Department of Geosciences
Guyot Hall
JUNIOR INDEPENDENT WORK / SENIOR THESIS
SHOPPING GUIDE

Are you shopping for a Junior or Senior Project???

Shopping for Prehistoric Ideas? OR Life on Other Planets or the Solar System

Perhaps Field Work OR Life in the Oceans

WHATEVER YOUR CHOICE
CHECK OUT THE GEOSCIENCES SHOPPING GUIDE FOR IDEAS

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NOTES

1. Projects suggested by the faculty members and research staff are listed here. Contact these researchers for further information.

2. In many cases topics suggested are general areas of research. Discussion will be needed to decide on a specific problem and the scope of the project, particularly those which have both Junior Paper and Senior Thesis potential.

3. Feel free to discuss ideas of your own with any faculty member, even those not listed (who had no ideas or did not meet the deadline).

CODES IN LEFT-HAND MARGIN

JP	=	suitable for Junior Independent Work.
ST	=	suitable for Senior Thesis Research.
JP or ST	**=**	could be scaled for either Junior Independent Work or Senior Thesis Research.

Prof. Jie Deng, Room 310 – University Tel. 203-500-6553
Email: jie.deng@princeton.edu

I use atomistic simulations, machine learning, and thermodynamic modeling to study material properties and key processes underlying the formation and evolution of planetary bodies. The projects below are **JP or ST**.

JP or ST 1. Machine learning planetary materials

Machine learning (ML), as a powerful tool to extract complex patterns and relationships from big datasets, is transforming all areas of science. The underlying principle of ML is to search for a suitable algorithm to represent the complex and unknown relationship between the input and output. This principle has been applied to earth and planetary sciences in fields, such as exoplanet autodetection using light curves, seismic phase recognition, thermodynamical model selection, and machine learning atomistic simulations. The present project aims to harness the broad potential of ML to explore the characteristics and properties of planetary materials. Students participating in this endeavor are strongly encouraged to employ machine learning algorithms to investigate materials that pique their interest. By utilizing this cutting-edge technology, participants can uncover novel insights and make significant contributions to our understanding of planetary materials.

JP or ST 2. On the mass-radius relation for Sub-Neptunes

Sub-Neptunes are exoplanets with radii between 1.8–3.5 $R_\oplus$ on orbits with periods less than 100 days. They are very common and yet their detailed properties are poorly understood. A sub-Neptune is composed of a thick H_2-rich atmosphere overlying a massive core (silicate+metal). Due to the blanket effect of the thick atmosphere, sub-Neptunes likely host large magma oceans. As H_2 and H_2O are highly soluble in magmas, a significant amount of the water and hydrogen may be stored in the magma ocean, which substantially affects the mass-radius relation of the host planet. However, this effect is generally ignored due to the lack of data on the partial molar volume of hydrogen and water in the magma. This project aims to employ the *ab initio* methods to determine the partial molar volume of hydrogen and water. The results will be used to revise the mass-radius relation for Sub-Neptunes.

JP or ST 3. Modeling the interior of rocky exoplanets

A large fraction of identified exoplanets is Earth-like, with Fe-rich cores surrounded by silicate mantles. Softwares to characterize the interiors of these rocky planets are scarce, and the only publicly available package (ExoPlex) is not suited to model the possible partial melting of the interiors. This project is designed to 1) convert the classical phase equilibria calculation code HeFESTo written in Fortran to Python; 2) include the thermodynamic datasets for liquids so that the new package will be able to model the partial melting; 3) model the interior structures of selected rocky planets with the new Python package. The new python package will be open source and stored in GitHub. APIs connecting other geophysics toolkits (e.g., Burnman) may also be developed.

