

Nano-Biomaterials

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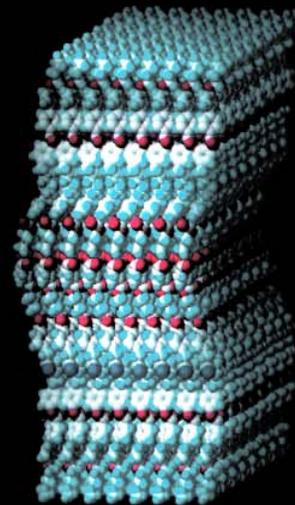
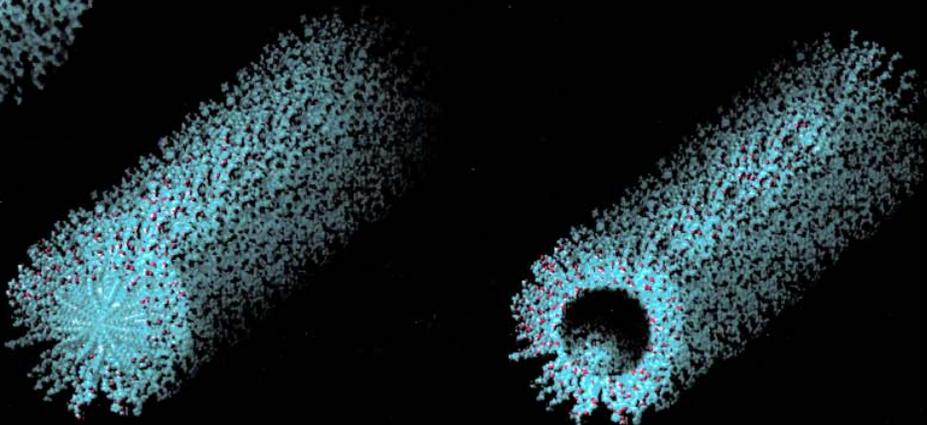
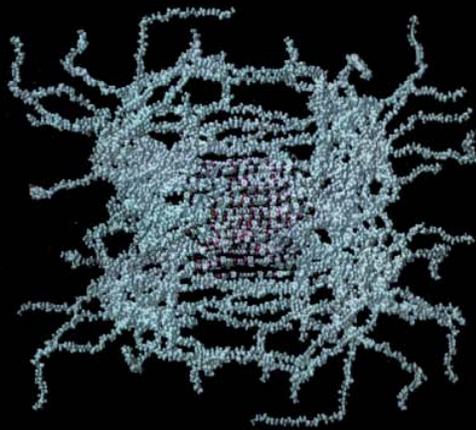
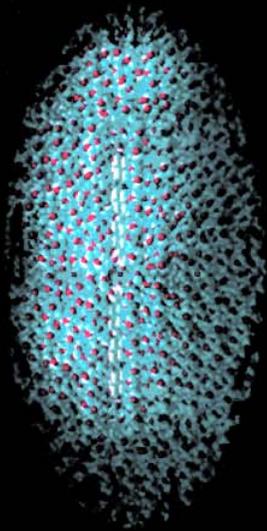
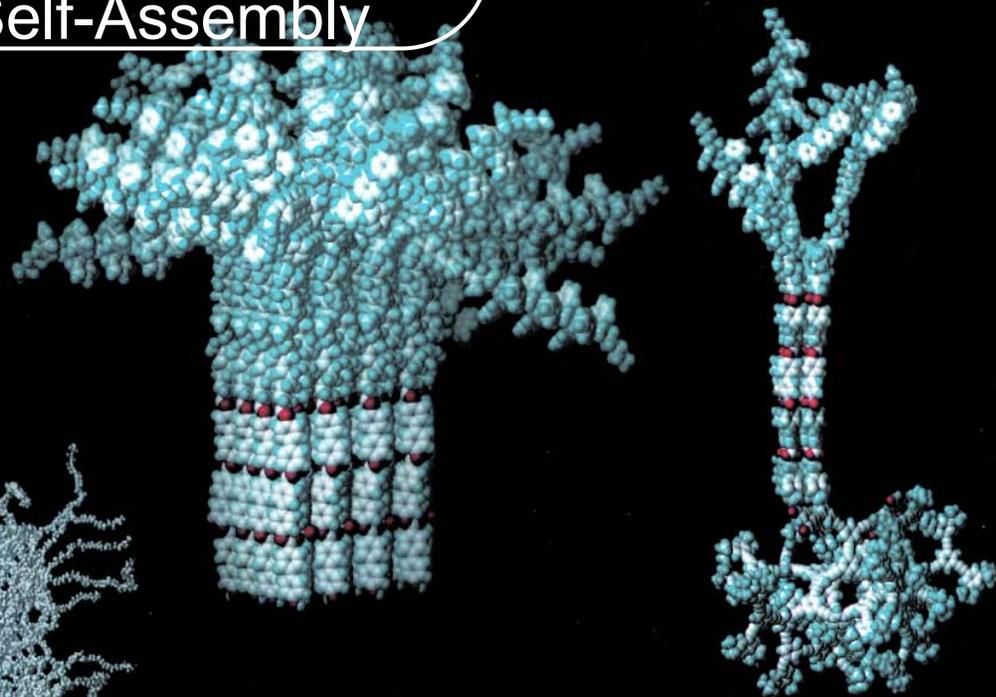
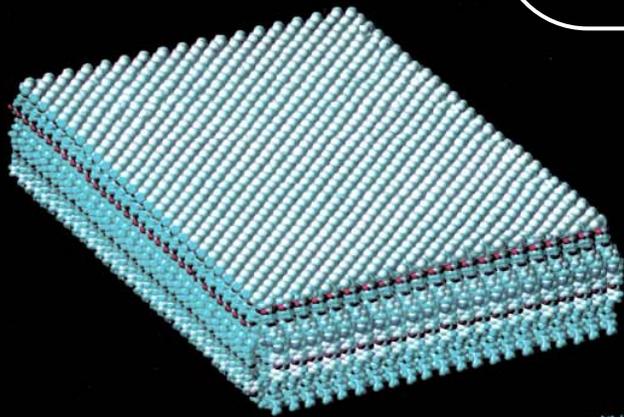
Human Health and Nano

- **Cells function largely through information flow triggered by contact among nanostructures-- mostly proteins**
- **We need artificial systems that talk to these nanostructures to either probe or control cell behavior**
- **Direct opportunities: regeneration of body parts, targeted drug delivery (“humane” cancer chemotherapy), very early detection of disease**
- **Related opportunities: bio-security (ultra-sensitive detection and neutralization of biological and chemical weapons), novel therapies for victims of biological weapons, genome mapping for better medicine**

