

**CORE 103**  
**The Process of Change in Science**  
THE DISCOVERY OF GLOBAL WARMING  
Fall 2023

## Course Description

*Synopsis* Today there is a quasi-absolute scientific consensus that human activities are warming the planet. How did we go from the idea that Earth was too vast and powerful for humans to possibly change, even comprehend, to the recognition that Earth's surface is a collection of fragile systems that humanity must manage and preserve for its own survival? This class will survey the discovery of global warming, whose 200-year history mirrors the fundamental progress of science: quantum physics, electromagnetism, fluid dynamics, biogeochemistry, radioisotope chemistry, chaos theory, ecology, supercomputing, state estimation, and the theory of complex adaptive systems. The journey will teach us much about the nature of scientific inquiry, the culture of "organized skepticism" at the root of scientific progress, and the emergence of scientific consensus based on a confluence of evidence involving theory, direct and indirect observations, as well as experiments *in silico*.

*Requirements* An open mind

## General Information

### *Instructors*

Professor:	Julien Emile-Geay	ZHS 275	<a href="mailto:julieneg@usc.edu">julieneg@usc.edu</a>
Teaching Assistant:	Alexander James	ZHS 275	<a href="mailto:akjames@usc.edu">akjames@usc.edu</a>

### *Where/When*

**Class** meets Tues/Thurs, 12:30–1:50 in **DMC101**

**Discussions** meet Fri at 9:00 or 10:00 in THH209 (register separately).

**Special events** Wed evenings, time TBD.

*Office Hours* Th 10-12:00 or by appointment. Zoom option possible when I am not on campus.

*Connectivity* All contact hours are designed to be interactive, and involve writing.

A recorded Keynote presentation will be posted no more than 24h after each class period. The latter will be used to clarify aspects that need to be, or delve deeper into topics of interest to you. Friday's discussion sections are highly interactive group discussions, based on assigned readings. A short written assignment pertaining to this reading will be due each Friday at class time, and group writing will be expected in each discussion section.

**Blackboard:** announcements, assignments, course materials, link to lectures.

Access at <https://blackboard.usc.edu>.

**Zoom:** recorded lectures

**Slack:** optional Slack channel in the **USC Dornsife workspace**. May be used for asynchronous discussions with everyone in the class, at your discretion. Standard rules of respectful online behavior apply. Enrolled students will receive an invitation the first week of class.

- Field trips* Field trips are scheduled on Fridays, 10am – 5pm. Three amazing trips:
1. Mount Wilson Observatory in the scenic San Gabriel mountains. This is where galaxies, and the expansion of the Universe, were first observed.
  2. the urban swamp of the La Brea Tar Pits, for a look behind the scenes at their unique collections, informing of megafaunal responses to fire and humans.
  3. NASA’s Jet Propulsion Laboratory, sending robots to Mars and Starshades to the edge of the solar system. And keeping eyes on Earth, too.

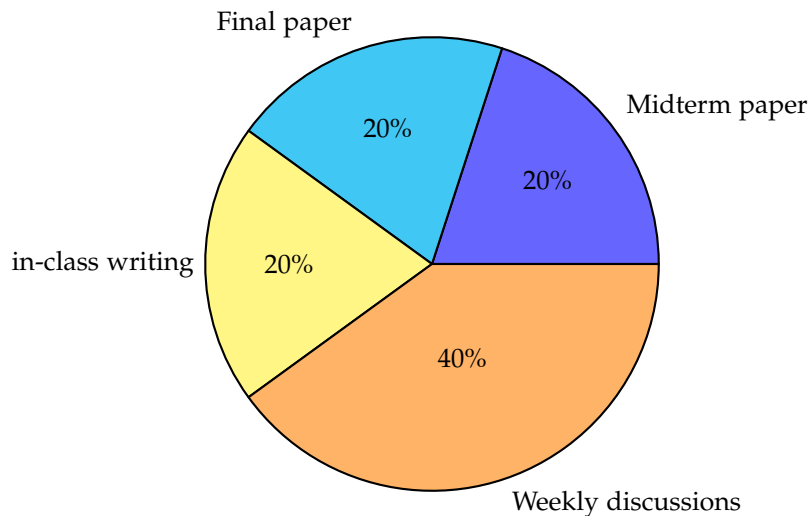
**Books**

*Required Books*

- Weart, Spencer R., *The Discovery of Global Warming*, 2nd edition, ISBN:978-0674031890. [URL](#)
- Archer, D. and Pierrehumbert, R., *The Warming Papers: The Scientific Foundation for the Climate Change Forecast*. ISBN: 978-1405196161. [URL](#) (hereafter, “WP”)

*Supplemental Reading*

- Oreskes, N. & Conway, E., *The Collapse of Western Civilization: A View from the Future*, [URL](#)
- Edwards, P.N., *A vast machine: Computer Models, Climate Data, and the Politics of Global Warming*, ISBN: 978-0262013925 [URL](#).



