

Eucoelomates

animals having a true coelom are referred to as being **eucoelomates**

eucoelomate animals have a body cavity that is completely lined with mesoderm

the **mesoderm** can develop into muscle layers & internal skeletal elements

→ a large fluid filled coelom surrounded by muscle layers makes a more effective **hydrostatic skeleton** in many worms

→ mesodermal layers lead to development of arteries and veins, ie circulatory systems; better blood supply to all internal organs

→ since mesoderm lines the digestive tract, this allows for the development of much more elaborate digestive organs

eg. compare the digestive tract of earthworms to *Ascaris*.

→ mesenteries to support internal organs

there are 2 main ways that a true coelom can develop in an embryo:

in **protostomes** the coelom appears as a split in the mesoderm layer of the embryo

most invertebrate coelomates are protostomes

in **deuterostomes**, the coelom appears as outpocketings of the archenteron

echinoderms and chordates and a few minor phyla are deuterostomes

Animals – Molluscs

110,000 living; 70,000 fossils

second largest phylum of animals in terms of number of *known* species

most versatile body plan of all animals

range from fairly simple organisms to some of the most complex and specialized of invertebrates

includes: snails, limpets, clams, mussels, chitons, octopus, squid, oysters, slugs, nautilus, tooth shells

good fossil record; since most secrete a shell

all living classes were well established early in the fossil record

but did not become dominant until the brachiopods mostly died out in the Permian Extinction (~250 MY ago)

microscopic to 20 M (50-60' = giant squid) and up to 900 kg (1980 lbs; ~ 1 ton)

eg. *Tridacna* 1.5 M and 250 kg (500 lbs)

but most (80%) less than 10 cm (~4")

molluscs are mostly aquatic; found from the tropics to

the polar seas

occur from the bottom of the oceans to 7000 M above sea level

typical fauna of all parts of the ocean, ponds, lakes, streams and rivers, mudflats, intertidal and terrestrial habitats

bottom feeders, planktonic, burrowers, borers, pelagic forms

one group, cephalopods, are considered the most intelligent of all invertebrates

the phylum originated in the sea and most of them remain there

→ only **bivalves** and **snails** moved to brackish and freshwaters

→ only **snails** invaded land

mollusks are closely related to segmented worms

→ same larval form = **trochophore**

Body Plan

well developed **bilateral symmetry**

most are **unsegmented**

a few primitive forms seem to show some segmentation.

most molluscs (except bivalves) have a well developed **head**

bears mouth and various sense organs

in spite of wide diversity of group most share basic features of **body plan**:

mantle - secretes shell or becomes outer body covering itself

shell - (internal or external)

radula - specialized feeding organ in mouth

foot - usually used for locomotion

1. Mantle

the body wall of mollusks consists of an outer layer of **epidermis** that extends over most of the animal as a **mantle**

often contains various **sense organs**

eg. **ocelli**, **sensory papillae**

glands in epidermis secretes mucous, cement and sometimes a shell

mantle is underlain by complex layers of muscle and connective tissues

the body cavity of molluscs is a true **coelom**

but is greatly reduced to a small space around the heart

it has become part of an open circulatory system

in some mollusks the mantle hangs down to create **mantle cavity** around the internal organs

houses respiratory organs; gills

sometimes the mantle itself serves as a respiratory organ

products from the digestive, excretory & reproductive systems empty into mantle cavity before release

a continuous current of water is created by **cilia** to bring in food and oxygen and to remove wastes and gametes

some molluscs are able to retract head or foot into mantle cavity for protection

2. Shell

in most molluscs the mantle secretes a **shell** which serves as a protective exoskeleton

great variation in shell form and structure

shell made of **calcium carbonate**

calcium extracted from water, soil or food

shell is composed of 3 layers:

periostracum = outer

especially thick in freshwater molluscs
→ protects from acidity common in fw

in many marine forms this layer is thin or absent

prismatic layer = middle

dense prisms of calcium carbonate crystals in protein matrix

nacreous layer = inner

gloss film of calcium carbonate sheets

secreted continuously through live thickens

produces iridescent "mother of pearl"

