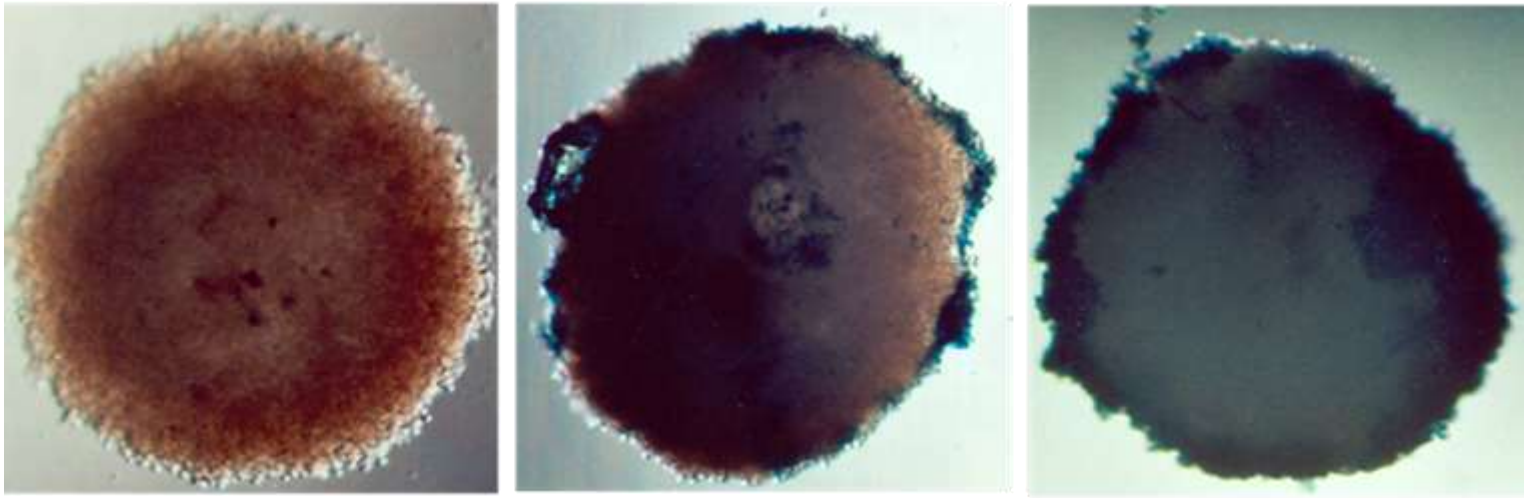
Welcome to NACK's Webinar

Nanotechnology in Medicine



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Nanotechnology Applications & Career Knowledge

Nanotechnology Applications and Career Knowledge Center located at Penn State University

National Science Foundation

Funded, in part, by a grant from the National Science Foundation.
DUE-08020498



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

Timothy Lyden Ph.D.
UWRF TCIC

Madhan Kumar Ph. D.
Penn State

Mylisa Parette Ph.D.
Keystone Nano

Bob Ehrmann
Director: NACK Penn State

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Nanotechnology in Medicine:
Introduction

John Wagner, Ph.D.
Chippewa Valley Technical College
Eau Claire, Wisconsin

Chippewa Valley Technical College
PROVEN.

Nano-Link
Midwest Regional Center for Nanotechnology Education

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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

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Nanoscience in Medicine Overview

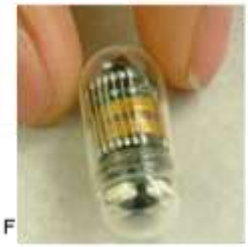
- Medical devices
- Stem cells and tissue engineering
- Disease detection
- Targeted delivery of therapies
- Personalized medicine

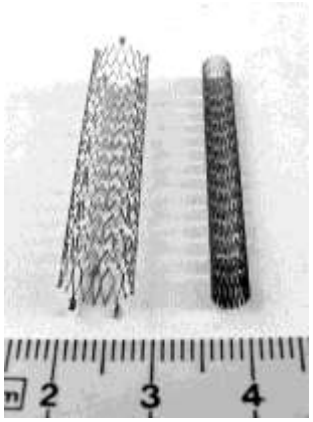


Medical Devices

- Implantable micro-devices
- Implants - stents and prostheses compatible with tissue
- Immune resistance
- Bacteria resistance
- Strength

From:
http://www.leblogsante.com/pillcam_2Dtof_small.jpg

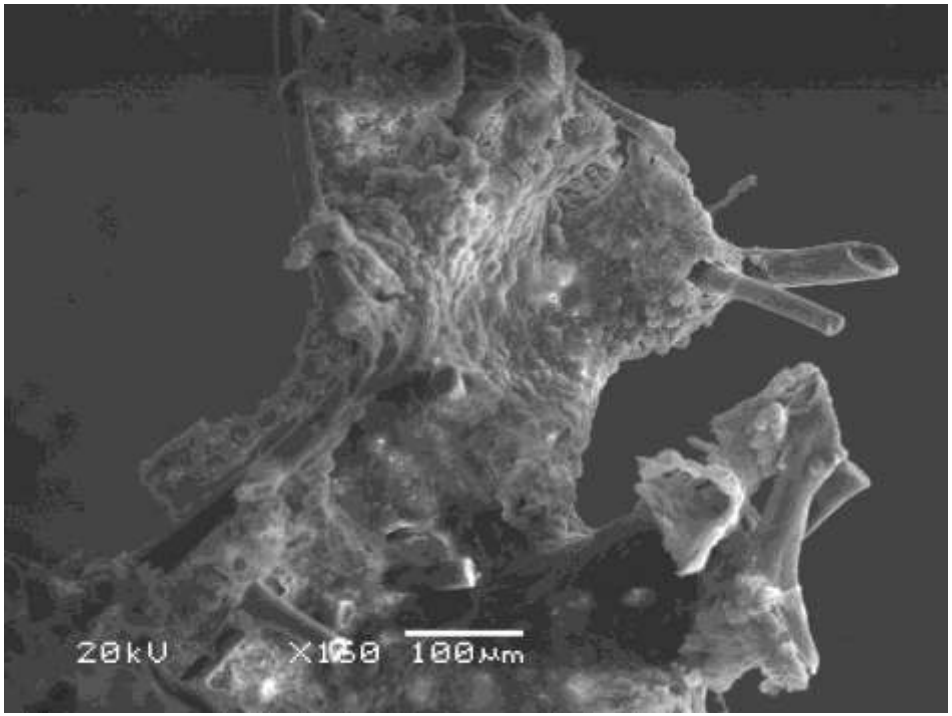




Stem Cells and Tissue Engineering Research

Thomas Matthiesen http://www.npr.org

University of Minnesota
scaffolding research (rat heart)



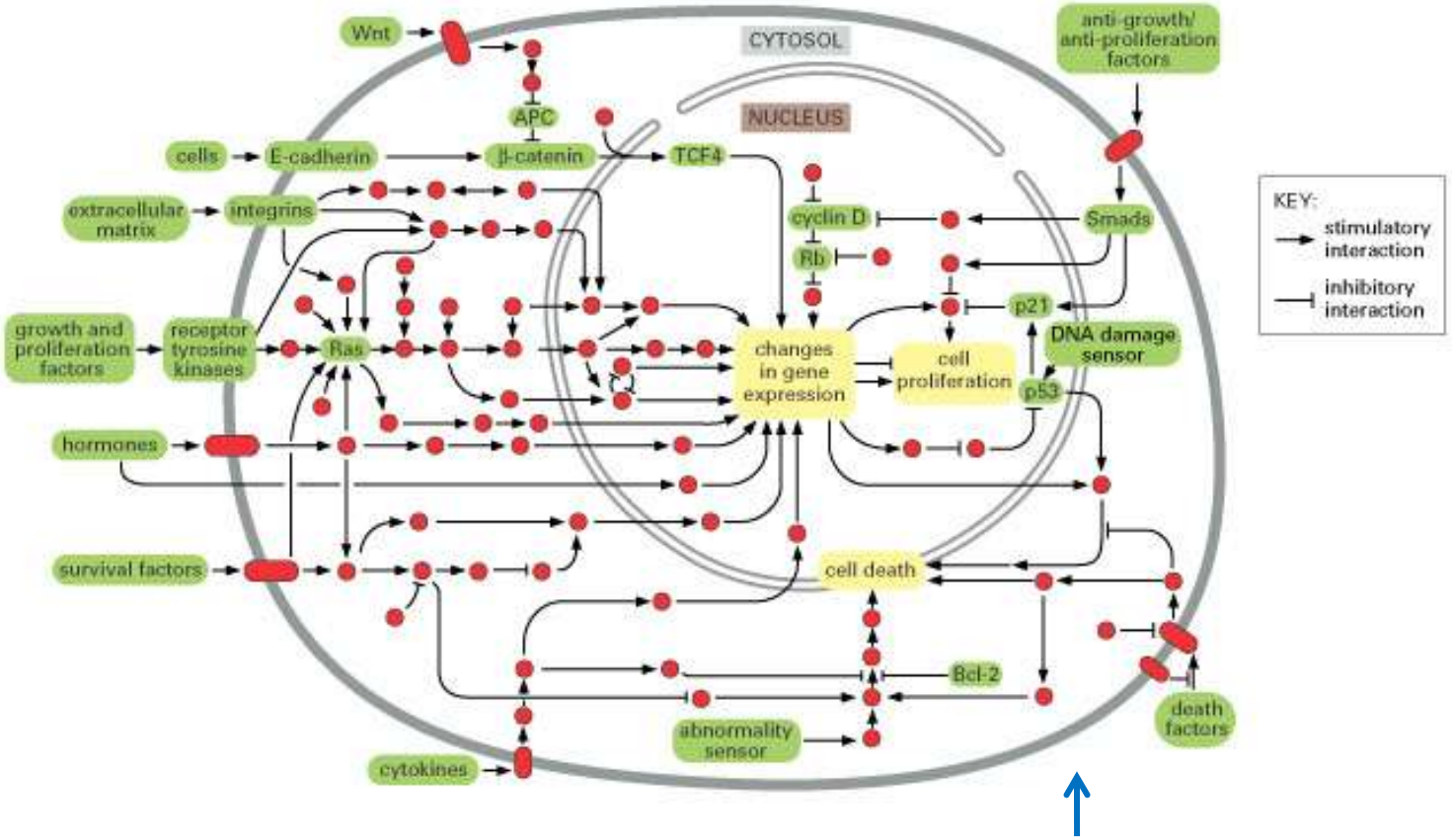
University of Wisconsin River Falls
artificial scaffolding infused with cells

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

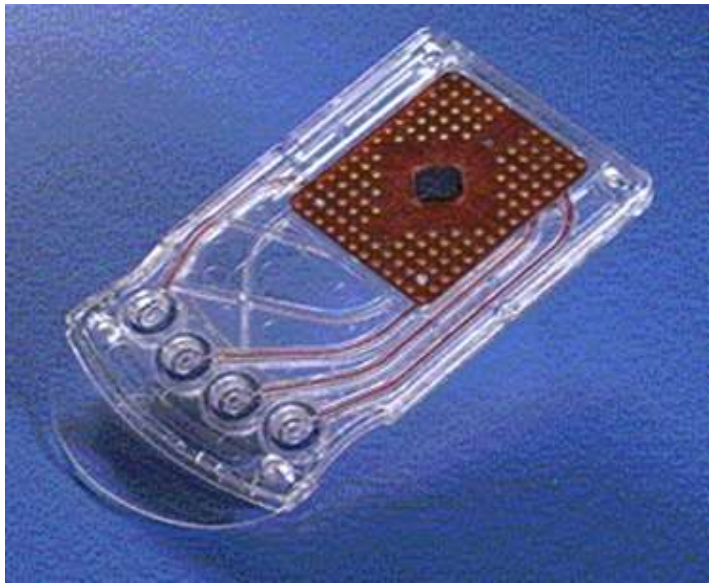


Cancer Critical
Components and Control

Figure 21-47 Essential Cell Biology, 2/e. (© 2004 Garland Science)

Disease Detection - Microarrays

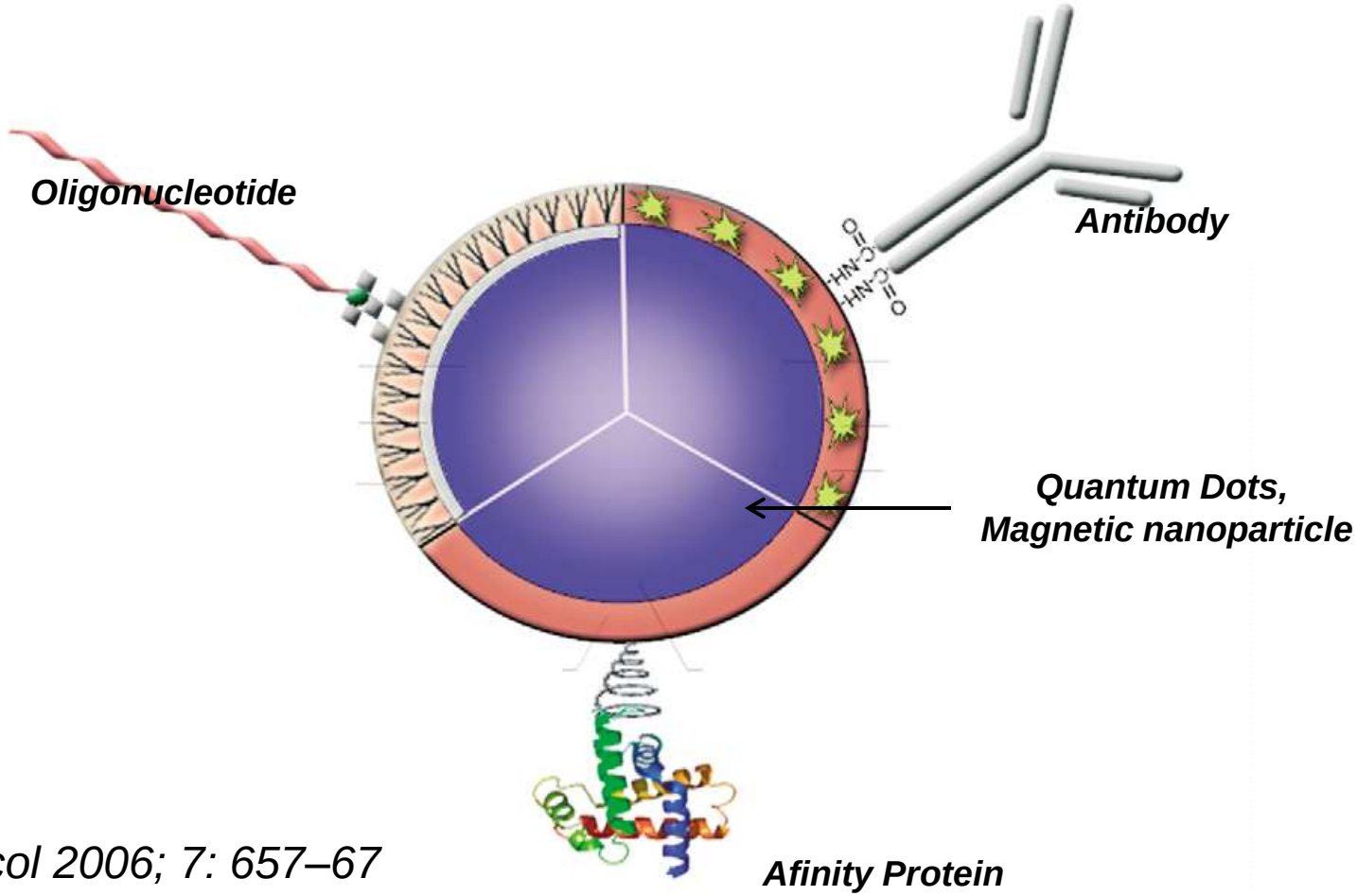
- Genetic markers
- Genomic microarrays can detect DNA markers



Early generation commercially available “NanoChip®”

GeneChip® by Affymetrix

Disease Detection - Nanoparticles



Lancet Oncol 2006; 7: 657–67

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

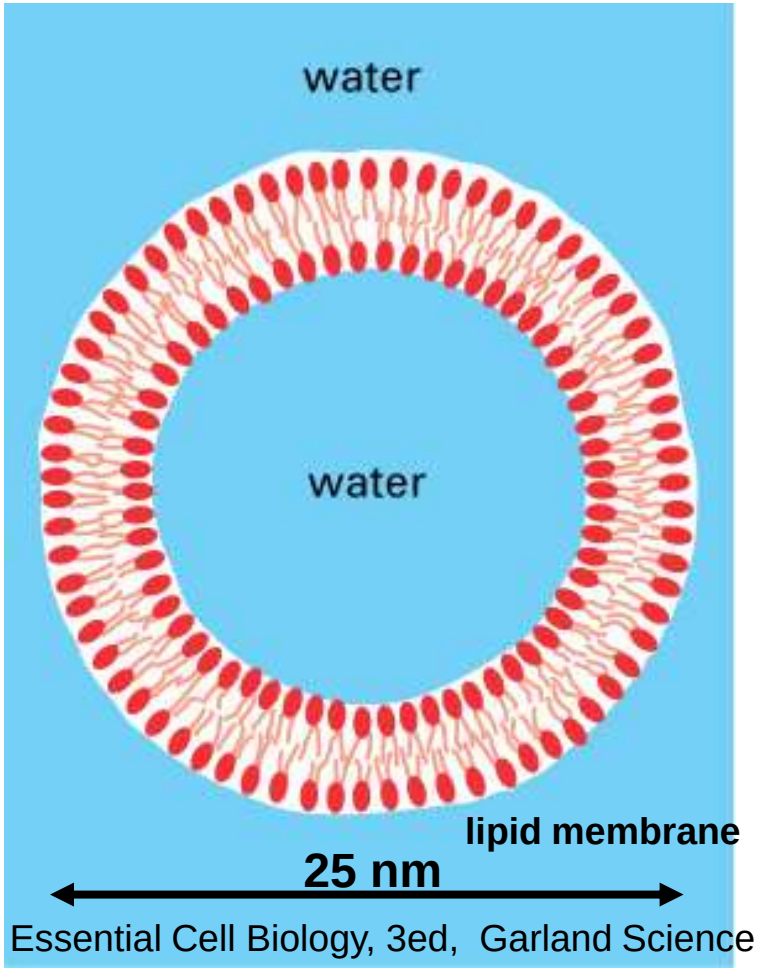


Targeted Delivery Model

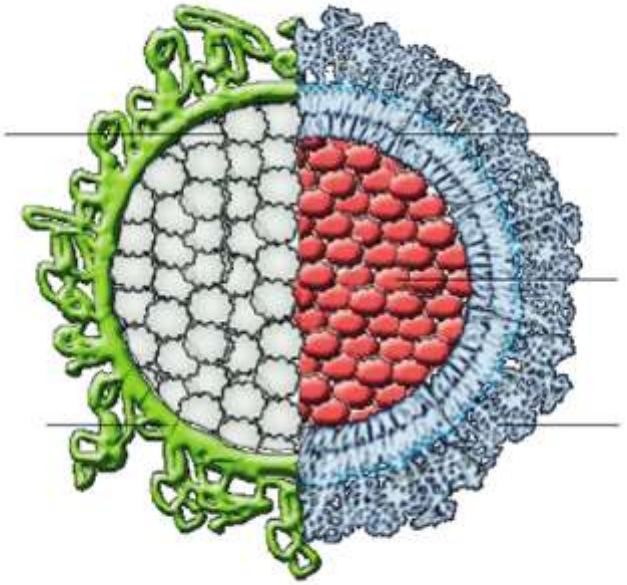
- Employs nanoparticle vesicle to contain drug or gene
- Vesicle surface contains ligand that bonds only to target cell
- Assembly must not be detected by body's immune system
- After attachment to cell, payload must be delivered to interior of cell
- Some therapies require payload to be transported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



Example Vesicle - Liposome

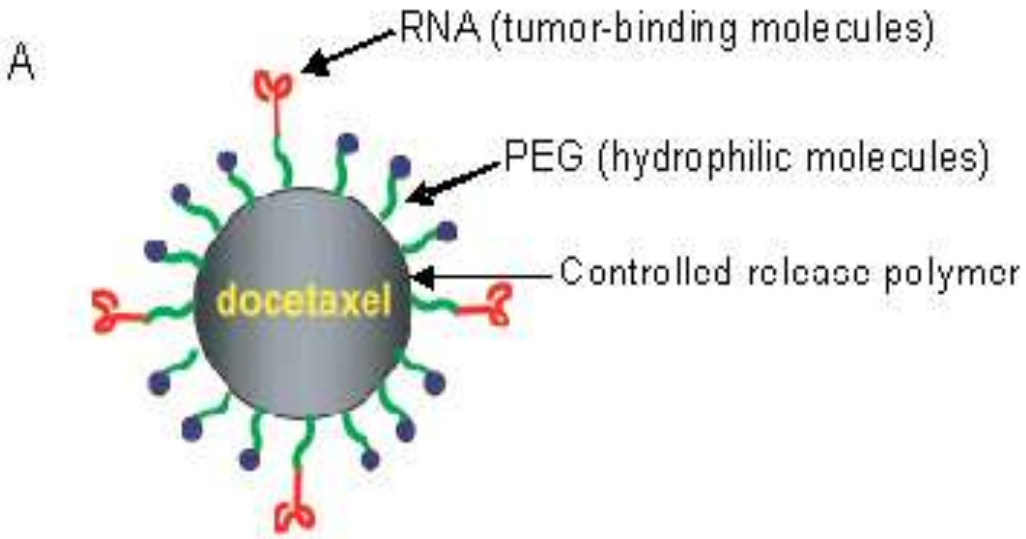


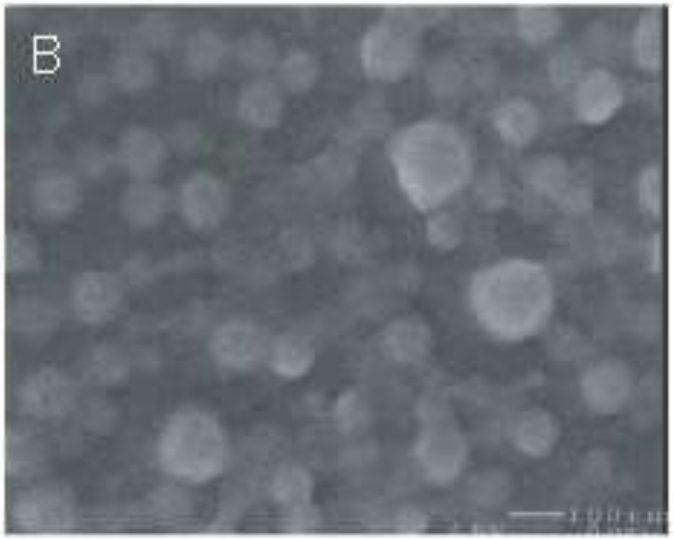
Essential Cell Biology, 3ed, Garland Science



Lancet Oncol 2006; 7: 657–67

Example of Nanoparticle Delivery System





(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

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

Scientific American Magazine

Some Current Nanoscale Therapies

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Target polymer-based particle	Clinical trials	Delivery System
Solid inorganic or metal particle	Clinical trials (gold) and pre-clinical	Delivery System
Dendrimer	Preclinical	Delivery of RNAi (gene silencing)

Scientific American Magazine

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

UWRF Tissue and Cellular Innovation Center

Marshfield Clinic Research Foundation

Chippewa Valley Technical College

University of Wisconsin Stout

Allina Hospitals & Clinics – Rivers Cancer Center

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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.



