4- Pathological changes in the mollscan tissues

* **Protozoa**
* **The** infected mussels **showed some behavioral, morphological, and histopathological changes**. **The behavioral and morphological changes are represented by weakness of valve closure and withdrawal of foot, while the shells have marked fracture holes leading to black masses inside the shell of *Caelatura aegyptiaca*..**
* ***the weakened shells were more vulnerable to predation and mechanical effects of wave action which caused fracture holes in the shell which is soon followed by mussel death***

* **change of normal colour in the infected soft parts and organs is an evidence for the severe infection by the parasite and the pathological effects of the parasite on the host tissues which are caused by a disturbance in the metabolic activities of the hosts *Mytilus californianus* .**

* **Protozoan parasites caused infection in gills, kidney mantle and digestive glands**

* **The Protozoan parasites *Marteilia refringens* caused histoplathological changes in the digestive gland of molluscan host *Mytilus galloprovincialis* . tumefactions, liquefaction necrosis, acute swelling cells, disruption and sloughing of epithelial cells in the lumen of the gland.**

* The gill epithelia were ruptured, while their connective tissue was increased in size and compressed towards the interlamelar spaces and disappeared in some cases
.

Water mites

* The **adult of mites** seek the mussels prior to reproduction, while the **nymphs seek** the mussels in order to transform into the adult stage.
* **The water mite *Unionicola intermedia* lives as a parasite in the gill region of *Anodonta anatina*.**
* **It attaches to the gills of its host by means of the pedipalps which cause displacement, rupture, and erosion of the gill epithelium. The pedipalps are sunk deeply into the underlying connective tissue of the gills and produce a leukocytic infiltration into the damage area and a consequent edema of the gill filaments.**
* **Edema is an abnormal accumulation of fluid beneath the skin or in one or more cavities of the body.**
* **Infiltration is the diffusion or accumulation (in a tissue or cells) of substances not normal to it or in amounts in excess of the normal.**

* Some of histopathological changes in the gill tissue of the molluscan host, *Anodonta rubens* infected by ***U. anodontae* and *U. niloticus*** These changes are:

* **1-displacement, rupture, and erosion of the gill epithelium.**
* **2- Swelling of the gill filaments epithelium,**
* **3-many gaps in the connective tissue,**
* **4-aggregation of leukocytes in different parts of the connective tissue, and caused leuckocytic infiltration**
* **5-swelling of gaps containing embryos and projecting into the interlamellar spaces,**
* **6-many yellowish brown cells scattered in the connective tissue and aggregation of cells below the epithelium in different parts of gill tissue**

IV- DEFENSE MECHANISMS IN MOLLUSCA

Generally, there are two types of defense mechanisms in Mollusca; external and internal. The first mechanism representing by physical and venomous, while the second one including innate and acquired.

External Defense :

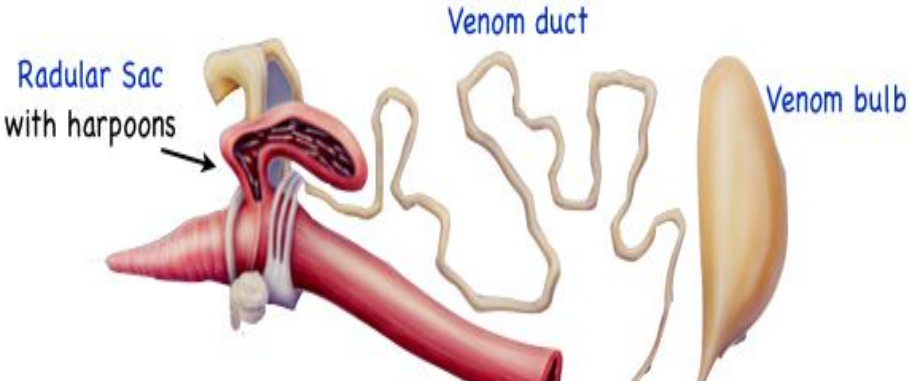
1- Physical : It includes the shell with its hard structure as in gastropods and mucus with its awful tasty which covering the soft parts and the shell as in Opisthobranchs and Cypridae. They acts as physical barriers that prevent the predators and parasites to approach or invade the mollusc

