

Bone remodeling and bone loss

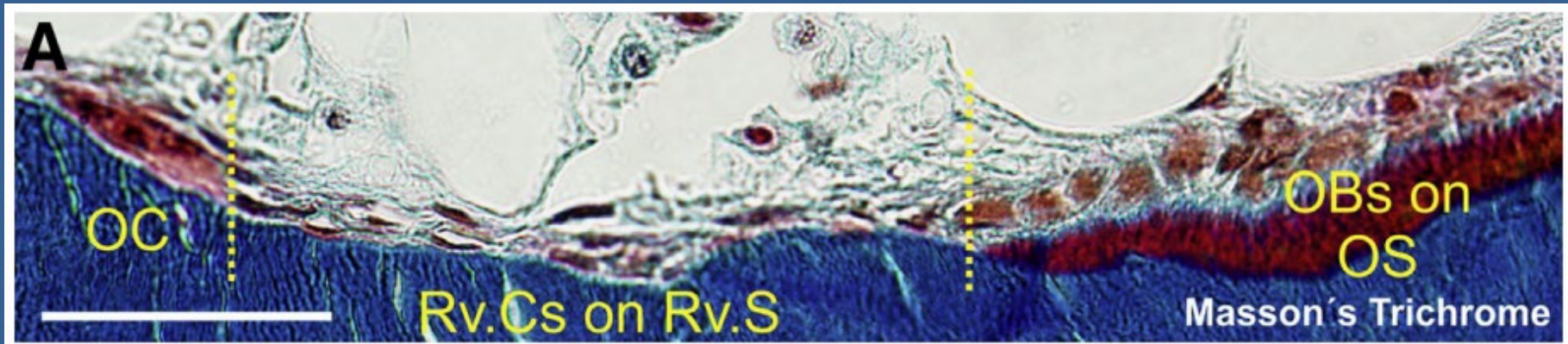
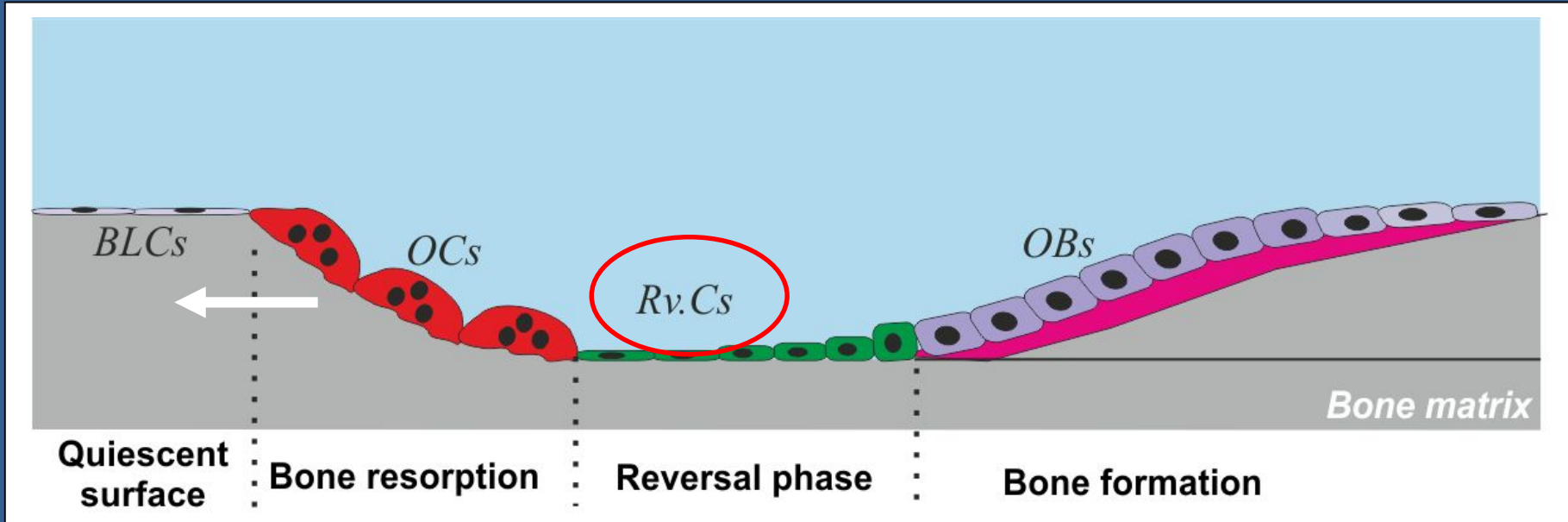
new lessons from cortical bone

Associate professor, PhD

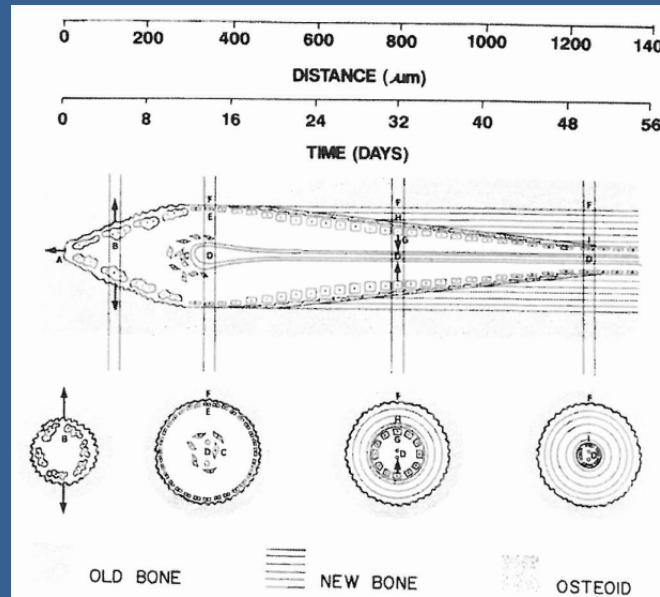
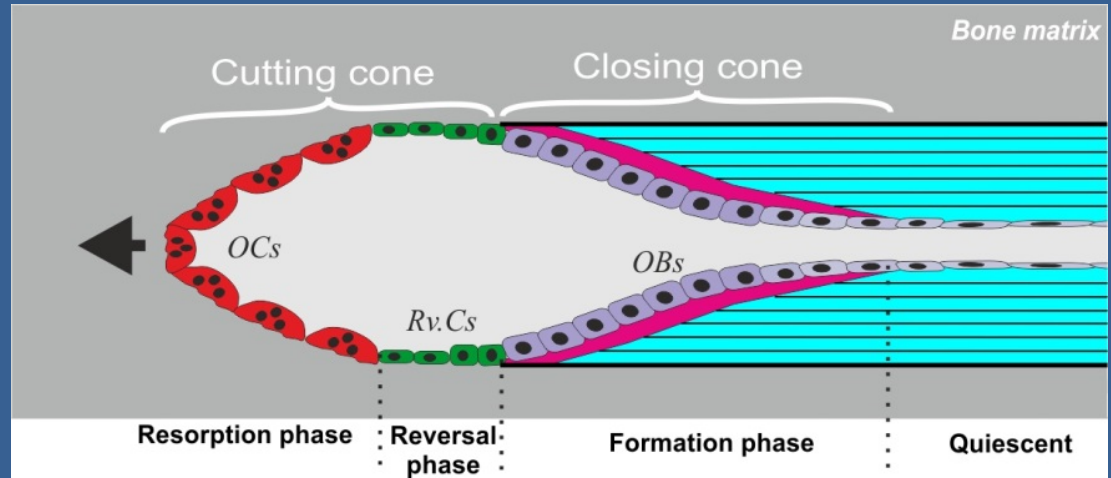
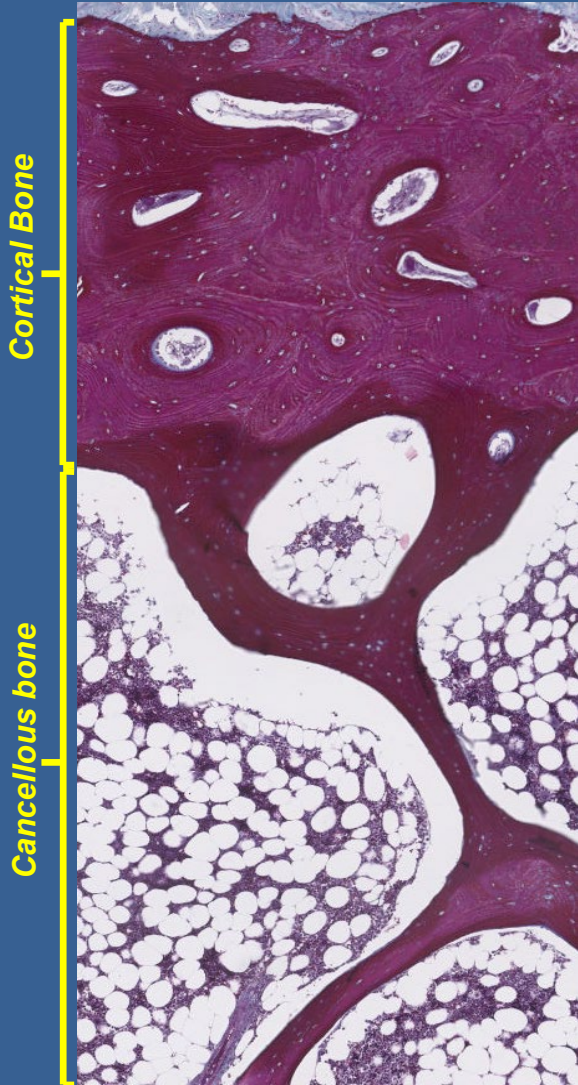
Thomas Levin Geiser Andersen

**Clinical Cell Biology
University of Southern Denmark
Odense University Hospital
Aarhus University**

Human Bone Remodeling: Cellular players of the basic multicellular units (BMUs)



Intracortical bone remodeling

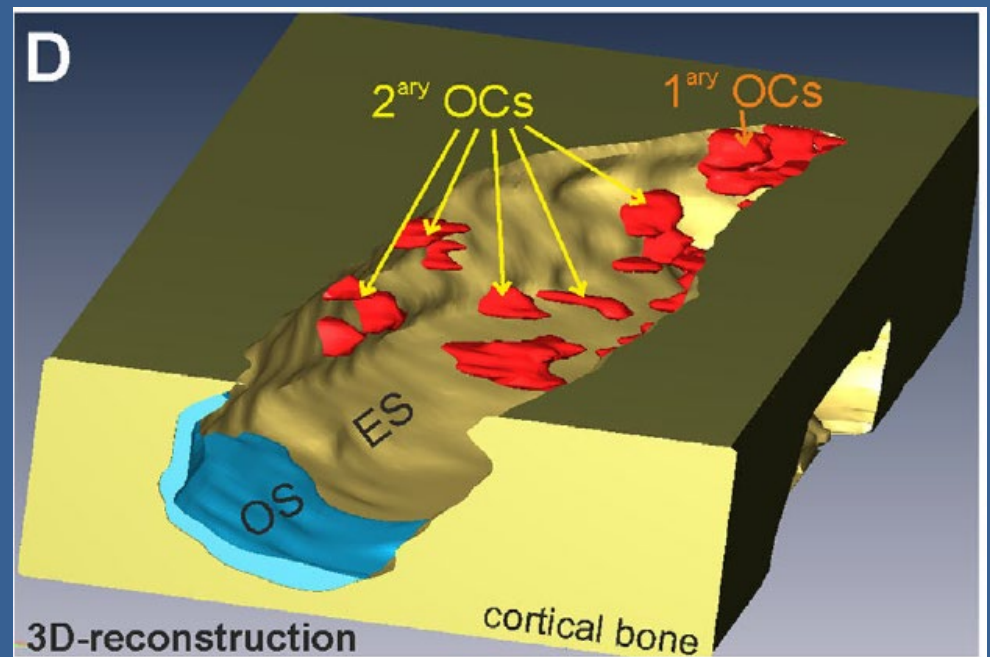
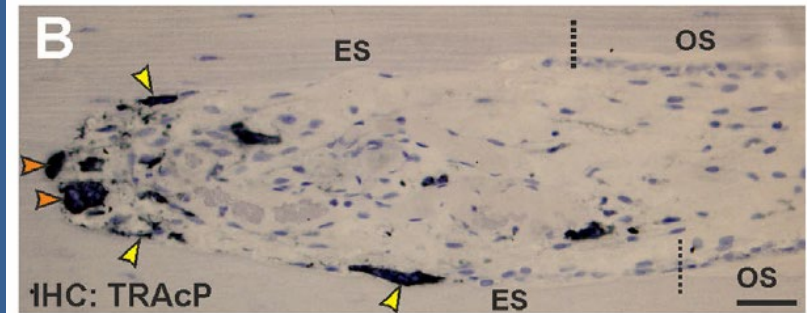
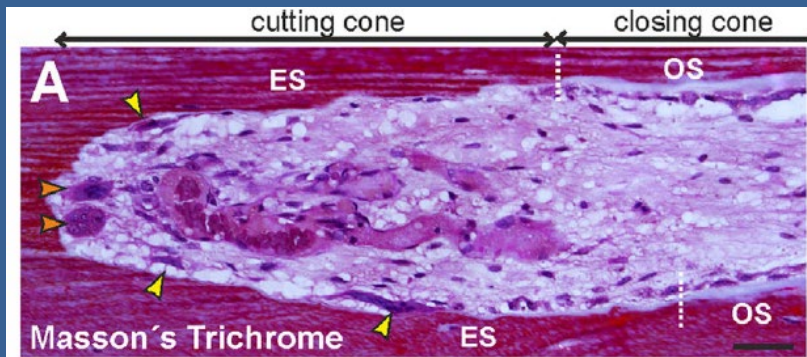
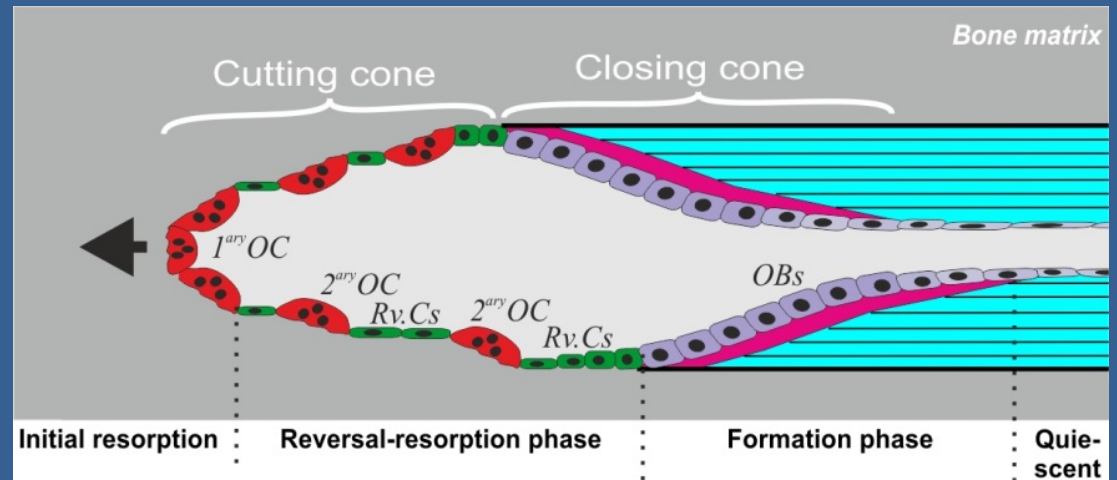


