



Structure of different types of cartilage

Classification of cartilage

Endochondral ossification types (appositional growth, interstitial growth)

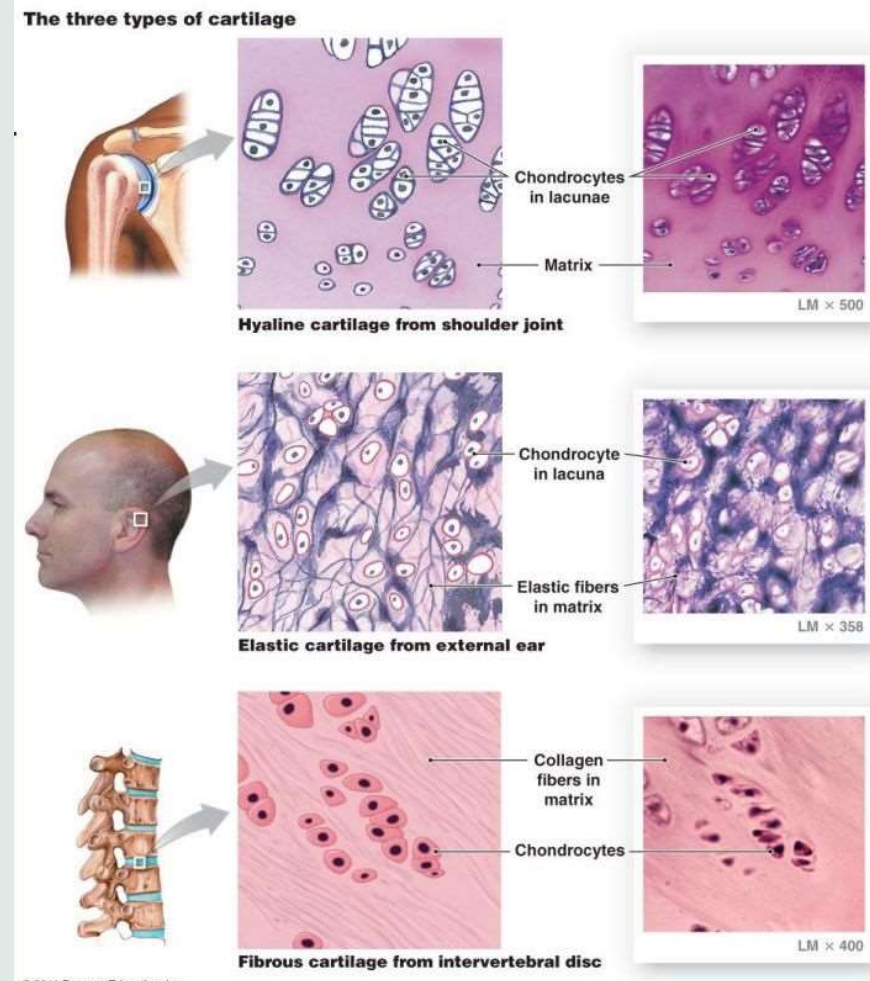
Intramembranous ossification

# What is cartilage?

- Specialised form on connective tissue that is made up of cell and extracellular matrix
  - has chondrocytes embedded within it – in a space called lacunae
- Make up of types 2,6,9,11 of collagen
- Its is weight bearing

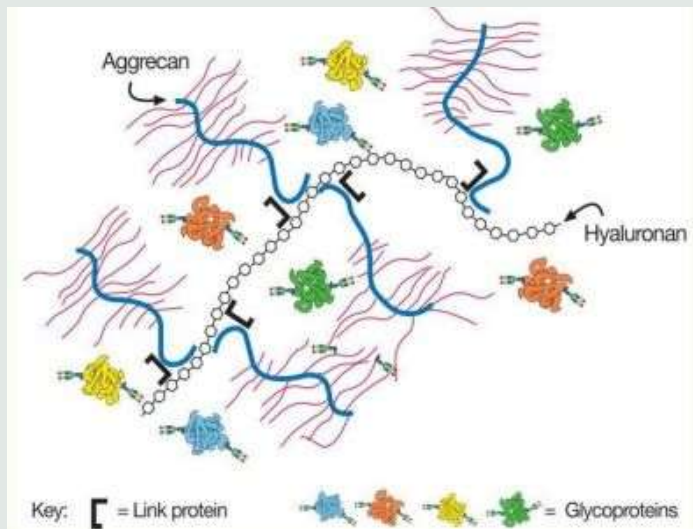
# What are the different types?

- Hyaline cartilage
  - Present in synovial joints to make articular cartilage
  - Function
    - Distribute load
    - Allow movement
- Elastic cartilage
  - Present in the larynx, epiglottis and etc
- Fibrocartilage
  - Found in secondary cartilaginous joints e.g pubic symphysis
  - And in intervertebral disc, meniscus etc

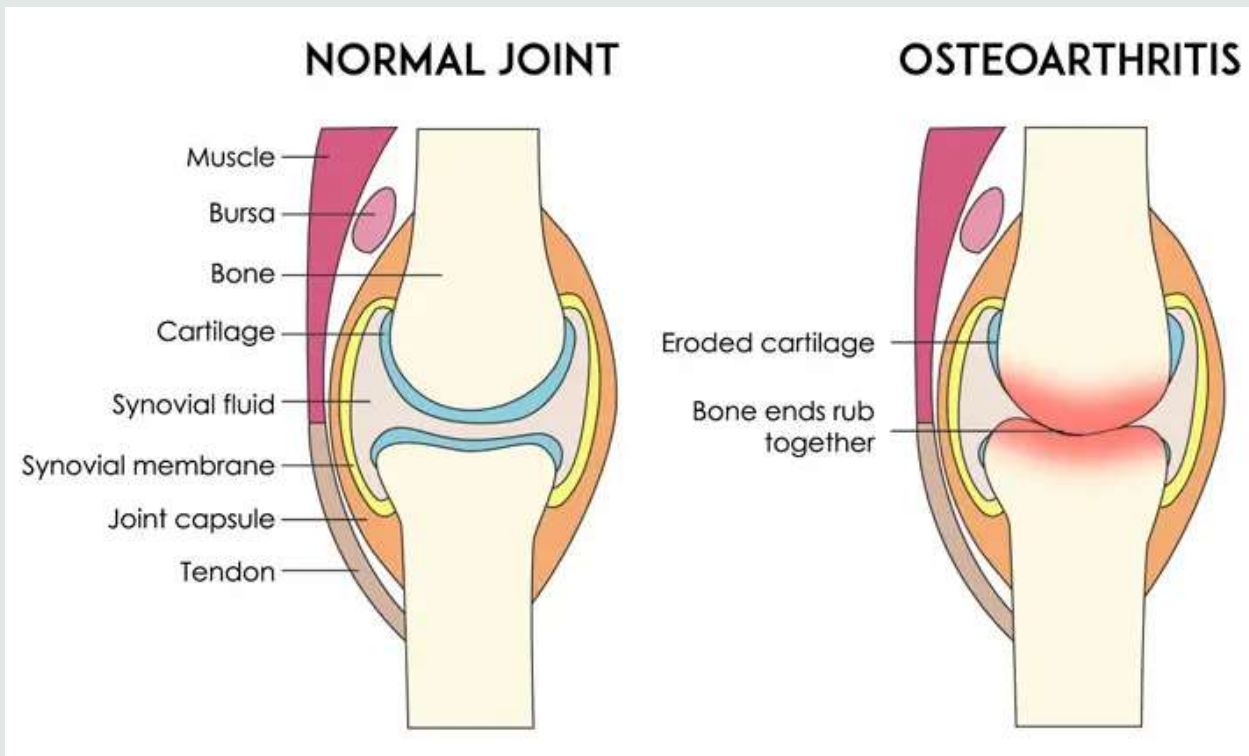


# Composition of cartilage

- Contains:
- Collagen for strength
- Elastic for flexibility
- Proteoglycan for large osmotic effect
  - Provides a large osmotic effect because it has loads of negatively charged sugar chains which pull more cations (positive charge) like  $\text{Na}^+$  and  $\text{Ca}^{2+}$ . And where sodium goes water follows.

