Bone Remodeling & Repair Pathologies

Skeletal system remodels itself to maintain homeostasis

Remodeling

- Maintainence
  - replaces mineral reserves (**osteocytes**) of the matrix
- Remodelling
  - recycles (**osteoclasts**) and renews (**osteoblasts**) bone matrix

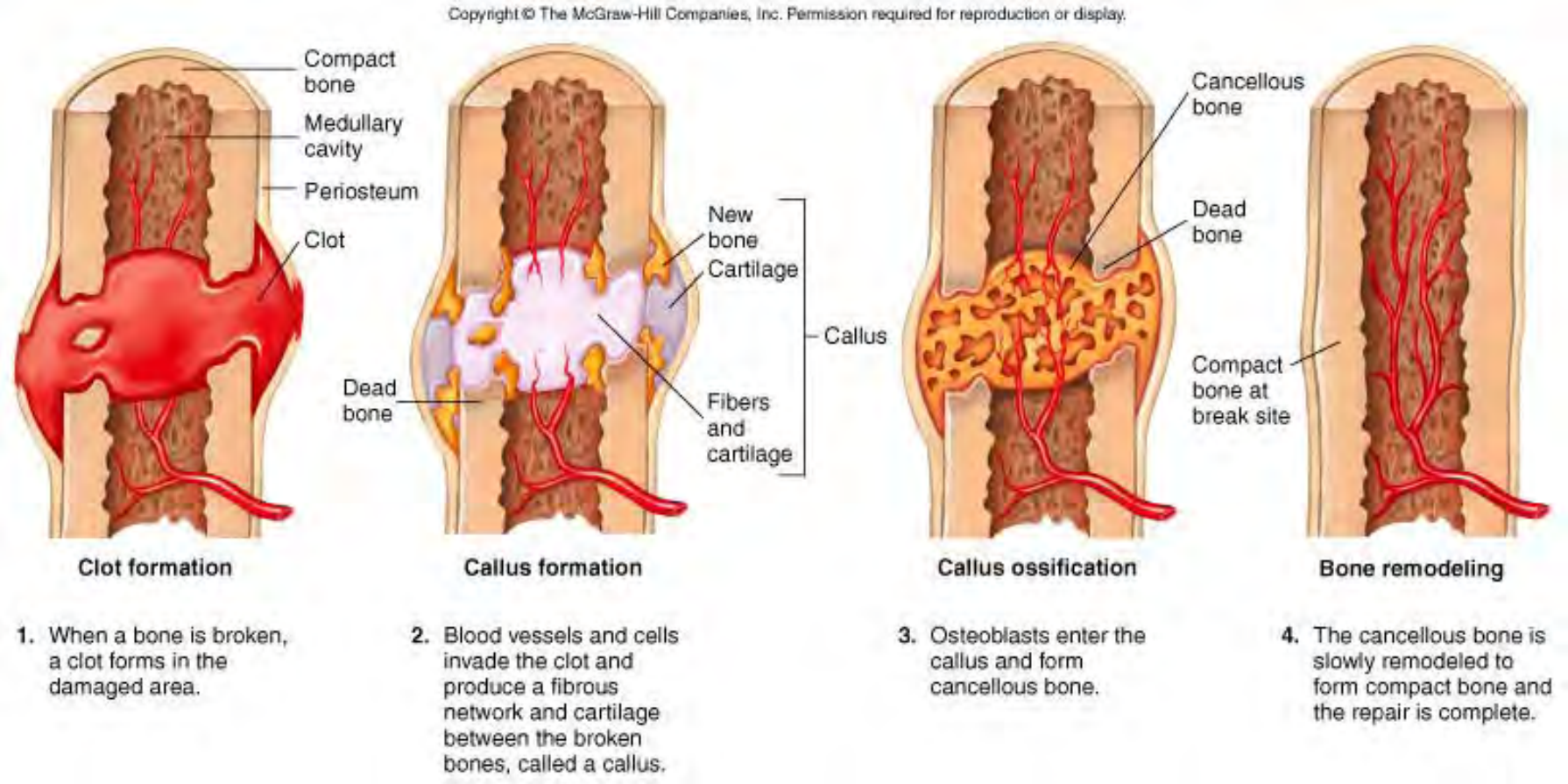
KEY CONCEPTS

- Remodeling (deposition & degradation) is **continuous**
- Turnover *rate* is variable
  - If deposition exceeds removal, bones get stronger
  - If degradation exceeds replacement, bones get weaker

