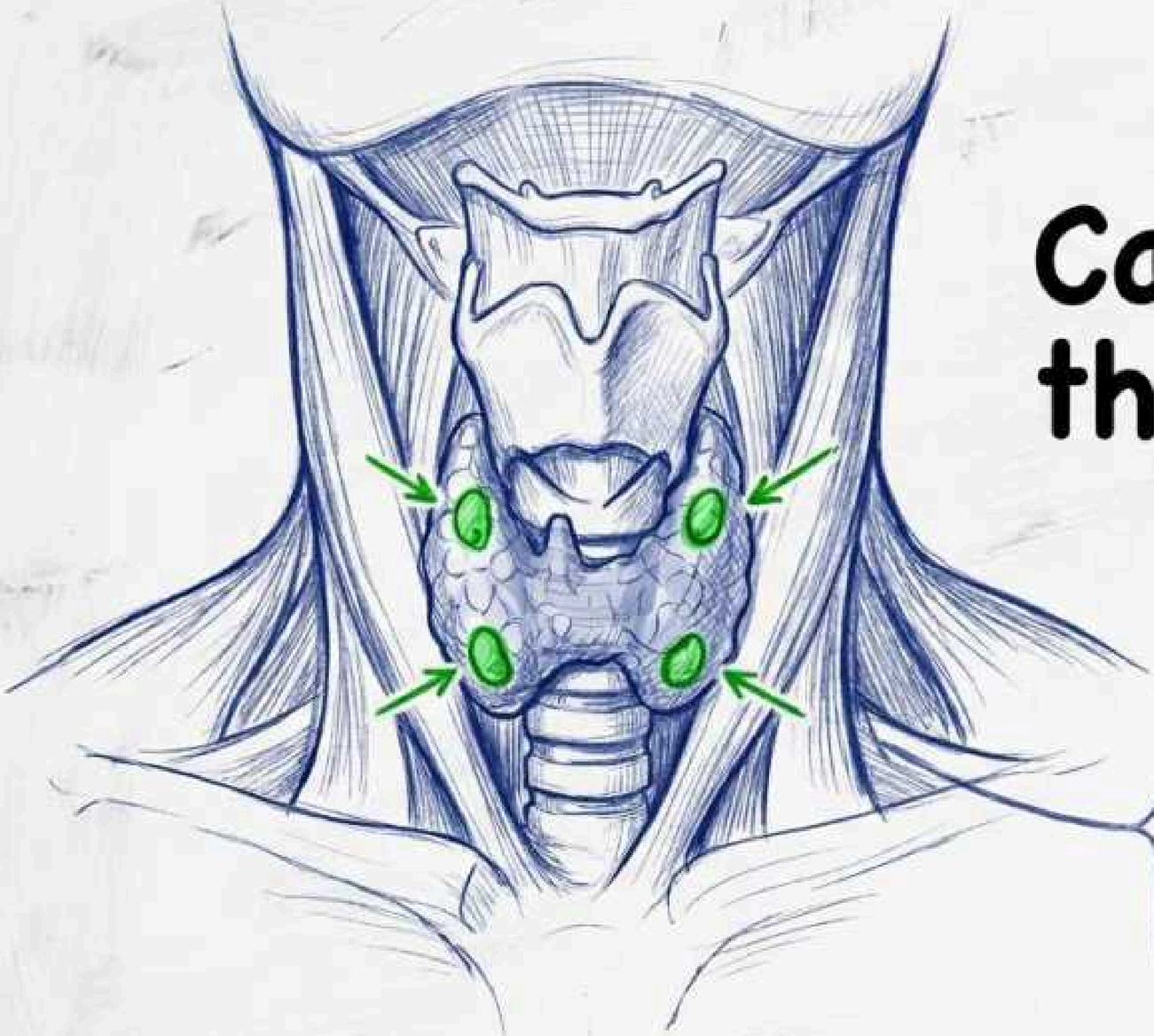


Calcium, Bone and the Parathyroids

MED 531 B • Lecture 5

At a glance: Calcium's roles, parathyroid hormone and vitamin D, high and low calcium, osteoporosis, and other bone diseases.

