Hands-on environmental science during a pandemic: activity design, results and efficacy

Rebekah A. Stein[1,2], Nathan D. Sheldon[2], Jenna E. Munson[2]

[1]University of California, Berkeley, Department of Earth & Planetary Sciences, 120 Haviland Path, Berkeley CA 94720

[2]University of Michigan, Ann Arbor, Department of Earth & Environmental Sciences, 1100 N University Avenue, Ann Arbor MI 48109

Abstract: Engagement with the natural world is imperative to student learning in the geo- and environmental sciences. Immersion in the environment is particularly useful for complicated subjects like nutrient cycling and biogeochemistry. However, access to the outdoors is not ubiquitous, and often students living in urban centers and/or remote locations are unable to access geo-, bio- and environmental science activities and demonstrations. This inaccessibility was exacerbated by the pandemic. During the summer of 2020, we created a remote learning activity to teach the carbon cycle to high school students enrolled in the University of Michigan's Earth Camp. These high school students from the greater Detroit area were admitted to this week-long summer program to facilitate their access to the natural world, but when Earth Camp was moved online for safety reasons, this access became more limited. Students collected hair from their pets and their pets' foods (or in the case of students without pets, their favorite snack foods) and sent it to the University of Michigan's Earth Systems Laboratory for isotope analyses. Prior to processing, students recorded ingredients in their specimens and hypothesized what isotope values their specimens should have, based on C_3/C_4 plant distribution. The students' results, which showed strong correlation between pet hair and pet food, allowed them to examine how the Earth's carbon cycle is reflected by common plants and animals living in their own homes as well as the opportunity to collect physical observations and analyze their own data. This activity received positive evaluations from students, and students felt their knowledge of isotopes and the chemistry behind their food increased after this activity. In addition to the Earth Camp audience, we created and shared an activity that can be used in high school and introductory undergraduate Earth and environmental science courses.

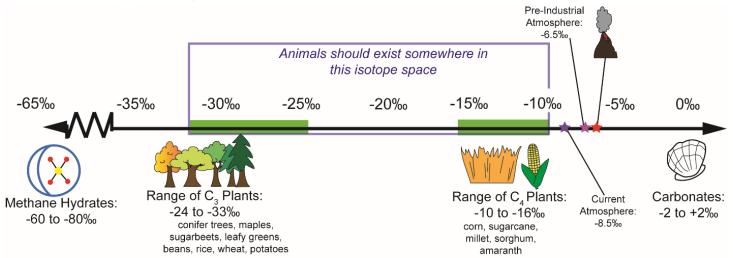

Figure 1: Diagram of range of carbon isotope values for plants and animals

Background:

- Complex earth & environmental science (EES) topics (e.g., biogeochemistry) more approachable from biological perspective[1]
- Hands-on approaches to EES help instill better learning, but this is challenging because outdoor access is not ubiquitous[2]
- Carbon isotopes can be used to understand modern ecosystems (agriculture, environmental & climate science) and ancient past[3]

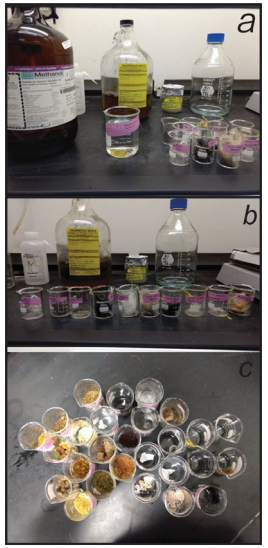

Figure 2: Pet hair rinse in a 9:1 DI-methanol treatment in a fume hood.

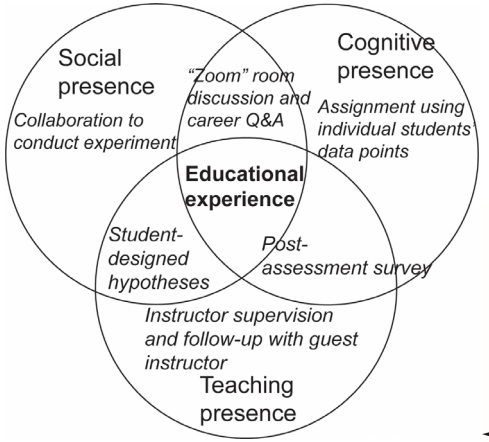

Figure 3: How this module created an online learning environment following Community of Inquiry Framework[4,5,6]

Methodology:

- The COVID-19 pandemic made hands-on activities difficult, especially science experiments

Following Community of Inquiry Framework[4,5,6], activity:

- Kitchen-based biogeochemistry investigations: students sampled their own pet and favorite foods
- Photos and Zoom discussion and laboratory tour supplement

References:

1. Soltis et al., (2021). *Journal of Geoscience Education*, **2.** Razani et al., (2020). *Pediatrics*, *146*(2). **3.** Sponheimer et al., (2003). *Canadian Journal of Zoology, 81* (5), 871-876. **4.** Garrison et al., (1999). *The internet and higher education*, *2*(2-3), 87-105. **5.** Garrison et al., (2001). *American Journal of distance education*, *15*(1), 7-23. **6.** Tan et al., (2020). *Journal of Chemical Education*, *97*(9), 2512-2518.

Results:

- Clear fractionation of carbon isotopes of pet food and pets.
- Data show composition of pet food & favorite snacks (C_3: e.g., soybeans, leafy greens, vs C_4: e.g., corn, sugarcane)

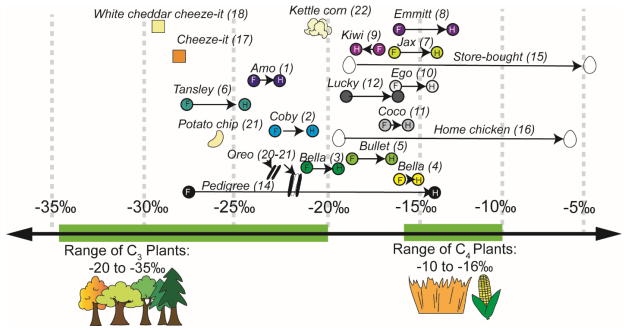

Figure 4: Diagram of range of carbon isotope values with results

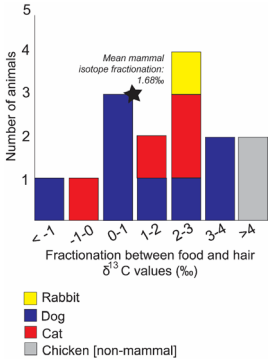

Figure 5: Carbon isotope fractionation by animal type

Category	Question prompt	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
LO	*Q1 I know what isotopes are*	6	18	0	0	0
LO	*Q2 I am familiar with the difference between radioactive and stable isotopes*	2	16	5	1	0
DI	*Q3 I believe isotopes can be useful for tracing food sources*	8	12	4	0	0
ME	*Q4 I am interested in isotope chemistry*	1	4	11	7	1
DI	*Q5 I think I know where my pet's food comes from*	2	14	6	2	0
		Earth Camp	**Both**	**School**		
LO	*Q6 Primary knowledge of isotopes is from*	11	7	4		

Figure 6: Student survey results

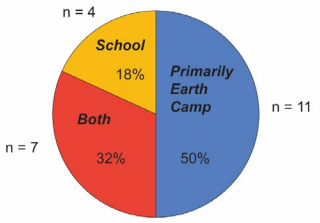

Figure 7: Basis of isotope knowledge for students

Conclusions:

- Students employed scientific method as a group, remotely
- Activity increased general isotope knowledge (18/22 students) and origin of food students and pets eat