Biological Frameworks for Engineers

ME 411 / ME 511

Biological Frameworks for Engineers

UNIVERSITY OF WASHINGTON

Class Organization

- Course evaluations on Friday

Biological Frameworks for Engineers

ME 411 / ME 511

Tissue Engineering

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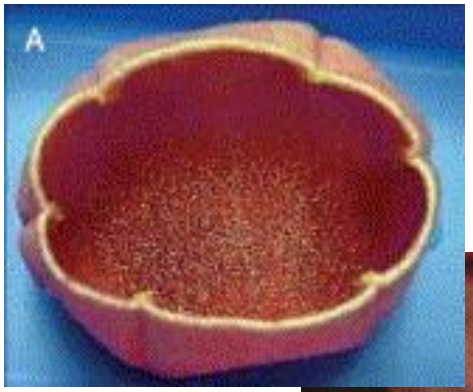
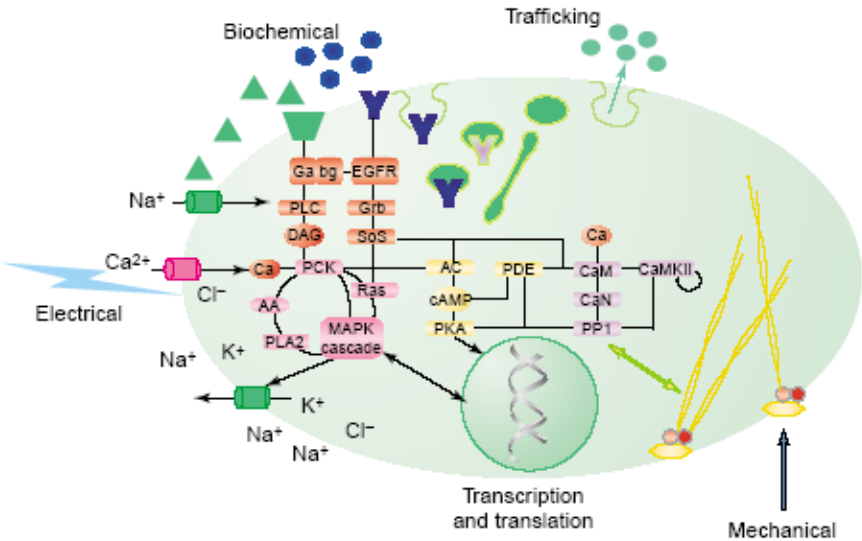
Tissue Engineering

- A field that seeks to replace, repair or enhance biological function at the scale of a tissue or organ by manipulating cells via their extra-cellular environment.



Atala (WF)
[TED talk]

Langer (MIT)



