SYLLABUS

CONTEMPORARY ISSUES IN SCIENCE
Instructor: Richard Wagner
Email:
Office Hours:
Language of Instruction: English
UO Credits: 4
Contact Hours*: 40

London, England

COURSE DESCRIPTION

Contemporary Issues in Science: Life – or sailing through chaos on quantum mechanics. In this course, students will investigate research and scientific discoveries with broad implications across disciplines as they build their skills as scientists. Specifically, students will understand quantum mechanics and how its properties relate across other STEM disciplines as we explore different course topics: **Q-eating, Q-feeling**, and **Q-being**. Students will learn how quantum physics, which analyses the behaviour of everything on an extremely tiny scale – protons, electrons, quarks or photons – is closely related to our life. Indeed, we will experience how biology is directly influenced by quantum physics and how important a pair of electrons may be for a bird or how crucial a few protons could be for evolution. With the broad scientific topics of study, the course is open to students across all STEM majors.

Students will read and discuss scientific primary literature, design and perform experiments to understand scientific perspectives and reflect on the process of discovery, the implications of research, and avenues for future study. We will examine cross-cutting concepts such as cause and effect, scale, proportion, quantity, systems and system models, structure and function or stability and change. Students will engage in independent writing projects and field trips will connect classroom discussions to place-based understanding of the science.

More specifically, this adventure will be triggered by a question: 'What is life?' Different historical theories will be proposed and analysed, working particularly on Erwin Schrödinger's theory that suggests quantum physics as a key element to answer such a complex question. From Schrödinger's hypothesis we will study quantum physics origins, researchers (Plank, Schrodinger, Heisenberg, Bohr, Pauli, Broglie), and specific properties (particle-wave, tunnelling, superposition, entanglement, decoherence). Once such bases are settled, we will start an adventure around London in which STEM-related fields will be discovered and discussed through three different sections (**Q-eating, Q-feeling** and **Q-being**). At the end of each one, we will reflect on how quantum properties, so highly confined to the subatomic world and so difficult to maintain outside it, are able to control our most basic processes. Students will realise how (and how much) quantum mechanics permeate our biology and our planet, thus permeating our life.

COURSE GOALS

Students will…

1. Understand the interconnected nature of scientific discoveries across disciplines.
2. Reflect on such a broad picture, where STEM fields (human physiology, biology, computer and information sciences, biochemistry, chemistry, physics, and earth sciences) are not independent but wired members of the knowledge that tries to explain our surroundings and our lives.
3. Expand their perspectives as scientists.
4. Understand the scientific method, the importance of obtaining clear and unbiased results to reach useful conclusions and the way to communicate them to both scientific peers and general audiences.
5. Acknowledge the value of creativity in problem solving through experimentation.
6. Examine ways in which contemporary scientific issues are geographically connected to London and the United Kingdom.

COURSE LEARNING OBJECTIVES

Students will be able to…

1. Write about scientists (biography, work, accomplishments, challenges) who are researching topics related to our course.
2. Analyze, reflect and write accurately on other's scientific theories.
3. Speak and write clearly and analytically using scientific terms correctly.
4. Read complicated scientific texts and critically evaluate their arguments and evidence.
5. Discuss scientific data rigorously to reach useful and true conclusions.
6. Debate about scientific problems, putting your message through effectively and making sure you listen, understand and value others' opinions and data.
7. Solve problems through appropriate experimental design.
8. Analyze Erwin Schrodinger's' theory about quantum biology.
9. Explain the main figures that gave form to quantum mechanics and understand the specific (and intricate) quantum properties.
10. Design an experimental approach to support quantum properties existence.

Q-eating

Description: Visiting Kew Royal Botanic Gardens we will learn about biodiversity and plant physiology, but, more importantly, it will move us to understand the biochemical process of photosynthesis together with cellular and molecular biology. We will review the role of photons, electrons and excitons and how quantum mechanics are involved with this essential biochemical process. Once we understand how plants obtain energy, we will examine cellular respiration in animals and how quantum properties are as well involved. In line with these two processes, we will also study general enzymology, catalysis and inhibition. The relevance of quantum mechanics in the enzymatic catalysis will be explored covering aspects such as isotopes, subatomic particles and other nuclear-physics related concepts.

Q-eating Learning Objectives Students will be able to…

1. Reflect and write about biodiversity, ecology, botany and plant physiology.
2. Evaluate biochemical, chemical and physical concepts gravitating around photosynthesis, cellular respiration and enzymology.
3. Design and perform experiments to replicate theoretical knowledge about photosynthesis, cellular respiration and enzymology.

