BIOMATERIALS-TISSUE INTERACTIONS:
INTRODUCTION

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• Tissue is a biological structure made up of cells of the same type.
  – Cells of the same phenotype (i.e., same genes expressed).
  – An aggregation of morphologically similar cells and associated extracellular matrix acting together to perform one or more specific functions in the body.
  – There are four basic types of tissue: muscle, nerve, epithelia, and connective.
  – An organ is a structure made up of 2 or more tissues.
Articular Cartilage

Extracellular Matrix

Cell

4 mm

10 µm
• Production of a product for human good using existing knowledge.
  – **Science** is the process of acquisition of new knowledge.
  – **Technology** is the means by which products are produced.
Permanent versus Absorbable Biomaterials

- Roles of permanent biomaterials for the production of permanent implants versus the roles as absorbable scaffolds for tissue engineering
Effects of Biomaterials on Tissue

• **In Bulk Form**
  – Tissue formation
  – Attachment
  – Remodeling

• **In Particle (Molecular) Form**
  – Tissue degradation
BIOMATERIALS-TISSUE INTERACTIONS

Effects of Biomaterials on Cells

• In Bulk Form
  – Cell attachment
  – Cell proliferation (mitosis)
  – Production of matrix molecules and enzymes (synthesis)
  – Migration
  – Contraction
  – Release of pre-packaged reactive molecules (exocytosis)

• In Particle (Molecular) Form
  – Ingestion of particles (endocytosis)
Permanent Biomaterials

• Positive Response
  – Tissue attachment

• Adverse Responses
  – Contraction
  – Reaction to particles;
    tissue destruction

• Passive Response
Permanent Biomaterials

- Positive Response
  - Tissue attachment

- Adverse Responses
  - Contraction
    - Reaction to particles; tissue destruction

- Passive Response
Food and Drug Administration
Breast Implant Complications

Photographs of
Breast Implant Complications
http://www.fda.gov/cdrh/breastimplants/breast_implants_photos.html

FDA has developed this website for displaying photographs and/or illustrations of breast implant complications. This website is not intended to be photographic representation of all breast implant complications. FDA will continue to add photographs and/or illustrations of complications associated with saline-filled and silicone gel-filled implants as they become available.

You should refer to the breast implant consumer handbook, which is available on the FDA breast implant website at http://www.fda.gov/cdrh/breastimplants/ for a description of potential breast implant complications.
Capsular contracture occurs when the scar tissue or capsule that normally forms around the implant tightens and squeezes the implant. It may be more common following infection, hematoma (collection of blood), and seroma (collection of watery portion of blood). There are four grades of capsular contracture.

The Baker grading is as follows:

- Grade I: the breast is normally soft and looks natural
- Grade II: the breast is a little firm but looks normal
- Grade III: the breast is firm and looks abnormal (visible distortion)
- Grade IV: the breast is hard, painful, and looks abnormal (greater distortion)

Additional surgery may be needed to correct the capsular contracture. This surgery ranges from removal of the implant capsule tissue to removal (and possibly replacement) of the implant itself. Capsular contracture may happen again after this additional surgery.
Breast Implant Position and “Capsular Contraction”

Images removed due to copyright considerations

Contracted Fibrous Tissue Capsule

Boston Globe, July 22, 1991
Photograph shows Grade IV capsular contracture in the right breast of a 29-year-old woman seven years after subglandular (on top of the muscle and under the breast glands) placement of 560cc silicone gel-filled breast implants.
BREAST IMPLANTS Capsular Contracture

Removed implant: viewing the outside of the fibrous capsule

Images removed due to copyright considerations
What is Capsular Contracture?
Scar tissue that forms around the implant which causes the breasts to harden (similar to what a contracted muscle feels like) as the naturally forming scar tissue around the implant tightens and squeezes it. While capsular contracture is an unpredictable complication, it is also the most common complication of breast augmentation.

How can Capsular Contracture be prevented?
Textured implants help deter contracture because of their rough surface which is intended to discourage a hard capsule from forming.
Under the muscle (sub-pectoral or 'partial sub-muscular') placement of the implant reduces risk of capsular contracture by an average of 8 - 10%.
Whereas over the muscle (in front of the muscle or 'sub-mammary') has 10 - 25% or more chance of capsule contracture.
**How can Capsular Contracture be prevented?**

Massage and or compression. This is usually only done with smooth implants and may be suggested for a period between a few weeks to as long as you have your implants. Do not massage bruises!

The "no-touch" technique. This method includes meticulously rewashing surgical gloves before handling any instrument and implants. Only the head surgeon touches the implant, using a unique Teflon cutting board and immediately inserting the implant underneath the muscle. All of these measures help ensure that no foreign substance attach themselves to the implant, which could inflame the surrounding tissue and cause complications such as capsular contracture.
BIOMATERIALS-TISSUE INTERACTIONS

Permanent Biomaterials

• Positive Response
  – Tissue attachment

• Adverse Responses
  – Contraction
  – Reaction to particles; tissue destruction

• Passive Response
“Small Particle Disease”
Particles Released From Implants

Newsweek, April 29, 1991

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Permanent versus Absorbable Biomaterials

- Roles of permanent biomaterials for the production of permanent implants versus the roles as absorbable scaffolds for tissue engineering
Absorbable Biomaterials

• Materials as scaffolds for tissue engineering
Laura Meckler, “Transplant waiting list climbs over 75,000.”
Articular Cartilage Defects Do Not Heal

- Avascular
- Aneural
- Low cell density
- Cells of low mitotic activity
- Cells cannot freely migrate through the extracellular matrix

The Clinical Problem

- Incidence is high and increasing due to increasing activity levels
- Causes pain and disability
- Profoundly impacts the quality of life

Articular Cartilage Defects

- Incidence is high and increasing due to increasing activity levels
- Causes pain and disability
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Arthroscopic Debridement

“Microfracture”

Osteochondral Autograft

Current Clinical Practice

Total Knee Replacement

Cells injected under a tissue or collagen cover
Autologous Chondrocyte Implantation

This process has been commercialized by Genzyme (for USD$11,500).

Debridement of the Degenerative Tissue in the Lesion

Collagen Membrane Used as Covering Material to Contain the Cells

Applying and Suturing the Collagen Membrane

Injecting the Autologous Chondrocytes grown in Vitro Cells

Video clips removed due to copyright considerations
Future Clinical Practice
Implementing Tissue Engineering

Implantation of a cell-seeded matrix

“Tissue engineered” cartilage implanted in a rabbit model did not remodel (Advanced Tissue Sciences, Inc.).
Future Clinical Practice
Implementing Tissue Engineering

Implantation of the matrix alone

“Microfracture”: Stem cells from bone marrow infiltrate the defect

Image removed due to copyright considerations.
Images removed due to copyright considerations.

Canine chondrocytes grown in a type II collagen-GAG scaffold for 2 weeks. (Safranin O stain for GAGs)