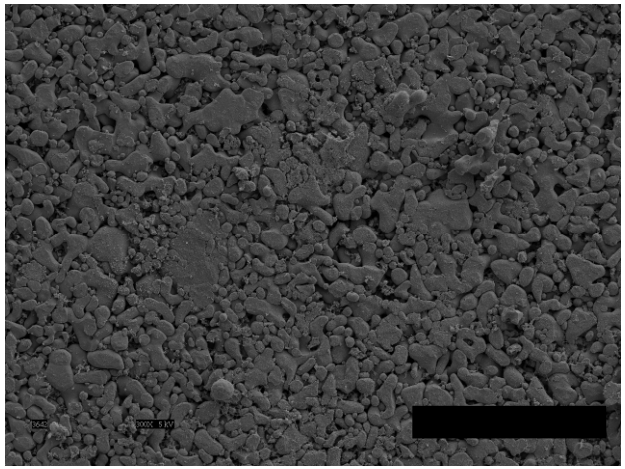
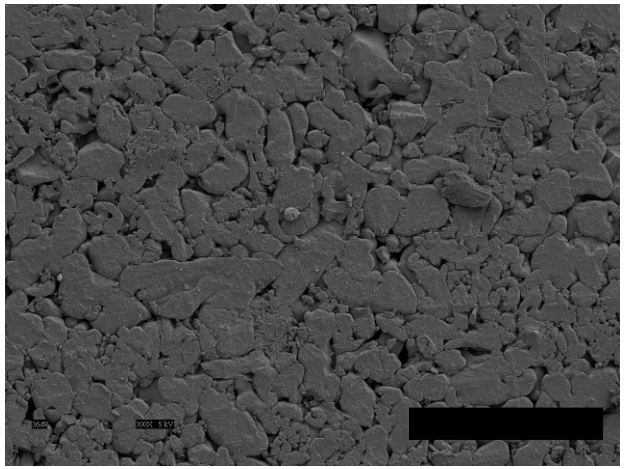
Directed Osteoblast Adhesion at Metal Particle Boundaries

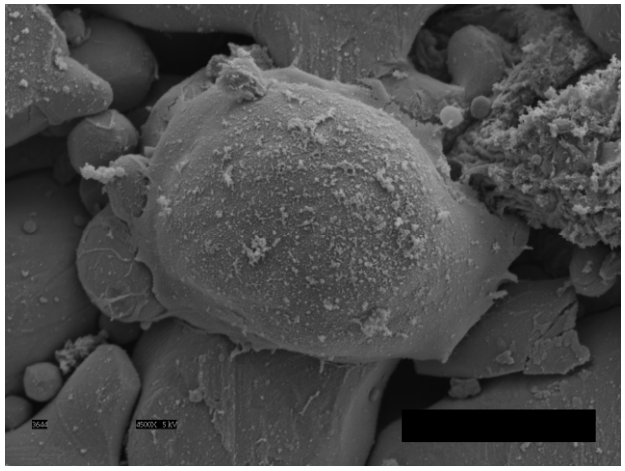


Ti6Al4V (nanophase)

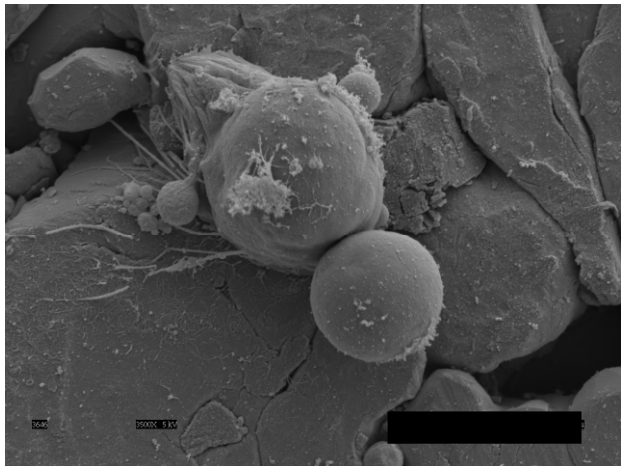


Ti6Al4V (conventional)

Bar = 100 μm.



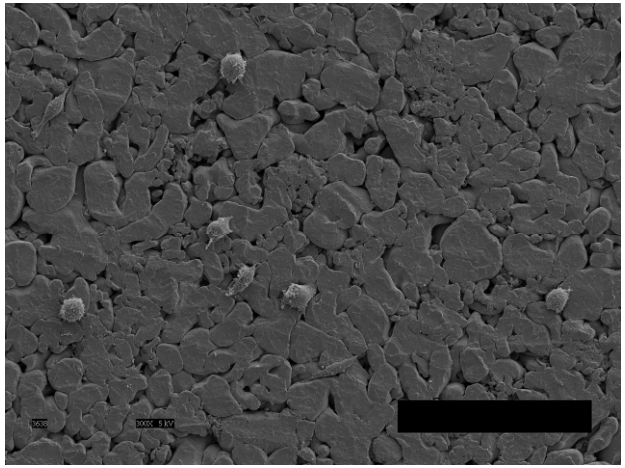
Ti6Al4V (nanophase)



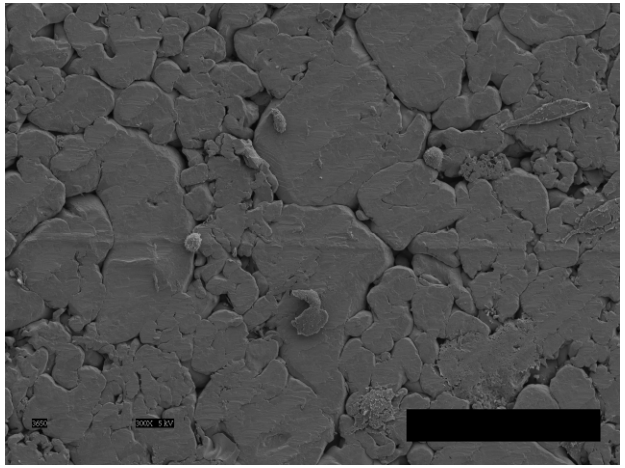
Ti6Al4V (conventional)

Bar = 10 μm.

Directed Osteoblast Adhesion at Metal Particle Boundaries

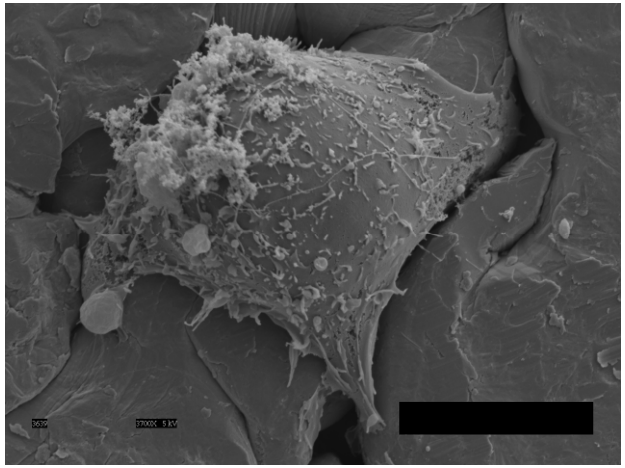


Ti (nanophase)

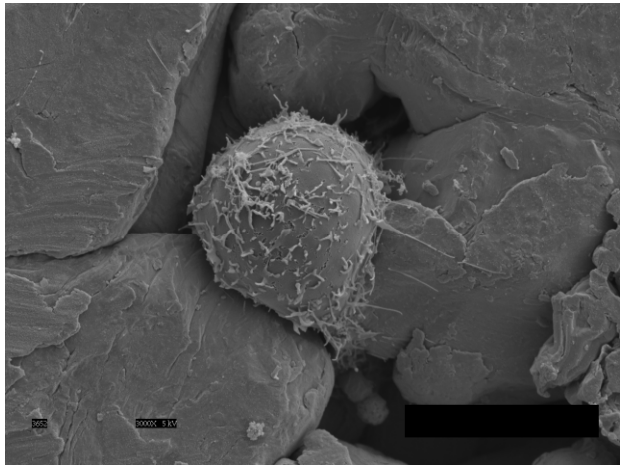


Ti (conventional)

Bar = 100 μm.



