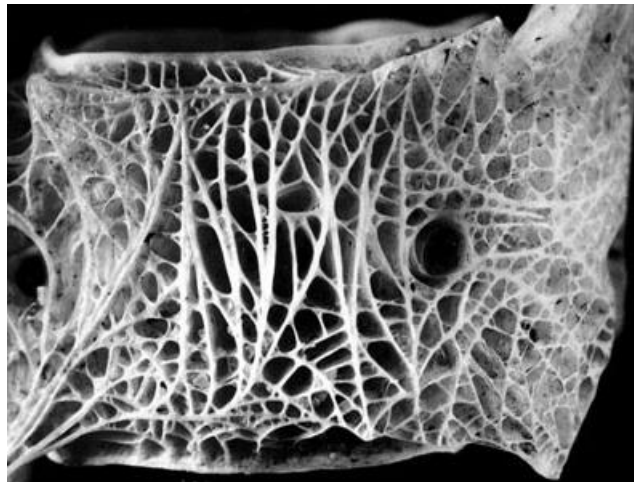


BIOMECHANIKA KRĘGOSŁUPA

Własności mechaniczne

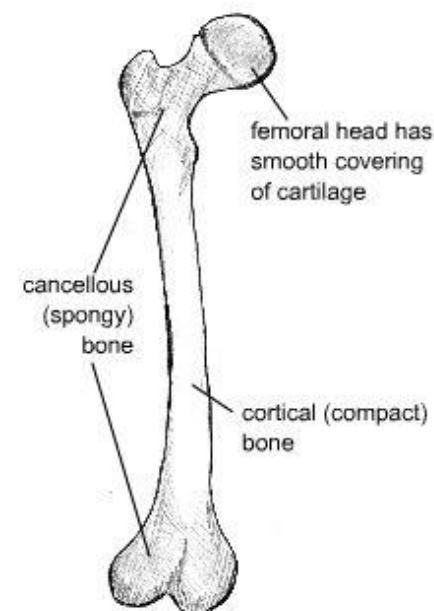
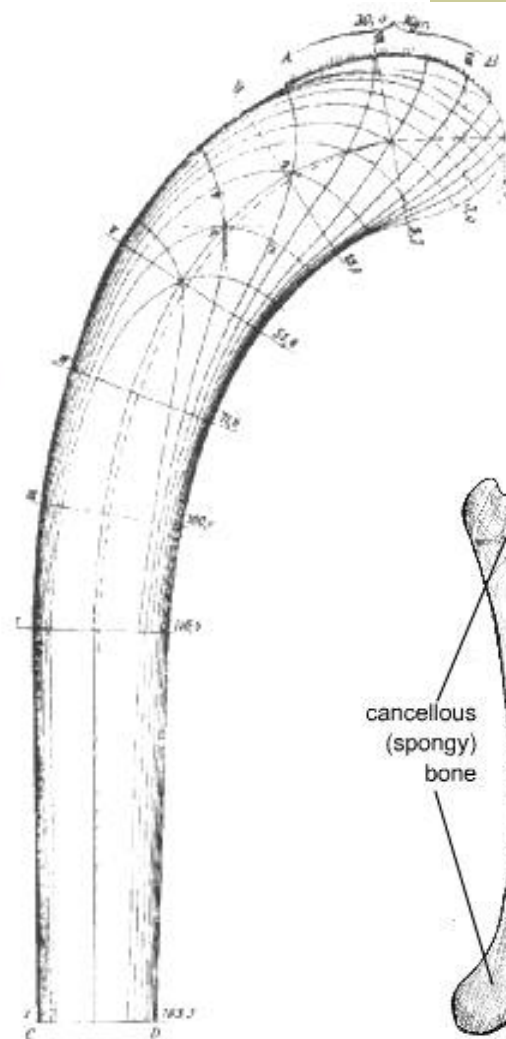
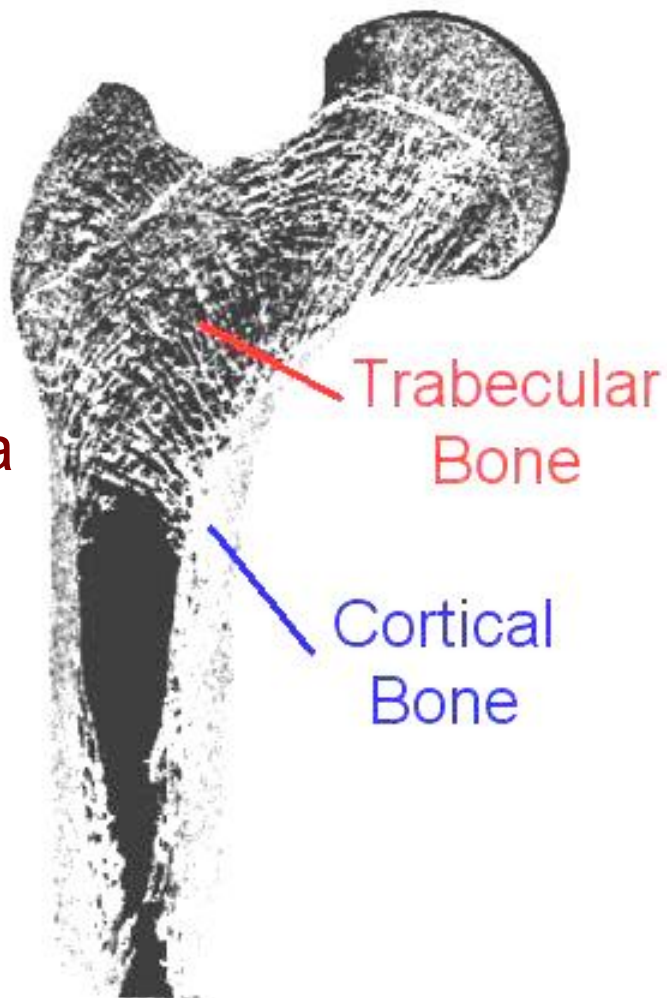




Budowa kości

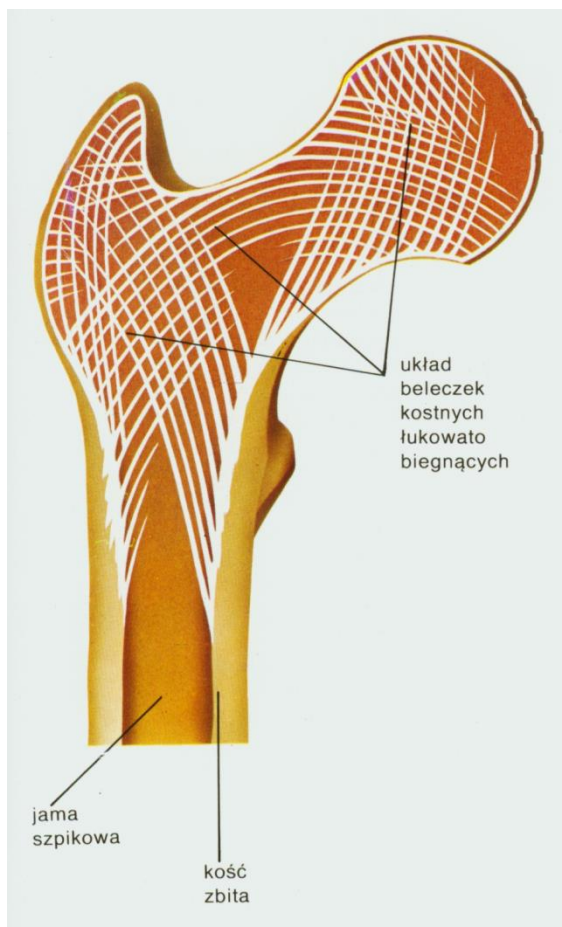
Kość
gąbczasta

Kość
zbita





Układ beleczek kostnych





Budowa kości

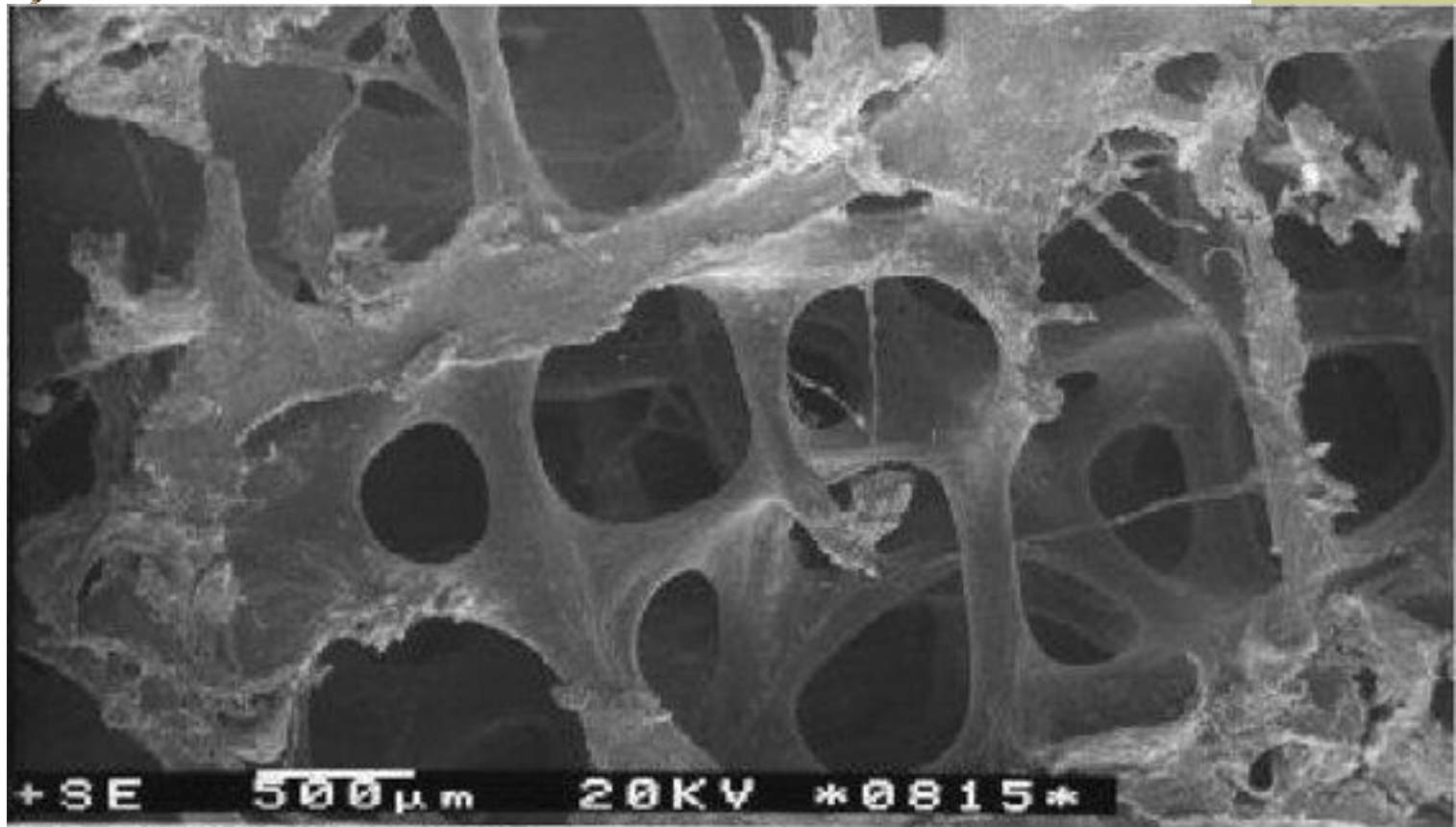
Substancja międzykomórkowa ulega silnemu wysyceniu solami mineralnymi, głównie wapnia, w mniejszym stopniu fosforanem magnezu.

