Amazing World of Mollusk
貝類淺談

VW2016

Content 內容

- Terminology & Classification 分類
- Shell making 造殼
- Habitat 居所
- Feeding 進食
- Locomotion 活動能力
- Sex & reproduction 性與繁殖
- Self Defense 自衛
- Usage 用途
- Key examples 主要品種
- Shell collecting 貝類收集

Terminology

- **Shell collection** 貝殼搜集

  Mainly aesthetic concern

- **Conchology** 貝殼學

  "Concha" – Latin for shell. The scientific study of only mollusk shells

- **Malacology** 貝類學 / 軟體動物學

  "Malakos" – Greek for soft. The scientific study of mollusks including the shell. It is a branch of zoology

What is Mollusk ?

- Kingdom 界 : Animalia 動物界
- Phylum 門 : Mollusca (soft body animal) 軟体動物門
- Class 綱 : Seven key ones -

1. Aplacophora 無板綱
2. Polyplacophora 多板綱
3. Monoplacophora 單板綱
4. Scaphopoda 掘足綱
5. Cephalopoda 頭足綱
6. Gastropoda 腹足綱
7. Bivalvia 雙殼綱

- Order 目
- Family 科
- Genus 屬
- Species 種 : current named species over 115,000
  2nd largest phylum after arthropods; 50% living in the sea, 30% in fresh water & 20% on land. Known Extinct species 35,000 !

Classification Example 命名舉例

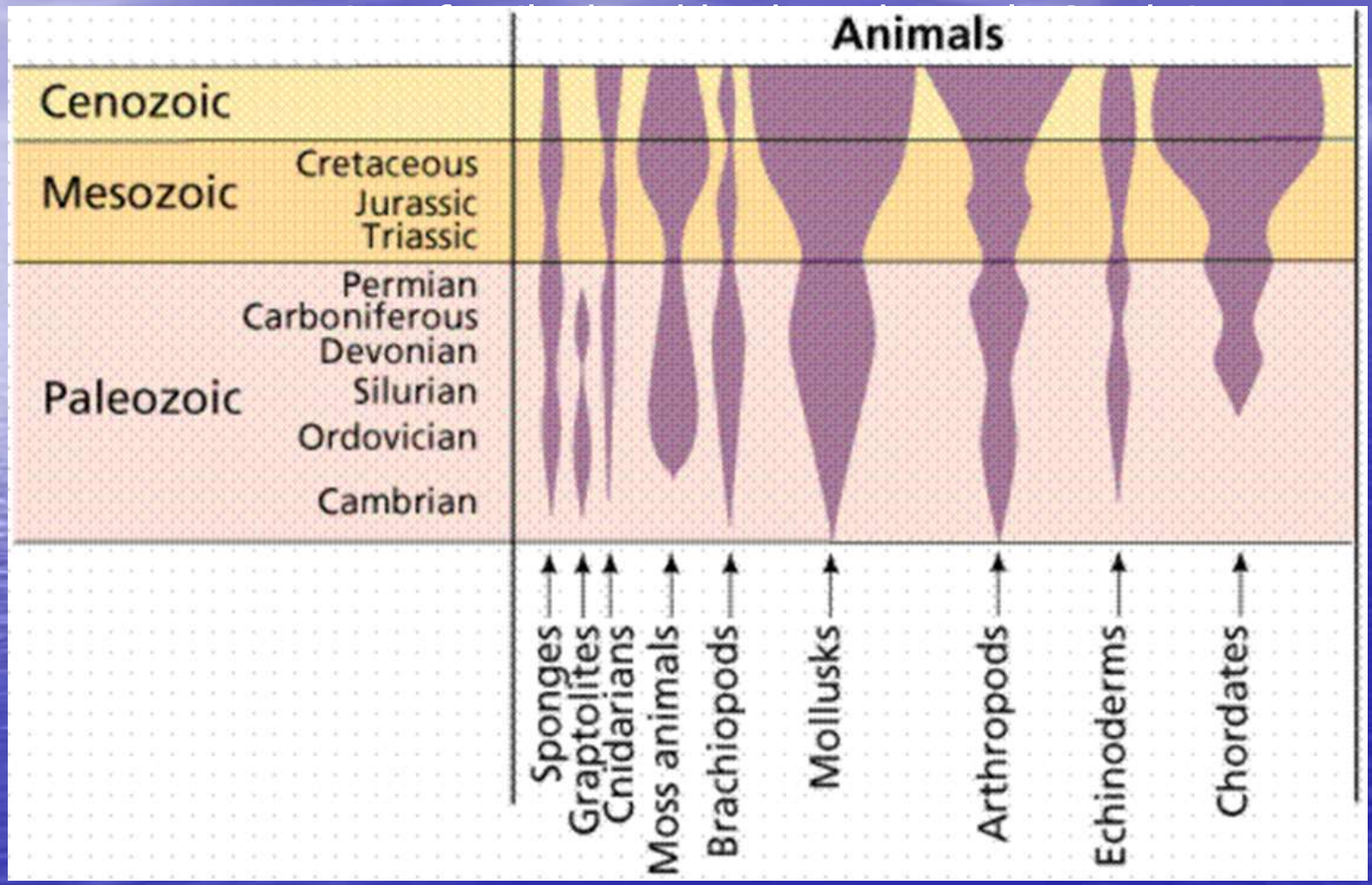
- Kingdom - Animalia
- Phylum - Mollusks
- Class - Gastropod
- Order - Mesogastropoda
- Family - Cypraeacea
- Genus - Cypraea
- Species - vitellus*

Cypraea vitellus *Linnaeus* (Binomial system)

Popular name – "Pacific Deer Cowry" 白星寶螺 /"豬仔螺"

*vitellus means the yolk of an egg

Mollusk Evolution 貝類演化



Mollusk Evolution 貝類演化

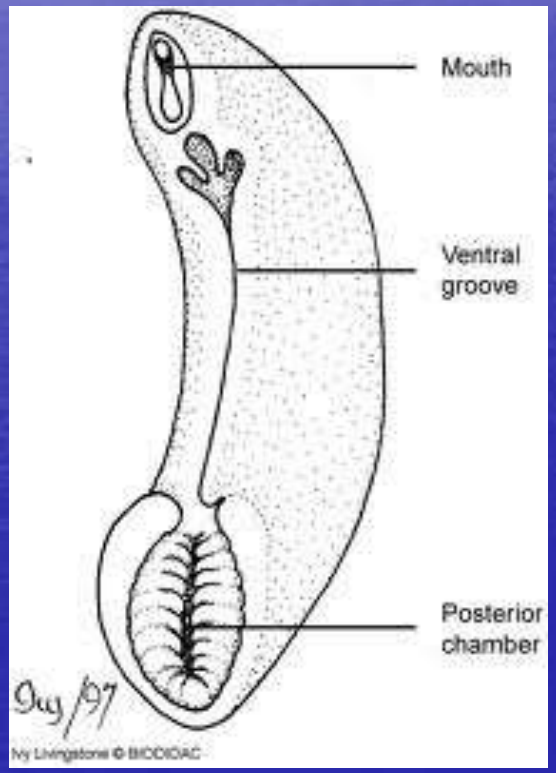
Likely evolutionary pattern

软体动物门（Mollusca）各纲的系统演化关系

（根据Salvini-Plawen and Steiner 1996 改编）

1. Aplacophora 無板綱

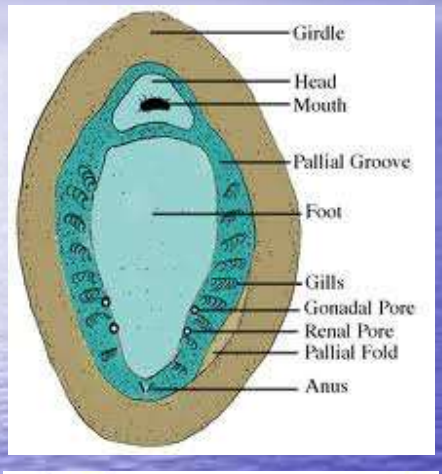
- A group of small deep water exclusively *benthic shell-less marine mollusk. No eye, tentacle or gill. Breathing through the skin. Two orders namely Chaetodermoida & Neomenioida with 320 species e.g. *Proneomenia* 龍女簪

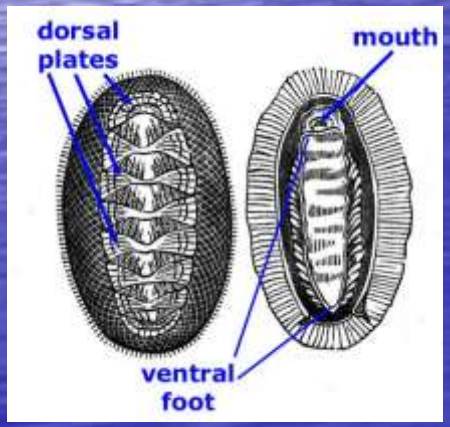


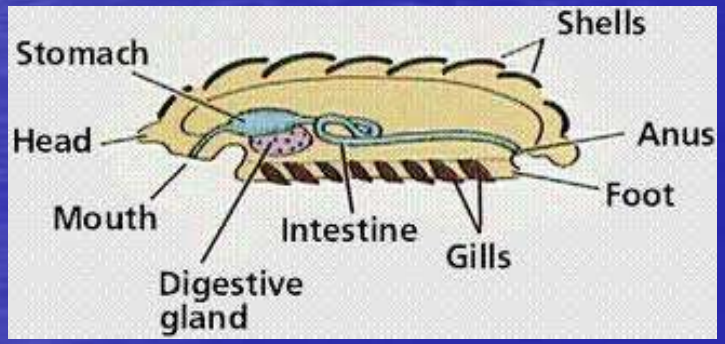
(* Benthic – lowest level of a body of water)

2. Polyplacophora 多板綱

- Primitive marine mollusk also known as coat-of-mail shell represented by Chitons 石鱉







- 6 families 1,000 species, all marine, maximum length 36 cm
- Eight overlapping shell plates held in place by a muscular ring called the girdle
- Large foot highly specialized for adhesion to rocks
- Live on rocks near shore & all herbivorous feeding on algae
- Move by crawling. Can curl up like armadillos


Some chitons 鱉 are very colorful









H.K. chitons

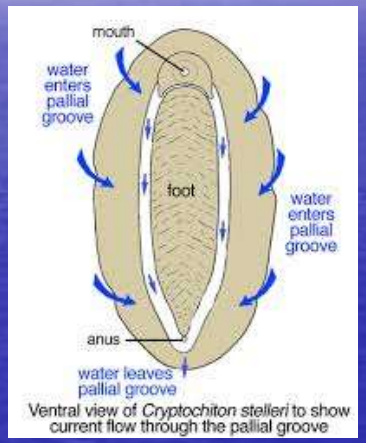
Acanthopleura japonica 日本花棘石鱉

It is the most commonly chiton found in HK water length 3-5 cm

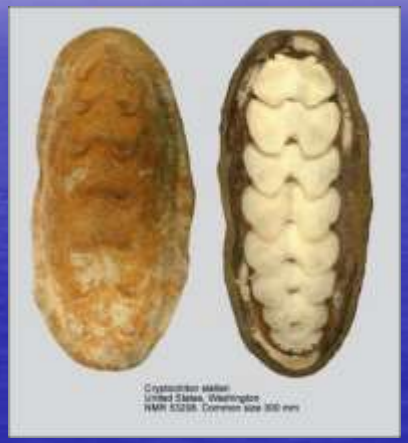
Onithochiton hirasei

Cryptochiton stelleri 巨石鰲

- Also called Gumboot chiton, it is the world's largest chiton growing to 36 cm weighing over 2,000 gm found along the shores of the northern Pacific ocean from central California to Alaska, the Aleutian Islands to Kamchatka Peninsula & south to Japan



Ventral view of *Cryptochiton stelleri* to show current flow through the pallial groove



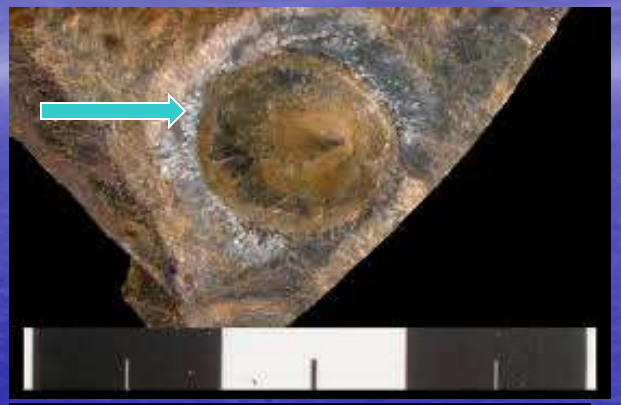
3. Monoplacophora 單板綱

- Meaning one plate (一枚貝). Very primitive with fossils existed in the Precambrian. Thought to be extinct until *Neopilina galatheae* 新蝶貝 was sensationally rediscovered in Costa Rica in 1957 in 3,570 m deep water !

- Only a few centimeters in length with single cap like shell & internal body segmentation with 3 to 6 pairs of Ctenidia 節鰓 & 6 t0 7 Nephridia 後腎

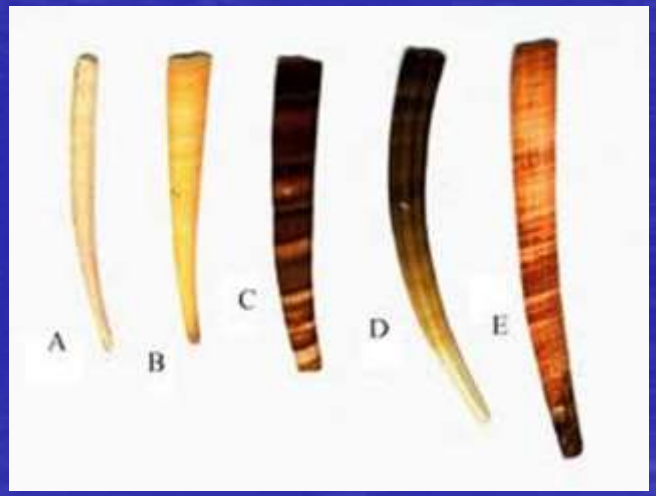
- Fossils at right. 31 living species all living on sea beds from a few hundred meters to the abyss in several oceans






4. Scaphopoda 掘足綱

Literally means "Boat-footed" & commonly called "Tusk Shell" 象牙貝 as it resembles an elephant's tusk with opening at both ends & shovel shaped foot for borrowing. Scaphopoda is the most recent mollusk to evolve developing during the Ordovician about 450 Ma

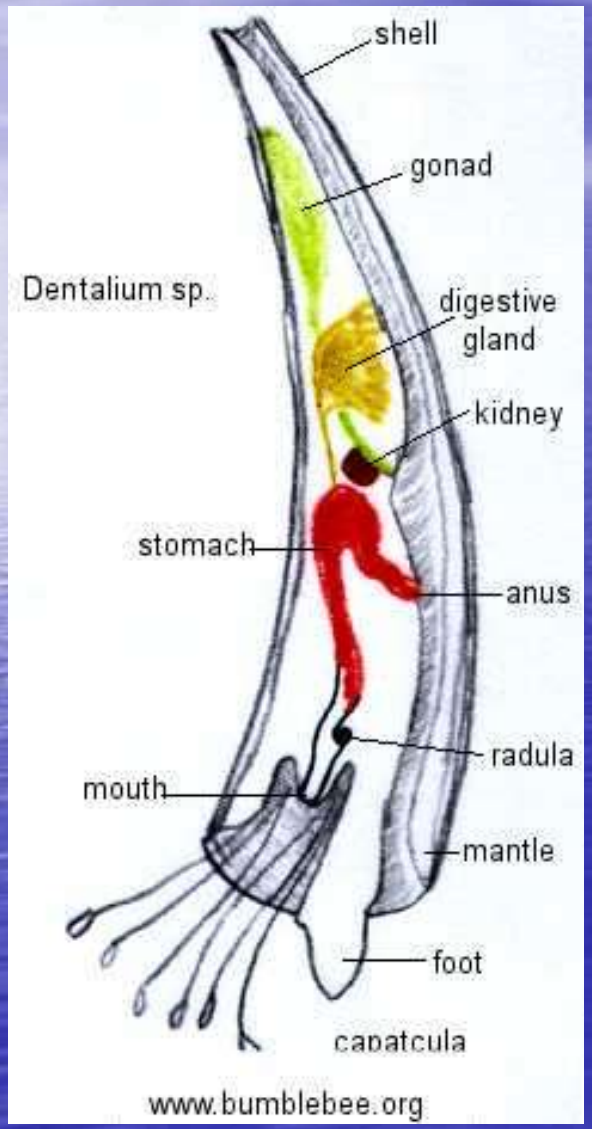


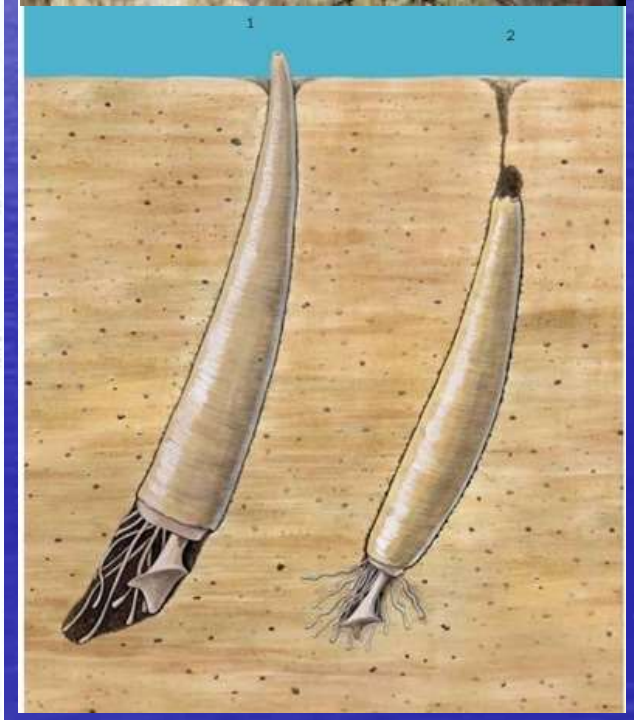
- 500 species, all marine, sedentary, living buried under layers of sand on the sea bed & feed on foraminifera & other detritus

- No gills, the mantle assumes this function, no head, eyes or true tentacles. Use sticky Capatcula 頭絲 to catch plankton as food

- Do not exceed 12 cm in length

Cross section of a tusk shell, its habitat & fossils





5. Cephalopoda 頭足綱

- "Head footed"
- All marine
- Prominent head, mouth (beak), eyes with advance vision, set of arms or tentacles varying from 8 to 90 plus
- Swim by jet propulsion or scramble
- Most have ability to squirt ink
- 900 species, all marine, most without shells
- They are the most advanced & intelligent of all mollusk
- One extinct & two living subclasses :

  a. Ammonoidea 菊石亞綱 all extinct

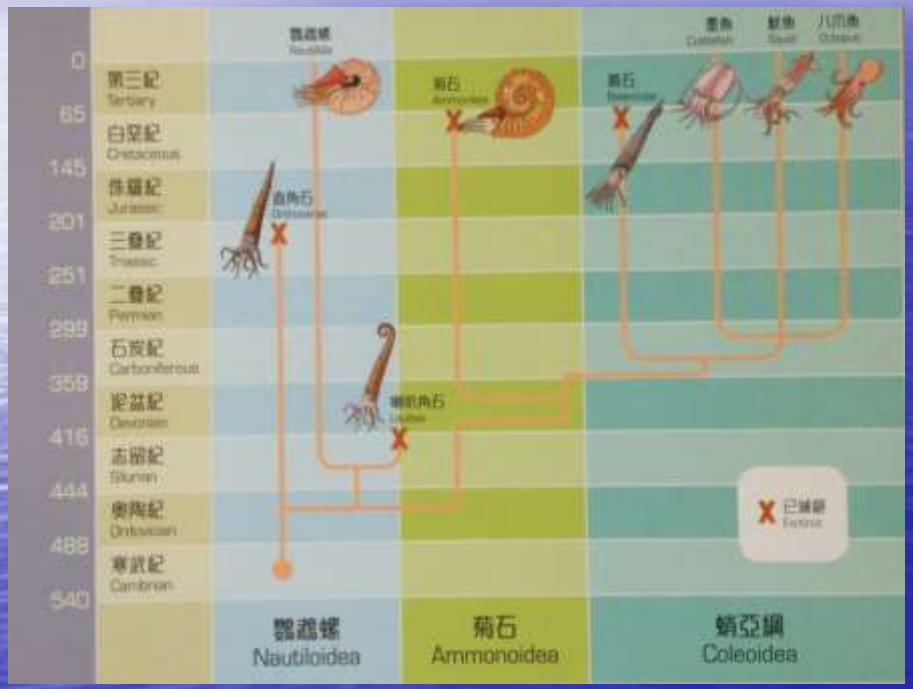
  b. Nautilodea/ Tetrabranchia 鸚鵡螺亞綱 /四鰓亞綱 (Nautilus, Allonautilus) Tetrabranchia meaning having 4 gills

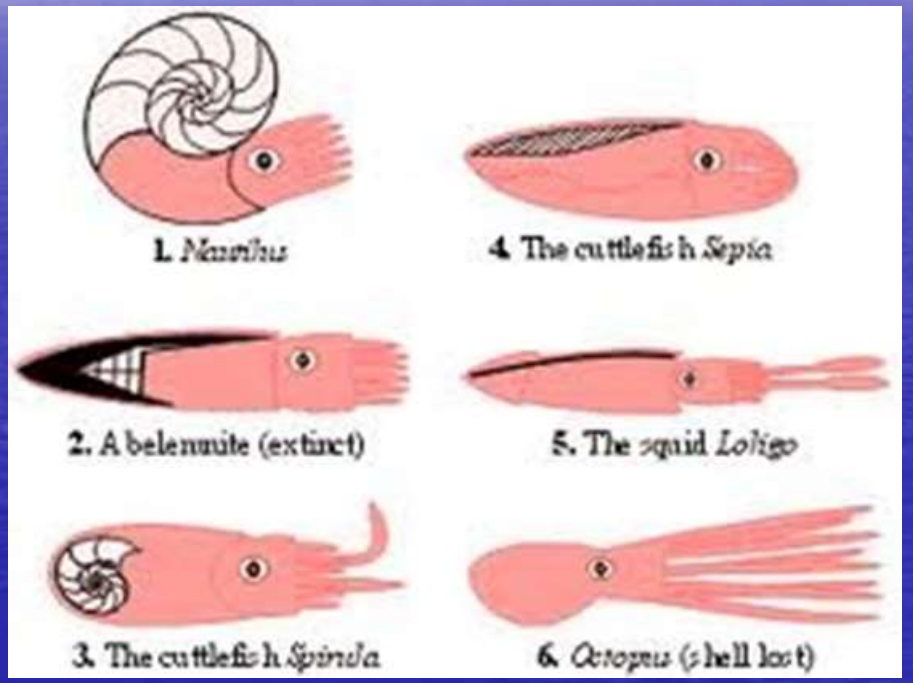
  c. Coleoidea / Dibranchia 蝤亞綱/二鰓亞綱，(cuttlefish, squid, octopus) dibranchia meaning having 2 gills

- 800 extinct relatives including *orthoceras*, *cameroceras* & *belemnite*

Evolution of Cephalopod

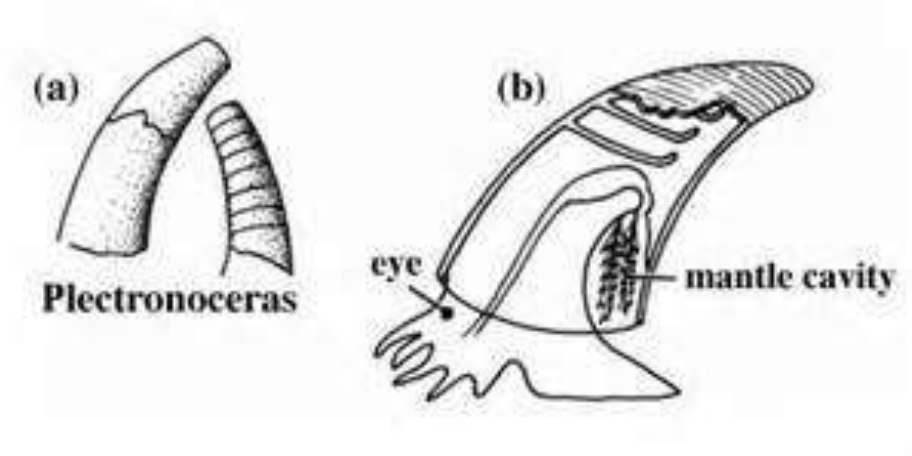
From outer shell (exoskeleton) to inner shell (endoskeleton) to shell less

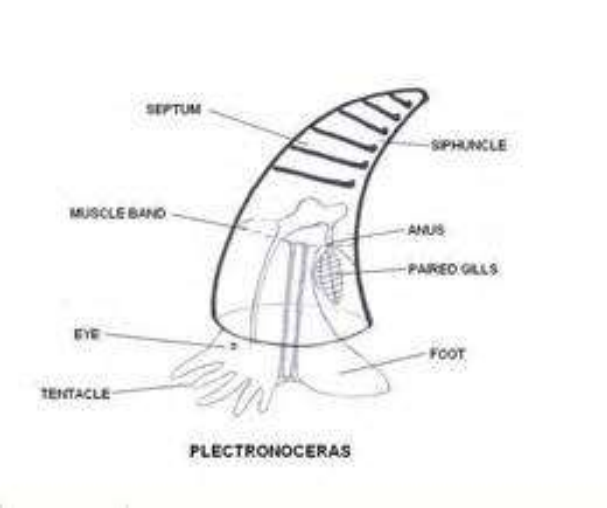




Plectronoceras 短棒角石

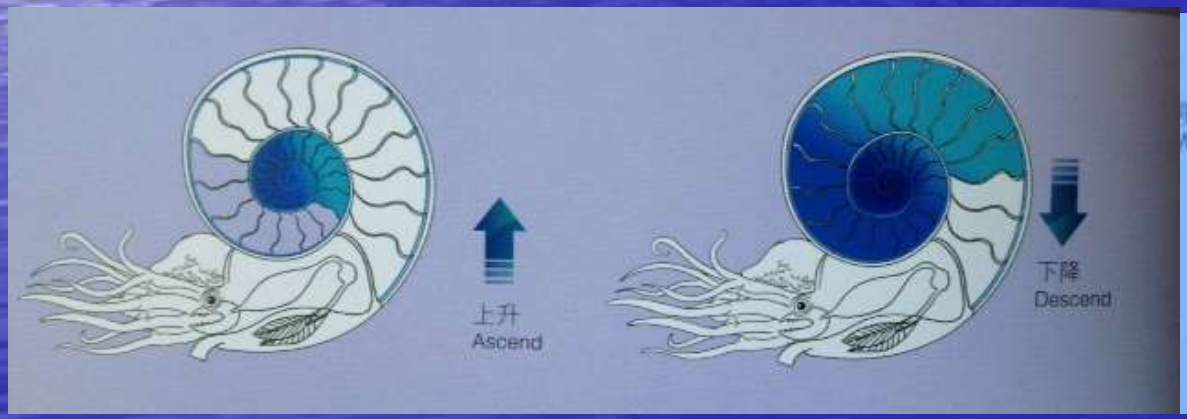
The oldest shelly cephalopod found at the Burgess shale (Upper Cambrian). 14 specimens were found in north-east China from the basal Fengshan Formation. None of the fossils are complete