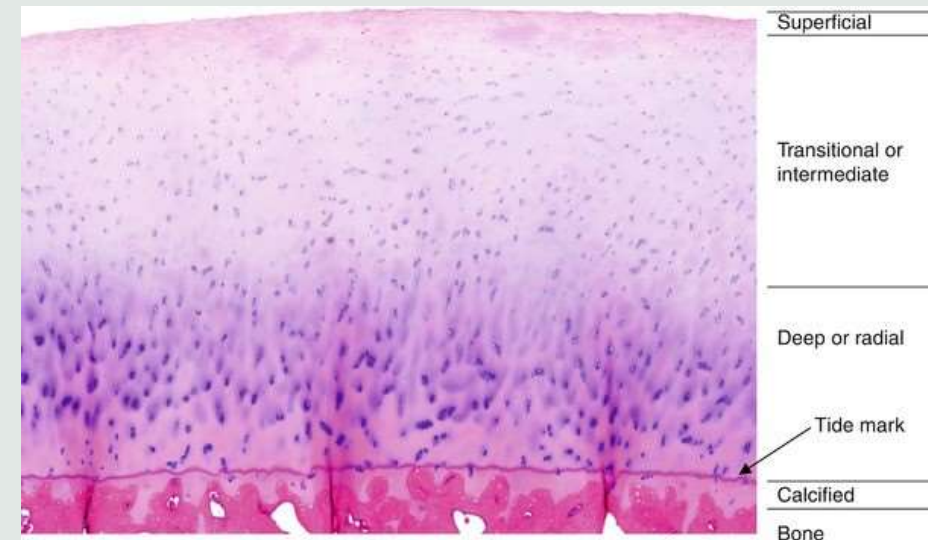
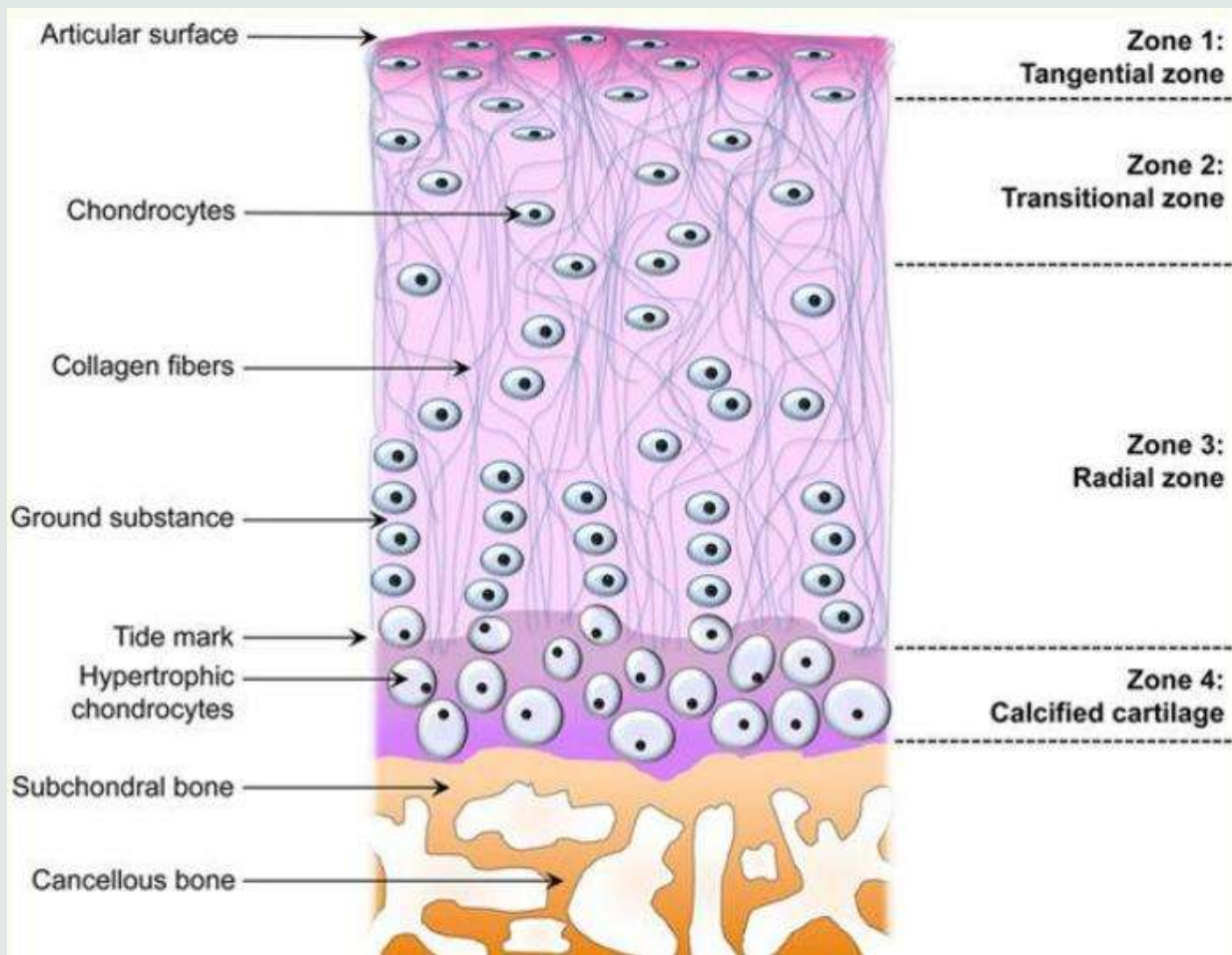


# Articular cartilage



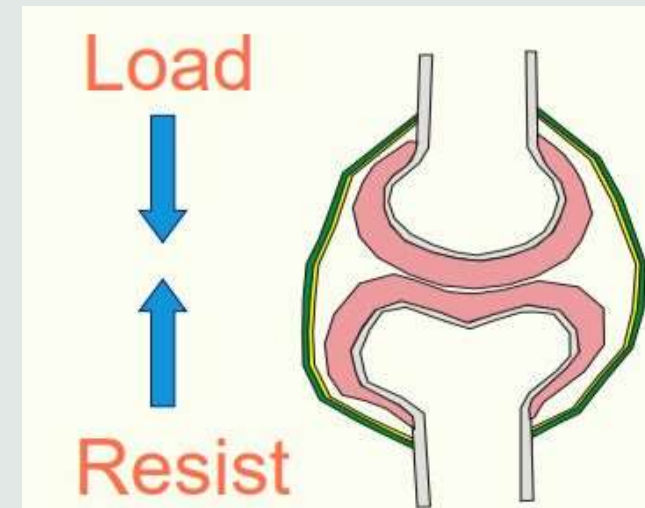


# Histology of articular cartilage



# Properties of articular cartilage

- The articular cartilage is made up of hyaline cartilage
- Like we said this are a high osmotic effect
- Meaning it brings in more water -> Swelling of the cartilage
- This swelling is counteracted by resistance of the intact collagen fibers
- This provides joints to resist compressive forces while maintaining high tensile strength



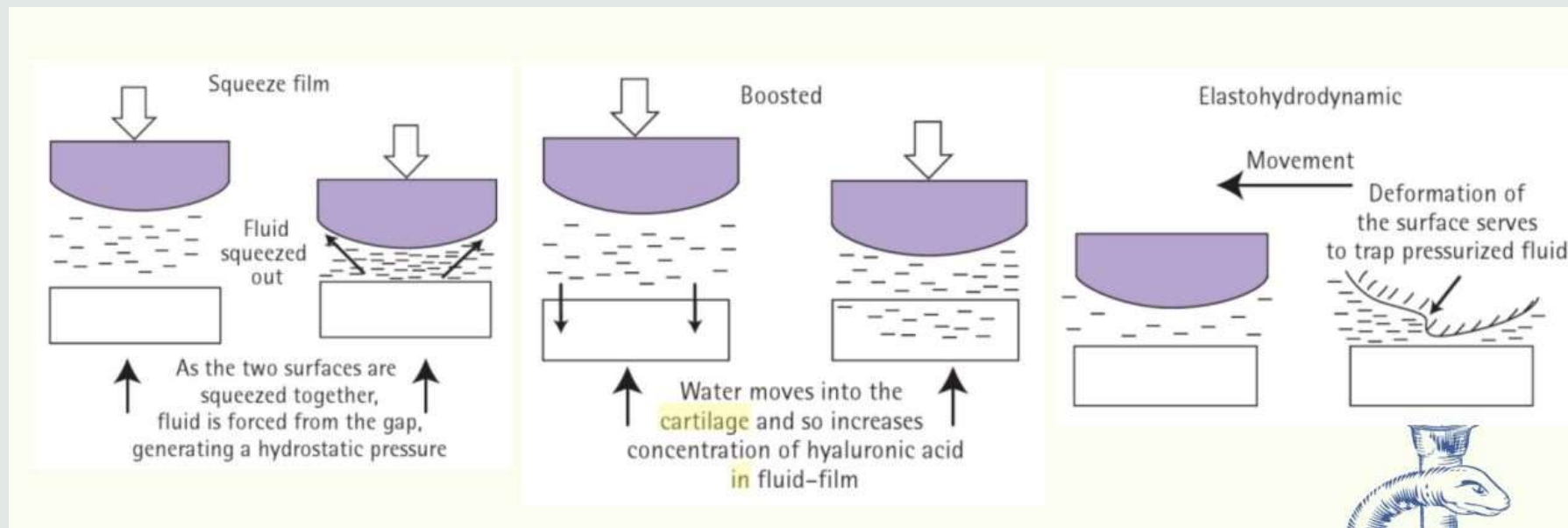
# What is synovial fluid

- Fluid between the bones – in simple terms
- Function – lubrication to reduce friction
- 3 component – lubricin, phospholipids, hyaluronan
  - Hyaluronan – non-sulfated GAG composed of the repeating sugars glucuronic acid and N-acetylglucosamine.
  - Phospholipids - Provide hydrophobicity to the articular surface and shield asperities from solid–solid contact.
  - Lubricin - proteoglycan encoded by the gene prg4 secreted by both articular cartilage and synovium



