Skeletal Systems

General Properties of Skeletons

• Connective tissues important in support
  - Collagen/tropocollagen molecules
    • Molecular rope
    • Pack closely together due to glycine content
    • Not elastic so good for support

Endoskeletons and Exoskeletons

• Composite materials made of fibers embedded in mineral salts or organic polymers
  - Ex Bone

• Skeletons must withstand forces
  - Compression
  - Tension
  - Shear
  - Torsion
  - Stiffness
  - Strength

Endoskeletons and Exoskeletons

• Cost benefit analysis
  - Exoskeletons
  - Stiffer but not as strong
  - Provide excellent support for muscle based movement
  - Increase in strength requires increase in weight
  - Animal must molt to grow – skeleton limits space for growth (predation hazard)

Endoskeletons and Exoskeletons

• Cost benefit analysis
  - Endoskeletons
- No limit on space for growth (no molting necessary)
- Allows larger body size
- Soft tissues prevent skeletal damage
- Excellent protection for internal organs
  • (heart/lungs)

**Hydrostatic Skeletons**

- Hydrostatic support from body fluid between cells
- *Hydrostatic* -of or relating to fluids at rest or to the pressures they exert or transmit
- Water is incompressible and transmits force in all directions
  - apply force to the fluid and it will be transferred to the body wall
  - Like a soft hose stiffening when filled with water

**Hydrostatic Skeletons**

- A hydrostatic skeleton manipulated by muscles can cause hydraulic movement
  - Ex. Squeeze a balloon at one end
  - Cnidarians (hydrazoa and anthozoa) rely on hydrostatic support and hydraulic movement
  - Bivalve molluscs use hydraulic mechanism to extent foot.

**Hydrostatic Skeletons**

- Longitudinal and Circular muscles create peristalsis as the exert pressure on the hydrostatic skeleton
- See animation
- Good for burrowing or crawling
  - Circular wave push front end forward
  - Longitudinal contractions broaden the worm making it push against the burrow

**Hydrostatic Skeletons**
• Advantages
  - Add little weight to the animal
  - Little energy needed to carry them around

• Disadvantages
  - Precise, local movements difficult
  - Contraction in one region stretches muscles in another region
  - Punctures of body immobilize the animal

Hydrostatic Skeletons

• Cnidarians
  - Hydra – fluids in the gastrovascular cavity act as a skeleton
  - 3 layers epidermis – mesoglea – gastrodermis. Collagen fibers pass spirally around the body
  - Perisarc- a delicate exoskeleton secreted by some cnidarians (chitinous)
  - Anthozoans – corals secrete an exoskeleton of calcium carbonate

Hydra Cell Types

Platyhelmintheyes

• Connective tissue and interstitial fluid are the main support
• Remember acoelomates!
• Body covered by one cell layer of fiberous basal lamina
• Cestoda and Trematoda have snyctal epidermus called a tegument (absorption)
  - Provides body support, resists digestion.
Triploblastic Body Design
based on Hickman Fig. 14-3

Nematoda

- One cell thick outer layer that secretes multilayered cuticle
- Spiral layers of collagen fibers
- High pressure up to 120 mm Hg
- Provides strong hydroskeletal support

Annelida

- Flexible cuticle secreted by epidermis
- Circular and longitudinal muscles in the cell wall
- Septa divide the animal into metameres
- Septa allow different pressures in different metameres
- Creates ability to have more extensive movements

Animals with Exoskeletons

- Arthropoda
  - Have a rigid jointed exoskeleton
  - Trichogen cells produce setae

Cuticle
• mainly chitin
  - Layers
    • Endocuticle, exocuticle, epicuticle
  - Hardness determined by sclerites (plates of cuticle)
  - tough, flexible, glucose-amine polymer
  - stiffened with calcium carbonate in crustaceans
  - permeable but resists chemicals
  - waterproofed with waxes in insects
• protection, support, muscle attachment

