The Respiration of *Octopus vulgaris*

Guided by the Respiratory Malacologists:
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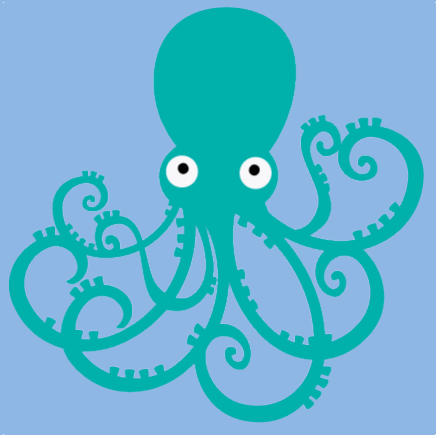
Roadmap

1. Octopus *vulgaris*
   - Part of the Mollusc family
   - Environment and Anatomy of Octopus *vulgaris*

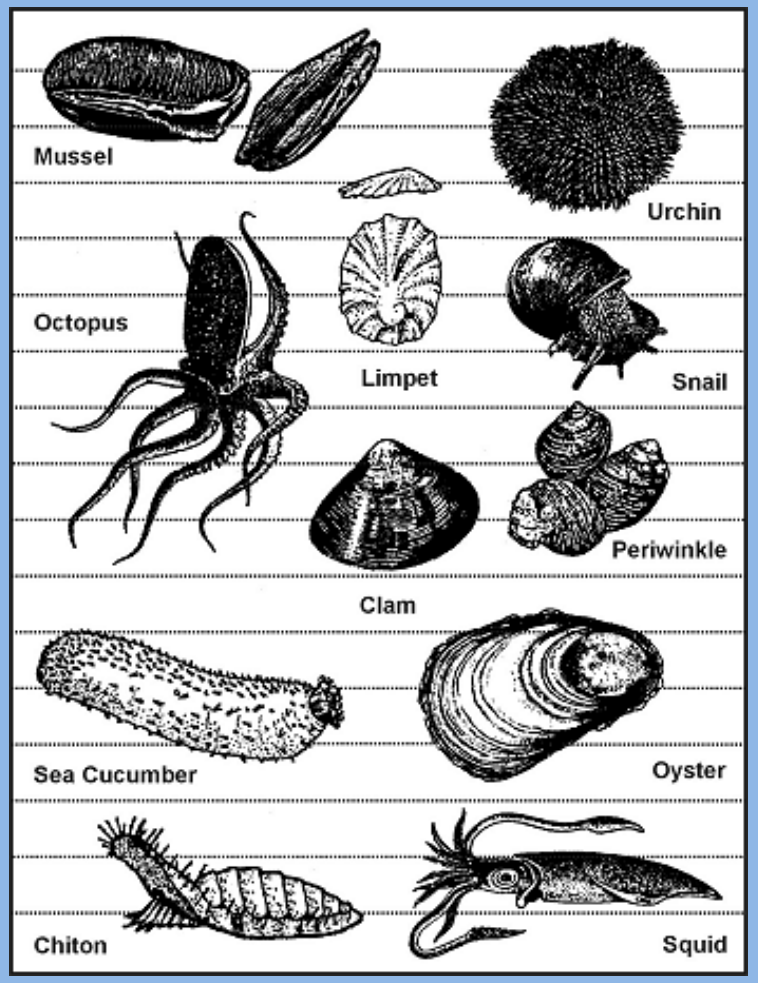
2. Ventilatory Respiration in the Octopus *vulgaris*
   - Gills
   - Ventilation cycle
   - Adaptions in the circulatory system
   - Oxygen transport: Hemocyanin

3. Skin Diffusion Respiration in Octopus *vulgaris*



What are Molluscs?

- Invertebrates
- One of the most diverse phylums
- With at least 50,000 living species
- More likely around 200,000 living species