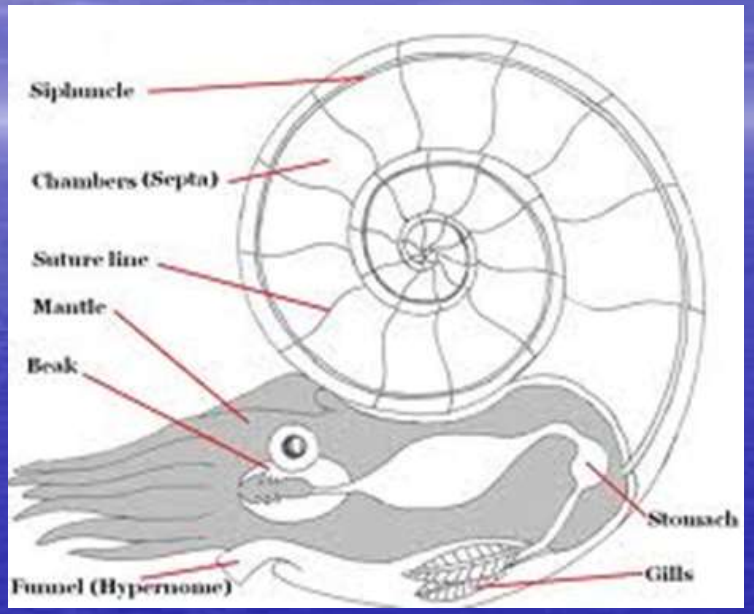


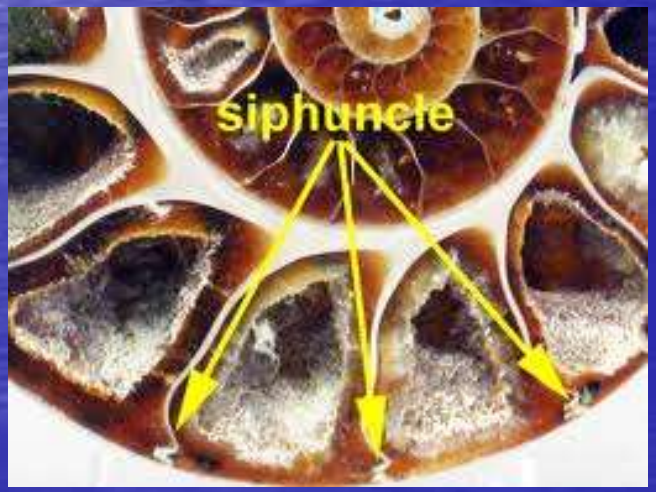
a. Ammonoidea 菊石亞綱

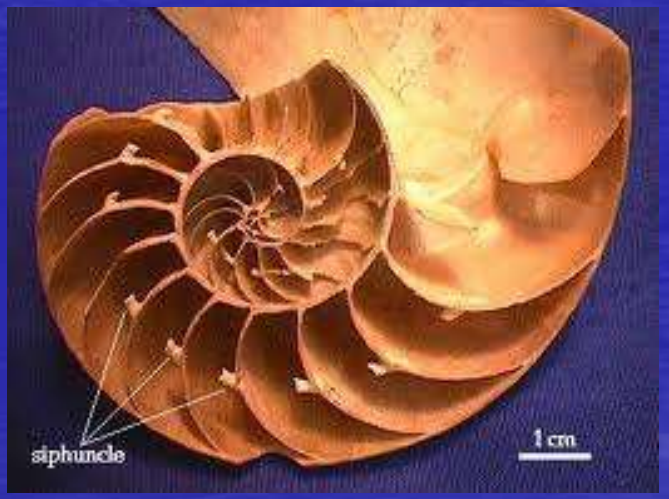
Named after the Egyptian god of fertility Ammon which has the head of a ram. Flourished in the Mesozoic. Ichthyosaurs favorite food. Extinct together with the dinosaurs after the K-T Event



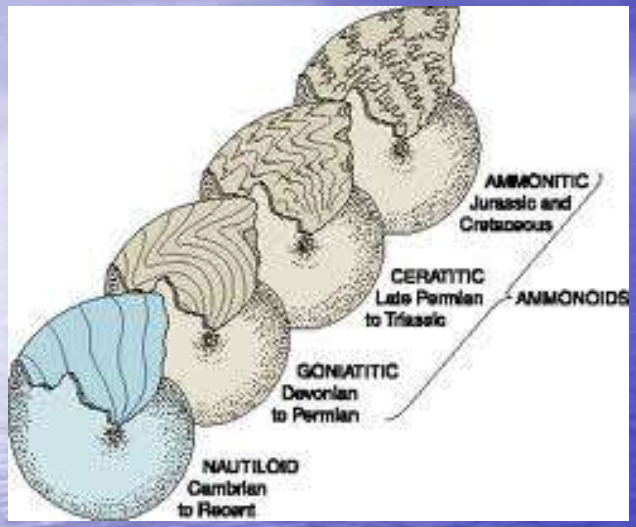
Cut section of Ammonite showing the chambered partitions separated by scepters 隔板 & position of siphuncle 體管 relative to nautilus







Ammonite showing complex seam or suture lines (growth lines) 縫合線 compared to much simpler nautilus



Parapuzosia is a giant ammonite 3 m in diameter & weighed over one ton. These fossils are found in the UK

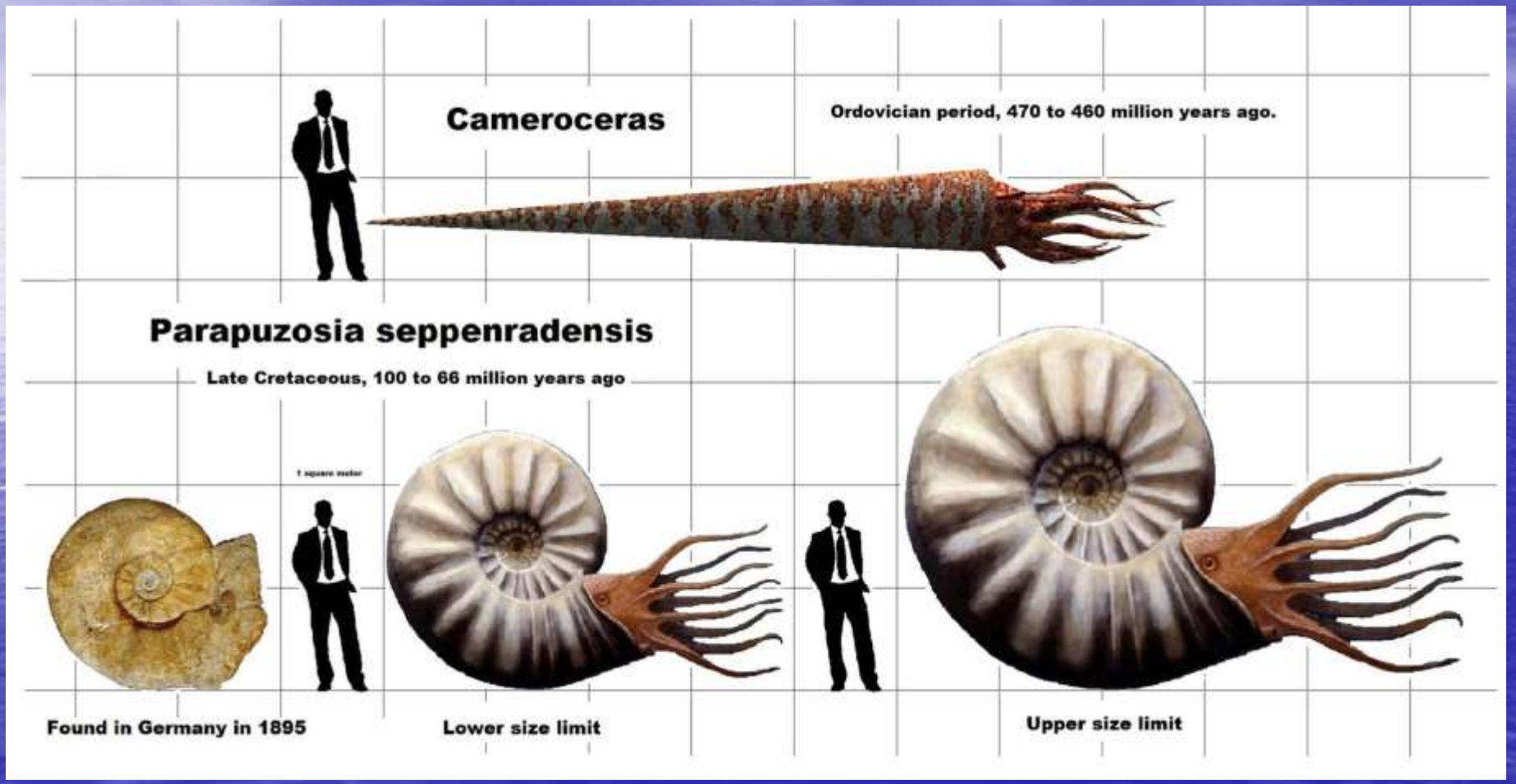
Heteromorph ammonites

These are ammonites with uncoiled shells. Examples include *Helioceras and Nipponites*

b. Nautiloidea 鸚鵡螺亞綱

Orthoceras 直角石 is an extinct nautiloidea. The species *Cameroceras* can be more than 11 m in length !

Ancient giants



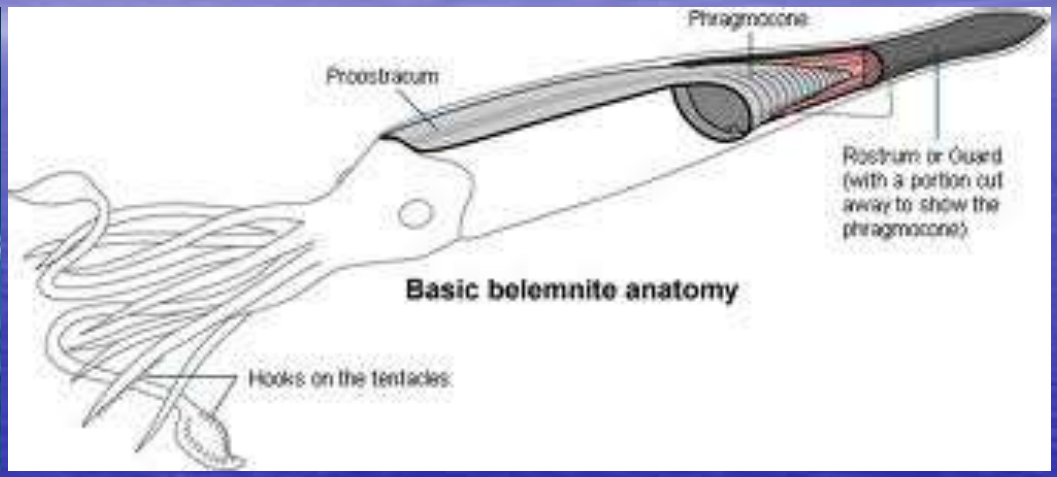
Lituites 喇吧角石 is another extinct nautiloidea

Modern Nautilus

6 species all Tetrabranchia 四鰓亞綱. Note the chamber partitions 氣室 & sipuncle 體管 for adjusting buoyancy, its 90 tentacles called cirrus, parrot like beak strong enough to crush crustaceans & the funnel or hyponome used for jet propulsion. Nautilus has no ink sac & also short sighted

c. Coleoidea 蝤亞綱

Belemnite 箭石 is an extinct Coleoidea which is also called "Thunder stone". Some belemnites can be 30 cm long e.g. *Megatheuthis.*



Living Coleoidea

900 species all Diabranchia 二鰓亞綱 under 3 orders :

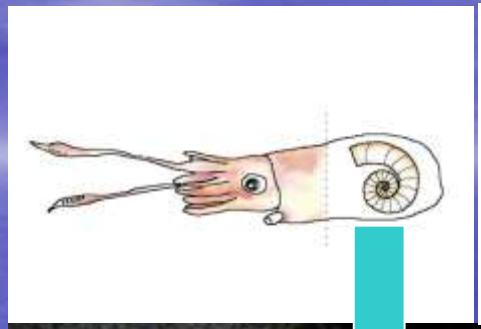
1. Teuthoidea 槍形目 including squid 魷魚/槍烏賊,

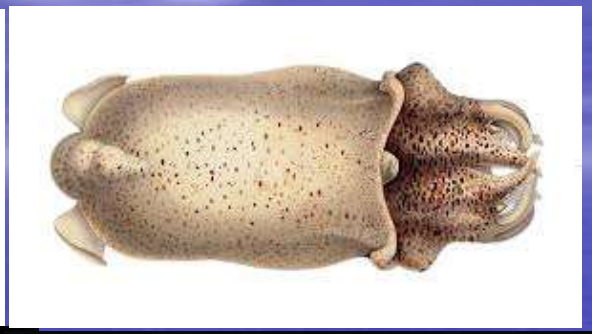
2. Octopoda 八腕目 including octopus 章魚/八爪魚

3. Sepiidac 烏賊目 including cuttlefish 墨魚/烏賊/花枝

No outer shell. Some with inner shell

Inner shells of cuttlefish (cuttlebone 海螵蛸), squid (gladius) & spirula spirula (捲殼烏賊) are made of chitin like our finger nails



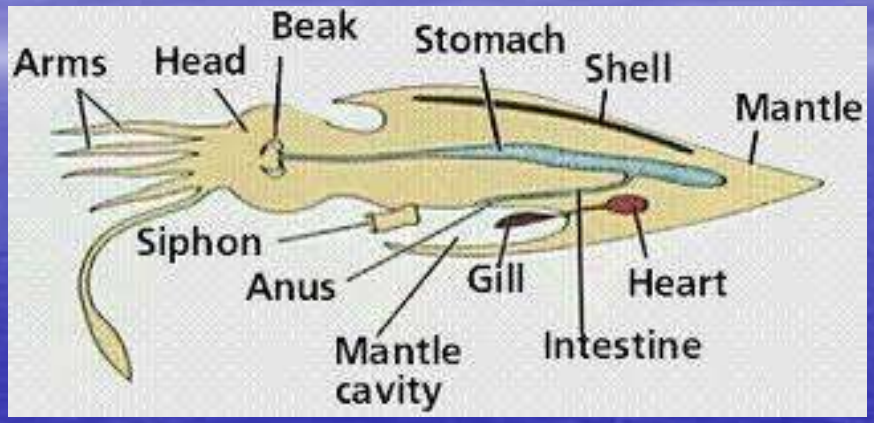


Argonauts or "Paper Nautilus" 船蛸

These are pelagic octopus totaling 4 species namely Greater, Brown, Rough-keeled & Tuberculated. The "shells " are actually paper-thin egg case called ootheca which is secreted by the female's flat arm. The male is only 1/5 the size of the female which is at 10 cm, a typical case of sexual dimorphism

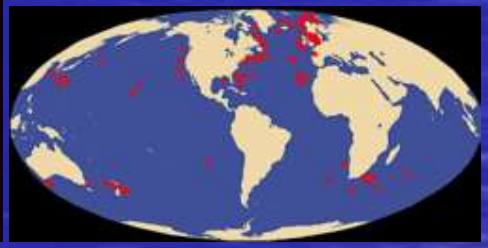
Humboldt squid (*Dosidicus gigas*) 美洲大赤魷

1.4 m long living in depth 200/ 700m body flashing red & white to confuse the prey & coordinate attack



Giant squid (*Architeuthidae architeuthis*) 大王魷

10 to 13 m long, sperm whales favorite food, life span 1.5 years



Colossal Squid (*Mesonychoteus hamiltoni*) 大王酸漿魷

Also known as Antarctic squid or Giant cranch squid, it is 14 m long being the largest of all invertebrate & also has the world's largest eyes (diameter 35 cm) & 7.6 cm hooks which can rotate 360 degrees on its base. Has 3 hearts & its blood is blue ! First complete specimen only caught in 2003

Giant Cuttlefish (*Sepia apama*)

World's largest cuttlefish weighing over 10 kilos & 50 cm in length

Giant Pacific Octopus (*Enteroctopus defleini*)

Weighing 70 kilos it is the largest of all octopus. Octopus can change skin color through pigment sacs called chromatophores & change its skin texture as well. Its arms have powerful suction cups which can also taste food. Apart from ink it can produce a pseudo morph to confuse attackers

Octopus has 300 species some of which are beyond one's imagination. They can change color by controlling the chromatophores which are cells embedded in the mantle that are filled with pigment granules. Despite this ability all of them are color blind ! Note the Blue Ringed Octopus & the Mimic Octopus









Bizarre octopus & squids living in the abyss - "Dumbo" & "Dracula"







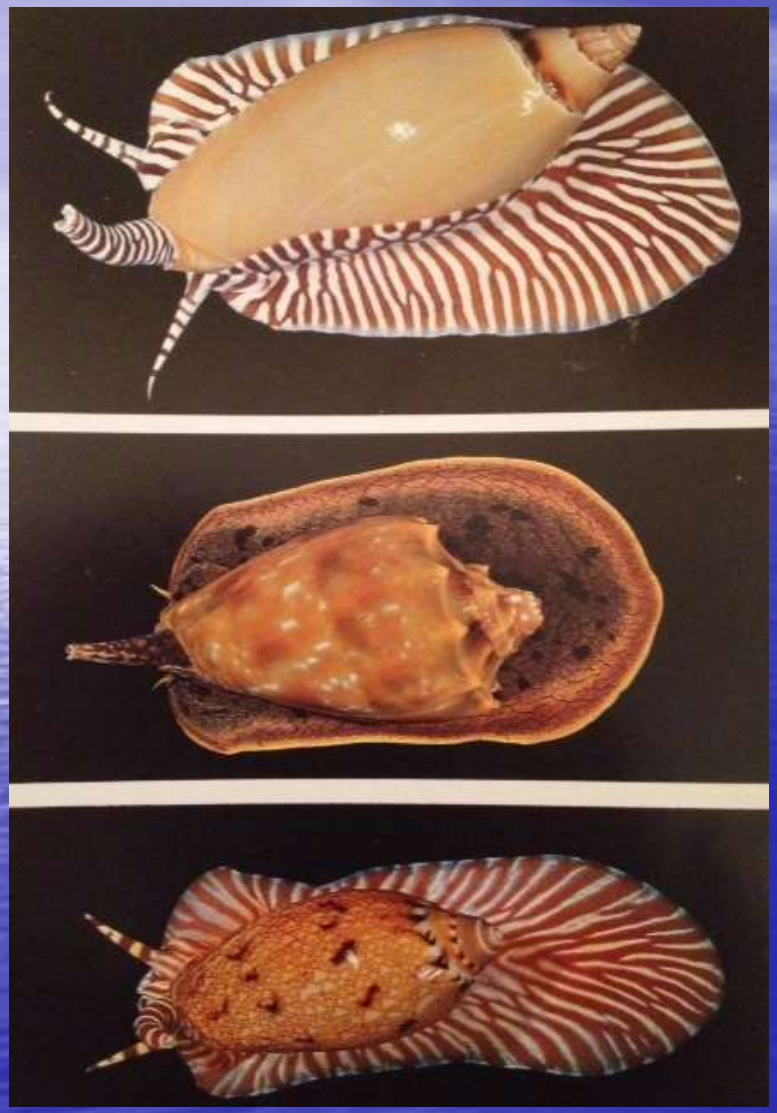




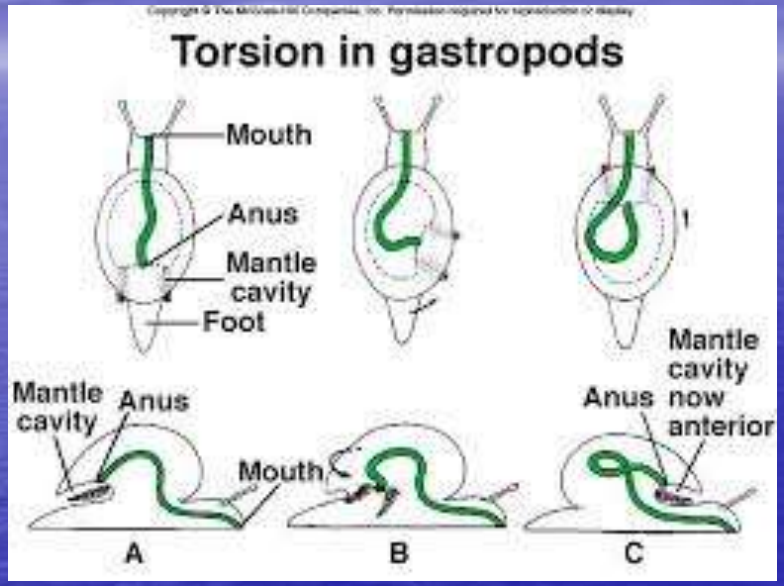
6. Gastropoda 腹足綱

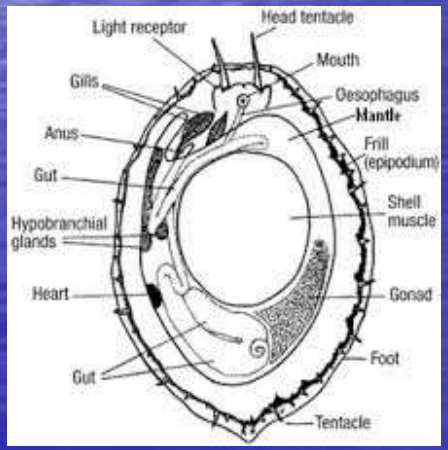
- Previously known as univalves & commonly called snails 蝸牛 (with shell) or slugs 蛞蝓 (without shell)
- 85,000 species, marine, fresh water & only mollusk managed to overcome many challenges to live on land
- Most have spiral shells, with head & siphon 吸水管, well developed **muscular foot**, some with operculum 口蓋
- Crawl or swim, some burrowers

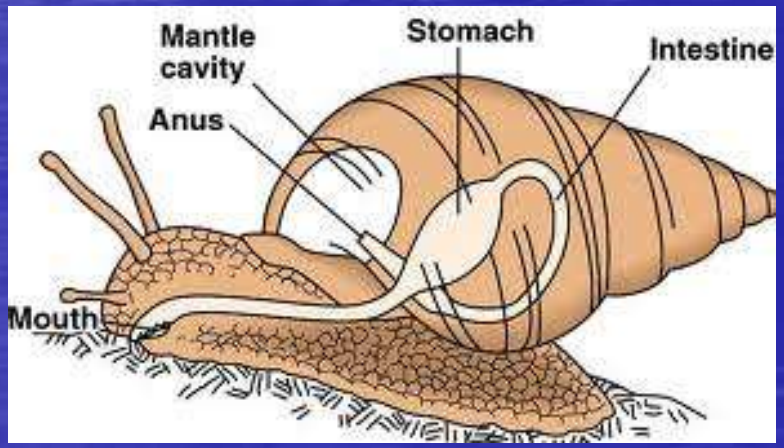
The beautiful "**foot**" of gastropods

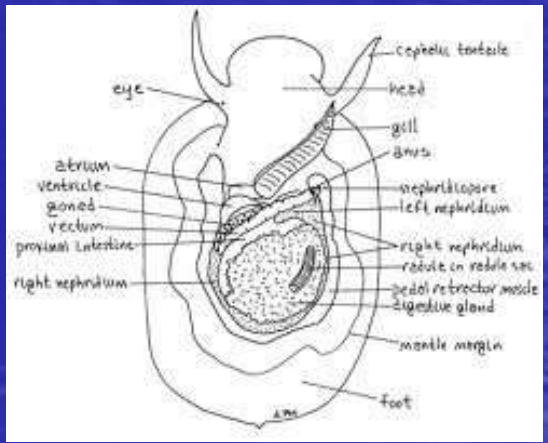


- Characterized by a 180 degree counterclockwise torsion on a horizontal plate during the growth process mainly to allow the animal to retract into the shell but created problem for waste disposal as the anus is now on the same side of the mouth. Due to torsion, adult gastropods are asymmetrical in form









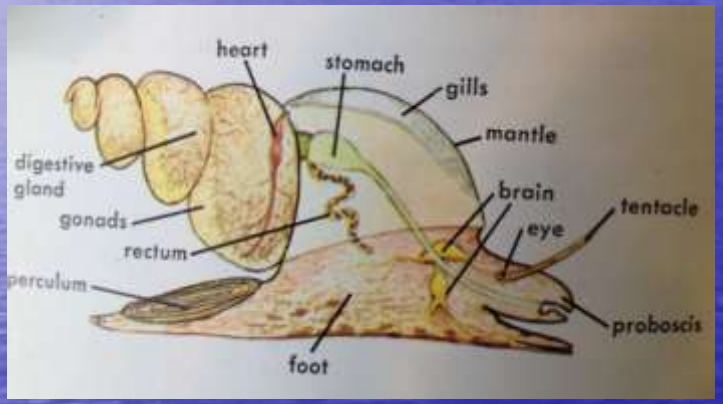
- The insanitary effect of the 180 degree counterclockwise torsion have led to the development of slit (slit shell), keyhole (Limpet), pores (abalone) & ultimately the siphon

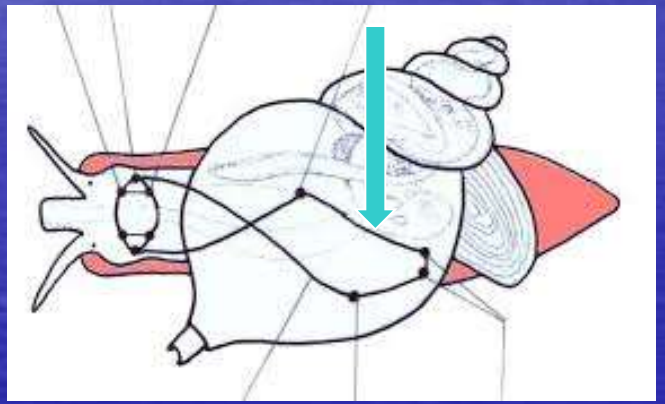
Gastropods can be subdivided into 3 main subclasses :

- **Prosobranchia** ： 前鰓亞綱
- **Opistobranchia** ： 後鰓亞綱
- **Pulmonata** ： 有肺亞綱

Prosobranchia 前鰓亞綱

- Majority of marine gastropods are prosobranchia. They breathe with fore gills located in front of the heart & have operculum . Also called Streptoneura 扭神經綱 as its nerve cord is twisted into a figure of eight. This is most numerous, widely distributed & diverse including sea snails & fresh water snails

