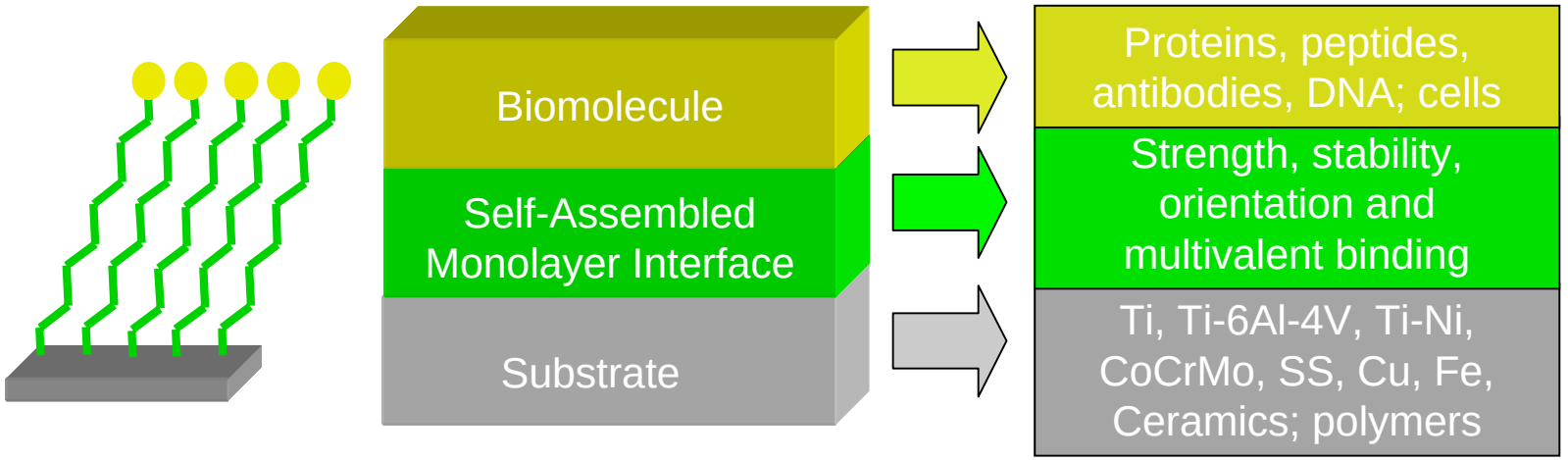
Reactive Interfaces for Functional Surfaces

Surface Modification of Biomaterials:

Interfacing Synthetics and Living Systems

Our Modular Approach to Surface Bio-Activation

SAMPs are ordered and quantitatively reproducible



A modular approach allows us to use a single SAMP “platform”,
and then attach biomolecules using “standard” organic transformations

Validate synthesis, structure, and function:
UHV; AFM; QCM; IR; cell biology

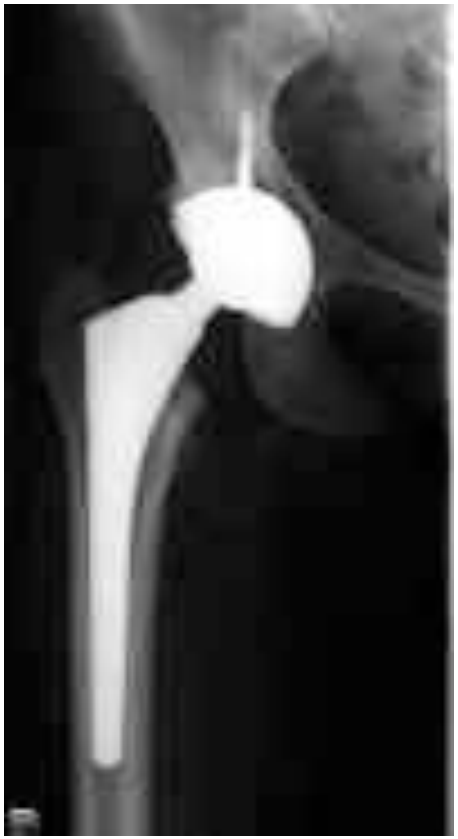
Surface Modification for Cell Adhesion: Orthopedic Device Fixation