Remodeling

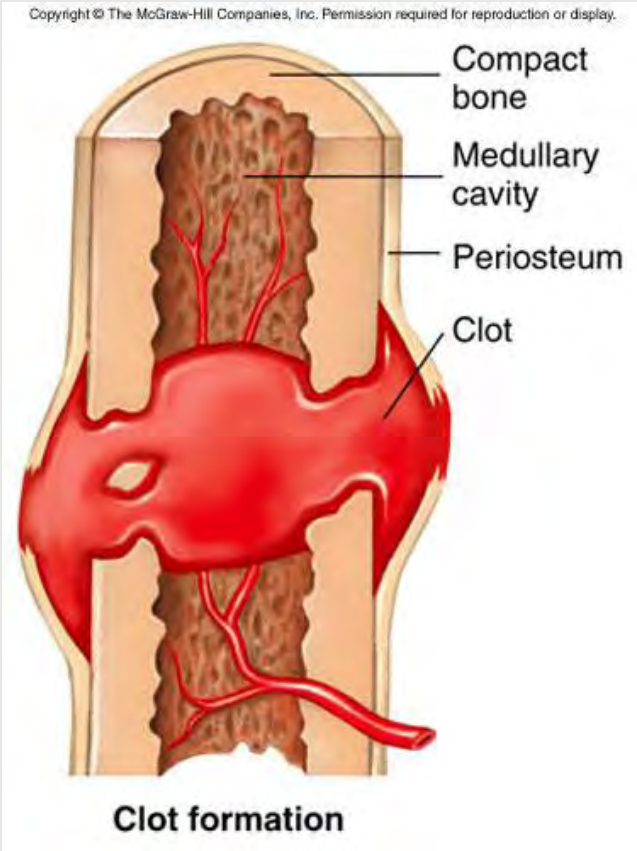
1. Responsible for bone **growth**
   - Remodeling of cancellous bone at the epiphyseal plate
   - Addition of new bone on outer surface
2. Changes in bone **shape**
3. Adjustment to physical stresses
4. Repair
5. Ca^{2+} regulation in body fluids

Fracture Repair



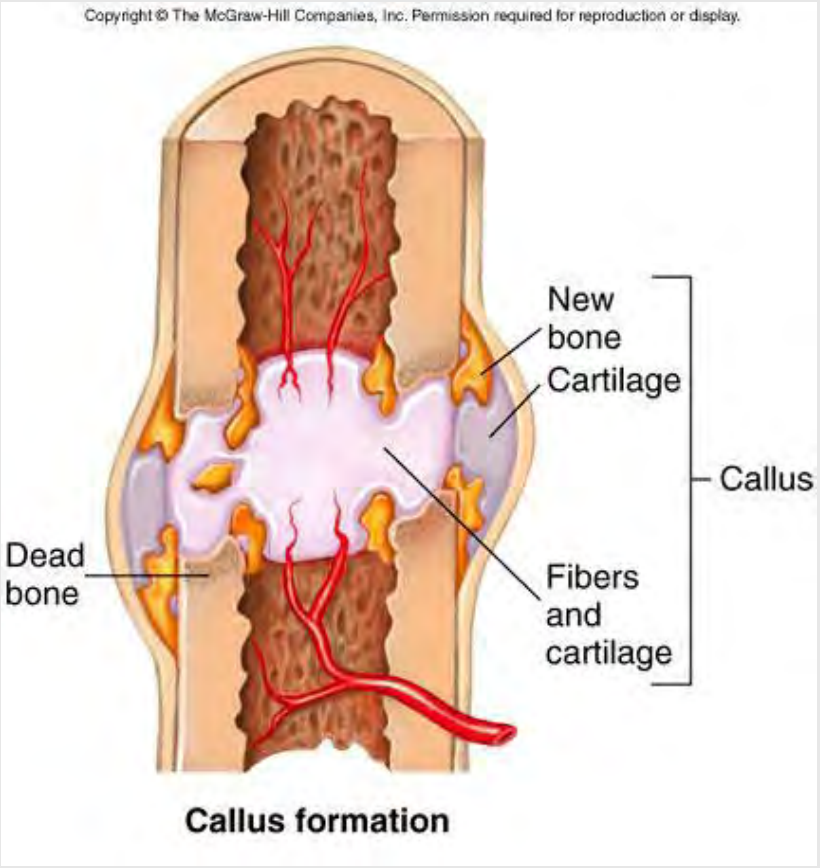
Fracture Repair

- Fracture breaks blood vessels within bone
  - Excessive bleeding forms a blood clot



