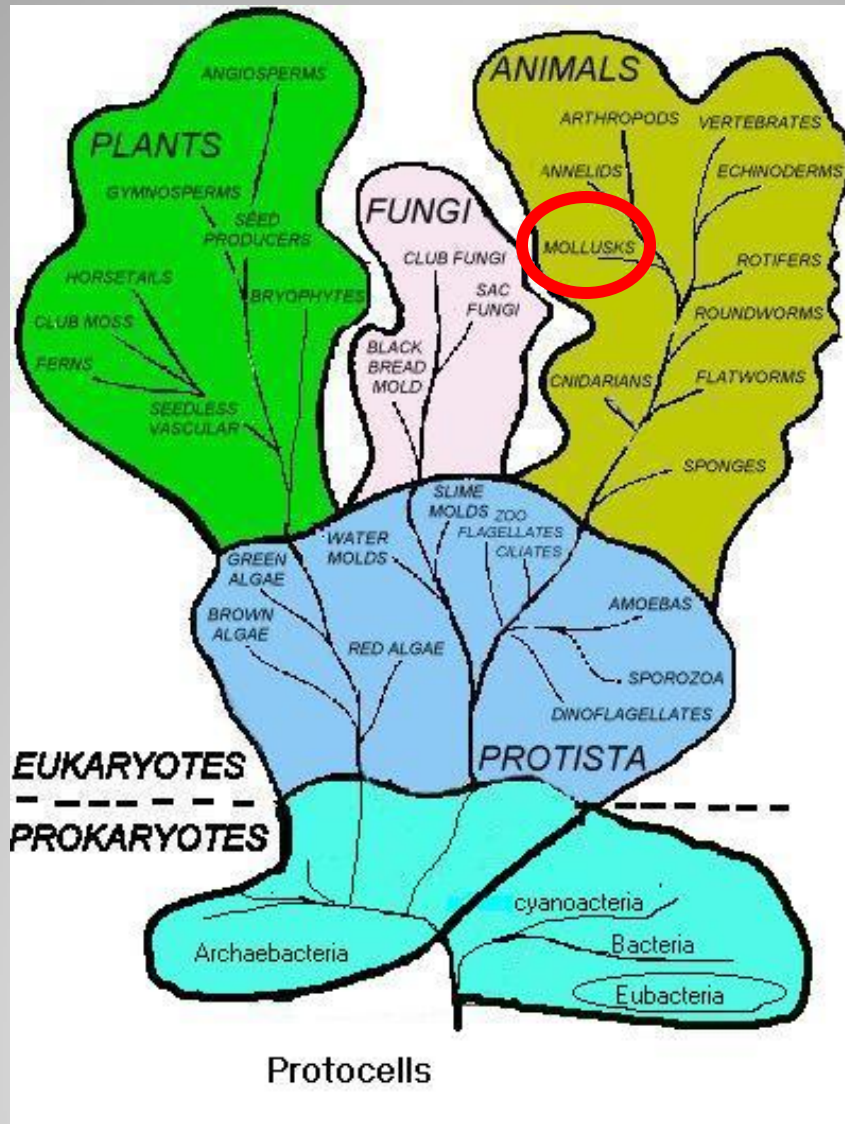


# Bivalve Biology

Dale Leavitt

ROGER WILLIAMS  
UNIVERSITY



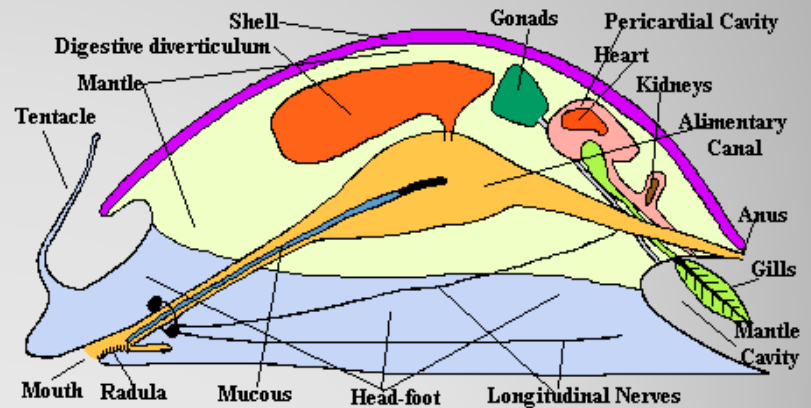
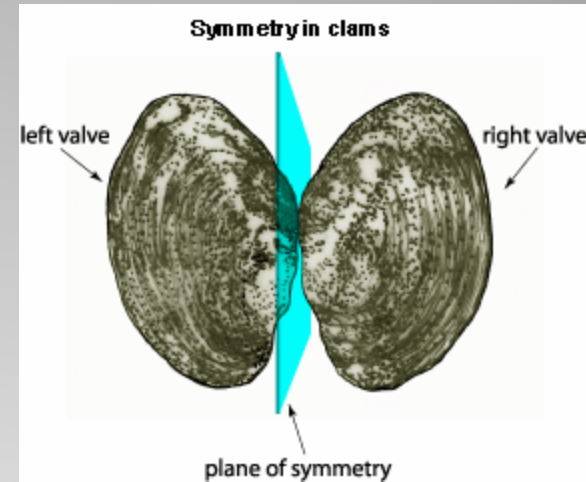
# Shellfish Biology 101

# Phylum Mollusca



- Best known group of invertebrates
  - animals without backbones
  - well known because of shell collecting
- Second largest Phylum
  - >80,000 living species have been named
  - 35,000 species in the fossil record
- Majority of mollusks are marine

- bilaterally symmetrical
- majority have a shell of some kind
- three distinct areas
  - distinct head area
  - visceral mass
  - large, muscular foot
- mantle is present
- simple digestive system => primarily herbivores



# Phylum Mollusca



*Murex (Murex) hystricosus* Houart & Dharma, 2001  
Kangean Island, East Java.



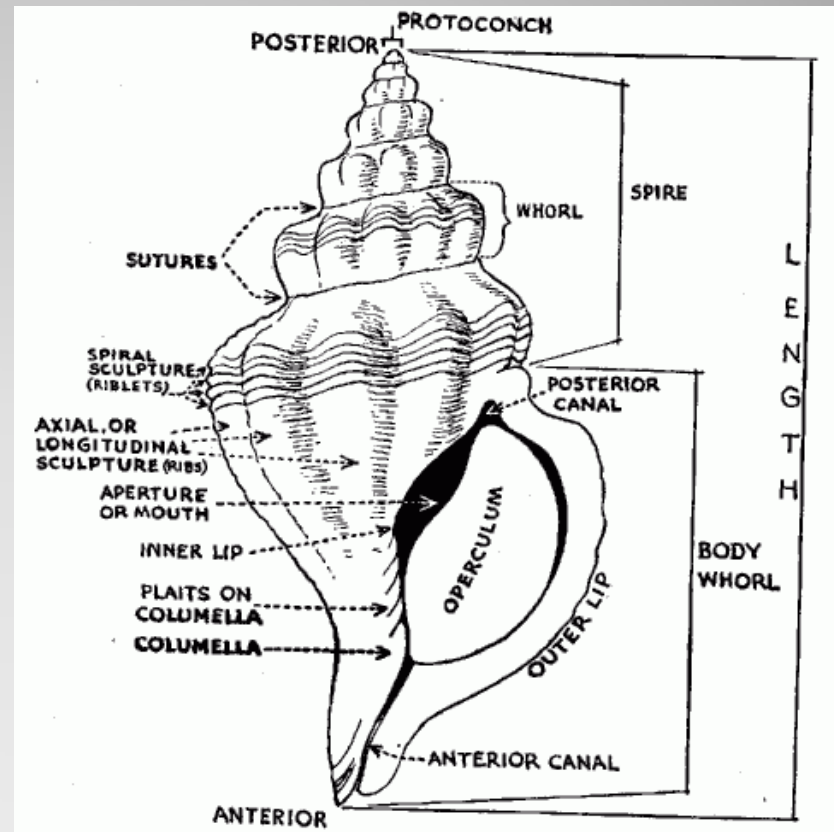
Blue-ringed Octopus



**Come in a variety of shapes and sizes**

## There are seven Classes of Mollusca:

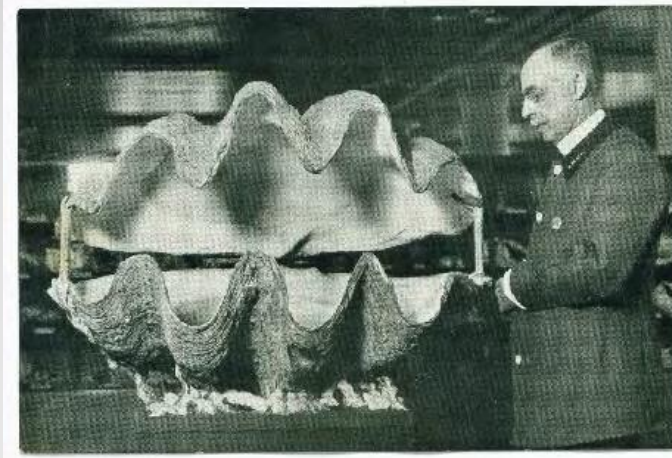
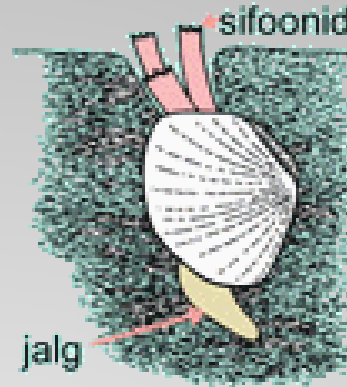
- Gastropoda single, usually spirally coiled shell into which the body can be withdrawn



# Phylum Mollusca

## There are seven Classes of Mollusca:

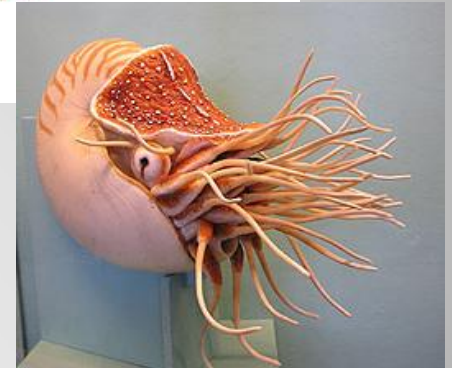
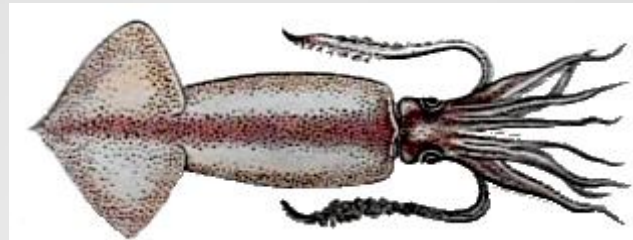
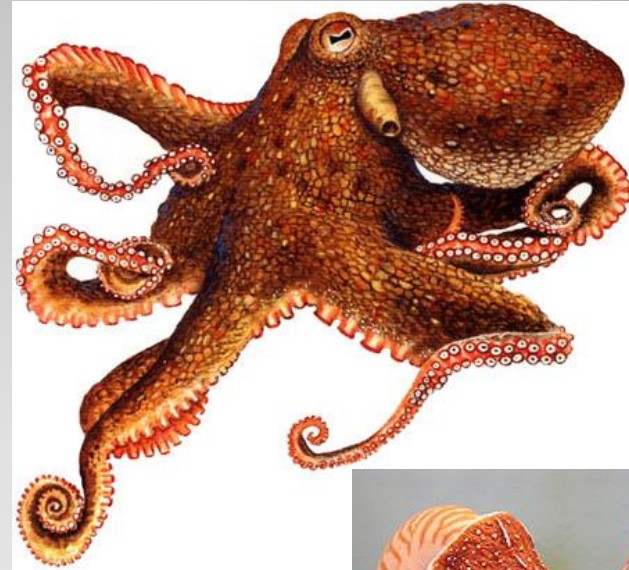
- **Gastropoda** single, usually spirally coiled shell into which the body can be withdrawn
- **Bivalvia** two laterally-compressed shells, hinged together by an elastic ligament and shell teeth



# Phylum Mollusca

## There are seven Classes of Mollusca:

- Gastropoda single, usually spirally coiled shell into which the body can be withdrawn
- Bivalvia two laterally-compressed shells, hinged together by an elastic ligament and shell teeth
- Cephalopoda A funnel derived from the molluscan foot - circumoral arms - chitinous beaks.



# Phylum Mollusca

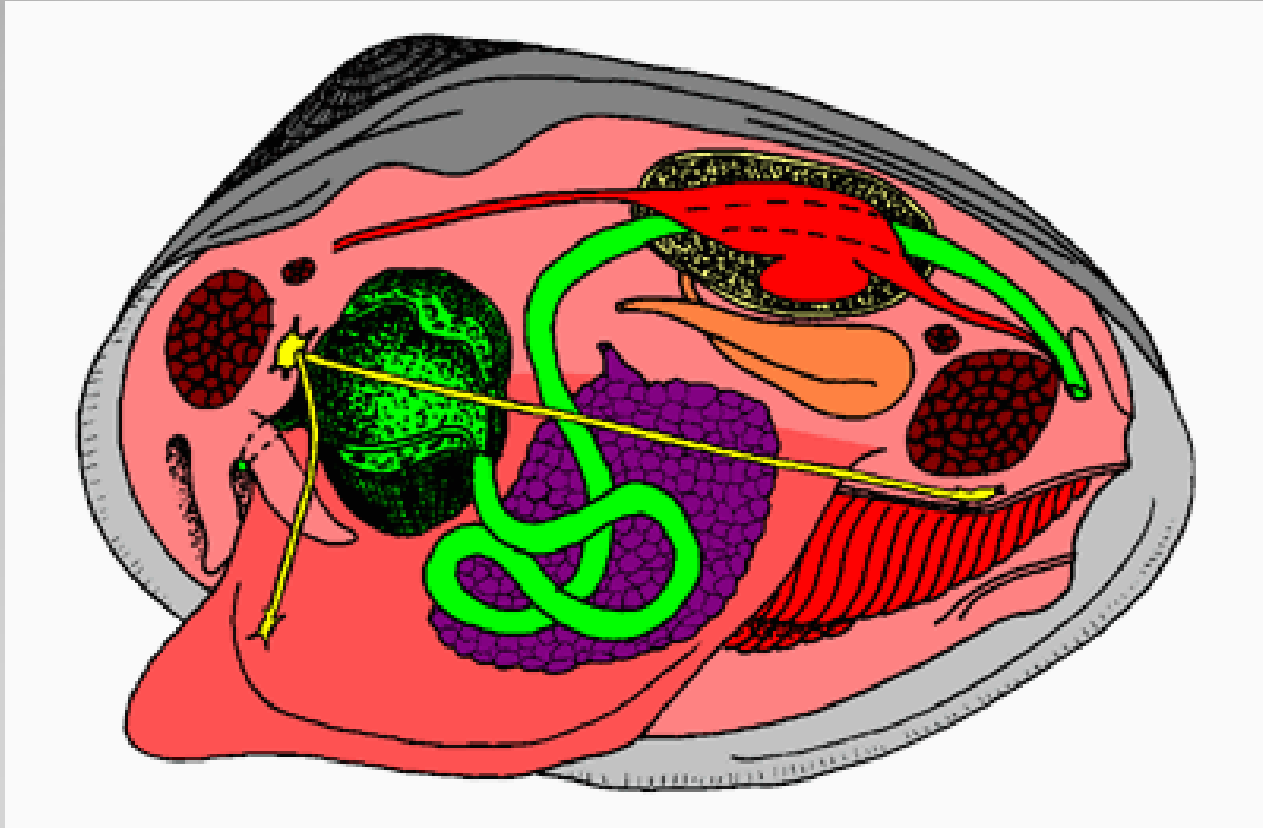


- Two shells (valves) with hinge
- Laterally compressed
- Head greatly reduced
- Fleshy mantle encasing the visceral mass and a muscular foot
- Lost the radula
- Gills are large and used for feeding
- Sedentary



"Who could guess that when the end came, it would be giant clams?"

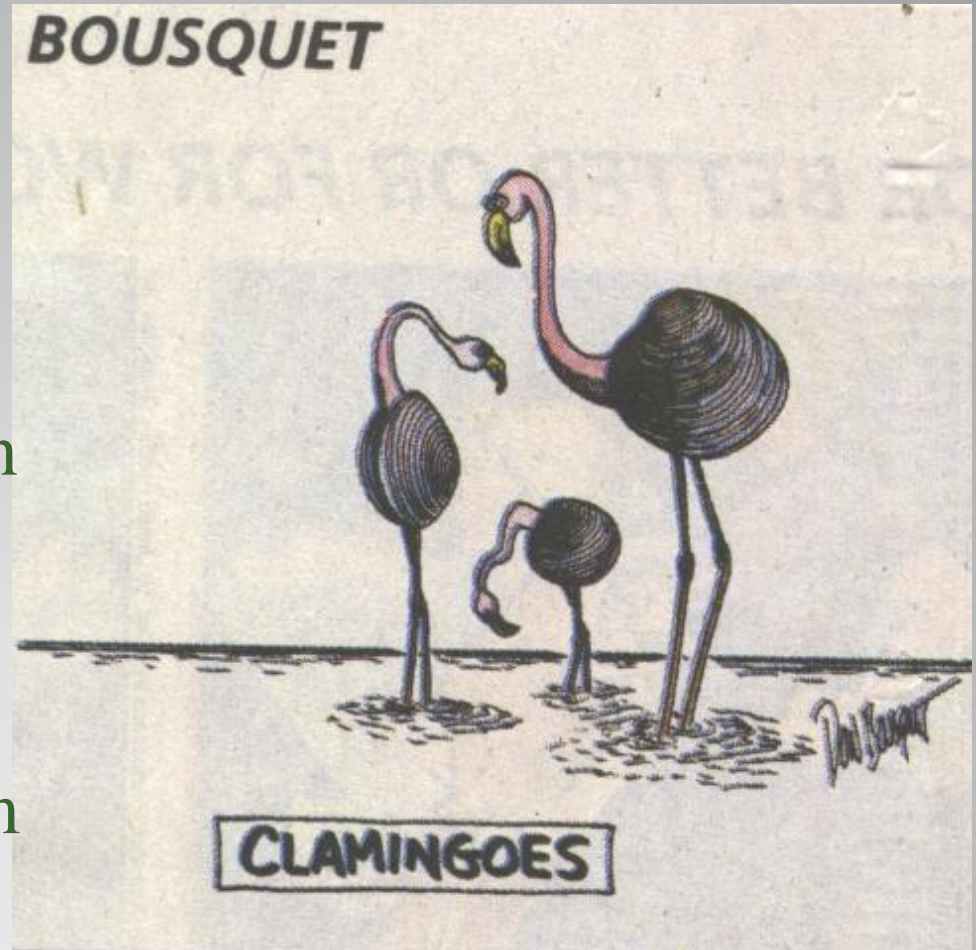
## Class Bivalvia



# Adult Biology

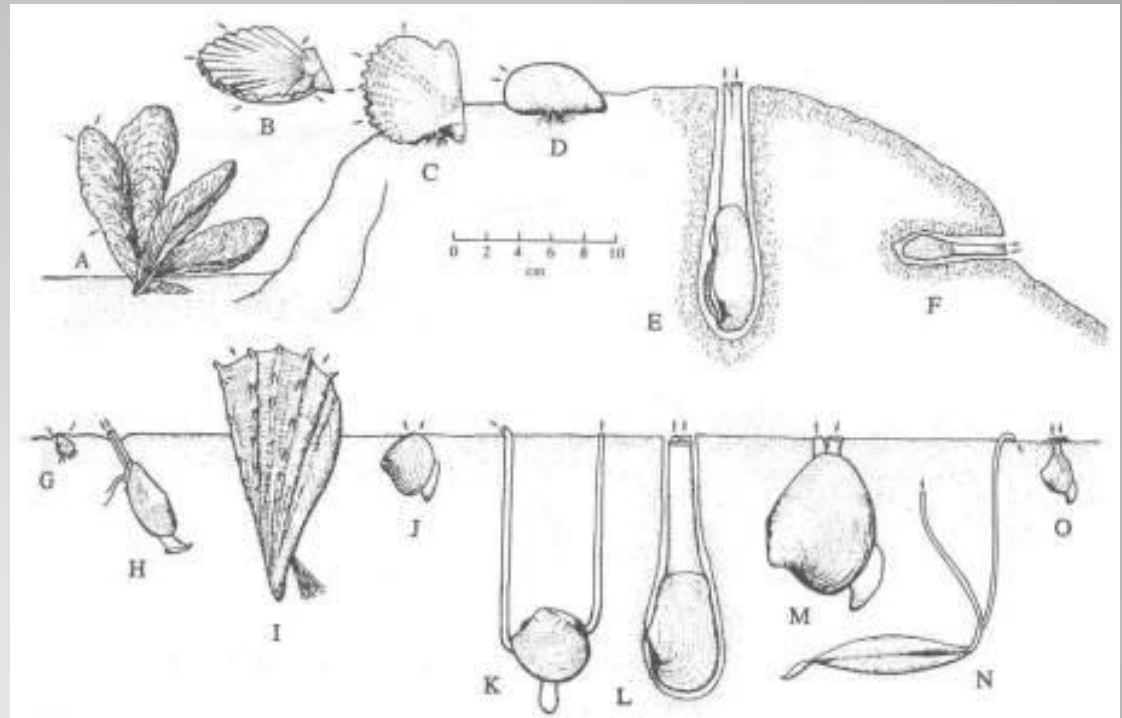
What do you need to know as a shellfish farmer?

- Life styles
- Anatomy
- Growth
- Respiration
- Feeding & Digestion
- Nervous system
- Circulatory system
- Locomotion system
- Reproductive system



**What does a shellfish farmer need to know about shellfish biology?**

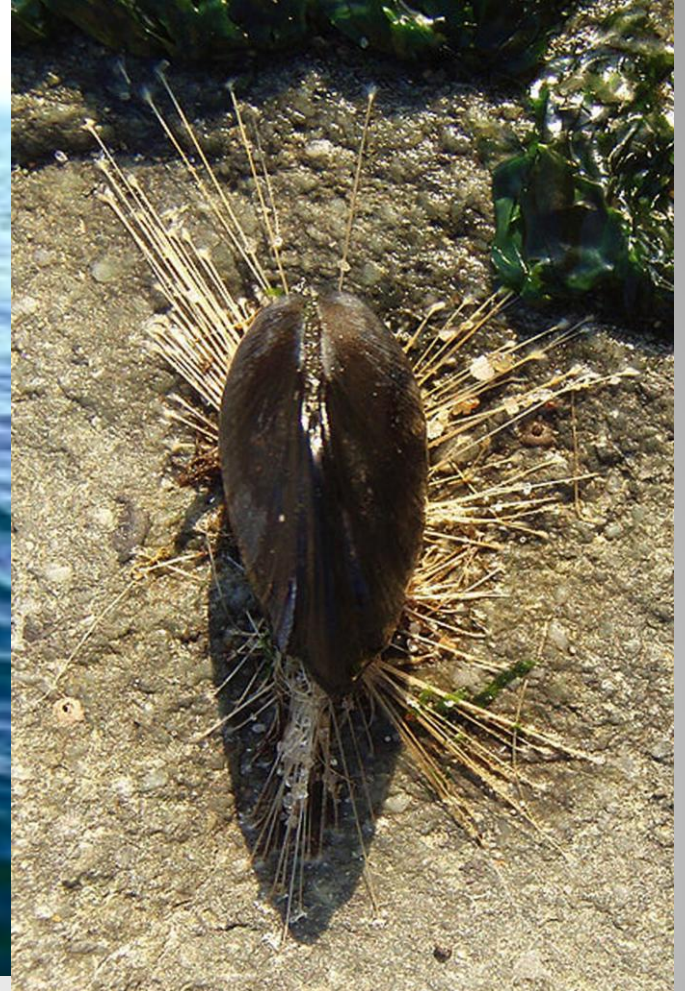
- Epifaunal
  - Byssally attached (blue mussel)
  - Reclining (giant clam)
  - Cemented (oyster)
  - Swimming (scallop)
- Semi-Infauanal
  - Byssally attached (ribbed mussel)
- Infaunal
  - Burrowing (quahog)
  - Boring (piddock)



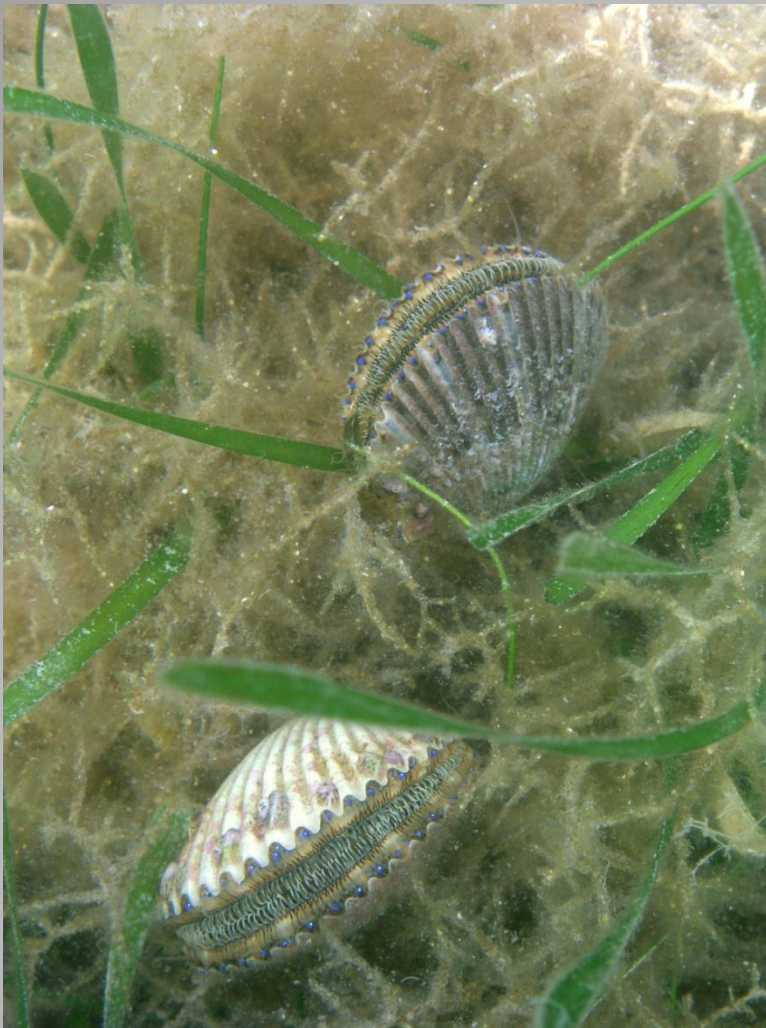
## Life Styles of the Shelled and Aquatic



