Bone Cell Biology

David W. Dempster, PhD
Professor of Clinical Pathology
Columbia University

Bone Remodeling

"The skeleton, out of site and often out of mind, is a formidable mass of tissue occupying about 9% of the body by bulk and no less than 17% by weight. The stability and immutability of dry bones and their persistence for centuries and even millions of years after the soft tissues have turned to dust give us a false impression of bone during life. Its fixity after death is in sharp contrast to its ceaseless activity during life."

A. Cooke, Lancet 1955

Christian Cemetery, Nordby, Denmark, 1050-1250 A.D.
Poulsen et al, Bone 2001

Cancellous and Cortical Bone

Remodeling Participates in Mineral Homeostasis

Remodeling Maintains Mechanical Strength

The Remodeling Cycle

- Resorption
- Reversal
- Resting
- Formation
Osteoclast

The Remodeling Cycle

Reversal

Human Osteoclast
The Remodeling Cycle

Formation

Osteoblast

Osteoblasts

Osteoblasts and Osteoid

Osteocyte – the Mechansensor

Marotti G. 1996.
Formation Completed

Resting

Cancellous Bone Packets

Cortical Bone Remodeling Cycle

Haversian Systems

Skeleton
Duration of Remodeling

Remodeling Balance on Different Envelopes

Changes in Bone With Age

The Importance of Bone Geometry for Cortical Bone Strength

Effect of Aging on Cortical Bone
Origin of Bone Cells

Dr. Dempster’s Osteoclasts

Osteoporosis

Progression of Osteoporosis – Three Generations

Photo credit: Geoff Higgs, MD, courtesy eMotion pictures – An Exhibition of Orthopaedic Art
Mechanisms of Cancellous Bone Loss


Trabecular Plate Perforation
MICROARCHITECTURAL CHANGES IN OSTEOPOROSIS

© 2000, David W. Dempster, PhD.
Normal Remodeling Cycle

Trabecular Plate Perforation

Disconnection of A Trabecular Rod

IL-6 Stimulates Osteoclastogenesis
Osteoclast Regulation by RANK Ligand and Osteoprotegerin (OPG)

Bone

Activated Osteoclast

CFU-M = colony forming unit macrophage

Effects of RANKL on Trabecular Bone in the Proximal Tibia

Vehicle
RANKL 0.4 mg/kg
RANKL 2.0 mg/kg

YY Yuan, ASBMR Meeting, Abstract #SA357

Convergence Hypothesis of Osteoclast Regulation


YY Yuan, ASBMR Meeting, Abstract #IA5A37
Normal Bone Biopsy Compared to Male Osteoporosis

Osteomalacia

Tetracycline Labeling – Abnormal Mineralization

**Dynamic Parameters**
(Bone Formation)

- Calcification Rate
- Extent of Labeled Surface
- Bone Formation Rate
- Osteoblastic Appositional Rate
- Mineralization Lag Time
- Formation Period of Packets

Normal biopsy compared to Primary Hyperparathyroidism