Bone Development and Peak Bone Mass

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Introduction

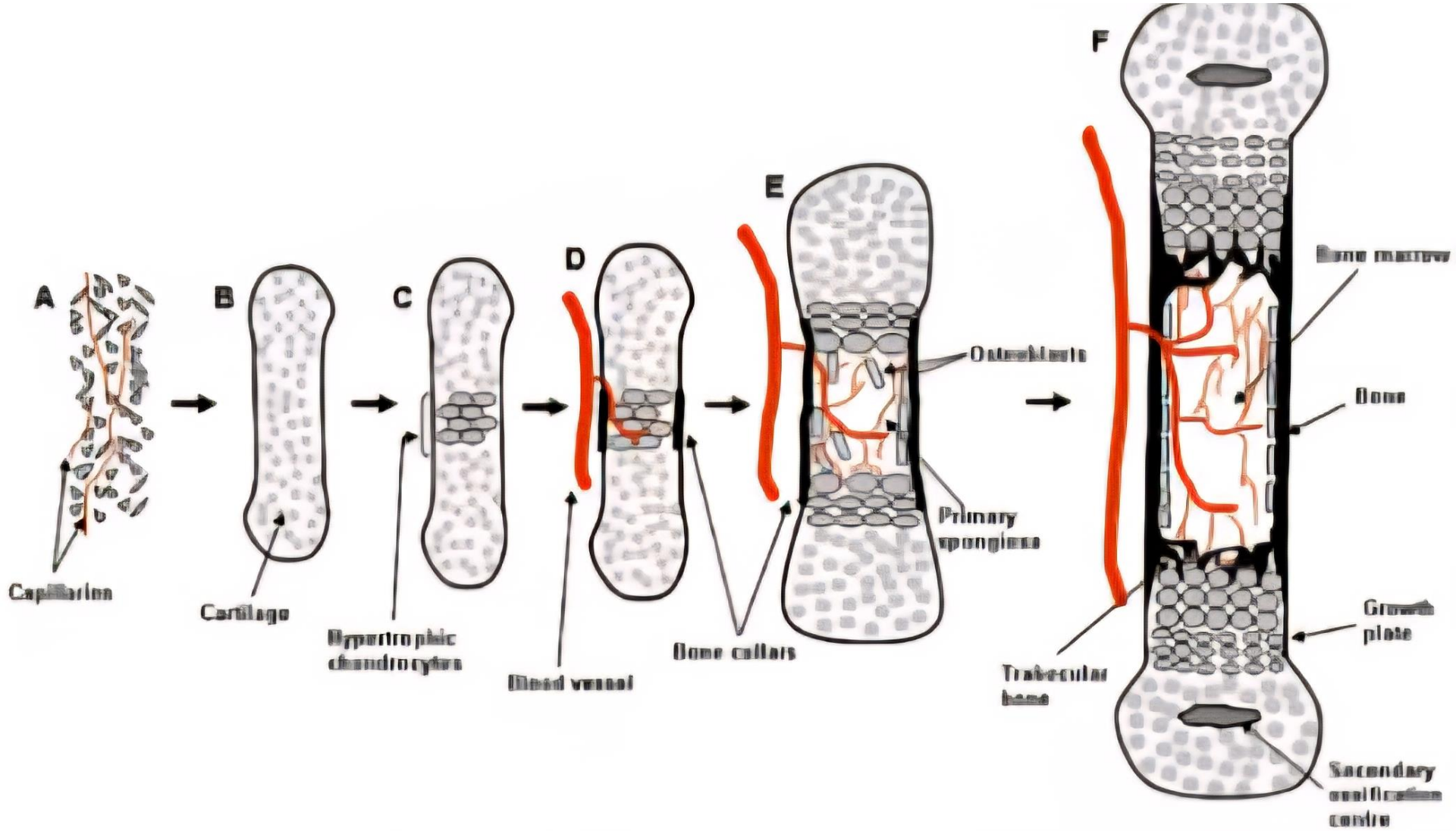
- Bone is a dynamic tissue undergoing continuous modeling and remodeling.
- Peak Bone Mass (PBM) defines the maximum bone strength achieved during life.
- PBM largely determines the lifetime risk of osteoporosis.