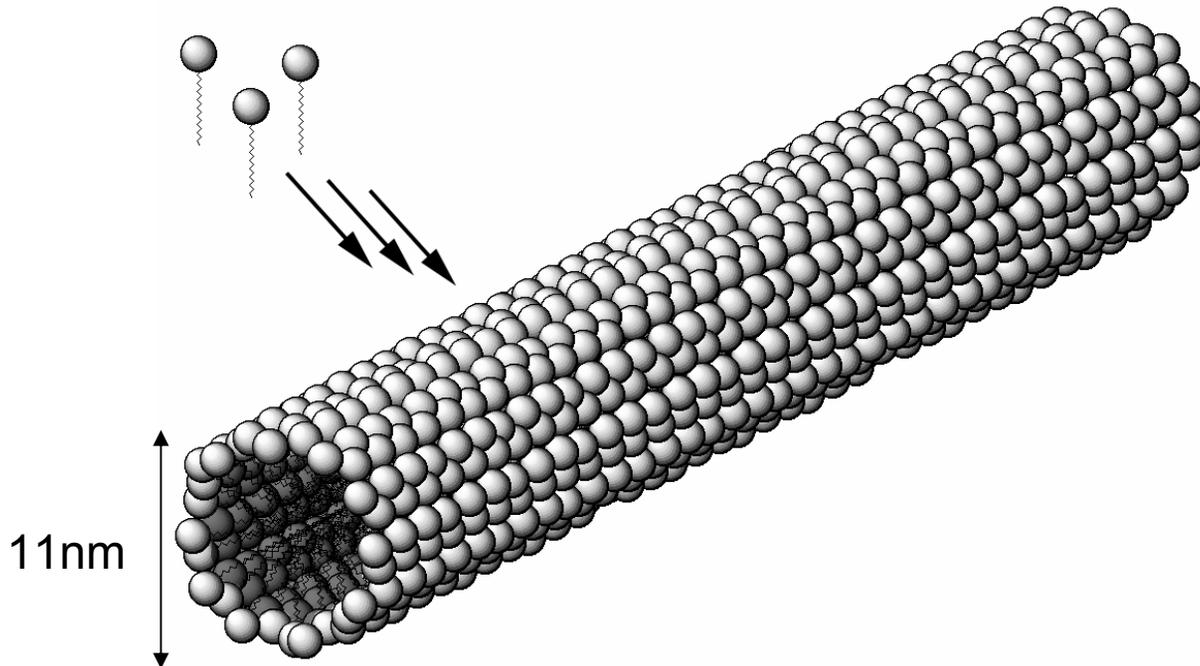
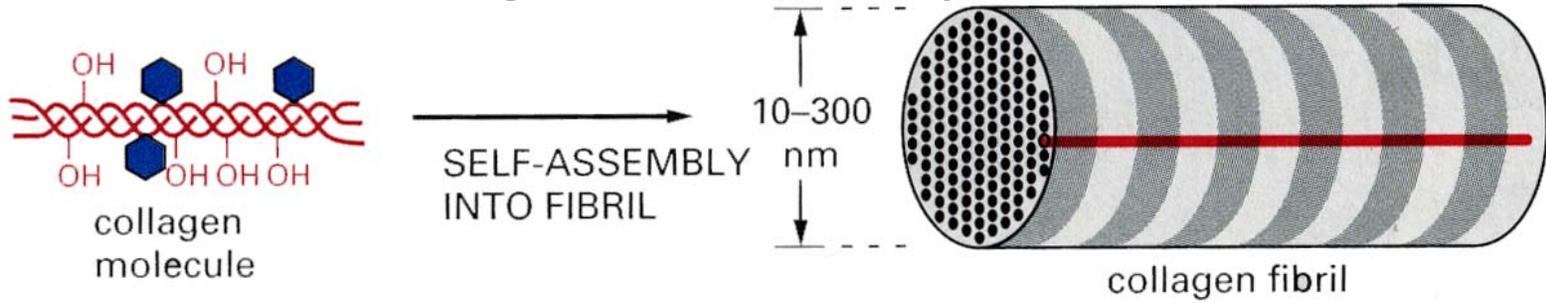
Regeneration of Body Parts



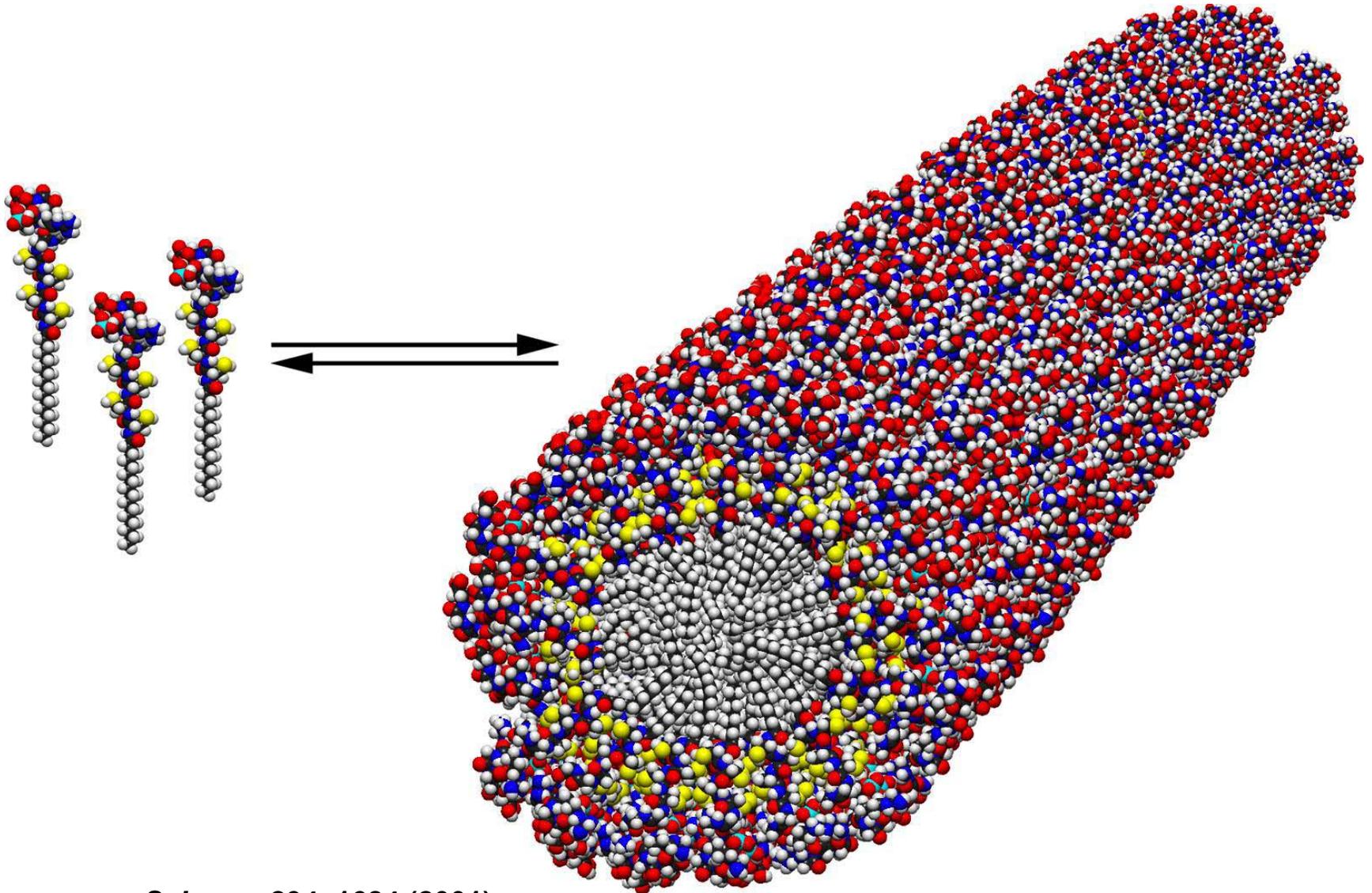
Organic Nanotechnology via Self-Assembly