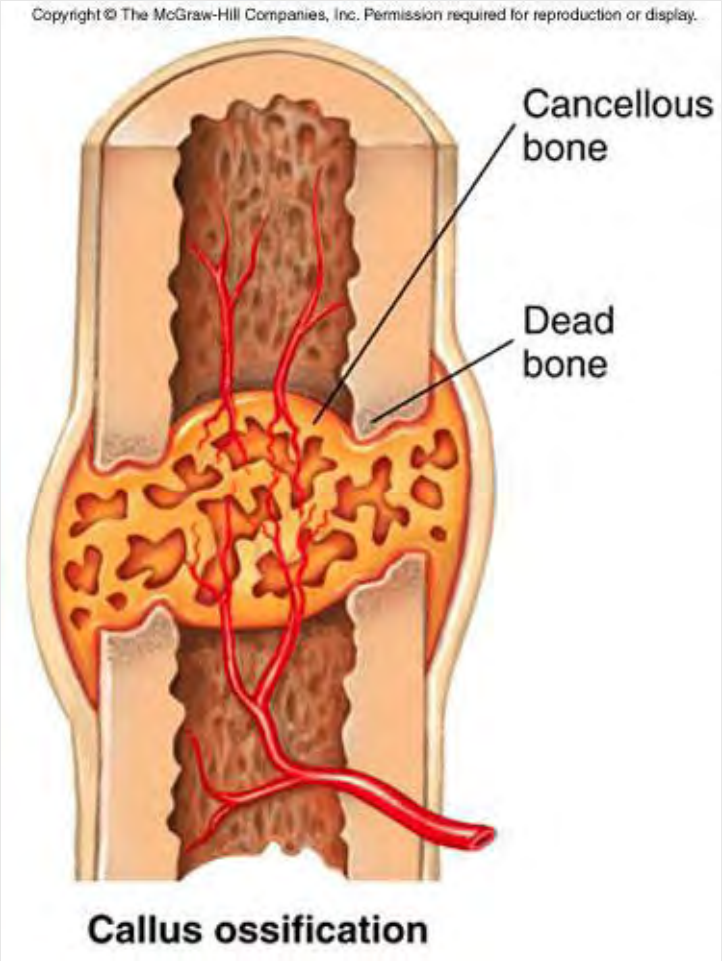
Fracture Repair

- Nearby blood vessels and cells invade clot
- Bring fibroblasts, which produce fibrous network of collagen and cartilage
- Zone of tissue repair = **callus**