Do ponad **2/3** suchej masy kości mogą stanowić związki mineralne, dlatego jest ona twarda oraz wytrzymała na duże obciążenia mechaniczne. Z wiekiem zawartość elementów organicznych maleje na rzecz nieorganicznych, przez co kości stają się kruche.

Pod względem chemicznym kość dorosłego człowieka zawiera przeciętnie **30-40%** związków organicznych, **30-45%** związków mineralnych i ok. **15-45%** wody.



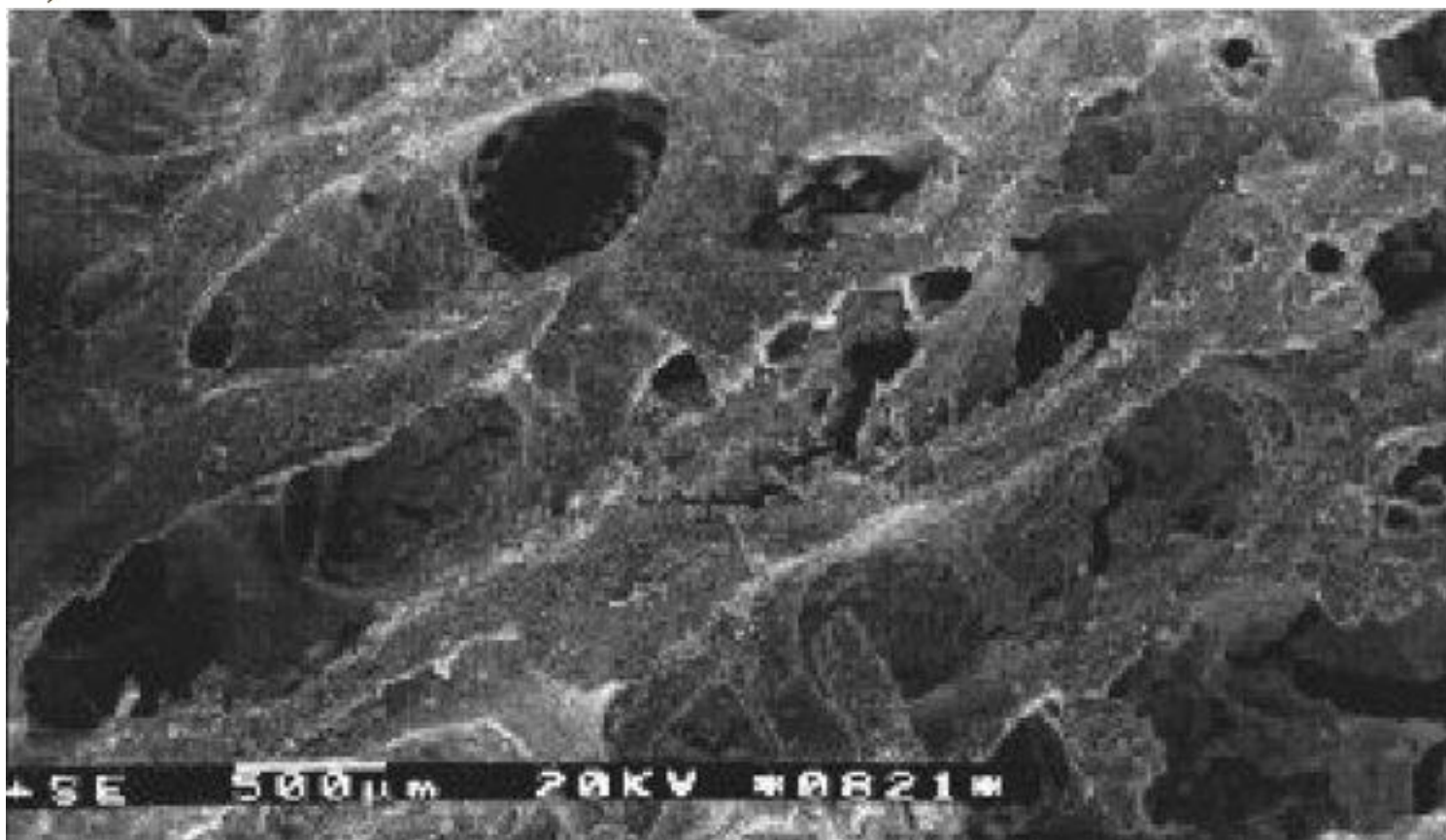
Kość beleczkowata (gąbczasta)



Trabecular structures in the L1 vertebra of a 24 year old



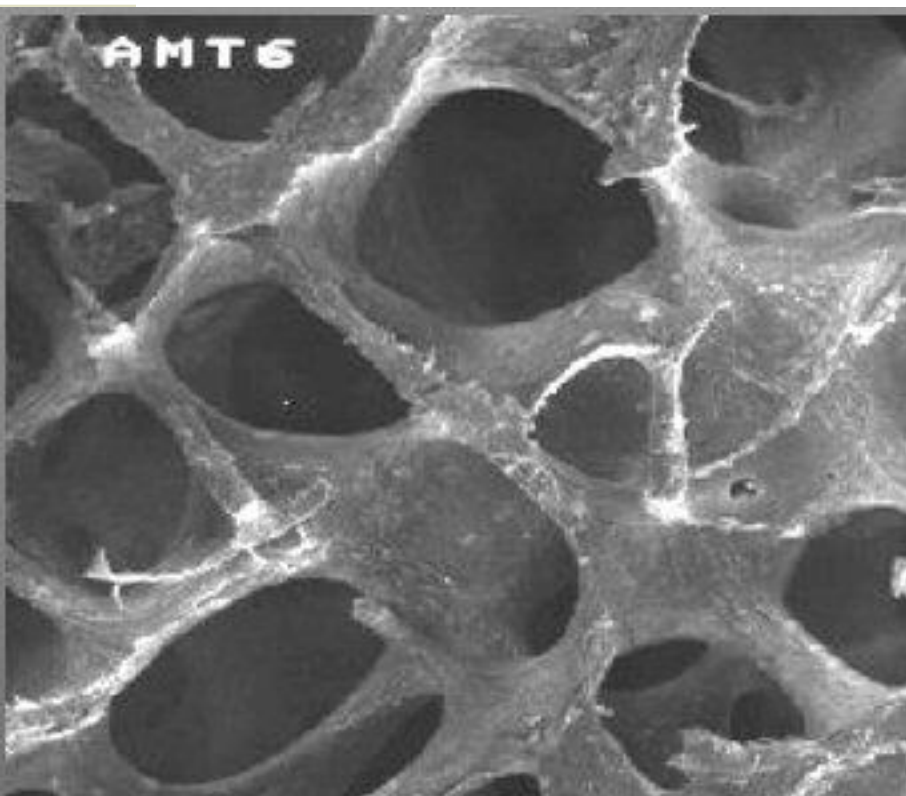
Kość zbita (zwarta)



