Name_____Date_____

Ch. 7 Marine Invertebrates

Mrs. Peck

Kingdom Animalia- eukaryotic, multicellular w/ cellular differentiation (CTOS)
lack cell walls.....other forms of support & protection (exo or endo skeleton)
heterotrophs...lack chloroplasts
sexual repro (some asexual as well)

2 groups: 1. **vertebrates** chordates with a backbone

2. **invertebrates** animals that lack a backbone
95% of kingdom Animalia

SPONGES

Phylum Porifera- meaning "pore bearing"

sponges- invertebrates that consist of a complex aggregation of cells, including collar cells, and have a skeleton of fibers and/or spicules

*simplest of all animal kingdom

mostly all 9000 species are marine: located in all waters, though mostly tropical

all are **sessile**-an organism that lives attached to the bottom or to a surface

only cellular level of organization (complex aggregation of specialized cells) C
no tissues

HETEROTROPH

suspension feeders- animal that feeds on particles suspended in the water

filter feeders- a suspension feeder that actively filters food particles

food: plankton, bacteria, or organic matter
plankton- organisms that drift in the water

STRUCTURE: skeleton: of spongin fibers (structural protein) wh/ may or may not have spicules (siliceous or calcareous) embedded b/w mesoglea(gelatinous layer between outer (choanocyte) & inner (pinacocyte) layers of cells.
fig. 7.1

spicules- any of the small calcareous or siliceous bodies embedded among the cells of a sponge or in the tissues of other invertebrates

spongin- the resistant fibers of a sponge
elastic fibers made of structural protein

pinacocytes- flat cells on the outer surface of sponges

porocytes- (pore cell), tube-like cell of sponges that forms a pore, or ostium

surface covered with **ostia**- (sing. ostium) tiny openings in a sponge

SPONGE STRUCTURE fig. 7.1 **2**

choanoctyes- (collar cells)- flagellated food trapping cell of sponges
located in inner layer
creates currents to move water into sponge

amebocyte- wandering cells of sponges, secrete spicules, transport food, store food, involved with regeneration, some cases dev. into gametes

located in middle layer

osculum- large opening in many sponges

REPRODUCTION

asexual reproduction- vegetative repro., takes place w/o the formation of gametes

sponges use budding, or branches will fall off and dev. into identical sponges

sexual reproduction reproduction that involves the union of gametes

gametes- a haploid reproductive cell that develops into a new individual after its union with another gamete. sperm cell or egg cell

gametes produced by collar cells or amebocytes
not in gonads as in most animal (sponges do not have CTOS)

both gametes may be produced by same sponge
some sponges have separate sexes

sponges undergo spawning:
spawning- the release of gametes or eggs into the water

IMPORTANCE

1. economic imp: commercial use: sponge divers collect and sell bath sponges
   bath sponges (remaining spongin fibers after cells are washed away)
2. produce chemicals that bcm drugs for humans or have potential of bcmg drugs
   eg. anti-inflammatories, pain killers, antibiotics
3. provide shelter for other marine organisms

Cnidarians

phylum Cnidaria meaning "to sting" or phylum Coelenterata meaning "hollow gut"

called 1. **cnidarians**- invertebrates with nematocysts and radial symmetry

2. coelenterates

evolved some cellular differentiation: dev. of tissues (perform special functions) CT
enabling: response to stimuli, ability to move (swim), ability to capture prey

Examples: jellyfish, sea anemones, and coral

Cnidarians

Body Plan

radial symmetry- the regular arrangement of similar body parts around a central axis
no head, front, or back
look same from all sides fig. 7.5 & 7.11
2 surfaces: 1. **oral surface**-surface with the mouth
2. **aboral surface**- the surface opposite the mouth

2 forms: 7.5 & 7.11
1. **polyp**- the cylindrical, typically attached, stage of cnidarians coral & sea anemones

2. **medusa** the bell-shaped, free-swimming stage of cnidarians jellyfish

no true nervous system: specialized nerves from nerve net (esp in medusa for movement)

1 opening digestive system: centrally located mouth surrounded by tentacles.
Mouth opens into gut.