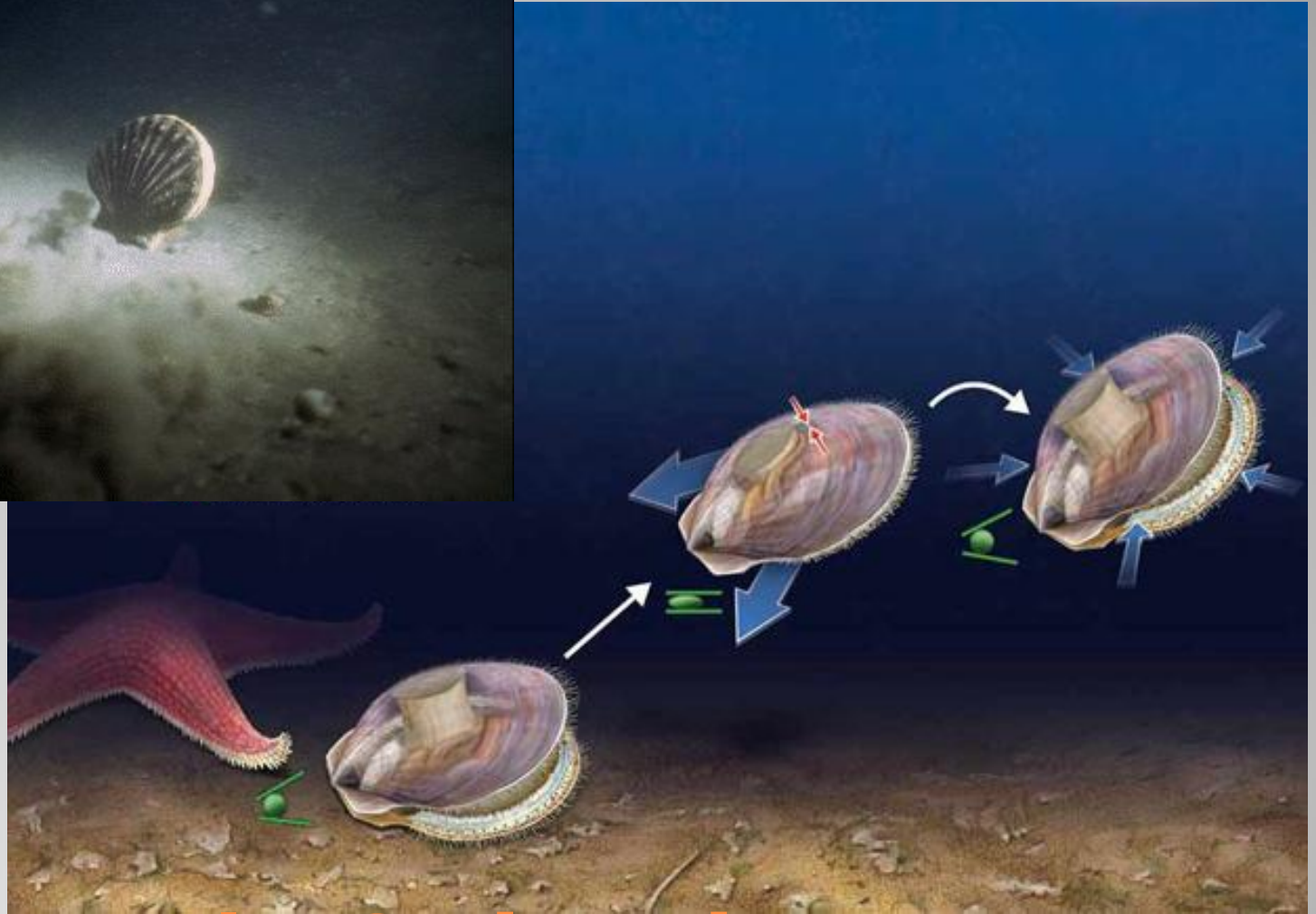
# Epifaunal - Cemented



# Epifaunal – Byssal attachment



# Epifaunal – Reclining



# Epifaunal - Swimming





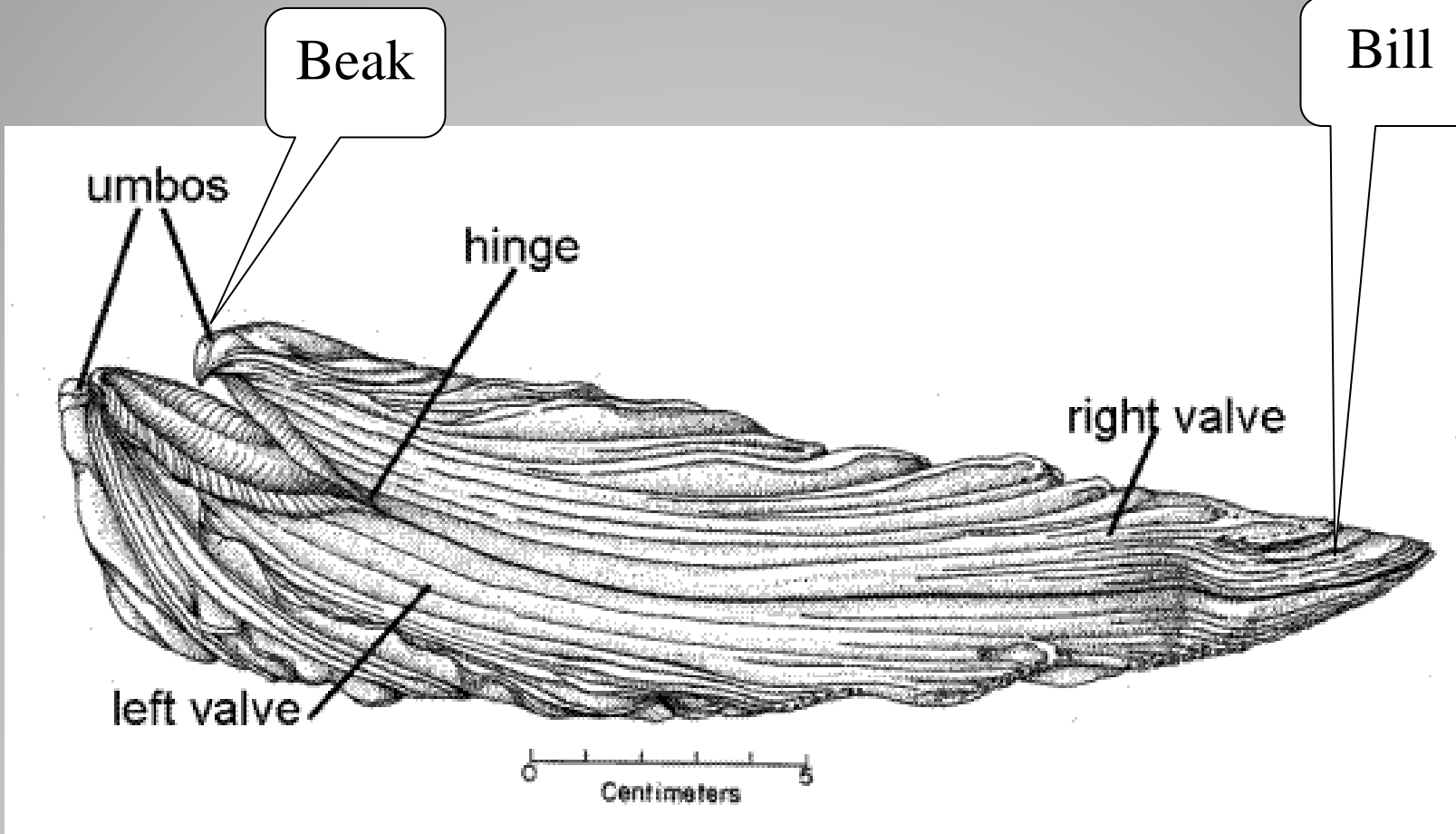
## Semi-infaunal – Byssal attachment



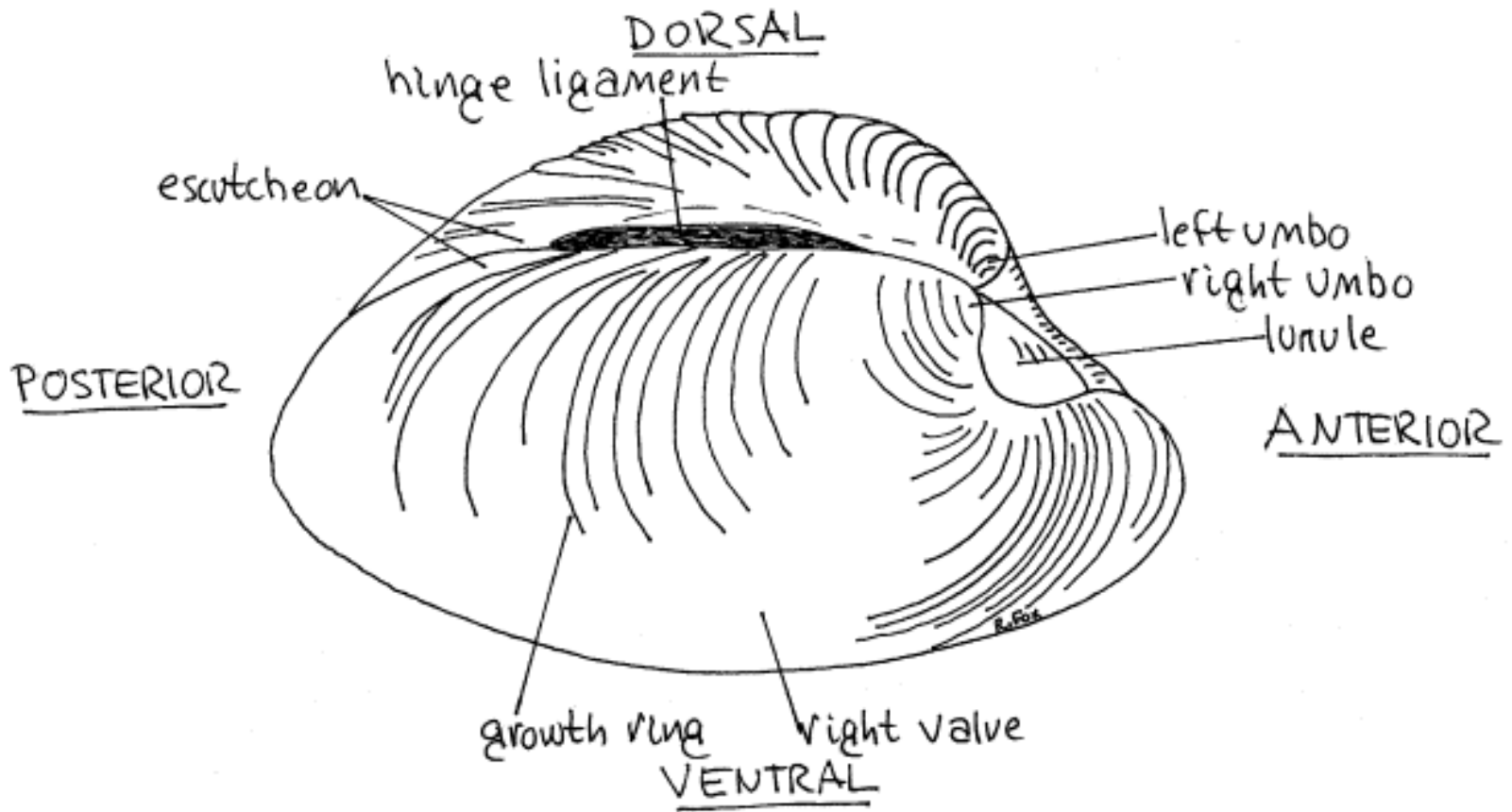
# Infaunal - Burrowing



# Infaunal - Boring



# External Anatomy - Oyster



# Exterior Anatomy - Quahog

- *Mercenaria mercenaria*  
*var. alba*

- White color
- Commonly found



- *Mercenaria mercenaria*  
*var. notata*

- Indian blanket or zig-zag pattern
- "Charlie Brown clams"
- 1-2% of the wild catch



## The two varieties of quahog



A large pile of quahog clams, showing various shell patterns and colors. The shells are densely packed and exhibit a range of hues from light beige to dark brown, with some showing prominent concentric ridges and others showing more irregular, mottled patterns. The clams are shown from various angles, highlighting their rounded, slightly flattened shape.

**Notata**

**White**

**What  
is  
this?**

The three varieties of quahog

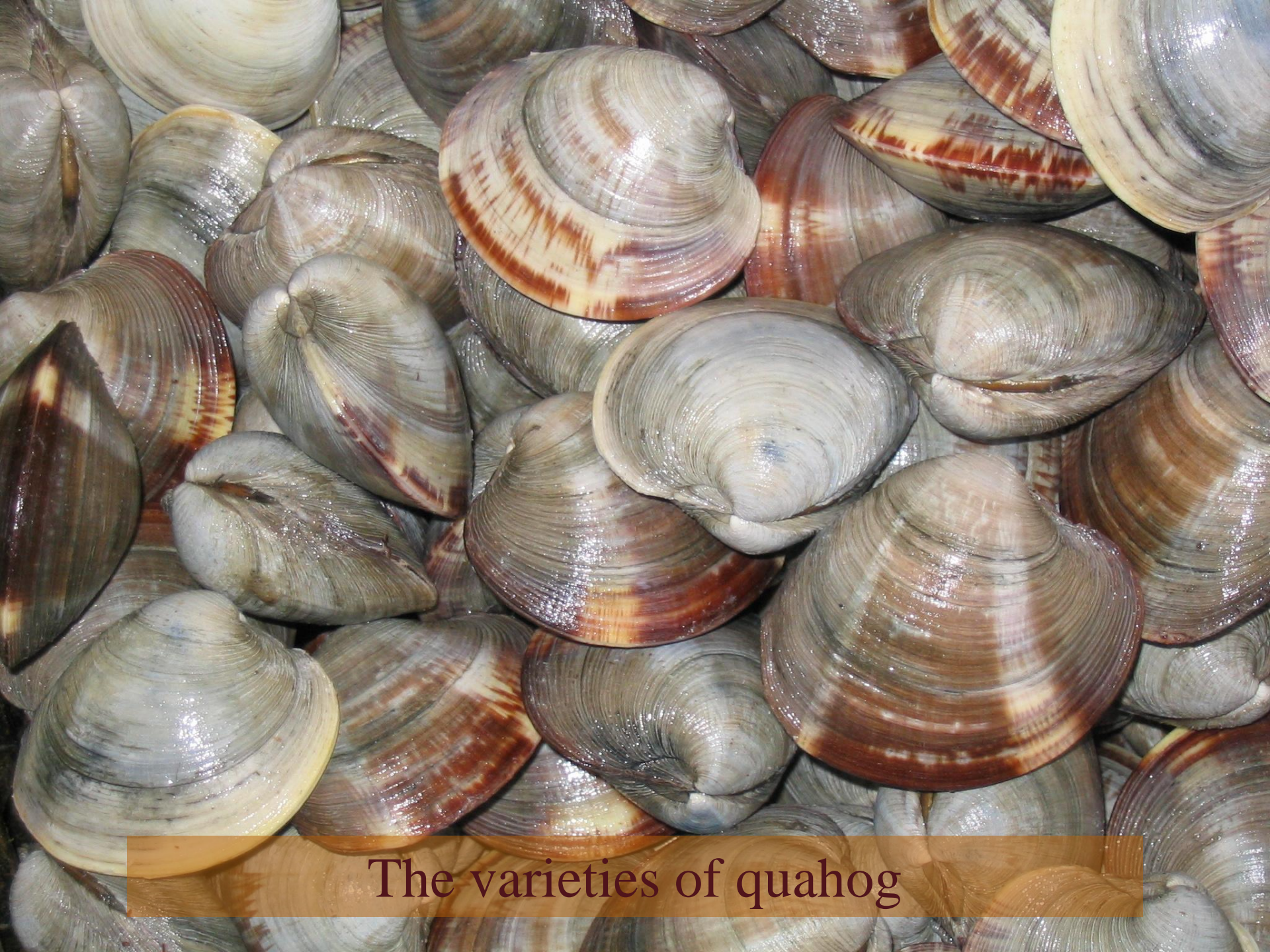
	Mm x Mm	M	m
White 	M	MM	Mm
Zig-zag 	m	Mm	mm

- Classic Mendelian genetic distribution
  - $\frac{1}{4}$  MM x  $\frac{1}{2}$  Mm x  $\frac{1}{4}$  mm
- Only see striped (mm) in hatchery stock???
- Just one of those mysteries of Mother Nature!!

Striped?

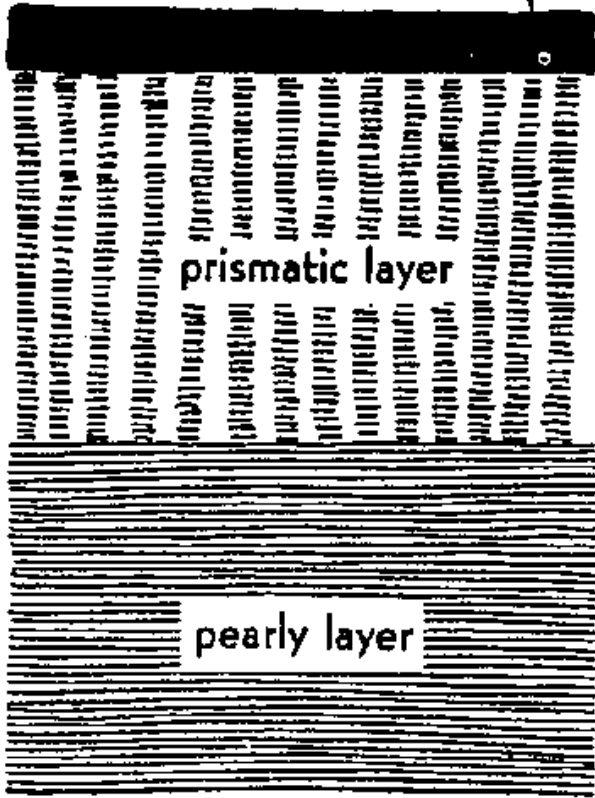
**Where did that third shell color come from?**





The varieties of quahog

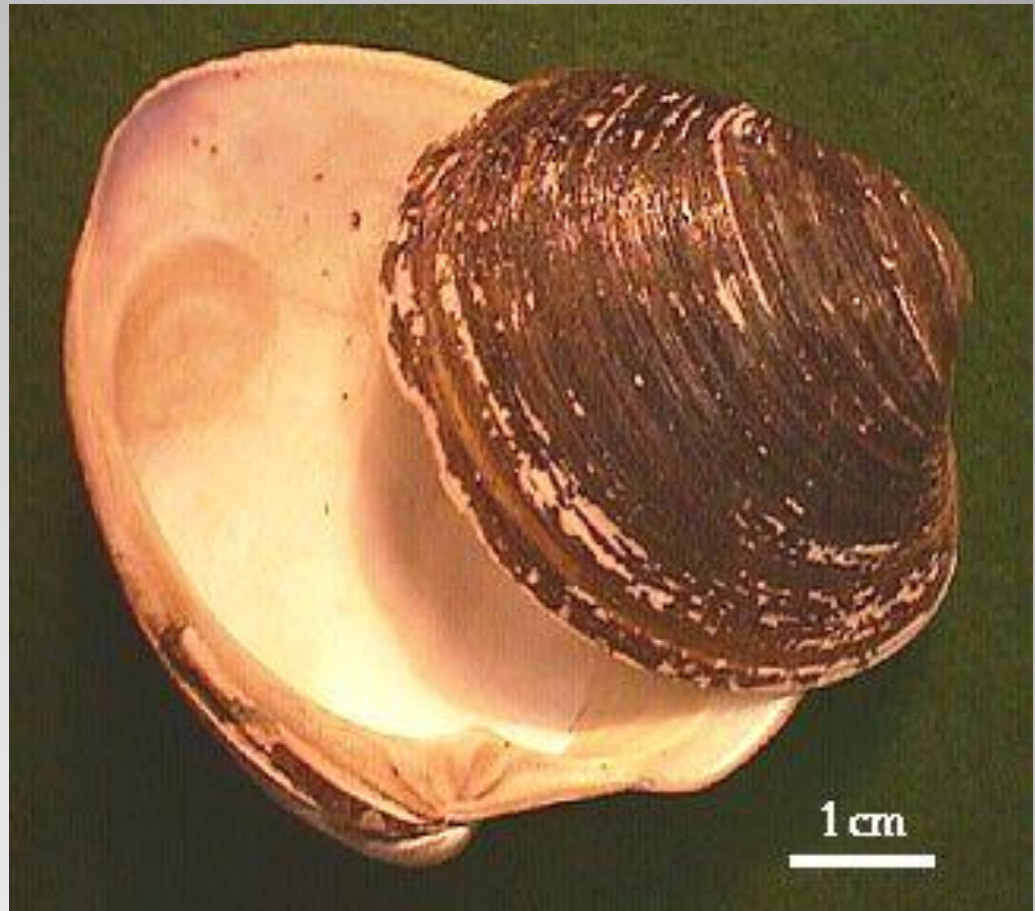
horny outer layer



prismatic layer

pearly layer

The **shell** consists of three layers.



1 cm

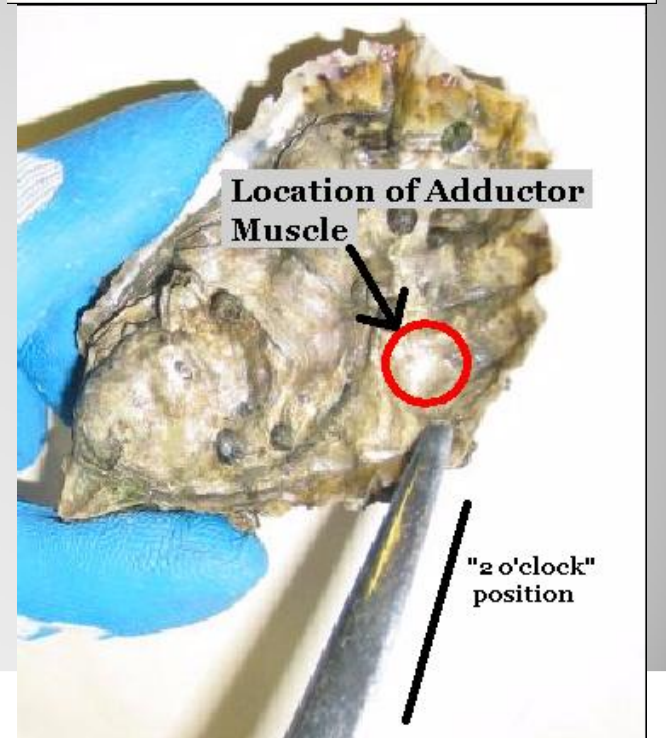
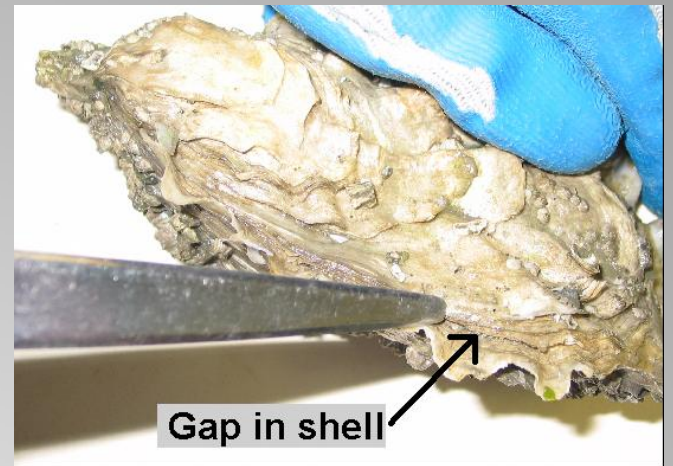
# Shell layers