Q-feeling

Description: This section will start at The Alan Turing Institute where we will talk about data science, history of computing, artificial intelligence, neural networks or "deep learning". All this information will lead us to discuss about sociological and philosophical implications of artificial intelligence but it will also trigger questions about how our brain works. We will thus study concepts of physiology of the nervous system, neuronal transmission, communication, consciousness and integration of feelings and perceptions. This will lead to discuss physiology of the eye (considering how migratory birds use magnetic fields for migration) and smell. How quantum mechanics permeate our senses and brain functionality will be discussed. Finally, quantum computing will be compared with the classical or binary computational approaches. We will explore the challenges of quantum computing, its milestones and its current situation as well as possible future applications.

Q-feeling Learning Objectives Students will be able to…

1. Reflect and write about artificial intelligence, algorithms, machine learning and other computational science concepts.
2. Evaluate biological, chemical and physical background of neurobiology and senses biology.

Q-being

Description: The third section will start with a visit to the Natural History Museum where biological and geological evolutions will be examined. Lamarckism, Darwinism and Neo-Darwinism (also reviewing classical Mendelian genetics), will be presented. We will examine different theories for the origin of life and associated geology and fossil studies. Back at class, we will talk about DNA and how mutations are responsible for evolution. Quantum properties affecting mutations and natural evolution will then be discussed and possibilities of quantum mechanics affecting formation of primitive life will be proposed.

Q-being Learning Objectives Students will be able to…

1. Reflect and write about origin of life, geology, evolution theories and classical and modern genetics.
2. Evaluate biological, chemical and physical background of DNA and RNA biology, mutations and genetic transference.

INSTRUCTIONAL METHODOLOGY

As your instructor, my priority is to create a learning environment where you each feel a sense of belonging, are challenged, explore new topics and a new city, and build connections. I am here as your teacher, coach and guide to set each of you up for success in your understanding of the content. In the introduction we will read materials, discuss among us and design and perform experiments that will answer our questions. Before every excursion, you will learn about the place you are about to visit and decide on an area of focus and study. On excursions, you will work on a proposal and write an essay about what you have learned. Later on, at class, you will continue to reflect about different scientific topics. After that, brainstorming and general discussions/debates will occur followed by a more formal explanation that will wrap up the suggestions put forward. Then, implications and conclusions will be discussed. If the jury is still out on a topic, you will work on the different possibilities currently under research and suggest potential ways forward. At the end, you will be expected to discuss actively (and respectfully), read (quite a lot) on many different topics,

think creatively, solve problems, design and perform experiments, write essays, make oral presentations, write laboratory reports and, above all, participate and enjoy.

Class Participation and Professionalism Participation includes class attendance, reading assigned materials, overall preparation for class, and actively contributing. Class will start promptly at the designated time. You are expected to be on time, attend all classes and site visits, and remain in the classroom for the duration of the class. Your involvement during class is critical to the exchange of ideas and fruitful discussions.

Preparation, professionalism, and mutual respect are all important elements of your participation score. Professional behavior is expected at all times. While in London, students should think of themselves as American Ambassadors. Everything you say and do should reflect well on yourself, America, and the GEO program. Right along with that is respect for the British culture and way of life. We are guests here.

Inclusiveness Open inquiry, freedom of expression, and respect for difference are fundamental to a comprehensive and dynamic education. We are committed to upholding these ideals by encouraging the exploration, engagement, and expression of divergent perspectives and diverse identities.

Attendance While students are here in London to experience the UK, attendance in class is critical. Refer to the attendance policy you received during orientation for more details. No make-up assignments are available for unexcused absences.

MATERIALS AND RESOURCES

We will use Canvas as the primary location for resources sharing, assignment submission, and communicating about grades. Specific simple materials will be required for experiments. For quizzes, Kahoot app can be used.

EXCURSIONS

Will include Kew Royal Botanic Gardens, Alan Turing Institute and Natural History Museum and will be coordinated with other program courses.

COURSE READINGS

1. Schrödinger, E. *What is life? : the physical aspect of the living cell*. (Cambridge University Press Cambridge [England], 1944).
2. Orzel, C. *How to Teach Quantum Physics to Your Dog*. (Oneworld Publications, 2009).
3. Al-Khalili, Jim McFadden, J. *Life on the edge : the coming of age of quantum biology*. (Bantam Press London, 2014).
4. Scholes, G. D. Quantum-Coherent Electronic Energy Transfer: Did Nature Think of It First? *J. Phys. Chem. Lett.* **1**, 2–8 (2010).
5. McFadden, J. & Al-Khalili, J. The origins of quantum biology. *Proc. R. Soc. A Math. Phys. Eng. Sci.* **474**, 20180674 (2018).
6. Lambert, N., Chen, Y.-N., Cheng, Y.-C., Li, C.-M., Chen, G.-Y. & Nori, F. Quantum biology. *Nat. Phys.* **9**, 10–18 (2013).
7. Marais, A., Adams, B., Ringsmuth, A. K., *et al.* The future of quantum biology. *J. R.*

Soc. Interface **15**, 20180640 (2018).
8. Goh, B. H., Tong, E. S. & Pusparajah, P. Quantum Biology: Does quantum physics hold the key to revolutionizing medicine? *Prog. Drug Discov. Biomed. Sci.* **3**, (2020).
9. Jedlicka, P. Revisiting the Quantum Brain Hypothesis: Toward Quantum (Neuro)biology? *Front. Mol. Neurosci.* **10**, (2017).

