

# Geometry & 'Breathing' Underwater

A MARINE BIOLOGY-THEMED GEOMETRY ADVENTURE

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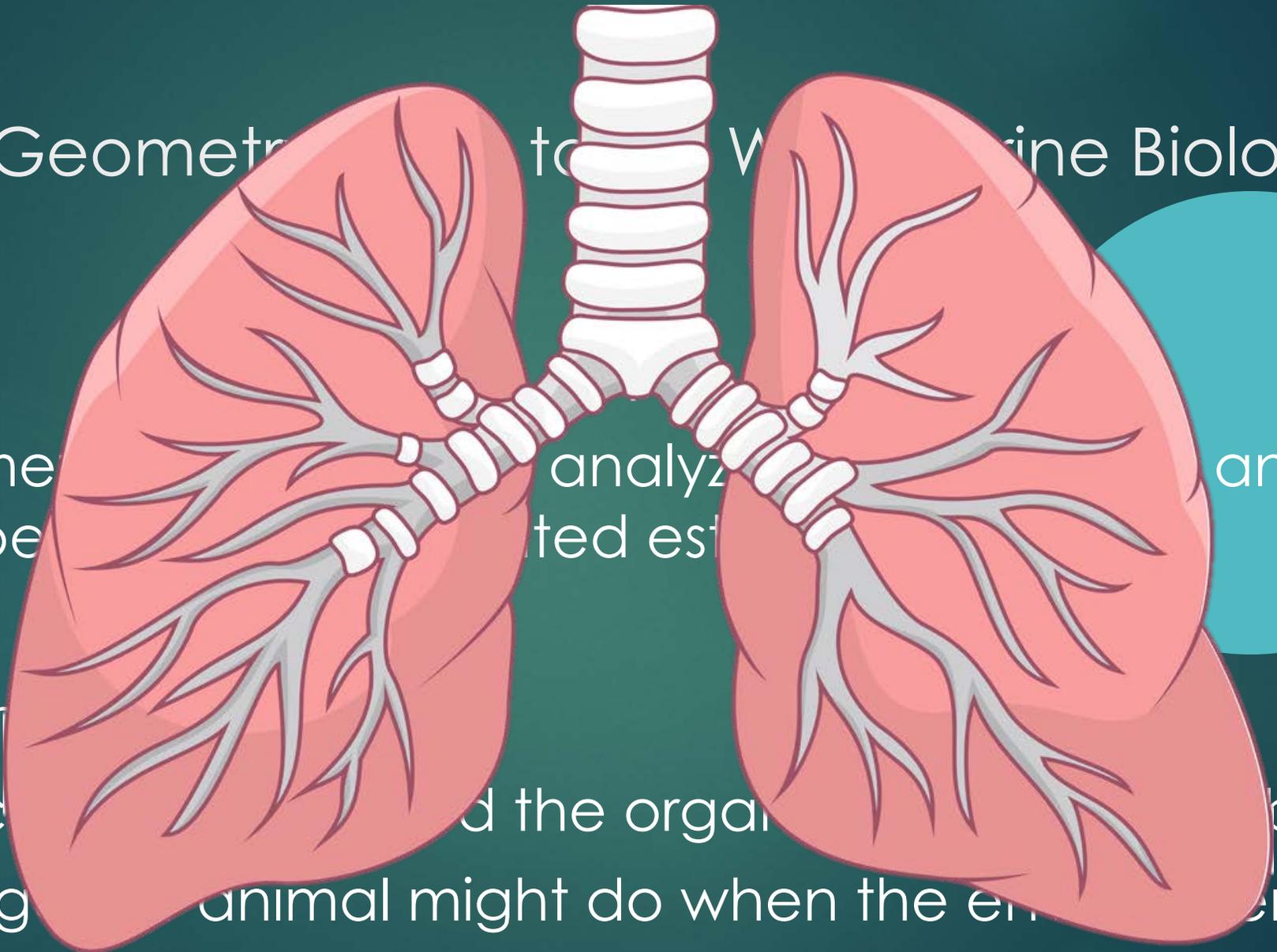
*Silver Cape*