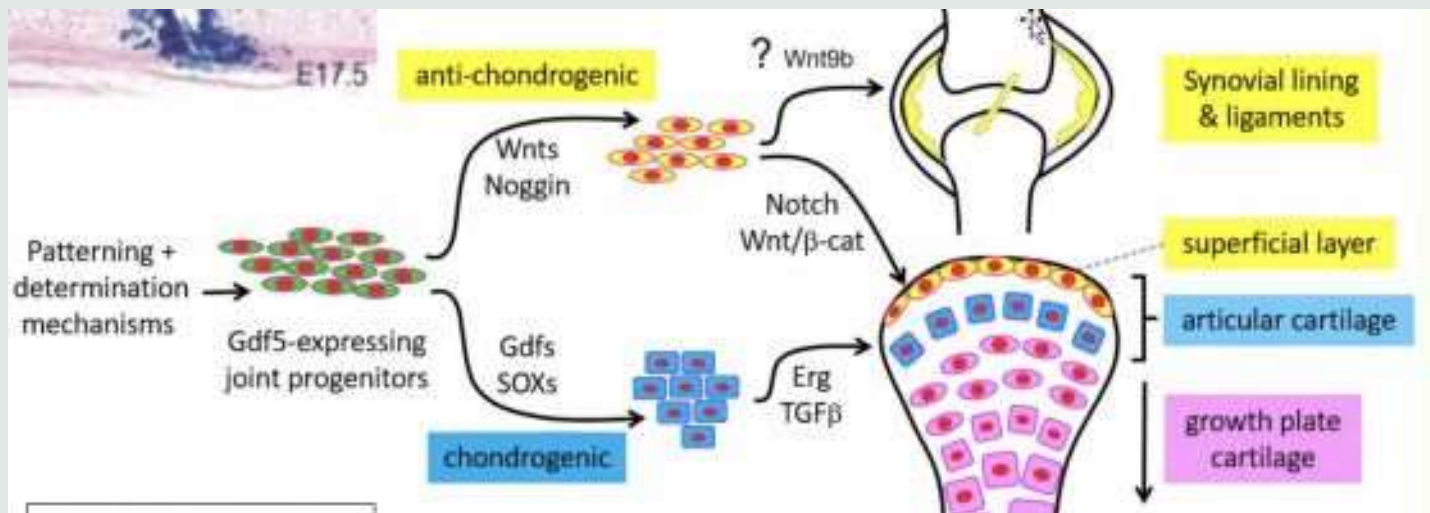
# 3 models of articular cartilage

- Squeeze film – when 2 surfaces squeeze together, fluid is forced from the gaps to generate hydrostatic pressure
- Boosted – water moves within the cartilage so increase the conc of hyaluronic acid in the fluid film
- Electrohydrodynamic – the surface is deformed to trap the pressurised fluid



# How is synovial cartilage formed

- Patterning and determination mechanism cause GDF5-expressive joint progenitors to form Wnt Noggin and GDFs SOXs
- Wnt noggin is ant chondrogenic – so from the synovial components
- GDF SOXs is chondrogenic – so forms the cartilage i.e growth plate and articular cartilage



# 2 types of ossification

- Endochondral
  - Bone replaces existing cartilage model
- Intramembranous
  - Bone develops directly from mesenchyme or fibrous connective tissue
  - Only flat bone e.g skull, clavicle, and most of the cranial bones

## ENDOCHONDRAL OSSIFICATION VERSUS INTRAMEMBRANOUS OSSIFICATION

### ENDOCHONDRAL OSSIFICATION

A type of ossification taking place from centers arising in cartilage and involving deposition of lime salts in the cartilage matrix followed by secondary absorption and replacement by true bony tissue

A cartilage is formed first and the bone is laid down on it

Proceeds through an intermediate cartilage

Important in the formation of long bones

Takes a longer time to form a bone

Stops at year two

### INTRAMEMBRANOUS OSSIFICATION

Development of osseous tissue within the mesenchymal tissue without prior cartilage formation

Bone is directly formed on a mesenchyme

Does not form an intermediate cartilage

Important in the formation of flat bones

Takes less to form a bone

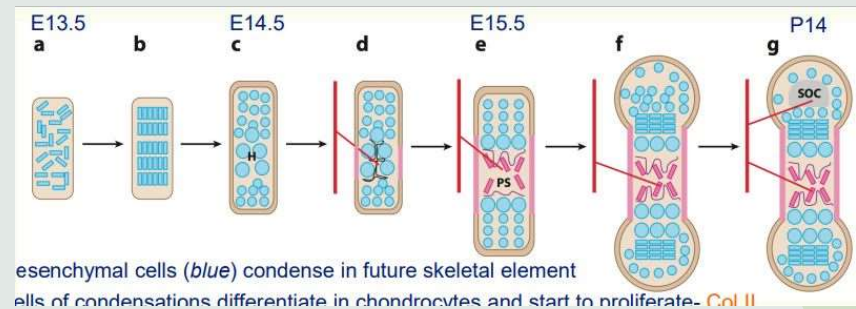
Stops at year 18 in females and 21 in males

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# Endochondral ossification

1. Mesenchymal cells condense to form chondrocytes and start to proliferate to form Collagens Type 1
2. Hypertrophic chondrocyte differentiation leads to formation of Collagen Type 10
3. The hypertrophic chondrocytes apoptosis favours matrix mineralisation and blood vessel invasion
4. Perichondral cells differentiate in osteoblasts forming the bone collar
5. Osteoblasts forms the primary spongiosa
6. Chondrocytes proliferate to lengthen the bones
7. The secondary ossification centres forms through vascular invasive

Hypertrophic chondrocytes secrete metalloproteinases -> which remodel the cartilage so the bone can invade



# There are 2 types of Endochondral ossification

- Appositional growth - When osteoblasts lay new bone tissue on the surface of old bone tissue.
- Interstitial growth - Where chondrocytes embedded in the cartilage continue to produce extracellular matrix. Increasing the length of cartilage

Interstitial vs Appositional Growth		
More Information Online: <a href="http://WWW.DIFFERENCEBETWEEN.COM">WWW.DIFFERENCEBETWEEN.COM</a>		
	Interstitial Growth	Appositional Growth
DEFINITION	Interstitial growth is the growth which increases the bone length	Appositional growth is the growth which increases the bone width
GROWTH FROM	Within	Outside
LOCATION	Within lacunae	On surface of pre-existing cartilage
INCREASE IN	Length	Width
SECRETING MATRIX	Chondrocytes within divide and secrete matrix	Chondroblasts in perichondrium secrete matrix
WHAT HAPPENS	Cartilage lengthens and is replaced by bone tissue	New bone tissue is deposited on the surface of pre-existing bone
RESULT	Longer bones	Thicker bones

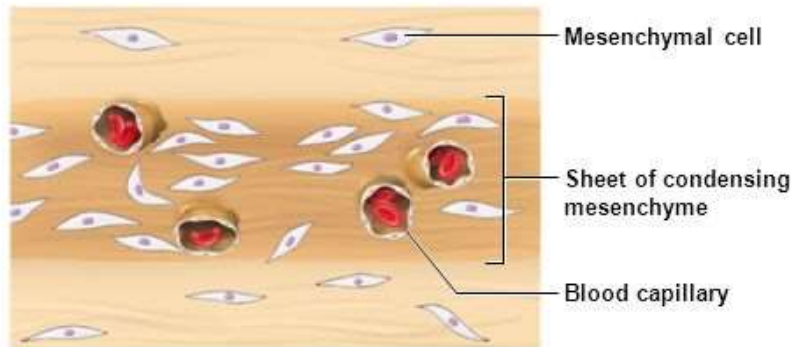
# Intramembranous ossification

1. Mesenchymal cells differentiate into osteoblasts and group into ossification centers
2. Osteoblasts become entrapped by the osteoid they secrete, transforming them to osteocytes
3. Trabecular bone and periosteum form
4. Compact bone forms superficially to the trabecular bone
5. Blood vessels form the red marrow