tentacles- flexible elongated appendages

gut- a blind cavity where food is digested, only one opening...the mouth

carnivores: 1. nematocysts in tentacles sting prey
2. tentacles capture prey pull into mouth
3. food enters gut and is digested (extracellular)
4. digested food enters gastrodermis & is further digested (intracellular)
5. waste is ejected from gut via mouth

nematocysts the stinging structure of a cnidarian

2 true layers, w/ gelatinous middle (no tissues in middle)

epidermis external layer of cells in body wall of cnidarian

gastrodermis- internal layer of cells in the body wall of cnidarians, lines the gut

mesoglea- layer between the epidermis and the gastrodermis in cnidarians

Worms

4 types: flatworms, ribbon worms, round worms, segmented worms

exhibit **bilateral symmetry**- arrangement of body parts in such a way that there is only one way to cut the body & get two identical halves (longitudinally)

adv.- enables animals to be more active in pursuit of prey or avoid being prey
can develop more advanced behaviors than radially symmetrical orgs.

anterior- front end, usually the head w/ brain or ganglia and sensory organs: eyes
posterior- rear end (opposite of anterior)
dorsal- back surface
ventral- belly surface

phylum Platyhelminthes- meaning flattened Flatworms

flattened dorsoventrally

simplest animal exhibiting cellular differentiation: w/ tissues organized into real organs and organ systems CTOS

3 true layers: epiderm, endoderm, and mesoderm (instead of mesoglea gives rise to muscles, repro. organs, & oth organs)

nervous system: brain and central nervous system (CNS)

1 opening digestive system: mouth to blind gut

marine types: turbellarians fig. 7.12

*flukes: all parasitic live in invertebrates (snails & clams), fish, and seabird hosts....eaten by humans

*tapeworms: live in intestine of marine vertebrates absorbing nutrients from host intestine directly into cells (no digestive system)

phylum Nemertea- Ribbon Worms

complete digestive system (2 openings: mouth & anus)

circulatory system

proboscis- long, fleshy tube used by ribbon worms to entangle prey fig. 7.13

all predators feeding on worms & crustaceans

Worms

phylum Nematoda- Roundworms

small slender cylindrical body pointed at both ends

complete digestive system (2 openings: mouth & anus)

inhabit sediments: feed on bacteria and organic matter (very common)

parasitic- live in tissues of marine organisms (most groups of marine orgs have nematode parasites-widespread)

humans may eat uncooked infected tissue of marine organism....causes flu like symptoms or may penetrate walls of digestive system (eg>sushi)

phylum Annelida- meaning segmented Segmented Worms

body in **segments-** series of similar compartments

digestive system runs through segments in coelom (cavity inside organism lined with cells derived from mesoderm)

types:

1. **class: polychaetes**- meaning many setae

most marine annelids are polychaetes 10,000 marine species

parapodia on each segment with setae on them

parapodia- flattened limb-like extensions

setae- stiff bristles

closed circulatory system- blood w/in blood vessels, circulated by pumping organ or muscular contraction around vessels

gas xΔ: have gills on parapodium

gills- thin walled extensions of body wall that have many capillaries allowing for gas xΔ (oxygen and carbon dioxide)

some crawling carnivores

some in mud or sand..**deposit feeders**- feed on organic particles that settle on bottom

phylum Annelida

Types: 1. **class: polychaetes**

2. **class: Oligochaetes**-

live in sand or mud

deposit feeders

marine relative of earthworm

lack parapodia

3. **class: Hirudinea**- Leeches

blood sucking worms attached to marine fishes and invertebrates

sucker at anterior end

lack parapodia

Particulate matter feeding: 2 types:

1. **deposit feeders**- feed on organic particles that settle on bottom

2. **suspension feeding**- feeding on particulate organic matter in the water fig. 7.16

2 types: filter feeding- water is actively pumped or filtering structures are swept thru water

passive suspension feeding- no active pumping, use cilia & mucus to move particles into mouth

Molluscs invertebrate w/ a soft, unsegmented body, a muscular foot, & usually a calcareous shell

phylum Mollusca- meaning "soft body" Molluscs

*largest group of marine mammals (more molluscs in ocean than any other group)
200,000 species (only arthropods have more organisms in their phylum)

soft body (with muscular foot) in a calcium carbonate shell (not always present)
shell is internal in squids and not present in octopuses

mantle- thin layer of tissue that secretes the shell of a mollusc

bilateral symmetry (although some parts of snail are asymmetrical)

use muscular **foot**- for locomotion

head usually has sensory organs (eyes ect)

radula- "rasping tongue" ribbon of small teeth used to "rasp" or scrape food from a surface (eg. algae)
made of **chiton**- a complex derivative of carbohydrate (in oth invertebrates too)

gas xΔ: through paired gills

TYPES OF MOLLUSCS

high diversity of structure and habit (rocky shores to hydrothermal vents)

