NANOTECHNOLOGY IN FOOD, AGRICULTURE AND ENVIRONMENT (AGG6503)

3 Credits- Every Spring

INSTRUCTOR: Dr. Zhenli L. He, Professor
University of Florida, IFAS, Indian River Research and Education Center,
2199 South Rock Road, Fort Pierce, FL34945
Tel 772-577-7353 Fax 772-468-4071
E-mail: *zhe@ufl.edu*

CATALOG DESCRIPTION:
Application of nanotechnology in crop production, food processing and preservation, and environmental remediation; behavior of engineered nanoparticles in plant, soil and the environment, and environmental toxicology and regulations of engineered nanoparticles.

PRE-REQUISITES/CO-REQUISITES:
Basic knowledge in soil sciences, soil and water chemistry, or environmental sciences.

COURSE OBJECTIVES:
This course will cover the fundamentals of nanoscience and nanotechnology, application of nanotechnology in crop production, food processing and preservation, and environmental remediation; behavior of engineered nanoparticles in plant, soil and the environment, and environmental toxicology and regulations of engineered nanoparticles.

- Understand basic concepts, principles, and components of nanotechnology. At the end of the course all students will be able to describe basic theory of nanoscience and nanotechnology.
- Develop skills in the creation and characterization of nanomaterials. At the end of the course all students will be familiar with methods for characterizing important properties of nanomaterials commonly used in agriculture and the environment.
- Gain expertise in application of nanotechnology in agriculture, food, and environment. At the end of the course all students will be able to apply nanotechnology to solve some problems in the fields of food, agriculture, and environment.
- Learn toxicology of engineered nanoparticles (EPs) and current methods of assessment. At the end of the course all students will be able to understand potential impact of EPs and conduct simple environmental risk assessment.

DELIVERY METHOD: Online-Canvas E-Learning System and audio/video lectures (with powerpoint presentations and reading materials)

OFFICE HOURS*:* Open for e-mail and phone call at any time or chat room by appointment.

FREQUENCY: Spring semester, every year

TARGET STUDENTS: Graduate students who wish to expand their knowledge in emerging sciences and become a specialist in food, agriculture, and environment.

CLASS ATTENDANCE: **Attendance of chat sessions is mandatory.** There is 5% grade for chat room participation.

CHAT ROOM SESSION: Chat room session is scheduled 5-7 PM every Thursday except for public holidays.

GRADING:

Homework/Quizzes:	30%
Chat room attendance	5%
Mid-term Examination:	20%
Review or research Paper / presentation	20%
Final Examination	25%
Total	100%

There will be no make-up homework and exams. Late submission of assignments will result in reduced credit (10% per assignment) if it is not agreed upon in advance.

A	94 – 100%
A-	90 – 93%
B+	87 – 89%
B	83 – 86%
B-	80 – 82%
C+	77 – 79%
C	73 – 76%
C-	70 – 72%
D+	67 – 69%
D	63 – 66%
D-	60 – 62%
E	< 60%

ASSIGNMENTS/ EXAMS/PROJECTS: Nanotechnology is one of the rapid development frontiers with application in many fields including food, agriculture /LECTURES and environment. This course involves new concepts, principles, application, and measurements. It is important that the students have a good understanding of the concepts and principles. Therefore, in addition to lectures, the students will be also provided with supplementary course materials to read and homework to do at the end of each chapter. The students are required to submit homework report timely in order to obtain scores. The mid-term examination is designed to check the study progresses of each student so that some adjustment can be made based on student's performance. In this course, each student is required to conduct an independent nanotechnology project. For this project, students will select one of the nanotechnology application areas (food processing/preservation, agricultural production/nanofertilizers, soil and water quality, and environment-pollution control/toxicology, *etc*.), conduct a literature review based on journal articles, book chapters, and/or proceeding papers, discuss the characteristics of the concept/approach, its limitations, and benefits, submit a report, and present results of their independent study.