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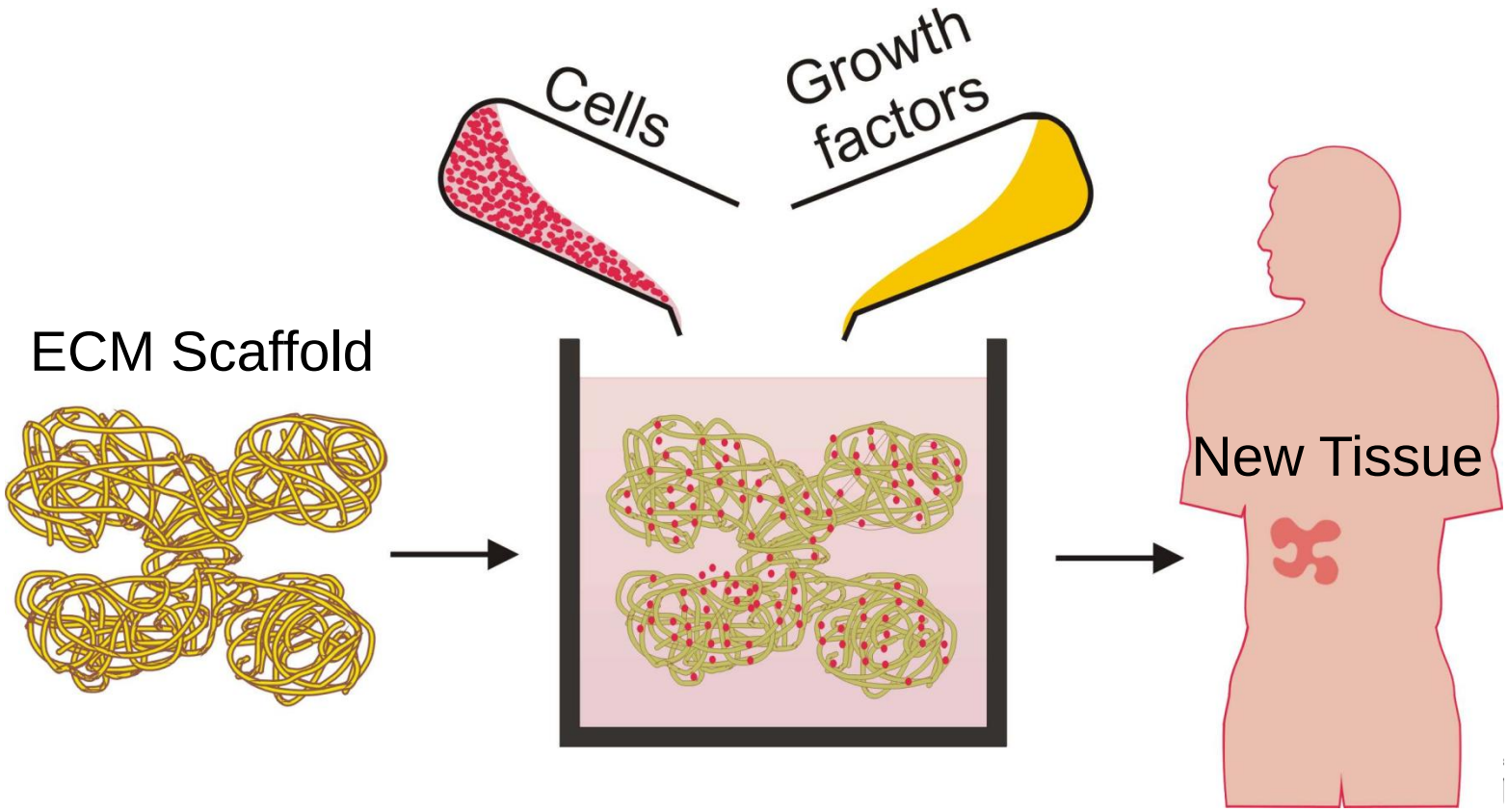
Central Hypothesis

Cells + ECM + GF = New Tissue



Defect Objectives

- Mechanical
  - Bone, cartilage, ligaments
- Metabolic
  - Replace physiological function (liver)
- Synthetic
  - Deliver secretory products (insulin production)
- Communication
  - Nervous system
- Any combination of the above

Success Stories

- Cornea
  - Corneal epithelial cells pre-seeded in hydrogels and transplanted into rabbit cornea, where remained adherent and proliferated up to 2 weeks
- Liver
  - Hepatocyte systems for extracorporeal and implantable applications
  - Implants offers the advantage of permanent liver replacement
- Pancreas
  - Destruction of pancreatic islets, leading to loss of glucose and insulin regulation
  - Transplant microencapsulated islets cells to avoid immune rejection
- Cartilage
  - collagen-glycosaminoglycan templates using chondrocytes
  - chondrocytes grown in agarose gel culture produce tissues with mechanical properties similar to articular cartilage
- Bone
  - synthetic and natural polymers should have optimal strength and degradation properties
  - use bone morphogenetic proteins (BMPs) and growth factors (e.g., TGF-b)
- Bladder
  - Seminal attempt in generation of complete organ
  - Collagen scaffolds seeded with autologous bladder epithelial cells on inside and smooth muscle cells on outside
- Skin (most successful application)
  - Implant a composite material of silicone upper layer and chondroitin-sulfate and collagen lower layer; prevents liquid loss and induce angiogenesis
  - in vitro culture of keratinocytes (epidermis) from burn patients and multiply 10,000-fold in laboratory; requires 4 weeks

