Nanotechnology in Cancer Therapy

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Nanomedicine AND Cancer

- *Nanotechnology has the power to radically change the way cancer is diagnosed, imaged and treated.*
- *Unique properties of nanoparticles like structural, optical, and magnetic features enable them a possible candidate in cancer therapy.*

- *Scope of nanomedicine in cancer include:*
    - *Prevention and control: designing multicomponent anticancer vaccines.*
    - *Early detection and proteomics: Developing tools for mass analysis of cancer-associated markers.*
    - *Imaging diagnostics: Designing targeted contrast agents that improve the resolution of cancer to a single cell.*
    - *Multifunctional Therapeutics: Creating therapeutic devices that can control the release of cancerfighting drugs and optimally deliver medications.*

Nano-based Platforms in Cancer Therapy

Type of carrier and mean diameter (nm)	Drug entrapped or linked	Current stage of development	Type of cancer (for clinical trials)
Polymer–drug conjugates (6–15)	Doxorubicin, Paclitaxel, Camptothecin, Platinate, TNP-470	12 products under clinical trials (Phases I–III) and *in vivo*	Various tumours
Liposomes (both PEG and non-PEG coated) (85–100)	Lurtotecan, platinum compounds, Annamycin	Several products in clinical trials (Phases I–III) and *in vivo*	Solid tumours, renal cell carcinoma, mesothelioma, ovarian and acute lymphoblastic leukaemia
Polymeric nanoparticles (50–200)	Doxorubicin, Paclitaxel, platinum-based drugs, Docetaxel	Several products are in clinical trials (Phases I–III) and *in vivo*	Adenocarcinoma of the oesophagus, metastatic breast cancer and acute lymphoblastic leukemia
Polymersomes (~100)	Doxorubicin, Paclitaxel	*In vivo*	
Micelles (lipid based and polymeric) (5–100)	Doxorubicin	Clinical trials (Phase I)	Metastatic or recurrent solid tumours refractory to conventional chemotherapy
	Paclitaxel	Clinical trials (Phase I)	Pancreatic, bile duct, gastric and colonic cancers
	Platinum-based drugs (carboplatin/ cisplatin), Camptothecin, Tamoxifen, Epirubicin	*In vivo* and *in vitro*	
Nanoshells (Gold-silica) (~130)	No drug (for photothermal therapy)	*In vivo*	
Gold nanoparticles (10–40)	No drug (for photothermal ablation)	*In vivo*	
Nanocages (30–40)	No drug	Chemistry, structural analysis and *in vitro*	
Dendrimers (~ 5)	Methotrexate	*In vitro / in vivo*	
Immuno-PEG-liposomes (100)	Doxorubicin	Clinical trials (Phase I)	Metastatic stomach cancer
Immunoliposomes (100–150)	Doxorubicin, platinum-based drugs, Vinblastin, Vincristin, Topotecan, Paclitaxel	*In vivo*	
Immunotoxins, Immunopolymers, and fusion proteins (3–15)	Various drugs, toxins	Clinical trials (Phases I–III)	Various types of cancer

PREMS

Cancer Detection

Conventional Method

- The physical growth/changes in the organ is detected by X-rays and/or CT Scans and confirmed by biopsy through cell culture.
- Limitations: not very sensitive; detection is possible only after substantial growth of the cancerous cells after which treatment may not possible.

Nanotechnology

- Nanoparticles (NP) are of a few of nm and so NPs can enter inside the cells and can access the DNA molecules/ Genes.
- Advantages: there is a possibility that the defects can be detected in the gene level; NPs do show potential of cancer detection in its incipient stage.

Cancer Treatment

Conventional Method

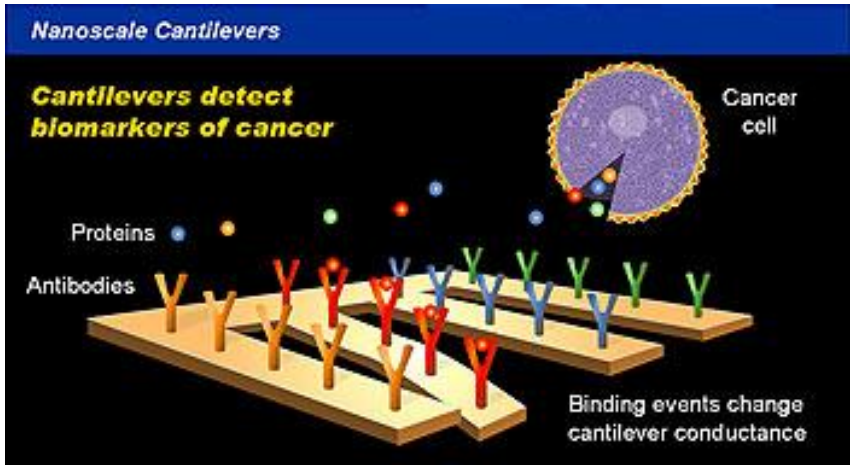
- Surgery
- Radiation therapy
- Chemotherapy
- Limitations:
  - Surgery: reappearance of cancer after removal of organ; surgery is not possible for all types of cases of the cancer.
  - Radiation: risk of healthy cells being burnt; cancerous cells
  - May not burn in uniform ; treated part may become dead and non functional.
  - Chemotherapy: harmful to healthy cells as the approach is gross; rarely successful if the cancer is in advanced stage.