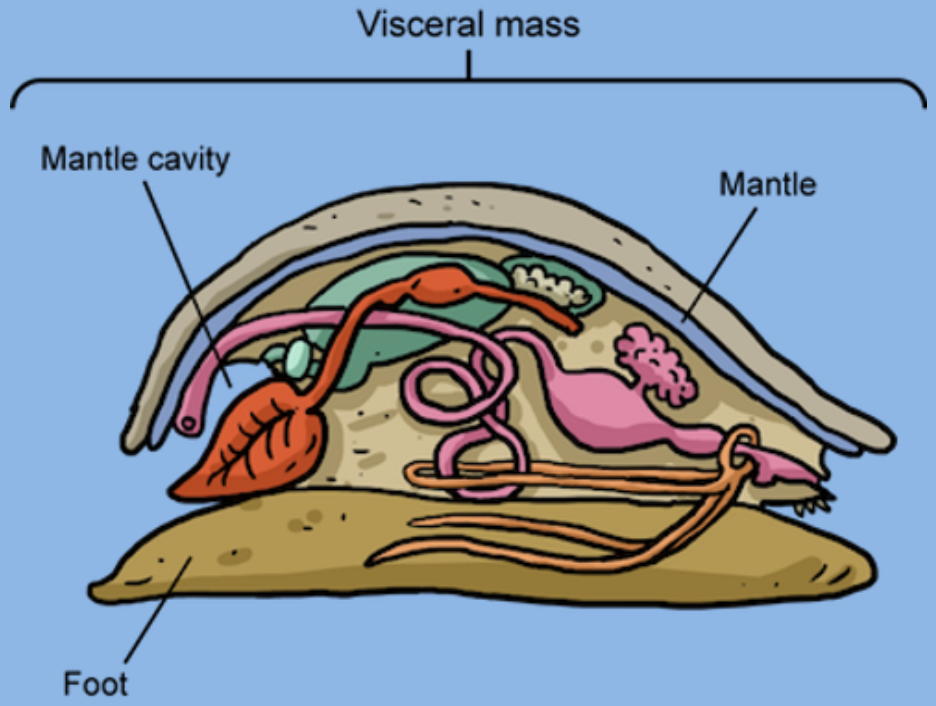


Molluscs Diagram [Photograph]. (n.d.). Retrieved from https://sharon-taxonomy2010-p2.wikispaces.com/Mollusca

Basic Molluscan Body Plan

Inside Mantle Cavity

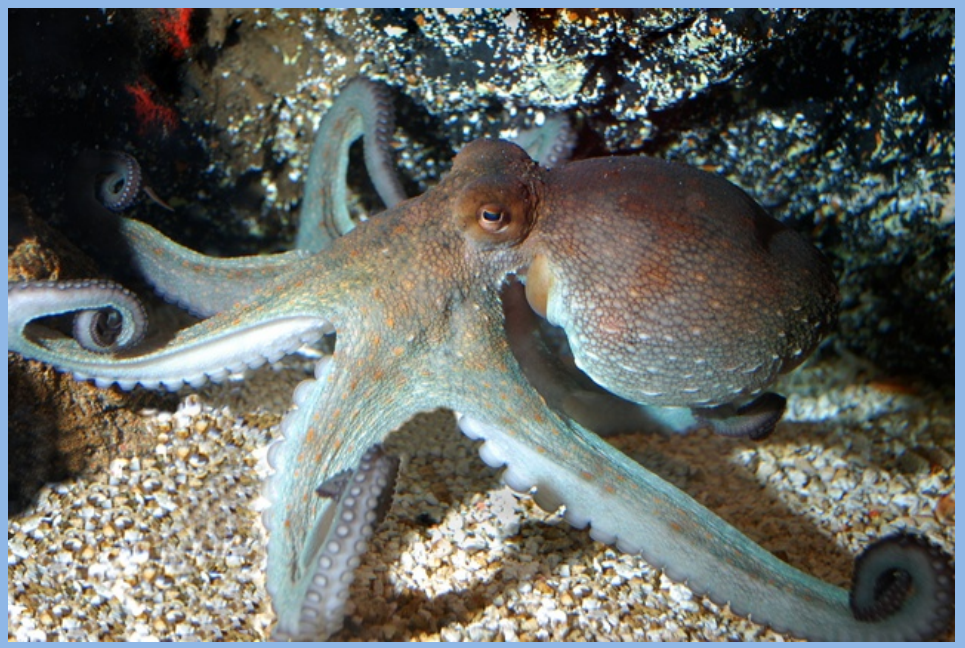
- Head
- Visceral Mass
  - Contain all the organs
- Foot



Mollusc Body Plan [Photograph]. (n.d.). Retrieved from http://media1.shmoop.com/images/biology/biobook_animevoldiv_graphik_11.png