shell appears in embryo

grows throughout life → often **growth lines**

usually used for **protection**

but some bivalves use shell to rasp into wood or rock

in some such as squid and octopus the shell is internal and greatly reduced

the **mantle** serves as the animals outer covering

3. Radula

in mouth is tongue-like rasping organ = **radula**

found in all groups except bivalves and aplousobranchs (solenogastres)

hardened file-like, up to 250,000 tiny teeth

the numbers and pattern of teeth are used to identify certain species

new rows of teeth are continually added to the back of the radula and the front teeth are worn down

the radula is supported by a cartilage-like rod (=odontophore)

used to scrape, pierce, tear or cut food

radula also acts as a conveyor belt to move food toward the digestive tract

4. Foot

all molluscs have a thick muscular **foot**

variously modified for **locomotion**:

creeping movements - produced by waves of muscular contractions that move through foot

or by creating a **slime trail** from mucous glands in the foot

eg. snails → gliding movement

or **digging** into sediment
being extended from body into sediment
hydraulically by engorging with blood to anchor
then draw rest of body into sediment

eg. bivalves
eg. scaphopoda

or for **attachment**:

may secrete mucus to adhere to solid substrate

eg. limpets, chitons, land snails

the foot of many bivalves contain a gland that produces **byssal threads** (sea silk) for attachment

silky filaments of keratin and other proteins

attached to substrate by extremely effective cement

in some molluscs a portion of the foot is modified into a long tubular **proboscis** for feeding

Feeding and Digestion

detritus feeders, burrowers, borers, grazers, carnivores, filter feeders, etc

in mouth is tongue-like rasping organ = **radula**

most internal organs, including the digestive system are embedded in solid tissue called the **visceral mass**, instead of being free inside a body cavity (coelom)

complete digestive tract divided into discrete, functionally specialized regions:

foregut

buccal cavity
mouth, radula, salivary glands, esophagus
receives and prepares food

midgut

stomach and associated **digestive glands**
sorting region, crushing region
crystalline style in some to grind food
some digestion takes place in digestive gland

hindgut

intestine usually long and coiled
absorption of nutrients
formation of feces (undigested residue)

Respiration

most mollusks have folded, ciliated **gills** (=ctenidia)

→ thin feathery sheets of tissue covered with cilia

also used for feeding in bivalves

some mollusks breathe through their skin

many terrestrial snails lack gills (=pulmonates)

→ mantle is modified into a sac-like "lung" for breathing air

Circulation

open circulatory system in most

→ blood not entirely contained within vessels

works good for slow moving animals

→ the most active molluscs, the cephalopods, have a closed circulatory system

simple heart with a few vessels

heart with 2 auricles and 1 ventricle

extending from heart is **aorta**

reduced coelom becomes a **haemocoel** surrounding heart

blood contains several kinds of cells:

oxygen carrying cells with pigments to improve efficiency of oxygen transport:

haemocyanin (Cu) - most - blue
some with **hemoglobin** (Fe) - red

some white blood cells

no clotting agents or thrombocytes

cephalopods have a closed circulatory system

Nervous & Endocrine Systems

CNS is a ring of **ganglia** in head area with paired nerves and ganglia extending to other parts of the body

eg. pedal ganglia → control foot

also well developed **endocrine system**

→ controls egg laying and growth

cephalopods show some intelligence

are active predators

→ can recognize prey with sharp eyes

→ can learn by watching

Excretion

usually 1 pair of **nephridia** (=metanephridia)

often called kidneys (not really true kidneys)