Parfitt AM, 1976 & 1994

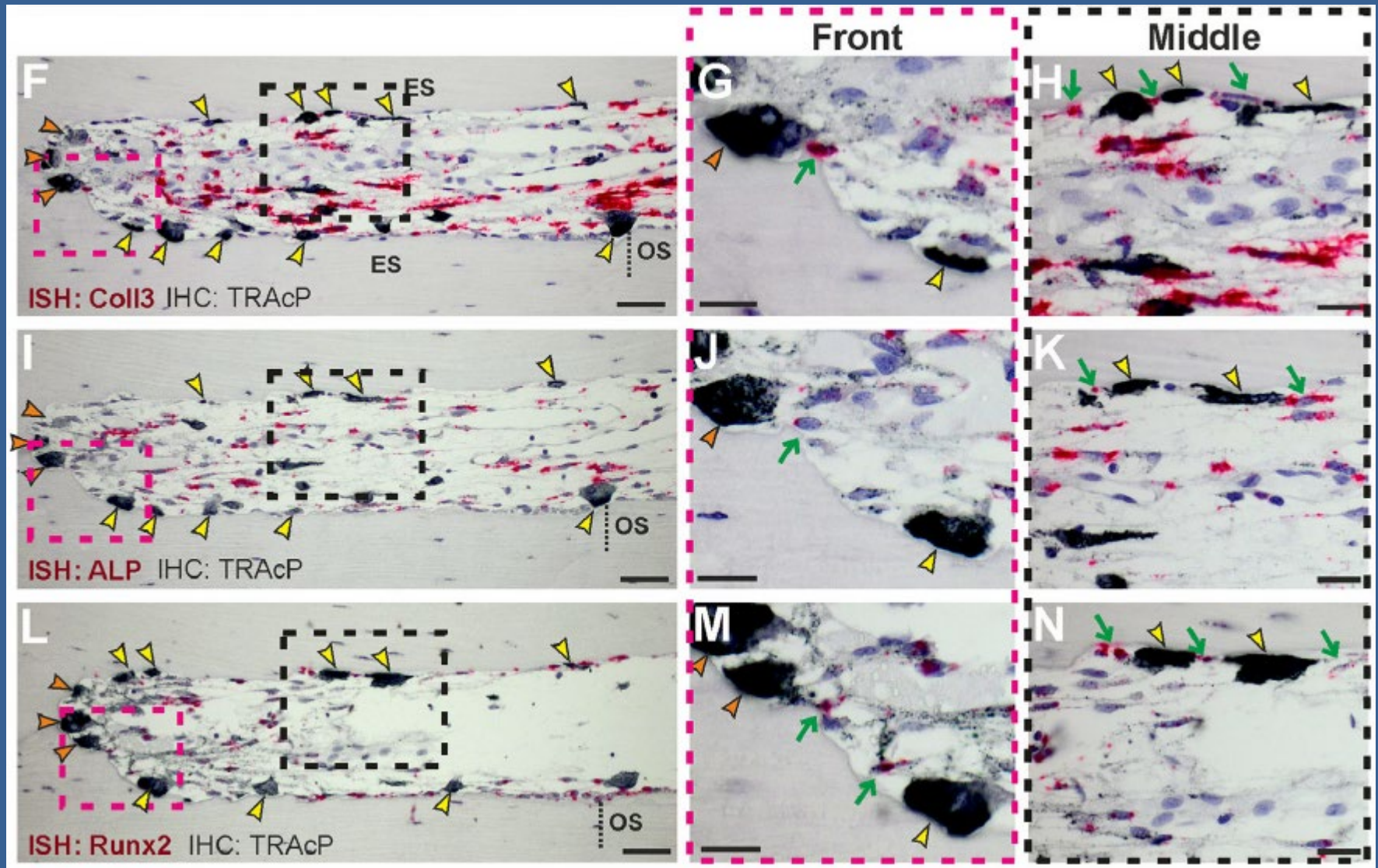
Intracortical bone remodeling



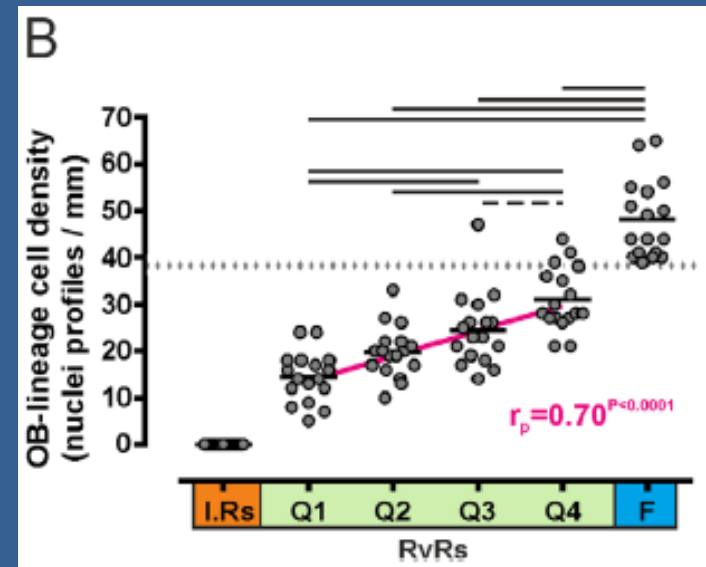
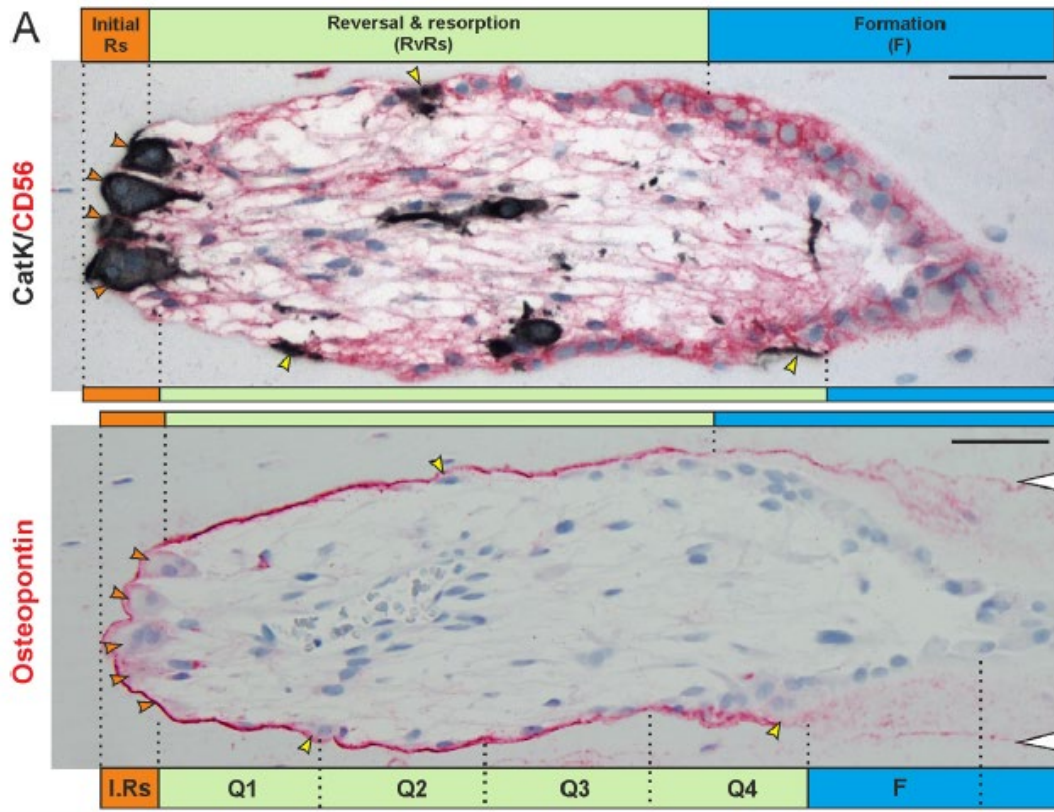
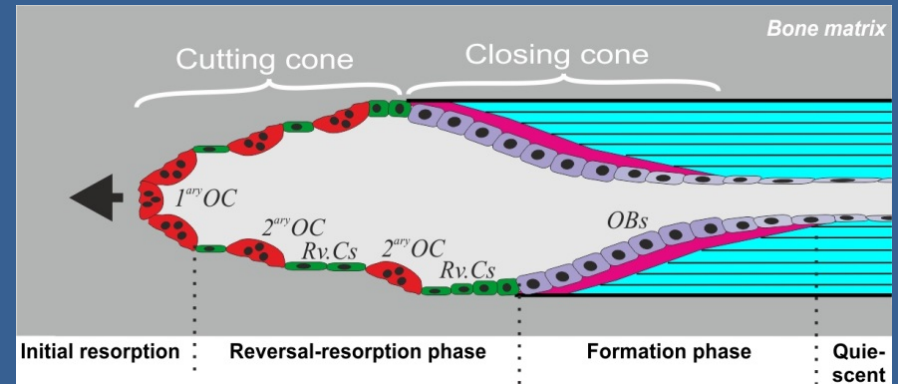
Nicolai E. Lassen



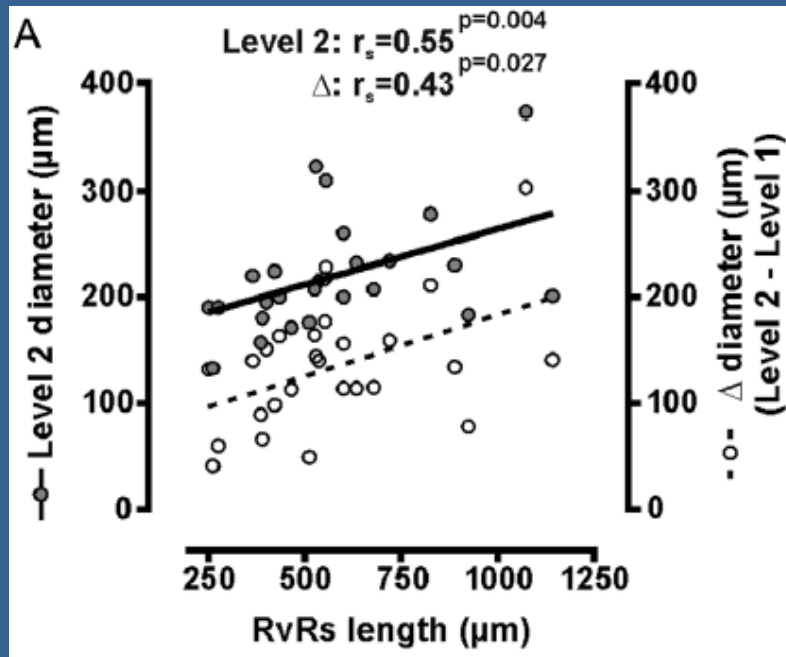
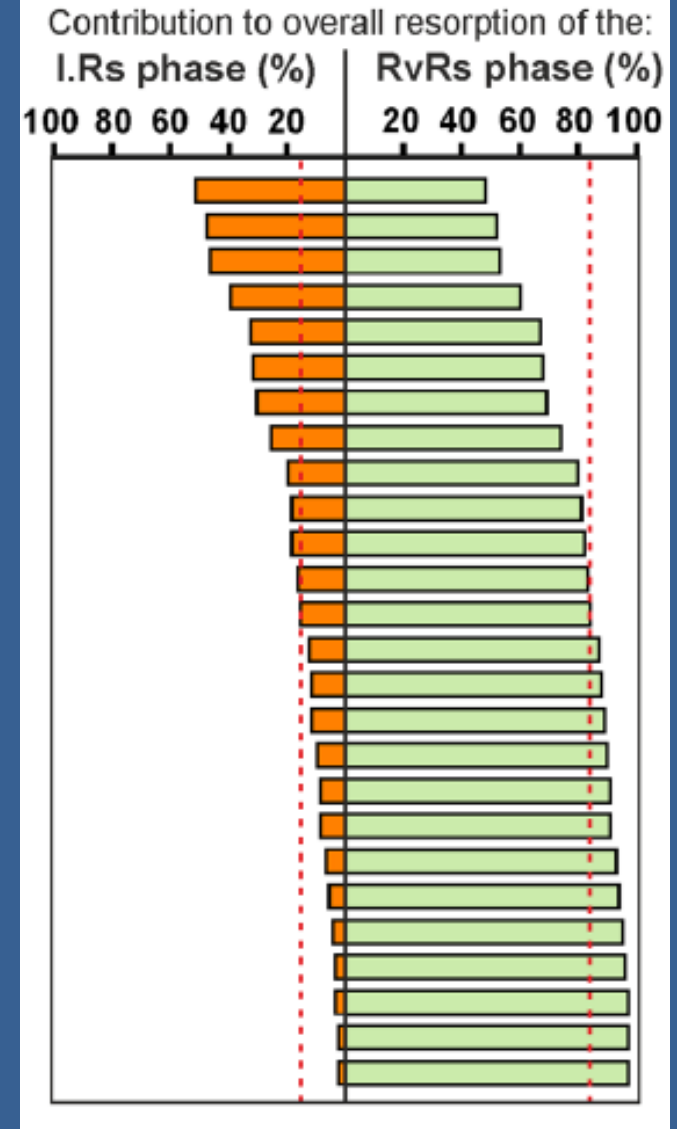
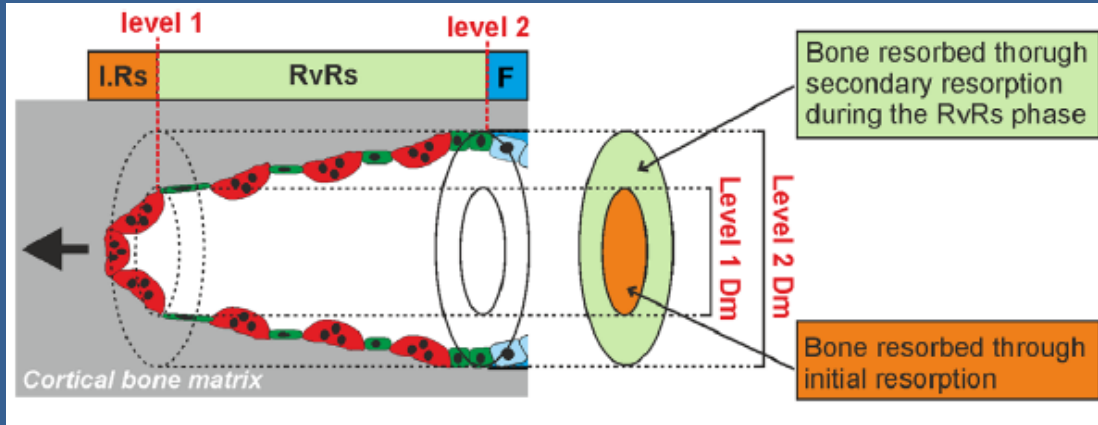
Reversal-resorption phase