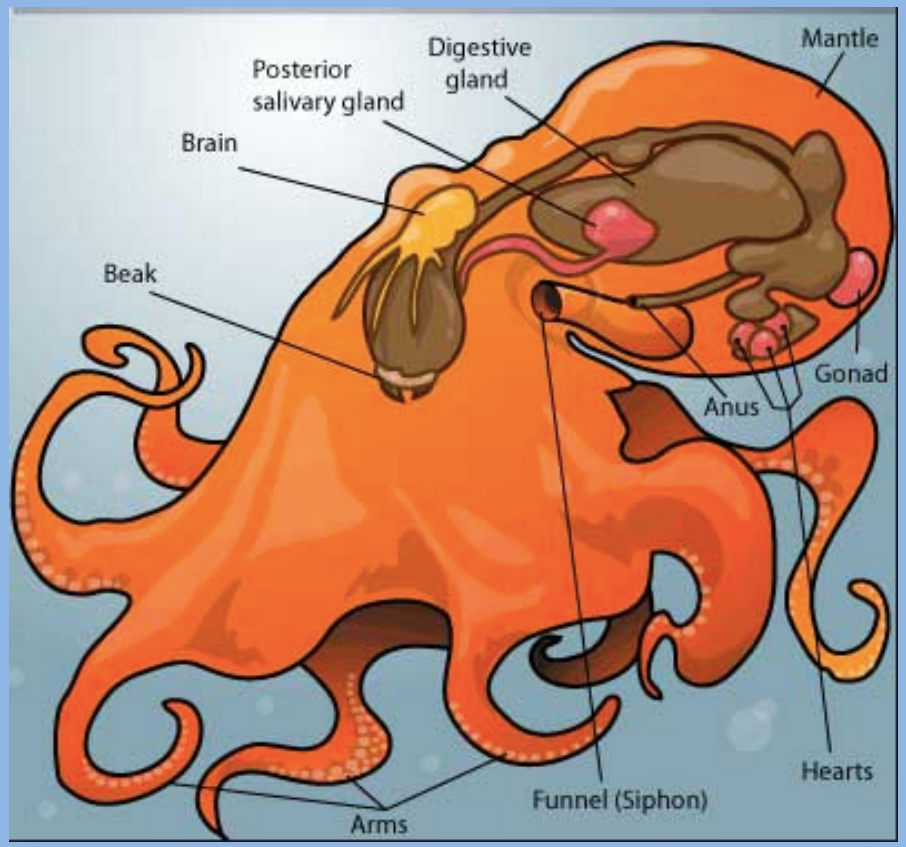
Octopus *vulgaris*

- Class: Cephalopoda
- Geographic range: Mediterranean Sea, Eastern Atlantic Ocean, Japanese waters
- Depth: 200 m
- Temperature range: 16 - 21° C
- Physical Description: 1-3 feet in length (including arms)
  - 8 arms with suckers
  - No internal shell
  - Bilateral symmetry
  - Ectothermic



Octopus vulgaris [Photograph]. (n.d.). Retrieved from http://www.biopix.com/common-octopus-octopus-vulgaris_photo-41060.aspx

Octopus *vulgaris*

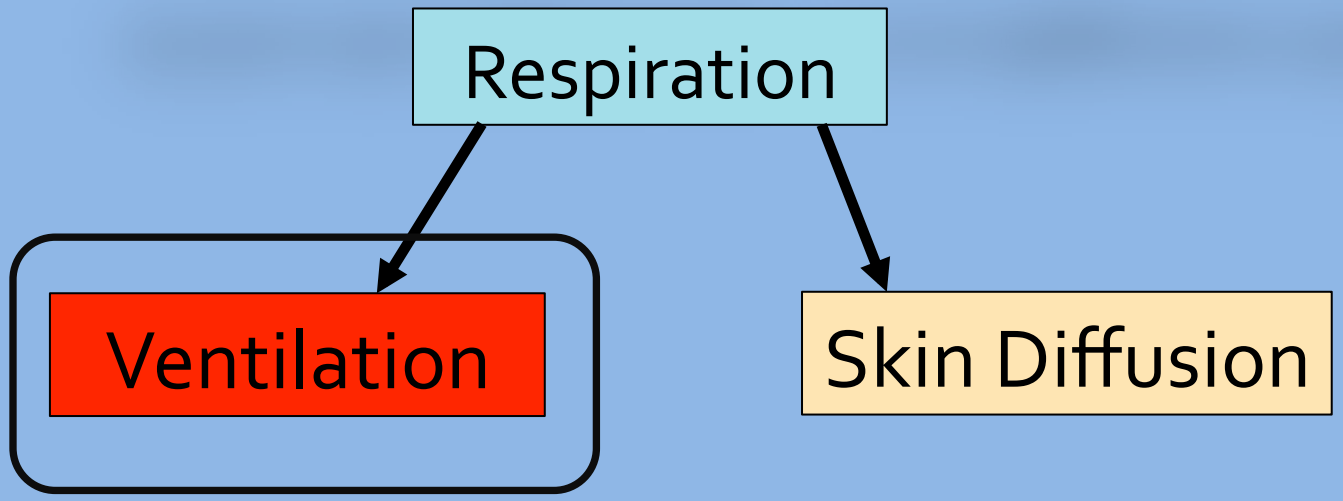


Body Structure:

- Arms branch from the head
- Siphon
  - Tube used for water exchange
- Mantle
  - Behind the head
  - Muscular structure which holds all the organs (gills, hearts, digestive system and glands)
  - Provides protection and aids in respiration