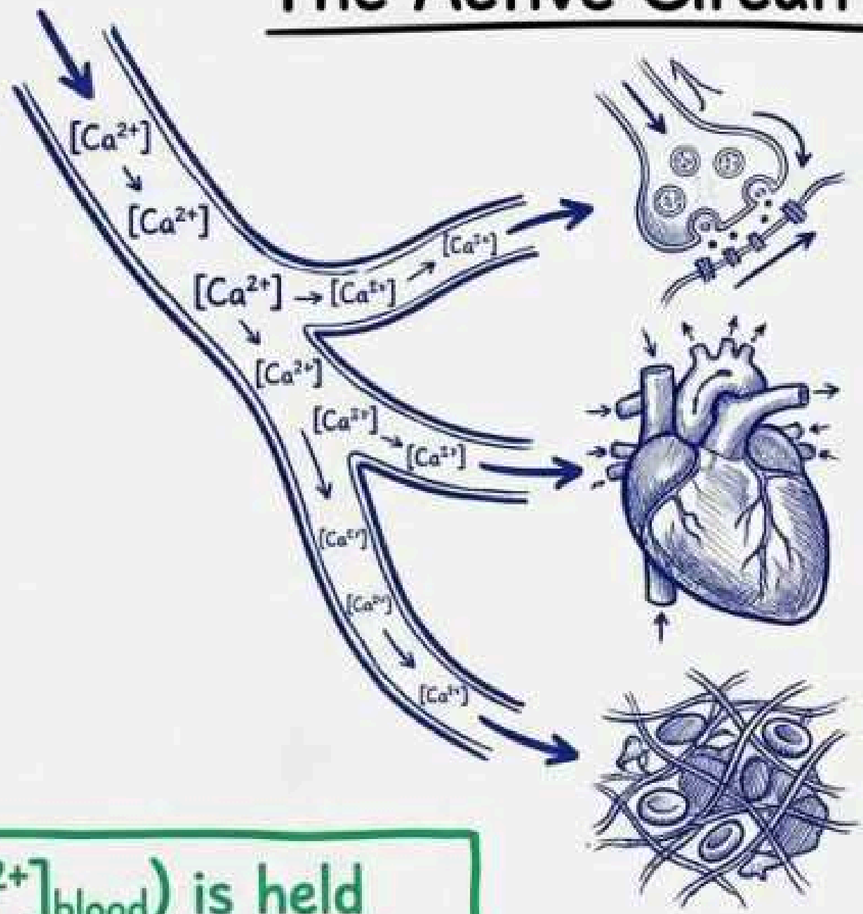
Calcium is heavily concentrated in bone but performs vital functions in the blood.

The Vault



Abundant Storage: Almost all body calcium is stored within the bone matrix.

The Active Circuit



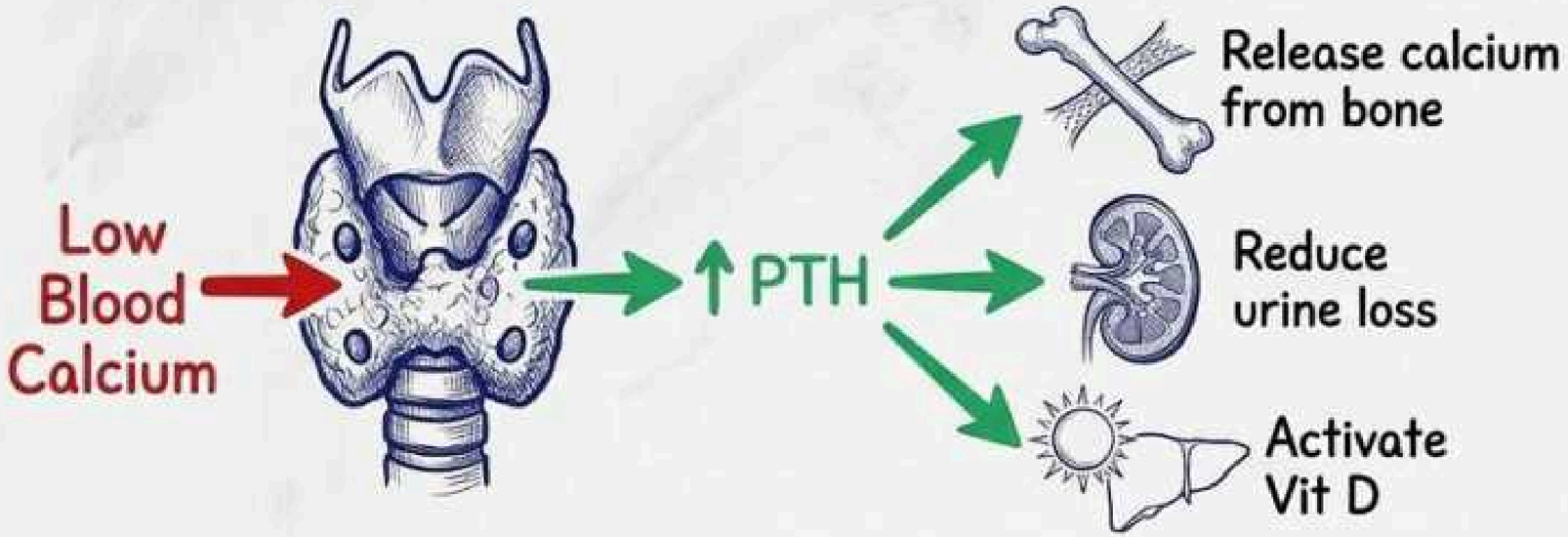
Controls nerve function

Drives muscle function (including the heartbeat)

