Basic Anatomy of Human Bone
Bone Facts

● Minerals
  ● Composed of hydroxyapatite, a calcium phosphate compound

● Properties
  ● High compressive strength (~200MPa)
  ● Low tensile strength (~130MPa)
  ● Some elasticity

● Cells
  ● Osteoblasts; Osteocytes; Osteoclasts
Bone Grafting

- **What is it?**
  - Surgical procedure to replace or fill in missing sections of bone
  - Implanted materials can be natural or synthetic
  - Should encourage bone healing and growth

- **Who needs it?**
  - Fractured, injured or defective bone
  - Diseases of the bone
  - Bone tumours
  - Bone cancers
  - Fusion of bone joints
Bone Grafting

This is a radiograph of a patient with an autograft transplant. The patient suffered from bone defects in the ulna.
Characteristics of an Ideal Graft

- Accepted by host system
- Strength & Support
- Osteoconduction
  - The likeliness of the material to allow growth of new bone cells
- Osteoinduction
  - The likeliness of the material to induce growth of new bone cells
- Osteogenesis
  - The process of living cells transforming into osteoblasts and create new bones
Types of Bone Grafts

- **Autograft**
  - Materials from the same individual
- **Allograft**
  - Materials from the a donor of the same species
- **Xenograft**
  - Materials from another species
- **Synthetic Substitutes**
  - Man-made materials
Types of Bone Grafts
Autograft

- **Pros:**
  - Ideal
  - Low risk of disease transmission
  - Quick incorporation

- **Cons:**
  - Limited availability
  - May not have the same properties
  - Donor site morbidity

- **From:**
  - Iliac crest
  - Distal radius
  - Proximal tibia
Allograft

- **Pros:**
  - Better availability
  - Eliminates morbidity
  - Similar mechanical properties

- **Cons:**
  - Contamination, often frozen/quarantined before surgery
  - May cause immune reaction
  - Transmission of diseases from donor

- **From:**
  - Donors
  - Cadavers
Xenograft

● Pros:
  ● Alleviate shortage of bones from donors
  ● Abundance of species

● Cons:
  ● Host rejects materials
  ● Mechanical properties may not be met
  ● Experimental
  ● Transmission of genetic disorders

● From:
  ● Other animals (i.e. swine, bovine)
  ● Coral
  ● Wood
Bone Composition Comparison

Cortical bone composition

Ash

Hydroxyproline

Extractable proteins

IGF-I
Synthetic Substitutes

- **Pros:**
  - Abundance
  - Low risk of transmitting disease
  - Customized form

- **Cons:**
  - Cause immune response
  - Texture
  - Weight

- **From:**
  - Metals, alloys
  - Ceramics
  - Polymers
Current Grafting Technology

- Xenografts
  - Grafts are produced from hydroxyapatite in coral
  - This material dissolves easily due to the calcium carbonate content

- Synthetic
  - Surface area of implants are given a rough texture
Nanocoated Bioactive Materials

- Designed to mimic natural texture of bone
- Suitable for repair of load-bearing bones
- Demonstrate superiority due to processing techniques
- Benefits for all people suffering from bone disorders and injuries
- BioAlmog, a hydroxyapatite derivative from coral
- Processed synthetic materials
Processing BioAlmog

- **BioAlmog**
  - ‘Double-conversion’ technique
    1. Coral is processed into pure hydroxyapatite
    2. Hydroxyapatite is undergoes a sol-gel procedure

- **Sol-Gel Technique:**
  - Solid metal salt and material to be refined are kept in a liquid phase
  - Mixture is then manipulated to form a gelatinous colloid
  - Resultant gel is then processed to extract fine particles through precipitation, spray pyrolysis, or emulsion
Sol-Gel Process
Processing Synthetic Particles

- Titanium prostheses
  - Blasted with 20\(\mu\)m aluminum grit
  - Soaked in an aqueous solution with a neutral pH for a 3 day period
  - Apatite coating will have a composition closely resembling natural bone mineral
- Cleaning and sterilization
Nano-coating

- Forming a thin layer of nano-size particles (whether organic or inorganic) onto materials
- Natural bones are a mixture of nano-particles and organic composites
Why is Nano-coating Effective?

Mechanical

- Microscopic and nanoscopic pores are filled in while retaining large pores
- Strength of final result doubled
- Scratch resistant surface
- Improved resistance to ‘wear and tear’
- Uniform thickness
Why is Nano-coating Effective?

Biological

- Reduce chances of host rejection
- Reduce chances of inflammation
- Stimulate growth of new bone cells
- Enhance adhesion between the bones and the implant (up to 90% of bonding between bone cells and the implant)
Effects of Nanocoating
Future of Nano-coated Bone Grafts

- Durable
- Wide range of placement
- Shape, composition
- Addition of remote controlled probes to nanoparticles
References

- http://adam.about.com/encyclopedia/9714.htm
Thank you for your attention!

Questions?