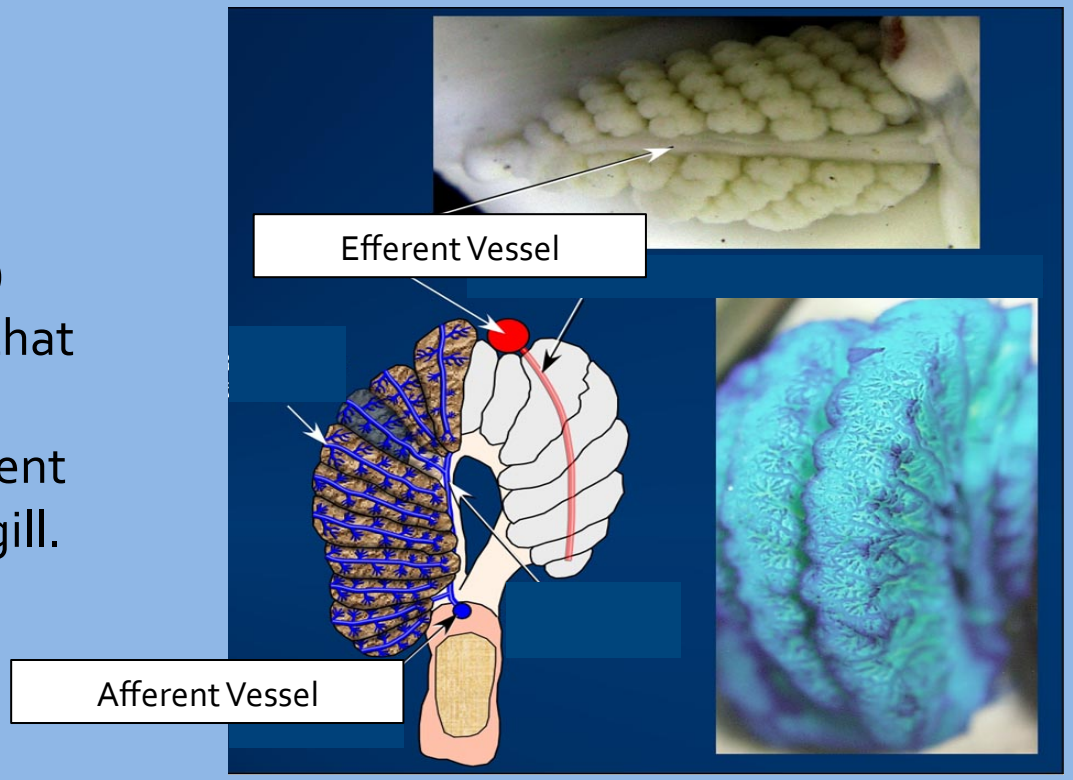
Williams, M (Artist). (2008). Inside the octopus anatomy [Drawing], Retrieved from http://animals.howstuffworks.com/marine-life/octopus1.htm