TEXTBOOK/REFERENCES:

No textbook is required. Reference books, journal articles, and related information links are provided on course website and in disk. Some examples of general readings that support several topics are listed as follows:

Reference Books:

Panpatte, D. G & Y. K. Jhala (Eds.). 2019. Nanotechnology for agriculture: advances for sustainable agriculture. Springer Nature, Singapore.

Nils O. Petersen (ed). 2017. Foundations for nanoscience and nanotechnology. CRC Press, Taylor & Francis Group, Boca Raton, FL. USA.

Sellers, K., C. Mackay, L. L. Bergeson, S. R. Clough, M. Hoyt, J. Chen, K. Henry, and J. Hamblen (eds.). 2009. Nanotechnology and the Environment. CRC Press, Boca Raton, FL.

Wiesner, M. R. and J. Y. Bottero (ed). 2007. Environmental Nanotechnology: application and impacts of nanomaterials. The McGraw-Hill Co, New York.

Poole Jr., C. A., and F. J. Owens (ed). 2003. Introduction to nanotechnology. John Wiley & Sons, Hoboken, NJ, ISBN 0-471-07935-9.

Journal Articles:

1. Xin, X., F. Zhao, J. Y. Rho, S. L. Goodrich, B. S. Sumerlin, and Z. L. He. 2020. Use of polymeric nanoparticles to improve seed germination and plant growth under copper stress. Science of the Total Environment 745: 141055.

2. Xin, X., J. D. Judy, B. B. Sumerlin, and Z. L. He. 2020. Nano-enabled agriculture: from nanoparticles to smart nanodelivery systems. Environ. Chem. https://doi.org/10.1071/EN19254.

3. Adisa I.O. et al. 2019. Recent advances in nano-enabled fertilizers and pesticides: a critical review of mechanisms of action. Environmental Science: Nano 6, 2002-2030.

4. Sarma G. K. et al. 2019. Nanomaterials as versatile adsorbents for heavy metal ions in water: a review. Environ. Sci. Pollut. Res. 26: 6245-6278.

5. Yang Q. et al. 2019. Uptake and Transformation of Silver Nanoparticles and ions by rice plants revealed by dual stable isotope tracing. Environ. Sci. & Technol. 53: 625-633.

6. Asadishad A. et al. 2018. Amendment of agricultural soil with metal nanoparticles: effects on soil enzyme activity and microbial composition. Environ. Sci. & Technol. 52: 1908-18.

7. Chen R. et al. 2018. Foliar application with nano-silicon reduced cadmium accumulation in grains by inhibiting cadmium translocation in rice plants. Environ. Sci. Pollut. Res. 25: 2361-68.

8. Cao Z. et al. 2018. The impact of cerium oxide nanoparticles on the physiology of soybean (*G. max L.*) under different soil moisture conditions. Environ. Sci. Pollut. Res. 25: 930-939.

9. Jiang L. et al. 2017. Adsorption of estrogen contmainants by graphene nanomaterials under antural organic matter preloading: comparison to carbon nanotube, biochar, and activated carbon. Environ. Sci. & Technol. 51: 6352-59.

10. Xu Y. et al. 2016. In situ immobilization of cadmium in soil by stabilized biochar-supported iron phosphate nanoparticles. Environ. Sci. Pollut. Res. 23: 19164-72.

11. Bakshi S. et al, 2015. Natural nanoparticles: implications for environment and human health. *Critical Reviews in Environmental Science and Technology* 45:861–904

12. Habuda-Stanic M. and M. Nujic. 2015. Arsenic removal by nanoparticles: a review. Environ. Sci. Pollut. Res. 22: 8094-8123.

13. Rico C. M. et al. 2015. Physiological and biochemical response of soil-grown barley (Hordeum vulgare L.) to cerium oxide nanoparticles. Environ Sci Pollut Res 22:10551–10558.