Prof. Thomas Duffy, Room 321C – University Ext. 8-6769
E-mail: duffy@princeton.edu

My research involves understanding the structure, composition, and evolution of planets through experimental study of minerals at high pressures and temperatures. Other interests include: mineralogy, high-pressure physics and chemistry, and planetary science. Potential projects are available in any of these areas. Some examples are:

ST 1. **Crystal structure of olivine at high pressure**

Olivine is the most abundant mineral in the Earth's upper mantle. Its phase transitions play a major role in determining the structure of the upper mantle. It is also important in understanding meteorite impact events. In this project, you will use a diamond anvil cell to compress iron-bearing olivine to very high pressures. Laser Raman spectroscopy will be used to identify changes in crystal structure and thermodynamic properties under compression. This is an opportunity to develop hands-on laboratory skills in high-pressure mineral physics research.

JP 1. **Interior structure of large terrestrial-type exoplanets**

Large terrestrial exoplanets with up to ~10 times the mass of the Earth are a novel type of planet not represented in our solar system. The project will involve developing models for the internal structure (density, pressure versus depth) for different sized planets. Of particular interest is how the iron content (and its distribution between the mantle and core) affect the interior structure and the conditions at the core-mantle boundary. The results will enable determination of how the mineralogy varies with depth in planets with different mass and iron content.

JP 2. **Shock compression of minerals**

In laboratory shock wave experiments, minerals are subjected to very high pressures and temperatures on microsecond time scales. Such experiments are relevant to understanding planetary accretion processes, shock metamorphism, and high-pressure phases of planetary interiors. Interpretation of shock wave data requires careful comparison with measurements under static high-pressure conditions. In this project, you will use new high-pressure experimental data on selected minerals to infer the nature of structures formed under the very high pressure-temperature conditions of shock compression.

Prof. John Higgins, Room 212, Guyot Hall, University Ext. 8-7024
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JP 1. What drove Earth's largest $\delta^{13}C$ excursion?

The largest perturbation to the carbon cycle in Earth history, as measured by the stable carbon isotopic composition ($\delta^{13}C$) of marine carbonate rocks, occurred in the Ediacaran Period (635–542 Ma). Known colloquially as the 'Shuram' excursion, workers have long noted its tantalizing, broad concordance with the rise of abundant macro-scale fossils in the rock record, variously interpreted as animals, giant protists, macro-algae and lichen and known as the 'Ediacaran Biota.' Thus, the Shuram excursion has been interpreted by many in the context of a dramatically changing redox state of the Ediacaran oceans – e.g., a result of methane cycling in a low O_2 atmosphere, the final destruction of a large pool of dissolved organic carbon (DOC), and the step-wise oxygenation of the Ediacaran oceans that paved the way for the radiation of animal life.

The Shuram excursion is so large, however, that many wonder whether such a dramatic carbon cycle perturbation is even possible. Therefore, several diagenetic hypotheses have been proposed to explain it alternatively, contending that the signal is caused instead by post-depositional alteration of carbonate rocks. This JP project will be a part of a multi-proxy, field-based study of the Wonoka Formation of South Australia, an Ediacaran-aged carbonate and siliclastic succession which hosts the excursion, to test the various explanatory models. Specifically, the project will be to develop strontium isotope data ($^{87}Sr/^{86}Sr$) from the Wonoka Formation. The $^{87}Sr/^{86}Sr$ of the ocean is influenced by two major, isotopically distinct sources – continental weathering and hydrothermal input from mid-ocean ridges – and has changed over the course of Earth history with changes in global tectonics and paleogeography. As the isotopic composition of Sr changes much more slowly than carbon, a stratigraphic record of $^{87}Sr/^{86}Sr$ will be helpful in discriminating between oceanographic and diagenetic processes that could be driving the Shuram excursion. Discerning which style of model is correct – is it a record of ancient global carbon cycling or of secondary diagenetic processes? – is vitally important to our understanding of the co-evolution of animal life and the surface environment.

JP or ST 2. Modern analogues for snowball Earth cap dolostone?

Learn how to measure a recently developed proxy (magnesium isotope ratios) in recent and ancient dolomites to gain insight into the mechanisms of dolomite formation. Explore implications for the interpretation of snowball Earth cap carbonates. Are recent dolomites an appropriate analogue for snowball Earth cap dolostones? How does the origin of the cap dolostone affect our understanding of the aftermath of a snowball Earth?

