

Examination 2
100 points
April 14, 2005

Exam 2 will consist of evaluating and interpreting data from Winston Weatherly's laboratory notebook. All of the data that will be on the exam are provided on the following four pages.

Your response to the actual exam questions (i.e., analyses and interpretations of these data sets) should be based on these data sets, lecture materials presented in class, and reading materials since the previous examination.

You are allowed to work singly or in groups to prepare for the exam. Furthermore, you will be allowed to prepare notes on the following pages of data and bring those materials into the examination on April 14th. No additional materials will be allowed.

Last year on a trip to the Serengeti Park in Tanzania (Africa), I was able to collect some muscle tissue from many animals that had died in the park. Below are the carbon and nitrogen isotope ratios of the muscle tissues:

| mammal | carbon isotope ratio, ‰ | nitrogen isotope ratio, ‰ |
|-----------------|-------------------------|---------------------------|
| cheetah | -14.9 | +8.6 |
| giraffe | -26.9 | +5.5 |
| Grant's gazelle | -22.3 | +5.9 |
| kongoni | -14.6 | +5.0 |
| lion | -15.2 | +8.5 |
| vulture | -15.0 | +11.4 |
| wildebeest | -14.4 | +5.2 |
| zebra | -12.9 | +5.1 |

I find this information a bit puzzling, but will explore the dietary ramifications of the data once I have a few days for data evaluations.

Last summer, we collected tree ring cores from Douglas fir trees in the Wasatch Mountains of Utah. We carefully divided the tree ring core into annual increments. Then we measured the carbon isotope ratio of each of the rings. From these data I observed the carbon isotope ratio data shown in the table below. Suspecting that the environment played a role in determining the carbon isotope ratios of tree rings, I collected the total annual precipitation and mean annual air temperature for this site; these data area also shown below. After thinking about the data for a while and remembering the lectures in "Stable isotopes in ecosystems", the explanation for variation in tree ring carbon isotope became very clear.

| year | carbon isotope ratio, ‰ | annual precipitation, mm | annual mean temperature, °C |
|------|-------------------------|--------------------------|-----------------------------|
| 2003 | -25.0 | 630 | 20 |
| 2002 | -25.7 | 690 | 18 |
| 2001 | -25.3 | 660 | 20 |
| 2000 | -26.0 | 720 | 18 |
| 1999 | -25.7 | 690 | 19 |
| 1998 | -28.0 | 900 | 18 |
| 1997 | -27.3 | 840 | 19 |
| 1996 | -26.7 | 780 | 20 |
| 1995 | -27.7 | 870 | 20 |
| 1994 | -26.3 | 750 | 20 |
| 1993 | -26.0 | 720 | 21 |
| 1992 | -26.7 | 780 | 20 |
| 1991 | -25.3 | 660 | 19 |
| 1990 | -25.7 | 690 | 19 |
| 1989 | -27.0 | 810 | 19 |

At a recent convention that I attended, one of the scientists asked each of the delegates at this international meeting to donate a hair sample for stable isotope ratio analysis. The stable isotope analyses have been completed and the data show a very interesting pattern. The individuals fall into two broad groups, even though we had identified ourselves as consisting of three dietary groups (vegans, vegetarians, and omnivores). Below are the results of the survey:

| carbon isotope ratio, ‰ | nitrogen isotope ratio, ‰ |
|----------------------------|------------------------------|
| -18.2 | 9.8 |
| -18.3 | 9.7 |
| -23.3 | 6.2 |
| -24.1 | 7.2 |
| -19.1 | 9.9 |
| -18.6 | 10.2 |
| -24.2 | 6.3 |
| -20.1 | 10.4 |
| -24.3 | 7.1 |
| -19.5 | 10.4 |
| -19.7 | 10.1 |
| -19.9 | 9.9 |
| -24.5 | 6.7 |

In recent years, I have been interested in the biomagnification and bioaccumulation of mercury in food webs. Two summers ago, I went to the arctic as part of a scientific expedition and we sampled different organisms in the arctic food web. Upon returning to Utah, I took each of the samples and measured the carbon and nitrogen isotope ratios and also the total mercury content in the biological sample. Of the materials collected, we sampled (a) invertebrates, (b) fish, (c) marine birds, and (d) marine mammals. We also sampled the particulate organic matter that some of the invertebrates were feeding on.

All of the data are shown below.

| Organism | carbon isotope ratio, ‰ | nitrogen isotope ratio, ‰ | mercury content (micrograms Hg per gram tissue) |
|----------------|----------------------------|------------------------------|--|
| 1 | -22 | 8.8 | 0.07 |
| 2 | -21 | 19.6 | 2.25 |
| 3 | -22 | 13.5 | 0.38 |
| 4 | -21 | 9.1 | 0.06 |
| 5 | -22 | 16.8 | 1.65 |
| 6 | -22 | 14.2 | 0.83 |
| 7 | -21 | 9.5 | 0.05 |
| 8 | -21 | 12.8 | 0.66 |
| 9 | -22 | 15.1 | 1.86 |
| 10 | -22 | 8.6 | 0.07 |
| organic matter | -21 | 5.4 | 0.02 |

The data were more definitive than I had expected. My hope is to present these results at a scientific meeting in Montreal next year.