Soft Shell Clam  
Scallop      Quahog

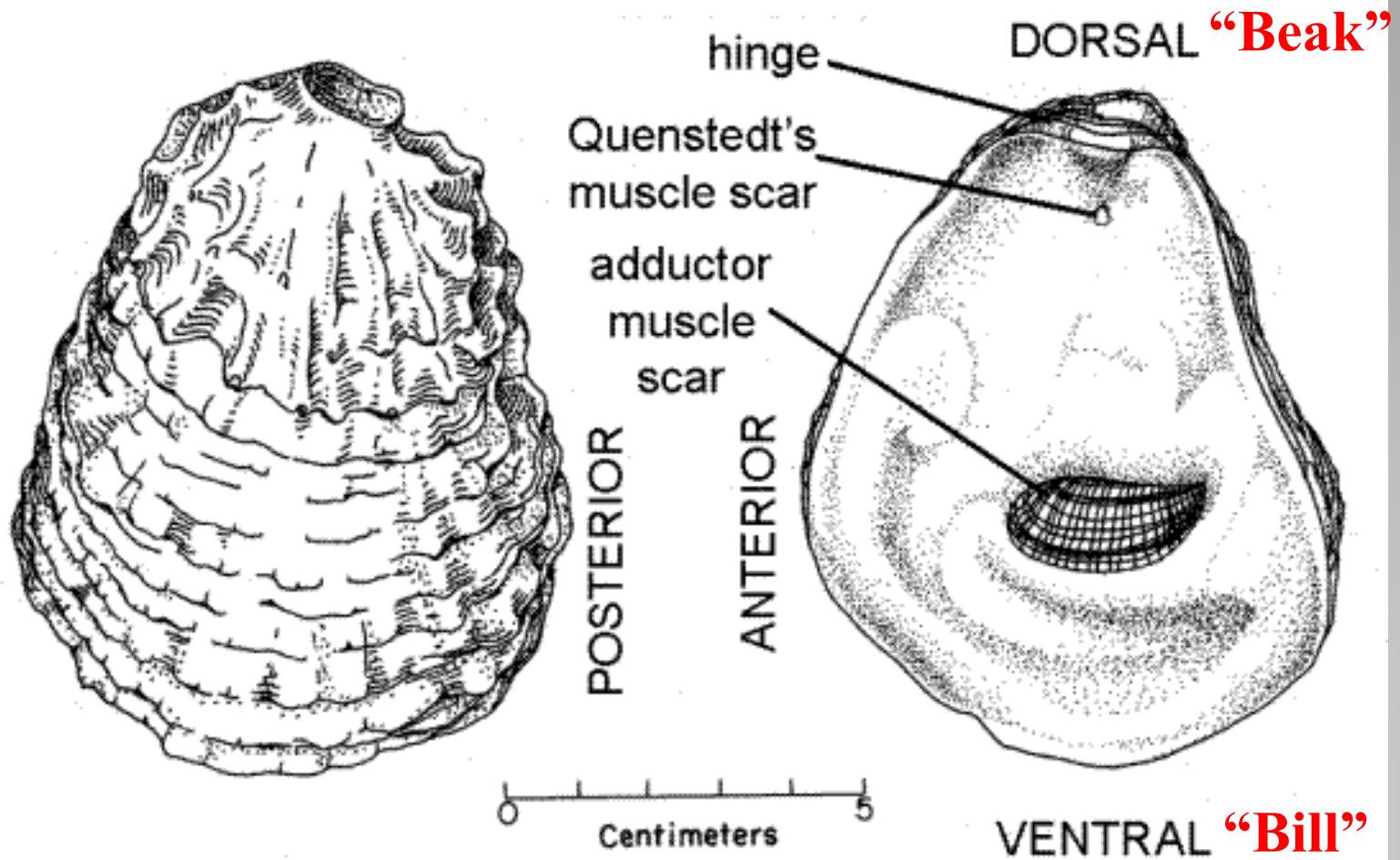


Oyster

# Opening shellfish



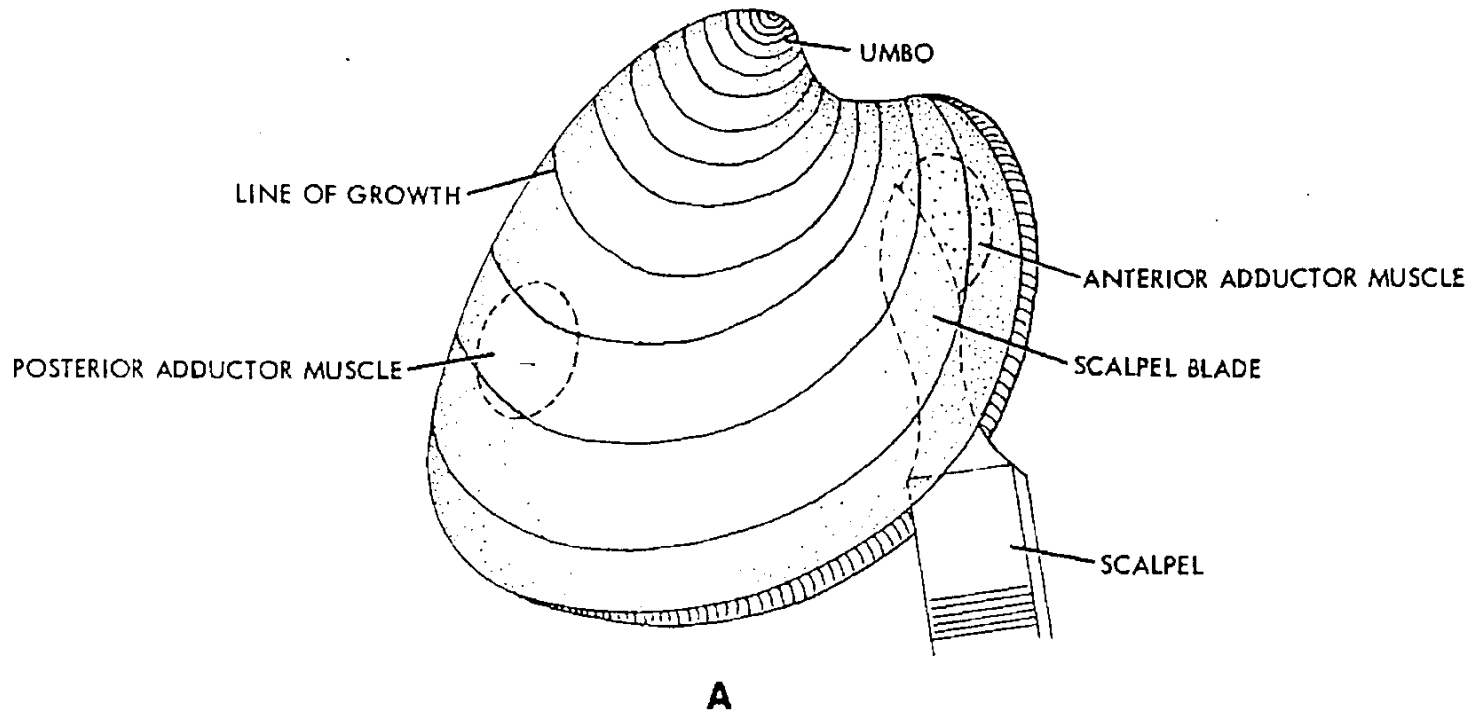
# Opening an Oyster



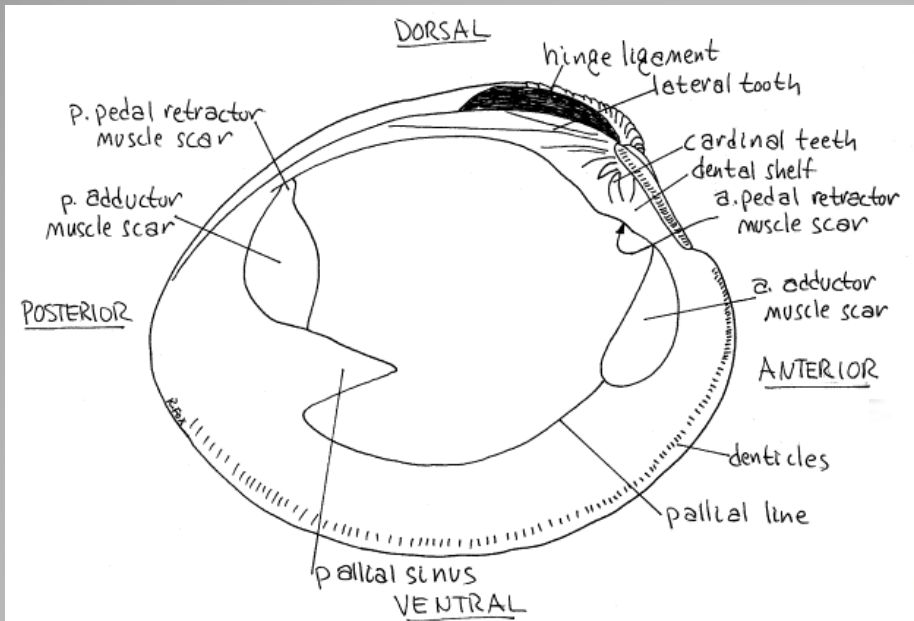
# Interior of an Oyster Shell



# Opening the quahog



# Opening the clam

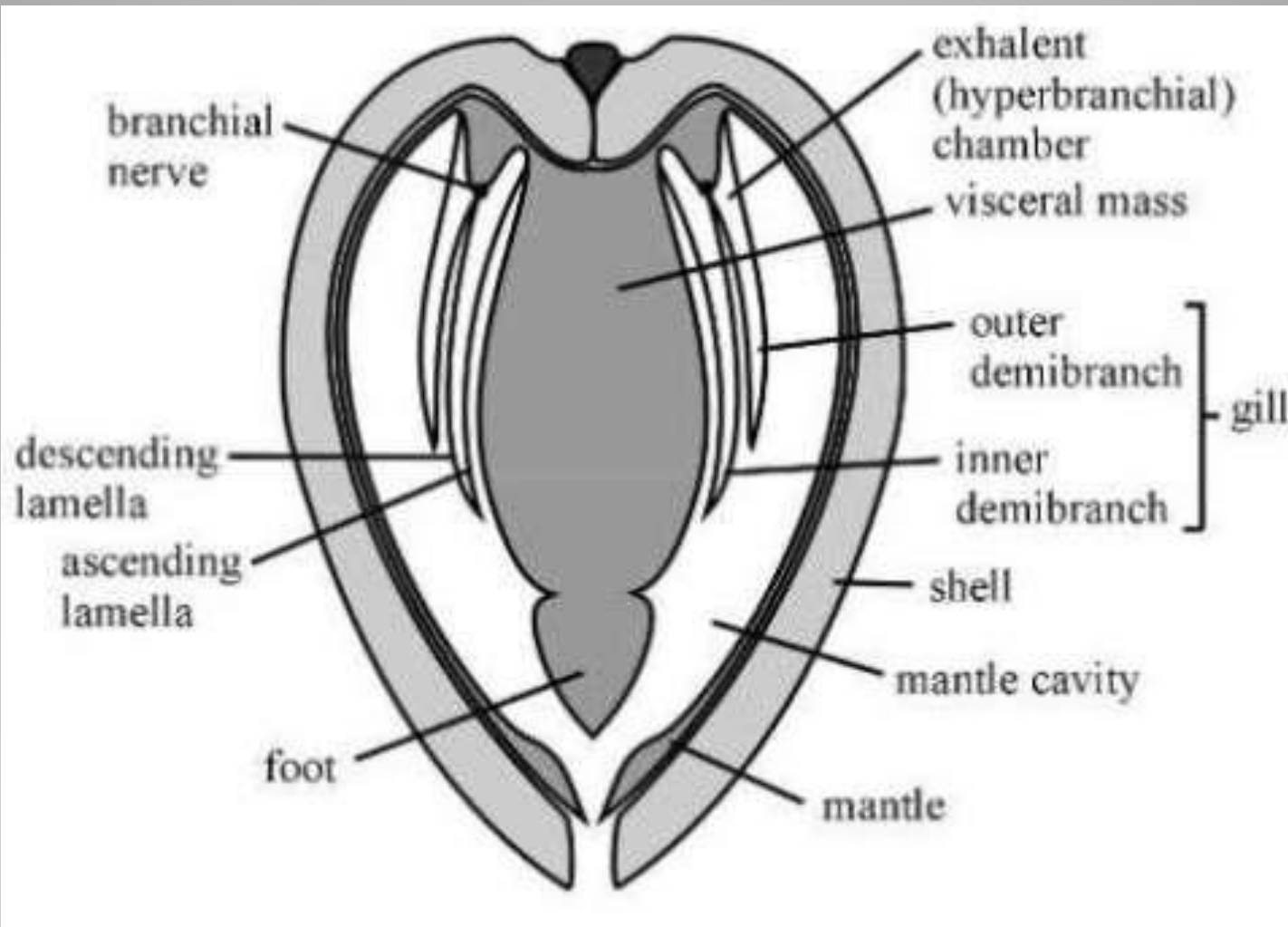


# Interior of a Quahog shell

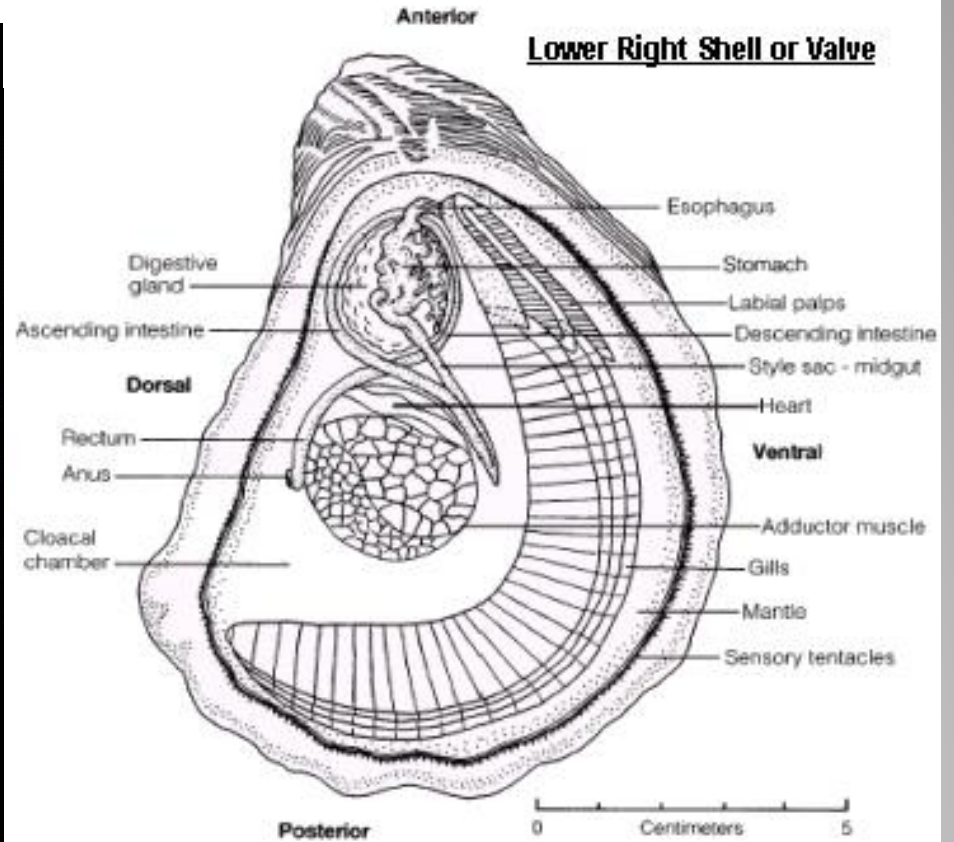




# Wampum (Suckáuhock)

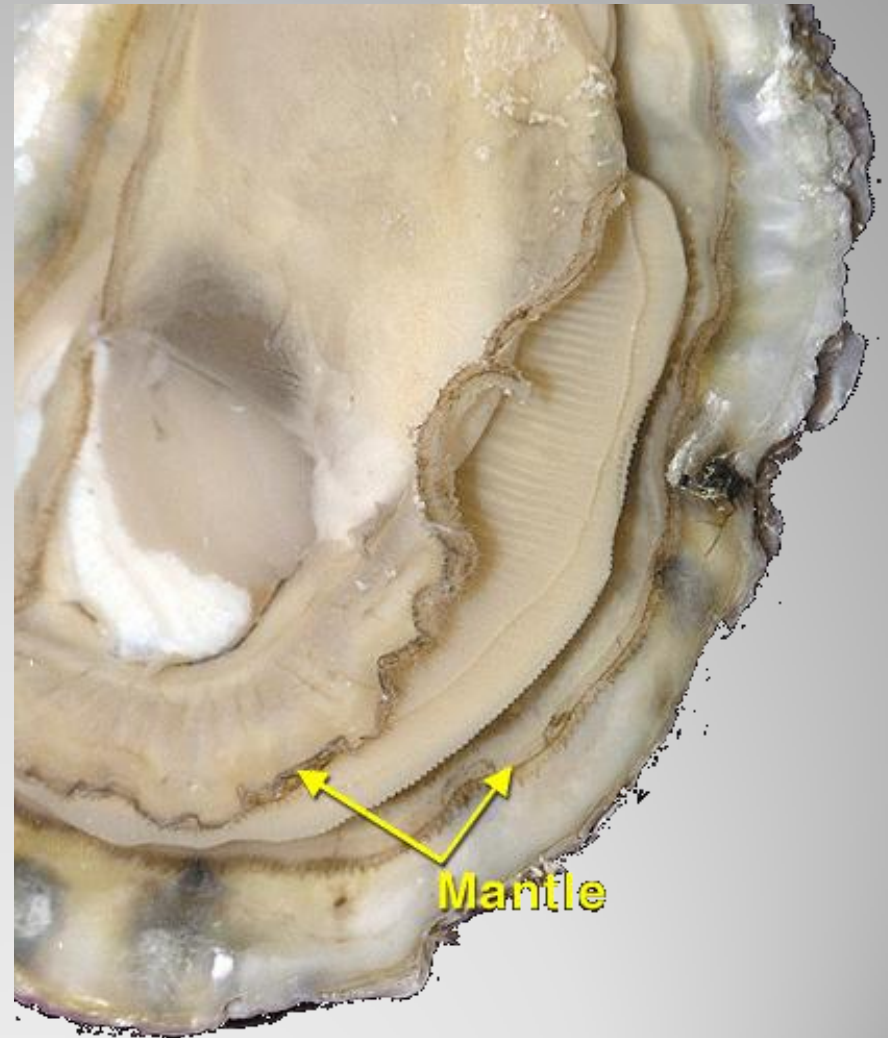


# Bivalve in cross-section



Source : Maryland Sea Grant

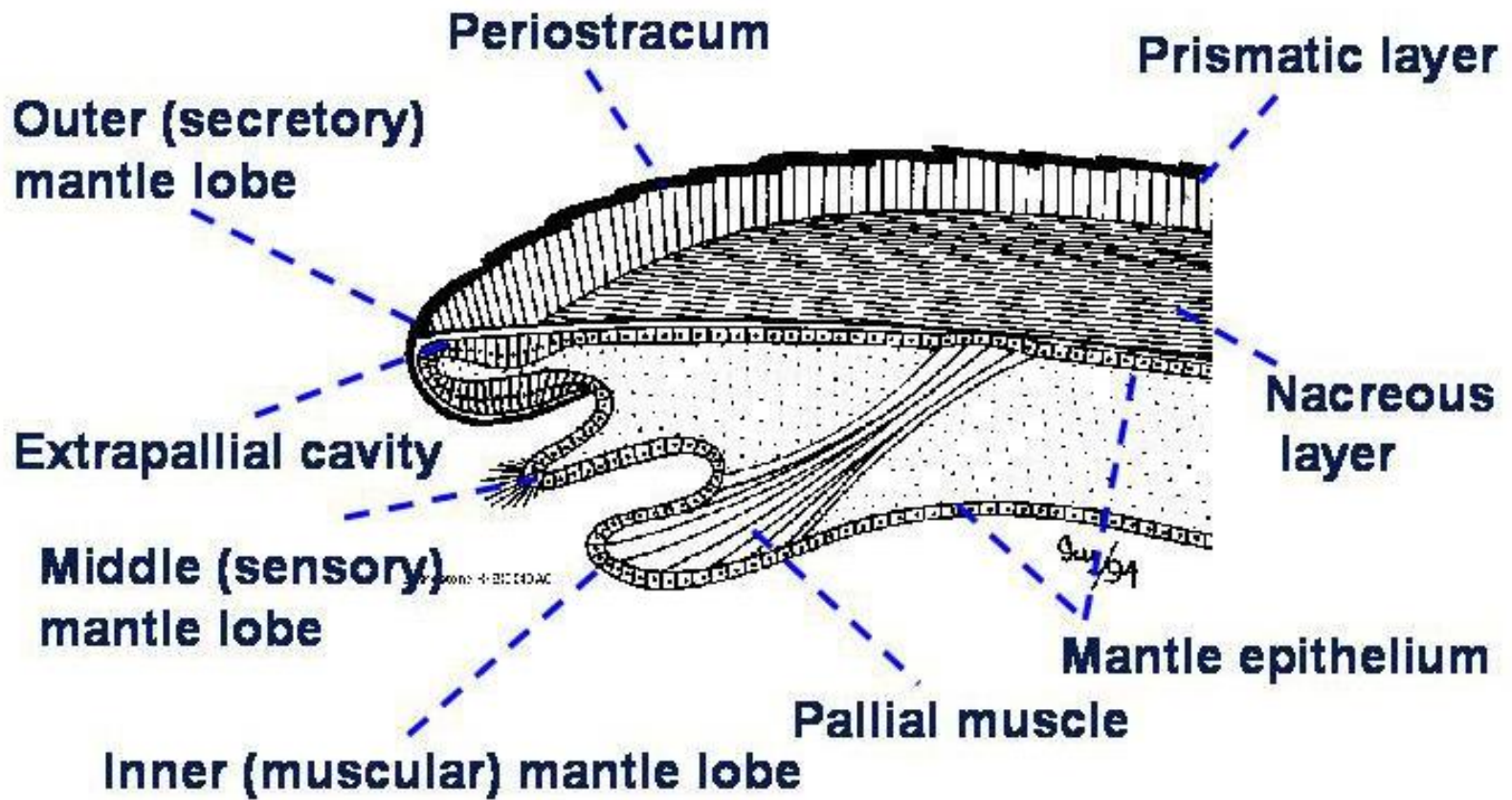
# Oyster internal anatomy



# Oyster Mantle



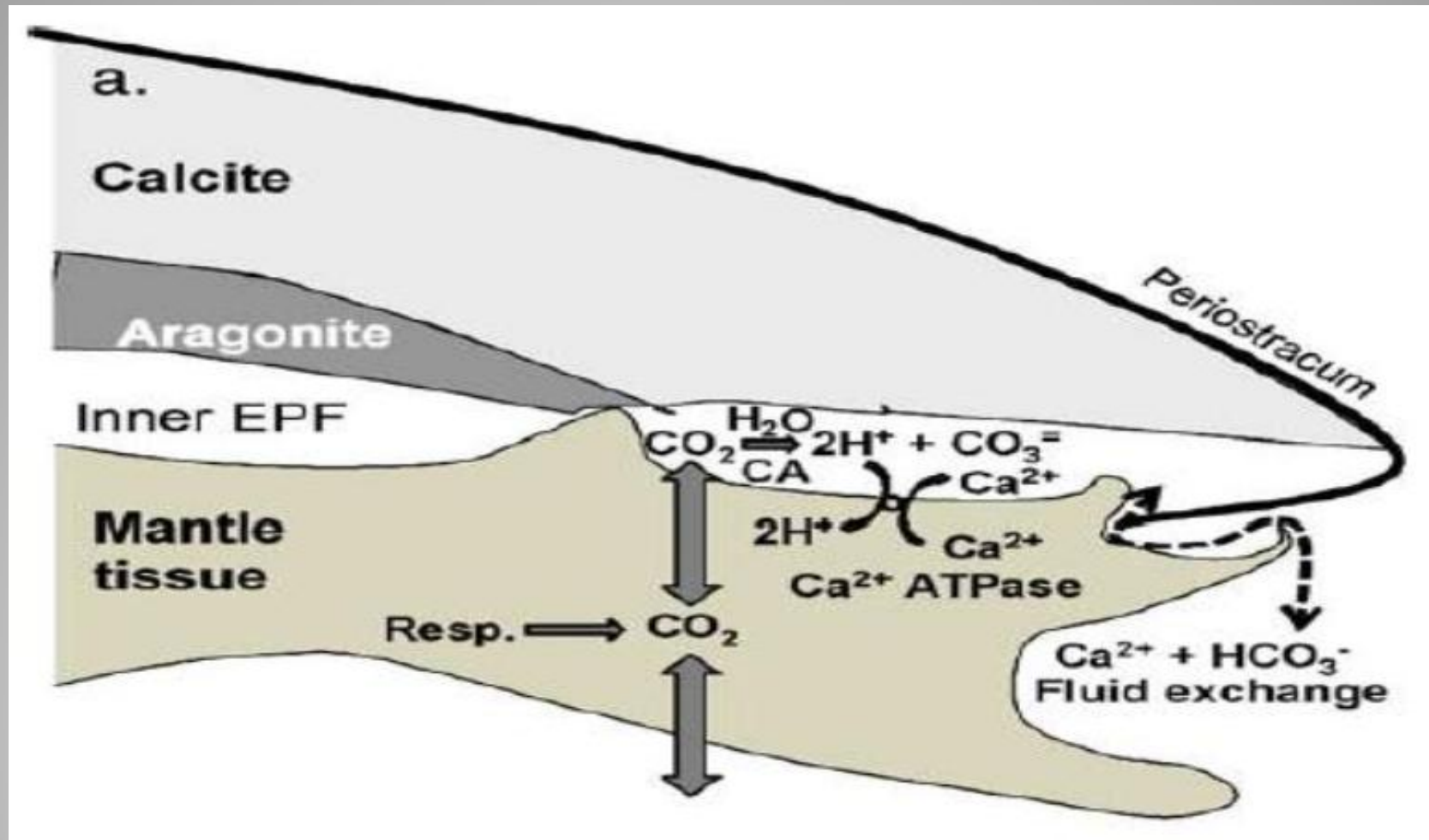
# Quahog mantle



# Mantle

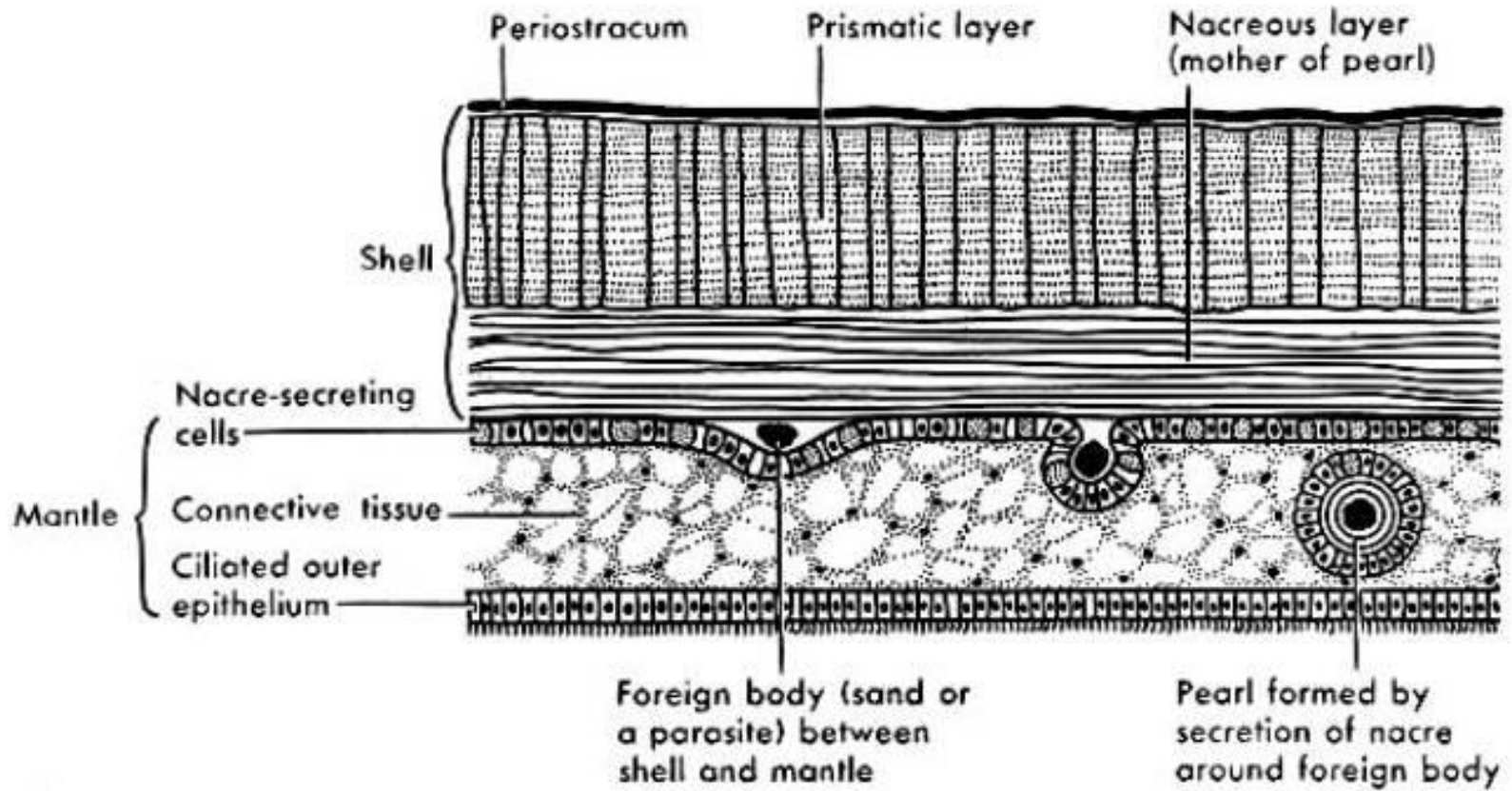


**Uses for the mantle**



# Shell growth - Mantle





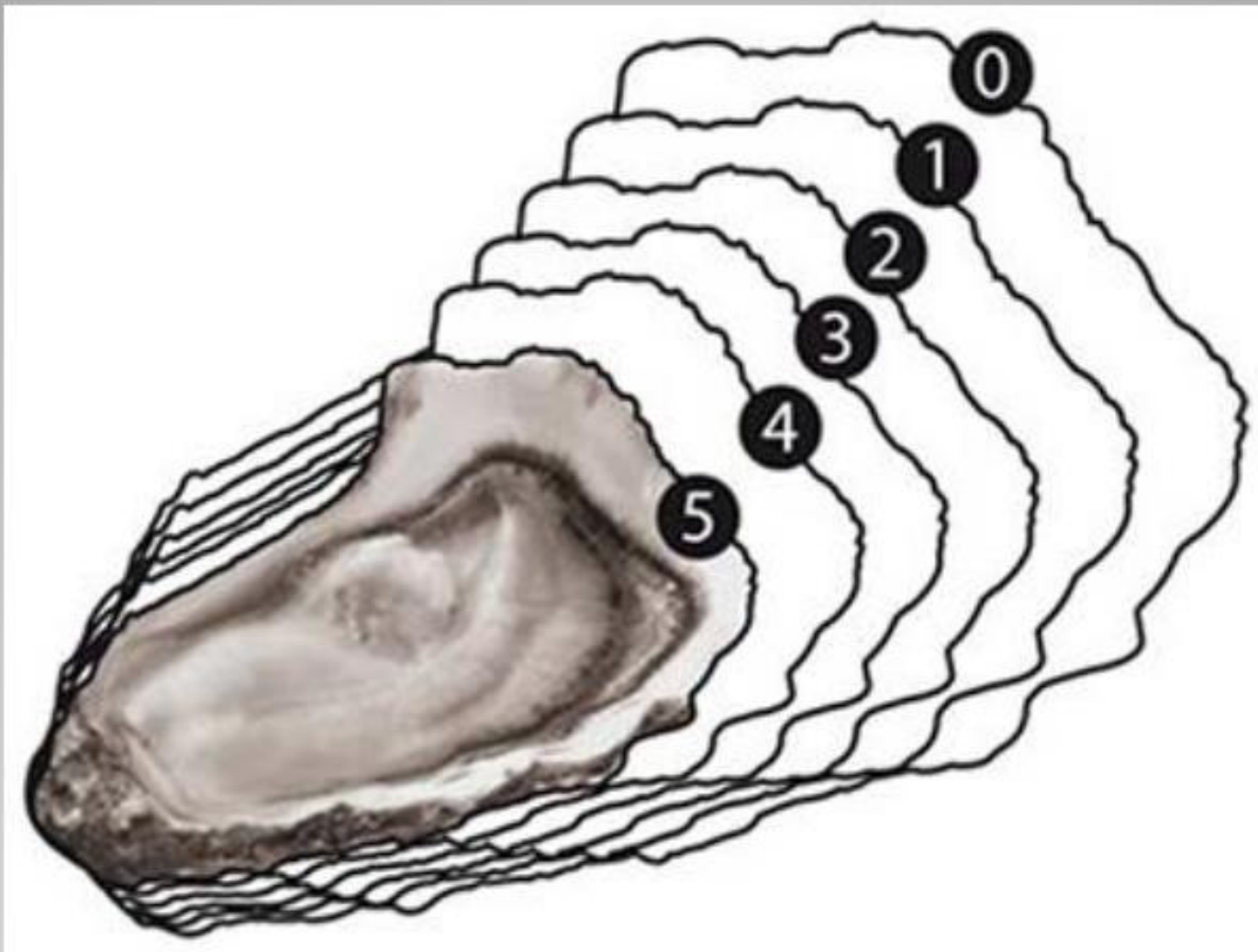
# Pearl formation



## Seeded Pearls (Freshwater clam)



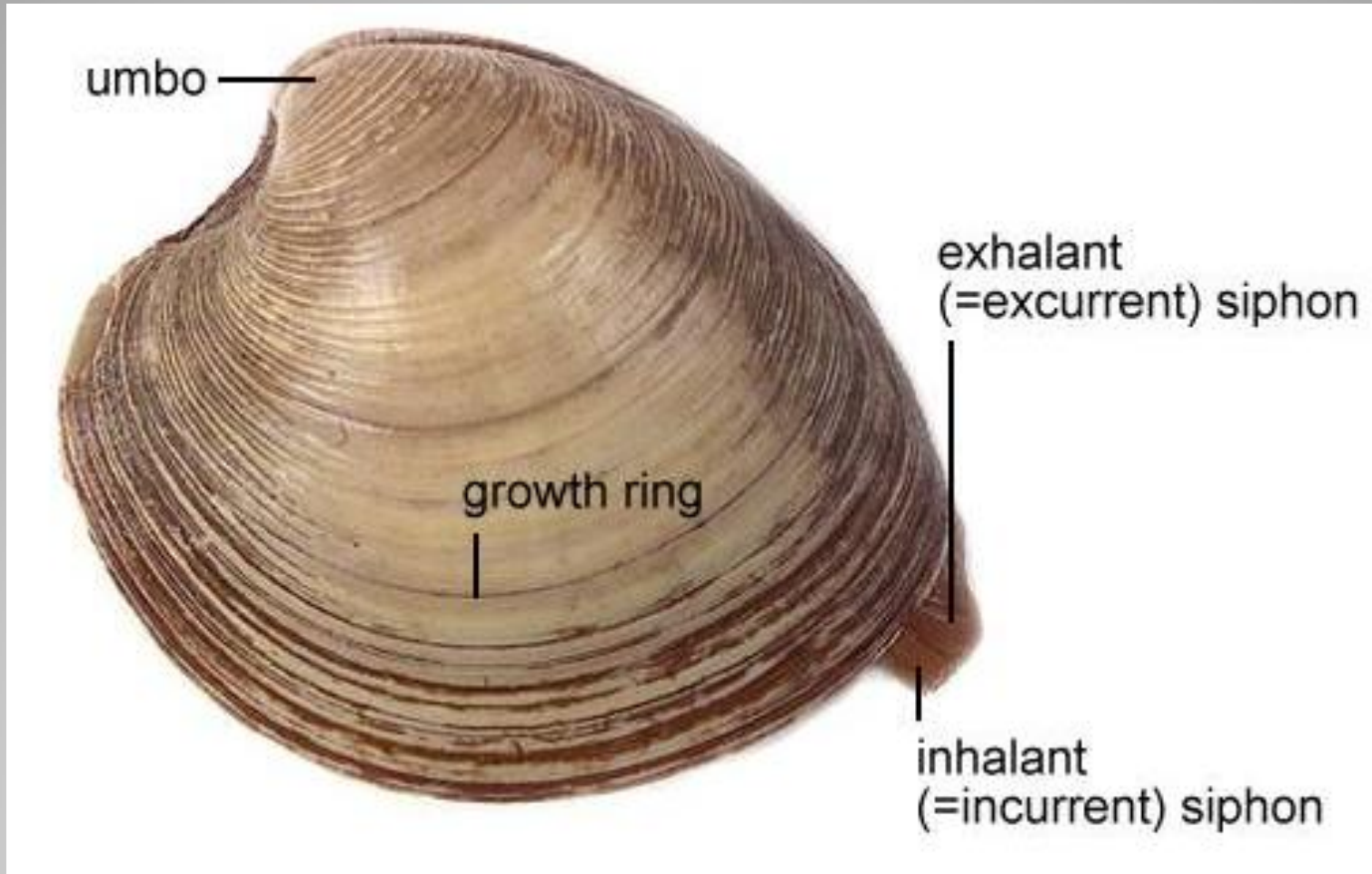
# Quahog Pearl



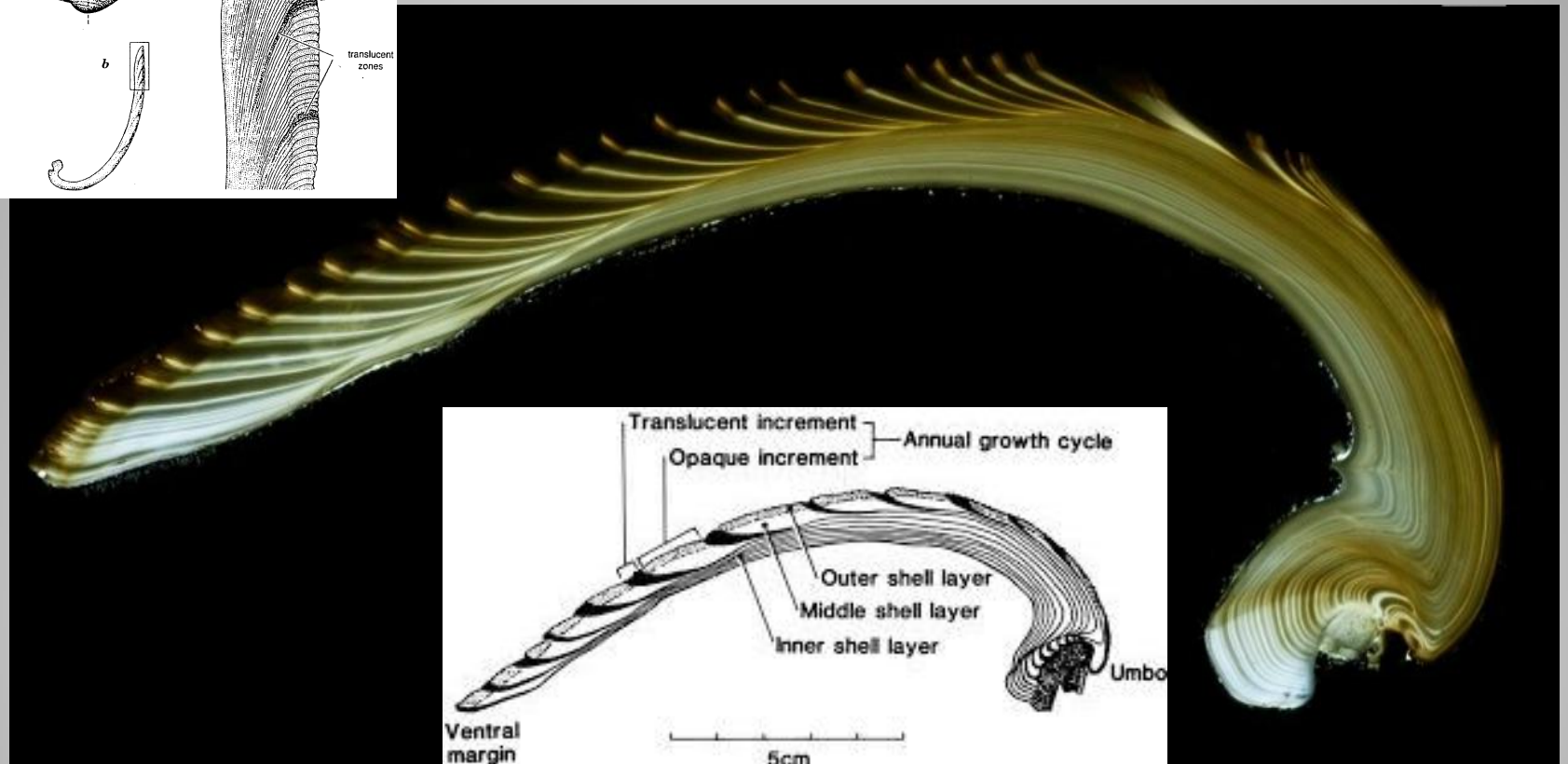
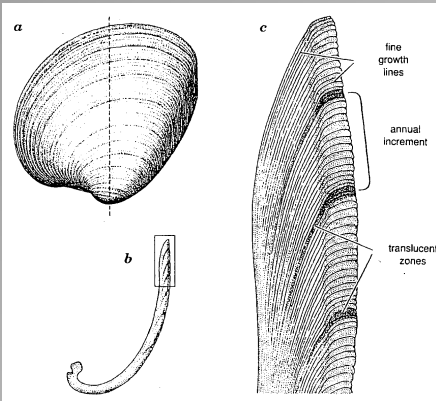
# Shell growth in the oyster