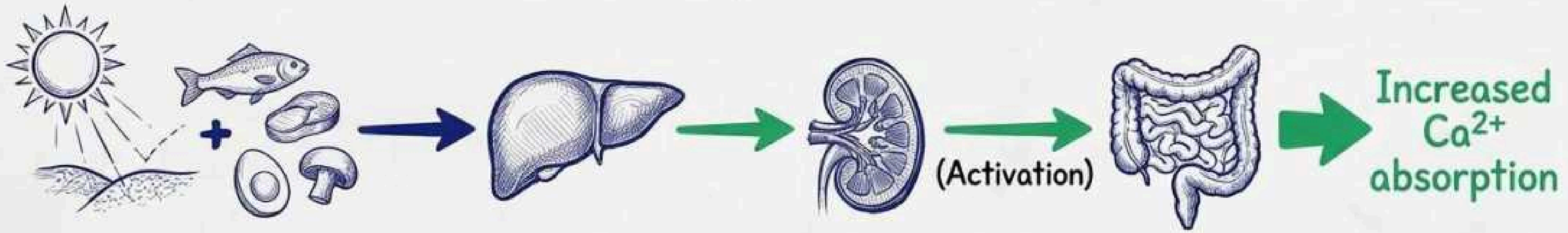
Essential for the blood clotting cascade

Blood calcium ($[Ca^{2+}]_{blood}$) is held within a tightly regulated, narrow range.

Two interacting hormones tightly control blood calcium levels.



Parathyroid hormone (PTH) rises when blood calcium falls. It releases calcium from bone, limits urine loss, and triggers Vitamin D.

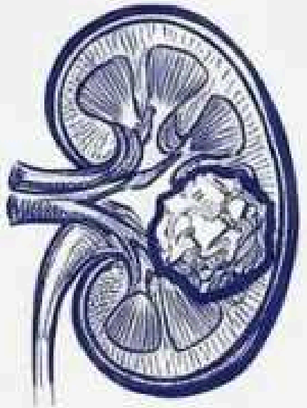


Vitamin D (from sunlight or food) requires sequential activation by the liver and kidney to increase gut absorption of calcium.

Hypercalcaemia presents with a classic constellation of systemic symptoms.

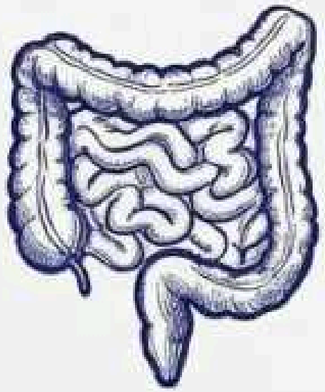
Bones
Bone pain.

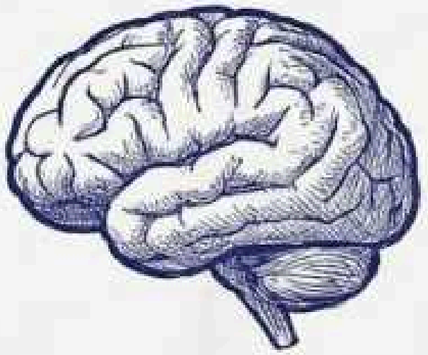




Stones
Kidney stones.

Groans
Abdominal pain and constipation.





Moans
Low mood or confusion.

Accompanying symptoms include thirst and passing large volumes of urine. Severe hypercalcaemia is a medical emergency.

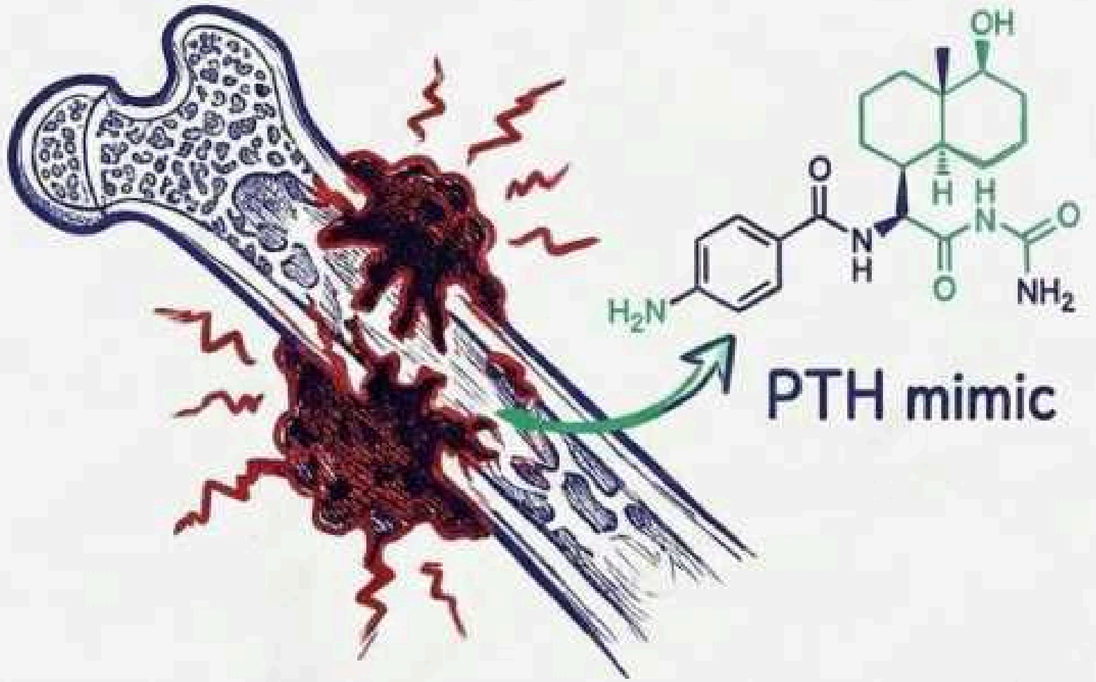
Primary hyperparathyroidism and cancer are the two most common causes of high calcium.