2009 Estimated US Cancer Deaths*

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

Men 292,540		Women 269,800	
Lung & bronchus	30%	26%	Lung & bronchus
Prostate	9%	15%	Breast
Colon & rectum	9%	9%	Colon & rectum
Pancreas	6%	6%	Pancreas
Leukemia	4%	5%	Ovary
Liver & intrahepatic bile duct	4%	4%	Non-Hodgkin lymphoma
Esophagus	4%	3%	Leukemia
Urinary bladder	3%	3%	Uterine corpus
Non-Hodgkin lymphoma	3%	2%	Liver & intrahepatic bile duct
Kidney & renal pelvis	3%	2%	Brain/ONS
All other sites	25%	25%	All other sites



Personalized Medicine

Nanotechnology Applications

Tissue engineering in personalized translational cancer medicine:

Development of artificial tissues and cellular modeling of tumors.

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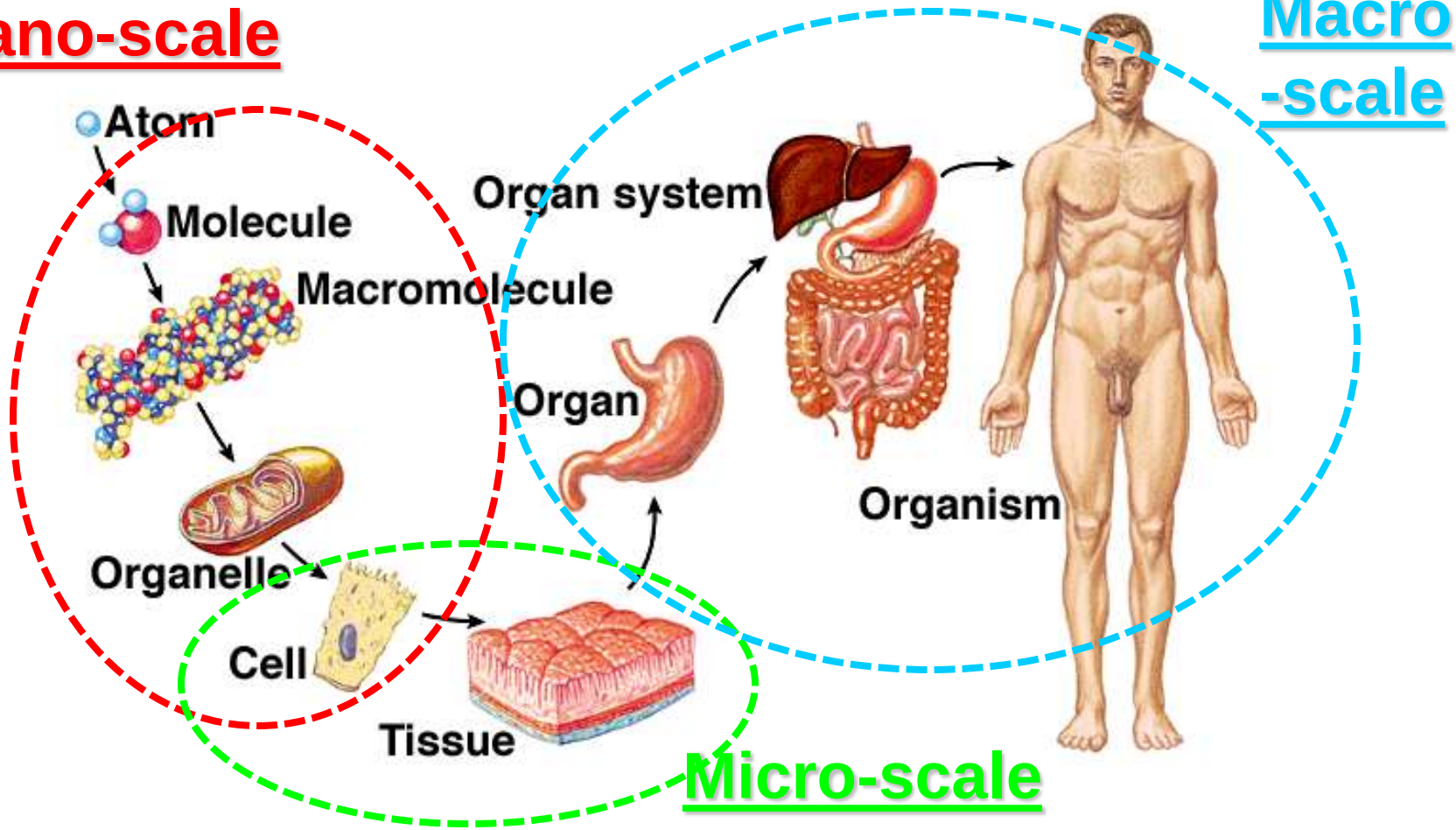
Nanotechnology: The Biological Context



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.

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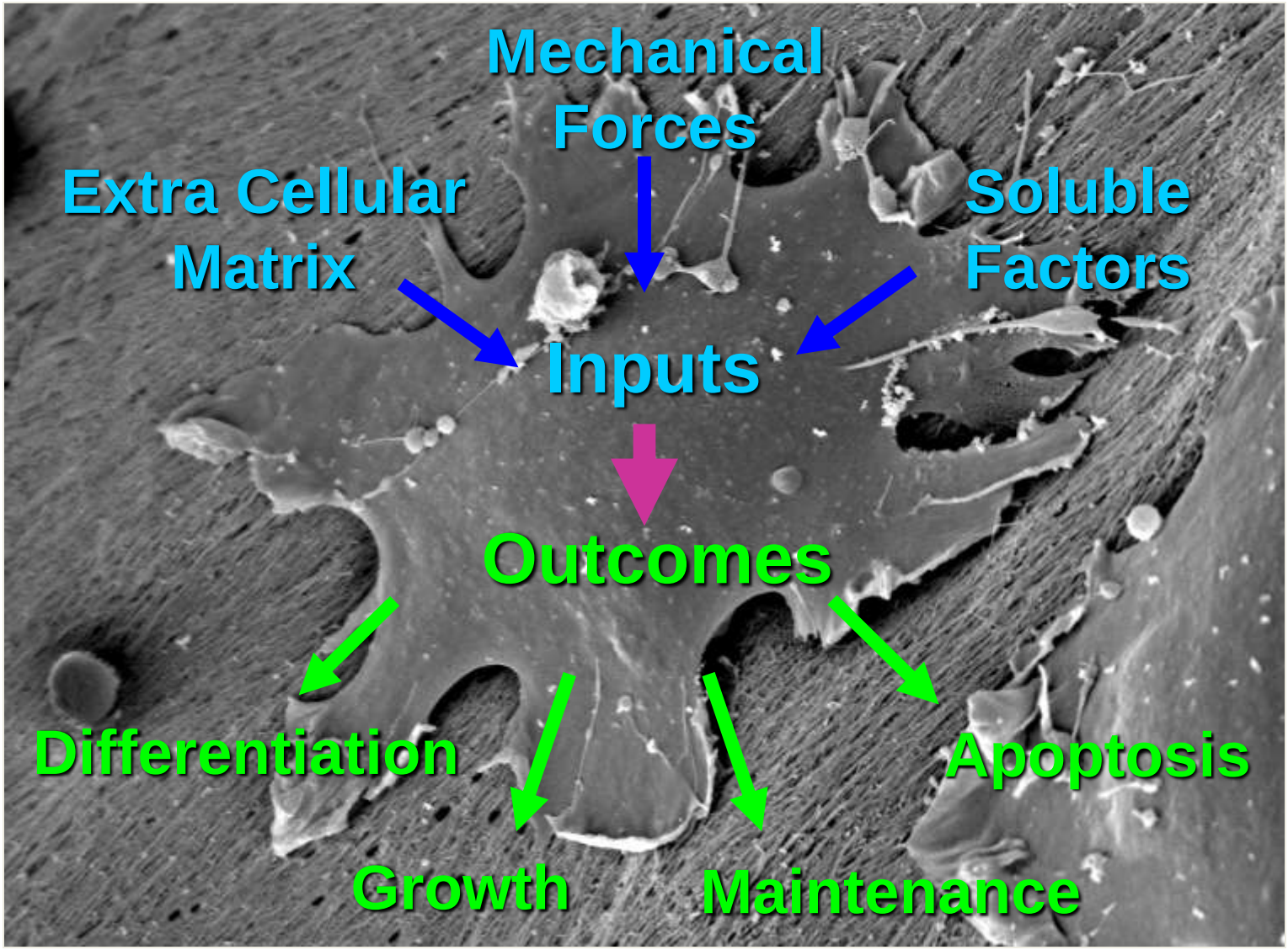
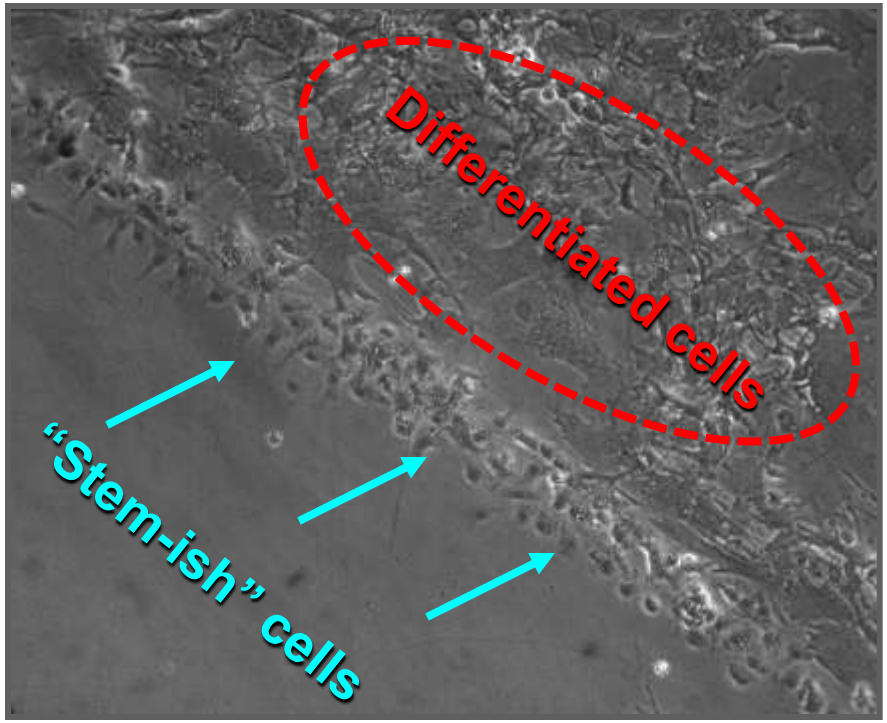
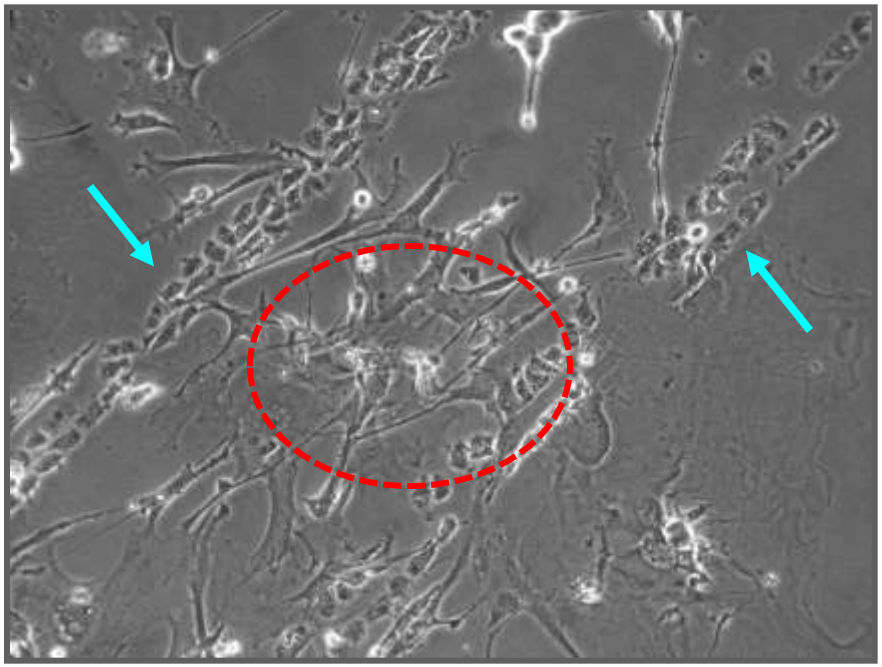
Microenvironments and Niches



Primary Tissue Cultures:

Neural Monolayer Cultures from Midbrain Region



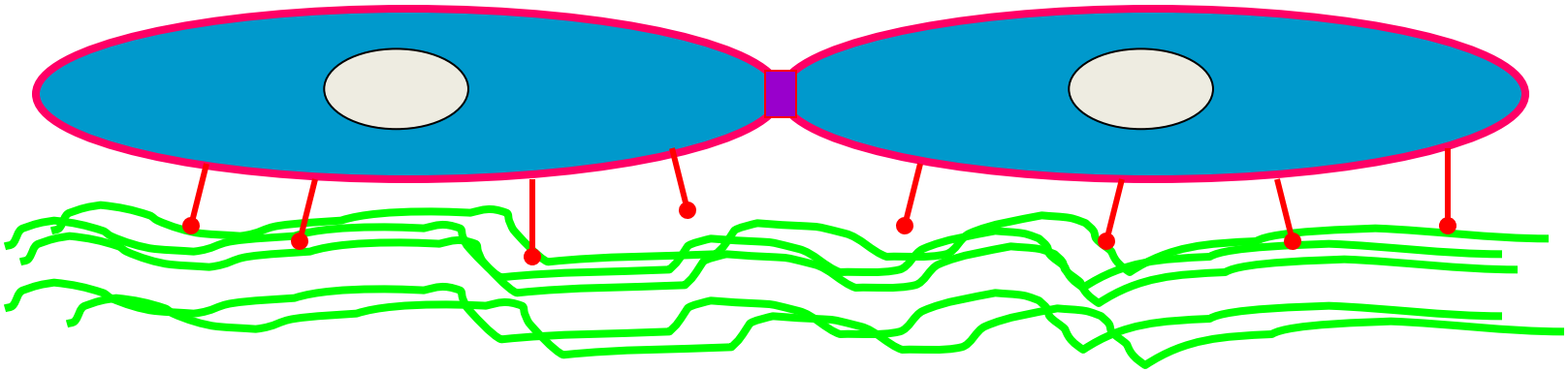


Even in "flat-cell" monolayer cultures, the environment of the cell can/does control its behavior.

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

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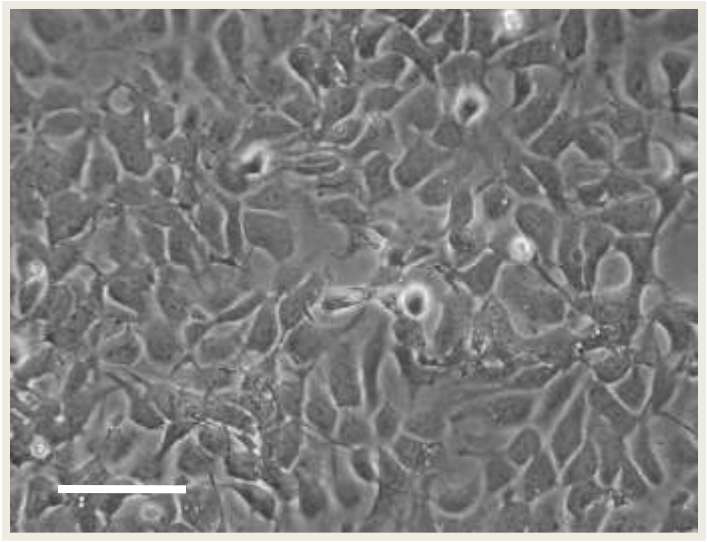
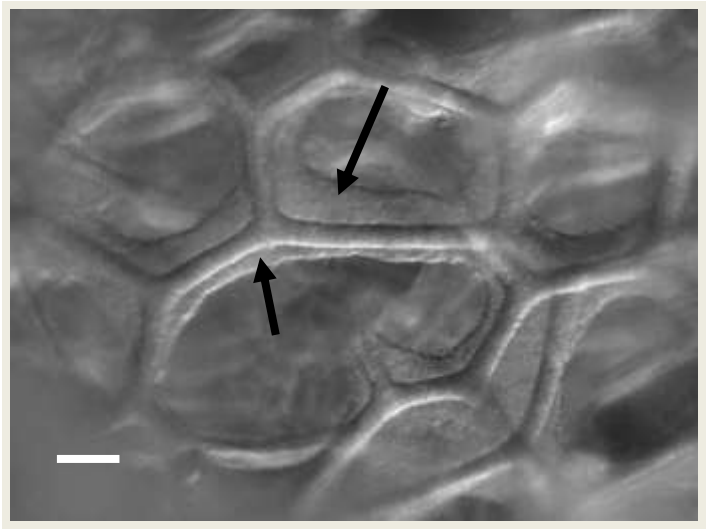
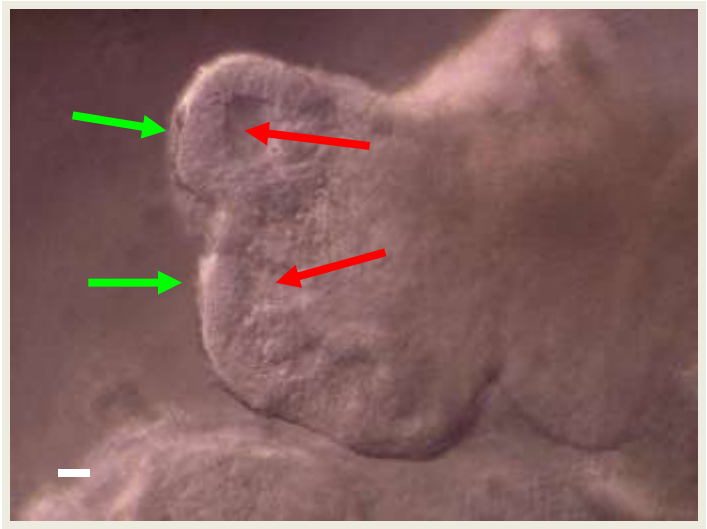
Artificial Tissues (ATs) from Cell Lines:

