Course Syllabus:

Nanobioengineering & Nanobiotechnology

BBE 4743/5743 – Spring 2016

Type: Lectures
Number of credits: 3
Semester: Spring**, Time and location:** TBD

Instructors:

Prof. Abdennour ABBAS
Office: 220 Kaufert Lab
E-mail: aabbas@umn.edu
Phone : 612-624-4292
Office hours: Friday, 9-11 am

Prof. Ping Wang
Office: 208 Kaufert Lab
E-mail: ping@umn.edu
Phone : 612-624-4792
Office hours: Friday, 1-3 pm

Course description:

This course will educate on the interdisciplinary areas of bionanotechnology/nanobiotechnology and nanobioengineering, including engineering principles and inherent technological applications. The course focuses on three different perspectives in the field:

- How does nature refine structure and functionality at the nanoscale;
- How are nanoengineering and nanotechnology used to understand, monitor and control biological and environmental processes and phenomena;
- How can biological sciences inspire new engineering and nanotechnological concepts.

Following a general introduction to the nanoworld and a description of the different properties emerging at the nanoscale and related visualization methods, we will discuss bionanomaterials and biological nanomachines. Subsequent chapters will address synthesis methods, properties and applications of engineered nanomaterials. We will also address the engineering aspects (micro-and nanofabrication, self-assembly, micro- and nanofluidics) of biosensors, lab-on-chips and biological/medical microdevices. The presentation of new emerging directions and applications of bionanotechnology will conclude this course. The knowledge gained in this course will enable the students to think and use nanotechnology as a new approach to address physical, chemical, biological, and environmental phenomena, but also as a powerful tool to develop new products for different industries (food, agriculture, health, cosmetics).

Course objectives:

- Learn the wide range of applications of nanotechnology and its interdisciplinary aspect.
- Learn the principles governing the effect of size on material properties at the nanoscale, and perform quantitative analysis.
- Familiarize the students with native bionanomachinery in living cells, how cells use these "soft machines" for generating energy, motion, synthesizing biomolecules, and how these principles can be applied to design new biomolecules and bionanodevices.
- Gain a working knowledge in nanotechnology techniques (synthesis, fabrication, characterization) and acquire the ability to use them to solve problems in bioengineering, biomedicine and agricultural/environmental issues.
- Correlate the impact of nanotechnology and nanoscience in a global, economic, environmental, and societal context.
- Identify career paths at the interface of nanotechnology, biology, environmental and agricultural engineering and medicine.

Prerequisites:

Calcul I (Math 1371), and at least one of the following courses: Phys 1301, Biol 1009, and Chem 1061, or equivalent or obtain Instructor consent.

Audience:

This course is designed for undergraduate students in CFANS, CSE, and CBS, who are interested in working on the applications of nanotechnology to biological, medical, environmental or agricultural/food applications. The course will be particularly of interest to students in the following departments:

- ✓ Bioproducts and Biosystems Engineering
- ✓ Biomedical Engineering
- ✓ Chemical Engineering and Materials Science
- ✓ Electrical and Computer Science and Engineering
- ✓ Mechanical Engineering
- ✓ Biochemistry
- ✓ Chemistry
- ✓ The Biotechnology Institute

Course Topics:

Date	Lecture Topics	Instructor	Textbook
Wk 1	Course overview, The world of small dimensions	A.A	-
	Nanoscale Properties (Electrical, Optical, Chemical)	A.A	[1] (page 24)
Wk 2	Nanoscale visualization techniques 1: Electron microscopy (TEM, SEM, Cryo-SEM)	A.A	[2]
	Nanoscale visualization techniques 2: Scanning probe microscopy (AFM, STM), Diffraction techniques (XRD, synchrotron)	A.A	[3]
	Field trip: Nanoscale Center and BioNano Lab		
Wk 3	Bionanomaterials 1: Biological building blocks	P.W	[4], [5]
	Bionanomaterials 2: Bionanostructures (nanofibers, nanotubes, nanocellulose) **+ Class Nano Sample Demonstration**	P.W	[6](page 977)
Wk 4	Biological nanomachines 1: Ribosomes, Photosynthesis systems,	P.W	[4](p135-166), [5]
	Biological nanomachines 2: Bionanomotors	P.W	[4](p167-225), [5]
	Test #1		
Wk 5	Engineered Nanomaterials 1: Carbon nanomaterials (fullerenes, graphene, nanotubes, nanofibers)	A.A	[6](page 37)
	Engineered Nanomaterials 2: Metal nanoparticles (synthesis, properties and applications) **+ Class Demonstration**	A.A	[6](page 301)
Wk 6	Engineered Nanomaterials 3: Magnetic nanoparticles (synthesis, properties and applications) **+ Class Demonstration**	A.A	[6](page 473), [7]
Wk 7	Engineered Nanomaterials 4: Quanatum dots, liquid crystals, **+ Class demonstration**	A.A	[8]
	Engineered Nanomaterials 5: Nanoporous materials (metalic, zeolite, MOFs)	A.A	[6](page 777)
	Test #2		
Wk 8	Microfabrication methods (photolithography, soft lithography, replication)	A.A	[1] (page 32)
	Nanofabrication methods (Top-Down approaches)	A.A	-
Wk 9	Nanotechnology by self-assembly 1 (Bottom-Up approach): Principles, thermodynamics, interactions, properties	P.W	[6]
	Nanotechnology by self-assembly 2: Supramolecular self-assembly	P.W	[6](page 905)
Wk 10	Nanotechnology by self-assembly 3: Protein nanotechnology	P.W	[4](p261-294), [9]
	Nanotechnology by self-assembly 4: DNA nanotechnology	P.W	[4](p261-294)
	Test #3		