3 Classes: 1. gastropoda
2. bivalvia
3. cephalopoda

GASTROPODA means "stomach foot" stomach down by foot-"crawling on belly

largest group of molluscs 75,000 species (mostly marine)
most common group of molluscs
most varied group of molluscs

coiled mass of viscera (vital organs) enclosed by a dorsal shell fig. 7.19
shell rests on a ventral creeping foot (shell is usually coiled)
foot has operculum on posterior end..can retract foot into shell blocking entrance w/ operculum

ex: snails, limpets, abalone, nudibranchs (sea slugs) fig. 7.21

most use radula to scrape algae from rocks
some are deposit feeders
some are carnivores (preying on clams, oysters, worms, sm. fish or oth. invertebrates)

nudibranchs have no shell, colorful branches of gut or gills, prey on sponges, invert., some keep toxins or nematocysts from prey and use as defense mechanism

TYPES OF MOLLUSCS

BIVALVIA means "2 valves"

body is laterally compressed and enclosed in a two-valved shell fig. 7.22

-no head

-no radula

Filter Feeder- gills expanded and folded to filter food particles from water & move them up to mouth, the palps then move food particles into mouth.

-food digested in stomach with help of a crystalline style

-gills involved with gas xΔ

-inner surface of body lined by **mantle**- the outer layer of tissue that secretes the shell of molluscs

-whole body lies in **mantle cavity**- space lined by the mantle of molluscs

-2 strong muscles used to close valves (scallops we eat are these muscles)

clams: shovel-shaped foot to burrow in sediment fig. 7.22

while buried use **siphon**-(tube-like extension) to draw water in and out
siphon formed by fusion of edge of mantle
siphon enables clam to get oxygen and food while buried

giant clam: largest mollusc (3 ft long)

mussels: non burrowers

secrete strong **byssal threads** to attach them to rocks

*strong threads secreted by mussels for attachment

oysters: non burrows

cement their left shell to hard surface (often shell of other oysters)

pearl oysters: source of commercially valuable pearls

pearls formed: particle or parasite lodges b/w mantle and shell
mantle secretes layers of calcium carbonate around particle
over time layers build up forming pearl

cultures pearls: insert piece of plastic b/w mantle and shell

scallops: some live unattached and "swim" by ejecting water from mantle cavity & clapping valves

-many bivalves bore into coral, rock or wood (mangroves, boats, pilings, driftwood)

fouling organism- organisms that live attached to submerged surfaces such as boats or pilings

TYPES OF MOLLUSCS

CEPHALOPODA means "head foot" (head pushed down to feet-tentacles)

650 species all marine squid, octopus, cuttlefish, nautilus

predatory, body plan designed for locomotion

-foot modified into arms and tentacles- usually have suckers to catch prey

-complex nervous system (octopus smartest marine invertebrate)
large eyes set to sides of head (similar to human eye)

-body protected by thick, muscular mantle

-mantle forms a cavity behind head that encloses 2-4 gills

water enters thru free edge of mantle and leaves via **siphon** or **funnel**

siphon- tube-like extension thru wh/ water flows in and out of mantle cavity
funnel-muscular tube formed by remains of foot wh/ projects from head

-swim by forcing water in and out of mantle cavity thru siphon (wh/ can be moved around so animal can move in any direction) "jet propulsion"

octopuses- 8 long arms
lack shell
common bottom dweller
size: 2 inches to 30 feet
prey on crabs, lobsters, shrimp: biting them with beak-like jaws
radula may help rasp away flesh from prey
some secrete toxins in bite or paralyzing toxins from skin
distract predators by emitting a cloud of dark fluid produced by **ink sac**
ink sac- a gland found in cephalopods that secretes a dark fluid to discourage predators