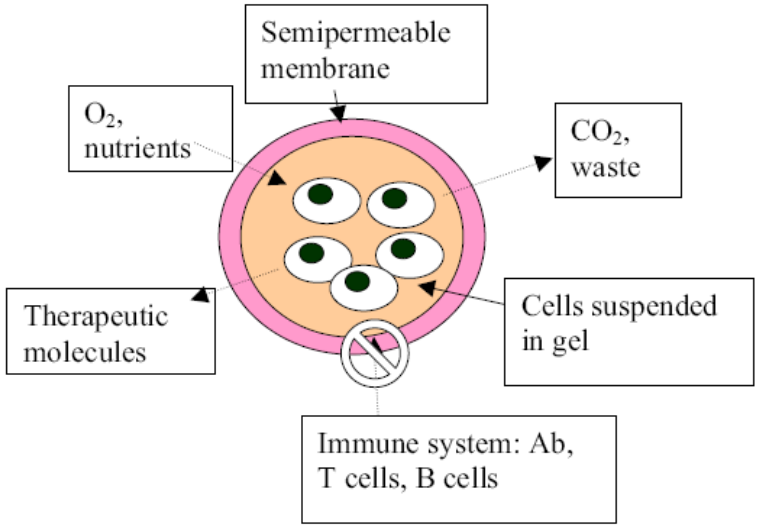
Next Frontier : Muscle and Blood Vessels

Extracorporeal Method

- "Microencapsulation"

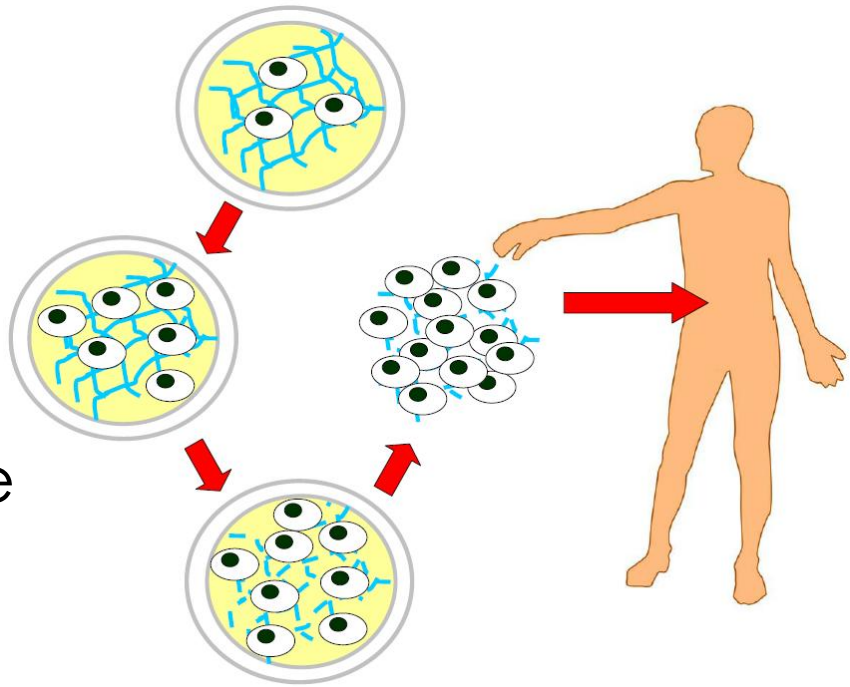
  Ex: insulin-secreting β-islet cells from pancreas of cadaver

  - Encapsulate cells within membrane construct
  - Immunoisolate from antibodies and leukocytes
  - Implant construct
  - Cells secrete product
  - Remove when concluded