Primary Hyperparathyroidism



- Usually caused by a benign tumour on a single gland making excess hormone.
- Common in older women. Often found on routine blood tests.
- Curable by surgically removing the overactive gland.

Cancer



- Raises calcium through two mechanisms: spreading directly to the bone, or releasing a substance that mimics parathyroid hormone.

Hypocalcaemia causes dangerous neuromuscular and cardiac instability.





Tingling around the mouth and fingers, muscle cramps and spasms.

If severe: seizures and heart rhythm problems.



Cardiac Instability

Accidental damage to parathyroid glands during thyroid surgery.

Severe Vitamin D deficiency.

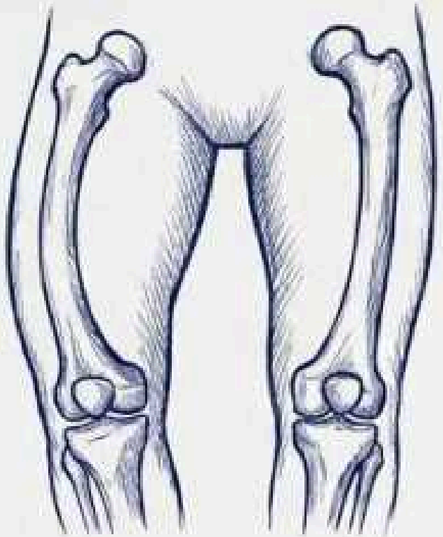
Kidney failure.

$[Ca^{2+}] \downarrow$

Vitamin D deficiency manifests differently depending on skeletal maturity.

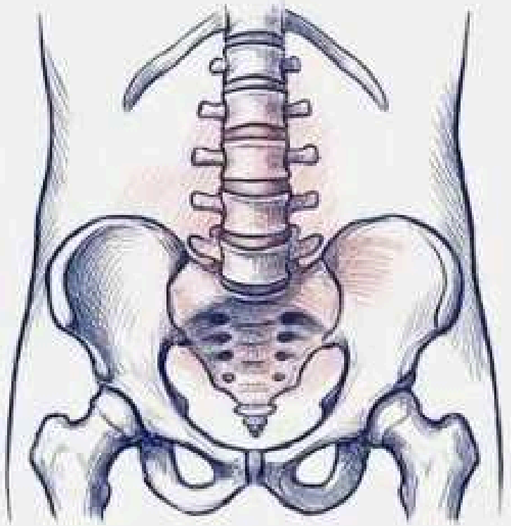
Risk Factors: Common in people with dark skin far from the equator, those who cover their skin, and those rarely outdoors.

Children (Rickets)



Severe deficiency causes soft, bent bones.

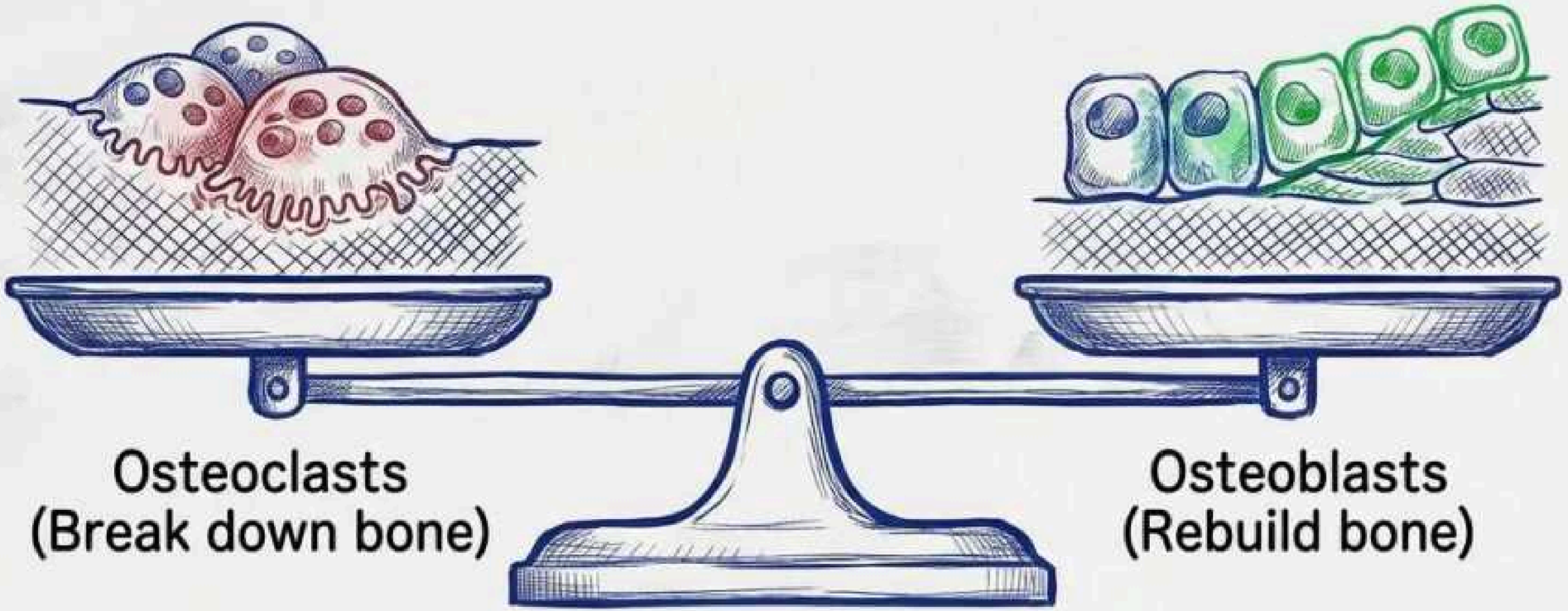
Adults (Osteomalacia)