Collagen Fibril Architecture in Nanostructures is Useful to Regenerate Body Parts

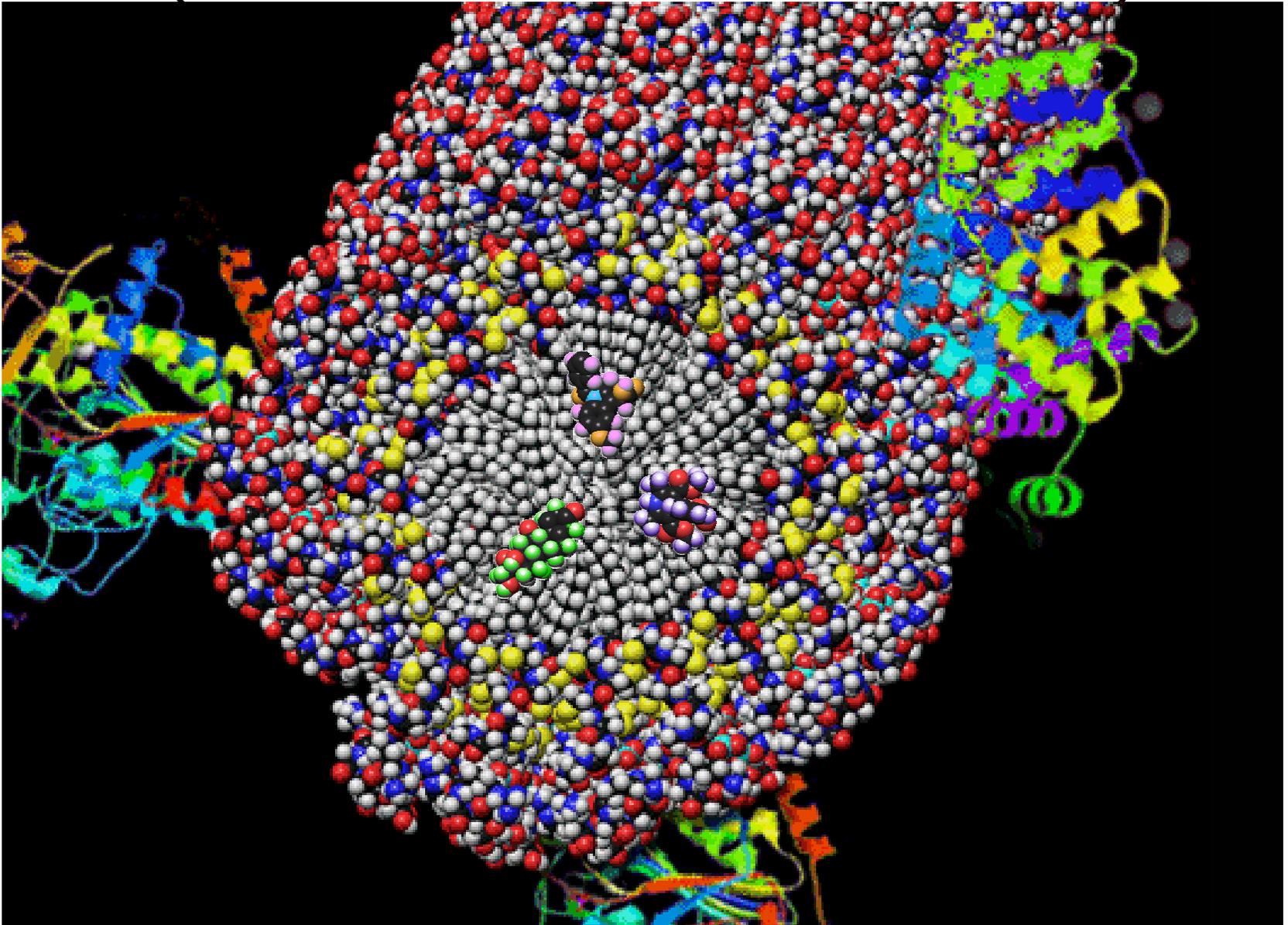


Self-Assembled Nanofiber



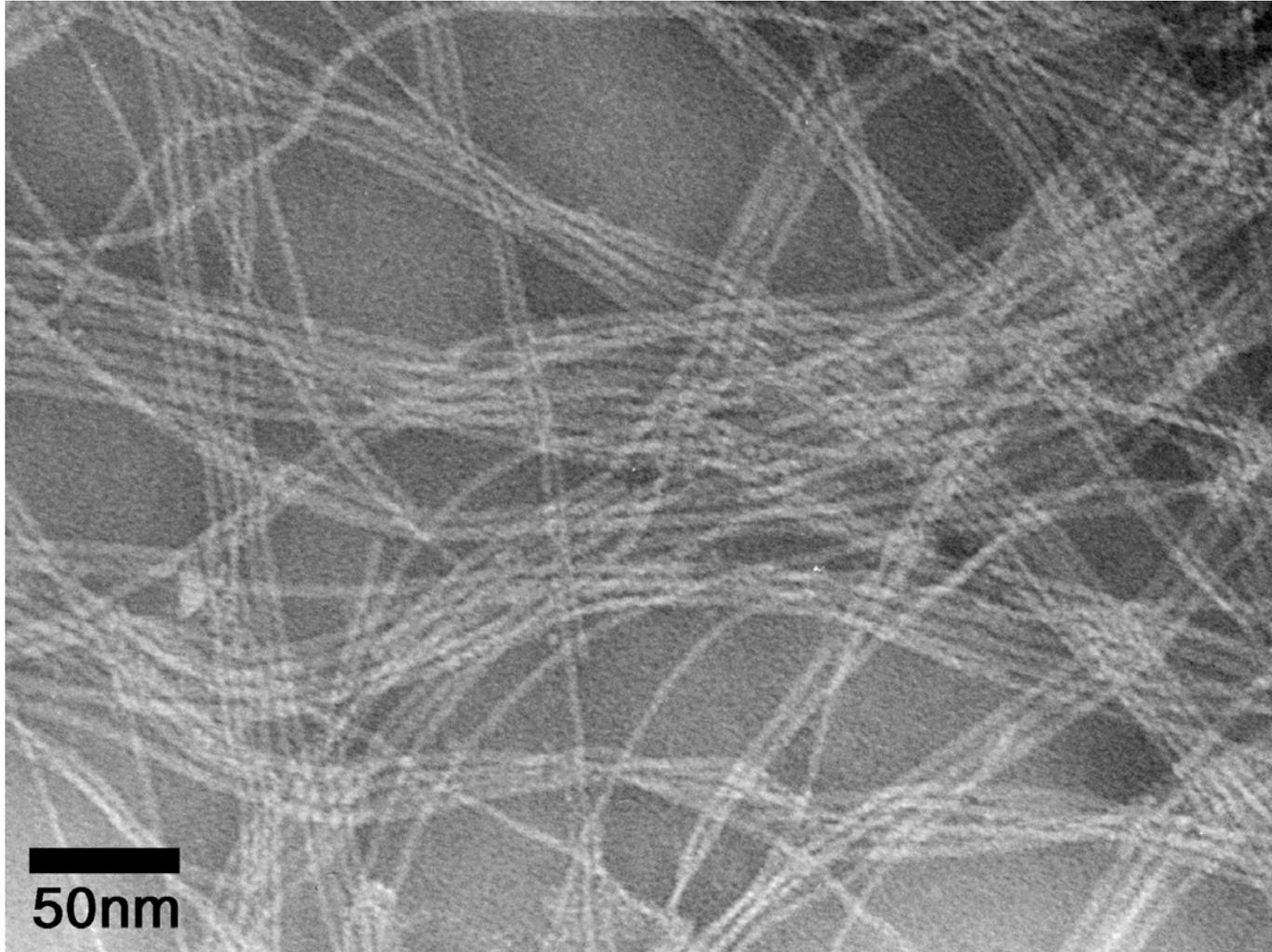
Science, **294**, 1684 (2001)