Nanotechnology

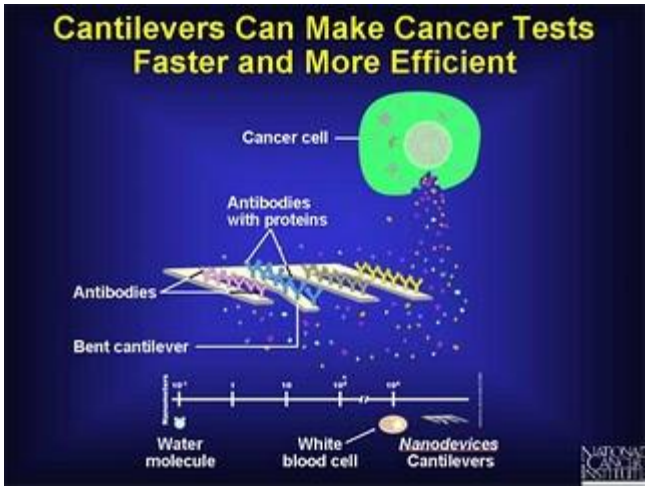
- Thermal approach
- Nanoemulsion
- pH responsive nanoparticles
- Nanoparticles used in combination with radiations
- Advantages:
  - Specificity
  - Targeted drug delivery and cell destroyal
  - Circulation through the body to detect cancer associated molecular changes
  - Assist with imaging release a therapeutic agent
  - Monitoring effectiveness of the intervention.

Nanotechnology Tools for Cancer Diagnosis & Treatment

- *Cantilevers : Tiny bars anchored at one end can be manipulated to bind with molecules associated with cancer.*



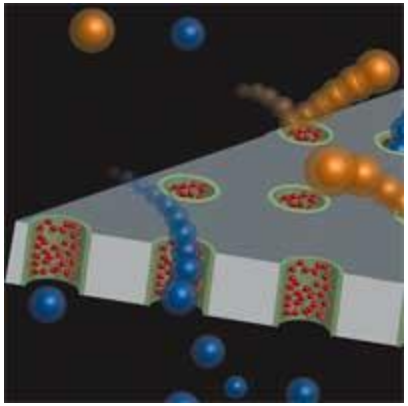
- *This binding to altered DNA or surface markers will change the surface tension and cause the cantilevers to bend.*



- *This allows to tell whether the cancer molecules are present and hence detect early molecular events in carcinogenesis.*

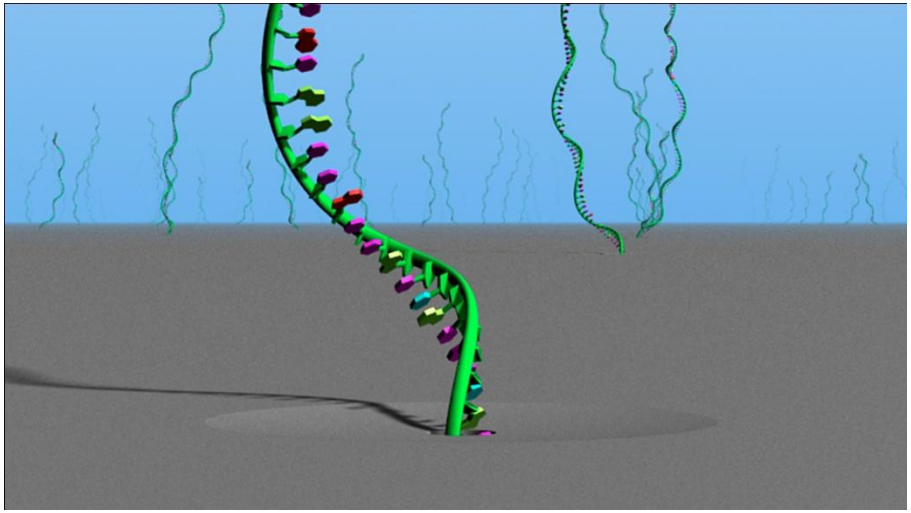
Nanotechnology Tools for Cancer Diagnosis & Treatment

