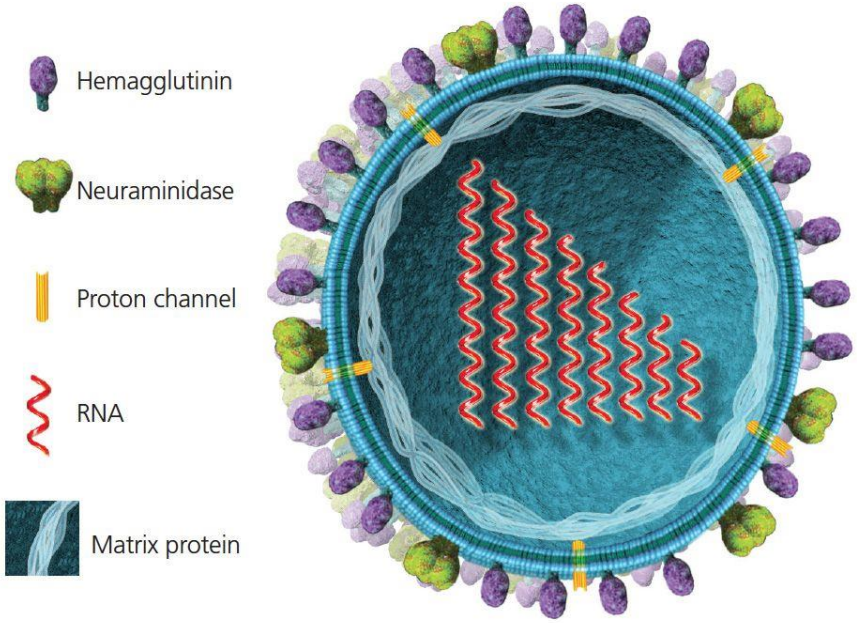
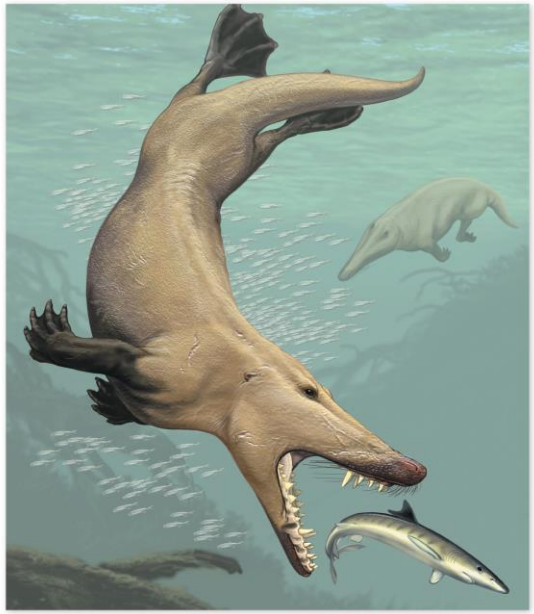
Evolution explains the diversity of life

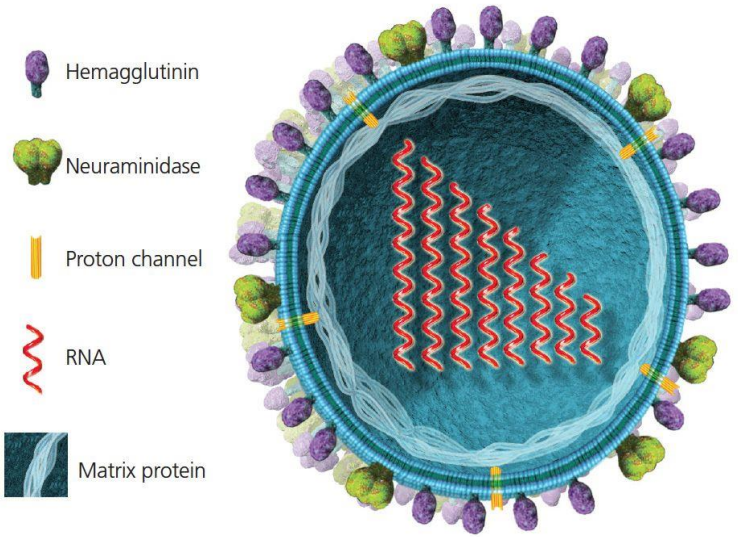


Chapter 1 Evolution case studies

- 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**

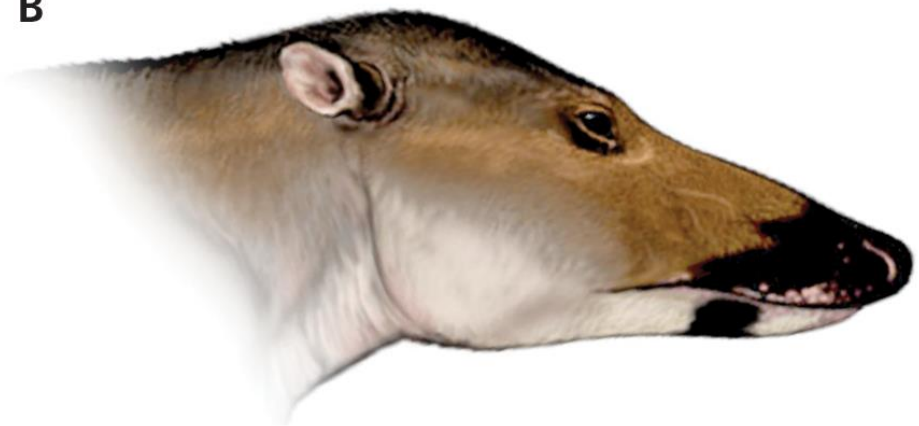
Q3. What are the two main extant (still living) lineages of Cetaceans and how do their feeding styles and teeth differ? (Fig 1.2)

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

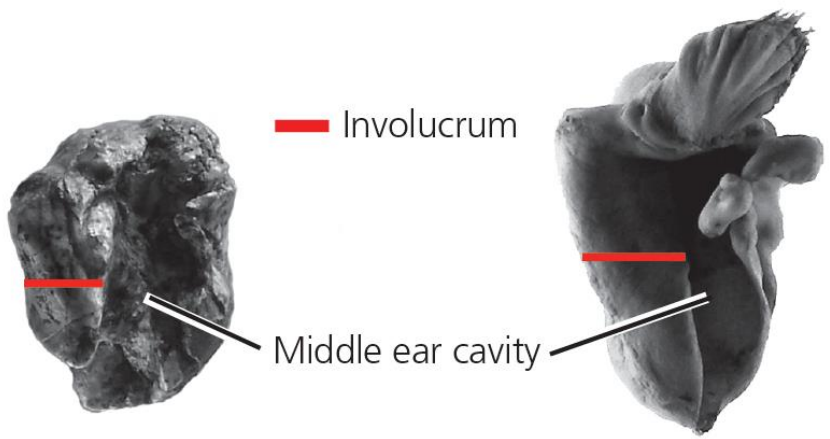
What other traits differ between these lineages? (Fig 1.8)

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?)

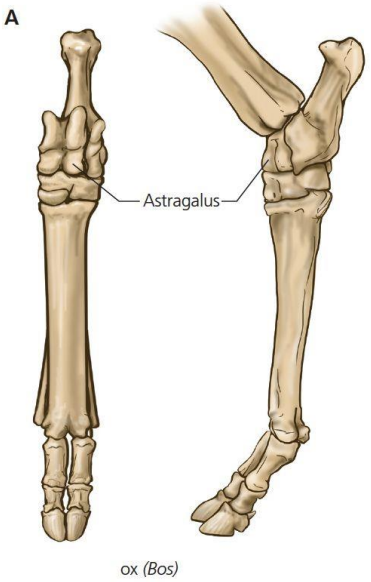
Q5. What is the astragalus and what was its role in understanding whale evolution? (Fig 1.7)

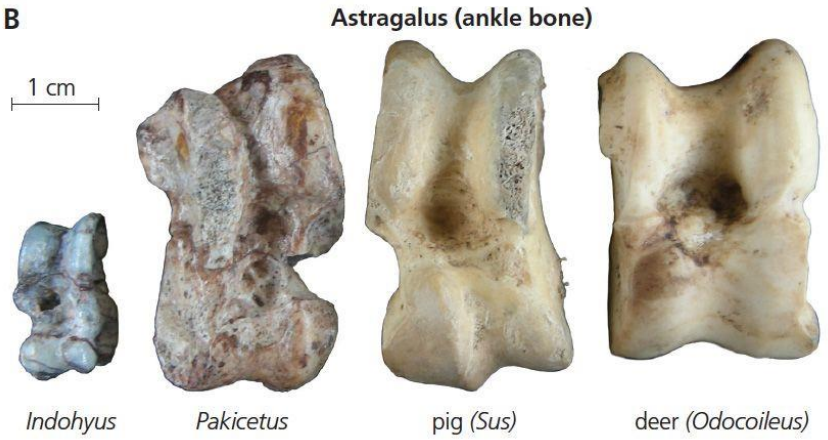
Q6. Would you call the astragalus a synapomorphy? Why? Why not?