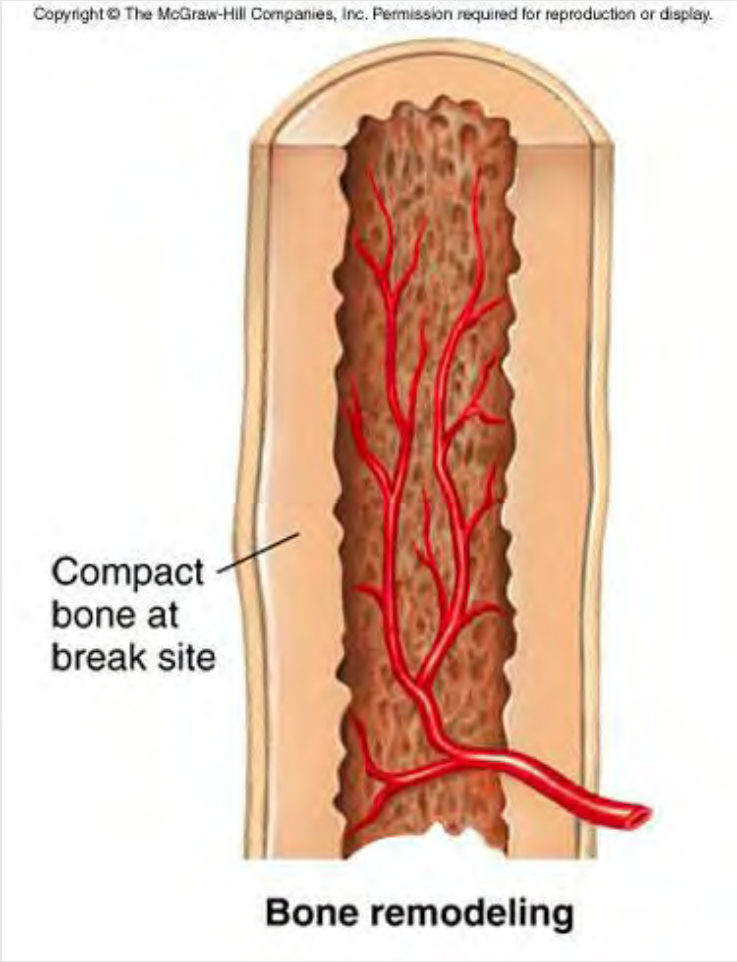
Fracture Repair

- Osteoblasts arrive, enter callus and form cancellous bone



Fracture Repair

- Cancellous bone remodeled into compact bone
- Only happens with **use:**
  - **Electrical currents** generated & propagated by Ca^{2+} salts **stimulate osteoblasts**



Bones and Exercise

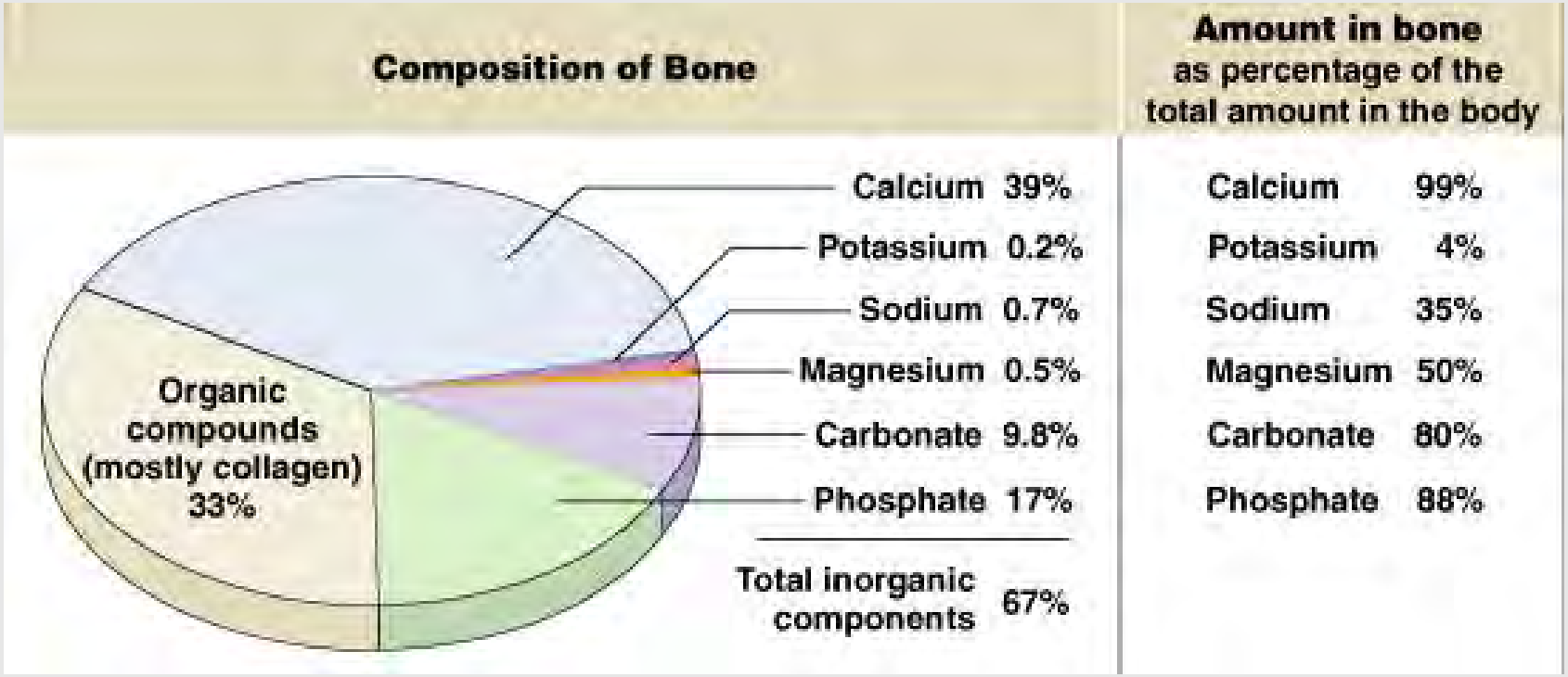
- Mineral recycling allows bones to adapt to **increased stress**…
  - Heavily stressed bones become thicker & stronger
- Or to **decreased stress**…
  - Bone degenerates quickly
  - Up to 1/3 of bone mass can be lost in a few weeks of inactivity
  - Use it or lose it!!
- HOW?