Problem:

- Poorly osseoconductive surfaces give mechanically weak implant-bone interfaces
- Gaps can be sites for debris buildup; increases osteolysis and aseptic loosening

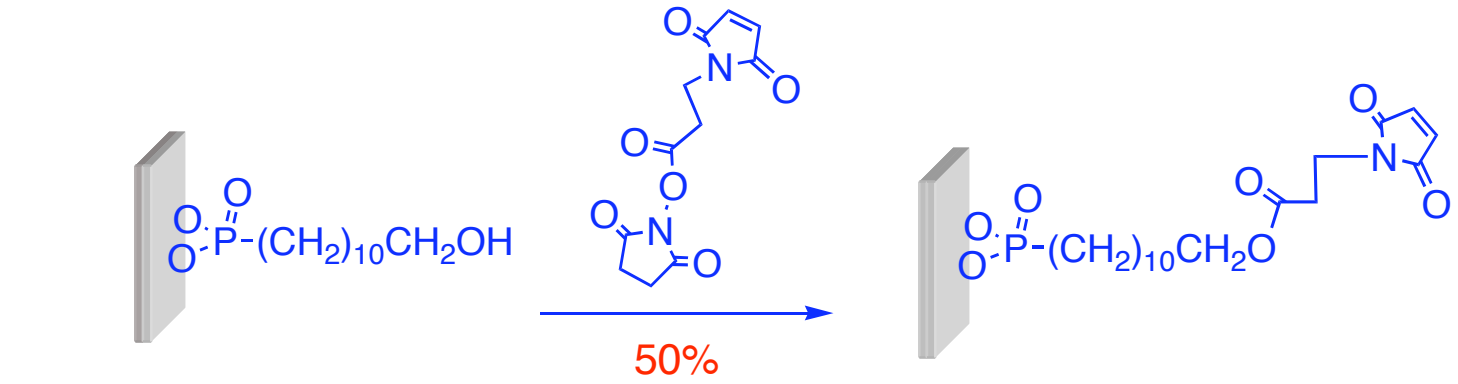
Goal:

- Design strongly adhering, cell attractive interfaces through surface modification chemistry of implanted materials
- Osseoconductive interfaces to enable rapid closure of the “gap”
- Reduce osteolysis