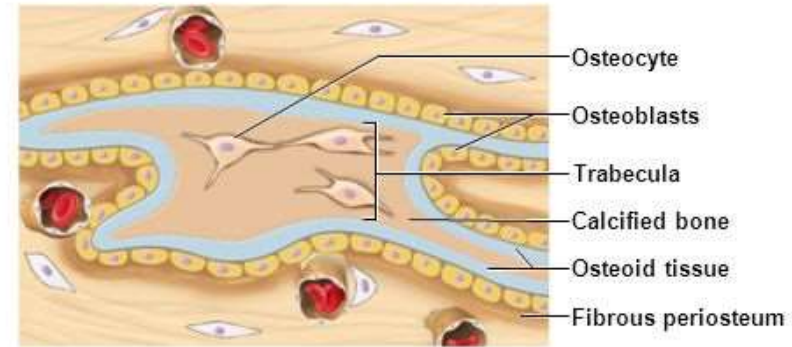


# Intramembranous Ossification

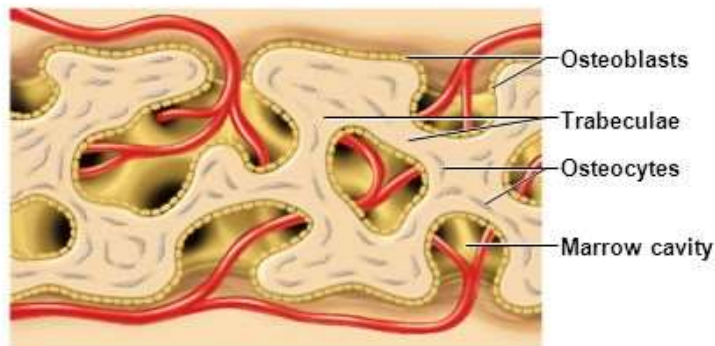
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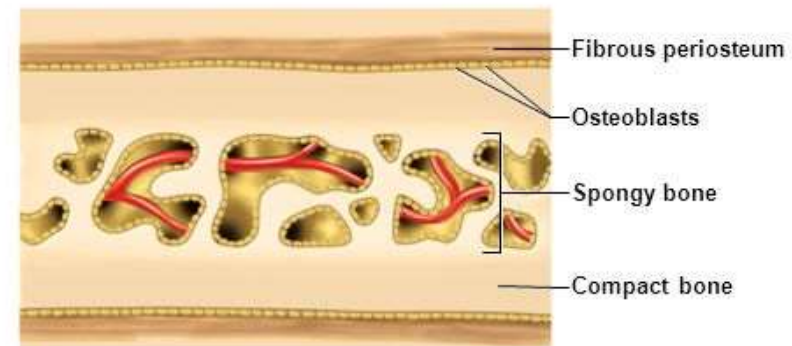
① Condensation of mesenchyme into soft sheet permeated with blood capillaries



② Deposition of osteoid tissue by osteoblasts on mesenchymal surface; entrapment of first osteocytes; formation of periosteum



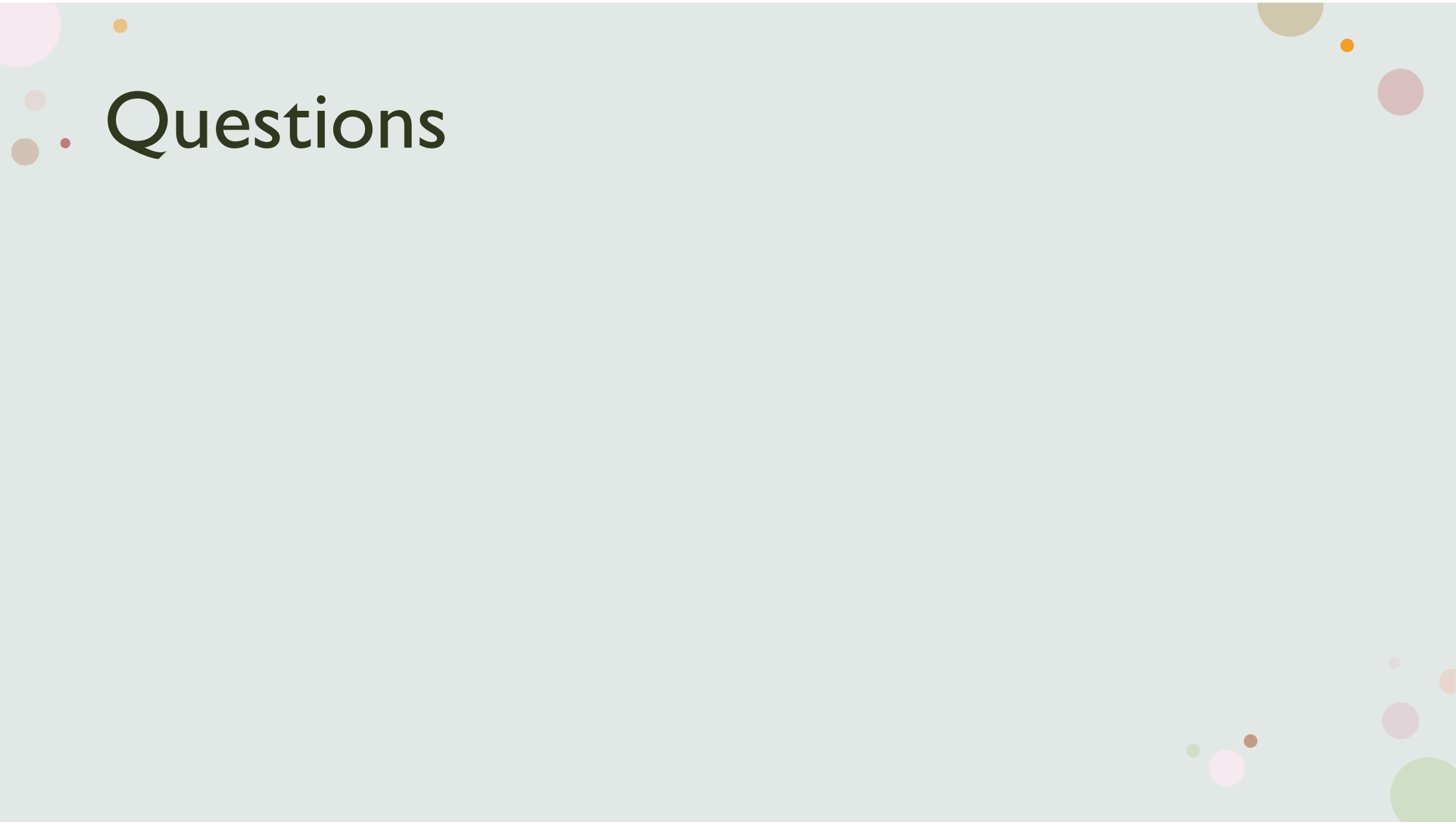
③ Honeycomb of bony trabeculae formed by continued mineral deposition; creation of spongy bone



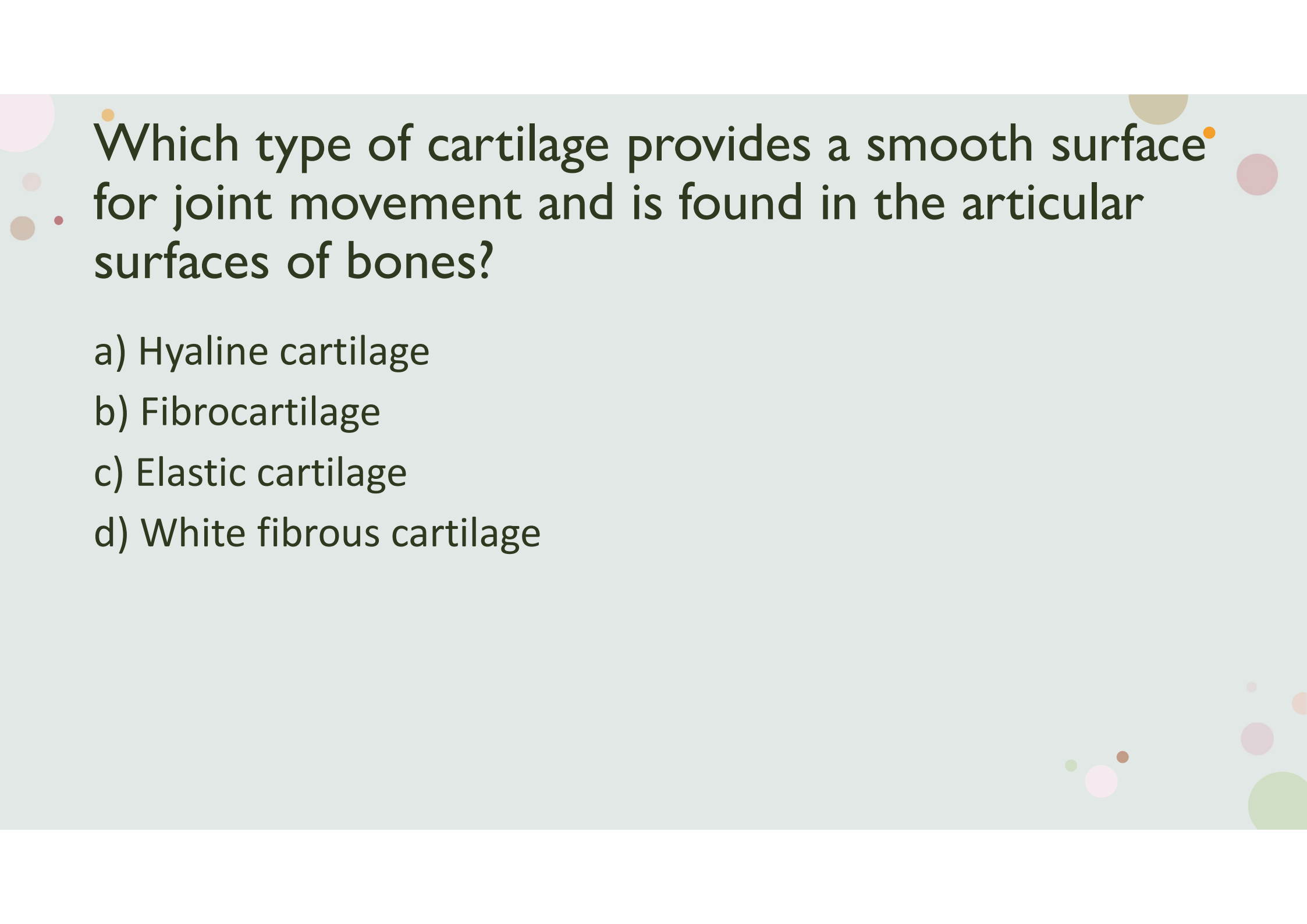
④ Surface bone filled in by bone deposition, converting spongy bone to compact bone. Persistence of spongy bone in the middle layer.