JP or ST 3. Investigating Earth's CO_2 thermostat

Learn about the role of silicate weathering in the global carbon cycle on million year timescales. Carry out experiments in the lab reacting seawater with basalt at low temperatures. Quantify rates of alteration using mass spectrometry and explore implications for the role of seafloor weathering in Earth's CO_2 thermostat. How does seafloor weathering affect planetary habitability?

JP or ST 4. Records of ancient seawater chemistry from deep-sea pore fluids

Learn how fluid in the pores of deep sea sediments retain a memory of past ocean chemistry and how we access these records using geochemical measurements and numerical models. Develop and upgrade a database of global pore fluid profiles to identify pristine records. Make state-of-the-art geochemical measurements of the pore fluid and sediment to reconstruct seawater chemistry. Explore implications for our understanding of the global carbon cycle and climate over the last 10-20 million years.

Prof. Adam Maloof, Room 215/213 – University Ext. 8-2844
E-mail: maloof@princeton.edu

Prof. Adam Maloof is on Sabbatical for AY 23-24

I am a field geologist studying Earth history and the limits of global change. My current work involves using modern landscapes and ancient sedimentary rocks to extract information about the coevolution of life and climate.

JP or ST 1. How is climate recorded in the geometry of dendritic channel networks?
Erosional stream networks have fractal branching patterns. The distribution of stream lengths and/or branch angles may be controlled by climate. This project will use available online stream network data and climate indices to test the idea that you can infer something about climate by looking at the geometry of river networks. If one can define such a relationship on Earth, channels on planetary bodies (e.g., Mars, Titan could become useful probes of extraterrestrial climates.

JP or ST 2. The extinction of the Dinosaurs recorded in a Bolivian lake
Sediments from an ancient lake currently outcrop in the Bolivian Altiplano. Radiometric dates from volcanic ash that fell in the lake suggest that the Cretaceous-Paleogene (K-Pg) boundary is preserved somewhere in this stratigraphy. The debate rages about the exact cause of the mass extinction, and few studies have examined the forensics from a restricted lake environment. Your project is to find the K-Pg boundary, using a combination of geophysical and geochemical measurements on samples we have in the lab, and to see if this unique paleolacustrine environment tells us something new about the causes of dinosaur demise. Your work on campus could lead to field research in Bolivia.

JP or ST 3. How do modern carbonates record information about sea water chemistry?
Virtually everything we know about ancient climate history comes from shallow water carbonates (e.g., Bahamas-like environments). However, because we have higher fidelity records of more recent climate change, such as ice cores and deep water fossiliferous sediment, little work has been done to calibrate our understanding of how shallow-water carbonates record changes in climate. In this project, you will work with 3D imagery and samples from the Bahamas or Western Australia to develop an understanding of the patterns in geochemical variability in modern shallow water carbonates. Your data will help you zero-in on the causes of geochemical variability and to sort out changes related to global seawater chemistry versus local processes.

JP or ST 4. A new climate record from Grottes de Bétharram, France
Stalagmites in caves preserve high fidelity records from at least the last half-million years. We collected a suite of beautifully laminated stalagmites from a privately owned cave in France are begging to be studied. Your analyses will include layer-counting (like tree rings), scanning x-ray fluorescence, and carbon and oxygen isotopes. Your goal will be to calibrate recent physical and geochemical patterns to one-hundred years of nearby weather date, and then to use that understanding to build a longer climate record for the Pyrenees.