squids- better adapted for swimming than octopuses
size: 1 inch to 66 feet
elongated body covered by mantle wh/ forms 2 triangular fins
use siphon to move in all directions-forward and backward
8 arms and 2 tentacles (all have suckers) surround mouth
tentacles are long, retractable & have suckers only on broadened tip
used to catch prey, shoot out quickly
pen-the reduced thin shell of squid embedded in upper surface of mantle
giant squid (66 ft long)- largest invertebrate

cuttlefish- 8 arms and 2 tentacles
body flattened w/ fin running on sides
cuttlebone: calcified internal shell for buoyancy
sold in pet stores for calcium source for birds

nautilus- smooth, coiled shell w/ series of gas filled chambers for buoyancy
60-90 suckerless tentacles used to capture crabs and fish

chitons: 800 species all marine
8 overlapping shell plates cover dorsal surface
rocky shores using radula to scrape algae

Biology of Molluscs:

Feeding and digestion

complete digestion system: 2 opening- mouth and anus

salivary and digestive enzymes

digestion: extracellular in gut and in digestive glands dig. algae

carnivorous snails us radula to cut or catch prey wh/ is dig. in gut

bivalves lack radula, ingest filtered food particles, dig. by **crystalline style**

crystalline style- enzyme secreting rod in stomach wh/ rotates food
food eventually moves into large digestive gland for intracellular dig.

cephalopods dig. large prey in stomach and in dig. sac: dig. all extracellular

circulatory system

most molluscs have **open circulatory system**-blood flows out of vessels into open blood spaces

dorsal muscular heart pumps blood to all tissues

cephalopods have **closed circulatory system**-blood remains in vessels

more adv. at delivering oxygen to tissues...eg. brain

nervous system and behavior

gastropods and bivalves: simpler, no brain only **ganglia**-clusters of neurons "local brains" located thru-out body

cephalopods: brain coordinates and stores info from env.

"smartest of all invertebrates" can learn

well dev. eyes

many exhibit color changes (cuttlefish too)

reproduction and life history

most separate sexes

some **hermaphrodite**- individual has both mail and female gonads

external fertilization: bivalves, chitons, some gastropods

internal fertilization: cephalopods, most gastropods

some fertilized eggs dev. into larva bivalves, gastropods

some fertilized eggs hatch out young cephalopods, gastropods

female octopuses protect eggs and die after hatching (starvation)

Arthropods phylum Arthropoda meaning "jointed-foot" **11**

*largest phylum of animals
more than 1,000,000 species (believe b/w 6-9 million actual species not discovered)
75% of animals are arthropods
most successful animals: conquered land, sea, and air

Characteristics:

-bilateral symmetry
-segmented body
-jointed appendages (legs and mouth parts)
-**exoskeleton**
tough, nonliving, made of chiton (protein), lipids and calcium carbonate
gives support and protection
appendages move by attachment of muscles across joint to exoskeleton
joint forms fulcrum-lever, increasing work that muscles can do heavy and cumbersome
therefore limiting size and growth of all arthropods

molt- slowly discard old exoskeleton
take in water to expand body
body soft and vulnerable during this period
chitonous exoskeleton secreted
with time exoskeleton hardens

-pair of compound eyes and one or more simple eyes (ocelli)
-open circulatory system
- mostly separate sexes
- most internal fertilization: lay eggs w/ metamorphosis

Classification:

Phylum Arthropoda

Subphylum Myriapoda
Class Diplopoda - centipedes
Class Chilipoda- millipedes

Subphylum Crustacea
Class Malacostraca- crabs, lobster, shrimp, krill
Class Maxillopoda- barnacles, copepods

Subphylum Chelicerata
Class Merostomata- horseshoe crabs (relative of land spider)
Class Pycnogonida- sea spiders (relative of land spider)
Class Arachnida- spiders

Subphylum Hexapoda
Class Insecta- insects

Crustaceans

subphylum **crustacea**- arthropods that have two pairs of antennae and an exoskeleton hardened by calcium carbonate

most marine arthropods are crustaceans 150,000 species

adapted to live in water:

-2 pairs of **antennae**-a sensory appendage on the head of arthropods, use 2 to pick up "smell" chemicals in water using chemoreceptors on antennae

-use gills for gas xΔ

-appendages for swimming, crawling, attaching to other animals, mating, and feeding