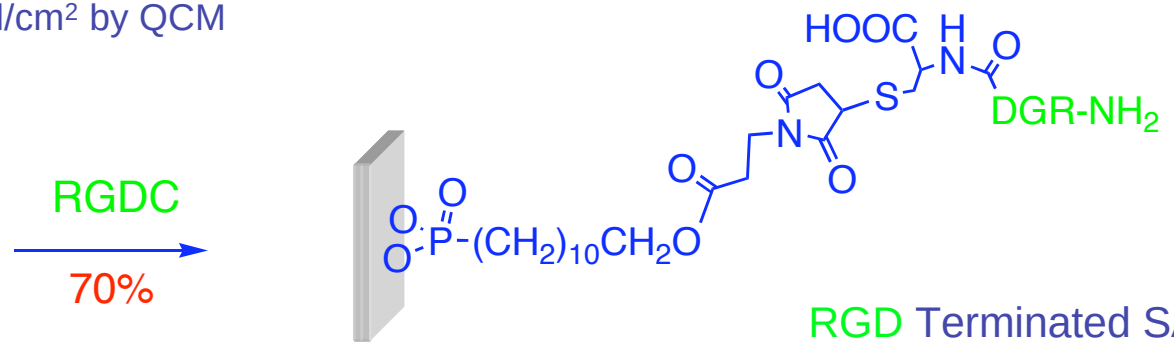


Our RGD-Terminated SAMPs Promote Cell Proliferation on Ti-6Al-4V

RGD is a common cell adherent peptide



PUL = 1.0 nmol/cm^2 by QCM



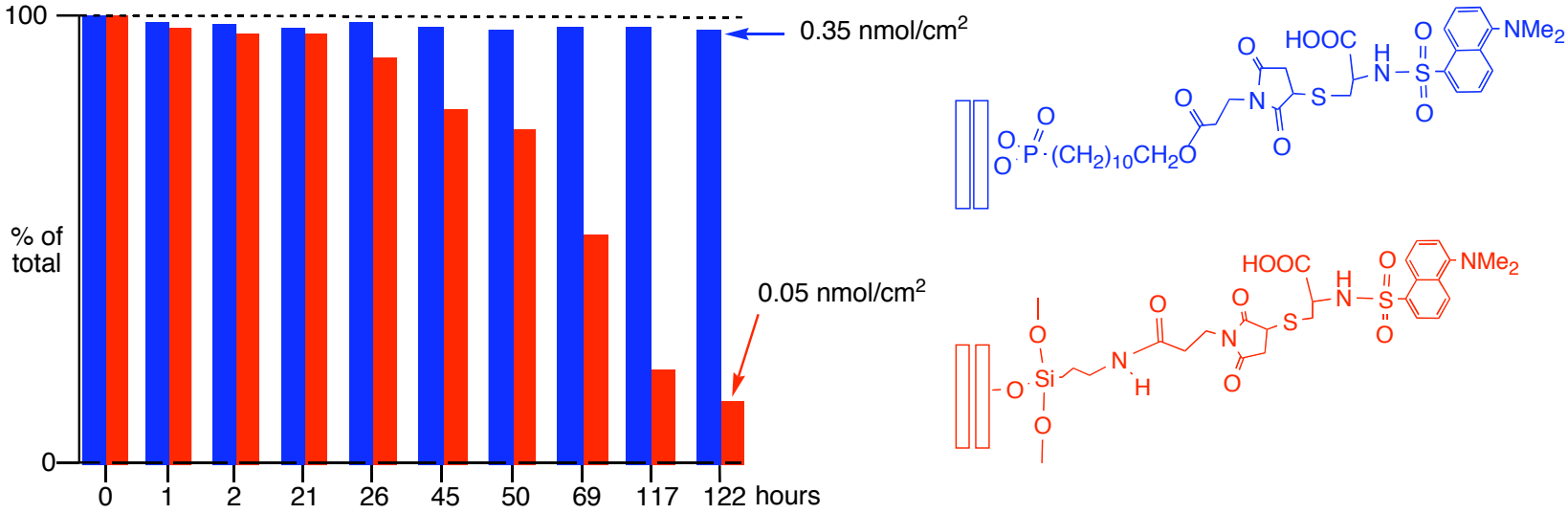
RGD Terminated SAMP

RGD = 0.35 nmol/cm^2 by QCM

Gawalt; Avaltroni; Danahy; Silverman; Hanson; Midwood; Schwarzbauer; Schwartz. Langmuir. 2003; 200

Silverman, Wieghaus, Schwartz. Langmuir 2005, 225

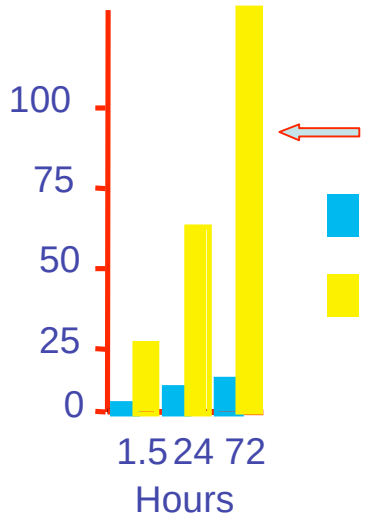
Our SAMPs Show Hydrolytic Stability



Siloxanes are quite commonly used reagents for surface treatment of metals. The hydrolytic stability of SAMP/Ti is much greater than that of siloxane/Ti (at pH 7.5, room temp.):

- Nearly all (0.35 nmol/cm^2) of the starting amount of fluorescent label remains on the SAMP-treated surface after 122 hours
- Nearly all (down to 0.05 nmol/cm^2) of the siloxane-treated surface is gone after this time.

