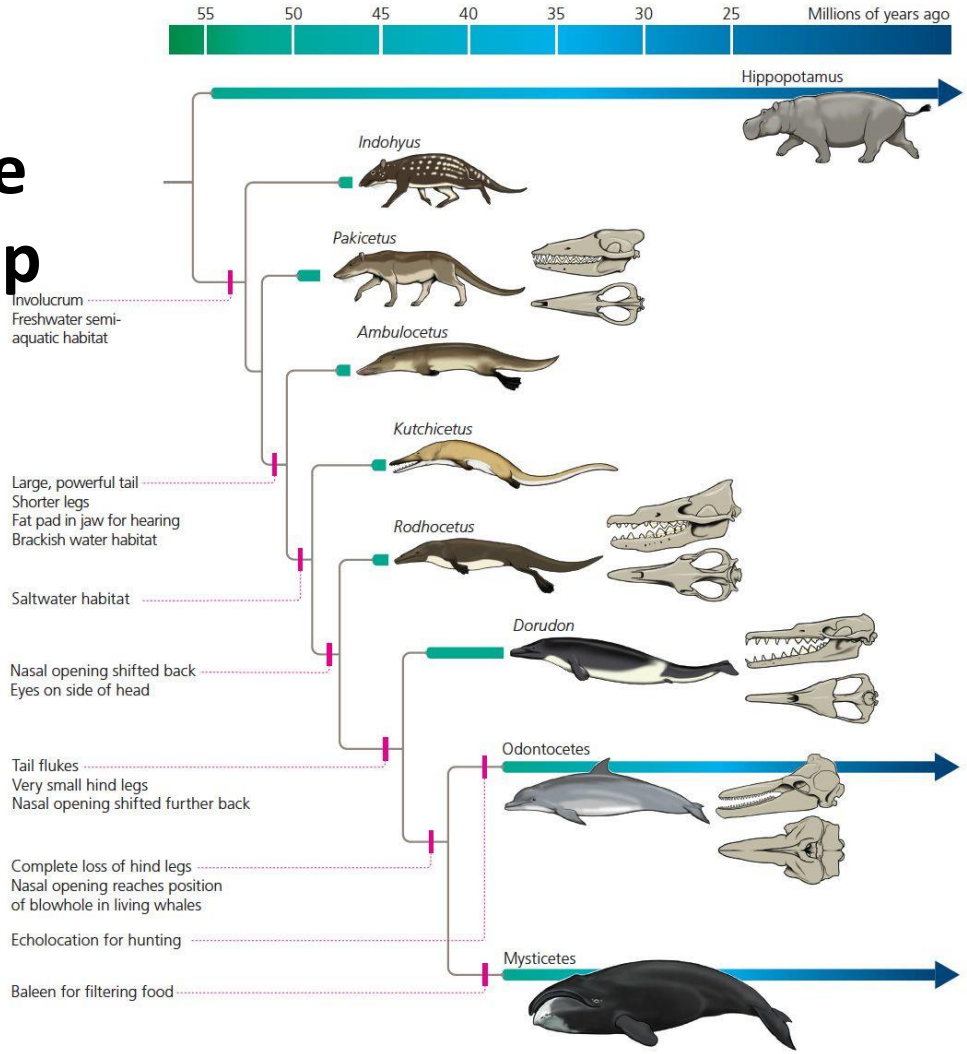
**Q10. What are the different adaptions to life in the water that the text describes?**

If you were going to modify your body to be a super competitive swimmer what would be convenient to change if you could about your body?

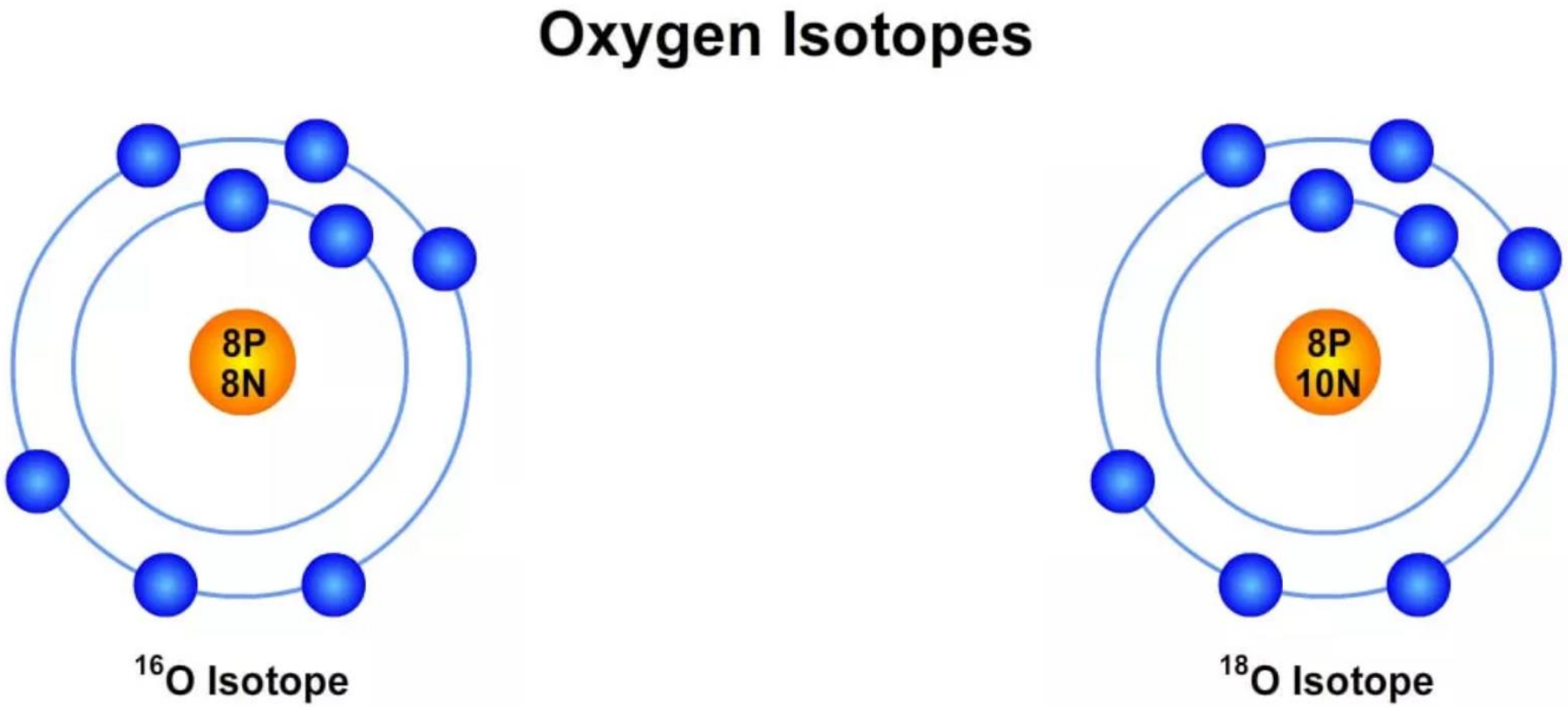


- limbs “lost” (front limbs reduced so much they now serve as flippers, back limbs? Vestigial pelvis!)
- nostrils, eyes high on head-why?
- bones dense-why?