Prof. Satish Myneni, Room M51 – University Ext. 8-5848
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Research webpages: http://geoweb.princeton.edu/research/geochemistry

Water is essential for the origin and survival of life on our planet and perhaps plays a pivotal role on the existence of life on other planetary bodies as well. In several different forms, water mediates the physical and chemical interactions between various components of the Earth's surface environment, which includes mineral oxides, biota and their byproducts, and the atmosphere. One of the challenges in environmental sciences is to gain a better understanding of interactions between these different components in nature, and to use it to predict a variety of biogeochemical processes such as elemental cycling, biological chemistry of elements, and the fate and transport of contaminants in the environment. This area of research is gaining importance, and researchers from different disciplines began conducting studies to explore these interactions in greater detail. I am interested in exploring one of these fundamental interactions, which include the evaluation of the chemical state of water in different geologic media and how this modifies the biogeochemical behavior of different inorganic and organic moieties in the natural systems. I am also interested in evaluating the chemical state(s) of important geochemical species to develop predictive patterns for explaining their macroscale behavior

All of my projects are related to environmental chemistry, and the research focus is on the macroscale and molecular level observations of various biogeochemical reactions. Background in chemistry is useful for these projects. For senior thesis, these projects involve experimental work with microscopy and spectroscopy tools in my laboratory, Princeton Materials Institute, and those available at the X-ray synchrotrons (such as National Synchrotron Light Source, Brookhaven, NY; Advanced Light Source, Berkeley, CA), and theoretical studies for chemical speciation and spectral analysis. Details of these research projects and results from senior theses submitted by my group members can be obtained from my research group web pages. Some of the available topics for senior thesis and summer research are as follows:

JP or ST 1. Naturally formed halocarbons (halogen containing organic molecules) in the environment.

Focus: Characterization; evaluation of biogeochemical parameters that influence the formation of halocarbons and their behavior in the environment; role of halocarbons in C- and other elemental cycles. Research includes field trips for water, soil and sediment sampling in Pine Barrens (NJ) and the nearby estuarine environments, detailed analysis either in our laboratory or in the campus. The following picture shows one of our field sites in Pine Barrens, NJ.

JP or ST 2. Chemistry of naturally occurring organic compounds in the environment.
Chemistry; molecular structure; reactions with minerals in soils and sediments, and their role in interfacial reactions in the natural systems.

JP or ST 3. Environmental chemistry of contaminants.
Biogeochemistry of selected contaminant metals in soil, sediment and aquatic systems, and their biological accumulation.

JP or ST 4. CO_2 reactions with geologic media.
The focus is on the influence of elevated atmospheric- and soil/sediment-CO_2 on mineral weathering and carbon storage in terrestrial systems, water quality, and biogeochemistry. This study involves prediction of mineral-fluid equilibria from thermodynamic speciation, and conduct laboratory investigations to verify these predictions for reactions at different time scales (direct laboratory experiments for reactions at short time scales, and observations from mineral weathering for long time scales). Field sampling is necessary at the Mammoth Mountain (CA).

Prof. Michael Oppenheimer - University Ext. 8-2338 - 313 Robertson Hall
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ST 1. Equity implications of US heat stress policy

Extreme heat events have large mortality consequences, which are concentrated amongst the most vulnerable in society. Adaptation through air conditioning (AC) purchasing has been shown to drastically reduce these mortality consequences, however AC technology is expensive and therefore not universally available. One solution, which has been rolled out in cities across the US, is to invest in public cooling centers in which vulnerable people can shelter during heatwaves. In this project, we will collect a new dataset which documents the location and policies of US cooling centers. We will then use statistical methods to analyse the causal impacts of cooling center investment on the relationship between heatwaves and mortality.

Prof. Laure Resplandy, Room 418B - University Ext. 8-9017
E-mail: laurer@princeton.edu

My group studies how climate and ocean circulation influence marine biogeochemistry and ecosystems, and how these changes can in turn impact the climate itself.

JP or ST 1. Influence of Human Activity on Indian Ocean Biological Productivity and Coastal Dead Zones

The northern Indian Ocean is characterized by very low oxygen levels impinge on the coastal waters of countries accounting for more than a 1/4 of the world's population, and can lead to what is called “coastal dead zones” that impact marine ecosystems and local fisheries. Human factors can reinforce biological productivity and the occurrence of coastal dead zones, in particular the input of nutrients by rivers (tied to fertilizers, waste waters and urbanization etc.) and by atmospheric deposition (tied to fossil fuel burning etc.). These two factors have increased dramatically in the Indian Ocean since 1980s and are projected to increase further over the next 50 years. We offer two projects on this topic. They will leverage a high-resolution regional ocean biogeochemical model of the Indian Ocean to quantify the influence of atmospheric deposition and riverine loadings on biological productivity and coastal hypoxia in the Indian Ocean.

