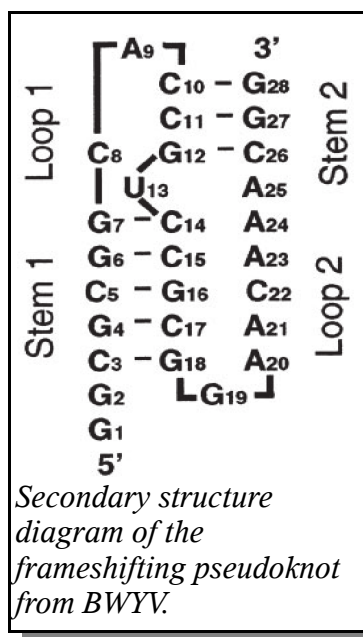


Electron density maps

15. December 2008 & 5. January 2009

In this exercise you will learn how biochemical molecular structures obtained via crystallography relate to electron density maps.



You will get to know the 1.25Å X-ray structure of the frameshifting RNA pseudoknot from beet western yellow *leteovirus* (BWYV). It offers the most detailed view yet of the conformational preference and flexibility of an RNA pseudoknot. The crystal and molecular structure has been determined on the BL1-5 beamline at Stanford Synchrotron Research Laboratory. See [EMSR02] for details.

First, you should get used to the electron density map and some basic functions of UCSF Chimera for displaying volume data. You can think of a density map as a contour plot with isosurfaces. To understand this you may think of the weather forecast. There is one that displays isolines or isobars, that is lines are drawn at levels of equal air pressure. In these pictures the pressures are measured near the ground. If one would also collect air pressure data at higher altitudes (e.g. 1000m above sealevel) then the same isobars would appear at a different position on the map or even disappear. Now, if corresponding isobars (i.e. of same pressure) from all altitudes were connected in 3D then the isosurfaces are constructed. Of course, for display it is reasonable to show only one isosurface at once.

Second, you will look at the model (pdb entry) that was derived from the electron density. You are supposed to superimpose this model onto the density map at a certain density level (i.e. isosurface). After you managed to do this you will learn how the structural properties of the model relate to the density map.

A documentation for UCSF Chimera can be found at <http://www.cgl.ucsf.edu/chimera/docindex.html>.

Answer the following questions briefly and hand them in (schenk@zbh.uni-hamburg.de) not later than 16. January 2009.

Tasks:

1. Load the file (`/home/schenk/teaching/WS_2008_2009/GST/density_maps/data/RNA_pseudoknot.omap`) into UCSF Chimera. It contains the unit cell (i.e. smallest entry in a crystal) of the electron density map of the RNA pseudoknot with some small ligands bound.

Play a bit with the Volume Viewer dialog. (**Be careful:** The rendering can get really slow, when using too much detail.) Please answer briefly some questions about rendering. What is the difference between surface and mesh? What do you think is displayed when using solid? What happens when you change Step? What happens when you change the position of the bar on the histogram? What does the histogram display? What else did you find useful in the Volume Viewer dialog?

2. Colour the map according to density (Tools->Volume Data->Surface Color). Where can you observe high density in the unit cell? Why?
3. Now colour the map using radius. Can you identify the backbone or some nucleosides? Which ones and because of what did you identify them? What values did you use in the Volume Viewer dialog?
4. Write down the sequence of bases.... no, just kidding.
5. Until now, you should have familiarised yourself with the electron density map. Load another file (*/home/schenk/teaching/WS_2008_2009/GST/density_maps/data/RNA_pseudoknot.pdb*). It contains the PDB model structure that was derived from the density map.
It is now your task to fit this model into the map. To do so move the model onto the fixed density map by hand (left and middle and Ctrl+middle mouse buttons). To locally optimise the position use the Fit Models entry in the Maps tool menu. You might want to select some atoms for the automatic fit in advance (for example backbone). If you achieved an average map value under 1.00 then probably your manual placement was not close enough. But do not give up too soon, you might want to use a different representation and colouring for the structure and map than default. How / with what did you orient yourself during the manual placement? Which atoms did you select for the local fit and what average map value did you achieve in the end? Please describe in a few words why your placement was successful or why you think it was not.
6. After the model is in its right place highlight/colour atoms with high B-factor (*@/bfactor>30*). Which atoms did you highlight, where do they belong to? What is different compared to others (not highlighted)? Why? Can you confirm your findings with the corresponding electron density?
7. Now have a closer look at the ligands. Where in the structure are they? Which other molecules/atoms that are not part of the RNA can you find? How can you distinguish between them in the electron density? To which residues do they form non-covalent contacts? Describe their coordination geometry, if possible. What are their B-factors? Why?
8. Finally, make a picture (and include that in your short report) that highlights your findings (for example with coloured surface and/or displayed H-bonds). Do it just for fun! The best painter will be rewarded with a beer.

[EMSR02] M. Egli, G. Minasov, L. Su, A. Rich, 2002, PNAS 99(7): 4302-4307