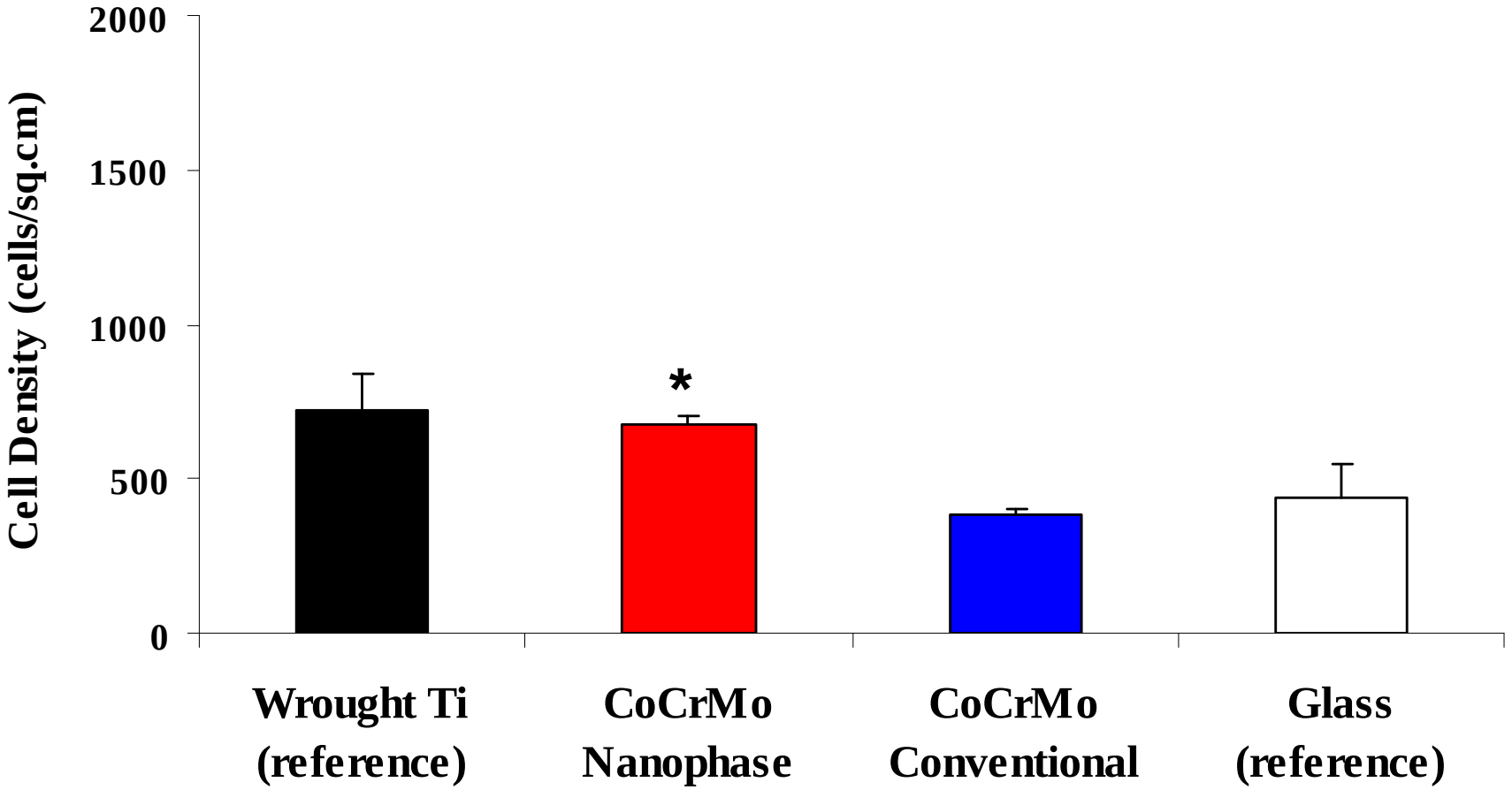
Ti (nanophase)



Ti (conventional)

Bar = 10 μm.

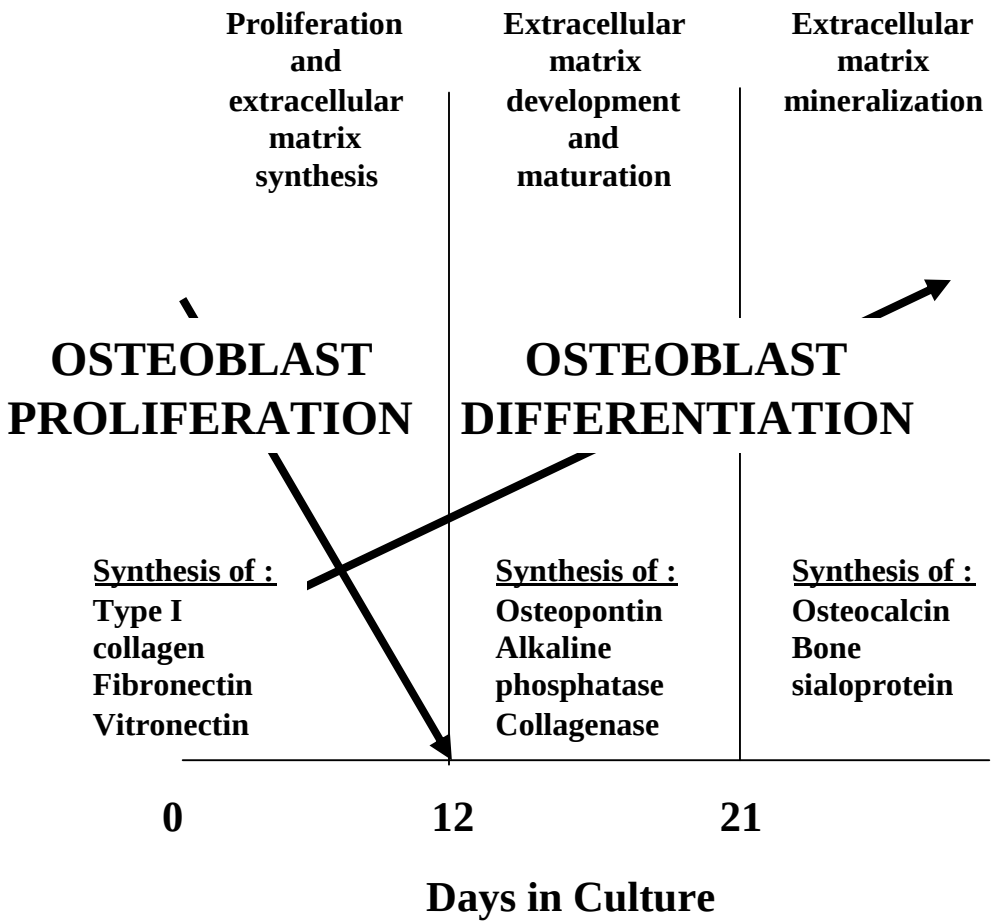
Enhanced Osteoblast Adhesion on Nanophase CoCrMo



Time = 1 hour.
Values are mean +/- SEM; n = 3; * $p < 0.1$ (compared to respective cell adhesion on conventional CoCrMo).