Results in generalized bone pain and weakness

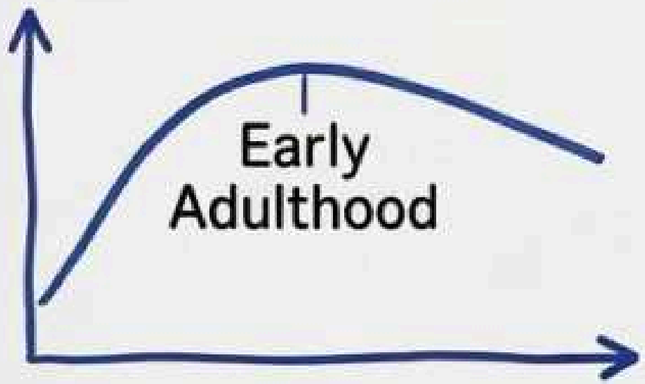
Supplements prevent both conditions. Many countries actively recommend them for at-risk groups.

Bone is living tissue held in a continuous balance of destruction and reconstruction.



Osteoclasts
(Break down bone)

Osteoblasts
(Rebuild bone)

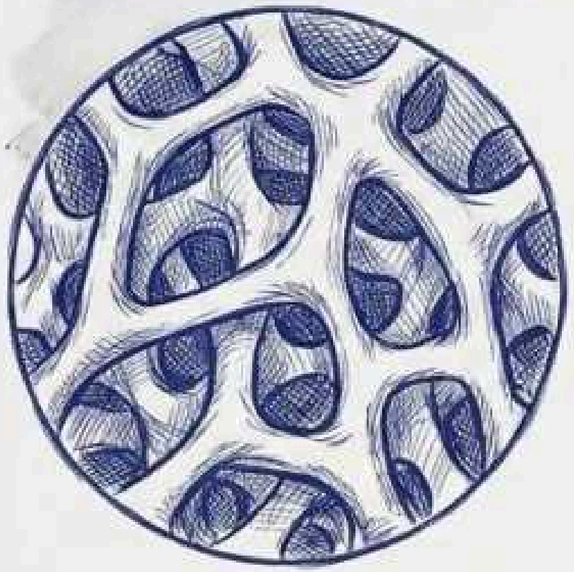


Bone mass peaks in early adulthood, followed by gradual decline.

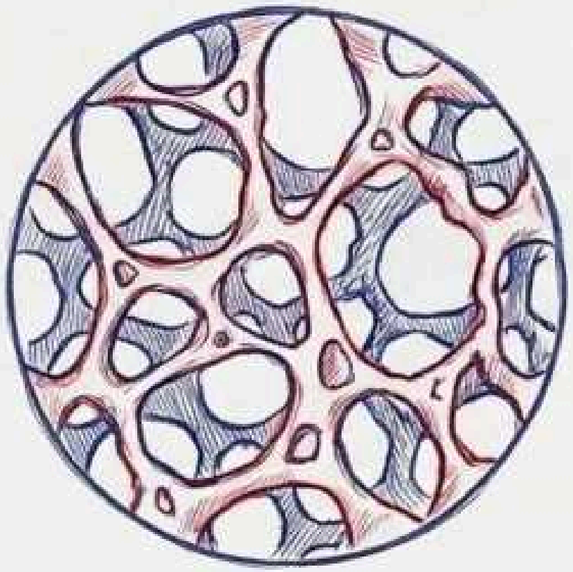
↓ Oestrogen (Menopause)
= ↑↑ Speed of Bone Loss
(accelerates for several years)

Osteoporosis causes asymptomatic loss of bone strength until a fracture occurs.