Q7. Who are the Arteriodactyls?

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

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

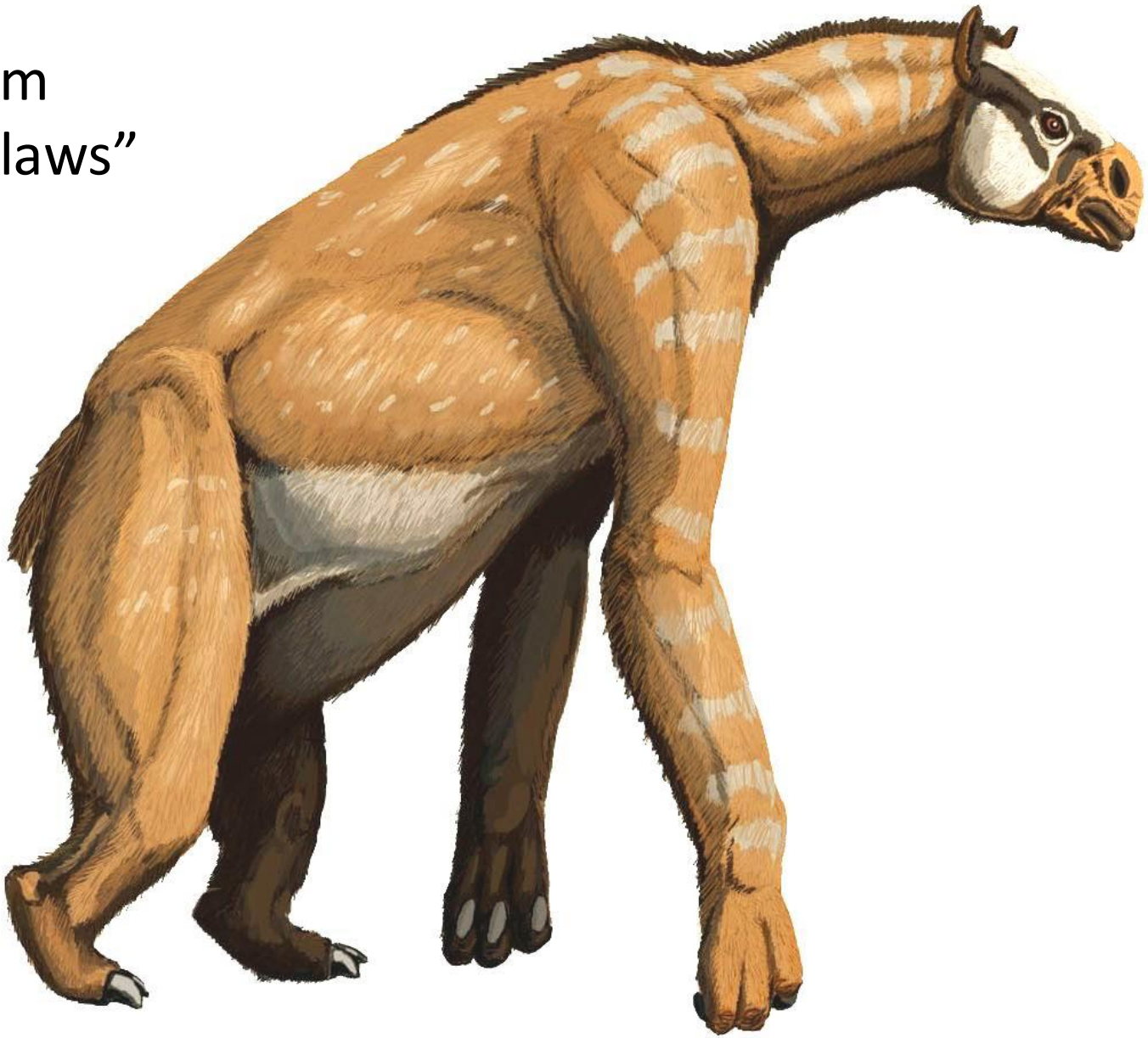




https://twitter.com/PepomintNarwh

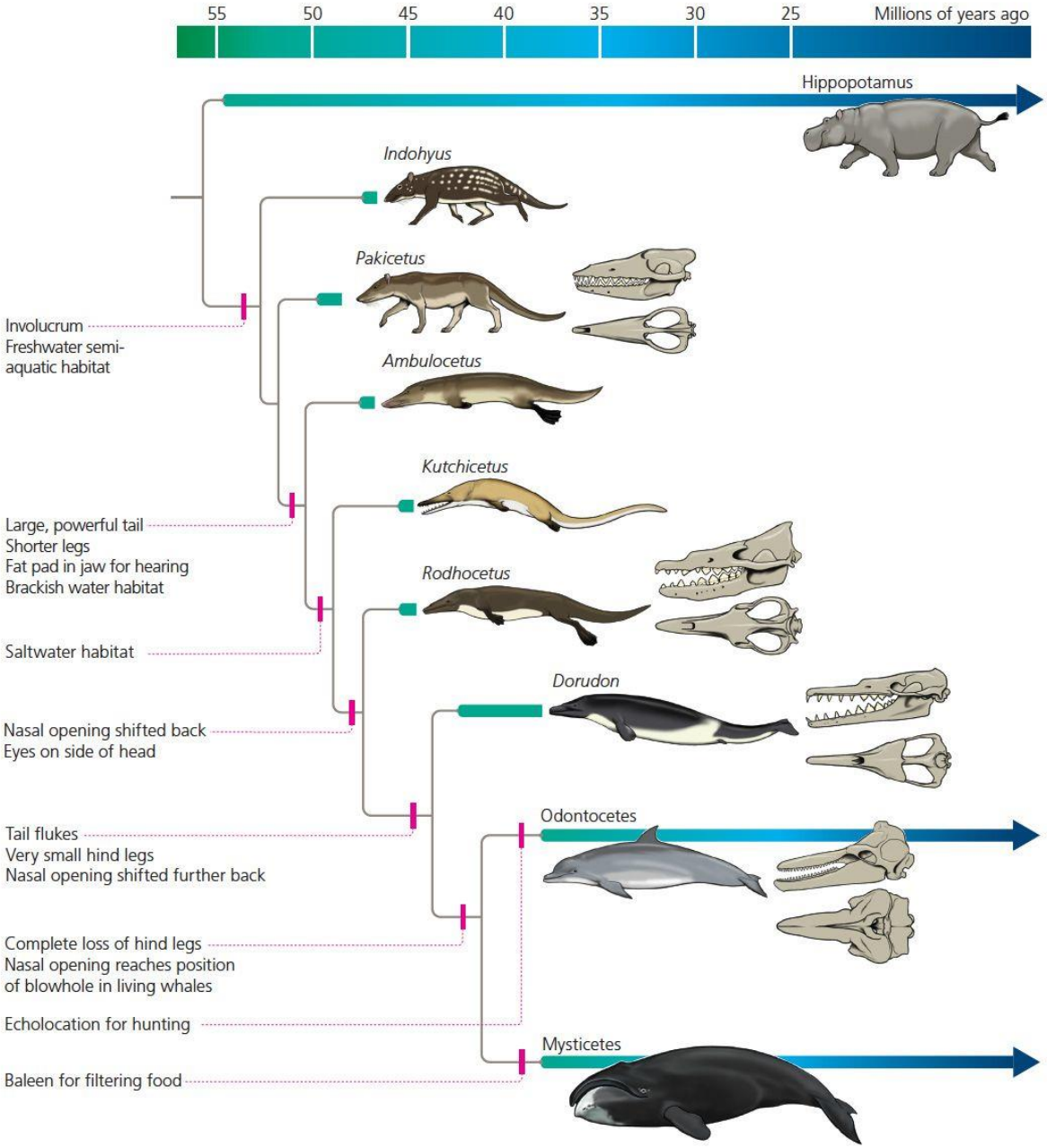
Another cool Perissodactyl…

Chalicotherium
“horse with claws”