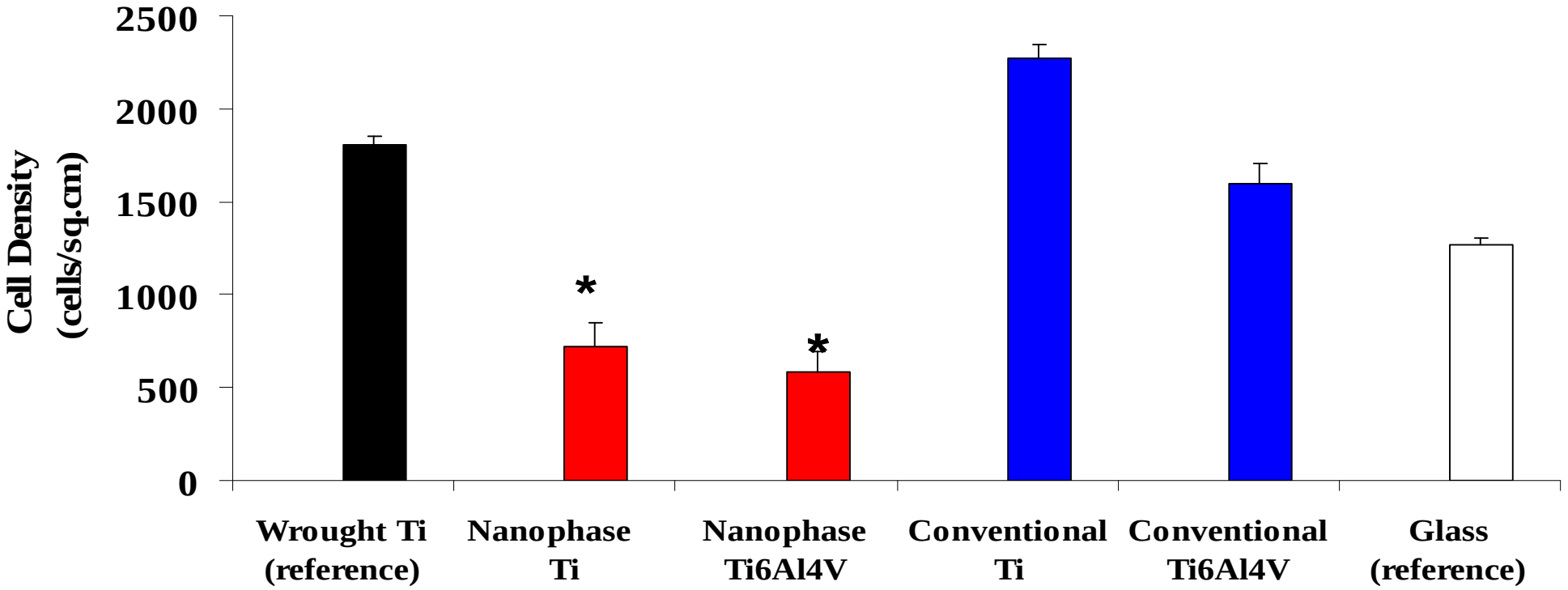
Enhanced Adhesion Translates into Increased Subsequent Functions

Stages of Osteoblast Differentiation



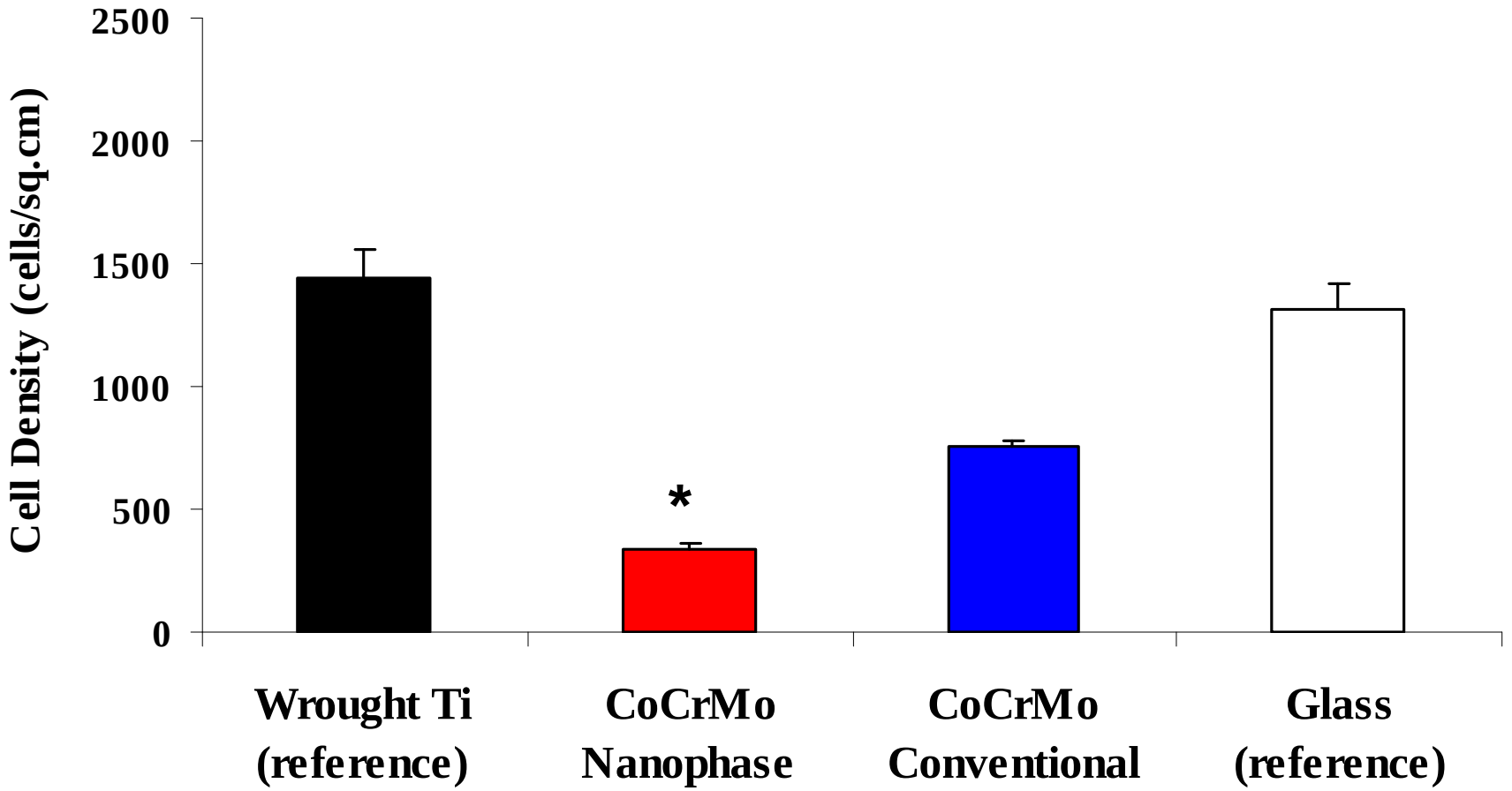
T. J. Webster, in Advances in Chemical Engineering Vol. 27, Academic Press, NY, pgs. 125-166, 2001.