Note: Although many of the readings will be handled to the students (so they are more guided), they will also be encouraged to actively search for information on internet, excursion or asking experts on the different fields.

METHOD OF EVALUATION (GRADING)

Introduction	**20%**
"What is Life?" essay	5%
Quantum mechanics presentation	5%
Quantum experiment report	10%
Q-eating	**20%**
Preparation for the excursion	5%
Excursion essay	5%
Q-eating final projects	10%
Q-feeling	**20%**
Preparation for the excursion	5%
Excursion essay	5%
Q-feeling final projects	10%
Q-being	**20%**
Preparation for the excursion	5%
Excursion essay	5%
Q-being final projects	10%
Formal Review or Original Scientific Outreach Proposal	**20%**

The introductory part will give the general bases of the course. We will initially discuss different theories trying to answer the question "What is life?". Then, students will be given fragments of Erwin Schrödinger's homonymous book and will be asked to analyse them and write a **short-essay** describing impressions of Schrodinger`s theory. From there, we will recognise the importance of quantum mechanics in Schrodinger's hypothesis so we will learn about the quantum physics origins, founders and properties. Students will be asked to work on different quantum researchers' biography and work as well on different quantum properties and make an **oral presentation** about their thoughts and discuss their findings together. This knowledge will be wrapped by the design of an experiment that can support quantum mechanics properties. Students will explore how to design such experiment and will perform it, writing down the results and conclusions in a **laboratory report**.

Each section (Q-Eating, Q-Feeling and Q-Being), will explore different STEM-related concepts and the implication of quantum physics in them. Each of the section will include a

short work-proposal, a **short-essay,** and a **final project. Short work-proposals** prepare students for excursions to use the visit not only as tourism, but also to develop an idea for work on-site. During excursions students will carry out the proposed idea and write a **short-essay.** Finally, students will reflect on different scientific concepts through **final projects** to solve problems by designing experiments and obtaining data that should be analyzed to make conclusions. The role of quantum mechanics in each of the main concepts will be debated and students will find why quantum properties are so crucial.

Students will choose from two options for a final summative assessment: a **formal review** of one of the topics or an **original scientific outreach proposal**. In the former, they may write a formal review following formal academic structure. In the latter, students can design an original and innovative format to communicate quantum biology to a lay audience. In preparation, we will discuss formal structures of review articles and different forms of scientific dissemination.

CLASROOM BEHAVIORS

All members of the class (both students and instructor(s) can expect to:

1. Participate and Contribute: Students are expected to participate by sharing ideas and contributing to the collective learning environment. This entails preparing, following instructions, and engaging respectfully and thoughtfully with others. Together, we will establish more specific participation guidelines and criteria for contributions.
2. Expect and Respect Diversity: All classes at the University of Oregon welcome and respect diverse experiences, perspectives, and approaches. What is not welcome are behaviors or contributions that undermine, demean, or marginalize others based on race, ethnicity, gender, sex, age, sexual orientation, religion, ability, or socioeconomic status. We will value differences and communicate disagreements with respect. We may establish more specific guidelines and protocols to ensure inclusion and equity for all members of our learning community.
3. Help Everyone Learn: Our goal is to learn together by learning from one another. As we move forward learning during this challenging time, it is important that we work together and build on our strengths. We are returning with a range of feelings about and comfort with being in person, and this means we need to be patient with each other, identify ways we can assist others, and be open-minded to receiving help and feedback from others. No one should hesitate to contact me to ask for assistance or offer suggestions that might help us learn better.

Academic Integrity

You are expected to do your own work. You are encouraged to discuss ideas with each other and to study together, but don't copy someone else's work and don't allow someone else to copy your work. By submitting an essay or other work, you are certifying that you are the student entitled to log in using a specific set of credentials. Allowing someone else to log in under your name, or logging in under someone else's name, to complete an assignment is a breach of university regulations. All students are expected to conform to the student conduct code (http://integrity.uoregon.edu/); students not in compliance will be brought to the attention of the university and risk removal from the program.