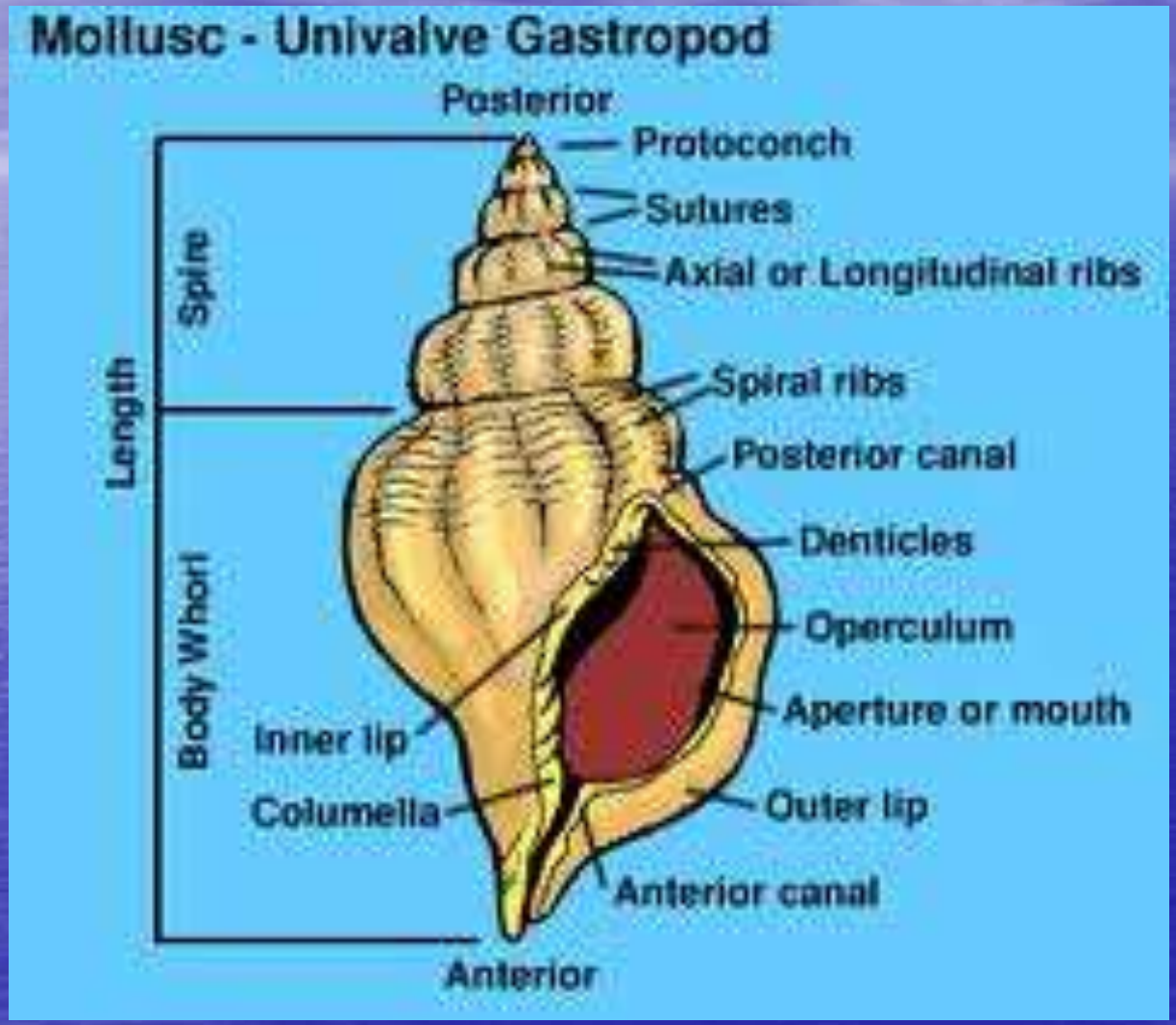




- 4 orders :

1. Archaeogastropoda e.g. Slit, Abalone, Limpet, Top, Turban
2. Mesogastropoda e.g. Nerit, Cerith, Conch, Cowry
3. Neogastropoda e.g. Murex, Whelk, Olive, Volute, Cone
4. Heterogastropoda e.g. Sundial, Wonder shell

Morphology of a prosobranchia shell

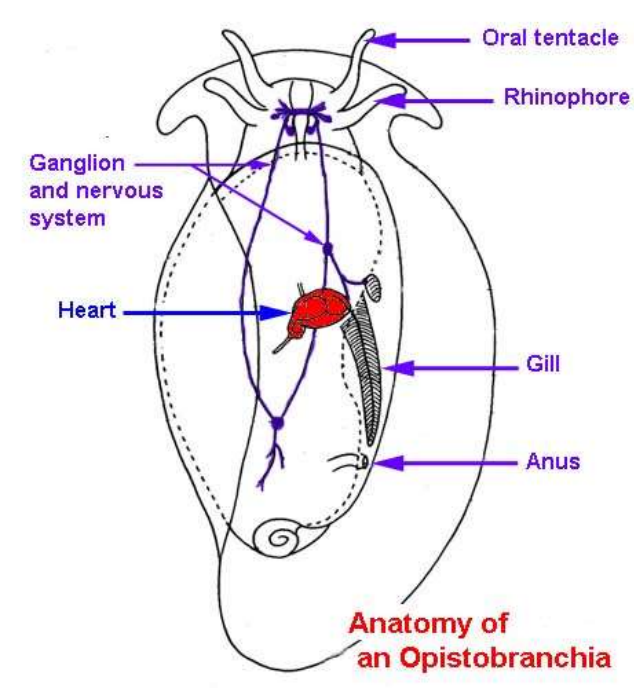


Different types of operculum 口蓋/廕

Can be horny like finger nails or calcareous hard as stone

Opisthobranchia 後鰓亞綱

- Commonly called Sea Slugs 海蛞蝓 most are without shell & with gills behind the heart, all marine. Those with shells are extremely thin & brittle. 3,000 named species with many thousands more to be discovered & studied



Examples of Opisthobranches – few still have shells & most are poisonous !









- Opistobrochia have 8 orders :

1. Cephalaspidea 頭盾目 e.g. bubble shell 捻螺
2. Sacoglossa 嚢舌目 e.g. Sea Cows 海天牛
3. Anasipidea 無盾目 e.g. *Aplysia* or Sea Hares 海兎
4. Notaspidea 背盾目 e.g. *Pleurobranchaea*
5. Nudibranchia 裸鰓目 e.g. Doris 海牛
6. Acochlidiacea 無殻目 e.g. Acochlidium
7. Thecocomata 被殻翼足目 e.g. Sea Butterfly *Cavolina*
8. Gymnosomata 裸体翼足目 e.g. Sea Angels

All have undergone "Detorsion" which is a evolutionary reversal

They can be herbivores, carnivores or detritivores*. The food for the carnivores includes protozoans, cnidaria, & sponges (*decomposing organic matters)

Self protection is by secretion of irritants such as strong acids as well as toxics which they have accumulated from their food

1.Cephalasopidea 頭盾目

Characterized by having very thin shells e.g. *Bulla* or bubble shell









2. Sacoglossa 襄舌目

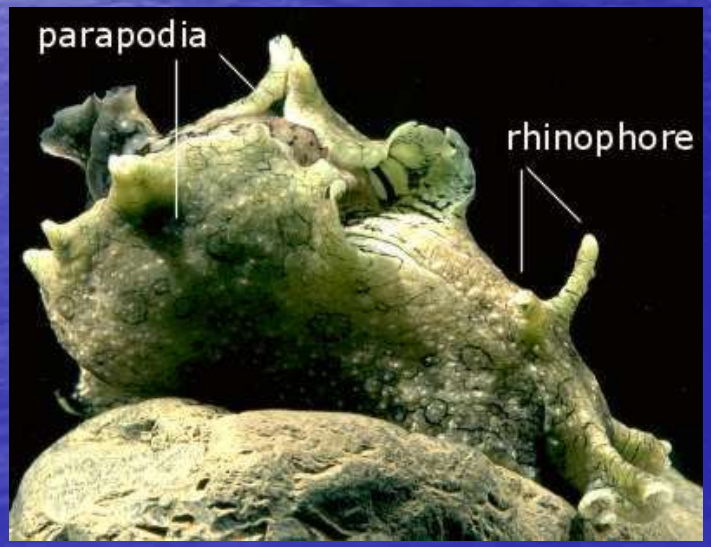
Two clades one with shell the other without. Possess small sag to collect the redundant radula. Commonly known as "sap sucking slugs". Many species can utilize the chloroplast of the algae they eat to carry out photosynthesis earning them the title of "Solar powered sea slugs" (kleptoplasty). This exceptional capability challenges the fundamental definition between plant & animal






3. Anasipidea 無盾目

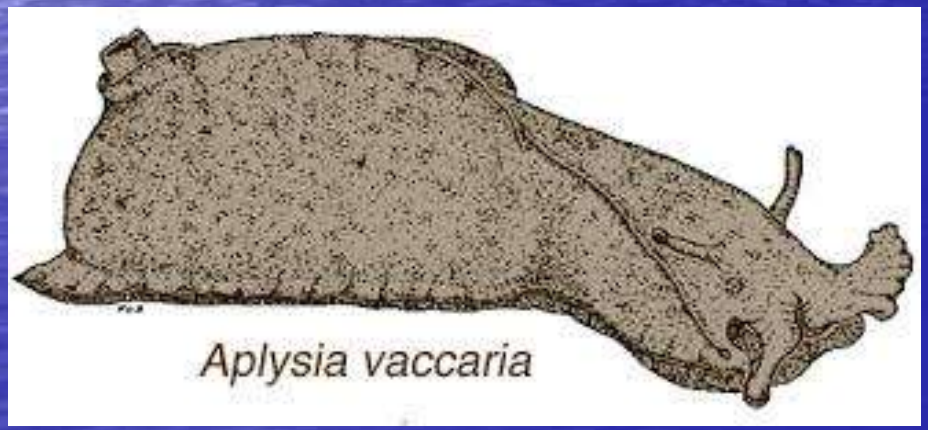
Commonly known as "sea hares" 海兔 with a soft internal shell made of protein. Most sea hares are herbivore & they are being eaten by man in China, Korea & Hawaii.

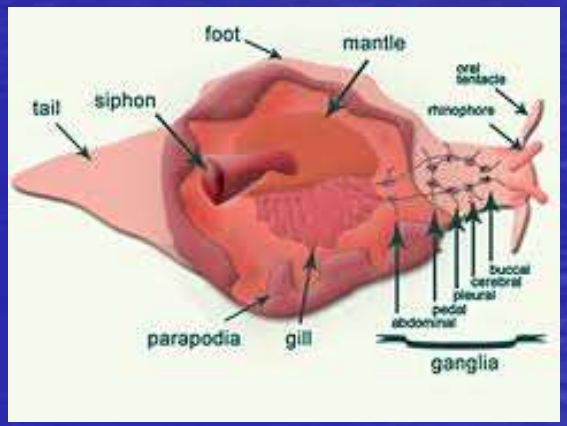


Sea Hares from Jizhou Island, Korea are sold as food

Sea hare living in Tung Ping Chau's tidal pool, probably *Aphysia kurodai* 黑斑海兔

The largest sea slug is a sea hare called *Aplysia vaccavia* (California black sea hare). At 1 m long weighing 14 kilos it is found along the west coast of North America





4. Notaspidea 背盾目

Commonly known as "side gill slugs" 側鰓海蛞蝓 with the ctenidum 本鰓 located on the right side & a flattened shell

5. Nudibranchia 裸鰓目 (海牛)

All have exposed secondary gills & a pair of rhinophore 犄角 for smelling







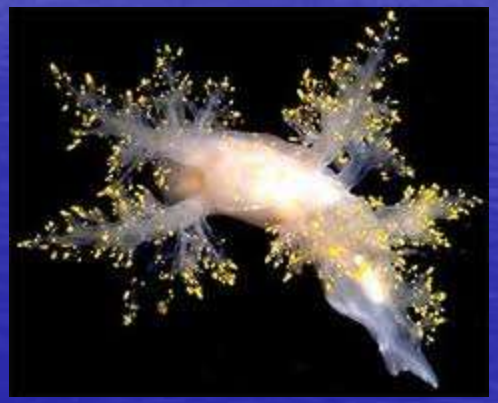


More examples of Nudibranch. Note the famous "Spanish Dancer"







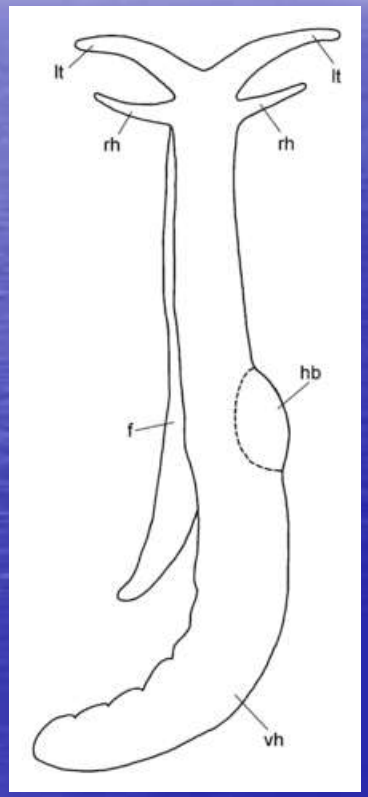



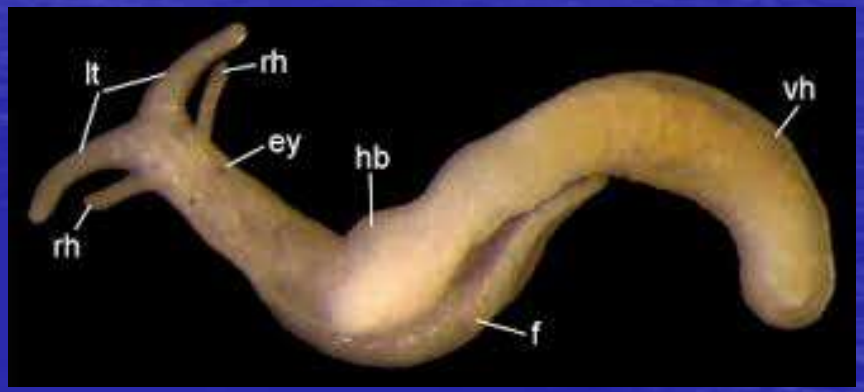


The smallest sea slug is *Glaucus atlanticus* which is also a nudibranch. At 3 cm long it is also known as the Blue Angel 藍天使, Blue Dragon 藍龍 or Sea Swallow. Its favorite food include the dangerously venomous jelly fish called the Portuguese Man O' War & the purple snail *Janthina Janthina*

6. Acochlidiacea 無殼目

With only 30 species they are very unusual sea & fresh water slugs which are very small, without a shell or gills and distinguished by the visceral mass (vh) 內臟團 being sharply set off from the rest of the body e.g. *acochlidium*





7. Thecosomata 被殼翼足目

Represented by the Sea Butterfly 海蝴蝶 it is a large group of small pelagic swimming carnivorous sea slug with underdeveloped shells. They are also known as the "canaries of the sea " monitoring the environment (ocean acidification)

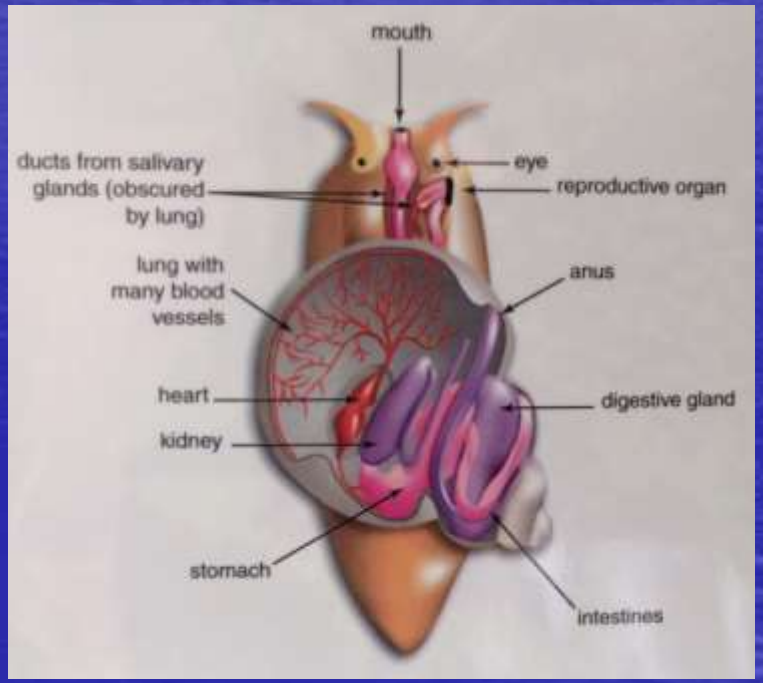
8. Gymnosomata 裸体翼足目

It is a large group of small pelagic poisonous swimming carnivorous sea slugs represented by the Sea Angels 冰海精靈 /海天使（ *Clione limachina*）. 6 different families and a wide geographical range from polar regions under the ice to equatorial seas.

Sea Butterflies & Sea Angels are predators used to be called pteropods ("wing-foot")

Pulmonata 有肺亞綱

- Instead of gills they breath air with pallial lungs formed by heavily vascularized mantle wall. No operculum. Only 200 plus families but most ambitious physiologically as they live on land as land snails 陸蝸牛, semi slugs 半蛞蝓 & land slugs 陸蛞蝓. Challenges include how to breathe air, dehydration, reproduction, shell making & food



Pulmonata has two orders*

- Basommatophora 基眼目 with only one pair of tentacle e.g. *Lymnaea*
  Most are fresh water snails & therefore have to surface to breath



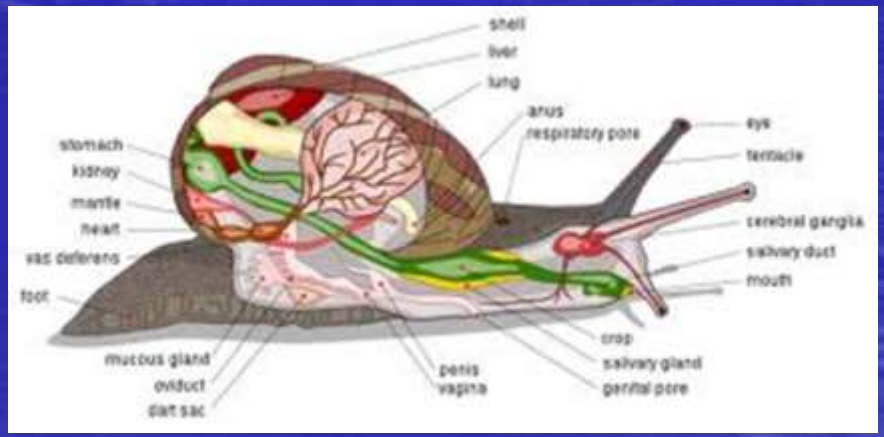
- Stylommatophora 柄眼目 with eyes located at the tips of the second pair of tentacles , represents 80% of all land snails e.g. *Helix*



(* land snails also include a more ancient lineage which includes a gill & operculum)

Land Snails 陸蝸牛

- Land snails evolved about 350 Ma
- 70 families with 24,000 species
- Largest 35 cm weighing over 6 kilos. Smallest only a few cm
- Life span between 5 to 25 years
- Majority Hermaphrodite but need to exchange sperms
- Slow movement – fastest garden snail creeping at 6 cm per minute
- Secreting slime to assist movement & keep their body from drying out
- Most are nocturnal & herbivores
- Cannot hear & with poor vision rely on smell
- Most hibernate in winter or when it is very dry



Samples of Land Snail 陸蝸牛









Some unusual Land Snails 陸蝸牛

Tree Snails 樹蝸牛

Common name for tropical air breathing arboreal snails









More Tree Snails 樹蝸牛









Semi Slugs 半蛞蝓

Some land snails' shell have degenerated to such an extent that the animal can no longer retract into










Land slugs 陸蛞瑜 /鼻涕虫

These are shell-less land snails with soft slimy bodies confined to living in humid environment



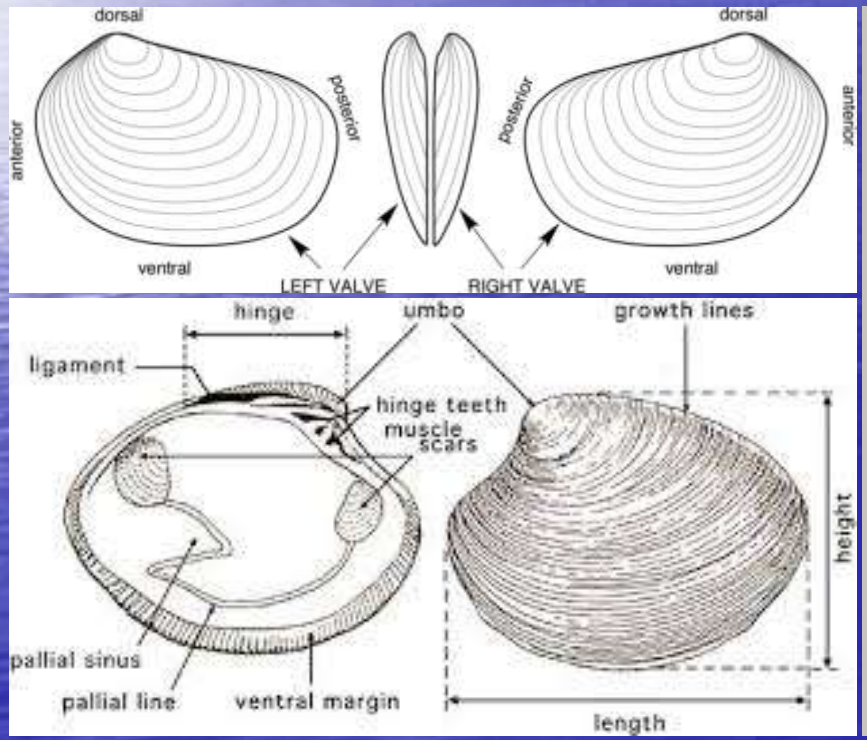




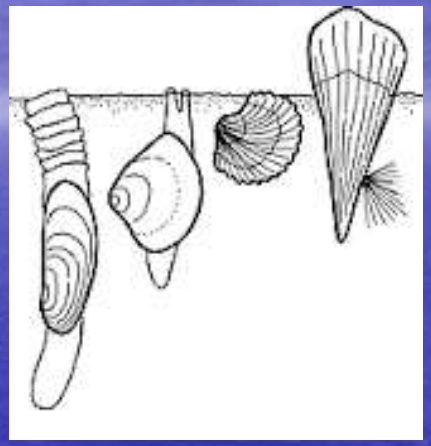


7. Bivalvia/ Lamelibranchia 雙殼綱/瓣鰓綱 (二枚貝)

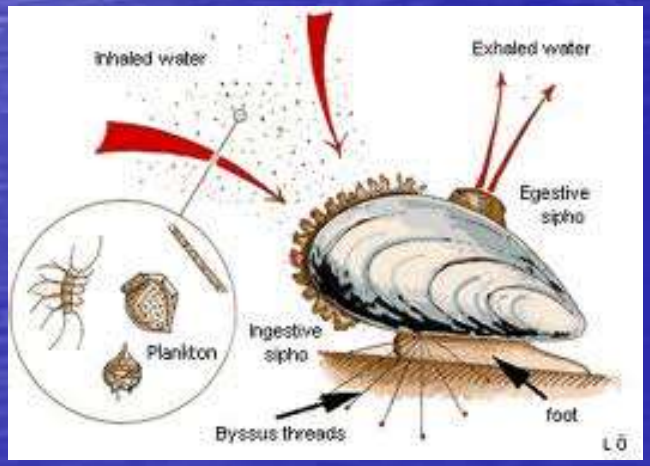
- 10,000 species with 8,000 marine and 2,000 living in fresh water
- Shells consisted of two valves (left & right) which are joined at the top held open by the ligament hinge 韌帶較located on each side of the umbo and kept closed by the adductor muscles 閉殼肌 . Some also have hinge toothed which is an important feature for identification

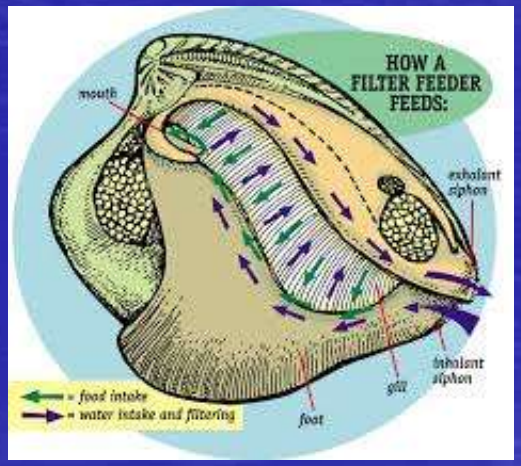


- Some like clams have axe shaped foot 斧足 (*Pelecypoda*) for digging into the sand. Some like oyster & mussels are sedentary. Some like scallops just lie on the sea bottom.



