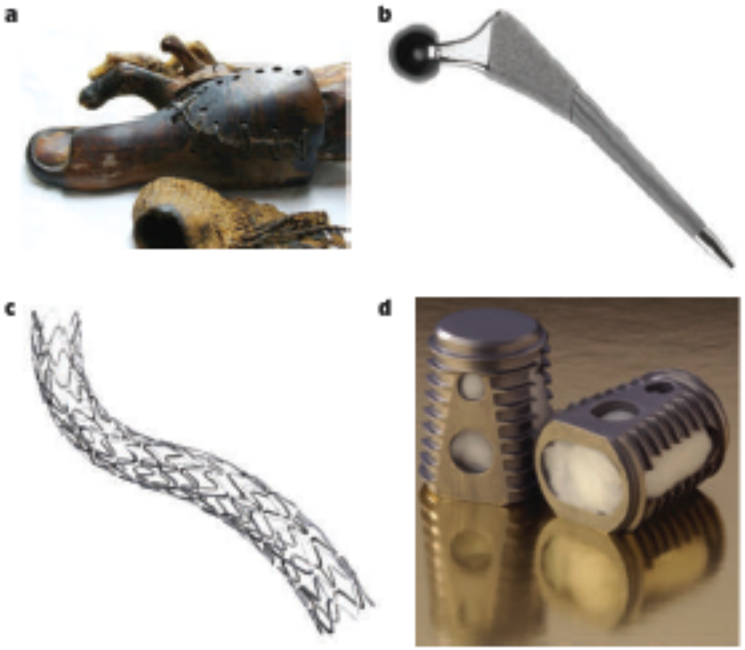
Introduction to Biomaterials

575: Lecture 7

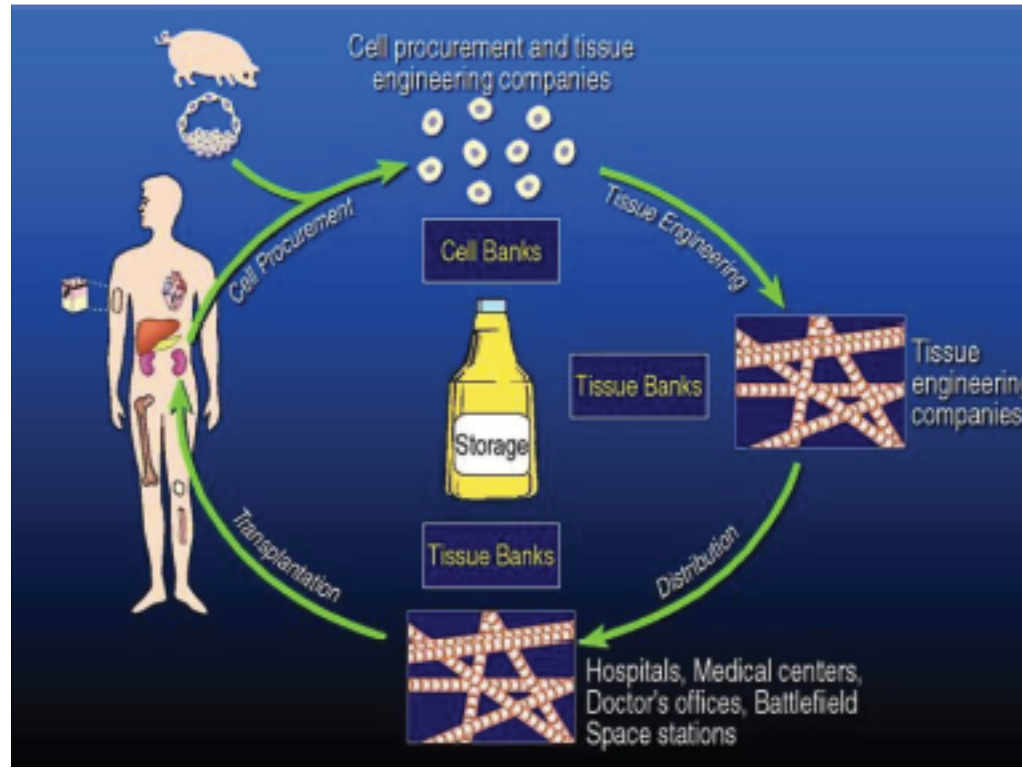
2/20/14

History of biomaterials



- Biomaterials developed, at least initially, for tissue engineering

- Biomaterials range from prosthetics, to stents, to implantable scaffolds



Huebesch and Mooney, Nature, 2009

Mikos et al., Tissue Engineering 2006

Bioinert materials

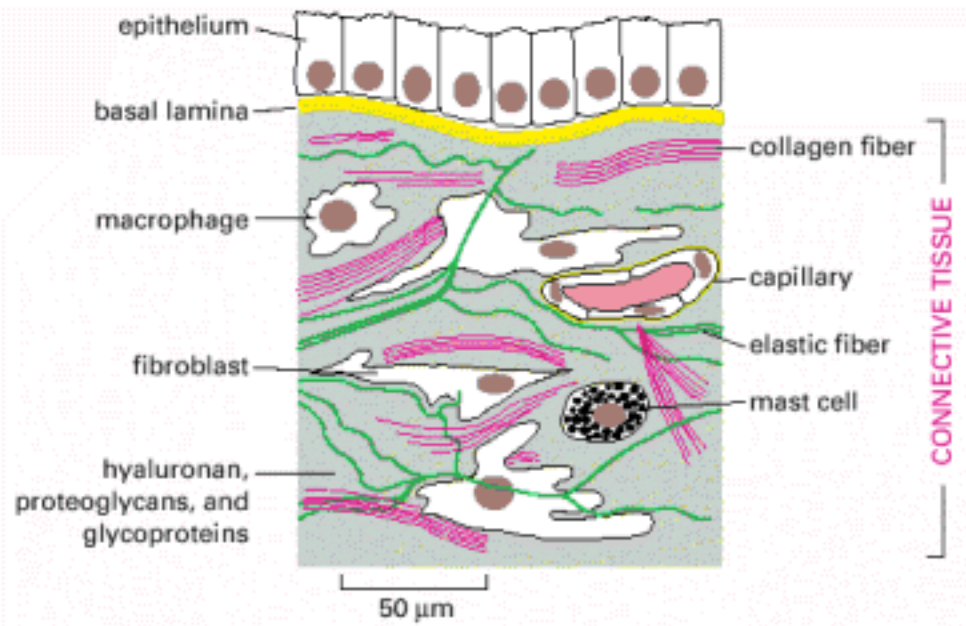
Purposes:
1) do not entice an immune response once implanted into the body.
2) Have incredible mechanical toughness withstand physiological loading
3) Long lasting in the body (won't degrade over time)

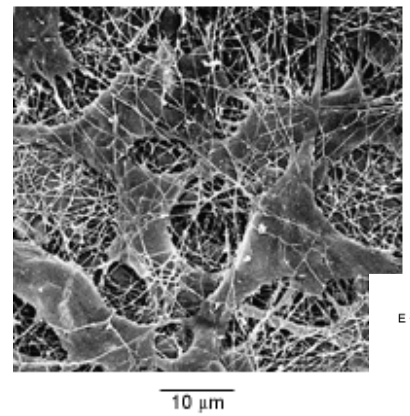
Metals	Ceramics	Polymers
316L stainless steel Co-Cr Alloys Titanium Ti6Al4V	Alumina Zirconia Carbon Hydroxyapatite	Ultra high molecular weight polyethylene Polyurethane

Applications:
1) Skeletal tissue prosthesis (hip, knee replacement)
2) Vascular stents, heart valves
3) Tooth caps, replacements, other dental applications