Small Crustacean *importance- major food source for many marine orgs

located: plankton, on the bottom, among sediments, on and in other animals, crawling among sea weed

copepods-small, mostly planktonic crustaceans

*very abundant, important in the plankton

-many keep near surface by using their enlarged first pair of antennae to swim

barnacles-crustaceans that live attached to surfaces and are typically enclosed by heavy calcareous plates

- filter feeders

*live attached to a surface including whales and crabs: among most important fouling organism

-use cirri(legs) to sweep water to filter out food particles fig. 7.29

amphipods- a group of small, laterally compressed crustaceans; includes beach hopper fig. 7.30

isopods- small dorsoventrally flattened crustaceans eg: sea louse

-have legs similar to each other

-cousin to the pill bug (rolly polly

*some parasites of fish and some crustaceans

krill- planktonic "shrimp-like" crustaceans

*important food of whales and other animals

-filter feeder : feed on diatoms

*billions aggregating in polar waters: exclusive food for whales, penguins and many fish

carapace-the shield-like structure that covers the anterior portion of some crustaceans (krill, shrimp, lobsters, crabs)

Crustaceans

1. **small crustaceans**
2. **decapods**- crustaceans with five pairs of walking legs and a well-developed carapace

10,000 species
decapods: means "ten legs"
-largest crustacean in size
*many prized as food for humans....great commercial importance
-includes: shrimp, lobster, hermit crabs, and crabs

-five pairs of walking legs, first is heavier and usually has claws for feeding/ defense
-carapace well developed, encloses part of body....called cephalothorax

-2 body segments: cephalothorax and abdomen

cephalothorax- the anterior portion of the body of many arthropods, which consist of the head fused with the other body segments

abdomen- posterior portion of the body of arthropods

shrimp- laterally compressed w/ elongated abdomen
*humans eat the "tail"
-scavengers

lobster-laterally compressed w/ elongated abdomen fig. 7.32
*humans eat the "tail"
- some appendages adapted for walking on bottom
-mostly nocturnal
-scavengers and catch prey

scavengers- an animal that feeds on dead organic matter

hermit crabs- not a true crab fig. 7.34
scavenger
hide abdomen in a gastropod shell (as grow find a new bigger shell)

true crabs- abdomen: small, tucked under, compact & typically broadened cephalothorax
-largest and most diverse group of decapods
-abdomen: males- V shaped plate fig. 7.36
females- U shaped plate
-most scavengers, some eat seaweeds, organic matter in mud, molluscs
-many live near shores exposed to air a lot
*food source for humans

Digestion:

maxillipeds- the food-sorting appendages of some crustaceans (decapods-3 sets)
food goes to stomach: use chitonous teeth or ridges to grind and bristles for sorting
stomach 2 chambered in decapods
stomach connected to digestive glands

Circulatory: open circulatory system, gas xΔ by gills attached to appendages

Nervous system:
small simple brain
compound eyes- consists of numerous light-sensitive units
in decapods eyes on end of movable stalks "periscopes"
keen sense of smell
use statocysts for balance
statocyst- a fluid-filled cavity provided with sensitive hairs & a small free body that is used to orient animals with respect to gravity
most behaviorally complex invertebrates: use variety of means of communication

Reproductive system:
separate sexes
males use specialized appendages to transfer sperm to female
even hermaphroditic species transfer sperm b/w individuals
some females can store sperm ....used to fertilize eggs later
some crustaceans carry their fertilized eggs using specialize appendages

Other Crustaceans:

horseshoe crabs- arthropods with a large horseshoe-shaped carapace
not a true crab
live on soft bottoms in shallow water fig. 7.38

sea spiders- arthropods that have a reduced body and four pairs of legs fig. 7.39
large proboscis w/ mouth at end....used to feed on soft invertebrates :sea anemone

insects- arthropods with three pairs of legs and one pair of antennae
few are marine except water striders fig. 15.16

Echinoderms Phylum Echinodermata

echinoderms-invertebrates with five-way radial symmetry and a water vascular system

7000 species....all marine found in all oceans most are benthic

include sea stars, brittle stars, sea urchins, sand dollars, sea cucumbers, sea lillies

meaning “spiny-skinned” refers to hard endoskeleton beneath epidermis

Endoskeleton made of calcium-rich ossicles: movable or fixed plates

1. plates are totally encased in living skin when first formed
2. plates fuse forming hard shell in adults
3. plates can bear spines (as indicated by name)
4. plates have perforations for tube feet to extend

