ME 498 / ME 599

Biological Frameworks for Engineers

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Tissue Replacement

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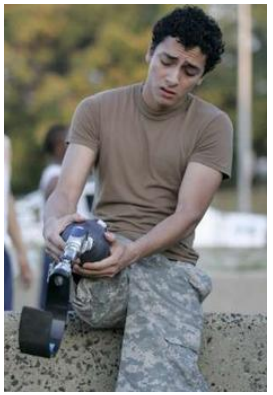
Replacement Body Parts

We wear out – we are easily damaged

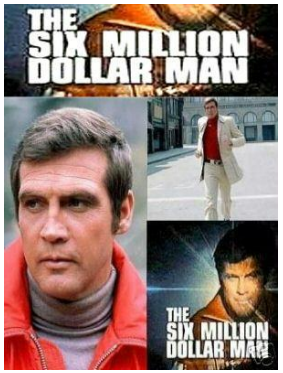
wear

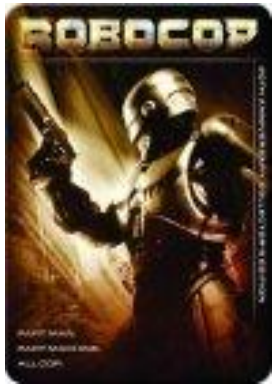
injury



trauma

Can we build it?
Can we build it *better*?
Can we build it *stronger*?
Can we build it to *last*?





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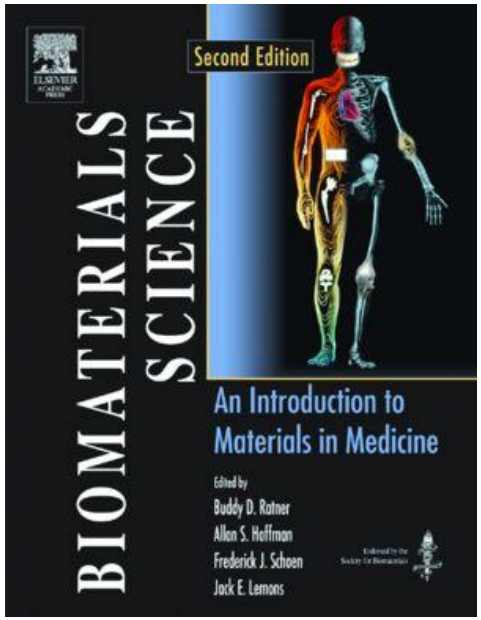
UNIVERSITY OF WASHINGTON ENGINEERED BIOMATERIALS

Buddy Ratner
(BIOE, ChemE)



http://www.uwtv.org/programs/displayevent.aspx?rID=20222

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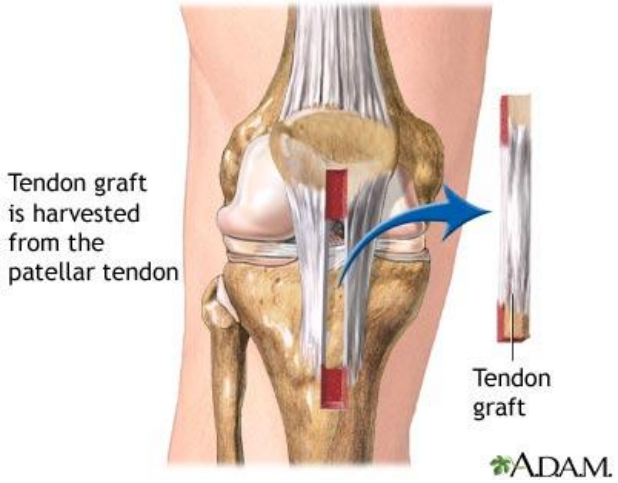
What do we need to know?

- Biomechanics :
  - How does the broken part work?
- Bioresponses :
  - Matrix protein
  - Cell
  - Tissue
- Healing:
  - Immune
  - Inflammation
  - Wound closure

Biologic or Synthetic?