14. Sharma et al. 2015. Natural inorganic nanoparticles–formation, fate, and toxicity in the environment. Chemical Society Reviews 44: 8410-8423.

15. Kasaraneni V. R., L. A. Schifman, T. B. Boving, and V. Oyanedel-Craver. 2014. Enhancement of surface runoff quality using modified sorbents. *Sustainable Chem. & Eng*. 2: 1609-1615.

16. Sekhon, B. S. 2014. Nanotechnology in agri-food production: an overview. *Nanotechnology, Science and Applications* 7, 31.

17. Bergeson, L. L. 2013. Sustainable nanomaterials: emerging governance systems. ACS Sustainable Chemistry & Engineering 1: 724-730.

18. Hartland A. et al, 2013. The Environmental Significance of Natural Nanoparticles. *Nature Education Knowledge* 4(8):7

19. Gogos, A., Knauer, K., and Bucheli, T.D. 2012. Nanomaterials in plant protection and fertilization: current state, foreseen applications and research priorities. *J. Agric. Food Chem.* 60: 9871-9792.

20. Weir, A, P. Westerhoff, L. Fabricius, K. Hristovski and N. von Goetz. 2012. Titanium dioxide nanoparticles in food and personal care products. Environmental Science and Technology 46: 2242-2250.

21. Zhu et al. 2012. Effect of surface charge on the uptake and distribution of gold nanoparticles in four plant species. Environmental Science & Technology 46: 12391-12398.

22. Batley, G. E., J. K. Kirby, and M. J. McLaughlin. 2011. Fate and risks of nanomaterials in aquatic and terrestrial environments. Accounts of Chemical Research 46: 854-862.

23. Mousavi, S. R., & Rezaei, M. 2011. Nanotechnology in agriculture and food production. J Appl Environ Biol Sci, 1(10), 414-419.

24. Rico, C. M., S. Majumdar, M. Duarte-Gardea, J. R. Peralta-Videa, and J. L. Gardea-Teooresdey. 2011. Interaction of nanoparticles with edible plants and their possible implications in the food chain. Journal of Agricultural and Food Chemistry 59: 3485-3498.

25. Lin D et al. 2010. Fate and transport of engineered nanomaterials in the environment. Journal of Environmental Quality 39: 1896-1908.

26. Upadhyayula et al. 2009. Application of carbon nanotube technology for removal of contaminants in drinking water: a review. *Science of the Total Environment* 408: 1-13

27. Gonzalez-Melendi, P. et al. 2008. Nanoparticles as smart treatment-delivery systems in plants: assessment of different techniques of microscopy for their visualization in plant tissues. Annals of Botany 101: 187–195.

28. Klaine, S. J., Alvarez, P. J., Batley, G. E., Fernandes, T. F., Handy, R. D., Lyon, D. Y., & Lead, J. R. 2008. Nanomaterials in the environment: behavior, fate, bioavailability, and effects. *Environmental Toxicology and Chemistry* 27(9), 1825-1851.

29. TASCIOTTI, E. et al. 2008. Mesoporous silicon particles as a multistage delivery system for imaging and therapeutic applications. Nature nanotechnology 3: 151-157.

30. ASTM International, 2006. Designation: E 2456-06. Standard Terminology Relating to Nanotechnology.

31. Weiss J., P. Takhistov, and D. J. McClements. 2006. Functional materials in food nanotechnology. *J. Food Sci.* 71:R107-R116.

32. Wang, Z.L., Y. Liu, and Z. Zhang. (Ed.). 2002. Handbook of Nanophase and Nanostructured Materials: Synthesis/ Characterization / Materials Systems and Applications I/Materials Systems and Applications II. Springer Science & Business Media.

33. National Science and Technology Council, 2000. National Nanotechnology Initiative: Leading to the next industrial revolution. A report by the Interagency Working Group on Nanoscience, Engineering and Technology. Washington, D.C.