*important member of bottom community from poles to tropics

*destroys commercial clam beds.....very costly

*undergoes regeneration....studied by medical field

pentamerous radial symmetry- symmetry based on five parts fig. 7.42

but larva exhibit bilateral symmetry radial symmetry associated w/ sedentary beh
bilateral symmetry associated w/ high motility

-no anterior or posterior end
-no dorsal or ventral side.....instead use oral and aboral surface

oral- surface where mouth is located

aboral- the surface opposite the mouth in echinoderms

coelom-the body cavity found in structurally complex animals

1. large coelom: helps provide for circulation and respiration
2. respiration and waste removal occur thru skin gills, projections near spines
3. digestive system is simple but complete: mouth, gut, anus (2 opening)
4. no head or brain: just a circular nerve ring & its branches

Reproduction 1. regeneration: may repro asexually by splitting into parts

2. sexual repro. separate sexes and external fertilization
   larva (bilateral free swimming)
   adult (radial symmetry...benthic & slow)

deuterosome larva

Echinoderms 16

Water Vascular System:

water vascular system- network of water-filled canals used in locomotion & food-gathering

tube feet-any of the external muscular extensions of the water vascular system
extended when water is pumped into them, sometimes w/ help of ampullae
often end with a sucker
used for attachment, locomotion, receiving chemical and mechanical stimuli
connects to outside through madreporite

ampullae- each of the muscular sacs that extend inside the body opposite the tube feet

madreporite- a porous plate that connects water vascular system of echinoderms to exterior

1. five radial canals extend from a ring canal around esophagus

2. radial canals det. 5 part symmetry
    a. water enters thru madreporite: a sieve-like plate
    b. flows to ring canal thru the tubular stone canal
    c. radial canals extend out into hollow tube feet
    d. some echinoderms have suckers at end of tube feet (others do not)
    e. each tube foot has a muscular fluid-filled ampulla at its base

3. operation of water vascular system
    a. ampulla (at base of tube foot) contracts, fluid can't enter ring canal bcs 1 way valve
    b. fluid forced into tube foot, extends it
    c. foot can attach to substrate
    d. longitudinal muscles contract and shorten tube foot
    e. water forced back into ampulla
    f. repeated movement results in locomotion

Types of Echinoderms

6 classes:

1. Crinoidea: sea lilies & feather stars
2. Asteroidea: sea stars
3. Ophiuroidea: brittle stars
4. Echinoidea: sea urchins & sand dollars
5. Holothuroidea: sea cucumbers
6. Concentricycloidea: sea daisies

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Class Crinoidea

Sea Lillies: flower-shaped body attached to substrate by a stalk
may move slowly with featherlike arms if detached from stalk
all species found deeper than 100m
only fully sessile living echinoderm

Feather Stars: attach to substrate by claw-like structures on branched arms
may swim short distances & move along substrate
found in shallower waters

Class Asteroidea "starfish"

Sea Stars: echinoderms with five or more radiating arms & tube feet that are used in locomotion

most have 5 arms though may have up to 50 arms

hundreds of tube feet protrude from oral surface along ambulacral grooves

ambulacral grooves- each of the radiating channels of echinoderms through wh/ tube feet protrude

endoskeleton : interconnected $CaCO_3$ plates..form flexible framework

pedicellariae- one of the minute pincer-like organs of the echinoderms that help keep the body surface clean

located on aboral surface "modified spines"

*predators of bivalves, snails, barnacles, and other attached or slower animals

abundant in intertidal zone (also at great depths)

most have 5 arms or multiples of 5 (may have up to 50 arms)
arms prominent merge gradually with disk
body flattened, flexible, covered with pigmented epidermis

Class Asteroidea "starfish" 18

Sea Stars

endoskeleton

1. calcium containing plates found beneath epidermis
   a. called ossicles
   b. bound together with connective tissue

2. spines project from ossicles
   a. minute pincerlike pedicellariae surround base of spines
      pedicellariae- minute pincer-like organs that help keep body surface clean
      located on aboral surface "modified spines"
   b. possess tiny muscle-operated jaws
   c. keep body free of debris, may help capture food particles

water vascular system

1. underside of each arm has deep groove, **ambulacral grooves**, running along its length
   a. bordered by rows of locomotive tube feet
   b. radial canal connects tube feet to ring canal in central disk

