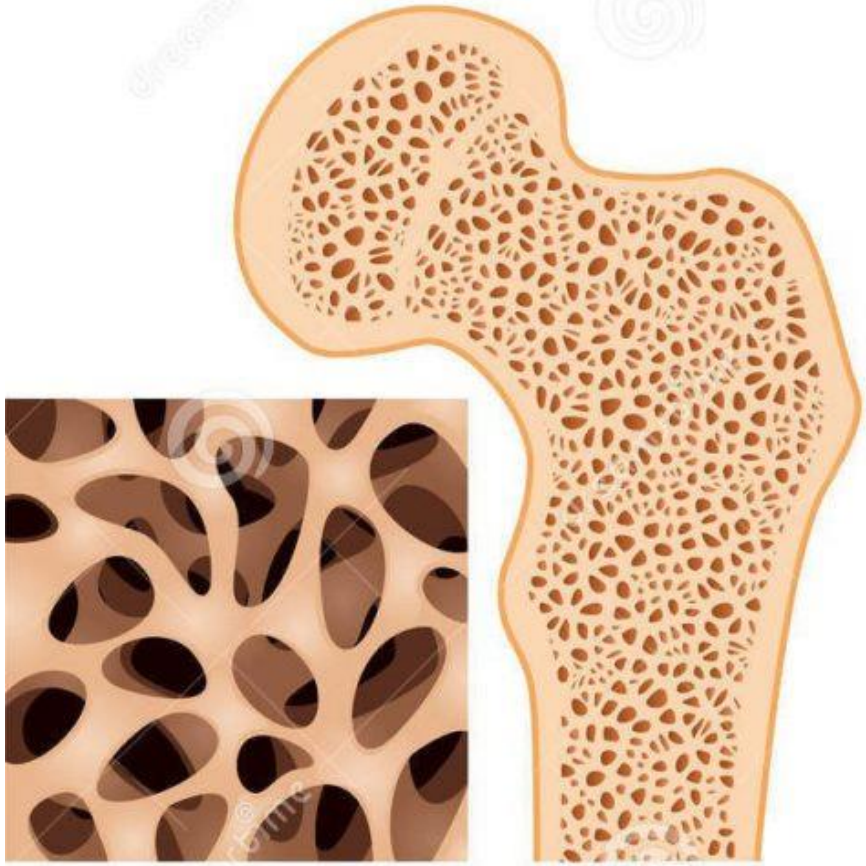
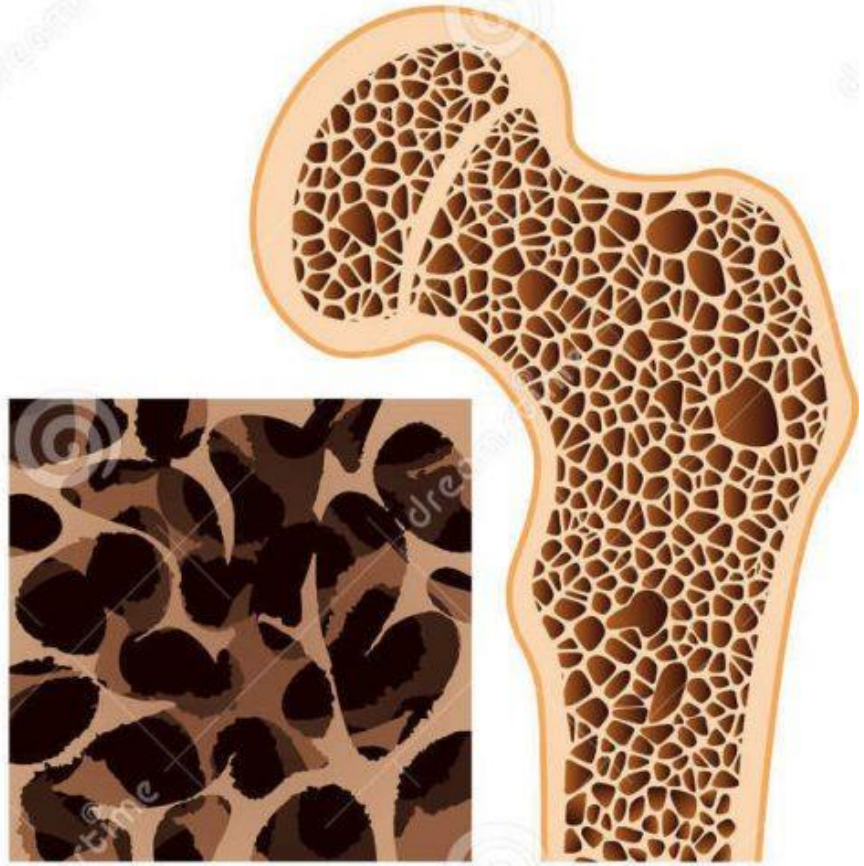
OSTEOPOROSIS: WHY IT'S MORE THAN WEAK BONES

What happens inside your body when bone loss begins and inflammation takes over?

