01:460:203* Building and Maintaining a Habitable Planet *(21C, NS)
Rutgers, the State University of New Jersey, Fall 2016
Tuesdays/Thursdays 3:20-4:40pm, Wright Labs 231, Busch Campus

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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: How do habitable planets operate as systems? What makes the Earth's climate well suited for life, while Mars is at best marginally so and Venus totally uninhabitable? How does human civilization fit into our planet's 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 system feedbacks, energy, entropy, evolution, extinction, and carbon cycling 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 and on first occurrence will lead to a failing grade on the assignment. On collaborative assignments, all group members should be clearly identified and all are responsible for ensuring the integrity of all group products.

Attendance

Much of the learning in the course will take place in the class sessions. We will engage in numerous in-class group activities, and if you are not here, your absence will be missed both by me and by the classmates with whom you are working.

Accordingly, 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, even for catching Pokemons. 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.

Accomodations for disabilities

Rutgers University welcomes students with disabilities into all of the University's educational programs. In order to receive consideration for reasonable accommodations, a student with a disability must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation: https://ods.rutgers.edu/students/documentation-guidelines. If the documentation supports your request for reasonable accommodations, your campus's disability services office will provide you with a Letter of Accommodations. Please share this letter with your instructors and discuss the accommodations with them as early in your courses as possible. To begin this process, please complete the Registration form on the ODS web site at: https://ods.rutgers.edu/students/registration-form

Active Citizenship

Part of the goal of this course, and of your Rutgers education as a whole, is to facilitate your activities as an active global citizen. In a democracy, voting in elections is the most basic level of being a citizen. For those of you who are U.S. citizens, I strongly encourage you to make sure you are registered to vote, and to vote in the general election on Tuesday, November 8.

Voter registration applications must be postmarked by Tuesday, October 18. You may choose to register either at your home address or your college address. If you have moved since you last registered (including between dorms), you should update your registration. To check your registration in New Jersey, or to determine your polling location, visit http://www.njelections.org/voting-information.html. For more information, visit: http://yppp.rutgers.edu/ru-voting/ru-registered/

Assessment and Grading (Subject to Revision)

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

10%: Reading questions
15%: Class participation
15%: Homework assignments
60%: Exams

We will have three exams in this class.

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 7:59am before each class session. This deadline is enforced by the submission system and has no exceptions. (I encourage you, however, to complete the questions significantly more in advance than this.) These questions 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.

It is your responsibility to check the Tests & Quizzes section of Sakai regularly for reading questions – you should assume these will be posted regularly, and you may not be reminded of this regularly in class.

Homework assignments

The homework assignments complement class activities, giving you additional hands-on expeiences with the relationships and quantitative mechanics of the Earth system. When specified, you are welcome to collaborate on the assignments. 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. For writing assignments, your words must be your own.

Extra credit

You may obtain extra credit in the class by attending astrobiology and climate change-related seminars, lectures, and symposia on campus and writing 1 page summarizing and critiquing the concepts discussed in the event. These extra credit summaries should be submitted through the Assignments section on Sakai. A number of extra credit events are denoted on the course schedule; I may add others, and you are welcome to highlight possibilities to me.

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 (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:

Jim Bell (2006), The Red Planet's Watery Past, *Scientific American* (Dec.), 63-69.
Rasmus Benestad (2010), A simple recipe for the greenhouse effect, http://goo.gl/zCaM
Lee Billings (2004), Onward to Europa, *Aeon.* http://aeon.co/magazine/science/its-time-to-look-for-life-in-europas-ocean/
T. C. Chamberlin (1890), The method of multiple working hypotheses. *Science* (old series) 15: 92.
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.
Excerpts from T. Houser et al. (2015), *Economic Risks of Climate Change: An American Prospectus*. http://www.climateprospectus.org.
James Kasting, Owen Toon and James Pollack (1988), "How Climate Evolved on the Terrestrial Planets," *Scientific American,* Feb. 1988: 90-97.
C. Kirkwood (1998), System beavior and causal loop dynamics. *System Dynamic Methods: A quick introduction*. Ventana systems.
J. Kirschvink (2005). Red Earth, White Earth, Green Earth, Black Earth. Engineering & Science (4): 10-20.
E. Lakdawalla (2013). Mars' chemical history: Phyllosian, Theiikian, Siderikian, oh my. http://www.planetary.org/blogs/emily-lakdawalla/2013/12051108-mars-chemical-history.html
G. Landis (2011). Terraforming Venus. *AIAA Space 2011 Conference & Exposition.*
Excerpts from James Lovelock (1988), *The Ages of Gaia* (ISBN 0393312399)
C. McKay (2009). Planetary ecosynthesis on Mars. In: *Exploring the Origin, extent and Future of Life*, C. Bertka, ed., Cambridge University Press, pp. 245-260.
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)
D. Sasselov and D. Valencia (2010). Planets we could call home. *Scientific American* (Aug), 38-45.
Will Steffen et al. (2011), "The Anthropocene: From global change to planetary stewardship," *AMBIO* 40:739-761.
Vox.com (2015). NASA's sending a probe to Jupiter's moon Europa. It might be home to life. http://www.vox.com/2015/2/16/8045979/europa-moon-jupiter

