Welcome to NACK’s Webinar

Nanotechnology in Medicine

Hosted by MATEC NetWorks  www.matecnetworks.org
Nanotechnology Applications and Career Knowledge Center located at Penn State University

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Objectives

1. Understand the role of dimensions in nanoscience.
2. Describe three areas of current nanomedicine research.
3. Describe targeted drug delivery and the benefits over systemic therapies.
4. List three issues related to commercialization of therapies.
NACK’s Webinar Presenters

John Wagner Ph.D.
Chippewa Valley Technical College

Madhan Kumar Ph. D.
Penn State

Bob Ehrmann
Director: NACK Penn State

Mylisa Parette Ph.D.
Keystone Nano

Timothy Lyden Ph.D.
UWRF TCIC
Nanotechnology in Medicine: Introduction

John Wagner, Ph.D.
Chippewa Valley Technical College
Eau Claire, Wisconsin
What is Nanoscience?

- Extension of physics, chemistry, biology and engineering to small dimensions
  - Size range of atoms and molecules

- Enabled by
  - Advances in technology to study small dimensions
  - Improved understanding of atomic processes in materials and molecular processes in cells

- Rapidly increasing number of commercial applications
Nanoscience in Medicine Overview

- Medical devices
- Stem cells and tissue engineering
- Disease detection
- Targeted delivery of therapies
- Personalized medicine
Medical Devices

- Implantable micro-devices
- Implants - stents and prostheses compatible with tissue
- Immune resistance
- Bacteria resistance
- Strength
Stem Cells and Tissue Engineering Research

University of Minnesota
scaffolding research (rat heart)

University of Wisconsin River Falls
artificial scaffolding infused with cells
Tissue Engineering Applications

- Stem cells to generate specific tissue
- Scaffolds to reconstruct damaged tissue
- Bone and organ regeneration
Disease Process Complexity

Example: Signaling Pathways in Human Cancer
Disease Detection - Microarrays

- Genetic markers
- Genomic microarrays can detect DNA markers

Early generation commercially available “NanoChip®”

GeneChip® by Affymetrix
Disease Detection - Nanoparticles

Therapy Model Shift

• Systemic approach
  – Therapy introduced to system
  – Attacks both diseased and healthy cells
  – Systemic side effects
  – Only small amount of medication attacks diseased cells
Therapy Model Shift

• Targeted approach
  – Diseased cell identified by protein markers in cell membrane
  – Transport vehicle contains drug or gene
  – Significant reduction of side effects
  – Lower cost due to efficiency of delivery
Targeted Delivery Model

- Employs nanoparticle vesicle to contain drug or gene
- Vesicle surface contains ligand that bonds only to target cell
- Assembly must not be detected by body’s immune system
- After attachment to cell, payload must be delivered to interior of cell
- Some therapies require payload to be transported from the cytoplasm to the nucleus
Example Vesicle - Liposome


Essential Cell Biology, 3ed, Garland Science
(A) Graphical representation of docetaxel-encapsulated nanoparticles
(B) Scanning electron-microscopy (SEM) image of docetaxel-encapsulated nanoparticles. The average particle size is approximately 150 nanometers in diameter
# Some Current Nanoscale Therapies

<table>
<thead>
<tr>
<th>Particle Type</th>
<th>Development Stage</th>
<th>Examples</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liposome</td>
<td>FDA- approved</td>
<td>DaunoXome, Doxil</td>
<td>AIDS carcinoma</td>
</tr>
<tr>
<td>Albumin-based</td>
<td>FDA- approved</td>
<td>Abraxane</td>
<td>Breast cancer</td>
</tr>
<tr>
<td>Polymeric micelles</td>
<td>Clinical trials</td>
<td>Genexol-PM, SP1049C, NK911, NK012, NK105, NC-6004</td>
<td>Lung cancer</td>
</tr>
<tr>
<td>Polymer-drug conjugate</td>
<td>Clinical trials</td>
<td>XYOTAX (CT-2103), CT-2106, IT-101, AP5280, AP5346, FCE28068 (PK1), PNU166148, PNU166945, MAG-CPT, DE-310, Pegamotecan, NKTR-102, EZN-2208</td>
<td>Stomach cancer</td>
</tr>
<tr>
<td>Targeted Liposome</td>
<td>Clinical trials</td>
<td>MCC-465, MBP-426, SGT-53</td>
<td>Delivery System</td>
</tr>
<tr>
<td>Target polymer-based particle</td>
<td>Clinical trials</td>
<td>FCE-28069 (PK2), CALAA-01</td>
<td>Delivery System</td>
</tr>
<tr>
<td>Solid inorganic or metal particle</td>
<td>Clinical trials</td>
<td>Carbon nanotubes, silica particles, gold particles (CYT-6091)</td>
<td>Delivery System</td>
</tr>
<tr>
<td>Dendrimer</td>
<td>Preclinical</td>
<td>Polyamidoamine (PAMAM)</td>
<td>Delivery of RNAi (gene silencing)</td>
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### Some Current Nanoscale Therapies