Wk 11	Microfluidics: surface tension, capillarity, Reynolds number, diffusion, viscosity	A.A	[10], [10b],
	Nanofluidics: nanopores and nanocapillaries, Debye length,	A.A	[11], [12],
Wk 12	Diffusion in solid phase and drug delivery	P.W	-
Wk 13	Biological and medical microdevices: lab on chips**,** organ-on-chips	P.W	-
	Biosensors (fabrication, functionalization, applications)	A.A	-
Wk 14	Nanotechnology safety and the environment	A. A	-
	Impact of nanotechnology on society and industry	A.A	-
Wk 15	**Test #4**		

Text and References (all references are available online at the U library)

1. Brydson, R. M.; Hammond, C., Generic Methodologies for Nanotechnology: Classification and Fabrication. In *Nanoscale Science and Technology*, John Wiley & Sons, Ltd: 2005; pp 1-55.
2. Brydson, R. M.; Hammond, C., Generic Methodologies for Nanotechnology: Characterization. In *Nanoscale Science and Technology*, John Wiley & Sons, Ltd: 2005; pp 56-129.
3. Leggett, G. J.; Jones, R. A. L., Bionanotechnology. In *Nanoscale Science and Technology*, John Wiley & Sons, Ltd: 2005; pp 419-445.
4. Bucke, C., Bionanotechnology—lessons from nature. By David S Godsell. Wiley-Liss, Hoboken, NJ, 2004. 352 pp, ISBN 0 471 41719 X. *Journal of Chemical Technology & Biotechnology* **2005,** *80* (8), 964-965.
5. Goodsell, D. S., In *Bionanotechnology*, John Wiley & Sons, Inc.: 2004; pp i-xii.
6. Dong, H.; Hu, W., Organic Nanomaterials. In *Springer Handbook of Nanomaterials*, Vajtai, R., Ed. Springer Berlin Heidelberg: 2013; pp 905-940.
7. Gibbs, M. R. J., Nanomagnetic Materials and Devices. In *Nanoscale Science and Technology*, John Wiley & Sons, Ltd: 2005; pp 203-236.
8. Mowbray, D., Inorganic Semiconductor Nanostructures. In *Nanoscale Science and Technology*, John Wiley & Sons, Ltd: 2005; pp 130-202.
9. Gerrard, J. A., *Protein Nanotechnology : Protocols, Instrumentation, and Applications, Second Edition*. Humana Press: Totowa, NJ, 2013.
10. (a) Lii, J.; Hsu, W.-J.; Lee, S. P.; Sia, S. K., Microfluidics. In *Kirk-Othmer Encyclopedia of Chemical Technology*, John Wiley & Sons, Inc.: 2000; (b) Renaud, L., Microfluidics: Manipulation of Nanovolume Samples. In *Chemical Sensors and Biosensors*, John Wiley & Sons, Inc.: 2012; pp 293-311.
11. Vlassiouk, I.; Smirnov, S., Biosensing with Nanopores. In *Biosensing Using Nanomaterials*, John Wiley & Sons, Inc.: 2009; pp 457-490.
12. Marie, R.; Kristensen, A., Nanofluidic devices towards single DNA molecule sequence mapping. *Journal of Biophotonics* **2012,** *5* (8-9), 673-686.

Grading:

Tests	20 points (x4)
Homework	15 points
Attendance and participation	5 points

Total for Undergraduate **100 points**

Grades will be assigned based on the total percentage for the course:

		B+	87-89%	C+	77-79%	D+	67-69%
A	93-99%	B	87-89%	C	73-76%	D	60-66%
A-	90-92%	B-	80-82%	C-	70-72%		

Extra Credit Parameters:

Any earned extra credit points will be added to your total points at the end of the term only if you have completed all of the course requirements satisfactorily.

Additional class guidelines

Attendance: Timely attendance in this course is expected. Advance notice for any non-emergency absence to the instructor is required.

Keep it Honest: Please note that all of your work is subject to the University of Minnesota ***Conduct Code*** *(http://www.oscai.umn.edu/conduct/student/procedure.html)**.*** Any violation of this code (cheating, plagiarism and other academic offences) will result in disciplinary measures from the College.

Disabilities

Students with documented disabilities, who are taking this course and wish to discuss academic accommodations, please contact me as soon as possible. Student life services at the University of Minnesota are available to assist students in arranging these accommodations.

Final Review Week:

A period of 1-2 class days prior to the first day of final examinations will be, in part, dedicated to reviewing the program and allow student to prepare for examinations. There will be no assigned homework in this period.

Examinations and Make-up Policy:

There will be four exams during semester. All exams are open book and open notes. All Students are expected to take the exams on the dates announced by the instructor. If a student is unable to appear for a mid-term or presentation or meet an assignment deadline, he is expected to give the instructor an advance notice by e-mail. A make-up test for the mid-term may be offered in case of documented emergency or if the instructor is notified in advance and provided with a reasonable written justification of absence.

Assessment

We seek informal feedback from the students at all times. Additionally, a feedback form will be distributed after mid-terms.