Figure 7.8

produces flat bones of skull and clavicle



# Questions



Which type of cartilage provides a smooth surface for joint movement and is found in the articular surfaces of bones?

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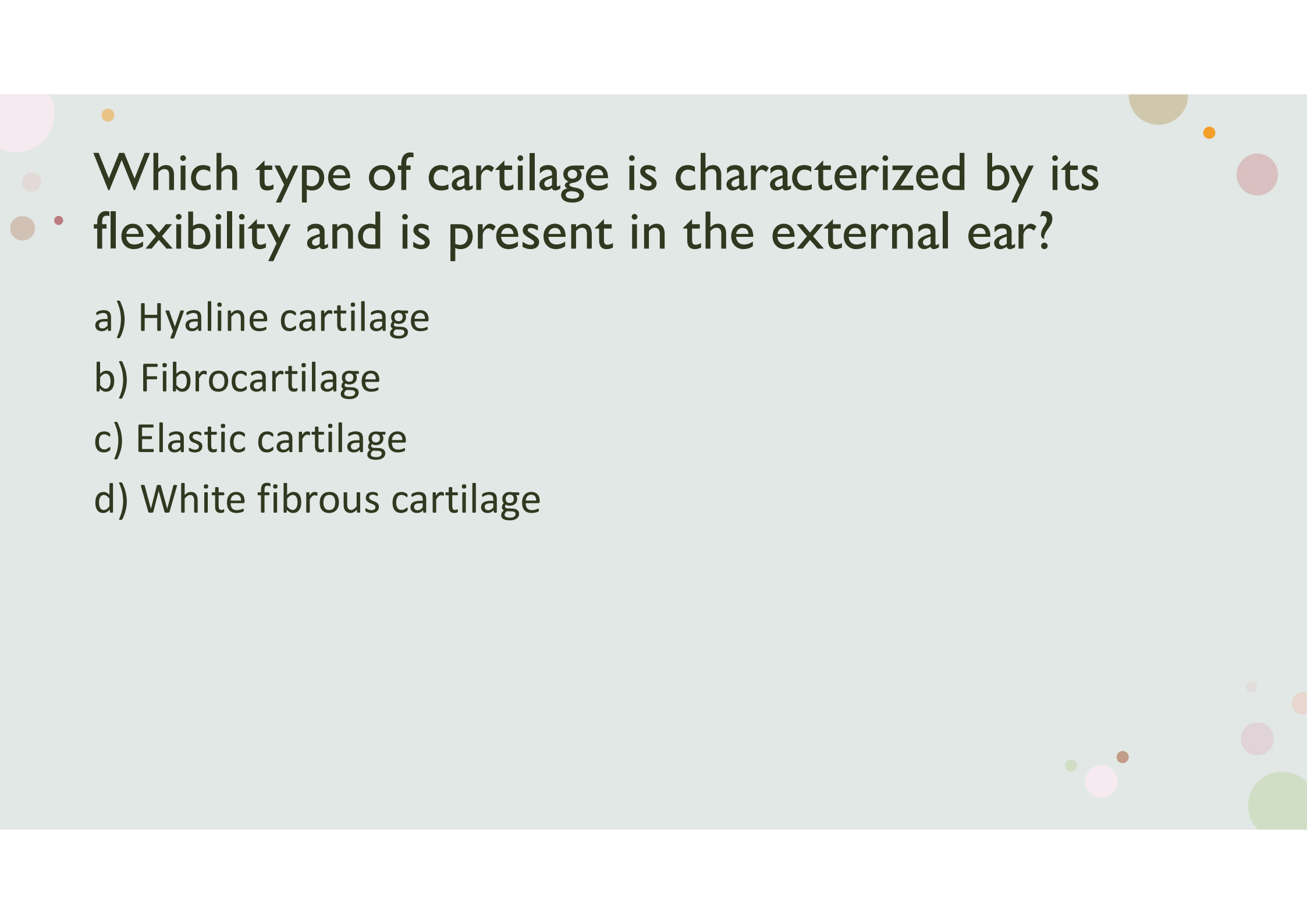
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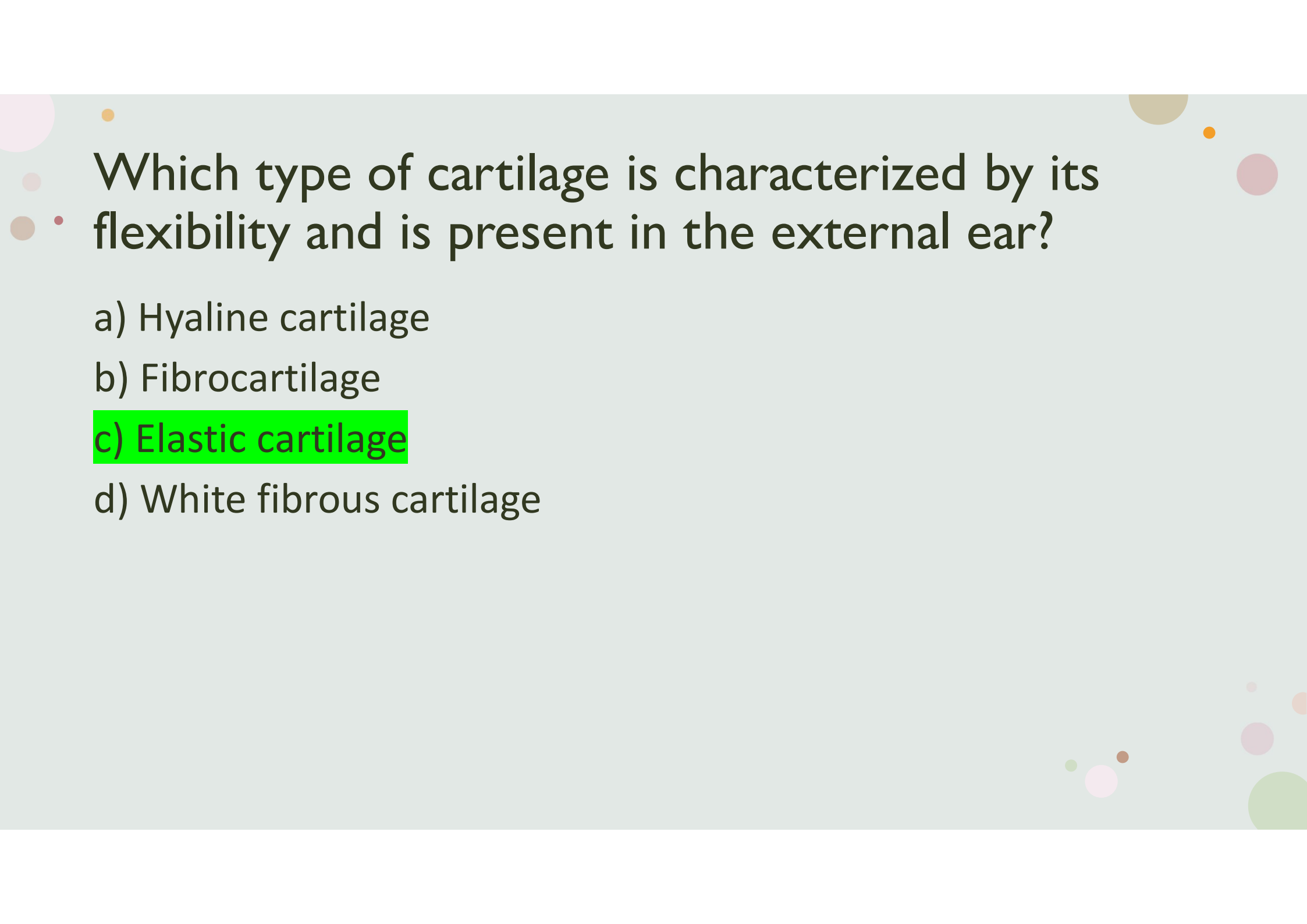
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Which type of cartilage is characterized by its flexibility and is present in the external ear?

