01:460:203* Building and Maintaining a Habitable Planet *(21C, NS)

Rutgers, the State University of New Jersey, Fall 2014
Tuesdays/Thursdays 3:20-4:40pm, Wright Labs 231, Busch Campus

Professor Robert Kopp
Email: Robert.Kopp@rutgers.edu / *Twitter:* @bobkopp
Office: 225 Wright Lab, Busch Campus
Office hours: Thursday, 2pm-3pm, or by appointment (please email ahead in either case)

Course Description

Humanity has become a geological force; we are reshaping Earth's land, atmosphere, oceans and climate through our activities. Some geologists have proposed that this era of human influence be recognized as a new geological epoch, the Anthropocene. "We are as gods and we HAVE to get good at it," the writer Stewart Brand says, yet "civilization's shortening attention span is mismatched with the pace of environmental problems." How do we reconcile the time scale of news cycles, quarterly reports, and elections with the timescale of our impacts, which will last for tens of thousands if not millions of years?

This course will prepare you to be an informed citizen of our empowered global civilization, able to step outside the realm of short-termism and interpret the environmental changes humanity is effecting today in in the context of our planet's 4.6 billion year history. We will address questions such as: Why is the Earth so habitable, while Mars is at best marginally so and Venus totally uninhabitable? How did life evolve to regulate the planet's chemical and energy flows before we arrived on the scene? How does human civilization fit into this long history, and what are the implications of the planetary and human experience for the frequency of intelligent life in the Universe?

Learning goals

The fundamental goal of this class is to equip you to interpret the environmental changes humanity is effecting today in the context of the long-term evolution of the planet's climate and biogeochemical cycles.

In this course, you will fulfill the ***Natural Sciences (NS)*** core curriculum requirement by (1) applying the concepts of energy, entropy, evolution, extinction, carbon cycling, and system feedbacks to the Earth system in the planet's past and in the current Anthropocene epoch, and (2) identifying and critically assessing ethical and societal issues related to science, technology, and the global environment.

In this course, you will also fulfill the ***21st Century Challenges (21C)*** core curriculum requirement by analyzing the relationship science & technology have to a contemporary global issue (namely, the human reshaping of the global environment).

Academic Integrity

All students are responsible for upholding the highest standards of student behavior, as specified under the University Code of Student Conduct (http://studentconduct.rutgers.edu/), including but not limited to strict adherence to the terms of the University's Academic Integrity Policy (http://academicintegrity.rutgers.edu/). Plagarism is not acceptable on any assignment; on collaborative assignments, all group members are responsible for ensuring the integrity of all group products.

Attendance

You are expected to attend and participate in all class sessions and to show up to class on time. If you have a legitimate reason for not attending (e.g., illness, family emergency, etc.), please use the University absence reporting website (https://sims.rutgers.edu/ssra) to indicate the date and reason for your absence. An email will be sent to me automatically. Absent extreme extenuating circumstances, notification should be sent at least twenty-four hours in advance, and absent extreme circumstances, you will not be allowed to make up missed in-class activities. No unexcused make-up exams and recitations will be given.

Electronic Devices (Phones, Computers, Tablets)

Please be respectful of me and your fellow students – do not use your phone in class. Laptop or tablet use in class is allowable only in support of class activities. Appropriate uses include taking notes or referring to readings. Examples of inappropriate uses include (but are not limited to) checking email, Facebook, Twitter, or GChat.

Assessment and Grading (Subject to Revision)

The grading metric will be subject to revision, but will be roughly:

15%: Attendance and course participation
15%: Reading questions
15%: Problem sets
10%: Final paper
45%: Mid-term and final exams

You may also get up to 5% extra credit by (a) posting news articles relevant to class discussion along with thoughtful commentaries (no more than a few paragraphs for each article), and (b) attending relevant seminars on campus and posting similarly thoughtful commentaries.

All assignments will either be collected in class (for in-class activities and examinations) or submitted online via Sakai. Deadlines for assignments are enforced by the submission system.

Reading questions

Reading questions will be posted on Sakai at least 1 week in advance (in the "Tests & Quizzes" section) and should be completed by 9am before each class session. They are intended to prime you to come to class ready to engage with the material, and they will be graded on completion and thoughtfulness, not on correctness.

Paper

Your final paper will use science fiction to explore possible future relationships between humans and the Earth system. For this assignment, you should choose your book by the beginning of October to ensure that you have sufficient time to read it. You are encouraged to form 'book clubs,' but the papers should represent your own work.

