Ask Weber
Session 4 (Week 7)

Weber Liu

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Topic 12

Support

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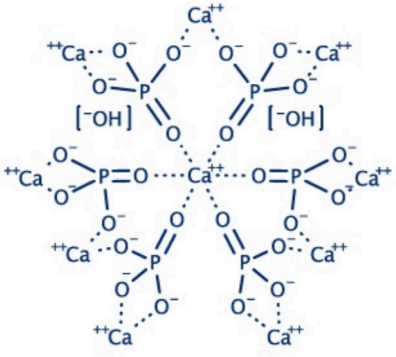
Describe the function(s) of bone

- **1. Give the body form and structure**
- **2. Enable movement**
- **3. Provide protection for internal organs**
- **4. Act as a store for minerals - homeostatic roles dominate bony roles**
- **5. House the bone marrow**
- **6. Endocrine functions**
  - Osteocalcin affects pancreas, adipose tissue, testis, and the nervous system.
  - FGF23 acts on parathyroid gland and kidneys.
  - Osteocytes change the environment in which immune cells are produced.

Describe the structure of bone

- **Organic material (30%):**
  - bone cells
    - Osteoblast, osteocyte, osteoclasts
  - extracellular organic matrix including collagen fibres
- **Mineral (70%)**
  - Hydroxyapatite



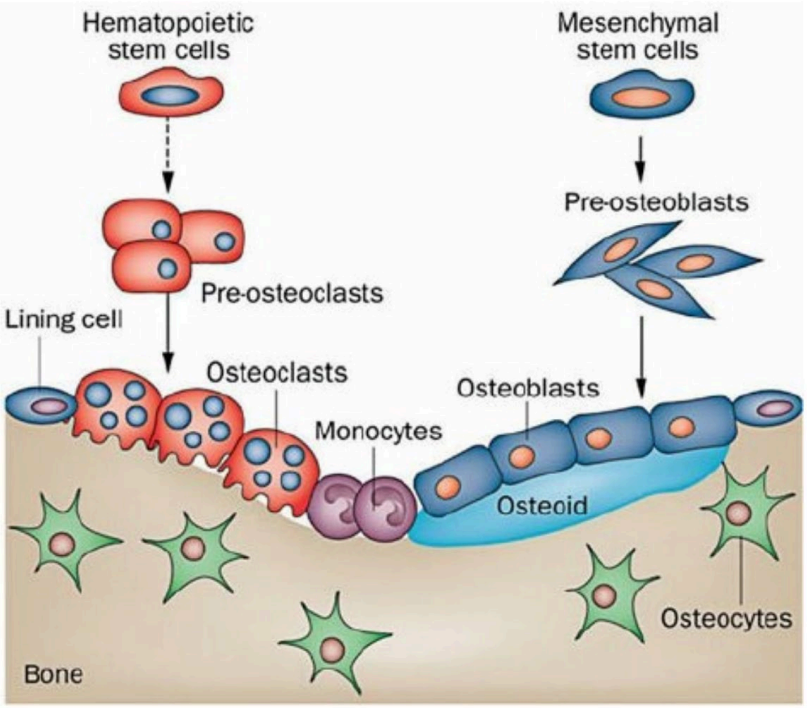
Describe the chemical composition of hydroxyapatite

- Calcium phosphate crystals

Why does the chemical composition of hydroxyapatite matter?

- When the body needs calcium, PTH is released which directs the breakdown of hydroxyapatite to mobilise more calcium

What are the bone cells?



- **Osteoblasts**
  - Bone forming cells – produce osteoid (which contains collagen) and alkaline phosphatase.
- **Osteocytes**
  - Cells located in the bone: responsible for maintenance
  - Related to osteoblasts (think of them as mature osteoblasts)
- **Osteoclasts**
  - Remove bone during repair and remodelling.

Clinically, the liver function test (LFT) measures GGT, ALT, ALP, AST. Raised LFTs could be indicative of a liver issue. What is the problem with interpreting a high ALP? How does ALP relate to bones?

- **ALP indicates mineralization (formation) of bone**

What cell in the bone releases the ALP?

- Osteoblasts

What are the types of bone?