**Nanofiber Device Carries Multiple Capabilities
Biodegradable or Bio-electronic**



Bioactive Signals, Homing Nanostructures, Drugs, Detectors

self assembled nanofibers



PNAS, 99, 5133 (2002)

Nanofibers can form rapidly in the body or in the field



Nanostructures can form upon contact with biological fluids



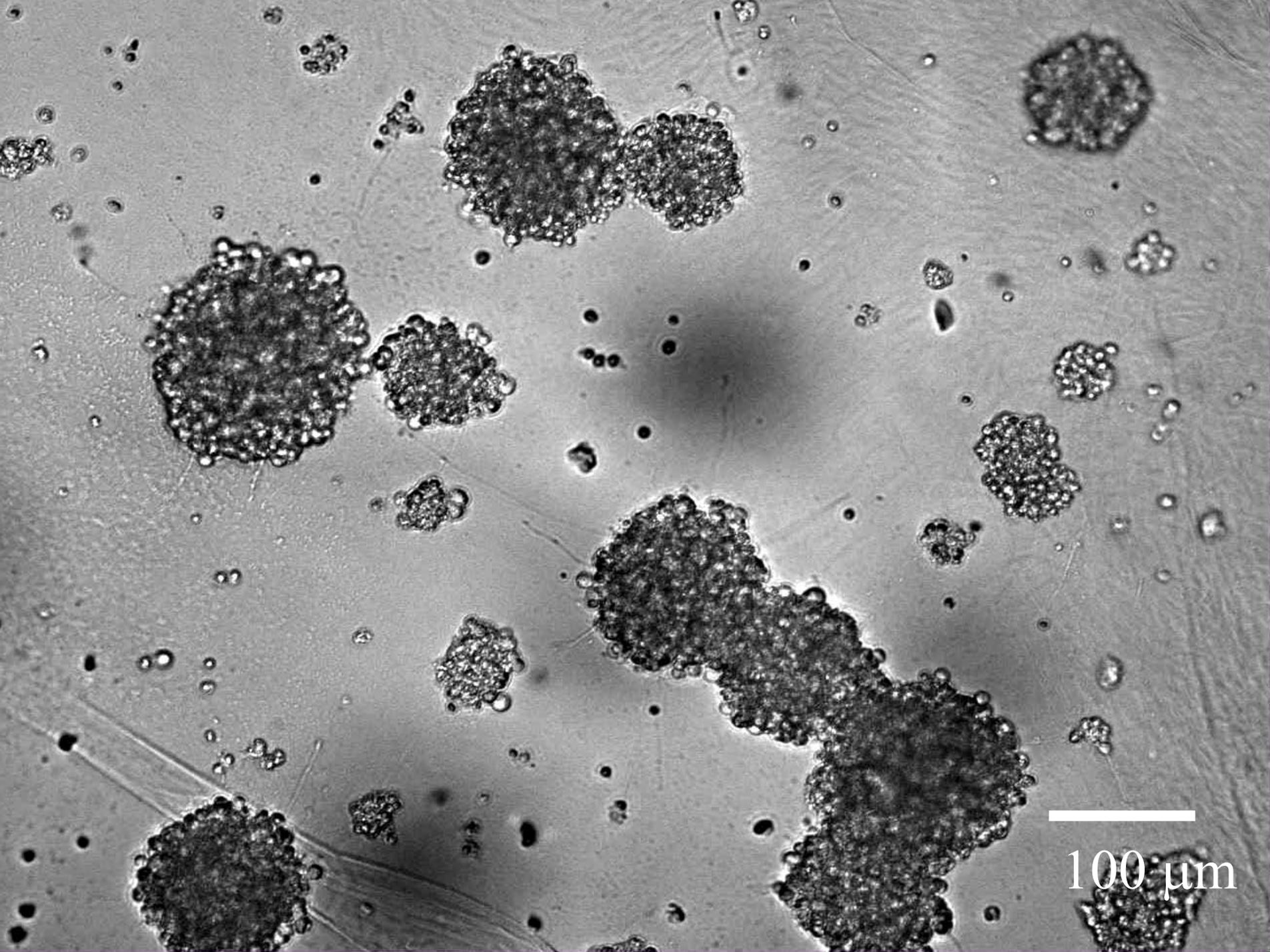
culture medium (DMEM)

peptide-amphiphile solution (10 mg/ml, pH 7.5)