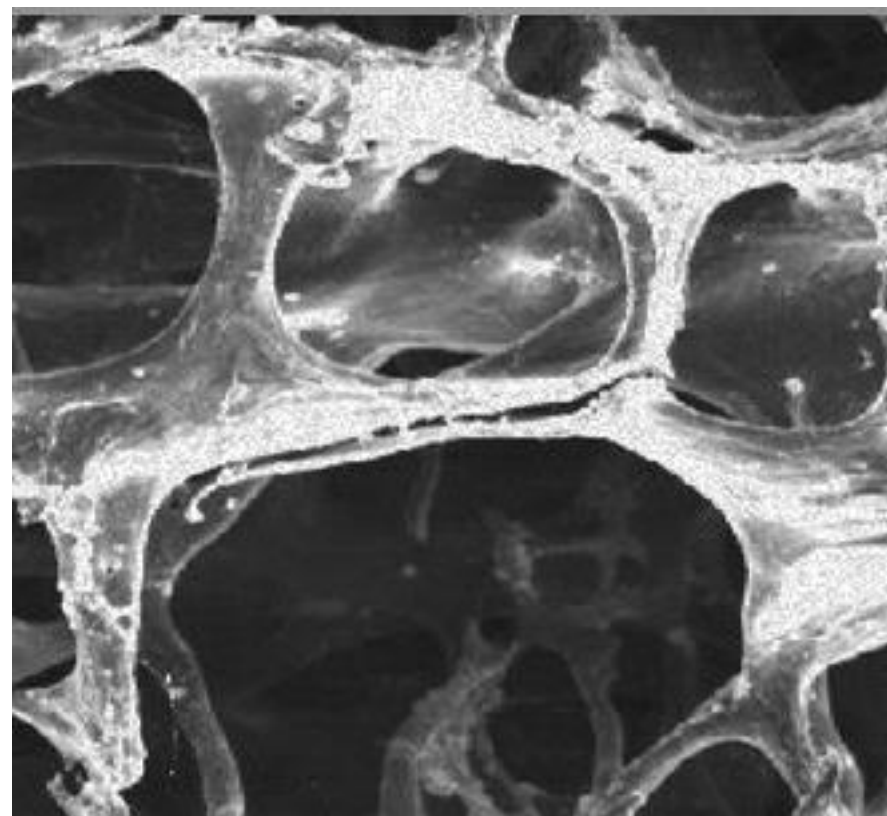
Trabecular structures in the calcaneus of a 24 year old



Starzenie kości



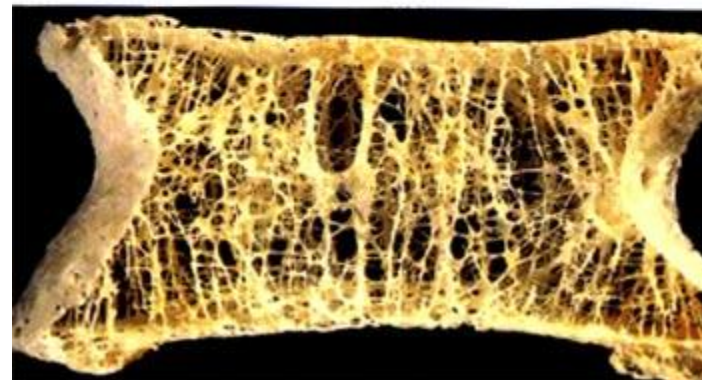
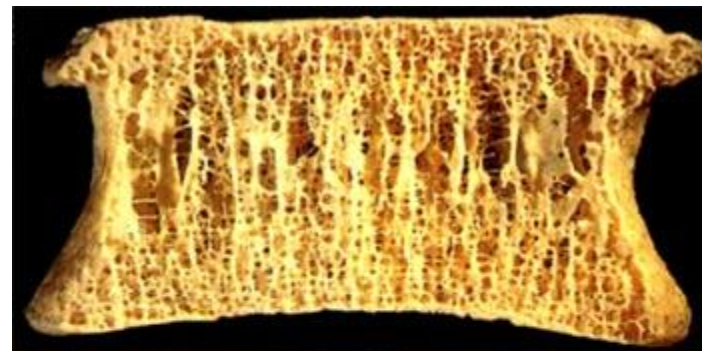
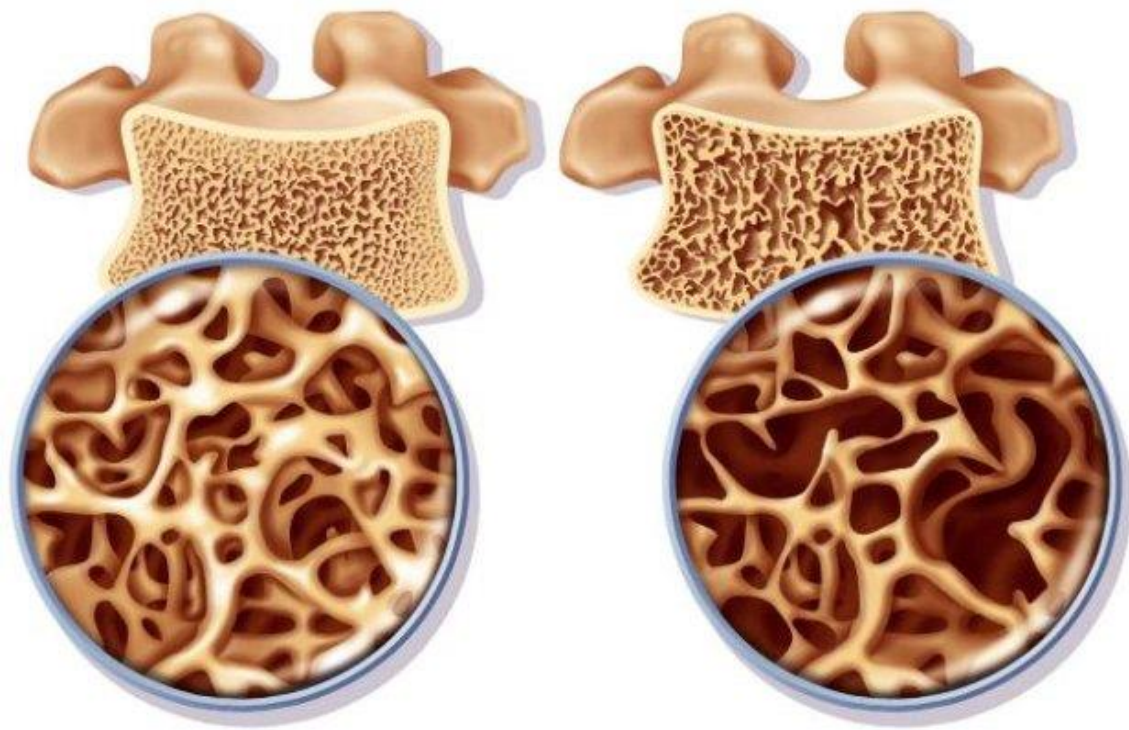
Kobieta 36 lat



Kobieta 74 lata



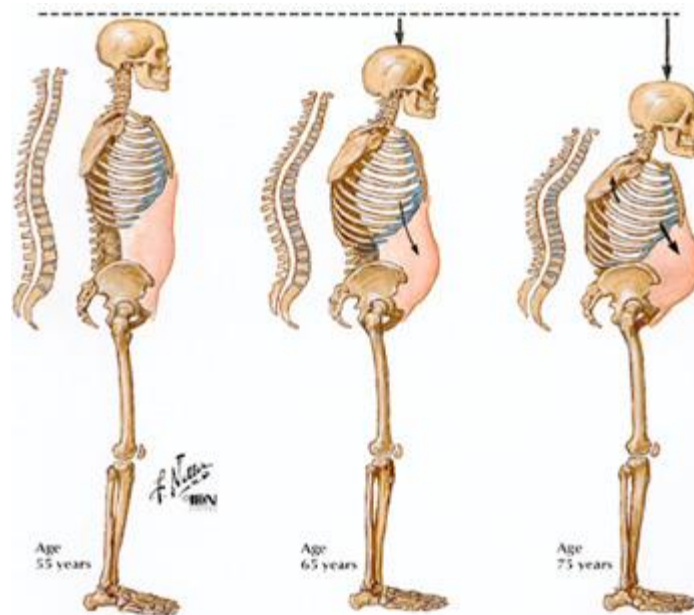
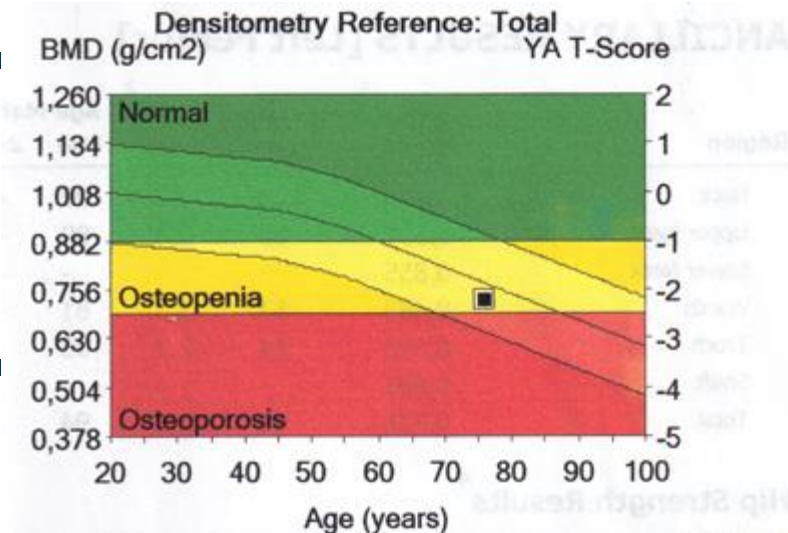
Osteoporozoza





