

Bi1x Spring 2010

**Caltech's Powers of Ten:
The Relative Sizes of Things in Biology**

IBM's short film "Powers of Ten" uses orders of magnitude to take a new look at physics, from the tiny subatomic particles in a proton to the huge, sweeping arms of distant galaxies. Many advances have been made that now take us well beyond the picture painted in 1977 and concern exotic states of matter at very small and very large scales.

Many other advances, in biology and medicine, fit comfortably below 1 meter. In a perfect world, we could use microscopes to resolve all of these scales in the ponds, but diffraction, the way light scatters and spreads when it meets small objects, prevents us from seeing it all. What is the resolution limit of the microscope you are using? You may find this site useful:

<http://www.microscopyu.com/articles/formulas/formulasresolution.html>

The scales of different organisms dictates in part how they interact with their environment: a frog swims just fine by kicking, but *E. coli* and other microbes would have trouble moving by a similar motion due to an decrease in the influence of inertia. To get around that, they have found other ways of moving with flagella. For a great explanation of the importance of size in motion, see "Life at low Reynolds number" by EM Purcell:
http://www.rpgroup.caltech.edu/courses/bi1x/2010/files_2010/caltech_only/Purcell.pdf

Your mission is to investigate, like the scientists in the Powers of Ten video, what is happening in the Caltech ponds at each power of 10 from 10^{-1} meters to 10^{-8} meters. Turn in a gallery of photos with descriptions, one for each order of magnitude, using the pictures you took with microscopes in the Bi1x . For orders of magnitude outside the capabilities of your microscope, add pictures you can take or find on your own. Use Matlab to convert pixels to microns on the graticules for each magnification and add scalebars to each picture. Be sure to discuss the biology of what's happening at each order of magnitude in the pond and how it relates to the world at large in a short paragraph with each picture.