- Filter feeders 濾食 eating detritus & algae through cilia 纖毛 Usually have two siphons for intake and outflow of water. Breathing through plate like gill called ctenidia 瓣鰓 (*Lamellibranch*)





Bivalve have 5 suborders

- Palacotaxodonta 古裂齒亞綱
  e.g. *Nucula* 胡桃蛤
- Ptreimorphia 翼形亞綱
  e.g. *Arca* 蚶目, *Mytilus* 貽貝目, *Pinctada* 珠母貝目, *Ostrea* 牡蠣目
- Palaeoheterodonta 古异齒亞綱
  e.g. *Unionoida* 蚌目
- Heterodonta 异齒亞綱
  e.g. *Veneroida* 窗蛤目, *Myoida* 海螂目
- Anomalodaesmacea 异韌帶亞綱 e.g. Pholadomyoida 箏螂目, Septibranchida 隔鰓目

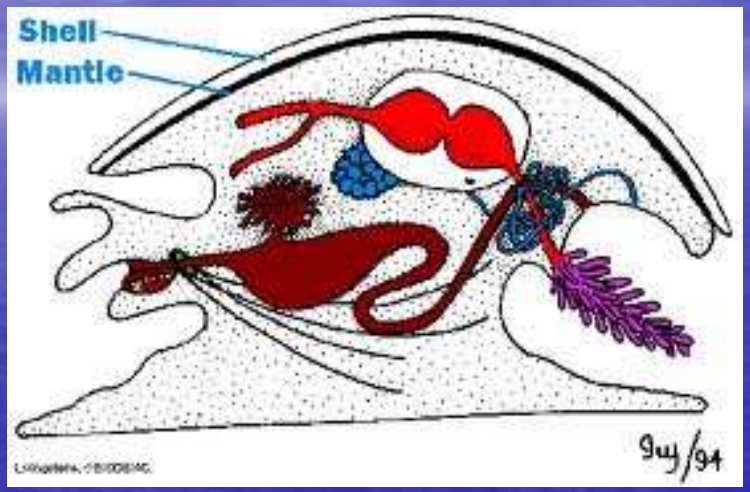
Major Bivalve families

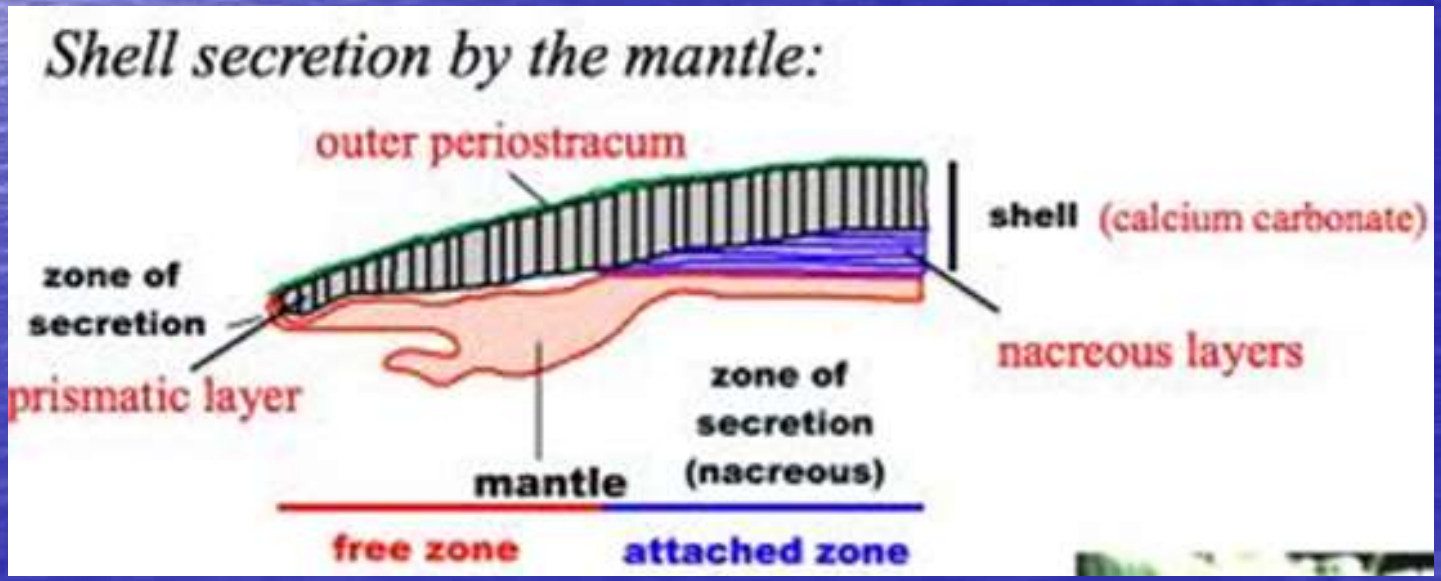
- Arcidae : ark shell 魁蚶
- Mytilidae : mussel 貽貝
- Pinnacea : pen shell 江珧
- Ostreidae : oysters 牡蠣
- Pectinidae : scallop 扇貝
- Cardidae : cockles 蚶
- Tridacnidae : giant clam 陣磲貝
- Cultellidae : razor shell 竹蟶
- Veneridae : window clam 窗蛤
- Lucinidae : full moon clam 滿月蛤
- Tellinacea : cherry clam 櫻桃蛤
- Solenacea : Jack knife clam 刀蟶
- Unionidae : freshwater clams 淡水蚌

Shell Making

Shell making

- Mantle 外套膜 , the shell maker secrets calcium carbonate ($CaCo_3$) & conchiolin 貝殼素 as well as color pigments to create the shell





Cowries with mantle extended. Note the line marking where the tips of the mantle meet

More Cowries displaying many different types of mantle

4 layers :

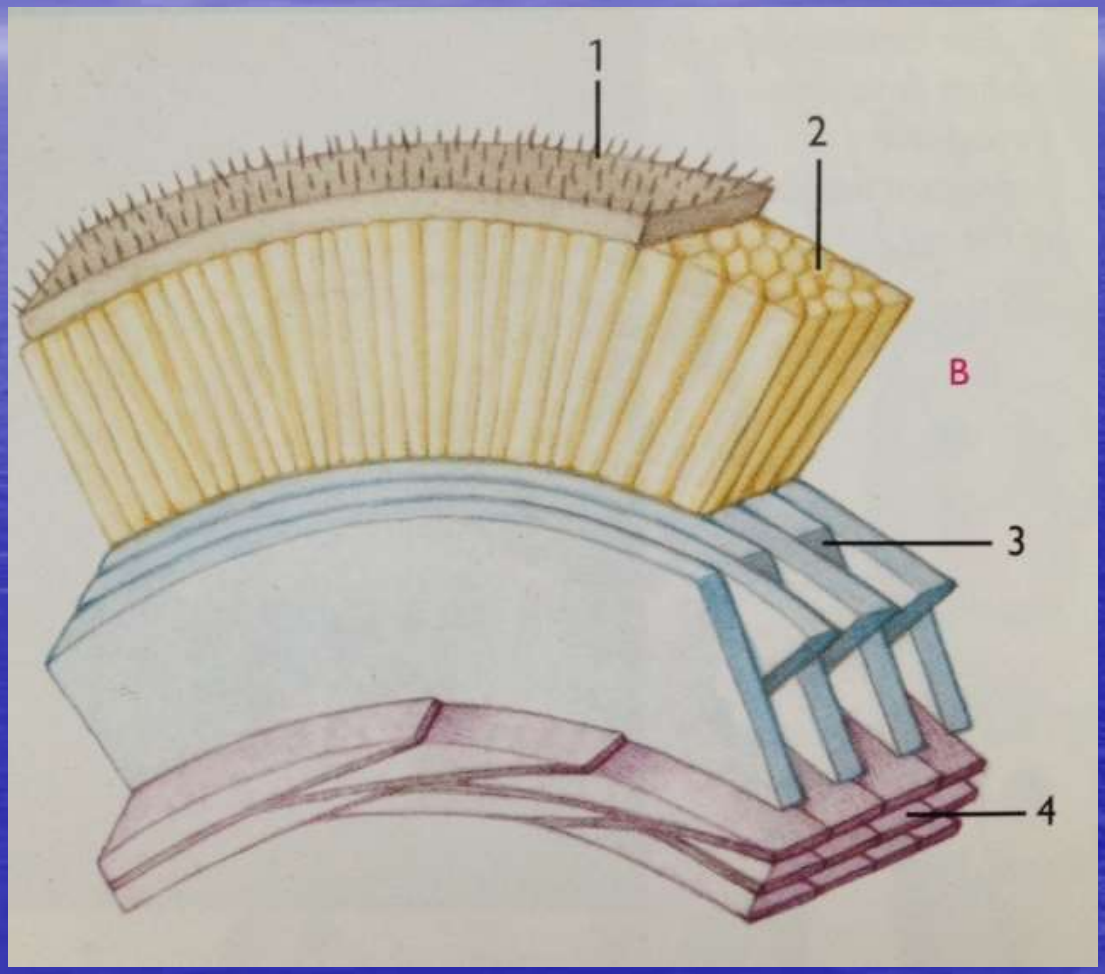
1. Periostracum 殼皮/角盾層 – consisted of organic protein (conchiolin 貝殼硬蛋白) 幾丁質

2. & 3. Ostracum 殼層 – made of aragonite or calcite
   layer one prismatic 梭柱層
   layer two laminated

4. Hypostracum 殼底 – either porcellaneous or nacreous both of which are acid resistant. The latter is iridescent formed by Mother of pearl 珍珠層 composed of very fine layer of aragonite 霰石

Calcite 方解石 /Aragonite 霰石 ($CaCO_3$) form layered structure of the shell :

1 Periostracum 2 & 3 Ostracum 4 Hypostracum



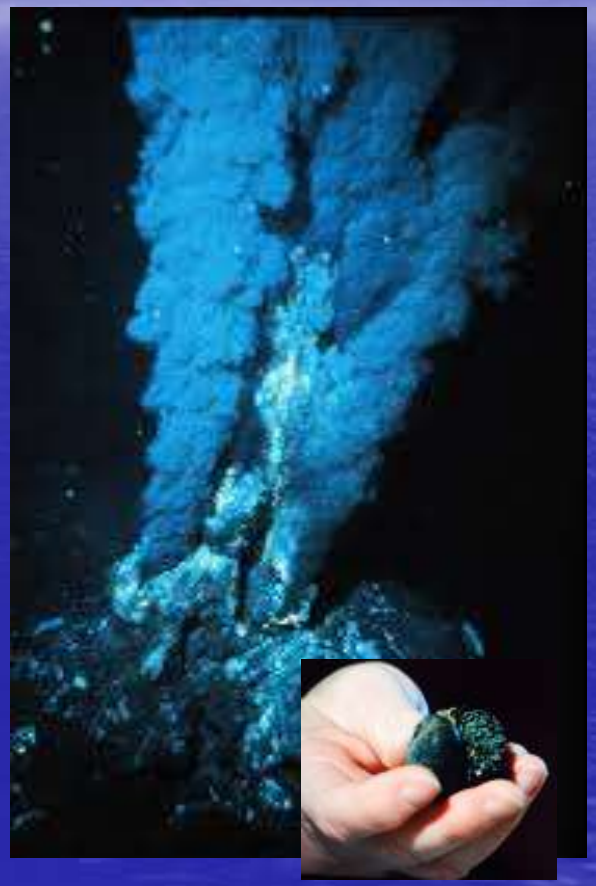
Hypostracum - the nacreous, Mother of Pearl or porcelaineous layer 珍珠層 , some are iridescent (change in surface color)





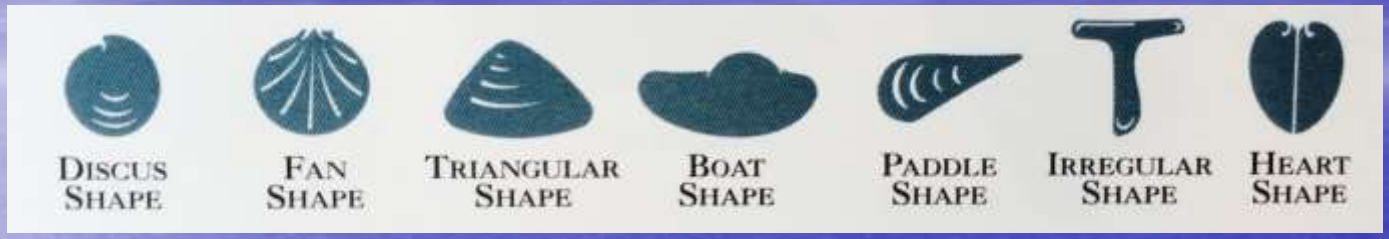

Crysomalion squamiferum 鐵甲深海螺

- Also called Scaly Foot Snail, it is a very unusual gastropod discovered in 2001 on the base of a "black smoker" at the Kairei hydrothermal vent in the Indian Ocean which is armored with iron-mineral scales on its foot (Fe_3S_4) to protect against turrid snails !



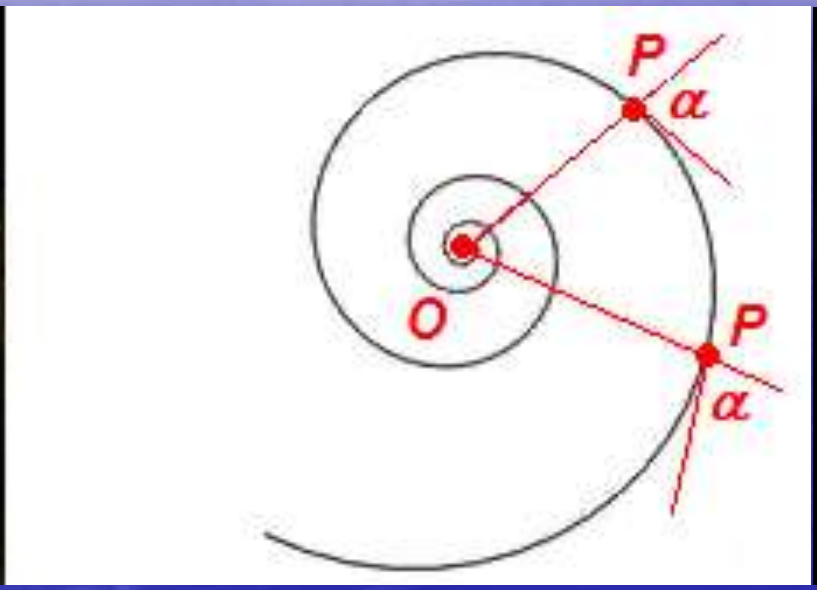
Shell designs

- Many different designs – disc, fan, triangular, boat, paddle, heart, club, pear, cone, ear, hat, egg, spindle & irregular



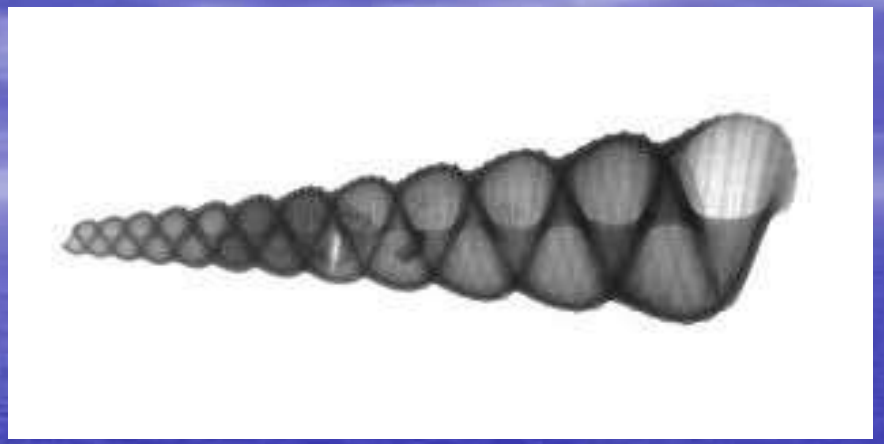
- Logarithmic spiral 等角螺線 – horizontal (coiled) or vertical (spiraled), basic shape unchanged but enlarged
- Nautilus has symmetrical coil
- Gastropods is asymmetrical coiled to one side which can be clockwise with the aperture on the right hand side known as dextral or anticlockwise with the aperture on the left hand side known as sinistral

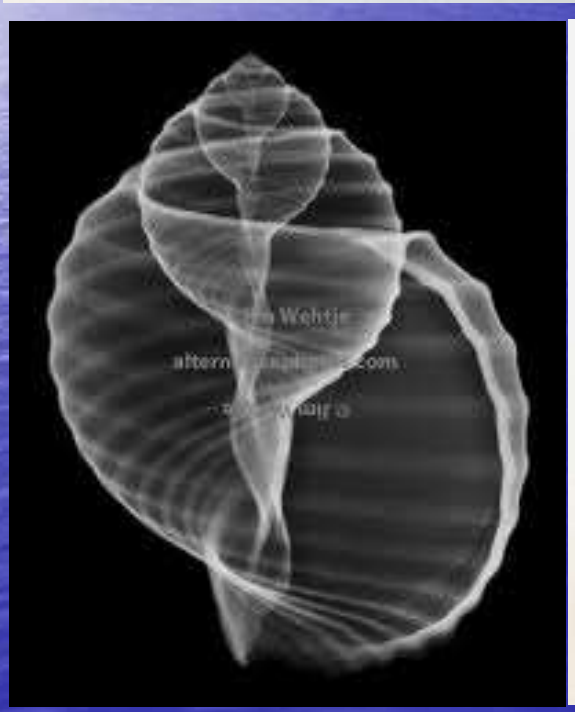
Cut away view of a Nautilus shell with logarithmic spiral noting clear chamber partitions 氣室 (septors) & sipuncle 串管 & the symmetrical coil

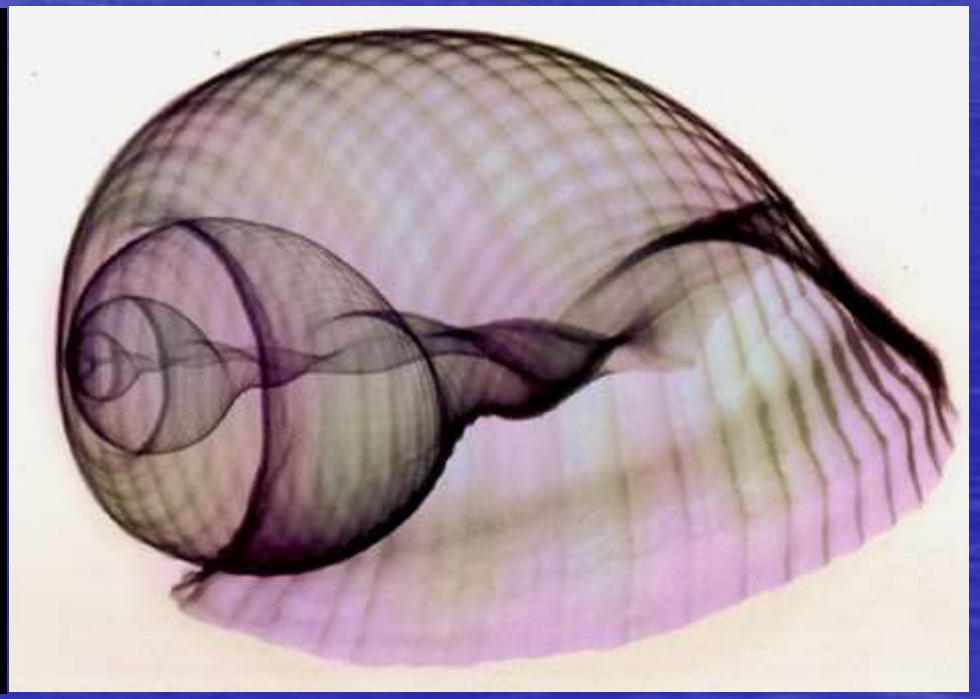


Logarithmic spiral of a spindle & a top shell

Logarithmic spiral of cowry, auger & ton shell







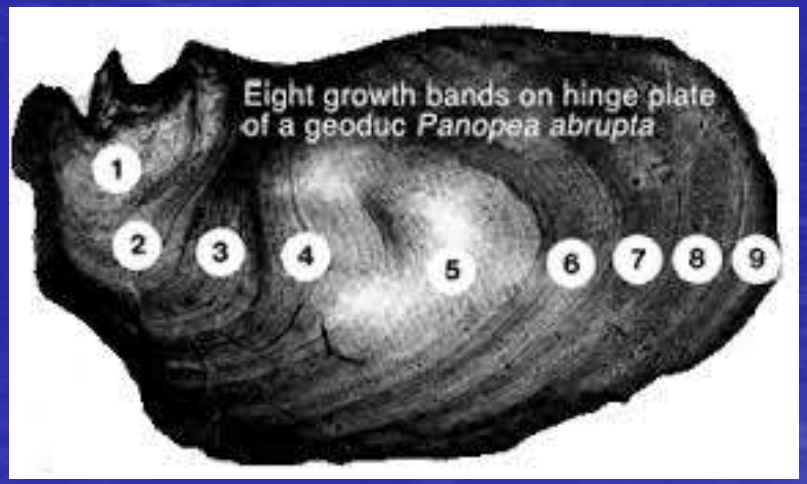
Left hand/clockwise spiral shells
Sinistral vs Dextral, the former considered rare
& therefore more expensive

- Size

  - Largest cephalopod colossal squid 14 m long.
  - Largest gastropod Australia Trumpet (*Syrinx aruanus*) 1 m weighs 18 kilos
  - Largest bivalve shell *Tridacna gigas* 4.5 m across weight over 230 kilos. Lifespan 100 years plus.
  - Smallest shell below 1 mm

- Thickness depends very much on habitat

- Clear growth lines especially for bivalves



Largest bivalve : Giant Clam *Tridacna gigas* 硨磲貝

6 species all in Indo Pacific, it is not a "Man Eater" as alleged

Largest gastropod : Australian Trumpet (*Syrinx aruanus*)

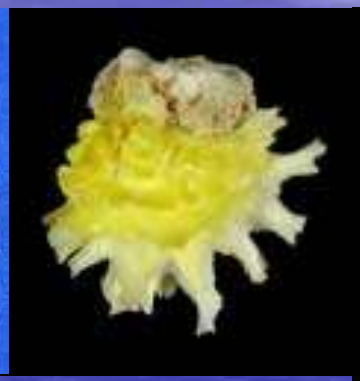
Largest Land snail : Giant African Snail (*Achatina achatina*)

Mini Columbellidae, Wentletrap & Land Snail

- Newly discovered micromolluscs in Papua New Guinea

- Color/pattern – color normally rich in the tropics and dull in the temperate regions - for protection/camouflage, warning or sex ? (Useless if the shell has a periostracom !) Mostly hereditary but also affected by diet, the food available & temperature












Habitat

Habitat 居所

1. Marine Habitat

By depth of water

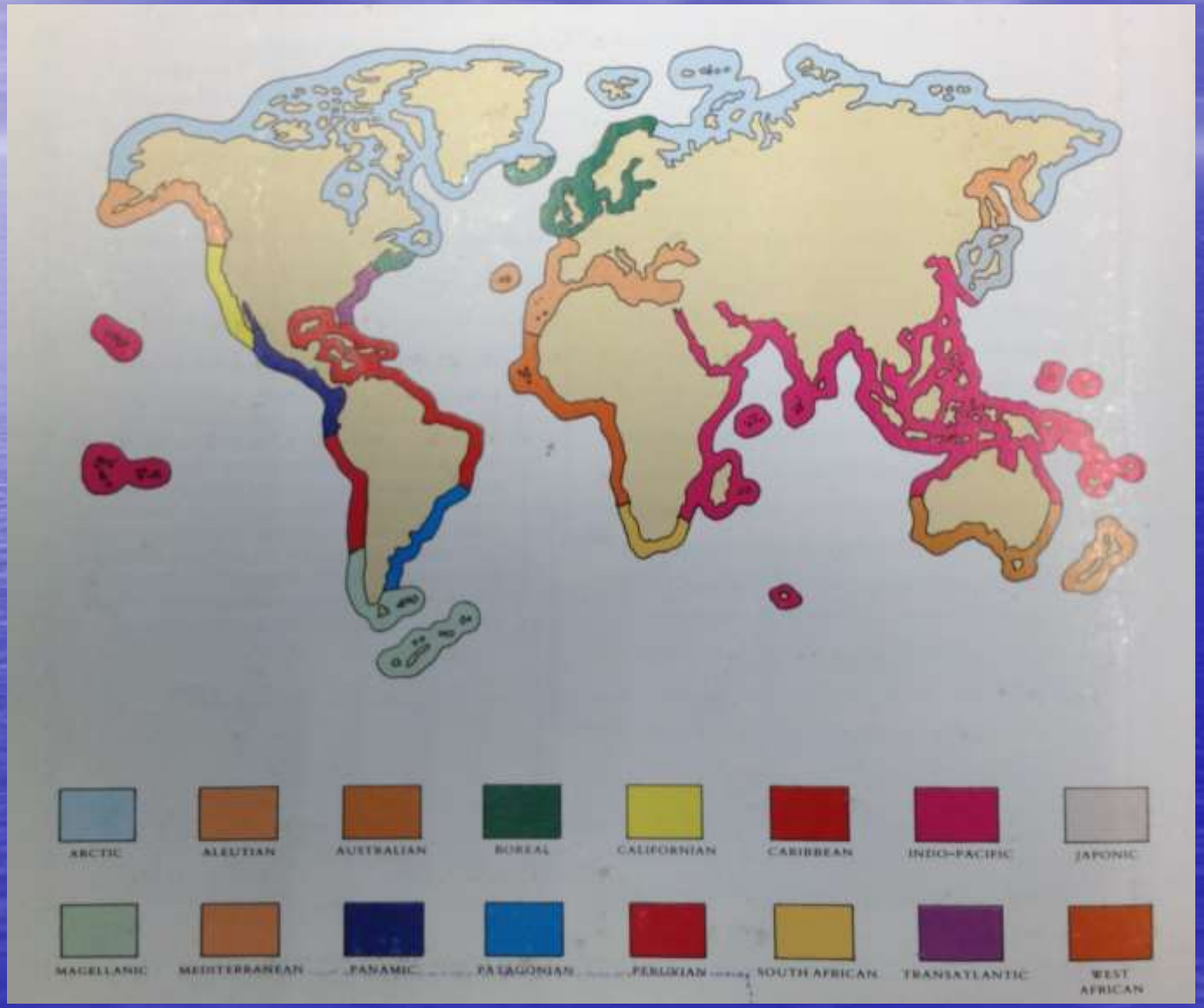
- Pelagic (surface)
- Intertidal or littoral zone
- Sub tidal zone – from low high tide line to 200m
- Bathyal zone – from 200m to 2,000m
- Abyssal zone – below 2,000m

Rocky, sandy, coral, mangrove, mudflats

Parasitic

16 Provinces Arctic, Aleutian, Australian, Boreal, Californian, Caribbean, Indo Pacific, Japonic, Magellanic, Mediterranean, Panamic, Patagonian, Peruvian, S.African, Transatlantic, W. Africa

The 16 Sea shell provinces



2. Land Habitat

- Land snails are everywhere including a large number of species of beautiful tree snails in Florida, Cuba, Philippines, Indonesia, Malaysia & Hawaii

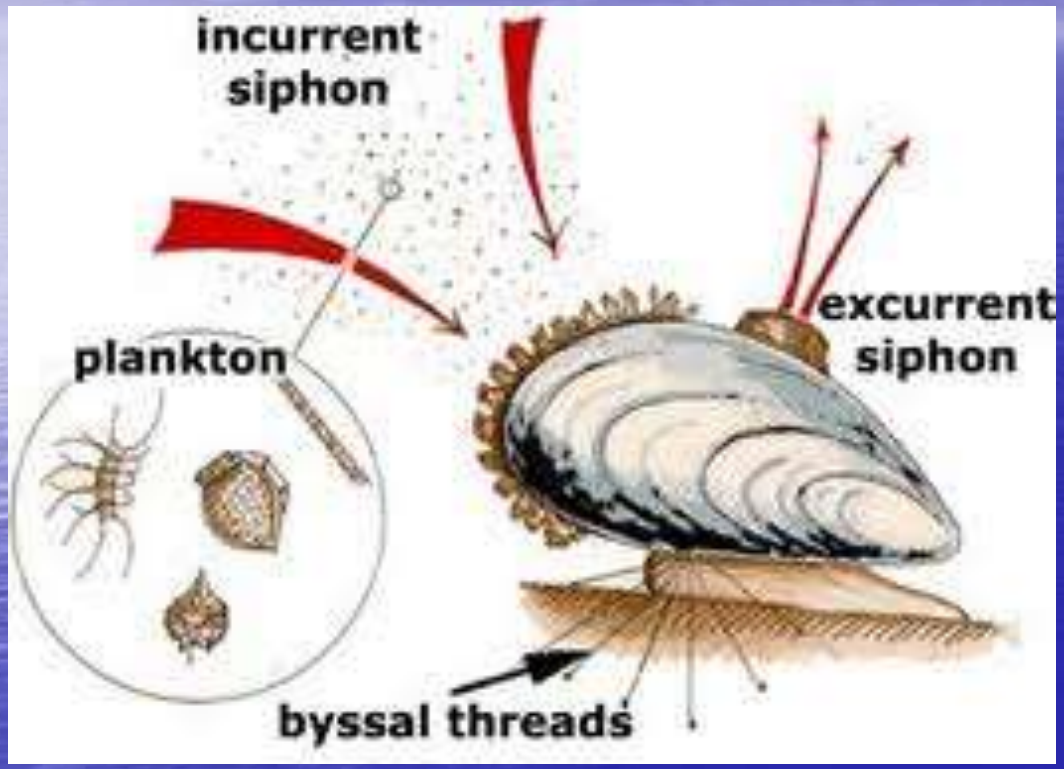
Feeding 進食

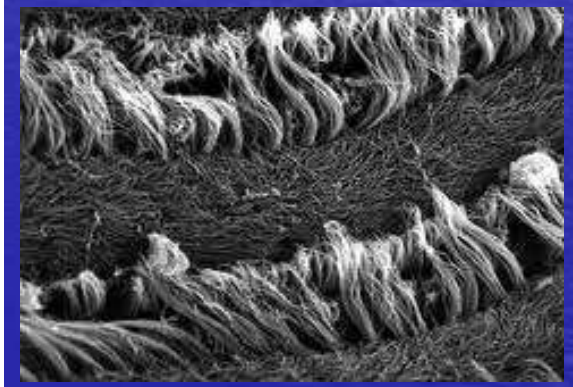
Mollusk can be herbivorous, carnivorous, omnivorous or parasitic. Cannibalism is not uncommon