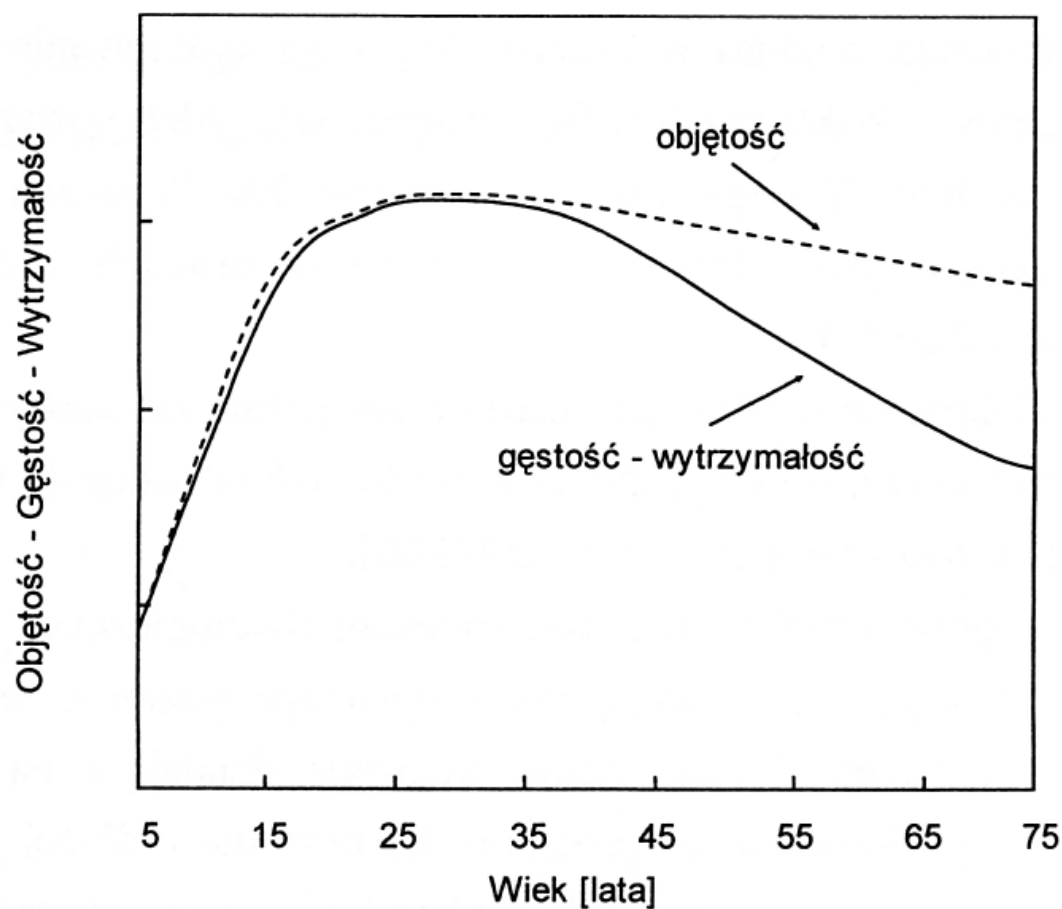
Osteoporoza

Zależność gęstości masy kostnej od wieku





Zmiany cech fizycznych kości



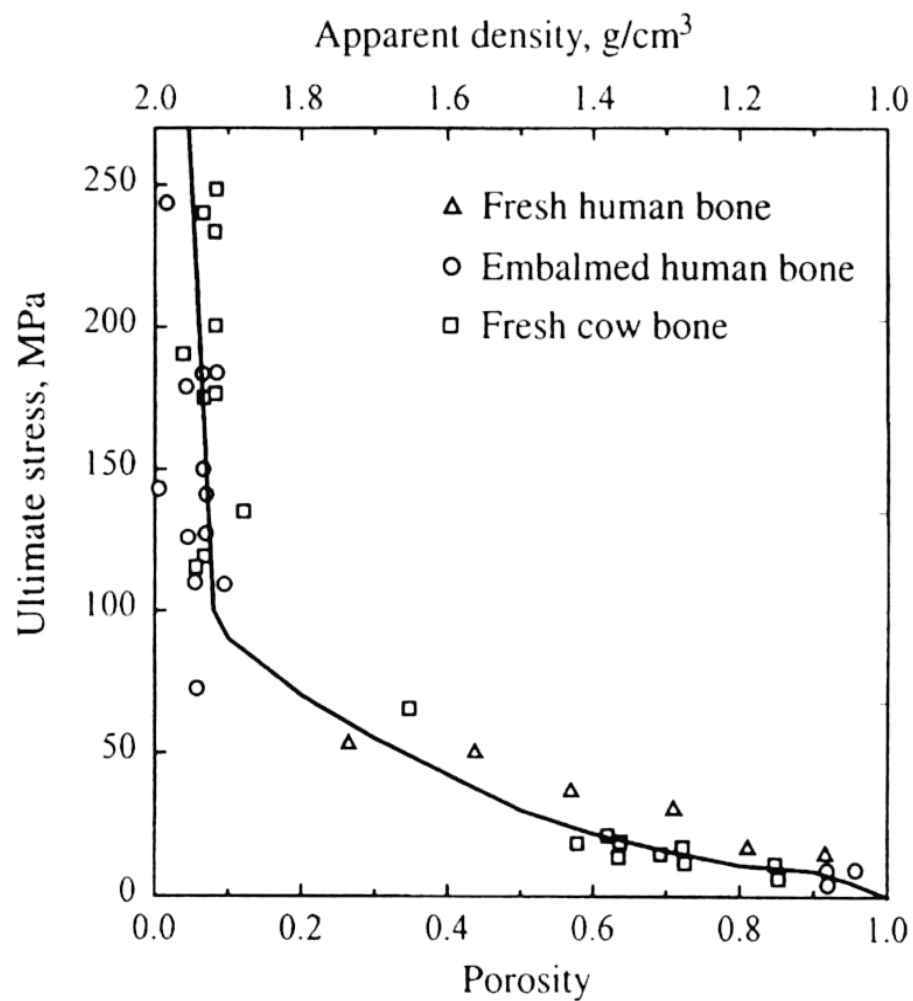


Wytrzymałość kości

Property	Age (years)						
	10 - 20	20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80
Ultimate strength (MPa)							
Tension	114	123	120	112	93	86	86
Compression	-	167	167	161	155	145	-
Bending	151	173	173	162	154	139	139
Torsion	-	57	57	52	52	49	49
Ultimate strain (%)							
Tension	1.5	1.4	1.4	1.3	1.3	1.3	1.3
Compression	-	1.9	1.8	1.8	1.8	1.8	-
Torsion	-	2.8	2.8	2.5	2.5	2.7	2.7



Wytrzymałość kości



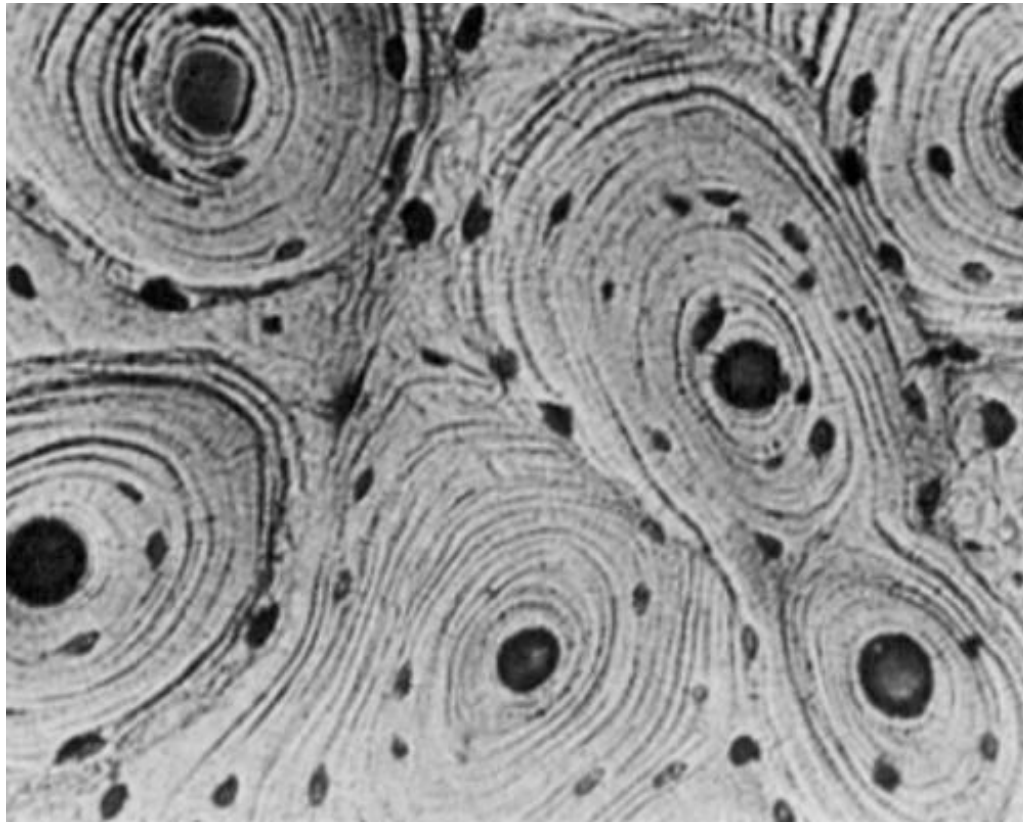


Wytrzymałość kości

Material	Young's Modulus, E (GPa)
Collagen (dry)	6
Bone mineral (Hydroxyapatite)	80
Cortical bone, longitudinal	11-21
Cortical bone, transverse	5-13

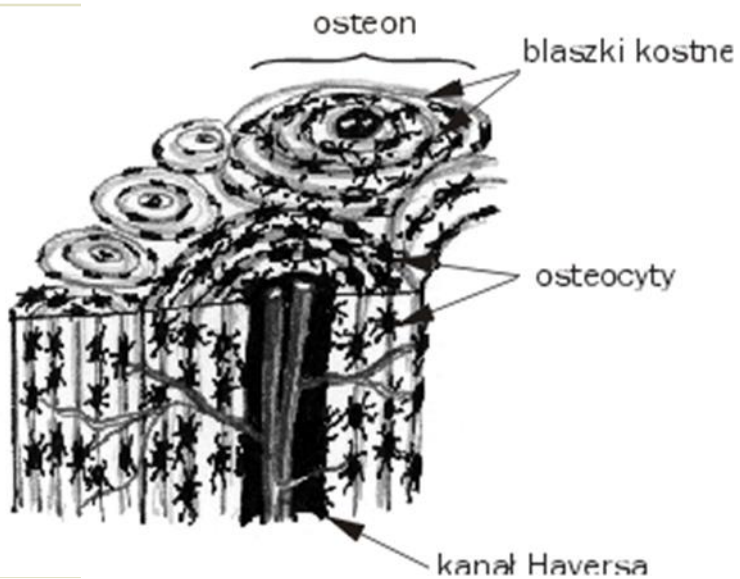
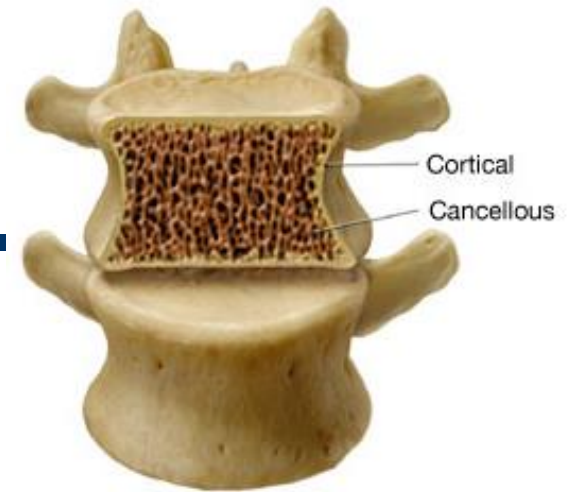