Respiration in Octopus *vulgaris*



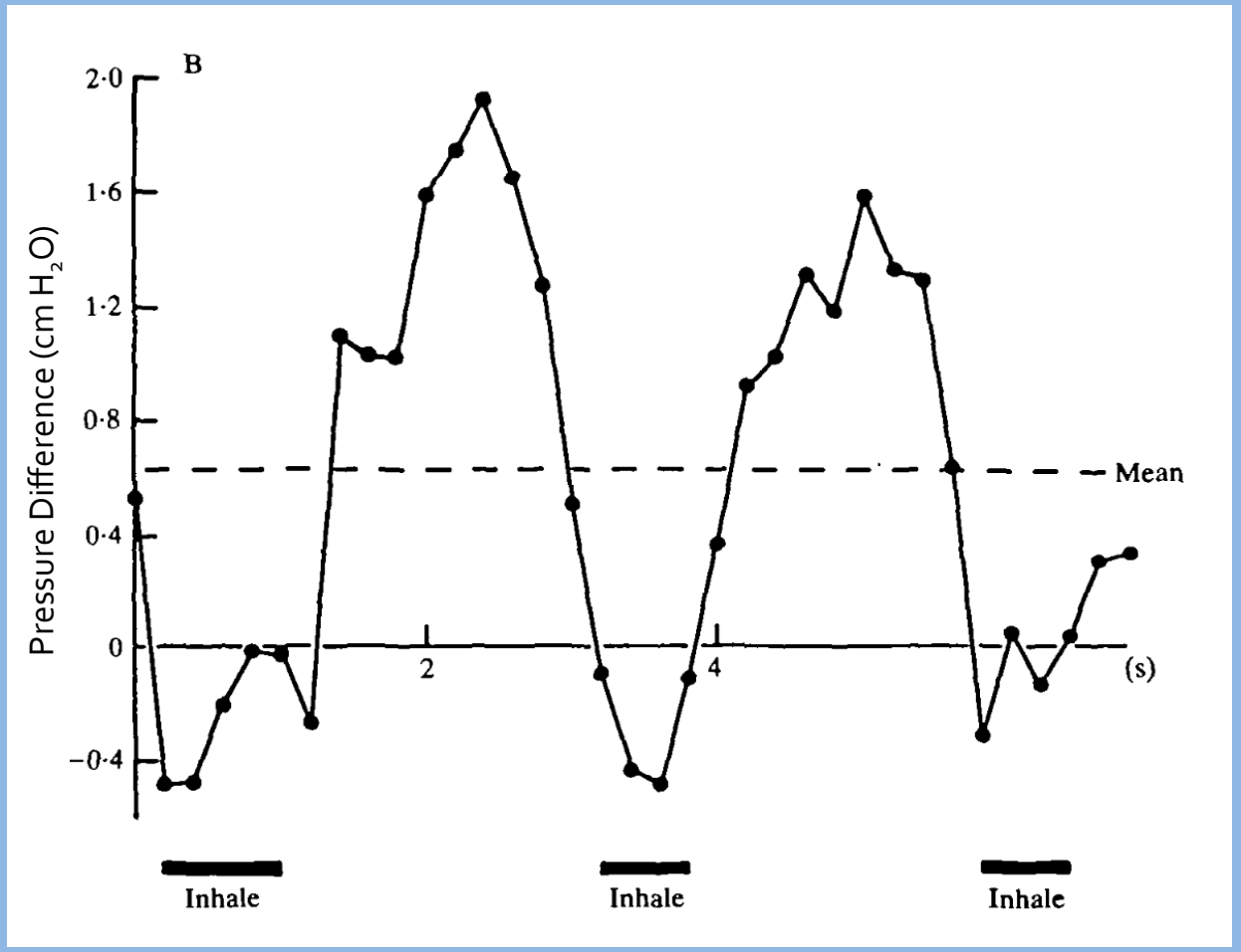
Gills

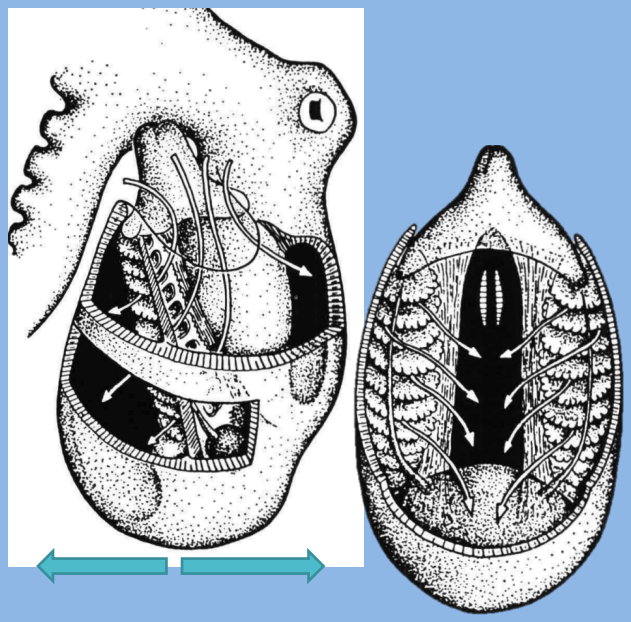
Lamella (thin plate structures) folds into complex structures that resemble a fan shape. The octopus has afferent and efferent vessels passing through each gill.

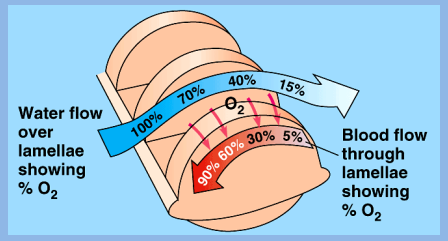


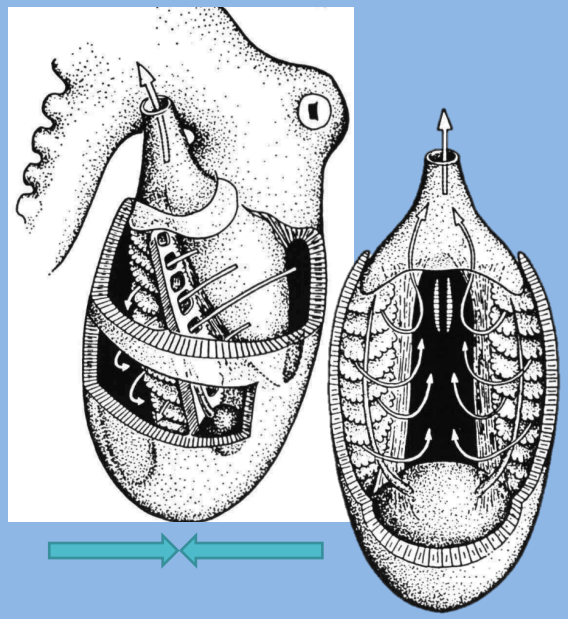
Octopus *vulgaris* Ventilation

Octopus *vulgaris* is a negative pressure breather (like humans!)









Steps of octopus ventilation

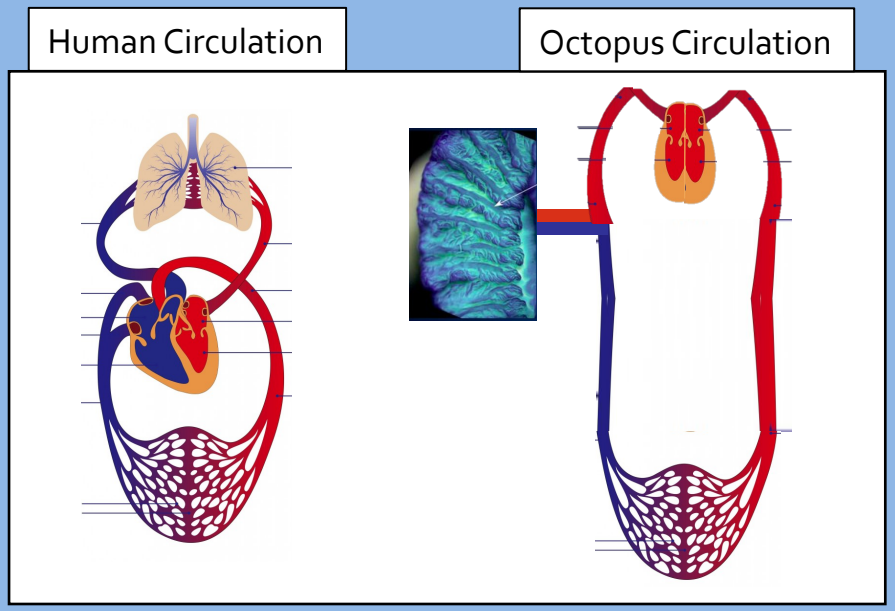
1. Contraction of radial muscles cause the mantle sac to expand. This decreases pressure in the mantle and water flows in through the siphon.