1. Herbivory – plant & algae
2. Predatory – marine life including other mollusk

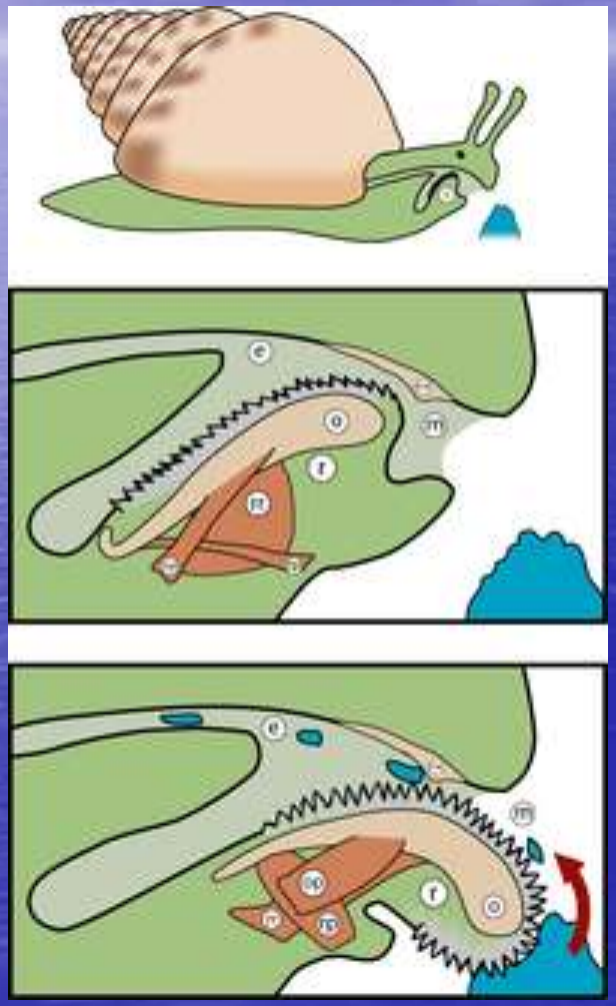
- Chipping (Fascilariidae)
- Wedging (Buccinidae)
- Drilling (Naticidae)
- Pedalasphyxiation (Olividae & Harpidae)
- Toxic secretion (Cymatiidae)
- Toxic injection (Conidae)
- Pedal manipulation/ probosics probing (Nassariidae)
- Symbiosis

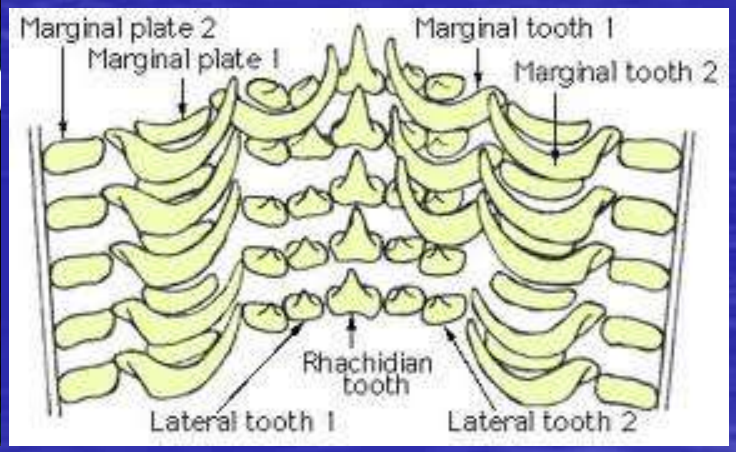
Bivalves are filter feeders using cilia to catch the food including plankton & detritus of non living organic material



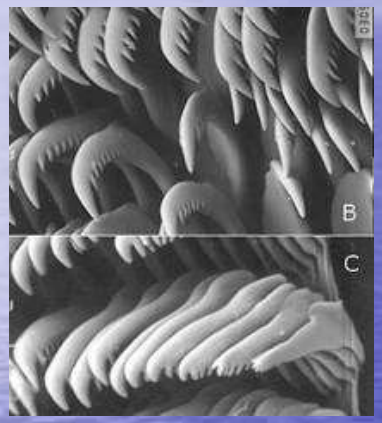


Other mollusk have radula 舌齒 which is a ribbon of teeth acting like a carpenter's rasp 銼 with new teeth being produced continuously to replace those worn out. There are 5 different types of radula each designed for consuming different types of food





The 5 major types of radula and X ray pictures showing radula teeth – can be as many as 100 rows totaling 50,000 to 100,000 teeth. Tooth production is rapid & can be up to 5 rows per day !



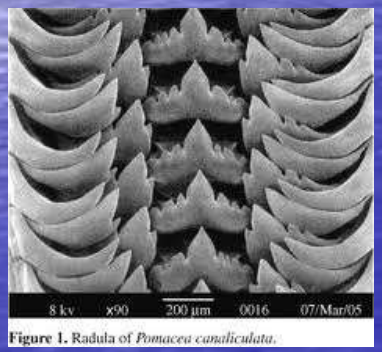
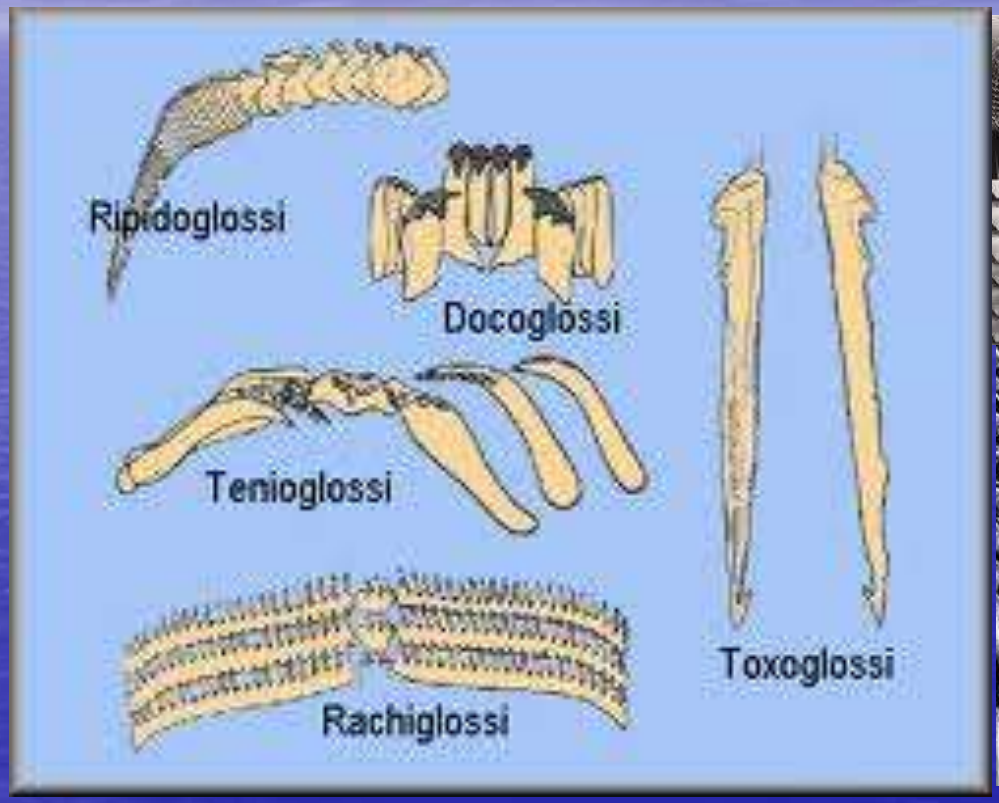
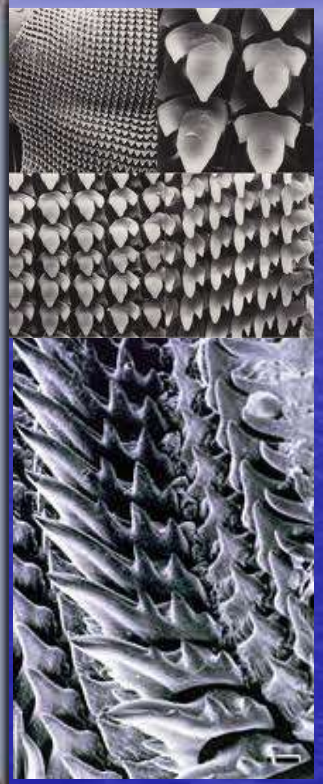
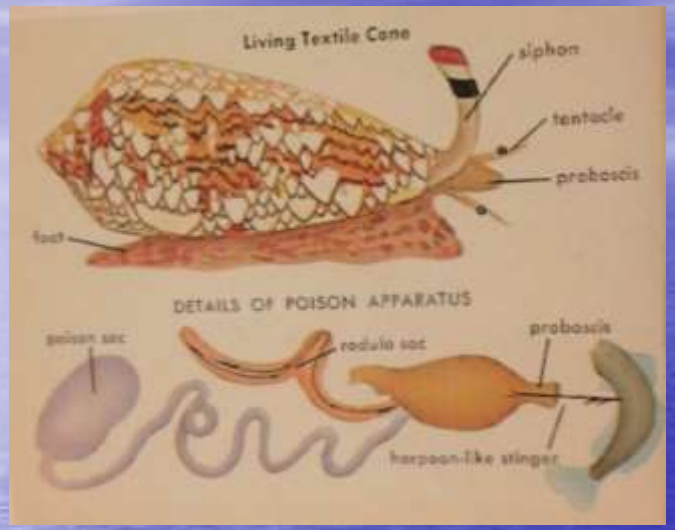


Figure 1. Radula of *Pomacea canaliculata*.





A Textile cone's poisonous stinger 織錦芋螺 is actually a modified radula.
Cone snail's poison is a conotoxin & had caused 30 death on human



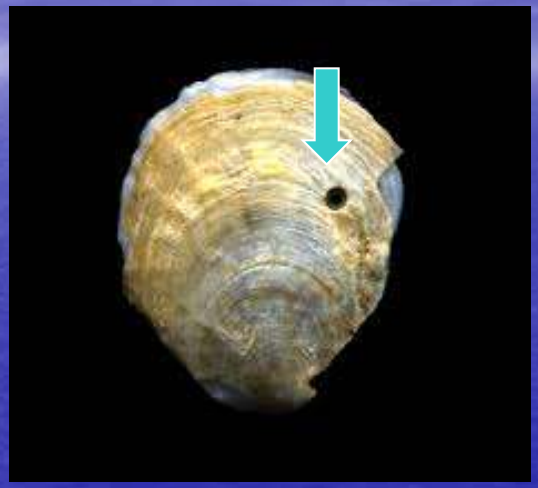
A Textile Cone 織錦芋螺 attacking a cowry

A Triton's Trumpet consuming its favorite food crown starfish

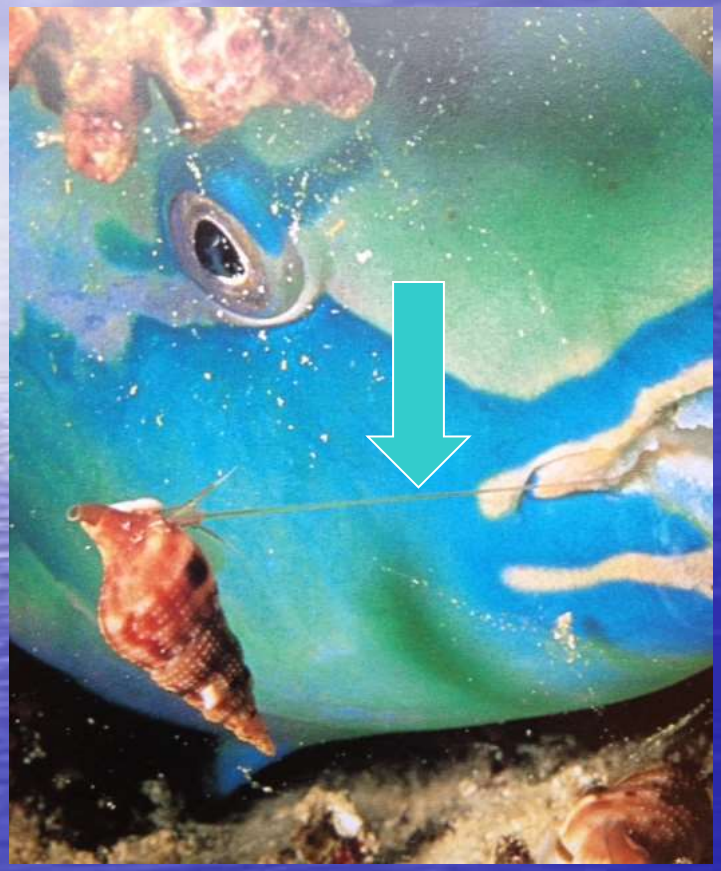
A melon or bailor shell swallowing a small fish

Moon snail 玉螺 able to drill through bivalves within 10 minutes !

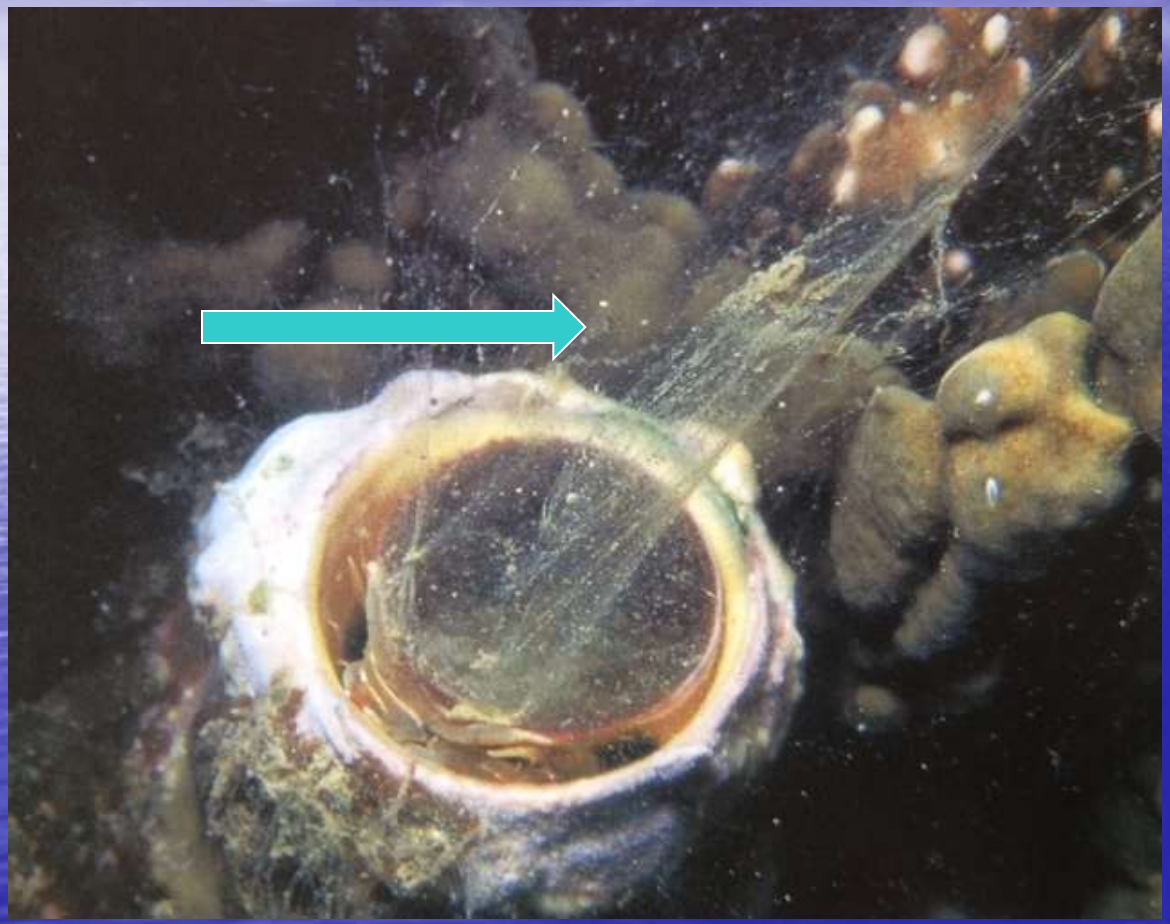
Similar to Moon snail, Oyster Drills (*Urosalpinx cinerea*), can also drill holes by their radula aided by the secretion of sulphuric acid and then digest the soft meat of the prey



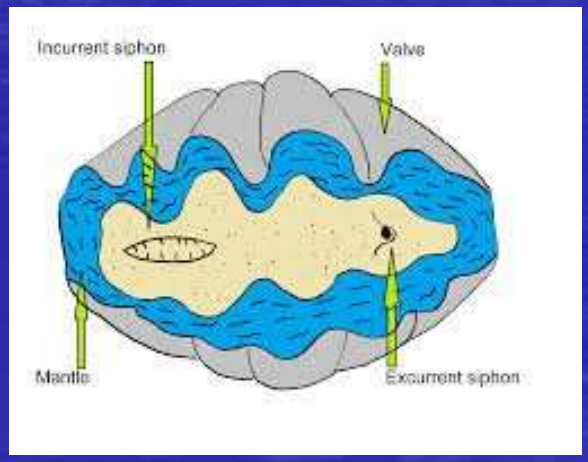
Parasitic snails are very small in size. One below is sucking blood from a sleeping parrot fish's tissue with its extended proboscis with another one sucking fluid from a shark. Others are feeding on echinoderm



The sedentary worm shell 大蛇螺 captures its food by making a mucous net from a gland in the foot to catch suspended particulate matters in the sea water

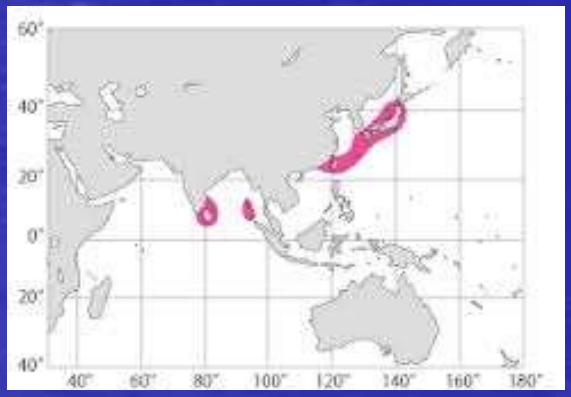


Feeding by symbiosis e.g. Giant Clams are associated with large number of algae called zooxanthellae which they farm within their mantle. The algae flourished through photosynthesis but eventually being digested – a case of "Solar Powered" food supply



Squid-Vibro Symbiosis

Apart from the giant clam, the "humming-bird Bobtail Squid" (*Euprymna berryi*) 墨豆仔 ability to display fluorescent color is by nurturing a type of bacteria called *Vibrio fischeri* inside its body. This phenomenon is called Squid- Vibro Symbiosis



Cannibalism caught in action – tulip & land snail

Locomotion 活動能力

Locomotion

- Sedentary 固著
- Burrowing 掘藏
- Boring
- Crawling 爬行
- Floating 浮動
- Swimming 游泳
- Jet propulsion 噴射

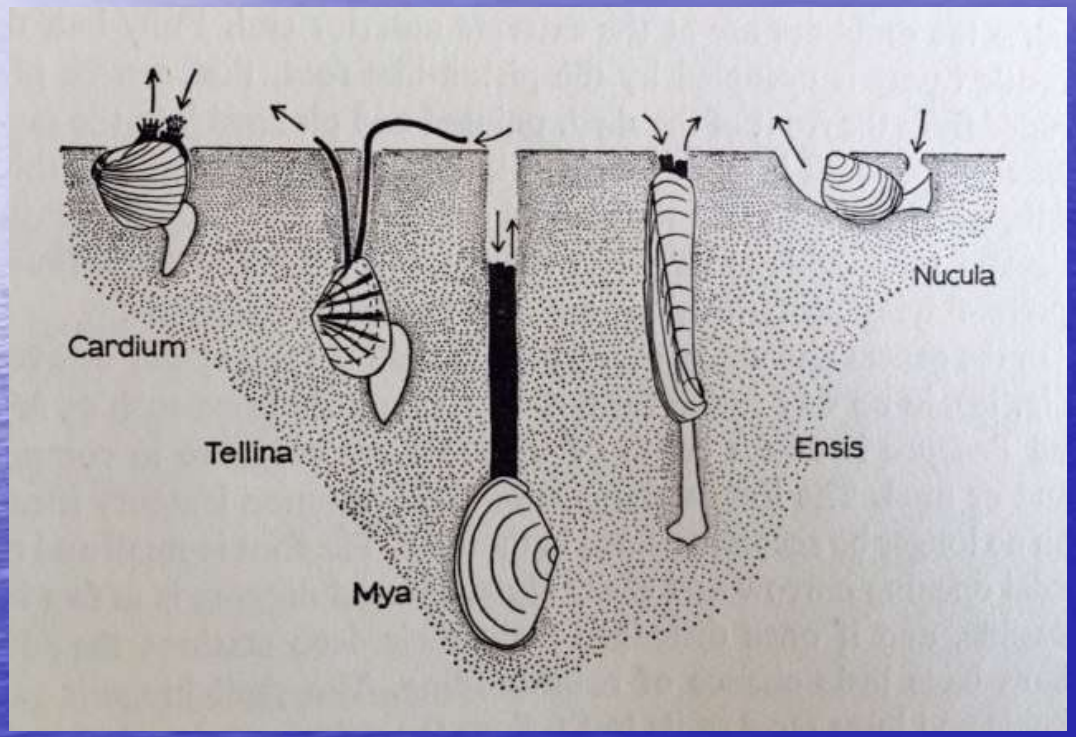
- 1. Sedentary 固著
  - Cemented on to rocks e.g. Oysters (Epifaunal bivalve as opposite to infaunal which means just laying on the bottom)
  - Attached by silky byssus 絲足 e.g. Pen shell & Mussels

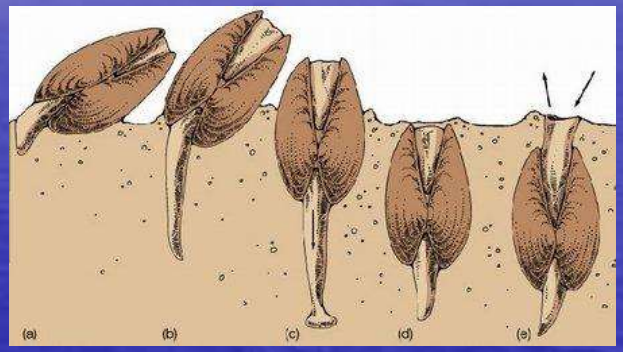


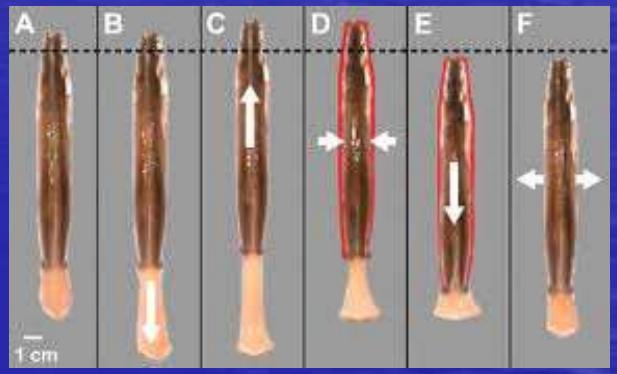



- 2. Burrowing 掘藏

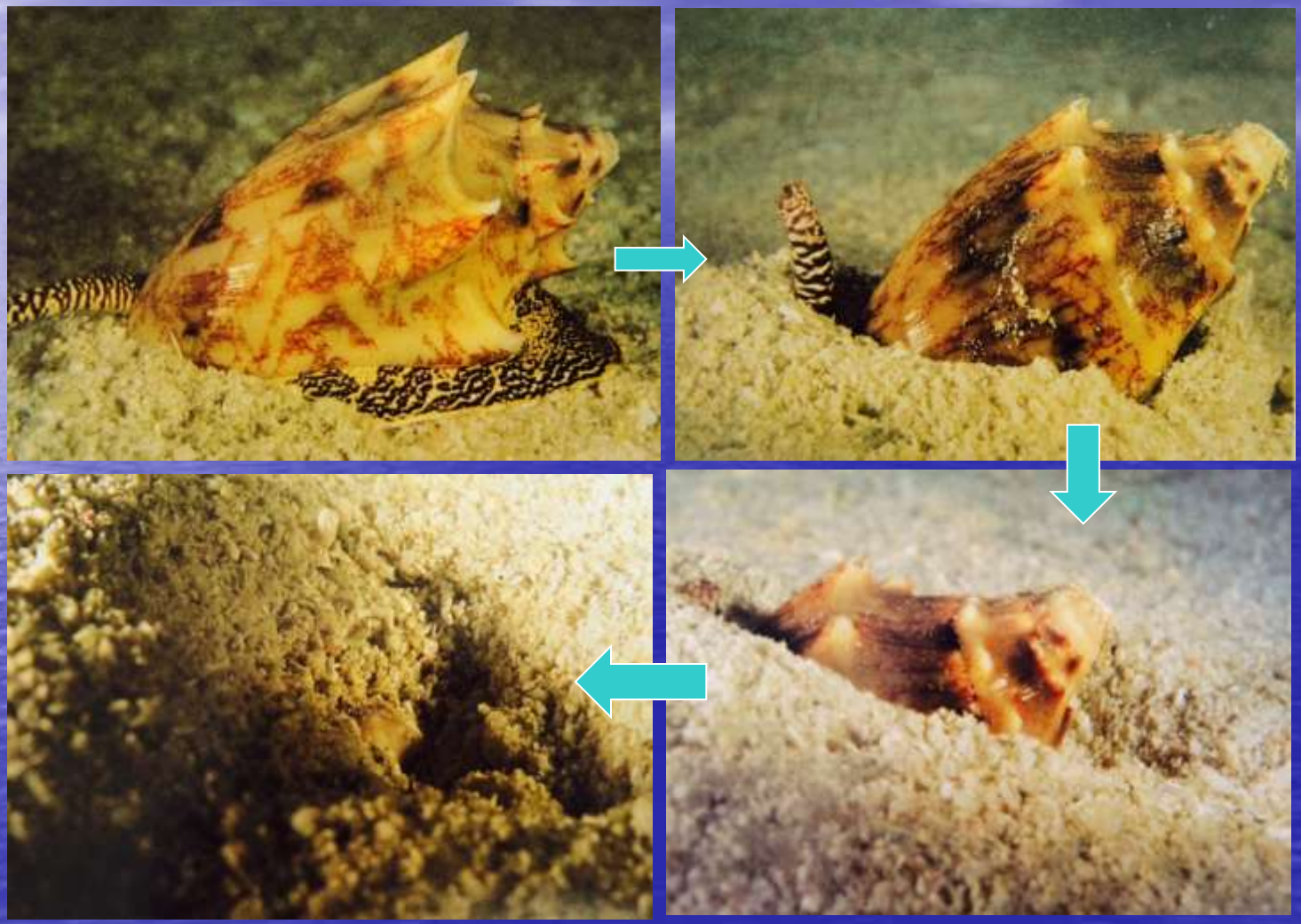
  Mainly bivalves, have different siphonic structure to facilitate burrowing into the sand or muddy bottom



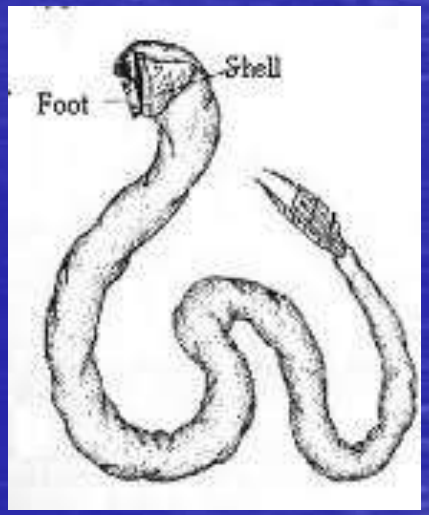




A burrowing volute – now you see it now you don't !