(**metanephridium** consist of a tube that opens into body cavity at one end and drains to the outside)

in many species the nephridial tubule also acts as gonoduct

some molluscs have several pairs of nephridia

some excretion occurs through body wall and gills

Reproduction & Development

most molluscs are **dioecious**; some are monoecious

many marine forms produce characteristic larva = **trochophore**

same larval form is found in some flatworms, annelids and a few other minor phyla

in some gastropods and bivalves a second larval form develops = **veliger**

it is also free swimming and has a foot, shell and mantle

in many molluscs the trochophore larvae develops in the unhatched egg and a veliger hatches to become the only free swimming larva in these species

some freshwater bivalves produce a parasitic larva = **glochidium**

it attaches to gills of host fish and feeds on blood

development is **direct**, ie. no larval stage: in cephalopods, many freshwater snails and some bivalves

Classification of Phylum Mollusca

Class: Aplacophora

Class: Monoplacophora

Class: Polyplacophora (chitins)

Class: Scaphopoda (tusk shells, tooth shells)

Class: Bivalvia (mussels & clams)

Class: Gastropoda (snails & slugs)

Class: Cephalopoda (octopus and squid)

Class: Aplacophora

(sometimes divided into 2 classes; Caudofoveata & Solenogastres)

means "no plate or shell"

~370 sp

features may be closer to ancestral mollusc than any other modern group

all marine; most are small; 2-140mm long

soft bodied, wormlike, no shell, no distinct head

body covered with calcareous **scales** or **spicules**

some are burrowers in muddy sediments

→feed on protozoa & microorganisms and detritus

others don't burrow and live on the sediment and feed on larger organisms including cnidaria

radula is present in some, absent in others

some have gills for respiration

no nephridia

monoecious or dioecious

Class: Monoplacophora

means: "one plate"

25 species

small; 3mm to 3 cm

fossils known from Cambrian

→was believed to be an extinct group until discovered near Costa Rica in 1952

small, single, low rounded shell with ventral creeping foot

superficially resemble limpets (gastropods)

unlike other molluscs; show some evidence of **segmentation**

some organs are serially repeated in body:
3-6 pairs of gills
8 pairs of muscles
3-7 pairs of kidneys (nephridia)

[it was once believed that the mollusc ancestor was a segmented wormlike animal but current research has discredited that hypothesis]

have **radula** for scraping food

ladderlike nervous system

similar to flatworms

Animals: Phylum Mollusca; Ziser Lecture Notes, 2012.10

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1 or 2 pairs of gonads

eg. *Neopilina* sp.

Animals: Phylum Mollusca; Ziser Lecture Notes, 2012.10

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Class: Polyplacophora (chitons)

means "many plates"

1000 species

body is flattened with convex upper surface

most 2-5 cm; some to 30 cm

prefers rocky intertidal zones;
but found to 4000 M deep

all marine

clings to rocks or hard surfaces

fairly sedentary; may move short distances to feed

head and cephalic sensory organs reduced

shell contains 8 overlapping plates on dorsal surface

if detached, can roll up like pill bugs/armadillo

Feeding

most feed using **radula** to scrape algae from surface

one predatory species (*Placiphorella velata*)

Animals: Phylum Mollusca; Ziser Lecture Notes, 2012.10

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captures small invertebrates by "jumping" on them

mantle forms a girdle around margins of plates

sometimes covers part or all of plates

broad ventral **foot** attaches firmly to substrate

the grooves along sides of foot form closed "tubes"
open at each end

Respiration

gills suspended in mantle cavity along sides of thick flat muscular foot

water is pumped across gills within the "tube"

at low tide when exposed, can breath air to some degree

Circulation

3 chambered heart pumps blood

Nervous System

2 long nerve cords extend along body

osphradia in mantle cavity near anus

Animals: Phylum Mollusca; Ziser Lecture Notes, 2012.10

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→ samples chemical in water

Excretion

pair of kidneys (metanephridia)

Reproduction

sexes separate (dioecious) in most

produce **trochophore** larva

Class: Scaphopoda (tusk shells, tooth shells)

means "trough foot"