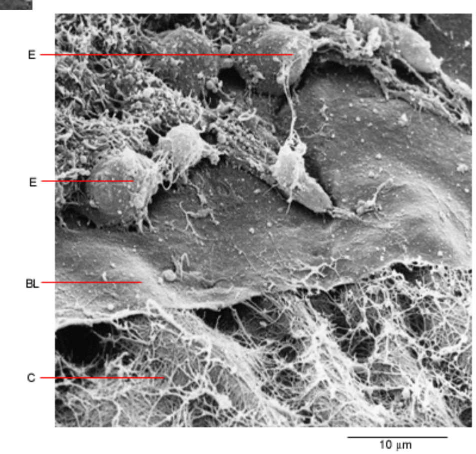
Natural biopolymers

Taken straight from body: are native proteins found in the ECM
Fibrous, instructive, soft (in bulk): the opposite of bioinert examples
Regulate cell function, act as a physical scaffold, can be remodeled by cells
Not very controllable (lumped parameters)





Images taken from Molecular Biology of the Cell

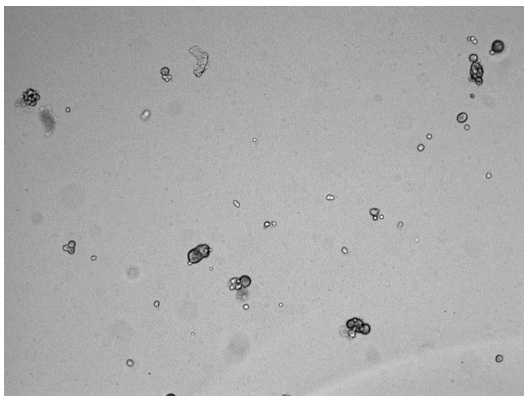


Examples: Type I Collagen, Fibrin, Matrigel

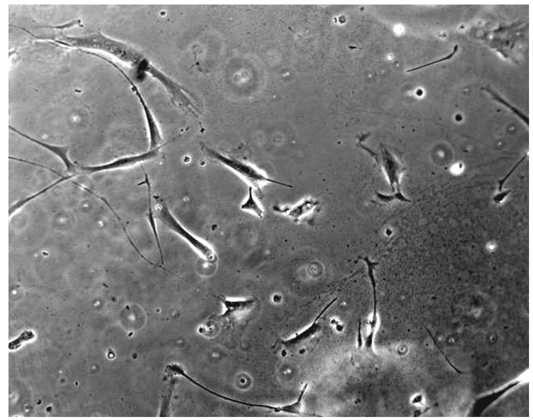
Can Functionalize inert surfaces with many cell-binding proteins

Attack amines, thiols on proteins, or biotinylate them

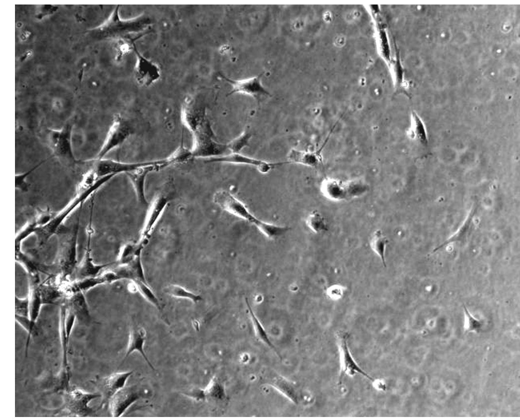
No treatment



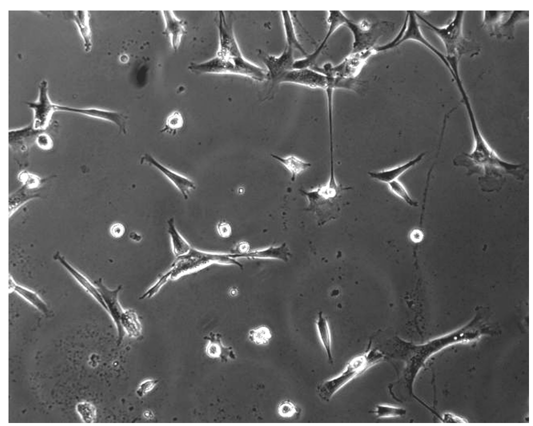
Hydrophilic surface, so no protein will stick