Prof. Allan Rubin, Room 319 - University Ext. 8-1506
E-mail: arubin@princeton.edu

Prof. Allan Rubin is on Sabbatical for AY 2023-2024

JP or ST 1. Earthquake catalogs include many features, including mainshocks, foreshocks, aftershocks, and swarms. These can potentially teach us, for example, about how the properties of the crust vary in space, where faults are "creeping" or "locked", and how to refine earthquake forecasts (i.e., using foreshocks). But first one must be able to recognize which earthquake belongs in which category, given that catalogs consists only of a string of numbers (earthquake origin time; location; magnitude). Recently, new methods for this classification have been proposed, but it is not clear that these are the best. For a JP or ST, work with high-quality catalogs from California, Japan, or elsewhere, to compare existing classification schemes, devise your own, and compare the results to what is known about the local geology, heat flow, etc.

JP or ST 2. Within the last decade, new styles of fault behavior have been discovered at depth within subduction zones and along the San Andreas fault. Rather than undergoing "stick-slip" (earthquake) behavior or creeping steadily at the plate rate, these regions exhibit "episodic slow slip", where every year or so the fault speeds up to about 100 times the plate rate, producing the equivalent of a magnitude 6+ earthquake over a period of days to weeks. Simultaneously, they produce a "chatter" that is observed on seismometers but that looks nothing like regular earthquakes. This "tectonic tremor" is a low-amplitude signal, continuous in time for minutes to hours, that lacks clear P-wave and S-wave arrivals but that nonetheless provides us with our best chance of mapping out the progression of slow fault slip at depth, if we can learn to locate it. I have been working with a new method that gives tremor locations beneath southern Vancouver Island that are much more accurate than have been obtained previously. We would like to know if this method works as well in other parts of Cascadia or in Japan, which also have dense seismometer networks. For a JP or ST, get available data from one of these regions and explore.

Prof. Blair Schoene, Room 219 - University Ext. 8-5747
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I am interested in the physical and geochemical evolution of Earth's crust and mantle and the interaction of the solid Earth with the ocean-atmosphere-biosphere system. My research pulls from methods in geochemistry, geochronology, sedimentology, structural geology and petrology. I run a radiogenic isotope geology lab that specializes in high-precision U-Pb geochronology. A few ideas for projects are listed below, but if you find your interests fall within my broad interests and want to discuss other options, please come see me or send an email.

JP or ST 1. **U-Pb geochronology.** The workhorse of my lab is a Thermal Ionization Mass Spectrometer, which measures isotopic ratios with very high precision. This methodology is the focus of many graduate student theses. And graduate students often need help and love teaching and supervising students in the lab. This work is very time consuming and difficult to learn, but will give you both general and specific skills in a modern geoscience isotope laboratory. These projects change on a yearly basis, so please inquire if this sounds interesting. Juniors will be discouraged from taking on projects with U-Pb geochronology unless they think they'll also want to do this work senior year.

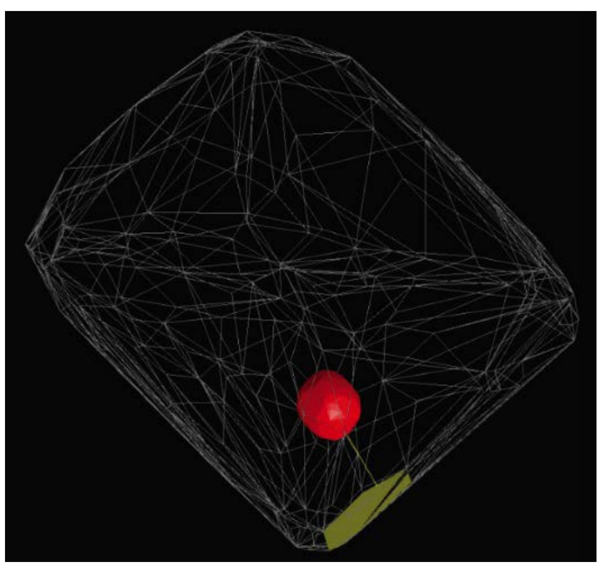
JP or ST 2. **Application of computational methods to igneous geochemistry.** The availability of geochemical data on online databases is opening doors for development of new computational methods towards problems in geochemistry. There are opportunities to explore applications of "big data" methods to understanding secular evolution of the crust and mantle and/or using big data to see through inherently complex processes to looking at driving forces.