~900 species

slender bodies in tubular shell, open at both ends

most 2.5-5 cm; some up to 25 cm

marine molluscs

subtidal to 6000 M deep

esp Atlantic coast

sedentary (not sessile),

→ burrows into mud or sand

mantle wrapped around viscera and fused to form a tube

foot protrudes through larger end of shell

→used to burrow into sediment

as it burrows it always leaves the small end exposed to water

Feeding & Digestion

feeds mainly on detritus and protozoa caught by **cilia** on foot

or using **captacula**

→mucous covered tentacles extending from head

captacula may also serve a sensory function

radula carries food to **gizzard** for crushing

Respiration

no gills

mantle wraps around viscera and fuses to form tube

movement of foot and cilia pump water through tubular mantle cavity

→gas exchange occurs across surface of mantle

Nervous system

no eyes

captacula may serve some sensory function

Reproduction

dioecious

produces **trochophore** larva

Class: Bivalvia

means: "two valves"

old name for class was pelecypoda = "hatchet foot"

includes mussels, clams, scallops, oysters, shipworms

1 mm to 1.5 M (*Tridacna*)
up to 500 lbs

all are aquatic
mostly marine,
many brackish,
some freshwater

most are filter feeders

no head, no radula, almost no cephalization

Shell

shell is laterally compressed; 2 valves (right & left)

"bulging" part of shell on dorsal side near hinge
= **umbo**

is the oldest part of shell; grows from edges

shell held together dorsally by **hinge** and **adductor muscles** extending between shells

shell is mainly used for **protection** but does have some other uses in some species:

eg. shipworms use shell to burrow into wood and then feed on wood particles

eg. some clams are able to bore into rock and concrete with spiny valves

eg. scallops use shell for propulsion by quickly closing them together to force out water

→ can swim in any direction

Mantle

shell is secreted by **mantle**

their mantle can also produce "**pearls**"

pearl production is a protective action toward some foreign body between shell and mantle

eg. sand grain, parasite, etc

mantle secretes layers around object

commercial pearls are produced by some oysters & some freshwater bivalves

posterior portions of mantle come together to form **incurrent and excurrent siphons**

in some bivalves the siphons can be quite long

Foot

muscular foot used for locomotion

changes in blood pressure as hydrostatic skeleton allow foot to dig in and anchor itself in sediment

then muscles constrict and pulls rest of animal in

some mussels are sessile and attach to substrate by **byssal threads** secreted by glands in the foot

Feeding & Digestion

most bivalves are **filter feeders**:

gills are used to filter food out of water

food is strained out as water passes over gills

trapped in **mucous** and moved by **cilia** to mouth

some bivalves are **deposit feeders**:

use long proboscis like organ formed from modified **foot** to collect food in sand or mud

some bivalves use their **shell** to bore into solid objects to extract food:

eg. **shipworms** "termites of the sea"
have long, wormlike appearance; long siphons
use small valves as rasping organs to drill through wood
and eat wood particles excavated
bacteria in gut digest the wood and fix nitrogen for host

some bivalves are **predators**:

eg. **septibranchs** slurp up tiny crustaceans by creating a strong suction in mantle cavity to draw in prey

eg. **razor clams** thrust proboscis between shells of other bivalves to kill and eat them

some bivalves get most of their food from symbiotic algae (**dinoflagellates**) that live in mantle tissue

eg. *Tridachna*

food enters mouth and enters stomach

in stomach, food is sorted

a gelatinous rod (= **crystalline style**) spins slowly (by cilia) & dissolves to release digestive enzymes

particles are **sorted** by size:

→ larger particles move to intestine

→ smaller particles move to digestive gland

Respiration

gills used for respiration

cilia on gills create incurrent and excurrent flow

oxygen is extracted from water passing over gills

Circulatory System

3 chambered **heart** (2 atria, 1 ventricle) in **pericardial cavity**

wraps around intestine

beats slowly

pumps blood to gills for oxygenation and to kidney for excretion

Nervous System

3 pairs of interconnected **ganglia**

sense organs poorly developed

statocysts in foot

tactile cells in mantle cavity

eyes in scallops along mantle edge
→ each has cornea, lens, retina, pigment layer

Excretion

pair of "U-shaped" kidneys (metanephridia)

