Molecular versus cellular distances: cells are usually measured in μm (microns; 10-6 meters), molecules are usually measured in nm (10-9 meters) or Å (Ångstroms; 10-10 meters or 0.1 nm). Many human cells are about 20-100 μm in diameter, and the nuclei are 5-10 μm.

In PyMOL, carbons are usually colored a specific color per molecule. Hydrogens are white, oxygens are red (often negatively charged), nitrogens are blue (often positively charged), phosphorous are orange, sulfurs are yellow.

Lipid bilyayer: lipid\_bilayer.pse

This file is a model based on a simulation (no experimental data; just a computer and our idea of how physics works) of a portion of a lipid bilayer in water.

1) Hide the water. Measure the distance from one end of the lipid bilayer to another (this number is in Å). What percentage of a typical cell’s diameter is that?

3) What parts of the lipid chain are interacting with (*i.e.* closest to) the water versus with other lipid? Why?

4) Hide the lipid, and look at just the water. How regularly is the water spaced? The length of an ideal hydrogen bond in water is ~2.5Å (from oxygen to oxygen). How often does it look like the water has ideal hydrogen bonds in this model? What does this suggest about its state in this model (gas, liquid, solid)?

DNA: DNA\_nucleosome.pse

This file contains models of two crystal structures, one of a short 12 bp helix of DNA, and the other of a nucleosome where DNA is wrapped around a histone core.

1) The human genome contains about 6,469,660,000 base pairs of DNA. Measure the length of the 12 bp helix. If all of the DNA in **one human cell** were laid out in a row, how long would that be?

2) In eukaryotic nuclei, the DNA is kept compact by wrapping it around histones. The nucleosome has 164 bp wrapped around it. What is the diameter of the nucleosome (how much more compact is that than the naked DNA?).

3) Two DNA strands anneal together to form their familiar helical structure by base-pairing. Histones have to recognize **all** DNA, regardless of sequence. What part of the DNA looks to be in contact with the histones?

4) A major problem with keeping DNA compact is the high charge density (it’s very negatively charged because of the phosphate backbone, so DNA doesn’t “like” being close together). How might nucleosomes help fix this problem? Hint: what type of atoms are nearby the DNA?

Transcription: RNA\_polymerase.pse

This file is a model of the structure of RNA polymerase caught in the act of transcribing RNA from a template DNA molecule.

1) Look how tightly the nucleic acid (DNA/RNA) is enclosed in the polymerase. Looking at the structure, can you imagine how the DNA might get inside (remembering that the transcription probably starts in the middle of a DNA molecule!)

2) Can you figure out the sequence of the DNA? Of RNA?

3) Hide the protein. Look just at the DNA. What has happened to the DNA helix where the RNA is being made?

4) What types of interactions are driving these changes and why is this important to the function of transcription?