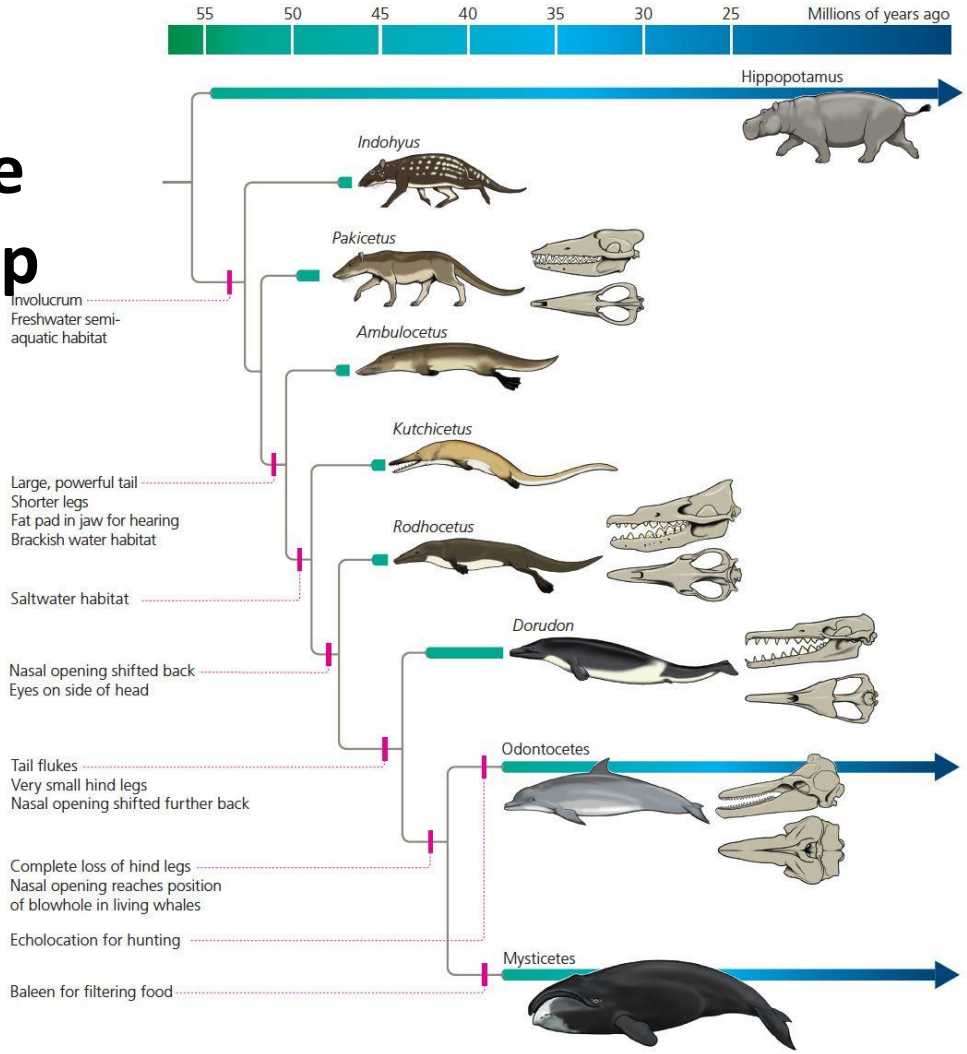
Q10. What are the different adaptions to life in the water that the text describes?

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?

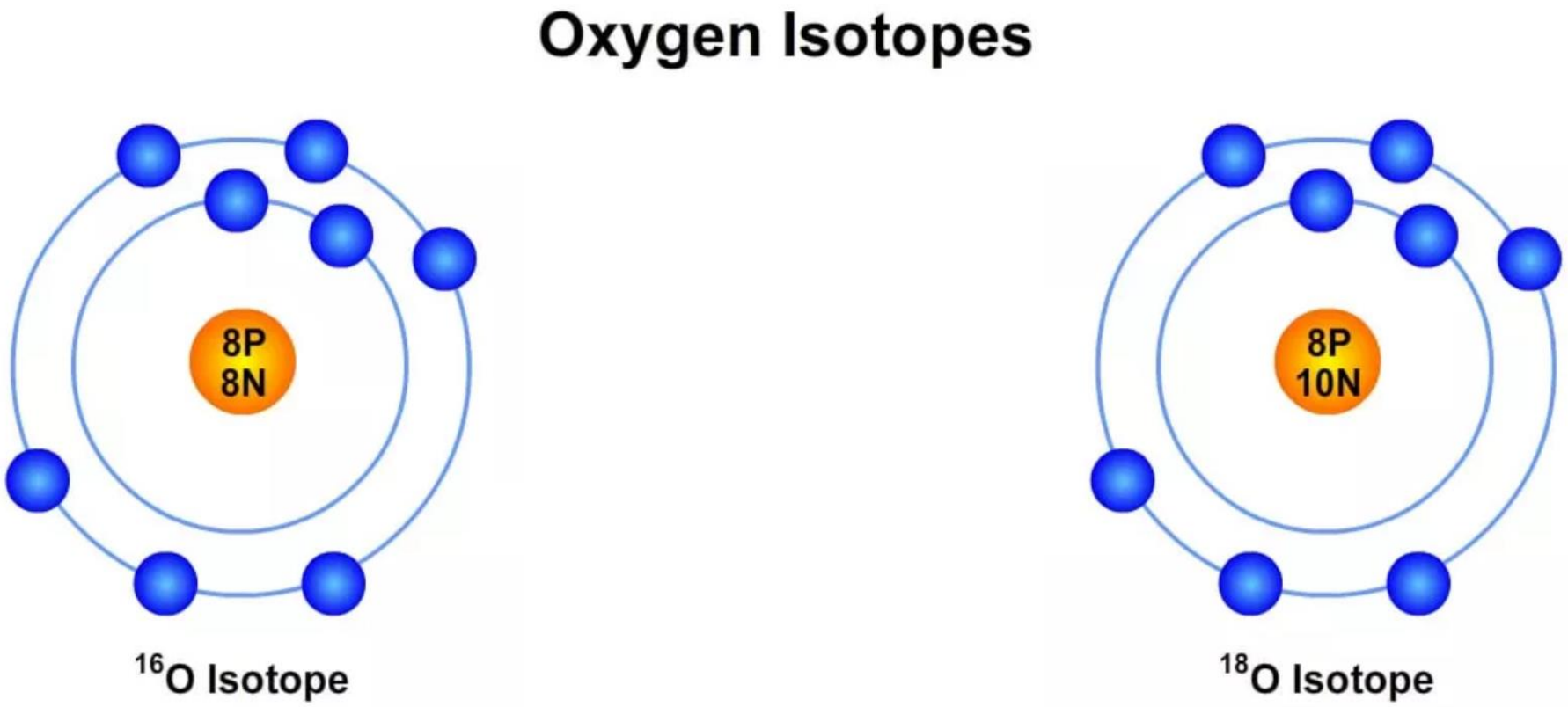


- limbs “lost” (front limbs reduced so much they now serve as flippers, back limbs? Vestigial pelvis!)
- nostrils, eyes high on head-why?
- bones dense-why?

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 (less of this one)

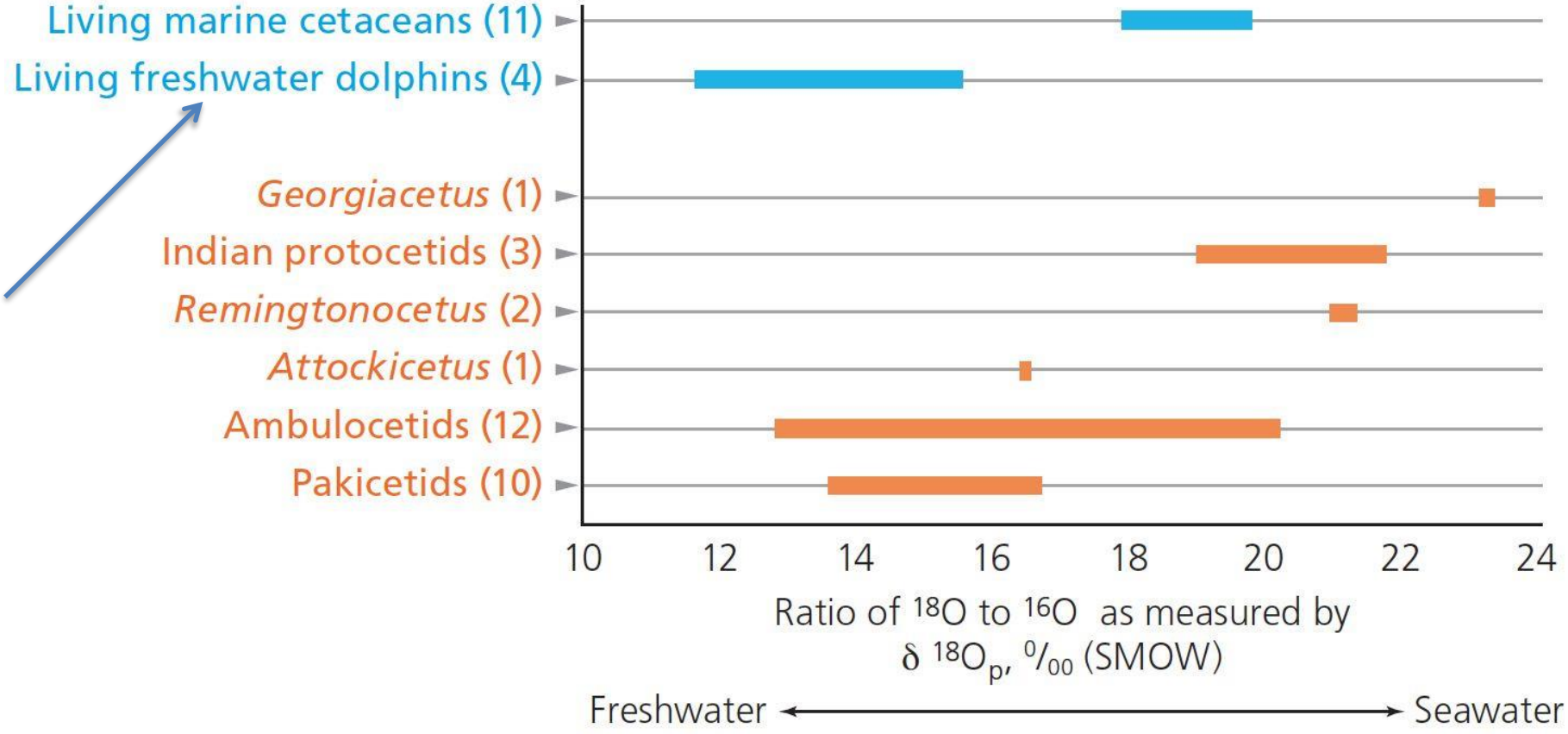
https://www.donovanpdennis.com/blog/sublimation-not-so-sublime-anymore