**Q11. Did these traits evolve all at once or gradually, step by step?**



# Q12. What can we learn by studying the stable isotopes of oxygen in the whale lineage?




**“Normal” Oxygen**

**“Unusual” Oxygen (there is generally less of this one)**

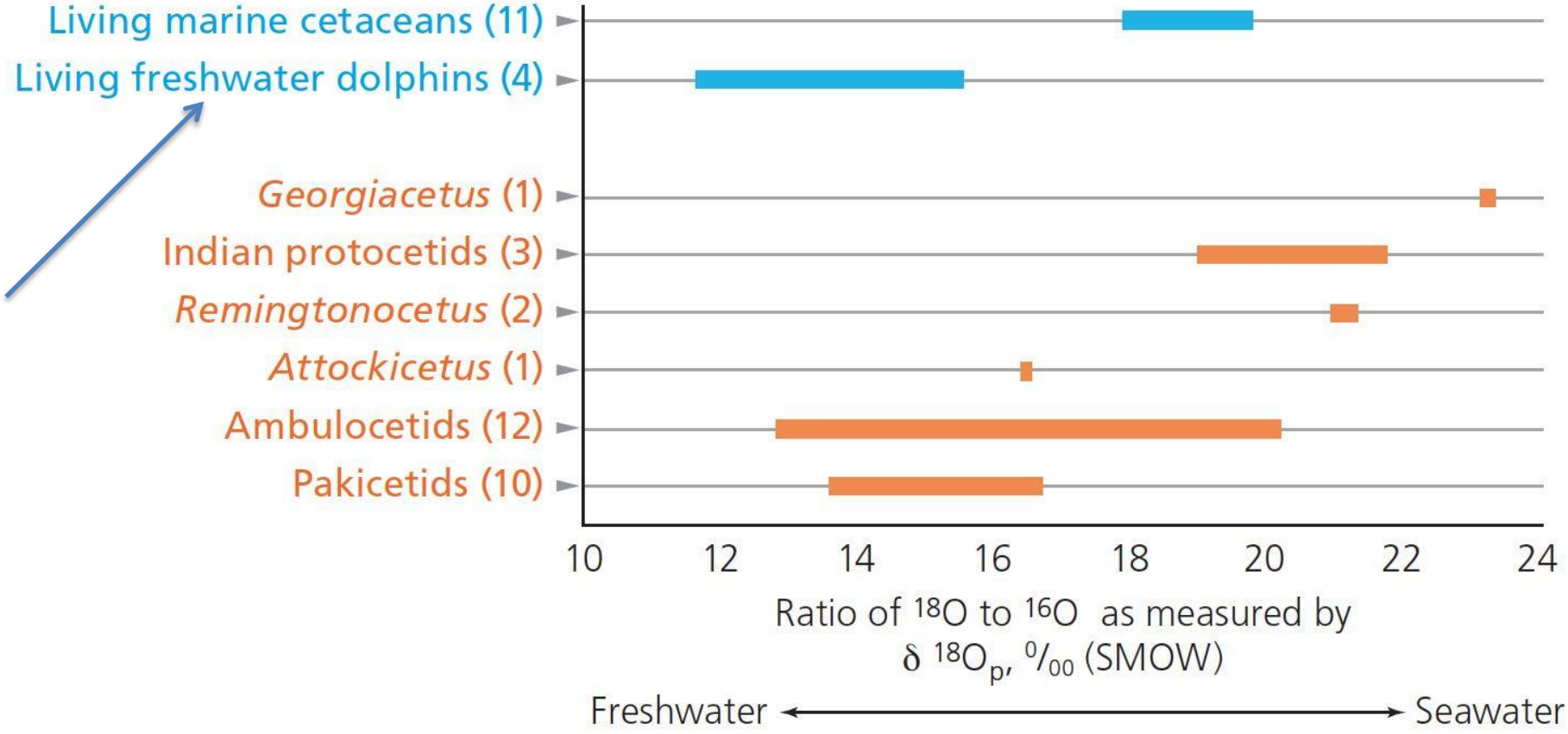
https://www.donovanpdennis.com/blog/sublimation-not-so-sublime-anymore

# Q12. What can we learn by studying the stable isotopes of oxygen in the whale lineage?

Look at bones!

$O^{18}/O^{16}$ ratio higher in saltwater (so more 18 relative to 16)

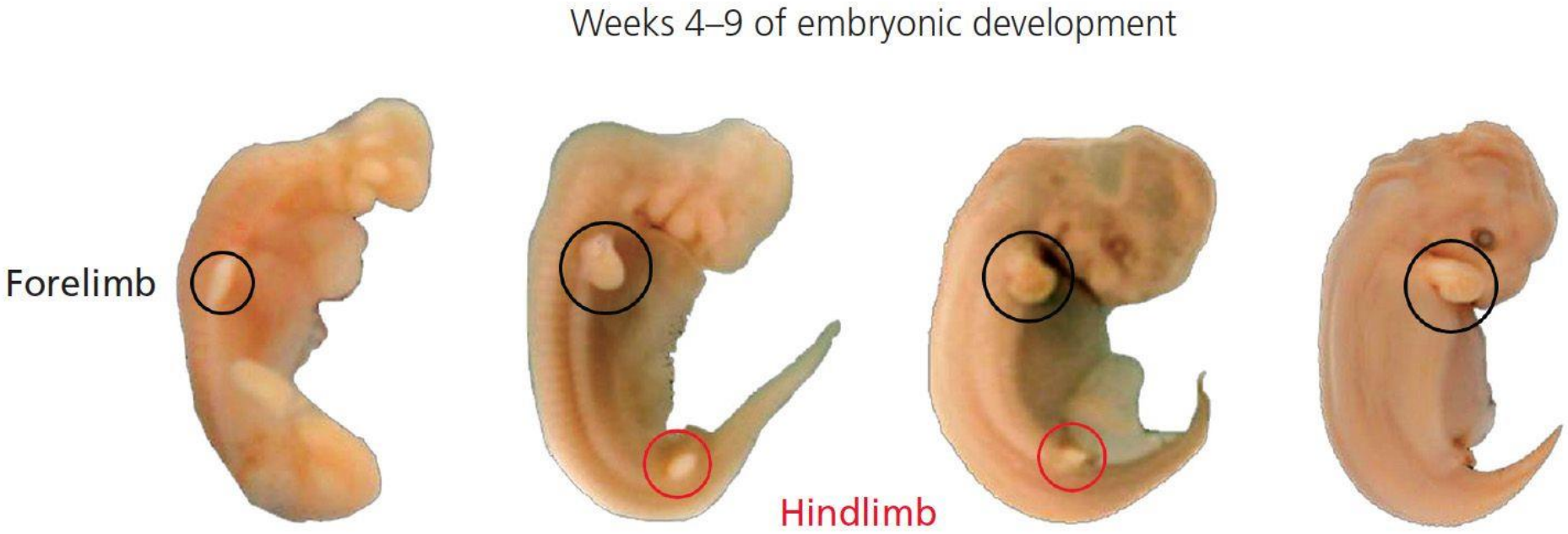
(FYI saltwater=seawater= ocean=marine)



**Q13. In dolphins, hindlimbs never start to develop and the genes to build a leg have been completely lost. T/F**

(Fig. 1.10)

Actually no loss of a gene, but has been a change in gene expression. (this statement will make more sense later)



**Q14. What is the difference between a Basilosaurus and a Basilisk?**

**Notice the "saurus" part of the term Basilosaurus!**

Before reading this chapter if I told you about an animal that used to live on this planet called a basilo**saurus** what might you imagine it was related to?