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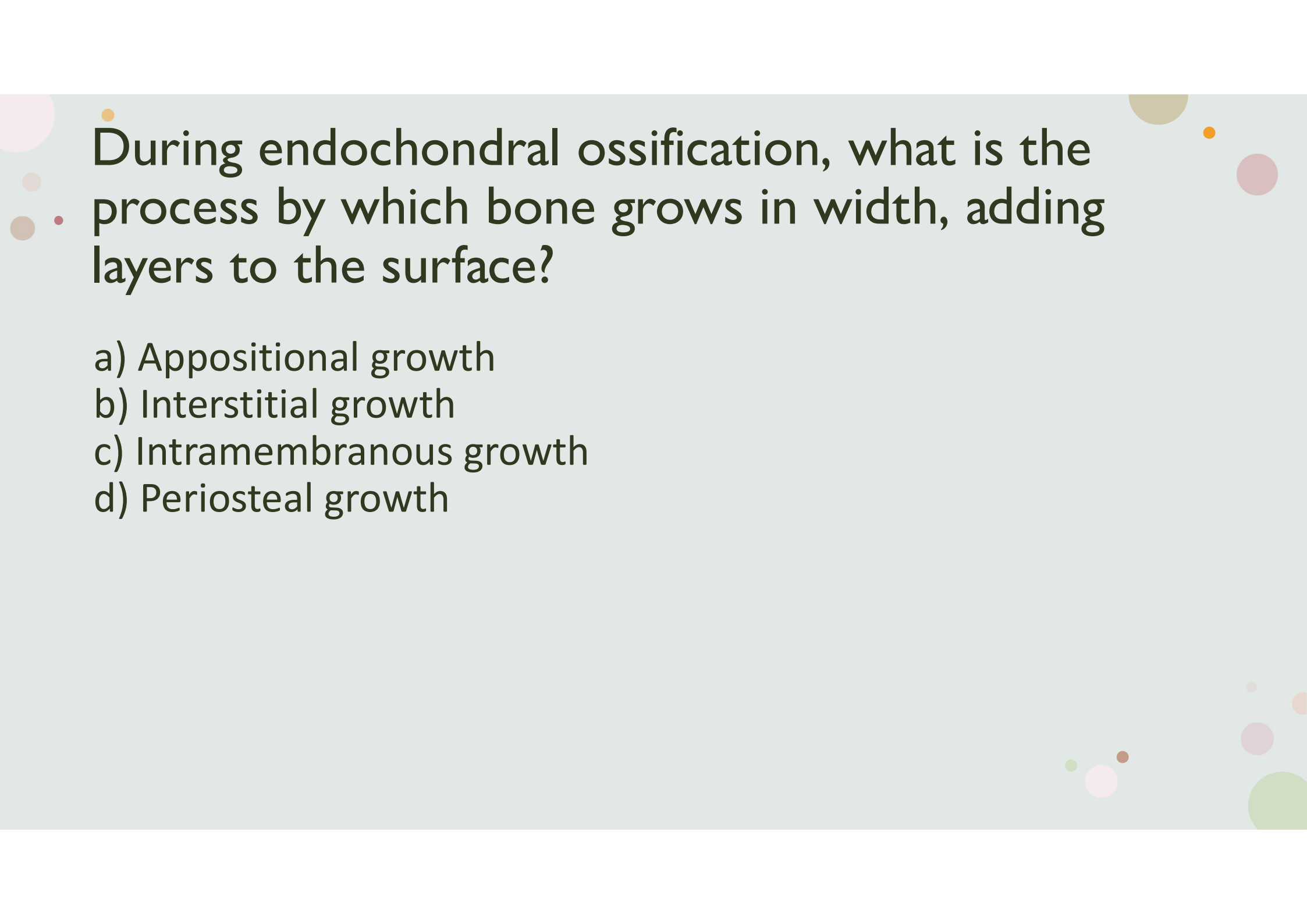
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During endochondral ossification, what is the process by which bone grows in width, adding layers to the surface?

- a) Appositional growth
- b) Interstitial growth
- c) Intramembranous growth
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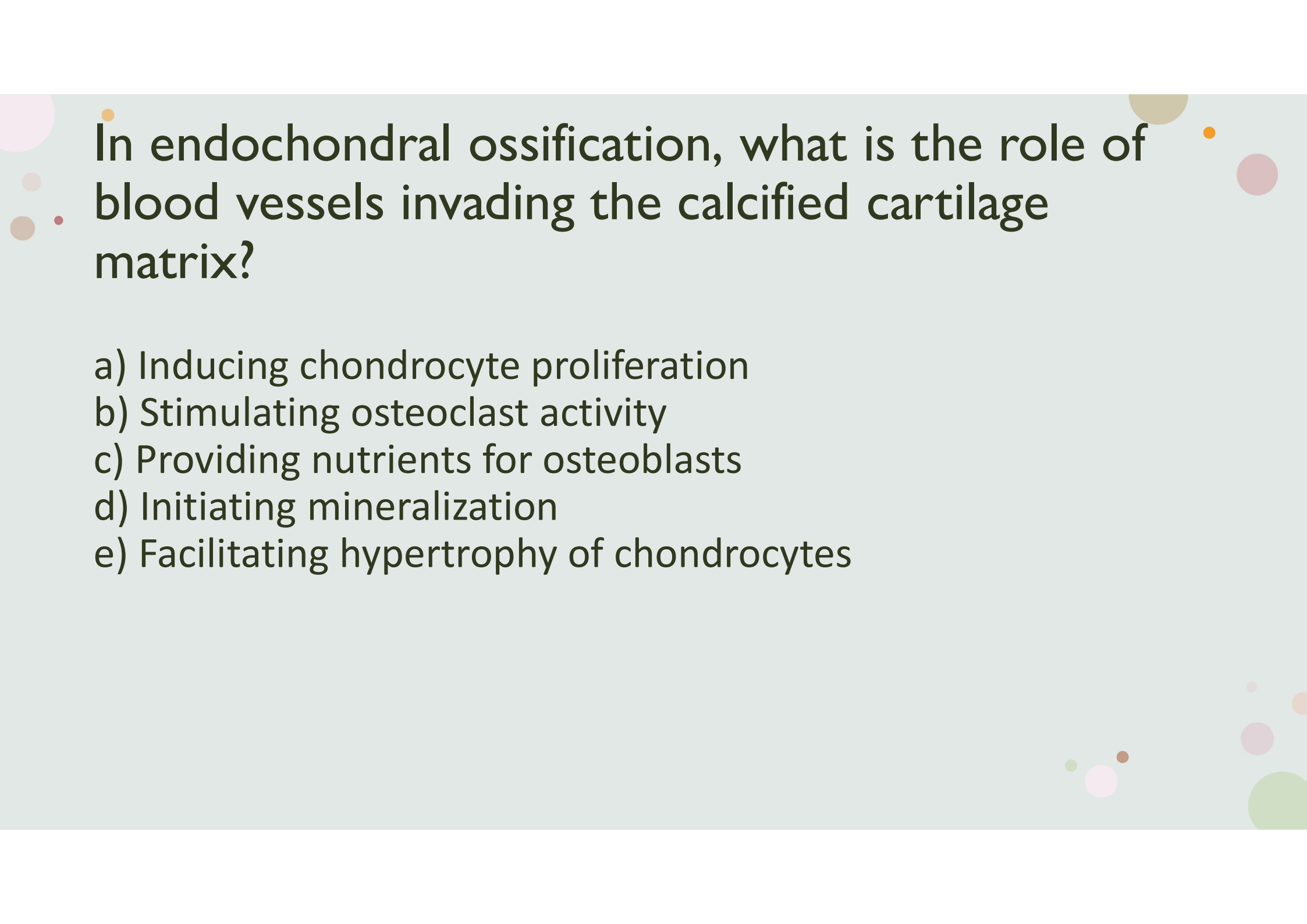
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In endochondral ossification, what is the role of blood vessels invading the calcified cartilage matrix?

- a) Inducing chondrocyte proliferation
- b) Stimulating osteoclast activity
- c) Providing nutrients for osteoblasts
- d) Initiating mineralization
- e) Facilitating hypertrophy of chondrocytes

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# What serves as a scaffold for intramembranous bone formation?

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- b) Perichondrium
- c) Endosteum
- d) Mesenchyme

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# Which of the following bones undergoes intramembranous ossification?

- a) The Parietal bone
- b) The Vertebrae
- c) The Humerus
- d) The Patella
- e) The Sternum



