Tech Intersection: Understanding the Bio & Nano Link
Welcome to NACK’s Webinar

Presenter

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Webinar Outline

GOAL:
The application (medicine and engineering) and implication (human health and environmental toxicology) of the Nano- Bio Interface

• **Part 1:** Introduction to the fields of nanomedicine and nanotoxicology

• **Part 2:** Commercialization case studies
PART 1

INTRODUCTION TO THE FIELDS OF NANOMEDICINE AND NANOTOXICOLOGY
Engineered “Model” Nanoparticle

Highly ordered

Huge surface areas

C₆₀
1nm

Monodisperse Cadmium Selenide nanocrystal
6 nm

Lysozyme
3 nm

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Nanomaterial Variety

• Size
• Shape
  – Fibers vs. particles
  – Tubes, rods, spheres, wires
• Composites & clays
• Classes
  – Carbon-based
  – Inorganic
    » Metals
    » Metal oxides
  – Organic
    » dendrimers
• Crystalline vs. amorphous
  – Crystal phase

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For nanomaterials, here are some of the properties you can characterize...

- Chemical composition
- Solubility
- Size, size distribution, surface area
- Surface charge
- Surface chemistry
  - Oxidation state
  - REDOX potential
- Crystallinity/purity
- Agglomeration, aggregation, coagulation
- pH
- Method preparation
- Exposure vs. intended use
- Morphology
- Rheological measurements
- Mechanical properties
- Thermal properties
- Spectroscopic properties
- Optical properties
- Magnetism
Poll Question:
What is the single most important property of a nanomaterial?

A. Size
B. Shape
C. Chemical Composition
D. Surface Charge
E. All of the Above
Key Challenges in Medicine

• Translating breakthroughs in:
  • understanding of disease into preventive medicine

• How to increase productivity, DRAMATICALLY

• How to align care with better outcomes and efficiencies

• How to design affordable healthcare for the bottom-of-the-pyramid

• How to reap the benefits of healthcare while reducing the inefficiencies
  • This is the largest factor of a country’s economic growth
NANOTECH PLATFORMS

FUNCTIONS

METHODS

DISEASE

nanoparticles

sensing

proteomics

cancer

nanoassemblies

imaging

Cell tracking

Neuro degenerative

nanotemplates

delivery

DNA-adducts

infectious

MRI

mental

blood

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Nanomedicine can also be about early diagnosis, early and regenerative treatment.
What are the most important characteristics of nanoparticles for medicine?

• Surface coating to allow for target specificity
• Extreme small size
• Can be encapsulated
• Can carry highly concentrated amount of drug
• Tunable surface charge
• Drug release
1. Particles must be on the same size scale as other biological entities
Governing Principles for Nanoparticles in Medicine

2. Particles must be robust and stable (most are metallic)

Metal Nanoparticle

Nanoshell

Quantum Dot
Governing Principles for Nanoparticles in Medicine

3. Particles must be bi-functional (have an imaging core and a biological shell)

Nanoparticle as imaging agent

Antibody or other targeting probe

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4. Functional group on nanoparticle surface must target a receptor.
Governing Principles for Nanoparticles in Medicine

5. Energy must be applied and nanoparticle must respond
The Global Nanomedicine Research Agenda

1. Nano-Diagnostics: early and accurate diagnosis
   • Biosensors and miniaturized devices
   • Targeted imaging agents to highlight of disease

2. Targeted Drug Delivery: on the spot
   • Bring the drug to the target site and monitor its impact

3. Regenerative Medicine: stimulated repair
   • Help the body to (re)build organs or systems

4. Meeting ELSA challenges
   • Ethical, Legal & Social Aspects

5. For the main diseases in the world:
   • Cancer, cardiovascular disease, musculo-skeletal, mental and infectious disease, and diabetes
Nano-Diagnostics