3. Boring：Piddok 海鷗蛤 & ship worm 船蛆 respectively bore into hard rock & wood using strong acidic secretions

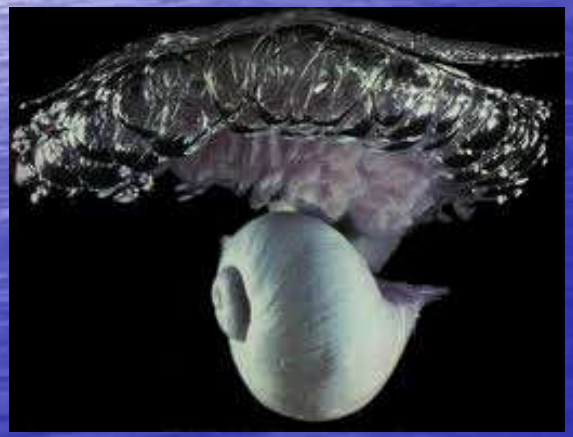


- 4. Crawling and some able to clink to rocks by suction

  e.g. Chiton, limpet & abalone. Land snail secrets mucus to aid crawling

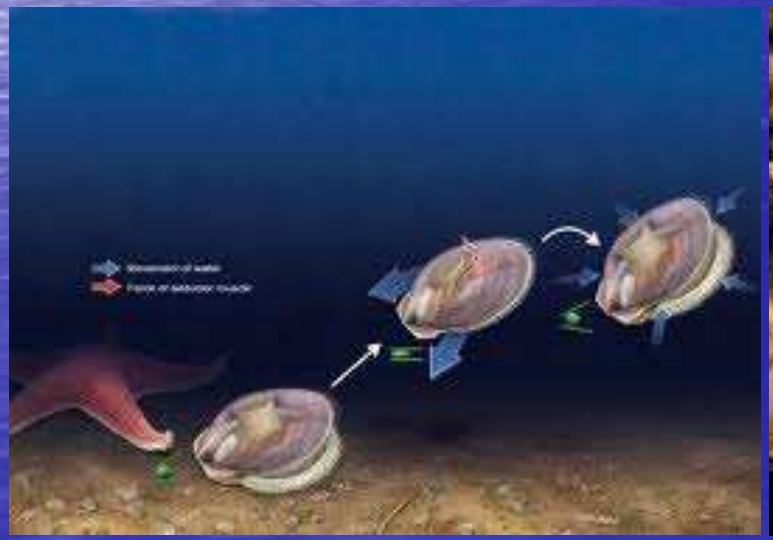


- 5. Floating e.g. *Janthina janthina*

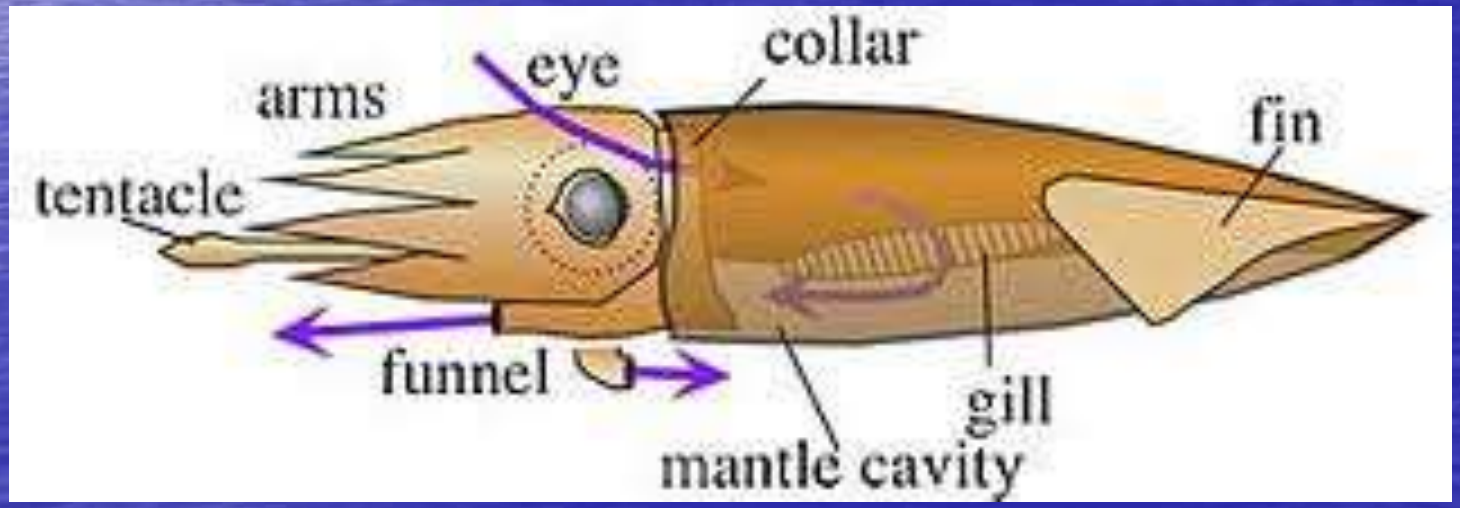


- 6. Swimming – with extended mantle e.g. Bubble shell & file shell

- 7. Jet propulsion : Scallops swim by opening & closing the shell acting like an accordion. Unlike most mollusk scallop has well developed eyes to detect approaching predators & fleed



Nautilus, squids, cuttlefish & octopus use real Jet propulsion. Nautilus gas filled chambers allow them to hover. Cuttle fish also uses its lateral fins for swimming



Sex & Reproduction 性与繁殖

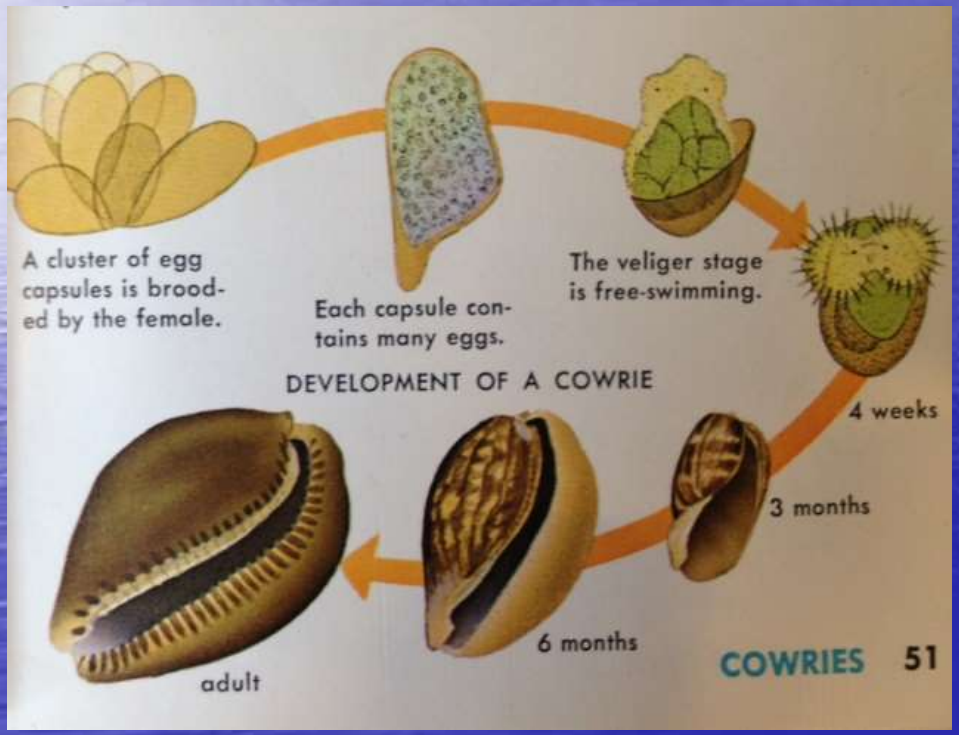
The reproduction behavior of mollusk varies tremendously from species to species. Can be Sexual 雙性繁植 or Asexual 單性繁植 (natural cloning). Sex wise some are Bisexual (hermaphroditic) 雌雄同體 e.g. bubble shell & scallop & Transsexual 變性 meaning changing sex is not uncommon e.g. Limpet, Slipper, Mussel & Oyster. Sex change can be triggered by food, temperature & environment.

Gastropods

- Extremely varied. Most marine gastropods have different sex – either male or female. Hermaphrodites are universal with pulmonata (land snail) and for most opistrobranchia (sea slug). Fertilization can be internal or external depending on species. Some produce egg case/capsules and carry by the animal. The eggs thence become free swimming larvae or veliger. More advance gastropod like land snail fertilize by copulating & internal fertilization with eggs maturing directly to snail with shell

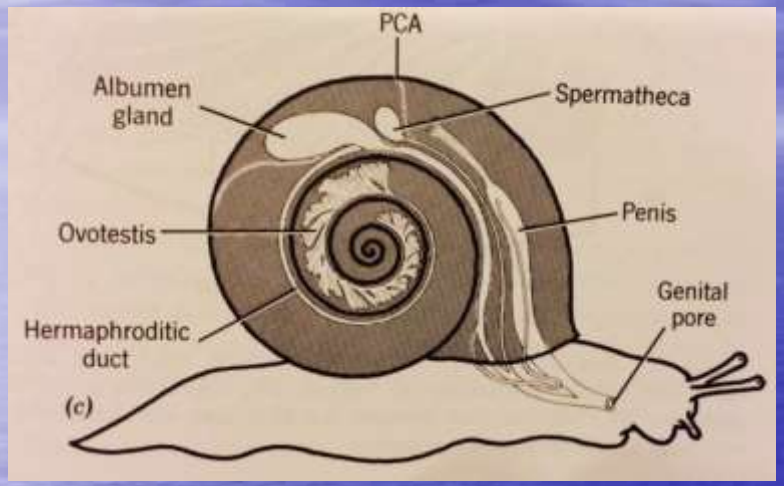
Reproduction Cycle of Cowry

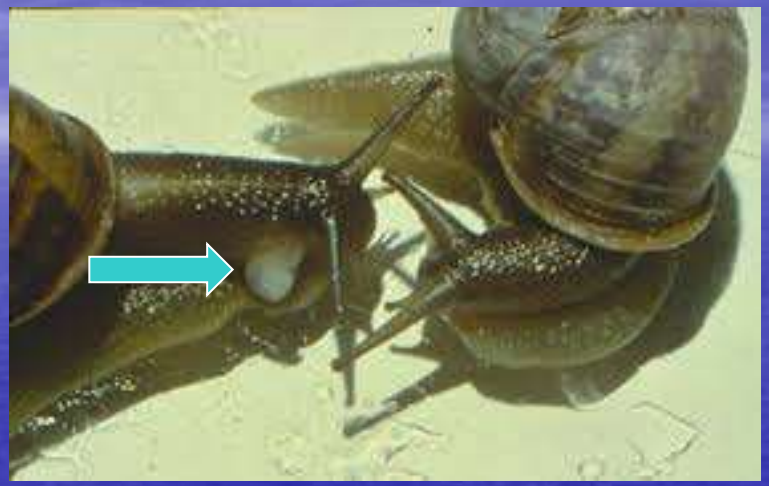
Cowry is a hermaphrodite with external fertilization by releasing the sperms & eggs into the water. From eggs to trochophore 擔輪幼虫 & free swimming Veligers 面盤幼虫 to mature adults with "teeth"



Land snail reproduction cycle

Mating African snail - note the white penis located on one side of the head which means Dexter snail cannot mate with Sinister snail !





When two hermaphrodite snails met, the male organ of each snail must fecundate the female organ of the other 異体受精.

Slipper limpet shells (*crepidula fornicata*) practice Sequential hermaphrodite – the largest & lowest one at the bottom are female and the younger & smaller ones at the top are male. If the female died the largest male on the pile will become a female !

Fertilized mollusk egg capsules






Egg capsules of mollusk, last row are all sea hare eggs







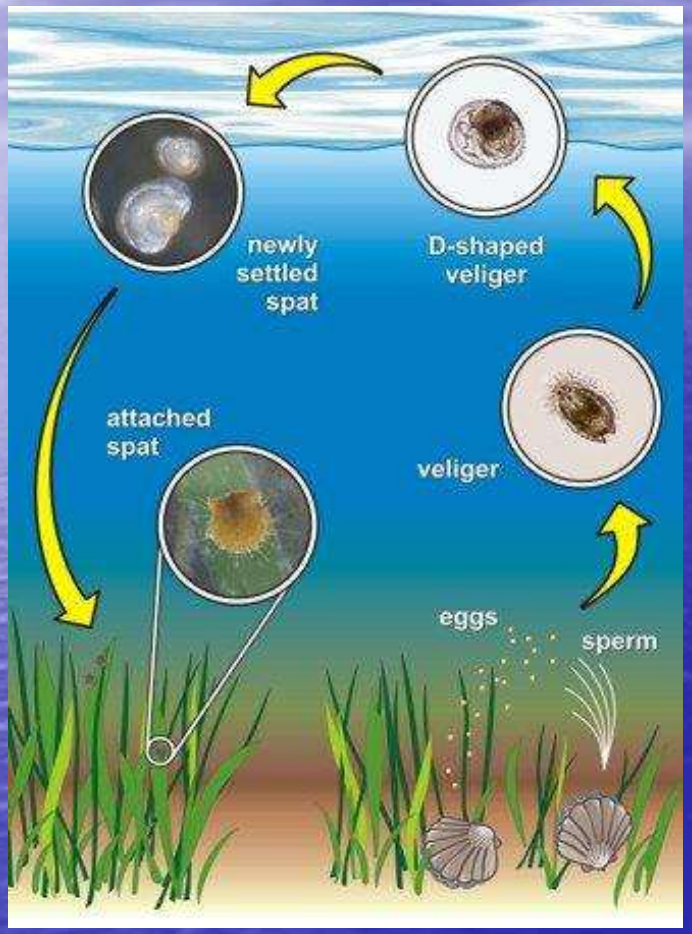

Mollusk Orgy

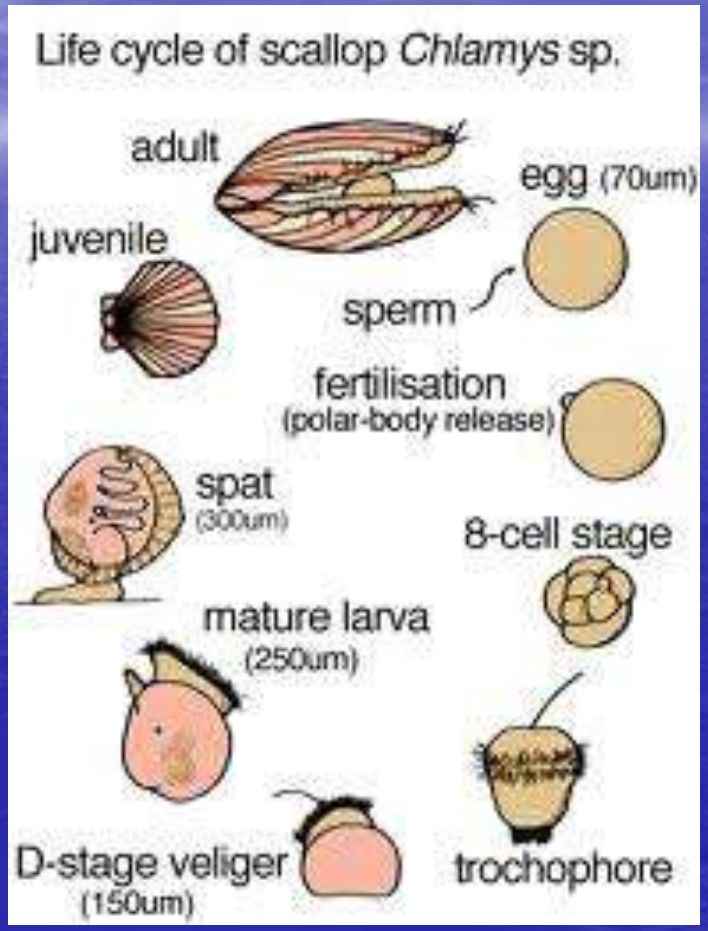
Sea hares are hermaphrodites which often form mating chains of 3 or more individuals with each one serving as male and female to different partners ! *Aplysia californica* has up to 20 partners in the chain !

Bivalvia

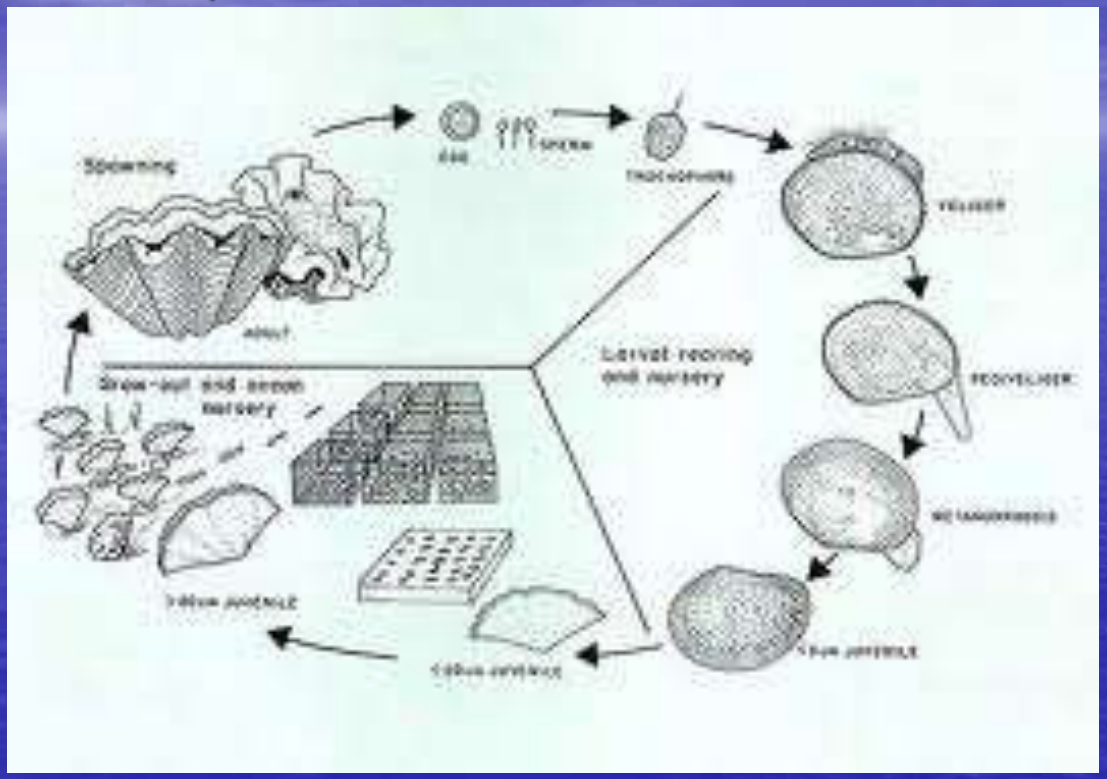
- Most bivalves e.g. Scallop & Thorny Oyster are hermaphroditic and produce both sperm & egg thus capable of self fertilization. Some mussel & oyster can change sex. Oyster often starts as male and ended up in the latter part of life as female. All have external fertilization. This has very high wastage e.g. The eggs of Bay scallop survival rate is one over 12 million !

Reproduction cycle of scallop





Tridacna gigas is a hermaphrodite but produce sexually. Since it cannot move, it practices broadcast spawning by emitting sperm & eggs into the water. An adult can release 500 million eggs at a time. Spawning is coincide with the tide & the moon phases !

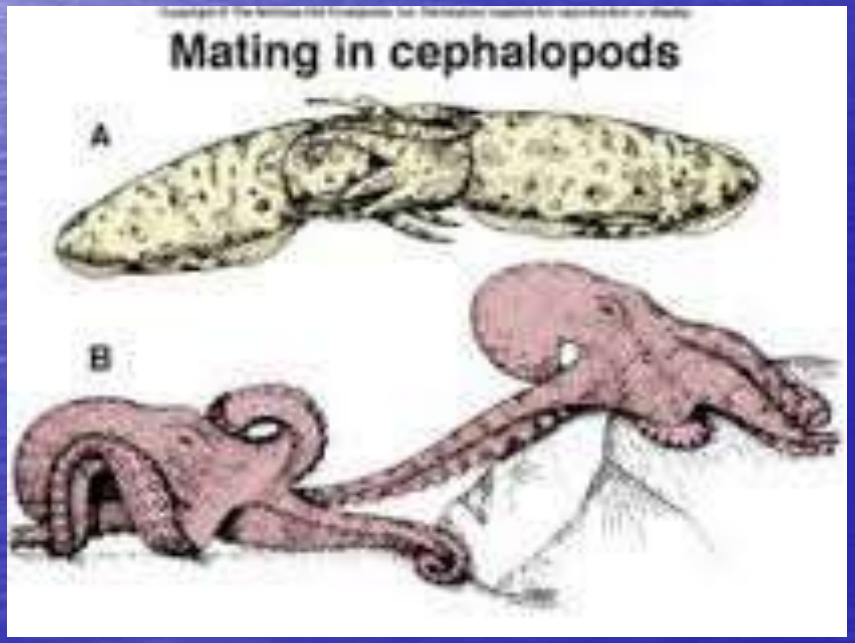


- Lampsilis is a North American fresh water mussel. Their youngs need to go through a parasitic stage attached to the gills of fish where they suck the blood. This is made possible by modifying the brood pouch which contains its young to mimic the apperance of a small fish to attract large predator fish to swallow it !




Cephalopod

Cephalopod always have separate sex & reproduce through sexual mating or copulation which involves the male inserting his hectocotylus arm (3rd right) 交接腕 into the mantle cavity of the female, along which the spermatophores 精夾 are conveyed. The male will die after the copulation. Female usually lay thousands of eggs after fertilization which can be as many as 200,000 eggs. Juveniles hatch directly from eggs with no swimming larvae



Self defense 自衛

Ways of self defense

- Thick & heavy shell e.g. Helmets
- Narrow aperture
- Operculum acting as door
- Bivalve closes both valves tight by adductor muscle
- Smooth shell, difficult to grip e.g. Cowry
- Thinner shell or no shell at all to enhance movement
- Spines e.g. Murex
- Camouflage e.g. Sun Moon scallop, carrier shell
- Stuck to hard surface e.g. Abalone, limpets
- Escape by swimming or burrowing
- Cut away foot e.g. Harp shell
- Secreting ink (melanin)
- Secretion of poisonous chemical (nudibranch)

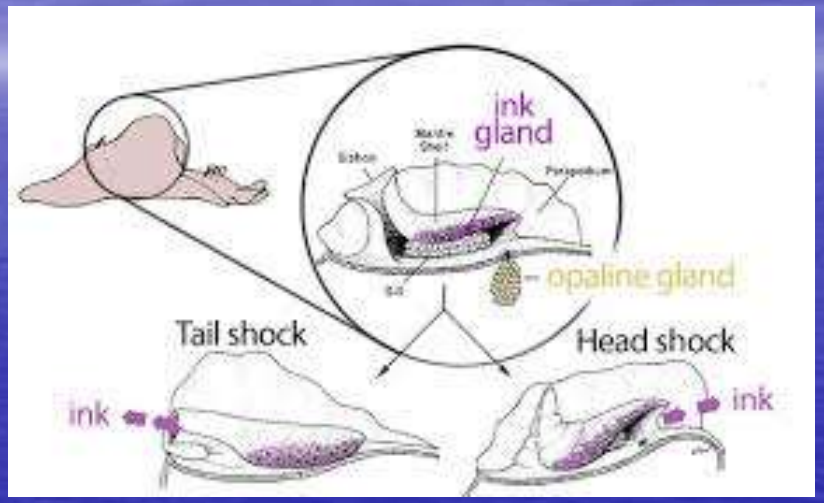
Ways of Self Defense

Self Defense by camouflage

Carrier shell (*Xenophoridae*) 綴殼螺

Ways of self Defense

Sea hare's mucous coating contains poisonous acids and other chemical compound can deter predators. It's last line of defense is by releasing a sticky ink which causes sensory inactivation.