Reversal-resorption phase

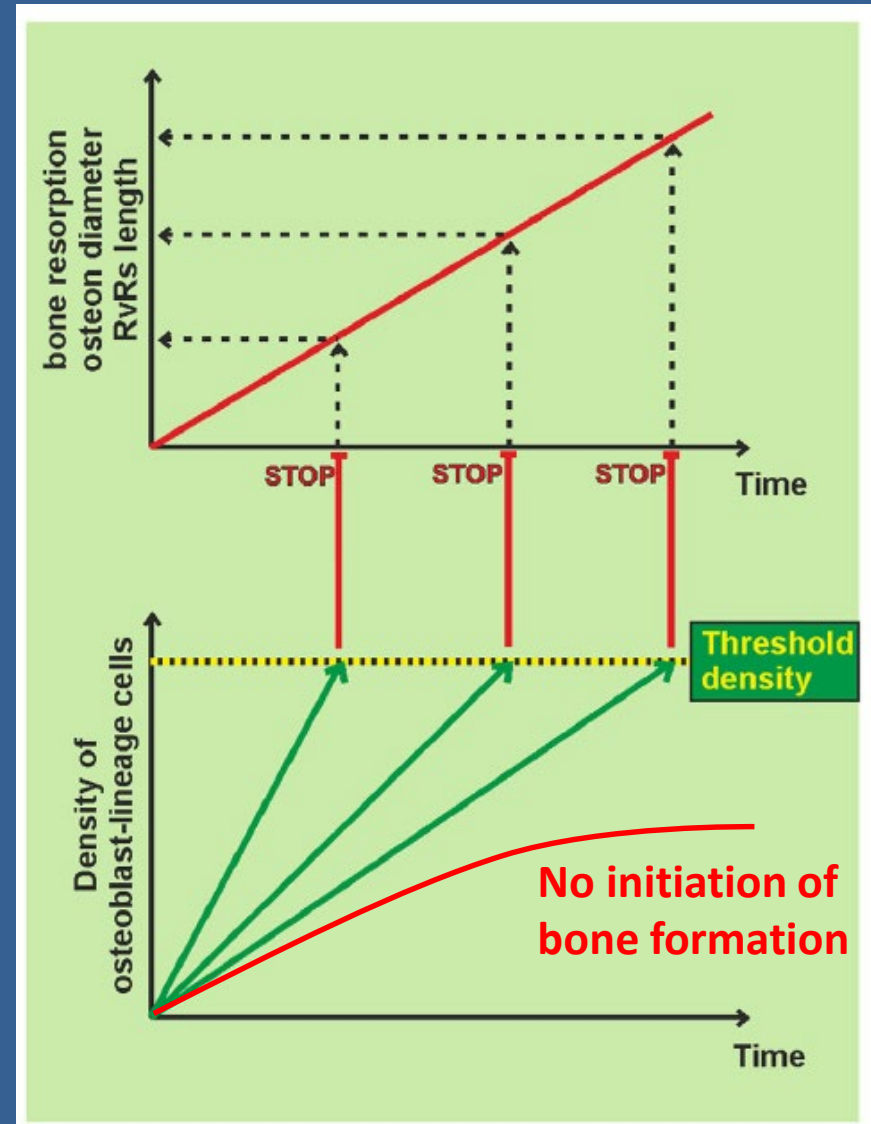
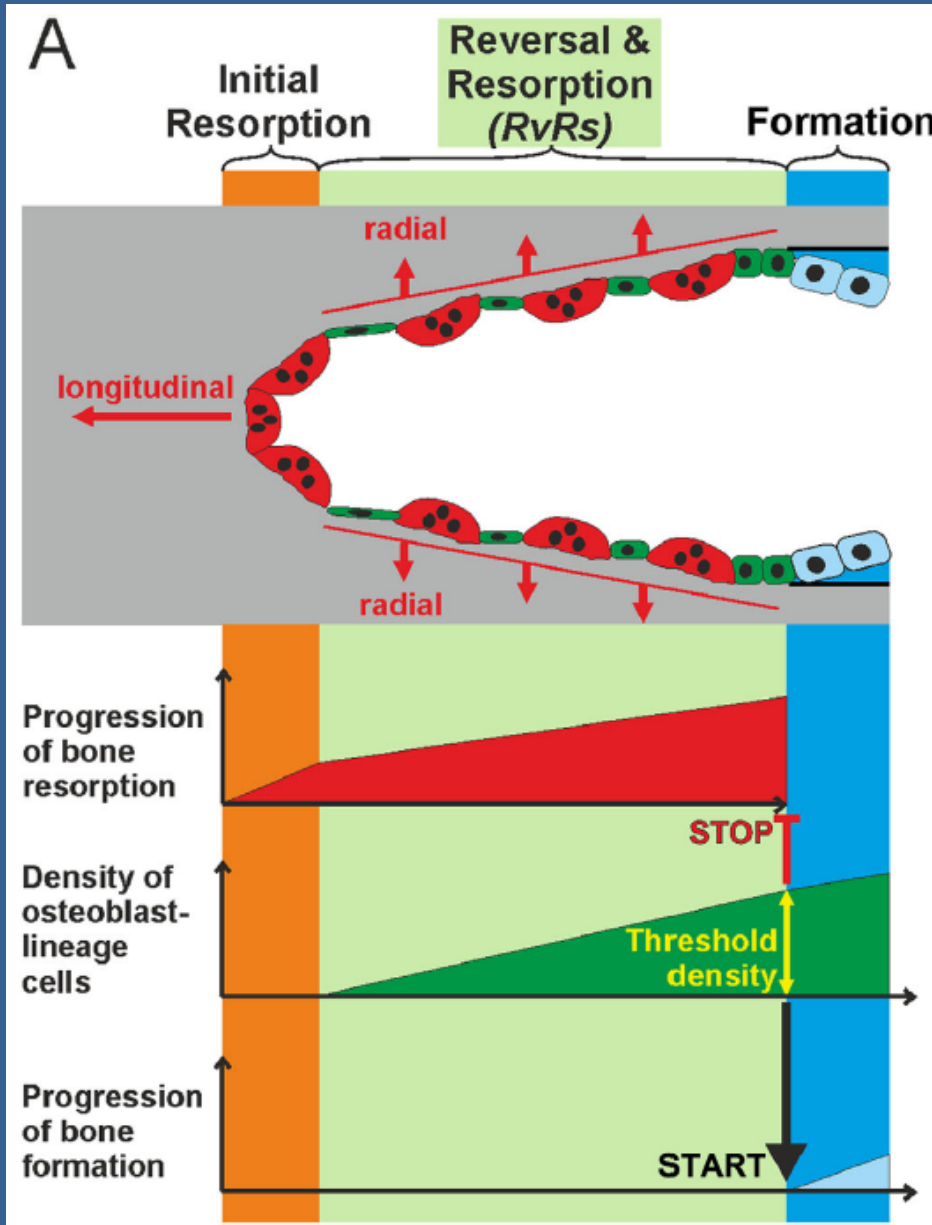


Reversal-resorption phase

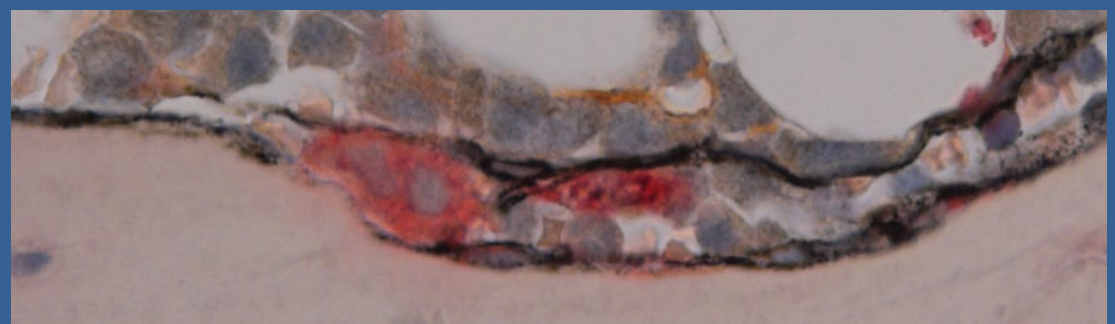
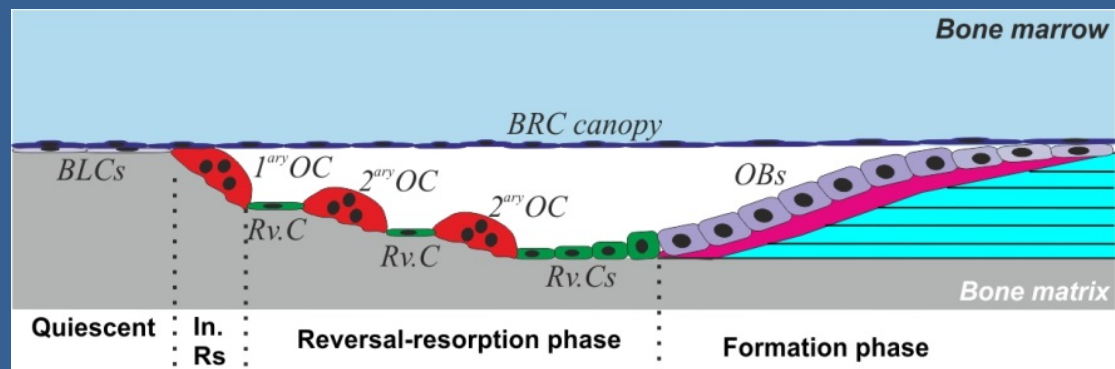
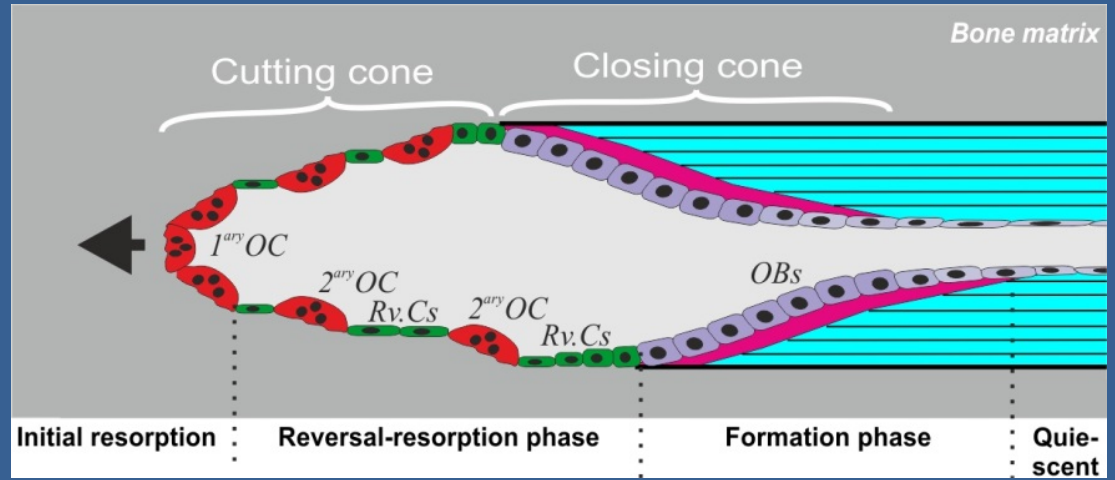
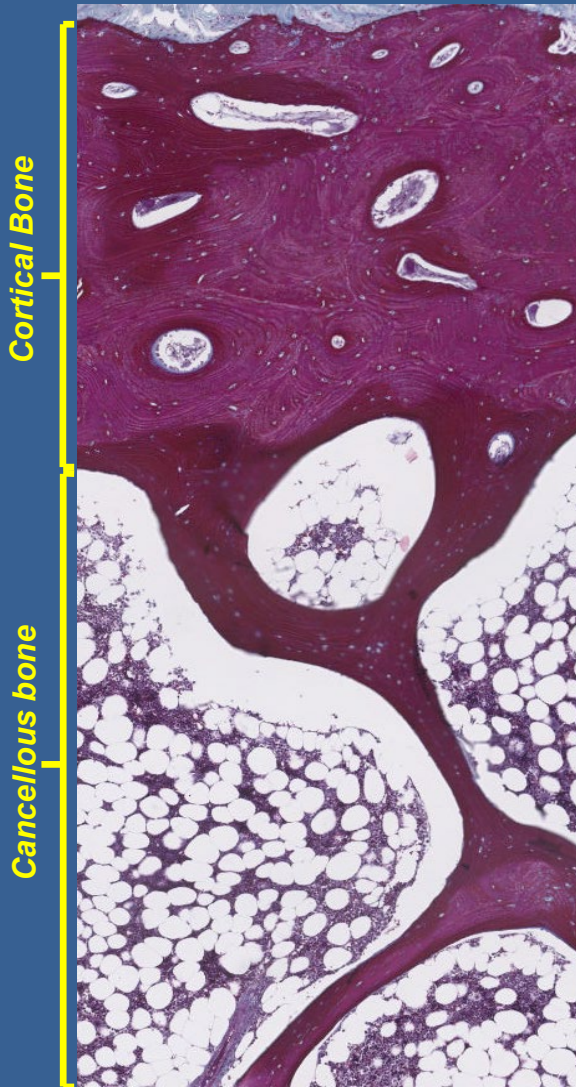