Reproduction

usually dioecious;

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some (eg some oyster species) are prodandrous
gametes discharged into mantle cavity and out
excurrent siphon

in most → fertilization is external

eggs develop into characteristic **trochophore larva**

in some marine forms a second free swimming larval
form is produced = **veliger**

(has shell, foot and mantle)

eg. oyster:

50 Million eggs released per season

embryo develops into trochophore

→ veliger

→ spat

freshwater bivalves have internal fertilization

gills become brood chambers

bivalved **glochidia larvae** (specialized veliger) are released

some moms can "shoot" larvae into water column

others produce a structure that looks like a small fish to
entice predatory fish

when fish bites the "bait" it gets a mouthful of
glochidia which then attach to the lungs

Animals: Phylum Mollusca; Ziser Lecture Notes, 2012.10

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they parasitize gills of fish for 1 - 3 weeks generally causing little
harm to their host but dispersing far and wide

then release and sink to bottom to become filter feeders

Animals: Phylum Mollusca; Ziser Lecture Notes, 2012.10

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Class: Gastropoda

means "belly foot"

70,000 living species; 15,000 fossils

→ 1/3rd of all molluscs

largest and most successful class of molluscs

extremely diverse group: snails, slugs, abalones,
limpets, whelks, conchs, periwinkles, sea slugs,
sea hares

microscopic to 1 M long; most 1-8 cm

marine, freshwater and terrestrial representatives

→ virtually every mode of life except aerial

marine: littoral to deepest ocean
some pelagic in open ocean
some brackish

freshwater: rivers, lakes, streams ponds, etc
tropics to poles

terrestrial: woodlands, pastures, mosses, cliffs,
some specialized for climbing

usually sluggish and sedentary

some sea slugs are brightly colored

Animals: Phylum Mollusca; Ziser Lecture Notes, 2012.10

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Body Plan

unlike clams, snails and slugs have a distinct **head** with brain, sense organs and mouth

sense organs: simple eyes
tentacles
chemical receptors

mouth with **radula**
→ rasps and scrapes algae

elongated body with **foot** below for gliding

mantle secretes shell and forms dorsal surface of animal

in slugs the mantle forms a hollow breathing chamber

Shell

most have a single heavy shell for defense

some shells with **operculum**

a few have no shell

snails are very well **protected**:

→generally secretive habits

→strong shell, some with door

→some can produce toxic secretions

→some can deliver an active blow with sharp operculum to deter attack

→some can even redeploy stinging cells from cnidarian prey

still many are eaten by insects, fish, birds & mammals

and parasitized by a variety of helminths

slugs have lost their shell

(but still produce one temporarily during embryonic development)

most shells show some degree of **coiling**; a few do not

coiling occurred early in the fossil record of gastropods

all living gastropods, whether coiled like snails or uncoiled like limpets and slugs, descended from coiled ancestors

in addition to coiling, some animals also show **tortion**

tortion was a separate evolutionary event from coiling; occurred later in evolution

animal begins with basic bilateral symmetry but becomes assymetrical due to **tortion**

tortion

→ brings gills up front for better gas exchange

→ makes more room in shell for retraction

→ but puts anus over head; greater chance of fouling mouth

some shells also show **spiral** winding instead of straight coil

makes shell more compact

but unbalanced → shell tipped over

gills, auricle, and kidney on right have been lost

this assymetrical loss helped reduce fouling of tortion

→ water is brought into left front side of shell and out right side of shell

Feeding & Digestion

wide variety of feeding types in the group

1. most gastropods are **herbivores**

a. use **radula** to scrap algae off of hard surfaces such as rocks

eg. aquarium snails

b. some are **browsers**

eg. abalone holds seaweed with foot and breaks off pieces with radula to eat

c. some are **plankton feeders**

they drift in plankton as they eat algae

2. some are **filter feeders**

eg. **limpets** use gill cilia to draw in water current with food particles then filters out food