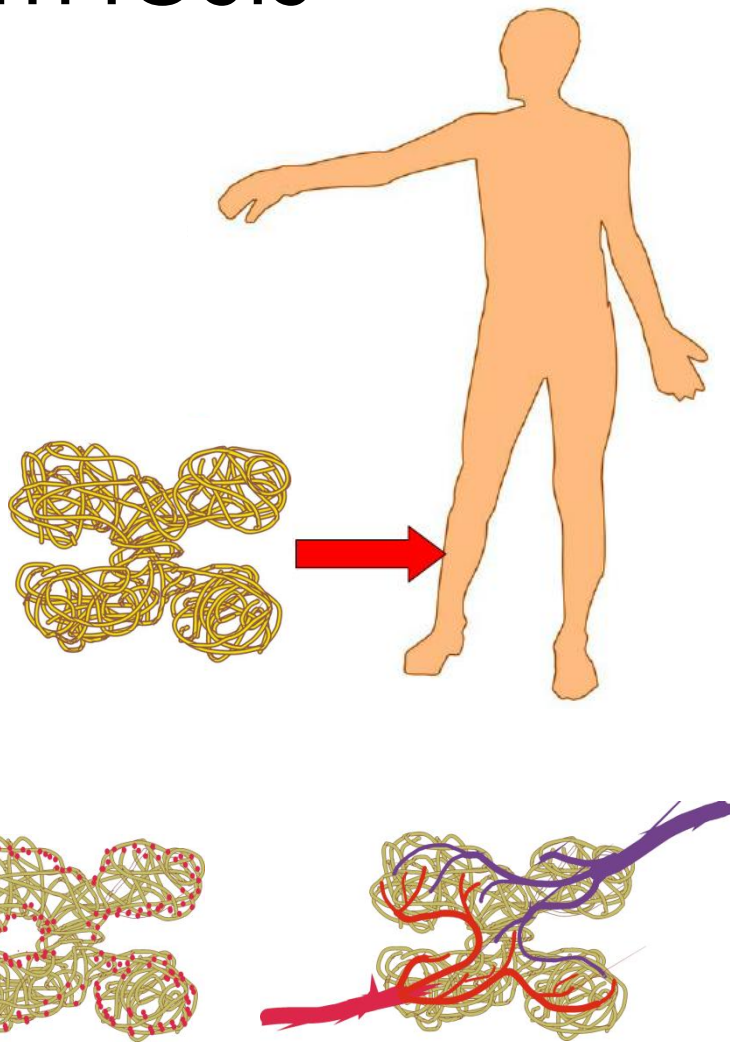
In Vitro Synthesis

- Cultured Scaffolds
  - Cells seeded onto scaffold in vitro
  - Cells maintained in culture to expand population and organize
  - Device implanted once colony established
  - Device degrades and replaced by remodeled tissue