Bone thickens

- Increased stresses build **muscle**
  - Muscles attach to bones via tendons @ bony projections
    - Increased muscle size and strength demand larger attachments
- Compressive and tensile forces cause Ca^{2+} crystals to produce tiny electrical currents that **stimulate osteoblasts**
  - Bone matrix is deposited faster than it is removed

Skeleton as Calcium Reserve

- Bones store calcium and other minerals
- Calcium is the most abundant mineral in the body



Functions of Ca^{2+}

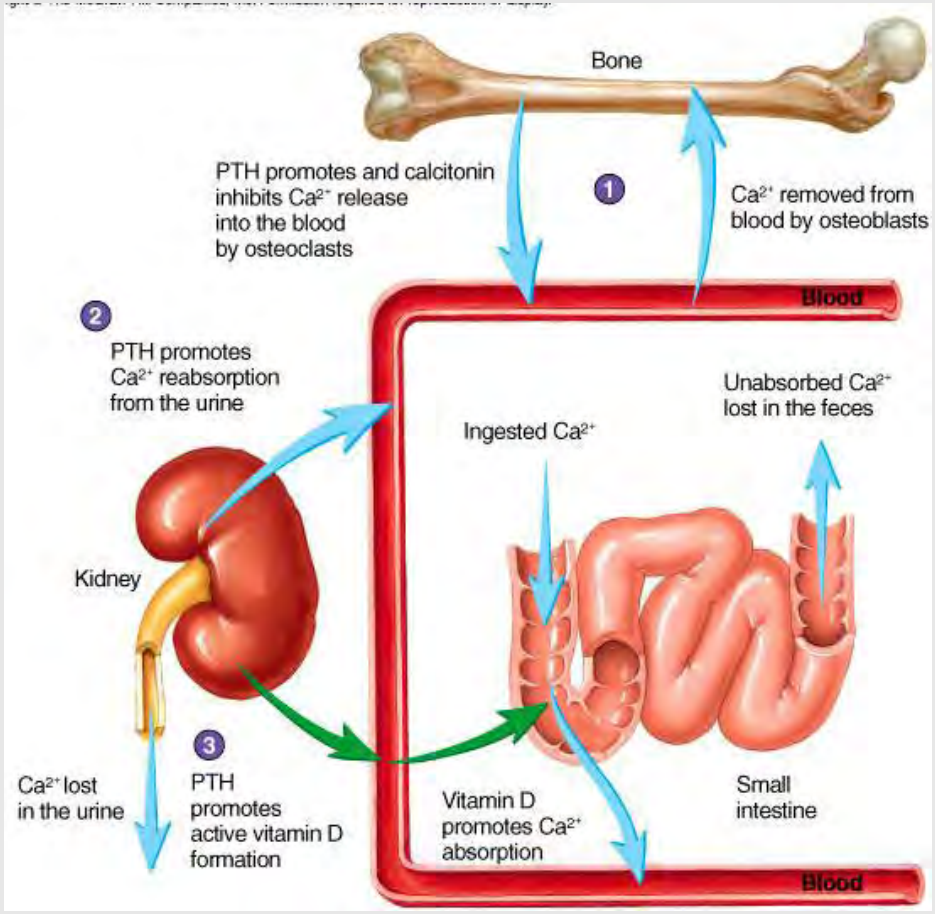
- Ca^{2+} ions are vital to:
  - Membrane function
    - Changes permeability of cells membranes to Na^{+}
  - Neurons
    - Neurotransmitter; influences sensitivity to excitation
  - Muscle cells, especially heart cells
    - Directly transmits stimuli; influences heart rate and blood pressure.