3. others are **scavengers**

feed on dead and decaying organisms

4. some are **carnivores**

feed on a variety of animals

eg. other mollusks, especially bivalves; soft corals, fish, worms, etc

some carnivores can follow chemical trails to locate their prey

often have a long tubelike **proboscis** that they can thrust between the shells of bivalves and kill and digest prey

some use **venom** to subdue their prey

eg. cone shells

one of the most specialized of the group

radula consists of individual teeth; each charged with a highly toxic **venom**

when prey is located the snail extends wormlike **proboscis** to attract prey, eg a fish

its proboscis is loaded with one of its toxic teeth

when close enough, the tooth is expelled like a harpoon to paralyze the prey

this allows a slow moving predator to catch often a much faster prey such as fish

the stings of some species are lethal to humans

eg. moon snail (*Polinices*) & oyster borer (*Urosalpinx*)

uses **radula** to help bore hole through bivalves

also secretes digestive chemicals to help drill through shell

once hole is complete, snail thrusts **proboscis** through hole and spends hours or days feeding on prey

using its radula to cut and tear off pieces of flesh

eg. sea butterflies

some secrete a mucus net to capture zooplankton

then draw their web into their mouth and eat web and all trapped food

eg. sea slugs (nudibranchs)

often brightly colored

Animals: Phylum Mollusca; Ziser Lecture Notes, 2012.10

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feed on sea anemones and corals

the undischarged nematocysts of their prey are preserved and transported to the surface of their bodies and used for defense

Respiration

simple gills (=ctenidia) are variously modified in aquatic forms

terrestrial snails (=pulmonates) lack gill but have highly vascularized mantle cavity that serves as an air breathing "lung"

lung opens to outside through a small opening (= **pneumostome**)

draw air in over moist surface of the mantle to extract oxygen

many pulmonates have returned to water and therefore must surface periodically to breath

Excretion

most gastropods have a single nephridium ("kidney") to remove metabolic wastes

Nervous System

3 pairs of **ganglia** connected by nerves

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sense organs:

simple **photoreceptors** that detect light and dark

a few have image forming **eyes** with cornea and lens

statocysts for balance

tactile organs – one or two pairs of tentacles
one pair usually contains the eyes

chemoreceptors – especially in incurrent areas of respiratory system

Reproduction

monoecious or dioecious

a few (eg *Crepidula*) are **protandrous**

many gastropods perform elaborate **courtship ceremonies**

many terrestrial snails eject a **dart** from dart sac into partners body to heighten excitement before copulation

after cross copulation, each partner deposits its eggs in shallow burrows

a few primitive gastropods eject sperm and eggs into water

in aquatic forms eggs may be attached to substrate or

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float freely in plankton

some marine forms enclose eggs in wide variety of tough **capsules**

eg. welk

a few freshwater forms brood their eggs in oviduct or bear live young (ovoviviparus)

Animals: Phylum Mollusca; Ziser Lecture Notes, 2012.10

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Examples of Gastropods

eg. Nudibranchs (sea hares, sea slugs, sea butterflies):

nearly all are marine

diverse group, widely distributed, mostly shallow waters
some pelagic,

brilliant colors

feed on sea anemones and corals

→ draw color from their prey

→ also able to salvage & absorb and use cnidocytes for protection

some contain toxins,

all except sea hares are avoided by predators,

unique coloration may be warning

eg. Pulmonates

mostly freshwater snails and slugs

some aquatic some terrestrial

hollow mantle cavity instead of gills → can breath air

land pulmonates are limited in distribution by temperature extremes, mineral content of soil, lack of humidity, acidity

those that are aquatic must come up for air

eg. Land Slugs

Animals: Phylum Mollusca; Ziser Lecture Notes, 2012.10

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Class: Cephalopoda

800 living species; 10,000 fossil species

means "head foot"

include squid, octopus, nautilus, cuttlefish

extensive fossil record back to Cambrian

dominant life in ancient oceans after trilobites declined

all marine

2 cm to 60' (giant squid, weighs almost a ton)