Healthy Trabecular Bone

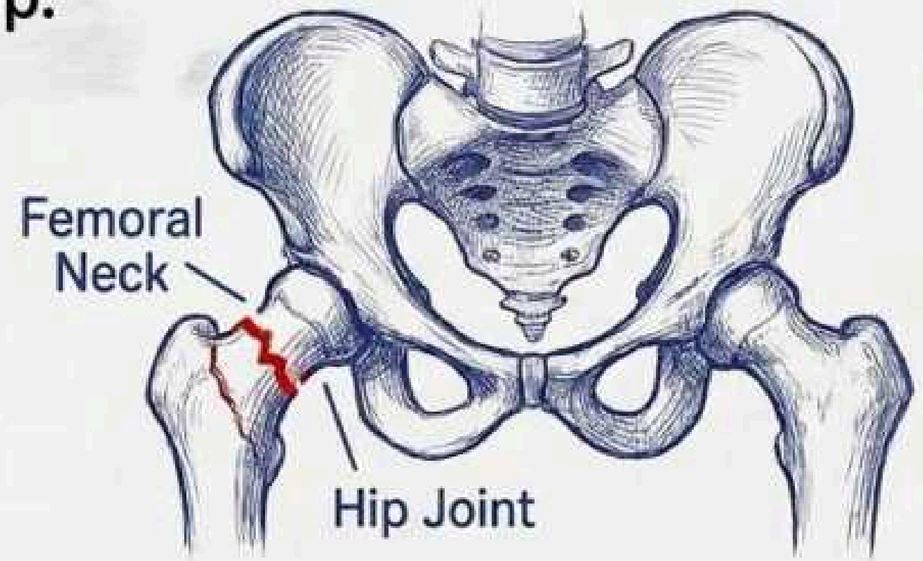


Osteoporotic Bone



Definition: Bones become structurally fragile, breaking with very little force.

Common Fracture Sites: Wrist, Spine, Hip.



Hip fractures in older people are uniquely serious. Many patients never regain previous independence, and a substantial share die within a year of the injury.

Treatment thresholds are based on overall fracture risk, not merely low bone density.

DXA Scan + (Age + Sex + Prev Fractures + Steroids + Smoking) = Overall Fracture Risk

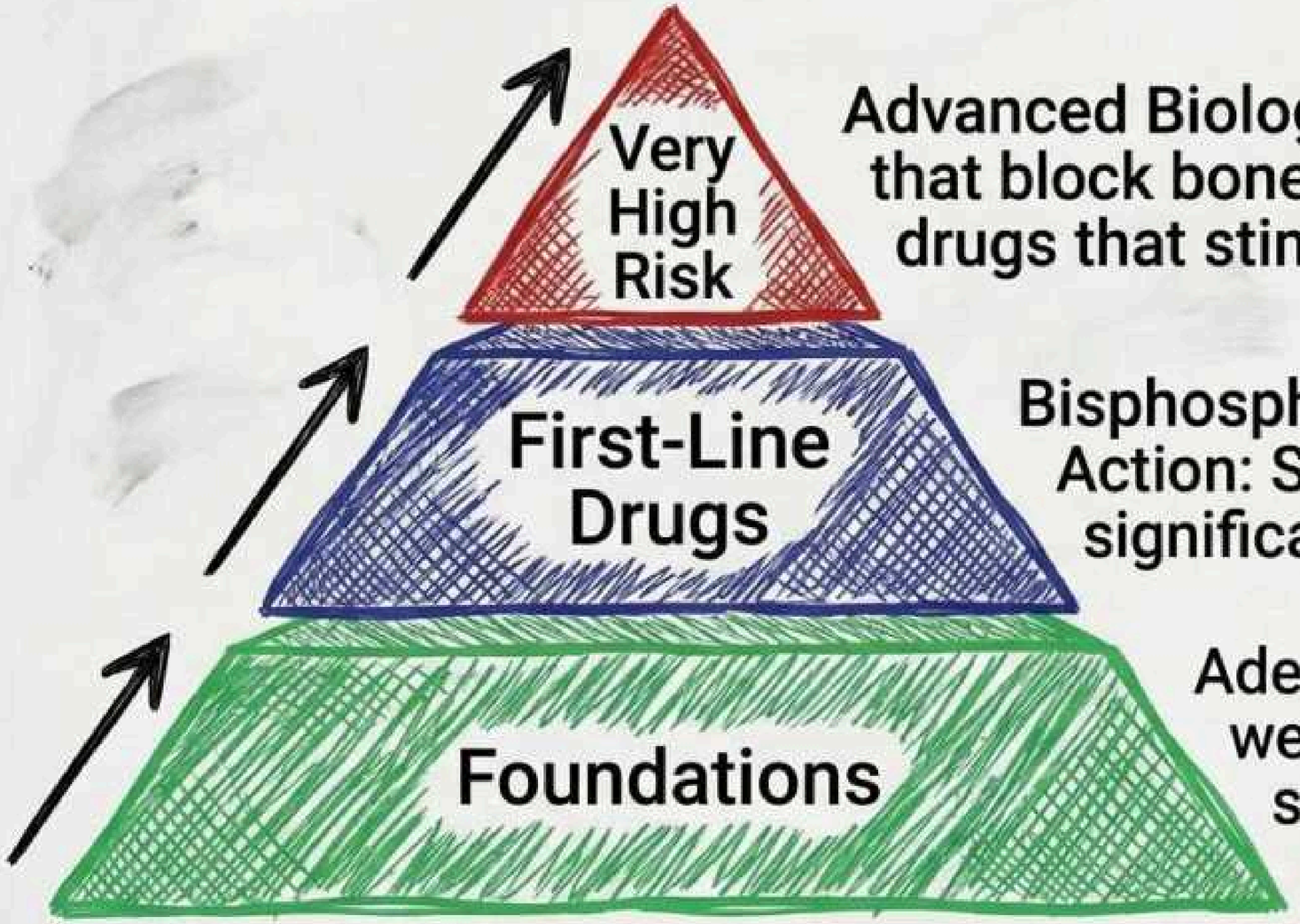
Low-dose X-ray used to measure raw bone density.