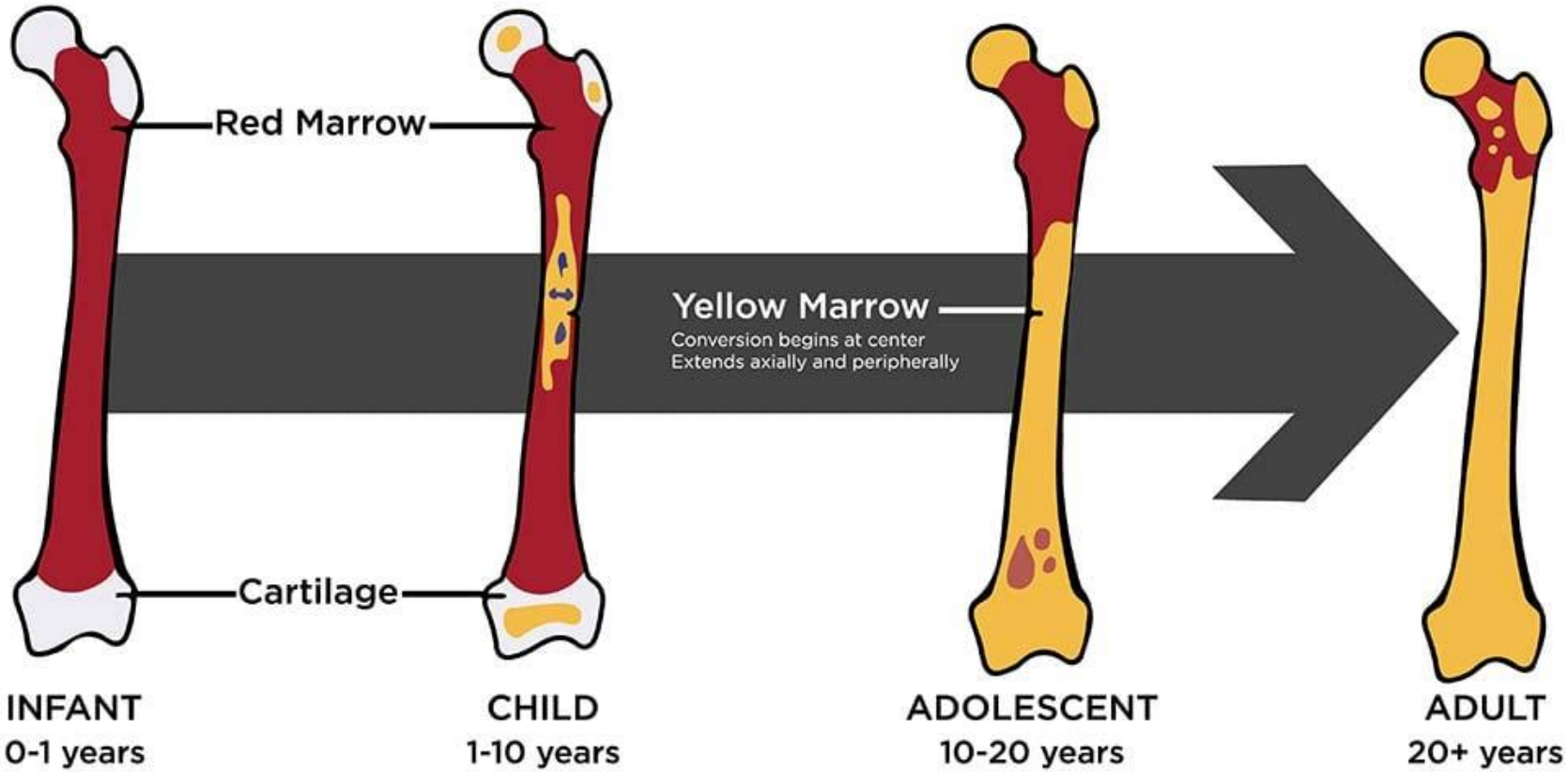
Osteoporosis



Healthy bone

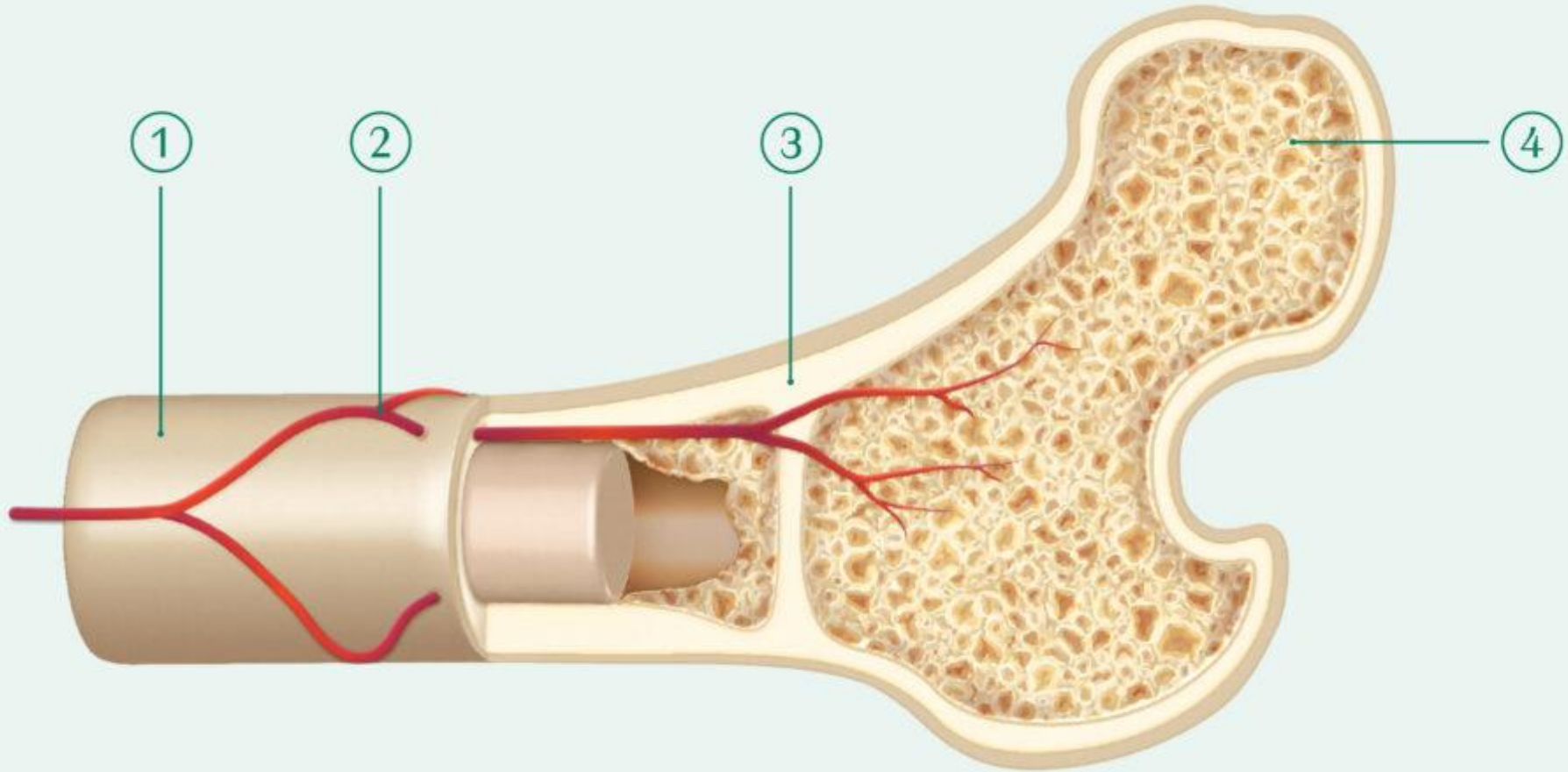


Osteoporosis



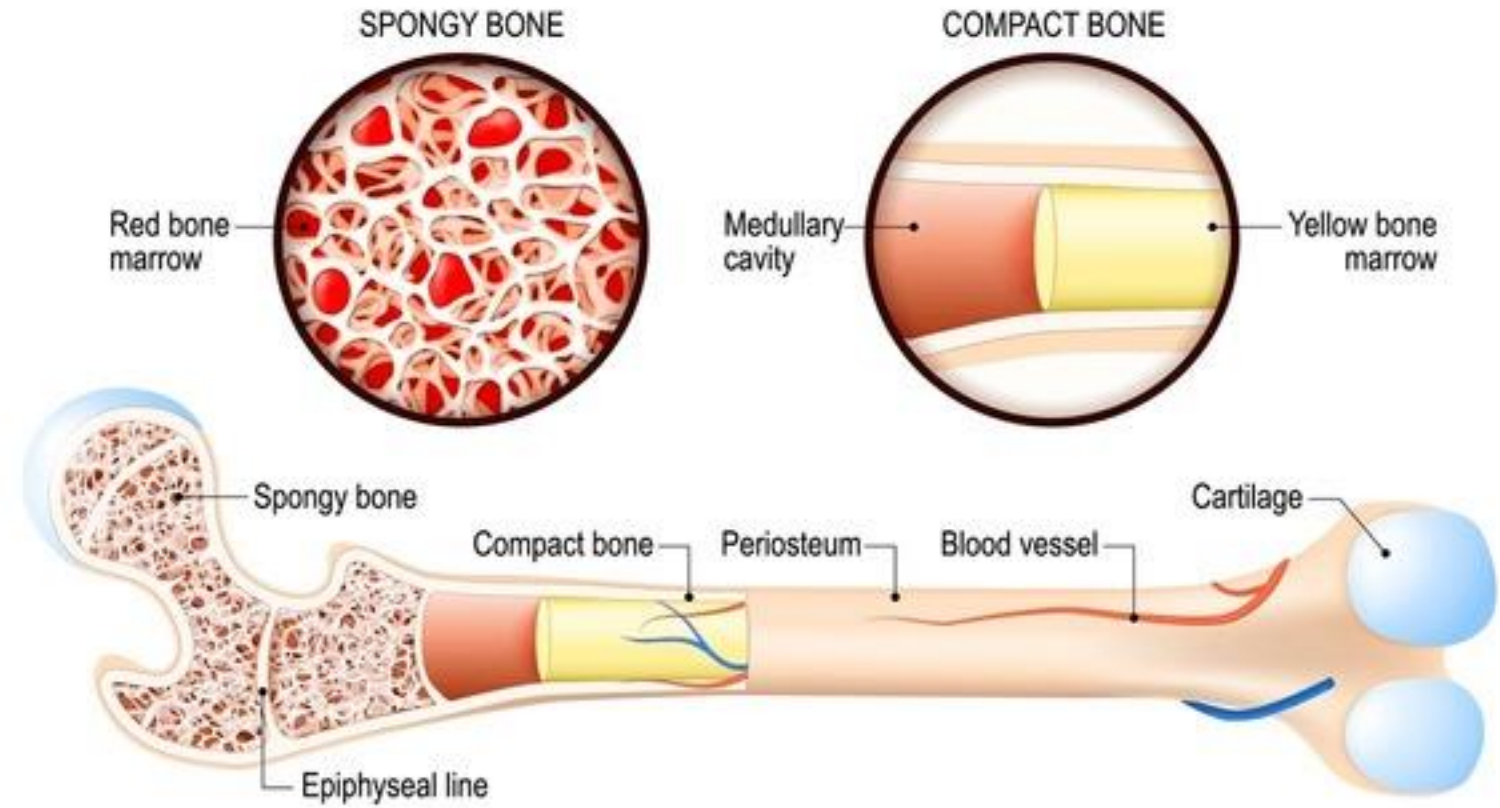
https://www.beckman.com/resources/sample-type/tissues/bone-marrow

Trabecular Bone Diagram



1. PERIOSTEUM
   (membrane covering bone)
2. BLOOD VESSELS
3. CORTICAL (HARD) BONE
4. TRABECULAR (SPONGY) BONE

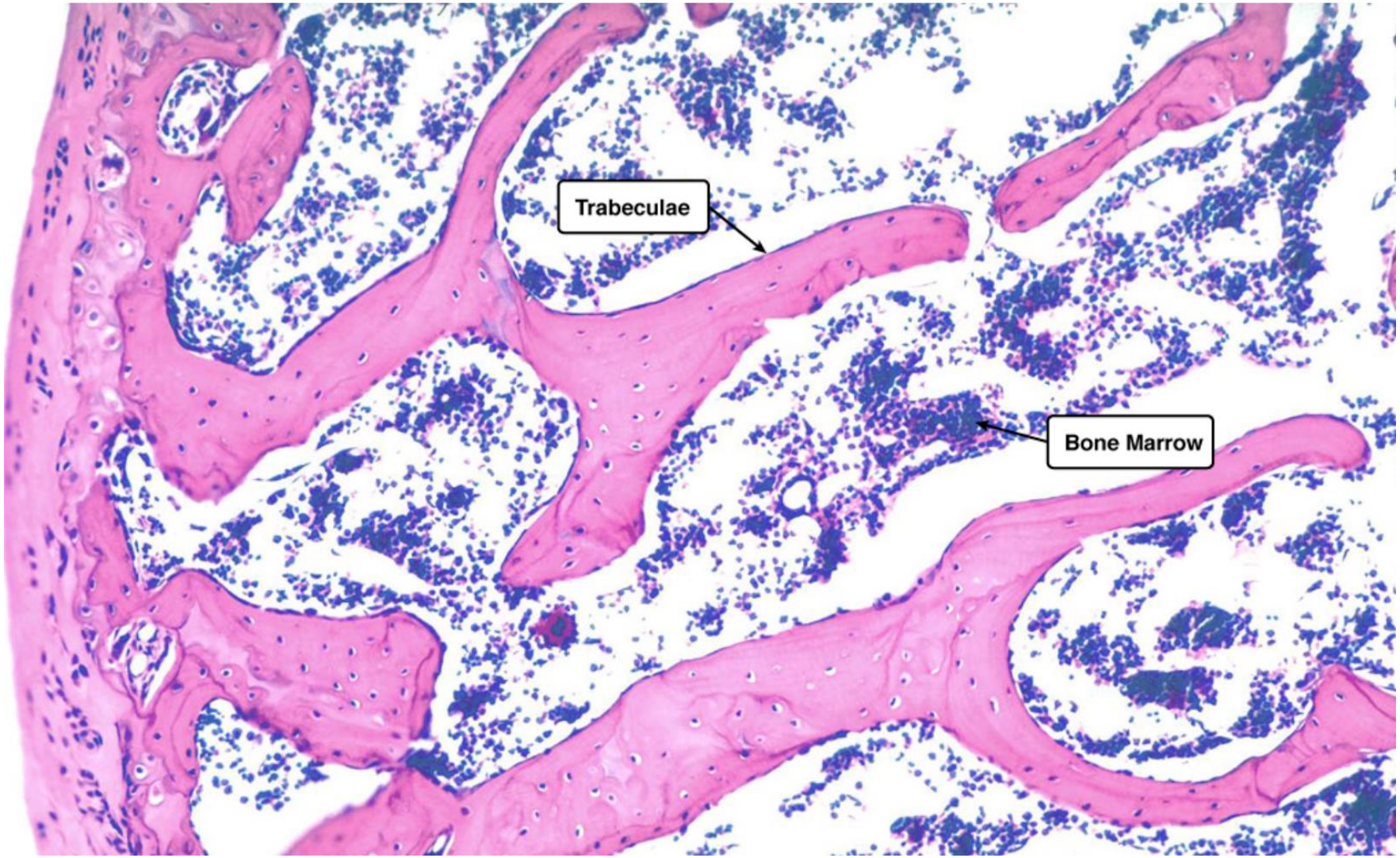
BONE ANATOMY



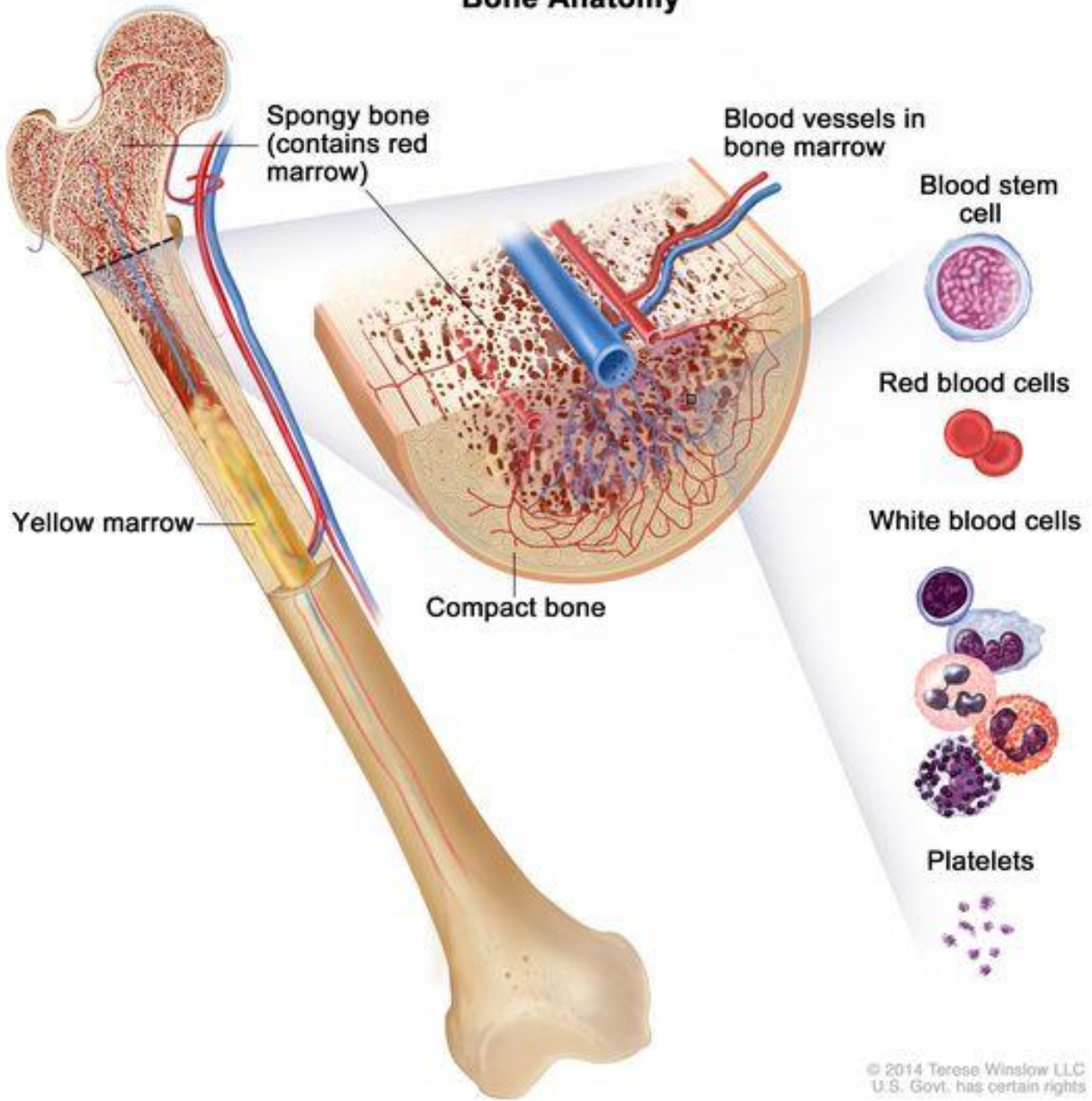
Trabecular bone, also known as cancellous or spongy bone, is a type of bone tissue that is found in the interior of many bones, such as the ends of long bones (e.g., femur, tibia) and the vertebrae.

