**Proposed New Nanomedicine Graduate Course**

**Title:** Foundations of Nanomedicine

**Instructors:**
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**Summary:** Nanomedicine is the application of nanostructured materials in medicine. Nanomedicine approaches are now being widely explored as diagnostic tools and novel therapeutics. Lectures and discussions will cover the synthesis and characterization of multifunctional nanoparticles, nanomaterial applications in imaging (optical and magnetic resonance imaging, computed tomography) and use of nanomaterials as a basis for novel therapeutics (drug delivery, genetic therapies and tissue engineering). The course will be directed towards students gaining a better understanding of the underlying concepts that control nanoparticle properties and interactions in vivo.

**Prerequisites:** Completion of first year core curriculum

**Structure:** Course will meet two times per week. The first meeting is a 2-hour powerpoint-based lecture format (with 15-min break) with instructors according to areas of expertise. The second meeting will be a 1-hour journal club format to critically review current research and allow oral presentations by students. These presentations will be made in a bi-weekly format. Weeks when journal clubs do not take place will be used for quizzes or other small group discussions as needed.

**Syllabus:** (1-2 hours of lecture per topic)
*Week Topic. Details – Instructor. Duration.*

1A) What is nanomedicine? Definition of nanoparticles, general introduction to the areas in which nanoparticles are used in medicine, types of nanoparticles, examples of FDA-approved nanoparticles. – Willem/David/Kevin. 1 hour.

1B) Targeting principles. EPR effect, vascular targeting, extravascular targeting. Targets and ligands. Conjugation. Pharmacokinetics. The Reticuloendothelial System (RES). – David. 1 hour.

2) Synthesis of self assembled materials. Principles of self-assembly. Synthesis of liposomes, micelles, polymersomes, emulsions, etc. Thin-film hydration, sonication, microfluidizers, extrusion, etc. – Willem. 2 hours.

3) Synthesis of inorganic nanoparticles. The chemical structure of nanoparticles. Influence of nanoparticle shape and size on biophysical properties. Synthetic routes to controlling the shape and size of gold nanoparticles, iron oxides and quantum dots. Routes to introduce different coatings. – David. 2 hours

4A) Techniques for characterizing nanoparticles. Transmission electron microscopy (TEM), scanning electron microscopy (SEM) and atomic force microscopy (AFM), etc. – Kevin. 1 hour.

4B) Optical imaging techniques. Quantum dots. Other fluorescent nanoparticles, including gold nanorods. QD vs small molecules. FRET. CLSM, NIRF. – Kevin. 1 hour.

5A) Computed tomography (CT). Use of nanoparticles in CT. Sensitivity of nanoparticles in CT. Gold and iodine nanoparticles.– David. 1 hour.

5B) Magnetic resonance imaging (MRI). Principles of MRI. Contrast generation in MRI. Nanoparticle contrast agents in MRI. Liposomes, micelles, emulsions, etc. Use of nanoparticles in cell tracking by MRI. 19F MRI and perfluorocarbons. – Willem. 1 hour.

6) Tissue engineering. Principles of tissue engineering, materials/scaffolds development, human cell sources, bioreactors, applications for in vitro screening and disease models – Kevin. 2 hours

7A) Drug delivery. Nanoparticle-based drug delivery systems. Principles involved in the design of nanoparticles for drug delivery. Difference between nanoparticle-based and traditional small molecule/biologic–based therapeutics. Examples of drug delivery nanoparticles. –Willem. 1 hour.

7B) Nucleotide delivery. Principles and concepts of gene transfer technology. Disease applications. Role of nanoparticles. Nanoparticles vs. viruses. Use of siRNA, dsDNA, morpholinos, microRNAs etc, as therapeutic modalities. Nanoparticle vectors. Preliminary results from studies in humans and non-human primates. – David. 1 hour.

8A) Oncological applications of nanoparticles. Specific examples of cancer applications. – Willem. 1 hour.

8B) Nanoparticle-based applications for cardiovascular disease (CVD). Specific examples of CVD applications. – David. 1 hour.

9) Development of nanomedicines by pharmaceutical and biotechnology companies. Invited Speakers. 2 hours.

10) Student project presentations.

**Assessment**: Student progress will be monitored via in-class quizzes, an end of course design paper, and a journal club presentation. Quizzes (1hr each) will be set after topics 1-3 (targeting and synthesis), 4-6 (characterization and imaging), and 7-9 (therapies). Each quiz will constitute 10% of the final grade.

For the end of course design paper, students will choose from topics approved by the instructors, focusing on imaging or therapeutic applications. The student will design a nanomedicine solution, explain their choice and approach, and outline the experiments they would use to test the effectiveness of their design. 50% of the final grade.

For the journal club presentation, the students will present on a paper from a selection chosen by the course instructors. The student is expected to briefly summarize the paper and offer a critique of the results, identifying both strong and weak aspects of the study. The student should suggest extensions to the work. 20% of final grade.

The paper and oral presentation are included as part of the assessment, as writing and presenting are considered vital skills for scientists, and they should be developed in this course.