83%

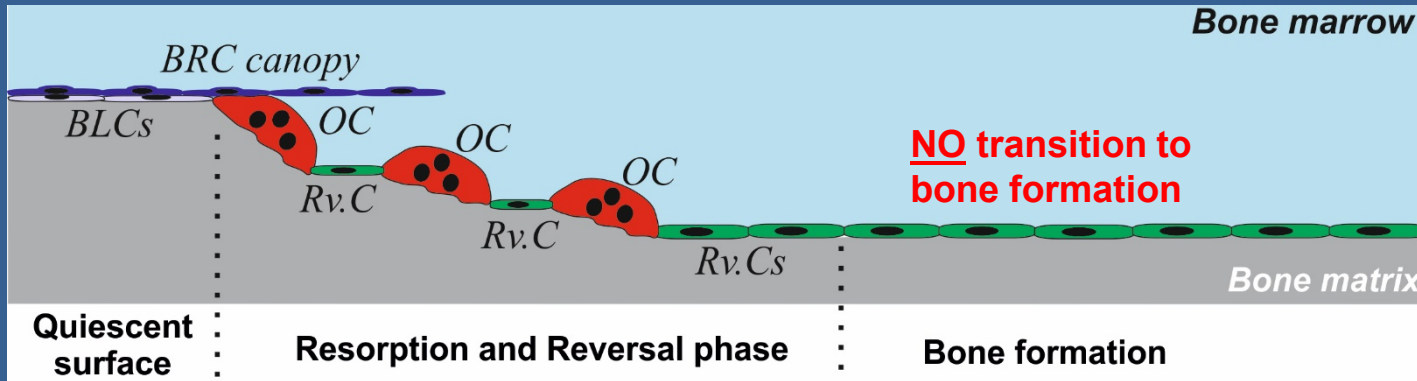
Reversal-resorption phase



Intracortical -> cancellous bone remodeling



Evidence for "arrested" reversal phase

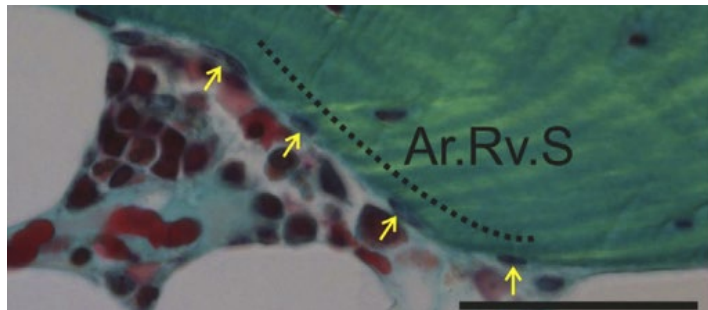
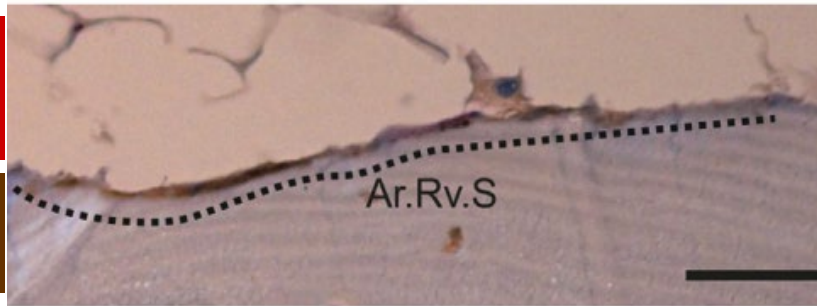


"Arrested" reversal phase:

TRAcP

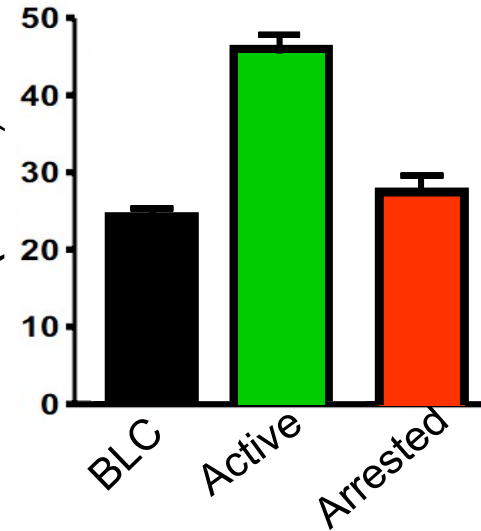
CD56

Masson's Trichrome

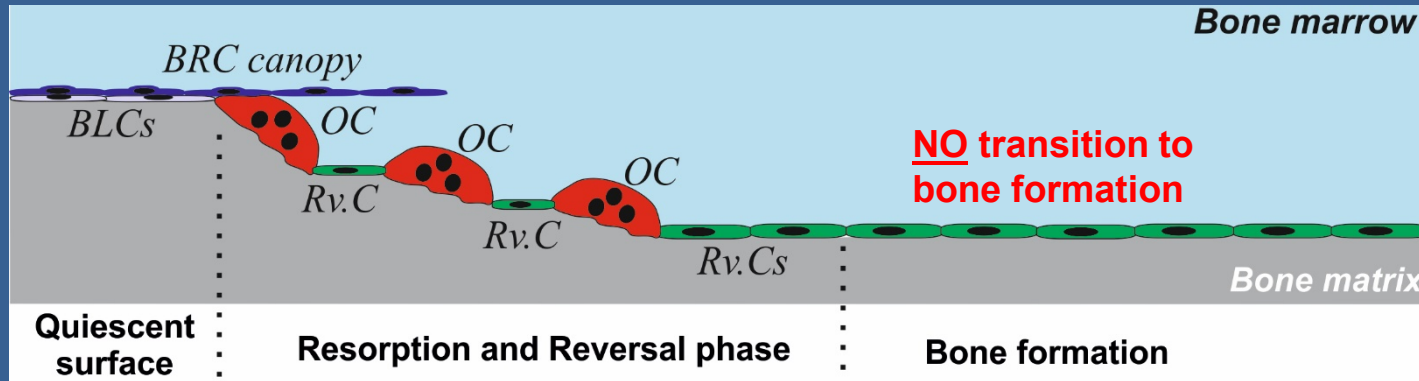


Reversal surfaces without neighboring OCs and/or bone-forming OBs

Nuclei profile density (N/mm)



Evidence for "arrested" reversal phase

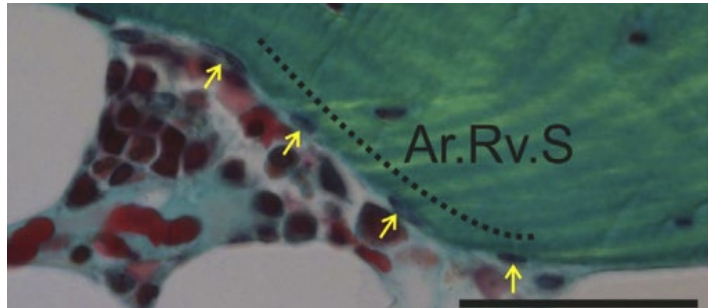
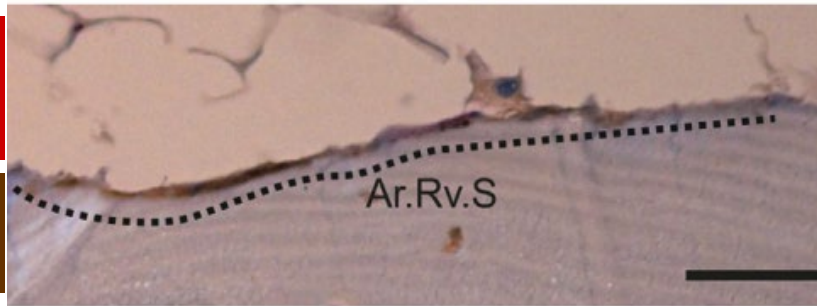


"Arrested" reversal phase:

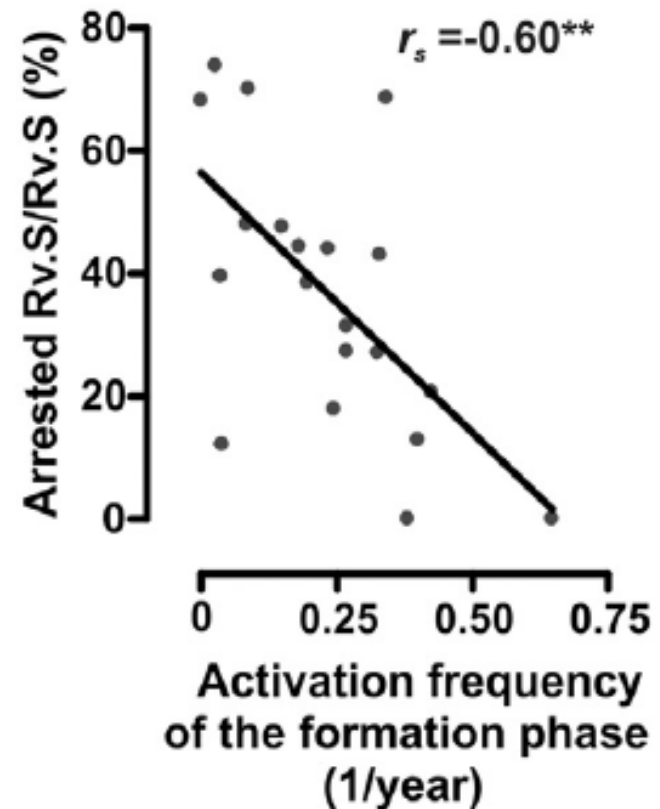
TRAcP

CD56

Masson's Trichrome

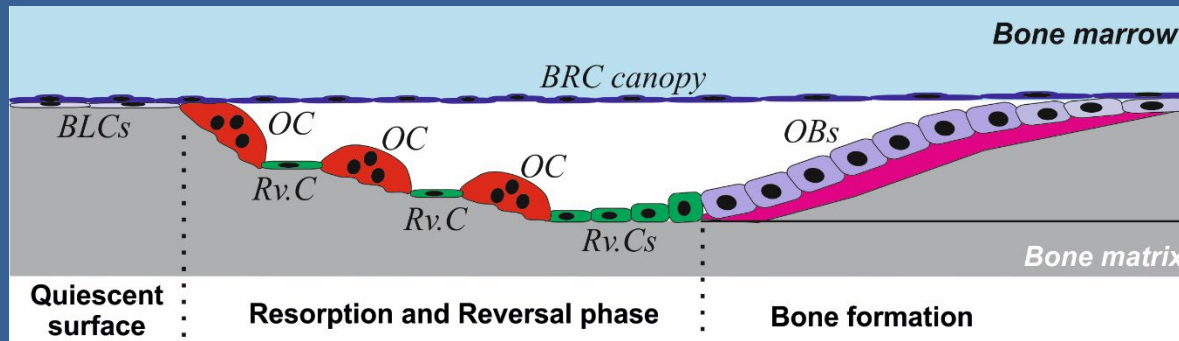


Reversal surfaces without neighboring OCs and/or bone-forming OBs



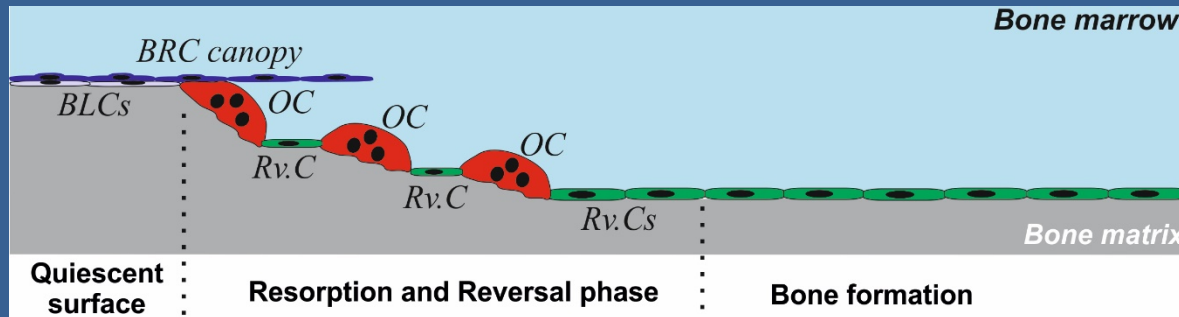
Potential bone multicellular units (BMUs)