- *__Nanopores :__ Nanopores (holes) are designed to allow one strand of DNA through them making DNA sequencing can be made more efficient. Thus*



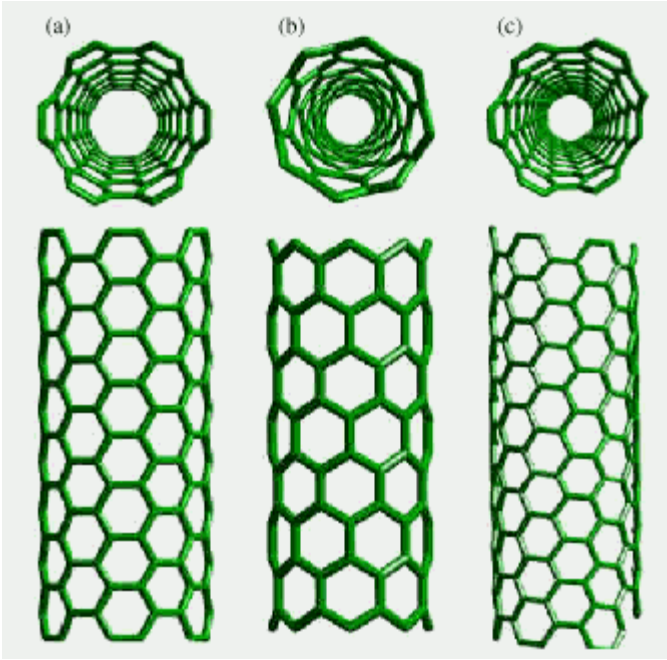
- *The shape and electrical properties of each base on the strand can thus be monitored.*

- *As these properties are unique for each of the four bases, the passage of DNA through a nanopore can be used to detect errors in the code known to be associatedwith cancer.*



Nanotechnology Tools for Cancer Diagnosis & Treatment

- *Nanotubes : are smaller than Nano pores, and about half the diameter of a molecule of DNA, will also help identify DNA changes associated with cancer.*
- *It helps to exactly pin point location of the changes and is important in predicting disease.*
- *Mutated regions associated with cancer are first tagged with bulky molecules and using a nano tube tip the shape of DNA can be traced. The bulky molecules identify the regions on the map where mutations are present.*



Nanotechnology Tools for Cancer Diagnosis & Treatment

- **Quantum Dotes (QD):** These are tiny crystals that glow when irradiated with ultraviolet light.
- The latex beads filled with these crystals when stimulated by light, emit colors that act as dyes and light up the sequence of interest.
- By combining different sized quantum dotes within a single bead, probes can be created that release a distinct spectrum of various colors and intensities of lights, serving as sort of spectral bar code.

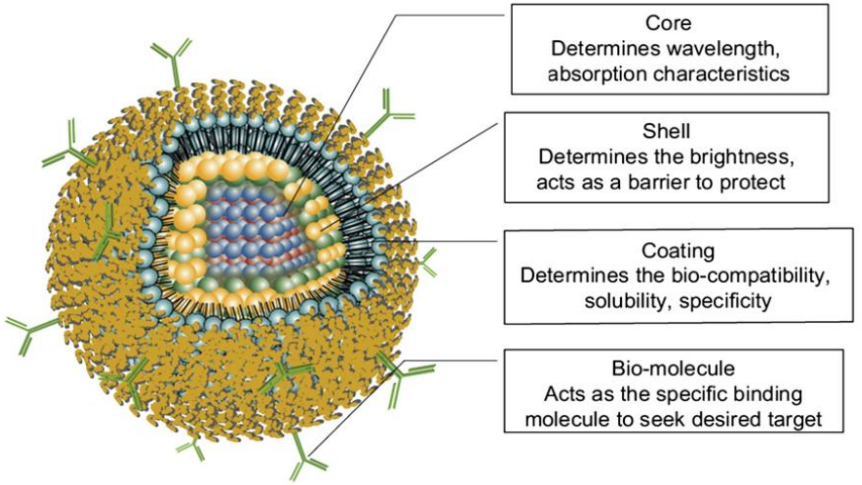
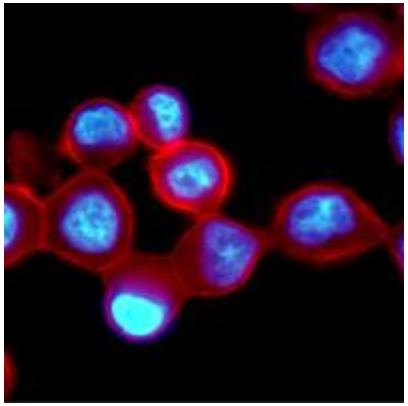
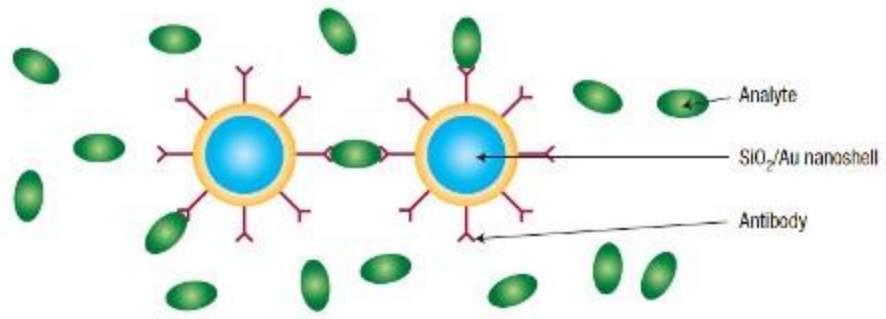