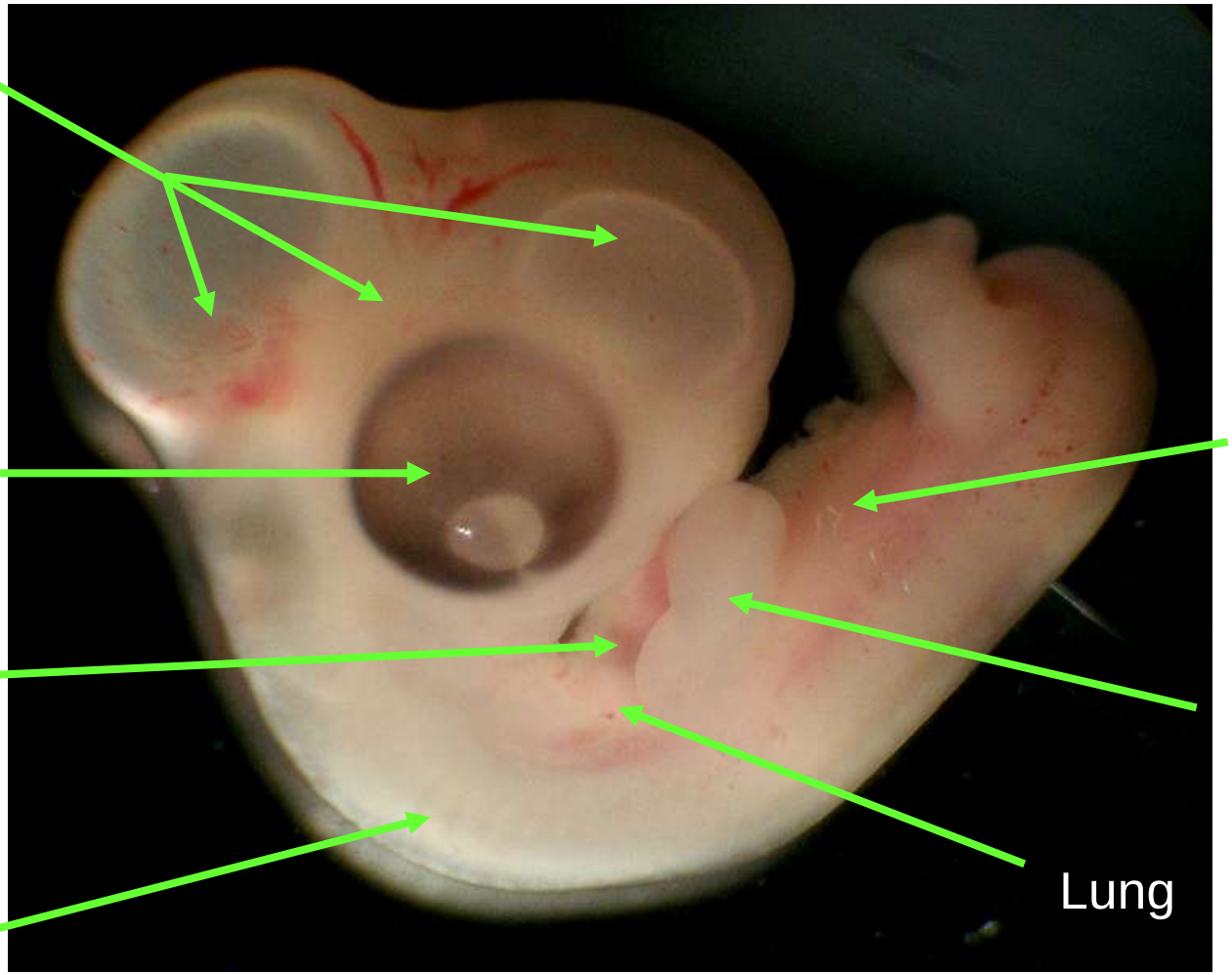
Epithelial (Embryonic Kidney)







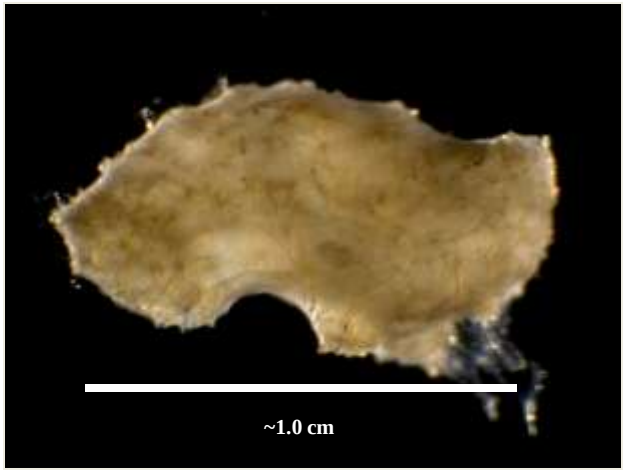
Avian Fetal ATs Studies

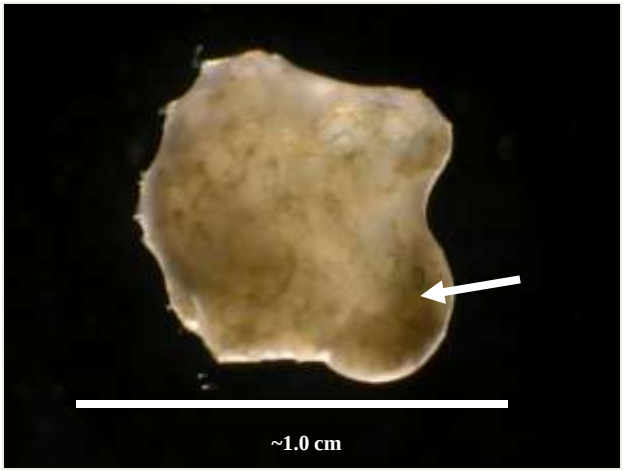


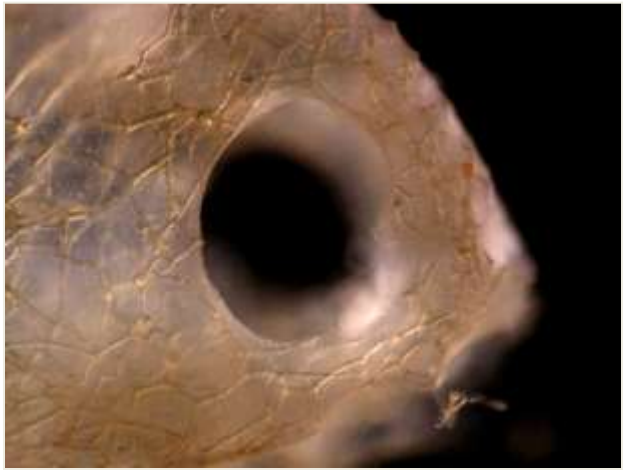
~6 day Stage Chicken Embryo

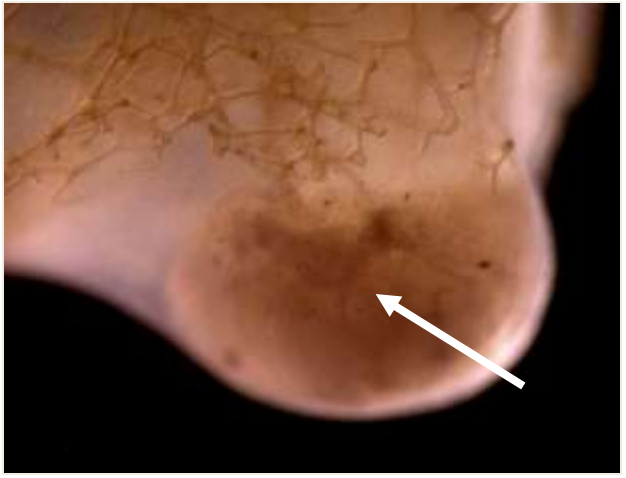
Artificial Neural Tissues

Large Scale Artificial Tissues from Midbrain Region



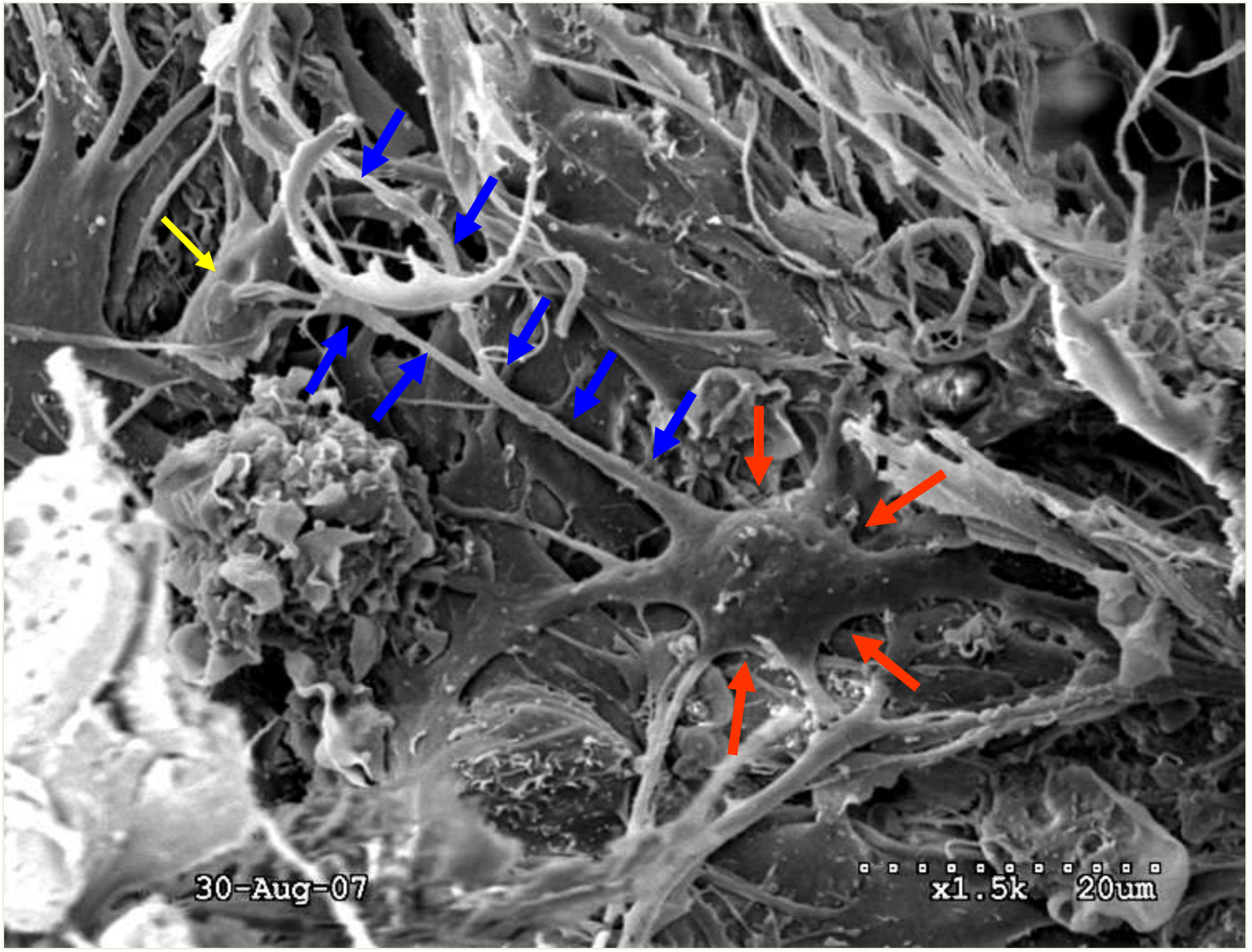






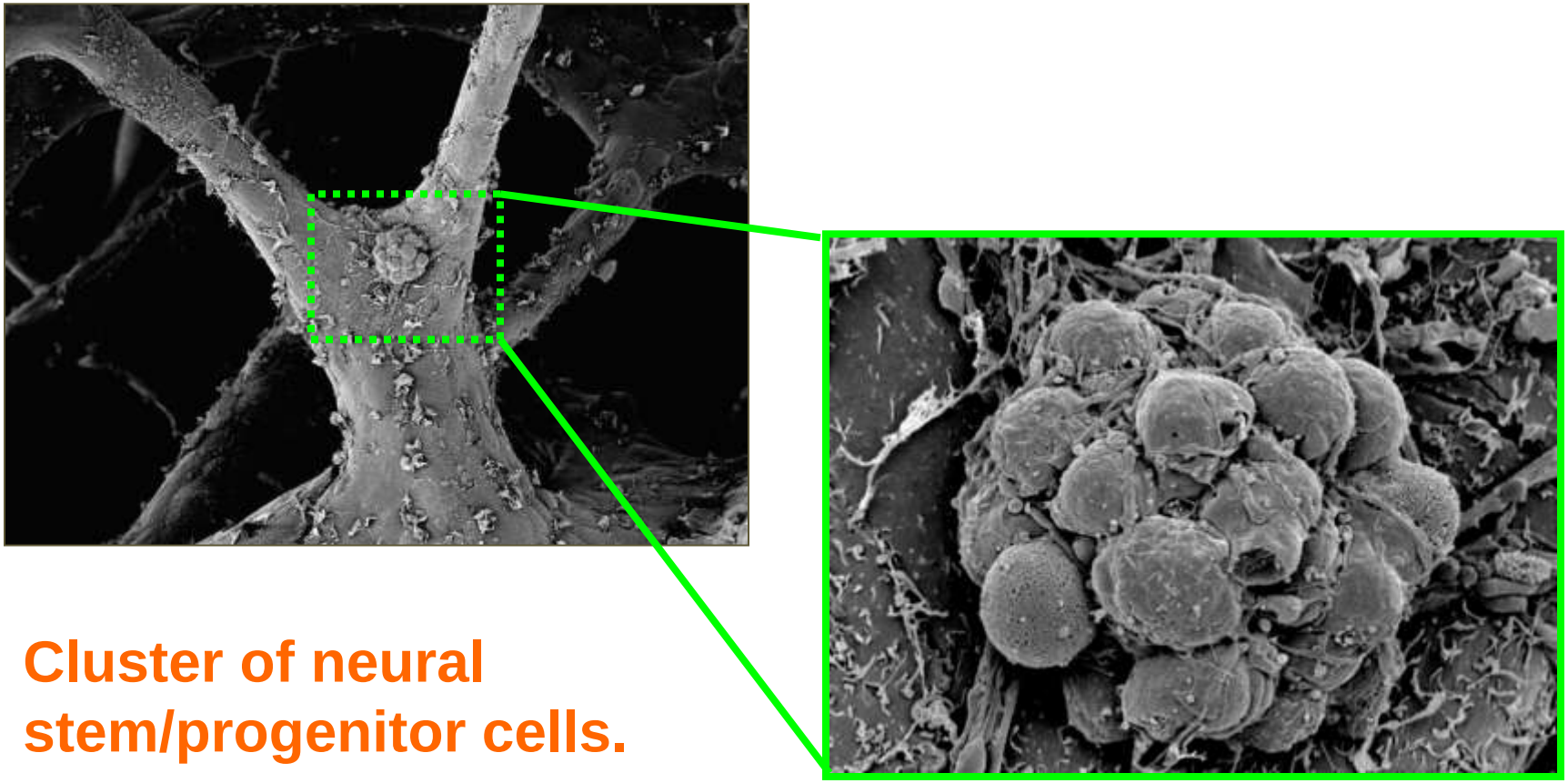
Artificial Neural Tissues

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

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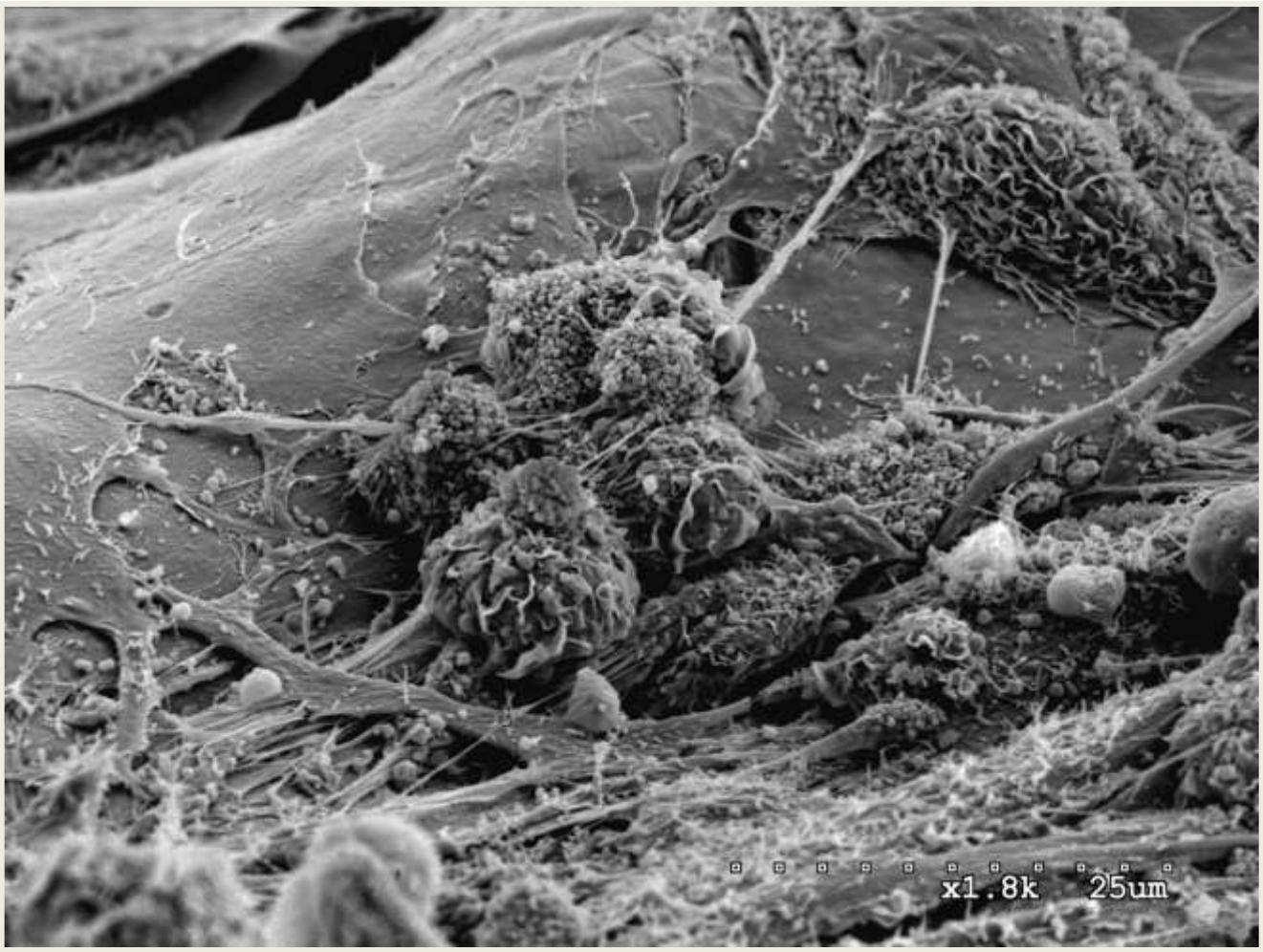
Artificial 3D Tumor Tissue: Glioblastoma