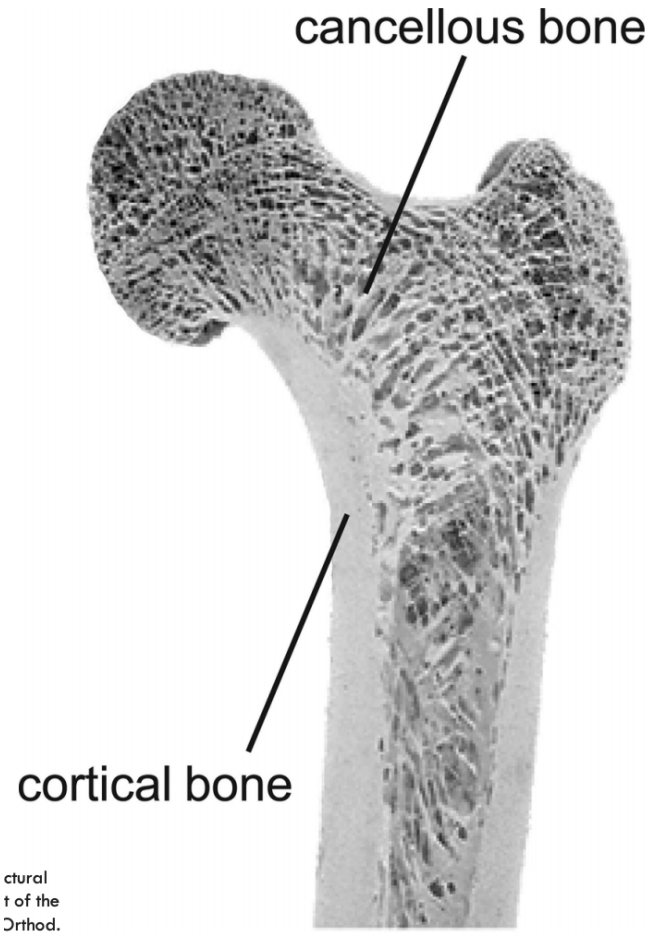
- **Cortical (compact) bone**
- **Cancellous (spongy) bone**

What is the function of cortical bone?

- Very important for the stability and structure of the bone
- The hard, compact structure means it is very stable – but also very brittle; fractures will snap through cortical bone but some cancellous bone may still hold together

Where in the body is cortical bone found?

- The outer bone-layer of all bones
- Consists of 80% of bone in the body



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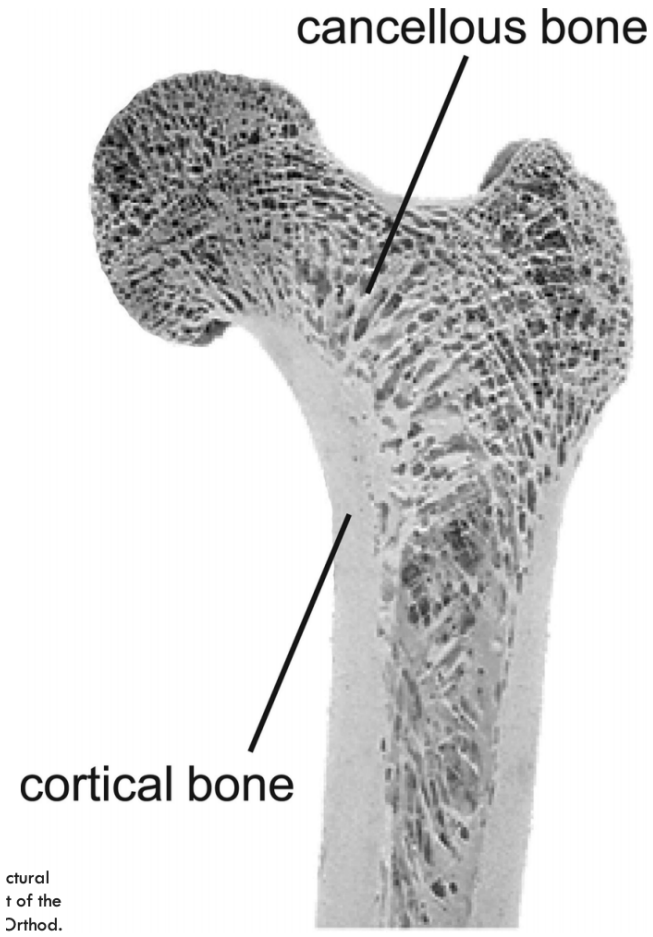
What are the types of bone?