Ca^{2+} Regulation

- Ca^{2+} homeostasis is maintained by hormones having OPPOSING effects:
  - Calcitonin and parathyroid hormone control **storage** (bones), **absorption** (small intestine), and **excretion** (kidneys) of Calcium

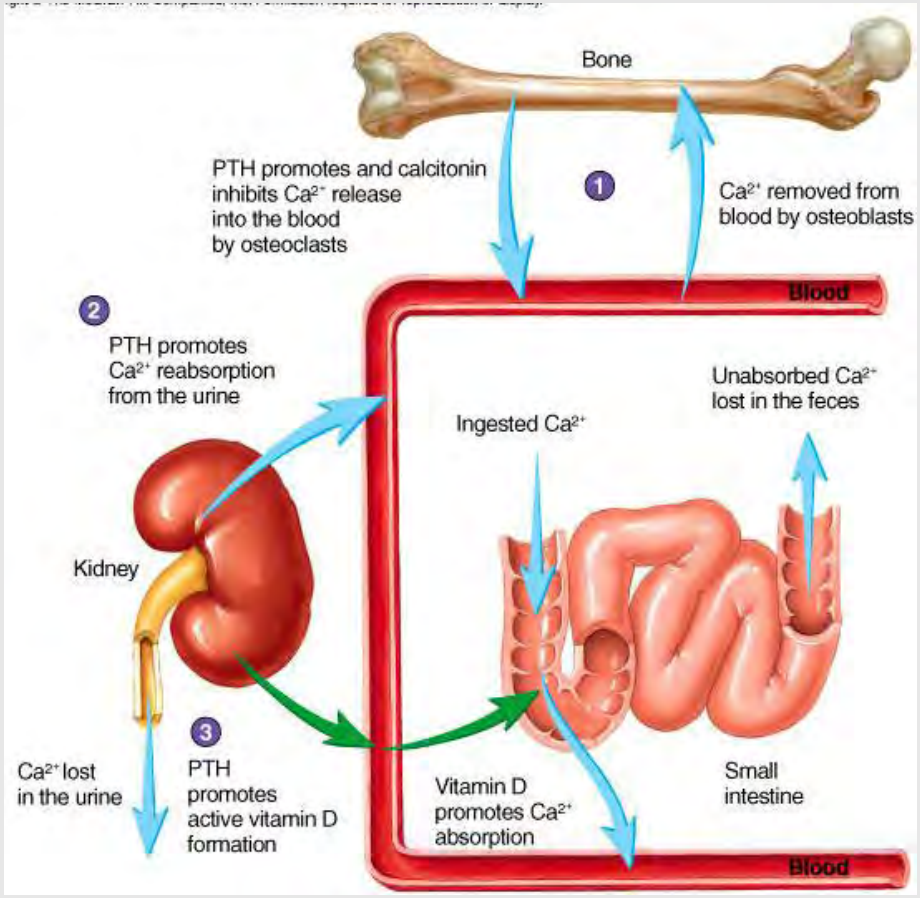
Ca^{2+} Regulation

- You drink some milk
  - Vitamin D (in your fortified milk?) aids Ca^{2+} absorption in small intestine
  - Absorptive cells deliver Ca^{2+} to blood
  - Blood delivers Ca^{2+} to osteoblasts