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<td>Clinical trials</td>
<td>Delivery System</td>
</tr>
<tr>
<td>Solid inorganic or metal particle</td>
<td>Clinical trials (gold) and pre-clinical</td>
<td>Delivery System</td>
</tr>
<tr>
<td>Dendrimer</td>
<td>Preclinical</td>
<td>Delivery of RNAi (gene silencing)</td>
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</table>
Personalized Medicine

• Detect disease by genetic or protein markers
  – Microbiology and biochemistry of disease
  – DNA microarrays and biochips

• Disease mitigation/cure
  – Customized therapies designed to meet individual requirements

• Medical clinics are advertising personalized medicine today (Marshfield Clinic in Wisconsin)
Questions?
Nanotechnology in Medicine: Nanotechnology Approaches to Translational and Personalized Cancer Medicine.

Timothy Lyden, Ph.D.
Director
Tissue and Cellular Innovation Center
Associate Professor
Anatomy and Physiology
UWRF Biology Department
Personalized Medicine

Concept:

• New paradigm in medicine.
• Focused on defining illness or disease for each individual patient.

Goal:

• Allow for more precise outcome predictions and therefore better or more effective treatment design.
<table>
<thead>
<tr>
<th>Cancer Site</th>
<th>Men 292,540</th>
<th>Women 269,800</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lung &amp; bronchus</td>
<td>30%</td>
<td>26% Lung &amp; bronchus</td>
</tr>
<tr>
<td>Prostate</td>
<td>9%</td>
<td>15% Breast</td>
</tr>
<tr>
<td>Colon &amp; rectum</td>
<td>9%</td>
<td>9% Colon &amp; rectum</td>
</tr>
<tr>
<td>Pancreas</td>
<td>6%</td>
<td>6% Pancreas</td>
</tr>
<tr>
<td>Leukemia</td>
<td>4%</td>
<td>5% Ovary</td>
</tr>
<tr>
<td>Liver &amp; intrahepatic bile duct</td>
<td>4%</td>
<td>4% Non-Hodgkin lymphoma</td>
</tr>
<tr>
<td>Esophagus</td>
<td>4%</td>
<td>3% Leukemia</td>
</tr>
<tr>
<td>Urinary bladder</td>
<td>3%</td>
<td>3% Uterine corpus</td>
</tr>
<tr>
<td>Non-Hodgkin lymphoma</td>
<td>3%</td>
<td>2% Liver &amp; intrahepatic bile duct</td>
</tr>
<tr>
<td>Kidney &amp; renal pelvis</td>
<td>3%</td>
<td>2% Brain/ONS</td>
</tr>
<tr>
<td>All other sites</td>
<td>25%</td>
<td>25% All other sites</td>
</tr>
</tbody>
</table>

ONS=Other nervous system.
Source: American Cancer Society, 2009.
Personalized Medicine

Nanotechnology Applications

Tissue engineering in personalized translational cancer medicine:

Development of artificial tissues and cellular modeling of tumors.
3D Tissue and Cellular Modeling

• 3D culture allows the study of complex mixtures of cells.

• Produces dynamic tissue-like interactions, cell-cell and cell-matrix.

• Establishes and maintains cellular level micro-environments or niches.