What is the function of Cancellous bone?

- Shock absorption
- Larger surface area means lower pressures for the same surface area (P = F / A)

Where in the body is cancellous bone found?

- Where-ever there is high pressures
  - Axial skeleton (i.e. the spine, etc.) where load transfer is very large (because your whole upper body remains upright because of this)
  - Near joints (because high pressures in joint regions)



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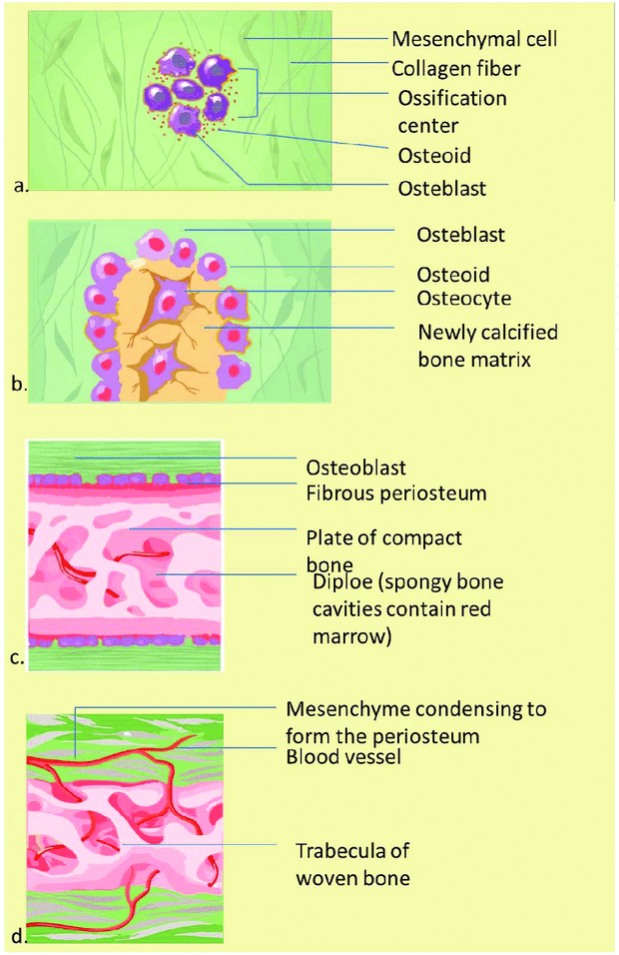
Which bones are formed by intramembranous ossification

- **Flat bones (skull, face, clavicle, pelvis)**
- **Everything else is formed from endochondreal bone formation**

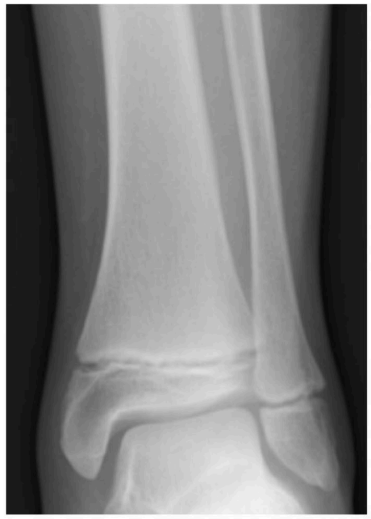
What is intramembranous ossification? How does it differ from endochondreal bone formation?

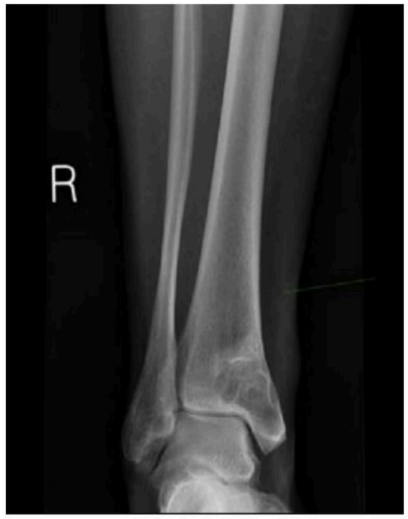
- Intramembranous – mesenchymal stem cells differentiate into osteoblasts which forms a calcification centre, and eventually lay down more bone to form the osteoid
- Endochondreal – osteoblasts convert a cartilage model into bone



How can a clinician 'estimate' the age of *a child* by looking at an X-Ray of their bones?