Venomous system

* The venom system in the family conidae used in feeding and defense against predators and enemies of the cone snails. The venom system of cone snails secretes the neurotoxin which causes death or narcotizing victims within few seconds or minutes
* The venom system consists of:
* Venom gland- Venom duct- Radular sac- Proboscis
* Cone snails are carnivorous, and predatory. They hunt and eat prey such as marine worms, small fish, mollusks, and even other cone snails. Because cone snails are slow-moving, they use a venomous harpoon (called a toxoglossan radula) in order to capture faster-moving prey such as fish.
* The venom of a few larger species, especially the piscivorous ones, is powerful enough to kill a human being.

* The osphradium (a chemoreceptory organ) in the family Conidae is more highly specialized than the same organ in any other family of gastropods. It is through this sensory modality that cone snails become aware **of the presence of a prey animal, not through vision**. The cone snails immobilize their prey using a modified, dartlike, barbed radular tooth, made of chitin, along with a poison gland containing neurotoxins. Small species of these cone snails hunt small prey such as marine worms, whereas larger cone snails hunt live fish.

* **Medical importance of conotoxins:**
* The venom of some cone snails, shows much promise for providing a non-addictive pain reliever 1000 times as powerful as, and possibly a replacement for, morphine
* Many peptides produced by the cone snails show prospects for being potent pharmaceuticals, such as AVC1, isolated from the Australian species, the Queen Victoria cone, *Conus victoriae*. This has proved very effective in treating post-surgical and neuropathic pain, even accelerating recovery from nerve injury.
* The first painkiller Ziconotide derived from cone snail toxins was approved by the U.S. Food and Drug Administration in December 2004 under the name "Prialt". Other drugs are in clinical and preclinical trials, such as compounds of the toxin that may be used in the treatment of Alzheimer's disease, Parkinson's disease disorder that affects nerve cells, or neurons, in a part of the brain that controls muscle movement and epilepsy common chronic neurological disorder .


Venom duct
Radular Sac
with harpoons
Venom bulb

Radular
sheath
Venom
duct
PC
Radular
teeth
"Harpoon"
Venom
bulb
DC
Proboscis
Salivary
gland
D
P
Pharynx
Esophagus

Internal chemical defense

* The internal defense mechanisms in Mollusca can be classified mainly into two types, innate and acquired
* **A- Innate: are those that are genetically, controlled and are manifested in animals that have not been previously exposed to a specific foreign substances.**
* **B- Acquired (gained): are those that only become obtaining appetent upon second or subsequent challenge with the foreign substances.**

Internal defense mechanisms			
Innate		Acquired	
Cellular	Humoral	Cellular	Humoral
1.Phagocytosis 2. Encapsulation 3. Nacrezation	Humoral factors 1.Agglutinins 2. Opsonins 3. lysins	No evidence	No antibody

Innate cellular internal defense mechanisms

If a foreign substance, an organism, a molecule, or even an element, invades a mollusc, and it recognized as being "non-self, it elicits a rapid increase in the number of leukocytes within the molluscan tissues. (leukocytosis) is appreciated by an increase in number of haemolymph cells within the heart, vessels.

Subsequent to leukocytosis, the foreign material displays one of the three types of innate cellular internal defense mechanisms; phagocytosis, encapsulation and nacrezation.

If the foreign materials are physically small enough to enter the cells, they will be arrested by the mollusc's haemolymph cells by phagocytosis.

