NANOTECHNOLOGY

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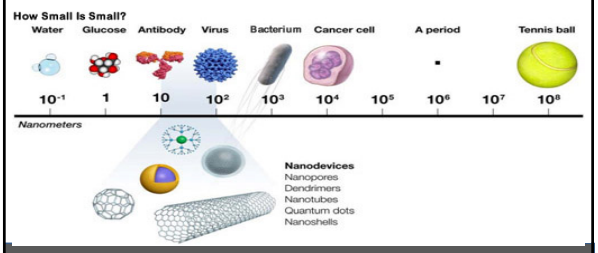
DISCLOSURES

- OKT – Strategic Planning & Regulatory Consulting
- OKT² – ISO 17025 A2LA Accredited Test Facility

NANO

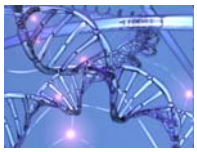
- Nanotechnology deals with sizes from 1-100nm range
- 10^{-9} m.



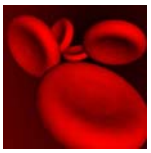
NANOMETERS - SIZE PERSPECTIVE

- Nanotechnology - 10^{-9} m.

DNA - 2 nm



RBC - 750 nm



Ant - 5 million nm

DEFINITION OF NANOMEDICINE

- Monitor, repair, construct, control of human biological systems at molecular level via engineered nanodevices

"An Engineered Nanodevice for RBC"

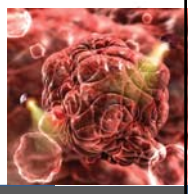
NANOMEDICINE STRUCTURAL COMBINATION

- Macro + Micro + Nano

Cellular Molecular

APPLICATION OF NANOMEDICINE

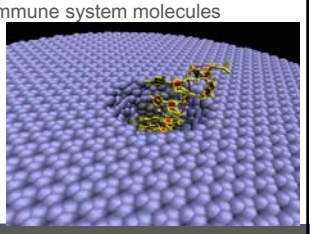
- Diagnostic
  - Imaging & identification
  - Detect cancer cells - very early– could increase survival
- Therapeutic
  - Delivering medication to the exact location
  - Killing of bacteria, viruses & cancer cells
  - Repair of damaged tissues.



EXAMPLES OF NANOTECHNOLOGY IN FUTURE MEDICAL APPLICATIONS

NANOPORES

- Create structures that control molecular passage
- Nanosized pores allow passage of molecules to target tissue
  - O_2, Glucose, Insulin
- Impede passage of larger immune system molecules
  - Immunoglobulin
  - Viruses



Nanopores & DNA

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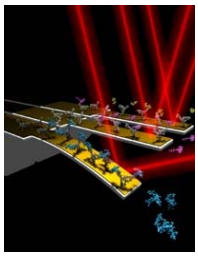
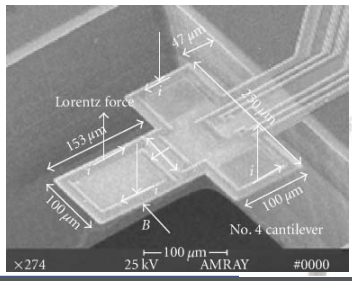
MEMS+NANO = Early Cancer Detection





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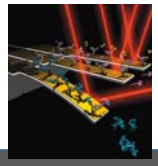
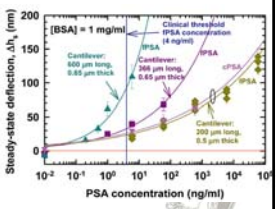
Example - Cancer Detection

- Cantilever Beam
  - coated with antibody to PSA
  - exposed to sample with PSA
  - better than 0.2 ng/ml
  - bending of cantilever
  - deflection monitored by laser





Microcantilever Biosensor

Wu et al., Nature Biotechnology, 19, p. 856 (2001)

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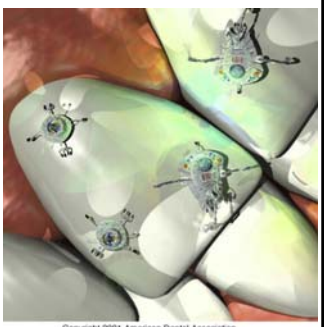
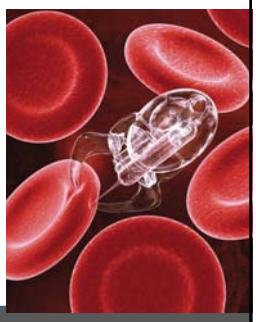
DENTAL ROBOTS

Remote-controlled nanorobots examine & clean subocclusal surfaces of a patient's teeth, near gumline.



NANOROBOTS

- Nanodevices used for purpose of maintaining & protecting body against pathogens.
- Total Size = 0.5 to 3 µm
- Component Size 1-100nm



NANOROBOT EXAMPLE - 2

A single inhaled nanorobot reaches deeply into lungs, enters an alveolar duct, & attaches to the tissue surface.

NANOROBOTS – HOW ARE THEY POWERED?

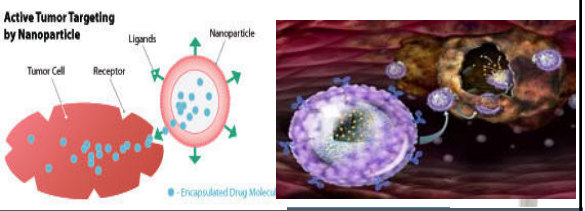
- Through metabolizing local glucose and oxygen for energy
- Other sources of energy within the body can also be used
- Simple onboard computers capable of performing 1000 or fewer computations per second.

HOW ARE THEY TRACKED (MONITORED)?