• Allows for the study of large scale tissue macro-environments.
Microenvironments and Niches

Extra Cellular Matrix

Mechanical Forces

Soluble Factors

Inputs

Outcomes

Differentiation

Apoptosis

Growth

Maintenance
Primary Tissue Cultures:
Neural Monolayer Cultures from Midbrain Region

Even in “flat-cell” monolayer cultures, the environment of the cell can/does control its behavior.
Tissue Engineering Concepts

Cellular Properties:
- Cell/cell adhesions
- Cell/matrix adhesions
- Mechano and biochemical transduction

Matrix Properties:
- Biochemical
- Physical / mechanical
- Geometry: macro, micro and nano-scales
New “Tissue Engineering” Technology:

- Utilizes Natural ECM Materials
- Produces Complex Artificial Tissue (ATs) Constructs
- Applied to Cell Lines, Primary Fetal / Neonatal Tissues, Cancerous Tumors, and Embryonic Stem Cells
Artificial Tissues (ATs) from Cell Lines:

Epithelial (Embryonic Kidney)
Avian Fetal ATs Studies

~6 day Stage Chicken Embryo

Forebrain
Midbrain
Hindbrain

Eye

Heart

Mid-Thoracic Region

Liver
Bone rudiment
Lung
Artificial Neural Tissues
Large Scale Artificial Tissues from Midbrain Region
Artificial Neural Tissues
Chick Midbrain, 6 Day Embryo/2 Months Culture
Avian Fetal ATs Studies: Neural

Chick Midbrain, 6 Day Embryo/2 Months Culture

Cluster of neural stem/progenitor cells.
Potential Applications of ATs Technology:

- Vaccine Development
- Pharmaceutical Testing
- Production of Recombinant Proteins
- Immunotherapy and Biomarker Development
- Personalized Translational Medicine
Artificial 3D Tumor Tissue: Glioblastoma
Artificial 3D Tumor Tissue: Glioblastoma

Modeling cancer cell motility and metastatic potential.
Artificial 3D Tumor Tissue: Glioblastoma

Modeling cancer cell differentiation.
Cancer Cell Line ATTs:
MCF-7, Breast Cancer
Cancer Cell Line ATTs: Hela, Cervical Carcinoma

Surface Features of Hela Cell ATTs
Tumor Stem Cell Hypothesis

Support for the hypothesis?

Applicable to personalized medicine?
Personalized Cancer Medicine Project

Concept:

• Employ individualized 3D ATTs to define the nature and responses of a patient’s own tumor.
• Accurately predict outcomes for specific treatment approaches.
• Design an individualized therapeutic plan based on the translational experimental results obtained in-vitro.

Overall Goals:

• More effective treatment design.
• Improved patient outcomes: survival and quality of life.
Human Tumor 3D Culture Studies

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Dr. Christopher Cold, Marshfield Clinic
Dr. Peter Dahlberg, Rivers Cancer Center
Dr. Michael Pickert, UW-Stout

Additional Contributors:
Dr. Wernberg
Dr. Douglas-Jones
Dr. Anderson
Dr. Kolquist
Dr. Wengert
Dr. Maki

Carol Beck, Clinical Research Coordinator
Faith Bosman, PA
Human Tumor 3D Culture Studies

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UWRF Biology Department

UWRF Foundation
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2003 Student Summer Stipend
2004 Imaging Center Grant
2006 Tissue Culture Teaching
and Research Grant
2008 Research Microscope Grant
Questions?
Nanotechnology in Medicine: Brain Tumor Targeted Nanodelivery Systems for Therapy and Diagnosis

A.B. Madhankumar
Department of Neurosurgery
Penn State Hershey
Nano Drug Delivery Systems

1. Lipid based drug delivery systems
   - Liposomes, Solid Lipid Nanoparticles (SLN)

2. Non-lipid drug delivery systems
   - Synthetic:
     - Dendrimers, Fullerenes, Quantum Dots (QD’s), Iron Oxide Nanoparticles
   - Natural:
     - Gelatin, Chitosan, Alginate Nanoparticles
Nano Drug Delivery System for Brain Tumors

• Cytotoxin delivery to tumor cells
  – Molecular Cancer Therapeutics (Madhankumar et al. 2006, 2009)

• Deliver contrast enhancement agents to visualize tumor cells
  – Magnevist liposomes (Kari Duck)

• RNA interference gene therapy to increase vulnerability of tumor cells to existing therapeutic agents and make resistant tumors vulnerable
  – Have a cationic liposome delivery platform (Xiaoli Liu, 2011)

• Target the tumor cells in CSF and tissues with fluorescent quantum dots (Cody Weston)
Liposomes: Lipid Bilayer Membranes

Hydophilic drugs   Hydrophobic drugs
Goal:

To modify the surface of liposomes with proteins to selectively target cancer cells.