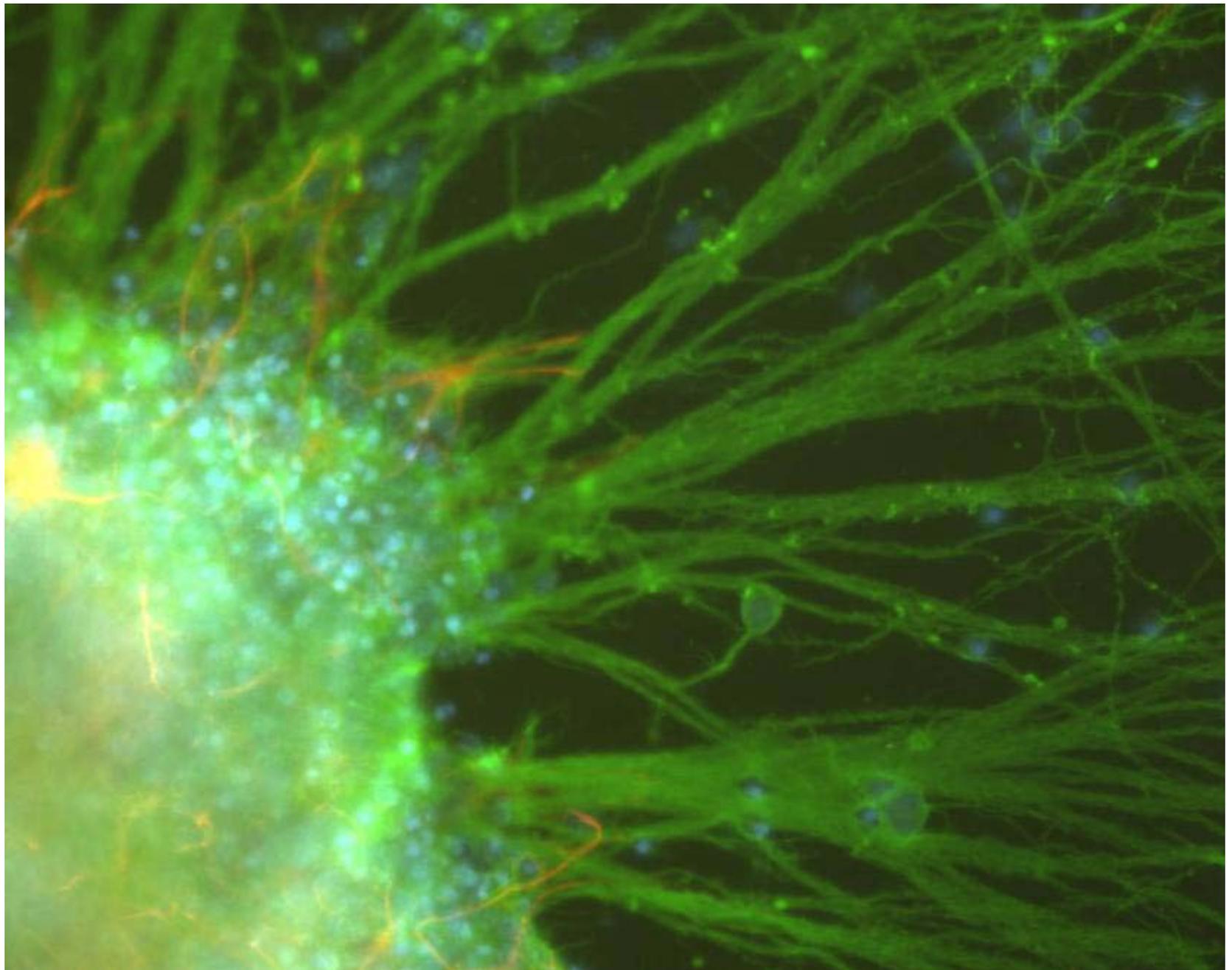
self-assembly in cell culture medium



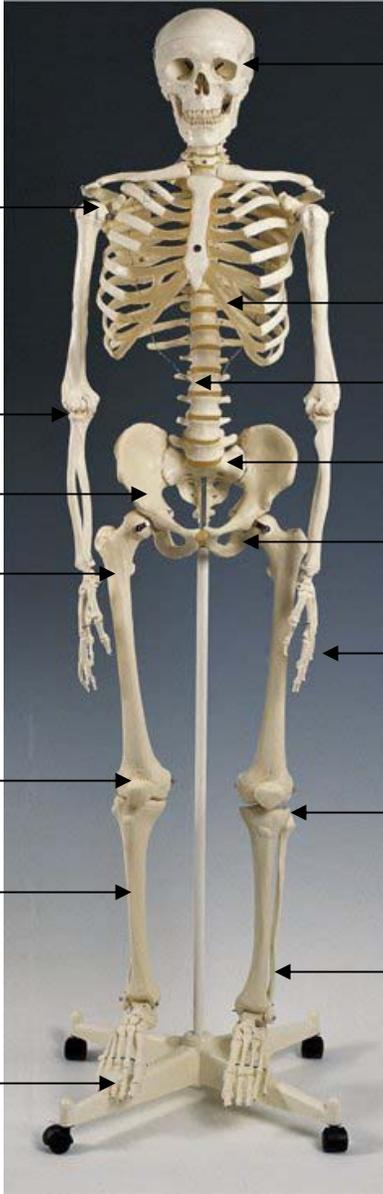
- Neuron-customized Nanofibers
- Regeneration of Peripheral Nerves and Spinal Cord
- Estimated 250,000 Americans paralyzed by SCI – 10,000 new cases annually
- Retinal regeneration