**Exoskeleton Structure**

**Molting**

• Controlled hormonally (ecdysone hormone)
  - Epidermis secretes molting fluid
  - Epidermis secretes new cuticle (procuticle)
  - Molting fluid dissolve the old cuticle
  - Animal swallows air or water and enlarges, splitting the old cuticle
  - New cuticle is hardened with sclerites
  - Animation http://www.aloha.net/~smgon/sutures.htm

**Mollusca**

• External, rigid, calcerous shell in most for protection of the soft body.
• Shell produced by mantle
  - 3 layers
    • Outer = perisostracum (conchiolin)
    • Middle= prismatic layer
    • Inner = nacerous layer ( alternating layers of calcium and proteoglycan layers)

**Animals with Endoskeletons**

• Porifera
  - Body of 2 layers
- Pinacocyte layer on outside and lining cavities
- Choanocyte layer on inside
- Gelatinous mesohyl in between
- Ameobocytes secrete spongin (spongocytes) and spicules (sclerocytes)

Porifera

Echinodermata

- Integument of thin ciliated epidermis
- Underlying connective tissue dermis
- Dermis produces ossicles
- Ossicles made from Mg and Ca carbonate crystals bound together by collagen
- Sea Urchins (asteroidea) Test (shell) made of platelike ossicles to create a hemispherical endoskeleton
- Spines (in sockets and movable) project from the ossicles

Chordata

- Endoskeletal notochord
- Semi-rigid rod extending the length of the body
- Made from large fluid filled cells encased in concentric sheathes of connective tissue
- Rigidity from hydrostatic pressure in the cells

Chordata

- Notochord replaced by vertebral column
- Vertebral skeleton
  - 2 parts
    - Axial skeleton (skull, vertebral column, ribs)
Appendicular skeleton supports girdles (pectoral and pelvic)

- Articulated skeleton (contains joints)
- Sutures (immovable joints)
- Bones held together at movable joints by tendons and ligaments
- Ends of bones coated with aticular cartilage to reduce wear
- Joints lubricated with synovial fluid

**Chordata**

- Appendages
  - Structure reflects mode of locomotion
  - Convergence
    - Bat (hand) vs Bird wing

**Chordata**

689-691

- Functions of the Vertebral Skeleton
  - Supporting the load of the body
  - Amphibian skeletons project laterally and bear less weight whereas bird and mammal skeletons are positioned under the body and bear more of a load
  - Arched for supporting the weight of visceral below it. (like a suspension bridge)
  - Load Bearing
    - Muscles and skeleton work together
    - Bones bear shear and torsion, muscles bear load
      - Ex jumping on femur bone and bowing

- Protection
- Mineral storage

**Chordata**

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- Functions of the Vertebral Skeleton
  - Protection
    - Operculum protects gills
    - Skull protects brain and inner ear
    - Sockets protect eyes
    - Ribs protect heart and lungs
Chordata

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• Functions of the Vertebral Skeleton
  - Mineral Storage
    • Calcium and Phosphorous reservoir
    • Calcium – parathormone and calcitonin

Chordata

• Vertebrate Skeletal Materials
  - Cartilage
    • Connective tissue formed by chondrocytes
      - Matrix of collagen fibers and proteoglycans joined by hyaluronic acid, with chondroitin sulfate and keratan sulfate

Chordata

• Vertebrate Skeletal Materials (190)
  - Bone
    • Long bone
      - Hollow tube (diaphysis) with expanded hollow end (epiphysis)
      - Bone marrow in cavity
    • Outer surface – periosteum
      - Attachment of tendons and ligaments
    • Compact vs spongy bone
    • Nutrient canals, osteons, haversian systems
    • Lacunae, osteocytes, canaliculi

Chordata

- Vertebrates have skeleton of fibrous connective tissue cartilage or bone
- Bone formation
  • Endochondral bone formation
    - (1) Fibrous connective tissue
    - (2) cartilage
- (3) osteocytes and bone matrix

- Dermal (membrane) bone
  - (1) fibrous connective tissue
  - (2) bone

**Chordata**

- Visceral and Somatic components
  - Gill arches
    - Formerly filter feeding structures