We use Interleukin 13:

IL13Rα2 (high affinity receptor) (glioma tumor)

IL13Rα2 receptors are over expressed on GBMs
Scheme of Liposome Preparation

DPPC, Chol, DSPE-PEG2000, DSPE-PEG-Maleimide

Methanol/chloroform
Or
Methanol/t-butanol

Solvent evaporation

Dry lipid film

Reconstitution
\((\text{NH}_4)_2\text{SO}_4\)
pH5.5
(sonication)

Tumor targeted liposomes

Conjugate with IL13

Liposomes

Extrusion
10 times, 55-60°C, 100nm, 50nm membrane

Liposome Conjugate with IL13 - Tumor targeted liposomes
Surface Conjugation of Proteins for Selective Targeting

DSPE-PEG-Maleimide

DOX

PEG

IL13R

Glioma cells

DOX

PEG
Surface Conjugation of Proteins for Selective Targeting

DSPE-PEG-Maleimide

DOX

PEG

IL13R

Glioma cells

DOX

PEG
Surface Conjugation of Proteins for Selective Targeting

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DOX

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Surface Conjugation of Proteins for Selective Targeting

DSPE-PEG-Maleimide

DOX

PEG

IL13R

Glioma cells

DOX

PEG
TEM Images of IL13 Conjugated Liposomes

Particle size analysis (50-150nm size range PDI= 0.2-0.4)

Zeta potential : -35 mV
Binding of Fluorescent IL-13 Liposomes to Tumor Sections: Receptor Mediated

GBM# 5  GBM#15  GBM#15 (after blocking with IL13Rα2 receptor antibody)

Medulloblastoma  Normal Human Cortex  Pilocytic Astrocytoma

These data show that the liposome Encapsulated drug (DXR) can avoid extrusion by the multi-drug resistance system for at least 2 hours (MDR was blocked by cyclosporine A)
### T1 Contrast MRI Images During the Treatment

#### Targeted DXR/LIP

<table>
<thead>
<tr>
<th>MRI</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st MRI</td>
<td>Prescan</td>
</tr>
<tr>
<td>2nd MRI</td>
<td>1 week post treatment</td>
</tr>
<tr>
<td>3rd MRI</td>
<td>2 week post treatment</td>
</tr>
<tr>
<td>4th MRI</td>
<td>3 week post treatment</td>
</tr>
</tbody>
</table>

#### Untargeted DXR/LIP

<table>
<thead>
<tr>
<th>MRI</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1st MRI Prescan</td>
</tr>
<tr>
<td>B</td>
<td>2nd MRI 1 week post treatment</td>
</tr>
</tbody>
</table>
Kaplan-Meyer Survival Graph

Median survival untargeted = 25 days
Median survival targeted = 142 days
P value = 0.0149
Serum Chemistry of Treated Mice:

Treatment with liposomes does not cause toxicity to liver or kidney.
Conclusions: Liposomes

• Targeted nanovesicles can deliver chemotoxins to human brain tumor cells more effectively than non-targeted nanovesicles

• Targeted nanovesicles appear safe

• This technology chosen by NCI/NCL for collaboration for pharmacokinetics and biodistribution studies
Tumor Specific Receptor Targeted Liposomes Carrying MRI Contrast Agents

Positive contrast enhancing agents (reduce T1 relaxation time of the surrounding water protons)
MRI images of tumor sections

T1 weighted images with a TR of 500ms of Normal Control and Glioblastoma Multiforme tissue with IL-13 Conjugated Liposomes. The image provides evidence for both selective binding of the IL-13 Conjugated Liposomes to GBM samples but also shows that liposomes containing gadolinium alter T1 contrast. The scale bar is 5mm in length for both images.