giant squid is most massive invertebrate

most active & most advanced of all molluscs

→ some argue: most advanced of all invertebrates

Shell

most fossil forms (eg. ammonites common in Texas)
had very large heavy shells kept buoyant by gas filled inner chambers

only a few today with large external shell

eg. Nautilus

Animals: Phylum Mollusca; Ziser Lecture Notes, 2012.10

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shell spiral as some gastropods

but divided into chambers

chambers not found in gastropods

chambers connected by cord of living tissue = **siphuncle**

can adjust gas in chambers for neutral buoyancy

some have **internal shell** completely enclosed by mantle

eg. cuttlefish, squid

some have completely lost shell and mantle encloses and protects animal

eg. octopus

shell was sacrificed for speed to avoid predation

Mantle

in most cephalopods the **mantle** serves as the animals outer covering

much thicker and more muscular than in other groups

protects internal organs

squid & cuttlefish are excellent swimmers

can forcefully expel water from the mantle cavity through a ventral **funnel** (siphon) creating "jet propulsion"

Animals: Phylum Mollusca; Ziser Lecture Notes, 2012.10

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the funnel can be pointed to quickly move in any direction

squid are streamlined and have **lateral fins** that greatly improve their swimming ability

the surface of the mantle and the rest of animal is covered by pigment cells called **chromatophores**

chromatophore is an elastic pigment cell

tiny muscles surround each one

contraction expands chromatophore and changes color of body

allows animal to rapidly change color

under nervous and hormonal control

can produce general darkening and lightening
flashes of pink, yellow, lavender

can form bars, stripes, spots and blotches

can indicate danger, protection, or used during courtship

many deep sea forms are bioluminescent

Animals: Phylum Mollusca; Ziser Lecture Notes, 2012.10

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Head & Foot

in cephalopods, the **head** is indistinguishable from the **foot**

the "head-foot" is elongated into 8 or 10 **tentacles** (up to 90 in nautilus) and 2 longer **arms**

mouth at center of arms; contains chitinous **beak** or **jaws**

octopus is better adapted to crawling than swimming

crawls over rocks and corals & into crevices using suction discs on its tentacles to pull or anchor itself

some deep water octopi have webbed tentacles and swim like jellyfish

Digestive System

all cephalopods are **predators**

use tentacles and arms to capture and handle prey
suction cups

strong beaklike **jaws** enclose tongue-like **radula**

octopus and cuttlefish have **poison glands** to help subdue prey

Respiration & Circulation

since the cephalopods are so active they require more oxygen than other molluscs

most have 1 pr of large gills; no cilia

mantle cavity expands and contracts to draw water over gills → more efficient than cilia

1-way valves allow water to enter along edges of mantle but force water to exit through funnel for locomotion

closed circulatory system

→ more efficient for gas exchange and transport

accessory (brachial) **hearts** at base of each gill improves pumping efficiency even more

Nervous System and Senses

largest brain of any invertebrate

several lobes with millions of nerve cells

more elaborate than in other classes

much of our current knowledge of nerve cell function is based on studies of the large nerve fibers of the squid

brain is located behind mouth

octopus and cuttlefish actual "think & plan"

learn and react to their environment

level surpassed only by some vertebrates

generally considered the cleverest of all invertebrates and rival mammals in some ways

masters of disguise

most versatile use of **chromatophores** in the animal kingdom, esp. cuttlefish

great curiosity; can solve problems

can easily learn behaviors by reward/punishment

if they see another rewarded for a particular choice they will do the same thing to get the same reward

one octopus would short circuit the light over her tank by squirting water at it if someone forgot to turn it off at night

can use rudimentary tools

biologists have recently (2010) reported the first example of "tool use" by an invertebrate:

a species of octopus in Australia has been observed carrying around coconut shells and using them for cover when threatened