Coupled and
Balanced BMU



$\Delta=0$

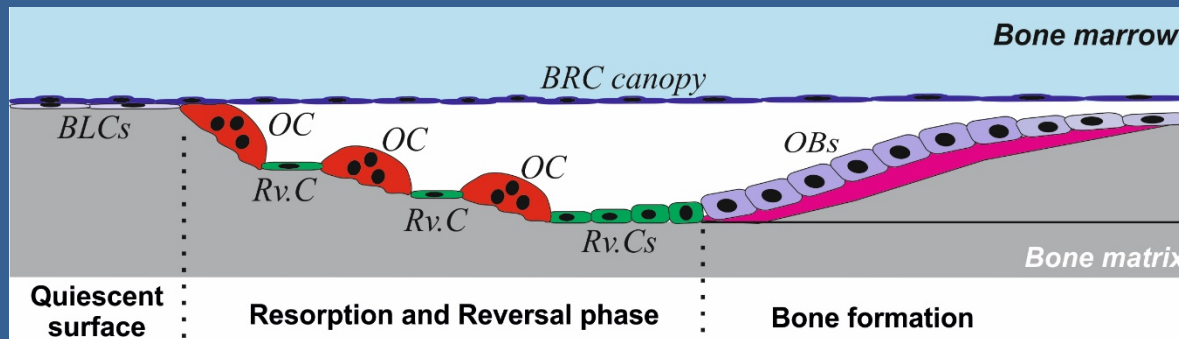
Uncoupled
BMU



$-\Delta$

Bone
loss

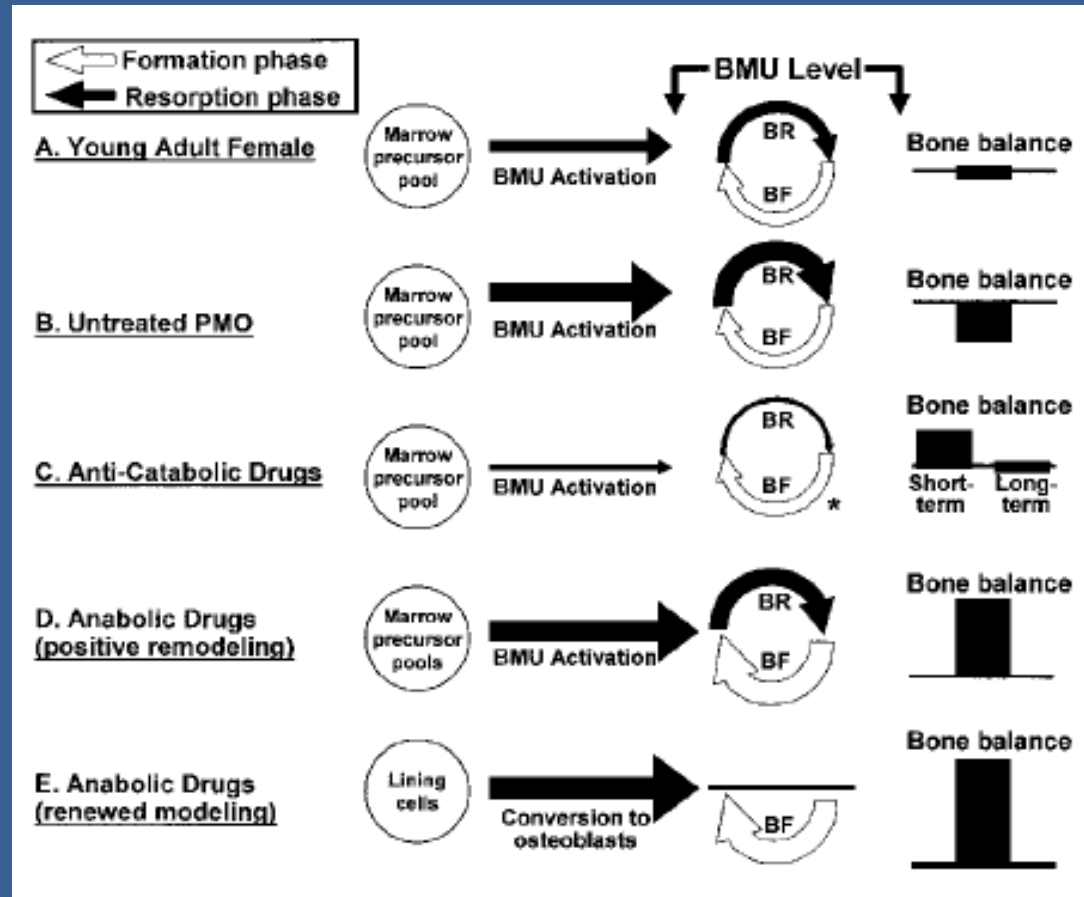
Coupled
but unbalanced
BMU



$I-\Delta$

Classical concept of bone loss

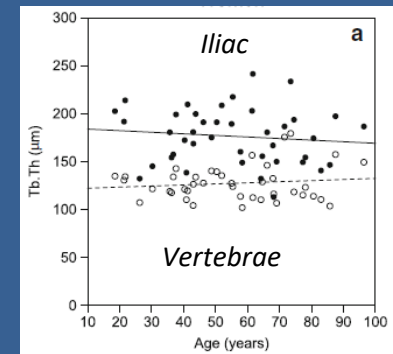
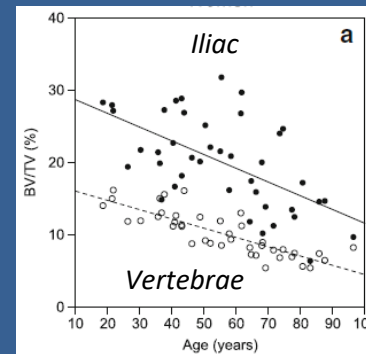
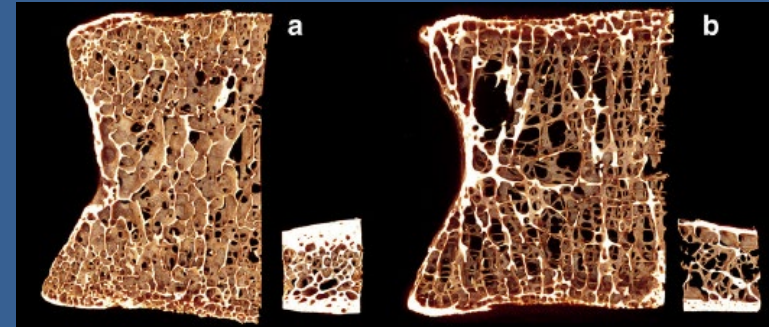
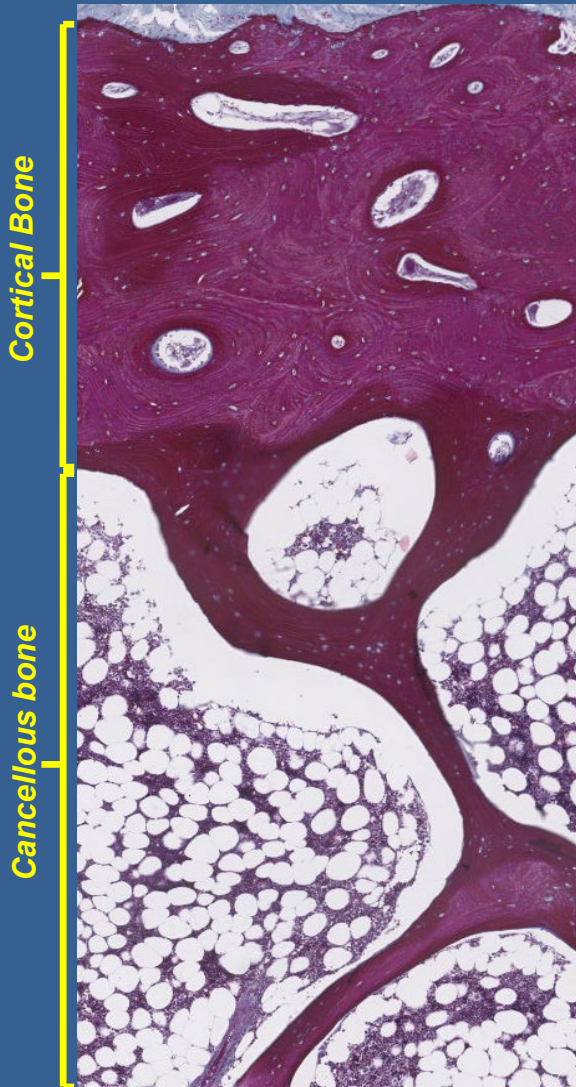
Bone Loss = activation freq. x BMU balance



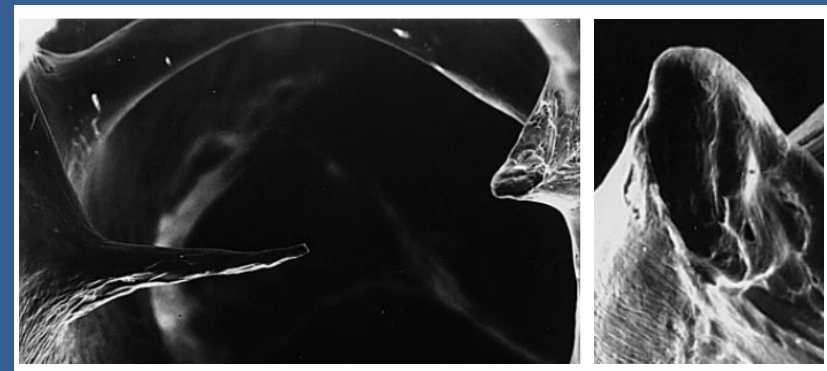
$$\Delta BS (\mu\text{m}/\text{y}) = \text{Ac.f} (\text{/y}) \times (\text{W.Th} - \text{E.De}) (\mu\text{m})$$

Cancellous bone loss

cancellous bone



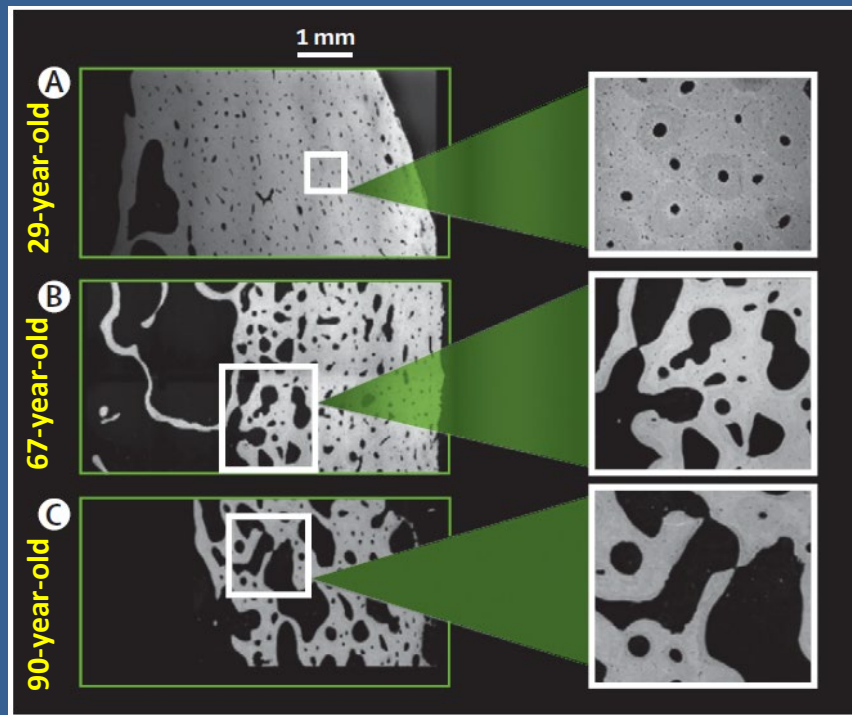
Thomsen JS et al. Bone, 2015



Mosekilde L, Z Rheumatol, 2000

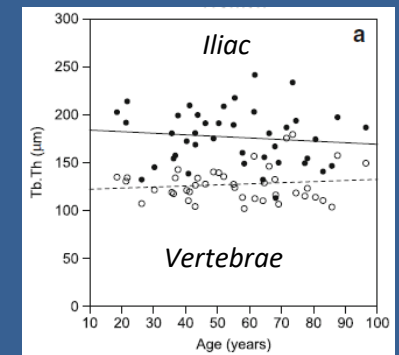
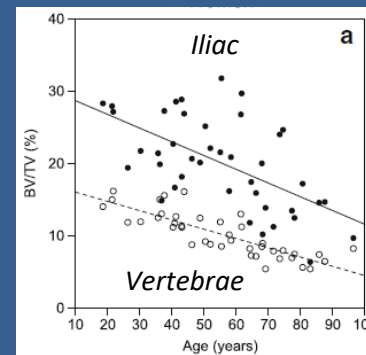
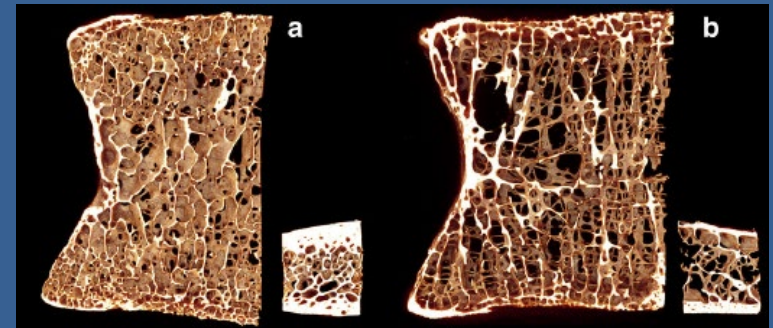
Cortical versus cancellous bone loss

cortical bone

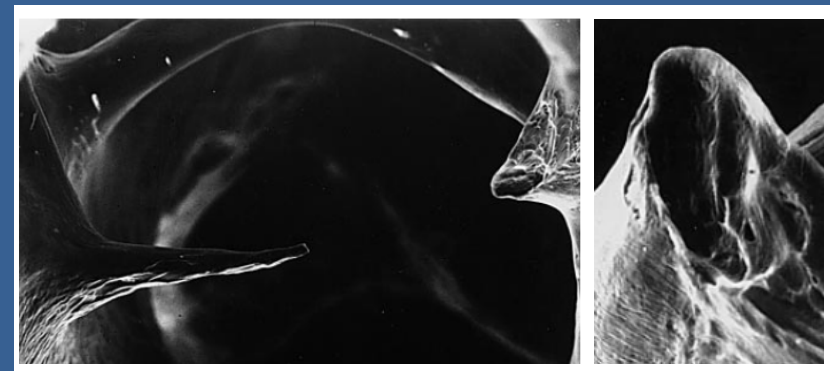


Zebaze RMD et al. *Lancet*, 2010

cancellous bone



Thomsen JS et al. *Bone*, 2015

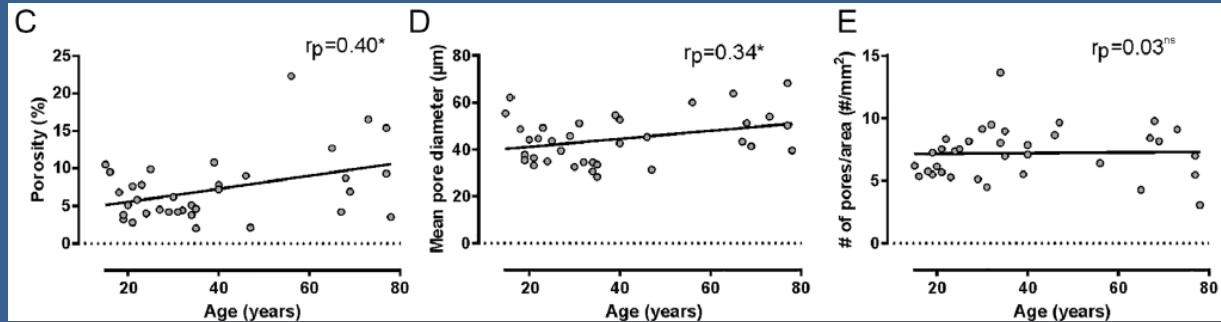
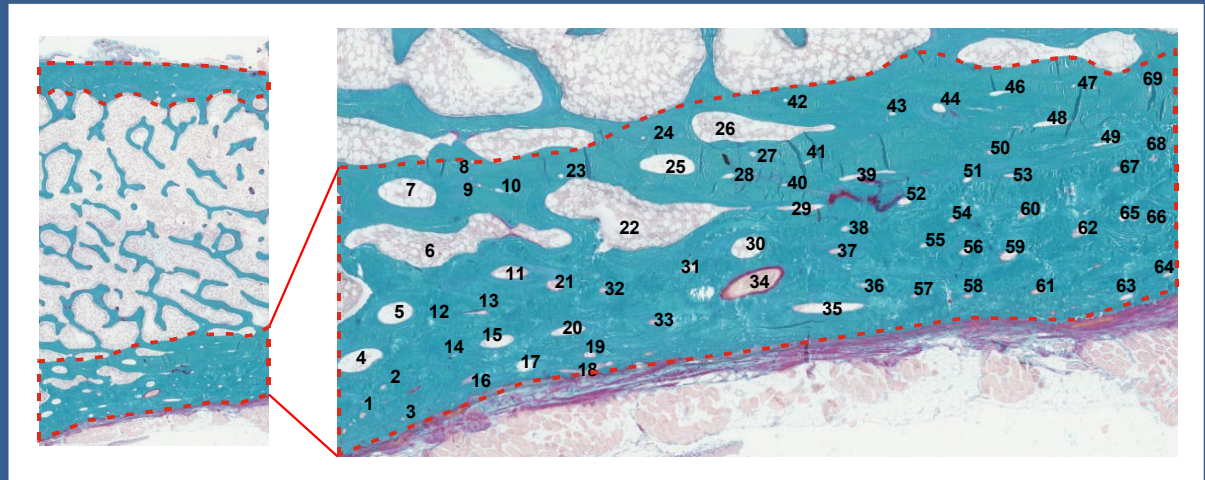