T1 weighted images with a TR of 500ms of (A) GBM and (B) Normal control tissue samples. The molar gadolinium concentrations of Magnevist and IL-13 Conjugated Liposomes containing Gadolinium were standardized to the clinical concentration of gadolinium in blood. Saline and Magnevist did not alter T1 for either GBM or control tissue samples. GBM samples incubated in IL-13 Conjugated Liposomes containing Gadolinium do show altered T1 contrast compared to control tissue. The included scale bar is 5 mm in length for both images.
T1 Contrast MRI of IL-13 Targeted Gadolinium Liposome in Subcutaneous Tumor

IL-13 Targeted Liposome

Magnevist Control

Prescan

30 min post injection
siRNA Delivery - Cationic Liposomes

20-24 base pair double stranded RNA molecule

siRNA pathway

(dsRNA) → Dicer → siRNA → RISC (RNA-inducing silencing complex) → mRNA → mRNA cleavage

Suppress protein expression
Gene Delivery to Decrease Expression of Ferritin

**Ferritin**, MW 450 kD, is an iron storage protein with 24 subunits of two kinds: **H** and **L-ferritin** chains.

**Ferritin** can keep iron in a soluble, biodegradable and non-toxic form.
Rationale to Suppress H-ferritin in Cancer Cells

- H-ferritin is present in nucleus of glioma cells
- H-ferritin protected the DNA from iron-induced oxidative damage in tumor cells
- BCNU (chemotherapeutic drug) and radiation has ability to induce DNA damage to cancer cells.
- Decreasing the H-ferritin expression will sensitize the tumors for chemo and radiation therapy
Down Regulating H-ferritin Increased Chemotherapeutic Efficacy in U251 cells: Human Brain Tumor Model

Method:

1. U251 cells were seeded for O/N.
2. Transfected with siRNA: liposomes.
3. BCNU was added 48 h post transfection.
4. SRB assay was performed 48 h post exposure of BCNU.

Result: Chemotherapeutic sensitivity in U251 cells was increased after H-ferritin was down regulated by siRNA.

H-ferritin LD50 = 38 µM
H-ferritin siRNA Increased Chemotherapeutic Efficacy in Vivo

Method:

1. Adult female athymic nude mice were inoculated s.c with 15 x10^6 U251 cells

2. The tumors (1.4 to 3.0 cm³) were formed in two weeks.

3. Intratumoral injection of HF(▲) and NS(▼) siRNA/liposomes weekly for seven weeks.

4. IP injection of BCNU was followed next day.

5. Size of the tumor was measured weekly

Result: Tumor growth was inhibited by synergistic approach. Importantly, 12.5mg/kg is half of the dosage for conventional treatment.
Method:

1. Adult female athymic nude mice were inoculated s.c with $15 \times 10^6$ U251 cells

2. The tumors (1.4 to 3.0 cm$^3$) were formed in two weeks.

3. Intratumoral injection of NS(▲) and HF(■) siRNA/liposomes weekly for seven weeks.

4. Radiation 4 (Gy) was followed next day.

5. Size of the tumor was measured weekly.

Result: Tumor growth was inhibited by synergistic approach.
Conclusions for Gene Delivery

• We can deliver a siRNA in a nanovesicle to tumors

• The siRNA will decrease the expression of ferritin

• Decreased expression of ferritin makes the tumor cells more vulnerable to chemotherapy and radiation
The Future: Targeting Quantum Dots for Detecting Cancer Cells in CSF

In vitro tumor diagnosis

U251 glioma cells after exposure to IL13-QD
Binding of Targeted Quantum Dots to Glioma and Melanoma Cells

(U251 glioma) (IL13 QD)  UACC903 Melanoma (9.2.27QD)

Red – quantum dot
Blue - DAPI
Using Our Targeted Delivery System to Deliver Nanoparticles

Iron oxide nanoparticles - MRI contrast enhancing

Particle size: 6.7(+/−) 0.7 nm
Perl’s Staining on Tumor Spheroid

Uptake of IL13-Fe2O3 by multicellular tumor spheroids cultured from U251 glioma cells

(10 ug/mL of Fe₂O₃-IL13 final conc.)
Conclusion

• We developed tumor specific delivery system for delivering chemotherapeutic agent and MRI contrast agent

• Established the efficacy of cationic liposomes to sensitize the tumors for chemo and radiation therapy

• Currently involved in tumor targeted iron oxide nanoparticles and QD’s for in vitro and in vivo diagnosis of tumors.
Thank You!
Questions?
Nanotechnology in Medicine: Commercializing Nanomedicine

