BE/Bi 101: Order-of-Magnitude Biology
Homework 1
Due date: Friday, April 8, 2016

"Satisfaction of one's curiosity is one of the greatest sources of happiness in life."

—Linus Pauling

1. The art of estimation.

In this problem, the goal is actually to make yourself do quick drills to get into the habit of just making guesses about quantities. Do not look up any facts—you can look at the included pictures. When appropriate, try to use the square root rule that we discussed in class. For each case, give a brief, but thorough description of how you came by your estimates. Don't just quote a single number. Give us some context about how you got your result. These problems are chosen from a wide variety of different biological contexts that will come up during the course and give us the chance to practice our skills at many scales and in many contexts.

a) What is the thickness of the beak of a ground finch (in mm)? Make an estimate of the beak-to-beak variation in beak size between adult ground finches. Use Figure 1 to help in making a rapid estimate.

Figure 1: Ground finch in the Galapagos.

b) How many starlings are in the flocks seen in Rome? How many kilograms of poop do these birds drop on Rome each day? Figures 2 and 3 can aid you in your thinking.

c) When a bacterium is infected by a bacteriophage (a bacterial virus), what is the typical burst size of the viruses (i.e. how many viruses emerge from the cell after it lyses?) Begin by looking at Figure 4 and quickly telling us how big a bacterium is, how big a

Figure 2: Starling flock in Rome.

bacteriophage is. Then for figuring out the burst size, use Figure 4, but don't count. Do quick estimating by picking a lower and upper bound.

d) How many atoms are in a "typical" amino acid? Figure 5 shows the *side chains* of the amino acids and should help you quickly make an estimate. Similarly, give an estimate of the typical mass of amino acids in Dalton units (remember, a Dalton is the mass of one hydrogen atom). How many atoms are in a typical base? Figure 6 shows various representations of bases and DNA. Similarly, give an estimate of the typical mass of nucleotides in Dalton units.

e) Use Figure 7 to estimate the speed of the ocean currents experienced by Rizal Shahputra. Using your estimate from the first part of the problem, give an estimate of the time spent in the ocean by the tortoise shown in Figure 8 in its journey drifting from Aldabra (see Figure 9) to Tanzania!

f) In this part of the problem, you are going to do an integral by eyeballing. Figure 10 shows the spectrum of radiation reaching the earth. By approximating the curve as a rectangle work out a simple statement for the flux of radiation on the earth from the sun in units of W/m^2. Then, using the blue region, figure out the flux 10 m below the surface of the ocean.

g) Every time an electron microscope is used to take an image it corresponds to roughly a 1µm $\times$ 1µm area. The electron microscope is used to explore the structure of the nanometer scale world of cells, for example. Biology is a subject characterized by great naturalist voyages in which figures such as Humboldt, Darwin, Wallace, Huxley and Hooker traveled around the world to try and collect data on biological diversity. The

Figure 3: Consequences of starling flock in Rome.

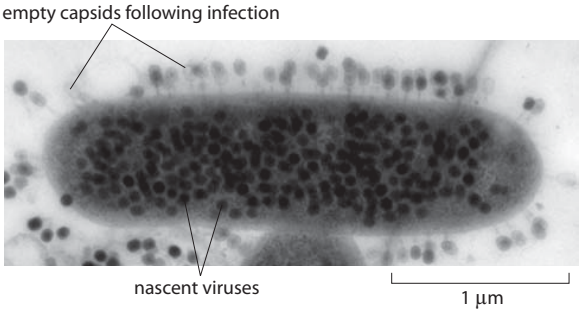

Figure 4: Burst size of an infected bacterium.

point of this problem is to get a sense of the *microscopic* diversity explored. Make an estimate of the total area looked at in biological samples using electron microscopes in the history of science. How does this correspond to the area of the Earth? What do you conclude about the extent to which we have "explored" the microbial diversity on the planet?