Bone as a Dynamic Tissue

- Two key processes: Bone Modeling (growth) and Remodeling (turnover).
- Balanced osteoblast and osteoclast activity is essential for skeletal integrity.

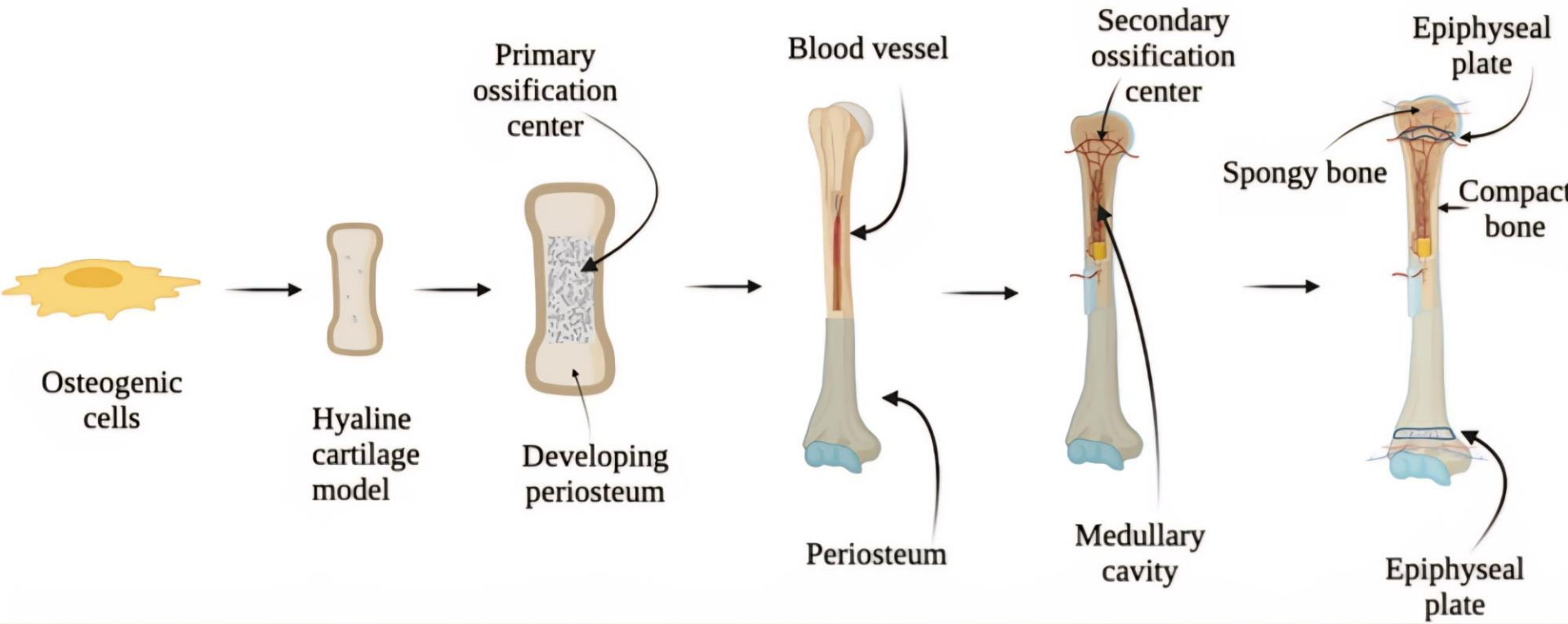
Stages of Bone Development

1. Fetal: Intramembranous and endochondral ossification.
2. Childhood: GH and thyroid hormone-driven linear growth.
3. Puberty: Sex steroids drive bone mass accrual.
4. Early adulthood: PBM attainment.