Osteony w kości zbitej

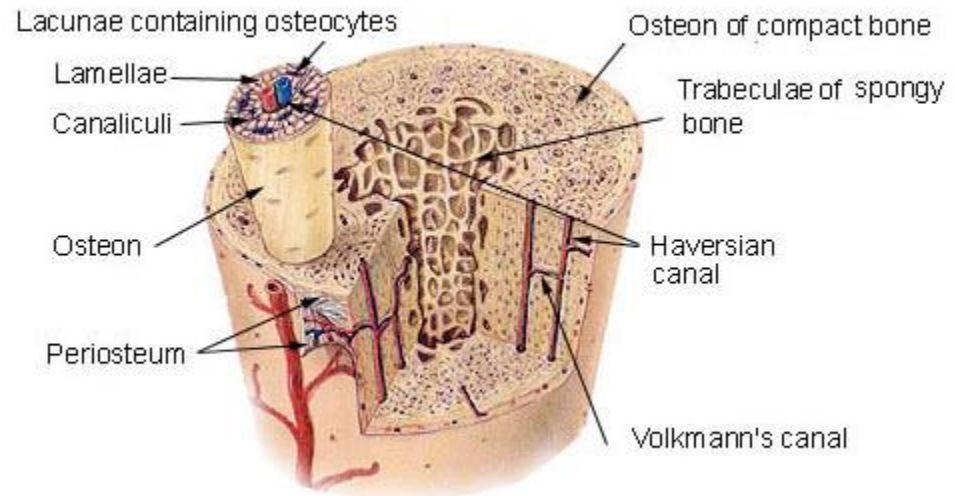


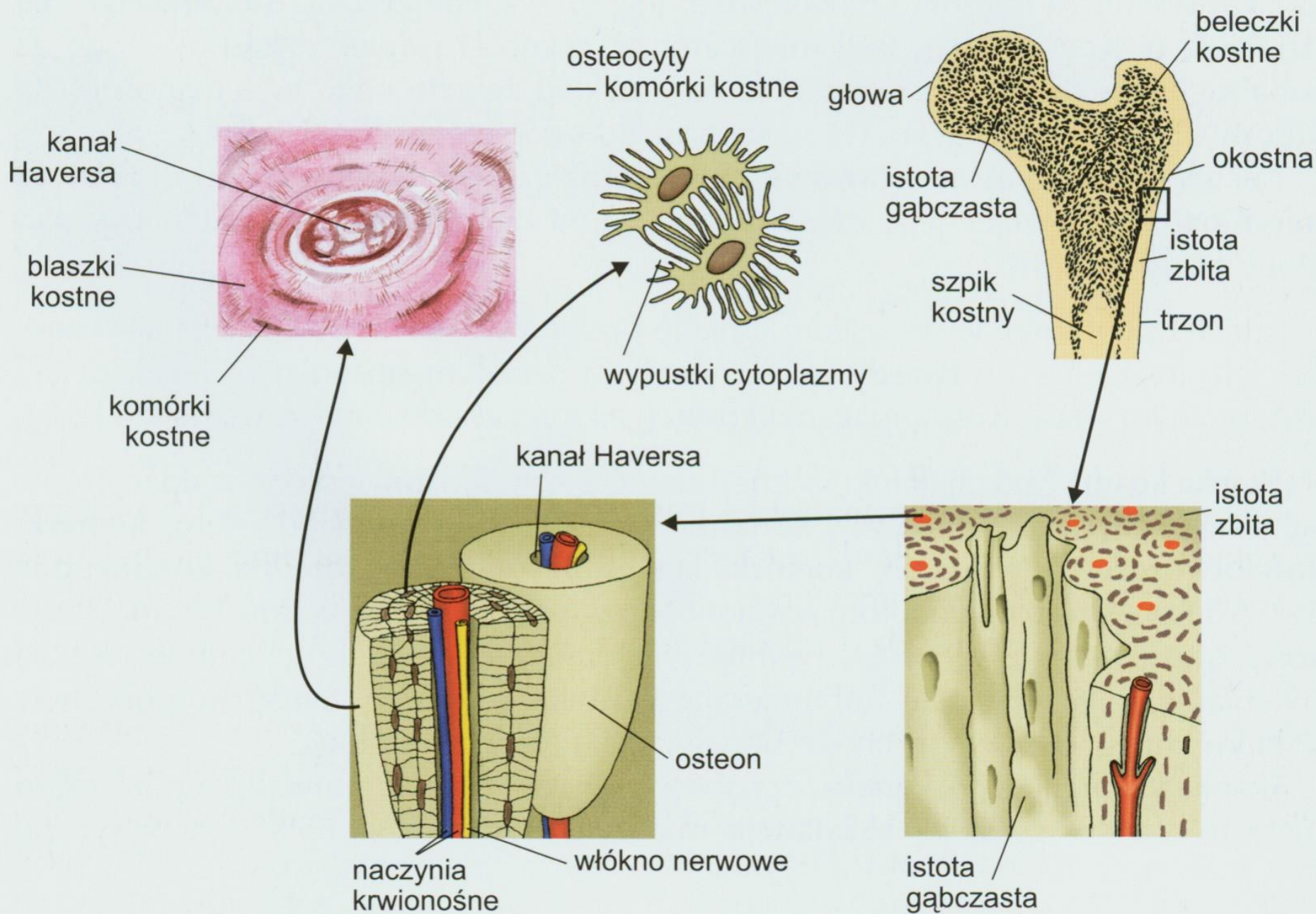
Lamellar structure of osteons in cortical bone

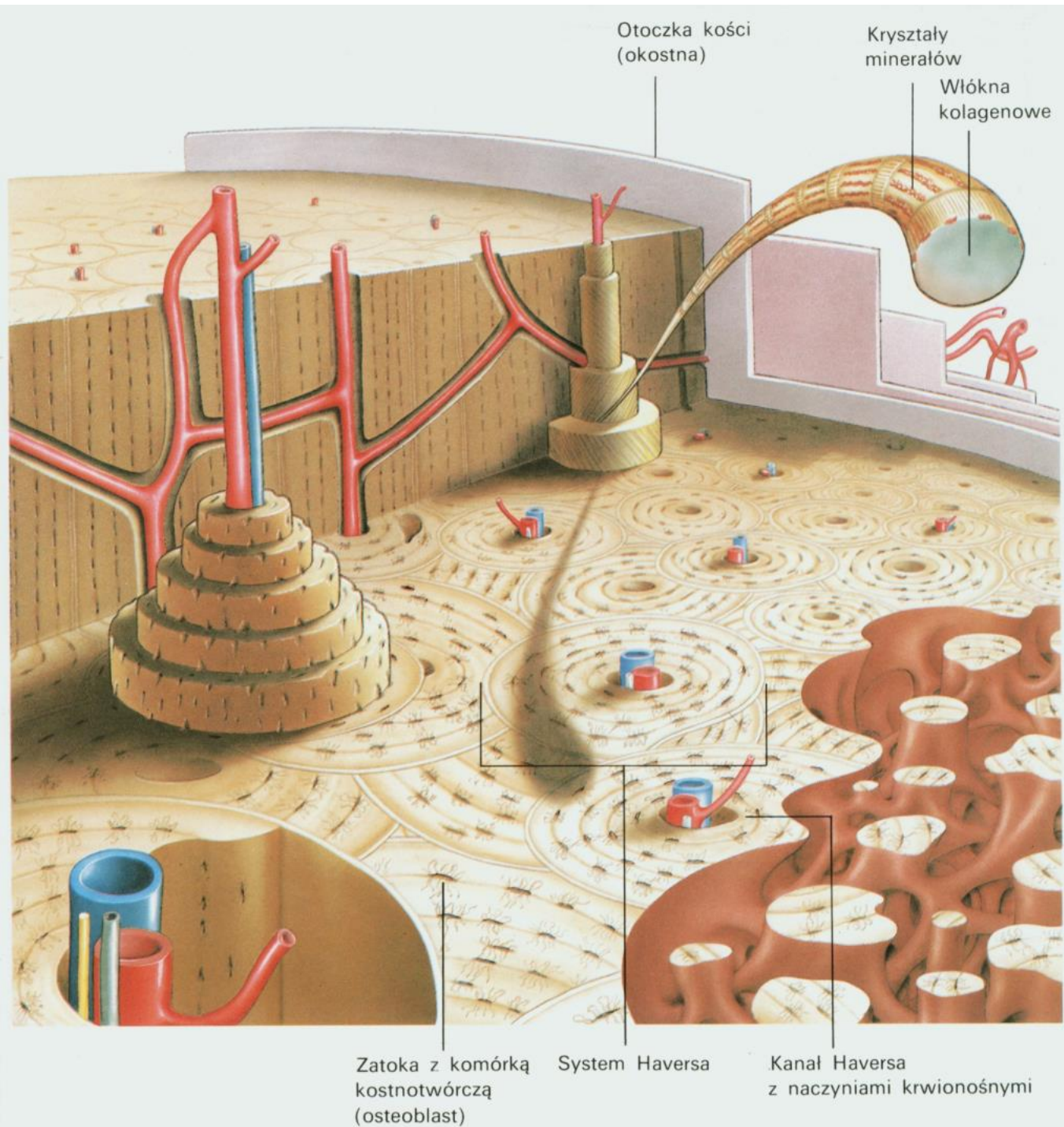
Osteony



Compact Bone & Spongy (Cancellous Bone)

