BME 695 Engineering Nanomedical Systems
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Lecture 3: Theranostics and Molecular Imaging

3.1 Nanomedical systems – levels of challenges
- 3.1.1 Diagnosis - difficult
- 3.1.2 Therapy – more difficult
- 3.1.3 Both ("Theragnosis") – most difficult!

3.2 How theragnostics relates to Molecular Imaging
- 3.2.1 conventional imaging is not very specific
- 3.2.2 types of In-vivo Imaging
  - 3.2.2.1 X-rays, CAT (Computed Axial Tomography) scans
  - 3.2.2.2 MRI (magnetic Resonance Imaging)
  - 3.2.2.3 PET (Positron Emission Tomography) scans
- 3.2.3 "molecular imaging" of nanoparticles in-vivo for diagnostics/monitoring of therapeutics

3.3 Engineering nanomedical systems for simultaneous molecular imaging
- 3.3.1 using nanomedical cores for MRI contrast agents
- 3.3.2 difficulties in using PET probes for nanomedical devices
- 3.3.3 using cell-specific probes for molecular imaging of nanomedical devices
- 3.3.4 breaking the "diffraction limit" – new nano-level imaging modalities

3.4 Theragnostic nanomedical devices
- 3.4.1 using nanomedical devices to guide separate therapeutic device
- 3.4.2 when might we want to combine diagnostics and therapeutics?

3.5 Requirements for specific cell targeting
- 3.5.1 must be cell surface biomarker that at least partially identifies that cell
- 3.5.2 OR a Boolean set of several biomarkers whose composite "signature" identifies a cell
- 3.5.3 OR a set of biomarkers that excludes all other cells
- 3.5.4 challenge – how to "multiplex" a Boolean set of targeting molecules

3.6 Consequences of mis-targeting
- 3.6.1 “side effects” to innocent bystander (normal) cells
- 3.6.2 these side effects may be lethal to bystander cells, or they may change the overall state of the patient so that the treatment problem is no longer the same
- 3.6.3 Side effects may be unpredictable and may lead to dangerous non-linear patient responses what are difficult to correct and potentially dangerous or even life threatening

3.7 Engineering around the consequences of mis-targeting
- 3.7.1 measure number of good (normal) cells destroyed to eliminate a diseased cell
- 3.7.2 put a weighting factor on the relative "goodness" or "badness" of normal cells and diseased cells
- 3.7.3 example: How many stem cells are you willing to lose to purge tumor cells during a bone marrow transplantation?

3.8 Some ways to lower mis-targeting to non-diseased cells
- 3.8.1 lower numbers of nanoparticles
- 3.8.2 improve specificity of targeting molecules according to what is learned about the identity of the mis-targeted cells
- 3.8.3 if possible, require an AND condition requiring simultaneous presence of two target molecules on the same cells being targeted
- 3.8.4 if necessary, design a non-specific targeting control switch on a secondary non-specific target molecule which inactivates subsequent nanomedical device action (off control switch upon detecting an error in targeting).

Lecture 3 References

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