

General Education 1029

What is Life? From Quarks to Consciousness

Harvard University, Fall 2020

Mon/Wed/Fri, 3:00–4:15pm, Synchronous Zoom attendance required

Website: <https://canvas.harvard.edu/courses/74888>

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Office hours: Mondays 5–6:30pm

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Office hours: Tuesdays 1–2:30pm

TFs: Richard Childers (rchilders@g.harvard.edu) Section **Thurs. 1:30pm**

Melissa Mai (melissamai@g.harvard.edu) Section **Thurs. 3pm**

Zhengyang Wang (zhengyangwang@g.harvard.edu) Section **Thurs. 9am**

Sections and Labs: All discussion and “lab” activity is integrated within the three 75-minute class meetings each week. **Attendance and participation is required.** The TFs lead *optional* weekly discussion sections to help with assignments & exams.

Course Books: E. Schrödinger, *What is Life?*
Cambridge Univ. Press, 2012. ISBN: 978-1107604667
J. Maynard Smith, E. Szathmáry, *The Origins of Life*.
Oxford Univ. Press, 2000. ISBN: 978-0192862099
A. Pross, *What is Life? How Chemistry Becomes Biology*.
Oxford Univ. Press, 2016. ISBN: 978-0198784791
These **short paperback books** are all available at the Coop or online.

Course Description: **Are we — wonderful, human us — really nothing more than complex constellations of interacting atoms?**

This course views life through multiple lenses. Quantum physics involves uncertainty and randomness, and yet paradoxically it explains the stability of molecules, such as DNA, that encode information and are critical to life. Thermodynamics is about the universe's ever increasing disorder, and yet living systems remain ordered and intact. This course will examine how these physical laws underpin life and how life itself has diversified since originating 3.5 billion years ago.

Assignments and Examinations: Weekly problem sets or short response papers will be due **Fridays** in class. There will be two **in-class exams** on **Wed., Oct. 14 and Wed., Dec. 2**. A **final paper or creative project** will be due on the scheduled final exam date for this course (TBA, sometime between Thu., Dec. 10 and Sat., Dec. 19).

Course Grading:

Weekly assignments	20%	(Due every Friday in class)
Class attendance and participation	20%	(80% attendance gets full credit)
Two in-class examinations	30%	(Wed., Oct. 14 and Wed., Dec. 2)
Final paper or creative project	30%	(Due during final exam period)

Prerequisites: Some familiarity with elementary math (algebra, geometry, exponentials, and logarithms). These concepts will be reviewed as needed.

Tentative Lecture & Reading Schedule (initials indicate lecturer):

Date	Lecture	Schröd.	Pross	MS & S
W 2-Sep-20	1. Introduction (AB/LM)			
F 4-Sep-20	2. Everything is made of atoms (LM)	<i>(Read before indicated lecture)</i>		
M 7-Sep-20	Labor Day - no lecture			
W 9-Sep-20	3. Physical laws are statistical (LM)	Ch 1		
F 11-Sep-20	4. Life vs. non-life: new laws for biology? (AB)			
M 14-Sep-20	5. Can physics explain biology? Schrödinger's concern (LM)			
W 16-Sep-20	6. DNA and heredity (AB)	Ch 2, 3		
F 18-Sep-20	7. Astrobiology: searching for life elsewhere (AB)			Ch 1
M 21-Sep-20	8. Wave mechanics: interference, discrete states (LM)	Ch 4		
W 23-Sep-20	9. Double slit experiment; quantum puzzles (LM)		Ch 1, 2	
F 25-Sep-20	10. Atoms and molecules (LM)			Ch 2
M 28-Sep-20	11. Isomers and Boltzmann (LM)		Ch 3, 4	
W 30-Sep-20	12. The Big Bang (LM)			
F 2-Oct-20	13. Origin of life: simple molecules (LM)			Ch 3
M 5-Oct-20	14. Origin of life: biomolecules and protocells (LM)		Ch 5	
W 7-Oct-20	15. New Life in the lab (AB)			
F 9-Oct-20	16. Case study: Vision and sunburn (LM)			
M 12-Oct-20	Columbus Day - no lecture			
W 14-Oct-20	Exam 1 - lectures 1–16			
F 16-Oct-20	17. Mendel and chromosomes (AB)			Ch 4
M 19-Oct-20	18. DNA: Replication, transcription, translation (AB)	Ch 5		Ch 5
W 21-Oct-20	19. Storing and communicating information (MM)		Ch 6	
F 23-Oct-20	20. Gene regulation (AB)			
M 26-Oct-20	21. Metabolism and photosynthesis (AB)			Ch 6
W 28-Oct-20	22. Entropy, the 2nd Law, and Life (LM)	Ch 6	Ch 7	
F 30-Oct-20	23. Evolution by natural selection; Population Genetics (AB)			Ch 7
M 2-Nov-20	24. Splitting the tree: Speciation (AB)			
W 4-Nov-20	25. Exploring the past: fossils and phylogenetics (AB)			
F 6-Nov-20	26. Research collections at the MCZ (RC, ZW)			
M 9-Nov-20	27. Evolution of complexity: multicellularity, sex, development (AB)			Ch 8, 9
W 11-Nov-20	28. Contingency in evolution: stochastic vs deterministic factors (AB)			Ch 10
F 13-Nov-20	29. Humans! Our 7 million year journey (AB)			Ch 11, 12
M 16-Nov-20	30. Quantum phenomena: photons and polarization (LM)		Ch 8	Ch 13
W 18-Nov-20	31. Quantum entanglement (LM)	Ch 7		
F 20-Nov-20	32. Consciousness and free will (LM)			
M 23-Nov-20	Project consultations			
W 25-Nov-20	Thanksgiving			
F 27-Nov-20	Thanksgiving			
M 30-Nov-20	Project consultations			
W 2-Dec-20	Exam 2 - lectures 17-32			
F 4-Dec-20	Reading Period			
M 7-Dec-20	Reading Period			
W 9-Dec-20	Reading Period			
F 11-Dec-20	Final papers / projects due during exam period (TBA)			