- **Bone marrow production:**

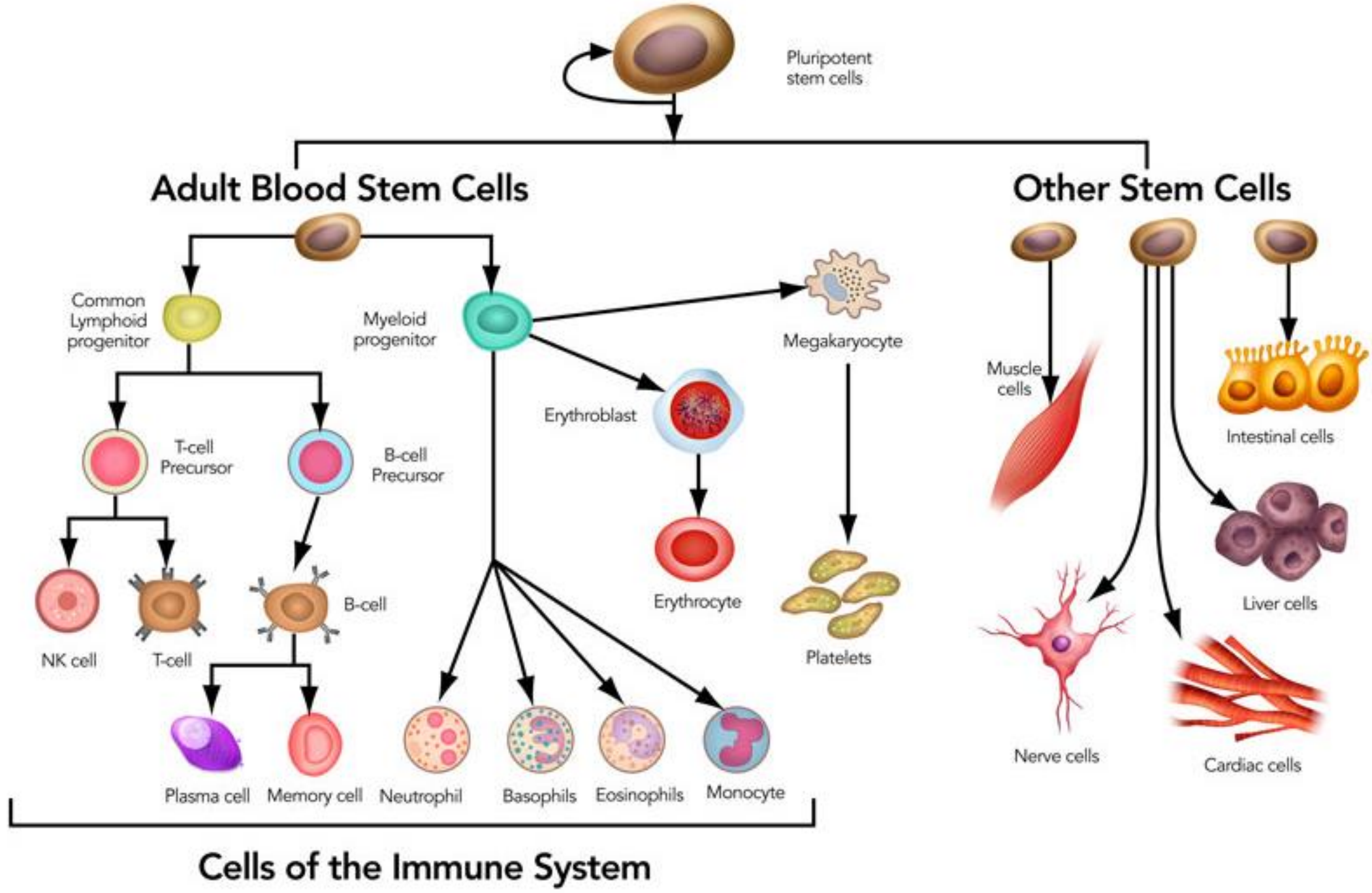
The spaces between the trabeculae are filled with bone marrow, which produces red blood cells, white blood cells, and platele

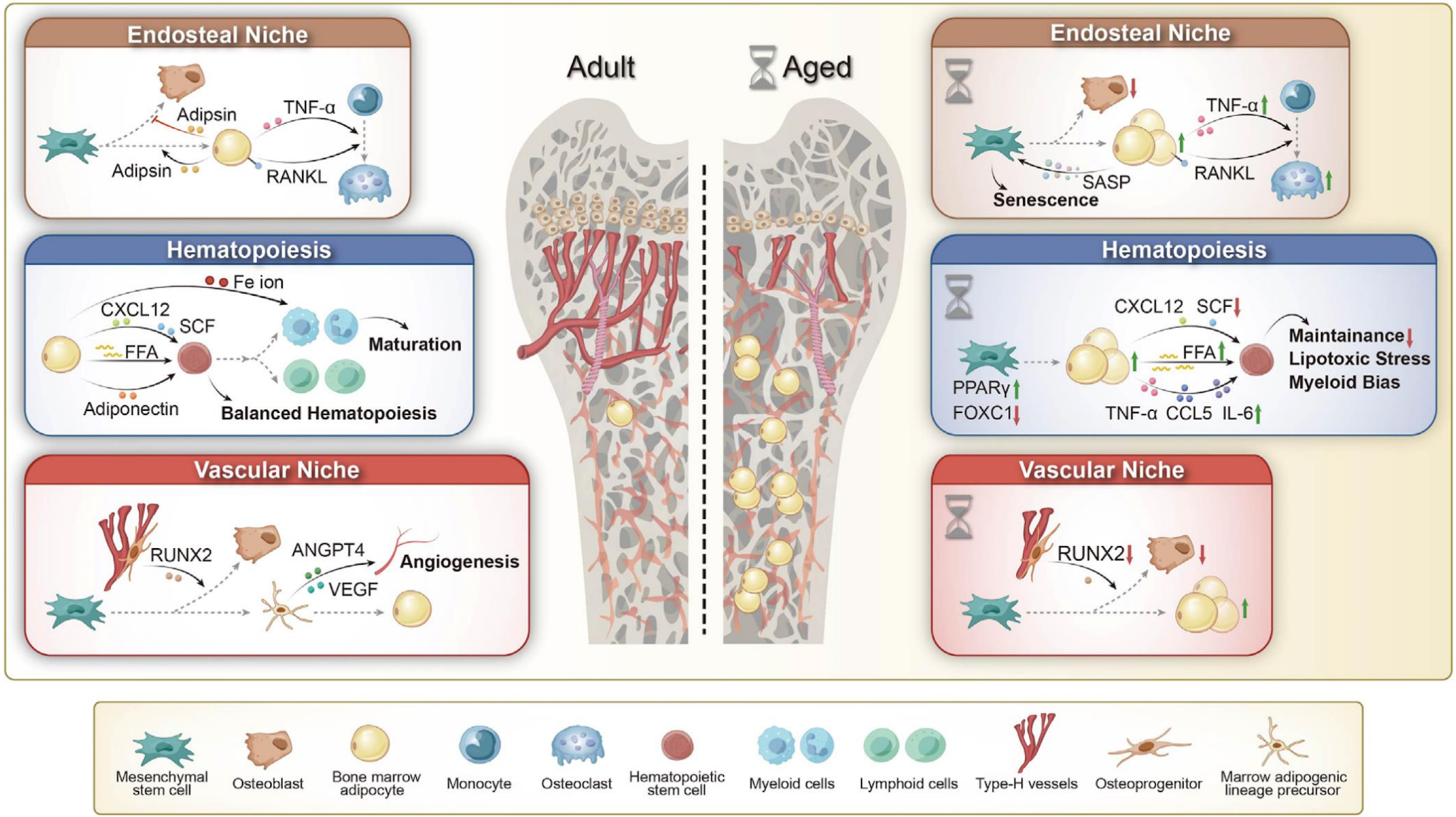

Trabeculae
Bone Marrow

Bone Anatomy



Stem cells are **made in the bone marrow**, which is the soft, spongy tissue found inside certain bones — especially the **hips, ribs, spine, and the ends of long bones** like the femur (thigh bone).


Pluripotent stem cells
Adult Blood Stem Cells
Other Stem Cells
Common Lymphoid progenitor
Myeloid progenitor
Megakaryocyte
Erythroblast
T-cell Precursor
B-cell Precursor
Muscle cells
Intestinal cells
Liver cells
Erythrocyte
Platelets
B-cell
NK cell
T-cell
Nerve cells
Cardiac cells
Plasma cell
Memory cell
Neutrophil
Basophils
Eosinophils
Monocyte
Cells of the Immune System



https://pmc.ncbi.nlm.nih.gov/articles/PMC12367753/

Front Cell Dev Biol. 2025 Aug 7;13:1633801. doi: 10.3389/fcell.2025.1633801

Bone marrow adipocytes: key players in vascular niches, aging, and disease

Yonggang Fan [1,†], Mai Elkhalek [1,†], Yuheng Zhang [1], Lu Liu [1], Qi Tian [1,2], Nareekarn Chueakula [1,3], Saravana K Ramasamy [3], Rinkoo Dalan [3,4], Shukry J Habib [5], Anjali P Kusumbe [1,2,*]

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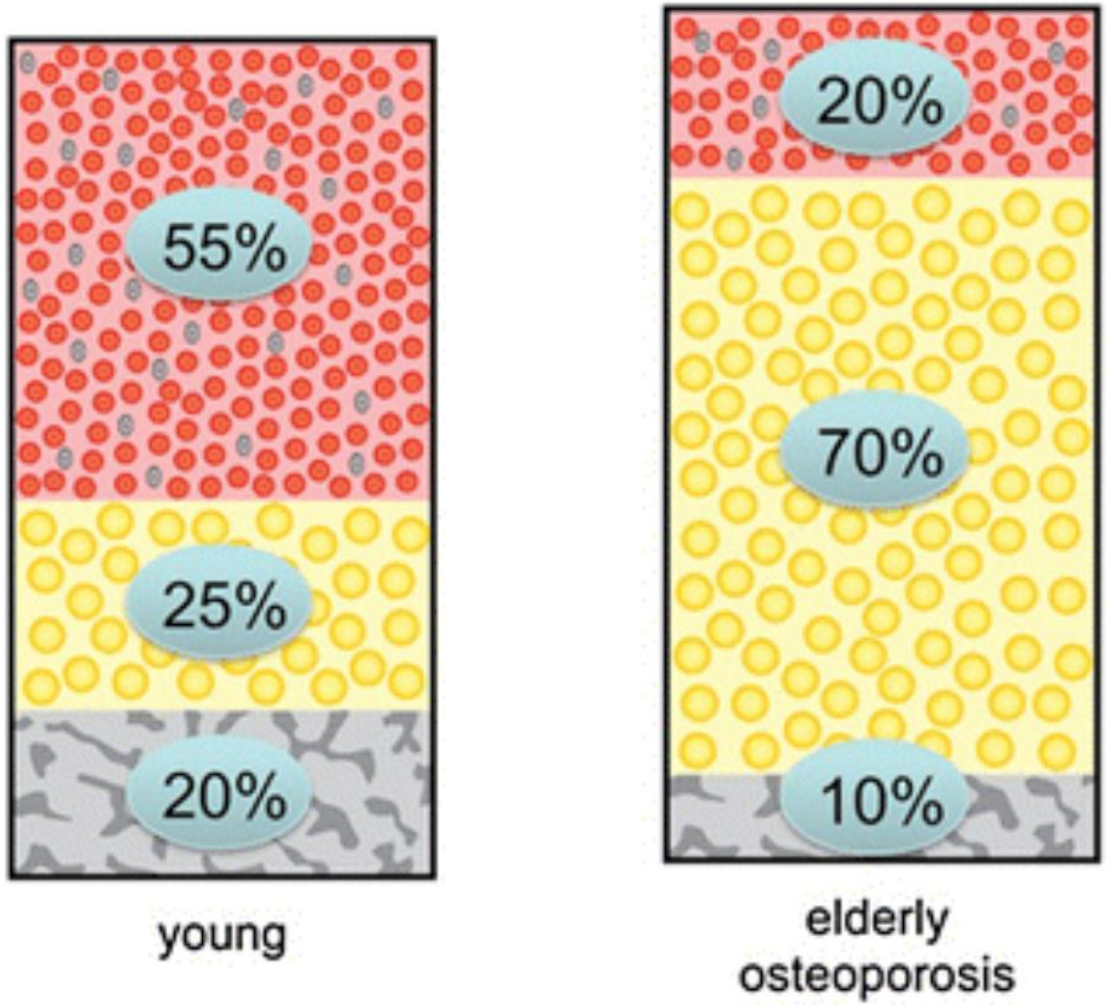
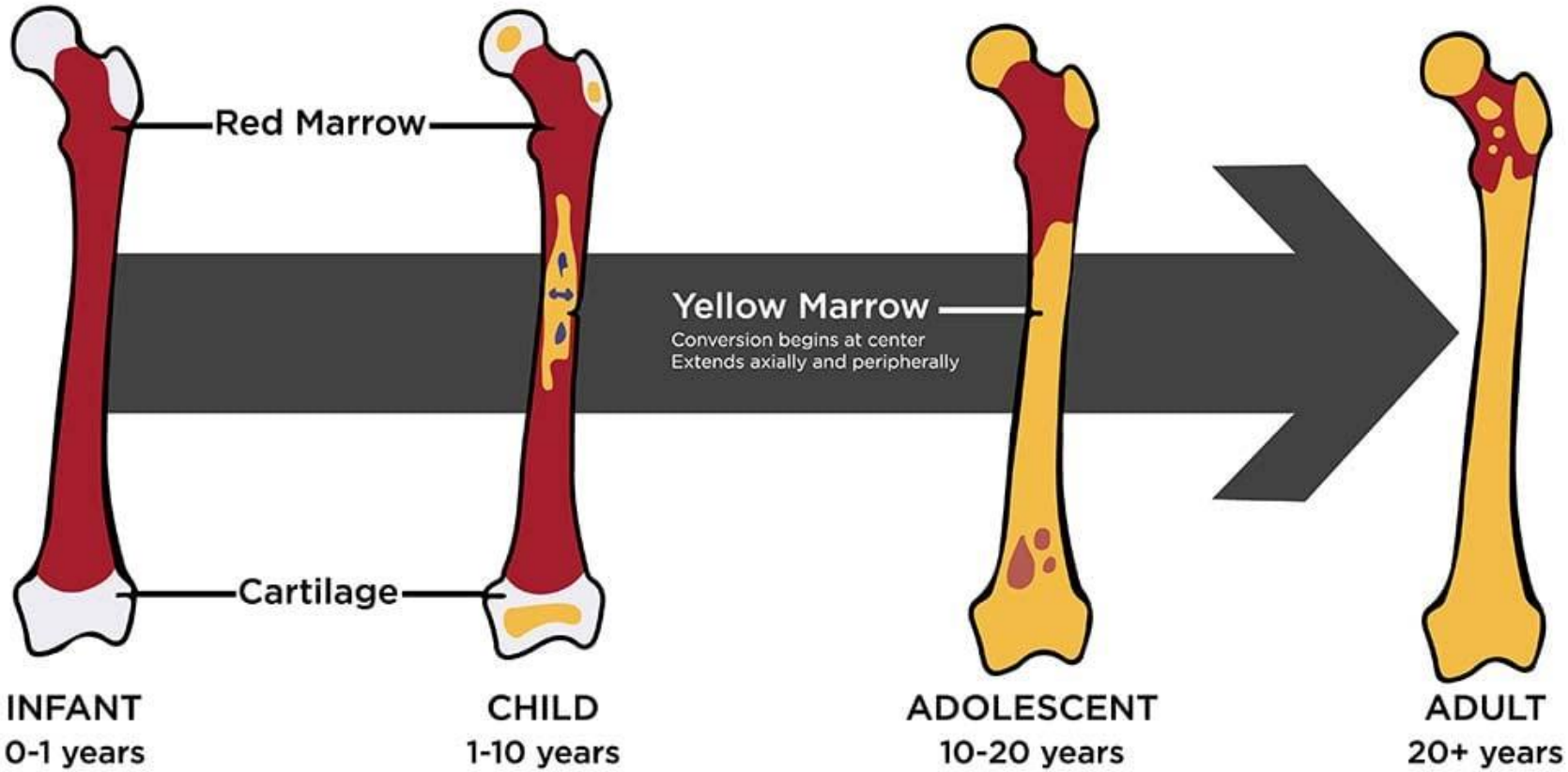
PMCID: PMC12367753 PMID: 40852589