Decreased Fibroblast Adhesion on Nanophase Ti and Ti6Al4V



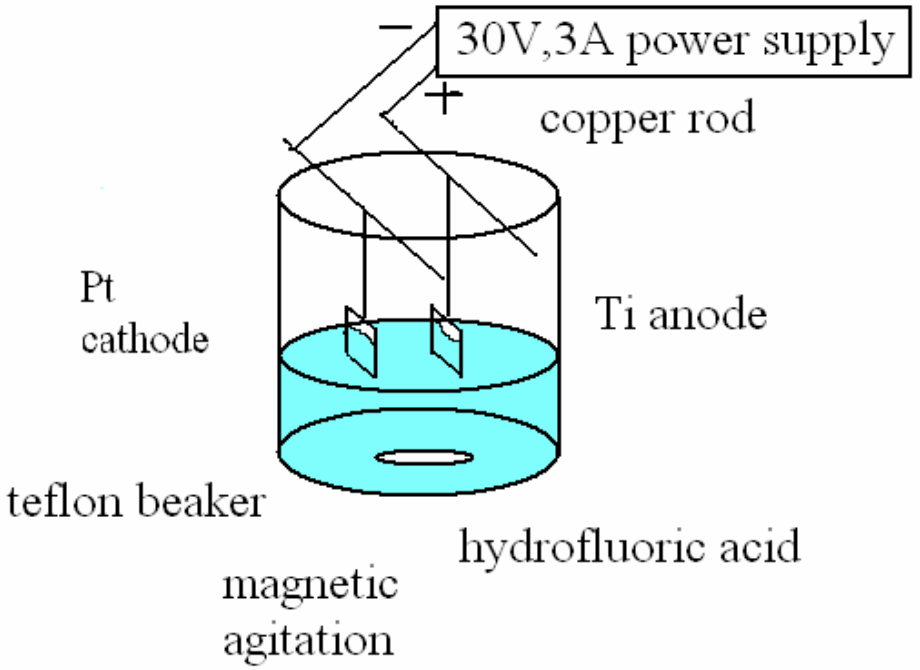
Time = 1 hour.
Values are mean +/- SEM; n = 3; * $p < 0.1$ (compared to respective cell adhesion on conventional Ti or Ti6Al4V) .

Decreased Fibroblast Adhesion on Nanophase CoCrMo



Time = 1 hour.
Values are mean +/- SEM; n = 3; * $p < 0.1$ (compared to respective cell adhesion on conventional CoCrMo).

Anodized Titanium



Sketch map of anodization system

PROCEDURES:

Pretreatment: chemical polishing using HF/HNO_3 mixture

Anodization: 0.5 or 1.5%HF

Voltage: 20V

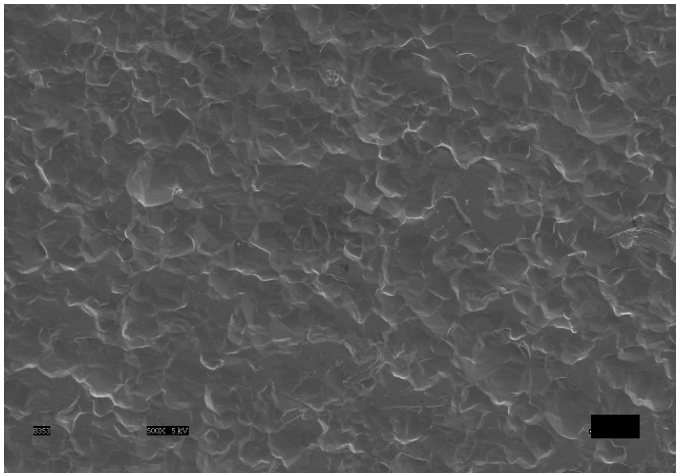
Time: 20 min

Rinse and dry

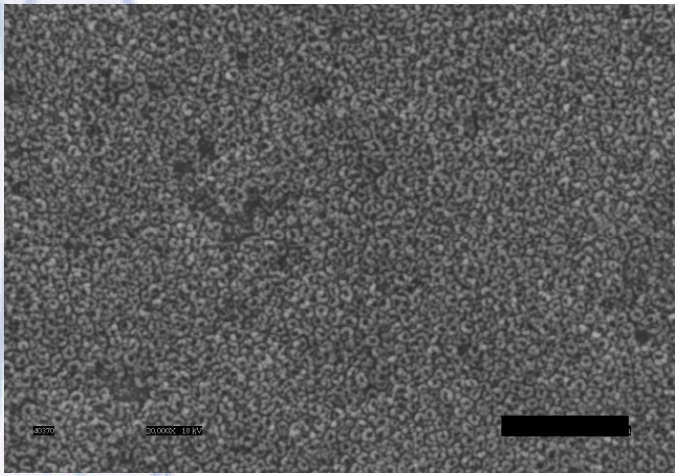
Clean: acetone and ethanol

Sterilize

Increased Osteoblast Functions on Anodized Ti

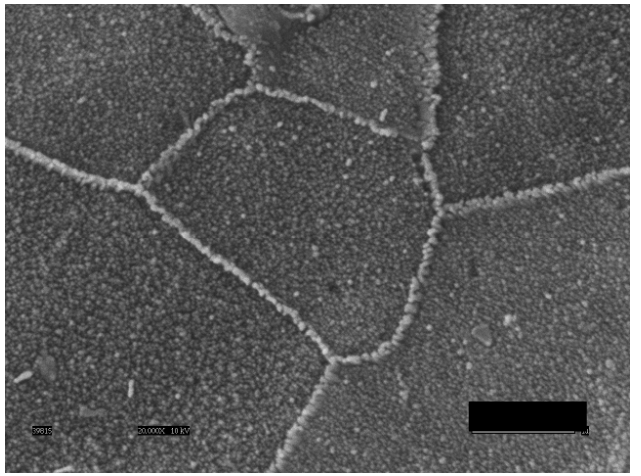


Unanodized Ti



Anodized Ti
1.5% HF treatment
Nanotube

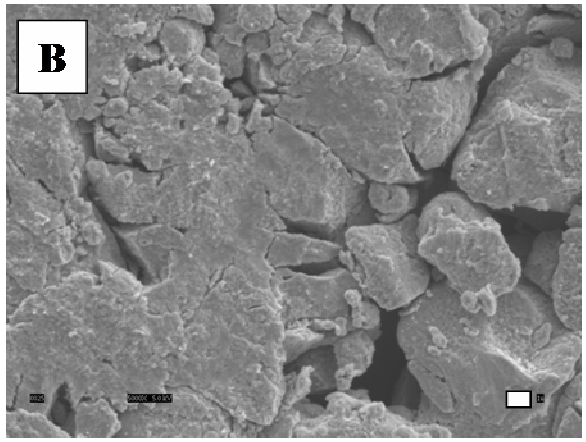
Bar = 1 micron

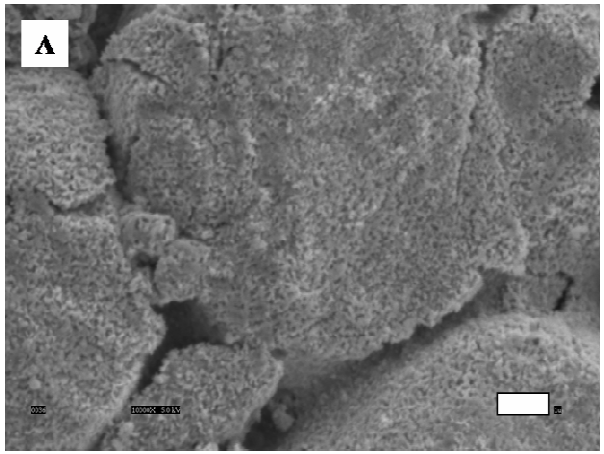


Anodized Ti
0.5% HF treatment
Nano-particles

PART I (cont.): BONE
Anticancer Implants

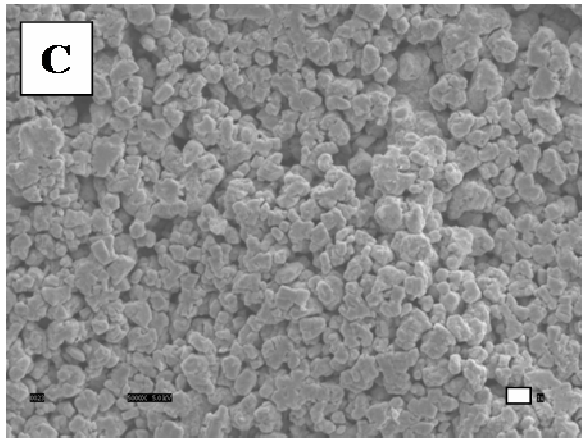
Se (Micron)