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

Look at bones!

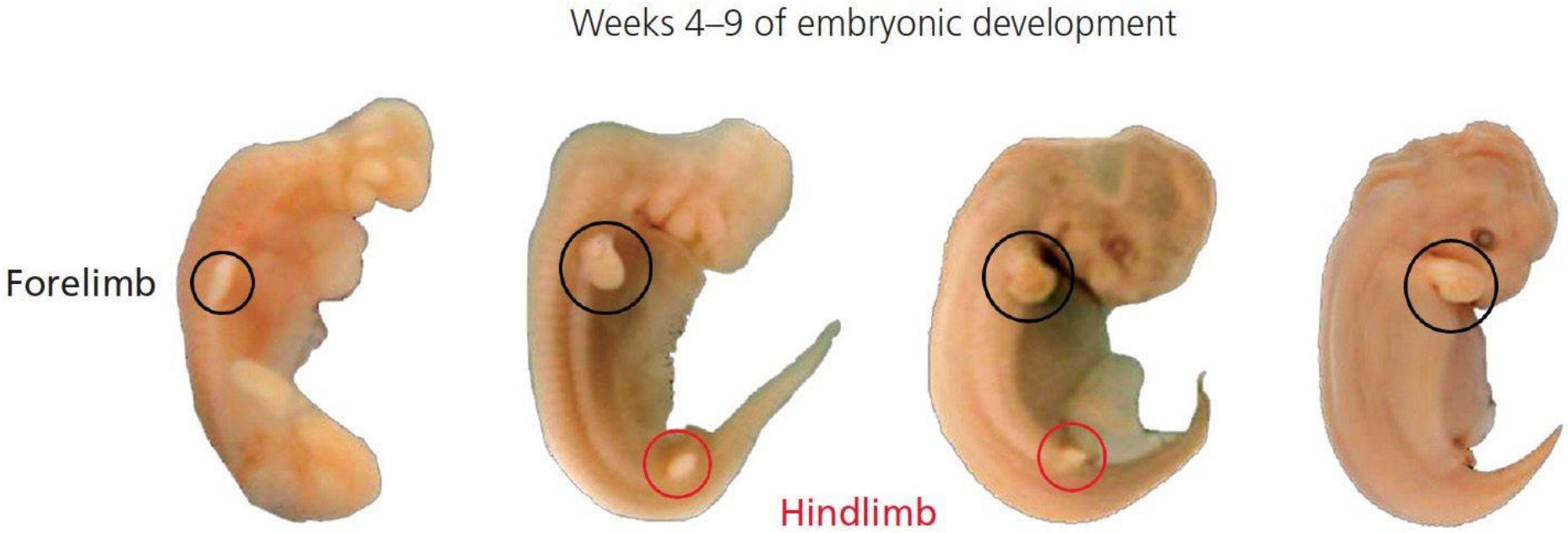
O^{18}/O^{16} ratio higher in saltwater (so more 18 relative to 16)

(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 basilosaurus what might you imagine it was related to?

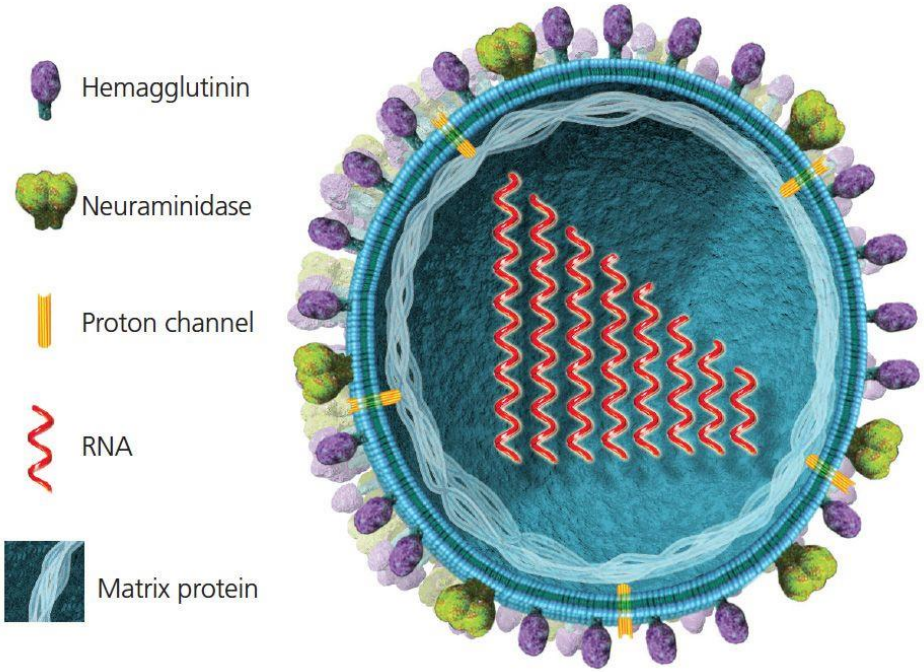
Q15. Which of these three time periods did this group diversify in?

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)