Fig. 3. Structure and applications of Q-dots. (*Courtesy of* Evident Technologies, Inc., Troy, NY; with permission.)



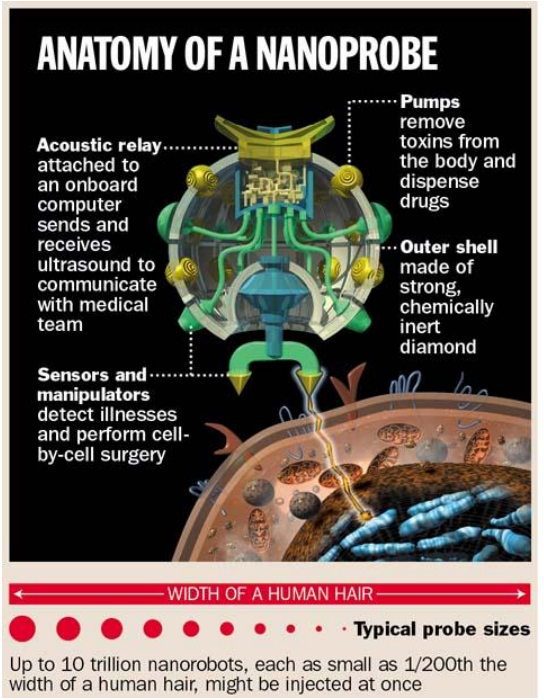
Nanotechnology Tools for Cancer Diagnosis & Treatment

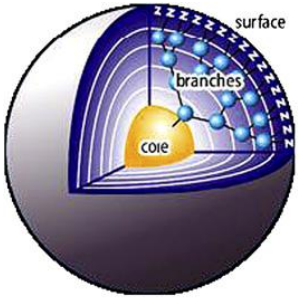
- *Nanoshells (NS):* These are miniscule beads coated with gold.
- By manipulating the thickness of the layers making up the NS, the beads can be designed that absorb specific wavelength of light.
- The most useful nanoshells are those that absorb near infrared light that can easily penetrate centimeters in human tissues.
- Absorption of light by nanoshells creates an intense heat that is lethal to cells.
- Nanoshells can be linked to antibodies that recognize cancer cells.

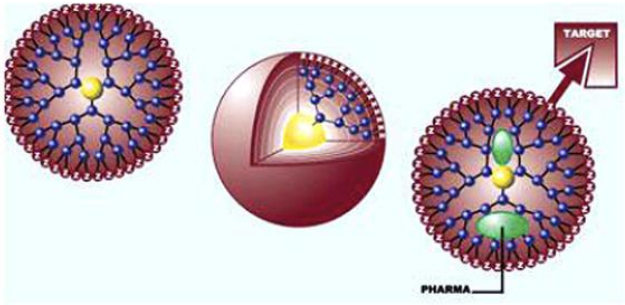


Nanotechnology Tools for Cancer Diagnosis & Treatment

- *__Dendrimer :__ A molecule that has potential to link treatment with detection and diagnosis.*
- *These have branching shape which gives them vast amounts of surface area to which therapeutic agents or other biologically active molecules can be attached.*
- *A single dendrimer can carry a marker, a therapeutic agent to kill cancer cells and a molecule that recognizes the signals of cell death.*
- *Following drug releases, the dendrimers may also report back whether they are successfully killing their targets.*







THANK YOU