*Grade*

The class is worth 4 units, which means that it requires assiduous and substantial work. Attendance to discussion sections is mandatory (register separately, please). You will write two papers: a midterm and a final. At each week’s discussion (12 total), short written assignments will be given and graded. The remaining 20% of the grade will be based on in-class writing. You will get full marks for completing at least 90% of those. If circumstances beyond your control compel you to miss more than 10% of assignments, please reach out the instructors as early as you can to figure out a solution. We’re all the same side, but we can’t help those who don’t help themselves.

Table 1: Numeric to letter grade conversion (cutoffs)

< 60	60	63	67	70	73	77	80	83	87	90	≥ 94
F	D-	D	D+	C-	C	C+	B-	B	B+	A-	A

## Schedule

### I LIGHT & MATTER

#### **Week 1 — 08/21/23— Foundations**

Reading: [Weart, Chapter 1](#).

**Tuesday** A brief history of global warming. Climate's Three Big Questions.

**Thursday** Earth's temperature: Fourier's Footing and Forays

**Friday** No discussion (starts in week 2).

#### **Week 2 — 08/28/23— Thermodynamics**

Reading: WP, Chapter 1 + [Pierrehumbert, \[2004\]](#).

**Tuesday** Energy and the First Law. Statistical mechanics and atomism.

**Thursday** The kind of motion we call heat. Entropy and the Second Law.

**Friday** Discussion: The temperature of the celestial sphere.

#### **Week 3 — 09/04/23— Radiant Energy**

Reading WP, Chapters 2 & 3. [Simple Climate, Arrhenius. Pierrehumbert \[2011\]](#).

**Tuesday** The Nature of light. Maxwell's equations. Planck's law

**Thursday** Light & Matter. The Quantum Revolution.

**Friday** Mount Wilson visit?

#### **Week 4 — 09/11/23— Planetary Energy Balance**

Reading: [Pierrehumbert \[2011\]](#). WP, Chap 4; [The CO<sub>2</sub> theory of Gilbert Plass](#).

**Tuesday** The Greenhouse Effect

**Thursday** Climate Feedbacks

**Friday** Discussion: "By the Light of the Silvery Moon".

#### **Week 5 — 09/18/23— Monitoring Earth**

Reading WP, Chapter 12. [A vast Machine, Chap 1](#). [The modern temperature record](#)

**Tuesday** Taking Earth's temperature

**Thursday** Eyes on Earth

**Friday** Discussion: "The Callendar Effect"

### II FROM ATOMS TO PLANETS

#### **Week 6 — 09/25/23— The Carbon Cycle**

Reading WP, Chapter 13. [Simple Climate: Suess; Broecker; Keeling](#).

**Tuesday** Short-term carbon: The Keeling Curve

**Thursday** Long-term carbon: plate tectonics

**Friday** Discussion: The Carbon Cycle.

**Week 7 — 10/02/23— Atomic Science, Cold War Science**

**Reading:** *Atoms in trees; World's loneliest tree records the Anthropocene; The age of the Earth; Simple Climate, Dansgaard*

**Tuesday** Nuclear Physics: isotopes and atomic bombs

**Thursday** Cold War Science (guest lecture by Andy Lakoff)

**Friday** Discussion: Atoms for Earth.

**Week 8 — 10/09/23— Space and Time**

**Reading** *Wear: Venus & Mars; The Sixth Extinction*

**Tuesday** A journey in space: Mars, Earth, Venus and the solar system.

**Assignment** Midterm Paper due.

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**FALL BREAK : Oct 12 – 15**

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**Week 9 — 10/16/23— Paleoclimatology**

**Reading:** *Wear: Ice Age Cycles; Simple Climate: Milankovitch; Broecker, part II.*

**Tuesday** Quaternary Ice Ages

**Thursday** Abrupt climate change

**Friday** Discussion: paleoclimates

**III SCIENCE IN SILICO**

**Week 10 — 10/23/23— Climate modeling**

**Reading** WP, Chapter 5 (Manabe & Wetherald 1967). *Schmidt: the physics that we know; Simple Climate: Manabe; Wear: GCMs.* Edwards: History of Climate Modeling.