Our RGD-Terminated SAMPs Promote Cell Proliferation on Ti-6Al-4V

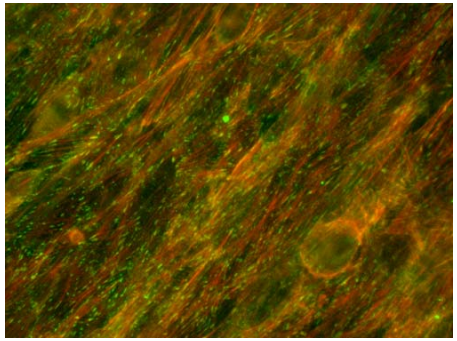


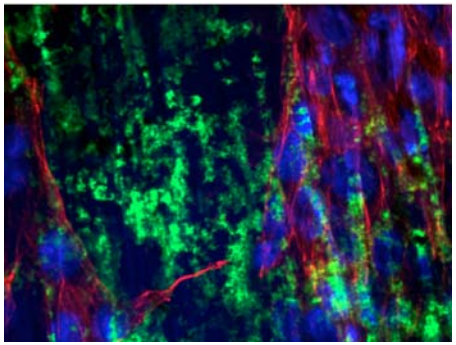
⇐ Increased osteoblast cell proliferation

Bare Ti alloy

RGD-Terminated SAMP

Formation of focal contacts ⇒

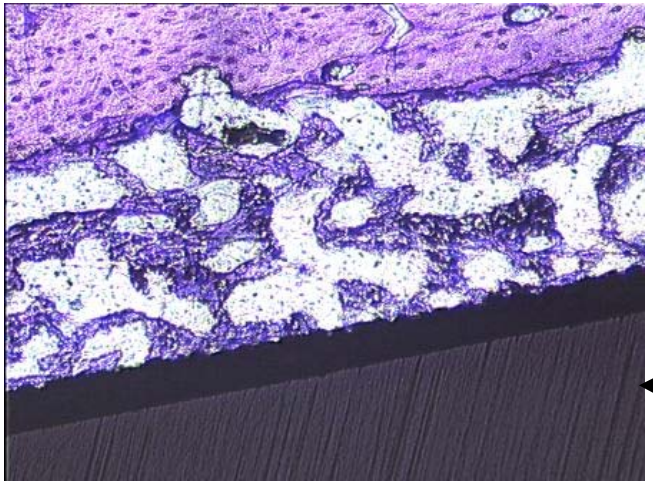




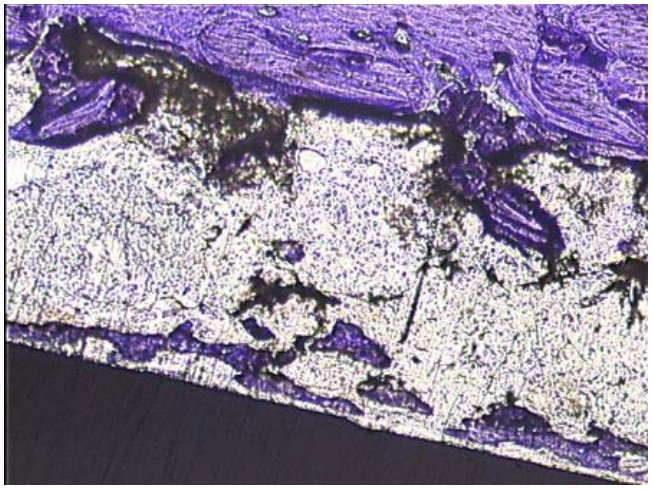
⇐ Formation of mineralized matrix

Gawalt; Avaltroni; Danahy; Silverman; Hanson; Midwood; Schwarzbauer; Schwartz. Langmuir. 2003; 200

Our First *In Vivo* Test: 2 Week Time Point Comparison



Using our RGD-SAMP: New bone is growing extensively between the implanted pin and the original bone, and the “gap” is closing.