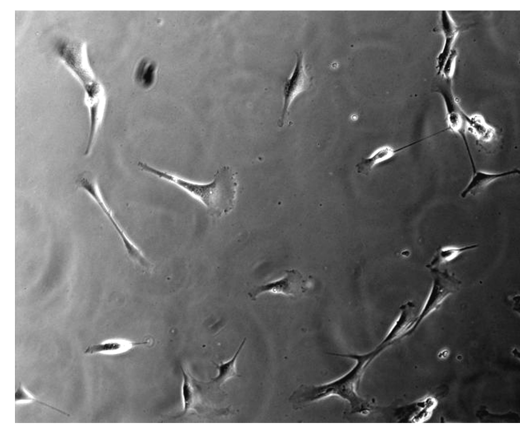
Type I Collagen



RGDS

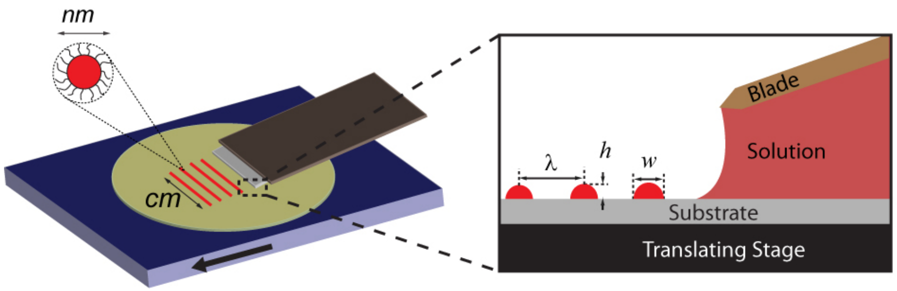


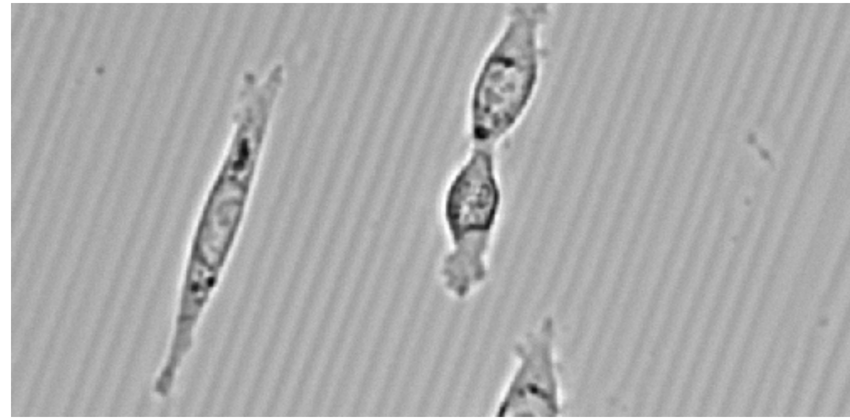
Fibronectin



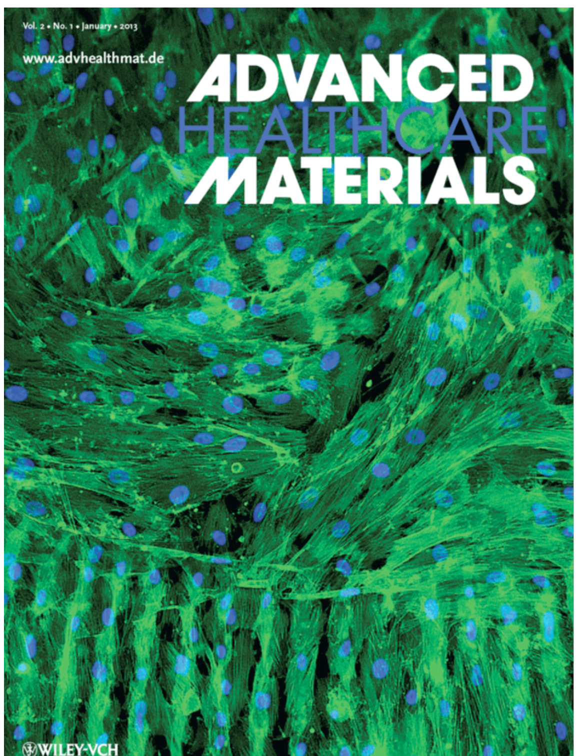
KQAGDV

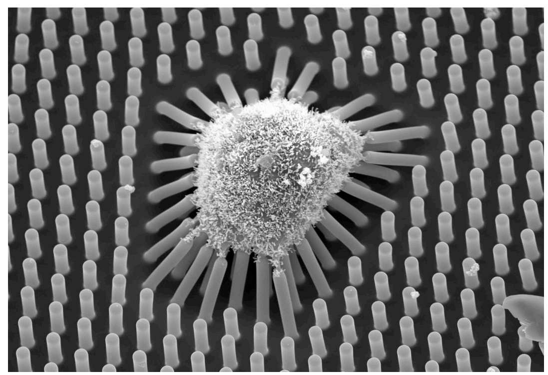
Patterning surfaces to control cell alignment, shape