- Screening: personal risk factors
- Identification of populations at risk
- Prediction of risk factors
  - Earlier, more sensitive, faster diagnostic
- Diagnosis of asymptomatic patients
- Higher sensitivity: detection of early biomarkers
- Non-invasive and painless diagnostic techniques
  - From a lab to physician’s office and the home
  - Genetic testing for individual therapy selection
- Pharmacogenomics

Real time probe for biomarkers in blood

http://www.foresight.org
Targeted Drug Delivery

• Protected Drug delivery to target sites
  – Nanoparticles
  – Miniature devices
• Higher doses? Lower doses?
• Healthy tissue not affected
• Theranostics

http://www.foresight.org
Targeted Drug Delivery: CANCER

A. Nanobot loaded with chemotherapy lands on blood vessel wall connected to vasculature

B. One latched on, nanobot releases its drug through blood vessel wall

C. Highly concentrated chemotherapy drug is targeted directly to cancer cell, which subsequently dies

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Regenerative Medicine

- Intelligent biomaterials
  - Adjustable rate biodegradation
  - Time-programmable biomaterials for tissue growth
- Targeted cell implantation
- Biomimicking cell membranes
- Polymers & proteins with programmable conformation
- Control of implant rejections

Destroy bacteria cell overgrowth on regenerated tissue

http://www.foresight.org
ELSA Compliance

• Nanomedicine touches familiar Ethical, Legal, & Social Aspects (ELSA) aspects known from biomedical ethics such as:
  – gap between diagnostics and therapy
  – sensitivity of genetic information

• And some new ones:
  – When do we call a person “ill”? 
  – Difference between medical treatment and enhancement?
  – Obtaining public acceptance
  – Differences in the role of IP between industries

• Regulatory challenges
Poll Question: What is the single most important aspect of nanomedicine?

A. Efficacy
B. Toxicity
C. Public Acceptance
D. Cost
E. Other (please type your response in the Chat Box)
# Examples Of Companies Commercializing Nanomaterials For Biological & Medical Applications

<table>
<thead>
<tr>
<th>Company</th>
<th>Major area of activity</th>
<th>Technology</th>
</tr>
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<tbody>
<tr>
<td>Argonide</td>
<td>Membrane filtration</td>
<td>Nanoporous ceramic materials for endotoxin filtration, orthopaedic and dental implants, DNA and protein separation</td>
</tr>
<tr>
<td>Biophan Technologies, Inc.</td>
<td>MRI shielding</td>
<td>Nanomagnetic/carbon composite materials to shield medical devices from RF fields</td>
</tr>
<tr>
<td>Capsulution NanoScience AG</td>
<td>Pharmaceutical coatings to improve solubility of drugs</td>
<td>Layer-by-layer poly-electrolyte coatings, 8–50 nm</td>
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<tr>
<td>Evident Technologies</td>
<td>Luminescent biomarkers</td>
<td>Semiconductor quantum dots with amine or carboxyl groups on the surface, emission from 350 to 2500 nm</td>
</tr>
<tr>
<td>Smith &amp; Nephew</td>
<td>Coated bandages</td>
<td>Nanocrystal silver is highly toxic to pathogens</td>
</tr>
</tbody>
</table>
Waterborne pathogenic microorganisms are a major source of disease worldwide. Pathogens and water system deficiencies that are identified in outbreaks may also be important causes of endemic waterborne illness.

NanoCeram® filters utilize a non-woven filter media containing a thermally-bonded blend of microglass fibers and cellulose infused with nanoalumina fibers. This method makes available greater than 42,000 square meters of nanofiber surface area per square meter of filter media of loading capacity.
The ACTICOAT family are a unique range of antimicrobial barrier dressings for use over partial, full thickness and acute wounds.

- Unique Patented Silver technology: SILCRYST† Nanocrystalline
- Silver Antimicrobial protection
- Effective barrier to over 150 wound pathogens
- Faster kill rates, longer wear times
Questions?

Please type all questions into the Chat Box
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Thank you for attending the NACK Center webinar

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