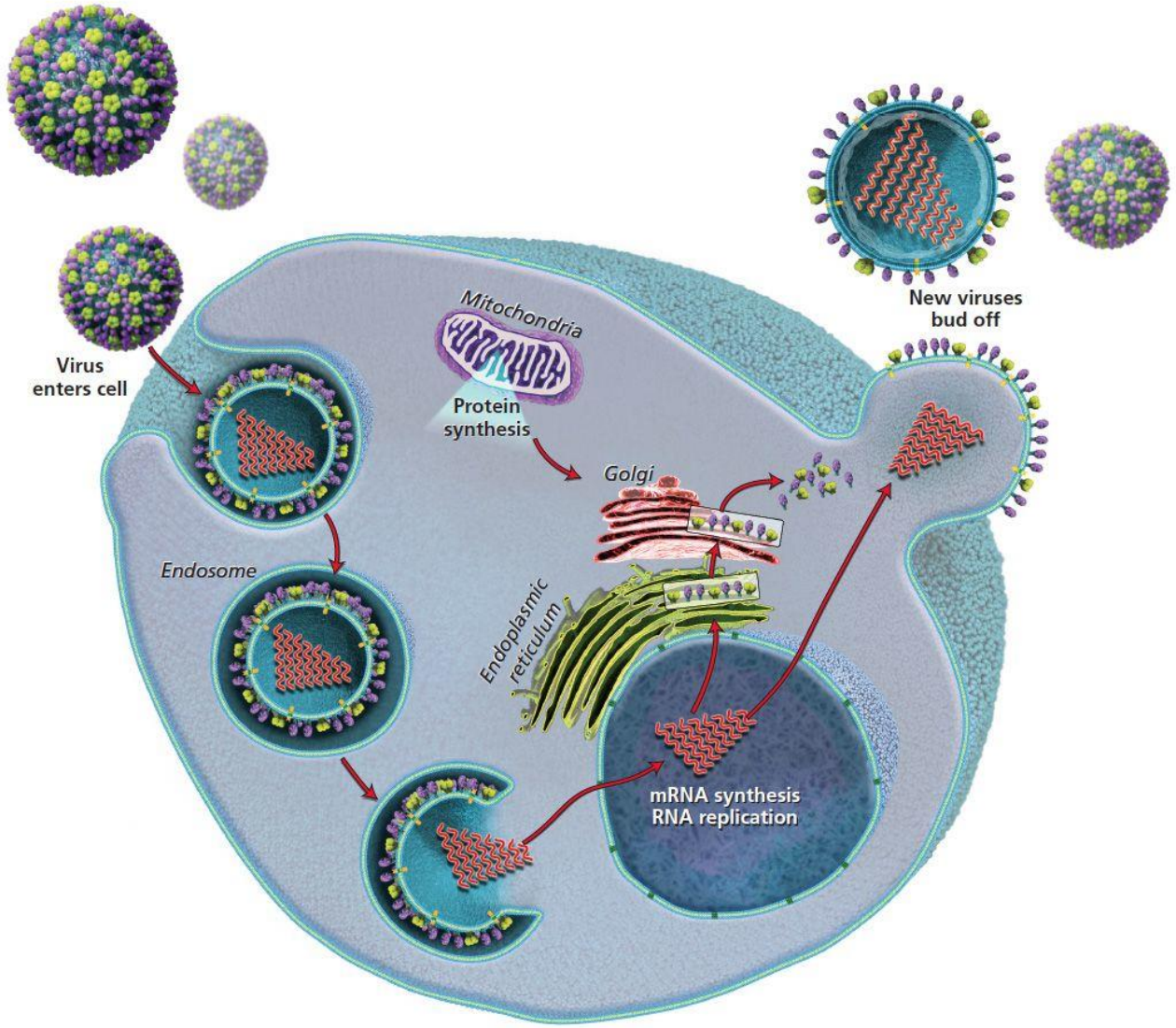
Evolution case studies

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



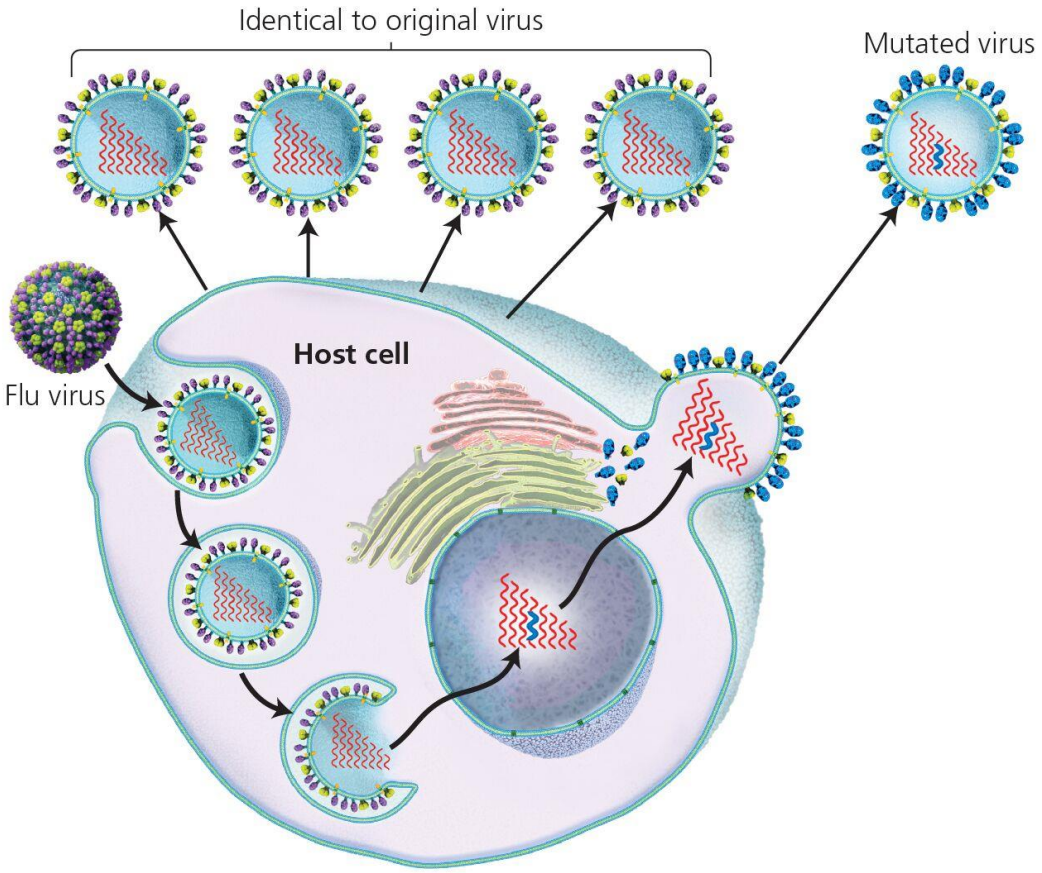
Q1. How do viruses reproduce?

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



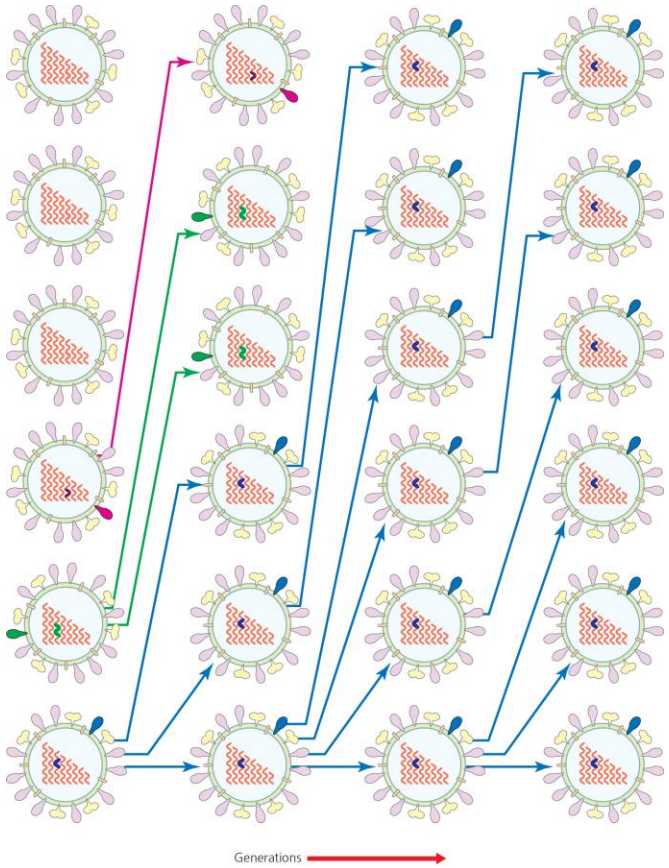
Q3. How do viruses evolve?

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!

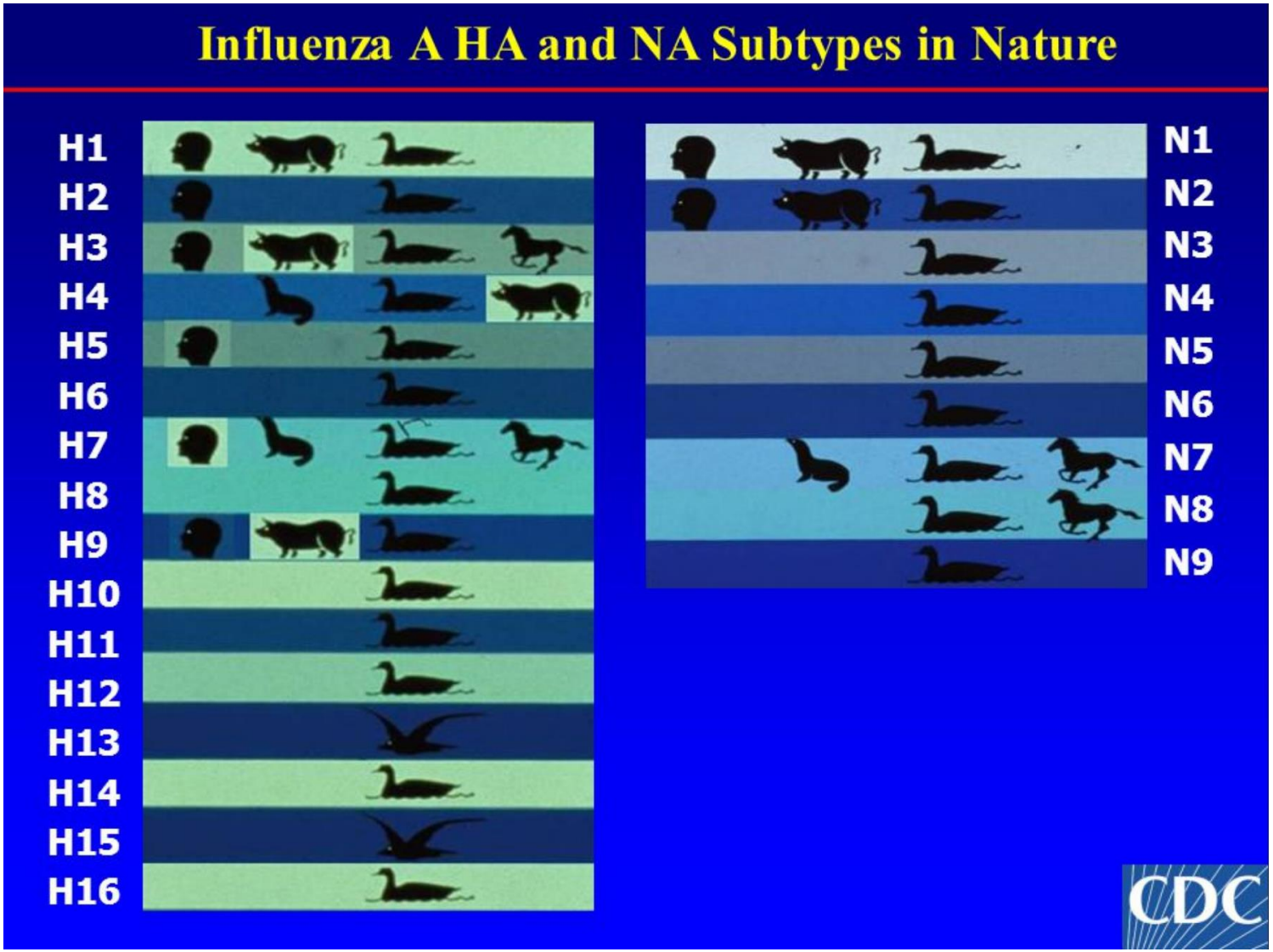
Q4. Why have many viruses evolved high mutation rates?