- A navigational network installed in body, which may provide high positional accuracy to all moving nanorobots
- This will enable the physician to keep track of the various devices in the body

TUMOR SEEKING NANOPARTICLES

- 1/100th the size of human cell
- Deliver high dose chemotherapy to cancer cells
- Target specific cells
- Precise delivery

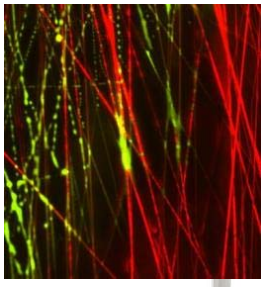


RESORBABLE NANO-SCAFFOLDS

- Scaffolds 3D porous structures need to fulfil the following criteria for tissue engineering (Spaans *et al.* 2000; Boccaccini *et al.* 2002).
- Material must be biocompatible and degradation non-cytotoxic.
- Must be biodegradable and resorb at same rate as tissue is repaired.
- Must possess highly interconnected porous network, formed by a combination of macro- and micropores -enable proper tissue ingrowth, vascularization, nutrient delivery.
- Less toxic – nanoparticles????.

NANOFIBERS

- Dynamic transition in fibrous biomaterial
- Electrospun polymeric nanofibers.
- Slow-degrading polymer
- Water-soluble polymer
  - Selectively removed to increase or decrease the spacing between fibers
- Stretchable fiber (textile)
- Seed with cells
- 3D Scaffold
- Brendon M. Baker, Ph.D.; Perelman School of Medicine, University of Pennsylvania



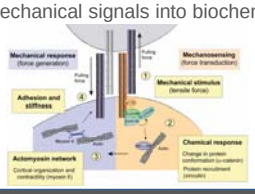
CURRENT: NANOSURFACES

NANOSURFACES & MECHANOTRANSDUCTION

- To understand nanosurfaces
- Must understand Mechanotransduction
  - Macro level
  - Micro level (cellular)
  - Nano level

MECHANOTRANSDUCTION - MOA

- Process where mechanical energy is converted in electrical and biochemical signals.
- Mechanical stimuli ⟺ Tissue ⟺ individual Cells
- Cellular Mechanotransduction – the mechanism by which cells convert mechanical signals into biochemical responses.

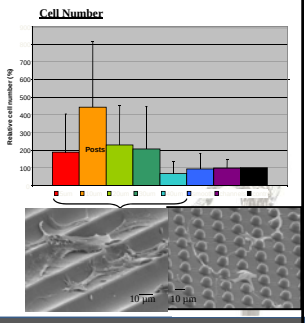


Surface Textures - Mechanotransduction

- Induce mechanotransduction
- Guide cellular growth
- Increased cell proliferation – or -
- Increased cell function
- On Metals: use of surface textures
  - Increase fatigue performance of implant
  - Careful not to compromise strength
  - Titanium = improve osseointerdigitation

SURFACE– CELL DIFFERENTIATION & AFFINITY

- Materials & Geometrical design
- Interface surfaces
  - (open architecture, pores, textured surfaces)
- Extent & planes of motion
- Frictional surface
- Surface area
- Biomechanics of region
- Cells have affinity for certain geometries, preferred sizing, shape, repetition, mechanical stimuli
- Chondrocytes - 10µm posts



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PEEK + BONE APPOSITION

thinking Different

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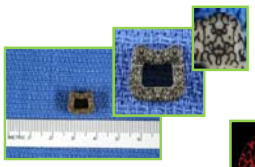
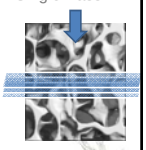
Laser Etch Nanosurface - Variable Depth in Single Pass

New material





Bio-Resonant Implants

TIM GANEY, PHD — AMENDIA

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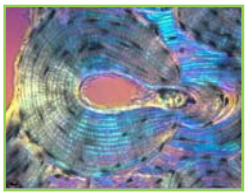
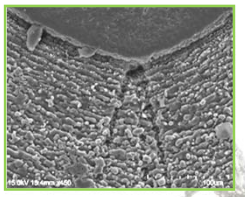
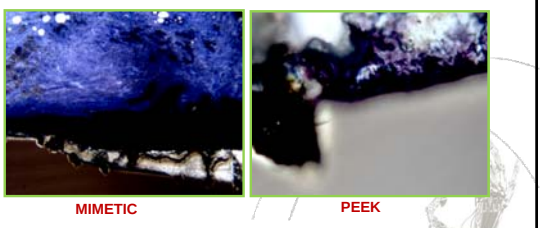




Mimic Lamellar Bone Structures

Offering Dimension as Substrate



Early Bone Formation & Apposition

3 mos.

Summary 6-month Histology

Mimetic

1. More extensive bone contact
2. Less evidence of fibrous tissue interface
3. Well-modeled lamellar bone
4. Highly cellular bone matrix

BUT……..

WHAT ABOUT SAFETY OF NANOTECHNOLOGY

RISKS & SAFETY OF NANOTECHNOLOGY

- Must understand toxic effects on nanosized elements in vivo
  - Shape, size, material, surface area, electric charge, other physicochemical structures
  - Dosage
  - Mode of application
  - Concentration in the target organ
  - Duration of action

TYPES OF TOXICITY

- Bio-degradation
- Bio-accumulation
- Animal toxicity
- Genotoxicity
- Ecotoxicity
- Cytotoxicity
- Primary vs. Secondary (leeching or residual products toxic)
- Local vs. Peripheral Tissue Reactions

MEASURING NANO EFFECTS

- Early stage equipment & methods to quantify nano effects
- Developing processes
- Still learning the technology and Effects

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THANK YOU