Mylisa Parette, BS, MAT, PhD
Research Manager
Keystone Nano, Inc.
Commercializing Nanomedicine

http://science401.com

www.clker.com
Current Pharmaceutical Development

\[ X_1 \ X_2 \ X_3 \ X_4 \ X_5 \ X_6 \ X_7 \ldots \]

Medicinal Chemistry
(1000s of derivatives)

\[ \rightarrow \]

High-throughput Screening
- Solubility
- Efficacy
- Toxicity

\[ \rightarrow \]

Formulation Development
- Solubility
- Stability/Shelf-Life

\[ \downarrow \]

In Vivo Testing
- Safety
- Efficacy

\[ \leftarrow \]

Preclinical Testing
- Efficacy
- Toxicity
- Biodistribution
- Pharmacokinetics

\[ \leftarrow \]

Clinical Trials

All clip art from www.clker.com
Picking the Right Compound
The Balancing Act

Efficacy

Solubility/Formulation  Toxicity/Side Effects
Nanomedicine
Picking the Right Technology

- Indication
- Size
- Composition
- Surface Groups
- Morphology
- Active Ingredient
- Loading
- Reproducibility
- Stability/Dispersion
- Biodistribution/Clearance
Technical Challenges

Manufacturing & Characterization

Regulatory Testing

$$$$$

NACK CENTER
Technical Challenges: Manufacturing & Characterization

Manufacturing Scale:
• How much can be made?
• How much is needed?
• What changes to manufacturing procedures are required to increase scale?

Manufacturing Consistency:
• How reproducible is manufacturing process?
• What are the process variables?
• How can the variables be controlled?

Characterization & Quality Control:
• What analytical techniques are used to analyze the product?
• What is the error in each measurement?
• Can manufacturing processes consistently produce acceptable product?
Technical Challenges: Regulatory Testing

Chemistry, Manufacturing & Controls:
- What are the physico-chemical characteristics?
- What is the stability/degradation profile?
- How can the active and carrier be measured in blood/tissues?

Preclinical Evaluation:
- Is the product efficacious?
- Does the product induce any toxicity?
- How is the product absorbed, metabolized and excreted from the body?
- Is the product safe to test in humans?
Technical Challenges: Regulatory Testing

Phase I Clinical Trial (small # of people – 20-80)

- What is the maximum safe dosage for humans?
- What side effects are induced?

Phase II Clinical Trial (larger # of people – 200-800)

- Is the product efficacious?
- Is the product and dosage safe in humans?

Phase III Clinical Trial

- Is the product efficacious in humans?
- Is the product and dosage safe in humans?
- Does the product provide a therapeutic advantage over existing drugs?
Realizing the Potential of Nanomedicine

FDA Approved Liposomal Drug Products
- Doxil (Doxorubicin),
- Daunoxome (Daunorubicin),
- Depocyte (Cytarabine),
- Ambisome (Amphotericin B)

In Clinical Trials
- Solid Lipid Nanoparticles
- Polyethyleneimine Nanoparticles
Developing a Nanomedicine: Ceramide NanoLiposome

*Indication* = Liver Cancer, Pancreatic Cancer, Leukemia

Size = 85nm mean liposome size

Composition = Synthetic lipids – PC, PE,

Surface Groups = Polyethylene glycol (PEG)

Morphology = Spherical

Active Ingredient = Ceramide

Loading = 30 molar%

Reproducibility = +/- 5nm mean

Stability/Dispersion = stable from pH 4-9, 4-60°C, 3+ months

Biodistribution/Clearance = distributes mainly to the lungs and liver, cleared through the hepatobiliary route
Developing a Nanomedicine:
Ceramide NanoLiposome

Tagaram et al, 2010
Questions?
Objectives

1. Understand the role of dimensions in nanoscience.
2. Describe three areas of current nanomedicine research.
3. Describe targeted nano drug delivery and the benefits over systemic therapies.
4. List three issues related to nano commercialization of therapies.
How Can We Better Serve You?

Whether you are joining us live or watching the recorded version of this webinar, please take 1 minute to provide your feedback and suggestions.

http://questionpro.com/t/ABkVkJ7e4
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May 26: Recruiting Under-Represented Minorities

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