Mosekilde L, *Z Rheumatol*, 2000

Cortical bone loss during aging

Cortical Porosity = bone loss

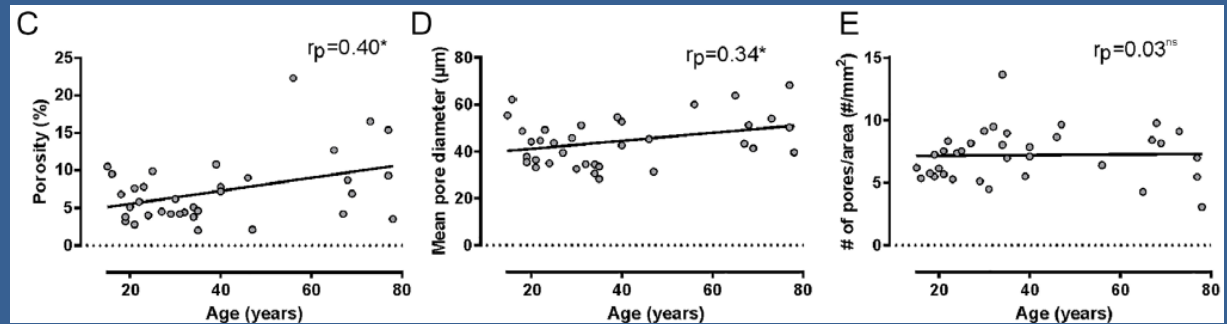
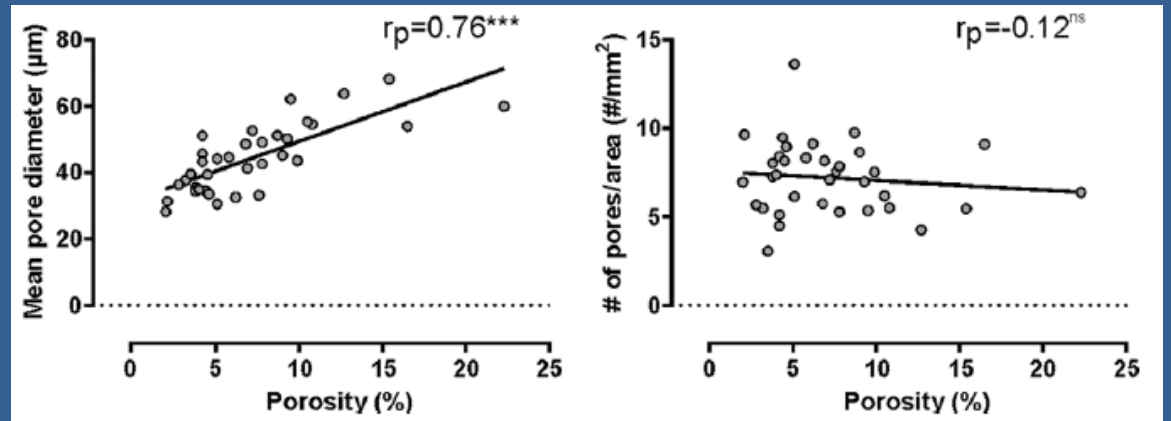
age



Cortical bone loss during aging

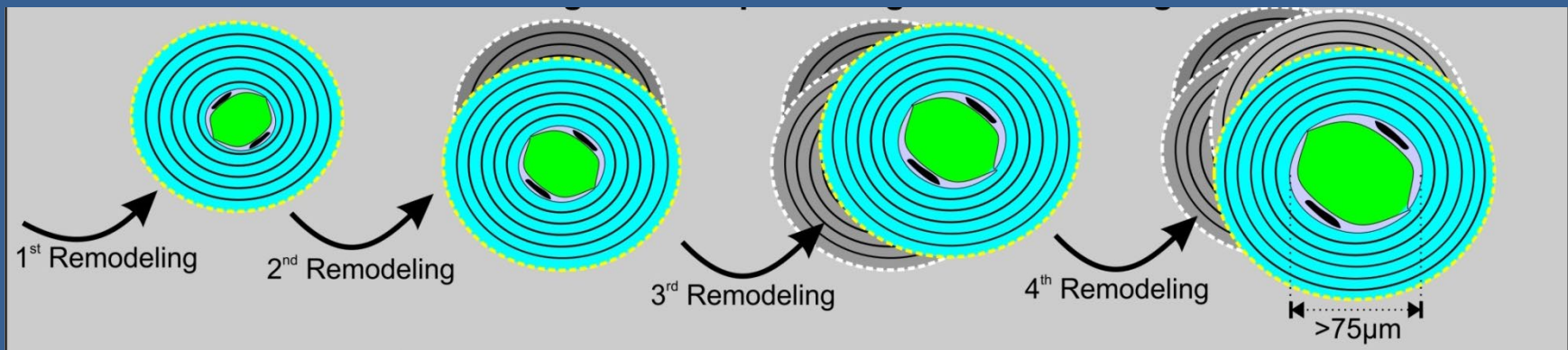
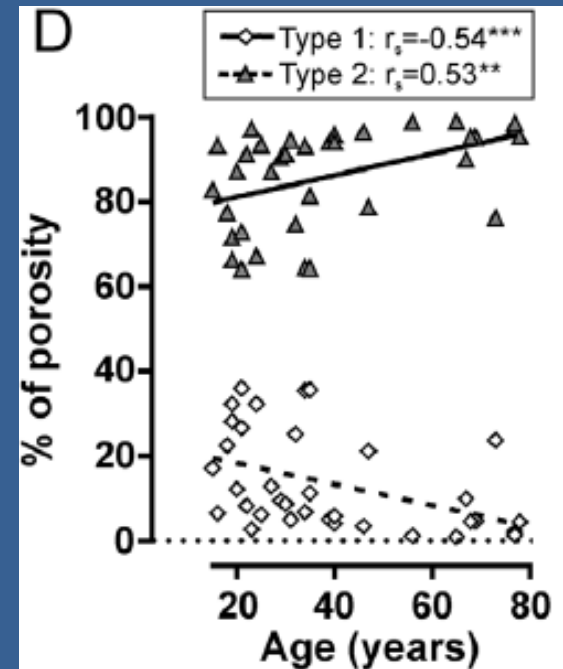
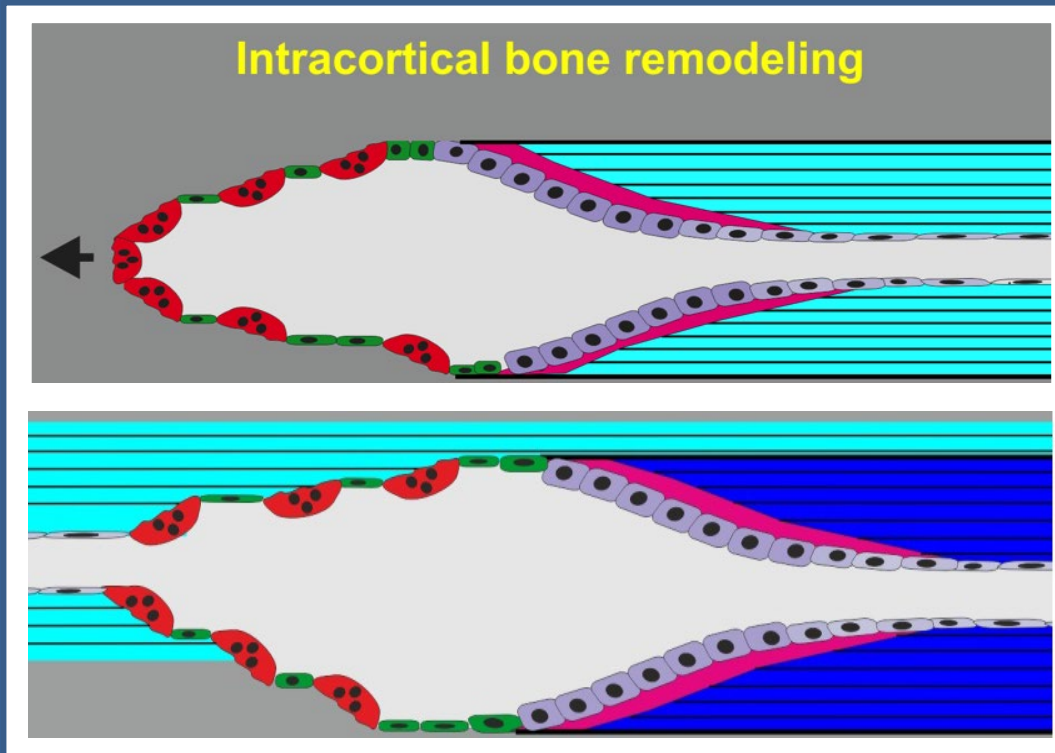
Cortical Porosity = bone loss

age



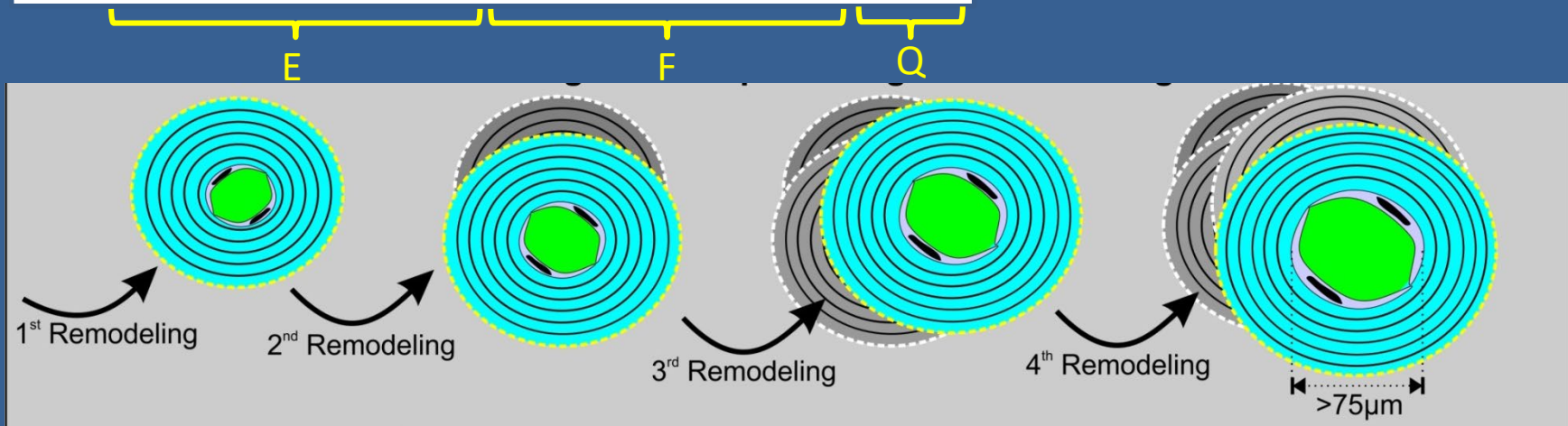
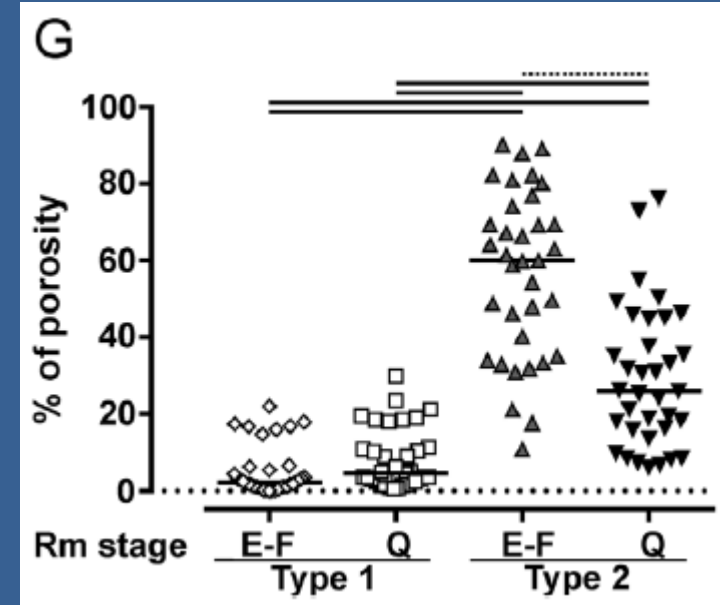
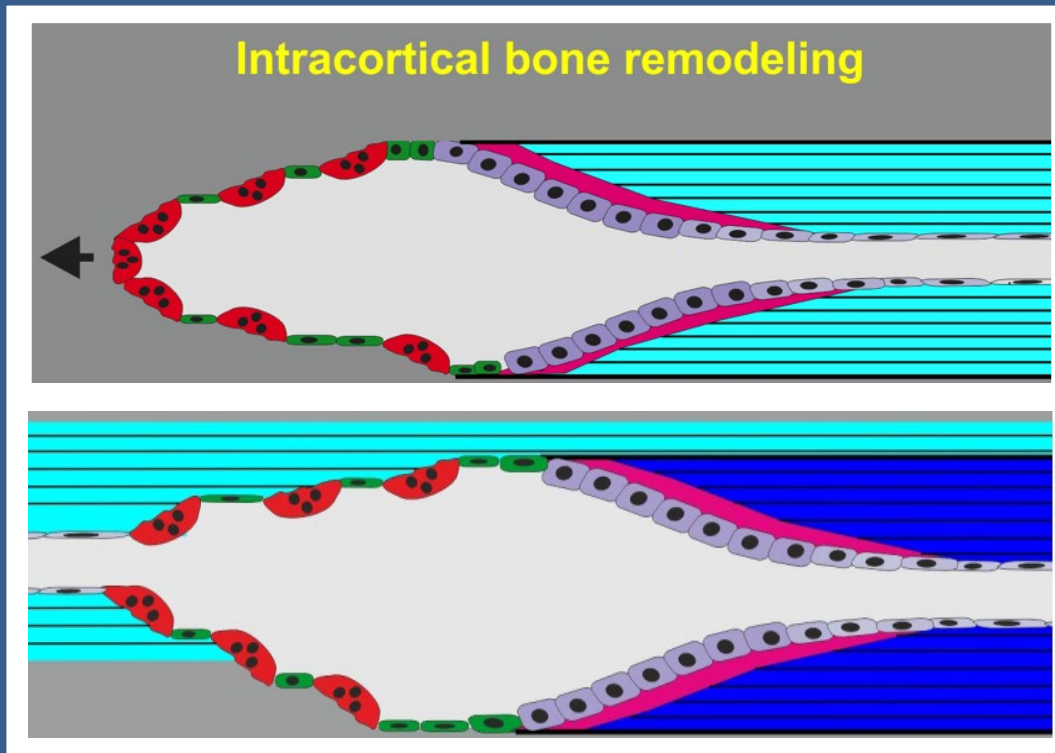
Intracortical remodeling during aging

