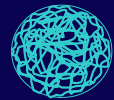


Applications of Nanomedicine

- Principal Applications of Nanomedicine:
 - Drug Discovery and Development
 - Imaging and Biosensing
 - Medical Devices and Equipment
 - Tissue Engineering (Regenerative Medicine)
 - Novel Drug Delivery Systems

Examples of Nanostructures in Nanomedicine

- Nanoparticles/Nanocapsules: Polymeric particles with a therapeutic agent either dispersed in polymer matrix or encapsulated in polymer.



Nanoparticle

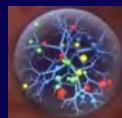
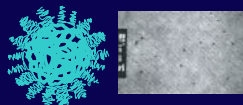


Nanocapsule



Examples of Nanostructures in Nanomedicine

- Nanomicelles: Self assembled block copolymers in aqueous solution arranged to form an outer hydrophilic layer and an inner hydrophobic core.
- Dendrimers: Monodispersed symmetric macromolecules built around small molecule with internal cavity surrounded by large number of reactive groups.



Examples of Nanostructures in Nanomedicine

- Nanotubes/Nanofibers: Nanostructures in tubular/fibrous structure.



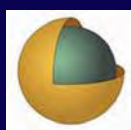
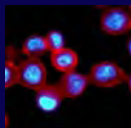
nanotubes



nanofibers

Examples of Nanostructures in Nanomedicine

- **Quantum Dots:** Nanocrystals that fluoresce in different colours depending on size. Core made up of inorganic element coated with organic materials.
- **Nanoshells:** Composed of copolymers used in combination with specific wavelengths of light and heat technology to release drug at selective site.



Examples of Nanostructures in Nanomedicine



1966!



Current!

- **Nanorobots:** Can travel throughout human body using molecular motors and computers, store and transport molecules, perform operations and communicate with physicians!

Applications of Nanomedicine

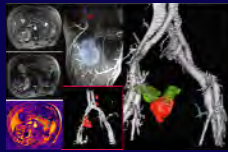
- **Principal Applications of Nanomedicine:**
 - Drug Discovery and Development
 - Imaging and Biosensing
 - Medical Devices and Equipment
 - Tissue Engineering (Regenerative Medicine)
 - Drug Delivery Systems

Drug Discovery and Development

- Faster introduction of new cost-effective drugs to the market through miniaturization, automation, speed and reliability of assays e.g. increasing the hit rate for promising compounds using microarray technologies based on nanotechnology.
- Synthesis of nanosized drugs – increased surface area-enhanced solubility, dissolution and bioavailability-more rapid onset of action.

Imaging and Sensing

- Nanotechnology used to deliver *in vivo* imaging agents for diagnosis, monitoring of disease and therapy and early disease detection.



- Nanotechnology enabled molecular imaging have been made in all imaging modalities e.g. optical, ultrasound, computed tomography and MRI-increased sensitivity.

Imaging and Sensing

- Imaging Biological Processes and Sensing of Biomarkers:
 - Can develop imaging tools to probe living processes at a molecular and cellular level-study how diseases disrupt normal molecular and cellular signals/pathways-achieved non destructively *in vivo* in real time.
 - Can develop nanosensors that will identify specific disease biomarkers, monitor biochemical levels-early detection and prevention of disease.

Medical Instrumentation and Devices

- Continued miniaturisation of devices-augmented sensitivity, spatial localisation, differentiation e.g.
 - Force microscope -differences in cancer and normal cells.
 - Carbon nanotubes better than glass pipettes for cellular delivery.
 - Incorporation of nanodevices into catheters, silver nanoparticles to impart antimicrobial activity.
 - Surgical gloves with ability to detect parameters!!



Tissue Engineering (Regenerative Medicine)

- Development of biological substitutes that restore, maintain, or improve tissue function/whole organ. Artificially stimulating cell proliferation by using suitable nanomaterial based scaffolds.
- Repairing damaged tissues and manufacturing of tissue and organs e.g. liver, pancreas, bone, cartilage etc.

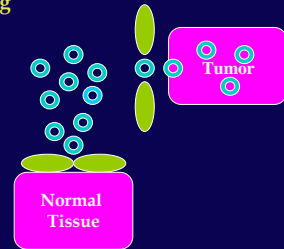


Nanostructures as Novel Drug Delivery Systems

- Rationale for Novel Drug Delivery Systems:
 - Lower cost research as compared to that for the discovery of a new molecule.
 - Enhanced delivery leads to superior performance characteristics of the medicine.
 - Lifespan of blockbuster drugs can be resurrected by reformulation.
 - Provides manufacturer with increased revenue on patent expiration.

Nanostructures as Novel Drug Delivery Systems

- Drug Targeting-Target drug to specific site of action only e.g tumour.



Nanostructures as Novel Drug Delivery Systems

- Gene Delivery - Treatment of disease by replacing/altering/ supplementing defective genes for disease treatment.
- Non-parenteral administration of peptides e.g. insulin - obviates the need for injections by preventing proteolytic degradation.
- Implantable Delivery Systems - prevents repeated injections at site e.g. ocular implants.

Nanostructures as Novel Drug Delivery Systems

- Vaccine Adjuvant - enhances immune response.
- Treatment of various cerebral diseases impeded by poor drug delivery to brain. Nanostructures can cross BBB - can alter the permeability of the BBB and increase endocytic activity.

Disease Conditions: e.g. Cancer, AIDS, Tuberculosis, Genetic disorders, Diabetes, Parkinsons, Alzheimers etc. - Improve therapeutic efficacy, decrease side effects, increase patient compliance!

Safety and Toxicity?