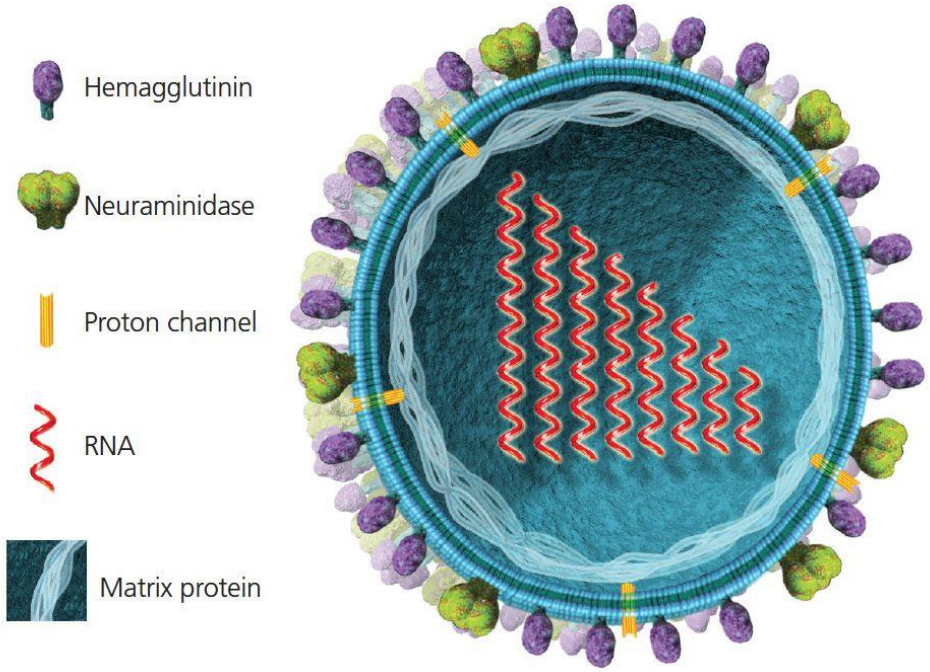
**Q15. Which of these three time periods did this group diversify in?**

Paleozoic? (roughly 550 to 250 mya)
Mesozoic? (roughly 250 to 65 mya)
Cenozoic? (roughly 65 to present)