Usually, the arrested materials inside the molluscan leukocytes migrate across the epithelial borders to

It is known that haemocytes are the phagocytic cells in molluscan bivalves. Two main haemocyte types can be distinguished in the haemolymph of the clam:

granulocytes and hyalinocytes.

the phagocytic process can be subdivided into 4 steps:

* 1- The attraction of the phagocytic cell to the non- self material (Chemotoxis)
* 2- Recognition involving the attachment of the foreign material to the surface of the phagocytic cell
* 3- Internalization of foreign particles by clam haemocytes occurred by invagination of the cell surface followed by pseudopod formation and particle internalization into endocytotic vacuoles (primary phagosome).
* 4- Degradation: intracellular degradation of internalized material occurs in secondary phagosome of the clam

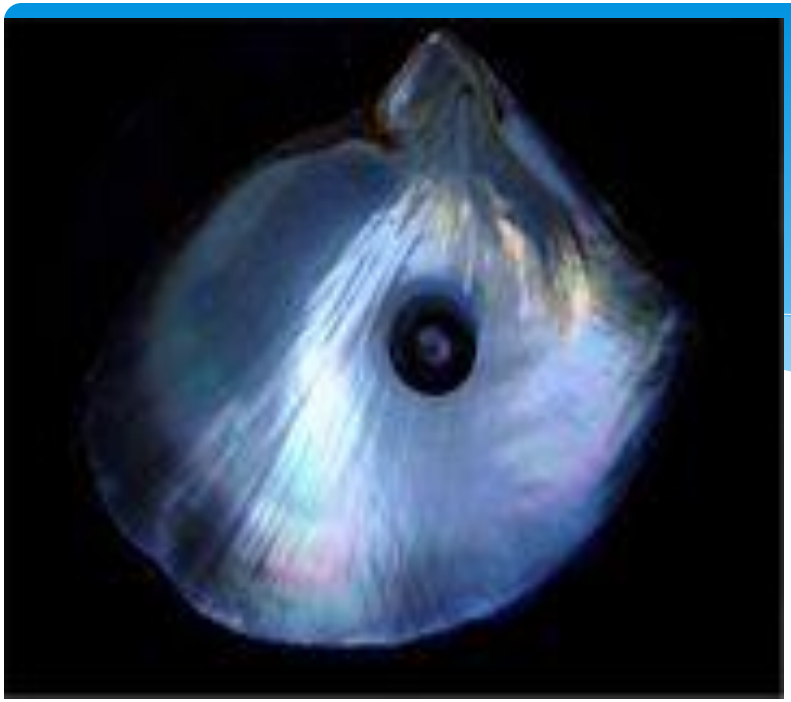
Encapulation

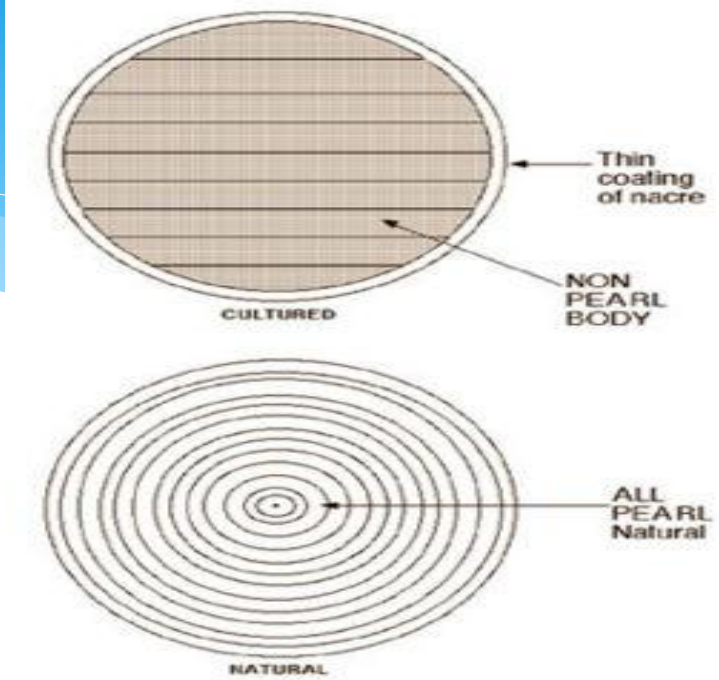
* The encapsulation defense occurs by designation a capsule around the metazoan parasites in incompatible hosts. However, slight and restricted encapsulstion may also occur around **metazoan parasites** in their compatible hosts.
* **The encapsulation process is defined as the walling of the "nonself" materials by cells and or by fibers of the molluscs around the parasite**