Algorithms combine density with critical patient factors.



Clinical treatment targets those at **high risk of fracture**, rather than just treating the low density number in isolation.

Osteoporosis management escalates from lifestyle foundations to targeted bone-modifying drugs.



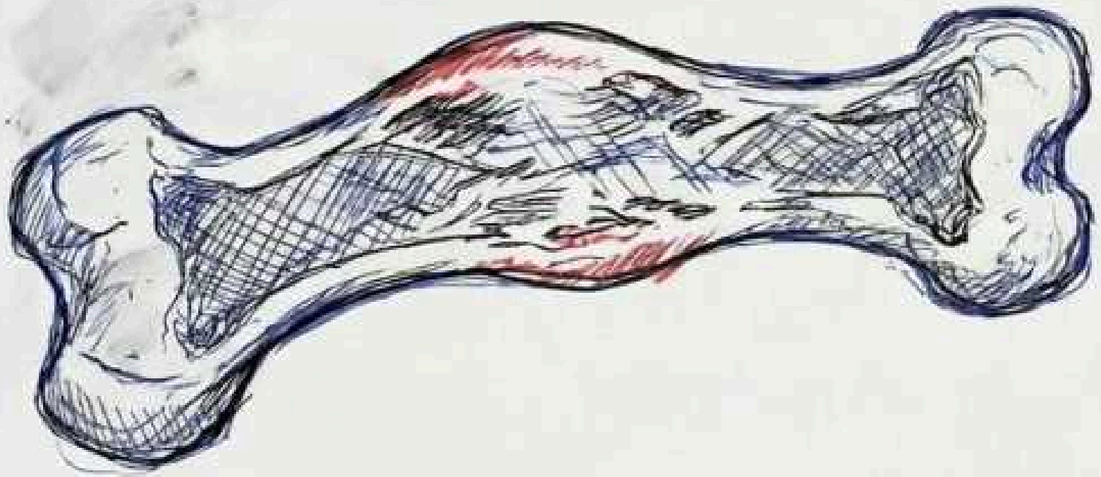
Advanced Biologics. Includes antibodies that block bone breakdown and specialty drugs that stimulate new bone formation.

Bisphosphonates.
Action: Slow bone breakdown and significantly reduce fractures.

Adequate Calcium & Vitamin D, weight-bearing exercise, stopping smoking, limiting alcohol, and reducing fall risk.

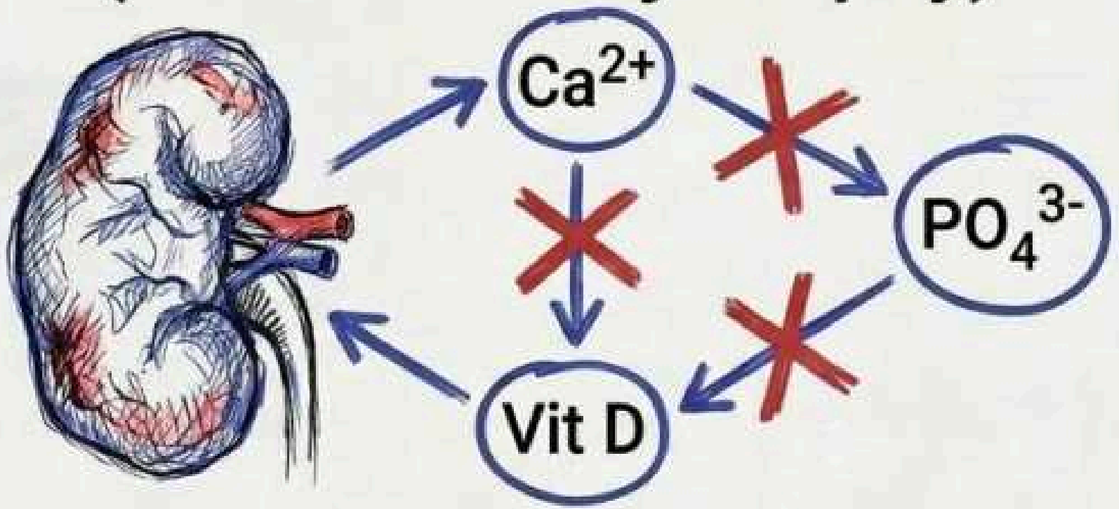
Other systemic diseases also profoundly profoundly disrupt skeletal architecture.