COURSE CHAPTERS

Nanotechnology in Agriculture, Food and Environment

Module I	**Basic concepts and principles of nanotechnology**
Chapter 1	Fundamentals of Nanoscience and Nanotechnology
2	Nanoscale Materials: Definition and Properties
3	Manufacturing and Characterization of Nanoparticles
4	Natural Nanoparticles and Their Role in Soil and Water Quality
Module II	**Nanotechnology Applications**
5	Nanotechnology Application in Agriculture
6	Nanotechnology Application in Food Sciences
7	Nanotechnology Application in the Environment
Module III	**Behavior, environmental toxicology and regulations of nanoparticle**
8	Environmental Fate and Transport of Engineered Nanoparticles
9	Environmental Toxicology of Engineered Nanoparticles
10	Environmental Regulation of Engineered Nanomaterials
Module IV	**Smart nano-delivery systems**
11	Smart Nanoscale Systems for Targeted Delivery of Drugs, Nutrients and Pesticides

Teaching schedule*

Week	Topics covered	Lectures/reading materials/assignments
1	Introduction/ historic development and fundamentals of nanoscience and nanotechnology	Lecture 1/Chapter 1 Reading materials

		Assignment 1
2	Nanoscale materials: definition and properties	Lecture 2/Chapter 2 Reading materials Assignment 2
3	Manufacturing and characterization of nanoparticles	Lecture 3/Chapter 3 Reading materials Assignment 3
4	Natural nanoparticles and their role in soil and water quality	Lecture 4/Chapter 4 Reading materials
5	Nanotechnology application in agriculture I & II	Lectures 5/Chapters 5 Reading materials Assignment 5
6	Nanotechnology application in food sciences	Lecture 6/Chapter 6 Reading materials Assignment 5
7		Spring break
8	Nanotechnology application in the environment	Lecture 7/Chapter 7 Reading materials Assignment 6
9	Course review	Mid-term exam
10	Environmental fate and transport of engineered nanomaterials	Lecture 8/Chapter 8 Reading materials Assignment 7
11	Environmental toxicology of engineered nanoparticles	Lecture 9/Chapter 9 Reading materials Assignment 8
12	Environmental regulation of engineered nanomaterial	Lecture 10/Chapter 10 Reading materials
13	Smart Nanoscale Systems for Targeted Delivery of Drugs, Nutrients and Pesticides	Lecture 11/Chapter 11 Reading materials
14-15	Course review	
16	Final exam	

* Dates for topics or exams are subject to change.

GRADES AND GRADE POINTS: For information on current UF policies for assigning grade points, see https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

ABSENCES AND MAKE-UP WORK: Requirements for class attendance and make-up exams, assignments and other work are consistent with university policies that can be found at: https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx

ACADEMIC HONESTY: As a student at the University of Florida, you have committed yourself to uphold the Honor Code, which includes the following pledge: "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity." You are expected to exhibit behavior consistent with this commitment to the UF academic community, and on all work submitted for credit at the University of Florida, the following pledge is

either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment."

It is assumed that you will complete all work independently in each course unless the instructor provides explicit permission for you to collaborate on course tasks (e.g. assignments, papers, quizzes, exams). Furthermore, as part of your obligation to uphold the Honor Code, you should report any condition that facilitates academic misconduct to appropriate personnel. It is your individual responsibility to know and comply with all university policies and procedures regarding academic integrity and the Student Honor Code. Violations of the Honor Code at the University of Florida will not be tolerated. Violations will be reported to the Dean of Students Office for consideration of disciplinary action. For more information regarding the Student Honor Code, please see: http://www.dso.ufl.edu/sccr/process/student-conduct-honor-code.

STUDENT RESPONSIBILITIES: Students should report any condition that facilitates dishonesty to the instructor, department chair, college dean or Student Honor Court.
More information about student responsibilities are available from the current University catalog, online at: http://www.registrar.ufl.edu/catalog1011/policies/students.html.