2. unique hydraulic system
   a. ampulla contracts and forces water into tube foot
   b. extends podium by force of water
   c. muscles in tube foot contract and force water back into ampulla
   d. small muscles at at end of tube foot contract forming suction cup structure

3. tube feet contracting or extending in unison move arm along surface

feeding

1. mouth located in center of the oral surface (lower)

2. often feed on bivalve mollusks
   a. grasp shell with tube feet
   b. extrude stomach into opening between shells as small a 0.1 m
   c. secrete enzymes, digesting soft parts of bivalve

reproduction

1. sexes separate, external fertilization

2. pair of gonads located within ventral regions of each arm

Class Ophiuroidea

Brittle Stars: largest class by number of species most abundant class

found in shallow water and deep in seas, one of most abundant animals in deep seas

secretive, avoid light, active in dark.....emerge to feed on plankton from current

1. slender flexible arms more sharply set off from central disk than sea stars

2. move by active movement of their arms along the substrate
   arms may be covered with spines that aid in movement
   may use arms to swim through water
   no central groove, instead there is a splitlike opening at base of each side of each arm

3. capture suspended particles with tube feet, long spines or arms
   tube feet are important sensory organs
   tube feet may help move food to mouth

4. arms detach readily, helping protect animals from predators

5. distinctly different from sea stars
   lack pedicellariae
   groove on arm is closed and covered with ossicles (2 side slits on each arm)
   tube feet lack ampullae and suckers, used for deeding not locomotion
   no replication of internal organs, just one set in central disk (smaller than disk of starfish)
   no anus: waste eliminated thru mouth which is on the underside center

6. reproduction
   separate sexes, external fertilization

Class Holothuroidea

Sea Cucumbers:

1. soft, sluglike organisms with tough, leathery outer skin lack spines, lack radial symmetr

2. most lie on sides at the bottom of the ocean

3. mouth is located on one end, anus on other (oral &aboral surfaces at ends)
   mouth surrounded by tube feet modified into tentacles
   tentacles secrete mucus to trap food (sediment) particles (deposit feeders)

4. calcareous skeleton reduced to widely separated, microscopic plates

5. have highly branched respiratory trees that originate from cloaca
   water brought into and out of cloaca by muscular contractions
   gas exchange occurs across the respiratory trees

6. separate sexes, external reproduction

7. have tube feet on body, may be restricted to five grooves (usually 5 rows concentrated onside)
   move by tube feet or wriggling of the entire body
   most are sluggish, some swim actively

8. lack spines

9. may eject portion of intestines when irritated: **evisceration** used to startle predators

10. secrete toxic substances or discharge toxic sticky filaments from anus

Class Echinoidea 20

Sea Urchins and Sand Dollars

1. lack distinct arms, still have five-part body plan
2. five rows of tube feet protrude from plates of skeleton
3. possess distinct openings for mouth and anus
4. endoskeletons are made up of fused calcareous plates
    a. sea urchins are globular in shape
    b. sand dollars are flattened

Sea Urchins 700 species

test- hard rounded endoskeleton
with long spines radiating from body
spines used for protection, for moving, & for trapping drifting algae to eat
some have venomous spines

5 paired rows of tube feet with suckers are among spines
ambulacral grooves w/ tube feet on outer surface of sphere
tube feet used for locomotion, capturing food, and holding onto seafloor

pedicellaria- small claw-like structures that are used for defense (can be stinging) & to get foo

no brain

mouth is claw-like and is located on the underside (ventral)

Aristotle's Lantern- 5 tooth-like plates that point inwards

anus and genital pores are on the top (dorsal)

diet: eat plant & animal matter (kelp, decaying matter, algae, dead fish, sponges, mussels, & barnacles)
most are algal grazers

predators: eaten by crabs, snail, sea otters, some birds, fish, and people

reproduction: external fertilization
during breeding season: body cavity filled with eggs or sperm

locomotion: by tube feet and movement of spines on ventral body
nocturnal, hide in crevices during day

ecology: an abundance of sea urchins can be a sign for bad water conditions

Sand Dollars

sea urchins with a flat, round test and short spines

live partly buried in soft sediments

deposit feeders using tube feet to pick up organic matter