Paget's Disease of Bone



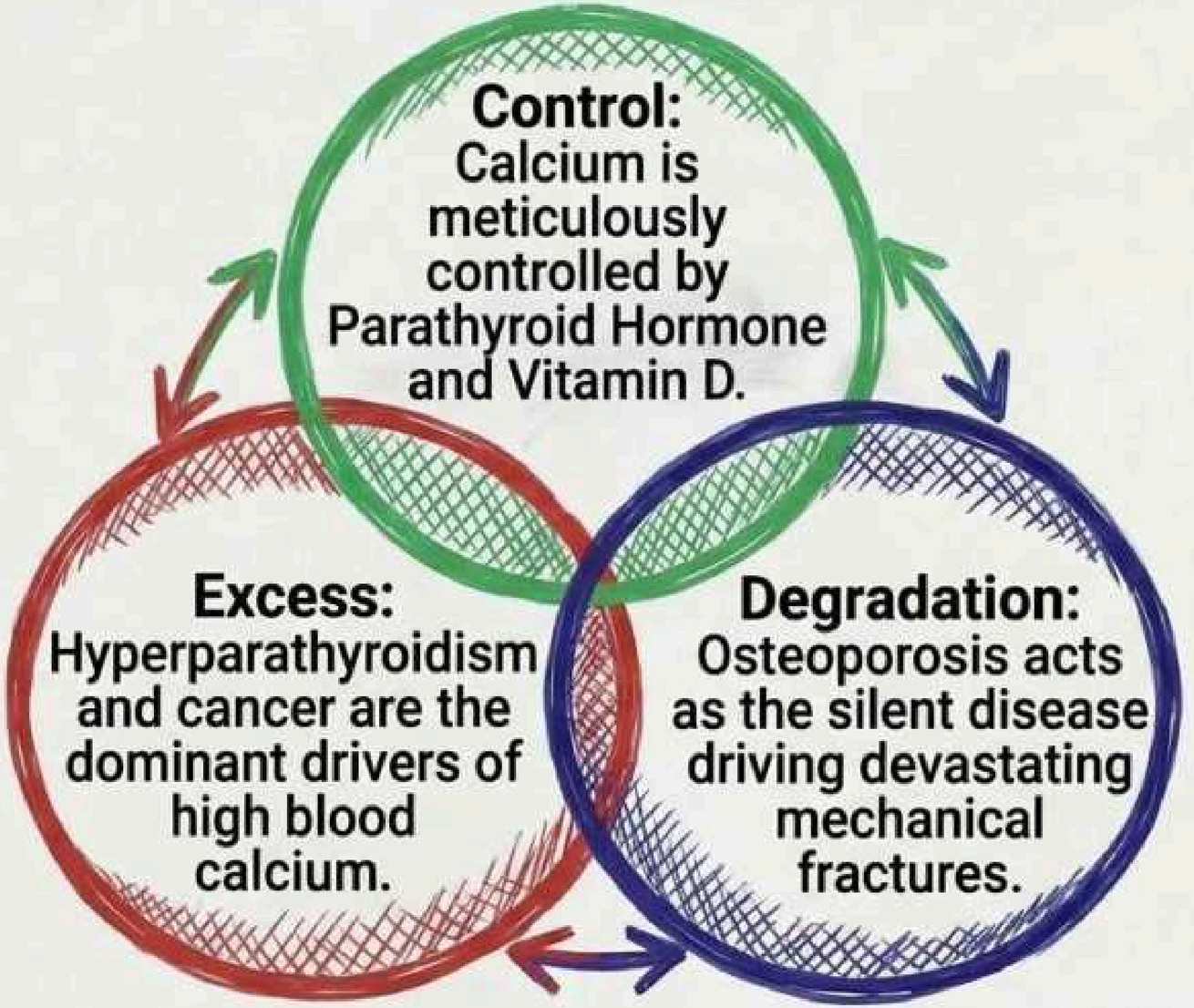
Usually seen in older people. Bone is broken down and rebuilt in a disorganised way, resulting in enlarged, weakened, and painful bones. Often responds well to bisphosphonates.

Kidney Failure (Renal Osteodystrophy)



As detailed in Med 523 B, failing kidneys disrupt the entire Calcium, Phosphate, and Vitamin D axis, leading directly to secondary bone disease.

Calcium balance dictates bone integrity and metabolic stability.



The Final Lecture turns to: Obesity, Growth and Puberty, and Endocrine Tumours.