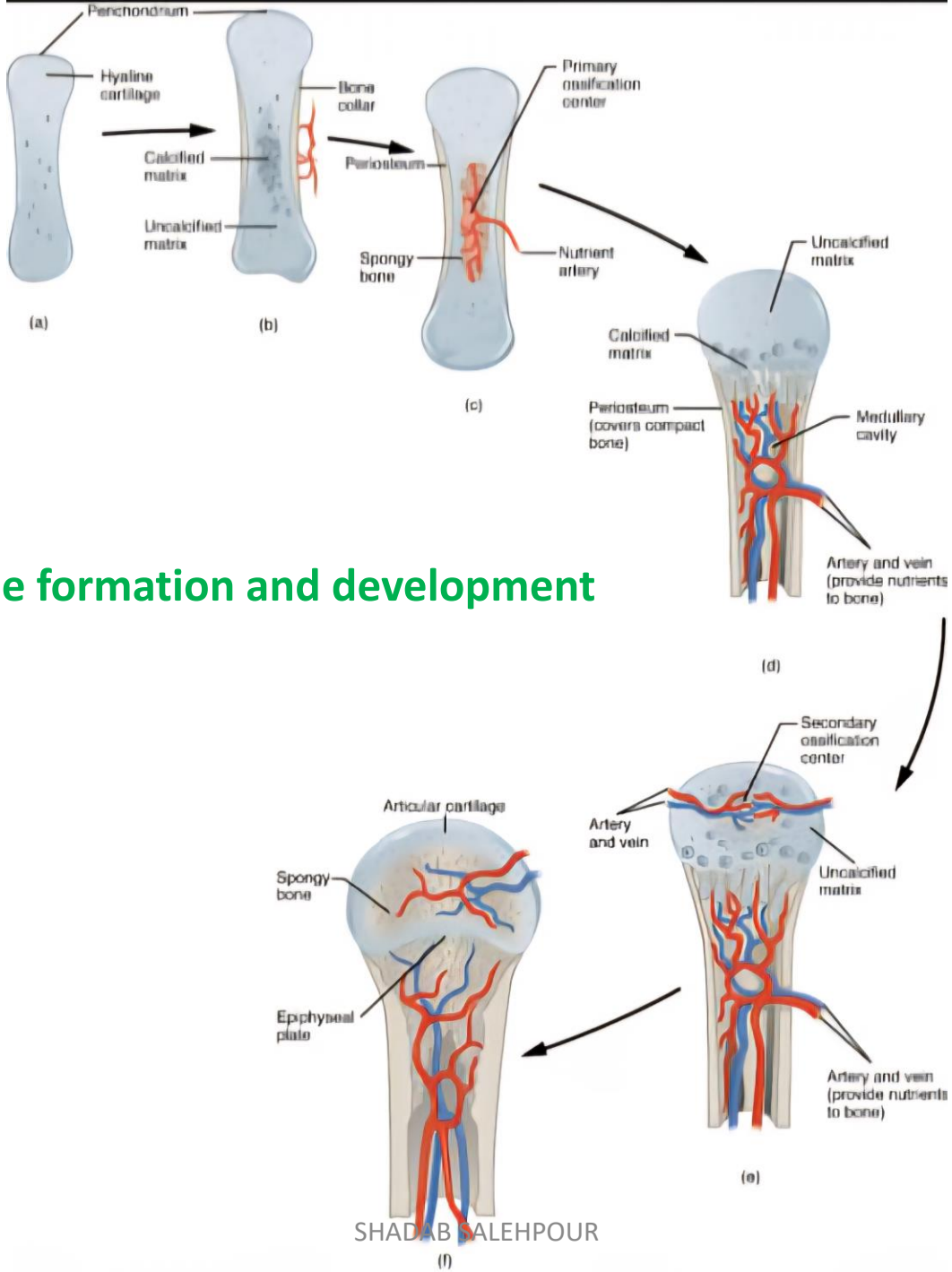


A schematic diagram of endochondral bone formation

The major stages of bone development



Bone formation and development