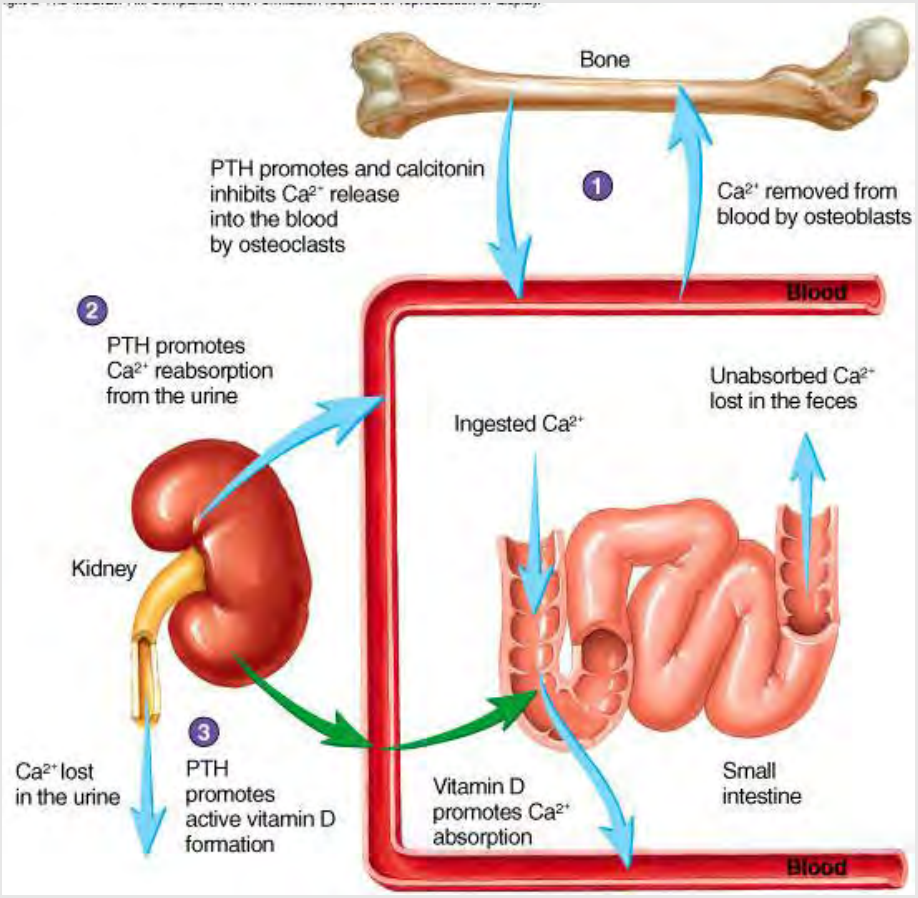
Ca^{2+} Regulation

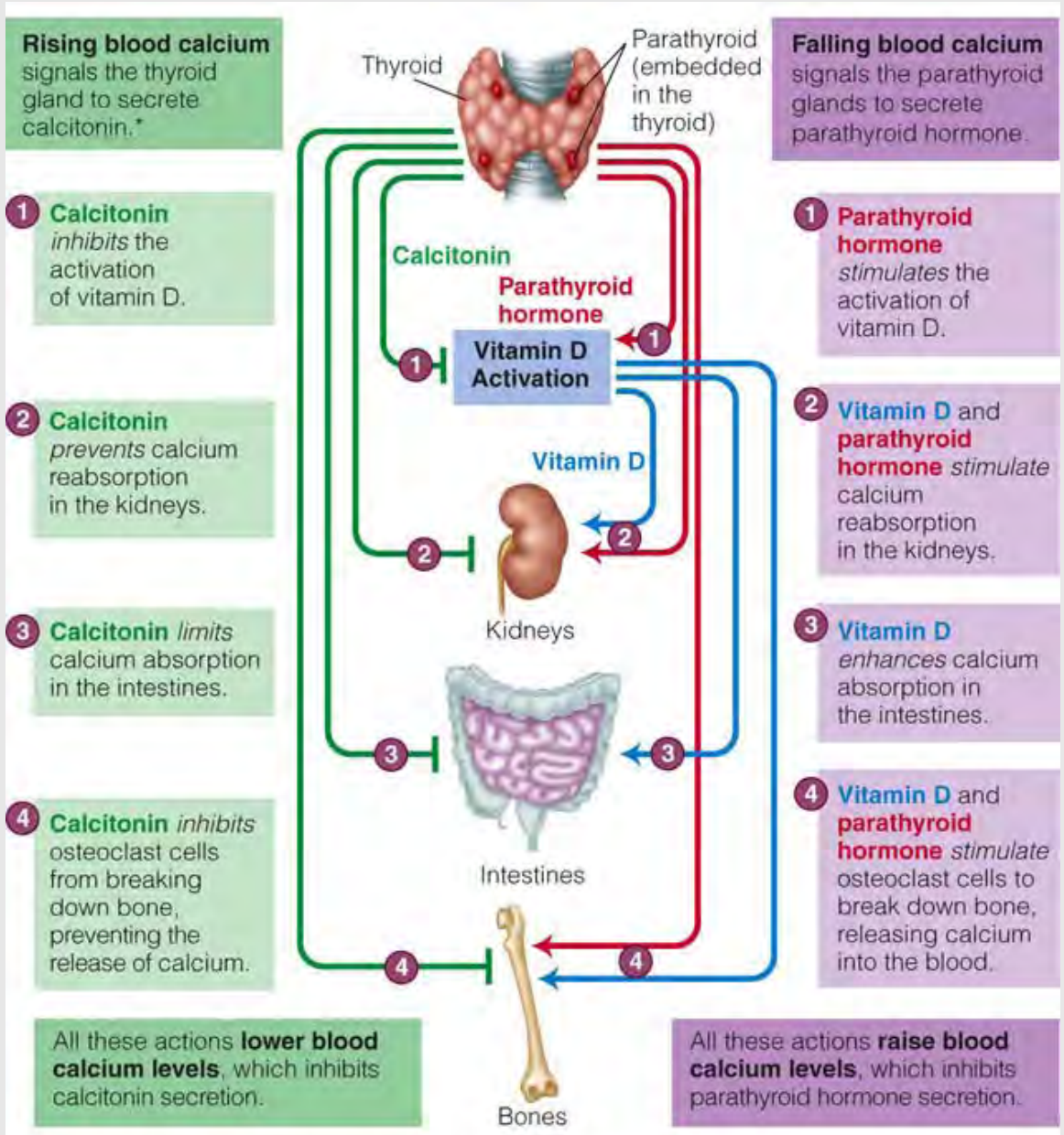
- Blood Ca^{2+} level drops *below* set point
  - Parathyroid hormone (PTH) is released
    - **Stimulates** osteoclasts
    - Increases Ca^{2+} retention in kidneys
    - Stimulates active vitamin D production