Ultimate=why questions are evolutionary questions

Proximate=how questions are mechanistic questions

Misconception:
High mutation rates are not simply a “side-effect” of rapid reproduction.

Q5. What is the original, original source for all influenza viruses?

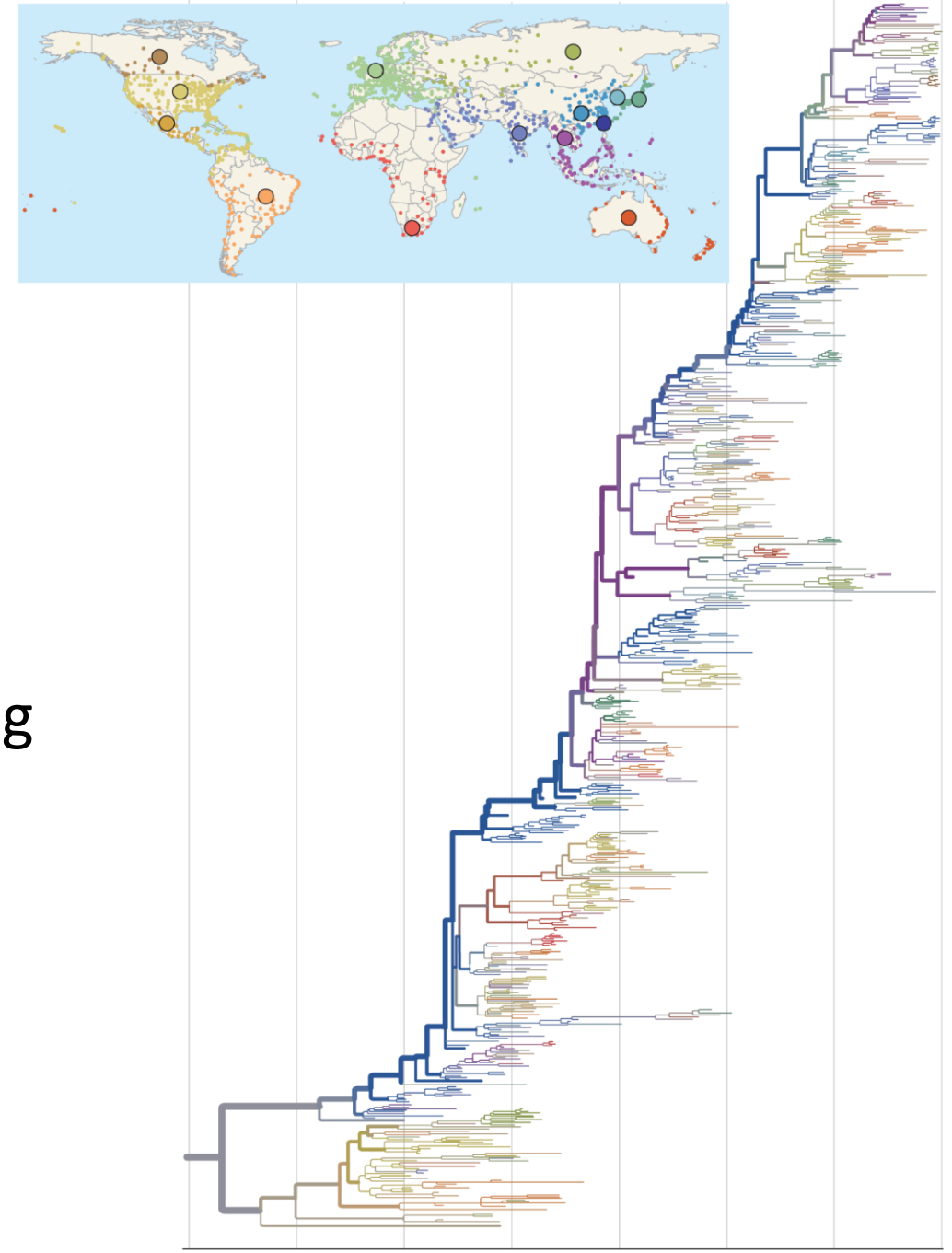


Natural selection creates increasing diversity over time!

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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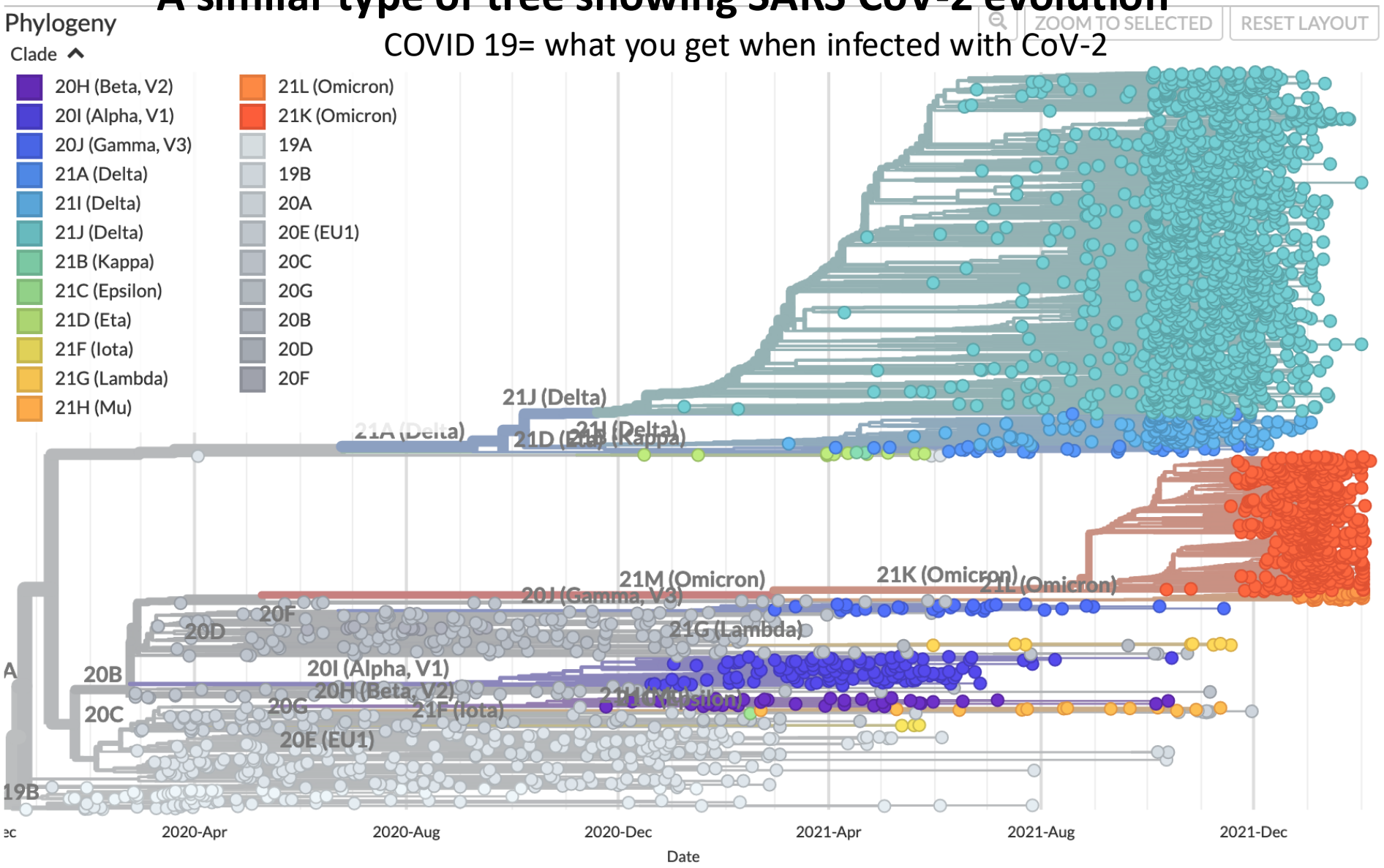
A similar type of tree showing SARS CoV-2 evolution