The bone marrow is a confined space. As marrow fat content increases with age, red marrow content decreases since any age-related and/or osteoporotic-related change in trabecular bone volume is relatively small. These physiological changes in the bone marrow are all exaggerated in patients with osteoporosis

https://www.researchgate.net/figure/The-bone-marrow-is-a-confined-space-As-marrow-fat-content-increases-with-age-red-marrow_fig5_316321170



https://www.beckman.com/resources/sample-type/tissues/bone-marrow

🦴 Changes in Bone Marrow Around Age 50

- **Stem-cell numbers decrease slightly** — fewer pluripotent (blood-forming) stem cells remain active.
- **Stem-cell function declines** — they become less efficient at repairing tissue and regulating immune balance.
- **Fat content increases** — more yellow (fatty) marrow replaces red marrow, a process called **marrow adiposity**.
- **Immune system becomes more pro-inflammatory** — known as **inflammaging**, leading to chronic low-grade inflammation.
- **Recovery slows down** — the body heals more slowly after illness, infection, or blood loss due to reduced stem-cell vitality.

Poor bone marrow function can lead to serious health problems, such as an **increased risk of infection, severe anemia, and bleeding**. It can also cause other issues like fatigue, pale skin, easy bruising, and in some cases, may progress to more severe conditions like leukemia or cause organ damage.

Symptoms and consequences

- **Infection:** A weakened immune system due to a lack of white blood cells makes you more susceptible to infections.
- **Anemia:** A shortage of red blood cells leads to fatigue, pale skin, shortness of breath, and dizziness.
- **Bleeding:** Low platelet counts can cause frequent or prolonged nosebleeds, easy bruising, and bleeding from minor cuts.
- **Fatigue:** The reduced number of oxygen-carrying red blood cells causes extreme tiredness and a lack of energy.
- **Organ dysfunction:** Some underlying conditions can lead to organ damage or dysfunction.
- **Bone issues:** In conditions like thalassemia, the bone marrow may expand, causing bone structure irregularities, and making bones thinner and more brittle, increasing the risk of fractures.

🧠 What Does Bone Marrow Do in Humans?

🩸 1. Makes Blood Cells (Hematopoiesis)

Bone marrow is the body's **blood cell factory** — it produces:

- **Red Blood Cells (RBCs):** Carry oxygen to tissues
- **White Blood Cells (WBCs):** Fight infections
- **Platelets:** Help blood clot after injury

💡 *Millions of new blood cells are made every second!*

🧠 What Does Bone Marrow Do in Humans?

🌱 2. Houses Stem Cells

Bone marrow contains **stem cells**, which can develop into:

- Blood cells
- Bone cells
- Fat cells
- Immune cells

These are the **“master cells”** that keep your body renewing itself.

🧠 What Does Bone Marrow Do in Humans?

🦴 3. Supports Bone & Immune Health

- Works with bone-building and bone-breaking cells to maintain **bone strength**
- Produces and trains **immune cells**, helping your body defend against illness

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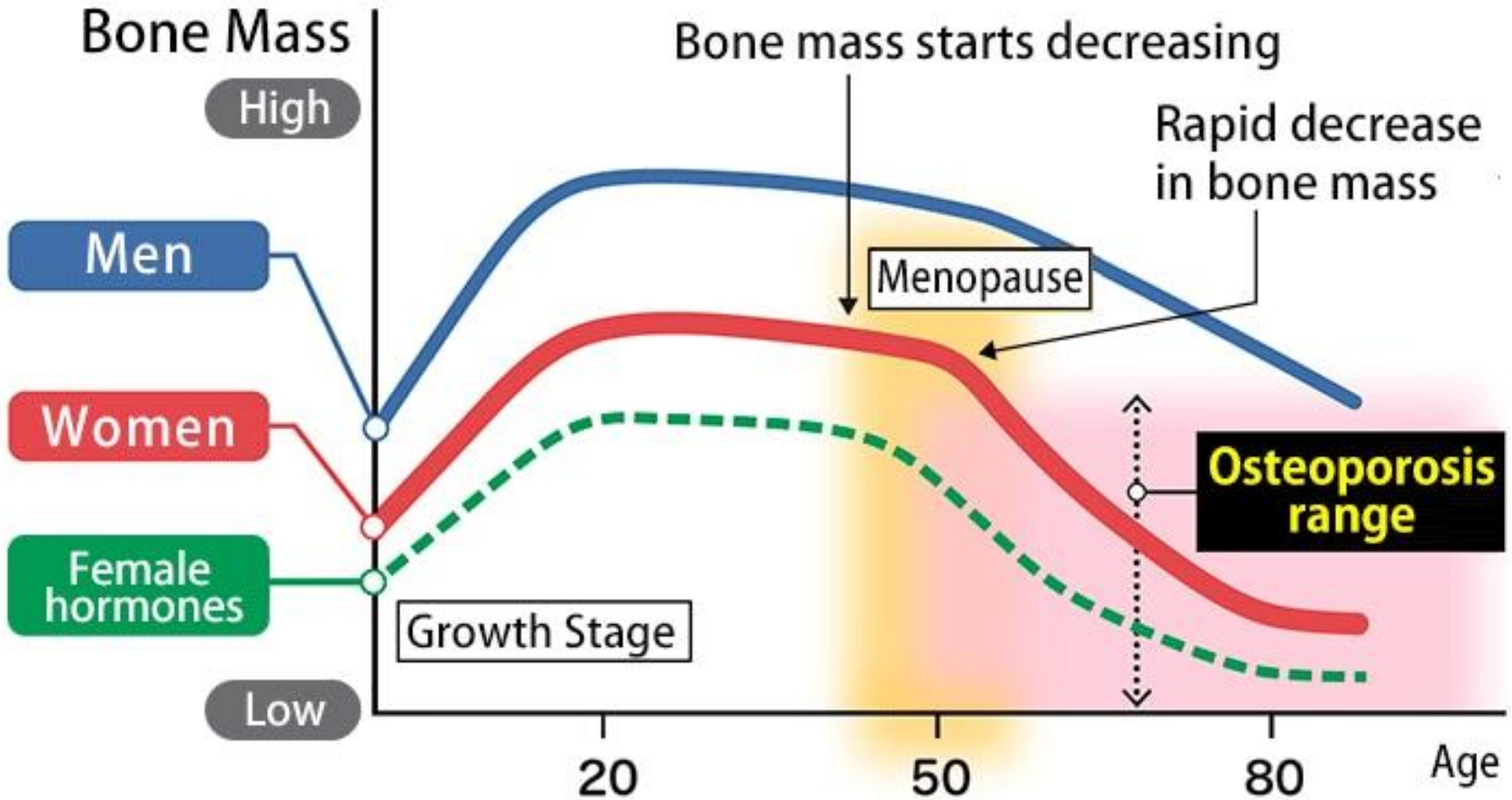
⚖️ 4. Stores Fat & Nutrients

- Contains **fat cells** that store energy
- Releases hormones that influence bone and immune health

Exploring How Inflammation Drives Bone Loss During Perimenopause and Menopause



In 1850, a woman in the United States was expected to live to about **43.0 years**, though this figure was heavily impacted by high infant and childhood mortality rates. If a woman survived childhood, her life expectancy at age 5 was significantly higher, around 51.2 years.

Key Laboratory Signs Indicative of Chronic Inflammation and Accelerated Bone Marrow Decline

⚙️ Summary of Key Lab Markers That Hinder Bone Marrow Function

Category	Key Markers
Inflammation	CRP, ESR, Ferritin, Fibrinogen
Metabolic	Fasting Insulin, HbA1c, Homocysteine
Nutritional	Vitamin D, B12, Folate, Iron Panel, Zinc/Copper
Immune/Cellular Stress	WBC Differential, LDH, A/G Ratio

Ordered Items

C-Telopeptide, Serum

TESTS	RESULT	FLAG	UNITS	REFERENCE INTERVAL	LAB
C-Telopeptide, Serum	37		pg/mL		01

Reference Range:
Note: The patient's date of birth (DOB) and/or gender was not provided. Consequently, a complete set of reference range data is shown. When DOB and/or gender is provided, only the appropriate age/gender reference range is printed.

Gender	Range
Males	38 - 724
Females	
Premenopausal	34 - 635
Postmenopausal	34 - 1037

🩸 CTX (C-Telopeptide) Blood Test – Bone Breakdown Marker

What CTX Measures (in simple terms):

The **CTX blood test** shows how quickly your bones are breaking down.

When your body removes old bone tissue, tiny pieces of a protein called **collagen** get released into your blood. These pieces are called **CTX**.

- **High CTX** means your bones are breaking down **too fast** — a sign of bone loss.
- **Low CTX** means bone breakdown is **slower and more balanced** — a healthier state.

Doctors use this test to **detect bone loss early**, often before it shows up on a bone density scan (DEXA).

Use **Serum CTX** if you are:

- Tracking **bone loss (osteopenia/osteoporosis)**
- Monitoring **response to functional medicine or nutritional therapy**
- Measuring **inflammation-driven bone resorption**
- Evaluating **post-menopausal bone health or long-term steroid use**

🧾 How Often to Repeat

- **Every 3–6 months** after an intervention
- Always under the **same conditions** (fasting, morning, same lab)

📊 3. How to Track Progress

Take baseline → intervene → retest → compare.