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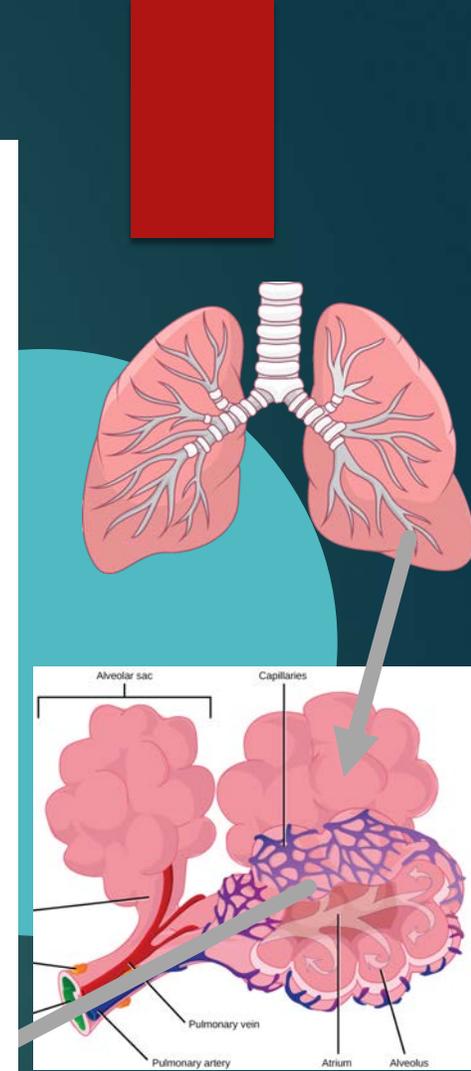
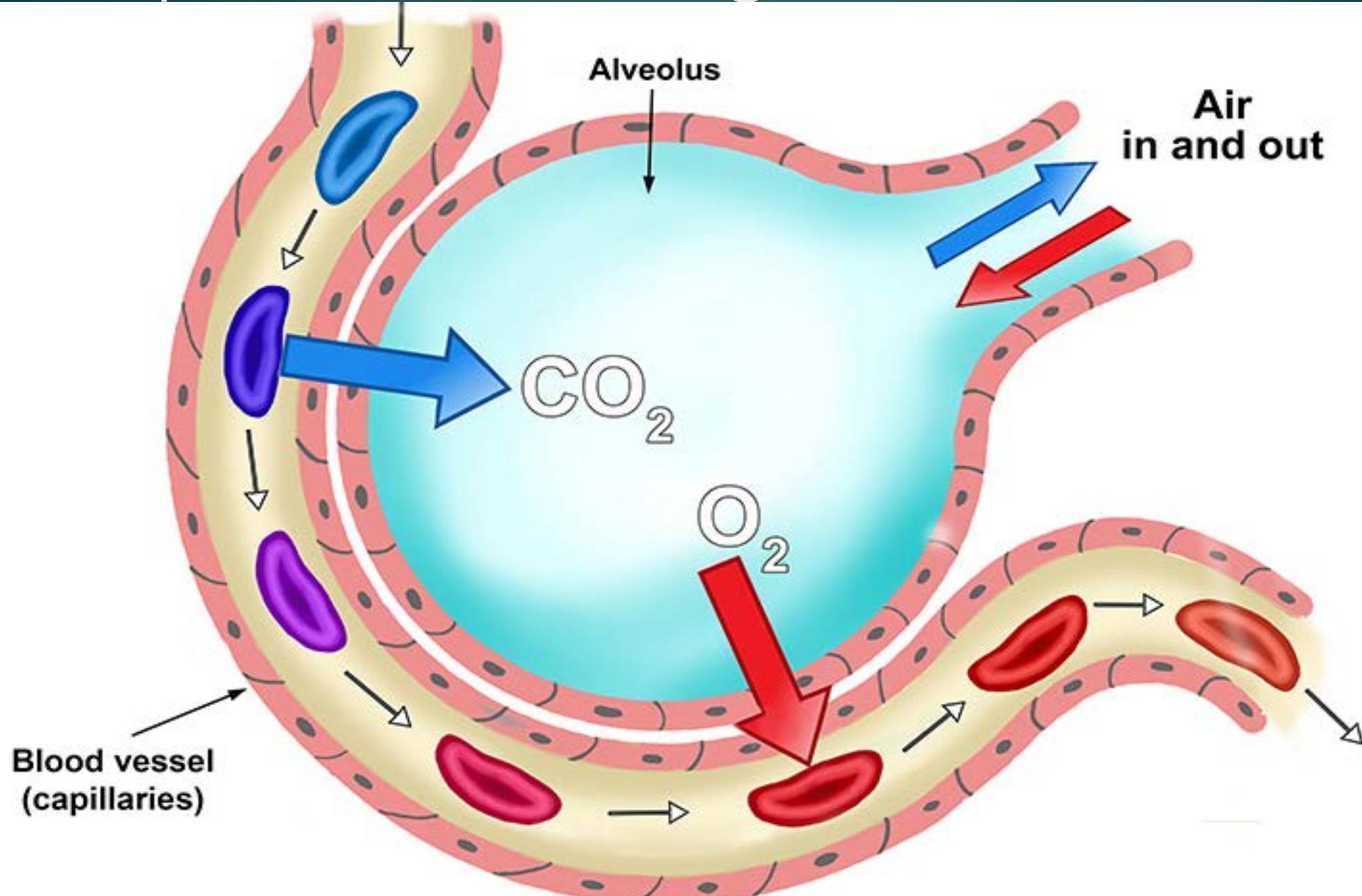