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

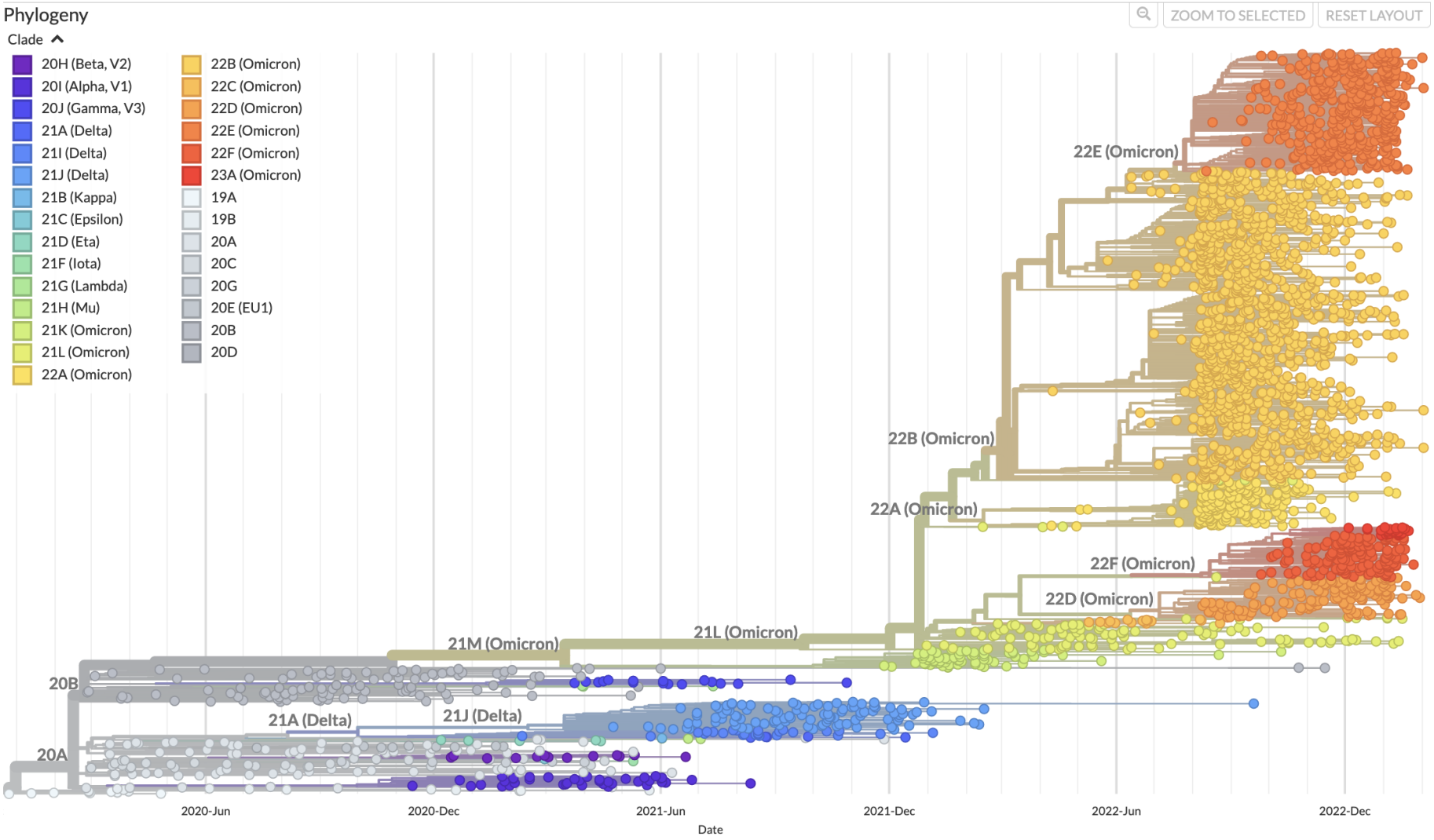


https://nextstrain.org/ncov/global

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.

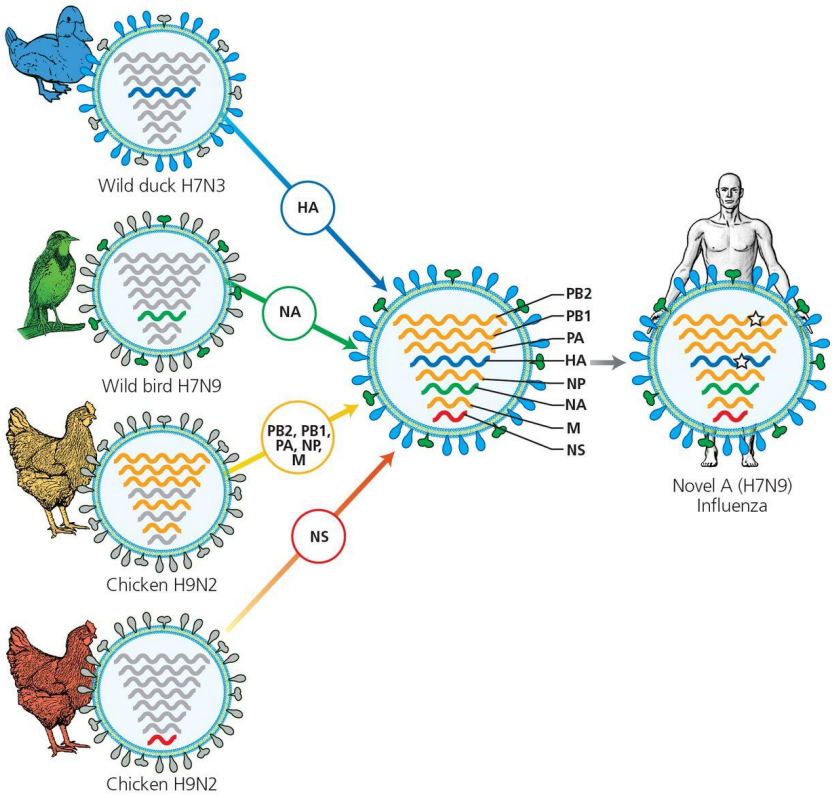


https://nextstrain.org/ncov/gisaid/global/6m?animate=2019-12-18,2025-01-25,0,0,30000

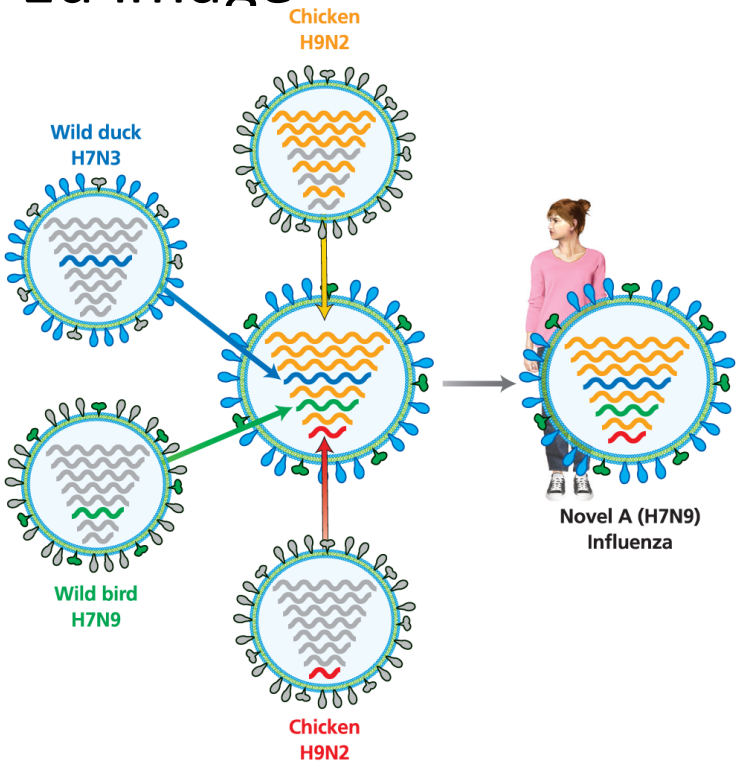
Back to the influenza's!