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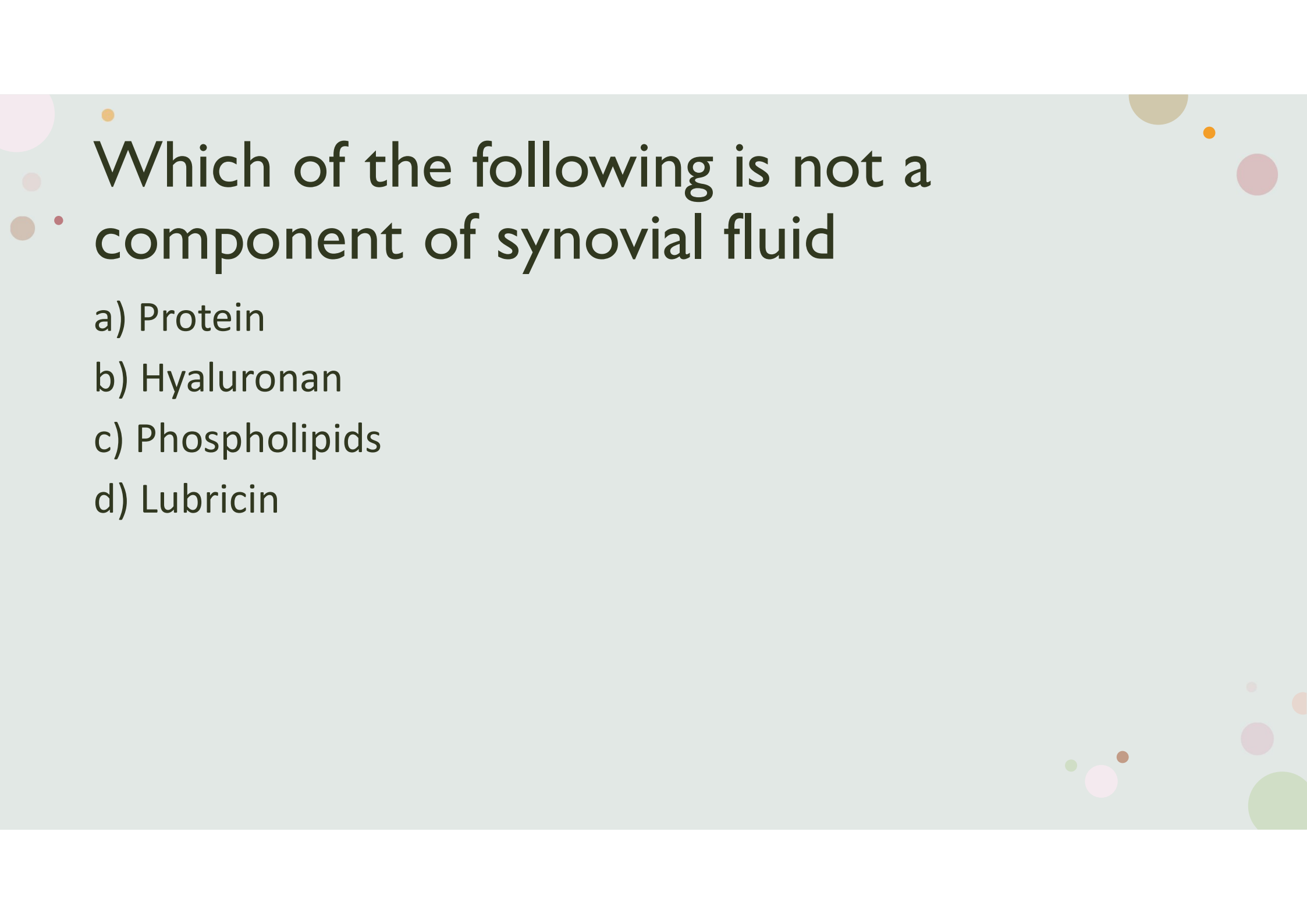
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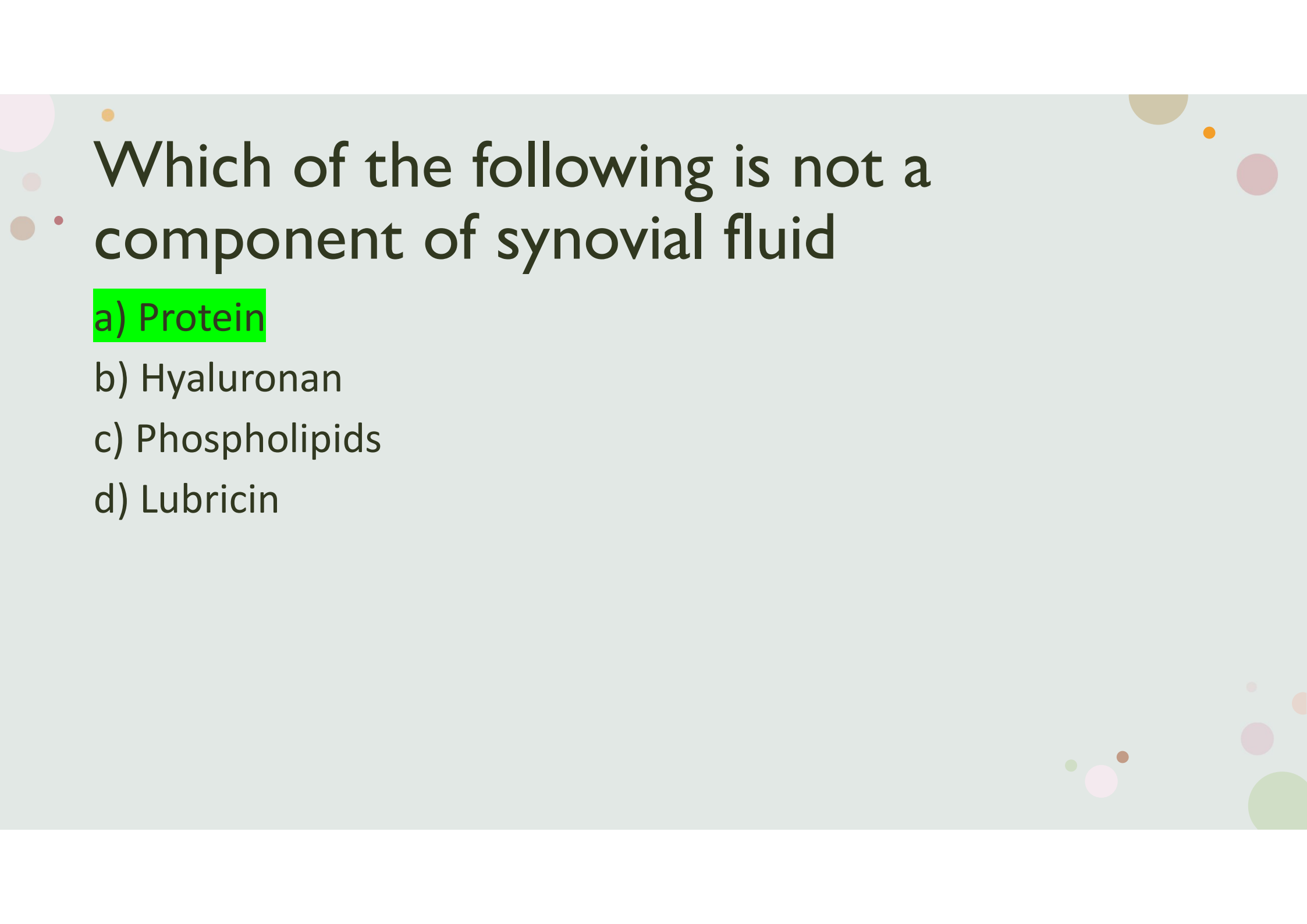
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# Which of the following is not a component of synovial fluid

- a) Protein
- b) Hyaluronan
- c) Phospholipids
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# Which of the following is a non-sulfated GAG

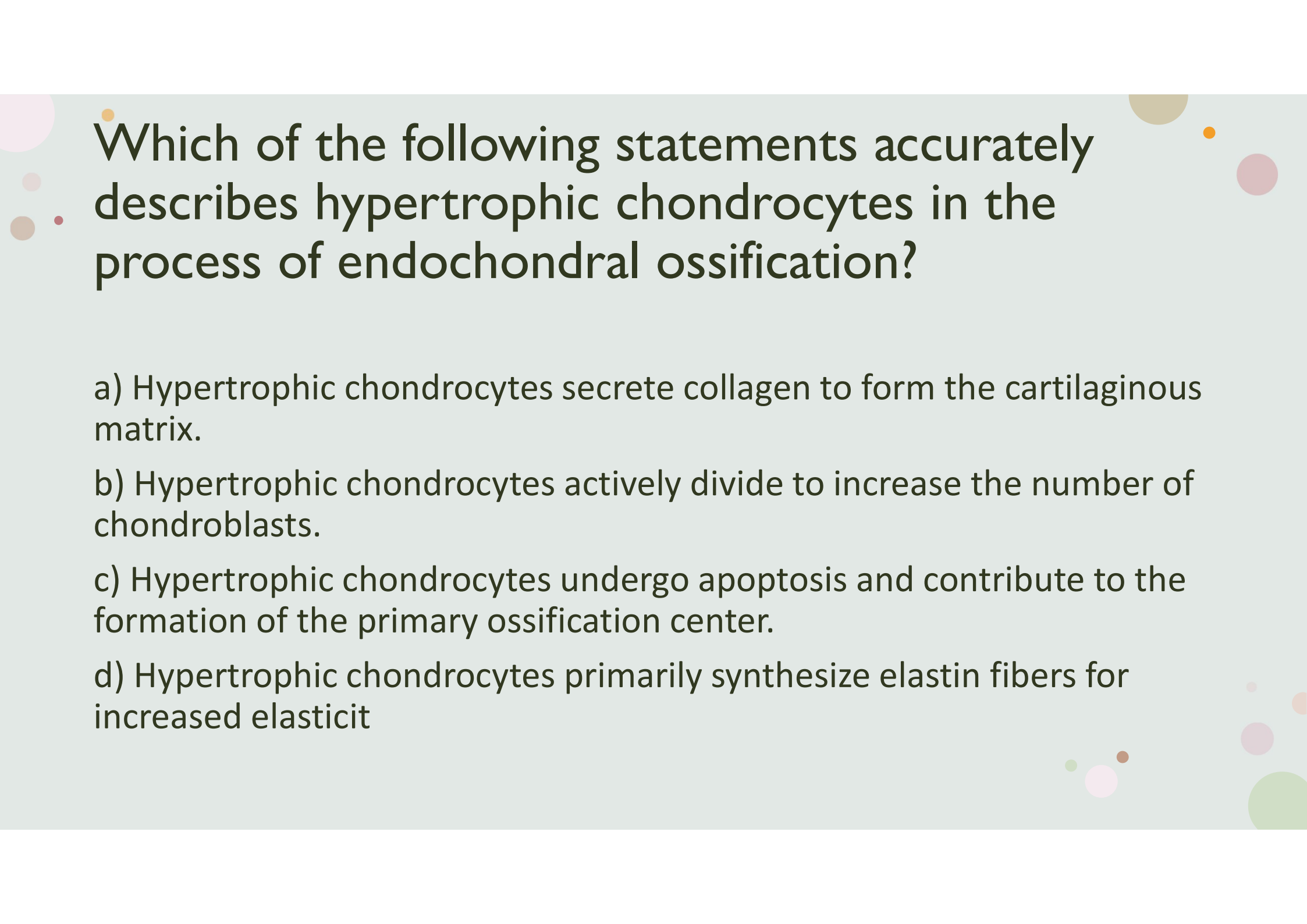
- a) Heparin
- b) Lubricin
- c) Hyaluronan
- d) Phospholipids
- e) Wnt ligand

The background of the slide is a light gray color. It is decorated with several semi-transparent circles of various colors, including pink, orange, yellow, and green, scattered across the top and right sides.