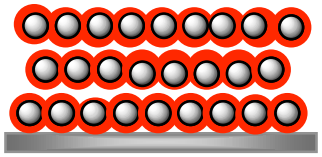
Control RGD-Au: New bone is not closing the “gap.” (The dark material is colloidal gold, from the sectioning process.)

Crowder, Schwartz

Our Second *In Vivo Test:* Histology Results (Ti)

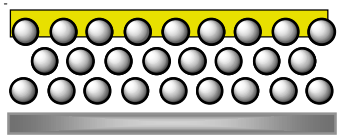
SAMP facilitates cell growth inside the pores ➡ better osseointegration of implant

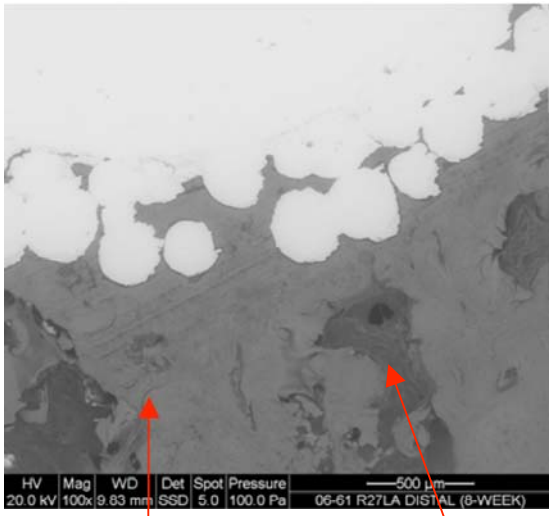
SAMP-RGD Coating



8 weeks

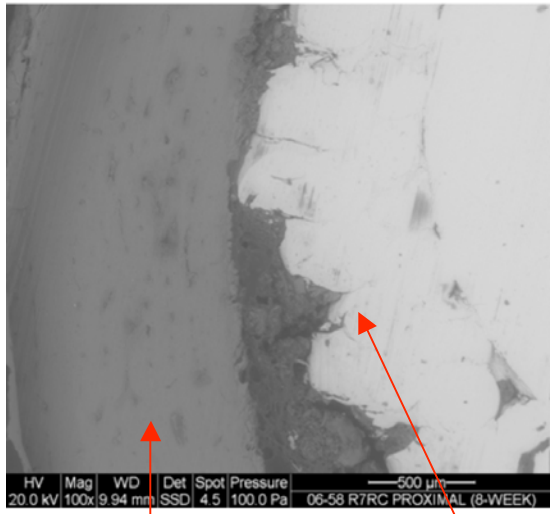
Control (HA)