- Autograft – same person
- Allograft – same species
- Xenograft – other species

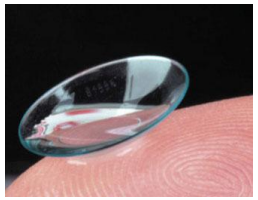


What is a Biomaterial?

- A material intended to interface with biological systems to evaluate, treat, and augment, or replace any tissue, organ, or function of the body.

Common Examples

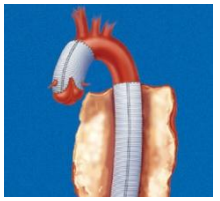
- Contact Lens…




- Dental Implants…

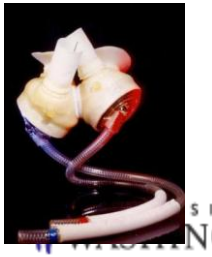

- Cosmetic…

- Vascular Grafts…

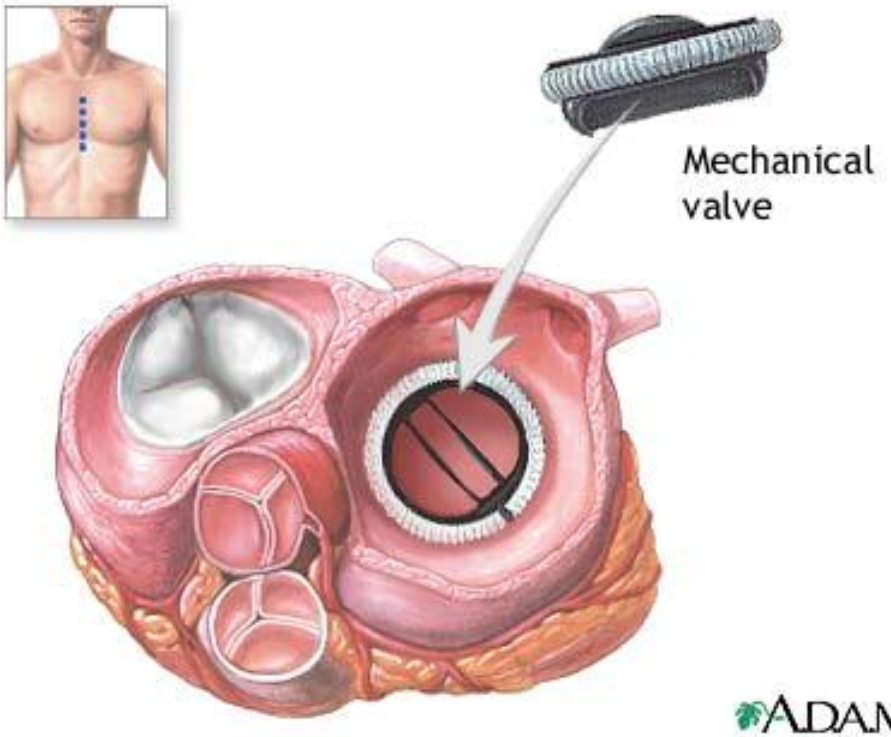
- Joint Replacement…

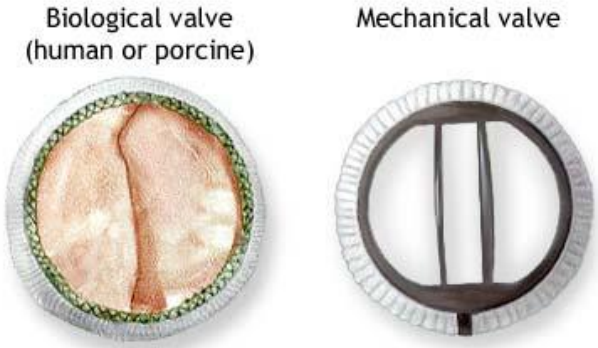

- Artificial Heart…

Biocompatibility

- Heart Valves – 100,000/yr





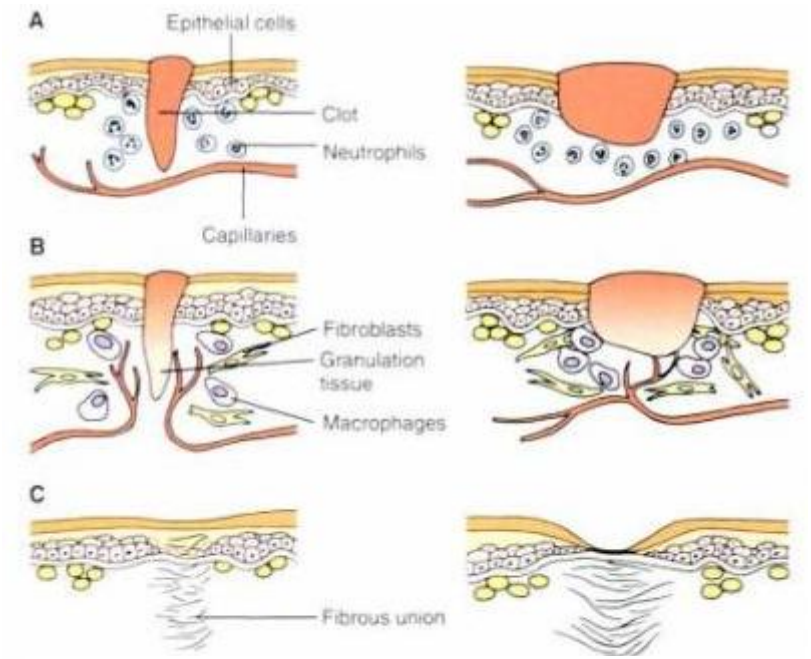
Correct Material Choices

- Inert (1960-1970)
  - Negative immune response
  - Artificial materials have few antigens
  - Nonspecific interactions
  - Hypersensitivity

- Bioactive (1990 – present)
  - Promote local healing
  - Smart/Instructive materials
  - Minimally invasive surgery
  - Nanomaterials

Integration with the Body

- After implantation
  - Integration into surrounding tissue
  - Isolation with fibrous encapsulation
- Wound Healing



Minor Incisions Large Wounds

Integration with the Body

- After implantation
  - Integration into surrounding tissue
  - Isolation with fibrous encapsulation
- Inflammation : angiogenesis and granulation tissue
- Immune response : antigen or nonspecific
- Blood clotting : platelets and thrombosis
- Infection : bacterial or viral invaders
- Tumor formation : excessive proliferation
- Calcification : deposition of $Ca_3(PO_4)_2$ nodules

Types of Biomaterials

- **Metals** (formable, strong)