JP or ST 3. **Is volcanic output controlled by surface erosion?** Island arcs are thought to be the building blocks of continents through subduction-accretion to larger continental blocks. The rates and mechanisms by which they are built are controlled by partial melting of the mantle above subducted slabs. The rate of magma production in these zones is purported to be roughly constant, but this poses a problem considering erosion rates of different island arcs should be very different, e.g., in Indonesia compared to Alaska. This project involves compiling data for erosion rates and crustal structure from different island arcs globally and asking the question: can surface erosion and climate control mantle melting?

JP or ST 4. **Understanding the Deccan Basalts, India.** I am part of an ongoing project with Prof. Gerta Keller trying to understand the role that massive volcanism could have played in the Cretaceous-Tertiary mass extinction event ca. 66 Ma (the one that killed the dinos). We are currently carrying out U-Pb geochronology on these basalts and various questions about the formation of datable horizons in the basalts need to be addressed. There are a number of projects that could be tailored to a student's interest that range from petrology and geochemistry to GIS and geophysical techniques.

ST 5. **Applications of field geology and geochemistry/geochronology to Appalachian tectonics.** The Appalachians are one of the world's oldest persisting mountain belts, and record a rich history of continental formation, amalgamation and subsequent destruction. Numerous unanswered questions pertaining to the 1.3 Ga crust and ore-deposit formation and the 200 Ma rifting event can be addressed with field-based projects in the New Jersey highlands and surrounding areas. Such projects involve the enthusiastic assistance of experts on the local geology from the New Jersey Geologic Survey. **Juniors**: it is nearly required that you begin field-work either the spring of junior year and/or summer before senior year for these projects to work out.

JP or ST 6. **What can crystals and bubbles tell us about supereruptions?** Supereruptions are gigantic volcanic eruptions (think 1000x Mount St. Helens), the likes of which we have never experienced – the last supereruption was 26.5 ky ago. Just because we haven't seen one, though, doesn't mean that one won't happen again in the future. Consequently, it is critical that we study deposits from past volcanic eruptions – both supereruptions and not-so-supereruptions - to understand how these magmatic systems develop, where they reside in the crust, when and why they ultimately erupt, and if/how they differ from the smaller systems that we know (comparatively) well. To do this, we will investigate microscale features of volcanic deposits to try and understand macroscale magmatic processes. This involves collecting and digging in to 3D x-ray tomographic data on textures (shapes, sizes, distributions) of crystals in rocks and melt inclusions in crystals, geochemical analyses, and numerical and thermodynamic models, to examine questions of magma accumulation and storage. Interested students must have taken or be currently enrolled in Mineralogy and Petrology.



3D rendering of a melt inclusion inside a quartz crystal. An individual quartz crystal is imaged using 3D propagation phase-contrast x-ray tomography. Image processingallows the size, shape, and position of the melt inclusion and to be quantified. These quantities are used to establish quartz crystallization timescales and growth rates.