**Tuesday** General Circulation Models.

**Wednesday** The computing revolution (guest lecture TBD)

**Thursday** The Attribution of Climate Change.

**Friday** Discussion: Climate Modeling

**Week 11 — 10/30/23— Chaos and Order**

**Reading** WP, pp 241–254. (Charney Report). *What is Chaos Theory?. Wear, "Chaos". The Science Behind the Butterfly Effect*

**Tuesday** Laplace and Lorenz: living on a butterfly's wings

**Thursday** Weather vs Climate Prediction

**Friday** Discussion: Predicting Climate

**Week 12 — 11/06/23— Experiments *in silico***

**Reading** Oreskes & Conway: The Collapse of Western Civilization; *Wear: Impacts*

**Tuesday** Climate Impacts

**Thursday** Climate Solutions

**Friday** Field Trip to La Brea Tar Pits?

#### IV SCIENCE: FROM WAR WINNER TO CULTURE WAR

##### **Week 13 — 11/13/23— On the shoulder of giants**

Reading **How do you know a paper is legit?**; Schermer: Why Climate Skeptics Are Wrong.  
**ExxonMobil's climate communications**

Tuesday Scientific progress & consensus

Wednesday? Movie night: Merchants of Doubt

Thursday Good Science, Bad Science, and Ugly Science

Friday Discussion: Consensus & Denial

##### **Week 13 — 11/13/23— Decoding the Mind**

Assignments Podcast: **tribal psychology**; Hoffmann: **Climate Science as Culture War**;

Tuesday motivated reasoning, confirmation bias, identify-protective cognition

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### Thanksgiving Break Nov 22–26

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##### **Week 15 — 11/27/23— Climate Narratives**

Assignments Podcast: **tribal psychology**; Hoffmann: **Climate Science as Culture War**;

Tuesday Dueling narratives: Climate vs Capitalism, People, Planet & Profit.

Thursday Rewriting the Climate Story

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### Dec 10 – Final Paper due

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#### V PARTICIPATION

Class participation is a critical aspect of this course. The first way to participate in class is to show up to class and discussions. However, *active participation* is what we're after: ask questions, offer comments. You are not required to know much science to take this class, so there is no such thing as a stupid question; also, we will encounter many controversial topics, in which your opinion matters – it would be too bad to keep it for yourself. Please contact the instructor if you are not able to attend sessions for any reason.

#### VI PAPERS

##### **Midterm Paper**

In this paper you will write a 6-10 page paper following the process of change in a branch of (any)science. It can be related to what we have seen in class, but that is not an absolute requirement.

##### **Term Paper**

This paper will allow you to develop your own topic based on class material, or choose from one of the following: *From Stasis to Crisis*; *From Biosphere to Noosphere*; *Science & Agnotology*; *Civilization as a geosystem*; *Natural Laws vs Human Nature*; *Anthropocentrism & Anthropocene*; *Revolutions in Earth Science*;

#### VII TECHNOLOGY

##### **USC technology rental program**

Attending classes online and completing coursework remotely requires access to technology that not all students possess. If you need resources to successfully participate in your classes, such as a laptop or internet hotspot, you may be eligible for the university's equipment rental program. To apply, please **submit an application**. The Student Basic Needs team will contact

all applicants in early August and distribute equipment to eligible applicants prior to the start of the fall semester.

### **Blackboard**

BlackBoard is our primary medium of communication outside the classroom. It is where I post class notes, announcements, and assignments. It is where you access that content, participate in discussions, and check your grades. **It is your responsibility to ensure that you receive BlackBoard announcements.** Make sure you enable email notifications, and importantly, make sure your inbox is not full; every year I get emails bounced from students too neglectful to clean up their inbox. If you have a doubt about when an assignment is due, go check it on BlackBoard. Also note that BlackBoard messages are richer than the email notifications they generate. Frequently, the announcements contain links to content archived on BlackBoard – those links will not appear in the emails. If the email digest you read does not make sense, please check it on BlackBoard; it might have the answer you need. If it still doesn't, please email me.