Example protocol:

Step	Action	Timing
Baseline Test	Measure CTX before starting treatment	Day 0
Intervention	Implement protocol (e.g., vitamin D, magnesium, K2, anti-inflammatory diet, resistance training)	8–12 weeks
Retest	Same conditions, same lab	3–6 months later

10/23/2025

CBC With Differential/Platelet

Test	Current Result and Flag		Previous Result and Date		Units	Reference Interval
▼ **WBC** [01]	**2.6**	**Low**	***2.4***	06/13/2025	x10E3/uL	3.4-10.8
RBC [01]	4.19		4.27	06/13/2025	x10E6/uL	3.77-5.28
Hemoglobin [01]	13.3		11.9	06/13/2025	g/dL	11.1-15.9
Hematocrit [01]	40.8		37.8	06/13/2025	%	34.0-46.6
MCV [01]	97		89	06/13/2025	fL	79-97
MCH [01]	31.7		27.9	06/13/2025	pg	26.6-33.0
MCHC [01]	32.6		31.5	06/13/2025	g/dL	31.5-35.7
RDW [01]	13.5		**17.1**	06/13/2025	%	11.7-15.4
Platelets [01]	221		213	06/13/2025	x10E3/uL	150-450
Neutrophils [01]	48		38	06/13/2025	%	Not Estab.
Lymphs [01]	38		42	06/13/2025	%	Not Estab.
Monocytes [01]	4		7	06/13/2025	%	Not Estab.
Eos [01]	10		13	06/13/2025	%	Not Estab.
Basos [01]	0		0	06/13/2025	%	Not Estab.
▼ **Neutrophils (Absolute)** [01]	**1.2**	**Low**	**0.9**	06/13/2025	x10E3/uL	1.4-7.0
Lymphs (Absolute) [01]	1.0		1.0	06/13/2025	x10E3/uL	0.7-3.1
Monocytes(Absolute) [01]	0.1		0.2	06/13/2025	x10E3/uL	0.1-0.9
Eos (Absolute) [01]	0.3		0.3	06/13/2025	x10E3/uL	0.0-0.4
Baso (Absolute) [01]	0.0		0.0	06/13/2025	x10E3/uL	0.0-0.2
Immature Granulocytes [01]	0		0	06/13/2025	%	Not Estab.
Immature Grans (Abs) [01]	0.0		0.0	06/13/2025	x10E3/uL	0.0-0.1

Insightful Clinical Case Study

Bone Marrow Recovery: Before &After Functional Medicine Care

Overall Summary: The bone marrow is clearly stronger and more active—producing healthier red and white blood cells. This shows improved immune defense, oxygen delivery, and reduced infiammation.

Key Improvements

Marker	Before	After	Functional Meaning
WBC (White Bloud Cells)	**2.4**	**2.6**	Bone marrow producing more immune cells
Neutrophils (Abs)	**0.9**	**1.3**	Stronger front-line infection defense
Hemoglobin	**11.9**	**13.3**	Improved oxygen & energy delivery
Hematocrit	**37.8**	**40.8**	Better red bloud cell mass
RDW	**17.1**	**13.5**	More uniform, healthy redblovd cells
MCV / MCH / MCHC	Low	Normalized	Balanced nutrients (B-vitamins, iron)

Functional Interpretation

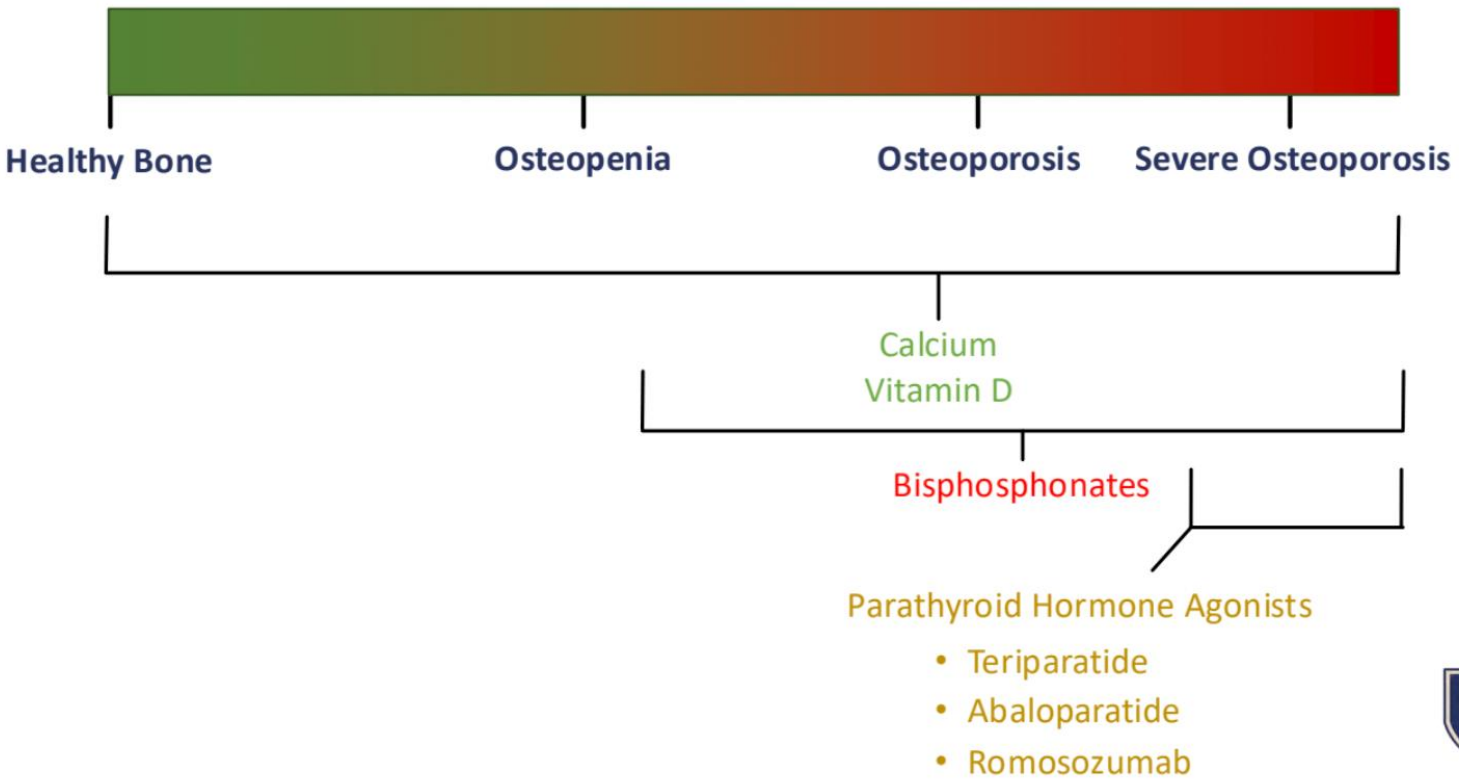
- **Bone Marrow:** Regenerating, prducing stable and healthy cells
- **Immune System:** More resilient and balanced
- **Inflammation:** Better controlled
- **Energy & Oxygenation:** Enhanced through improved red cell quality

Summary

After several rmonths of Functional Medicine care, labs now reflect:

- ✓ Healthler bone marrow output
- ✓ Improved Immune capacity
- ✓ Stronger oxygen transport

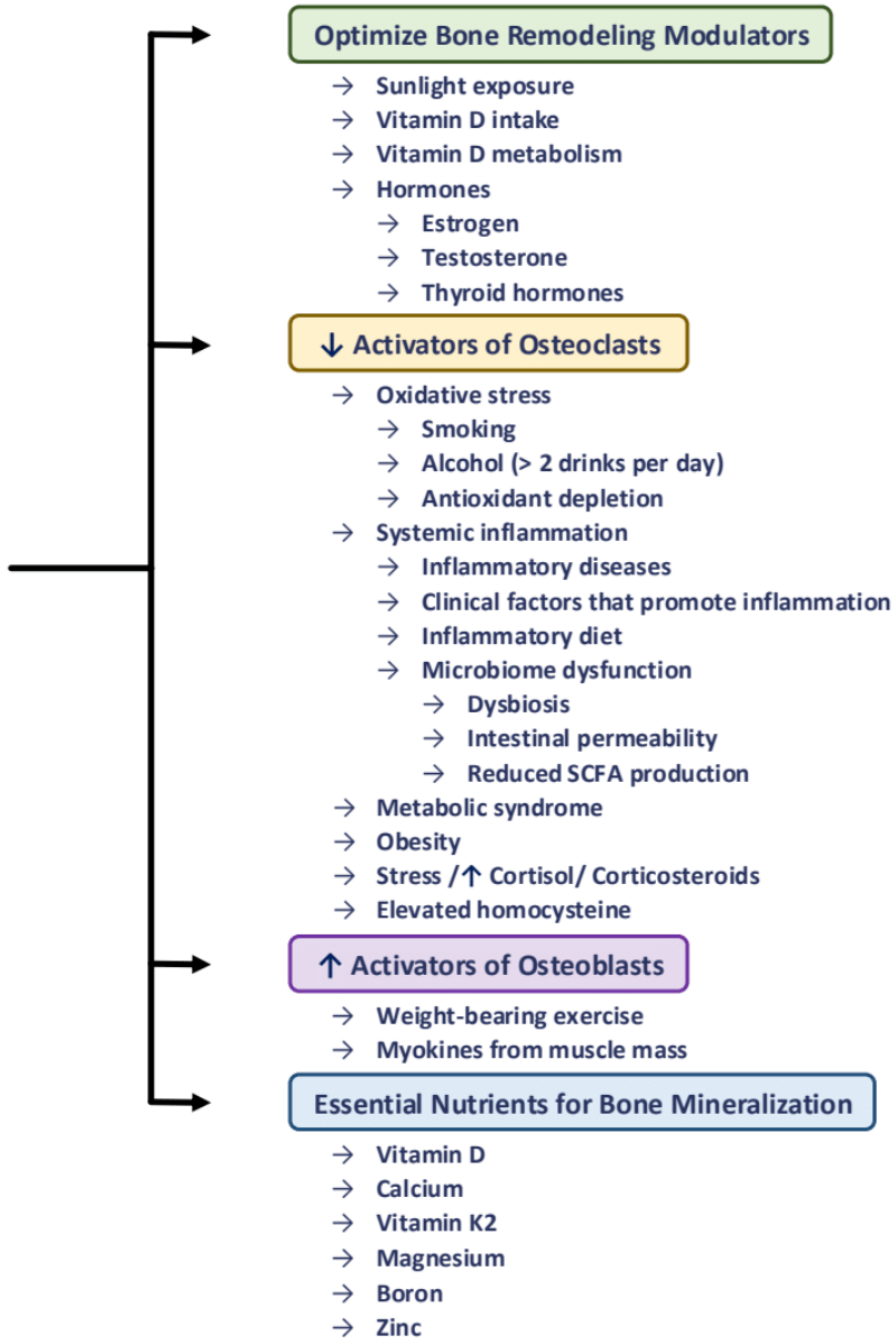
Current Approaches to Bone Loss



- The conventional model for osteoporosis management is heavily weighted towards pharmacological support and does not adequately address the management of underlying risk factors for bone loss.

Effective functional medicine approaches to halt chronic inflammation and restore both bone marrow and bone health.

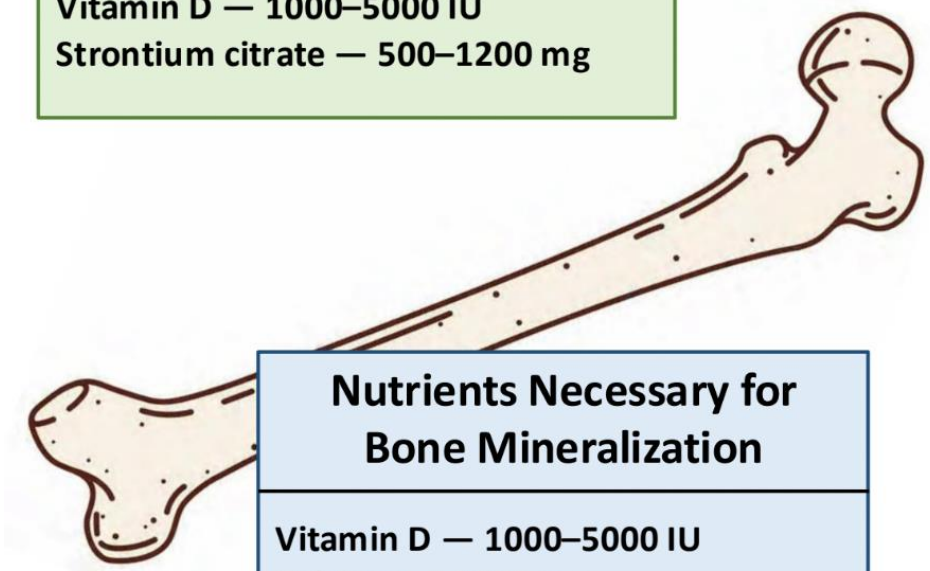
Clinical Strategies for Healthy Bone Maintenance



Nutraceutical Considerations for Osteopenia / Osteoporosis

Stimulate Osteoblasts

Vitamin D — 1000–5000 IU
Strontium citrate — 500–1200 mg



Nutrients Necessary for Bone Mineralization

Vitamin D — 1000–5000 IU
Calcium — 2000 mg
Vitamin K2 — 800 mcg
Magnesium — 1200 mg
Manganese — 4 mg
Boron — 12 mg
Zinc — 10 mg

↓ Osteoclast Response

Anti-inflammatories
- EPA/DHA
- Turmeric
- Resveratrol

Microbiome support
- Short-chain fatty acids
- Probiotics

Antioxidants
- Vitamins A, C, E
- Polyphenol compounds
- Glutathione

Homocysteine reduction
- B12
- Methylfolate

Yes, from a functional medicine perspective, systemic inflammation can get into the bone marrow and disrupt its function. Functional medicine focuses on addressing the root causes of chronic inflammation throughout the body, as opposed to simply treating symptoms.