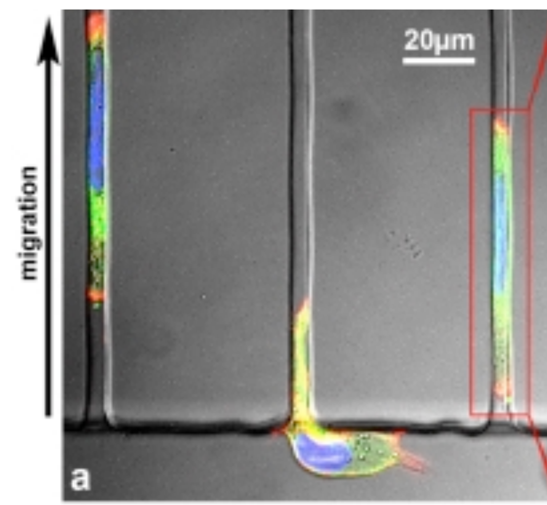


Crosby, Emrick, Peyton





Courtesy Chen Lab, Penn

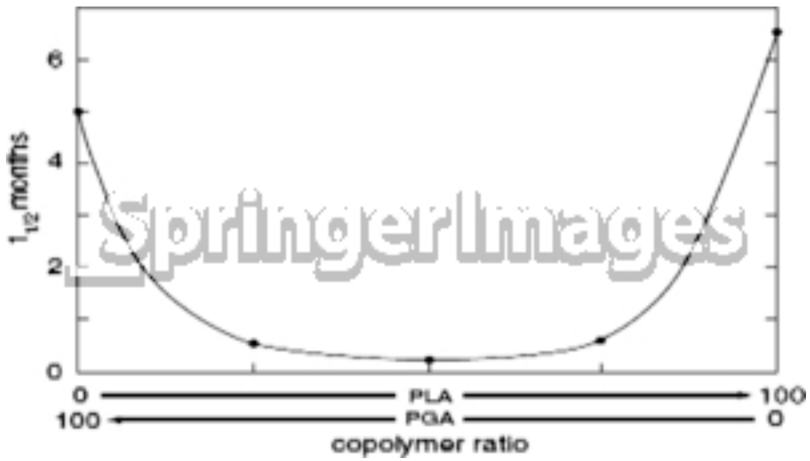


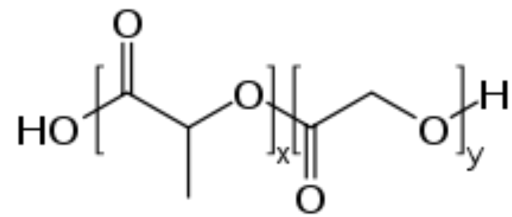
Plos One, 2012

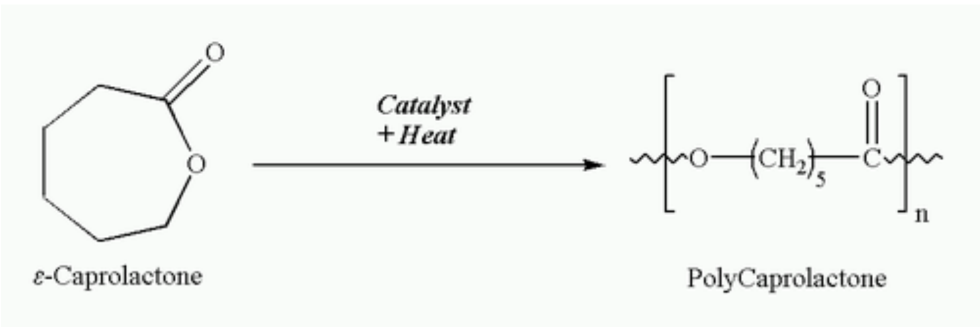
Degradable polymers

Purposes:

1. Temporary space holder for tissue replacement
2. Not entirely bioinert – meant to degrade away while being replace by native tissue *in vivo*