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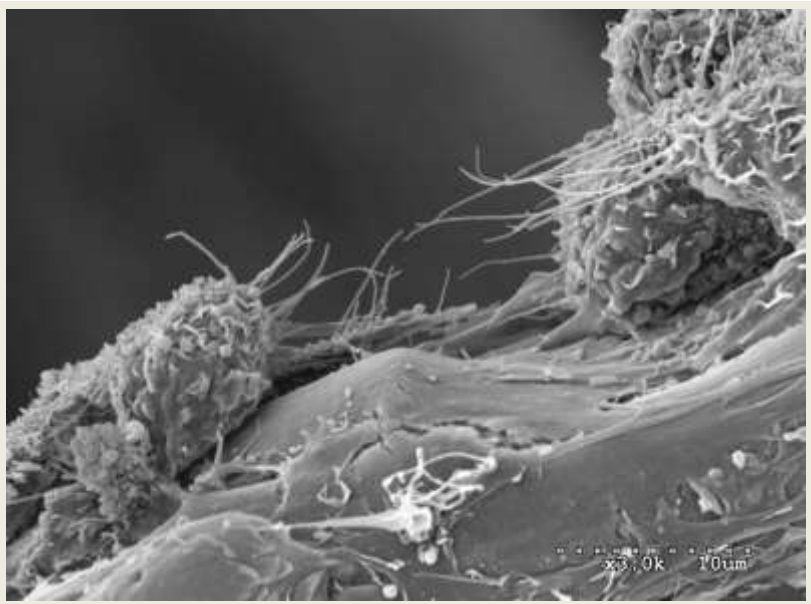
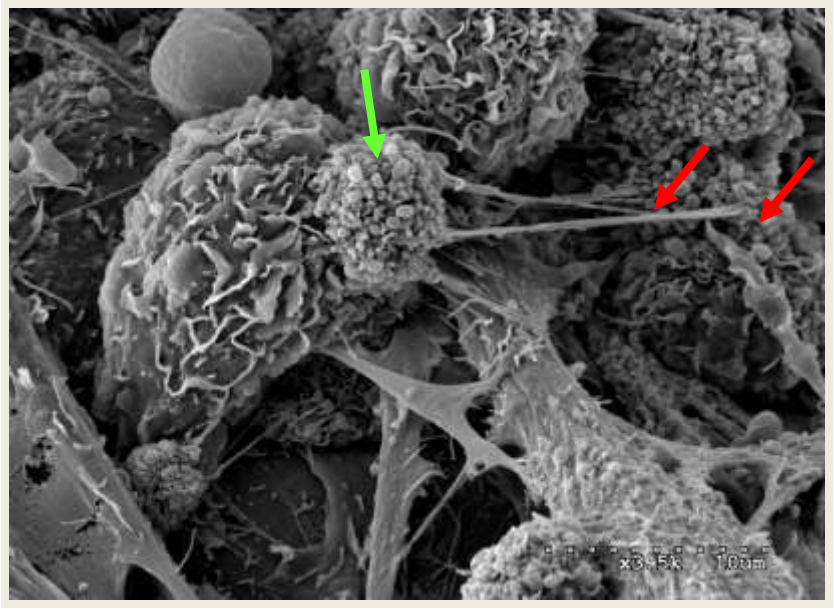
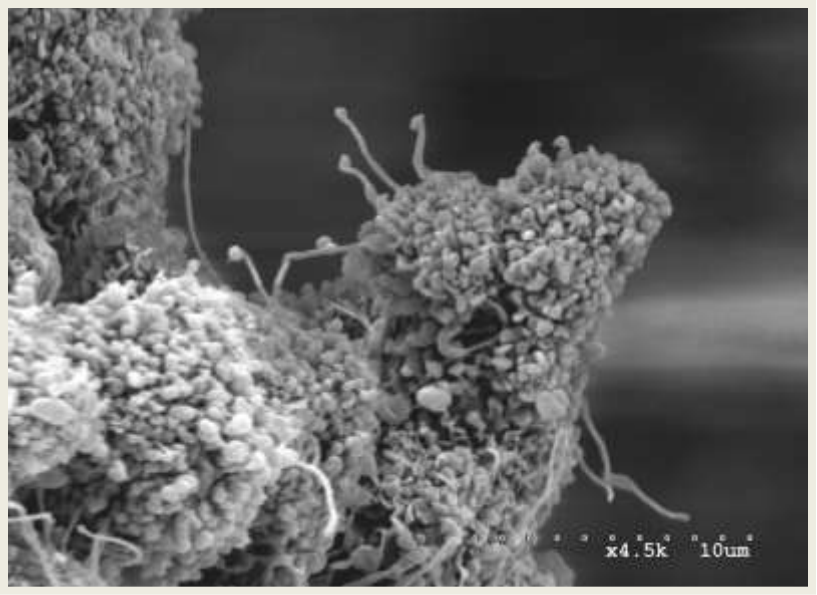
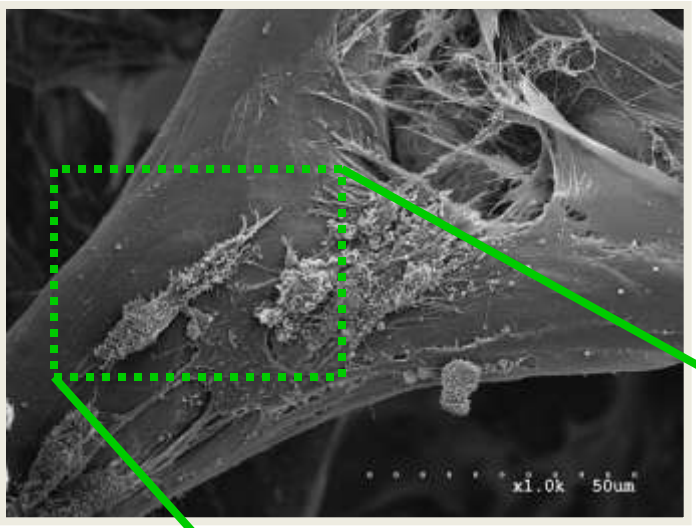


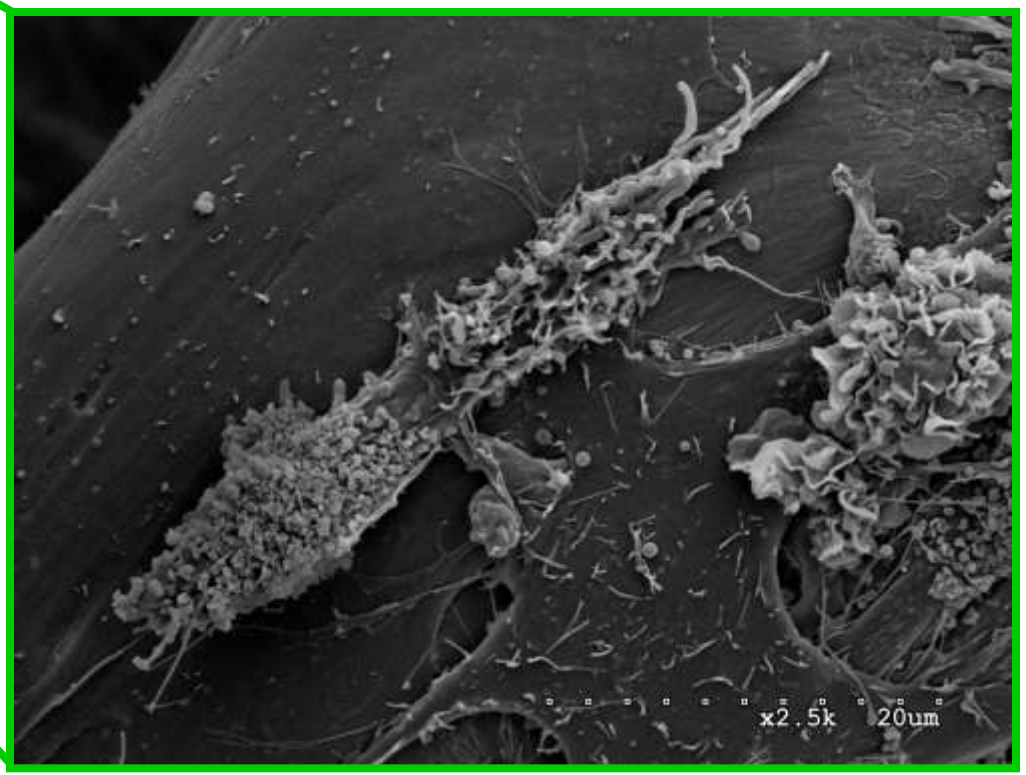




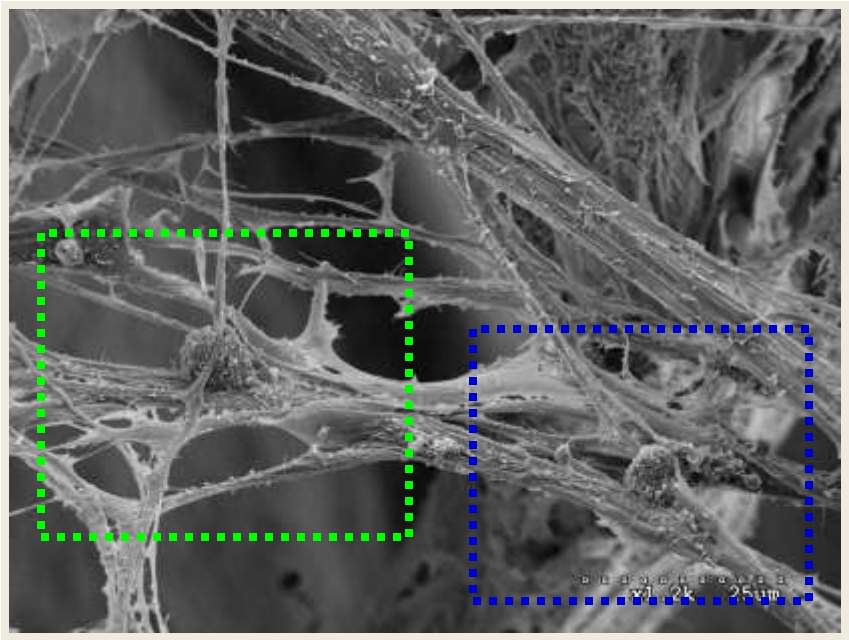
Artificial 3D Tumor Tissue: Glioblastoma

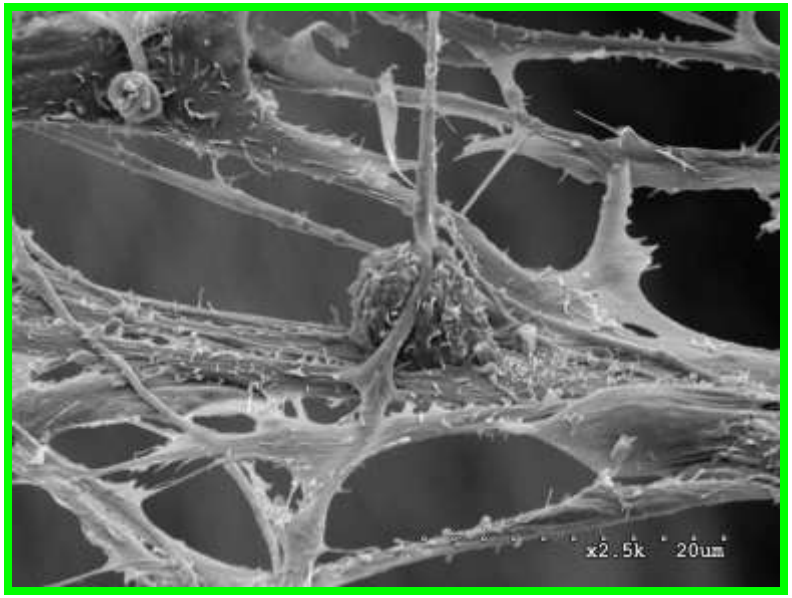


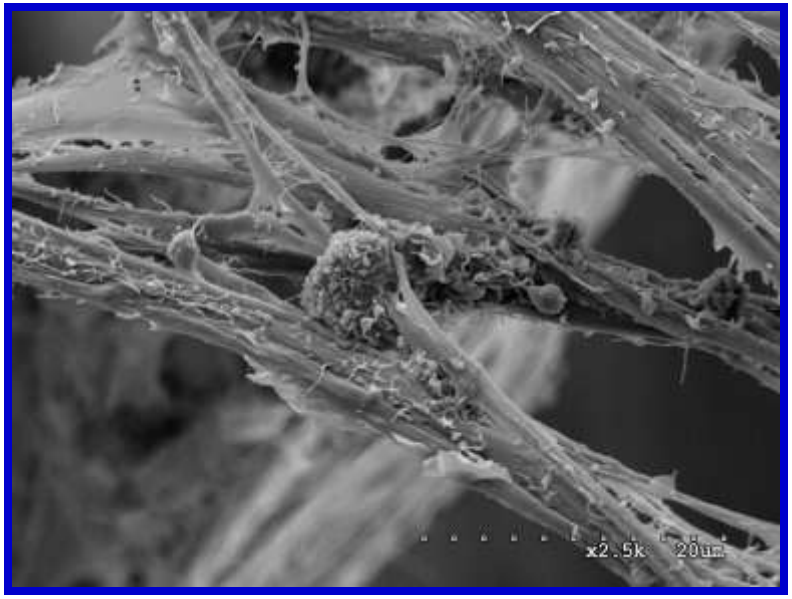
Modeling cancer cell motility and metastatic potential.



Artificial 3D Tumor Tissue: Glioblastoma



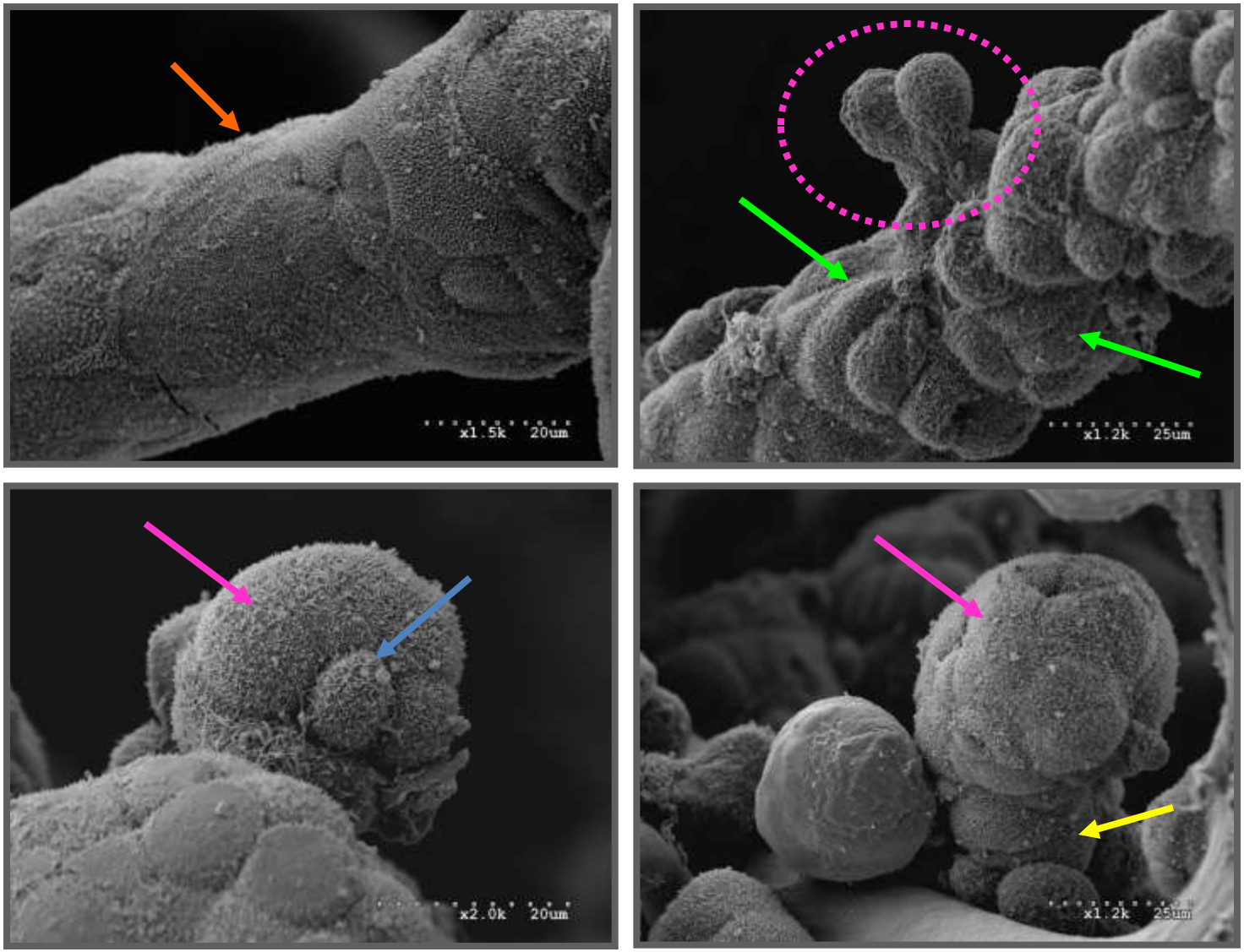




Modeling cancer cell differentiation.

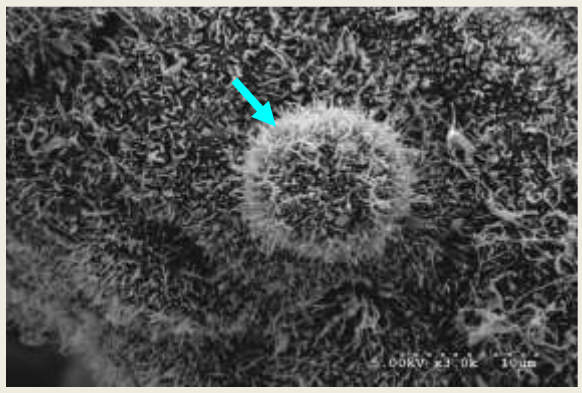
Cancer Cell Line ATTs:

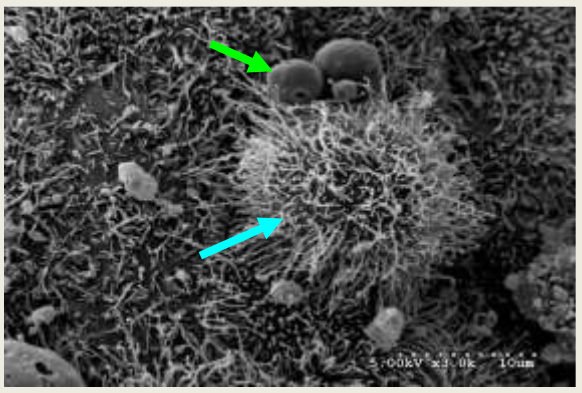
MCF-7, Breast Cancer

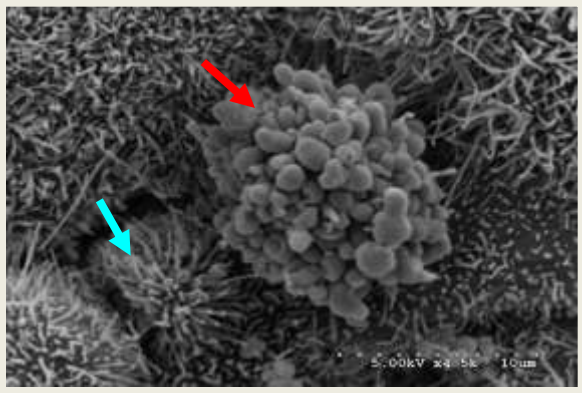


Cancer Cell Line ATTs: Hela, Cervical Carcinoma

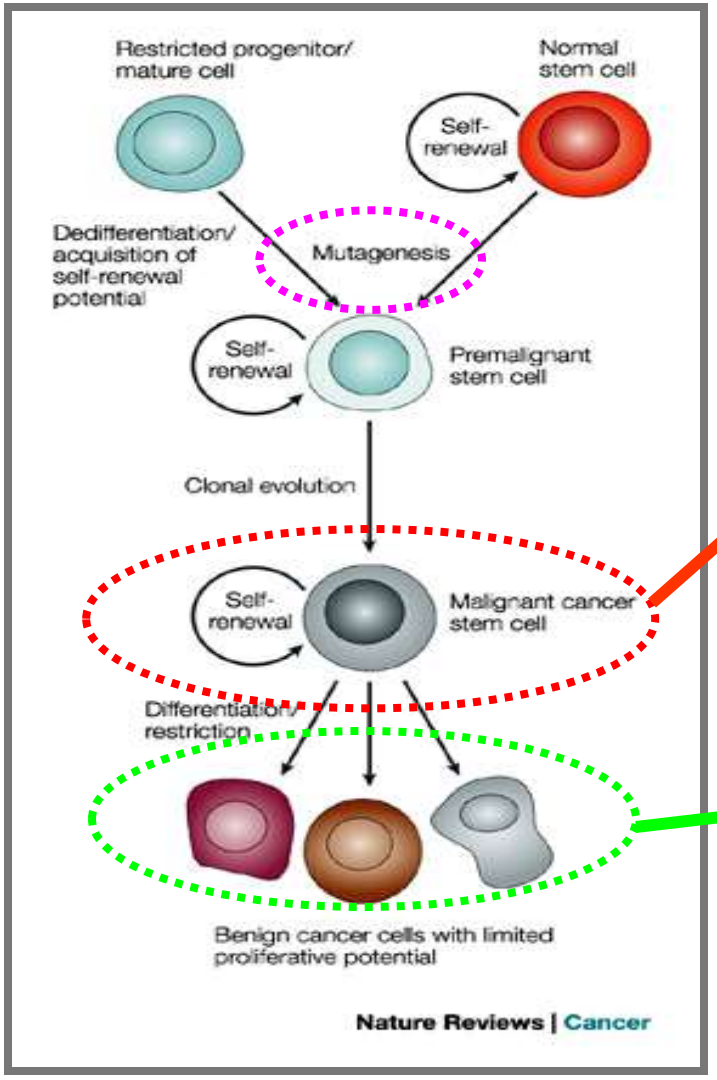
Surface Features of Hela Cell ATTs

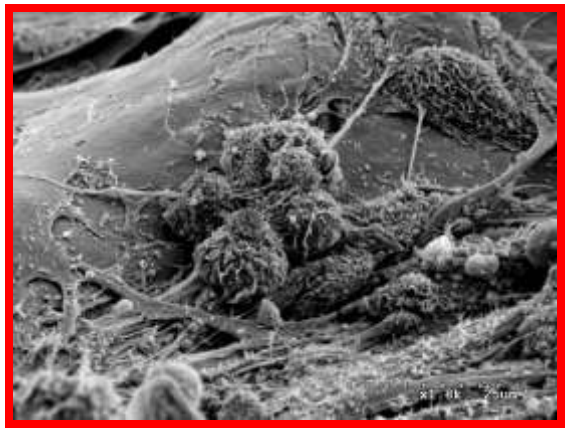




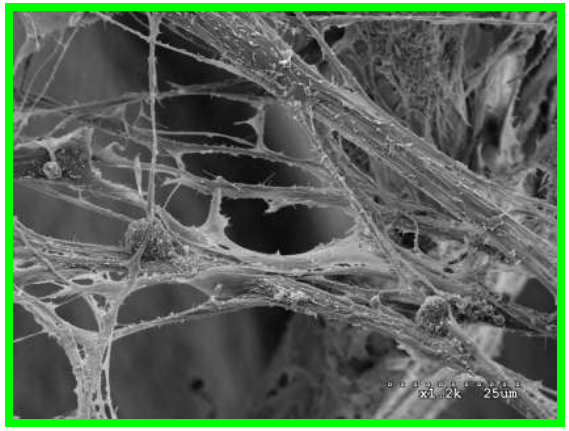


Tumor Stem Cell Hypothesis





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.