2. Water pushed through the gills countercurrent to the capillaries (countercurrent exchange) and into the central post-branchial space

3. Radial muscles relax and lateral mantle muscles contract pushing water back out through the siphon

Adaptations to the circulatory system

- Octopus are highly active and require high delivery of oxygen.
- As a member of the mollusca family, octopus have gills upstream of the heart and therefore have very low blood pressure passing the gills



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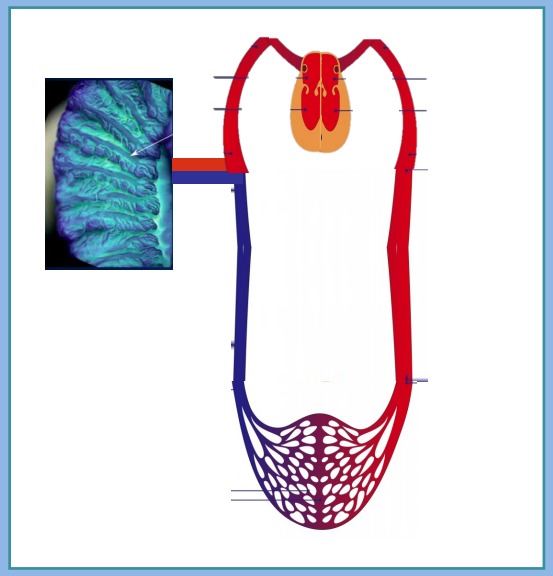
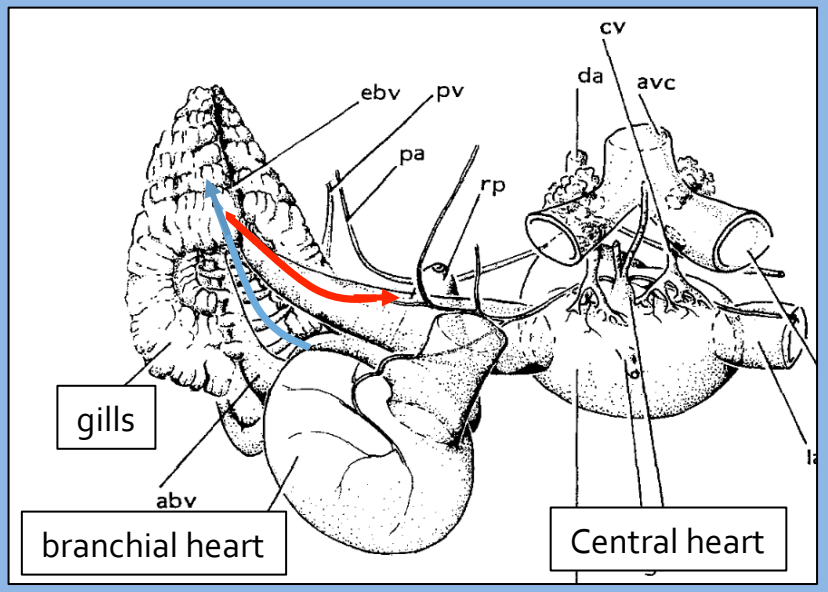