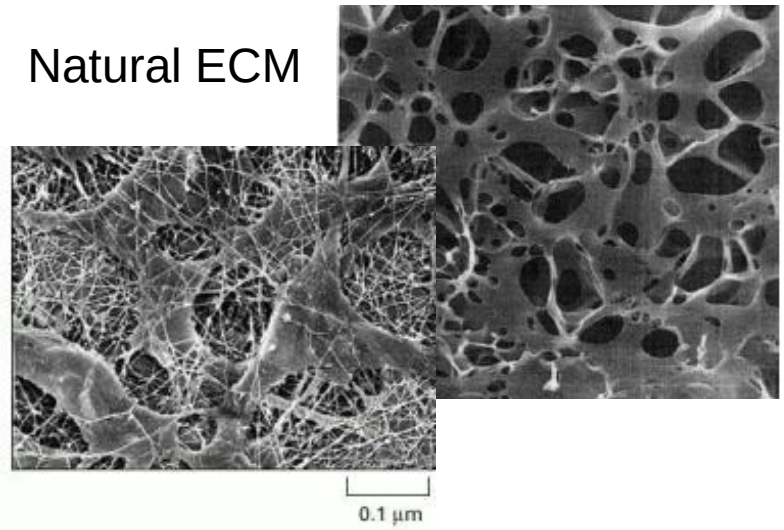
In Vivo Synthesis

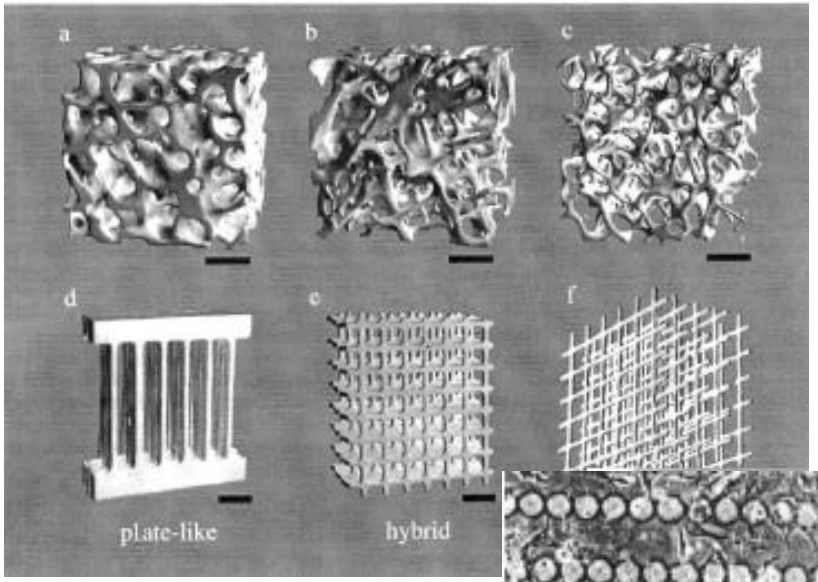
- Implanted Scaffold
  - Constructed bioactive scaffold (ECM, GFs, topology)
  - Implant porous scaffold device
  - Cellular in-growth in vivo (integration and vascularization)
  - Scaffold replace by remodeled tissue