Type 1
Type 2



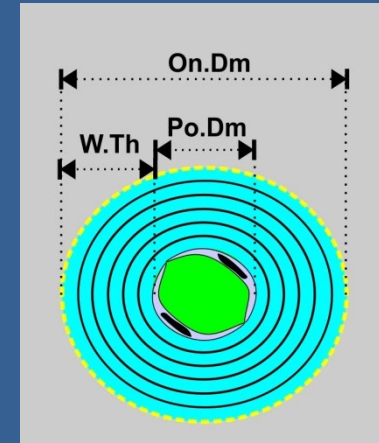
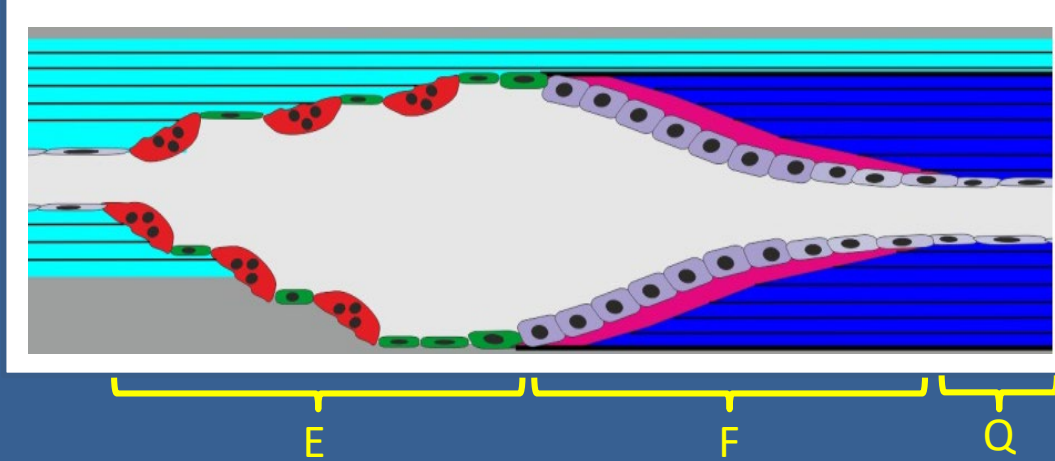
Intracortical remodeling during aging

Type 1
Type 2

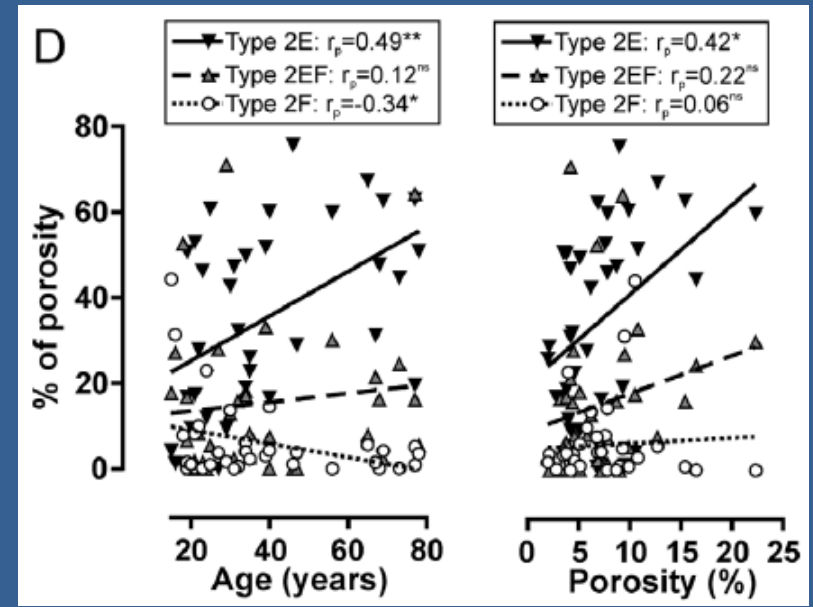
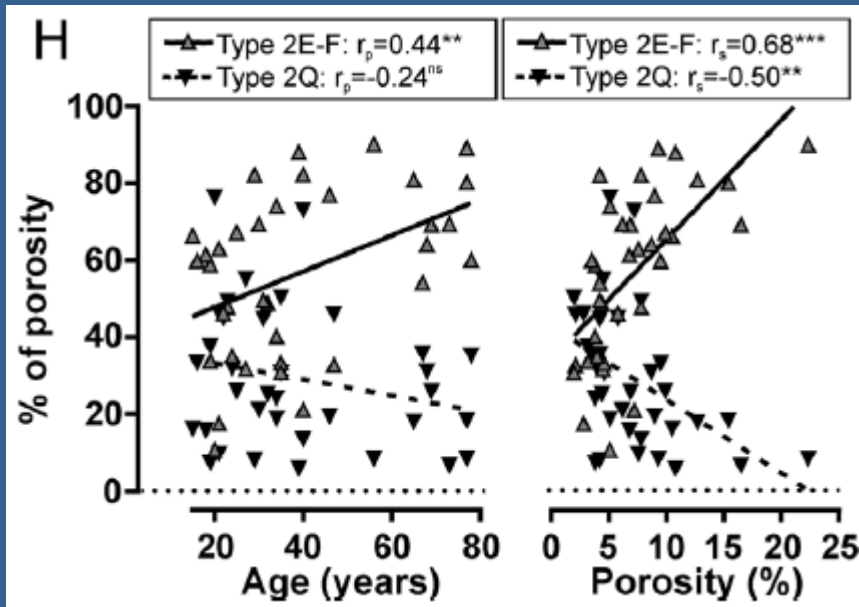


Intracortical remodeling during aging

Type 2

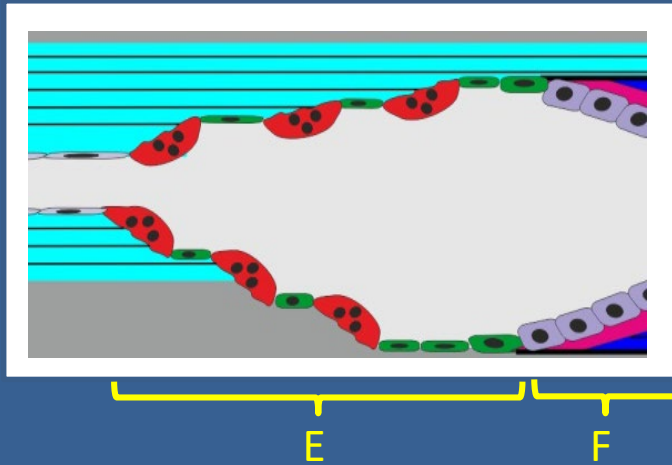


No change with age

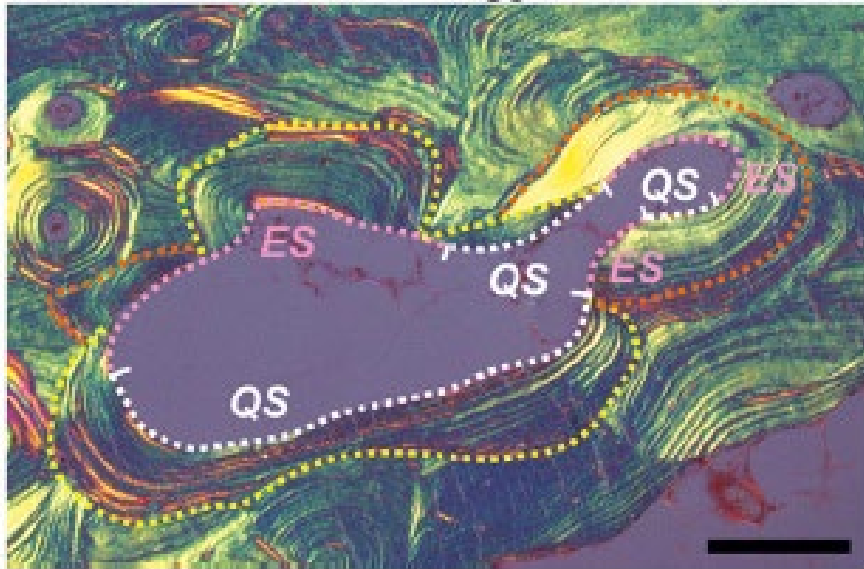


Intracortical remodeling during aging

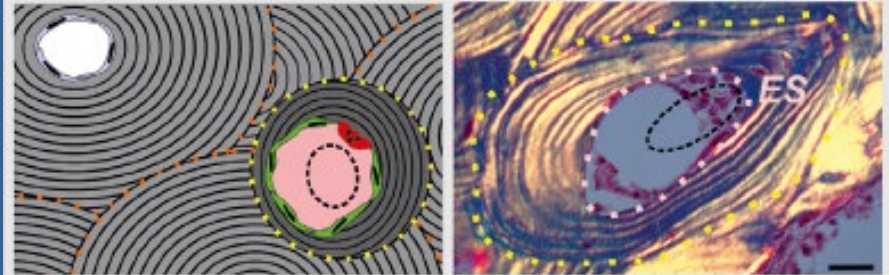
Type 2



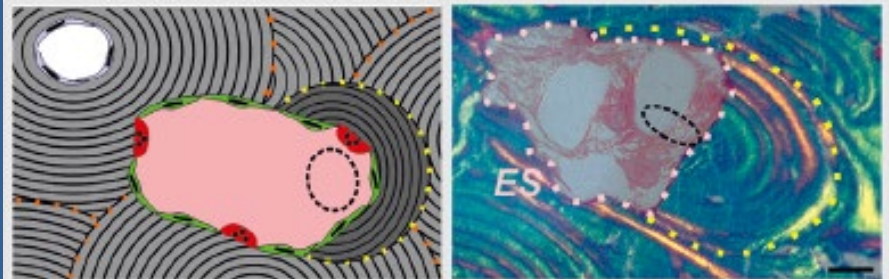
B Type 2E_{co} pore



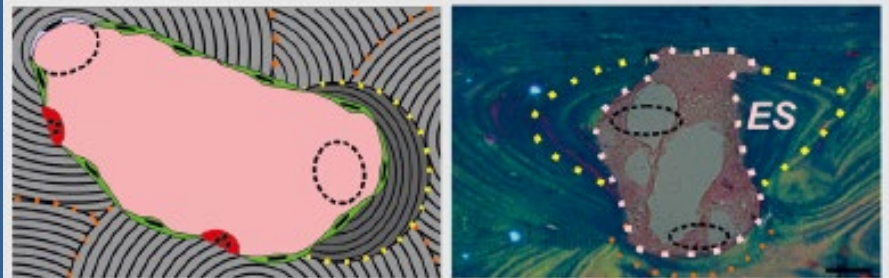
Eroded intra-osteonal type 2 pore (Type 2E_{IN}) (within the cement line of existing parent osteon)



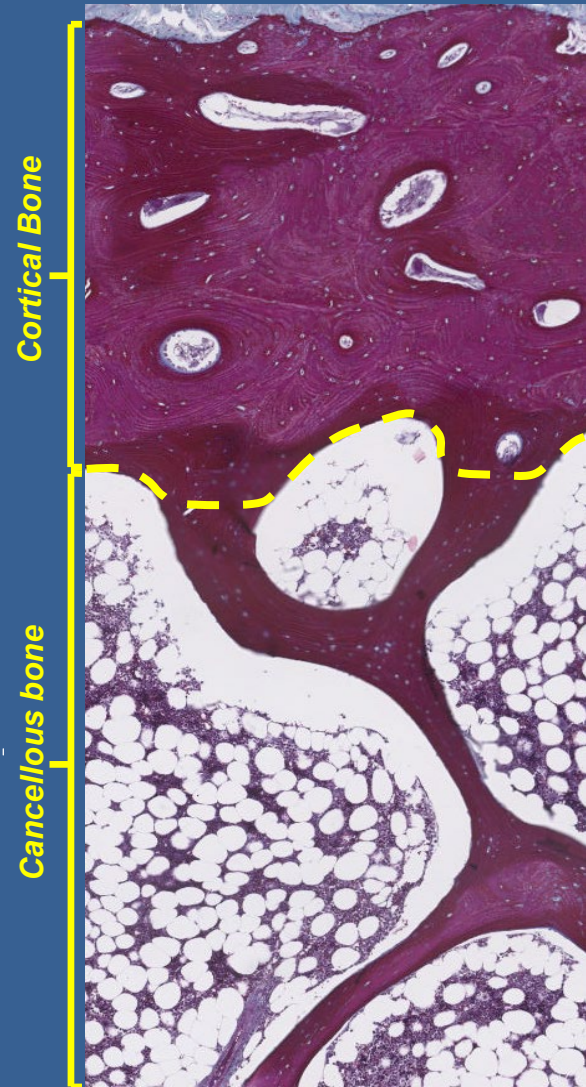
Eroded cement-line breaking type 2 pore (Type 2E_{BK}) (breaking the cement line of existing parent osteon)