Here is how chronic inflammation affects the bone marrow and how a functional medicine approach can address it.

How inflammation impacts the bone marrow

- **Affects blood cell production**: The bone marrow is where hematopoietic stem cells (HSCs) reside and develop into all types of blood cells. Chronic inflammatory signals can force these stem cells into "emergency hematopoiesis," pushing them to produce more immune cells like neutrophils. Over time, this over-proliferation can exhaust the stem cells and lead to bone marrow failure, anemia, and an increased risk of blood cancers.
- **Alters the bone marrow microenvironment**: The bone marrow contains a specialized microenvironment, or niche, that is critical for maintaining healthy HSCs. Inflammation, aging, and exposure to toxins can alter this microenvironment by changing the cellular and cytokine composition, which can lead to dysfunctional hematopoiesis.
- **Creates bone marrow edema**: Inflammation can also lead to bone marrow edema (fluid accumulation in the marrow), which is visible on an MRI and can cause bone pain and disability.
- **Promotes bone breakdown**: The bone marrow microenvironment also influences the balance of bone-building osteoblasts and bone-resorbing osteoclasts. Chronic inflammation can trigger an increase in osteoclast activity and a decrease in osteoblast activity, leading to conditions like osteoporosis.

https://www.google.com/search?q=can+inflammation+get+into+your+bone+marrow+on+a+functional+medicine+level&sca_esv=8154411a606eb35c&rlz=1C5CHFA_enUS1118US1118&sxsrf=AE3TifNY0ZTuF-7-atOX6blIGAk2hLpoZw%3A1760738706357&udm=50&fbs=AIIjpHxU7SXXniUZfeShr2fp4giZ1Y6MJ25_tmWITc7uy4KIemkjk18Cn72Gp24fGkjjh6w8f_UmwvItOb-_M1yJww2SbnHRjS3sgxwVBPbo0fTnaJwpHy9xTpJcr5tWJ3jPBc0A50RX_-oaTJiytR-LvyR8uw8kQFPd0v68xBK5GvI2z1LwwSpFUi6Vn_vuveFd2AEfe1epcD_27WUwsf4jm7AqkJ1E_A&aep=1&ntc=1&sa=X&ved=2ahUKEwjA2onpnqyQAxWH4MkDHVX2E0cQ2J8OegQIDBAE&biw=1185&bih=952&dpr=1.8&mtid=rr3yaOquJLijptQPlcbwEA&mstk=AUtExfAOEkjrhFQ5YFsjIE3YBDNoUZSdmxYypiN1sxMoEX16NEakBroF2IHsj2-GaWu0OrTqAfO_IjHgaOt9k_vkUvuSlzN8-wZwnJqH1728ff-HAHR_4T_544h6jixVGTJx9cpSFsUG2UNe_HhhEdLY1hxOYrslEA3lCYaMY6oKOVwEcuPVHnyBPDZ6OfbToL4UuZdUa78r24x_Z6gZ9QmwNINuMysvZobAuweluAyehTiolMiLqn7P3eVowF7J23GirFo0a3pVwfB6MBTARL-4xlXdRlWhhk6CAXYAVe31iYdYB0dBKJMru-U_2lYJPZMT6kpIDaLs_KpfLa2NqXSFomFpze1tQihO9kjZFfDQkHZGaAEbItTptKXeDNKXIGuVnSFwXsQqO9I8fPmZQFl9V4oYv7L7r4PiL_7vzNVGtjAoTFIQERiqV6ujNRswJHdJw3LJrj2A4Py3-0cdg6qfCmI2hDzsV6mk&csuir=1

Hematology Am Soc Hematol Educ Program. 2019 Dec 6;2019(1):294–302. doi: 10.1182/hematology.2019000045

Inflammatory bone marrow microenvironment

Nils B Leimkühler [1], Rebekka K Schneider [1,✉]

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PMCID: PMC6913454 PMID: 31808897

Abstract

Self-renewing hematopoietic stem cells and their progeny, lineage-specific downstream progenitors, maintain steady-state hematopoiesis in the bone marrow (BM). Accumulating evidence over the last few years indicates that not only primitive hematopoietic stem and progenitor cells (HSPCs), but also cells defining the microenvironment of the BM (BM niche), sense hematopoietic stress signals. They respond by directing and orchestrating hematopoiesis via not only cell-intrinsic but also cell-extrinsic mechanisms. Inflammation has many beneficial roles by activating the immune system in tissue repair and as a defense mechanism. However, chronic inflammation can have detrimental effects by stressing HSPCs, leading to cell (DNA) damage resulting in BM failure or even to leukemia. Emerging data have demonstrated that the BM microenvironment plays a significant role in the pathogenesis of hematopoietic malignancies, in particular, through disrupted inflammatory signaling, specifically in niche (microenvironmental) cells. Clonal selection in the context of microenvironmental alterations can occur in the context of toxic insults (eg, chemotherapy), not only aging but also inflammation. In this review, we summarize mechanisms that lead to an inflammatory BM microenvironment and discuss how this affects normal hematopoiesis. We pay particular attention to the process of aging, which is known to involve low-grade inflammation and is also associated with age-related clonal hematopoiesis and potentially malignant transformation.

Abstract

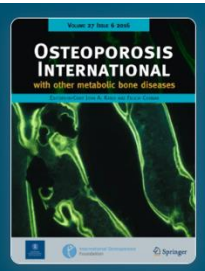
Bone turnover markers (BTMs) are used widely, in both research and clinical practice. In the last 20 years, much experience has been gained in measurement and interpretation of these markers, which include commonly used bone formation markers (bone alkaline phosphatase, osteocalcin, and procollagen I N-propeptide); and commonly used resorption markers (serum C-telopeptides of type I collagen, urinary N-telopeptides of type I collagen, and tartrate-resistant acid phosphatase type 5b). BTMs are usually measured by enzyme-linked immunosorbent assay or automated immunoassay. Sources contributing to BTM variability include uncontrollable factors (eg, age, gender, ethnicity) and controllable factors, particularly relating to collection conditions (eg, fasting/feeding state, and timing relative to circadian rhythms, menstrual cycling, and exercise). Pregnancy, season, drugs, and recent fracture(s) can also affect BTMs. BTMs correlate with other methods of assessing bone turnover, such as bone biopsies and radiotracer kinetics, and can usefully contribute to diagnosis and management of several diseases such as osteoporosis, osteomalacia, Paget's disease, fibrous dysplasia, hypophosphatasia, primary hyperparathyroidism, and chronic kidney disease–mineral bone disorder

https://pmc.ncbi.nlm.nih.gov/articles/PMC10166271/

Risk of osteoporosis and fracture after hysterectomies without oophorectomies: a systematic review and pooled analysis

Review | Published: 29 March 2022

Volume 33, pages 1677–1686, (2022) Cite this article



Osteoporosis International

Aims and scope →

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Conclusions

This is the first study to quantify the association between hysterectomy without oophorectomies and osteoporosis/fracture risk through a meta-analysis and has subsequently confirmed its positive relationship. Additional large-sample rigorously prospective cohorts are still warranted to validate the present evidence.

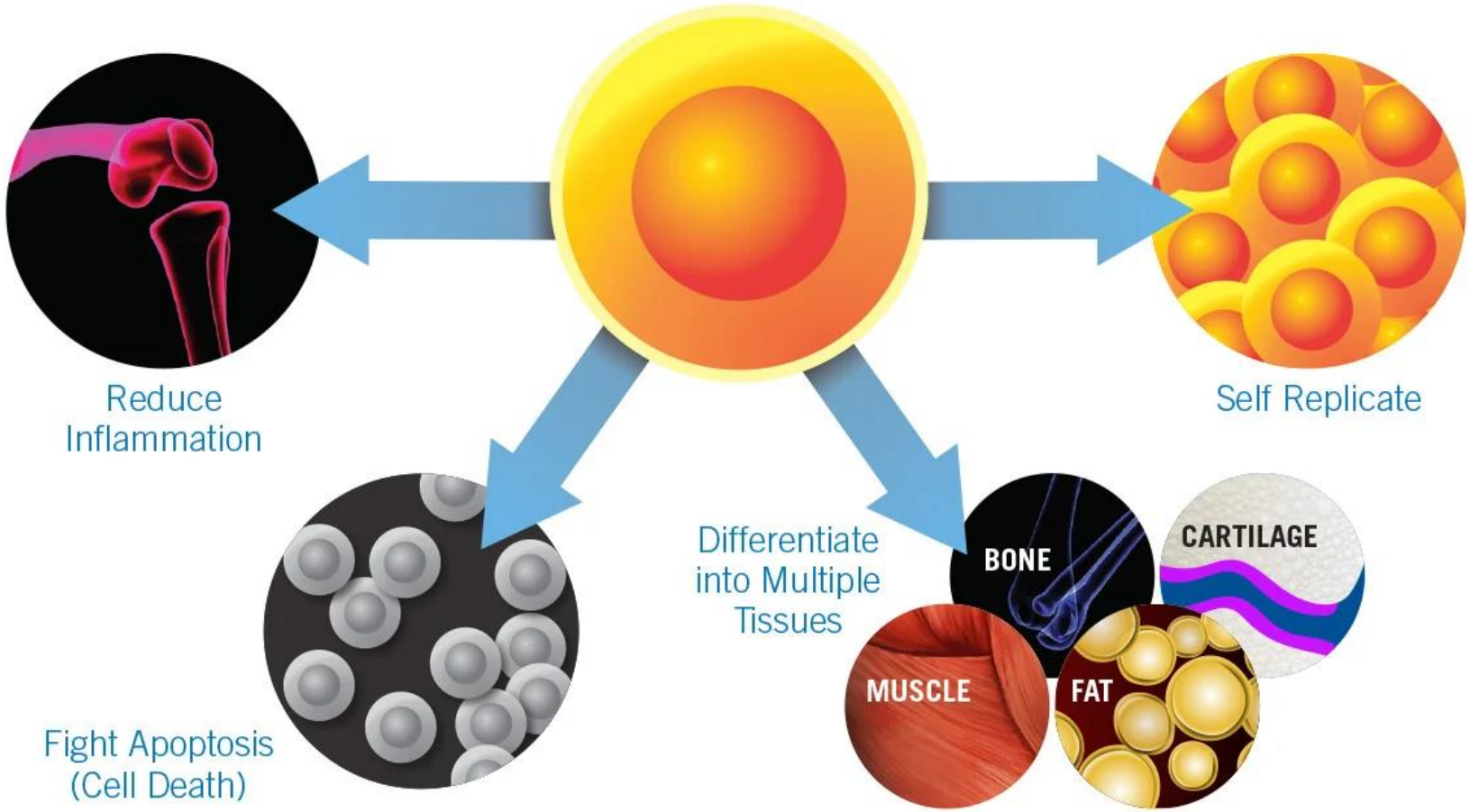
https://link.springer.com/article/10.1007/s00198-022-06383-1#change-history