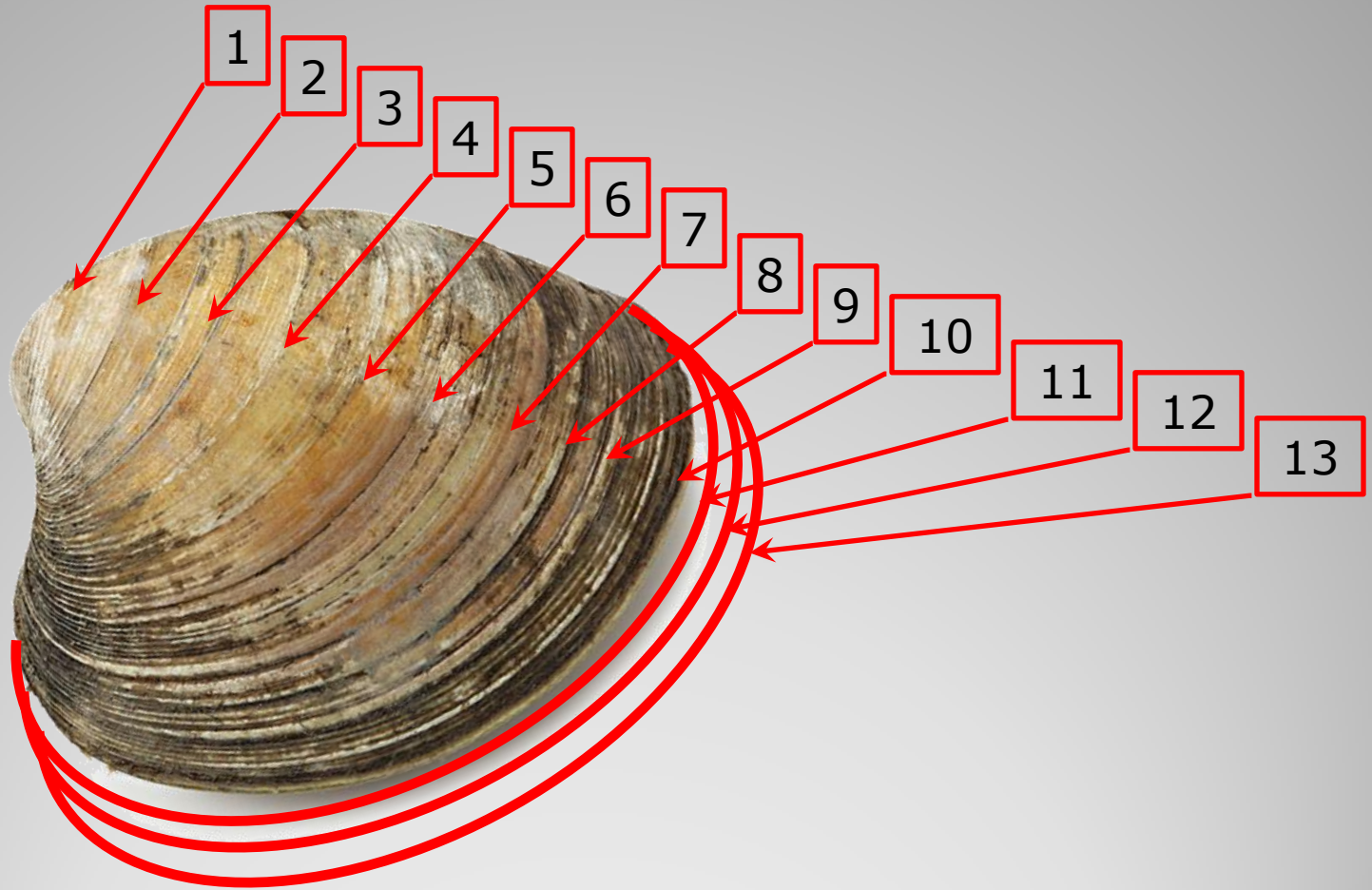
# Seed oyster growth



# Clam external features



# Quahog shell growth



# Shell Growth in a Quahog



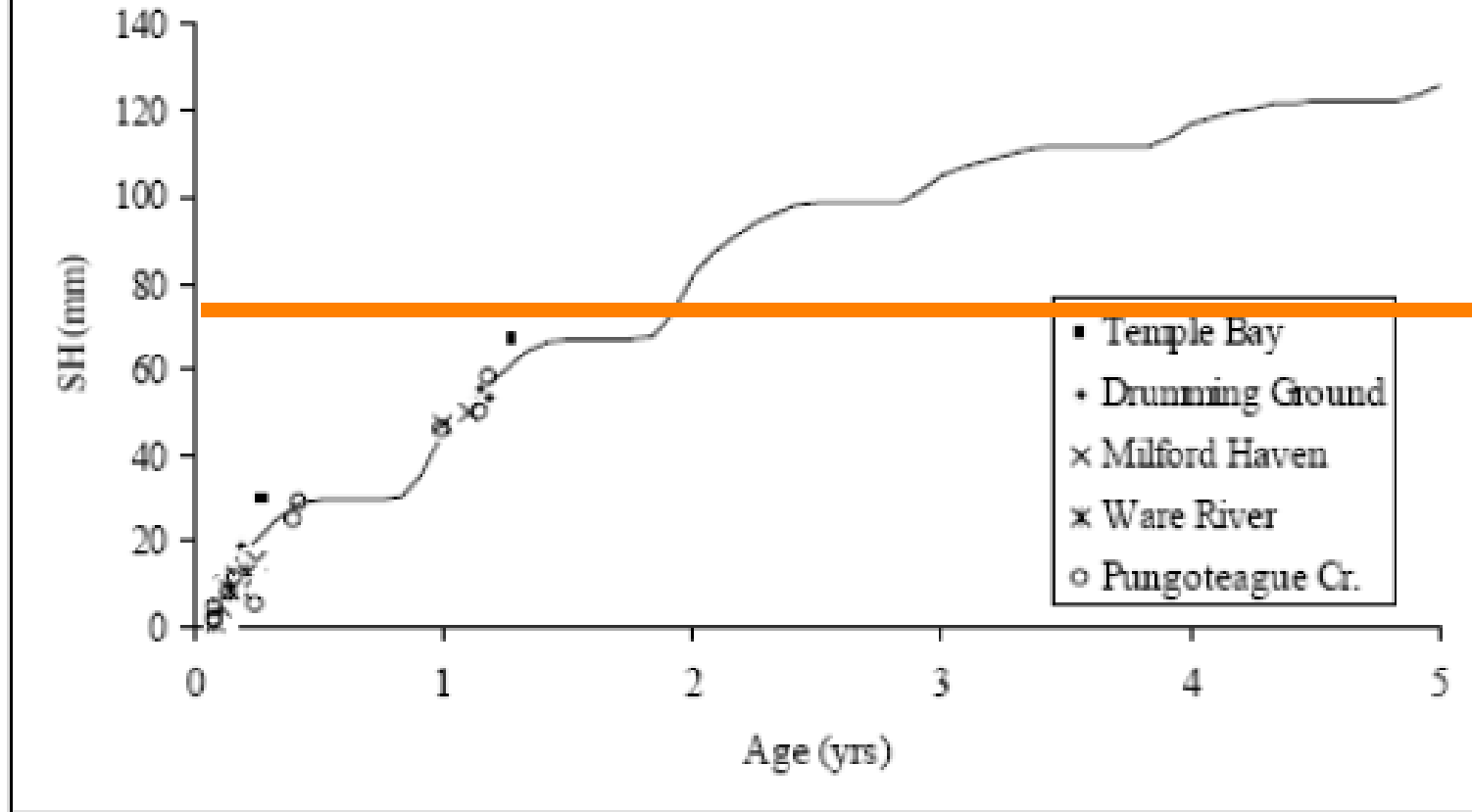
# World's oldest animal (507 yrs old)

**Genus:** *Arctica islandica*  
**Ref #:** 061294  
**Locality:** Iceland  
**Station:** B05 AD03  
**Dredge/Tow #:**  
**Ave. Latitude:** 66° 31,59N  
**Ave. Longitude:** 18° 11,74W  
**Water depth:** 83-81 m  
**Collector:** Scourse  
**Cruise:** Bjarni Saemundsson,  
Iceland B05  
**Collection Date:**  
**Method:** Arctica dredge  
**Live(Y) or dead(A/R/L):** YA  
**Length:** 86.9 mm  
**Height:** 72.5 mm  
**Max Height:** 82.1 mm  
**Width:** 48 mm  
**Weight of shell valve:** 52.08g  
**Periostracum:** 1  
**Ligament:** 4 **Shell margin:** 4  
**Bioerosion:** 4  
**Nacre:** 1  
**Sex:** Spent?  
**Flesh wet weight:** 40.28 g  
**Notes:**



“Ming”

## Shell Height at Age



**Oyster growth (shell length mm)**

**Littleneck  
Clam**



**Topneck  
Clam**



**Cherrystone**



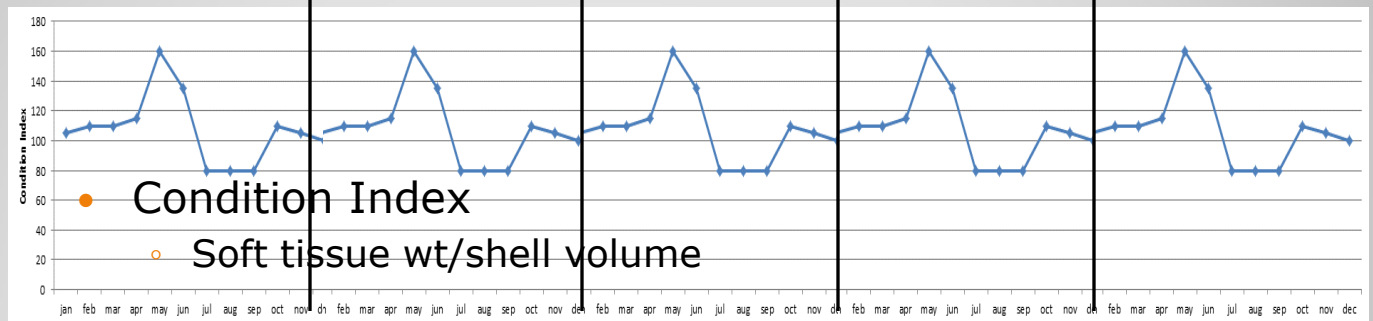
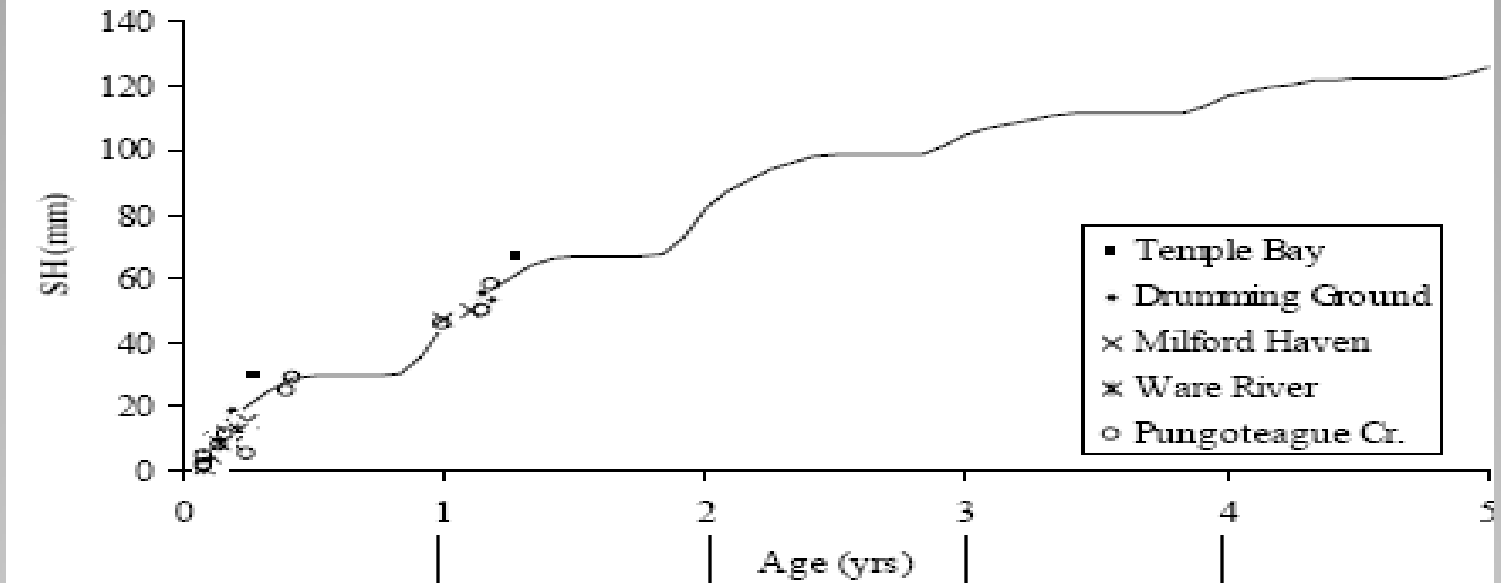
**Quahog**



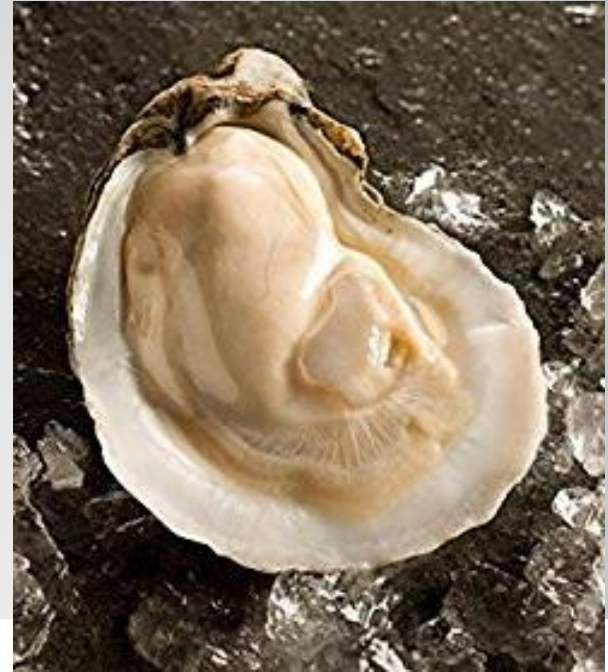
**Button  
or Bean**

**Size often dictates value**

## Shell Height at Age



# Shell vs. Soft Tissue growth



# Meat Quality

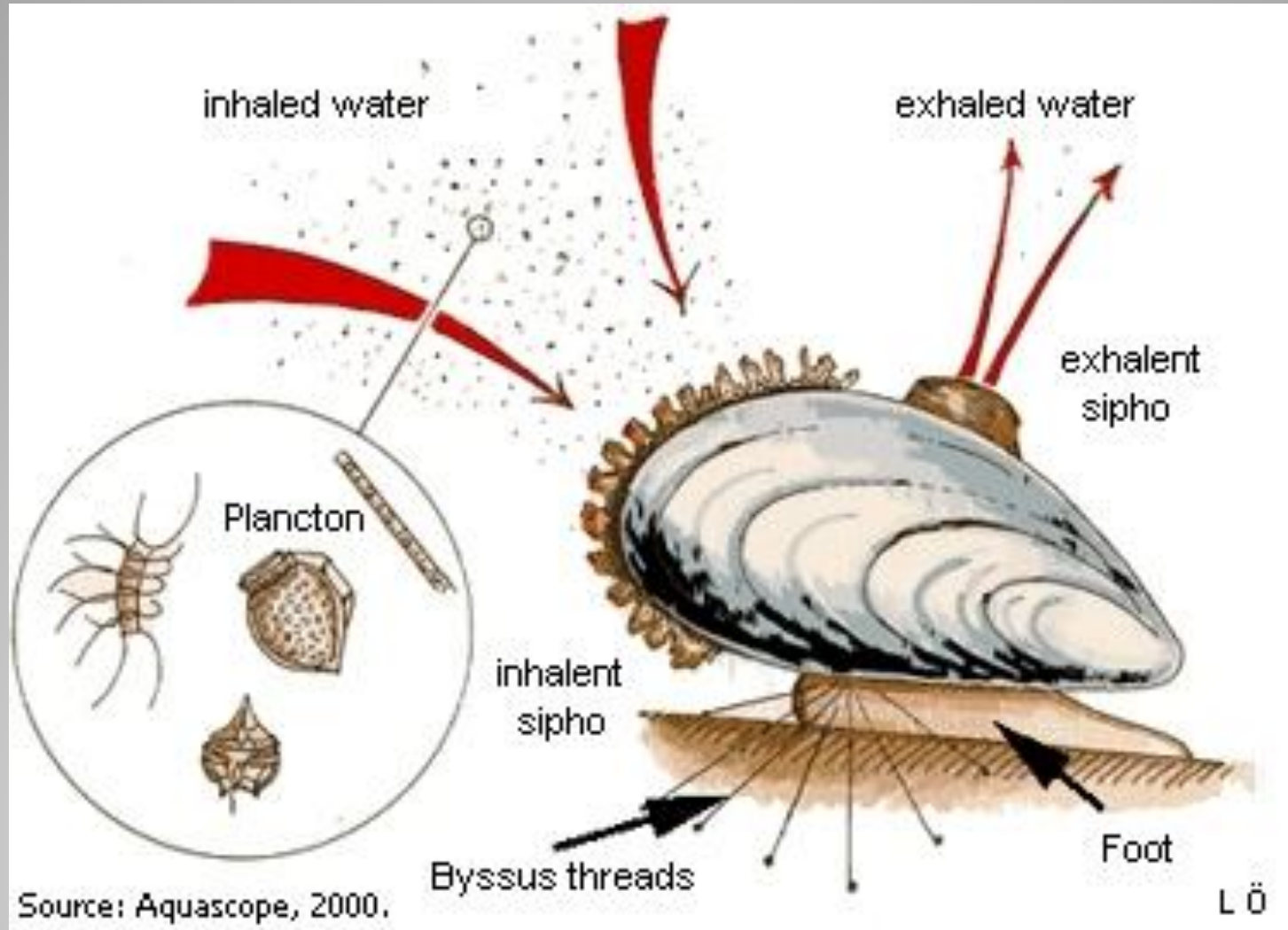


Oysters

• R •

in Season

SHELTER ISLAND OYSTER CO.



## Respiration & Feeding

# SHELLFISH

VACUUM  
CLEANERS  
OF THE  
SEA

by K.T. Pirquet



- Filter feeder
  - “Pumps” a large volume of water to feed
  - Has been reported to be up to 50 gallons per day!
  - Removes very small particles (2-3  $\mu\text{m}$ )

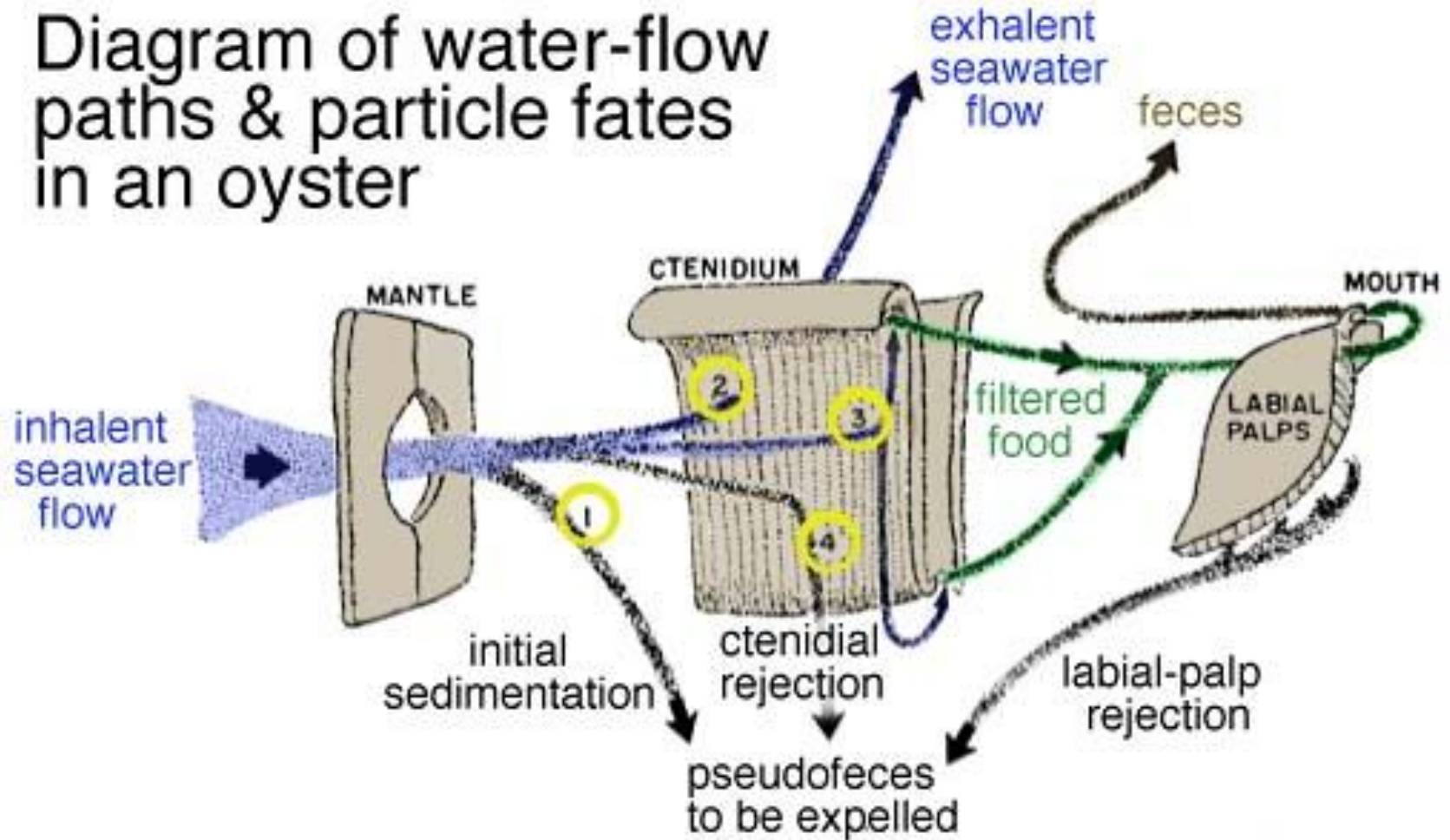


Time Lapse ~ 4 hours

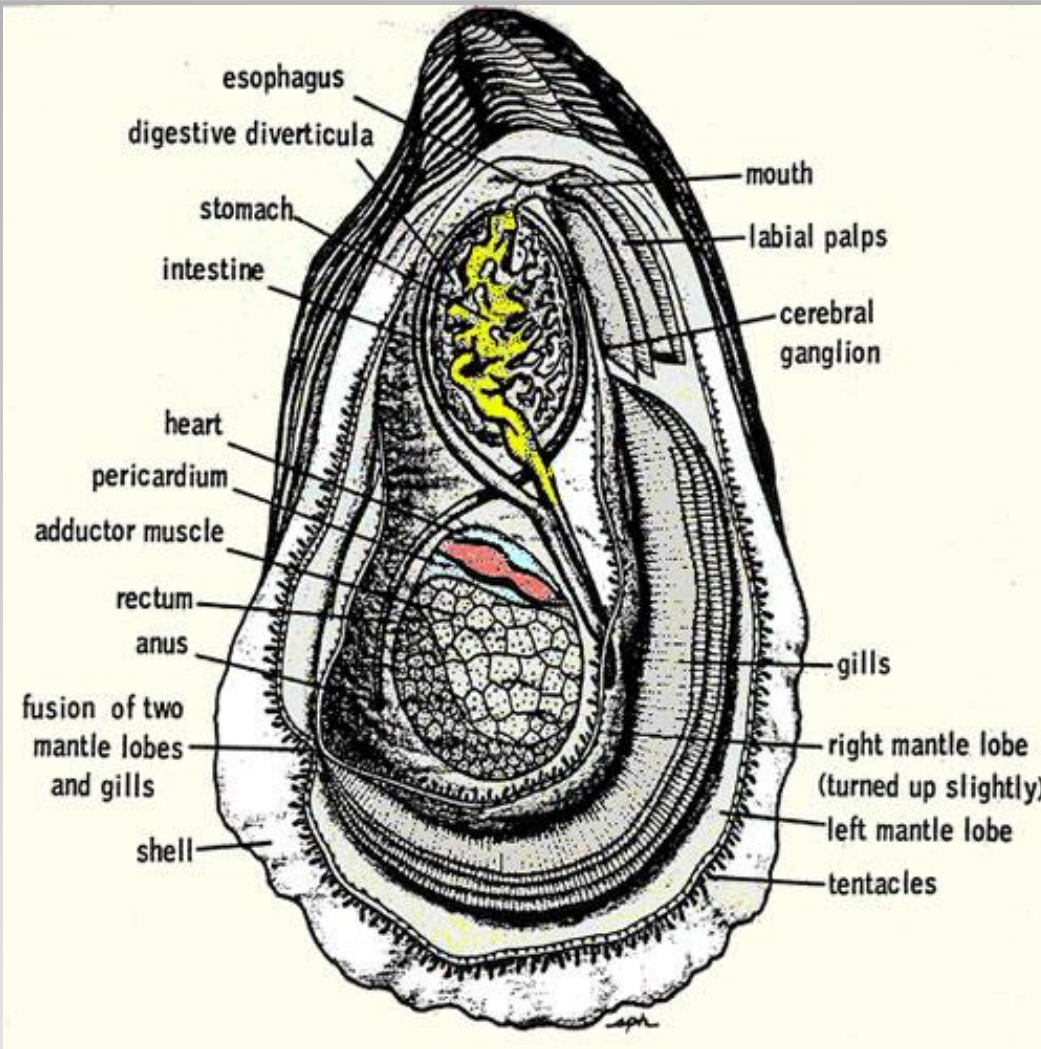
## Respiration & Feeding



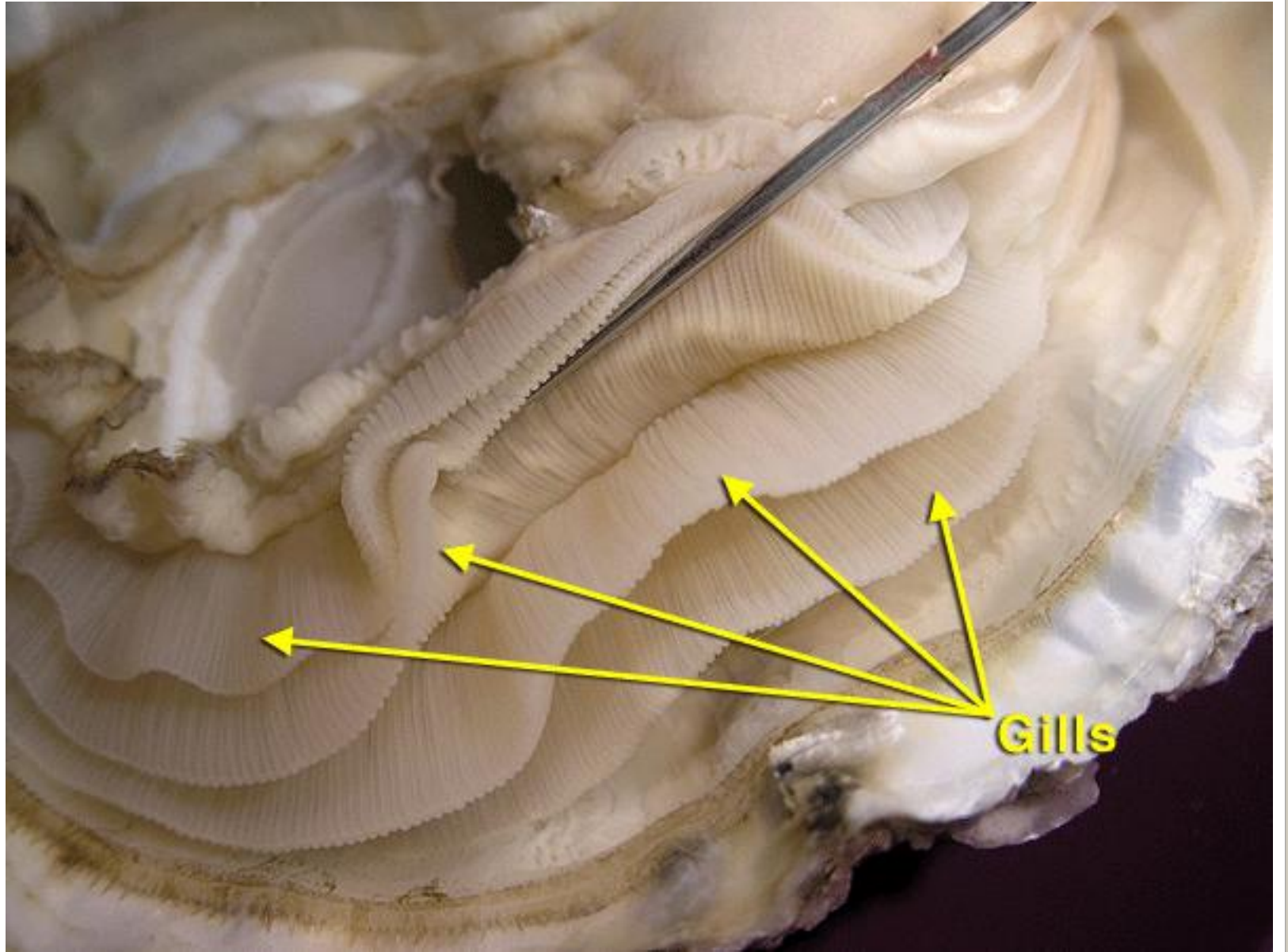
# Diagram of water-flow paths & particle fates in an oyster