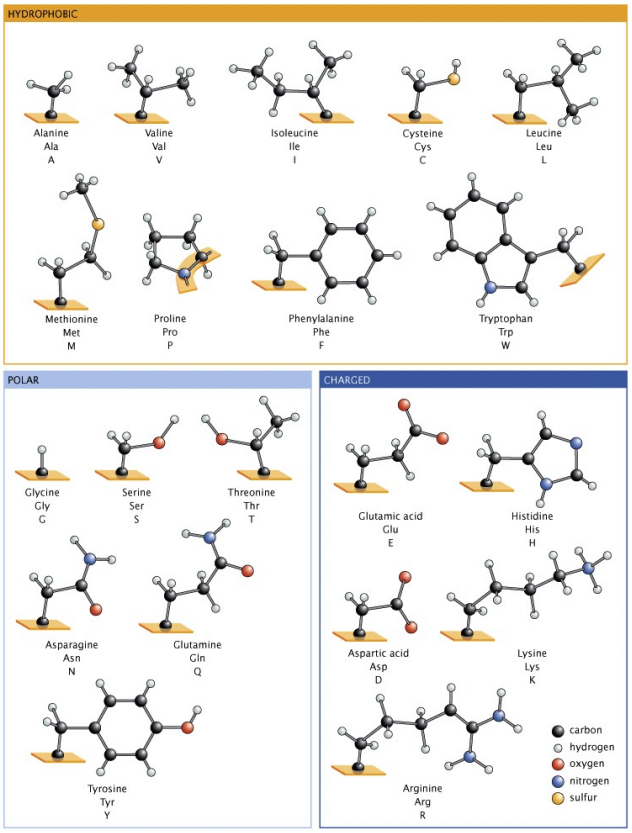

Figure 5: Amino acid side chains.

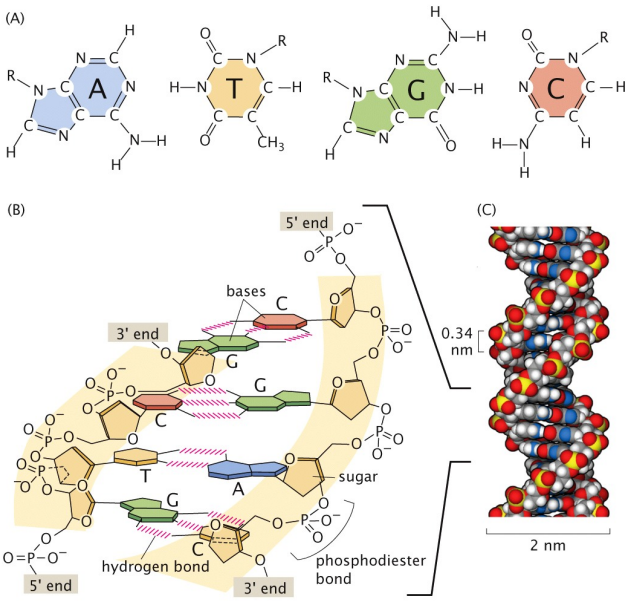

Figure 6: Structure of DNA.

Tsunami man survives week at sea

An Indonesian man has been found floating on tree branches in the Indian Ocean, eight days after a devastating tsunami struck the region.

Rizal waved to a passing cargo ship

Rizal Shahputra, 23, said he was initially swept out to sea with other survivors and family members, but that one by one they drowned.

He was rescued on Monday by a passing container vessel.

He was taken to Malaysia where officials said he was in good condition - he survived eating floating coconuts.

Rizal said he was cleaning a mosque in Banda Aceh on the northern tip of Sumatra on 26 December when the tsunami struck. Children ran in to warn him, but he was swept out to sea, along with several other people.

"At first, there were some friends with me," Rizal told reporters. "After a few days, they were gone... I saw bodies left and right."

He drank rainwater, and ate coconuts, which he reportedly cracked open with a doorknob.

Rizal said at least one ship sailed by without noticing him before the MV Durban Bridge spotted him, 160km (100 miles) from Banda Aceh.

Figure 7: Article about tsunami survivor after Boxer Day earthquake in Indonesia in 2004.

Figure 1. The Aldabra tortoise at Kimbiji, shortly after its discovery in December 2004. Photograph: C. Muir.

Figure 8: Tortoise found in Tanzania after traveling across the ocean. Notice the barnacles that have attached to the tortoise.

Figure 9: Map showing the position of the Aldabra Atoll in the Indian Ocean.

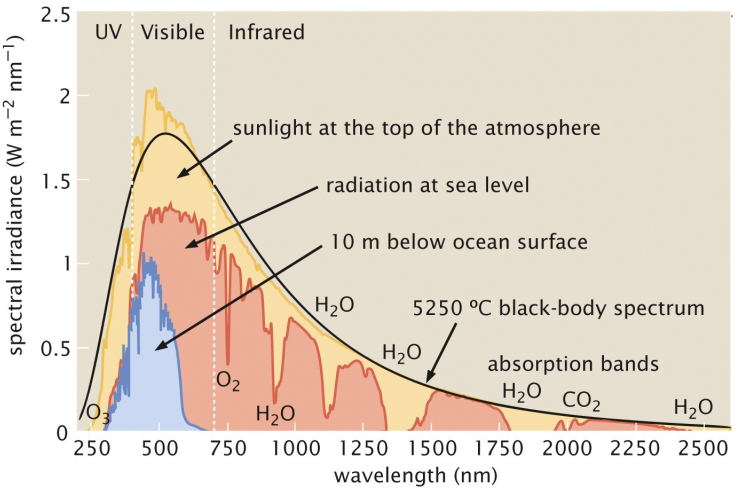

Figure 10: Spectrum of solar radiation reaching the Earth.