# What Does Geometric Morphometrics Tell Us About Avian Biology?

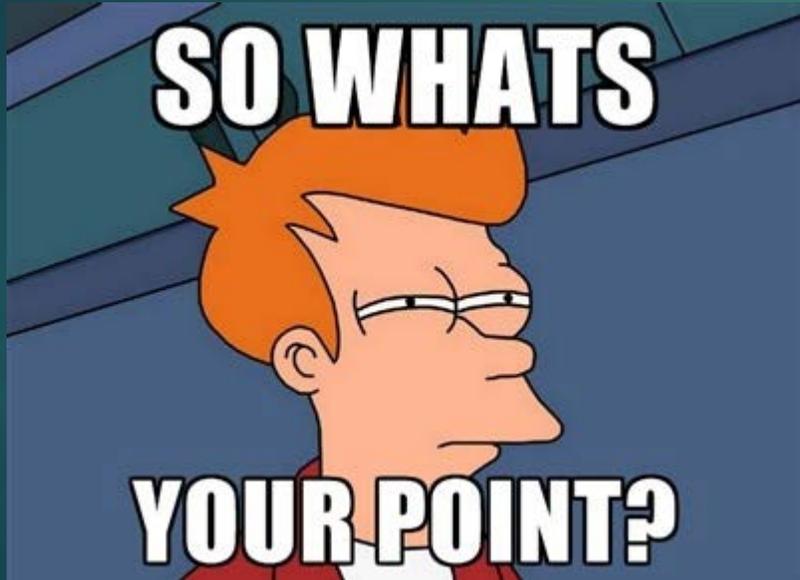
- ▶ Using geometric morphometrics to analyze organ shape and structure
- ▶ Organ & airway morphology
- ▶ Organ efficiency and the organ's role
- ▶ How the organ might do when the environment changes