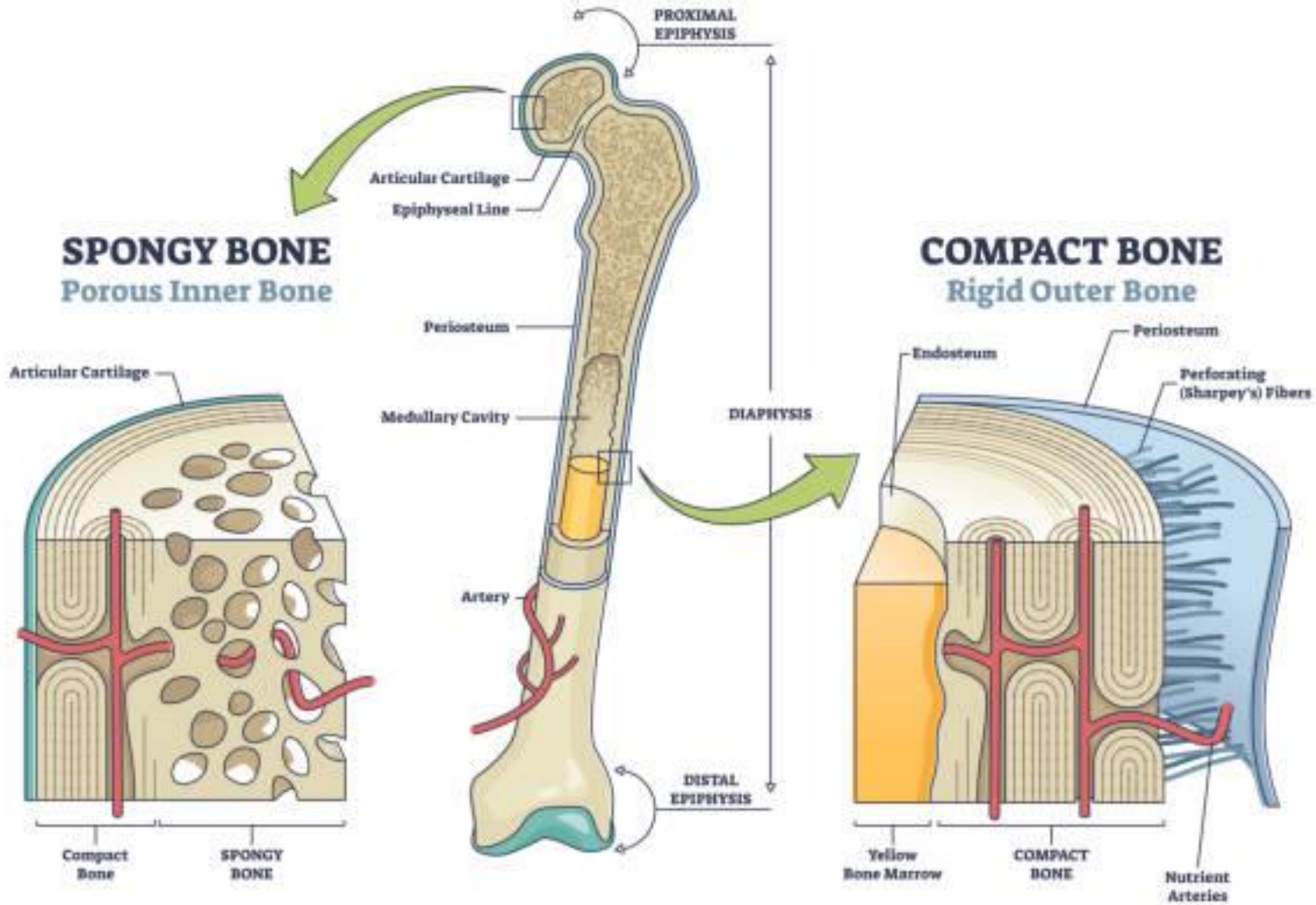
C-Telopeptide cross-links are peptide fragments from type I collagen that are released into the bloodstream during bone resorption. They are used as a sensitive marker to measure the rate of bone breakdown in conditions like osteoporosis and osteoarthritis. The concentration of C-telopeptide (CTX) can be measured in serum or urine to monitor therapies that affect bone metabolism.

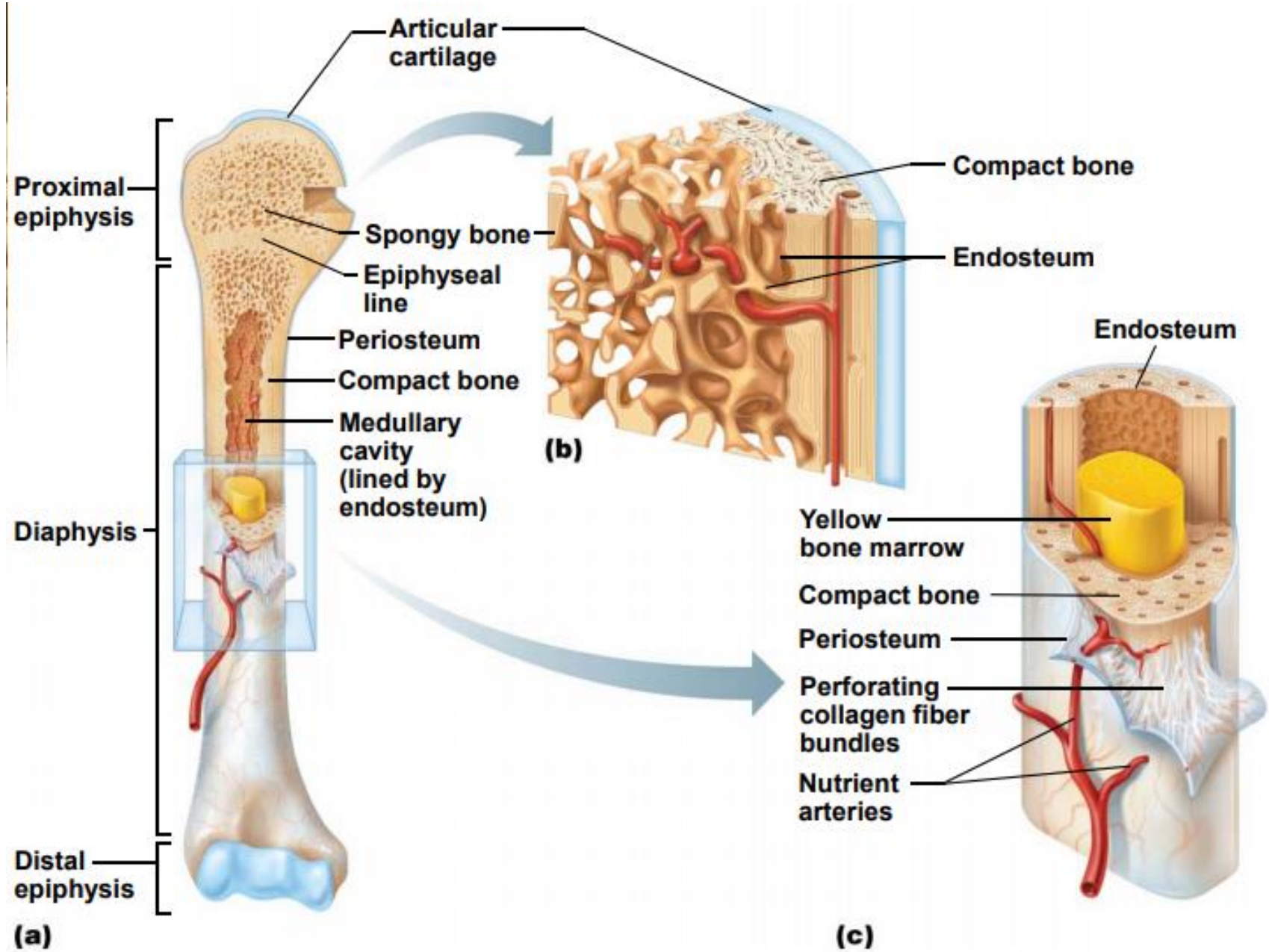
https://www.google.com/search?q=C-Telopeptide+Cross-links)&rlz=1C5CHFA_enUS1118US1118&oq=C-Telopeptide+Cross-links)&gs_lcrp=EgZjaHJvbWUyBggAEEUYOTIICAEQABgWGB4yCAgCEAAYFhgeMggIAxAAGBYYHjIICAQQABgWGB4yCggFEAAYChgWGB4yDQgGEAAYhgMYgAQYigUyDQgHEAAYhgMYgAQYigUyDQgIEAAYhgMYgAQYigUyDQgJEAAYhgMYgAQYigXSAQcyMDFqMGo3qAIIsAIB8QVjxLqBiAJD6_EFY8S6gYgCQ-s&sourceid=chrome&ie=UTF-8

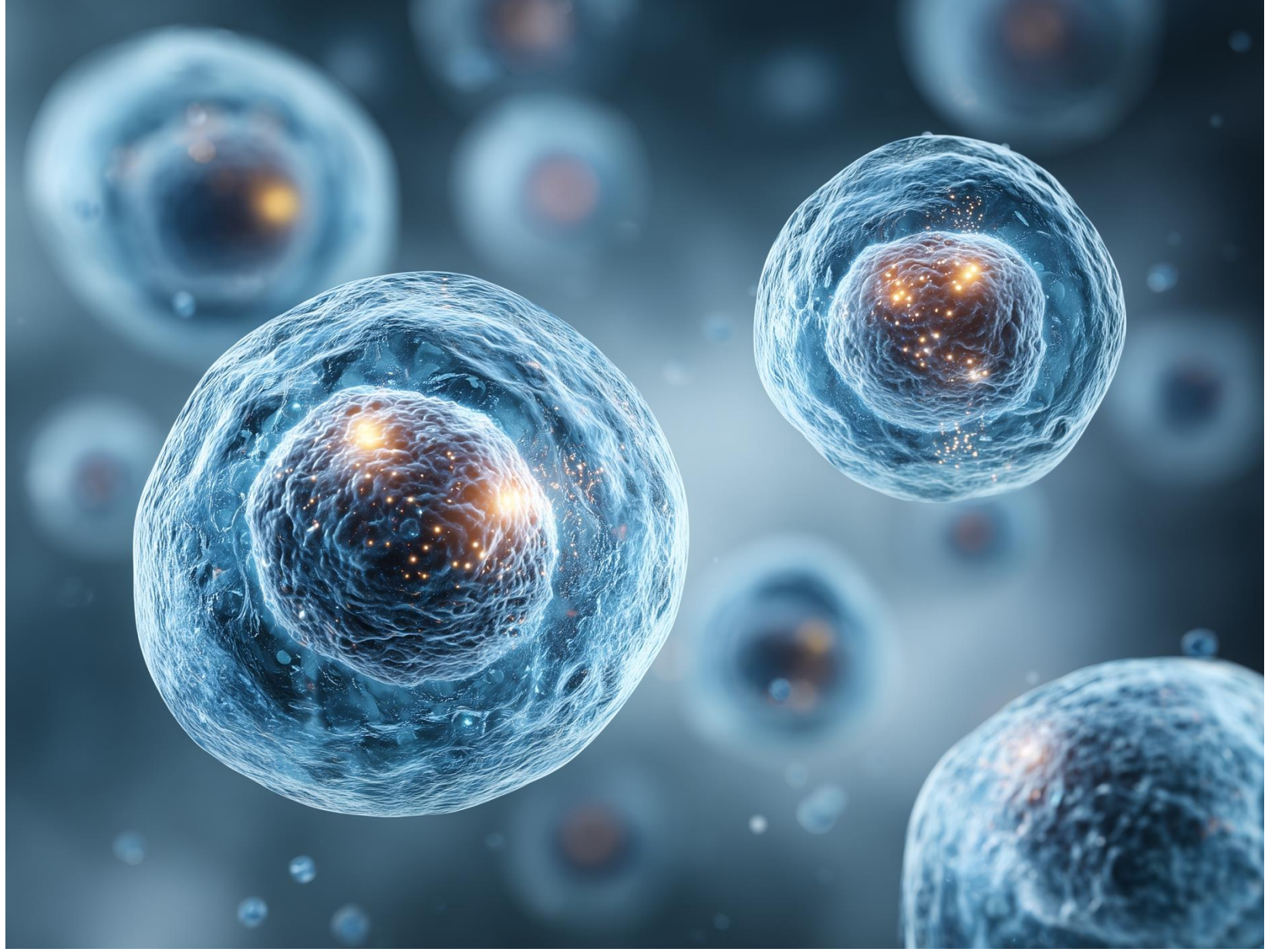
WHAT IS A STEM CELL?

