Molluscs and the Intertidal
Phylum Mollusca

- Over 100,000 species
  - Includes snails, clams, octopuses and chitons
- Marine, freshwater and terrestrial
- Soft bodied, unsegmented
- Open circulatory system
- Similar body plan
  - Muscular foot
  - Visceral mass
  - Mantle
  - Radula (except bivalves)
- Exoskeleton
  - Shells of calcium carbonate
Mollusc Body Plan

**Visceral mass:** contains internal organs

**Muscular foot:** used for locomotion

**Mantle:** secretes calcium carbonate shell

**Radula:** specialized feeding structure
Mollusc Body Plan

- Radula: feeding structure comprising tiny, tooth-like projections used to scrap or cut food
Phylum Mollusca, Class Gastropoda

- Snails, slugs, limpets, nudibranchs
  - ~ ¾ of all molluscs
- Marine, Freshwater, and Terrestrial
- Shell coiled
  - Reduced or absent in some
- Asymmetrical due to torsion
- Foot for locomotion
- Radula present
- Most herbivores (some carnivores)
Phylum Mollusca, Class Polyplacophora

- Chitons
- Shell with eight overlapping plates
  - Unsegmented body
- Marine
- Foot used for locomotion
- Head reduced
- Radula used to scrap algae off rocks
- Intertidal zone
Phylum Mollusca, Class Bivalvia

- Clams, oysters, mussels and scallops
- Marine and Freshwater
- Flattened shell with two valves
- Head reduced
- Filter feeders (siphons)
- No radula
Bivalve Anatomy

- Gas exchange and feeding occur across the gill surface

**Water movement**
- Incurrent siphon → Gill surface → Excurrent siphon
Internal Anatomy of the Bay Mussel

- Periostracum
- Umbo
- Nacreous layer
- Posterior adductor muscle
- Anterior adductor muscle
- Byssal threads
- Mantle
The Bay Mussel

- Intestine
- Ventricle of heart
- Mantle
- Posterior adductor muscle
Labial palp
Gills
Byssal gland
Mantle
Muscular foot
Byssal threads
Phylum Mollusca, Class Scaphopoda

- Tusk shells
- Benthic
  - Burrow into sand using foot
- Filter feeders
  - Sift through sediment and move food to gizzard using its radula
**Phylum Mollusca, Class Cephalopoda**

- Octopuses, squid, nautilus
- All Marine
- Shell external, internal or absent
- Mouth with radula and beak
- Locomotion by siphon
- Chromatophores
- **Closed** circulatory system
- Most developed invertebrate nervous system
  - Complex brain
  - Camera eye
FIGURE 12-13 Posterior view of mantle cavity of a squid. Left, female. Right, male.
Female Squid

- Nidamental gland
- Ovary with eggs
The intertidal zone is the area between the mean low tide and mean high tide.
- The intertidal zone is exposed during low tide.

Intertidal zone substrate can be rocky or soft bottom.
- Rocky substrate can vary as to the type of rock and the slope angle.
- Soft bottoms can vary from sand to silt or a mixture (mud).
Intertidal organisms typically occupy distinct bands or vertical zones within the intertidal ecosystem.

Zonation is due to varying degrees of exposure:
- Upper intertidal (most exposed)
- Middle and lower intertidal (least exposed)
Intertidal Zonation

- **Splash zone**: ~5ft above sea level. Only inundated during highest high tides.
- **High-tide zone**: ~2 to 5ft above sea level. Inundated during high tide and exposed to air during low tide.
- **Mid-tide zone**: 0 – 2ft above sea level. Exposed to air only during low tide.
- **Low-tide zone**: Below sea level. Only exposed to air during lowest low tides.
Intertidal organisms deal with periods of exposure during low tide, wave action, and changes in salinity and temperature.

- Mostly shelled organisms
- Many soft-bodied organisms and algae
Splash Zone and Upper Intertidal
Upper and Middle Intertidal
Middle and Lower Intertidal
**Intertidal Zonation**

**Splash zone:** ~5ft above sea level.
- Only inundated during highest high tides.
- Organisms sprayed with water during high tide but are rarely submerged.

**Organisms found in splash zone**
- Periwinkle snails
- Small acorn barnacles
Intertidal Zonation

High-tide zone: ~2 to 5ft above sea level.

- Inundated during high tide and exposed to air during low tide.