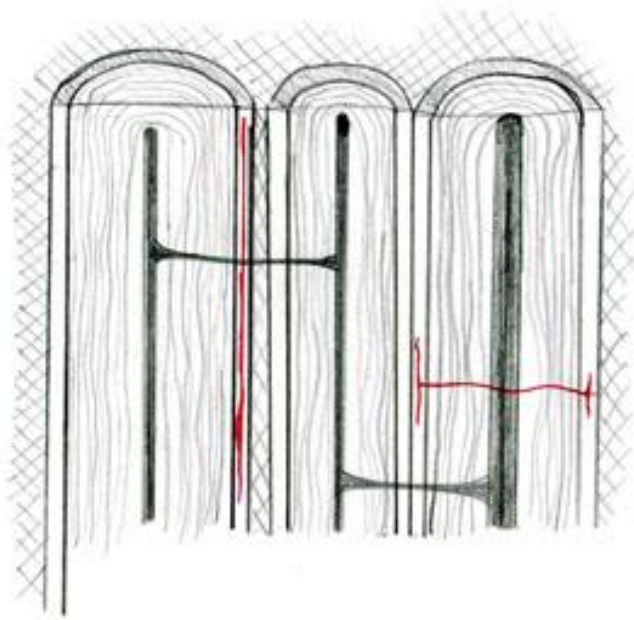








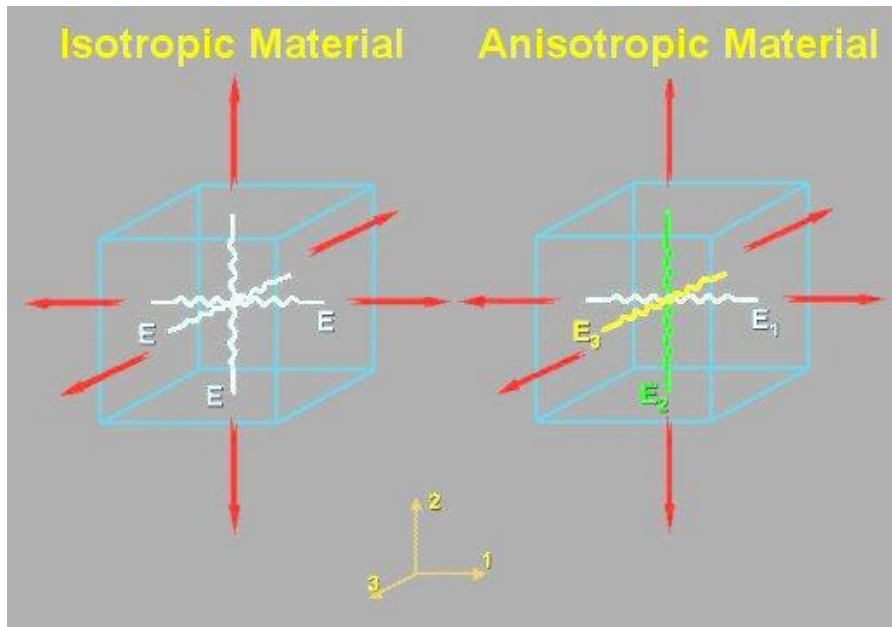
Wytrzymałość na pękanie



Bone's fracture energy, G_c , is approximately 1.5 kJ m^{-2} , comparable to steel at low temperatures and wood when measured parallel to the grain.



Stale materiałowe

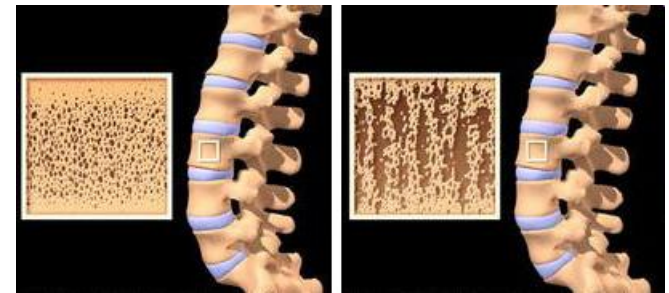
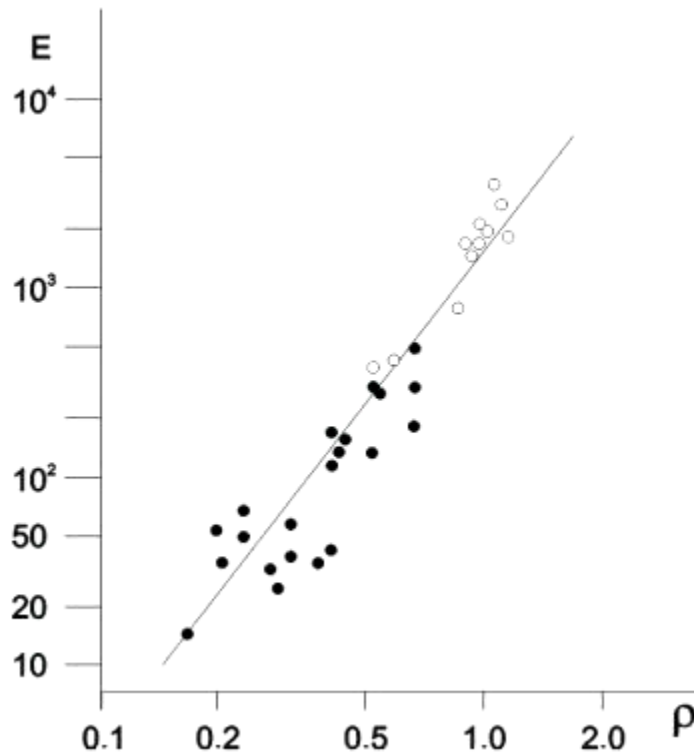


	corpus	ramus
E_1 [GPa]	10.93	11.77
E_2 [GPa]	14.78	16.25
E_3 [GPa]	18.89	20.42
G_{12} [GPa]	4.24	4.8
G_{13} [GPa]	5.13	5.72
G_{23} [GPa]	6.27	6.67
ν_{12}	0.224	0.157
ν_{13}	0.295	0.292
ν_{23}	0.275	0.273
ν_{21}	0.276	0.211
ν_{31}	0.501	0.5
ν_{32}	0.28	0.033

Average elastic constants of mandible bone in corpus and ramus



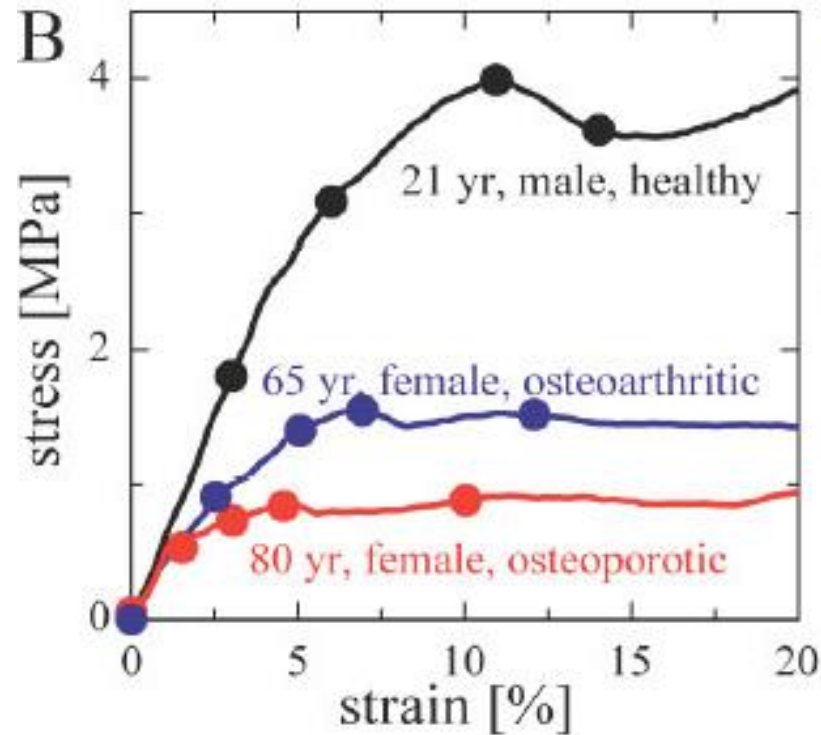
Moduł Younga



Young's modulus of trabecular bone as a function of density of bone. Bone density ρ is expressed in g/cm^3 and Young's modulus E in MPa.