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Human Tumor 3D Culture Studies

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Human Tumor 3D Culture Studies

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Research Foundation

UWRF
Tissue and Cellular Innovation Center

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2006 Tissue Culture Teaching and Research Grant

2008 Research Microscope Grant

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Questions?

Nanotechnology in Medicine: Brain Tumor Targeted Nanodelivery Systems for Therapy and Diagnosis

A.B. Madhankumar
Department of Neurosurgery
Penn State Hershey

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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)

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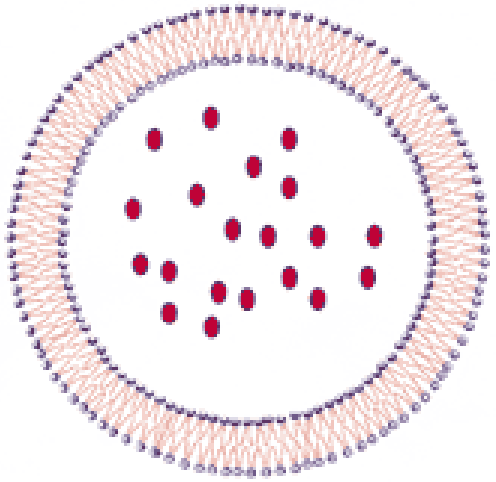
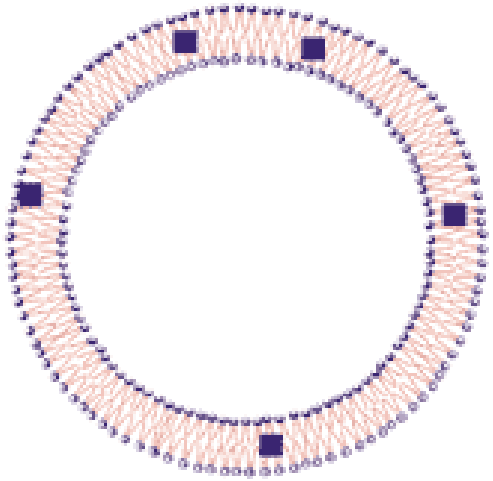
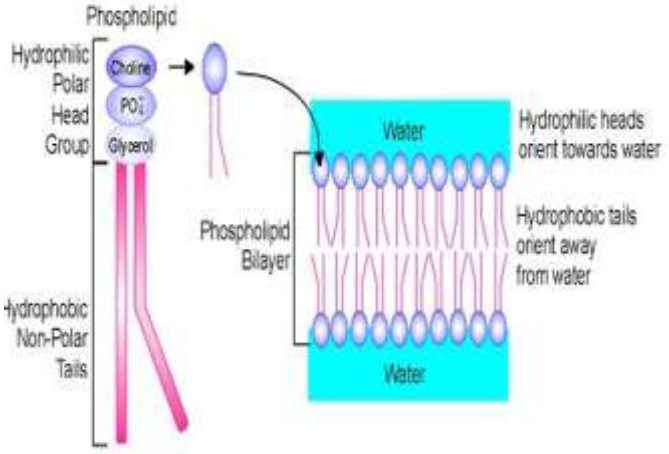
Liposomes: Lipid Bilayer Membranes







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
$(NH_4)_2SO_4$
pH5.5
(sonication)

Liposomes

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

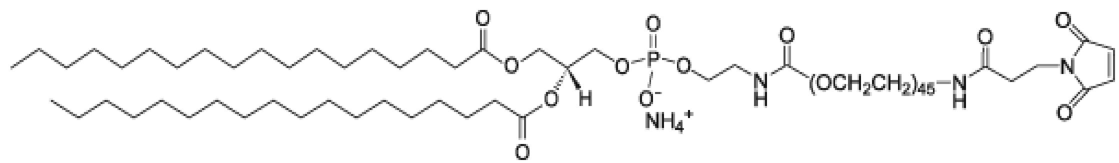
Conjugate
with IL13

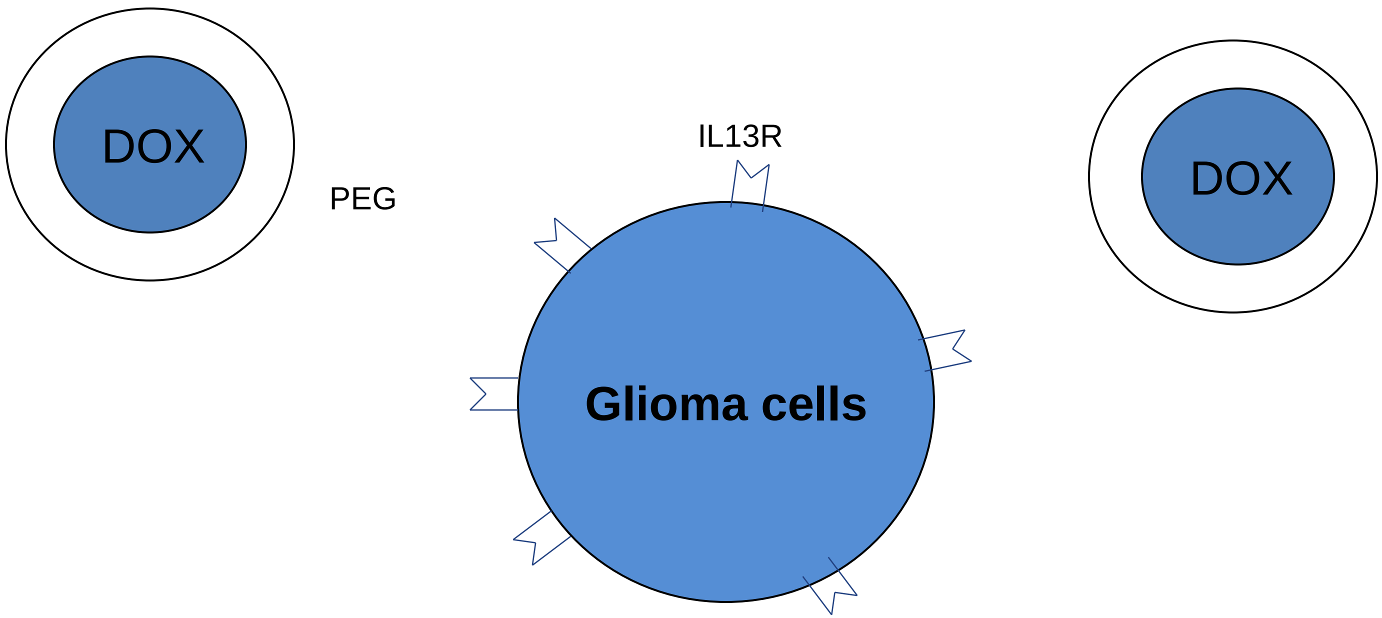
Tumor targeted liposomes



Surface Conjugation of Proteins for Selective Targeting

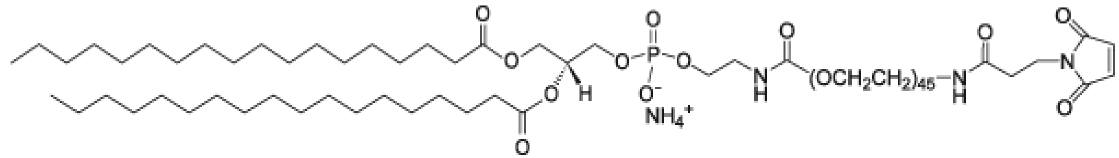
DSPE-PEG-Maleimide

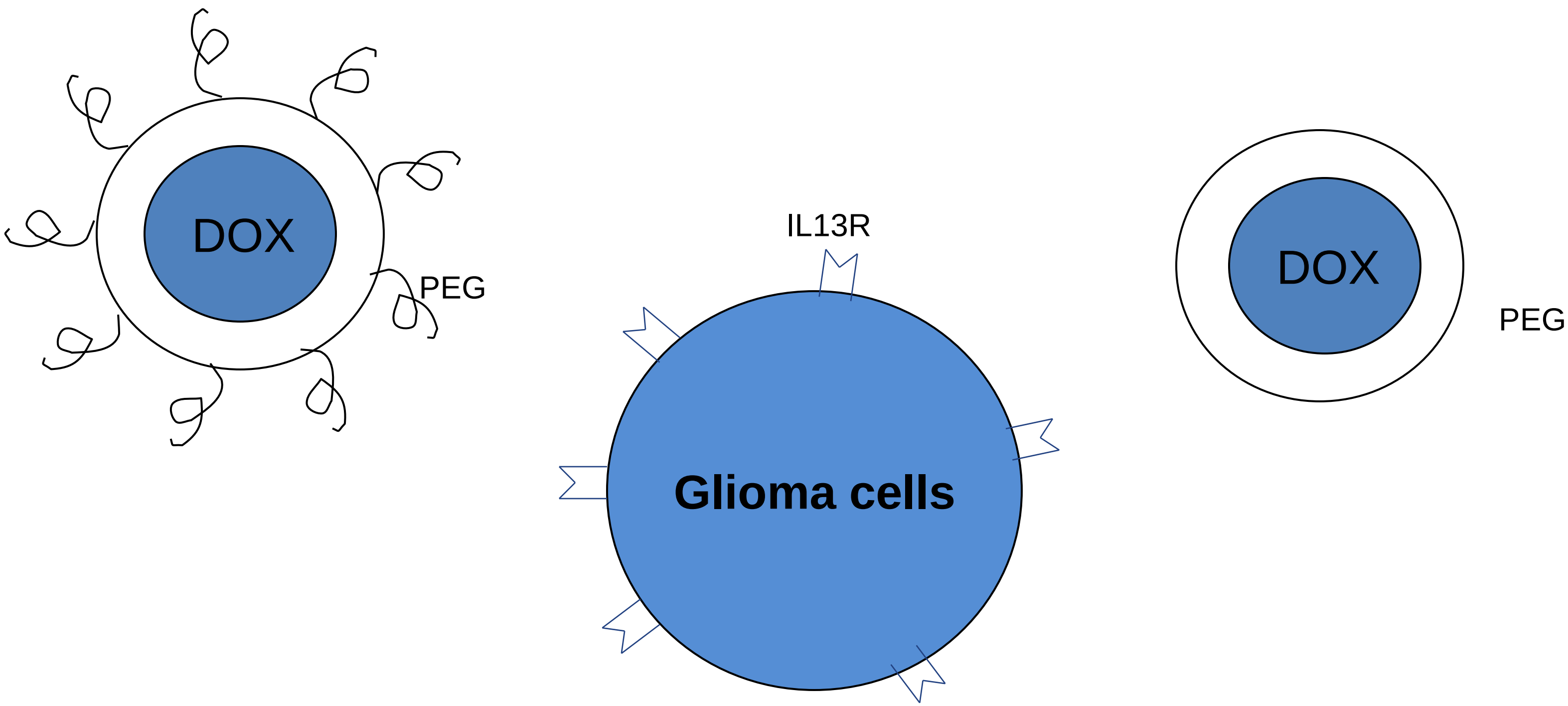




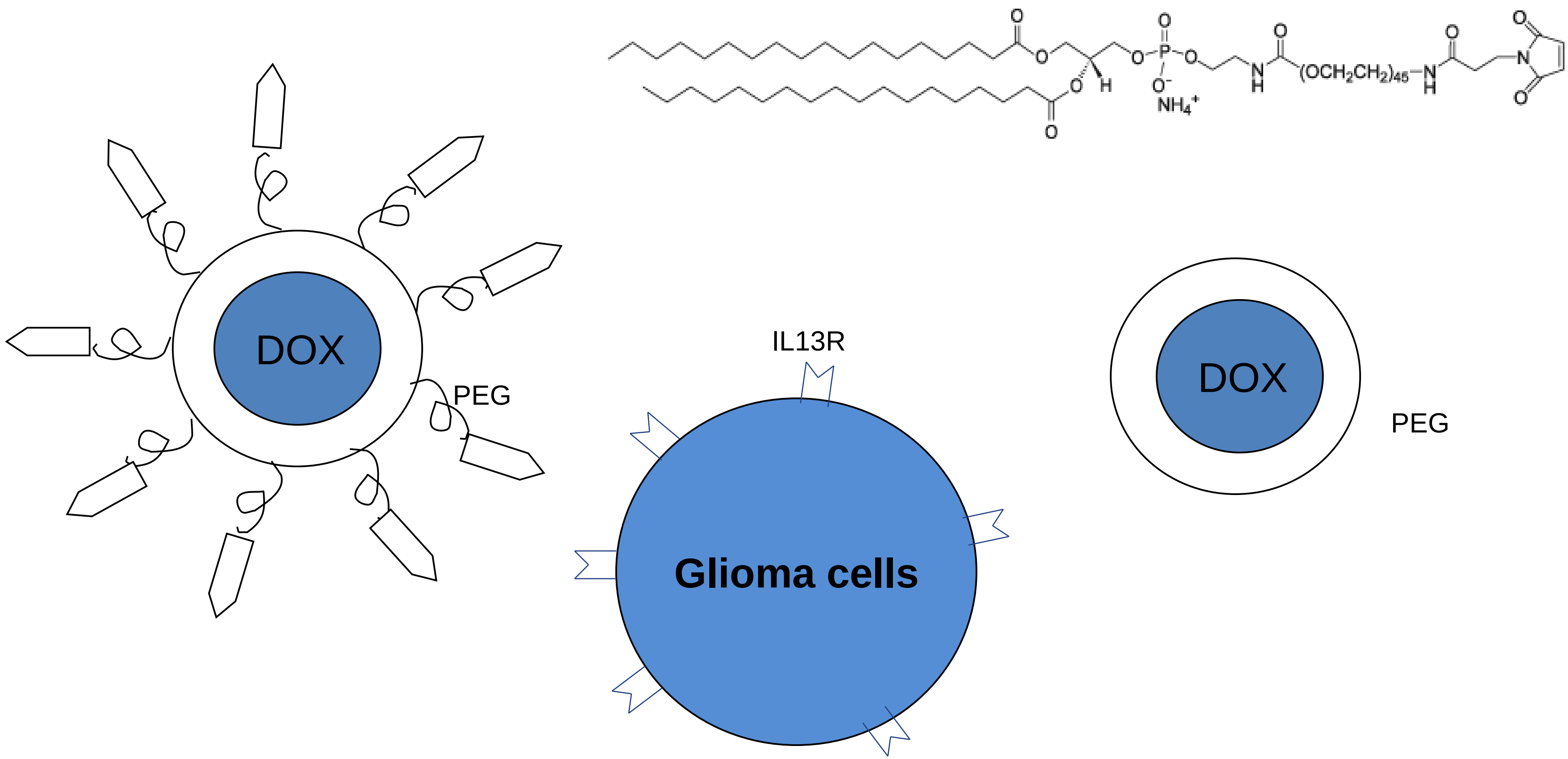
Surface Conjugation of Proteins for Selective Targeting

DSPE-PEG-Maleimide





Surface Conjugation of Proteins for Selective Targeting



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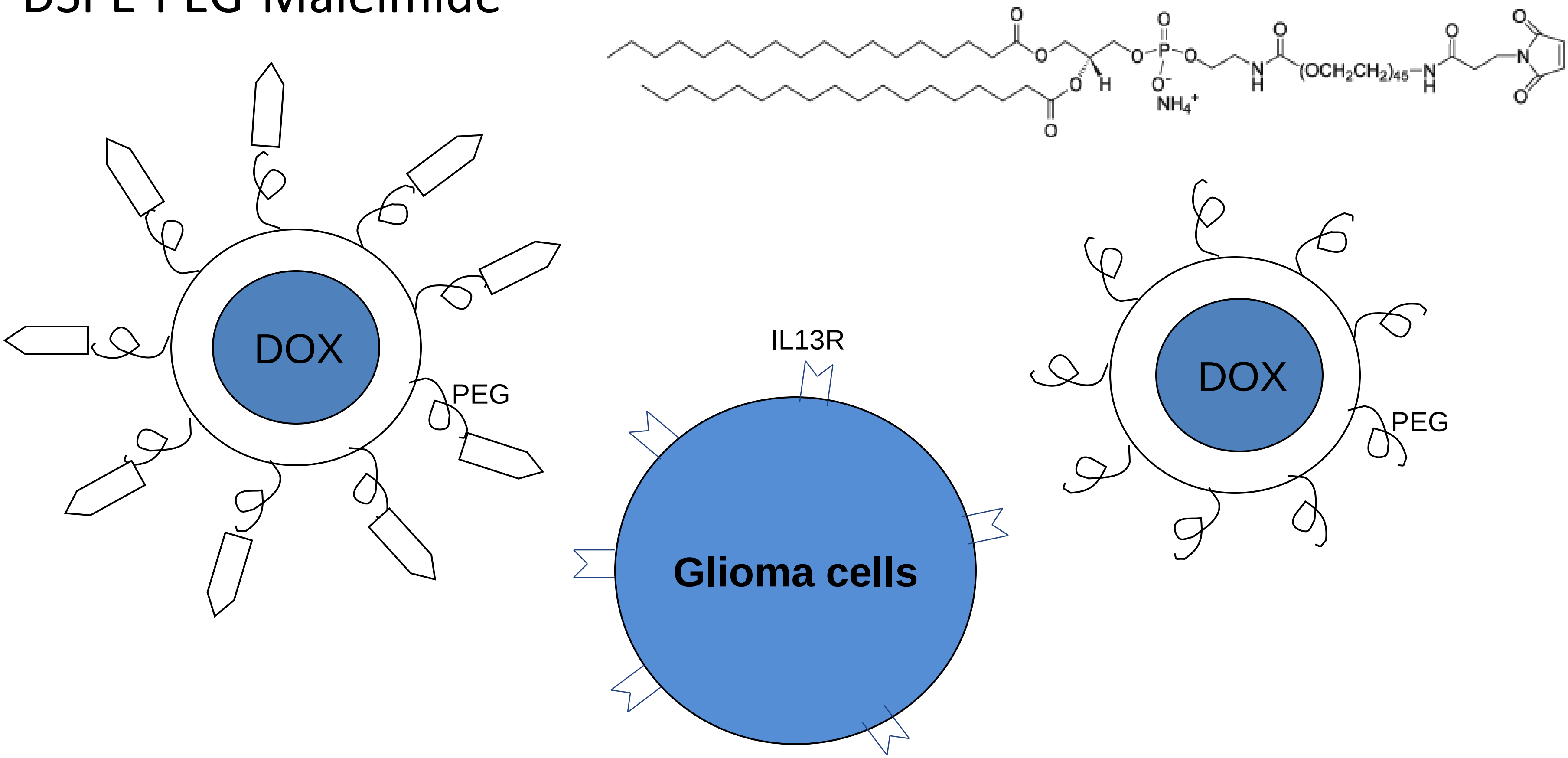
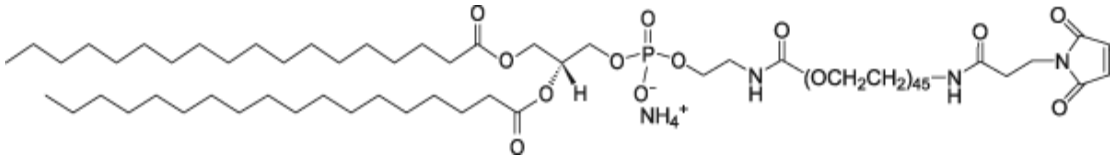
Surface Conjugation of Proteins for Selective Targeting