Problem sets

The problem sets complement class activities, giving you additional hands-on expeiences with the relationships and quantitative mechanics of the Earth system. You are welcome to collaborate on the

problem sets. You can also use any resources available to you. Scientists collaborate with each other all the time; they just cite each other to avoid "stealing" ideas. Explicitly cite any ideas or hints you get from other people, books, the Internet, or other resources, in your homework.

Texts

The two required texts for the course are:

Charles Langmuir & Wally Broecker (2012), *How to build a habitable planet* (ISBN 0691140065)
Oliver Morton (2009), *Eating the Sun* (ISBN 0007163657)

In addition, you will be asked to watch several episodes from Neil DeGrasse Tyson (2014), *Cosmos: A Space-Time Odyssey*, which is available streaming from numerous sources online (Amazon, Netflix, Hulu, Google Plus, and others).

Additional articles will be posted on Sakai (under "Resources") and assigned during the course of the term. These may include:

T. Houser et al. (2014), American Climate Prospectus: Economic Risks in the United States. http://www.climateprospectus.org.
Rasmus Benestad (2010), A simple recipe for the greenhouse effect, http://goo.gl/zCaM
James Hansen et al. (2013), "Assessing ''Dangerous Climate Change'': Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature," *PLOS One*, 8:e86148.
James Kasting, Owen Toon and James Pollack (1988), "How Climate Evolved on the Terrestrial Planets," *Scientific American,* Feb. 1988: 90-97.
Michael Lemonick (2013), "The Dawn of Distant Skies," *Scientific American*, July 2013: 40-47.
Excerpts from James Lovelock (1988), *The Ages of Gaia* (ISBN 0393312399)
Phil Plait (2013), "The Universe is 13.82 billion years old", http://goo.gl/rLcIZt
Phil Plait (2009), "The Universe is 13.73 ± .12 billion years old", http://goo.gl/0YR4vK
John Playfair (1822), "John Hutton Observes the Unconformity at Siccar Point"
Excerpts from Carl Sagan (1996), *The Demon-Haunted World: Science as a Candle in the Dark* (ISBN 0345409469)
Will Steffen et al. (2011), "The Anthropocene: From global change to planetary stewardship," *AMBIO* 40:739-761.

Links to these videos will also be posted on Sakai (under "Resources"). These include:

Vicky Arroyo (2012), Let's prepare for our new climate, TEDGlobal 2012. http://on.ted.com/sNEn
James Balog (2009), Time-lapse proof of extreme ice loss, TEDGlobal 2009. http://on.ted.com/hjPf
Ensia (2013), A song of our warming planet. http://vimeo.com/69122809
David MacKay (2012), A reality check on renewables, TEDxWarwick. http://on.ted.com/pMKv
Miracle Planet (2005), Episode 2: Snowball Earth. http://youtu.be/87hHbiWBwmY
NASA (2012), This World is Black and White. http://youtu.be/sCxIqgZA7ag
Johan Rockstrom (2010), Let the environment guide our development, TEDGlobal 2010. http://on.ted.com/dhm8
C. Sagan (1994), Pale Blue Dot. http://youtu.be/4PN5JJDh78I
C. Sagan (1994), We humans are capable of greatness. http://youtu.be/oY59wZdCDo0

Preliminary Course Schedule (Subject to Revision)