3. Is adhesive to matrix proteins
4. Tune biodegradation to match body's kinetics (rate of tissue production/replacement)
5. Degradation can be either hydrolytic (PLGA), or biospecific/enzymatic (via MMPs)
6. Unstable.



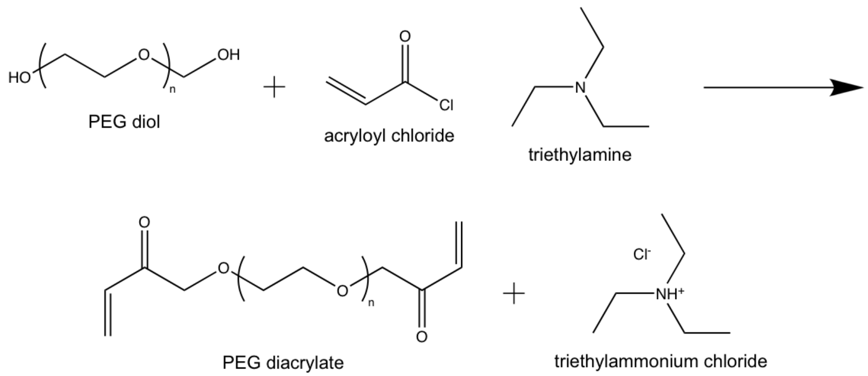


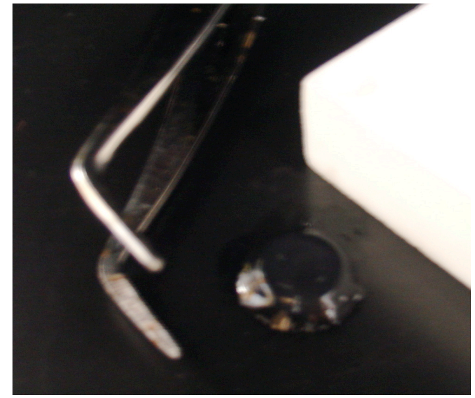


Applications:

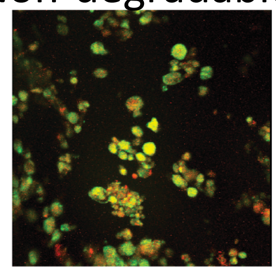
1) Both Hard and Soft tissue repair
2) where vascularization is needed