Type of encapsulation	Description
Antiqufibrous	Fibrous elements (collagenous, reticular, elastic) not formed as the result of parasitic stimulation but represent preexisting fibers present in the immediate vicinity of the parasite .
Novufibrous	Fibrous elements formed as the result of parasitic stimulation.
Fibroblastic	Capsules are comprised of fibroblasts or fibroblast-like cells.
Leukocytic	This type involves the aggregation of leukocytes to form a tunic surrounding the parasite
Myofibrous	Capsules are comprised of preexisting muscle cells present in the immediate vicinity of the parasite

-Nacresation

* Marine bivalves and freshwater mussels have unique character, which defends themselves against the foreign materials invading the area between the mantle and the inner surface of the shell.
* The nacrezation reaction at which the host construct a nacre around the invading materials for example, nacre-secretory mantle in mussels and oysters.
* The natural pearls are formed when the pearl oyster reacts to an irritant by coating it with nacre, the shiny iridescent material found on the inner surface of the shell (nacreous layer).
* The coating of the foreign materials by nacre is continued may be for several years, leading to the increase of pearls into the maximum size. The natural pearls are usually small in size, various colours and irregular in shape and expensive in price

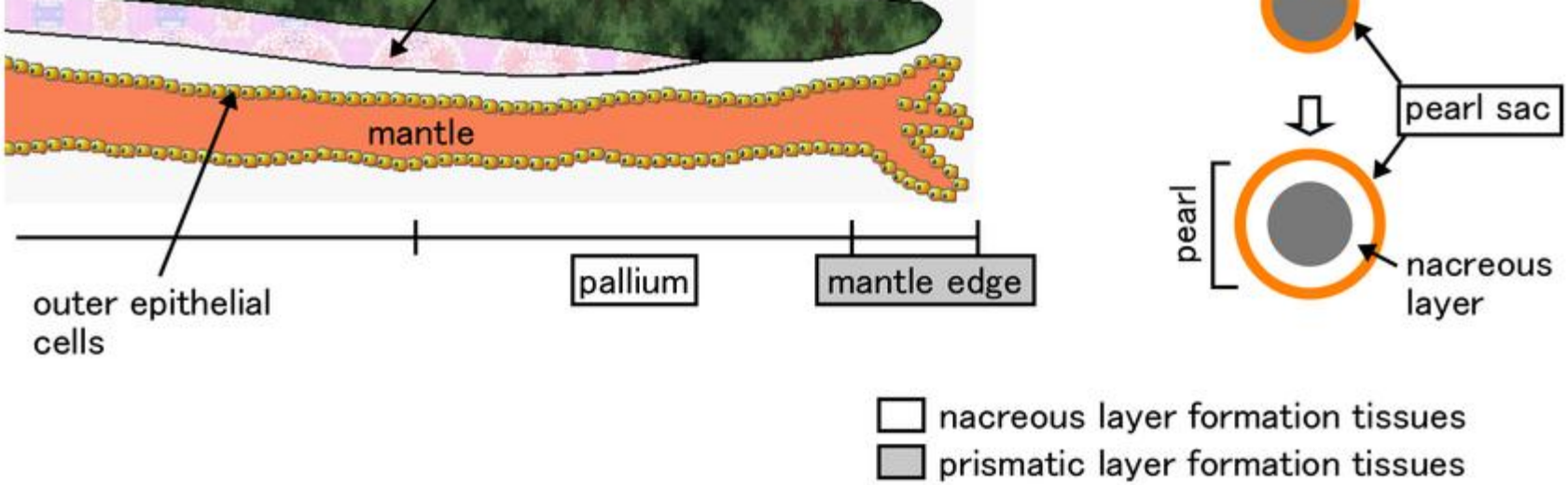



Thin coating of nacre
NON PEARL BODY
CULTURED
ALL PEARL Natural
NATURAL

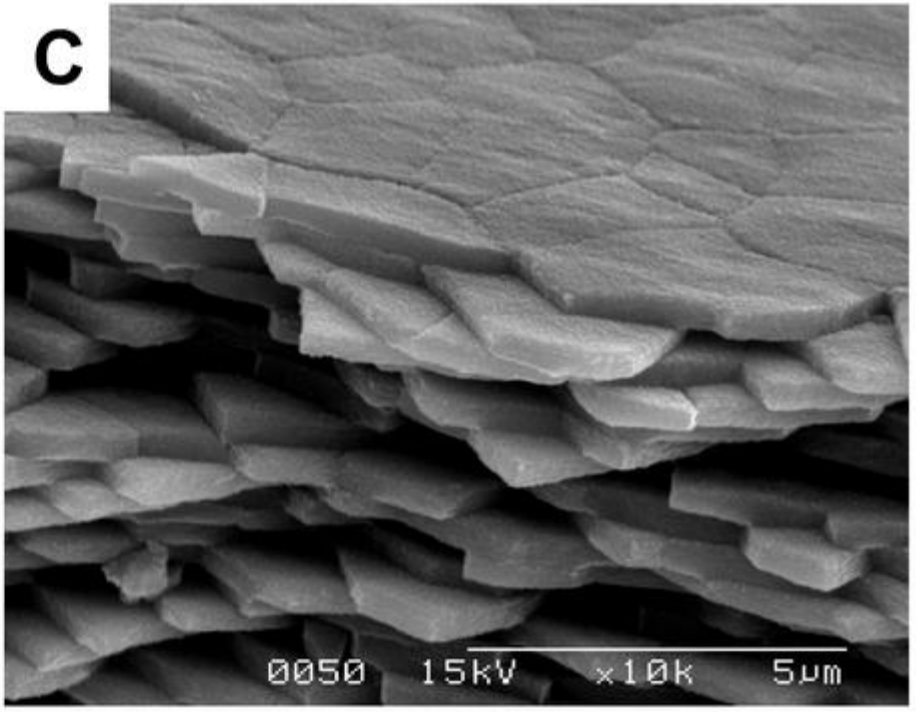
Cultural pearl

* A **pearl** is a hard, rounded object produced within the soft tissue (specifically the mantle) of a living shelled mollusk. Just like the shell of mollusks, a pearl is composed of calcium carbonate in minute crystalline form, which has been deposited in concentric layers. The ideal pearl is perfectly round and smooth, but many other shapes of pearls occur .
* The finest quality pearls have been highly valued as gemstones and objects of beauty for many centuries.
* True iridescent pearls, the most desirable pearls, are produced by two groups of molluscan bivalves or clams. One family lives in the sea: the pearl oysters. The other, very different group of bivalves live in freshwater, and these are the river mussels, for example, see the freshwater pearl mussel.

* Saltwater pearls can grow in several species of marine pearl oyster in the family Pteriidae.
* Freshwater pearls grow within certain (but by no means all) species of freshwater mussels in the order Unionida, the families Unionida and Margaritiferidae.


mantle
outer epithelial cells
pallium
mantle edge
pearl sac
pearl
nacreous layer
nacreous layer formation tissues
prismatic layer formation tissues


B
5mm


C
0050 15kV ×10k 5μm