Accessible Education

Please let me know within the first week of the term if you need assistance to fully participate in the course. Participation includes access to lectures, web-based information, in-class activities, and exams. The Accessible Education Center (http://aec.uoregon.edu/) works with students to provide an instructor notification letter that outlines accommodations and adjustments to class design that will enable better access. Contact the Accessible Education Center for assistance with access or disability-related questions or concerns.

If you are not a student with a documented disability through AEC, but you would like for me to know about class issues that will impact your ability to learn, I encourage you to come visit with during office hours so that we can strategize how you can get the most out of this course.

Reporting Obligations

I am a student-directed employee. For information about my reporting obligations as an employee, please see Employee Reporting Obligations on the Office of Investigations and Civil Rights Compliance (OICRC) website. Students experiencing any form of prohibited discrimination or harassment, including sex or gender-based violence, may seek information and resources at safe.uoregon.edu, respect.uoregon.edu, or investigations.uoregon.edu or contact the non-confidential Title IX office/Office of Civil Rights Compliance (541-346-3123), or Dean of Students offices (541-346-3216), or call the 24-7 hotline 541-346-SAFE for help. I am also a mandatory reporter of child abuse. Please find more information at Mandatory Reporting of Child Abuse and Neglect.

Academic Disruption due to Campus Emergency

In the event of a campus emergency that disrupts academic activities, course requirements, deadlines, and grading percentages are subject to change. Information about changes in this course will be communicated as soon as possible by email, and on Canvas. If we are not able to meet face-to-face, students should immediately log onto Canvas and read any announcements and/or access alternative assignments. Students are also expected to continue coursework as outlined in this syllabus or other instructions on Canvas.

Accommodation for Religious Observances

The university makes reasonable accommodations, upon request, for students who are unable to attend a class for religious obligations or observance reasons, in accordance with the university discrimination policy which says "Any student who, because of religious beliefs, is unable to attend classes on a particular day shall be excused from attendance requirements and from any examination or other assignment on that day. The student shall make up the examination or other assignment missed because of the absence." To request accommodations for this course for religious observance, visit the Office of the Registrar's website (https://registrar.uoregon.edu/calendars/religious-observances) and complete and submit to the instructor the "Student Religious Accommodation Request" form prior to the end of the second week of the term.

COURSE OUTLINE

Week	Topic and Learning Objectives Students will be able to…	Readings and Assignments
1	**Introduction (class work – 3 days)**	
	*Analyze and reflect on Erwin Schrödinger's theory of "quantum biology"	Erwin Schrödinger's "What is Life?"[1] / Short essay
	*Learn about quantum mechanics' main figures and properties	Quantum physics properties readings[2] / viva
	*Design an appropriate experiment to observe quantum properties and experiment them	Quantum physics experiments videos / laboratory report
	Q-eating (preparation and excursion – 2 days)	
	*Learn about biodiversity, ecology, botany and plant physiology (Kew Royal Botanic Gardens)	Participation and Excursion
2	**Q-eating (class work – 3 days)**	
	*Explore photosynthesis (overall reaction, specific steps, specific components, implications)	Photosynthesis readings / laboratory report
	*Explore cellular respiration (overall reaction, specific steps, specific components, implications)	Cellular respiration readings / viva
	*Explore enzymes (discovery, chemical meaning, social importance, biological importance, biological/chemical/physical functioning)	Enzymology readings / riddle solving
	*Understand implication of quantum properties in the above-mentioned fields	"Life on the Edge"[3] book and other readings[4–8]
	Q-feeling (preparation and excursion – 2 days)	
	*Learn about computational science, artificial intelligence, algorithms, machine learning	Participation and Excursion

3	**Q-feeling (class work – 3 days)** *Explore nervous system (neurons, action potential, neurotransmitters) *Explore how sight works (general biology, related cells, biochemical process, cellular pathways, biophysics, neuronal-associated response) *Explore how smell works (olfactory theories, general biology, related cells, biochemical process, associated-molecular chemistry and biophysics) *Understand implication of quantum properties in the above-mentioned fields **Q-being (preparation and excursion – 2 days)** *Learn about origin of life, geology, evolution, populations, Lamarckism vs Darwinism vs Neo-Darwinism, genetics	 Nervous system and neurobiology readings / viva Visual system readings / problem solving Olfactory system readings / smelling quest "Life on the Edge"[3] book and other readings[5,9] Participation and Excursion
4	**Q-being (class work – 3 days)** *Explore DNA, genetic duplication, genetic transference, mutations, tautomerization, hydrogen bonds, nitrogenous bases *Explore origin of life theories, geology, RNA and ribozymes *Understand implication of quantum properties in the above-mentioned fields **Final reflection and assessment (class work – 2 days)**	 Molecular genetics readings / viva Origin of life readings / short-essay "Life on the Edge"[3] book and other readings[8] Final Reflection