Day	Topic	Readings	Videos	Assignments	Learning goals

				Due	
Sep. 2	Introduction	Sagan (1996)	Sagan (1994a,b)		* To distinguish between scientific and non-scientific explanations of cosmological and geological phenomena
Wed. Sep. 3	Extra-credit Seminar (noon, Wright auditorium): Prof. Bob Kopp, *American Climate Prospectus: Economic Risks in the United States*				
Sep. 4	Astronomical time	L&B ch. 2; Plait (2008, 2013)	Tyson Episodes 1, 4, 13		* To identify key traits of dating techniques * To assess the age of the universe from red-shift data
Sep. 9	Geological time	L&B ch. 6.1-2, 14.1-2; Playfair (1822)	Tyson Episode 7		* To intuit the difference between human and geological/cosmological time scales
Wed. Sep. 10	Extra-credit Seminar (noon, Wright auditorium): Prof. Ben Horton, *Common Era Sea-Level Change*				
Sep. 11	Evolution	L&B ch. 14-15, Morton ch. 5-6	Tyson episode 2	MINI-PROBLEM SET: Evolution	* To explain how natural selection can give rise to complex organisms
Sep. 16	Extinction (Ken Miller)		Tyson episode 9		* To explain the role of catastrophes in shaping long-term biological evolution
Sep. 18	NO CLASS				
Sep. 23	The Earth as a system	Morton 2.1, 4.1; L&B ch. 1			* To explain the relationship between life and entropy * To explain how feedbacks can stabilize or destabilize complex systems
Sep. 25	ROSH HASHANAH -- NO CLASS				
Sep. 30	Daisyworld	Lovelock (1988) ch. 2-3	NASA (2012)		* To explain how models allow us to gain insights into systems not amenable to direct experimentation * To apply the concepts of blackbody radiation and albedo to explain the temperature of a dead, atmosphere-free planet and of Daisyworld
Oct. 2	Daisyworld (cont'd)			SELECT BOOK FOR FINAL PAPER	* To explain how models allow us to gain insights into systems not amenable to direct experimentation * To apply the concepts of blackbody radiation and albedo to explain the temperature of a dead, atmosphere-free planet and of Daisyworld
Oct. 7	The greenhouse effect	L&B ch. 9; Benestad (2010)			* To apply the concept of the greenhouse effect to explain the difference between blackbody and surface temperatures on the Earth
Oct. 9	Earth's climate feedbacks	Morton 5.2, 6.2	Tyson episode 12		* To assess the role of positive and negative feedbacks in regulating Earth's climate on different timescales
Sun. Oct. 12				PROBLEM SET: Feedbacks	

Oct. 14	The planetary habitable zone	Kasting et al. (1988)			* To explain the climatic differences between Earth, Venus and Mars using the concepts of the greenhouse effect and Earth system feedbacks
Oct. 16	The planetary habitable zone (cont)				
Oct. 21	The planetary habitable zone (cont) / Review				
Oct. 23	The planetary habitable zone (cont) / Review	Morton ch. 7, L&B ch 18			
Fri. Oct. 24	Extra-credit Seminar (10:30am, Amalpi Auditorium, IMCS, Cook Campus): Dr. David Morrow, *Ethics of geoengineering*				
Oct. 28	MIDTERM EXAM 1				
Oct. 30	BUSCH COGEN PLANT TOUR	L&B ch. 19, Morton ch. 8			
Nov. 4	Natural climate variability				* To explain multi-million-year cycles in planetary climate in terms of positive and negative feedbacks * To explain glacial-interglacial cycles in terms of orbital changes and climate feedback
Nov. 6	Energetics of human civilization				* To assess the major flows of energy in human civilization
Nov. 11	Energetics of human civilization (continued)				* To compare your personal energy flows to those of the average human
Nov. 12				PROBLEM SET 2: Energy Audit DUE	
Nov. 13	The Kaya identity / Intro to climate change	L&B ch. 20, Steffen et al. (2011)	Rockstrom (2010) TEDGlobal	PROPOSAL DUE FOR FINAL PAPER	* To understand the relationship between population, affluence, technology and environmental impact * To describe the fate of human emissions of carbon dioxide and their impact on the Earth's energy balance
Nov. 18	Global climate change: Projections	Morton ch. 9, Hansen et al. (2013)	Ensia (2013), Balog (2009) TEDGlobal		* To understand how projections of climate change are constructed from relationships like the Kaya identity * To assess how the climate will respond to different future greenhouse gas emissions scenarios
Nov. 20	Global climate change: Impacts	American Climate Prospectus, Preface and ch. 2-4	Arroyo (2012) TEDGlobal		* To identify major impacts of climate change of human systems
Fri.	Extra-credit Symposium: Regional Climate Summit (RSVP at climatechange.rutgers.edu)				

Nov. 21					
Nov. 25	Global climate change: Mitigation and Policy		MacKay (2012) TEDxWarwick		* To understand the technological options for decarbonizing the energy system * To understand the policy options and ethical issues associated with climate change
Nov. 27	THANKSGIVING -- NO CLASS				
Dec. 2	Life in the Universe	L&B ch. 21, Lemonick (2013)	Tyson episodes 11, 13		* To assess key factors needed for the emergence of intelligence life in the universe
Dec. 4	*Futures of civilization*			FINAL PAPER DUE	* To compare and evaluate alternative visions for human-Earth system interactions
Dec. 9	MIDTERM EXAM 2				