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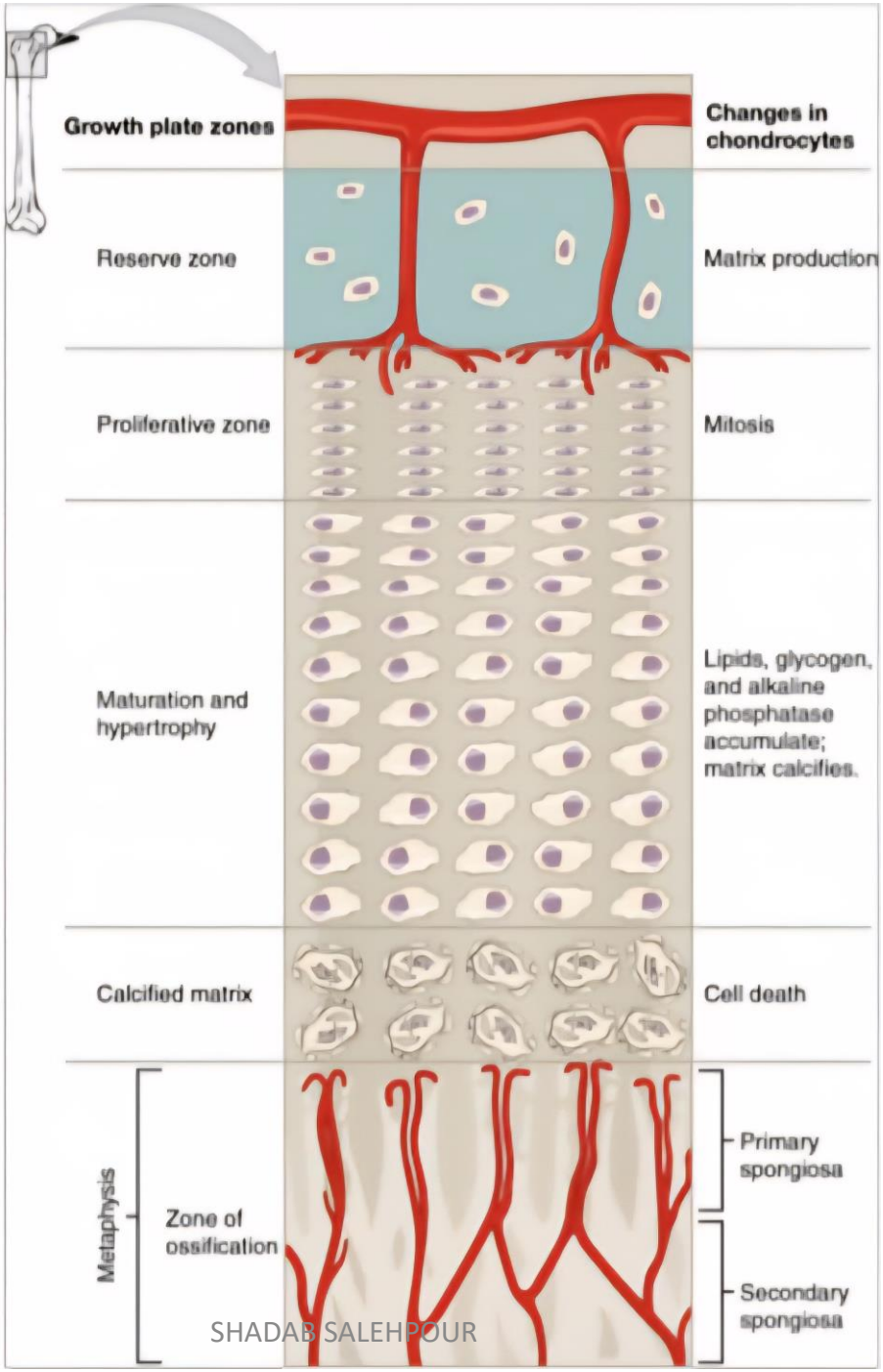
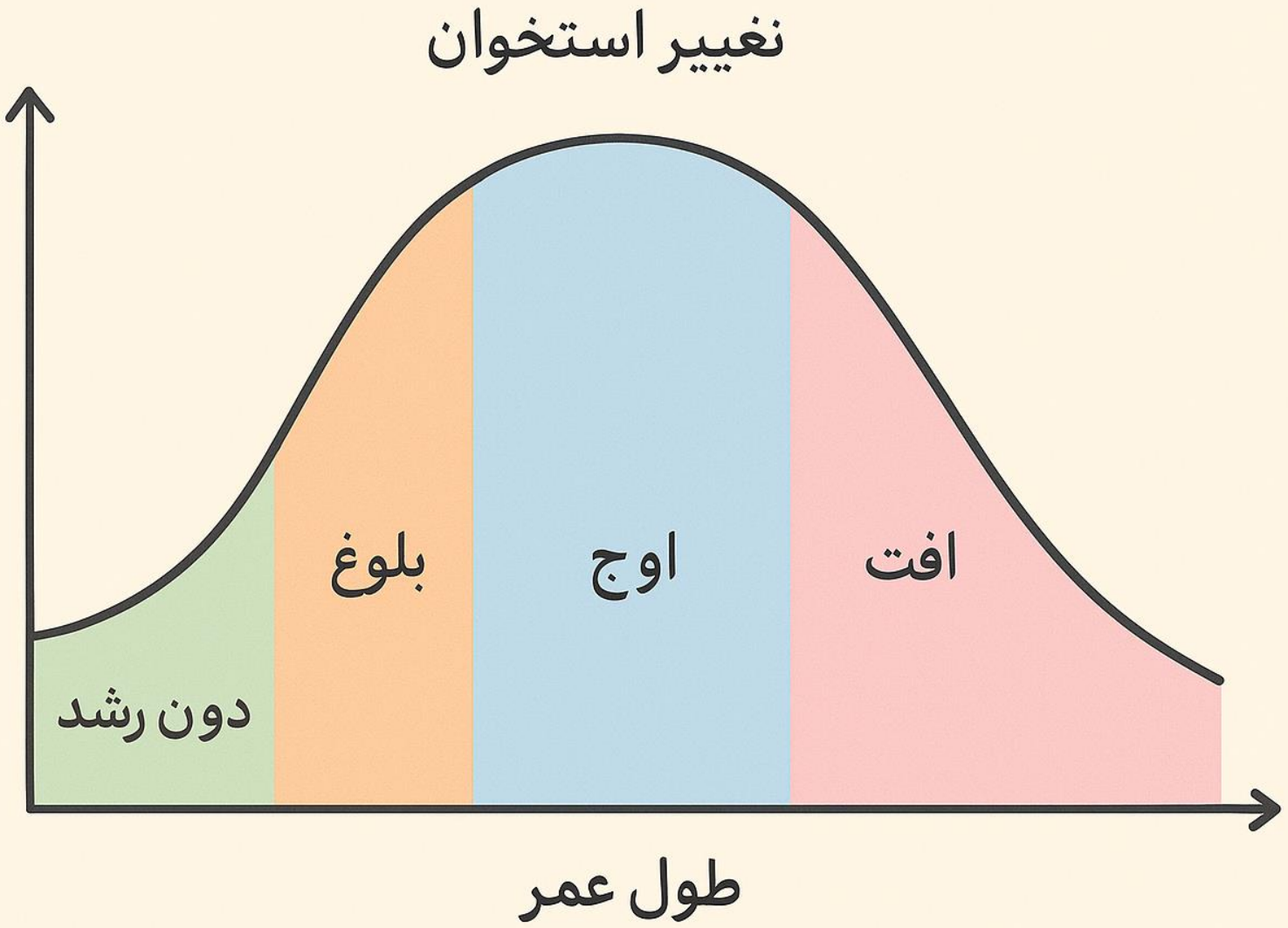