- **Epiphyseal growth plates are radiotranslucent whereas bone is radio-opaque, meaning you can see bone but not the growth plate**





What are the 3 phases of bone remodelling?

- **Phase 1: Stimulus such as hormone, drug, physical stress stimulates osteoclasts.**
- **Phase 2: Osteoclasts resorb bone leaving behind resorption cavity. This takes about two weeks**
- **Phase 3: Osteoblasts lining the resorption cavity lay down new bone. Takes about 4 months.**

Remember

- Bone resorption is always coupled to bone formation (known as coupling)
- Think of the process as just a 'rebuild' of old bone, which replaces anything that might have been broken or missing (like someone replacing all smoke alarm batteries every few years regardless of if they're depleted)
- More stress on bone = more remodelling

Why are post-menopausal women at higher risk of osteoporosis?

- **Decoupling of bone remodelling**
- **Menopause**
  1. No more follicles = no more estrogen (or at least reduced)
  2. Estrogen normally inhibits osteoclasts – reduced estrogen means more osteoclast activity
  3. More osteoclast activity means inhibited osteoblast activity
  4. This increases the rate of bone resorption
- **Older age**
  - Senile osteoporosis is mainly due to a decrease in the supply of osteoblasts in proportion to demand.
- **What we're born with**
  - Genetic factors
- **What happens to us**
  - Endocrine changes
  - Diseases in other body systems
  - Inflammation
- **What we do to ourselves**
  - Nutrition
  - Lifestyle choices
  - Medications

Topic 13

Movement

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Name 6 functions of muscles

- 1. Movement
- 2. Thermoregulation
- 3. Energy metabolism and storage
- 4. Appetite regulation
- 5. Drug storage
- 6. Endocrine functions

Name the 3 types of muscles and where they are found

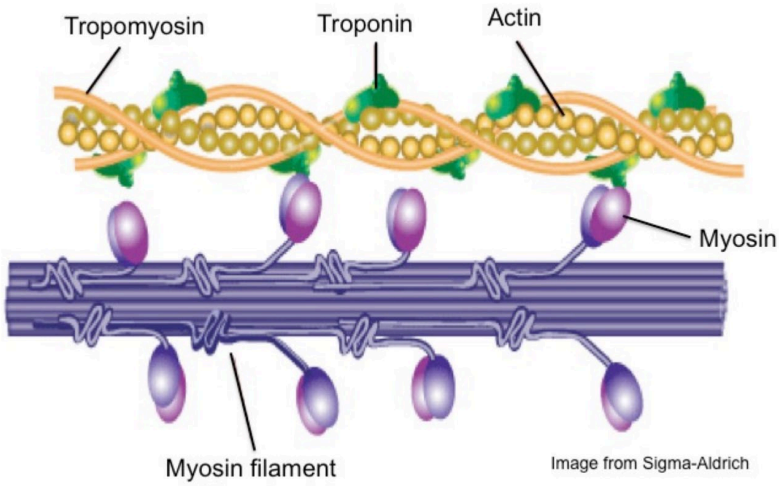
- **Skeletal**
  - Attached to the skeleton – responsible for movement
- **Cardiac (myocardium)**
  - Forms the heart – responsible for pumping blood
- **Smooth**
  - Located in the tissues – responsible for controlling diameter of structures and peristalsis

Which of these muscles are under voluntary control, and which are involuntary?

- Only skeletal muscle is under voluntary control
- That is, anything you can CHOOSE to move is skeletal

Name the 4 important proteins involved in muscle contraction and describe the cross bridge cycle in skeletal muscle

- **4 proteins**
  - Actin – forms thin filament
  - Myosin – forms thick filament
  - Troponin
  - Tropomyosin