DSPE-PEG-Maleimide

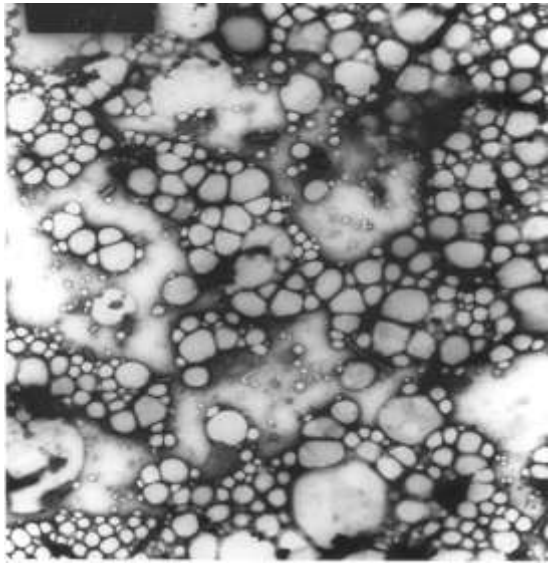


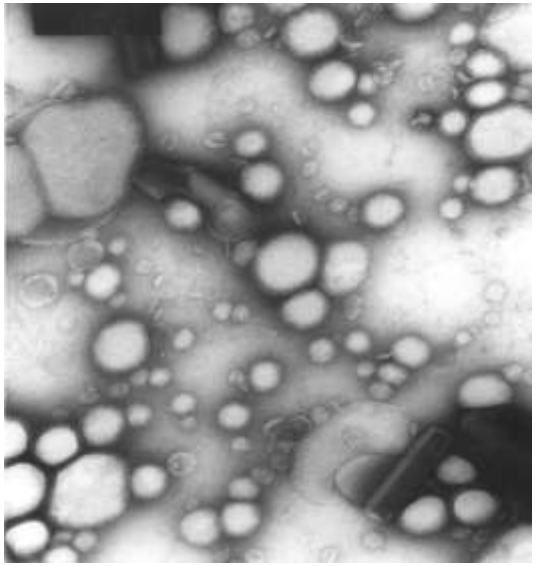
Surface Conjugation of Proteins for Selective Targeting

DSPE-PEG-Maleimide



TEM Images of IL13 Conjugated Liposomes

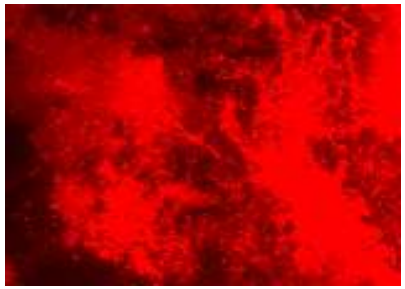




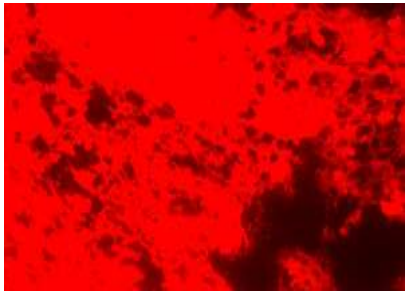
Particle size analysis (50-150nm size range PDI= 0.2-0.4)

Zeta potential : -35 mV

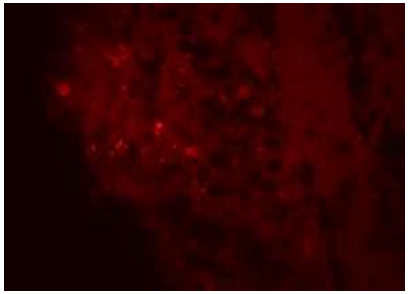
Binding of Fluorescent IL-13 Liposomes to Tumor Sections: Receptor Mediated



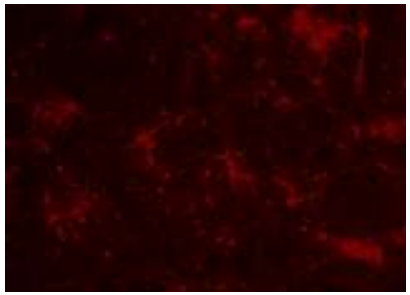
GBM# 5



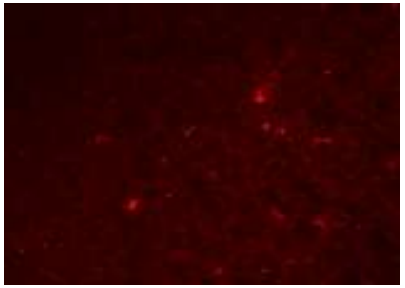
GBM#15



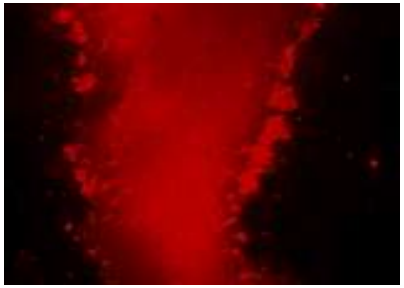
GBM#15(after blocking with IL13Rα2 receptor antibody)



Medulloblastoma



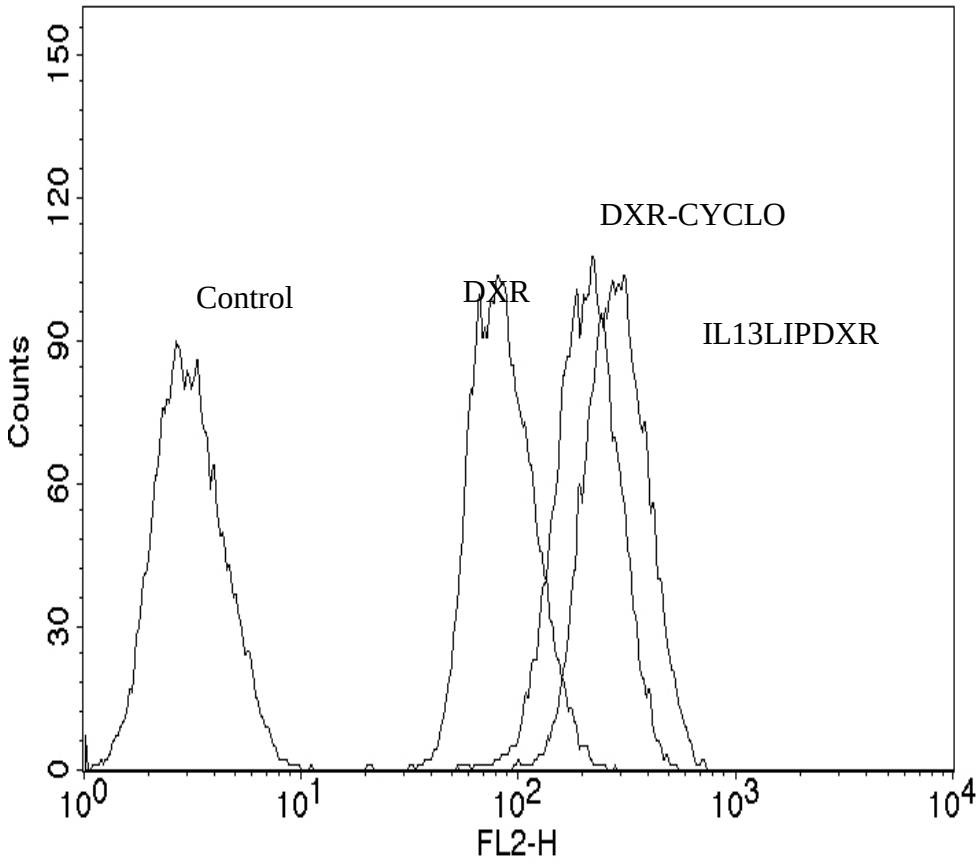
Normal Human Cortex



Pilocytic Astrocytoma

Molecular Cancer Therapeutics 5(12):3162-3169, Dec 2006.

Pgp Mediated Drug Resistance: U251 Glioma Cells

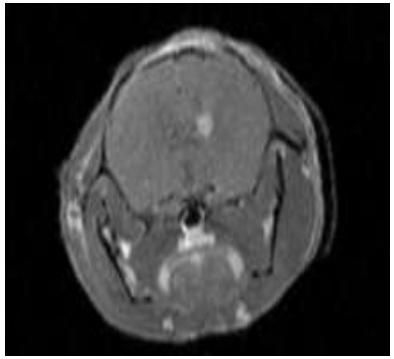
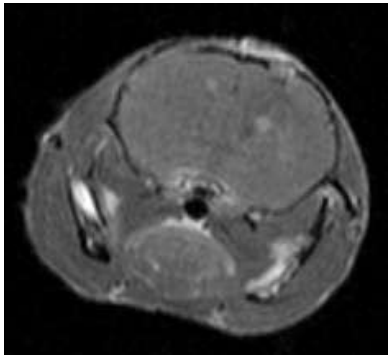
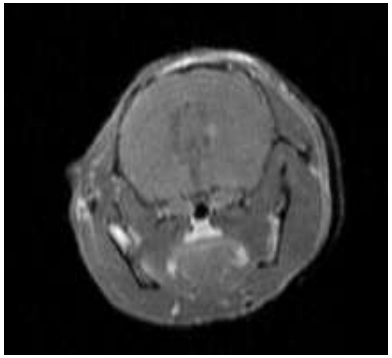
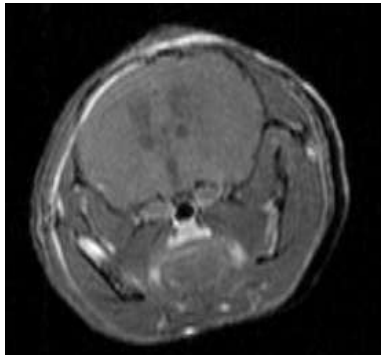


These data show that the liposome Encapsulated drug (DXR) can avoid extrusion by the multi-drug resistance system for at least 2 hours

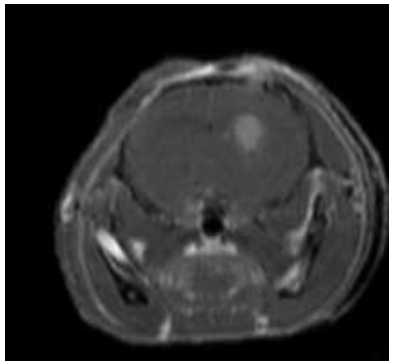
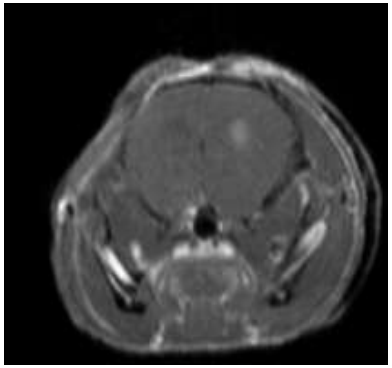
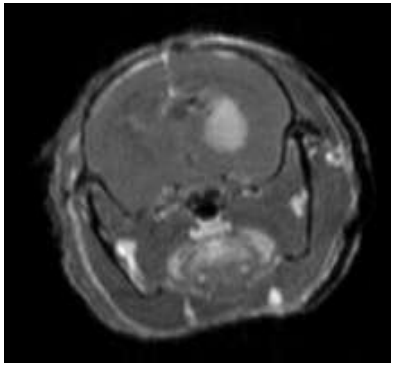
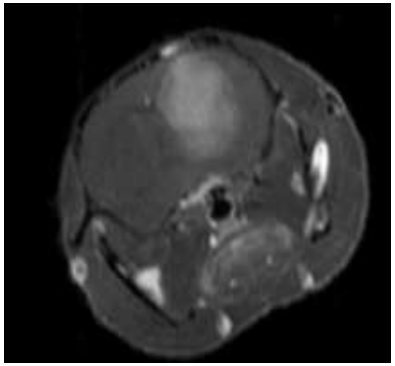
(MDR was blocked by cyclosporine A)

T1 Contrast MRI Images During the Treatment

Targeted DXR/LIP

	1st MRI Prescan	2nd MRI 1 week post treatment	3rd MRI 2 week post treatment	4th MRI 3 week post treatment
A				

Untargeted DXR/LIP

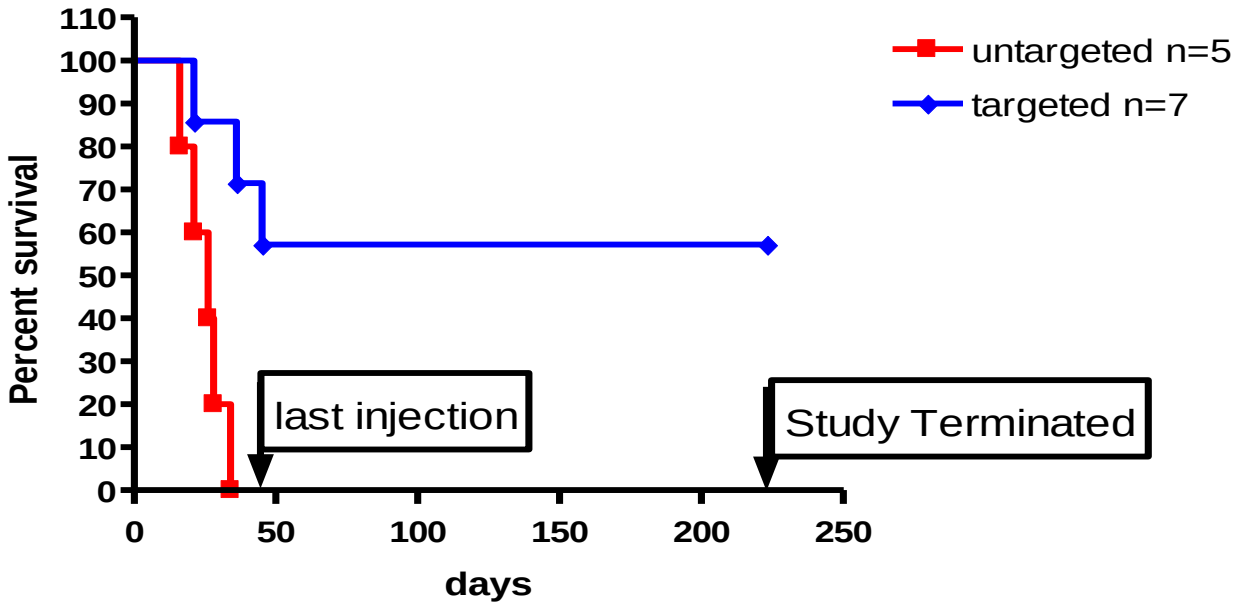
B				

Kaplan-Meyer Survival Graph

Median survival untargeted=25 days

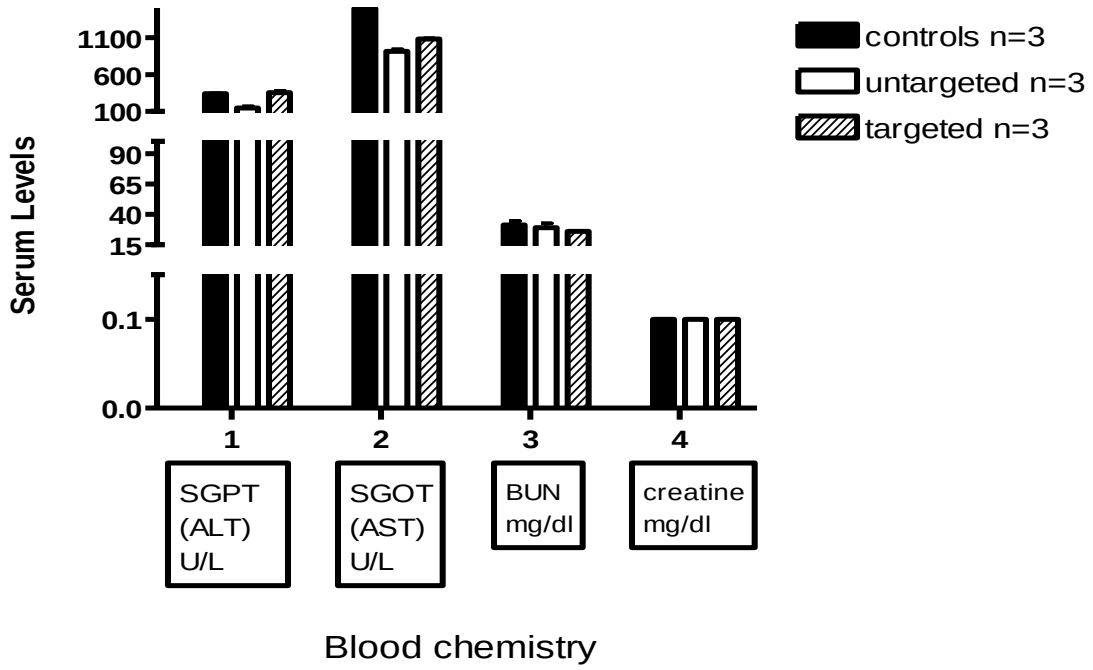
Median survival targeted=142 days

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

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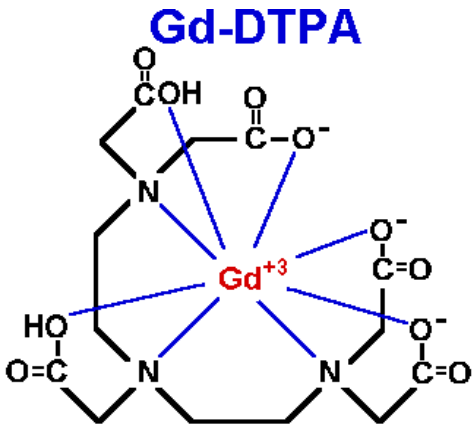
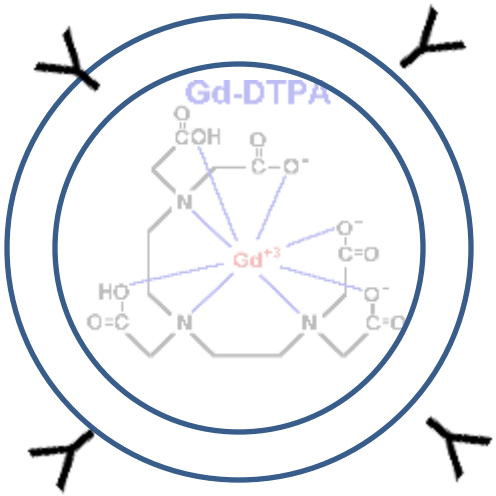
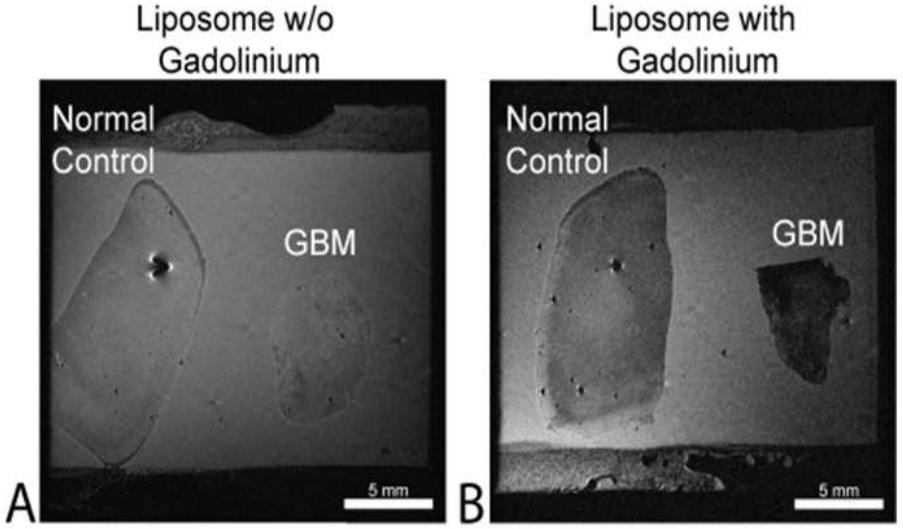
Tumor Specific Receptor Targeted Liposomes Carrying MRI Contrast Agents

Positive contrast enhancing agents (reduce T1 relaxation time of the surrounding water protons)

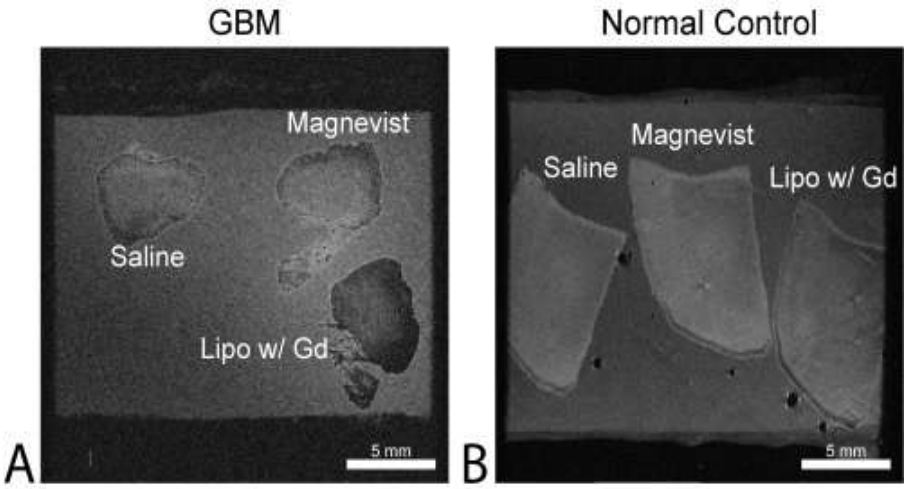




MRI images of tumor sections



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.