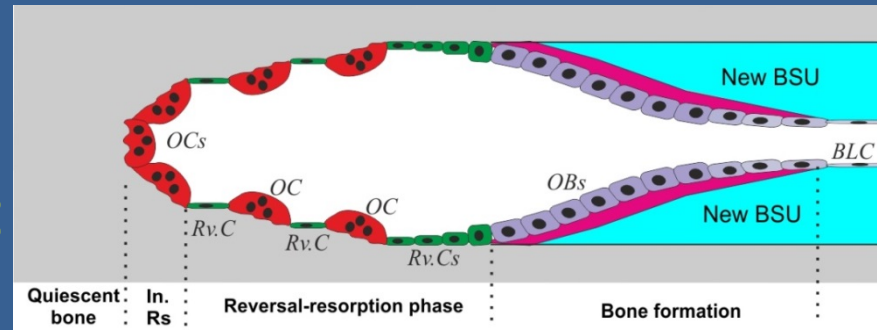
Eroded osteon coalescing type 2 pore (Type 2E_{co}) (overlapping with the pore of two or more existing parent osteons)



Intracortical remodeling during aging

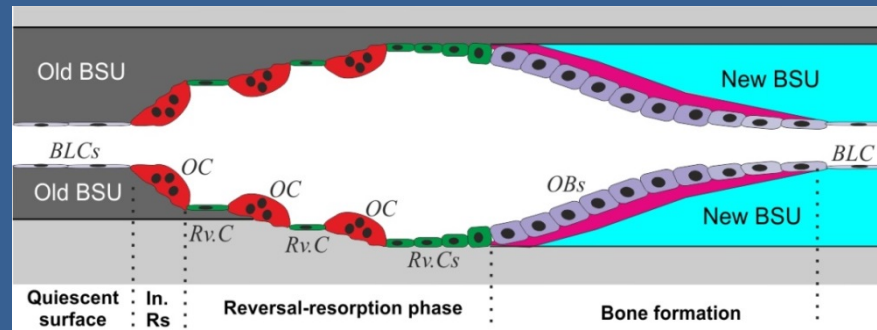


Type 1

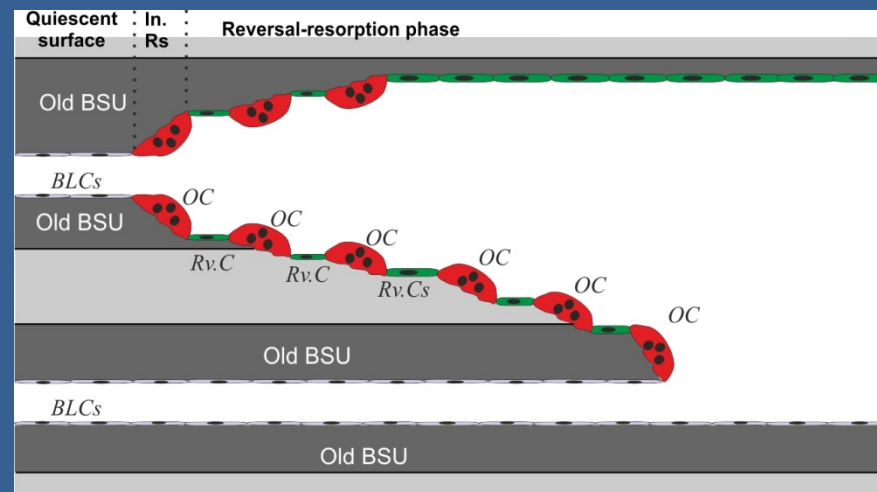


II No change with age

Type 2

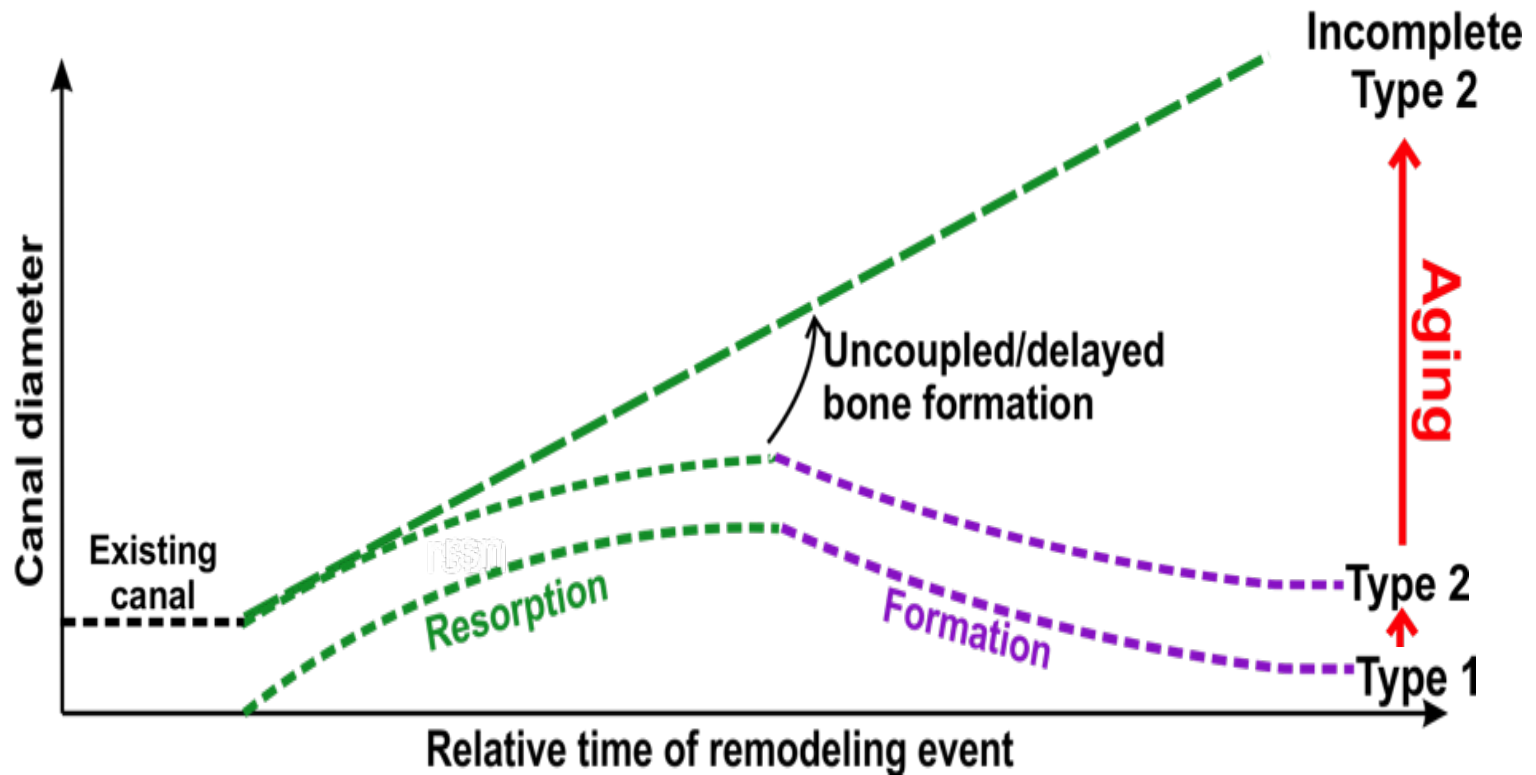


Age

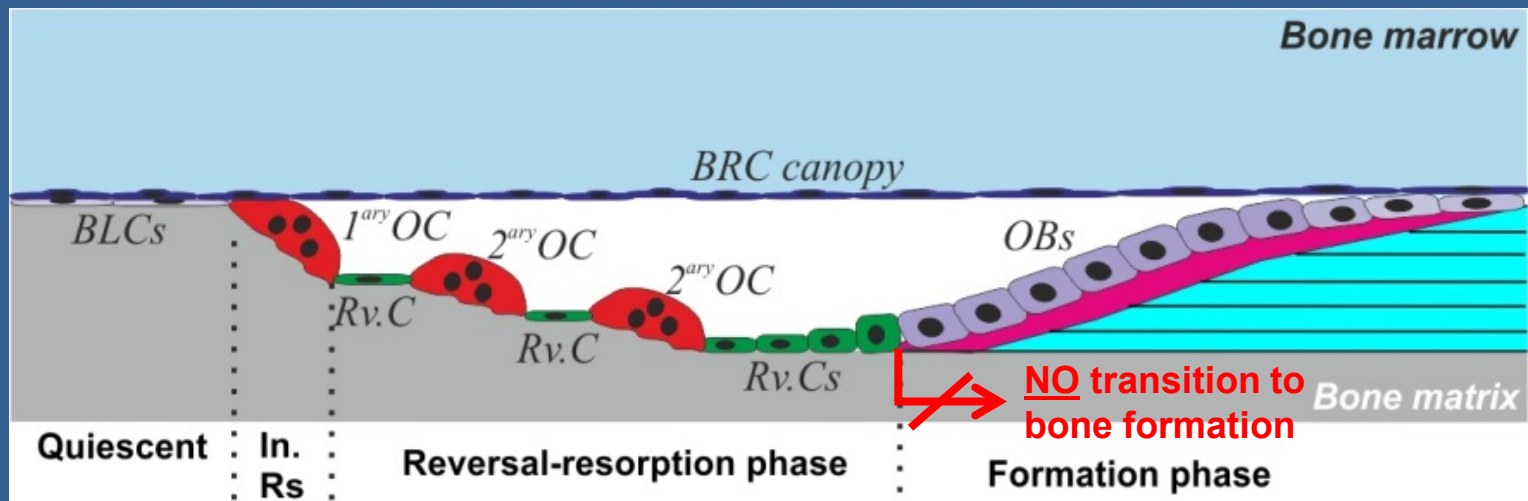
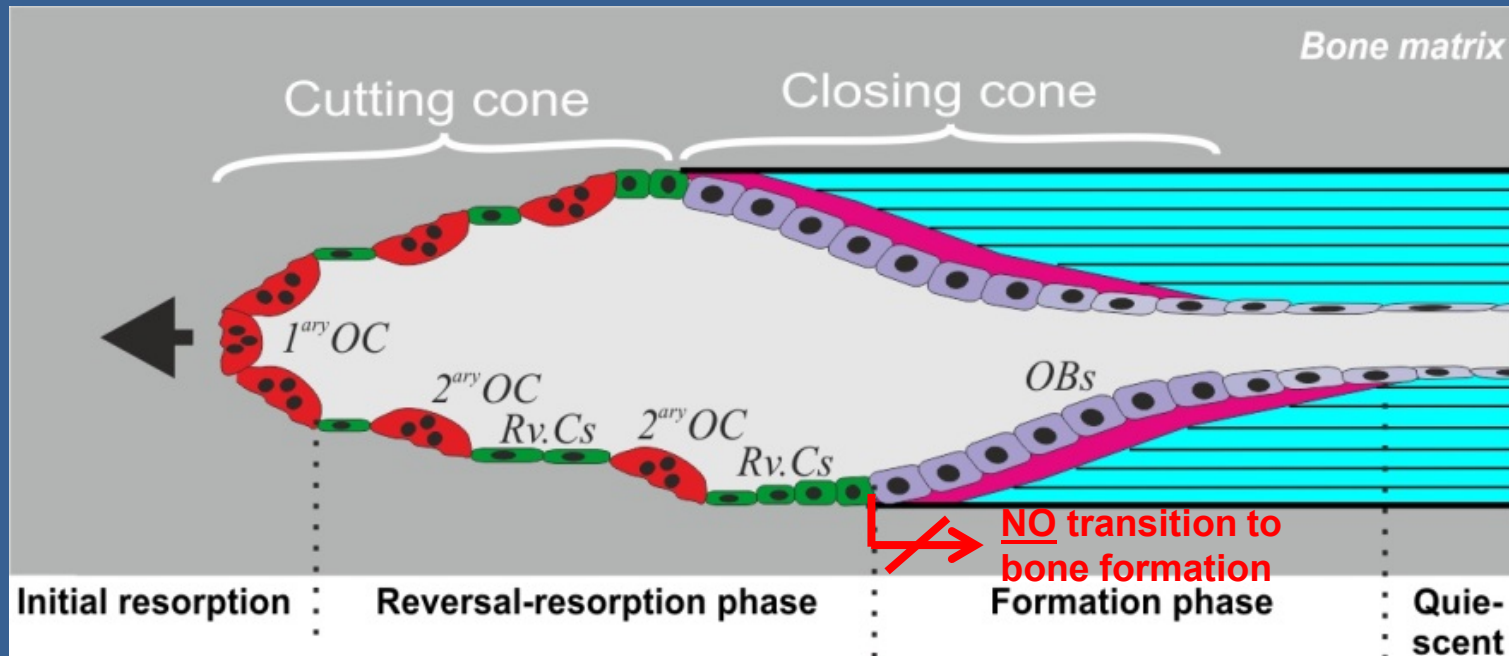


Age

Intracortical remodeling during aging



Cellular mechanism of bone loss



Acknowledgements



Christina Andreasen
Nicolai Lassen
Jean-Marie Delaisse
Ming Ding
Kaja Rau Laursen
Birgit MacDonald



Jesper S. Thomsen
Annemarie Brüel
Ellen M. Hauge
Birgitte Jul Kiil
Jette Barlach
Søren Harving



Lydia P. Bakalova
Mariana E. Kersh



Bram von der Eerden
Hans von Leeuwen

Funding:

The Velux Foundation (VELUX34368) and the Danish Southern Region Research Grant (15/24851)