European Union has recently (2012) offered them the same protections as lab rats

sensory organs are better developed in cephalopods than in other mollusk classes

eyes: most have very well developed eyes with cornea, lens retina

statocysts: large and more complex than in other classes important in controlling eye position

tentacles: use tentacles for tactile exploration

Protection: Ink Sac

most cephalopods have an **ink sac** for protection

melanin pigment

→ creates smoke screen to facilitate escape from danger

Reproduction

dioecious

before copulation, males often make color displays to compete against rival males

sperm encased in packets = **spermatophores**

and stored in mantle cavity

arm of male is used to transfer sperm to female = **hectocotylus arm**

plucks spermatophore from its own mantle cavity and inserts it into females mantle cavity

eggs attached to stones or brooded by female

direct development; no free-swimming larvae

juveniles hatch from eggs

Major Groups of Cephalopods

1. nautiloids
2. ammonoids - all extinct
3. coleoidea - all living forms except nautilus

Ecological Impacts of Molluscs

1. important in **food webs** in aquatic ecosystems and even in terrestrial ecosystems

mollusks are eaten by a large number of animals

2. snails are major source of calcium for birds
3. oysters are **keystone species** since they tend to form reefs nearshore

the cracks and crevices provide homes for a large variety of animals creating a complex community of interactions

4. threatened & endangered mollusks

freshwater bivalves are now the most threatened group of invertebrates in the US

some can live up to 50 years

once >300 species in rivers, lakes, etc

today: ~24 are extinct
>160 endangered or threatened

11 species in Texas about to be listed in the endangered list ⁽²⁰¹⁰⁾

especially due to:

hunting and harvesting & poaching

were actively harvested by native americans for food, tools, jewelry

early settlers collected massive quantities for food and pearls

even today 1000's are collected for pearls & meat often sold as pet food; some human consumption

damming rivers

pollution, sedimentation

since they filter the water they are especially sensitive to pollutants and sediment

they are often the first species to disappear or decline when environmental conditions change

due to mining, industry & agriculture

5. Bioinvasives

eg. asian clam

eg. zebra mussel

named for distinctive striped shell pattern

arrived in US in 1986 via ballast water from European freighter into Lake Erie

now found throughout the Great Lakes

voracious eaters that disrupt food chains by competing for same food as native species

extremely fertile and can disperse at any stage of life

able to strongly attach to any hard surface by tough byssal threads

→ have found 15000 attached to a single 4" clam

able to completely block water inlet pipes of water treatment plants and power plants

highly costly to remove

have been found clinging to boats and are quickly spreading throughout the US

not yet in Texas but already have been found in Oklahoma

Human Impacts of Molluscs

1. tusk shells used as money (=wampum) by native Americans

2. as food: oysters, scallops, mussels, octopus, squid

eg. >2 Billion pounds of oysters are eaten each year

oysters first cultivated for food for 2000 yrs

oyster middens are found from ancient roman times and are common at coastal archaeological sites

certain species consumed cooked or raw

eg. octopus, squid & cuttlefish: 3 million tons/yr are consumed; an industry valued at >\$6 Billion

3. precious "stones"

shell nacre → buttons, cameos, etc

some species of oysters and some fw clams produce **pearls**

generally produced when a parasite gets between the shell and mantle of the animal

natural pearls take many years to grow and are very expensive

cultured pearls use "blank" of polished shell placed under mantle of oyster, then allows layers to deposit for 3-6 years

much quicker process, much cheaper, preferred today

4. ink → sepia dye

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5. cuttlebone from cuttle fish

6. Pharmaceuticals

eg. medication derived from cone snail venom alleviates some kinds of chronic pain that even morphine can't control

5. shell collecting

6. pollution control

oysters consume nitrates and ammonia helping to clean & purify eutrophic waters

a project in Chesapeake Bay is using oyster reefs to remove 19 million pounds (8.6 M kg) of nitrogen compounds/yr from the bay waters

6. destructive species

snails and slugs → gardens

boring snails destroy oyster beds

shipworms → damage wooden ships and warves

some are not deterred by creosote treatment

some bivalves can even bore into concrete

bioinvasions; eg zebra mussel

intermediate hosts to parasitic helminths

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