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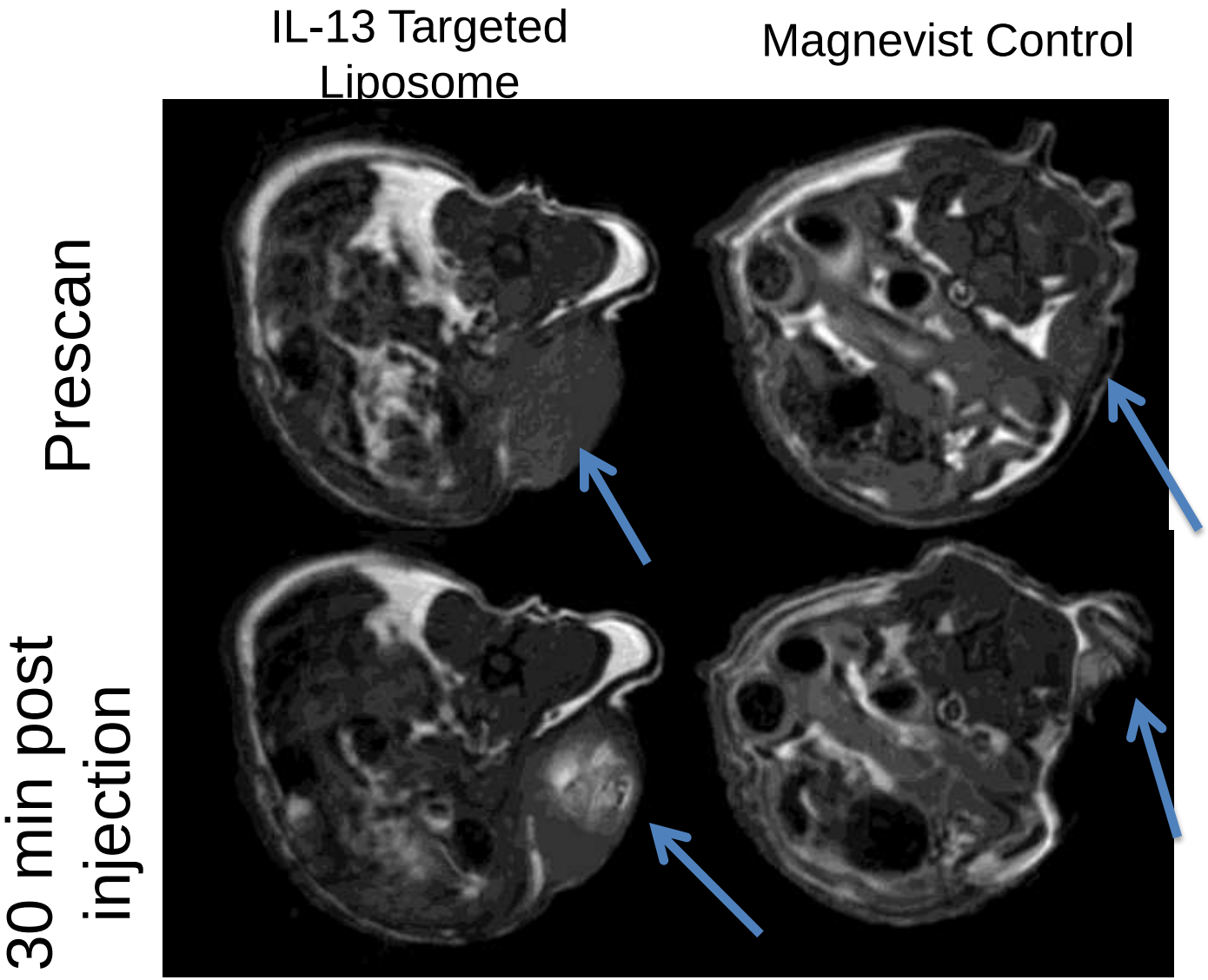
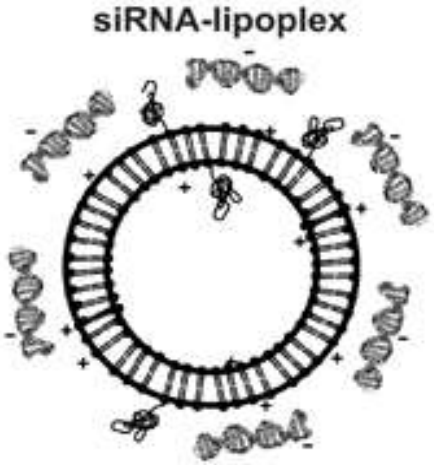
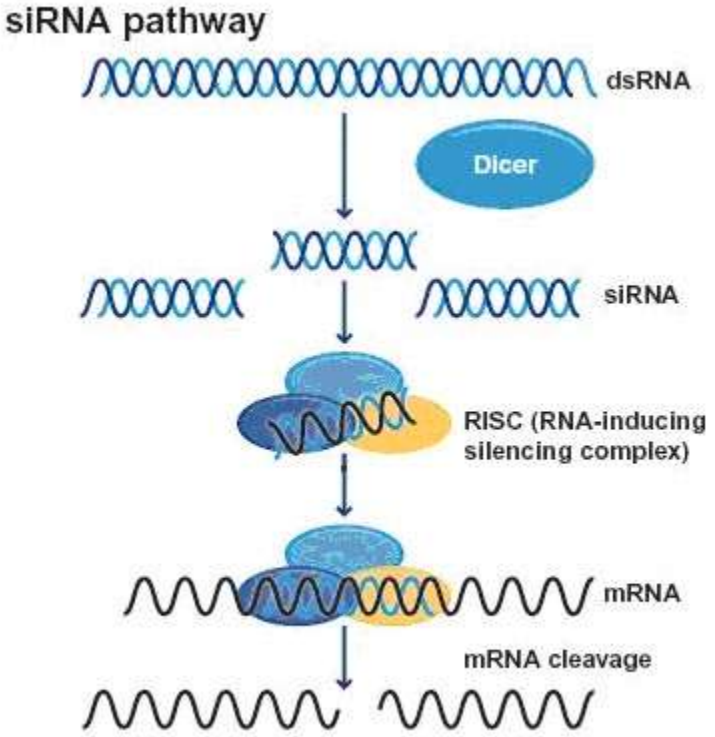
T1 Contrast MRI of IL-13 Targeted Gadolinium Liposome in Subcutaneous Tumor



siRNA Delivery - Cationic Liposomes



20-24 base pair double stranded RNA molecule



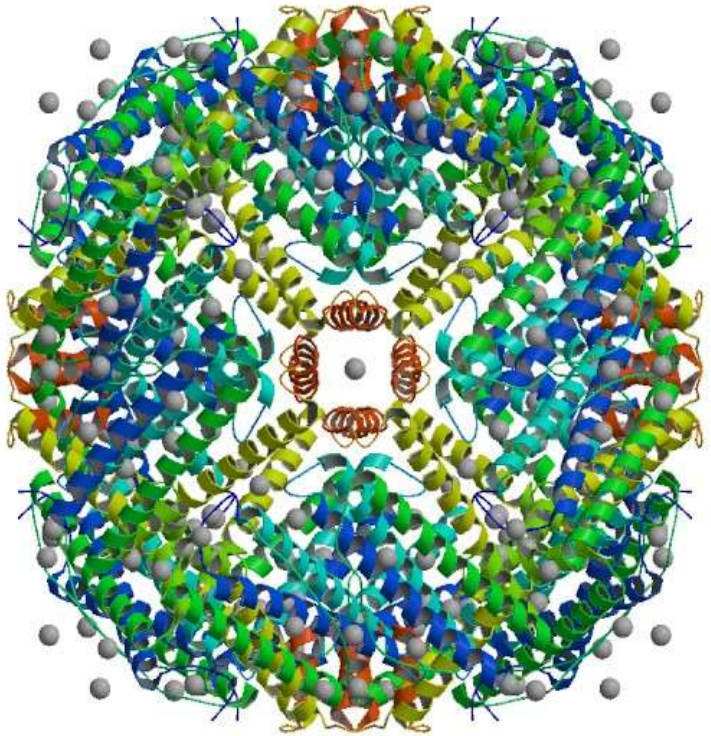
Suppress protein expression



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

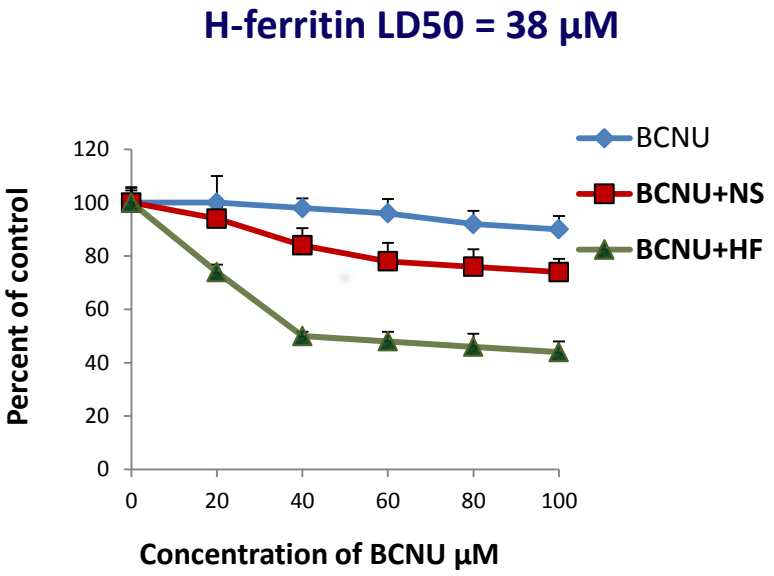
- H-ferritin is present in nucleus of glioma cells
- H-ferritin protected the DNA from iron-induced oxidative damage in tumor cells
- BCNU (chemotherapeutic drug) and radiation has ability to induce DNA damage to cancer cells.
- Decreasing the H-ferritin expression will sensitize the tumors for chemo and radiation therapy



Down Regulating H-ferritin Increased Chemotherapeutic Efficacy in U251 cells: Human Brain Tumor Model

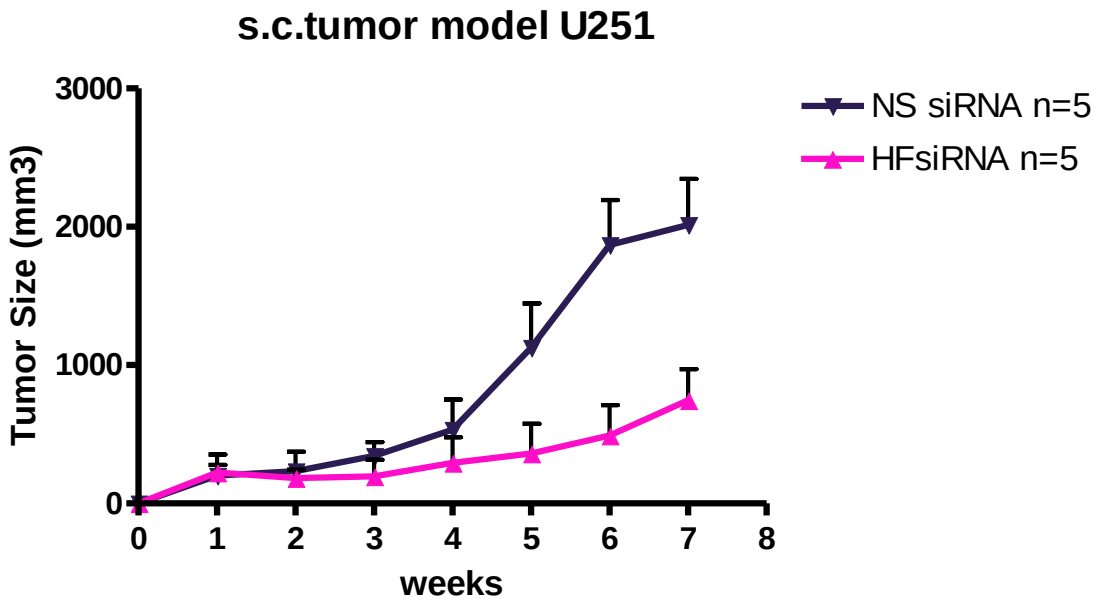
Method:

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 siRNA Increased Chemotherapeutic Efficacy in Vivo

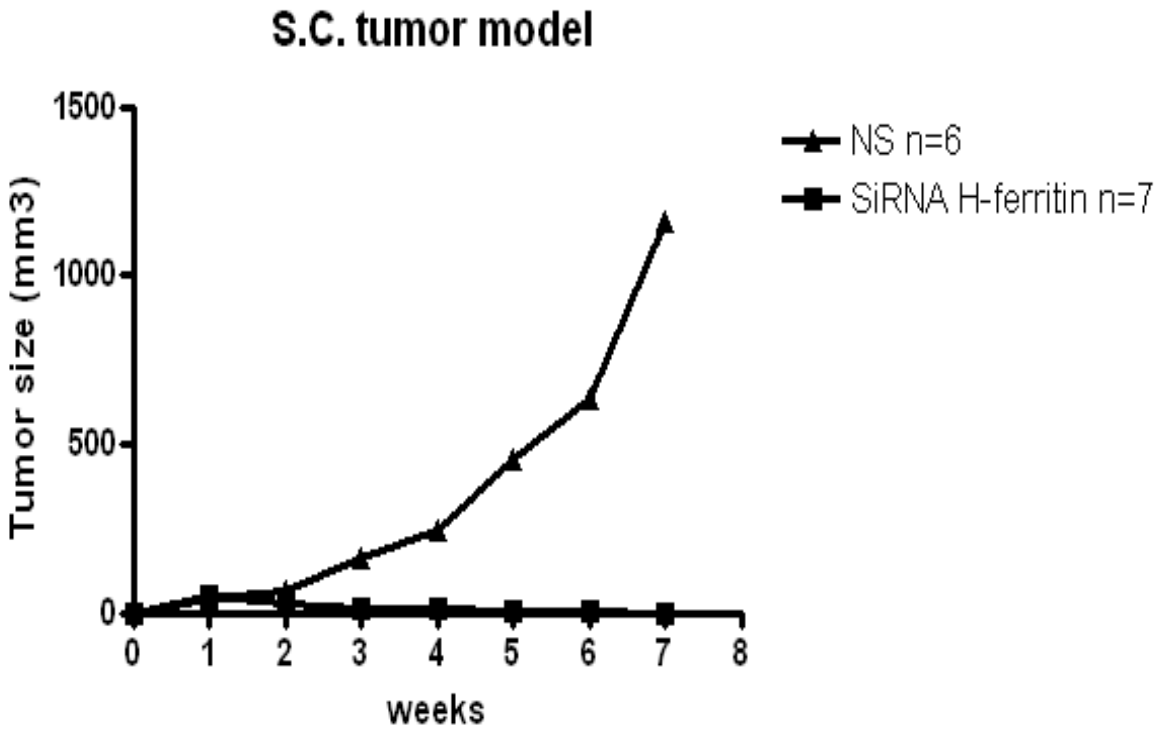


Method:

1. Adult female athymic nude mice were inoculated s.c with 15 x10^6 U251 cells
2. The tumors (1.4 to 3.0 cm^3) 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

H-ferritin siRNA Increased Radiation Efficacy in Vivo



In vivo study

Result: Tumor growth was inhibited by synergistic approach.

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 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

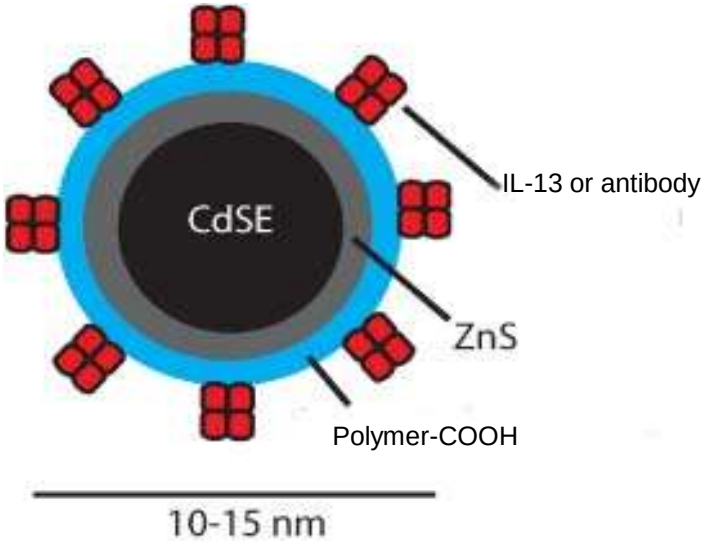
Conclusions for Gene Delivery

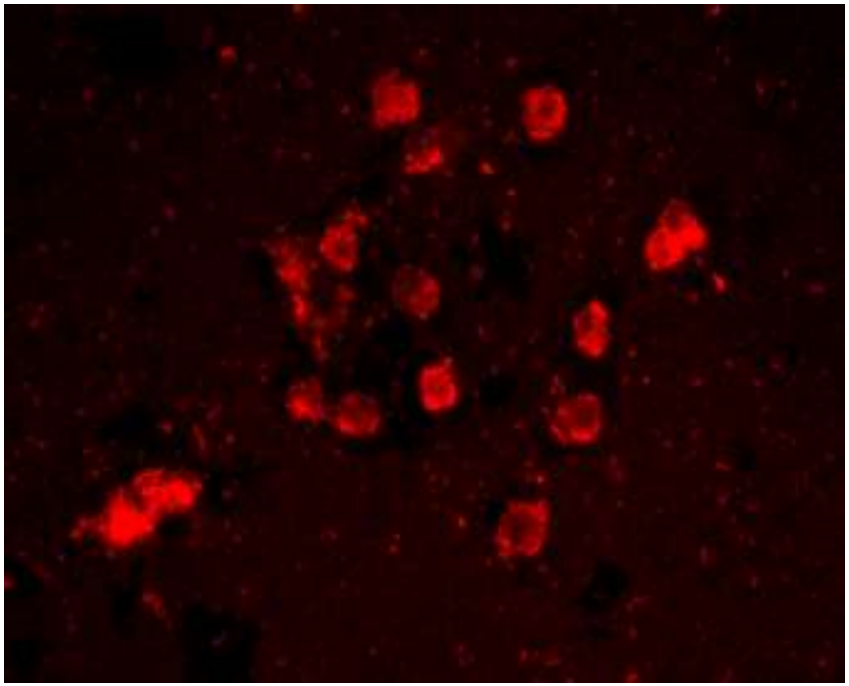
- We can deliver a siRNA in a nanovesicle to tumors
- The siRNA will decrease the expression of ferritin
- Decreased expression of ferritin makes the tumor cells more vulnerable to chemotherapy and radiation