Peak Bone Mass: Definition and Importance

- PBM is achieved between 18–25 years in females, 20–30 in males.
- 60–80% of adult bone density is genetically determined.
- Higher PBM lowers lifetime fracture risk.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Genetic Factors

- Genes in Wnt/β-catenin, RANK/RANKL/OPG, and estrogen receptor pathways.
- Variants in LRP5, RUNX2, and ESR1 affect bone formation and turnover.

Hormonal Regulation

- GH/IGF-1 axis promotes osteoblast differentiation.
- Estrogen suppresses bone resorption in both sexes.
- Thyroid hormones and glucocorticoids: dual role depending on concentration.
- Vitamin D and PTH maintain calcium-phosphate balance.

Nutritional and Lifestyle Factors

- Adequate calcium, vitamin D, and protein intake are essential.
- Physical activity (weight-bearing exercise) enhances PBM.
- Sedentary lifestyle and excessive phosphate intake are detrimental.

Disease and Drug Effects

- Chronic diseases (JIA, IBD) and endocrine disorders reduce PBM.
- Long-term glucocorticoid or anticonvulsant therapy weakens bone.
- Delayed puberty and malnutrition are critical risk factors.

Clinical Assessment

- DXA: adjusted for age, sex, and body size.
- Bone turnover markers: ALP, P1NP, CTX.
- Assess hormonal and nutritional status.

Optimizing PBM in Children

- Early treatment of chronic diseases.
- Ensure adequate calcium/vitamin D intake.
- Encourage physical activity.
- Avoid unnecessary corticosteroid exposure.