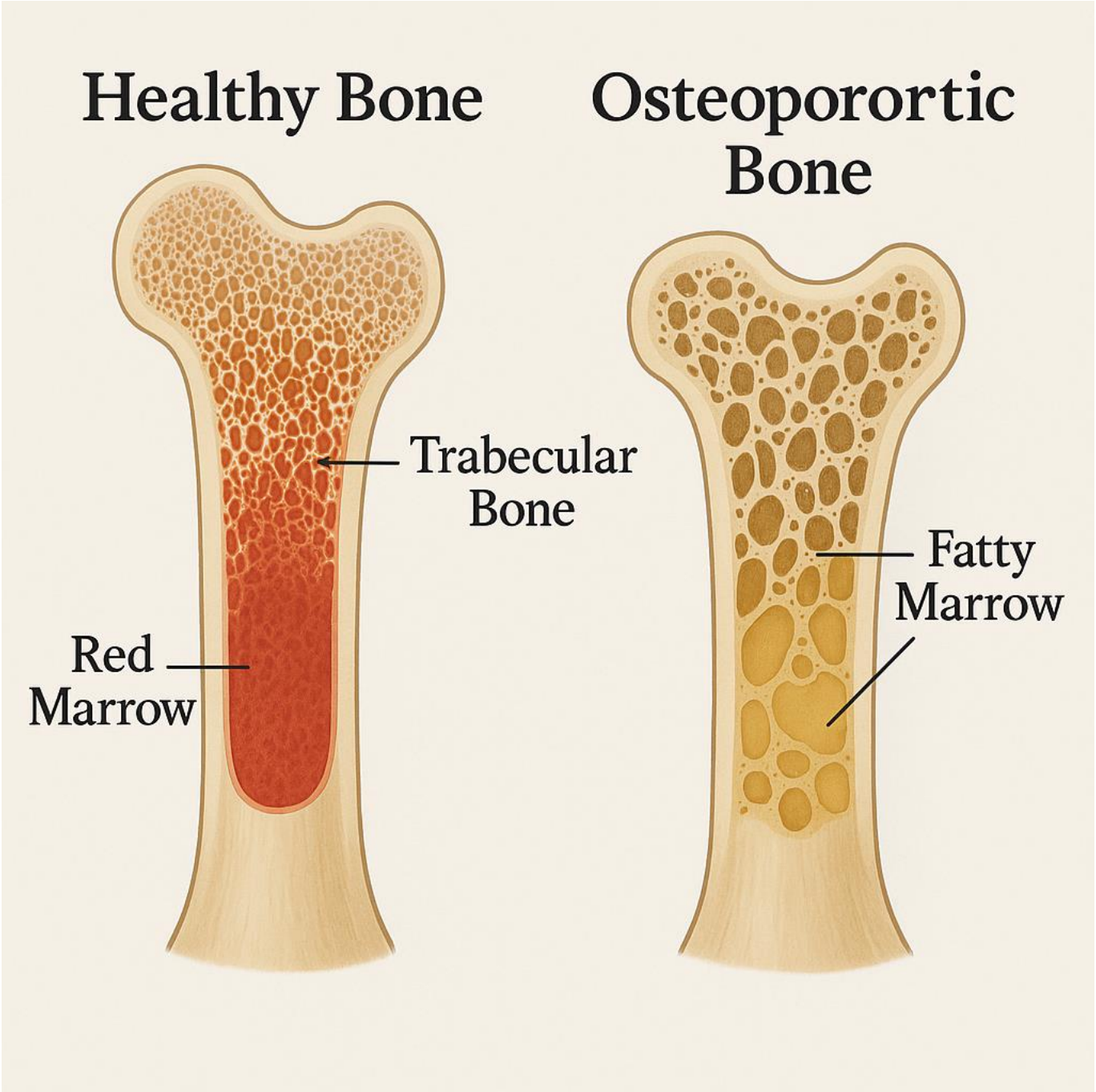
A mesenchymal stem cell is a primitive cell with the ability to:

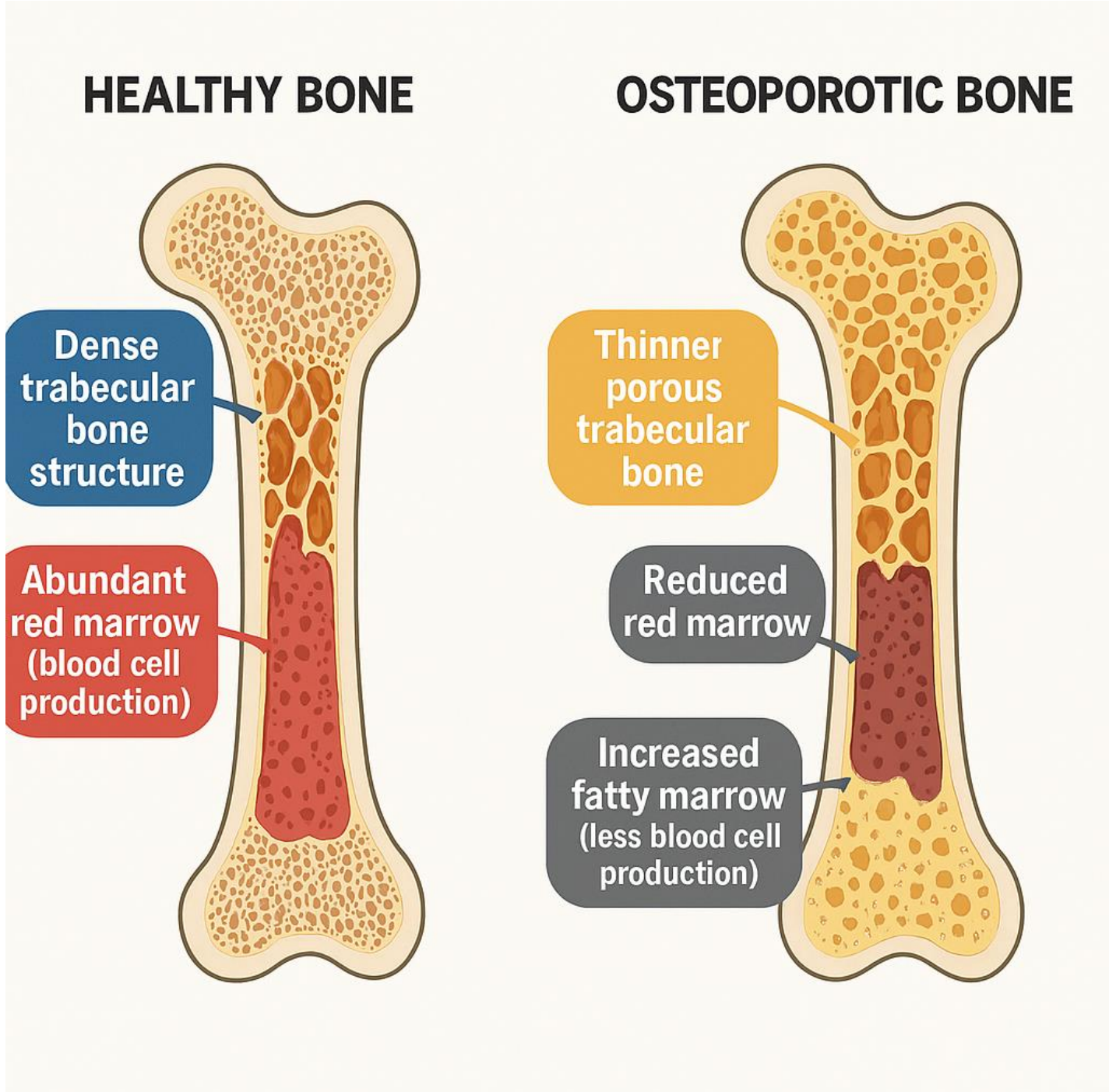


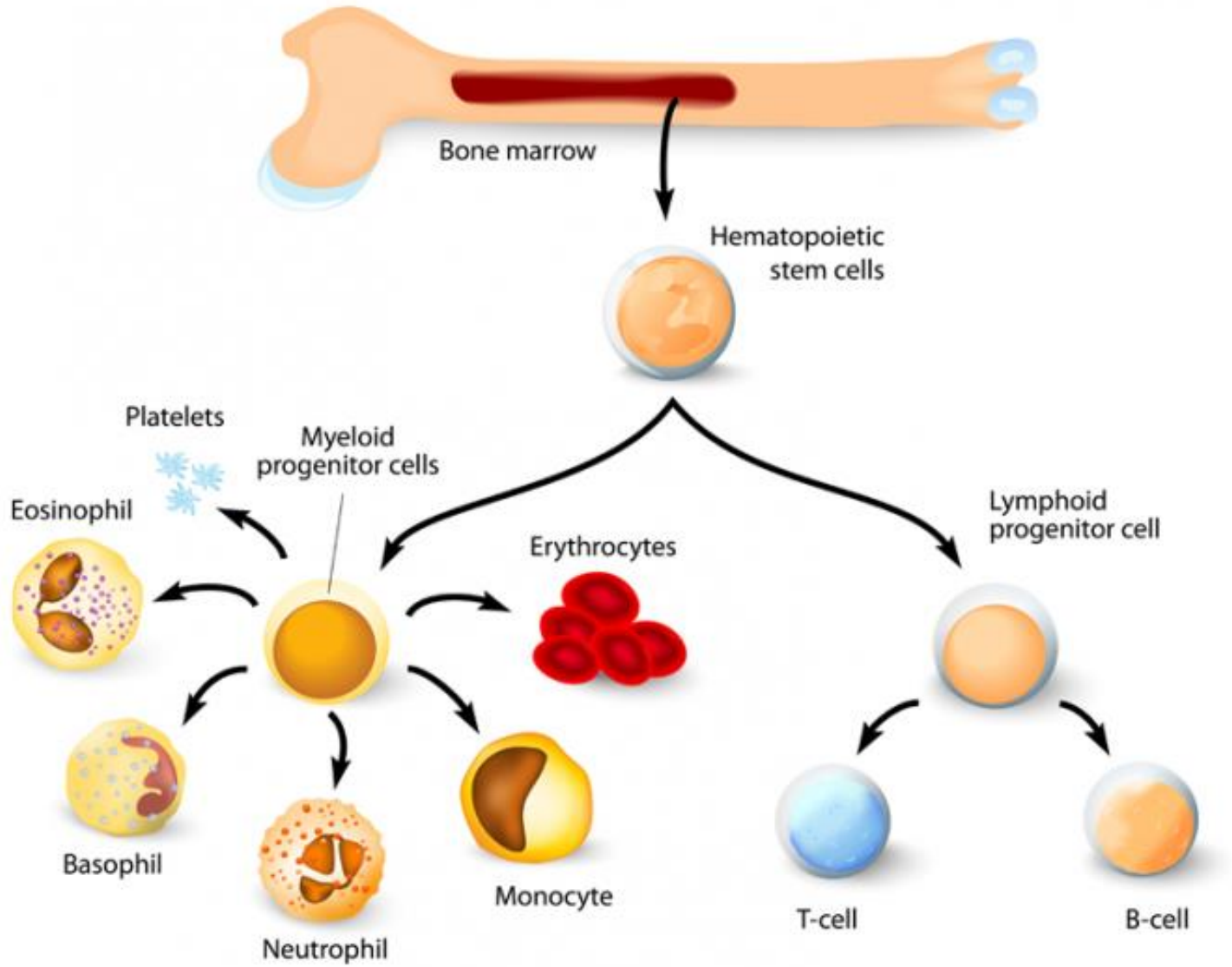

PROXIMAL EPIPHYSIS
Articular Cartilage
Epiphyseal Line
SPONGY BONE
Porous Inner Bone
Periosteum
Articular Cartilage
Medullary Cavity
DIAPHYSIS
Artery
DISTAL EPIPHYSIS
Compact Bone
SPONGY BONE
COMPACT BONE
Rigid Outer Bone
Periosteum
Endosteum
Perforating (Sharpey's) Fibers
Yellow Bone Marrow
COMPACT BONE
Nutrient Arteries


Articular cartilage
Proximal epiphysis
Spongy bone
Epiphyseal line
Periosteum
Compact bone
Medullary cavity (lined by endosteum)
Diaphysis
Distal epiphysis
(a)
Compact bone
Endosteum
(b)
Endosteum
Yellow bone marrow
Compact bone
Periosteum
Perforating collagen fiber bundles
Nutrient arteries
(c)




Healthy Bone
Osteoporortic Bone
Trabecular Bone
Red Marrow
Fatty Marrow


HEALTHY BONE
Dense trabecular bone structure
Abundant red marrow (blood cell production)
OSTEOPOROTIC BONE
Thinner porous trabecular bone
Reduced red marrow
Increased fatty marrow (less blood cell production)



https://microbenotes.com/bone-marrow-types-structure-and-functions/

🧬 **In adults:**

- **Red bone marrow** makes **almost all** of the stem cells — around **90–100%** of all new blood stem cells.
- **Yellow bone marrow** makes **very few** stem cells — it's mostly **fat** and is **not active** in producing new blood cells under normal conditions.