Degradable, Bioinstructive Polymer



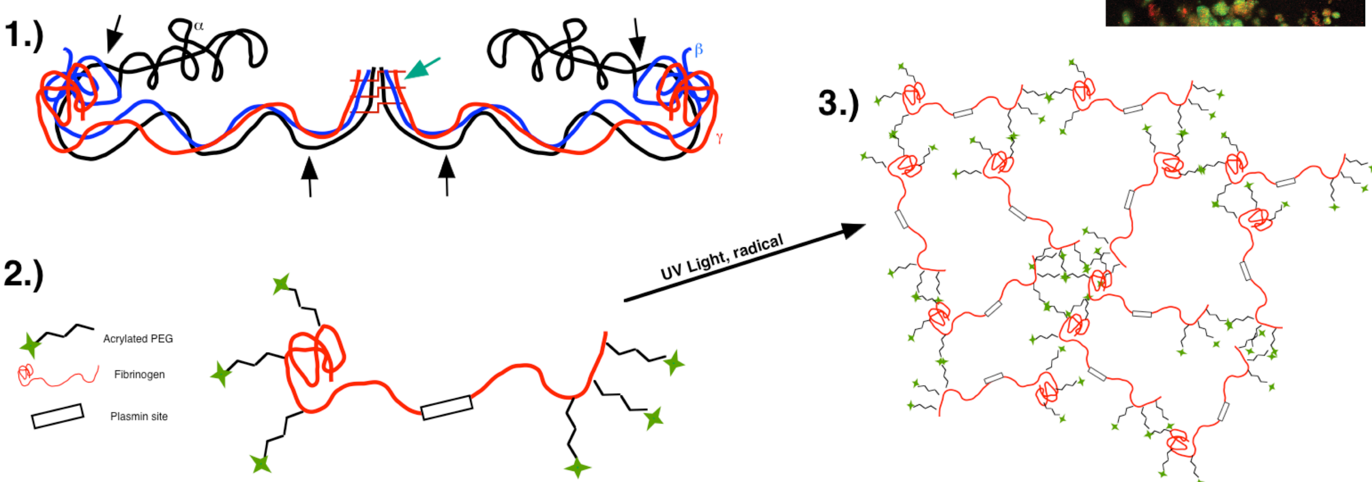


Non-degradable



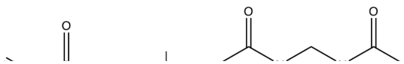
PEG-fibrinogen
For 3D culture, need to make PEG degradable

