

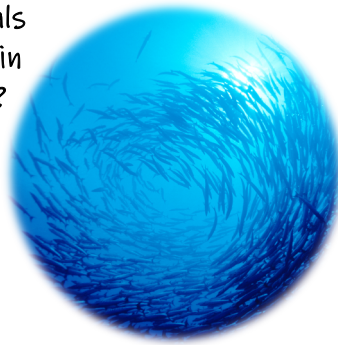
GEOL 165: Metals and life on Earth

Prof. Seth John; T/Th 11-12:20

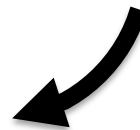
All of life on Earth depends on metals such as iron, zinc, and chromium, which are crucial micronutrients for every living thing, from the microscopic algae which inhabit the ocean, to animals, to humans. Metals can also be toxic to life when their concentrations are too high, and many of the most notable public health disasters relate to metal contamination in the environment, such as elevated lead from the burning of gasoline, the poisoning of well water with arsenic, and the health impacts of mercury poisoning in the Arctic.

This class will explore the role of metals in life. We will start with the origin of the universe and the creation of metals, explore the unique chemistry of metals which allows them to have so many important biological functions, and discuss numerous examples of the ways in which metals have affected human life and our environment. Topics of discussion will include the role of metals in the first cells on earth, “geoengineering” Earth’s climate by adding iron to the ocean in order to stimulate algae blooms, and public health disasters including the occurrence of lead in the Flint, Michigan water supply and arsenic in California groundwaters.

How do metals support life in the oceans?



How does metal pollution affect human life?



What role did metals play on the early Earth?

GEOL 165: Metals and life on Earth Syllabus for Fall 2024

Instructor: Prof. Seth John
Office ZHS 271, ph. x00696, email: sethjohn@usc.edu
Office hours: by appointment

Teaching Assistant: Cat Odendahl

TAs will announce their office hours during discussion section meetings.

Lectures: Tues & Thurs, 1:30-2:50, SAL 101.

Lab sections: 2 hours per week, in ZHS B56

You may not switch lab times without approval of the TA

- The first lab/discussion section will meet during the 2nd week of the semester — DO NOT MISS THE FIRST SECTION MEETING!

Readings: Assigned readings are listed below. A small number of additional readings may be added as the semester proceeds.

About this course

Catalogue Description: The role of metals in life, from the origin of life to modern environmental problems. Lecture - 3 hours/wk; discussion/lab - 2 hours/wk.

More detail: Metals are integral to the chemistry of life. This course will explore the relationship between metals and life, starting at the beginning of the universe and working up to modern day environmental problems. The chemistry and reactivity of metals will be explored in order to understand what makes metal atoms so special. The history of metals in the universe, in the solid Earth, and in the oceans will be explored. Then we study the specific biological roles which metals play in life processes such as photosynthesis, respiration, and cellular replication, followed by a more specific focus on the role of metals in human health. These topics will be explored through several case studies, including the role of iron (Fe) in the oceans, the man-made contamination of the environment with lead (Pb), the contamination of drinking water with arsenic (As), and the contamination of the food chain with mercury (Hg).

There are several themes that we intend to develop in this class, and these will unite the material we cover. These include:

- exploring how the **basic chemistry** of metals determines their chemical reactivity, and how that chemical reactivity determines their role in life
- learning the **language of science**, by comparing scientific journal articles to magazine articles written for the general public, to newspaper reports of scientific issues
- an appreciation of **data visualization**, the ways in which scientists and writers turn quantitative data (numbers) into figures (pictures) in order to convey ideas.

Learning objectives: By the end of the class, you should have gained a greater appreciation for the role of metals in biology, and how interactions between metals and biology influence life on earth. Metal biochemistry is just one small part of science, but by diving deeply into a few details of this field, I hope that you will not just learn new subject matter, but that you will also learn how science is done. As you begin to understand the language scientists use to describe their work and their findings, I hope you will appreciate what professional scientists do all day, and what it is which makes science such a fun (and occasionally frustrating) endeavour.

This course is intended for students with little or no science background, but it will require scientific and numerate thinking. In the process of exploring metals and life, the class will meet the learning objectives of the [USC General Education program](#) related to the Life Sciences ([Category GE-D](#)), including:

- gain an appreciation for science's influences and applications to society in the past, present and future;
- gain a better understanding of scientific methods; from constructing models of the natural and living world, to testing the validity of these models using empirical evidence;
- understanding how data are generated, presented and interpreted
- learning how scientific discovery spurs technology growth and impacts society

All of these learning objectives are woven into every lecture addressed in some way in every reading assignment and lecture.