**Q16. Why were whales exploited and what does that mean for the population today?** (Fig. 1.14)

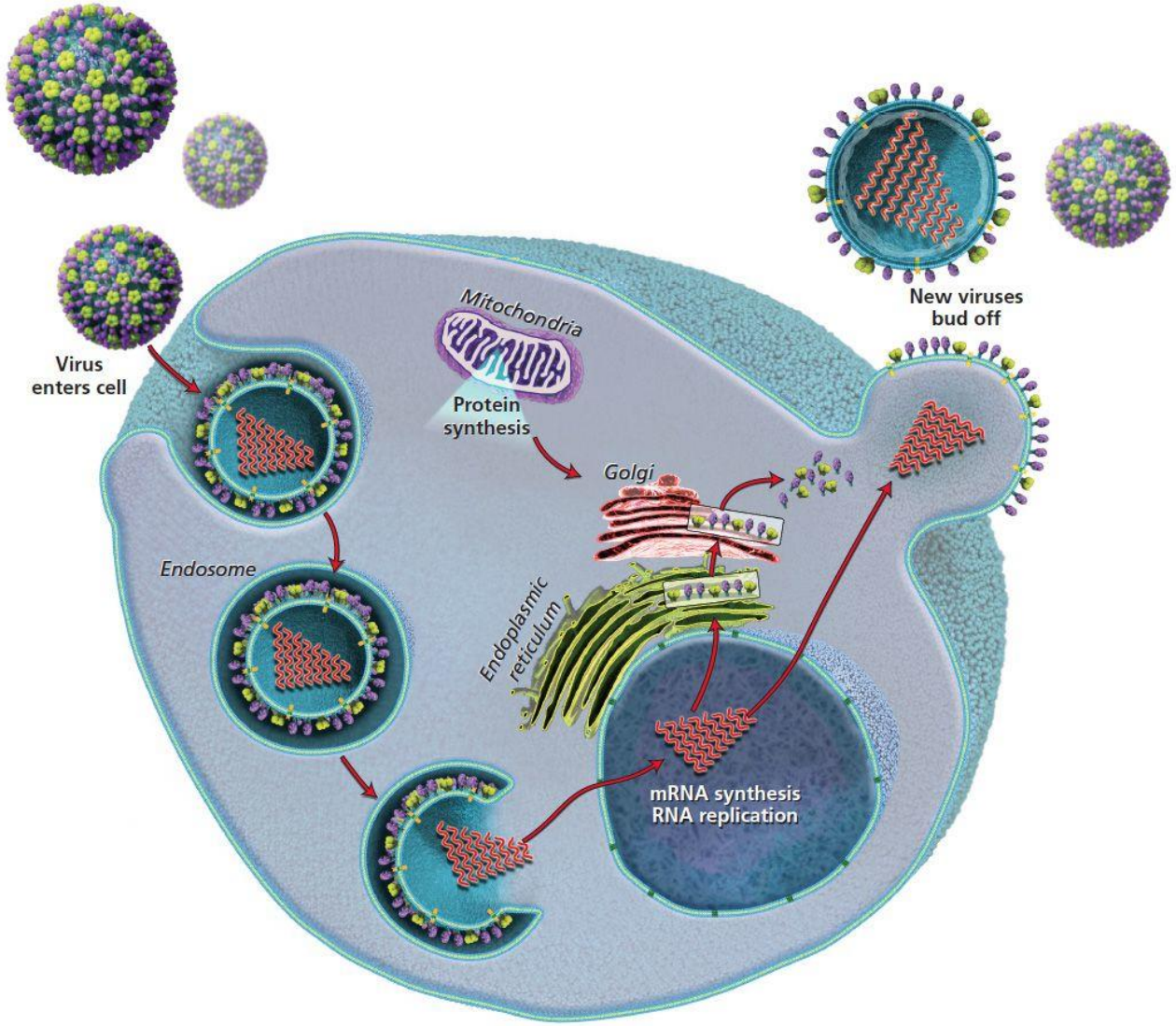
# Evolution case studies

- Whales: mammals gone to sea
- **Viruses: the deadly escape artists**



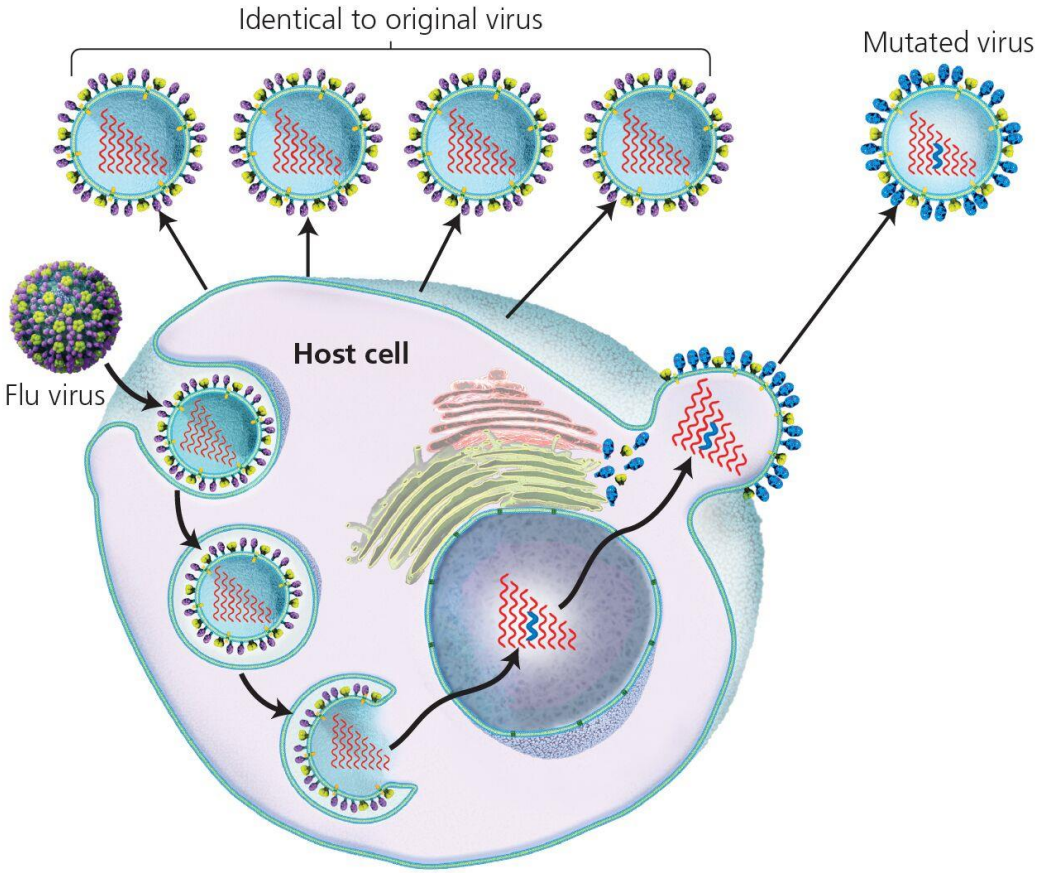
**Q1. How do viruses reproduce?**

**Q2. How does the virus get in and out of the cell it is infecting? What is HA and N?**



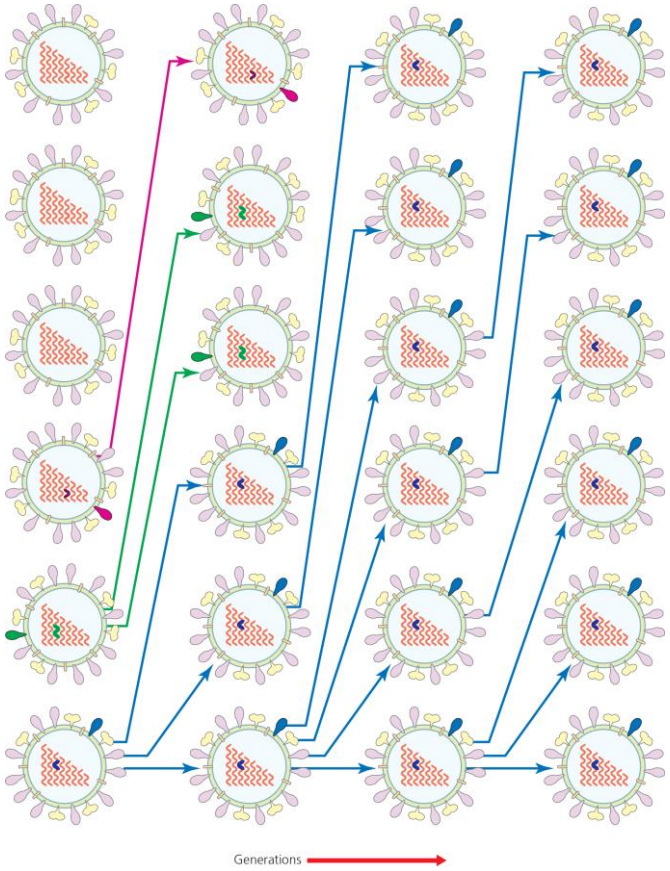
## Q3. How do viruses evolve?

Sometimes when genetic material is being copied (replicated) mistakes are made (mutations).




Mutations may be harmful or beneficial!

# Viral **strains** with beneficial mutations may increase in frequency through **natural selection**




Imagine a mutation that results in the virus no longer being recognized by the immune system!

It won't get killed by your immune cells and so may be more of that type in next generation.

Change in frequency or change in proportion of that type over time = evolution!