100 μm



Bone Disorders



neurofibroma

degenerative joint disease

chordoma

chondromyxoid fibroma

osteoporosis

giant cell tumor of bone

osteoblastoma

osteoporosis

ewing's sarcoma

meloreostosis

conventional intramedullary osteosarcoma

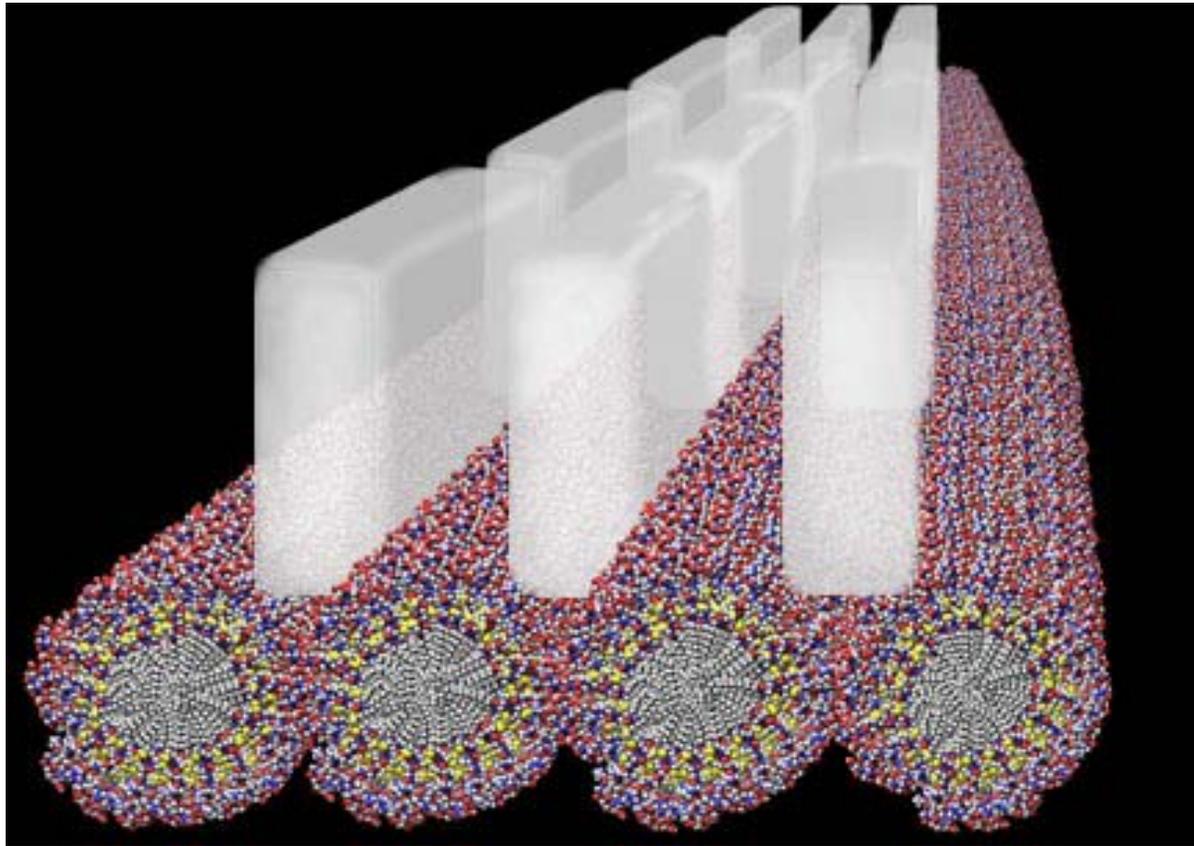
chondroblastoma

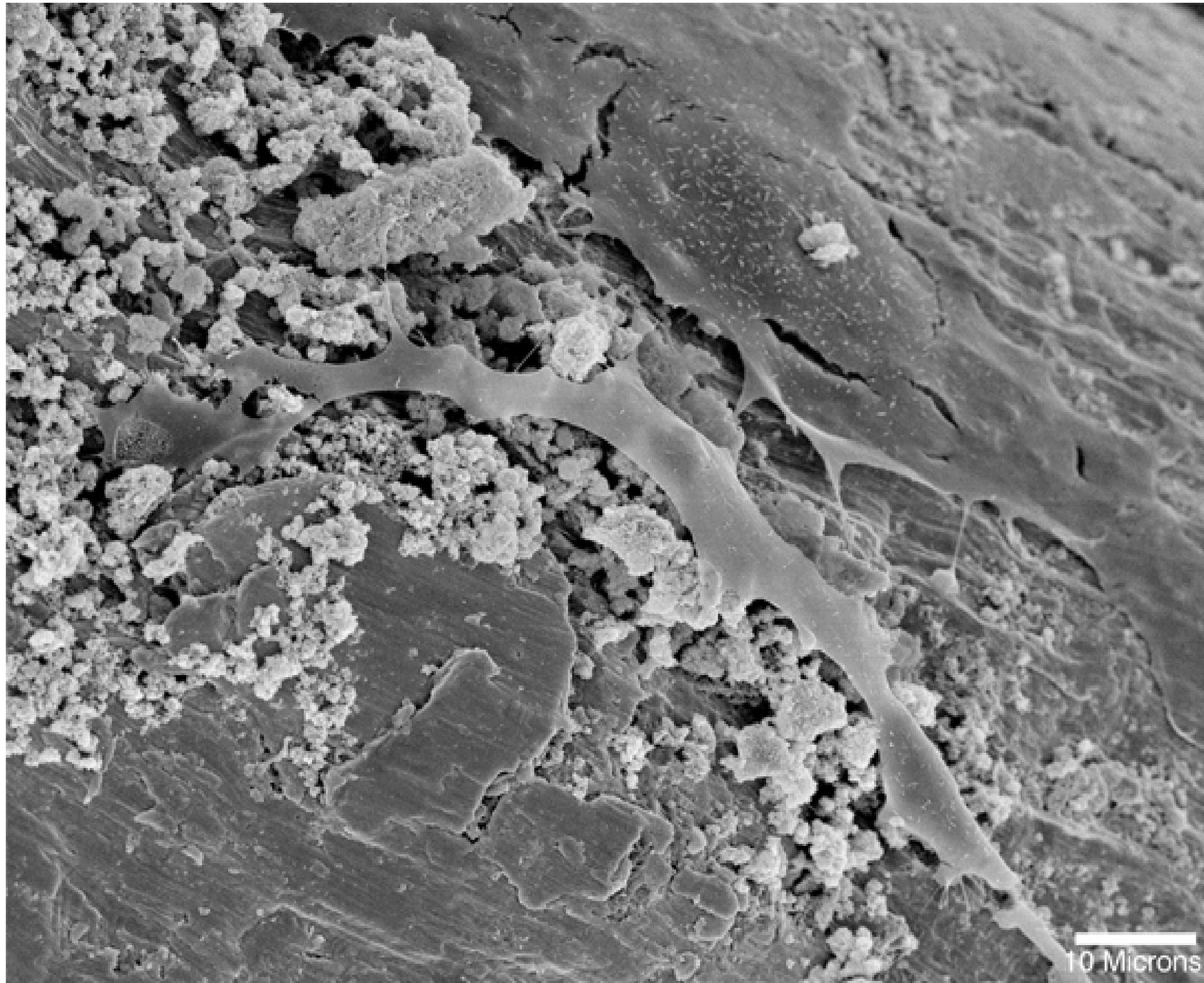
angiosarcoma

periosteal osteosarcoma

stress fracture

Bone crystals can form in contact
with specially designed nanostructures



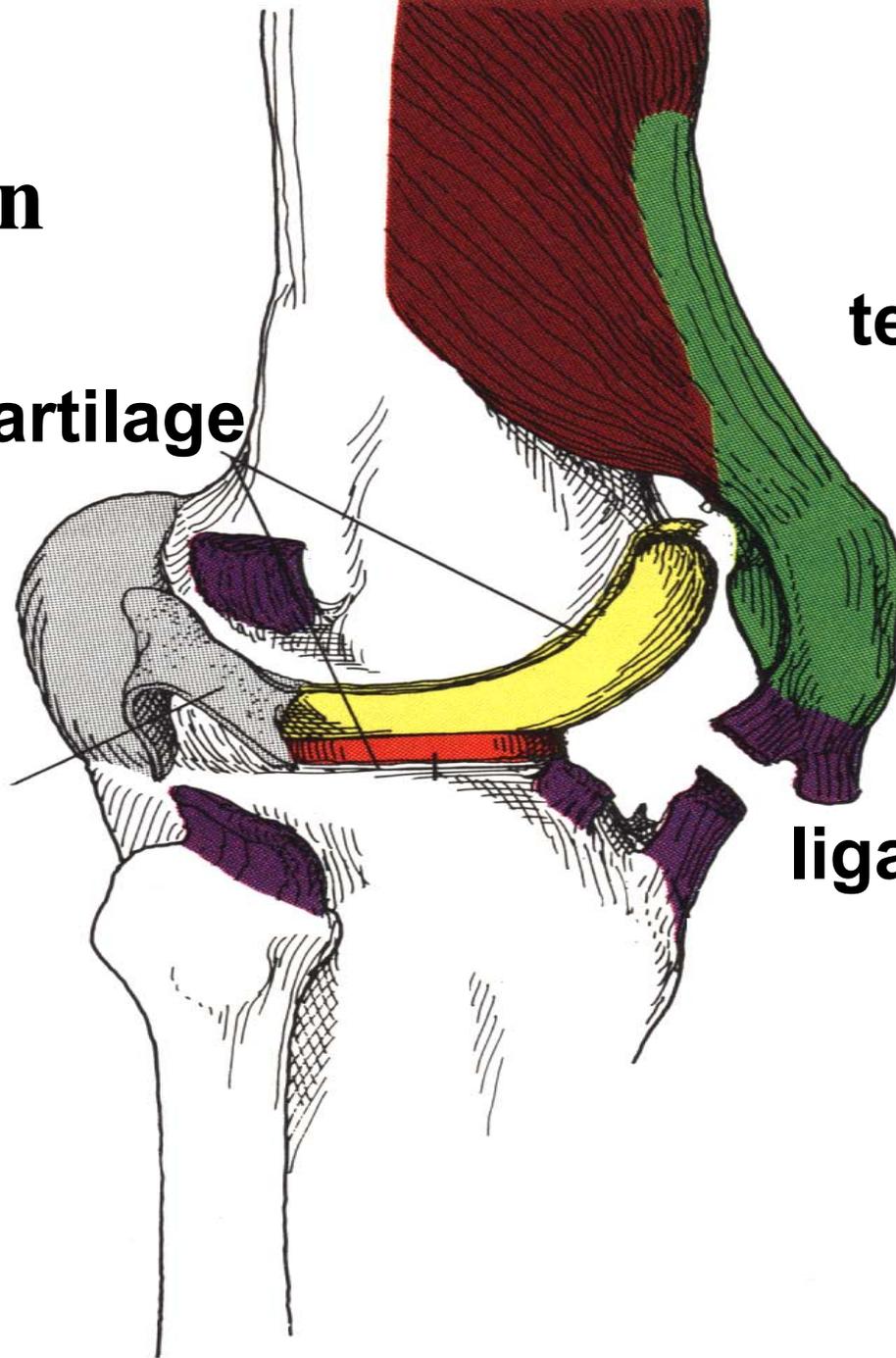