The Future: Targeting Quantum Dots for Detecting Cancer Cells in CSF

In vitro tumor diagnosis

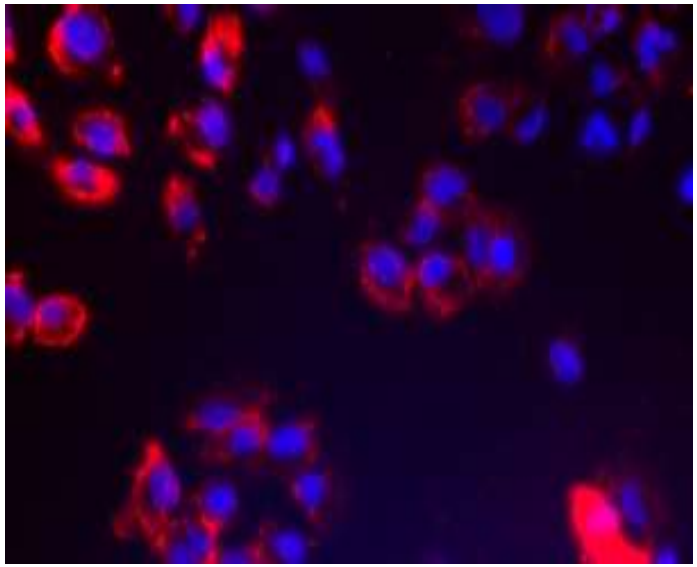




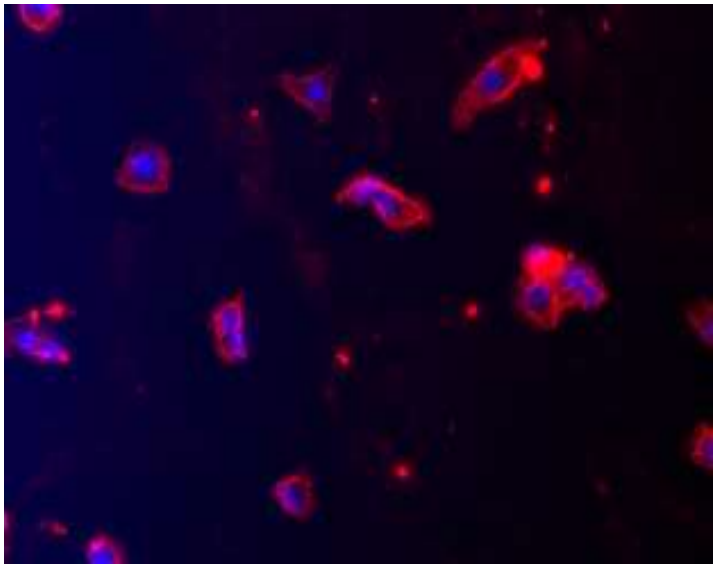
U251 glioma cells after exposure to IL13-QD



Binding of Targeted Quantum Dots to Glioma and Melanoma Cells



(U251 glioma) (IL13 QD)

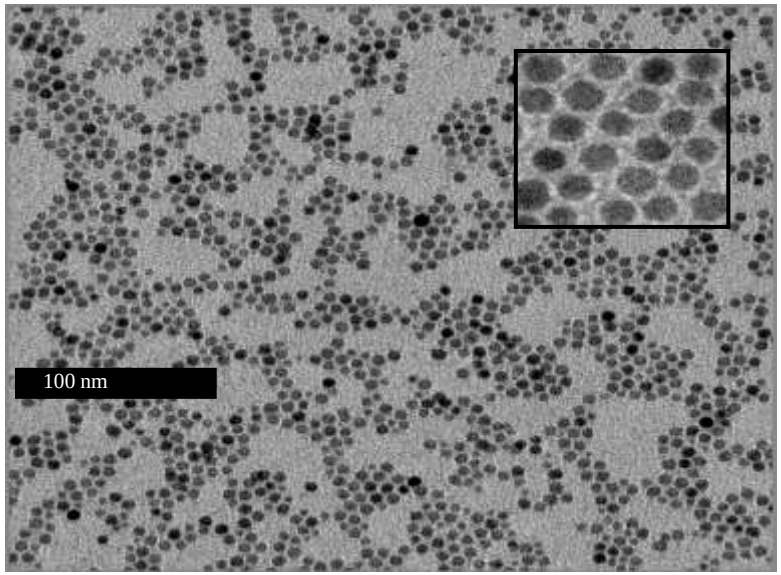


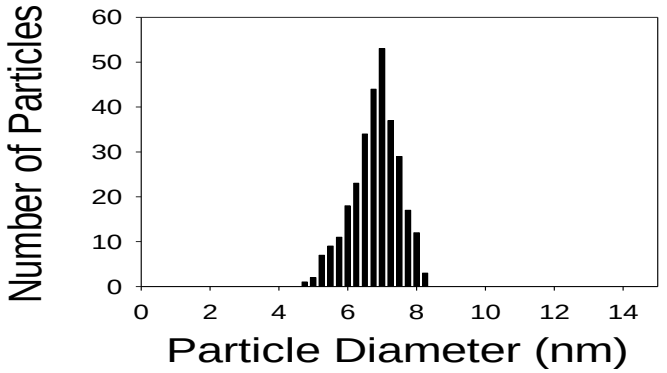
UACC903 Melanoma (9.2.27QD)

Red –quantum dot
Blue-DAPI

Using Our Targeted Delivery System to Deliver Nanoparticles

Iron oxide nanoparticles - MRI contrast enhancing



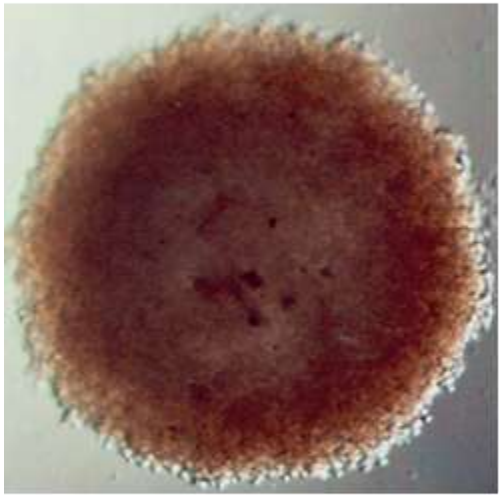


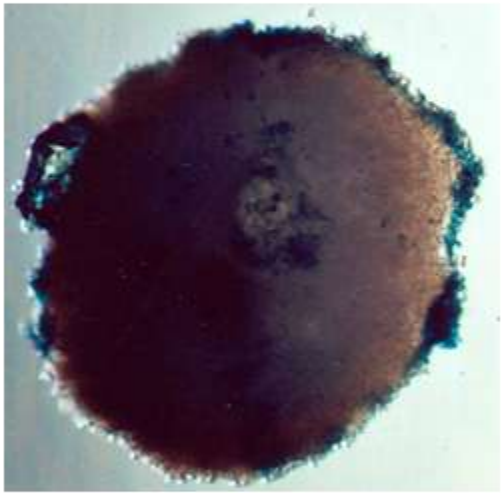
Particle size: 6.7(+/-) 0.7 nm

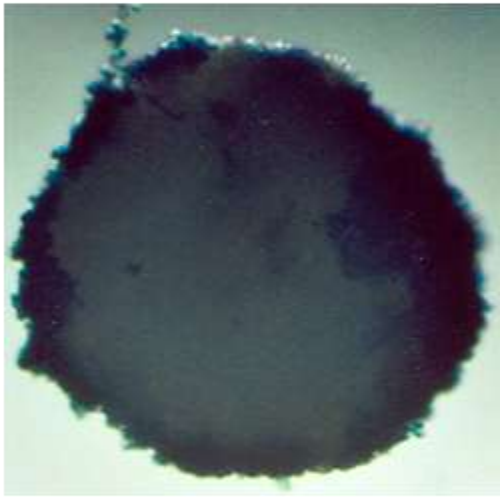
Perl's Staining on Tumor Spheroid

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

(10 ug/mL of Fe_2O_3-IL13 final conc.)







Without Nanoparticles

12 h exposed to nanoparticles

24 h exposed to nanoparticles

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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.

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Thank You!

Connor Laboratory: 2011

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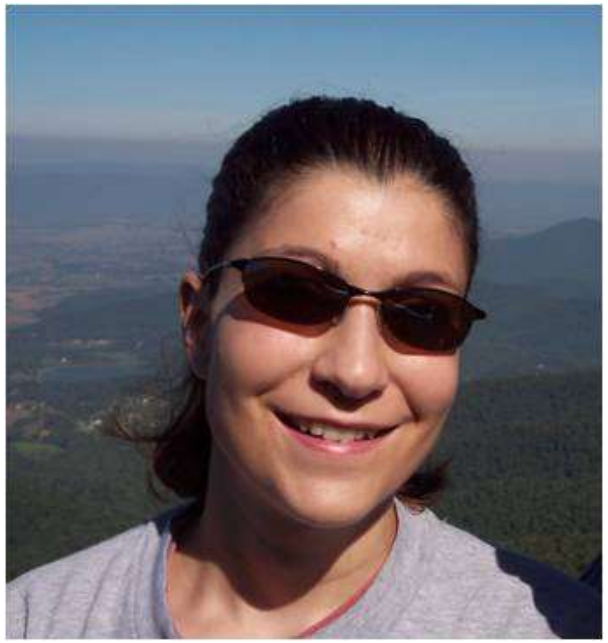
Questions?

Nanotechnology in Medicine: Commercializing Nanomedicine

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



Commercializing Nanomedicine

http://science401.com

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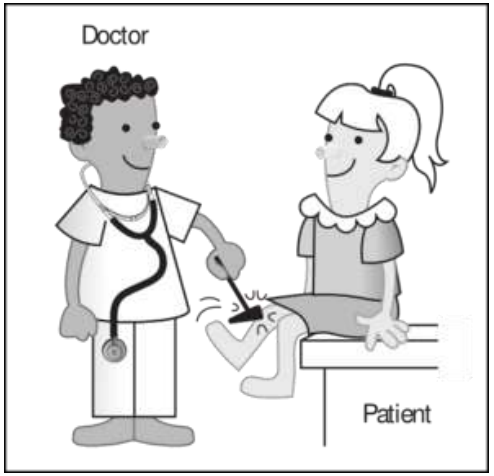

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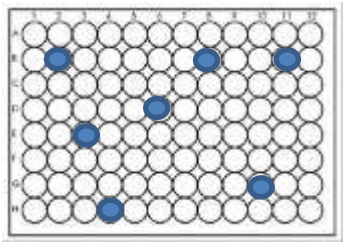
Current Pharmaceutical Development

X_1 X_2 X_3 X_4 X_5 X_6 X_7.....

Medicinal Chemistry
(1000s of derivatives)

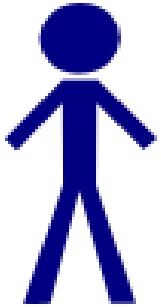


High-throughput Screening
- Solubility
- Efficacy
- Toxicity

Formulation Development
- Solubility
- Stability/Shelf-Life

In Vivo Testing
- Safety
- Efficacy

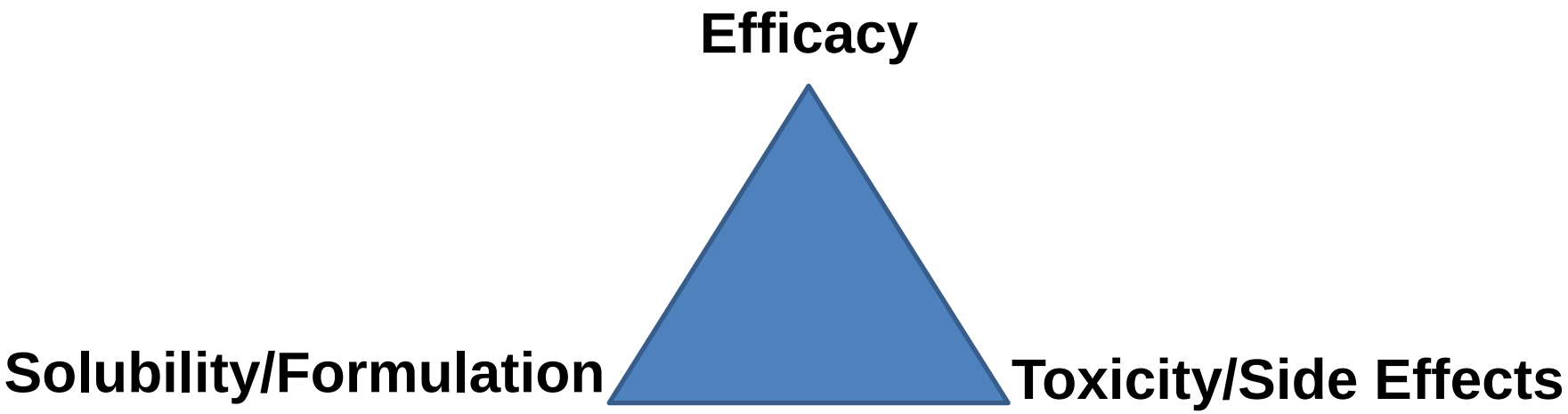
Preclinical Testing
- Efficacy
- Toxicity
- Biodistribution
- Pharmacokinetics



Clinical Trials

All clip art from www.clker.com

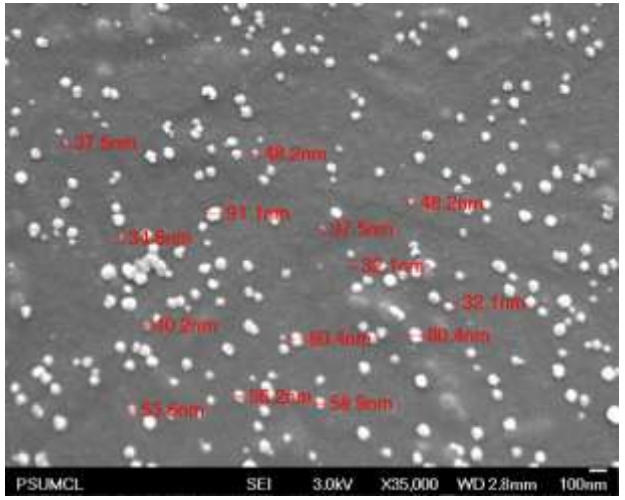
Picking the Right Compound
The Balancing Act





Nanomedicine
Picking the Right Technology

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



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Technical Challenges

Manufacturing & Characterization

Regulatory Testing

$$$$

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?

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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?

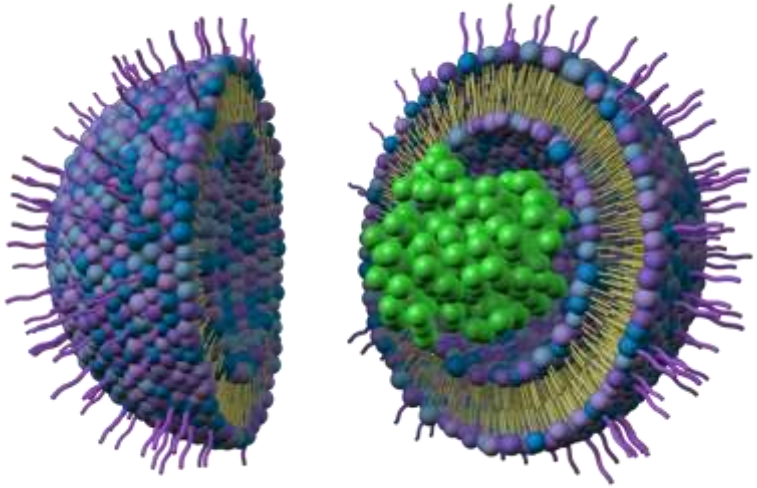
Phase III Clinical Trial

- 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

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



<u>In Clinical Trials</u>
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

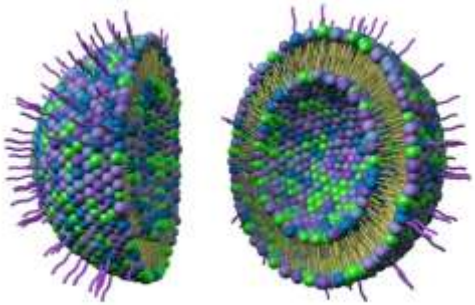
Active Ingredient = Ceramide

Loading = 30 molar%

Reproducibility = +/- 5nm mean

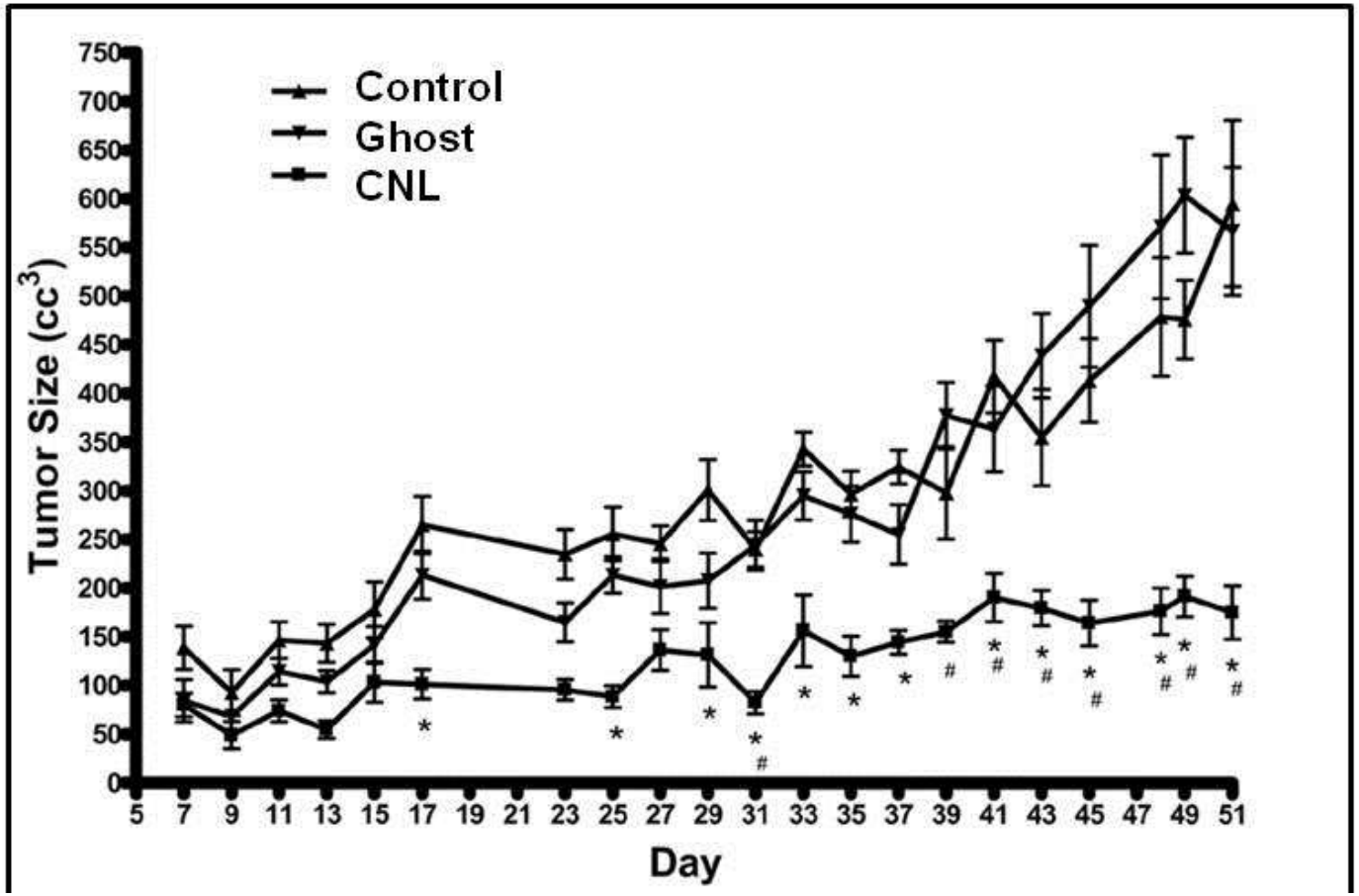
Stability/Dispersion = stable from pH 4-9, 4-60^{o}C, 3+ months

Biodistribution/Clearance = distributes mainly to the lungs and liver, cleared through the hepatobilliary 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.



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