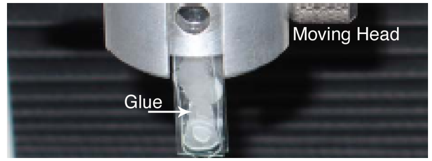
degradable

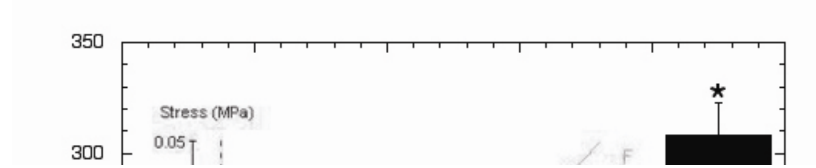


Biomaterial Stiffness

Polyacrylamide



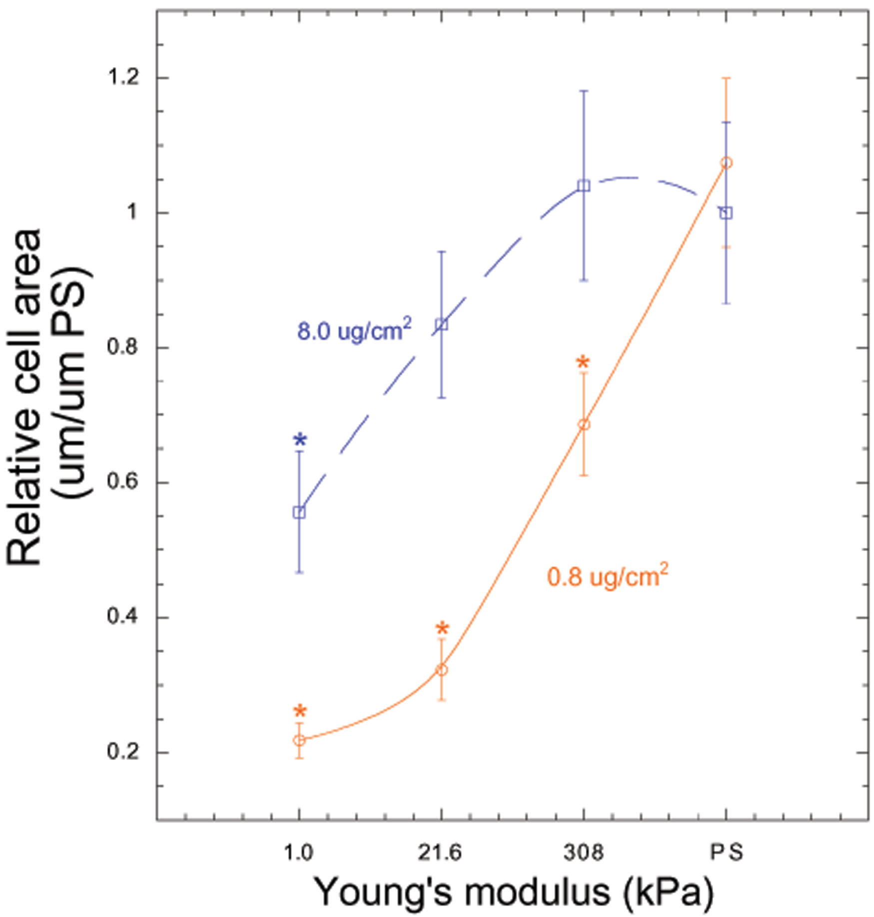


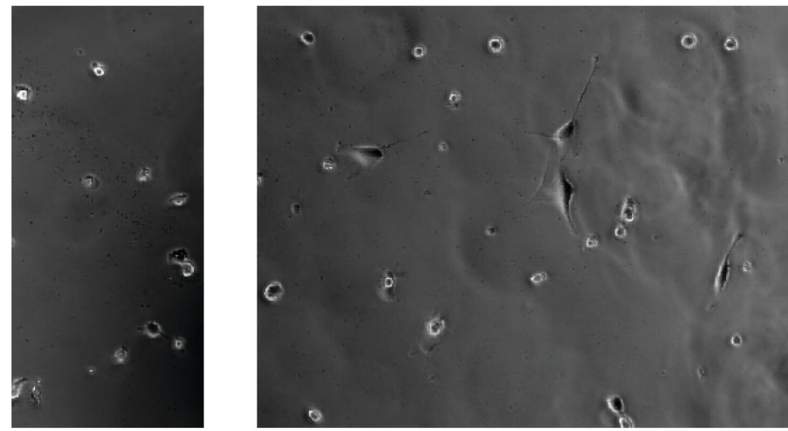


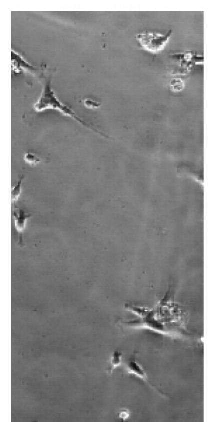
1.0 kPa

21.6 kPa

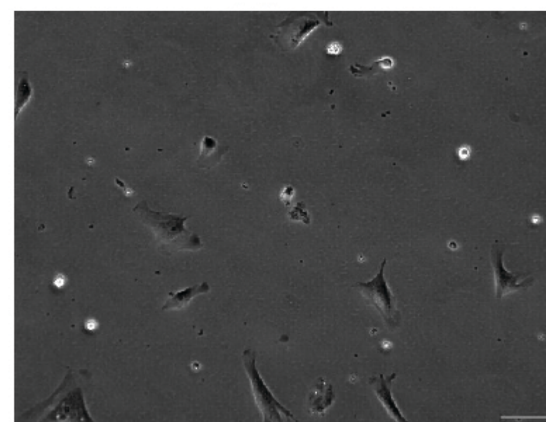
45.8 kPa







PS



Overview

- There's a biomaterial out there for every need
- Establish design criteria from biological purpose
- Some are easier than others to modify
- Some are cheaper than others
- Some, but not many, (PAA) are starting to be used by biologists.