Clinical Take-Home Messages

- PBM is a major determinant of lifelong bone health.
- Puberty offers a critical window for bone mass accumulation.
- Genetic, hormonal, and environmental factors interact closely.
- Pediatric endocrinologists and rheumatologists play a key preventive role.

References

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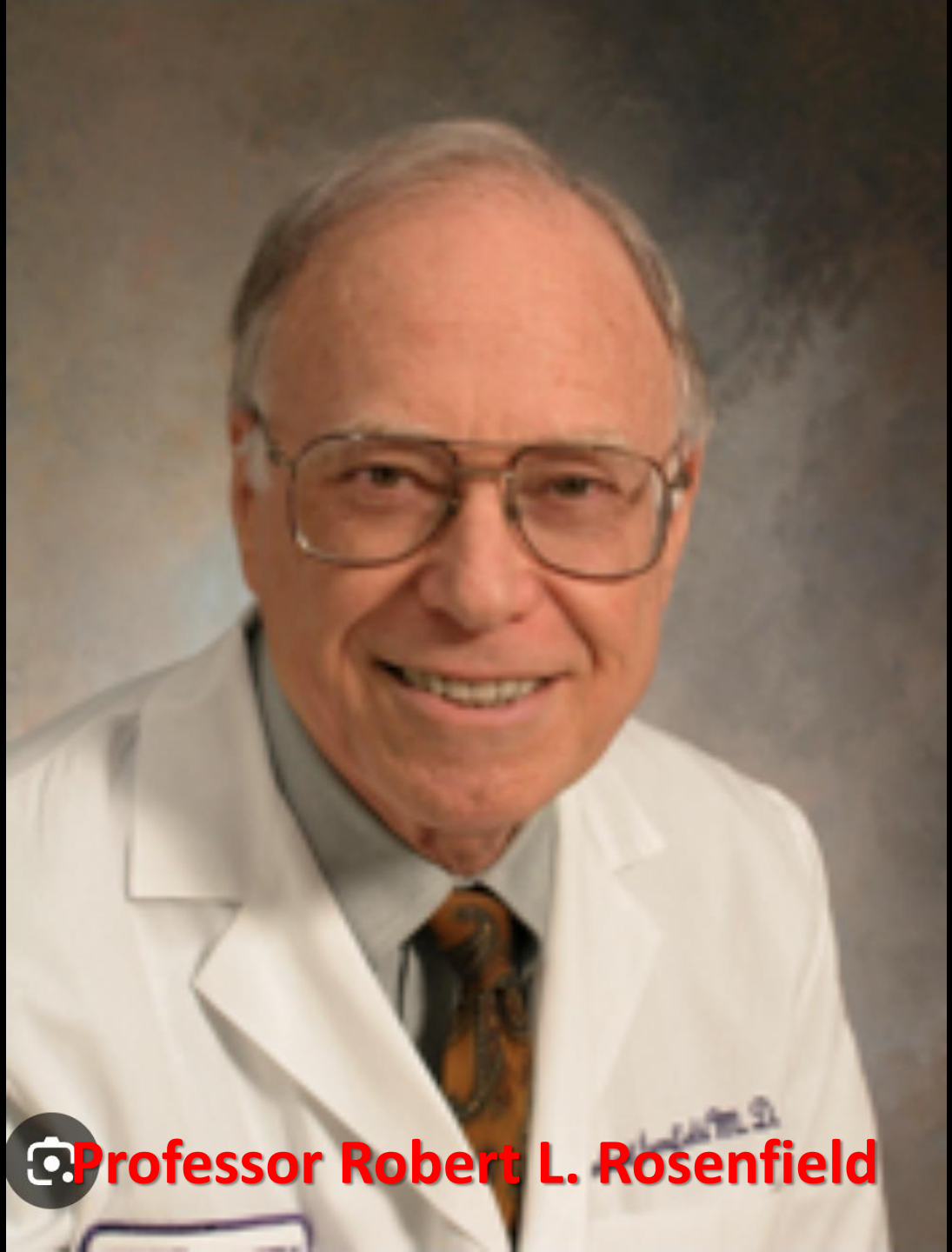
Professor Maryam Razzaghi Azar



Professor Robert L. Rosenfield