Prof. Daniel Sigman, Room M52 - University Ext. 8-2194
E-mail: sigman@princeton.edu

Website: https://sigman.princeton.edu/

Prof. Daniel Sigman is on Sabbatical for AY 2023-2024

JP or ST 1. **Modern nitrogen cycle.** Biologically available nitrogen is a critical nutrient for the algae and plants that represent the base of all foodwebs, but its inputs, outputs and cycling are poorly understood in many environments, and the global nitrogen budget remains extremely uncertain. Humans' nitrogen inputs to agricultural soils and the atmosphere are one of our greatest environmental challenges. The stable isotopic composition of nitrogen and oxygen in bio-available nitrogen compounds is a promising tool for providing new insight into the nitrogen cycle at both small and large scales. Apply novel methods developed at Princeton to analyze liquid and solid nitrogen samples collected from the environment. Identify your own field site and collect your own samples, or analyze samples collected by the Sigman group during their fieldwork in the ocean.

JP or ST 2. **Organic matter trapped in fossils.** The Sigman group has developed methods for studying the isotopic composition of the trace organic matter trapped within the fossils of organisms and micro-organisms. Our focus has been on the use of fossils from the ocean (diatoms, foraminifera, stony corals, fish otoliths, shark teeth, and others), especially for studying biological, chemical, and physical changes in the ocean over ice age cycles and their role in changing the concentration of carbon dioxide in the atmosphere. However, the environments and questions we are addressing is expanding rapidly, for example, with studies of teeth from past mammals and dinosaurs. Identify your own fossils and questions, or ask for suggestions.

JP or ST 3. **Dissolved organic N in the ocean.** Dissolved organic nitrogen is a dynamic component of the nitrogen cycle in the surface ocean, yet its composition, origin, and fate are a mystery. Work with water samples from different ocean basins to investigate where dissolved organic nitrogen is produced and destroyed and the role that it plays in supplying nitrogen to upper ocean biology.

JP or ST 4. **Novel microbiological tools for geochemistry.** Microorganisms can be good chemists. Contribute to the development of new, microbe-based methods for the isotopic analysis of trace quantities of bioavailable nitrogen in the environment. This project requires prior experience in microbiological lab techniques.

JP or ST 5. **Numerical models of biogeochemistry in the present and past ocean.** Studies of environmental geochemistry and Earth history are aided greatly by the use of numerical models that include the circulation of the ocean. A student with the appropriate background could use one of our spectrum of numerical models or build their own to address key questions regarding the biology, chemistry, and physics of the ocean over Earth history.

JP or ST 6. **Studies of open ocean seaweed mariculture.** Seaweed mariculture is a promising approach for advancing global humanity's welfare by providing food, animal feed, agricultural fertilizer, bioplastics, carbon sequestration, and possibly biofuels. The Sigman group is undertaking research to understand the carbon and nutrient fluxes associated with seaweed growth platforms, and collaborations with other research groups will explore a broader range of questions.

Prof. Frederik J. Simons, Room 321B - University Ext. 8-2598
E-mail: fjsimons@princeton.edu

Prof. Frederik Simons is on Sabbatical for Fall Semester (ONLY) 2023-2024

Interests: Geophysics, geodesy, geomagnetism, seismology; structure and evolution of (planetary) lithospheres; seismic waveform analysis and tomography; topography and gravity anomalies; satellite measurements and inverse problems; oceanic instrumentation; earthquake early-warning studies; wavelet analysis; image analysis; spectral analysis; sea level variation; inferential statistics. You can find my evolving areas of expertise on my webpages, see www.frederik.net

JP 1. *Come talk to me for ideas.* Past Junior Papers with me have been on the analysis of tree rings; the use of localizing basis functions to study geomagnetic satellite data; the analysis of hydrophone records in the oceans; the study of acoustic wave speeds in the oceans; the creation of new computer algorithms for the synthesis of seismograms via normal-mode summation; the influence of earthquakes on the Earth's gravity field over the last three decades; the study of gravity hills in New Jersey using relative gravimetry and GPS positioning; geological mapping of the Venusian lithosphere; the signals of time-dependent mass redistribution in California as measured by the GRACE satellites; a reproducibility study of magnetometry with data collected in the field; the development of a software package for the analysis of cyclicity in outcrop photographs; numerical experiments on the recovery of harmonic components in the Jovian gravity field; evaluating precipitation algorithms in landscape evolution modeling; bathymetric analysis to evaluate geopolitical claims in the South China Sea; oceanic float coarse prediction using historic trajectory data. *All my projects involve computer programming.*