Q7. What is reassortment? (Fig. 1.21)

2nd Ed Image



3rd Ed image



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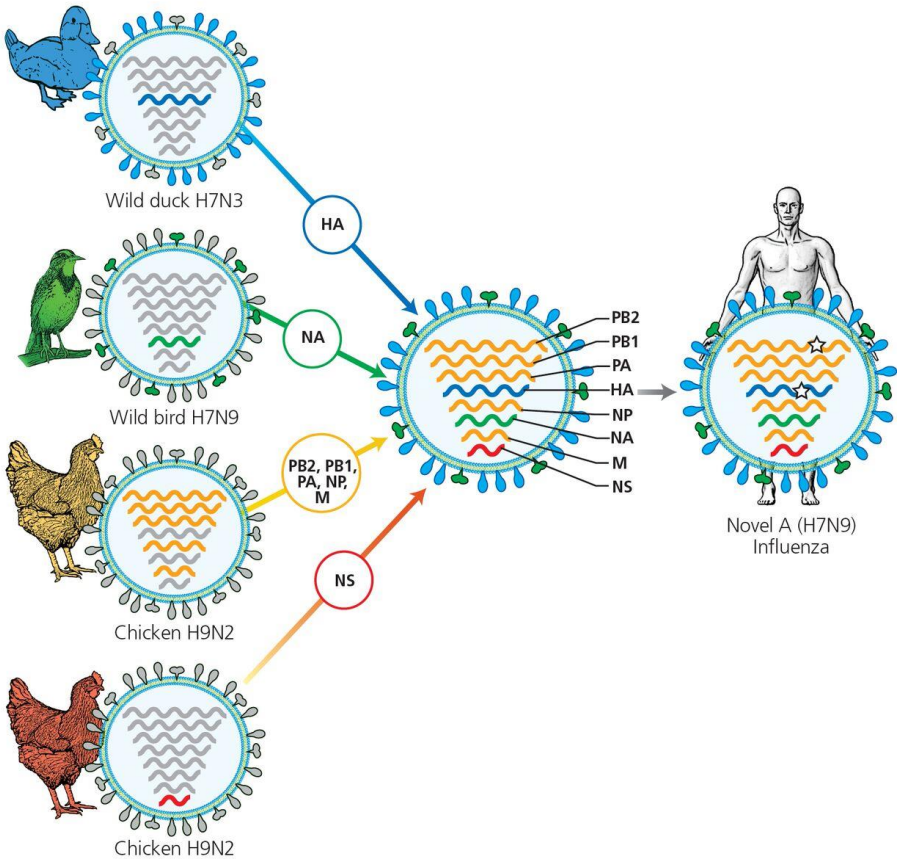
Q8. What happened about a 100 yrs ago?

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)



Egg prices high?

Have you heard something about cows getting sick and milk getting contaminated?

That is due to an influenza or “bird flu” outbreak. The current strain killing many, many birds (chickens, turkeys, owls) and mammals (seals, cats) is **H5N1**.

We also have **H7N9** strains infecting wild water birds.

Big News: On a duck farm in California we had a **reassortment** in Nov!!

H5N1+H7N9=H5N9

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

https://www.agriculturedive.com/news/us-detects-rare-bird-flu-strain-h5n9/738642/

Bird flu in the U.S. has become a pressing issue for the agriculture industry, with the virus jumping from chickens to cows in 2024. More than 17 million birds have been impacted by the virus in the last 30 days, with 66 commercial flocks reporting outbreaks.

Farmers have depopulated flocks to prevent further spread, which created supply shocks at the grocery store. Egg prices have jumped considerably with a resurgence in the virus over the past two months, becoming a political flashpoint in a larger debate around inflation.

Public health experts say the detection in the U.S. may pave the way for "unpredictable new viruses" that could affect animals and humans alike.

"This is bad news," Angela Rasmussen, a virologist with the Vaccine and Infectious Disease Organization at the University of Saskatchewan in Canada, said on X, formerly Twitter. "Reassortment makes pandemics."

The rare strain's N9 gene stems from the subtype H7N9, according to the Journal of Virology, which was the cause of a number of human and poultry outbreaks that led to the deaths of 616 people in China.

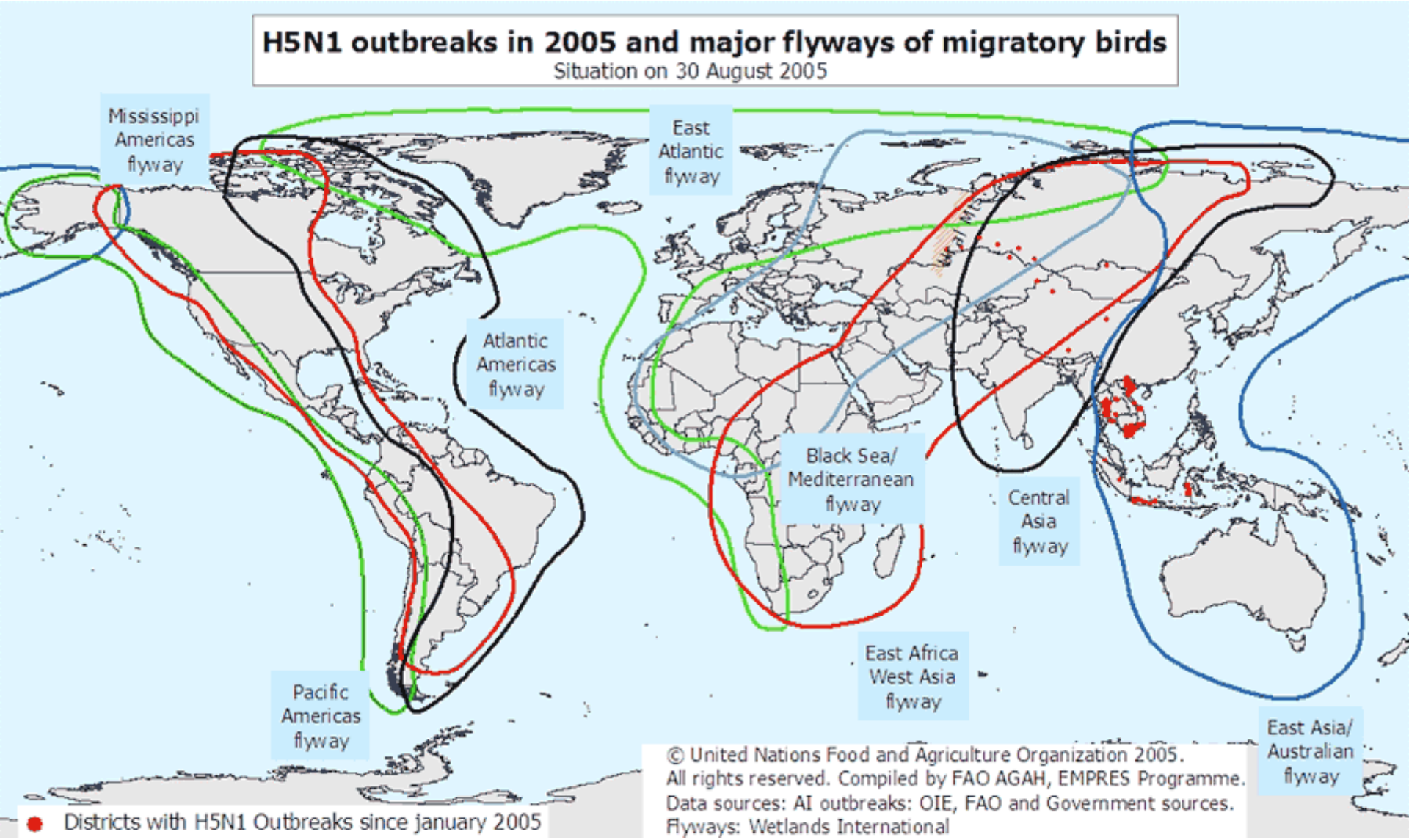
While there's limited research on H5N9's impact on humans or animals, clinical signs on the California farm included "increased mortality," according to the update from WOAH. The virus caused low mortality rates in mice, but it's unclear whether "this novel H5N9 virus will cause human infections from its avian host and become a pandemic subtype," the Journal of Virology said.

"It is therefore imperative to assess the risk of emergence of this novel reassortant virus with potential transmissibility to public health," according to the report, published in 2015.

Rasmussen said ducks are considered "great hosts" for reassortment, which occurs when two or more viruses infect the same host and combine to create a new strain. While the H5N9 case indicates reassortment of avian viruses, it could still pose a threat to people if it were to combine with human viruses.

"We need to do more surveillance to limit opportunities for different viruses to reassort," Rasmussen said.

Next several slides should make you think!


H5N1 outbreaks in 2005 and major flyways of migratory birds
Situation on 30 August 2005
Mississippi Americas flyway
East Atlantic flyway
Atlantic Americas flyway
Black Sea/ Mediterranean flyway
Central Asia flyway
East Africa West Asia flyway
Pacific Americas flyway
East Asia/ Australian flyway
Districts with H5N1 Outbreaks since january 2005
© United Nations Food and Agriculture Organization 2005.
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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??