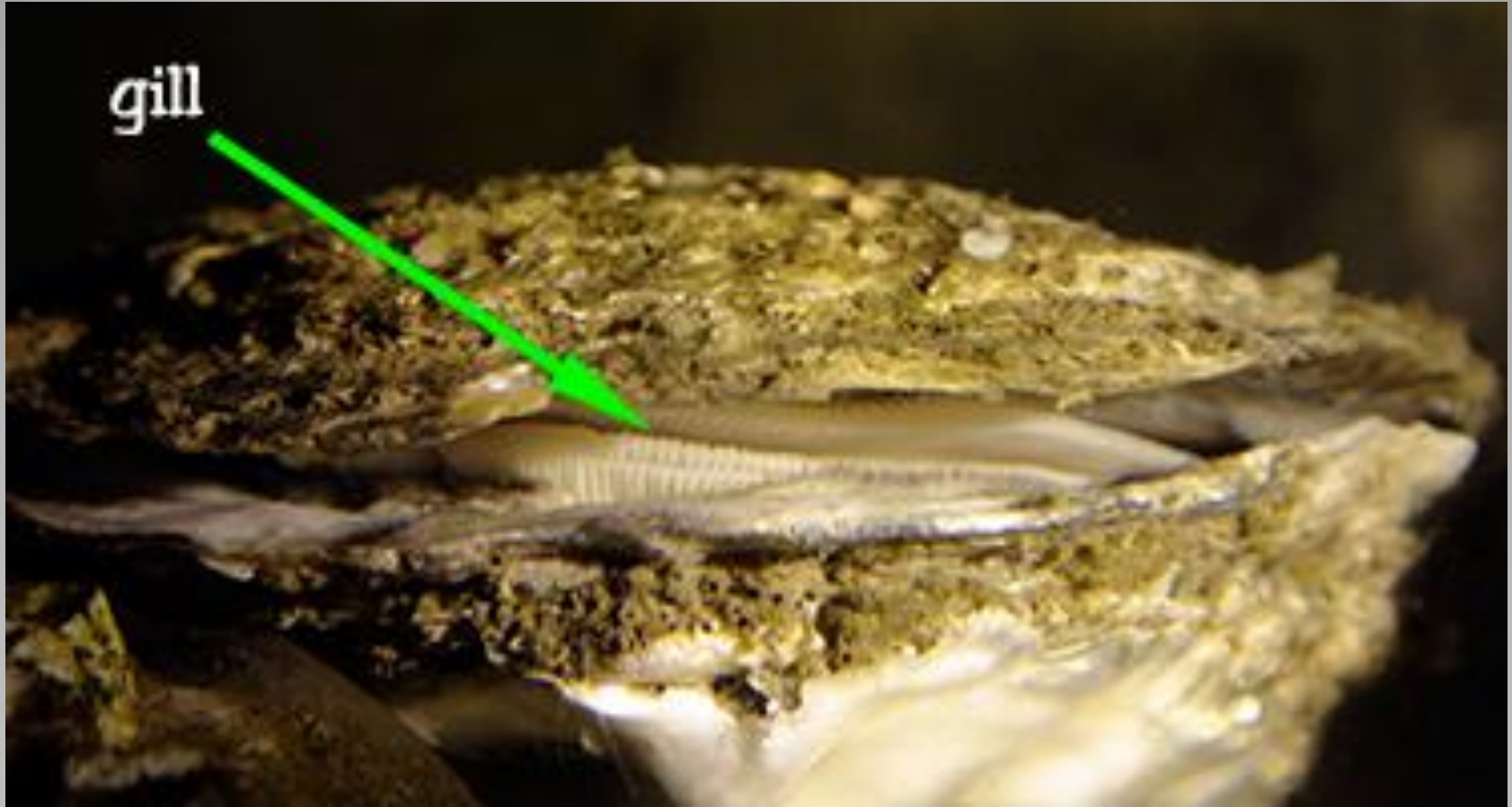


## Feeding

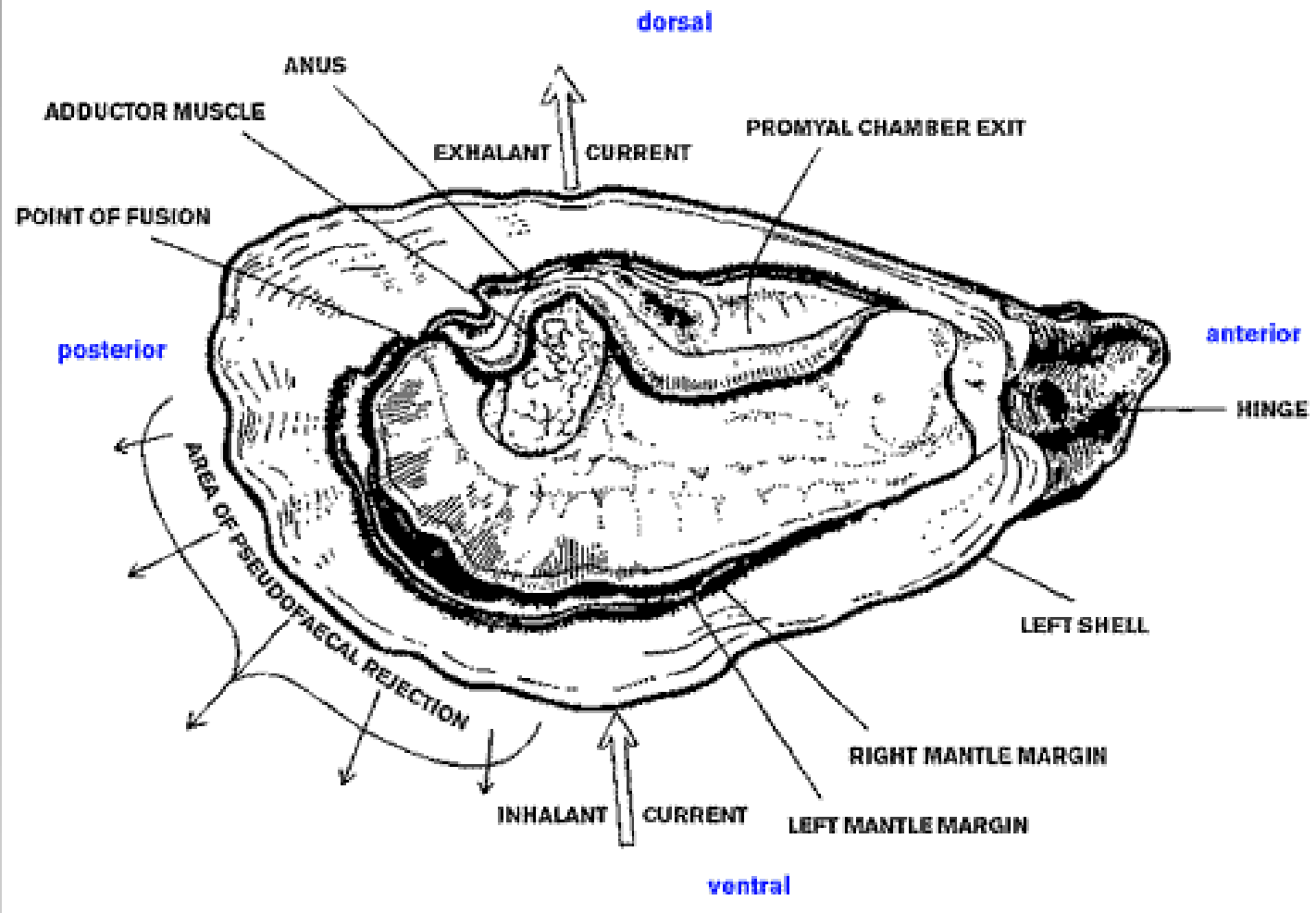


# Oyster internal anatomy





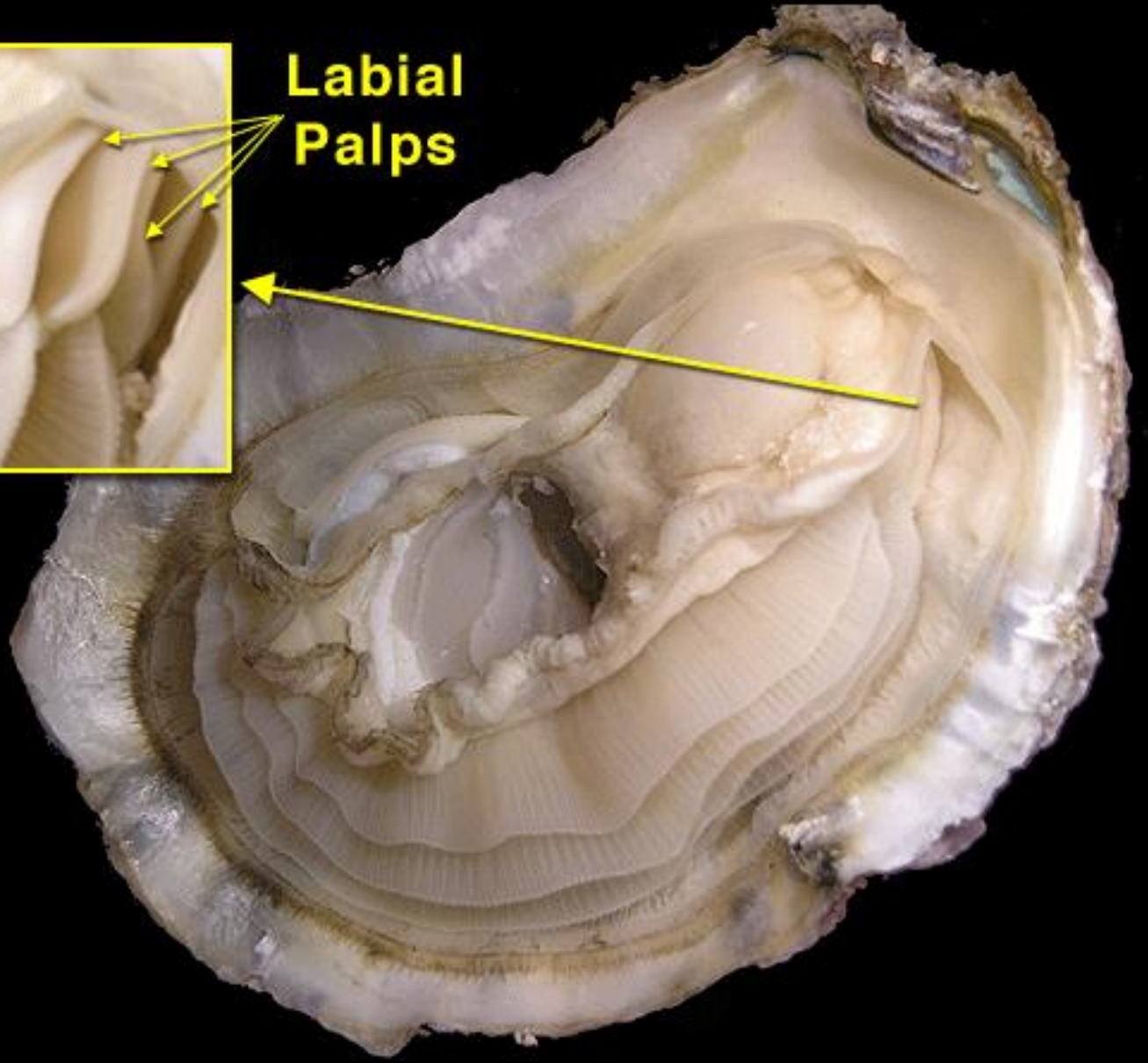
# Oyster feeding

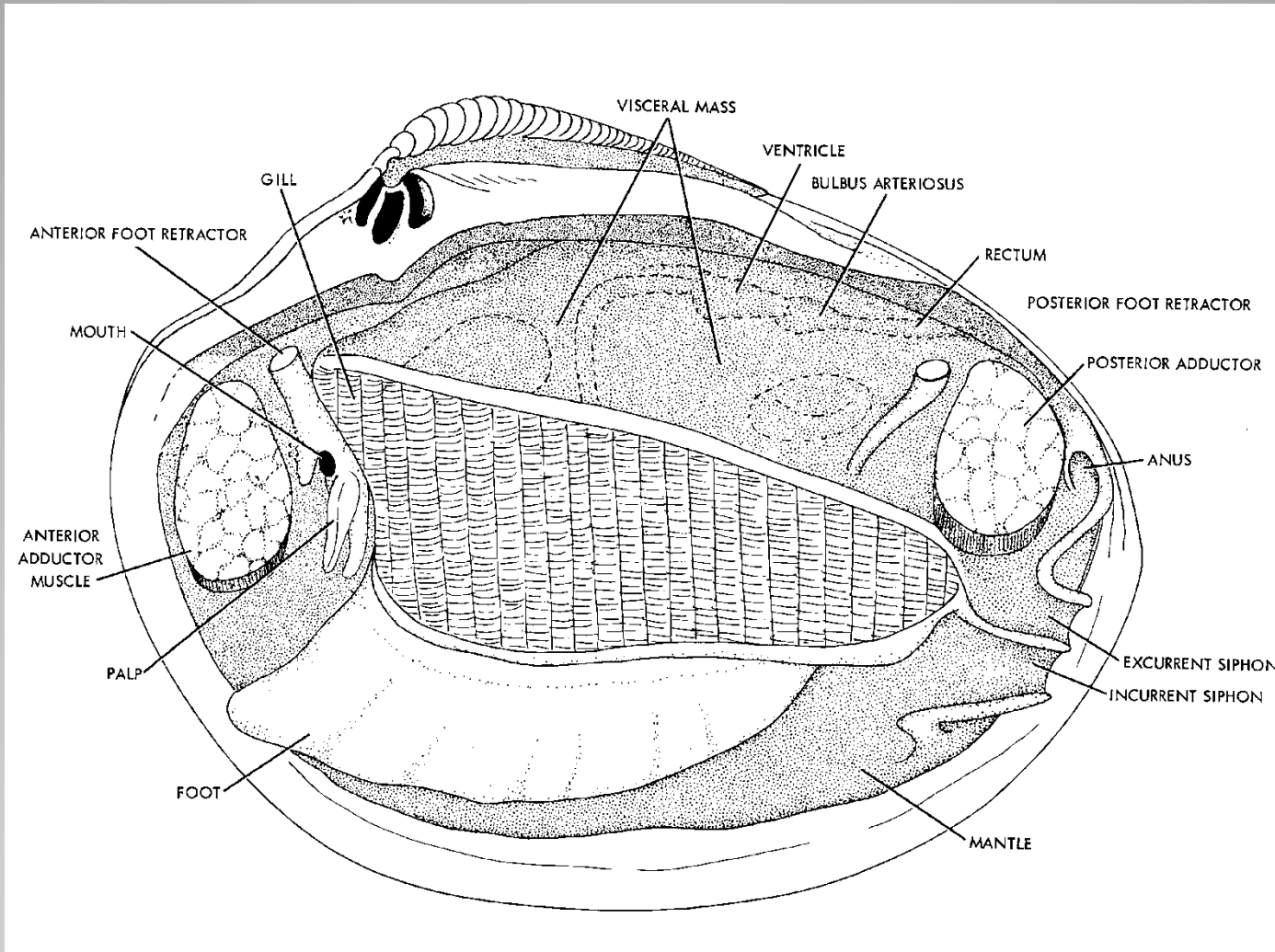


# Oyster feeding/respiratory current

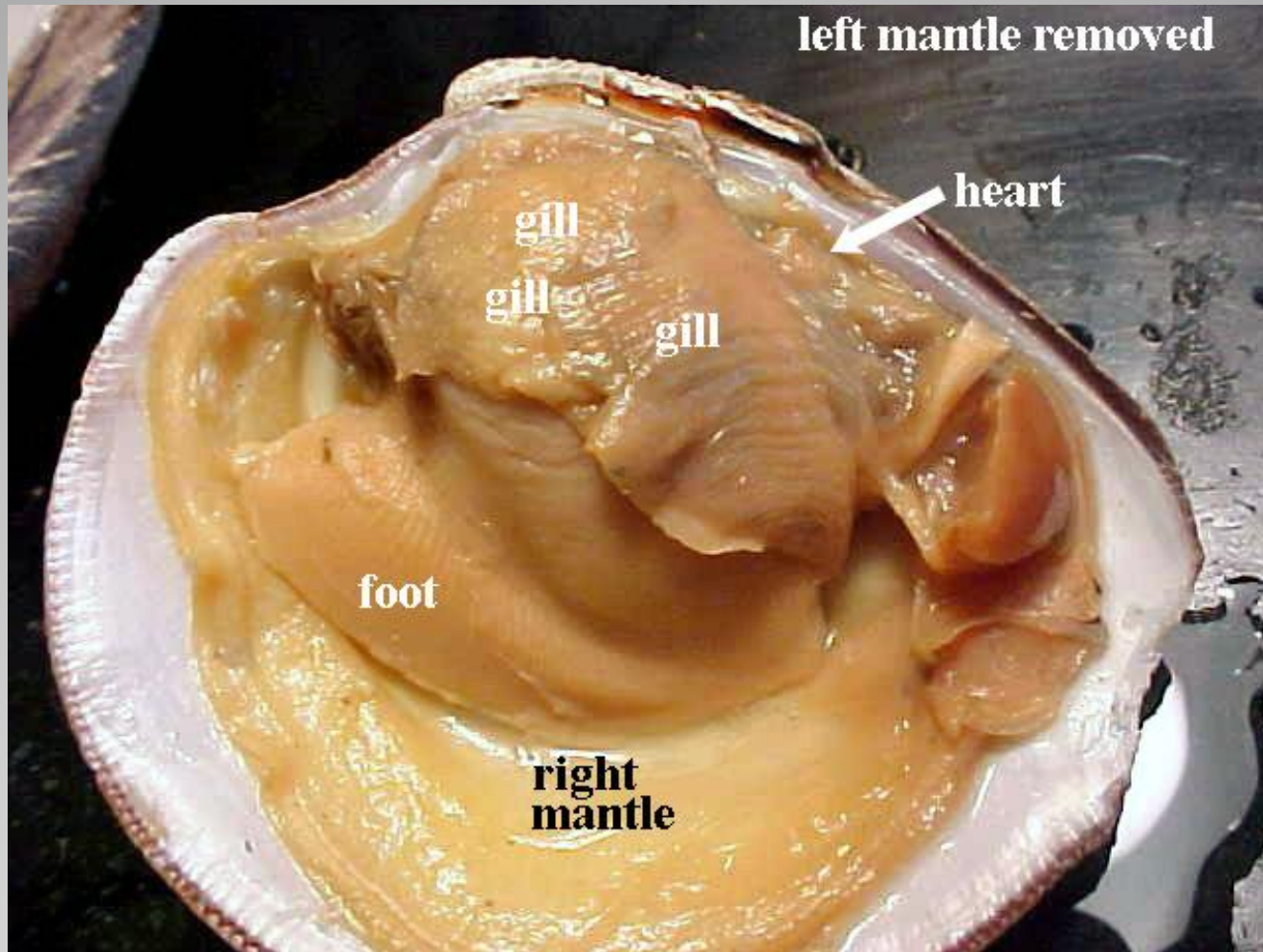


**Labial  
Palps**





# Gills - Respiration & Feeding



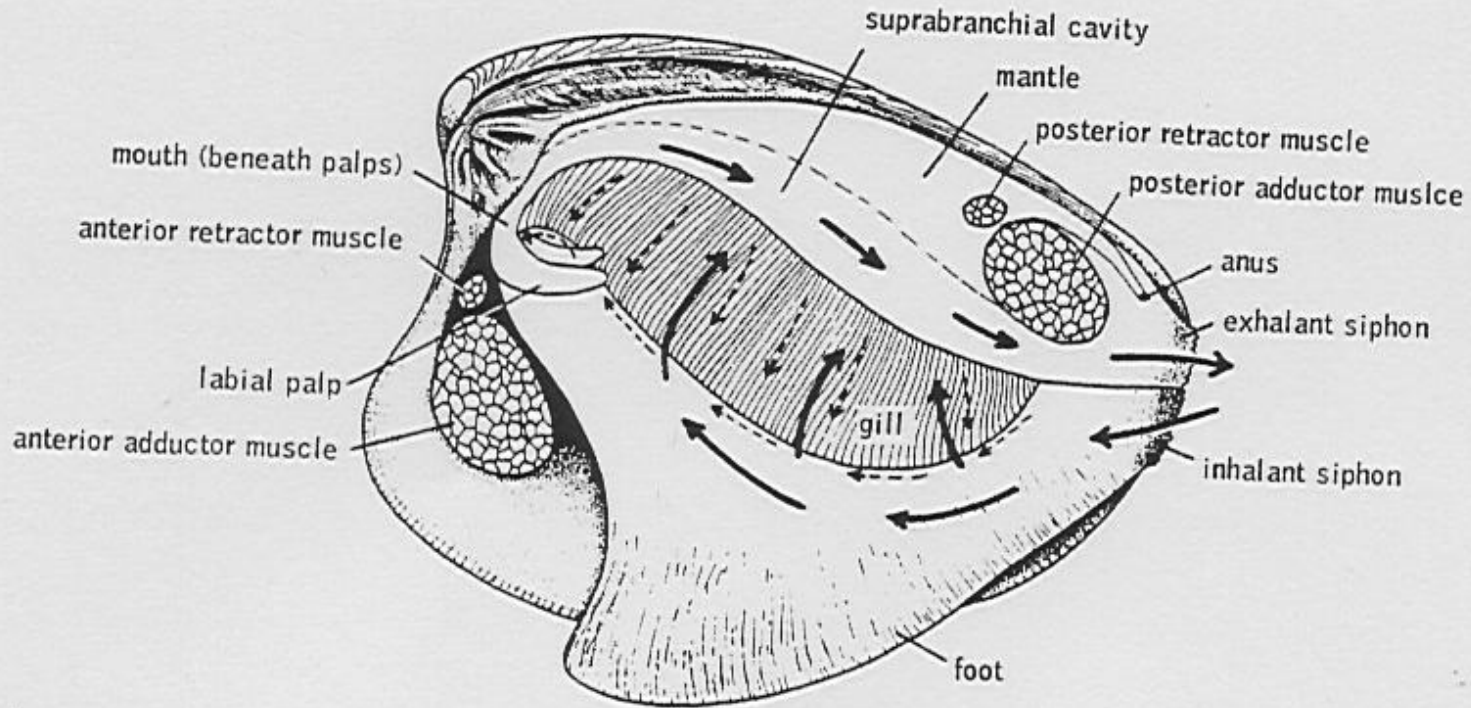
# Quahog Gills





## Soft Shell Clam Gills

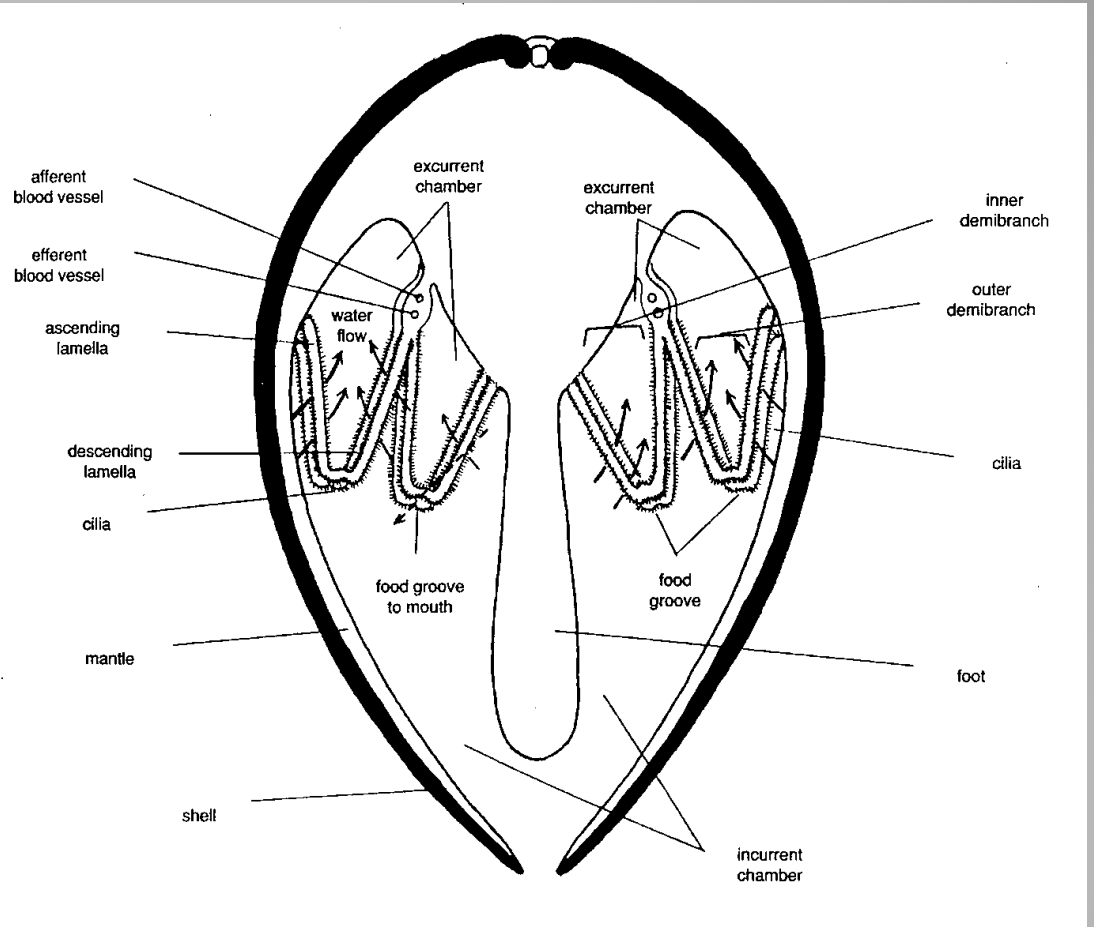
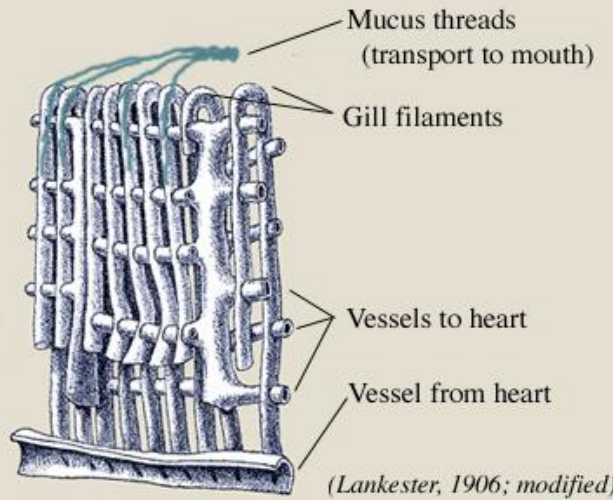
## THE MOLLUSKS



# Respiration & Feeding

## A Food Filter for the Venus Clam

(showing a fold in the gill structure)



# Respiration & Feeding



# Mussel Filter Feeding

ROGER WILLIAMS  
UNIVERSITY

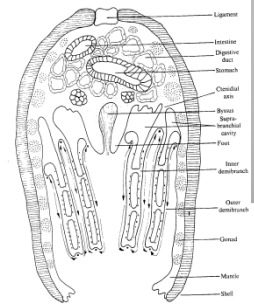
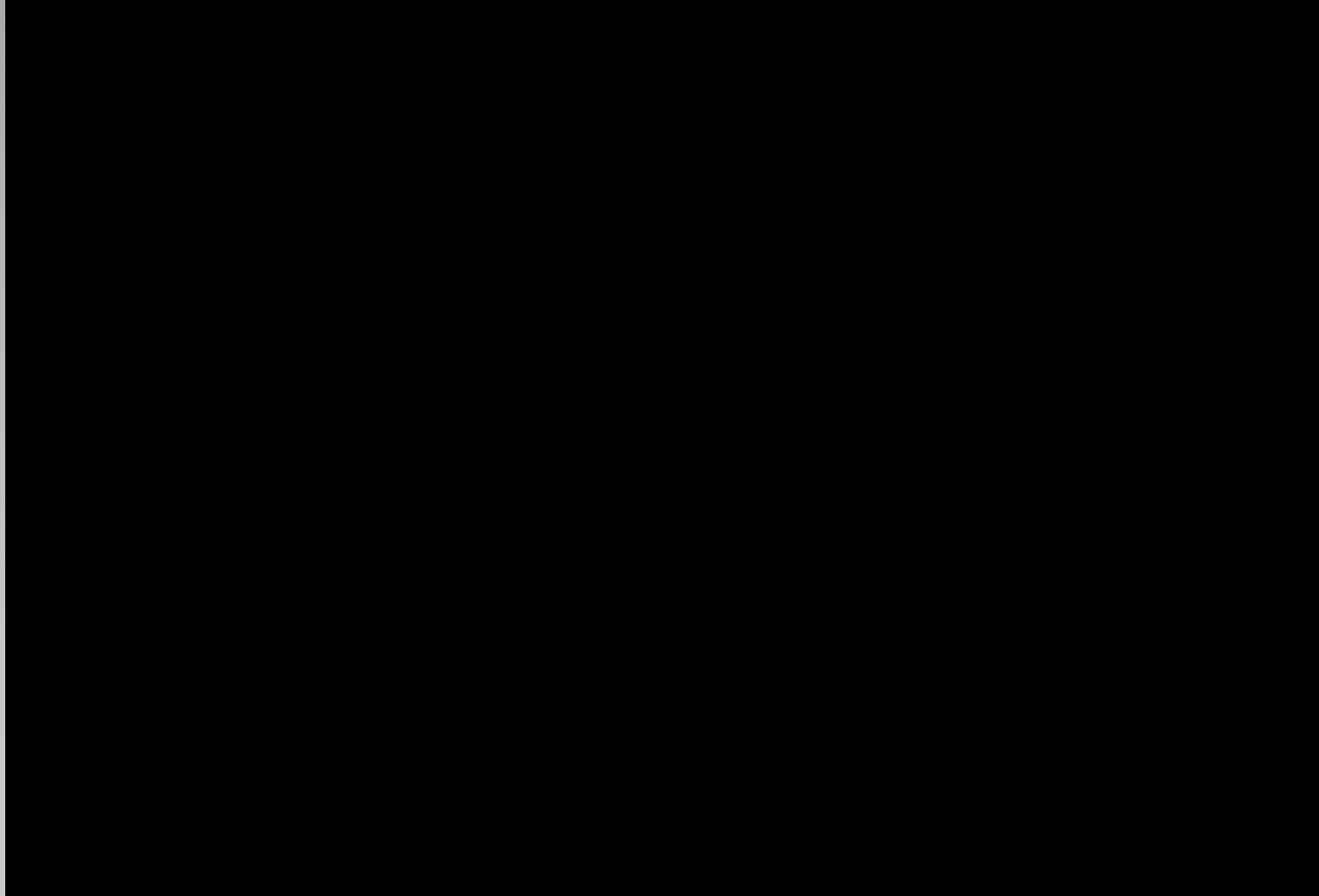
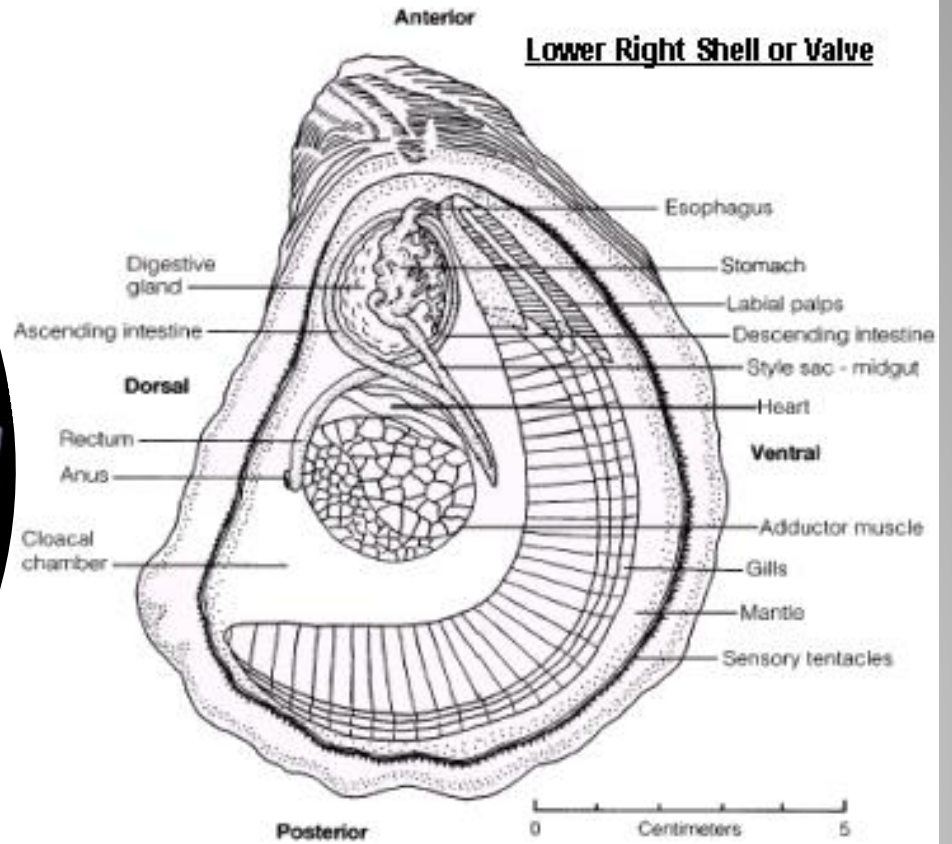


Fig. 1.1. Diagrammatic transverse section through *Mytilus edulis* to show the form of the gills and the direction of the mass silty currents, represented as arrows.