Ca^{2+} Regulation

- Blood Ca^{2+} level rises *above* set point
  - Calcitonin (hormone) is secreted from thyroid gland
    - **Inhibits** osteoclasts
    - **Increases** Ca^{2+} excretion at the kidneys

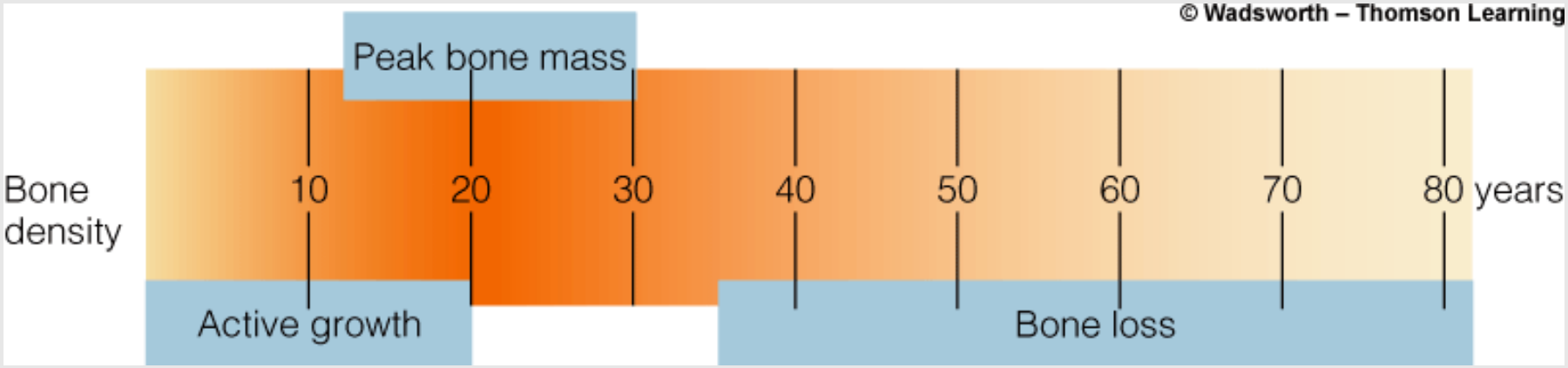




*Calcitonin plays a major role in defending infants and young children against the dangers of rising blood calcium that can occur when regular feedings of milk deliver large quantities of calcium to a small body. In contrast, calcitonin plays a relatively minor role in adults because their absorption of calcium is less efficient and their bodies are larger, making elevated blood calcium unlikely.

Ca^{2+} & Vitamin D

- **Deficiency** symptoms
  - In children: stunted growth; rickets
  - In adults: bone loss (osteoporosis) or improper mineraliztion (osteomalacia)



Rickets

- ***Wrick***, to twist; bones become twisted
- Retarded bone growth caused by deficiencies of:
  - **minerals** (Ca^{2+}, P) necessary for normal ossification
  - **Vitamin D**; necessary for Ca^{2+}, P absorption in small intestine
    - Bones become soft, weak, easily broken
    - often in children with nutritional Vitamin D deficiencies or lack of <u>sunlight</u>

Osteoporosis

- ***Osteo,*** bone + ***poros,*** pore + ***osis***, condition; Reduction in overall bone quality and quantity
  - Osteoclast activity exceeds osteoblast activity
    - Inadequate intake of Ca^{2+}
    - Inadequate absorption of Ca^{2+}
    - Lack of exercise
    - Lowered estrogen levels

Osteomyelitis

- ***Osteo,*** bone + ***myelos,*** marrow + ***itis,*** inflammation
  - Often caused by bacterial infection; leads to degradation of bone
    - **Staph** infections, usually introduced through wounds
    - **Tuberculsosis**