# Example: Human lungs



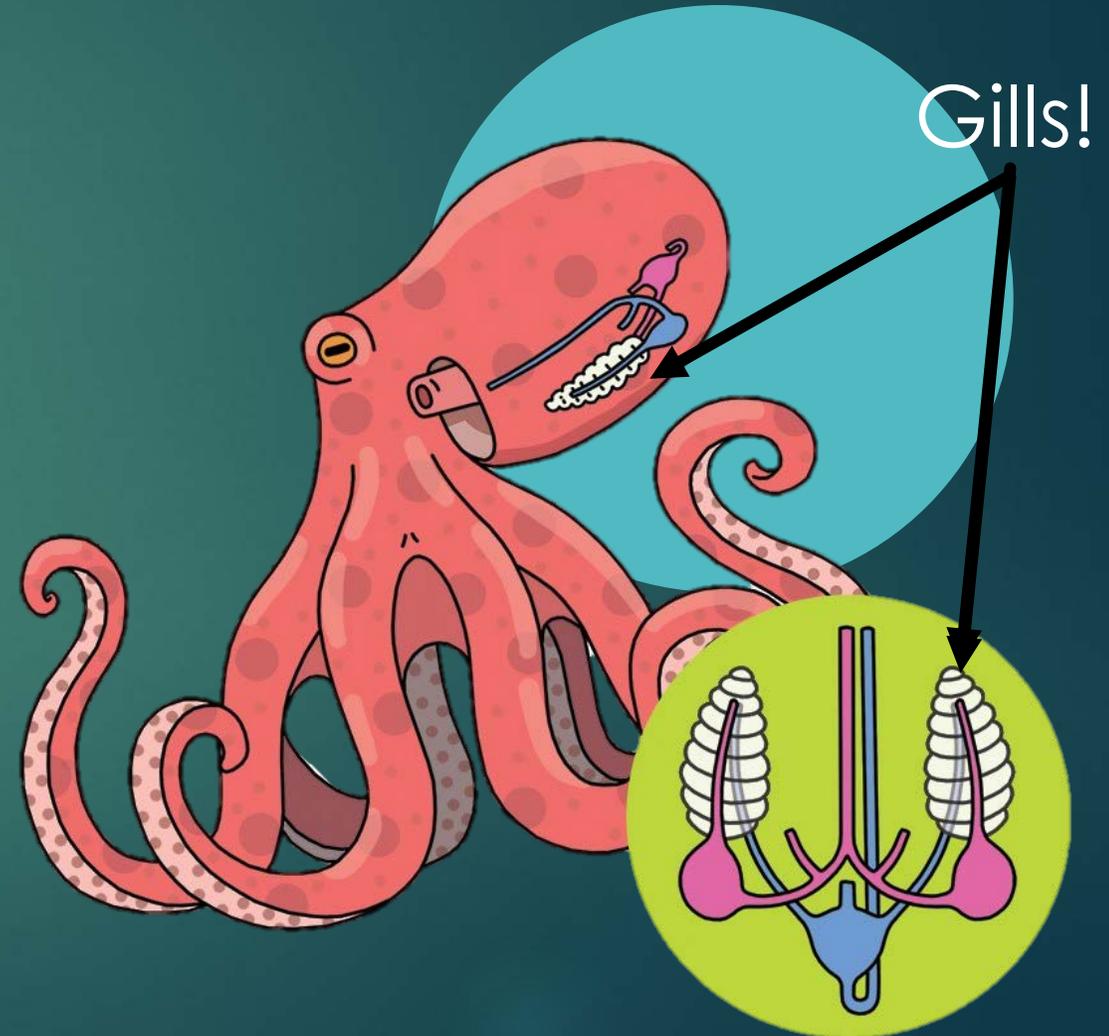
Great. So what does this have to do with marine animals?