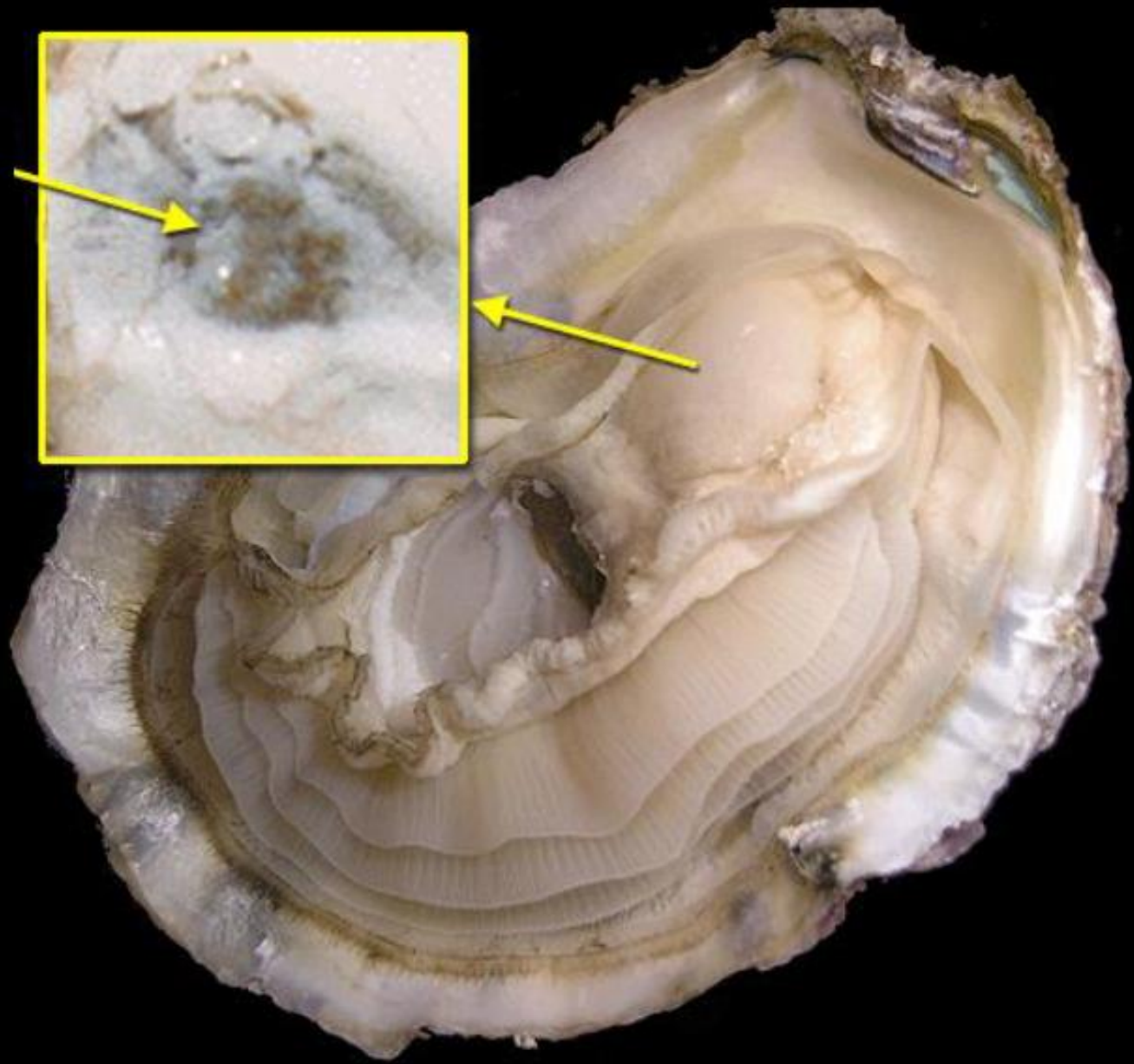
# Oyster feeding



Source : Maryland Sea Grant

# Oyster internal anatomy

**Stomach**



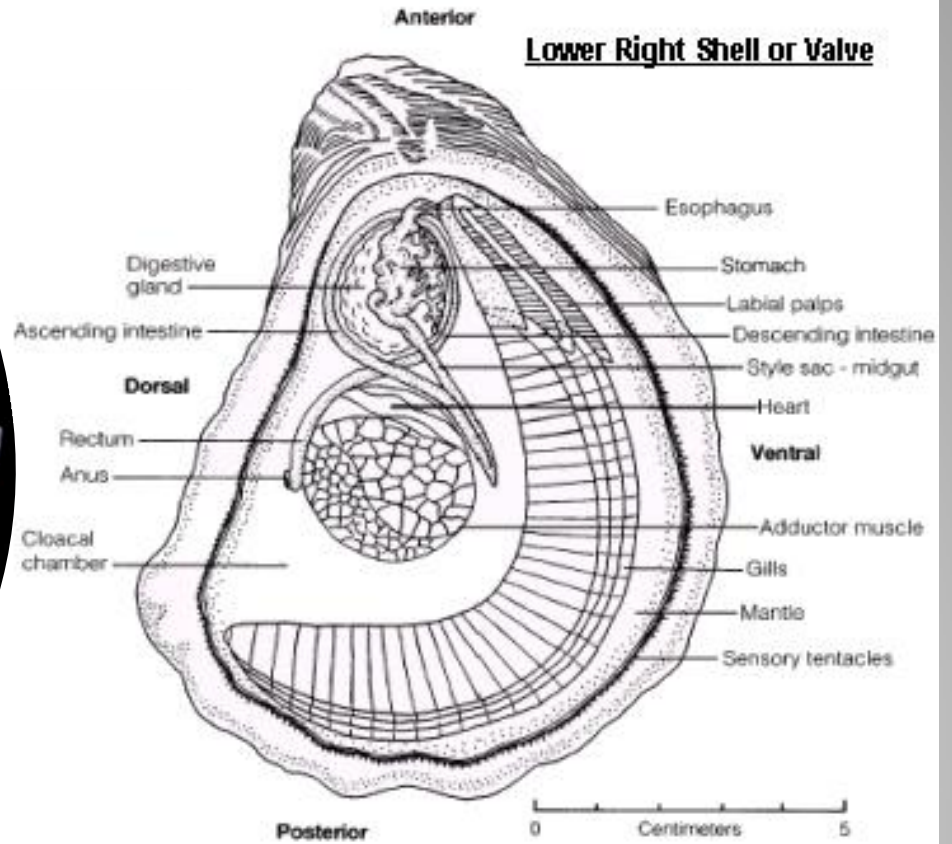


**Full stomachs**



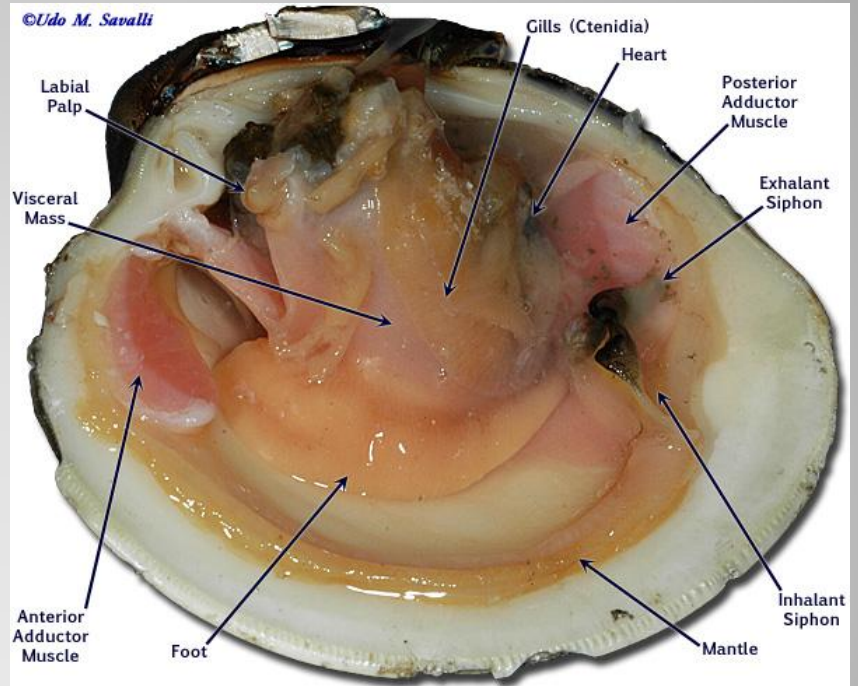
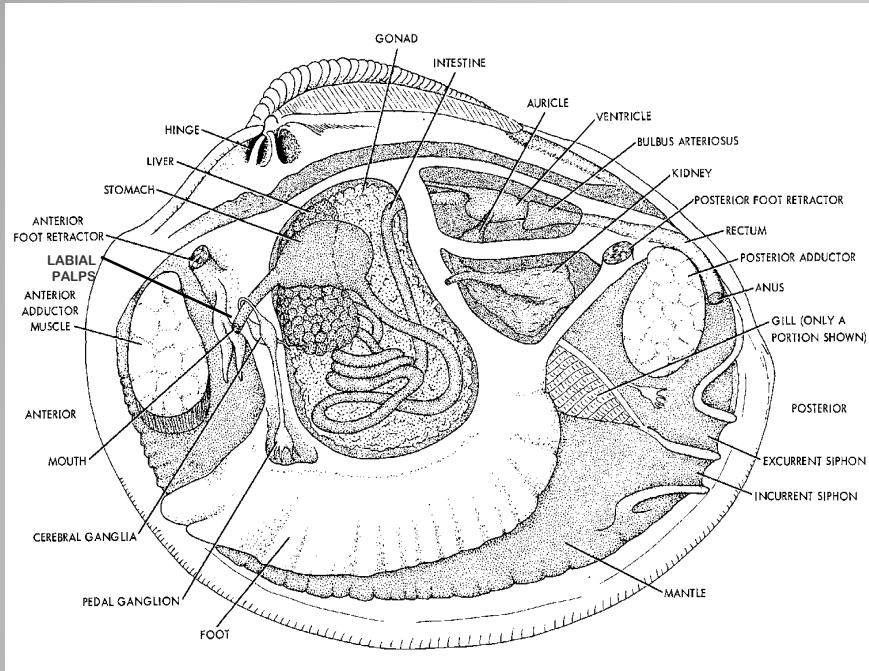


# Technicolor bivalves

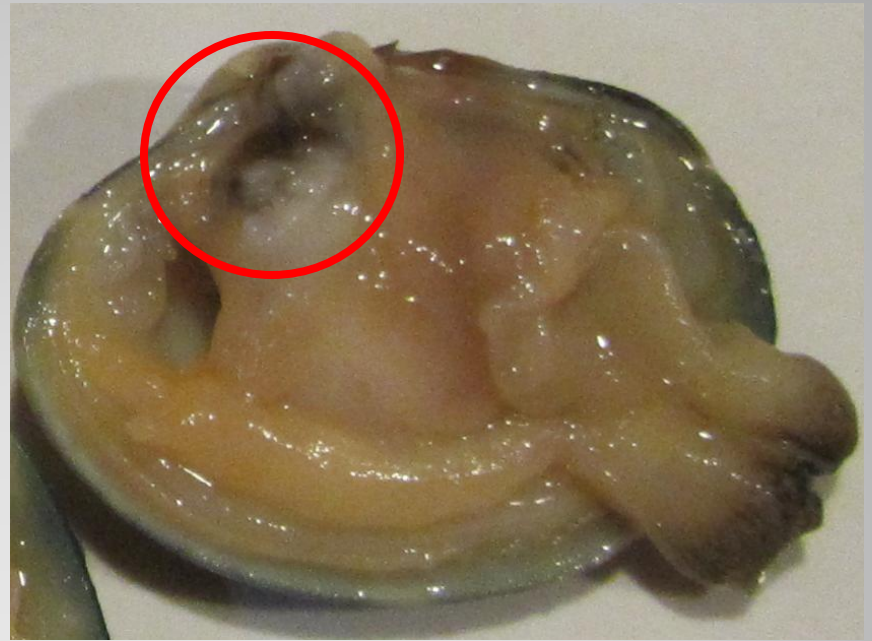
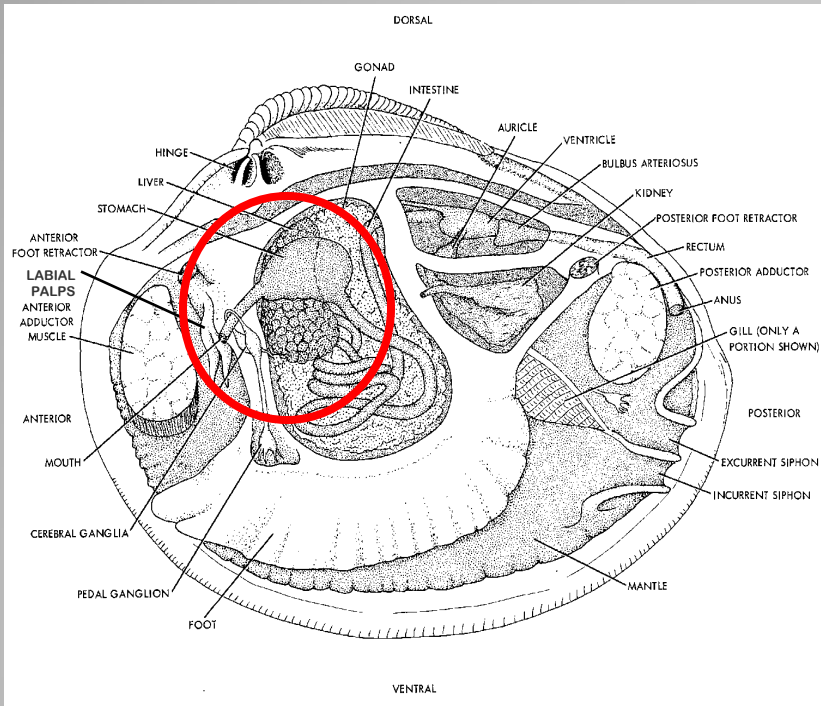


Source : Maryland Sea Grant

# Oyster internal anatomy



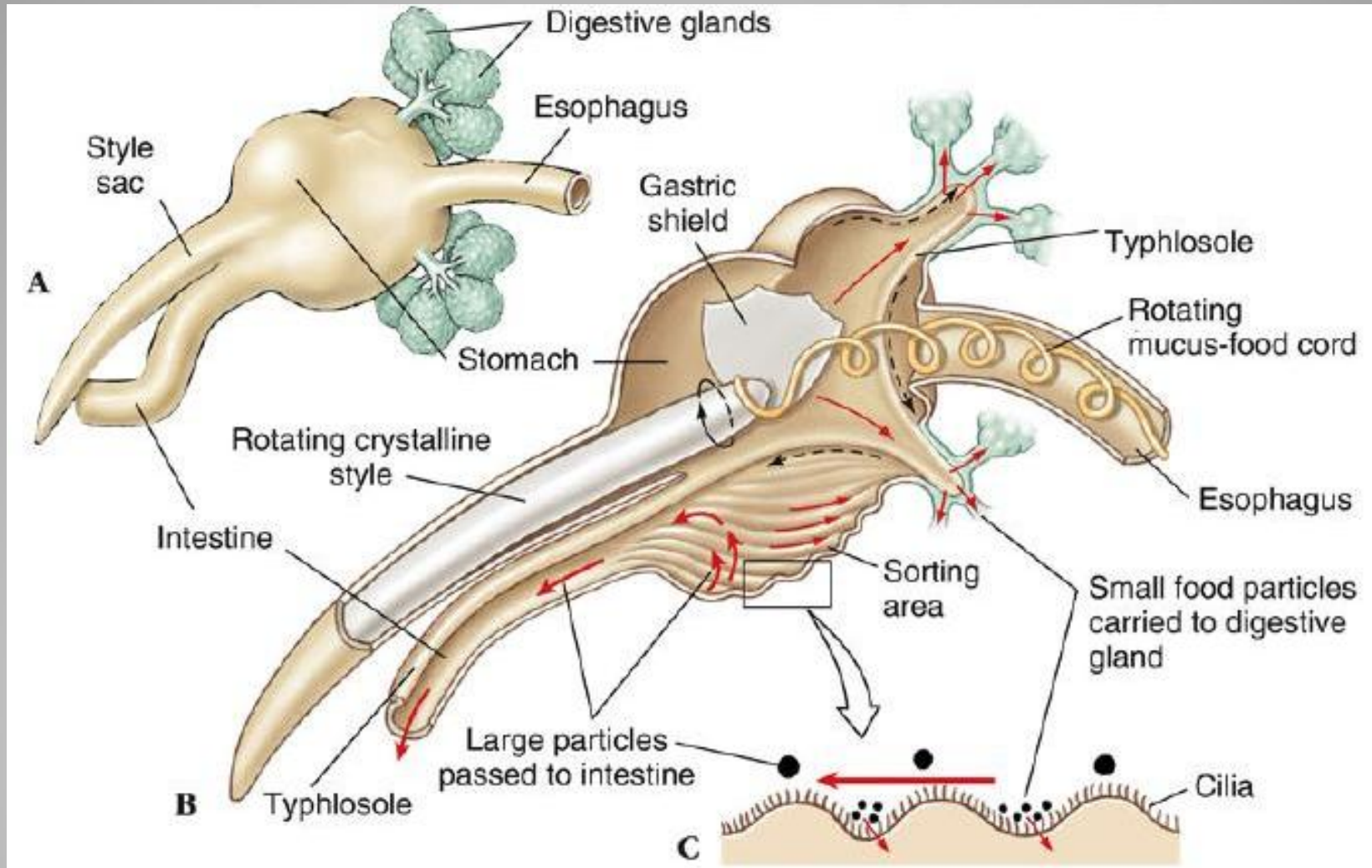
# Clam Internal Anatomy



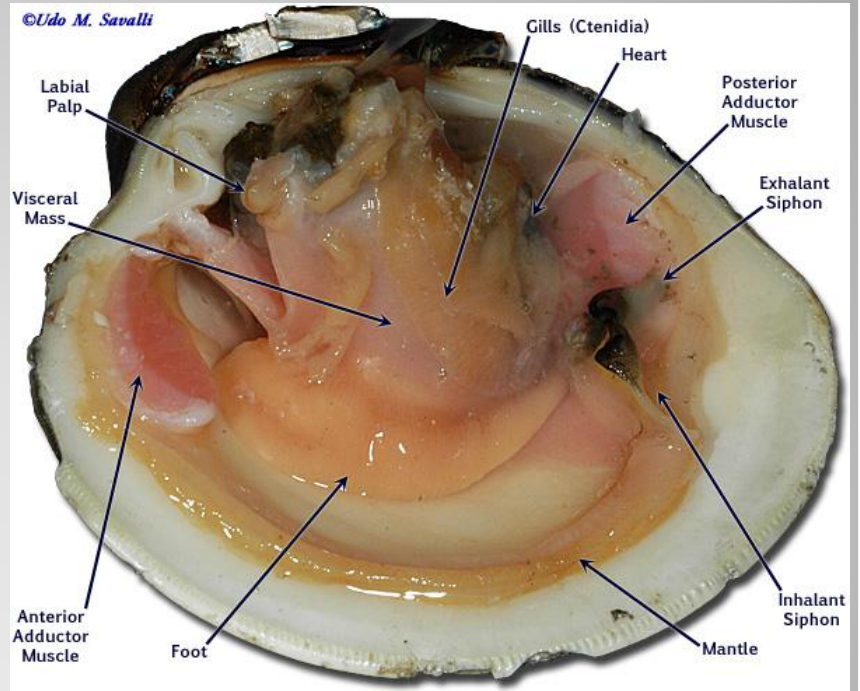
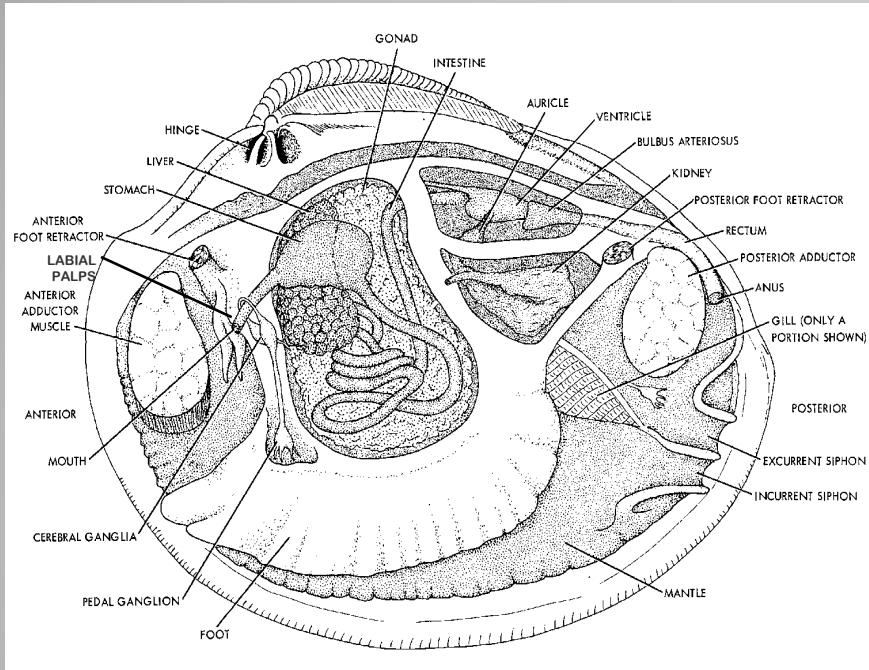
# Clam Stomach