New bone

Marrow



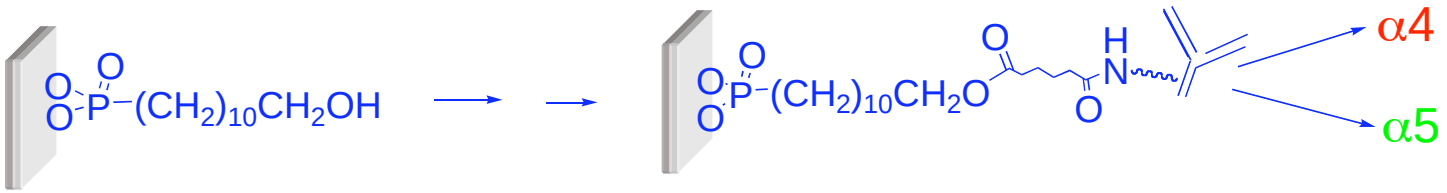
Existing bone

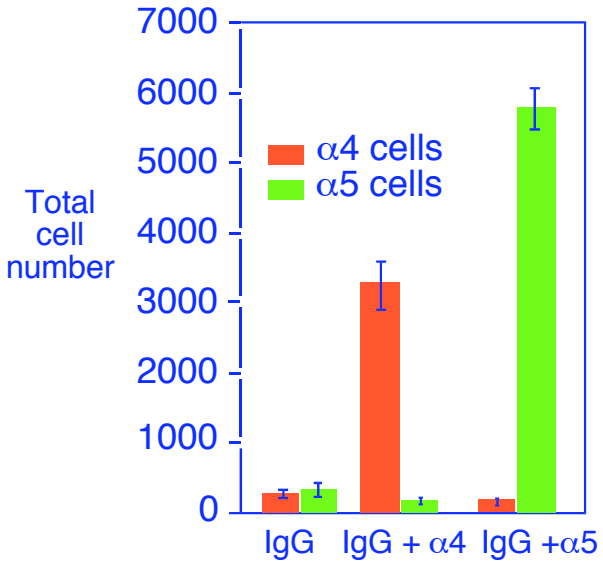
Hydroxyapatite

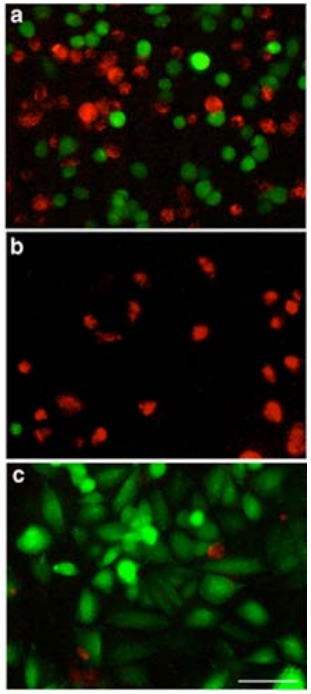
Crowder, Schwartz

Antibody Attachment Enables Selective Cell-Surface Binding on Si

A basis for cell-selective sensors



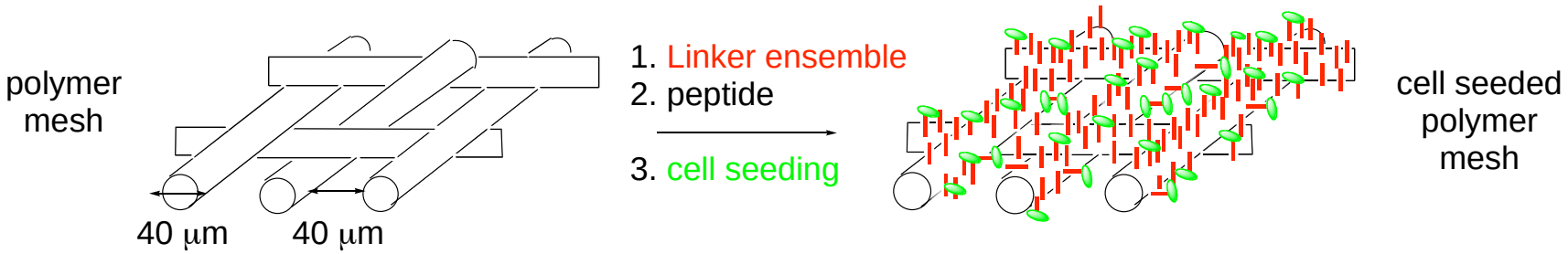




Midwood, Carolus, Danahy, Schwarzbauer, Schwartz. Langmuir. 2004; 5501

A Problem with Tissue Scaffolds

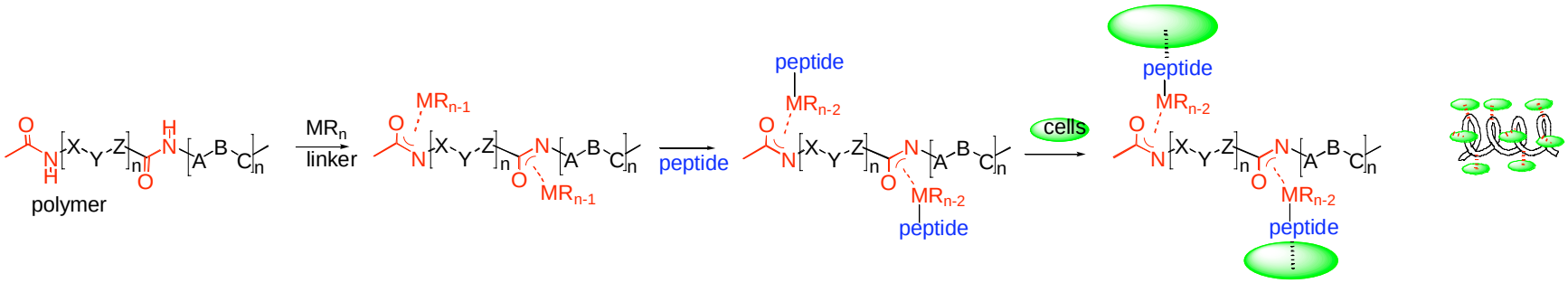
Polymer scaffolds are designed for biocompatibility and to have good mechanical properties. However, they need to be seeded with cells that can proliferate and function.



With poor seeding:

- tissue integration into the device may be poor