Class logistics

1. Grading - Grades are based on the following point system:

Midterm Exam 1:	150 points
Midterm Exam 2:	150 points
Final Exam:	300 points
In-class quizzes:	150 points
Lab/discussion sections:	250 points
Extra credit	50 points

Total possible: 1050 points

At the end of the semester, **grades are assigned as follows: >930 = A; 900-929 = A-, 850-899 = B+; 800-849 = B; 750-799 = C+; 700-749 = C; 650-699 = D+; 600-649 = D; 0-599 = F.** I will try to give an indication around the middle of the semester about where each student stands. ***If you are caught cheating on any portion of the class, whether exams, in-class responses, or other, you will be withdrawn from the class with a grade of F.***

2. Lectures – A schedule of lecture topics is below. *You are expected to attend lectures in person*, and you will not be able to receive credit for quizzes unless you are in class when the quiz takes place. Lecture slides will be posted on Blackboard, but in order to learn the class material you must attend, listen, and engage yourself in the lectures.
3. Assigned reading – Most weeks there will be an assigned reading for class. ***The readings will be difficult, but they are important, you should expect to spend a few hours each week completing the reading.*** Generally these assigned readings complement the in-class lecture material, and will be discussed during lecture. However, there is always more detail in the readings than I can cover in lectures, and *exams may include questions based on the assigned readings, whether or not that material was covered during lecture.*
4. Exams – The exams will be multiple-choice. The final exam will be an integrative evaluation, drawing on your knowledge from the whole course. Make-up exams are generally not permitted except in extreme circumstances such as a medical emergency. If you have to miss an examination because of illness or a USC-sanctioned event (such as athletic competition), you must provide notice (email is OK) before the exam start time, and you must provide documentation (afterwards is fine).
5. Recitation/lab sections – Recitation/lab sections account for a significant portion of your grade (25% of the total) and will be assessed based on your participation in the class activities and discussion as well as assignments. Material from discussion/lab sections will show up on the exams, even if it was not directly discussed in lecture.
6. In-class quizzes/written assignments – You will have the opportunity to respond to class material by answering in-class questions by writing a few sentences or drawing diagrams on notecards, or by submitting answers to PollAnywhere questions. There are no make-ups if you miss these quizzes.
7. Extra credit – There is an opportunity for extra credit in this class, but it is not an ‘easy’ way to get points. In general, the best way to get a good grade in class is to attend regularly so that you receive all of the in-class quiz points, to attend lab regularly and complete the homework, to attend and pay attention in lectures, and to study hard for exams.

However, occasionally a student wants to engage with the class material in a unique, surprising, and exciting way. Past examples included a student who measured arsenic contamination in their home town over Thanksgiving break and wrote a report on the results, two students who wrote and performed a musical video on the class material, a screenplay including elements of lead poisoning, and a student who created a GIS interface to look at Pb data from the labs. All of the projects described above yielded between 25 and 50 points of extra credit. Uninspired projects receive little credit, for example a rather uninteresting summary of the health effects of metals based on reading the internet, lyrics for a song metals which I thought didn't make much sense, and a marketing report on makeup that only included a few sentences about metals in makeup, each of which received 0 to 5 points. *The key to success is that the project should be unique and original to you, and should demonstrate your individual interests and passion.* In contrast, anything which could have conceivably have been written by ChatGPT (even if it was not the product of generative AI and you wrote it yourself) is unlikely to be personal and unique enough to receive points. Students may submit a single project in between the end of class and before the final exam, which will be subjectively graded on a scale from 'not-very awesome' (0-10 points) up to 'very-very-very awesome' (50 points).

8. Blackboard – The TAs and I will try to keep your grade record updated on Blackboard. I will also try to keep PDF copies of lecture slides posted there. However, the PDFs of the lecture slides do not provide all of the information that will be covered in lectures, so do not try to use them as a substitute for attending lectures.
9. Missed lectures – I appreciate that you may have a sick day or an extra-curricular event that forces an absence. Most lectures will be recorded on Zoom, so you can catch up by listening to the lectures afterwards. Also, make sure to keep up with the assigned readings and lecture slides posted on Blackboard. There are no make-up opportunities for missed quizzes.
10. Missed labs – The policy for missed discussion sections is outlined on the separate discussion section syllabus that you will receive during the 1st meeting.

Other important information

Statement for Students with Disabilities

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to Prof. John (or to your TA) as early in the semester as possible. If you approach us the day before an exam, it may be difficult to accommodate all of your needs! DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

Statement on Academic Integrity

USC seeks to maintain an optimal learning environment. Academic honesty means respecting the intellectual property of others, with the expectation that individual work will be submitted unless otherwise allowed by an instructor. Students are obliged both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. Academic misconduct will not be tolerated in this class, and will be subject to disciplinary action.

SCampus, the Student Guidebook, contains the Student Conduct Code in Section 11, with recommended sanctions in Appendix A:

<http://www.usc.edu/dept/publications/SCAMPUS/gov/>

If there is any suspicion of academic dishonesty, students will be referred to the Office of Student Judicial Affairs and Community Standards for further review. The Review process is described at: <http://www.usc.edu/student-affairs/SJACS/>

Further information about USC's guidelines for appropriate scientific conduct can be found here:

<https://policy.usc.edu/scientific-misconduct/>

Statement of University and Instructor Responsibilities and Liabilities

Field and laboratory activities have associated risks. We have worked to minimize these, but neither USC nor the instructors (Prof. John or the TAs) can assume liability. You will be required to sign a USC liability waiver for off-campus fieldtrips, as well as waiver forms for the specific sites where we will be guests. For the lab activities, you will be provided safety warnings and safety equipment, as appropriate. It is your responsibility to maintain safe practices.