SOFTWARE USE: All faculty, staff, and students of the University of Florida are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against university policies and rules, disciplinary action will be taken as appropriate.

CAMPUS RESOURCES:

Health and Wellness

U Matter, We Care:
If you or a friend is in distress, please contact umatter@ufl.edu or 352 392-1575 so that a team member can reach out to the student.
Counseling and Wellness Center:
http://www.counseling.ufl.edu/cwc/Default.aspx, 392-1575;

Sexual Assault Recovery Services (SARS)
Student Health Care Center, 392-1161.

University Police Department, 392-1111 (or 9-1-1 for emergencies).
http://www.police.ufl.edu/

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling.
http://www.crc.ufl.edu/

Library Support, http://cms.uflib.ufl.edu/ask . Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. http://teachingcenter.ufl.edu/

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers. http://writing.ufl.edu/writing-studio/

Student Complaints Campus: https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf
On-Line Students Complaints: http://www.distance.ufl.edu/student-complaint-process

STUDENTS WITH DISABILITIES: The Disability Resource Center coordinates the needed accommodations of students with disabilities. This includes registering disabilities, recommending academic accommodations within the classroom, accessing special adaptive computer equipment, providing interpretation services and mediating faculty-student disability related issues. Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, www.dso.ufl.edu/drc/) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

ONLINE COURSE EVALUATION: Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

STUDENT COMPLAINTS: Each online distance learning program has a process for, and will make every attempt to resolve, student complaints within its academic and administrative departments at the program level. See http://distance.ufl.edu/student-complaints for more details.

PRIVACY STATEMENT OF RECORDED MATERIALS
Our class sessions may be audio visually recorded for students in the class to refer back and for enrolled students who are unable to attend live. Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image. Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the "chat" feature, which allows students to type questions and comments live. The chat will not be recorded or shared. As in all courses, unauthorized recording and unauthorized sharing of recorded materials is prohibited.

The grading rubric for graduate student's final project

Components	Poor (≤ 60 %)	Acceptable (61-80 %)	Good (81-90 %)	Excellent (91-100 %)	Full score
Content					
Scientific questions	No obvious scientific questions to be addressed.	Scientific question is not explicitly presented.	There is a scientific question clearly stated.	Significant questions are logically addressed.	10
Hypothesis	No hypothesis.	There is hypothesis, but not well presented.	There is a well presented hypothesis.	Meaningful hypotheses are logically addressed.	5
Methodology	No experimental design and lack of adequate methods.	There is experimental design, but lack of adequate methods.	There is experiment design with measurement methods.	The experiments are statistically designed with adequate methods.	10
Data process & statistical analysis	No statistical analysis of the data.	There is statistical analysis of the data but not sufficient.	The data are statistically analyzed but not well presented.	The data are statistically analyzed and well presented.	5
Results and Discussion	Interpretation of the data is lacking.	The results are presented but not well discussed.	The results are adequately presented and discussed.	The results are well presented and discussed.	20
Communication					
Organization	No logical structure of the paper and presentation.	The paper and presentation is structured in a way but hard to follow.	The paper and presentation is logically structured.	Well organized with proper proportions of text, figures, and pictures.	10
Language	Poor with many errors in grammar and spelling.	Adequate with minor errors in grammar and spelling	Written clearly without obvious errors in grammar and spelling	Well written with good flow of ideas and easy to follow	10
Colors & figures	Colors are arbitrarily chosen and figures are poorly designed.	Use of some colors and figures to present information.	Colors and figures are used to enhance presentation.	Colors and figures are well designed to communicate ideas.	10
Presentation	Not clear and timely	Good speech but not timely	Good speech and timely	Well presented and timely	10
Acknowledgment	Minimal citation	With some citations and references	Completely cited and acknowledged.	Well cited and acknowledged with journal standards	10