# Which of the following is a non-sulfated GAG

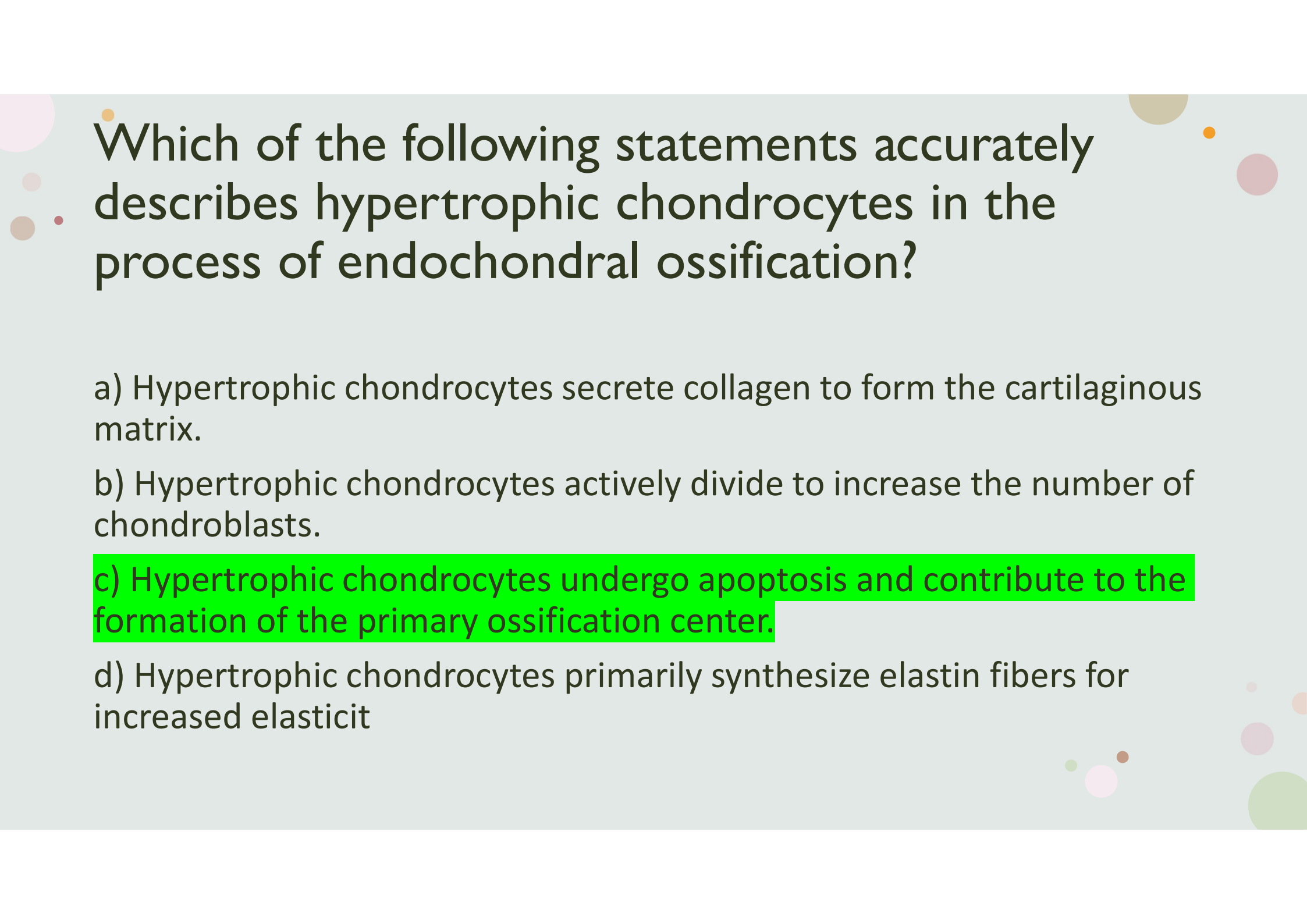
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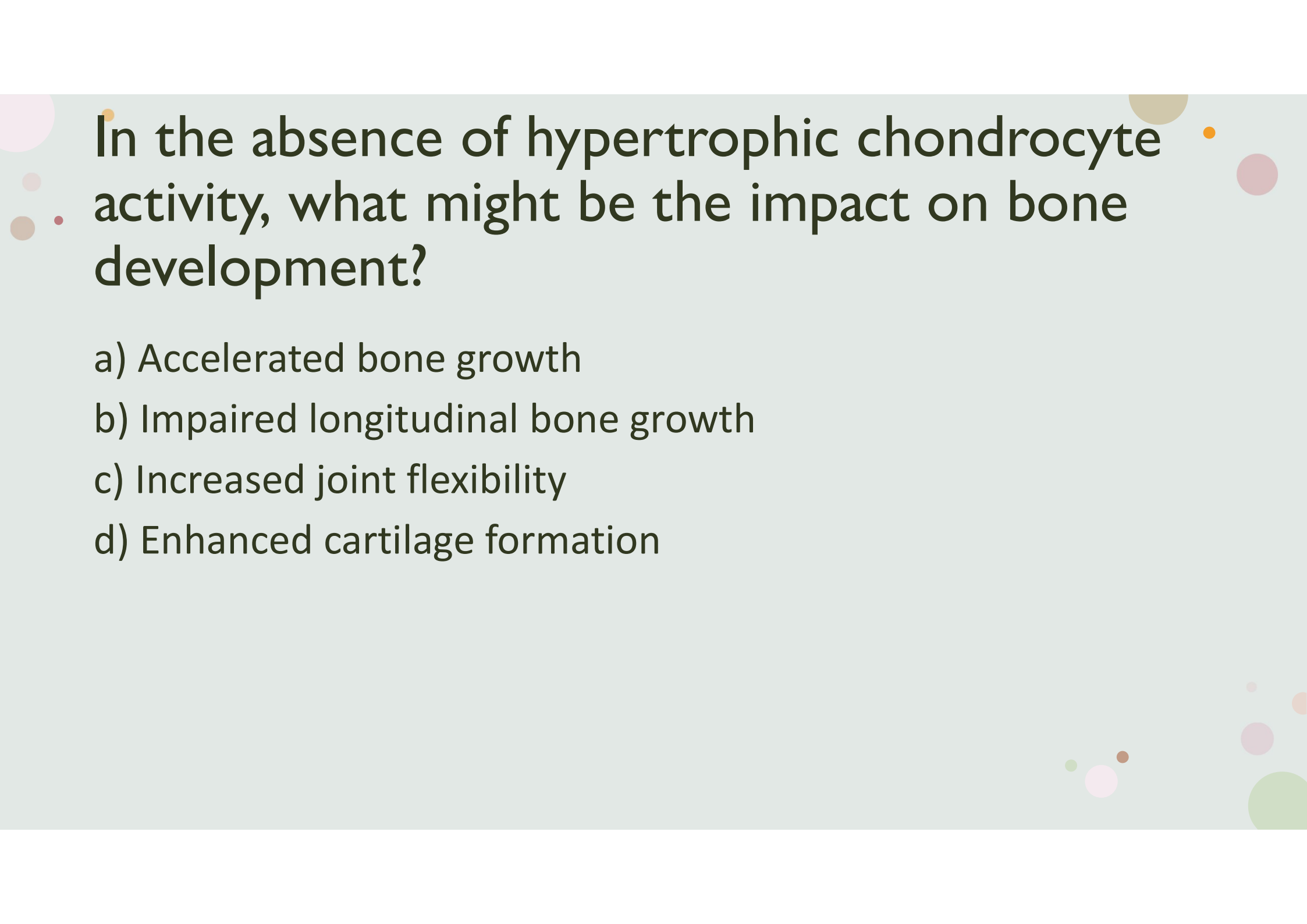
Which of the following statements accurately describes hypertrophic chondrocytes in the process of endochondral ossification?

- a) Hypertrophic chondrocytes secrete collagen to form the cartilaginous matrix.
- b) Hypertrophic chondrocytes actively divide to increase the number of chondroblasts.
- c) Hypertrophic chondrocytes undergo apoptosis and contribute to the formation of the primary ossification center.
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In the absence of hypertrophic chondrocyte activity, what might be the impact on bone development?

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