  - Cobalt-chromium alloy
    - Heart valves, dental prostheses, orthopedic plates and joints, vascular stents
  - Gold, platinum
    - Dental fillings, electrodes for cochlear implants
  - Silver-tin-copper alloys
    - Dental amalgams
  - Stainless steel
    - Dental prothesis, orthopedic fixation plats, vascular stents
  - Titanium alloys
    - Heart valves, dental implants, orthopedic joints & screws, pacemakers, vascular stents

Types of Biomaterials

- **Ceramic** (hard, degradation resistant)
  - Aluminum oxides
    - Orthopedic joint components, load-bearing components, implant coatings, dental implants
  - Bioactive glasses
    - Orthopedic and dental coatings, dental implants, facial reconstruction components, bone graft substitute materials
  - Calcium phosphates
    - Orthopedic and dental coatings, dental implant materials, bone graft substitute materials, bone cement

Types of Biomaterials

- **Polymers** (natural vs. synthetic, elastomers, hydrogels, composites)
  - Synthetic (PMMA, PDMS, PE, PTFE, PLGA, etc.
    - Contact lenses, cosmetic implants, orthopedic wearing implants, vascular grafts, resorbable meshes and sutures
  - Natural (Collagen, Elastin, Fibrin, Hyaluronic Acid, GAGs, etc.)
    - Matrices: orthopedic repair, tissue engineered parts, skin repair, hemostatic sealants

Biomaterial Properties

- Degradable
  - pH resistant
  - Inflammation resistant
  - Biodegradable for cell/factor release
- Surface properties
  - Mechanical coatings
  - Hydrophobic/philic
  - Roughness or topology
- Bulk properties
  - Strength and stiffness
  - Anisotropy
  - Fatigue
  - Temperature
- Fabrication

Questions?