- the device may fail as the scaffold degrades

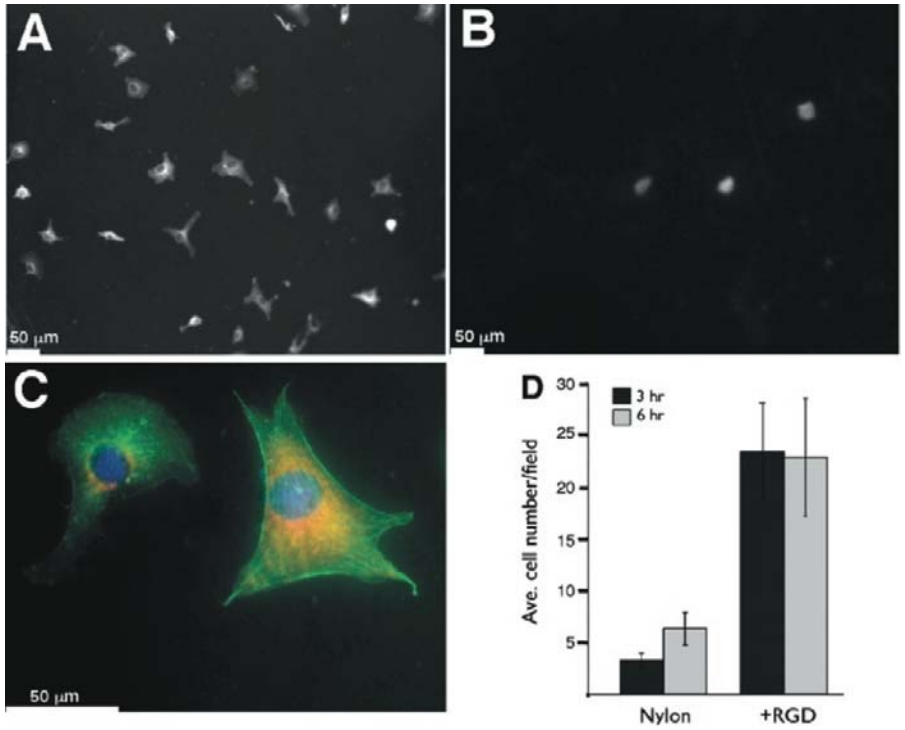
Our Platform Technology for Polymers: Activate “Backbone” Units



With our new method, we can:

- activate any backbone amide group using reactive linker complexes;
- surface attach the highest densities of peptide (RGD) thus far reported;
- attach peptides throughout a 3D mesh;
- systematically control loading without changing substrate surface topography.

Cell Adhesion Results on Nylon Are Excellent



A: Our surface
B: Untreated nylon control
C: Blow-up of cells on our surface
D: cell growth on our surface vs untreated nylon control

Dennes; Hunt; Schwarzbauer; Schwartz , J. Am. Chem. Soc. 2007; 93-97