- Despite rapid advances - increasing concerns over possible downsides of nanotechnology for medicine.
- Small size of particles-potentially dangerous to health. (Harmless bulk materials - become more toxic when made into ultrafine particles). Understanding of toxicity and potential health risks associated with nanomaterials extremely limited.

Safety and Toxicity?

- Current Concerns:
 - Inhalation of airborne nanoparticles and impact on lung disease.
 - Oral ingestion / skin penetration-adversely affect patient immune responses and neuronal uptake?
 - Effect of Nanoshape on toxicity.
 - Entry of nanoparticles to non - desired sites.
 - Mechanisms of toxicity - still in infancy. E.g. particles that enter bloodstream may affect the blood vessel lining/function-promote blood clot formation.

Other Limitations and Future Considerations

- Scale up and Bulk Manufacturing issues.
- Preclinical and clinical studies in relevant animal models, disease states, patients to substantiate proof of concept.
- Cost should be in acceptable low range to be affordable.
- Translation from science (lab) to commercialisation complications.
- Compliance of a new technology with complex regulatory specifications for medicine/device registration.

THANK YOU!



Nanomedicine's Promise Is Anything but Tiny
(Washington Post, 2005)

REFERENCES FOR CONTENT AND PICTURES

- Agarwal, S, Wendorff, J, Greiner, A, Polymer, 49(2008), 5603.
- Bawarski, WE, Chidlow, E, Bharali, DJ, Mousa, SA, Nanomedicine: Nanotechnology, Biology and Medicine, 4 (2008) 273-282.
- Bawa, R, Nanomedicine: Nanotechnology, Biology and Medicine, 5 (2009), 5.
- Caruthers, SD, Wickline, SA, Lanza, GM, Current Opinion in Biotechnology, 18(2007), 26.
- Chan, VSW, Regulatory Toxicology and Pharmacology, 46 (2006), 218.
- Freitas, RA, Nanomedicine: Nanotechnology, Biology and Medicine, 1 (2005), 2-9.
- Govender, T, et al., J. Controlled Release, 75(2001), 249.
- Gu, FX et al., Nanotoday, 2(2007), 14.
- Illum, L. and Davis, S, J Pharm Sci., 72(1983), 1086.
- Kagan, VE, et al., Nanomedicine: Nanotechnology, Biology and Medicine, 1 (2005), 313.
- Kawasaki, F and Player, A, Nanomedicine, Nanotechnology, Biology and Medicine, 1 (2005), 101.
- Koo, OM, Rubinstein, I, Onyukel H, Nanomedicine: Nanotechnology, Biology and Medicine, 1 (2005), 193-212.
- Kumil, R, et al., Eur. J. Pharm. Biopharm. 67 (2007), 9.
- Linkov, I, Satterstrom, FK, Corey, LM, Nanomedicine: Nanotechnology, Biology and Medicine, 4 (2008), 167.

REFERENCES FOR CONTENT AND PICTURES

- Shah, IK and Amiji, MM, Pharm. Res. 23 (2006), 2638.
- Sahoo, SK and Labhasetwar, V, DDT, 8(2003), 1112.
- Sahoo, SK, Parveen, S, Panda, JJ, Nanomedicine: Nanotechnology, Biology and Medicine, 3 (2007), 20; Maynard, A, Nanotoday, 1(2006), 22.
- Murday, JS, Siegel, RW, Stein, J, Wright, JF, Nanomedicine: Nanotechnology, Biology and Medicine, 5 (2009), 251.
- Prompruk, K, et al., Int. J. Pharm., 297(2005), 242.
- Vyas, SP, Khar, RK, Targeted and Controlled Drug Delivery: Novel Carrier Systems, CBS Publishers and Distributors, India, 331-386.
- Xu, Z, et al., Int. J. Pharm., 288 (2005), 361.
- <http://www.nanotech-now.com/current-uses.htm>
- http://en.wikipedia.org/wiki/List_of_nanotechnology_applications
- cmir.mgh.harvard.edu, www.sciencedaily.com, www.altenergystocks.com, es.epa.gov

REFERENCES FOR CONTENT AND PICTURES

- <http://www.gksydnev.um.dk/NR/rdonlyres/91AE5D07-2B8E-455B-BE85-BE286E385DC9/0/medicaldeviceI.jpg>
- <http://www.gksydnev.um.dk/NR/rdonlyres/401E6F90-22BE-46C8-8887-66A68947F1BB/0/medicaldeviceIII.jpg>
- <http://www.nextgenmd.org/vol2-5/pictures/davinciI.jpg>
- <http://www.spineuniverse.com/displaygraphic.php/1426/intuitI-BB.jpg>
- http://www.nanotechbuzz.com/8022671/nanoknife_nanosHELLS_kill_cancer_tumors.php
- http://www.nist.gov/msel/ceramics/mechanical_properties/nanoparticle-metrology.cfm
- <http://www.nanopaprika.eu/photo/1612324-Photo:7526?context=latest>
- <http://www.nanotech-now.com/nanotechnology-glossary-V-Z.htm>
- <http://images.google.co.za/imgres?imgurl=http://cmir.mgh.harvard.edu/imgs/cdp/frontpa...>
- <http://www.nanotechnologytoday.blogspot.com/2007/01/health-and-safety-impacts-of.html>
- <http://www.electronics.howstuffworks.com/nanorobot.htm/printable>

REFERENCES FOR CONTENT AND PICTURES

- <http://einiverse.eingang.org/cin2/archives/2004/10/index.html>
- <http://www.nanonet.go.jp/english/mailmag/2006/062a.html>
- <http://www.physorg.com/news6961.html> <http://dsc.discovery.com/technology/tech-10/nanotech-cancer/gene-therapy-324x205.jpg>
- <http://www.ehponline.org/members/2004/112-13/segman.jpg>