1. **Electrical stimulation at the neuromuscular junction occurs, sending depolarization signal to the sarcoplasmic reticulum**
2. **Sarcoplasmic reticulum releases Ca2+ into the sarcomere**
3. **Ca2+ binds troponin which induces a conformational change, this will twist tropomyosin out of the way and expose the binding sites on the actin filament**
4. **Myosin (bound to an ATP molecule) will be attracted towards the exposed actin filament (i.e. cross bridge formation)**
   1. The ATP will be hydrolysed to provide myosin with the energy to move the actin filament, in effect causing the 'contraction'
   2. The myosin head 'rotates' in order to move the actin filament
5. **Another new ATP molecule must bind to myosin in order to release the actin-myosin crossbridge**
6. **Troponin/tropomyosin will naturally cover up the binding sites on the actin, Ca2+ will be pumped back into the SR (to prevent chronic contraction)**

In death, your body's metabolic processes stop. This results in a global muscular contraction known as 'rigor mortis' (latin: stiffness of death). Describe why this occurs given your knowledge of the cross-bridge cycle

- **No metabolic process = no more ATP produced**
- **No more ATP produced = myosin-actin cross-bridge cannot be separated**
- **No myosin-actin cross-bridge separation = sarcomere in chronic contracted state**
- **This is why the cadavers you see can be in a stiff state of contraction (Rather than have relaxed bones) – it is also why we tenderise meats before we cook them!**

Where is ATP produced in the muscle cell?

- in the cytoplasm – anaerobic metabolism
  - This process is known as glycolysis, it is very fast
  - Can produce lactic acid in excess, the thing that causes our muscles to hurt after exercise
  - Primarily used in Fast twitch fibres (b/c you need a 'fast' source of ATP)
- in the mitochondria – aerobic metabolism
  - This process is known as the Kreb's cycle (citric acid cycle) – it takes a long time to do but makes A LOT of ATP
  - Primarily used in Slow twitch fibres

Name 4 means of controlling the contraction of smooth muscle

- **Hormones**
  - Oxytocin – contraction of uterine muscle
- **neural stimulation by the ANA**
  - Sympathetic NS causes contraction of pupillary muscles resulting in dilation of pupils
- **local factors**
  - Inflammatory mediators can induce dilation of vascular smooth muscle resulting in hyperaemia
- **stretching the muscle.**
  - Bladder muscle stretching can induce nerve responses to induce urination

Define motor unit

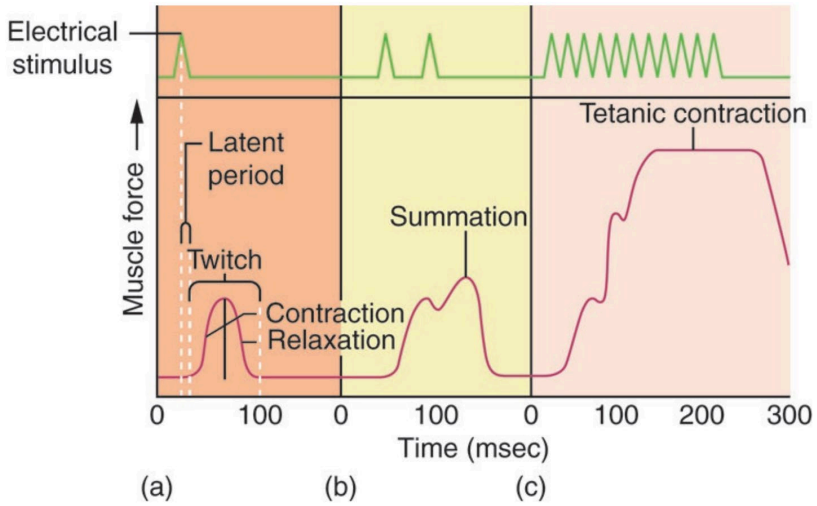
- **The muscle fibres which are supplied by a SINGLE nerve**

- **Benefits of a smaller motor unit**
  - Controls finer movement (b/c it implies less muscles are involved by that nerve)
  - More resistant to fatigue

- **Benefits of a larger motor unit**
  - Generates greater tension (i.e. more force – obviously, as there are more muscle fibres!)

Describe muscle summation

- **Single AP**
  - Produces a single small twitch
- **Temporally close APs (i.e. a temporal summation)**
  - Twitches will add together in amplitude
  - Second twitch will be greater due to increased Ca2+ in sarcomere



What are the factors that describe the STRENGTH of a contraction?

1. **Size of the motor unit**
   - Big motor unit = more muscle fibres involved = bigger contraction
2. **Summation/frequency of neural stimulation**
   - More stimulation = greater summation = greater amplitude addition of the twitches