Harp shell's last defense is to detach the posterior end of its foot when attacked by predator like a box crab

Usage of shells 貝殼用途

Usage

- As status symbol – Golden cowry, Egg cowry
- Currency – money cowry/tusk shell, related Chinese characters
- Ornamental – from simple "souvenirs" to collectors' items
- Shell craft - lamp shades, wind chimes, bangles, handbags, byssus gloves, trumpets
- Mother of pearl – pearl, jewelry, cameos, inset work, buttons
- Industrial use – dye, pottery glazes, floor tiles
- Medicinal & cosmetic use
- As home for hermit crabs
- For food

Money cowry shells decorated the skull of a pre historical chieftain

Ornaments on a horse head harness also made of money cowrie

Western Zhou Tomb, (771BC), Xian

Golden cowry

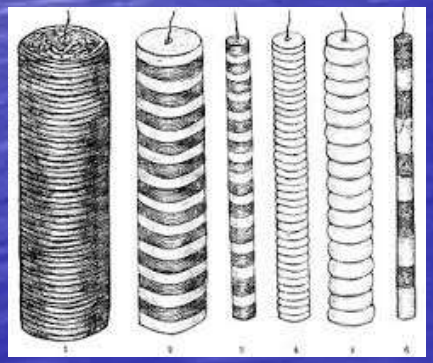
(*Cypraea aurantium*)

Symbol of fertility & authority by tribal chiefs in the Fijian Islands

Bow of a tribal war canoe decorated with Egg cowry as "Eyes" & necklaces/ear rings/bracelets made of different types of sea shells. Dentalia shells have been collected & traded in Western North America for thousand of years

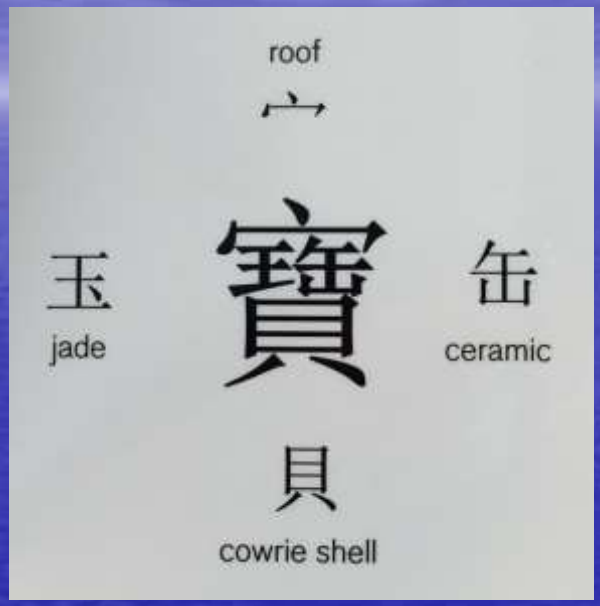
Shell Money

Basic criteria : readily recognizable, attractive, easy to carry, available in large quantity but not easy to obtain - *Cypraea moneta / Cypraea annulus* . Used in China 2,000 years ago (Shang & Chou dynasty) & also in S E Asia & W Africa (one slave worth 10,000 cowries total 30 billion shells used for the Slave trade) as well as Polynesia



There are some 82 Chinese characters related to sea shells

目貝見殼



財貪貧賊貸寶賜賤賦

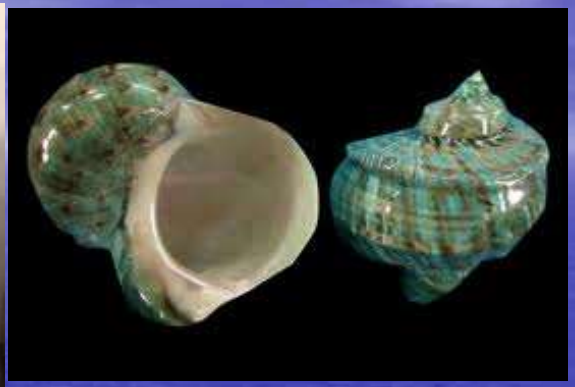
蛞蜆蛤蚶貽

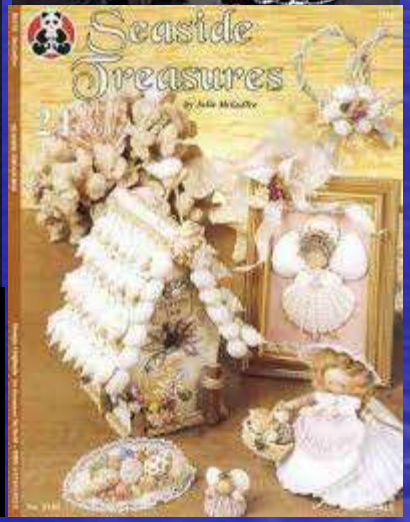
Dye :Tyrian Purple or Imperial Purple robes were worn by Phoenician & Roman rulers since 1570 BC. The dye was made from a Spiny Murex called *Boninus brandaris*

Sea Silk is the byssus of Noble Pen Shell (*Pinna nobilis*) which is fine and silky and was once spun into fabric to make expensive gloves in the Mediterranean. Nobel Pen Shell is the largest bivalve growing to 1 m tall. The byssus can be 20 cm long and as thin as human hair. It takes 150 shells to make a pair of glove !

Water bailers (volutes)/ wash basins (trumpets)

Cameo lampshape, brochures, shell inset (螺鈿) jewelry box polished desk decoration, buttons & wind charm





Some beautifully made shell crafts

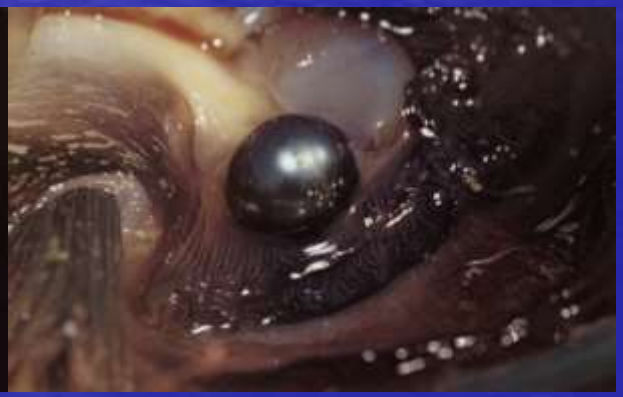
Popular lamp shades & wind chasm from the Philippines made of window pane oysters (*Placuna placenta*). Its "stop crack" property can also be used in the making wind screen & visors space helmet



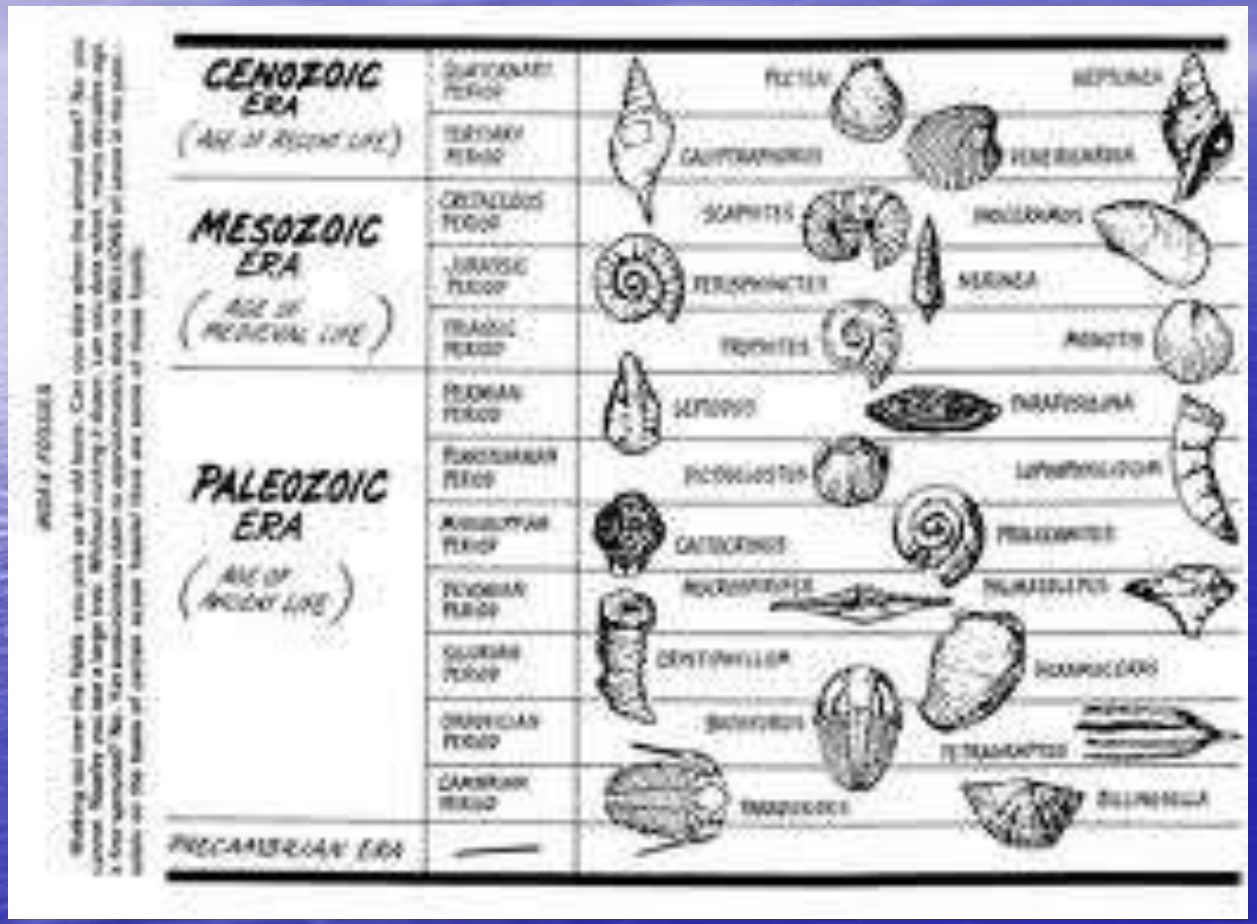



Pearl Oyster & Fresh water pearl in clams (Blister pearl)

Pearl can also be found in mussels & a few snails such as the Queen Conch & helmet shell can also produce pearl-like structure which is a nacre made of aragonite mortared together by layers of chitin



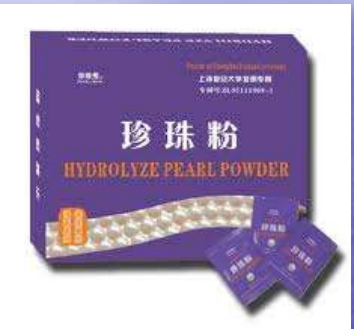
- Trace fossil 指標化石 mollusk fossils are commonly used for geological dating in Biostratigraphy



- Religious & spiritual use

  Tritons trumpet & Indian Hindu chunks, sinistral ones are considered more holy !

- Medical & cosmetic use : using crushed abalone shells 石缺明 & pearl powder 珍珠末. Cuttlefish bone is used in toothpaste. Bio glue from mussels byssus. Conotoxin from cone shells for pain killing, anesthetic & treatment of neuro diseases



- Home for hermit crabs : there are over 1,100 species of hermit crabs living on land as well as in the sea. Many shells are being used more than once !









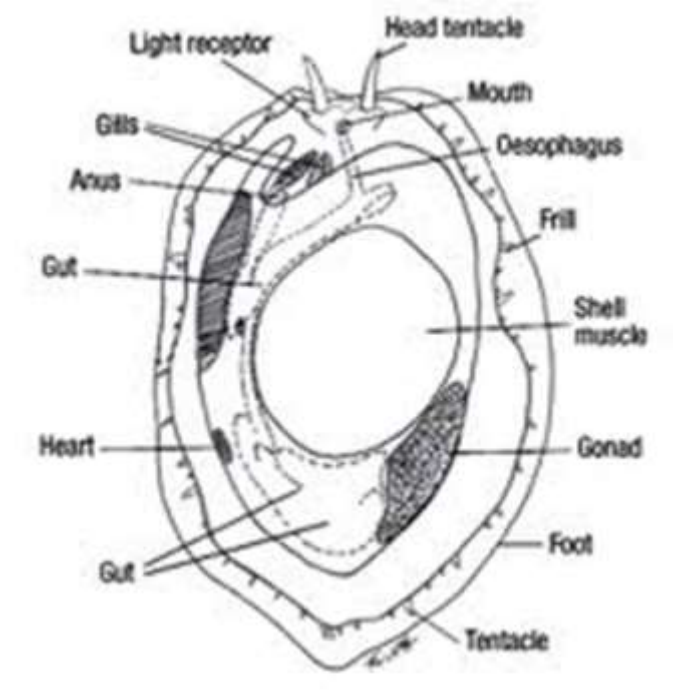
- The mollusk itself is an important food source for man& other animals. Only 85 specie are poisonous. Man consumed over 16 million tons of mollusk per year worth US$5 billion

Mollusk Aquaculture is now an important industry we eat

Squid, octopus, cuttlefish	:	mantle
Abalone	:	foot
Conch	:	foot
Scallop	:	adductor muscle
Pen shell	:	adductor muscle
Elephant trunk	:	siphon
Oyster / jack knife clam	:	everything goes

Abalone

Called ormers or sea ears in Europe & paua in New Zealand



鮑

Tasmania abalone

Tasmania has the largest wild harvest abalone fishery in Australia occupying 25% of world market share & increasing as Japan stock is decreasing due to the 2011 tsunami. Greenlip (*Haliotis laevigata*) is more common than Blacklip (*Haliotis rubra*)

Live Greenlip abalone in Tasmania (*Haliotis laevigata*)






Catching

• Organised poachers • Licensed divers • Shore-based divers • Extended family groups • Individuals

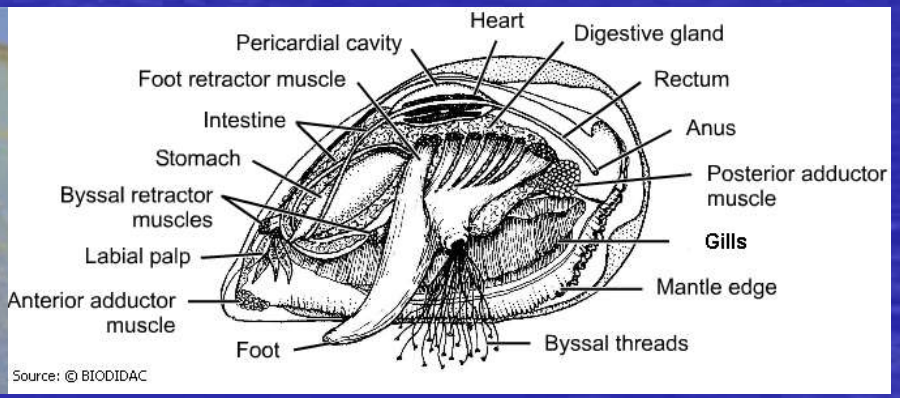
Processing

• Fresh frozen • Cryovac (vacuum) packed • Canned • Boiled • Par-boiled • Dried

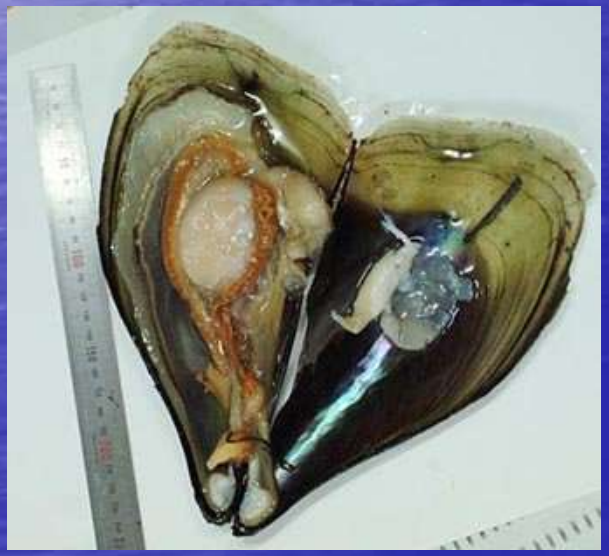
Selling to end consumer

• Export • Retail • Personal use

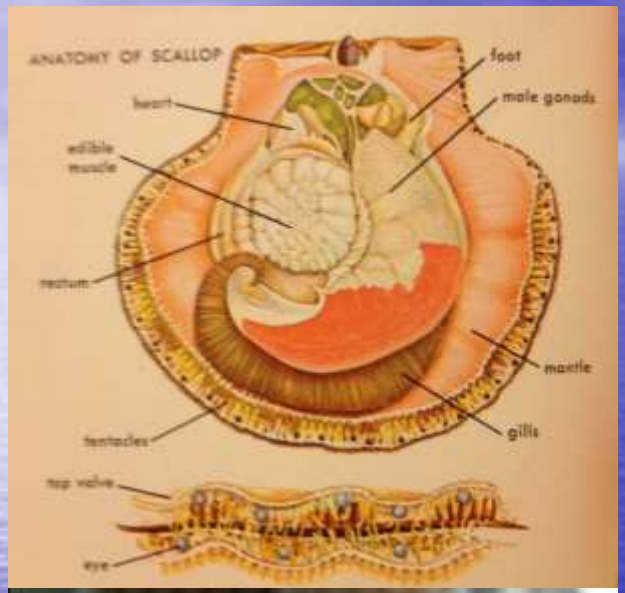
Mussels (*Mytilidae*) 貽貝/菜蛤/青口/淡菜



Pen shell (*Pinnidae*) 江瑤柱 /沙插



Scallop (*Pectenidae*) 扇貝/元貝/帆立貝

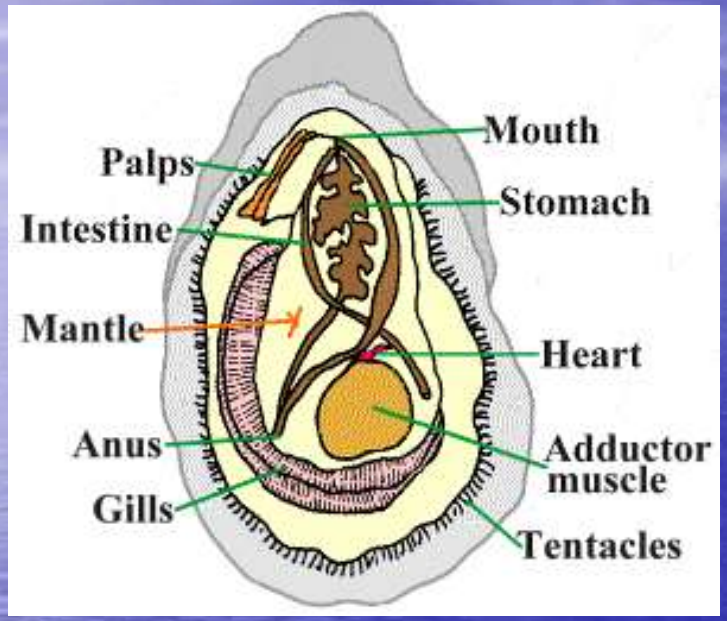


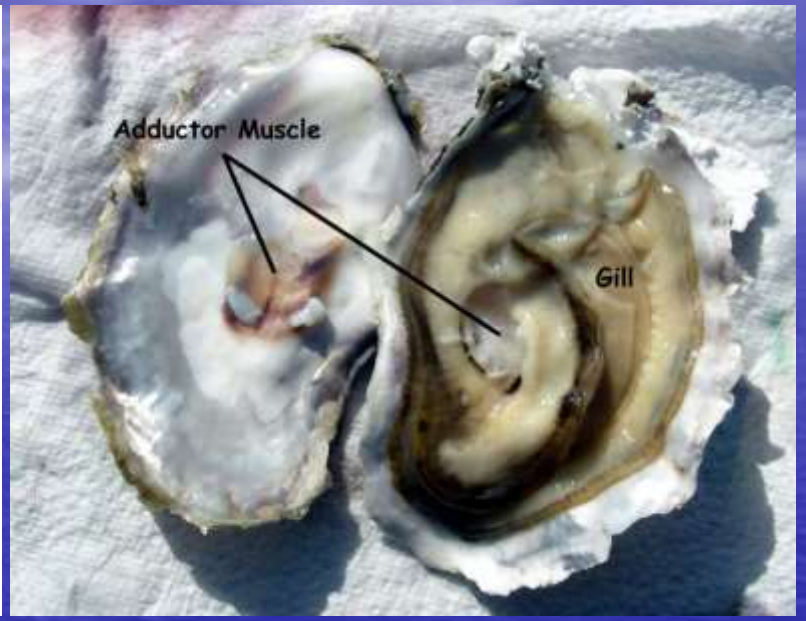
Giant Clam (*Tridacna gigas*) 干貝

Japanese Himejako. Giant Clam is now being farmed

Oyster (*Ostreoidae*) 牡蠣/蠔

Oyster grows continuously throughout life & may live 100 years





- Oyster Farm at Freycinet Tasmania – oysters sold at 2 years old

Elephant trunk clam 象拔蚌

(Geoduck – *Panopee generosa*)

Cooked land snails

France – "Escargots" (*Helix pomatia*) ; Spain - "caracoles a la madrilena" ; Portugal – "Theba pisana"

Cerith ,Babylonia, Top shell & Clams

Key shell species

主要品種

Gastropods 腹足綱

- Archaeogasgtropoda：原始腹足目 540 Ma
- Mesogastropoda：中腹足目 250 Ma
- Neogastropoda：新腹足目 66 Ma
- Heterogastropoda：異腹足目

Archaeogastropoda

- Slit shells (Pleurotomaridae 翁戎螺)
- Abalones (Haliotidae 鮑螺)
- Limpets (Fissurellidae 笠螺)
- Top shells (Trochidae 蠑螺)
- Turbine (Turbinidae 鐘螺)
- Nerite (Neritidae 蜑螺)

Emperor's Slit Shell 翁戈螺（*Pleurotomaria*）

Existed over 500 Ma it is a living fossil with 16 species l– 8 in West Indies, 6 in japan & Taiwan, one each in Brazil and South Africa all living in deep water

Taiwan slit shells & fossil

Abalone shell 鮑螺 (*Haliotidae*)

130 species e.g. Red, Black, Green, Nine holes, donkey's ear, wrinkle, goat , discus & polished abalone shells








Limpet shell 笠螺

Tortoise, pine, shield & star Limpet shells all living in the intertidal zone

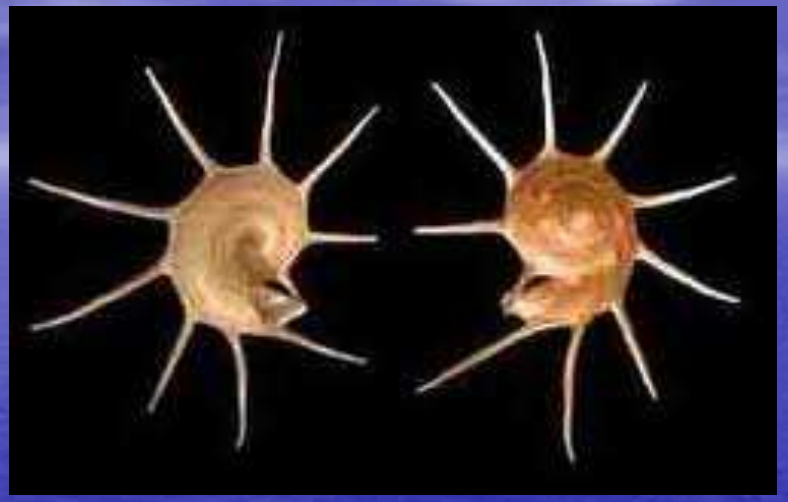
Colorful Limpet shell 笠螺

Turban 蠑螺

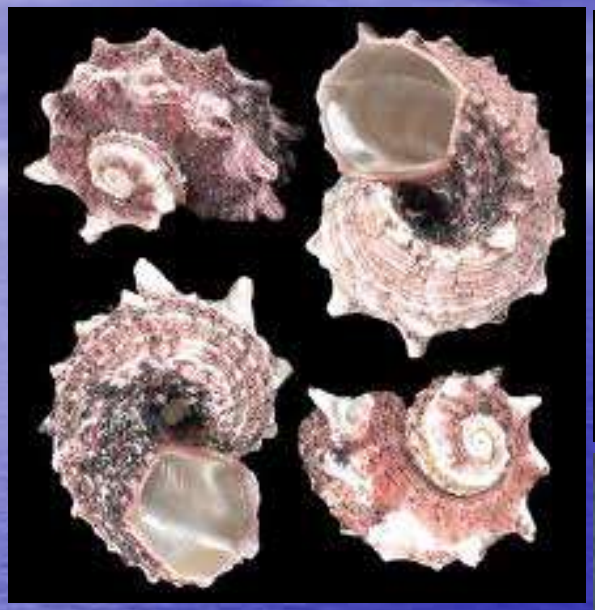
Tapestry or Cats Eye turban (*Turbo petholatus*) & Green turban (*Turbo marmoratus)*

Horned turban & *Turbo sarmarticus*

Star Turban : Yoka Star, Triumphant Star & an unnamed turban from Okinawa



Dolphin shells 棘冠螺



Top shells 鍾螺

Common winkle & crowned prickly winkle 玉黍螺

(*Tectarious coronatus*)

Nerite shells 蜑螺



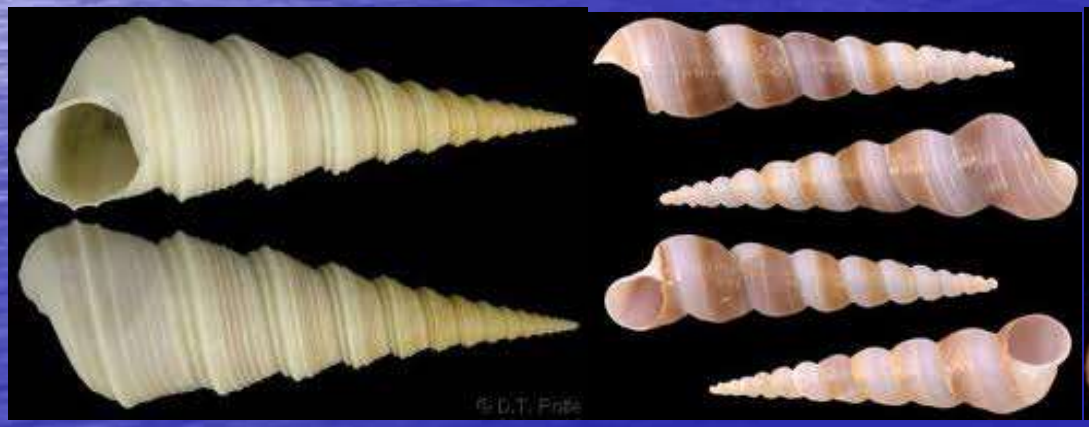





Mesogastropoda

- Turritellidae
- Cerithiacea
- Epitoniacea
- Calyptracea
- Strombacea
- Cypraeacea
- Tonnacea
- Naticidae

Tower screw shell 錐螺 (*turritilladae*)

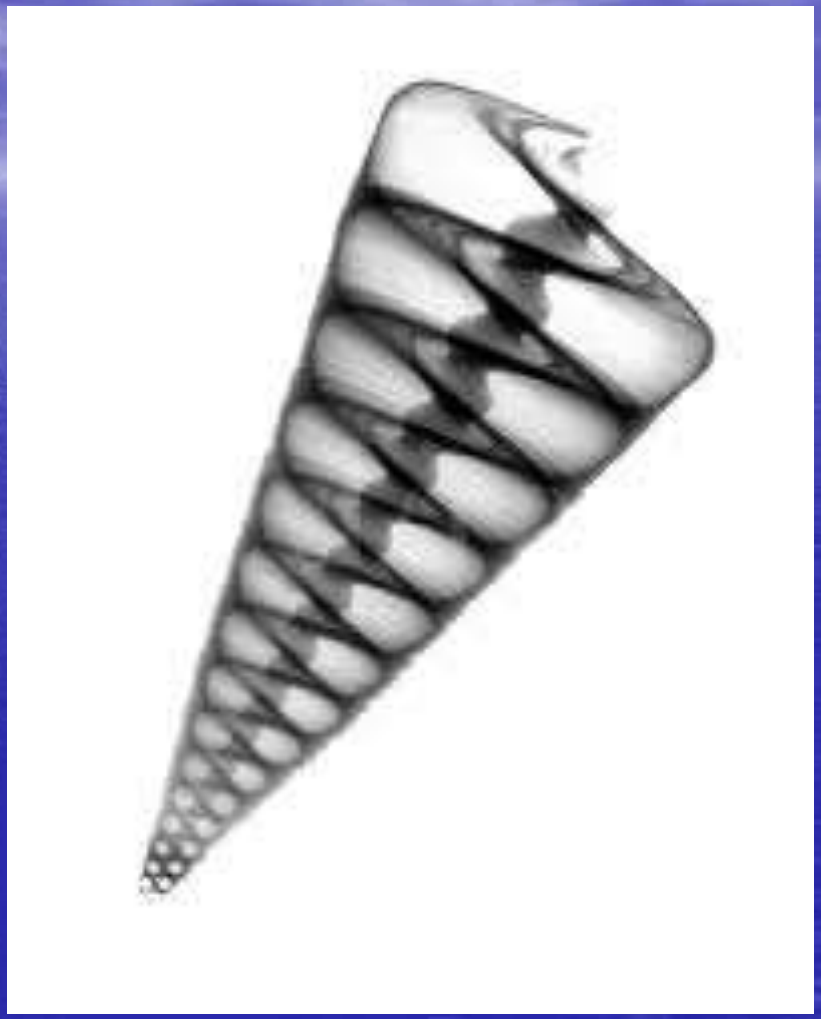


Cerith 蟹守螺

cerithium nodulosum & others

Cerith shells 蟹守螺

Telescope shell 海螺



Worm shell 蚯蚓/蛇螺

Sun Burst Carrier shell

Carrier shell 綴殼螺

The real shell collectors！






Strombus conch 鳳凰螺

Mirabilistrombus listeri or "golden axe strombus" was once considered very rare but now can be easily found in the northern part of the Indian Ocean. Also note siphon notches