Organisms found in high-tide zone

- Large acorn barnacle
- Chiton
- Limpets
- Shore crabs
Intertidal Zonation

**Mid-tide zone:** 0 – 2ft above sea level.
- Exposed to air only during low tide.

**Organisms found in mid-tide zone**
- Sea star
- California mussel
- Gooseneck barnacles
- Hermit crabs
- Sea anemones
Intertidal Zonation

**Low-tide zone:** Below sea level.
- Only exposed to air during lowest low tides.

**Organisms found in low-tide zone**
- Brown algae
- Opaleyes
- California sea hare
- Two spotted octopus
- Sea urchins
Zonation in the Intertidal

- Biological interactions (competition for space, predation, grazing) are often important factors in determining the lower limit of rocky intertidal organisms, while physical factors (desiccation) often determine the upper limit.
Zonation in the Intertidal

- Competition is greatest in the lower intertidal because it is exposed to a lesser degree than the upper intertidal.

- The lower intertidal has the greatest number of species because it is the least extreme of the zones.
Intertidal Zone Organisms

- **Epifauna**: organisms that live on the surface of the substrate
  - More common in rocky intertidal
    - Ex: mud snails on soft bottoms, barnacles on hard substrates

- **Infauna**: organisms that live in the substrate
  - More common in sandy intertidal
    - Ex: clams burrowing in soft bottoms
Challenges of the Intertidal Zone

- **Desiccation**: drying out during low tide.
- **Wave action and tides**: impacts from waves and other objects. Wear from sandy water.
- **Exposure**: exposure to heat and UV from sun.
- **Temperature changes**: drastic shifts in air and water temperature.
- **Salinity changes**: evaporation from pools changes salinity.
- **Predation**: intertidal predators including octopus, sea stars and fish.
- **Limited space**: intertidal organisms compete for space on the substrate.
- **Oxygen availability**: lack of oxygen in the water when exposed.
Challenges of the Intertidal Zone

**Desiccation:** drying out during low tide

- Bivalves close shells
- Snails secrete slime
  - Operculum seals shell
- Anemones close tentacles
- Limpets and chitons trap moisture under shell
- Motile organisms move to lower tide zones
Challenges of the Intertidal Zone

**Wave shock**: impacts from waves and other objects. Wear from sandy water.

- Hard external skeleton
  - Shells or exoskeleton

- Attachment to rocks
  - Byssal threads in mussels
  - Tube feet in echinoderms
  - Muscular foot in molluscs
  - Pelvic fins of cling fish

Modified pelvic fins to form sucking disc
Challenges of the Intertidal Zone

Exposure: exposure to heat and UV from sun.

- Barnacles and muscles cluster together to reduce individual exposure
- North side of rocks in northern hemisphere
- Move out of most exposed area
Challenges of the Intertidal Zone

**Temperature changes**: drastic shifts in air and water temperature

- Ectothermic
  - Can withstand a wide range of temperatures
- Ridges in shell aid in evaporative cooling
Challenges of the Intertidal Zone

**Salinity changes:** evaporation from pools or rain can change salinity

- Alter solute concentration in cells making them isotonic to sea water
  - *Euryhaline:* broad range of salt tolerances
- Salt excretion
Challenges of the Intertidal Zone

**Predation:** Intertidal predators including octopus, sea stars and fish

- Enclose themselves in hard shell
  - Mussels and barnacles
  - Snails and hermit crabs
- Hide in rock crevices
- Firmly attach to rocks
- Ink (sea hare)
Challenges of the Intertidal Zone

**Limited space**: Intertidal organisms compete for space on the substrate

- Efficient dispersal
  - Asexual reproduction (budding) in aggregate anemone
- Strong attachment to the substrate
  - Mussels and barnacles
Challenges of the Intertidal Zone

**Oxygen availability:** lack of oxygen in the water when exposed or when there is a high density of organisms and a lack of photosynthetic algae

- Breathe atmospheric air in oxygen poor water
  - Tide pool sculpin and juvenile opaleye
Predators act to control prey populations

Keystone species: a species whose absence in the community would bring about significant change in that community

Predator: Pisaster ochraceous

Prey: Mytilus californianus

Effect of keystone predator on species richness
Sea stars are especially important in controlling California mussel populations in the lower intertidal zone. The absence of sea stars can lead to the expansion of the mussel beds into the lower intertidal.
Sea Star Wasting Disease (SSWD) is a disease that affects various echinoderm species causing them to decay and die.

- Some areas in southern California experienced a 99% decline in sea star populations.
- Sea water temperature may be correlated with the spread of the disease.
- Cause of the disease has yet to identified.