Support Systems

USC provides several support services, the details for which can be found at:

<https://undergrad.usc.edu/services/support-systems/>

GEOL 165 Schedule of Lectures

Week	Date	Lecture topic	Reading	Other events
Week 1	Aug 28 Aug 30	Anthropocentric history of the universe The periodic table		
Week 2	Sep 4 Sep 6	Proteins and metalloproteins and ACE-2 How we fight germs for iron	NIH Covid Guidelines: Zinc	
Week 3	Sep 11 Sep 13	History of metals on earth Life in the modern oceans	tbd	Lab I
Week 4	Sep 18 Sep 20	GUEST LECTURE: Phil Kong Trace-metals oceanography Iron in the modern ocean	Pinedo-Gonzlez et al., Anthropogenic Fe	Lab II
Week 5	Sep 25 Sep 27	Ocean iron fertilization I Ocean iron fertilization 2	ExOIS report	Lab III Midterm 1
Week 6	Oct 2 Oct 4	Midterm #1 Mining in the sea	EASAC report	Lab IV
Week 7	Oct 9 Oct 11	Mining on the land Ecological impact of the Gold King Mine	Gold King EPA report	Lab V
Week 8	Oct 16 Oct 18	GUEST LECTURE: Elizabeth John NO CLASS – Fall recess	tbd	Fall recess, no labs
Week 9	Oct 23 Oct 25	Arsenic in drinking water Arsenic local and global	ECAR flyer	Lab VI
Week 10	Oct 30 Nov 1	Mercury and human health GUEST LECTURE: Emily Seelen	tbd	Lab VII
Week 11	Nov 6 Nov 8	Mercury and vaccines Midterm #2	Wakefield et al., RETRACTED	Lab VIII
Week 12	Nov 13 Nov 15	Health effects of Pb Film: The Clean Room	Nriagu, Lead, gout, and the fall of the Roman Empire	Lab IX
Week 13	Nov 20 Nov 22	The use of lead through early history Leaded gasoline and the environment	Tatsumoto and Patterson, Lead in seawater and snow	Lab X
Week 14	Nov 27 Nov 29	NO CLASS – Thanksgiving NO CLASS – Thanksgiving		Thanksgiving holiday, no labs
Week 15	Dec 4 Dec 6	Long term historical records of lead Wrap up and results from this year's labs	McConnell et al., Pb in ice cores	
FINAL EXAM				Date: Tuesday December 12, 8 AM

Readings

Week 2: NIH COVID-19 Treatment Guidelines. **Read: Only the section on Zinc, starting on page 394.**

Week 4: Paulina Pinedo-González, , Nicholas J. Hawco, Randelle M. Bundy, E. Virginia Armbrust, Michael J. Follows, B. B. Cael, Angelicque E. White, Sara Ferrón, David M. Karl, and Seth G. John, 2020. Anthropogenic Asian aerosols provide Fe to the North Pacific. Proceedings of the National Academy of Sciences 117, 27862-27868. **Read: Highlighted sections.**

Week 5: ExOIS White Paper – Ocean Iron Fertilization. **Read: Everything EXCEPT sections 10 and 11.**

Week 6: EASAC Report Deep-Sea Mining: assessing evidence on future needs and environmental impacts. **Read: Everything EXCEPT Table 1, Box 2, Section 3, 4.3, 5.3, 5.5, 5.6**

Week 7: EPA report on Analysis of the Biological Data Collected from the Animas and San Juan Rivers Following the Gold King Mine Release. **Read: Executive Summary, Chapter 1, Chapter 6.**

Week 9: D Hernandez, S Bandaru, K Boden, and A Gadgil. Electrochemical Arsenic Remediation (ECAR). **Read: the whole flyer, it's short!**

Week 10: TBD

Week 11: A J Wakefield, S H Murch, A Anthony, J Linnell, D M Casson, M Malik, M Berelowitz, A P Dhillon, M A Thomson, P Harvey, A Valentine, S E Davies, and J A Walker-Smith, 1998. RETRACTED: Ileal-lymphoid-nodular hyperplasia, non-specific colitis, and pervasive developmental disorder in children. The Lancet 351, 637-641. **Read: Get through as much as you can, definitely the Summary, and the last five paragraphs starting with "Disintegrative psychosis..."**

Week 12: Jerome Nriagu, 1983. Saturnine Gout Among Roman Aristocrats, New England Journal of Medicine. **Read: entire article.**

Week 13: M Tatsumoto and C Patterson, 1963, Concentrations of Common Lead in Some Atlantic and Mediterranean Waters and in Snow, Nature 199, p. 350-352. **Read: entire article.**

Week 15: McConnell et al., 2018. Lead pollution recorded in Greenland ice indicates European emissions tracked plagues, wars, and imperial expansion during antiquity. Proceedings of the National Academy of Sciences 115, 5726-5731.