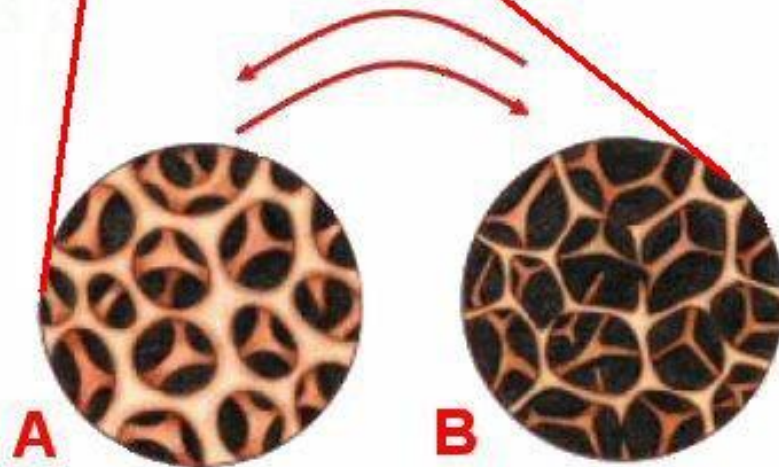
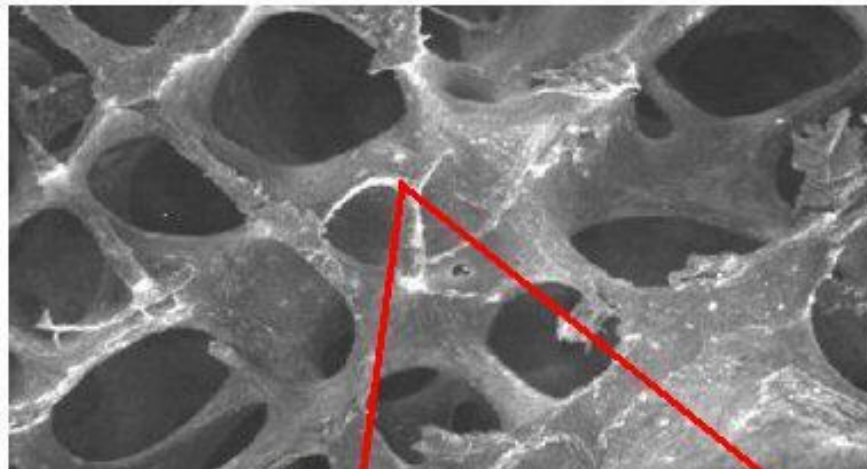


Naprężenie - odkształcenie



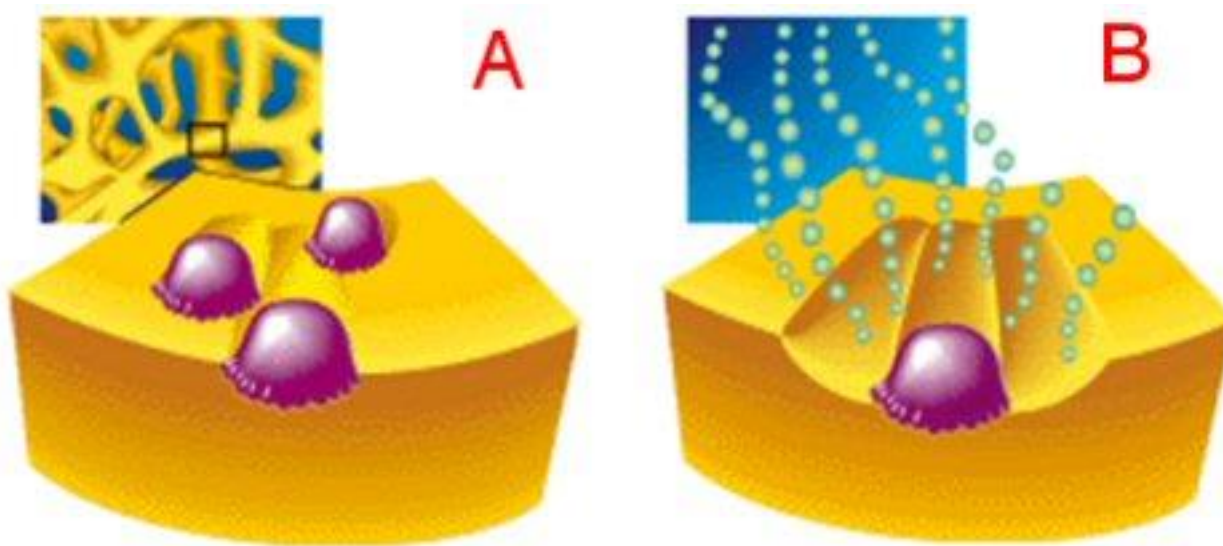


Remodeling kości





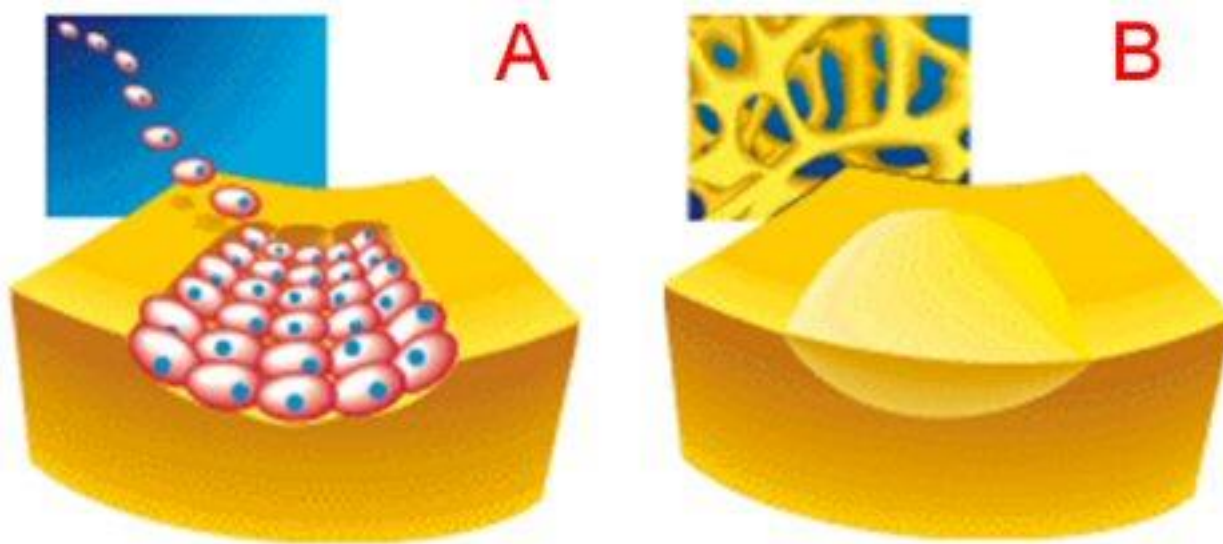
Remodeling kości



Bone resorption



Remodeling kości



Bone deposition



Przebudowa osteonów

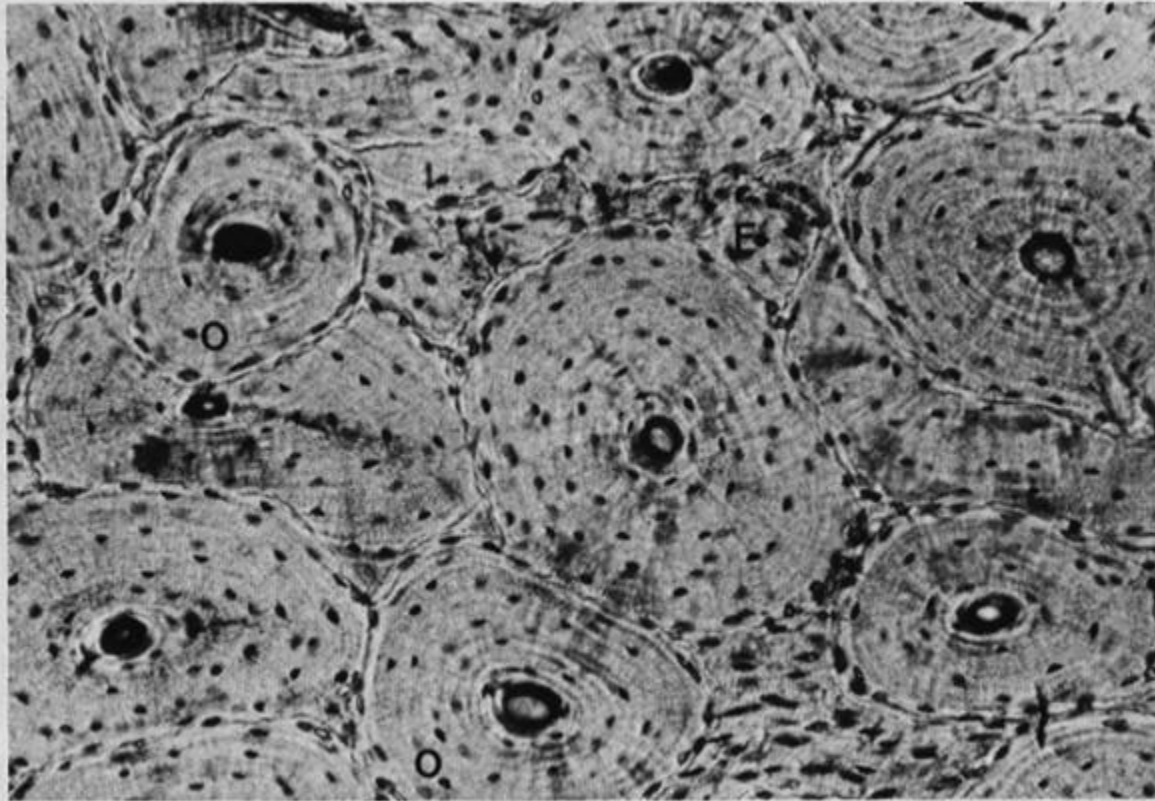
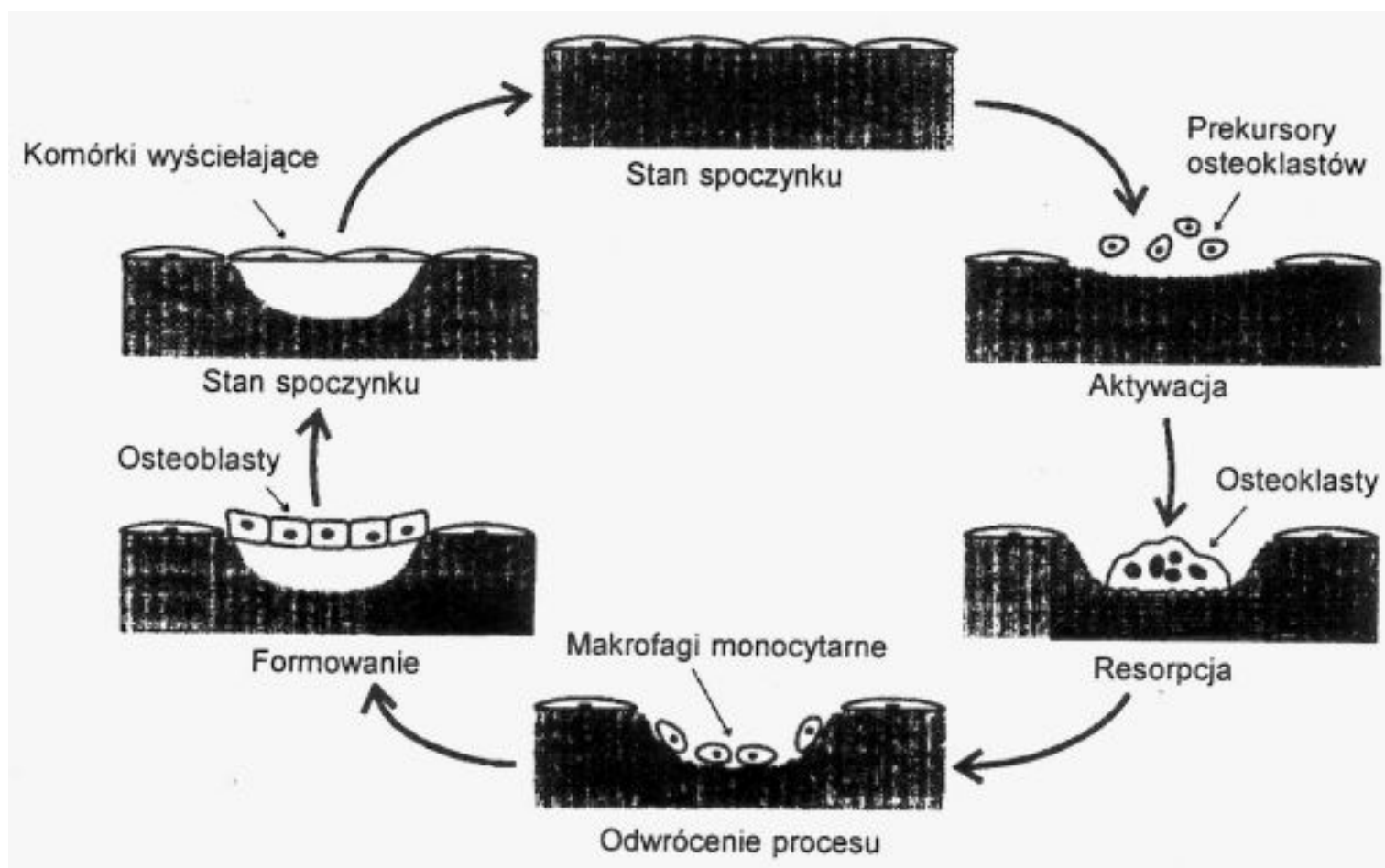