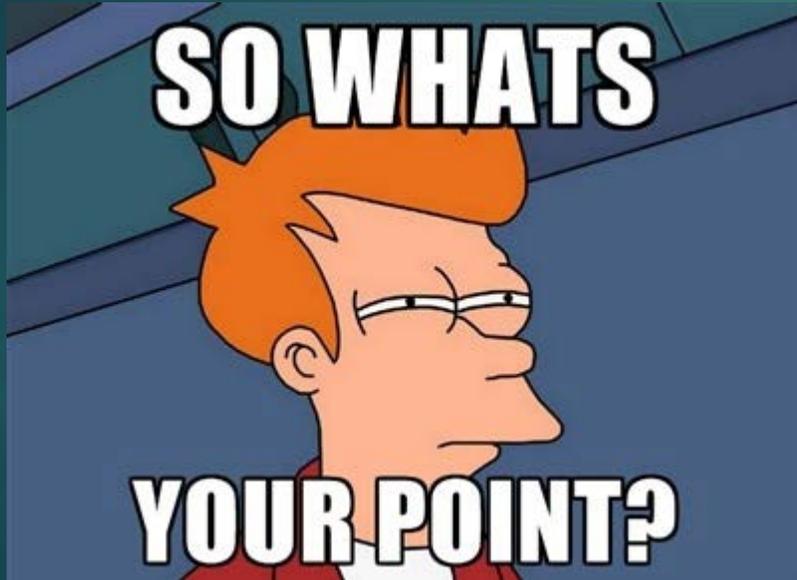
- ▶ The same applies to marine animals!
- ▶ Lungs → Gills
- ▶ Air → Water

# Marine Invertebrates : Octopus

- ▶ Invertebrate gills are:
- ▶ Highly folded
- ▶ Allow for blood cells to take up oxygen, and deliver carbon dioxide as waste
- ▶ Marine invertebrate gills do the same jobs as our lungs



Great. So what does this have to do with geometry?



- ▶ Gill efficiency (success of gathering oxygen) changes with size and shape
- ▶ Oxygen absorption is easier when the organ or animal has a high surface area to volume ratio

▶  $\frac{\text{Surface Area}}{\text{Volume}}$

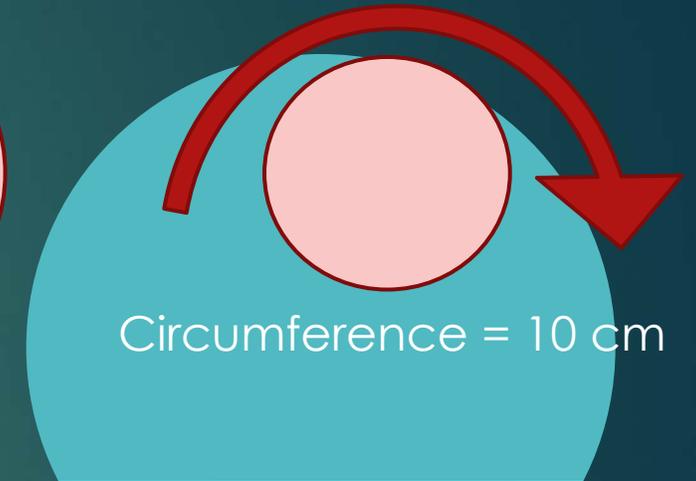
# Let's compare 2 types of gills

- ▶ Smooth

- ▶ Smaller circumference
- ▶ Smaller Surface area



Surface Area: 116 cm<sup>2</sup>

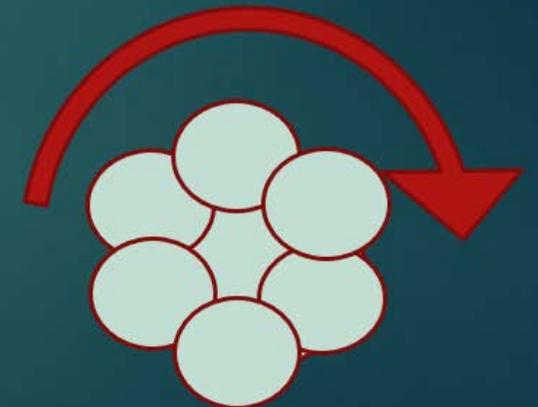


- ▶ Bumpy (folded)

