Stable Isotope Ecology

IB c227 / ESPM c220 / EPS c241 (this 5 credit course combines lecture and lab)
Course control numbers (LEC 001/LAB 101):
IB #25588/89 / **ESMP** #27851/27875 / **EPS** #26075/76
Offered odd numbered years; Sp 2021; Course not repeatable for credit; Enrollment limit: 25
Instructors: Todd Dawson and Stefania Mambelli

Lecture Schedule
T, Th 2-3:30 pm, REMOTE INSTRUCTION

COURSE SYNOPSIS:
This course has always focused on how the principles of isotope physiochemistry, behavior of elements and their isotopes, and the measurements me must make have been, or might be, applied to major areas of ecological research in terrestrial, aquatic and marine systems. Our focus in this course will therefore be on topics of major interest and/or concern to ecologists (e.g., organism-environment interactions, competition, population and community processes, ecophysiology, resource limitations, etc.). But we intend to explore these topics in light of where stable isotope tools have provided ***new insights in ways that no other method(s) can***. Additionally, we will explore how emerging, "special topics" of broad or specific interest (e.g., how stable isotope data can inform questions about topics such as = organismal responses to novel changes in the Anthropocene are 'seen' in the data?).

In the laboratory students will participate in a set of reviews and exercises involving the collection and preparation of diverse samples for isotopic analyses, the use of the mass spectrometer and optical analysis systems, and the analysis of isotopic data. Several weeks of the lab course will include working with isotope data that lead into lab exercises.

GRADING:
- Exams (x2) based on real data, problem solving and answering specific questions = 40%
- Lab assignments (x3) structured around critiques of the peer-reviewed literature = 60%

Outline of Lecture Topics

PART 1: Introduction: Stable Isotopes in an Ecological Context
A new field of science: Stable Isotope Ecology (SIE)
Historical insights and key events in the development of SIE
Fundaments of isotopes in our solar system and on Earth
Terminology and notation
Principles and concepts of isotope behavior
Methods for measuring isotope abundance

PART 2: Oxygen and Hydrogen Isotopes
Isotopes in the hydrological cycle
Global Meteoric Water; precipitation patterns and water sources for rivers and life
Understanding the basis for isotope variation in precipitation
Plant Transpiration, Ecosystem Evapotranspiration and isotopes
Evaporation and isotopes; lakes, soils, leaves, bodies
H and O isotopes in carbonates and organics; tree-rings, soils, teeth, shells, corals
Biomarkers in neo- and paleo-ecology
Applications and case studies = plant & soil water, dendrochronology, organic matter, ice cores, carbonates, compound-specific and position-specific isotope analysis.

PART 3: Carbon Isotopes
Isotopes and the Global C cycle
Stable C isotopes
Radiocarbon production
Photosynthesis and isotopes
Organic matter synthesis, decomposition/transport
CO_2 production/diffusion in water, soils, plants, microbes and animals
C isotopes in carbonates and organics; tree-rings, soils, teeth, shells, corals
Applications and case studies = plants, photosynthesis and water use-efficiency, isotope biogeography, diet and migration, C cycling and turnover, paleo-vegetation, archaeology) including compound-specific and position-specific isotope analysis

PART 4: Nitrogen & some Sulfur Isotopes
Isotopes and the Global N & S cycles
N fixation & deposition
Soil N cycle
N uptake by plants and microbes
S biogeochemistry
Plants & soils in global context
Applications and case studies = archaeology, nutritional ecology, food webs, diet and migration, compound-specific and position-specific isotope analysis.

PART 5: Emerging topics
New measurement technologies (optical, clumped, probing), using "odd" isotopes (e.g., $\delta^{17}O$) and other stable isotopes of interest (Strontium, Calcium, Germanium) and enriched tracers in ecological research + the value of experiments.

Laboratory Schedule
Thursday, 10am - 1 pm, Remote Instruction (if possible, in-person in 5053 and 1140 VLSB)

PART 1:
Students will be introduced to: the principles of isotope ratio mass spectrometry (IRMS) for stable isotopes analysis of light elements, and use of interfaces; sample collection and preparation techniques; significance of standards and data quality control; data processing computation, ways to work with isotope data (mixing models, isotope mapping etc.)
A virtual or in-person tour of the Center for Stable Isotope Biogeochemistry, UCB will be scheduled.

PART 2:
Independently, students will engage in completing no. 3 assignments. Each assignment will include: reading a given research article from the recent literature on a particular isotope approach, and submitting a written report/review (max 3 pages). A cumulative discussion of the main findings of each research article will take place at the end of the semester with the class.

Textbooks (to be used or related to *Ecology*)

Sharp, Z. 2007. *Principles of Stable Isotope Geochemistry*. Pearson Prentice Hall, Publishers, New Jersey (Strongly recommended; E-COPY PROVIDED).

Criss, R.E. 1999. *Principles of Stable Isotope Distribution*. Oxford Press. (Strongly recommended)

Fry, B. 2006. *Stable Isotope Ecology*. Springer-Verlag, New York. (Required; E-COPY PROVIDED)

Dawson, T.E. & R.T.W. **Siegwolf** (eds) 2007. *Stable Isotopes as Indicators of Ecological Change*. Elsevier Academic Press, San Diego, CA.

Kendall, C & J.J. **McDonnell** (eds) 1998. *Isotope Tracers in Catchment Hydrology*. Elsevier Science, Amsterdam.

DeGroot, P.A. (ed) 2004, *Handbook of Stable Isotope Analytical Techniques*. Amsterdam, Elsevier (http://users.pandora.be/handbook/index.html)