### **USC Technology Support Links**

**Zoom** information for students: <https://keepsteaching.usc.edu/start-learning/>

**Blackboard** help for students : <https://studentblackboardhelp.usc.edu>

**Software** available to USC Campus: <https://software.usc.edu>

## VIII ACADEMIC CONDUCT

### **Integrity**

The University of Southern California is foremost a learning community committed to fostering successful scholars and researchers dedicated to the pursuit of knowledge and the transmission of ideas. Academic misconduct is in contrast to the university's mission to educate students through a broad array of first-rank academic, professional, and extracurricular programs and includes any act of dishonesty in the submission of academic work (either in draft or final form).

This course will follow the expectations for academic integrity as stated in the USC Student Handbook. All students are expected to submit assignments that are original work and prepared specifically for the course/section in this academic term. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s). Students suspected of engaging in academic misconduct will be reported to the Office of Academic Integrity.

Other violations of academic misconduct include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see the [student handbook](#) or the [Office of Academic Integrity's website](#), and university policies on [Research and Scholarship Misconduct](#).

## Plagiarism

Presenting someone else's ideas as your own, either verbatim or recast in your own words, is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in [SCampus](#) in Section 11, [Behavior Violating University Standards](#). Other forms of academic dishonesty are equally unacceptable. See additional information in [SCampus](#) and university policies on [scientific misconduct](#). These comments apply as well to text generated by artificial intelligence.

## Generative Artificial Intelligence

In a few short months, generative A.I. tools like ChatGPT have taken academia by storm and rocked the very foundations of the college experience. Mindfully used, large language models (LLMs) can be incredible tools to boost productivity and get your creative juices flowing; mindlessly used, they will stifle your creativity, dull your critical thinking, and stunt your intellectual growth. In an age where AI's capabilities are rapidly catching up with humankind's, your only competitive edge going forward is to use your limitless creativity to do what machines can never do: imagine, dream, intuit, critically evaluate and create. If you surrender to them now, there is no future for you.

In this class, instructors will assume that, if you are using LLMs, you are doing so mindfully and ethically. That means:

- critically evaluating their output
- keeping a record of the conversation you had with the chat bot, and documenting your prompts (e.g. in an appendix)
- appropriately [crediting](#) the LLM in your written assignments
- providing adequate citations for every statement made by the algorithm. That's right: even if ChatGPT ad libs without citations, you, the writer, are not exempt from basic intellectual honesty, and must substantiate argumentative points with actual references. ChatGPT is currently bad at this, though it may no longer be so by semester's end.

Some writing assignments will explicit leverage ChatGPT, and ask you to critique its output based on what you know. However, you are under no obligation to use them for other assignments ; in fact, we strongly advise you to think without the crutch of an AI, lest you want to be replaced by one.

## Discrimination

Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the [Office of Equity and Diversity](#) or to the [Department of Public Safety](#) . This is important for the safety whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can help initiate the report, or can initiate the report on behalf of another person. The [Center for Women and Men](#) provides 24/7 confidential support, and the [Relationship and Sexual Violence Prevention and Services webpage](#) describes reporting options and other resources.

## IX SUPPORT SYSTEMS

### **Trojans Care For Trojans (TC4T)**

An initiative within the Office of Campus Wellbeing and Crisis Intervention that empowers USC students, faculty and staff to take action when they are concerned about a fellow Trojan challenged with personal difficulties.

A [private and anonymous request form](#) provides an opportunity for Trojans to help a member of our Trojan Family.

**Office of the Ombuds** The UPC Ombuds Office is located at the University Park Campus in room 203A of the URC (University Religious Center)\* located at 835 W. 34th Street. To schedule an appointment with the UPC Ombuds, please call (213) 821-9556. <https://ombuds.usc.edu>

**Student Counseling Services (SCS)** (213) 740-7711 – 24/7 on call

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

<https://sites.usc.edu/counselingandmentalhealth/>

**National Suicide Prevention Lifeline** –1-800-273-8255

Provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

<http://www.suicidepreventionlifeline.org>

**Sexual Assault Resource Center** For more information about how to get help or help a survivor, rights, reporting options, and additional resources, visit the website: <https://sites.usc.edu/clientervices/>

**Office of Equity and Diversity (OED)** (Title IX compliance) – (213) 740-5086

Works with faculty, staff, visitors, applicants, and students around issues of protected class. <https://equity.usc.edu/>

**Diversity at USC** Tabs for Events, Programs and Training, Task Force (including representatives for each school), Chronology, Participate, Resources for Students.

<https://diversity.usc.edu/>