**Q4. Why have many viruses evolved high mutation rates?**

Ultimate=why questions are evolutionary questions

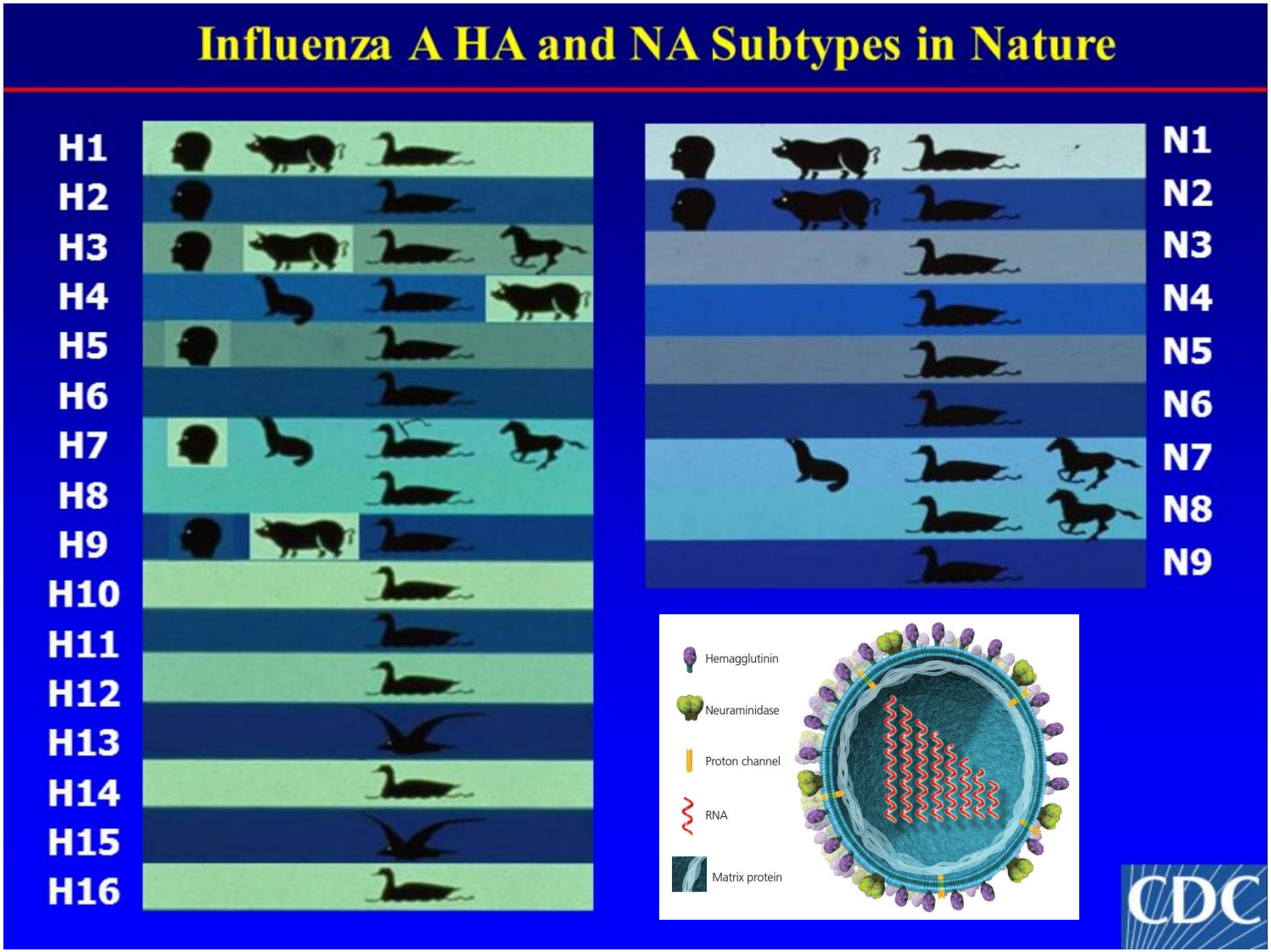
VS

Proximate=how questions are mechanistic questions

- *They have a high mutation rate because they are RNA viruses.*
- *They have a high mutation rate because they replicate rapidly.*
- *They have a high mutation rate because when they are copied they make mistakes.*

Instead think about the fact that viral strains with high mutation rates were more successful (left more offspring) because they were better at evading the immune system (were not recognized so survived).

# Q5. What is the original, original source for all influenza viruses? (anything identified with an H and an N)

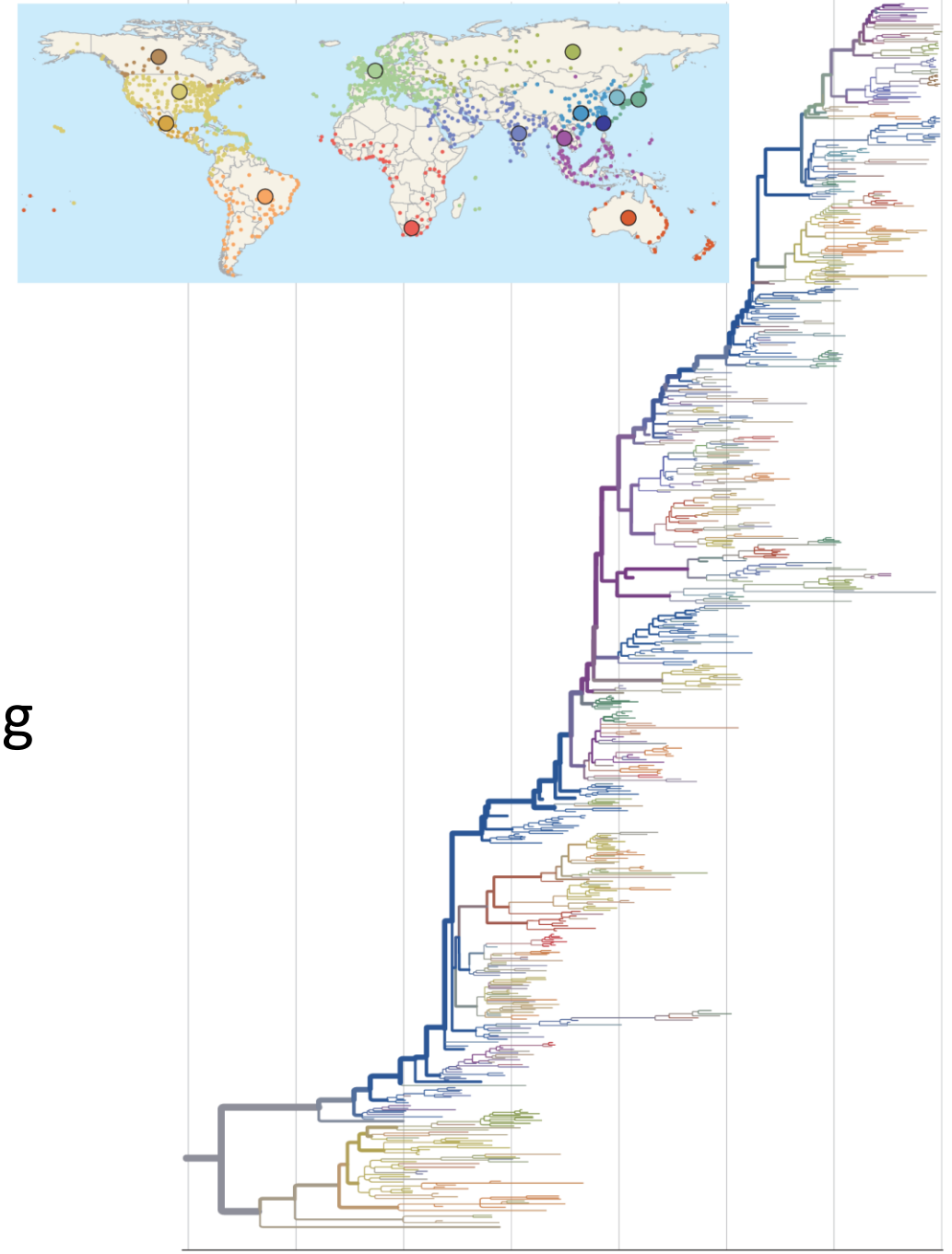


Natural selection creates increasing diversity over time!