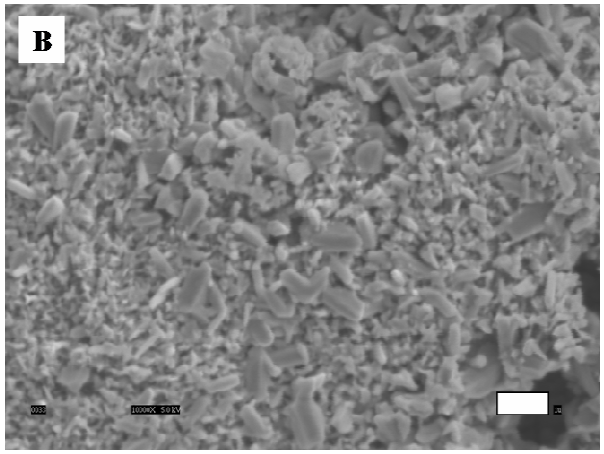




Se (Nano)

Se (Sub-Micron)





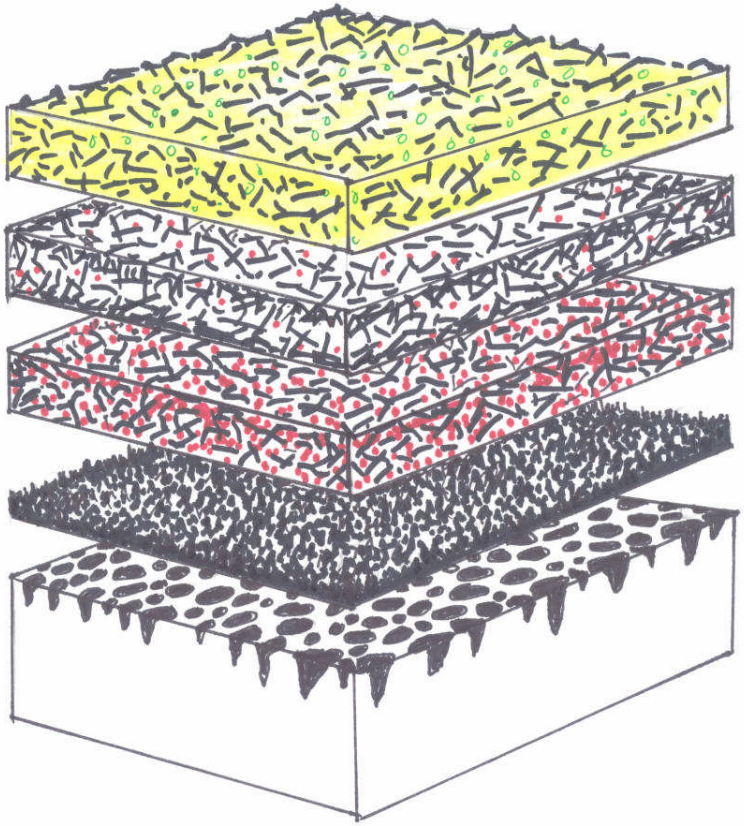
Se (Nano)

Bar = 1 micron

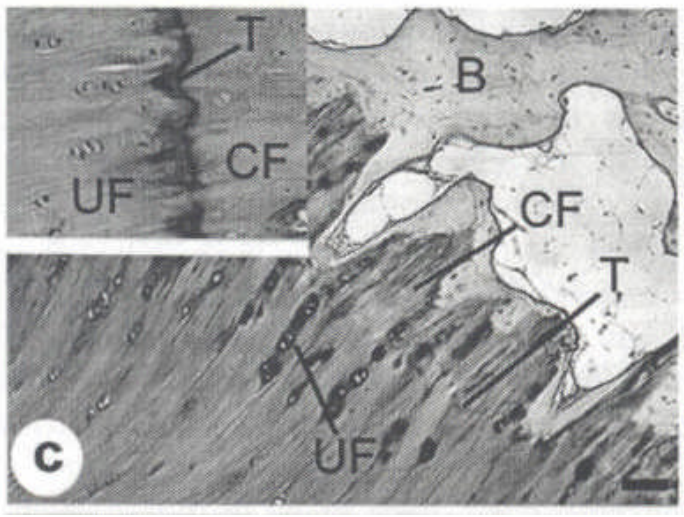
PART I (cont.): Development of New Entheses (Collaboration with DePuy Orthopedics)

Bioactive region

Mechanical Interlock to Implant (LPS)



- Cell modulating layer
- Bioactive uncalcified zone
- Calcified zone
- Nanomaterial
- Metal implant with porous surface



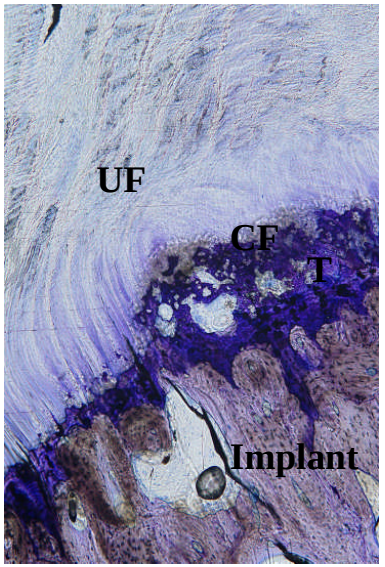
T-Tidemark;

B-Bone;

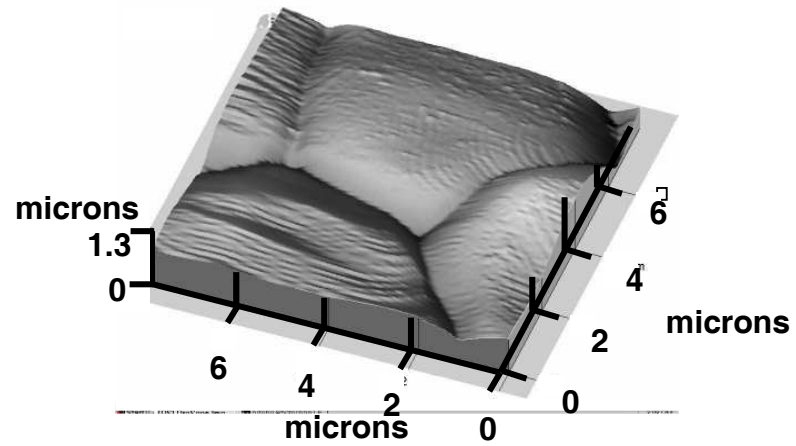
CF-Calcified fibrocartilage;

UF-Uncalcified fibrocatrilage

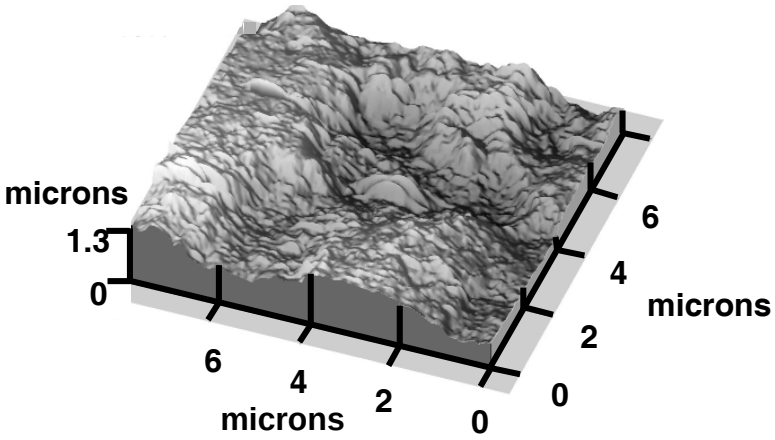
Successful Regeneration of Entheses →



Summary for Bone Applications



Conventional Grain Size



Nanophase Grain Size

Compared to conventional formulations, nanophase:

- **spherical particle size ceramics,**
- **fiber particle size ceramics,**
- **carbon nanofibers/nanotubes,**
- **polymer composites containing nanophase particles,**
- **polymer molds of nanophase materials,**
- **organic nanotubes,**
- **chemically-treated metals, and**
- **spherical particle size metals,**

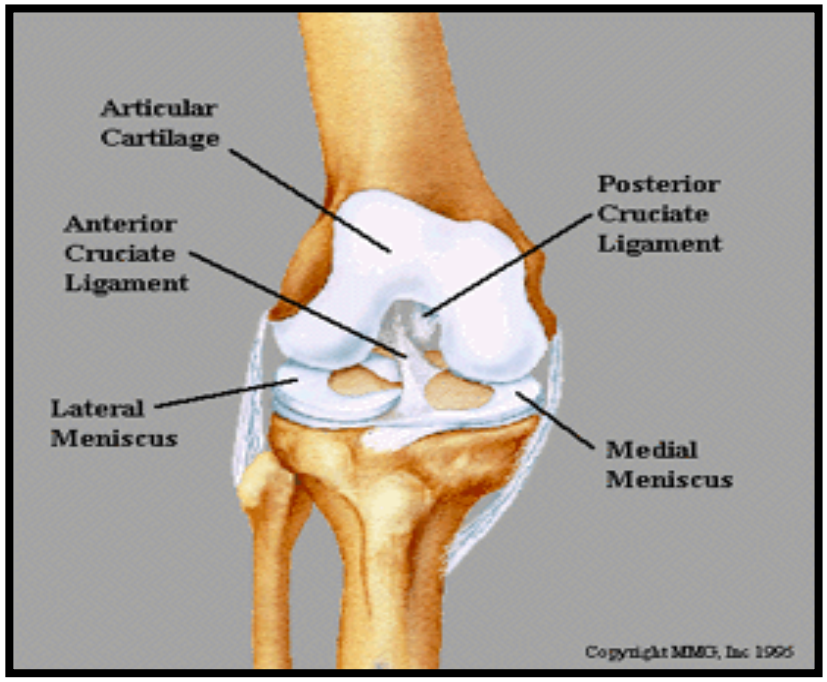
increase bone tissue regeneration.

T. J. Webster, in Advances in Chemical Engineering Vol. 27, Academic Press, NY, pgs. 125-166, 2001.

PART II
Cartilage: Nanostructured Polymers

The Problem:
Current Cartilage Implant Failures

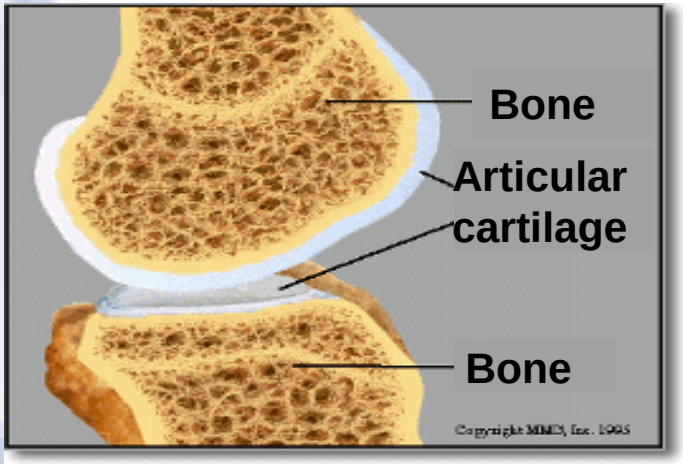
- 1 – 4 mm in thickness
- Provides a smooth joint lubrication ($\mu \approx 0.02$)[1]
- Wear resistant
- Shock absorbent
- Distributes applied load throughout the bone

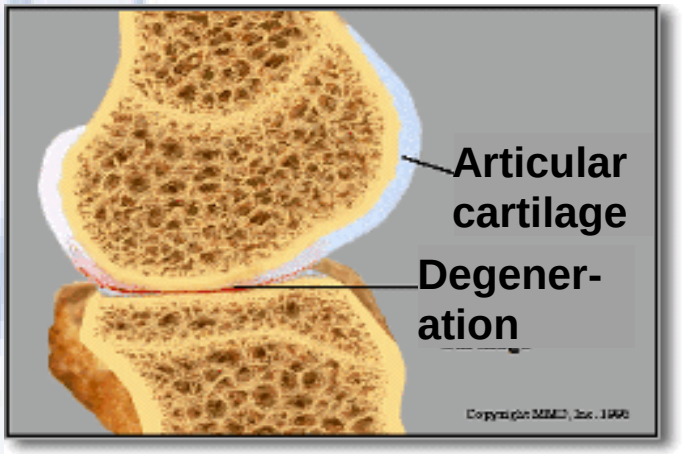


http://www.soarmedical.com/medical-library/knee/anatomy/

[1] Armstrong, C.G. et al. Scientific Foundations of Orthopaedics and Traumatology. London: William Heinemann, 1980:223-232.

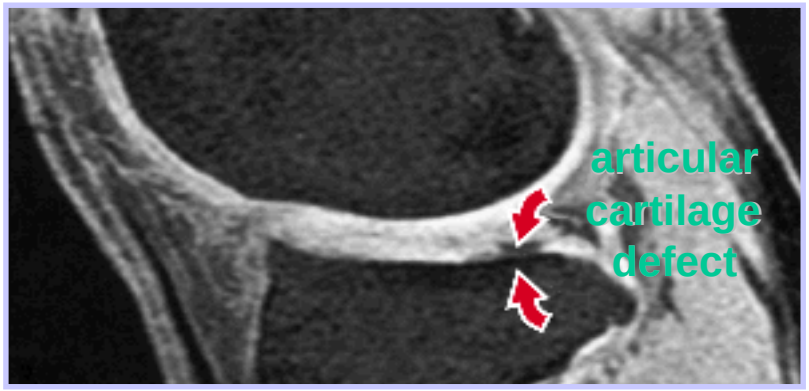
The Problem:
Current Cartilage Implant Failures



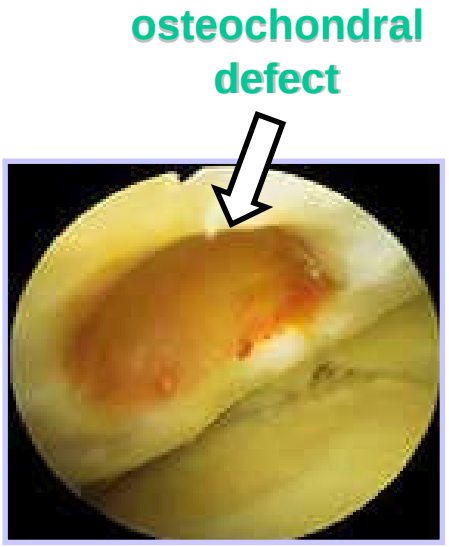


http://www.scarmedical.com/medical-library/knee/anatomy/

- Direct trauma
- Degeneration due to ACL tear
- Arthritis



LaPrade R, Konowalchuk B, Fritts H, Wentorf F. *The physician and sportsmedicine*, 2001;29:5.