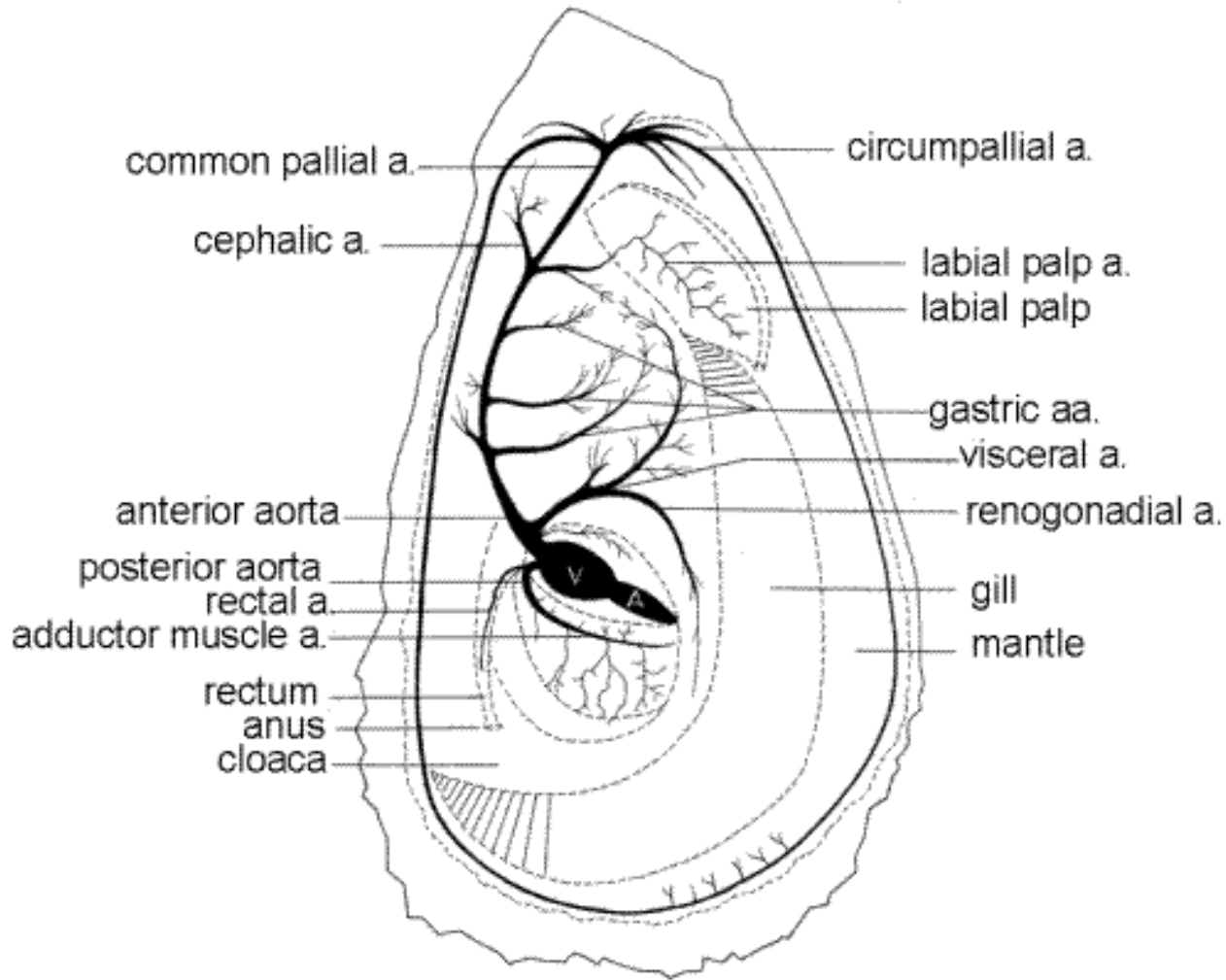
# Crystalline Style



# Digestion



# Clam Internal Anatomy

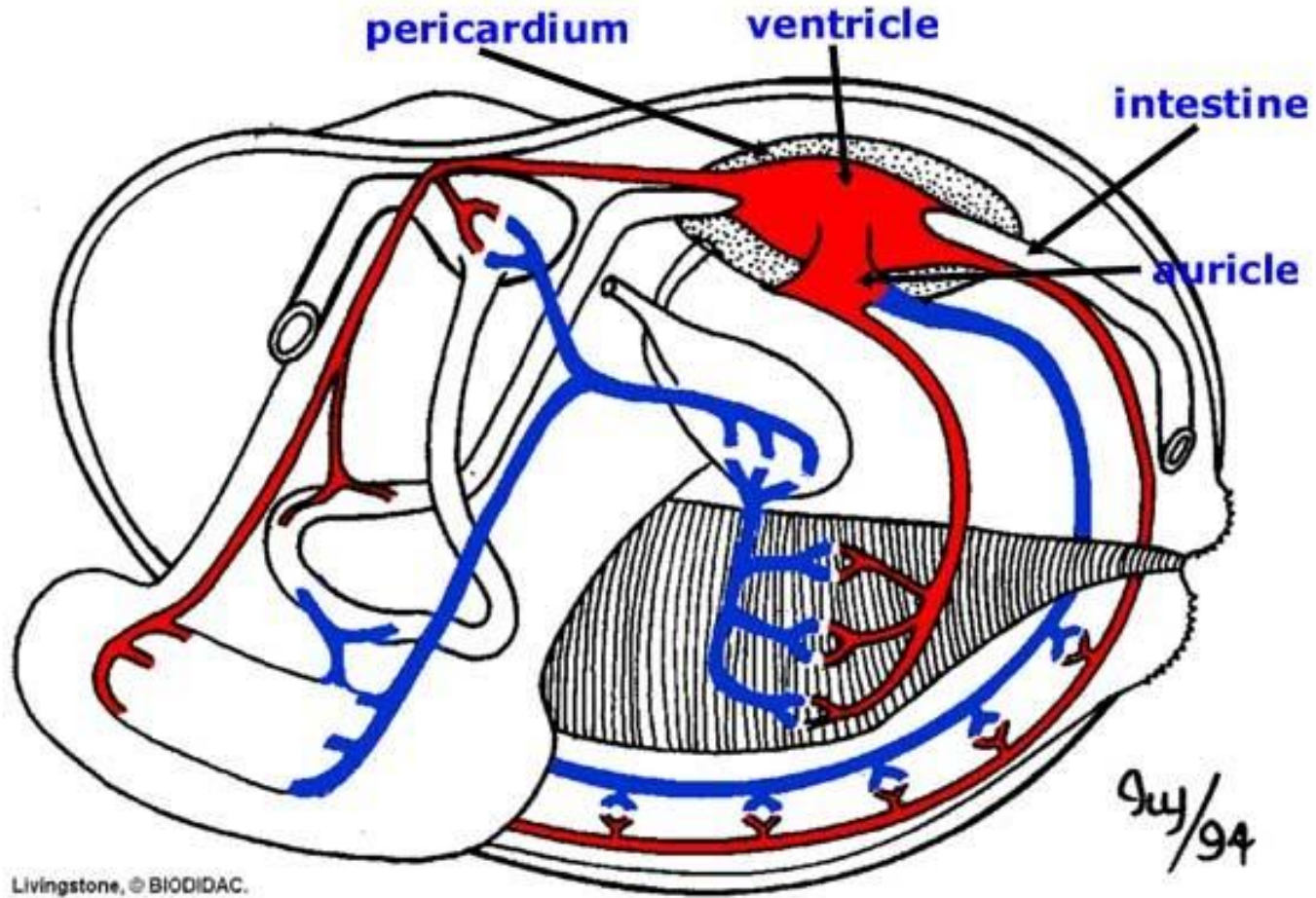


# Oyster Circulatory System



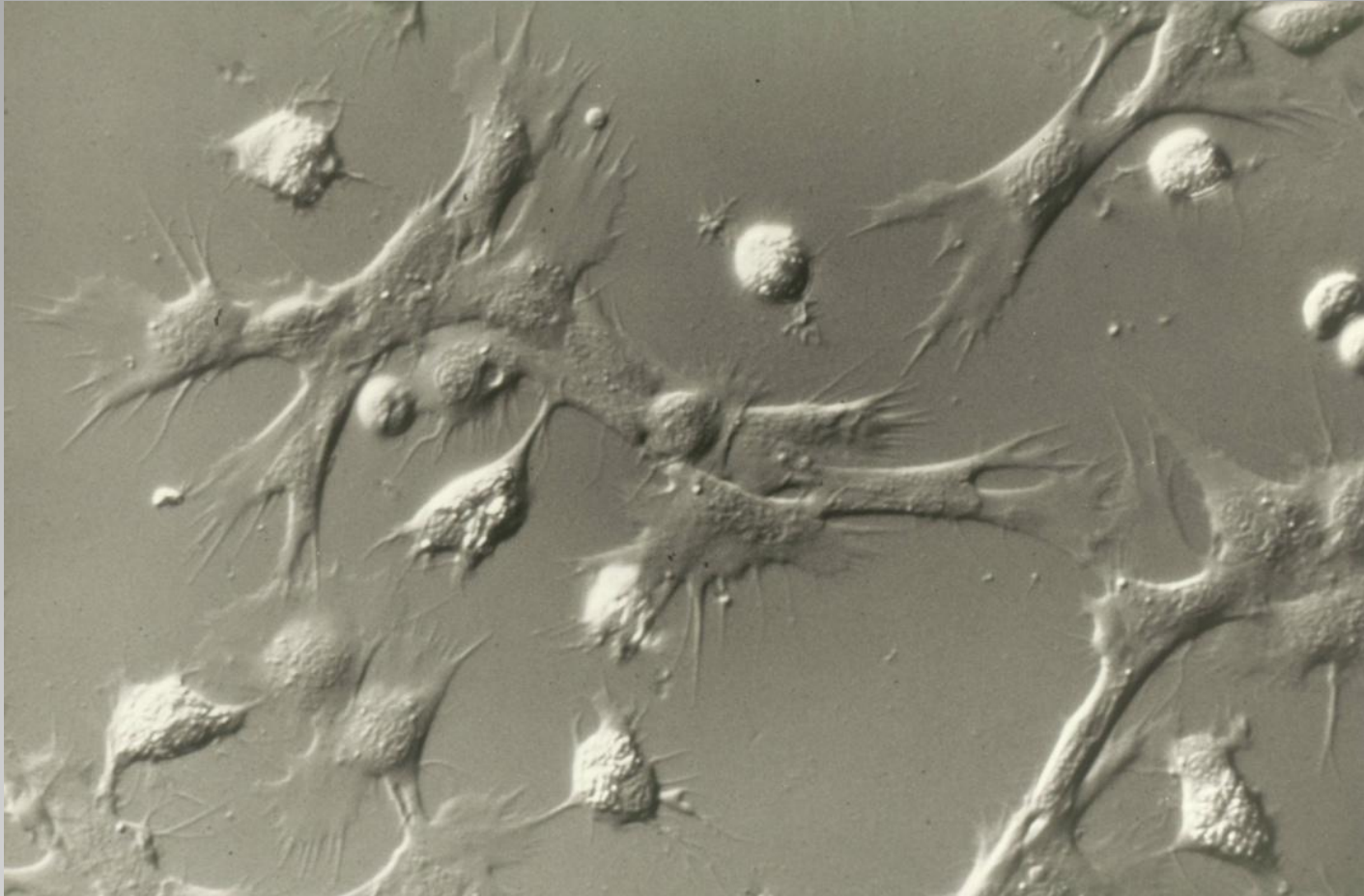


# Oyster heart

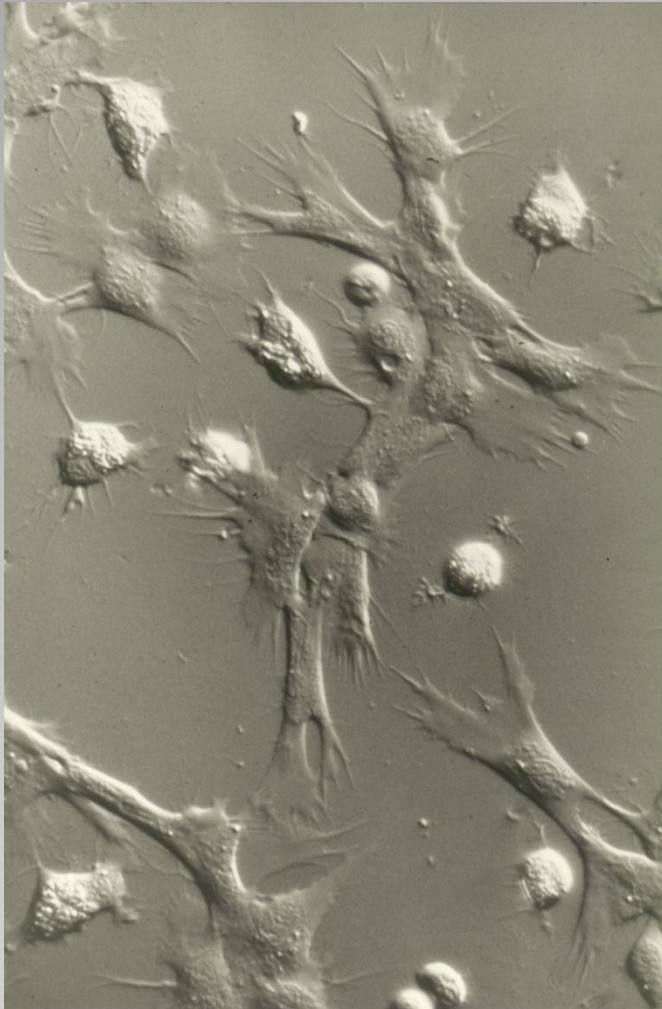


Livingstone, © BIODIDAC.

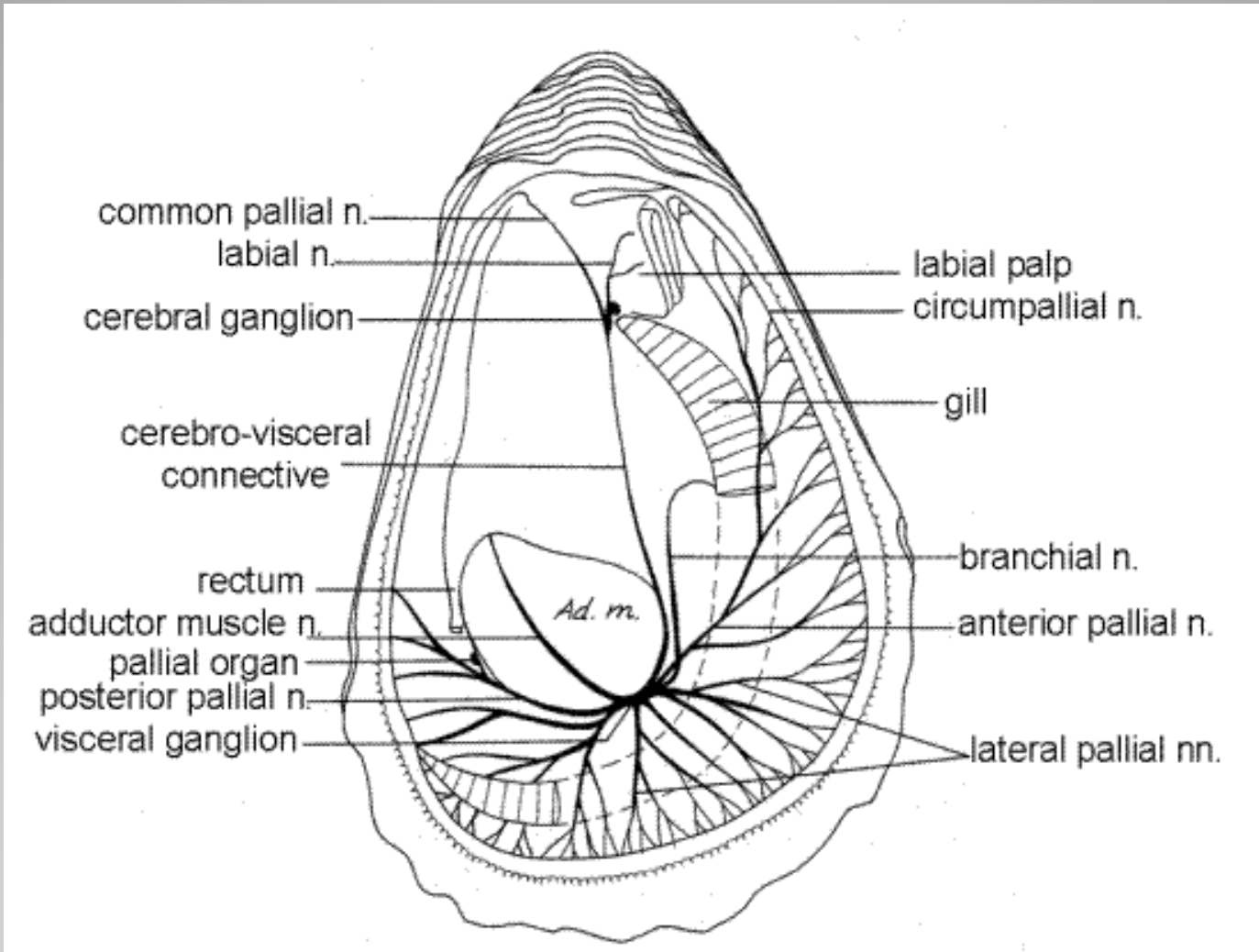
# Circulatory System



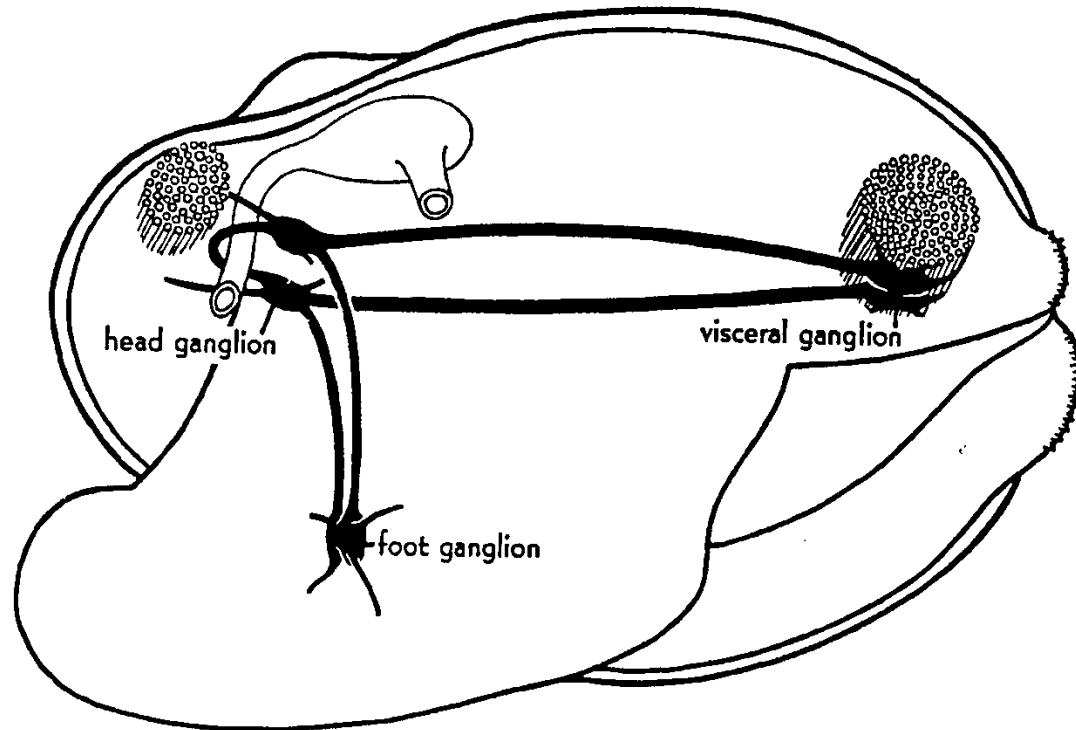
# Circulatory System – blood cells



## Hematopoietic neoplasia (aka Clam leukemia)

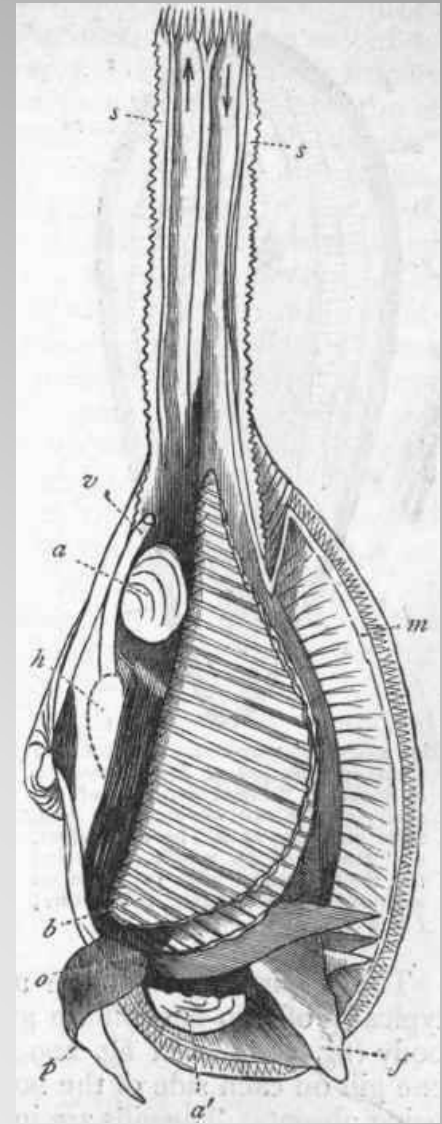
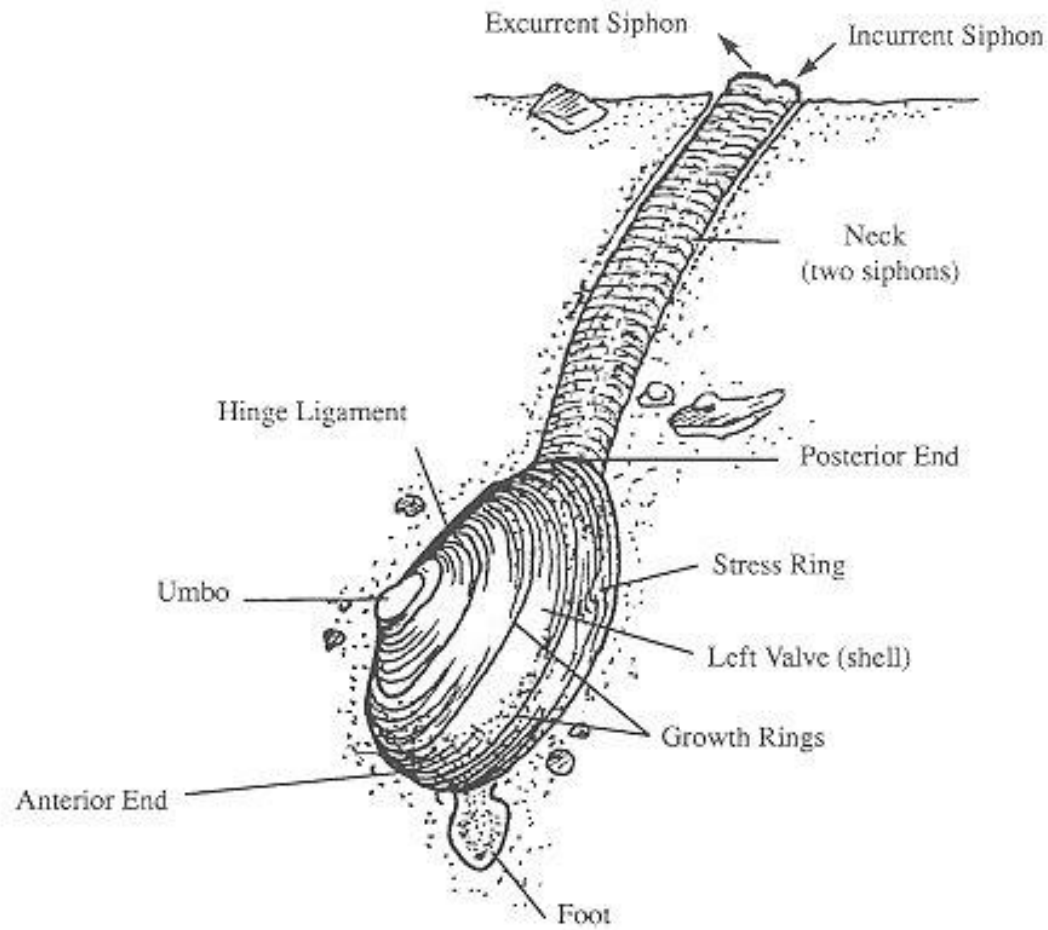


# Oyster Nervous System

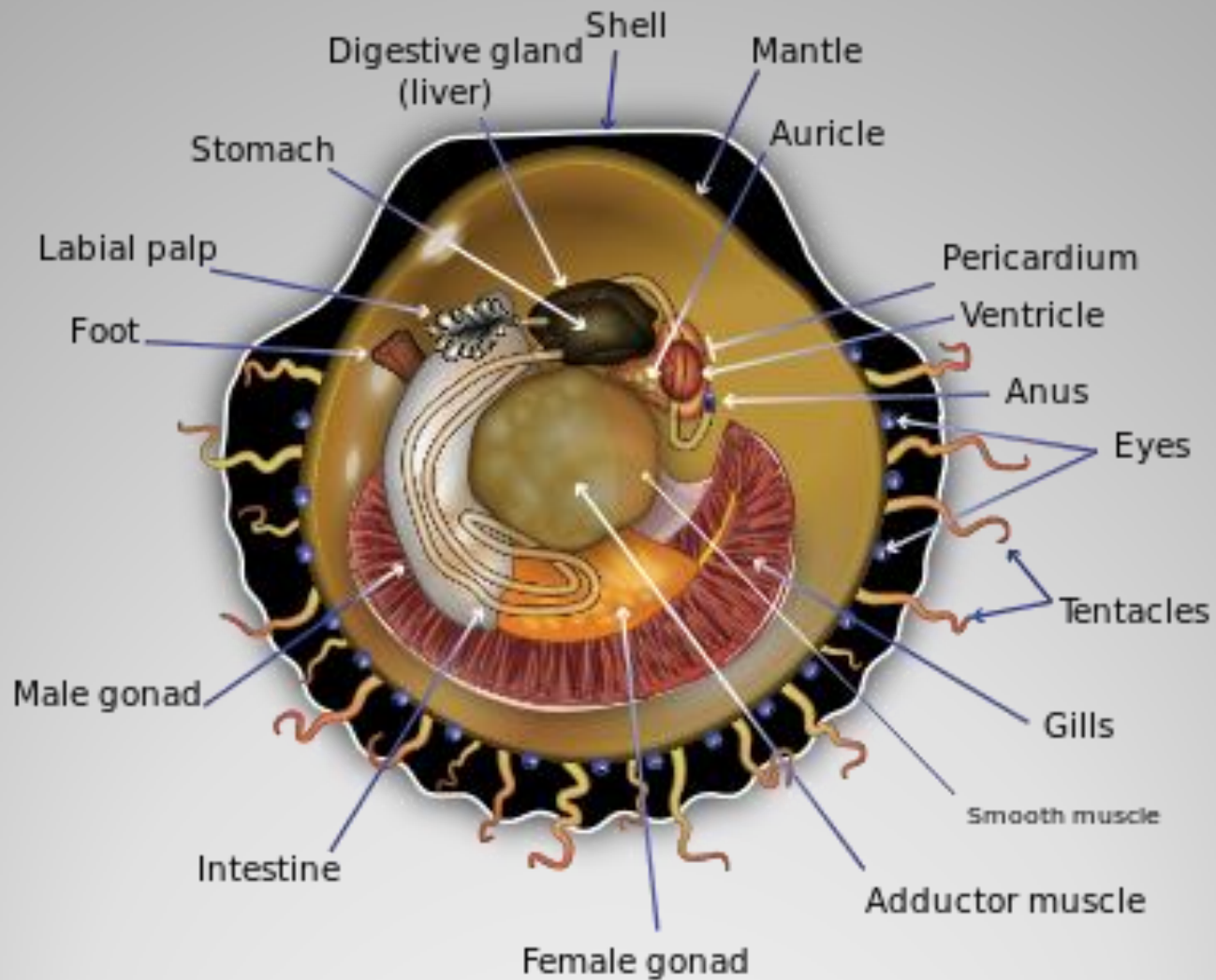


The **nervous system** of the clam has a pair of ganglia for each main region of the body. The head ganglia correspond to the double but fused “brain” of other animals. They lie on each side of the mouth, joined by a commissure that runs around the esophagus. They send nerves to palps, anterior shell muscle, and mantle. From each head ganglion a connective runs ventrally to the ganglia which supply the muscles of the foot. Two connectives also run from the head ganglia to the visceral ganglia, which send nerves to the digestive tract, heart, gills, posterior shell muscle, and mantle.

# Clam Nervous System

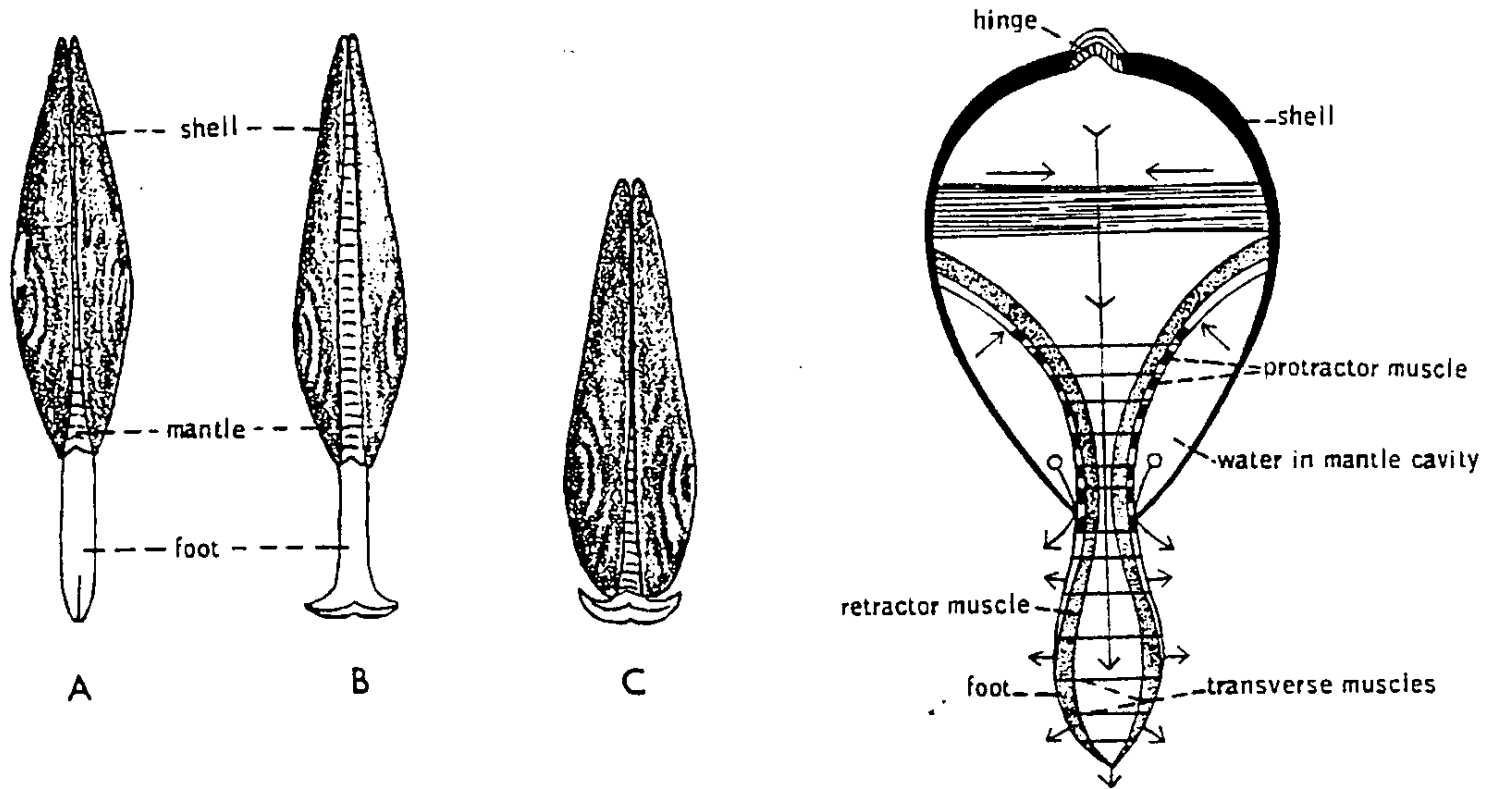


# Soft shell clam

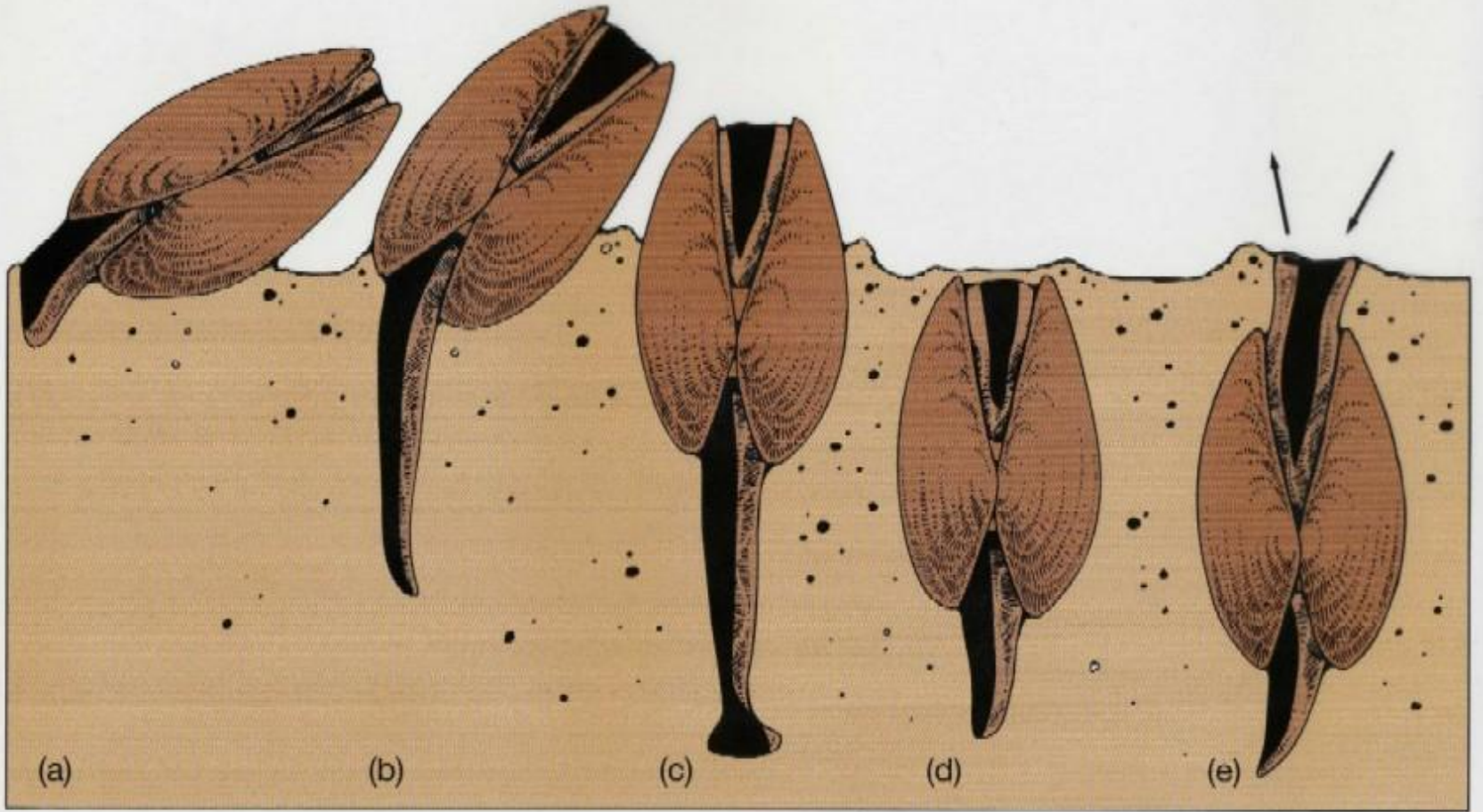


# Scallop anatomy





# Locomotion



# Digging

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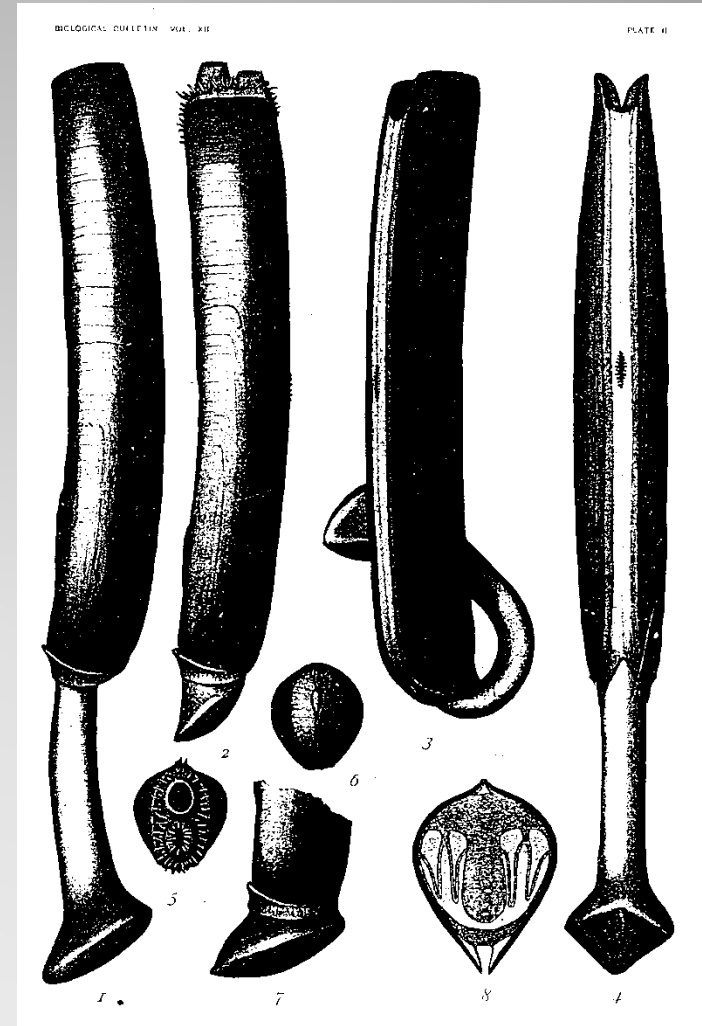
## Digging (Jellybean clam)