**Q6. What is this image??**

What do you notice?
(you will get better at looking at these)

Shows history of the H3N2 influenza strain.

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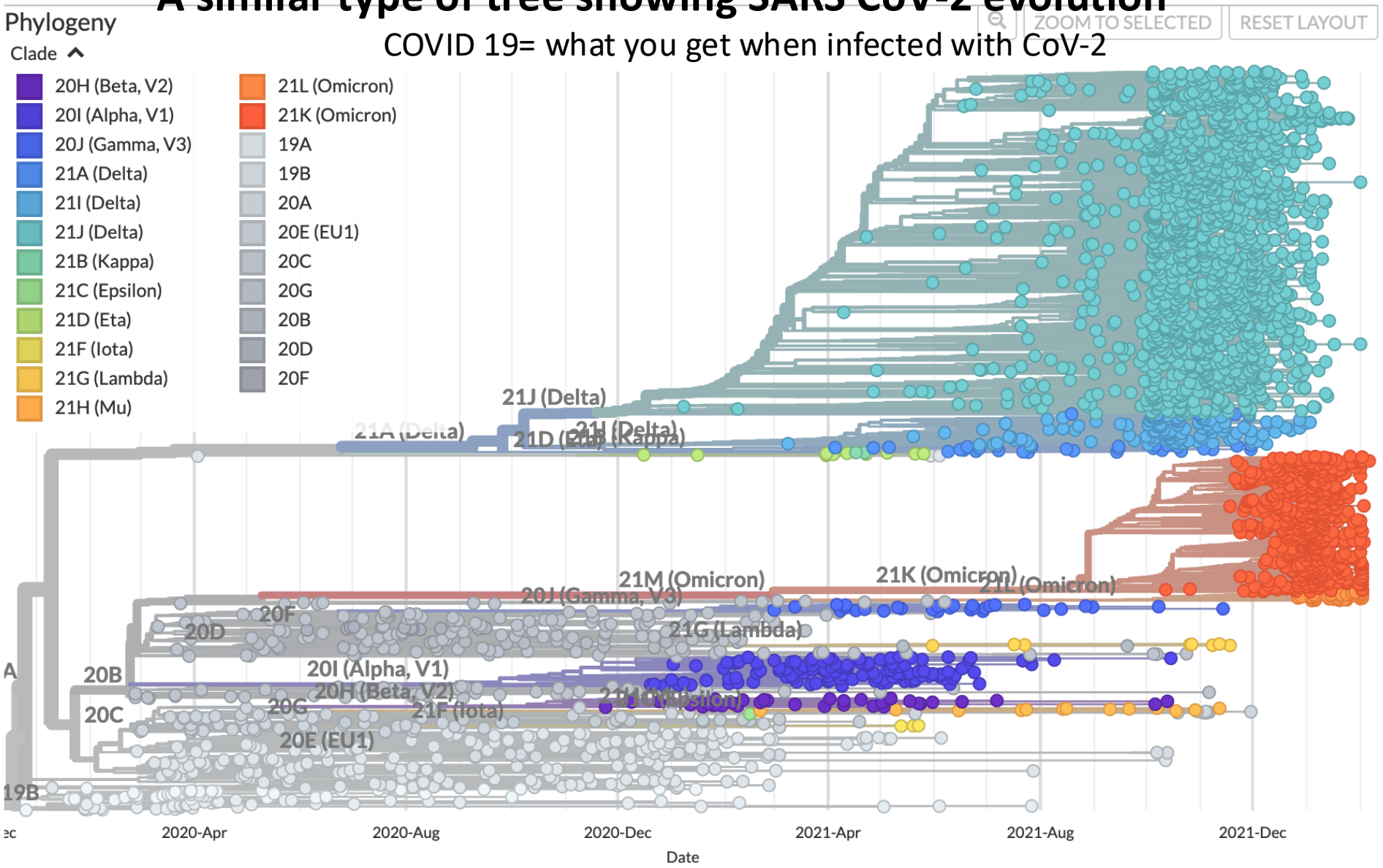
# A similar type of tree showing SARS CoV-2 evolution