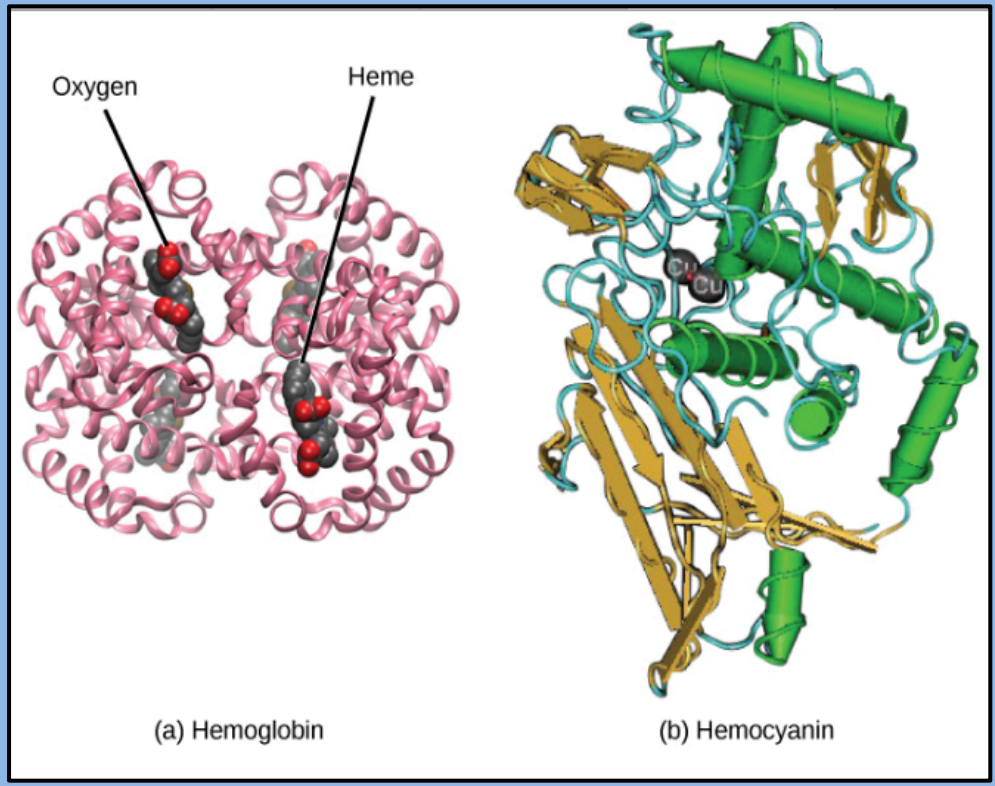


Octopus has contractile veins and accessory pumps (branchial heart) to push blood through the gills.

Oxygen Transport

What is Hemocyanin

- Less evolved version of hemoglobin
  - Hemocyanin is much larger than hemoglobin: less efficient
- Copper-protein complex that binds reversibly with oxygen
- Suspended in Hemolymph of Octopus vulgaris,
- Calibrated through evaluation to low oxygen and cold temperature conditions (like that of Octopus vulgaris)



Adapted from the Concepts of Biology (1st Canadian edition)

What would happen if hemocyanin replaced hemoglobin in humans?

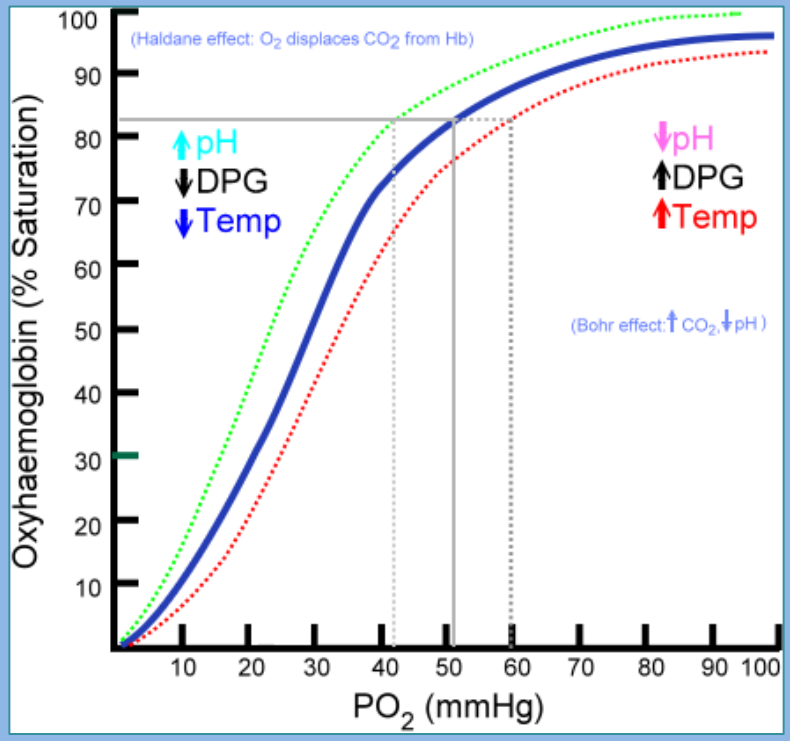
Keep in Mind: Hemocyanin, similarly to hemoglobin, has an oxygen and carbon dioxide dissociation curve.

What would happen if hemocyanin replaced hemoglobin in humans?

Recall the Oxyhemoglobin Dissociation Curve:

Left shift --> Increases the affinity of oxygen to hemoglobin, oxygen isn't released easily

Right shift --> Decreases the affinity of oxygen to hemoglobin, oxygen unbinds easily