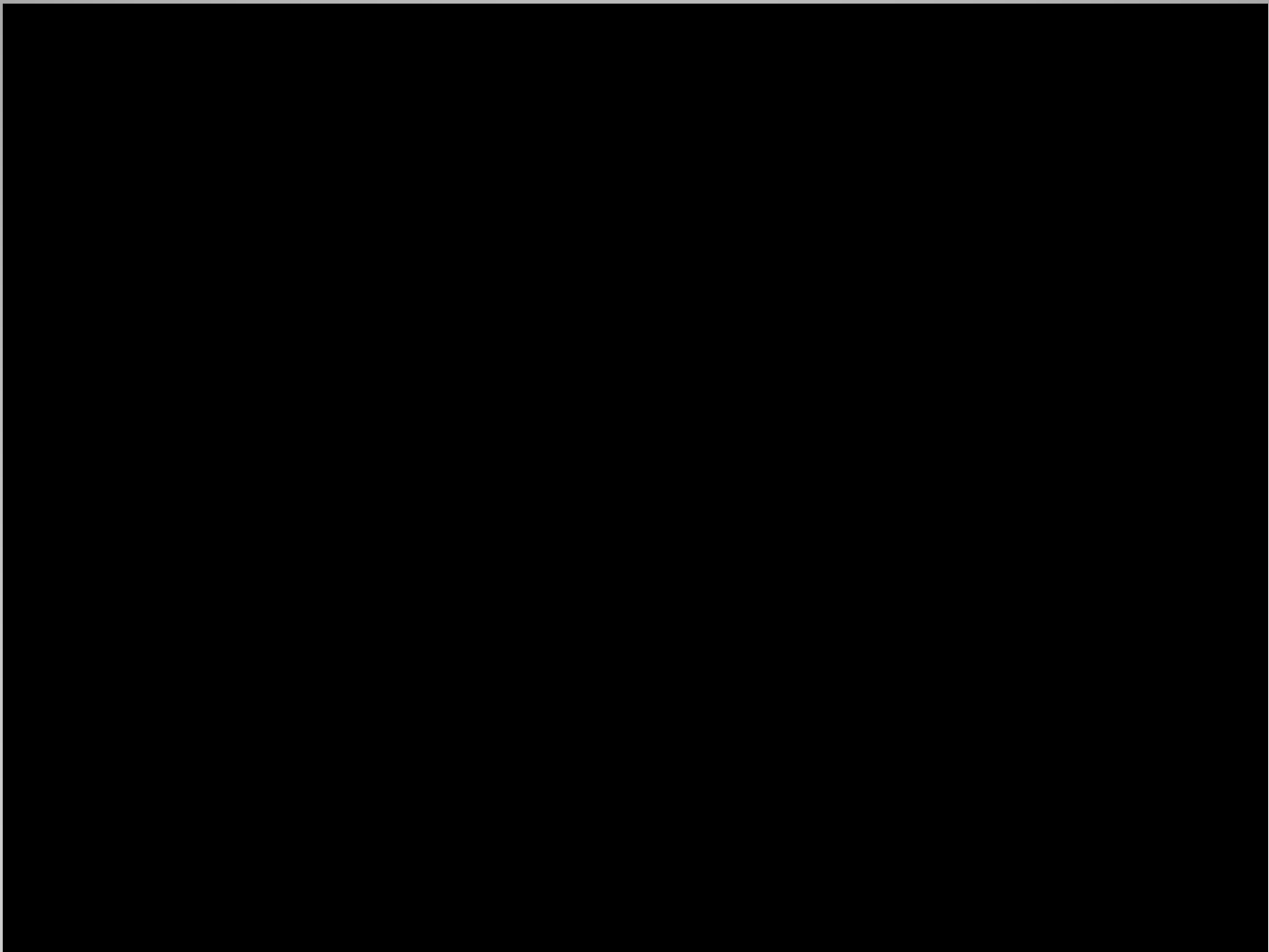
## Digging In (Pismo clam)



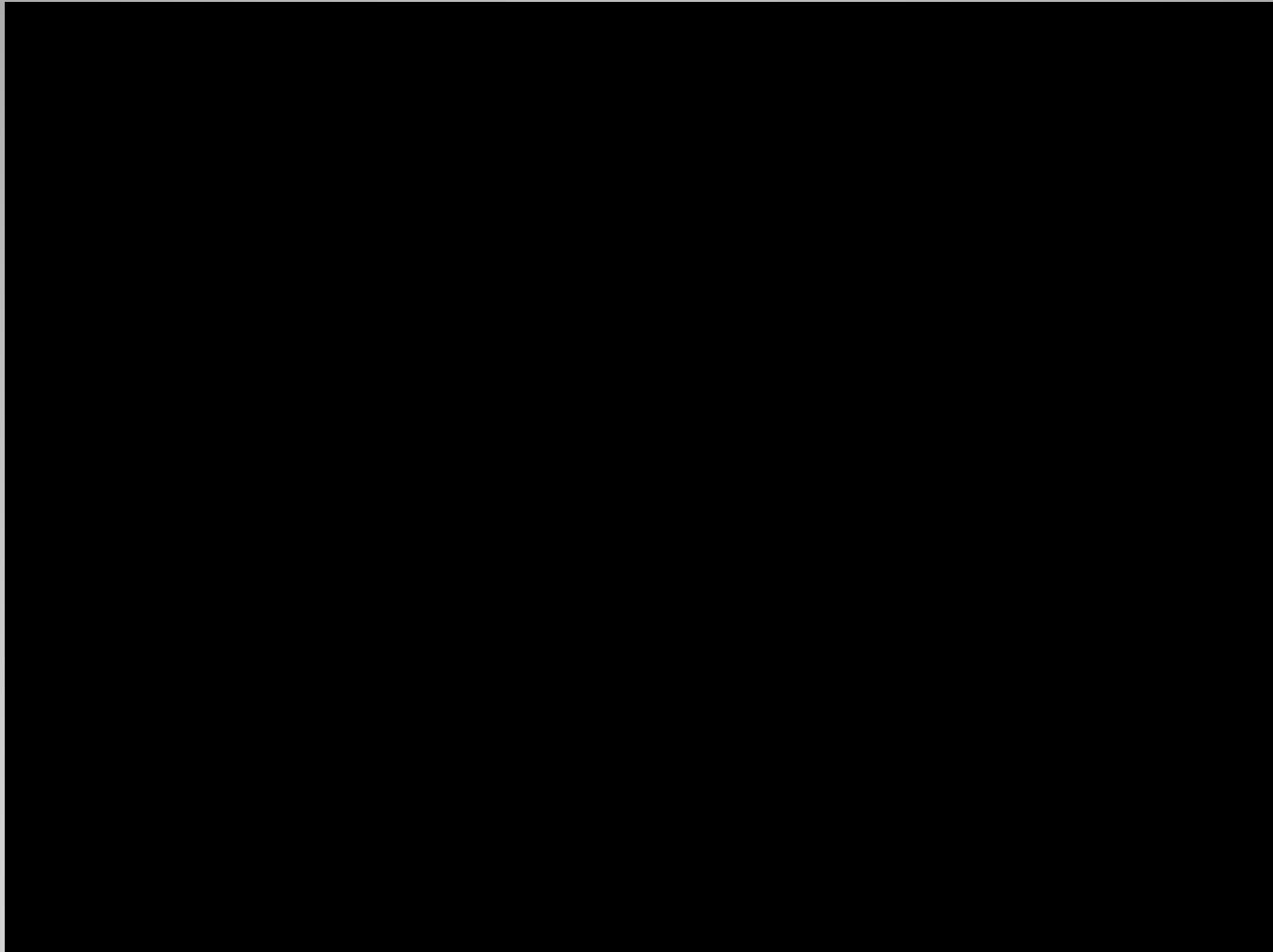
## Other bivalve movement



# The Locomotion King!



# Swimming then Burrowing



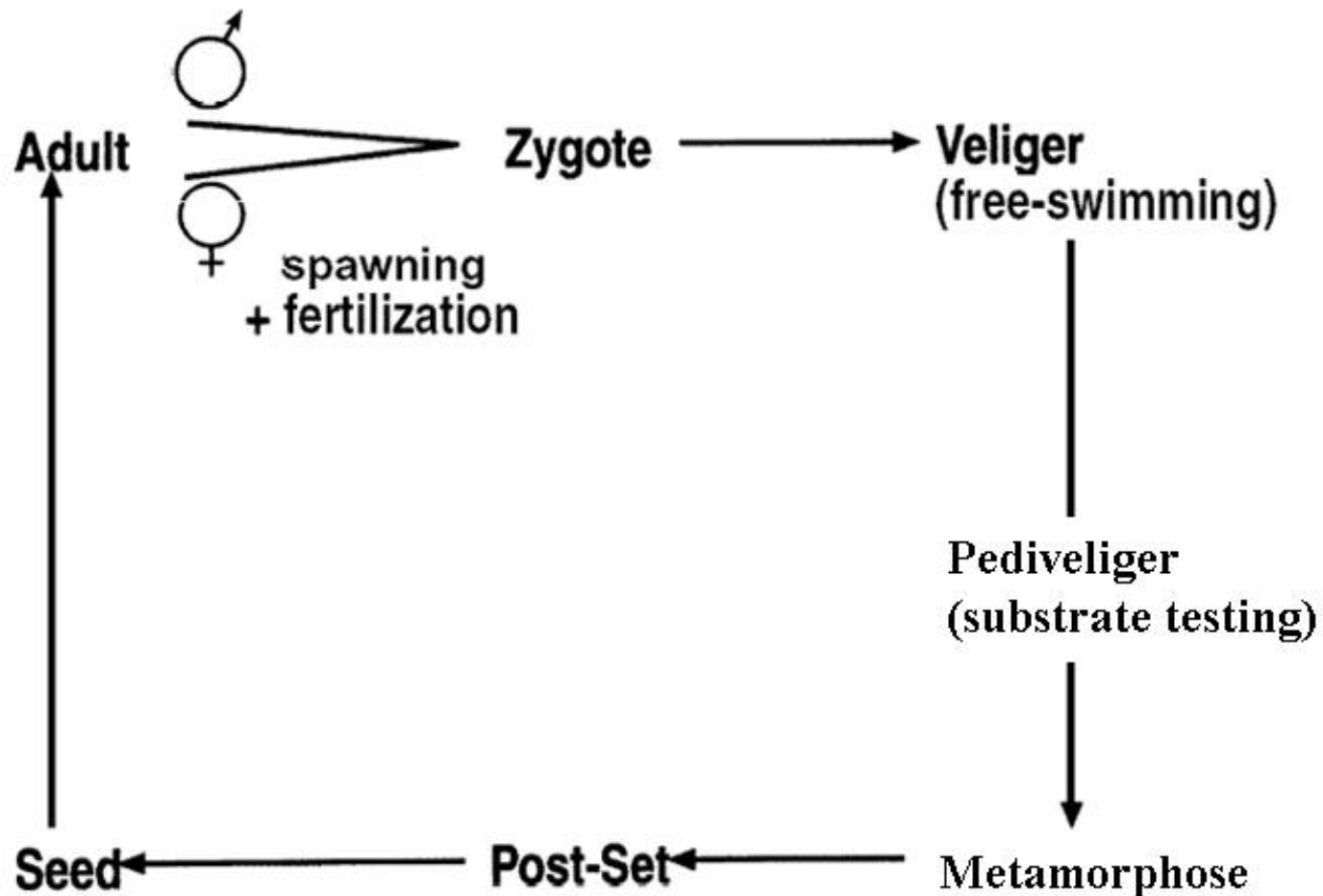
**Walking?**

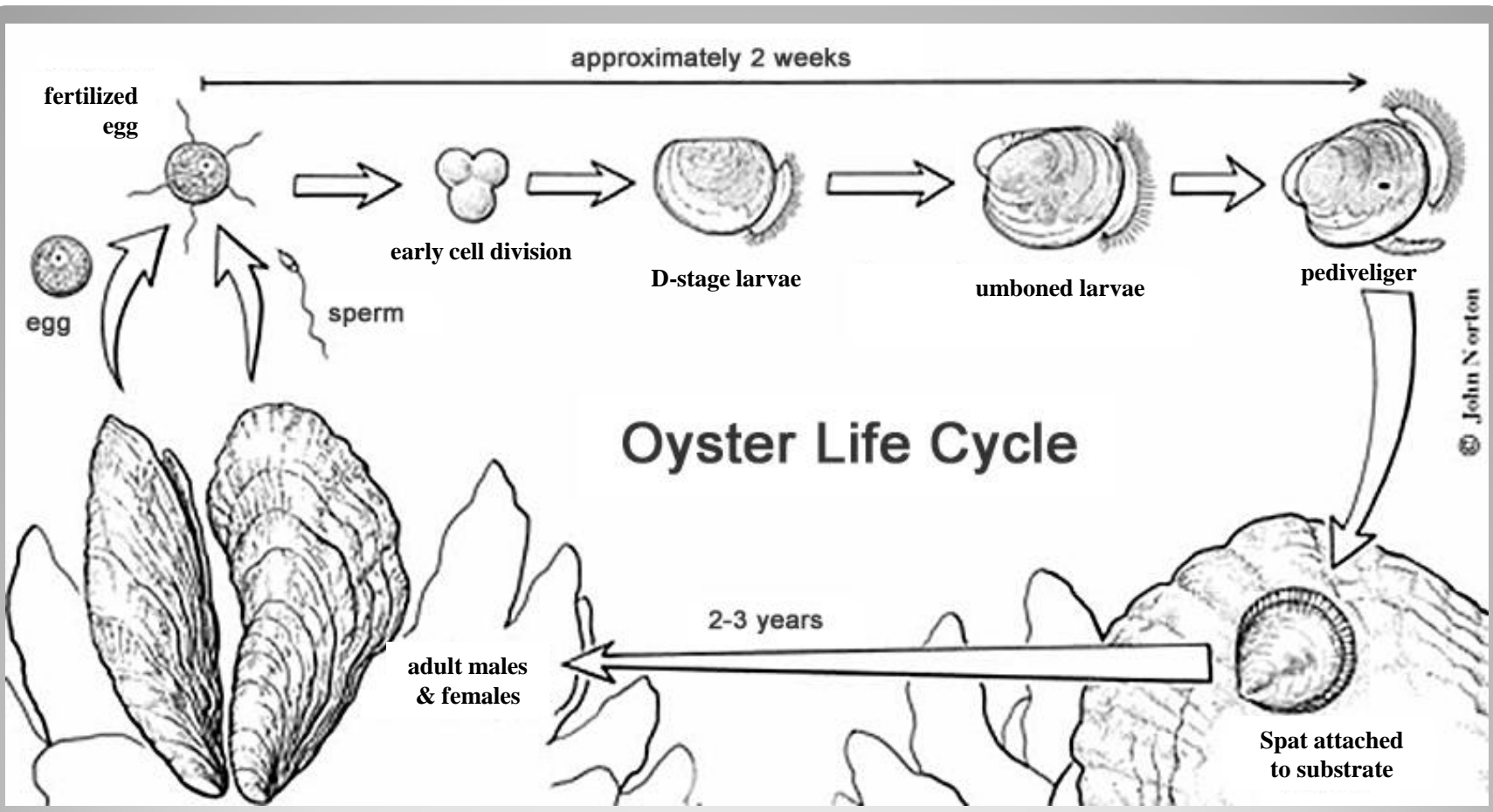


# Reproduction in Bivalves



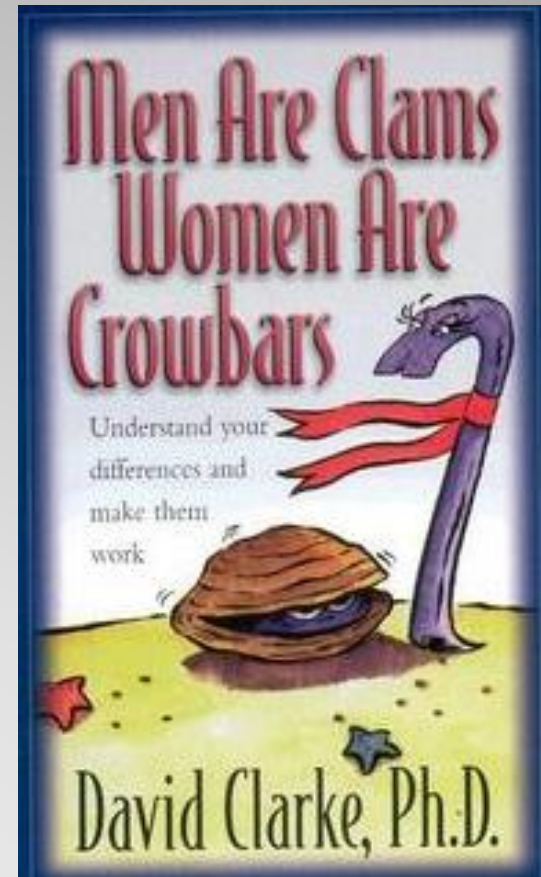
## Life Cycle of Clams





# Oyster Reproduction

- Commonly separate sexes in the bivalves (dioecious)
  - although hermaphroditism (monoecious) occurs
  - e.g. bay scallop



# Shellfish Gender

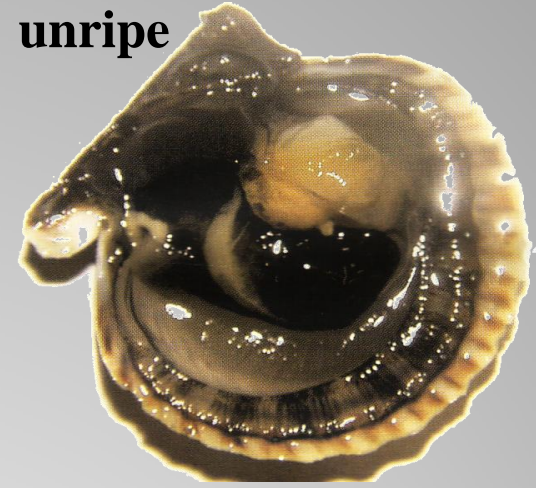
- Protandric
  - Protandry - development of male organs before female to avoid self-fertilization.
- Most begin life as males and then may change over to female
- As they grow, proportion of functional females in each size class increases
  - Females occur in larger (older) animals
- However, if the number of males is too low, some of the older females may change back to males!

## Oysters & Quahogs

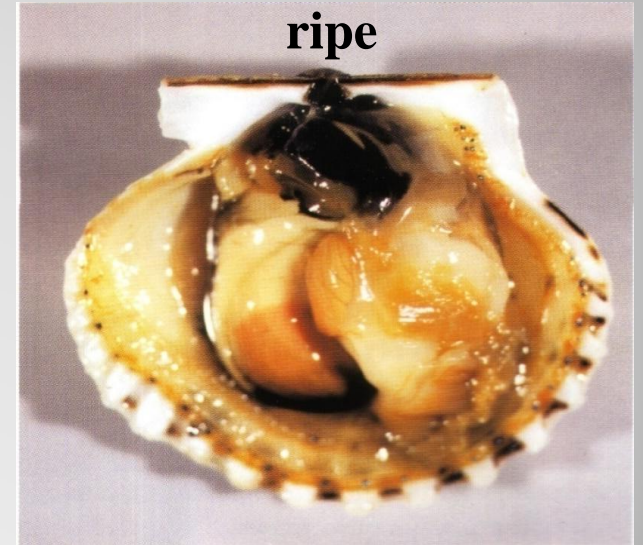
- Sex is unknown until observed spawning
  - Except bay scallops

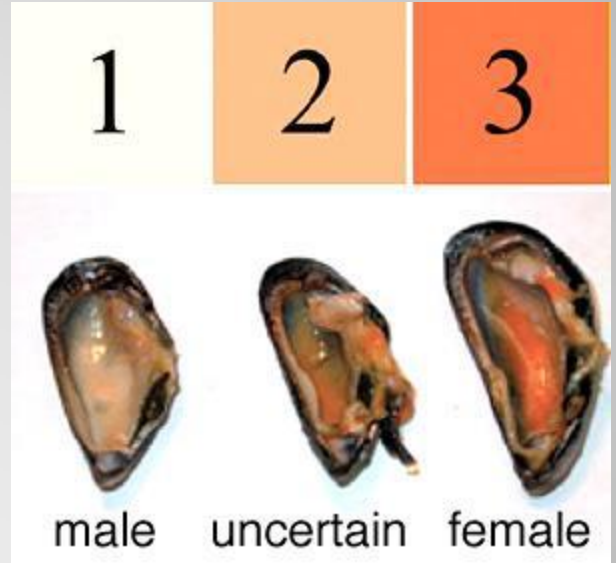
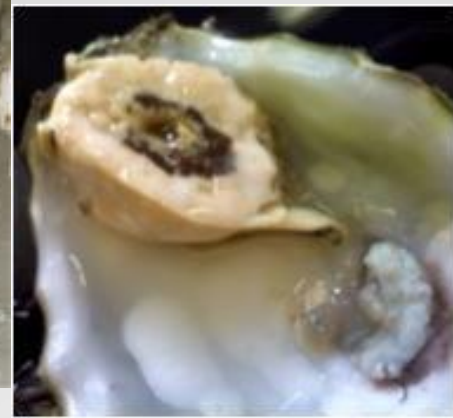
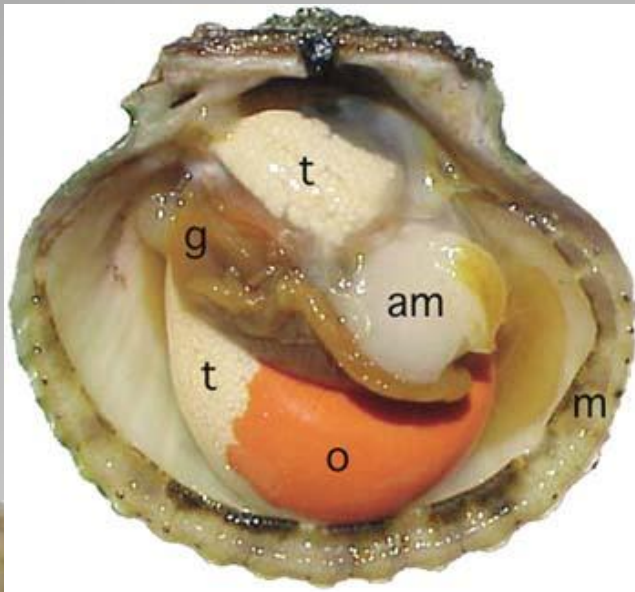


unripe



ripe

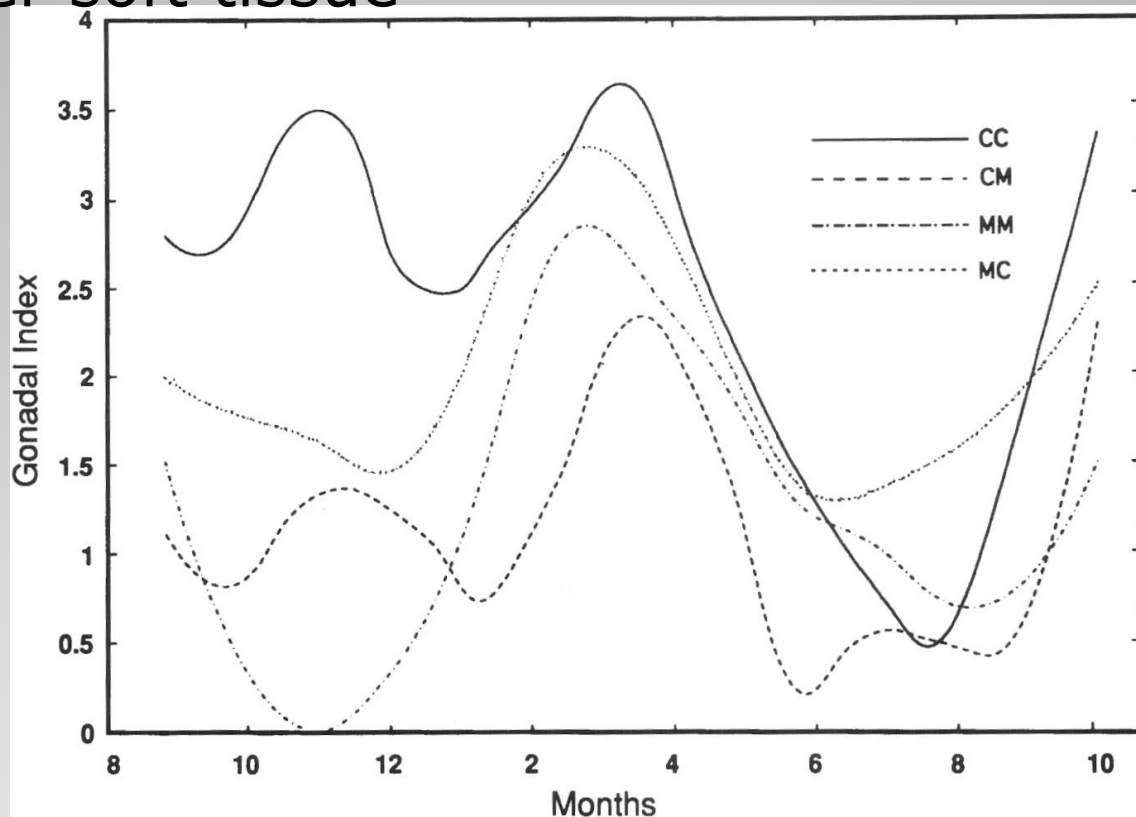




# Gonad Anatomy

- Gonad Index

- Size of the gonad relative to the size of the other soft tissue



# Gonad Index of Quahogs



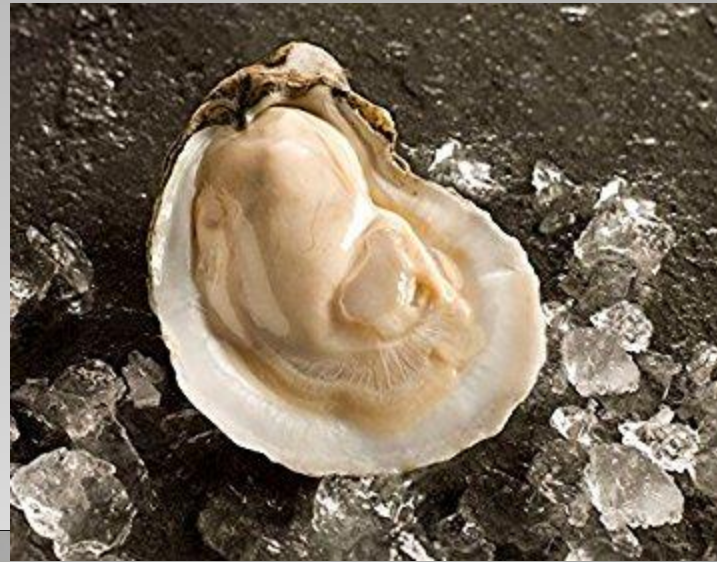


Oysters

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in Season

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# Meat Quality

- Larvae
  - Free-swimming babies during the first 2-3 weeks of the bivalve's life
- Metamorphosis
  - When an larvae transforms to their adult body shape
- Settlement (Setting)
  - When a metamorphosing shellfish occupies it's adult-type of habitat
- Spat/Seed
  - Spat - A juvenile bivalve after it has settled onto a location
  - Farmers call this "seed" when they purchase it to place on their farm
- Recruitment
  - When the current pulse (cohort) of larvae settle into a location

# Shellfish Terminology