COVID 19= what you get when infected with CoV-2



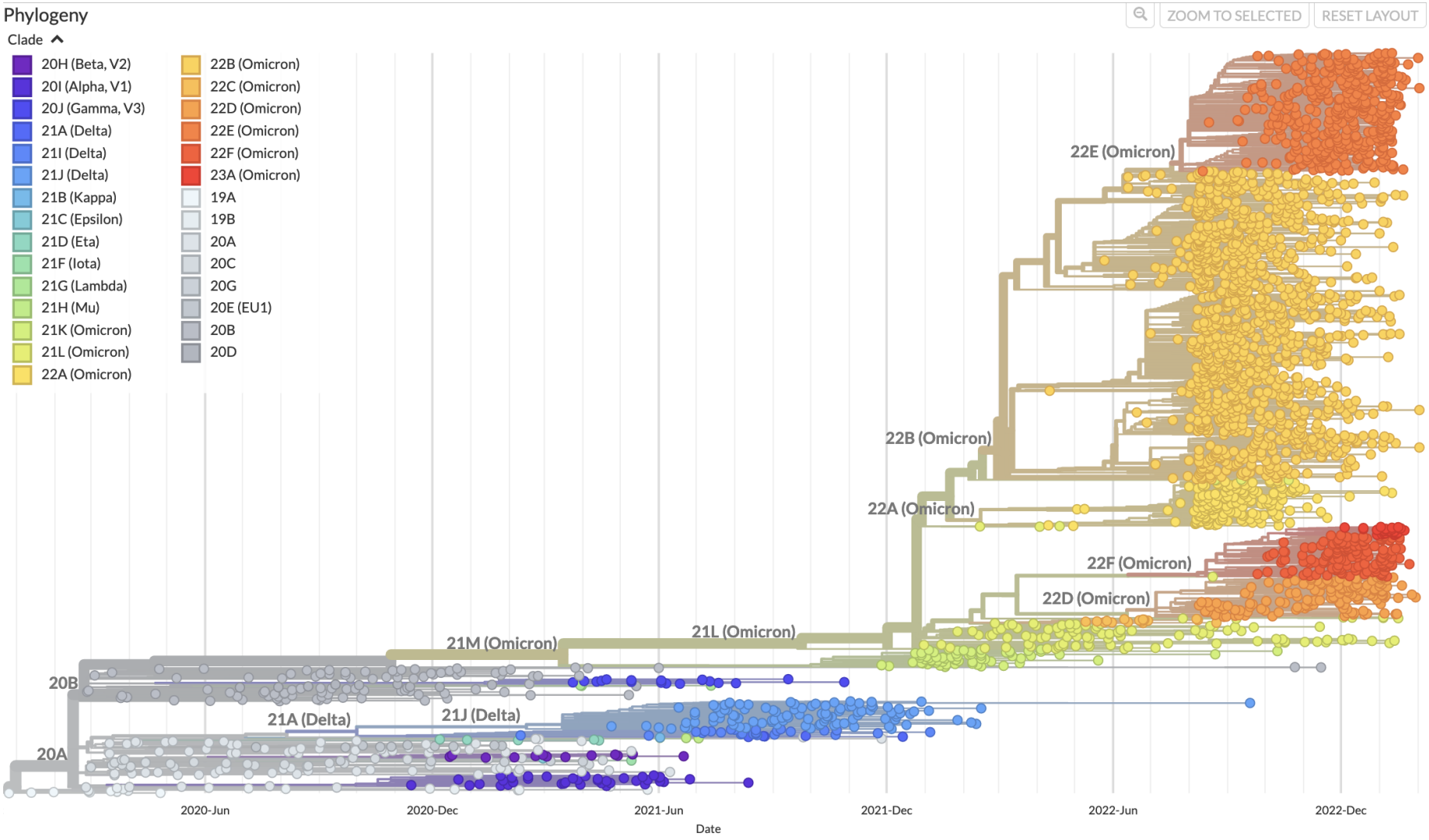

https://nextstrain.org/ncov/global

# Genomic epidemiology of SARS-CoV-2 with subsampling focused globally over the past 6 months

Built with nextstrain/ncov. Maintained by the Nextstrain team. Enabled by data from GISAID.

Showing 2767 of 2767 genomes sampled between Dec 2019 and Feb 2023.

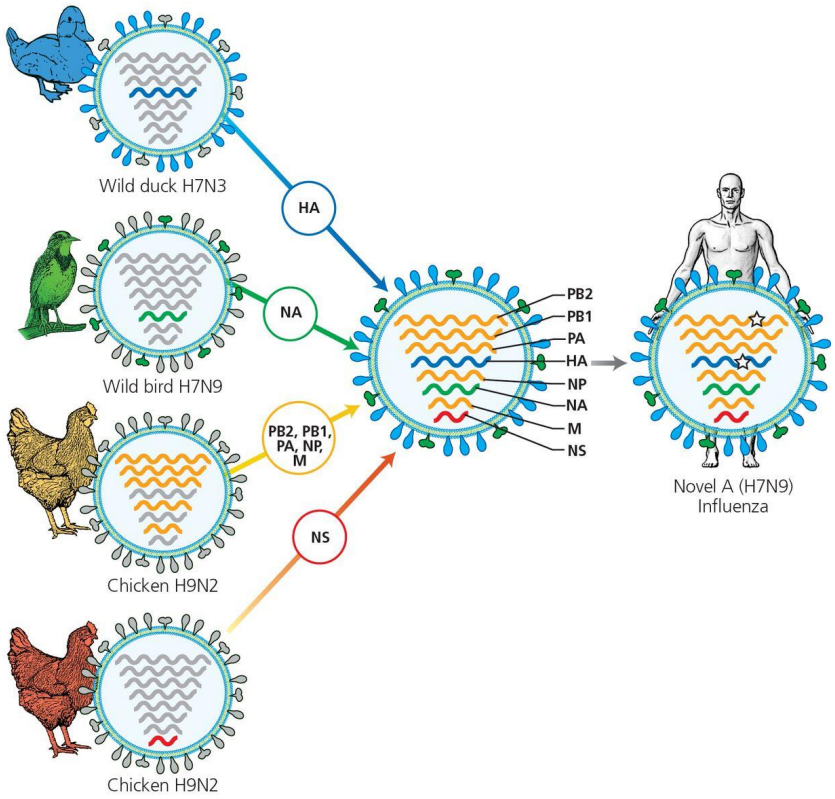
**A more recent screenshot...**



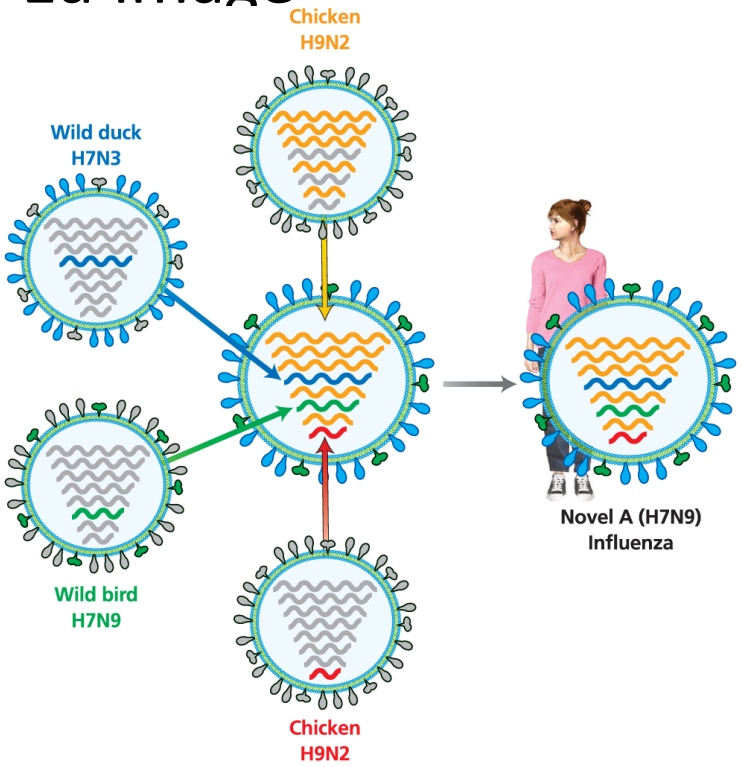
# Back to the influenza viruses!

## Q7. What is reassortment? (Fig. 1.21)

2nd Ed Image




3rd Ed image

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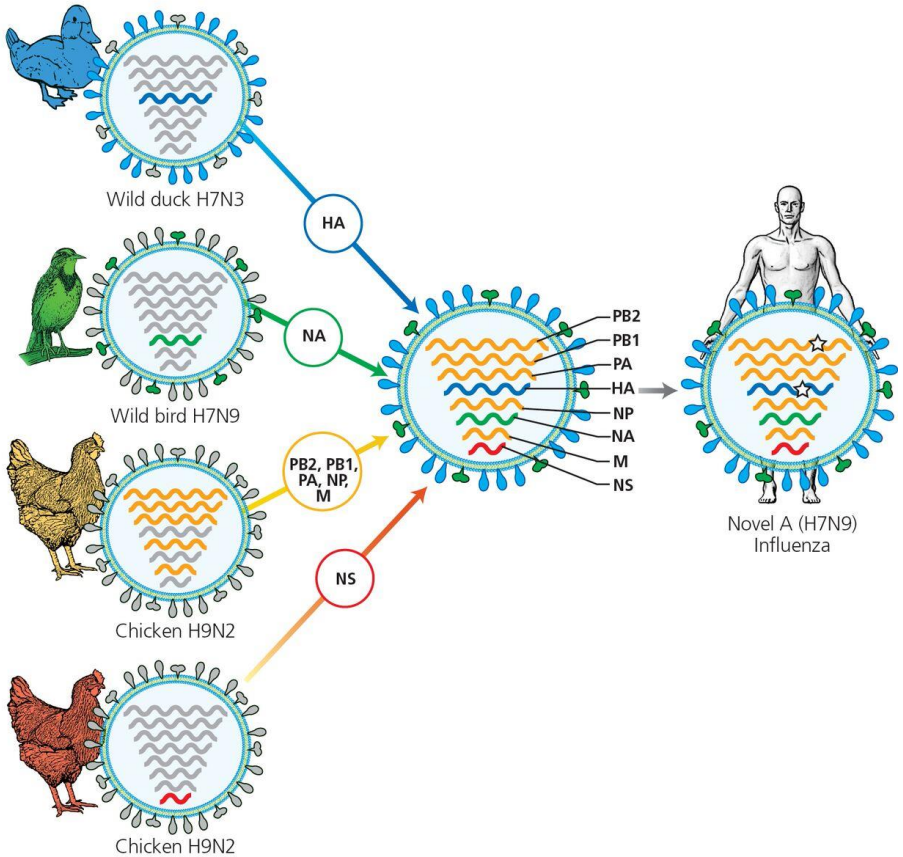
# Q8. What happened about a 100 yrs ago?