Tibia conch 長尾鳳凰螺

Note the long siphon canal for protecting the siphon

Millipede/ Spider/ Scorpion Conch

Conch

Pink conch, Silver Lip conch, Lip conch, Rooster conch

Cowry – *Cypraeacea* 寶螺

Tiger Cowry & Map Cowry : *Cypraea tigris & mappa*






Hundred eyed cowry 百眼寶螺 (*Cypraea argus*)

Snake head & Asellus cowry

(*Cypraea caputserpentis* & *Cypraea asellus*)

Zig Zag Cowry








Sieve cowry (*C. cribraria*) Stolida cowry (*C.stolida*)

Chick pea cowry

(*Cypraea pustularia, Cypraea nucleus*)

Cypraea Friendi

Cypraea teulere, Cypraea mouse, Cypraea theritorite, Cypraea mauritana, Cypraea cercineta

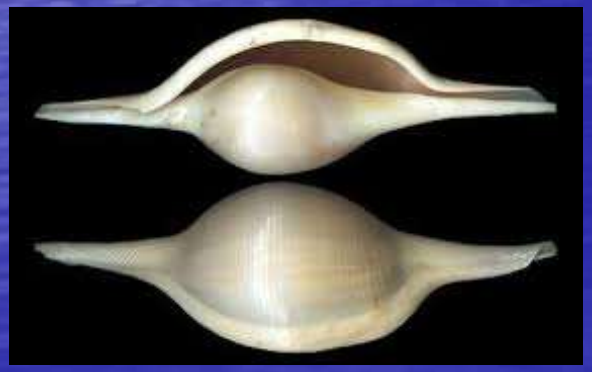
Three rare & expensive cowry : Fulton's cowry (*C. fultoni*),
Hirase's cowry (*C. hirasei*) & White tooth cowry (*C. Leucodon brodevip*)

Cypraea aurantium & Cypraea guttata
are still highly priced

False cowry – *ovulidae* 兔螺





Horned helmet 冠螺 – *Cassis cornuta*

King helmet

Bull Month Helmet (*Cypraecassis rufa*) 冠螺

Craftsman favorite choice for making cameo

Bonnet shell 鬘螺







Tun shell Tonnidae 鼉螺

Moon snails – *naticidae* 玉螺

including "Shark's eye" & "Paul Newman's eye"

Neogastropods

- Muricacea 骨螺
- Buccinacea 蛾螺
- Conacea 芋螺
- Volutacea 渦螺
- Olividae 橄螺

Murex shells 骨螺

including the Venus Comb






Alabaster Murex & Pink Murex

Radish murex

(*Hexaplex radix*)

Murex






Zambo's murex & Key murex

Murex





Snipe's bill murex

(*Haustellum haustellum*)

Characterized by its extraordinary elongated siphon tube

Thais 岩螺

Thick strong shells ideal for the rocky coastal environment






Thais 岩螺

Ordinary frog & Ruddy frog shell 蛙螺

(*Tutufa rubeta*)

Frog shells

Harp shells 豎琴螺/ 楊桃螺

Cone shells – *conacea* 芋螺

Geography Cone, Captain's Cone, Tent cone

Glory of the Sea (*Conus gloriamaris*) & Gloria of India

Volute 渦螺

With the most beautiful ones found in Australia, they are sometimes called the "Rolls-Royce of conchology". Many are rare and highly priced

Imperial volute

(*Aulica imperialis*)

Melongena corona

Live volutes

Spindle shells 長旋螺

With 3,000 species they are the most diverse family of sea shells which posses a poison gland

Banded tulip 紡錘旋螺
(*Fasciolaridae*)

Japanese wonder shell 旋梯螺

Thatcheria mirahilis (*Turridae*) many considered it a freak when first discovered & named in 1877

Vase shell – *vasidae* 拳螺

Whelks (*Buccinidae*) 蛾螺

Whelk - Babylonia shells 鳳螺 /"東風螺"

Whelks - Knobbed whelk 角香螺

Busycon carica (Lightning whelk) *Busycon contrarium*






Olives 橄欖螺





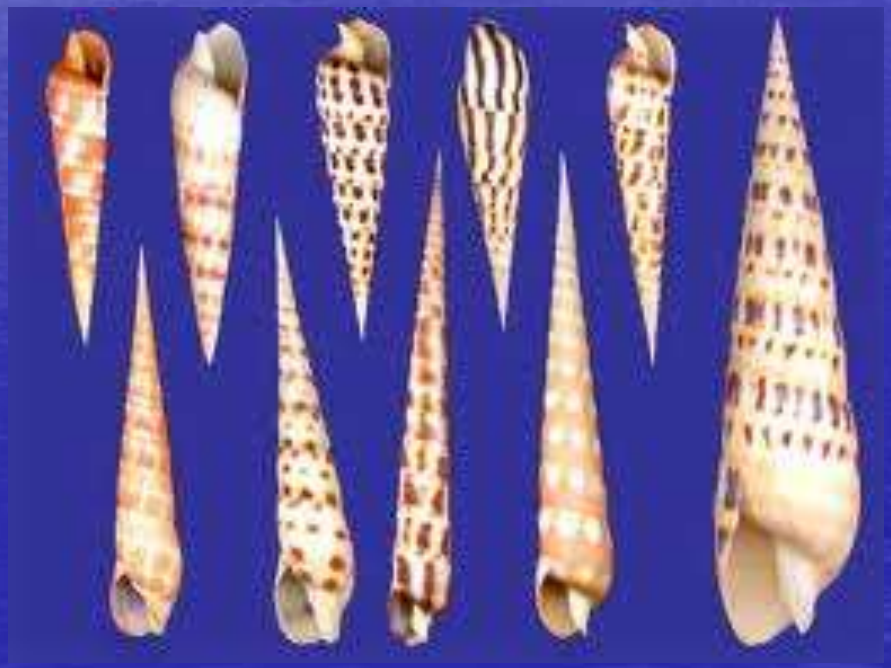

Niters 筆螺- Episcopal Miter & others






Pontifical miter
(*Mitra stictica*)

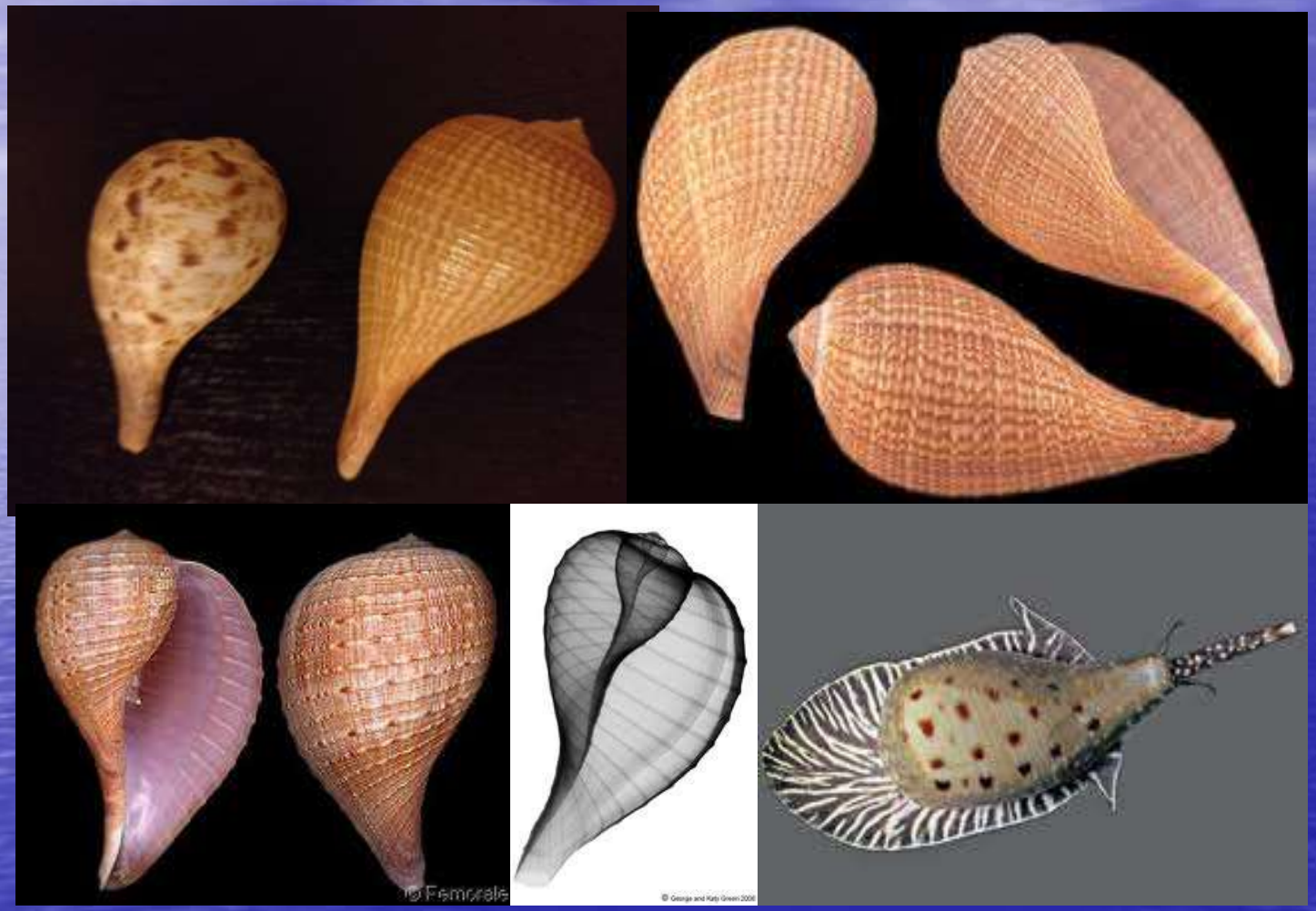
Terebra shells 筍螺



Auger shell 大筍螺

(*Terebri maculata*)

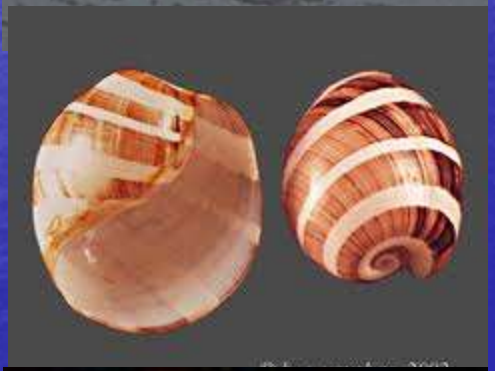
Fig shells 枇杷螺



Bubble shell 泡螺









Triton shells 法螺

Triton's trumpet & Australian trumpet

Heterogastropoda

- Architectonicides
- Epitonium

Heterohgastropoda – Sundials 車輪螺
(*Architectonicidae*)



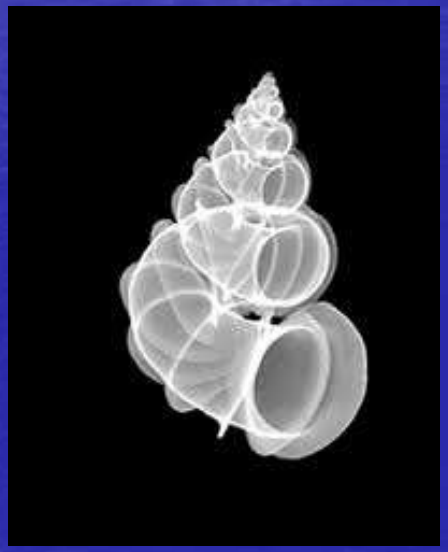






Heterogastropoda

Precious wentletrap or “Staircase shell” 綺蠑螺



Fresh water/Land snails

Fresh water/ land snails

Tree snails

MARINE BIVALVES

Family *Veneridae*
(680 species)window clam 窗蛤

Family *Lucinidae*
(500 species) full moon clam 滿月蛤

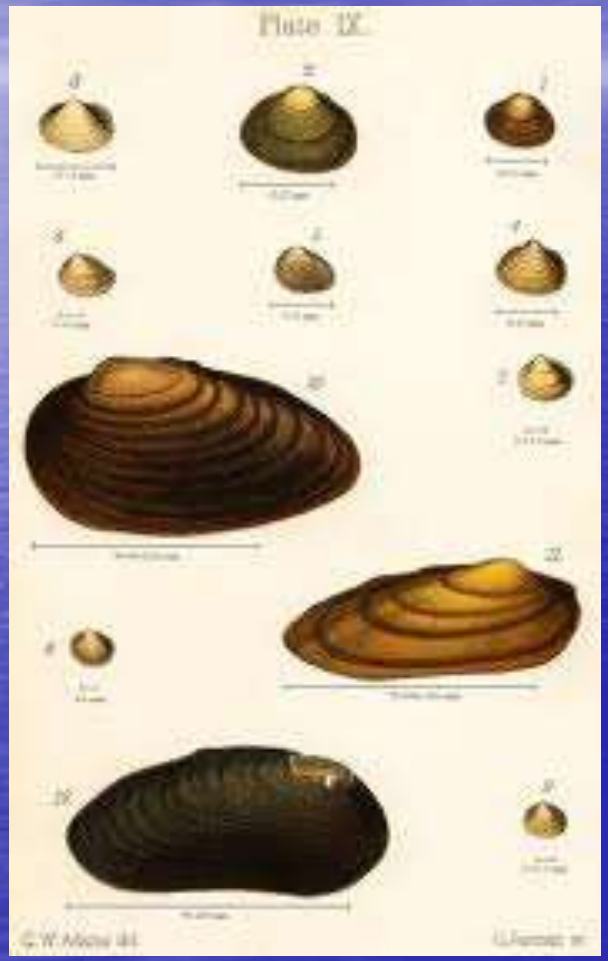
Family *tellinidae*
(500 species) – cherry clam 櫻蛤






Unionidae 淡水蚌

(freshwater 700 species)

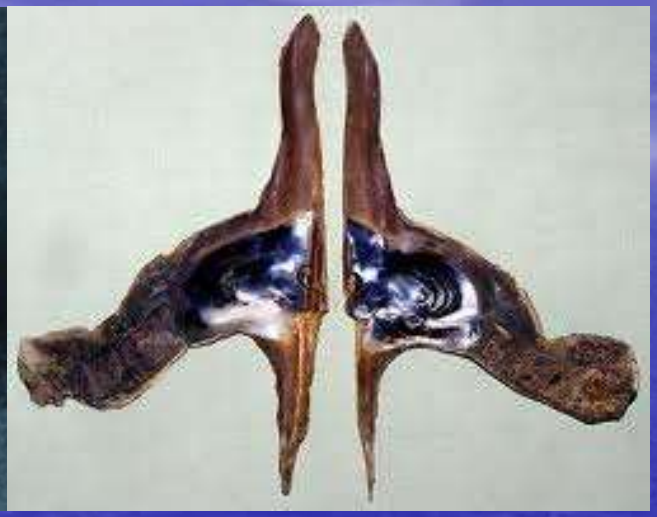


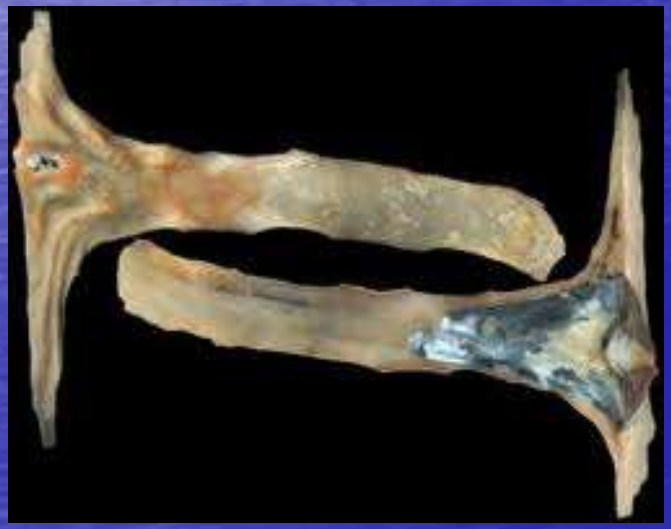
Pacific thorny oyster – *spondylus* 海菊蛤

Thorny oysters

Pearl oysters

Hammer oyster/Thorny oyster/cockscomb oyster





Royal cloak scallop & Noble scallop 海扇蛤

(*Cryptopecten pallium*)

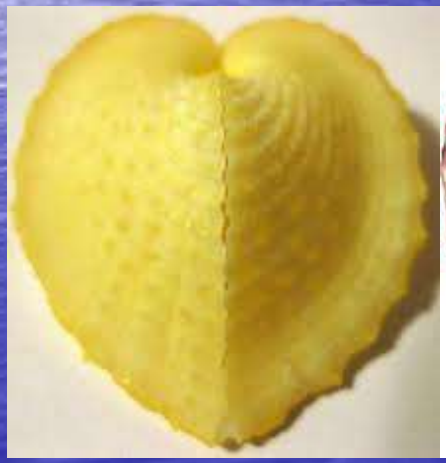
Tiger & Lion's paws

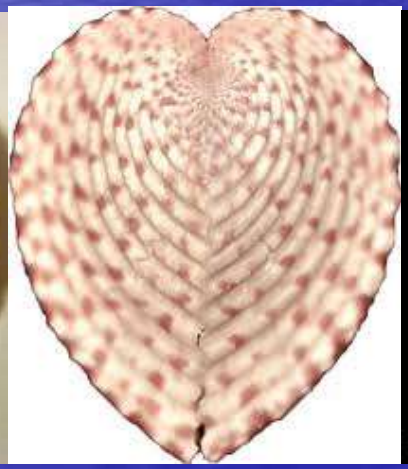
Cockles 鳥尾蛤






Broken Heart cockle 同心蛤





Heart cockles 心蛤

Ark shell 魁蛤

Sanguin / Spengler clam 紫云蛤

Giant clam 硨磲蛤 （*Tridacna gigas*）

Infant, fully grown & pearls known as ”The Pearl of Allah” which can weigh up to 7 kilos measuring 22 cm. Life span up to 75 years

Fluted giant clam 鱗硨磲蛤

(*Tridacna squamosa*)

Piddoks 天使之翼海鷗蛤

Angel's Wings (*Cyrtopleura costata*)

This large bivalve live in the North America Atlantic coast buried to 1 m deep




Jack knife clams & razor shells 蠘

Jack knife clam 剃刀蛤/蠘子

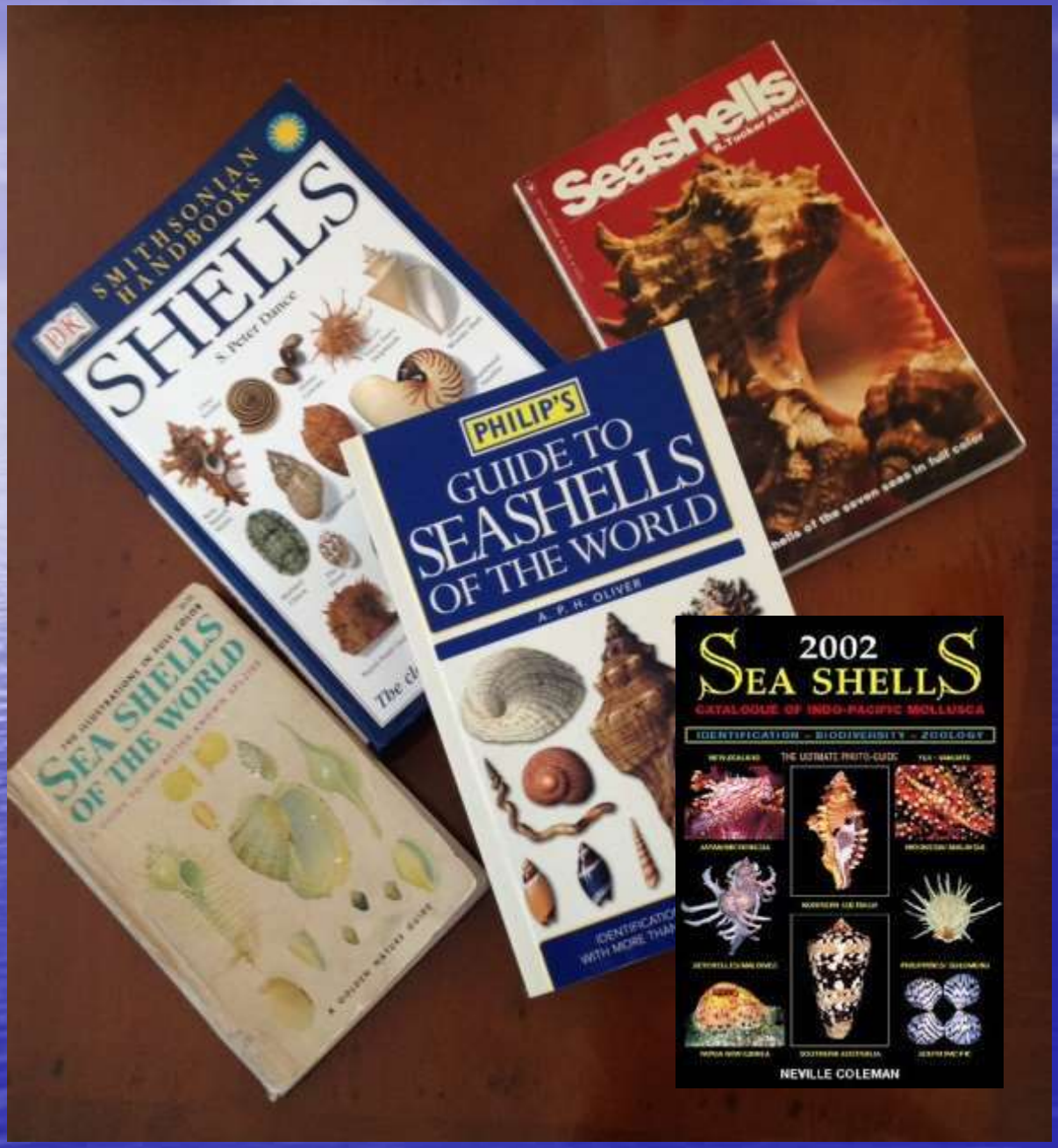
A variety of mussels (*Mytilidae*) 殼菜蛤/ 青口

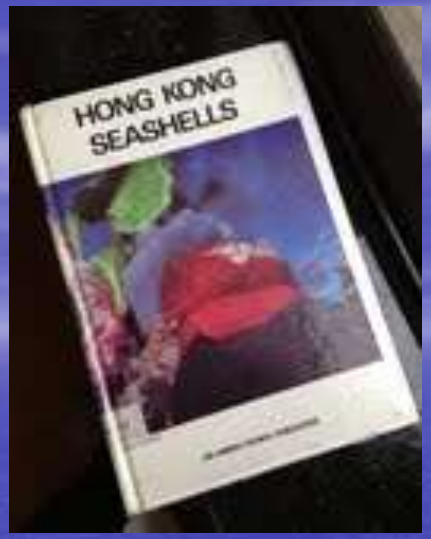
Watering pot 噴管蛤 – the most unbivalvelike bivalve
(*Penicillus strangulatus*)

Shell Collecting

- By type, by region, by size (mini means <1mm), by rarity
- Direct collecting / methods of preparation / protection
- Exchange by joining conchological societies
- Buying from local shops/ e-purchase
- Grading : Gem, Fine +++,++,+ , fine/ Freaks
- Valuation

Freak Shells


SMITHSONIAN HANDBOOKS
SHELLS
S. Peter Dance
DK
Seashells
PHILIP'S
GUIDE TO SEASHELLS OF THE WORLD
A. P. H. OLIVER
SEA SHELLS OF THE WORLD
2002
SEA SHELLS
CATALOGUE OF INDO-PACIFIC MOLLUSCA
IDENTIFICATION · BIODIVERSITY · ZOOLOGY
THE ULTIMATE PHOTO-GUIDE
NEVILLE COLEMAN


HONG KONG SEASHELLS

Museums & shops

- Natural History Museum London (9 million shells)
- Smithsonian Museum Washington DC
- Delaware Natural History Museum Wilmington
- Seashell Museum, Lakes entrance, Melbourne
- Dalian Shell Museum PRC
- Sanya Shell Museum PRC
- Kaohsiung Sea Shell Museum Taiwan
- Lion's Nature Education Centre Shell House, Saikung
- Phuket Seashell Museum Thailand
- H K Shops – So Ku Wan, Lamma Island; Tai O Market; Kwai Fong Mall
- philippe@conchology.be/Topshells.topshells.com

Buying sea shell via the net

Image	Species	Name	Author / Date	Size (mm)	Description	Place	Quality	Price (US $)
	MURICIDAE	DIGITATUS	SOWERBY 1841	46.70	VERY UNCOMMON , OLD COLLECTION , COLLECTED IN JUNE 1973	ETHIOPIA - NEAR MASSAWA	FINE+++/GEM	$ 80.00
	MURICIDAE	MACROPTERUS TREMPERI	HEMPHIL 1910	52.60	LARGE AND EXCEPTIONAL SPECIMEN FOR THIS FORM , VERY NICE , COLLECTED IN 1980 S	USA - CALIFORNIA , OFF DANA POINT	FINE+++/GEM	$ 220.00
	CYPRAEIDAE	MAPPA ELUCETA	LORENZ & HUBER 2000	56.40	RARE AND VERY NICE SPHERICAL SHAPE	KWAJALEIN ATOLL	GEM	$ 180.00
	VOLUTIDAE	MORRISONI	PETUCH 1980	44.00	RARE AND VERY NICE SPECIMEN	HONDURAS	FINE+++/GEM	$ 240.00
	MURICIDAE	PATAGIATUS	HEDLEY 1912	40.00	TOP SPECIMEN AND QUALITY FOR THIS RARE SPECIE , COLLECTED IN 1969	AUSTRALIA - QUEENSLAND , CAPE MORETON	FINE+++/GEM	$ 480.00
	PECTINIDAE	PATAGONICA	KING & BRODERIP 1832	82.20	RARE AND NICE	ARGENTINA - TIERRA DEL FUEGO , ISLA DE LOS ESTADOS	FINE+++	$ 95.00

Thank You !