- ▶ Larger circumference
- ▶ Larger surface area
- ▶ Slightly larger volume



Surface Area: 232 cm<sup>2</sup>



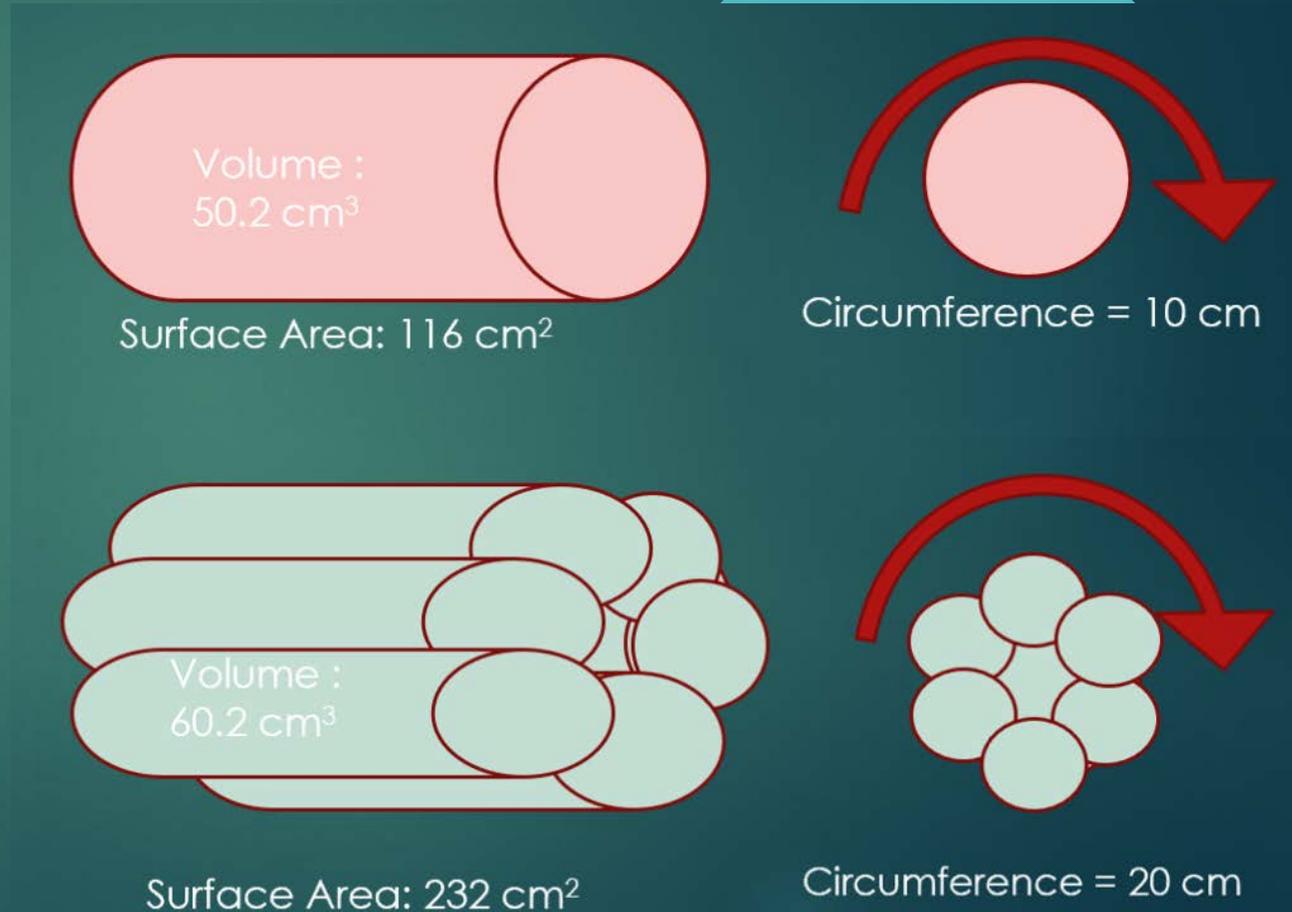
# Surface Area : Volume

▶  $\frac{\text{Surface Area}}{\text{Volume}}$

▶  $\frac{116}{50.2} = 2.3$

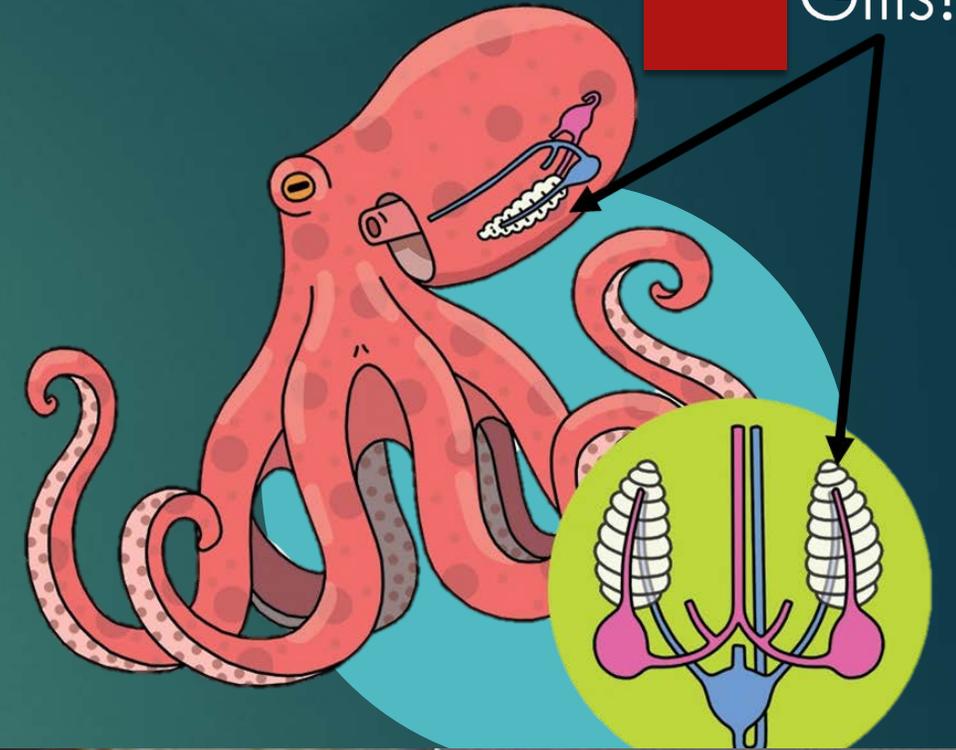
▶  $\frac{232}{60.2} = 3.9$

Bumpy Gills are have a higher SA:V, And are more efficient!



# Bumpy gills look familiar?

- ▶ They should!
- ▶ Gill bearing invertebrates all have bumpy gills!
- ▶ Maximizing the surface area to volume ratio!



Some invertebrates don't have gills  
and take up oxygen through their skin!

Anemones!



# The Basket star

- ▶ The animal I do research on
- ▶ Has 10 'pouches' of internal folded skin that take up oxygen from the sea water



# What happens when the oxygen concentration in seawater changes?

- ▶ Hypoxia - Lower than normal oxygen concentrations
  - ▶ Happens in the ocean
  - ▶ But is increasing in length of time, intensity, and how often it happens due to climate change
  - ▶ The famous 2013 “BLOB” was a huge mass of hypoxic ocean water that killed millions of invertebrates & fish along the Oregon coast
- ▶ By studying gill efficiency using geometry, scientists can estimate how certain species might fare when exposed to hypoxic conditions (will they be able to survive or not)