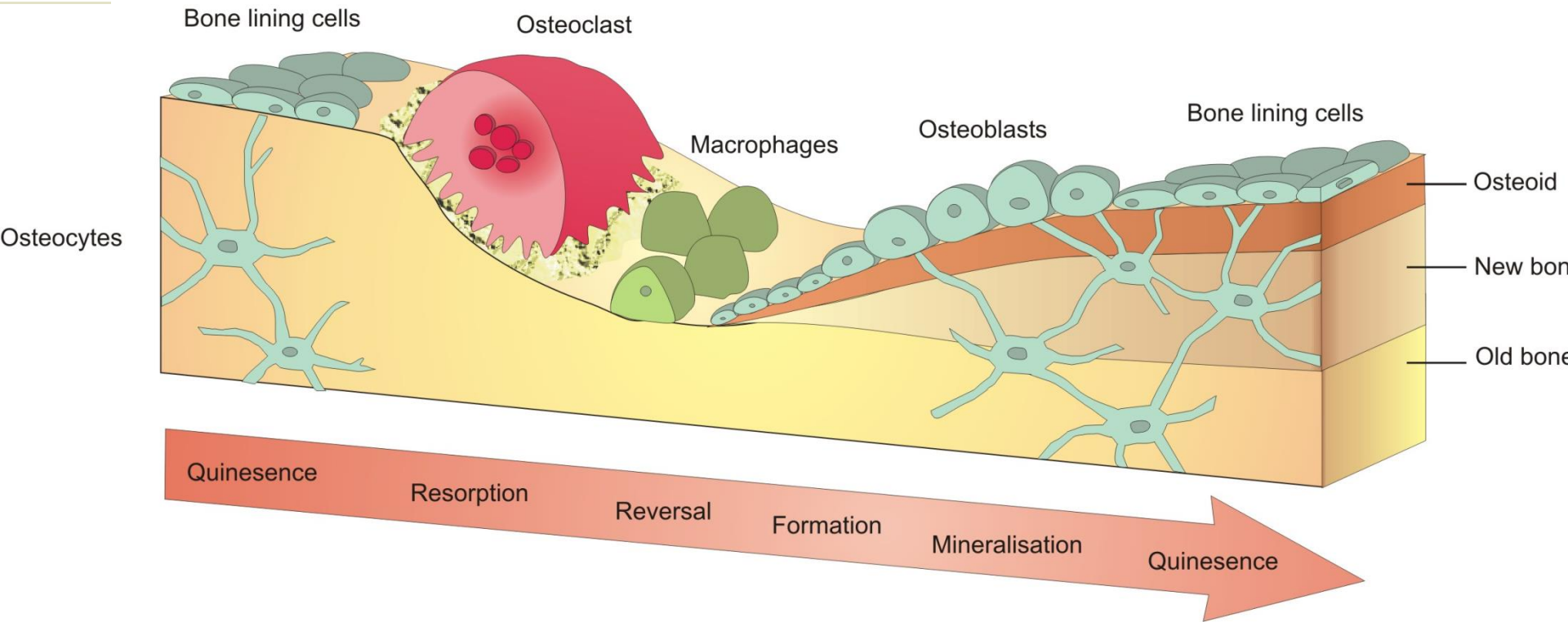
FIG. 2-15 Cortical bone consisting of numerous osteons (O) and interstitial fragments (F). Unstained section of mineralized bone.



Remodeling kości



Przebudowa tkanki kostnej

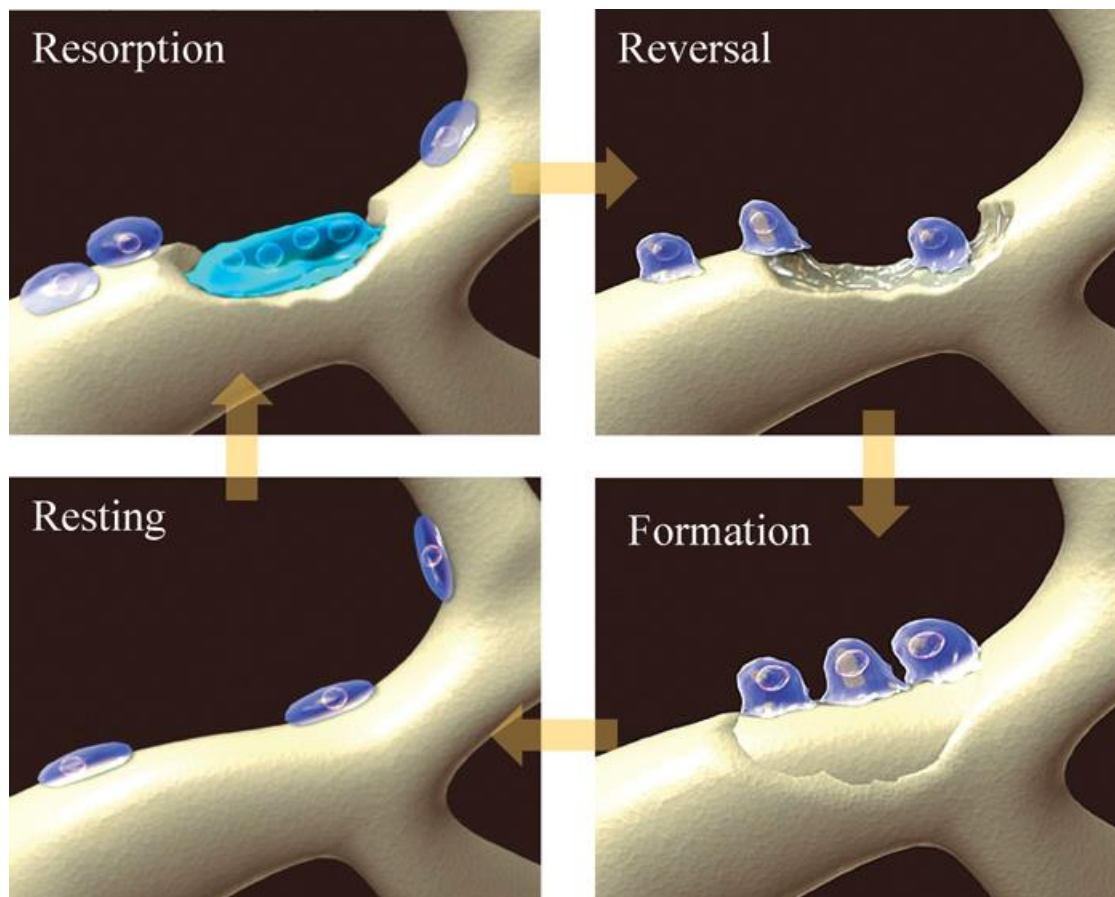


The bone remodelling process.

Bone is continuously remodelled at discrete sites in the skeleton in order to maintain the integrity of the tissue. During this process, old bone is resorbed by osteoclasts and replaced with new osteoid, secreted by osteoblasts. First osteoclasts are activated, and the resorption phase takes



Proces przebudowy





Prawo Wolffa