ST 1. *Come talk to me for ideas.* Past Senior Thesis with me have been on normal-mode based calculation of gravitational potential differences due to large earthquakes; the statistical (covariance) structure of topography on Venus and Mars; the precision and accuracy of Global Positioning System augmentation techniques; the signature of growth and decay of the Tibetan ice sheets from time-variable gravity; and the analysis of seismic data recorded by a broadband seismometer located in the basement of Guyot Hall; a study of underground hydrocarbon pipelines in the US and their relationship to groundwater arsenic. *All my projects involve computer programming.*

Prof. Bess Ward, Room 217 - University Ext. 8-5150
E-mail: bbw@princeton.edu

Research Interests: Biological and Chemical Oceanography, Microbial Ecology
Ward Lab webpage: http://www.princeton.edu/nitrogen/

JP or ST 1. **Characterize microbial nitrogen transformations using metagenomics.** Learn bioinformatics approaches to discovering microbial metabolic pathways in metagenomic data obtained from oceanographic research cruises in the Pacific Ocean and in Chesapeake Bay. Both laboratory molecular biology and computational projects are possible.

JP or ST 2. **Nitrogen nutrition of coral reefs.** Analyze samples from experiments from Bermudian coral reefs. Quantify different coral tissue and symbiont abundance using quantitative PCR, and quantify the pathways of N assimilation in corals using mass spectrometry.

JP or ST 3. **Nitrogen cycling in marine environments.** Analyze samples from oceanographic cruises and perform laboratory experiments on nitrogen biogeochemistry. Projects concern marine sources and sinks for nitrous oxide (N_2O, an important greenhouse gas), measure rates of N transformations with stable isotopes using mass spectrometry, sampling Chesapeake Bay for N_2O, cultivating microbes responsible for N_2O consumption in the ocean.

Prof. Xinning Zhang, Room M47 – University Ext. 8-2489
Email: xinningz@princeton.edu

I am an environmental microbiologist interested in understanding how microbial metabolism shapes the biogeochemical cycling of major (C, N, H) and minor elements (Fe, Mo, V). Research in my group involves both laboratory and field work and the application of methods from biogeochemistry, culture based microbiology, molecular biology, and stable isotope geochemistry. Current themes of research are biological nitrogen fixation and the microbiology of trace gases in soils and wetlands.

JP or ST 1. *Characterizing biogeochemistry and microbial communities in aerobic biodigestion of food waste, fiber-based and bioplastic disposable dining ware to improve soil fertility and limit greenhouse gas emissions*

Princeton University, which has prioritized composting as part of its sustainability plan with the Sustainable Composing Research at Princeton (SCRAP lab), is exploring various methods, from in-vessel biodigestion to more traditional outdoor piles, to optimize the composting process for the campus community. In collaboration with Princeton's SCRAP lab, Campus as a Lab, Campus Dining, and the NJ Composting Council, JP and ST students will evaluate the compostability of campus bioplastics and related alternatives. Students will gain exposure to biogeochemical wet lab methods and the use of analytical equipment, including chromatographic and spectroscopic tools, and to bioinformatics analyses of nucleic acid sequences for characterization of compost composition and activity. They will be involved in monitoring the compost microbial community using 16S ribosomal gene sequences, compost biogeochemistry (e.g., C/N ratios, porosity, leachate nitrate), biodigestor gas composition (CO2, CH4) as a function of different input treatments (shredded and unshredded food w/fiber, food w/PLA plastics). Student findings comprise an integral component of a larger NJ DEP supported project to advance institutional recycling goals.

Associated Scientists

Dana Ehret-Paleontological Staff, NJ State Museum, Trenton
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JP or ST Both junior papers and senior thesis projects may be arranged, using the collections and field research projects of the New Jersey State Museum. Past projects have included both invertebrate and vertebrate paleontology, most frequently in New Jersey (Cambrian-Pleistocene).