Important Regeneration targets

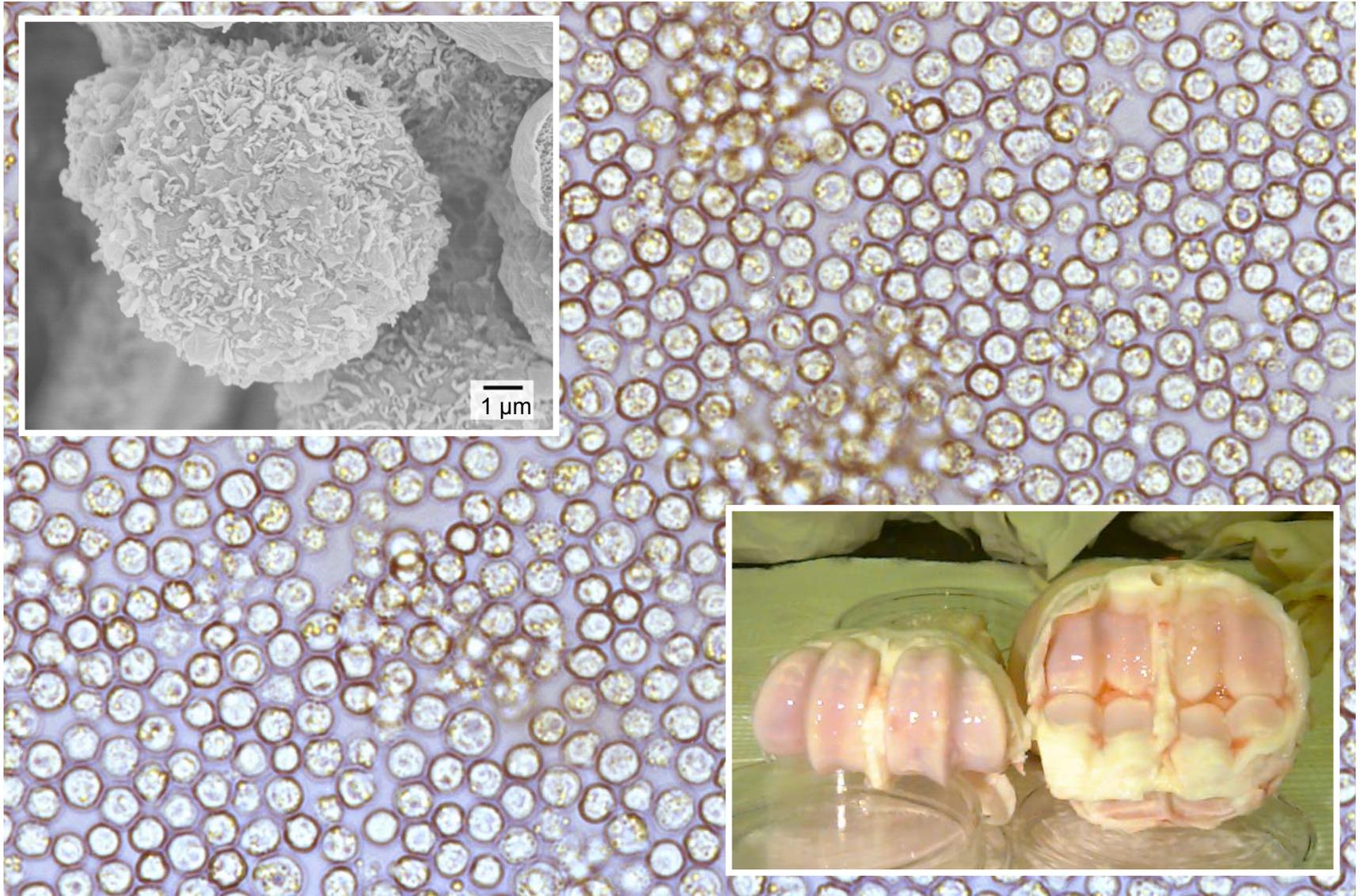
cartilage

tendon

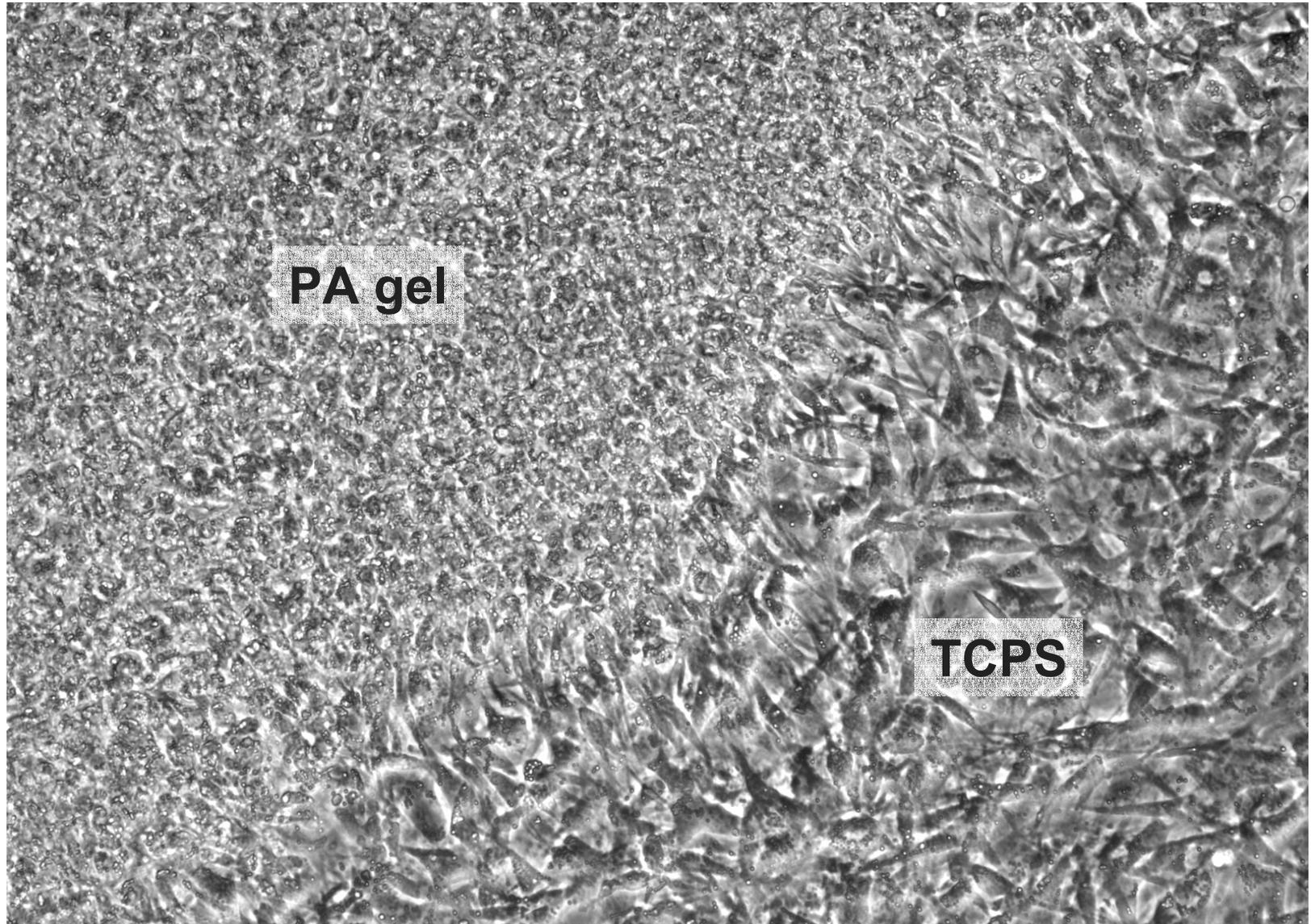
ligaments



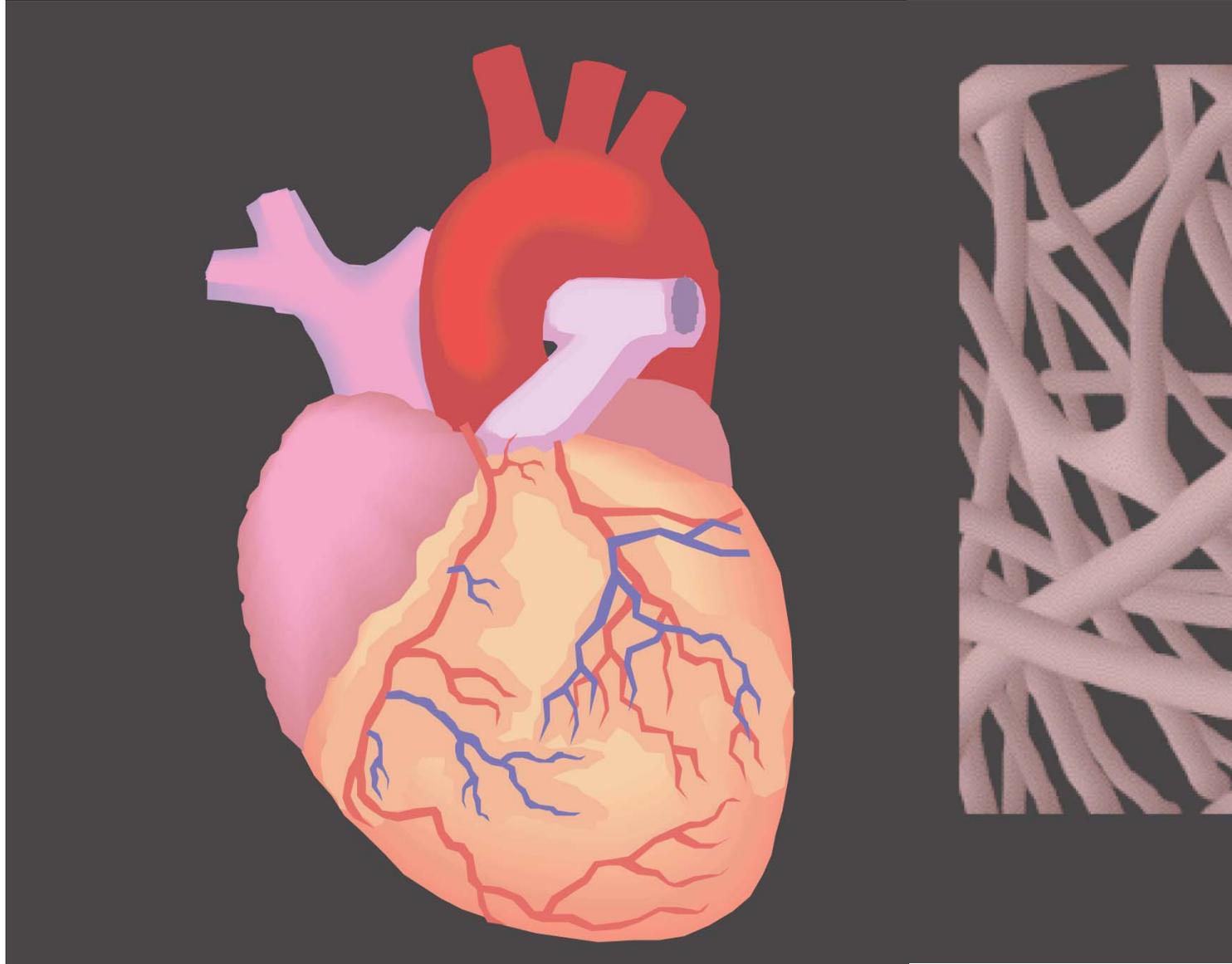
Field of Chondrocytes Isolated from Bovine Cartilage



Chondrocytes produce cartilage in contact with nanostructures



**Another great target,
the heart**



How do we proceed?

- **Biologists will continue to generate information about cell signalling**
- **The artificial systems needed will be developed by creative teams of physical scientists, engineers, biologists, and clinicians**
- **The interdisciplinary culture will not always emerge spontaneously, federal encouragement is useful to do it effectively**
- **Universities are very willing to do technology transfer, VCs are not investing in high risk/quantum leap projects**
- **Business as usual will most likely not do**

NRC Review of the NNI August 2001-June 2002

**A study requested by the White House Economic
Council**

**S.I. Stupp, chair
Northwestern University**