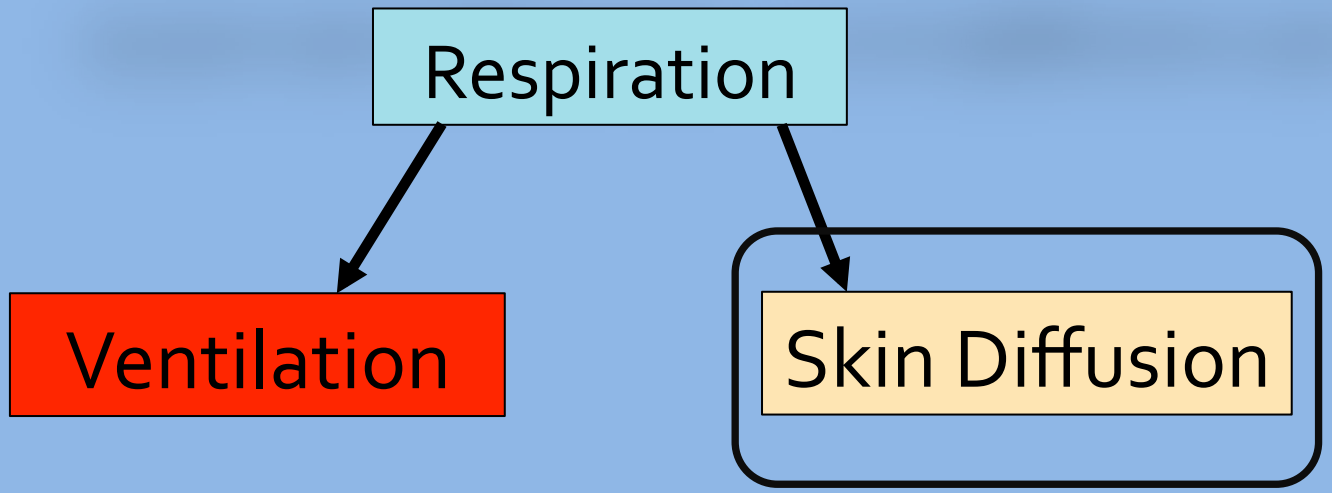
Hemoglobin saturation curve [Graph]. (2006). Retrieved from https://en.wikipedia.org/wiki/Oxygen-hemoglobin_dissociation_curve#/media/File:Oxyhaemoglobin_dissociation_curve.png

Substituting hemoglobin with hemocyanin in humans will cause a RIGHT shift.

In the octopus, temperatures range from 16 - 21°C. The human body temperature is approximately 37 °C. The right shift decreases the affinity of hemocyanin to oxygen. This causes very poor binding of oxygen to hemocyanin with little oxygen reaching the tissues → Hypoxia!

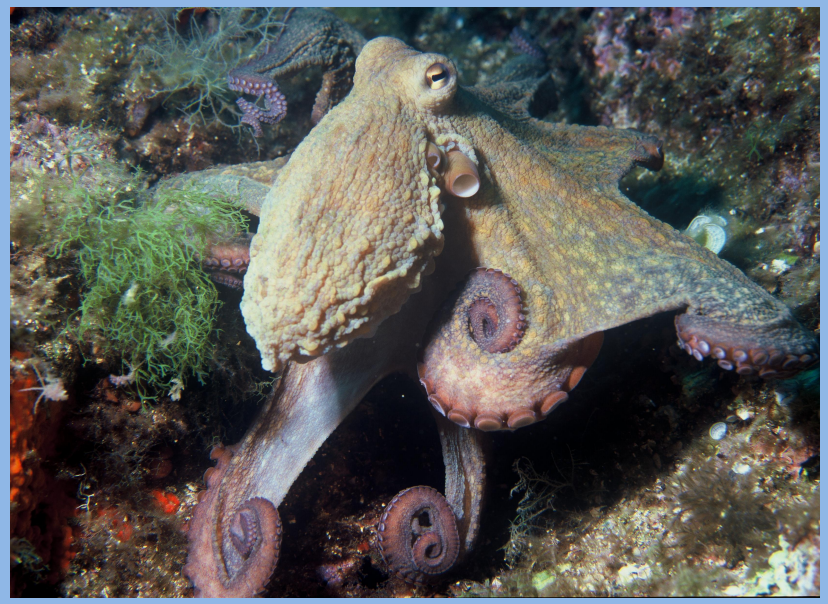
Also acceptable:
Immune response
Blue blood

Respiration in Octopus *vulgaris*



Skin Breathing

- When the body position is curled:
  - Exposed areas to moving water include the internal mantle surface
- Based on this, it is estimated that well - ventilated areas of skin could undergo 41% of the total oxygen uptake (as long as water is flowing over the body)



O. vulgaris from the Mediterranean Sea [Photograph]. (2007). Retrieved from https://en.wikipedia.org/wiki/Common_octopus#/media/File:Octopus_vulgaris_2.jpg

Skin Breathing Ctd.

- When boundary layers (slow moving water or still water) form:
  - Decreases to 8%
  - Exposed area isn't as well ventilated anymore
- During exercise/active movement:
  - Skin surface exposure increases
  - Cutaneous uptake can only provide 33% of the total oxygen uptake

Muller, J.S. (Photographer). (2012). Retrieved from https://www.flickr.com/photos/joachim_s_mueller/6775464689

Differences between Octopus and Humans

	Humans	Octopus
Phylum	Chordata	Mollusca
Breathing Organs	Lungs	Gills Skin
Pressure Breathing	Negative	Negative
Oxygen Availability	210,000 ppm	0-20 ppm
Internal Temperature	37°C	16-21°C
Oxygen Transporter	Hemoglobin	Hemocyanin

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Thanks for listening!