**Q9. What was the story with the H7N9 virus that appeared in 2013? How did H7N9 form?**

4 strains from wild birds were combined
Can't transmit from human to human..

Why is **reassortment** so dangerous? (see Fig 1.21)



**Just in case you were not aware of what was happening!**

https://www.cidrap.umn.edu/avian-influenza-bird-flu/more-avian-flu-outbreaks-pennsylvania-colorado

# More avian flu outbreaks in Pennsylvania, Colorado

*News brief | February 5, 2026*

*Stephanie Soucheray, MA*

*Topics: Avian Influenza (Bird Flu)*

**This Influenza out break is happening right now all over the country- H5N1.**

**Millions of birds**, including 1.3 million commercial table egg layers in Weld County, Colorado, have been sickened with highly pathogenic avian influenza, per this week's notifications from the US Department of Agriculture's Animal and Plant Health Inspection Services (APHIS).

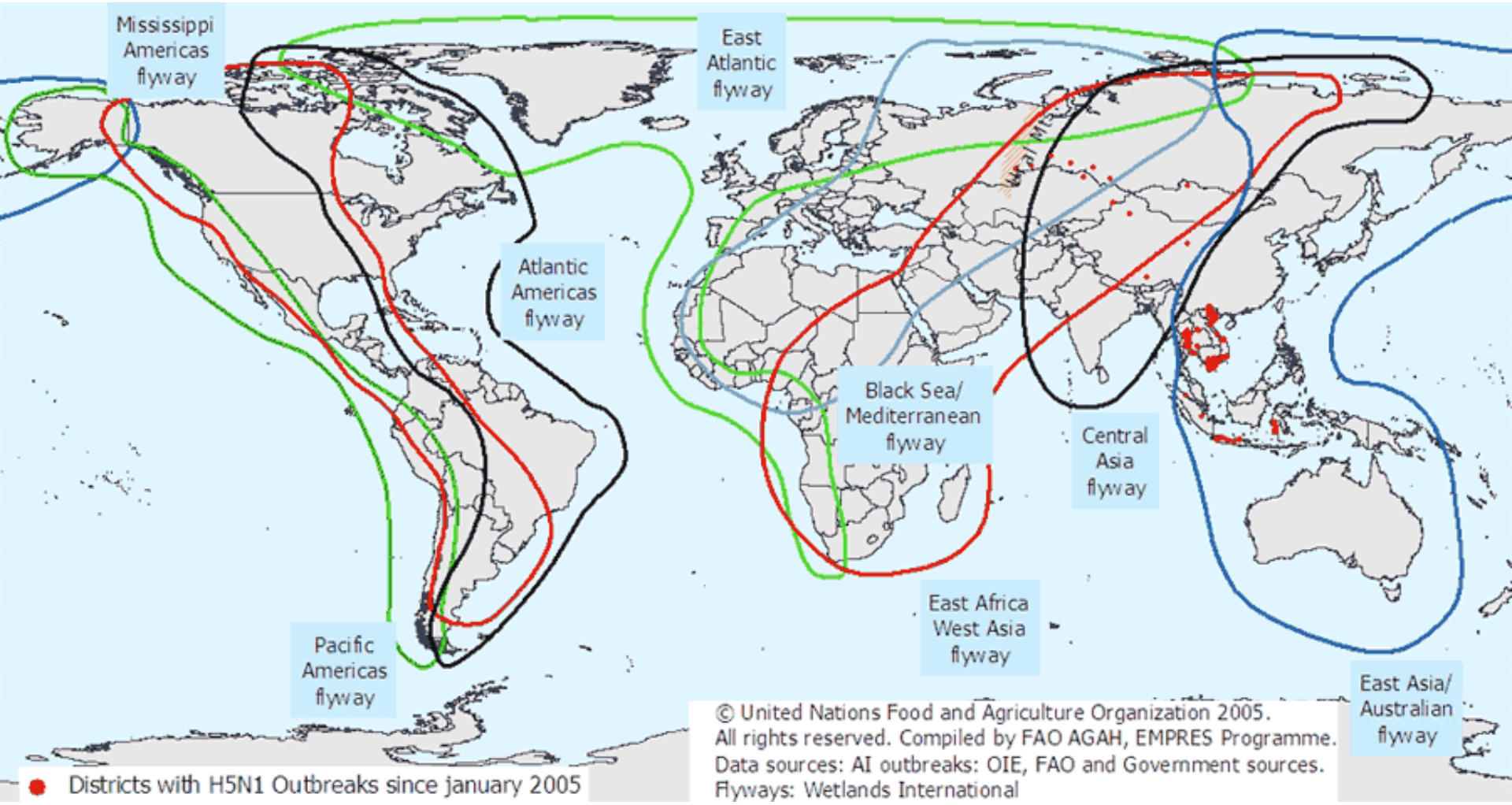
*Joel Carillet / iStock*

In addition to the major outbreak in Colorado, 722,000 birds on a commercial table egg layer farm facility in Lancaster County, Pennsylvania, were also sickened. Lancaster County had two other detections this week involving roughly 70,000 poultry. Also of note, two live-bird markets in Philadelphia reported avian flu among 500 animals.

In Charles Mix County, South Dakota, 71,800 animals were infected at a commercial turkey meat facility.

Within the past 30 days, avian flu has been detected in 59 flocks, including 19 commercial flocks and 40 backyard flocks. A total of 4.9 million birds have been involved in these outbreaks.

In wild bird detections, APHIS noted 25 detections, including several Canada goose detections in multiple counties in New York, and Canada geese in Garfield County, Oklahoma.





Data sources: AI outbreaks: OIE, FAO and Government sources.
Flyways: Wetlands International

## Figure 1. North American Flyways for Waterfowl

Pathways for Avian Influenza


**Source:** U.S. Fish and Wildlife Service.

**And what happens when all those migrating birds stop over in ponds near places where there are high densities of chicken raising facilities??**