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
Carl Sagan (1994), Pale Blue Dot. http://youtu.be/4PN5JJDh78I
Gavin Schmidt (2014). The emergent patterns of climate change, TED2014. http://www.ted.com/talks/gavin_schmidt_the_emergent_patterns_of_climate_change
Lord Nicholas Stern (2014). The state of the climate – and what we might do about it, TED@Unilever. http://www.ted.com/talks/lord_nicholas_stern_the_state_of_the_climate_and_what_we_might_do_about_it

Preliminary Course Schedule

This schedule is a work in progress and will be updated on Sakai over the course of the term.

Day	Topic	Readings	Videos	Assignments	Learning goals
Sep. 6	Introduction and Scientific Reasoning	Syllabus	Sagan (1994)		* To distinguish between scientific and non-scientific explanations of cosmological and geological phenomena * To understand the use of models in scientific reasoning
Sep. 8	Astronomical time	Sagan (1996) ch. 2; L&B ch. 2 *Optional:* Chamberlin (1890)	*Optional:* Tyson episodes 1, 4, 13		* To identify key traits of dating techniques * To assess the age of the universe from red-shift data
Sep. 13	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
Sep. 15	The Earth as a system	Morton 2.1, 4.1; L&B ch. 1; Kirkwood ch. 1			* To explain the relationship between life and entropy * To explain how feedbacks can stabilize or destabilize complex systems * To construct causal loop diagrams explaining systems behavior
Sep. 20	Causal loop diagrams				
Sep. 22	Natural systems (con’t)	Lovelock (1988) ch. 2-3	NASA (2012)		

Sep. 26	EXTRA CREDIT: Rep. Bob Inglis evening public lecture http://climateenergypolitics2016.weebly.com/				
Sep. 27	Daisyworld				* 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
Sep. 29	Daisyworld (con't)	Benestad (2010); L&B 9.4, 9.5			
Oct. 4	The greenhouse effect / Review			Assignment 1: Daisyworld Simulation	* To apply the concept of the greenhouse effect to explain the difference between blackbody and surface temperatures on the Earth
Oct. 6	EXAM 1 (Covers through Daisyworld)				
Oct. 11	Greenhouse effect (con't)	Morton 5.2, 6.2; L&B 9.6	Tyson episode 12	`	
Oct. 13	Earth's climate feedbacks				* To assess the role of positive and negative feedbacks in regulating Earth's climate on different timescales
Oct. 18 (NJ VOTER REGISTRATION DEADLINE)	The planetary habitable zone	Kasting et al. (1988), Sasselov (2010)			* To explain the climatic differences between Earth, Venus and Mars using the concepts of the greenhouse effect and Earth system feedbacks

Oct. 20		Landis (2011)			
Oct. 25	Venus	McKay (2009), Bell (2006), Lakdawalla (2013)			
Oct. 27	Mars			Assignment 2: Planetary climates	
Oct. 27	EXTRA CREDIT: Prof. Kopp evening public lecture				
Nov. 1	Brief history of life /review	Morton ch. 7, L&B ch 18			
Nov. 3	EXAM 2 (covers through Mars)				
Nov. 8	ELECTION DAY – No class				
Nov. 10	Natural climate variability	L&B ch. 19, Morton ch. 8			* 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. 15	Energetics of human civilization				* To assess the major flows of energy in human civilization
Nov. 17	Energetics of human civilization (con't)	L&B ch. 20, Steffen et al. (2011)	Rockstrom (2010) TEDGlobal		* 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	EXTRA CREDIT Rutgers Climate Institute symposium				

Nov. 22	Kaya Identity	Morton ch. 9, Hansen et al. (2013)	Ensia (2013), Balog (2009) TEDGlobal, Schmidt (2014) TEDGlobal	Assignment 3: Energy audit	* To compare your personal energy flows to those of the average human * To understand how projections of climate change are constructed from relationships like the Kaya identity
Nov. 24	THANKSGIVING — NO CLASS				
Nov. 29	Global climate change: Projections and Impacts	Houser (2015) Preface and ch. 2-4	Arroyo (2012) TEDGlobal		* To assess how the climate will respond to different future greenhouse gas emissions scenarios * To identify major impacts of climate change of human systems
Dec. 1	Global climate change: Solutions	IEA (2015)	MacKay (2012) TEDxWarwick, Stern (2014) TEDGlobal		* To understand the technological options for decarbonizing the energy system
Dec. 6	Global climate change: US policy in a new administration				* To critique proposed climate policies of the new U.S. administration
Dec. 8	Review				
Dec. 16, 9-11am	EXAM 3				