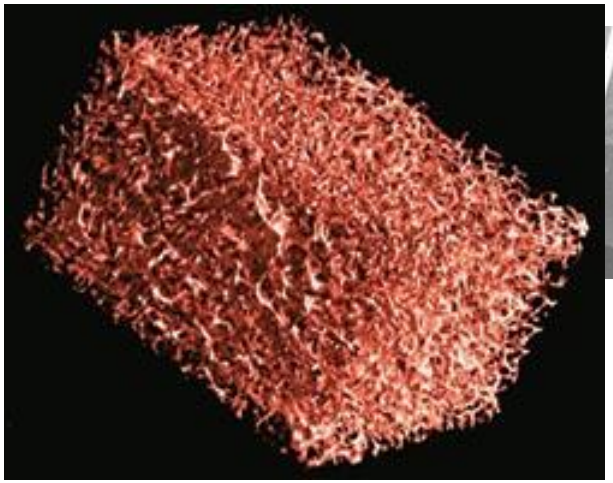
Scaffolds

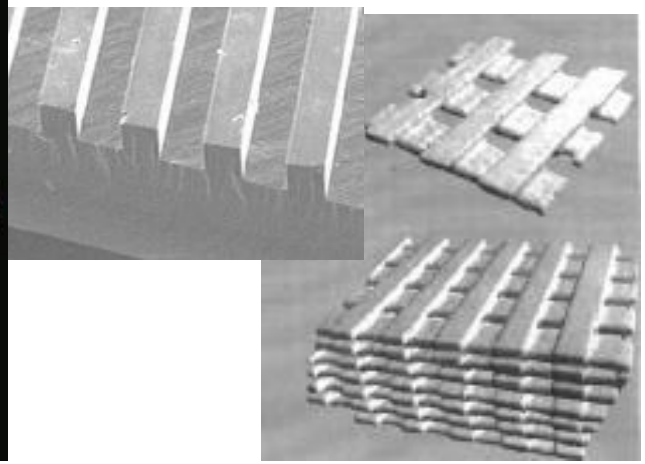
Natural ECM

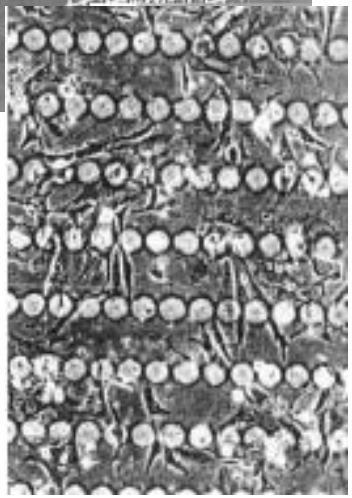




Synthetic ECM

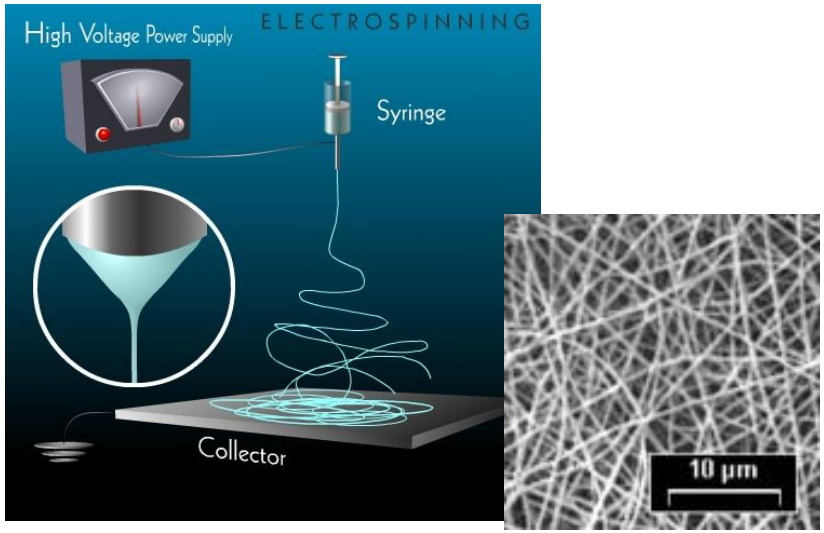


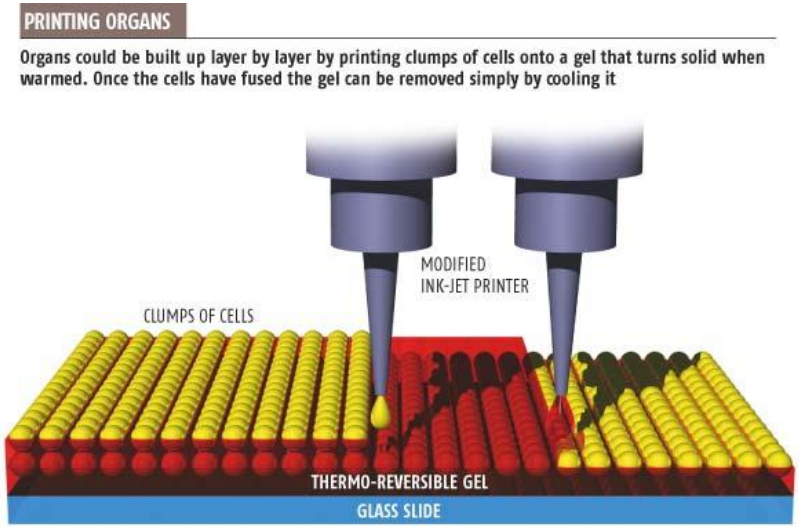




Fabrication

- Biological
  - Decellularization Collagen
  - Hydrogels
- Textile Fibers
  - Weaving/Braiding
  - Electrospinning
- Particles
  - Colloidal Sintering
  - Nanoparticle Condensation
- 3D fabrication
  - Stereolithography
  - "Ink" printing





Questions?