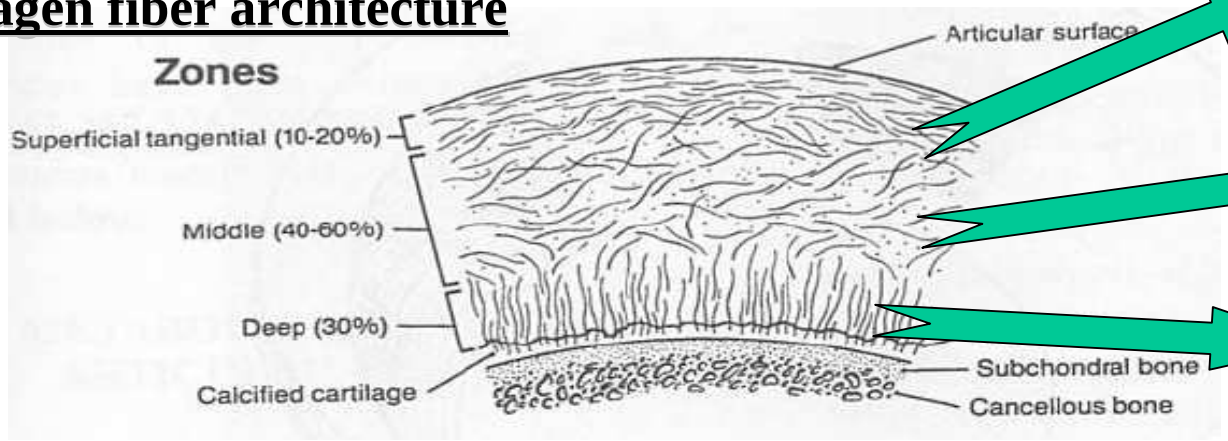


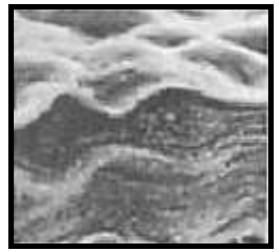
http://www.kneeclinic.info/problems_articular_cartilage.php

Cartilage Tissue: Another Nano-structured Tissue

- Fibrous Extracellular Matrix
  - Water, collagen type II, proteoglycans, other proteins
- Chondrocytes

Collagen fiber architecture

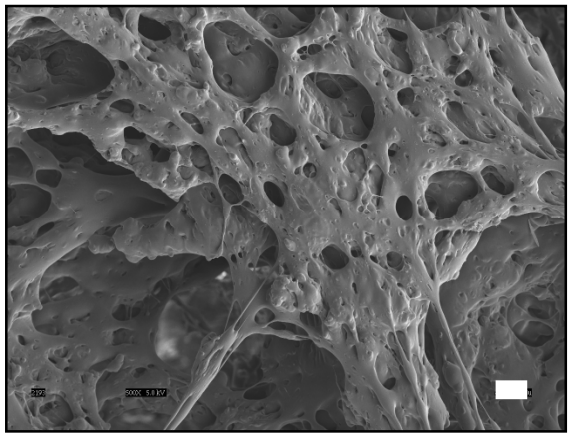




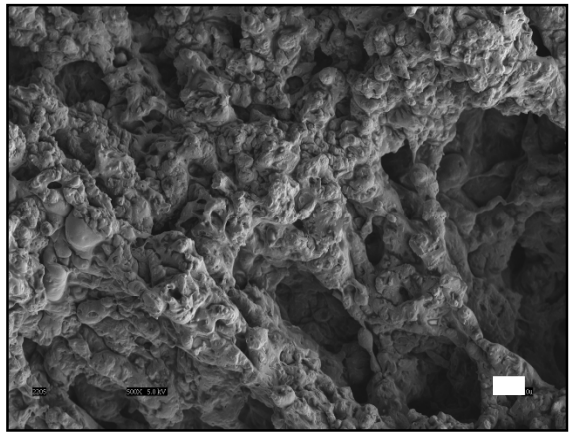
Mow VC, Proctor CS, Kelly MA, in Nordin M, Frankel VH (eds): Basic Biomechanics of the Musculoskeletal System, ed 2. Philadelphia, Lea & Febiger, 1989, pp 31-57.

Increased Functions of Chondrocytes on Nano-structured Polymers

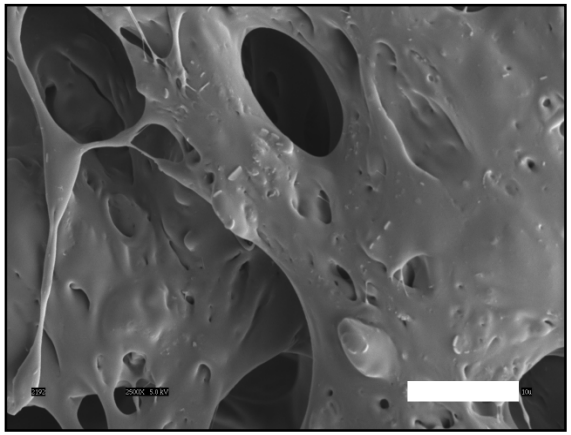
Bar =
10 microns



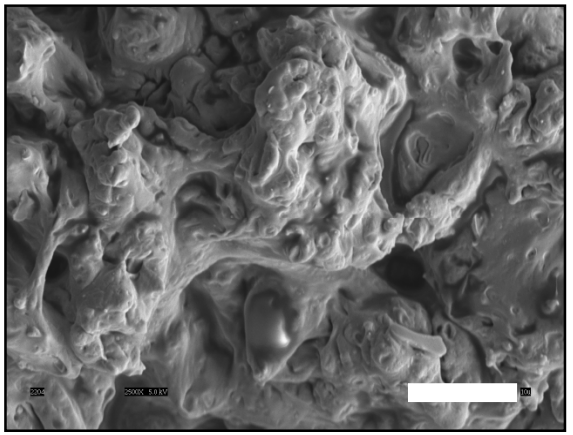
Conventional PLGA



Nano-structured PLGA



Conventional PLGA

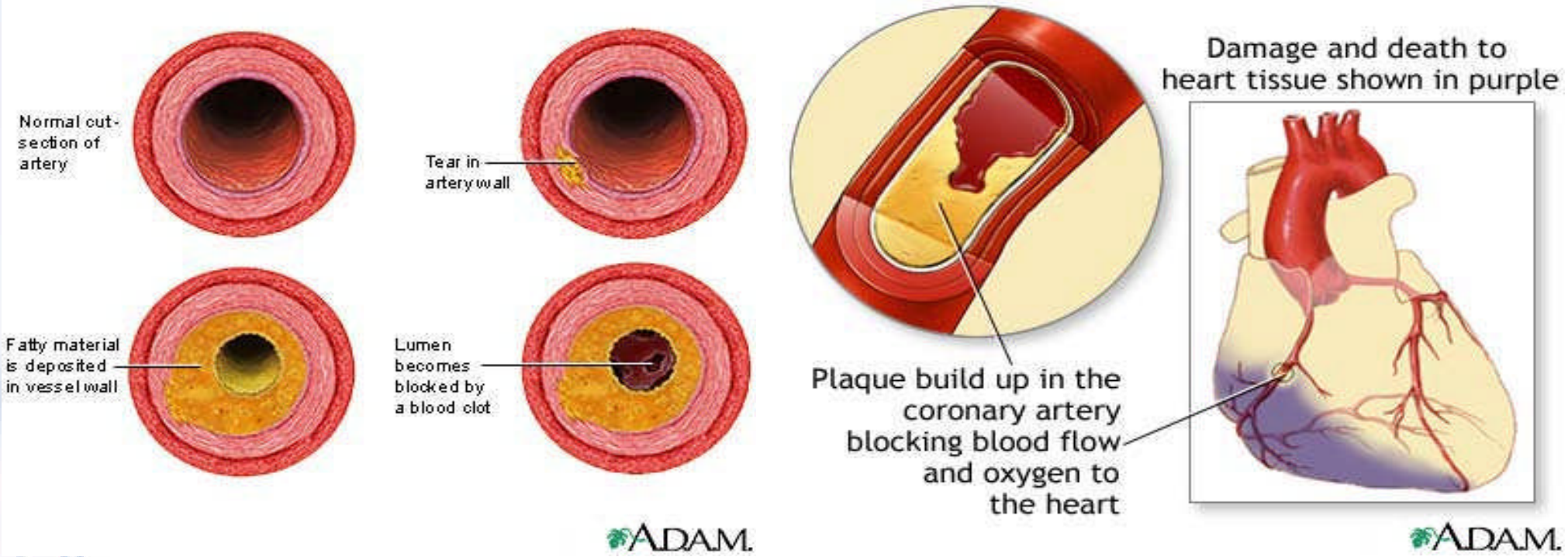


Nano-structured PLGA

PART III
Vascular: Nanostructured Polymers

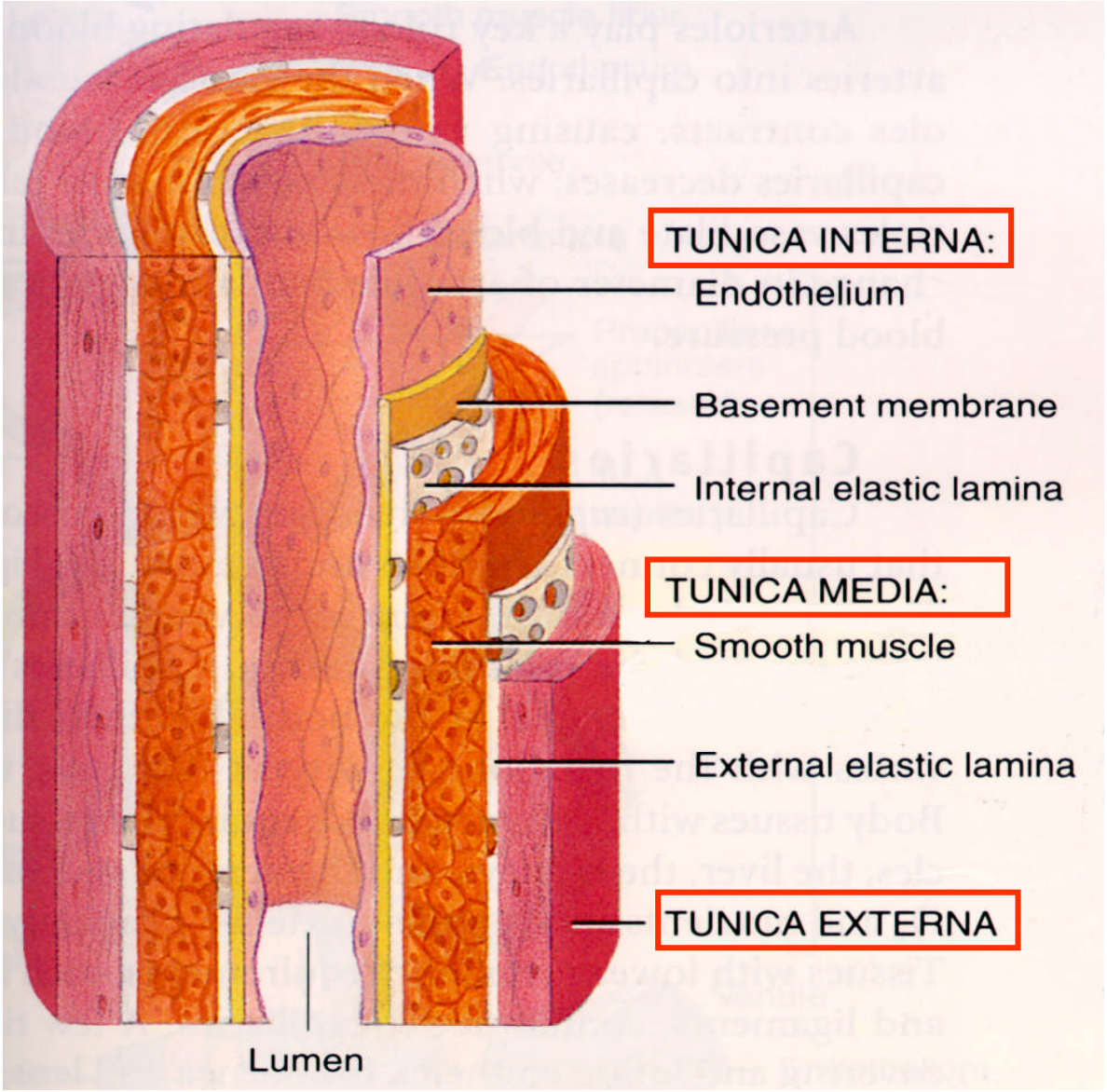
The Problem:
Current Vascular Implant Failures

- Vascular Disease
  - One of the leading causes of death in the US
  - Peripheral and coronary artery diseases (hardening of the arteries)
  - Affects approximately 58 million people

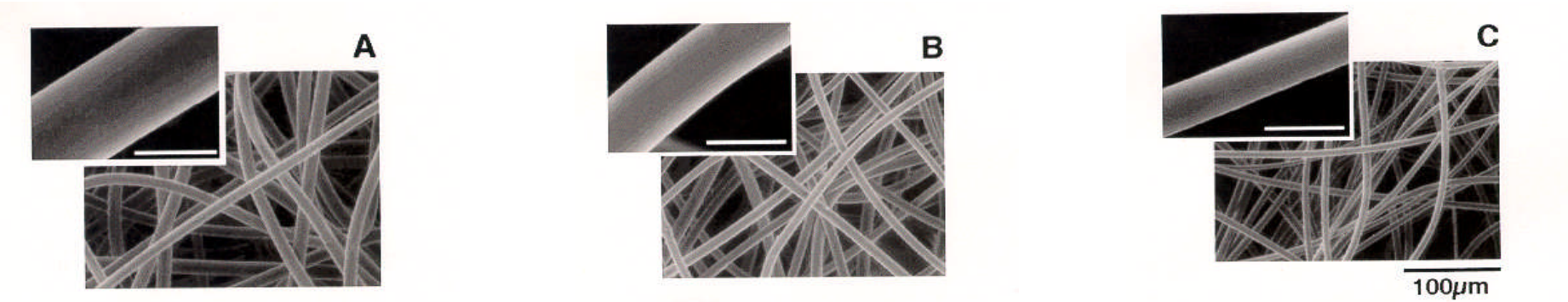


Source for pictures: http://www.nlm.nih.gov/medlineplus.

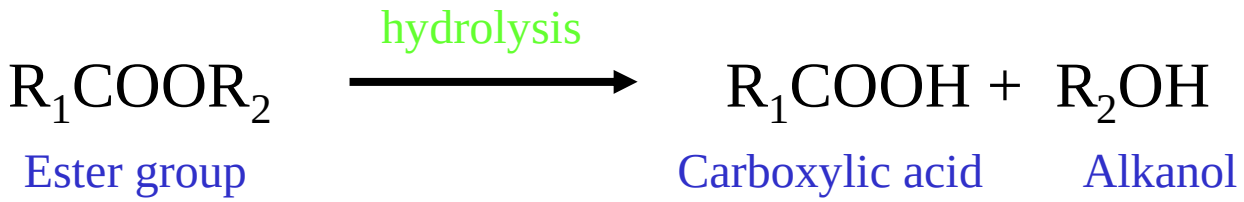
Vascular Tissue:
Another Nano-structured Tissue



Attempts to Improve Vascular Tissue Engineering Scaffolds



Reduction of PGA fiber size has been observed from A (more than 10 microns) to C (less than 10 microns) after treatment with 1N NaOH for 10 minutes*. Bar = 100 μm



* Source: Gao J et al., J. Biomed. Mat. Res. 42(3):417-424, 1998 .