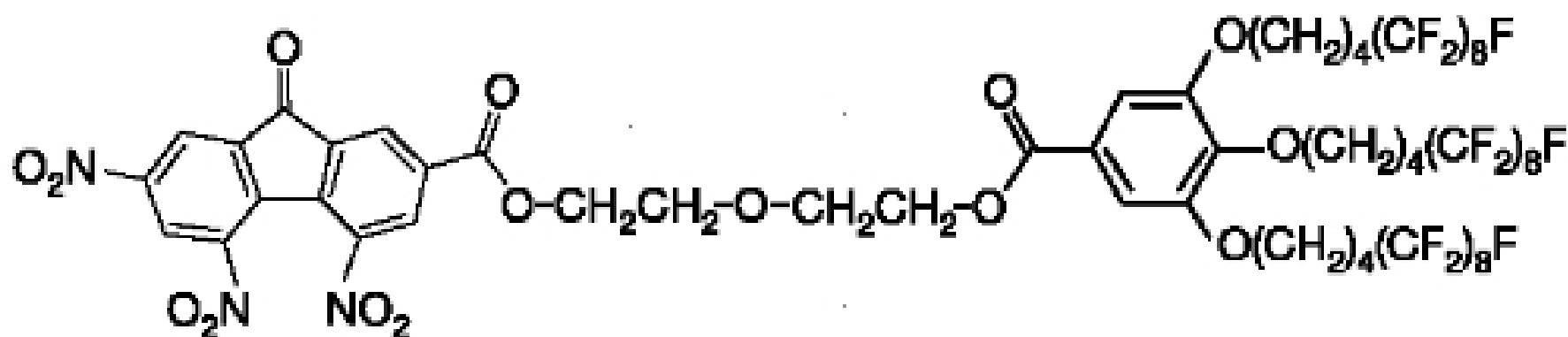


3. (4 minutes) In yesterday's issue of the journal *Nature* [vol. 419, p. 384] is a description of "helical dendrimers" that show promise as electronic materials. The formula below shows one of the molecules discussed. Neglecting the three $(\text{CH}_2)_4(\text{CF}_2)_8\text{F}$ groups on the far right, circle FOUR DIFFERENT functional groups in this molecule and give their names. Make sure the groups have different names.:

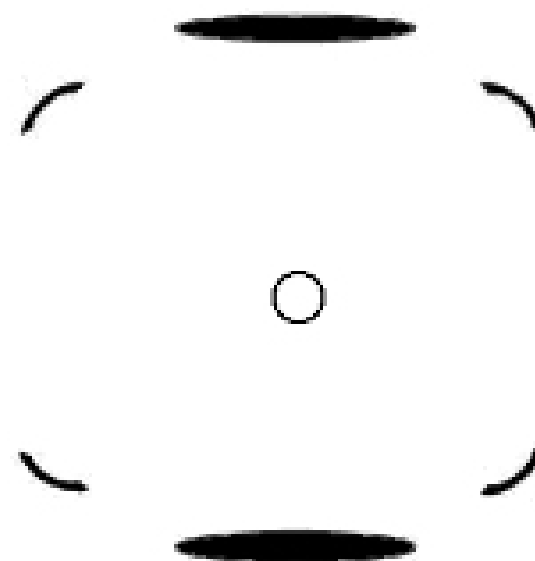
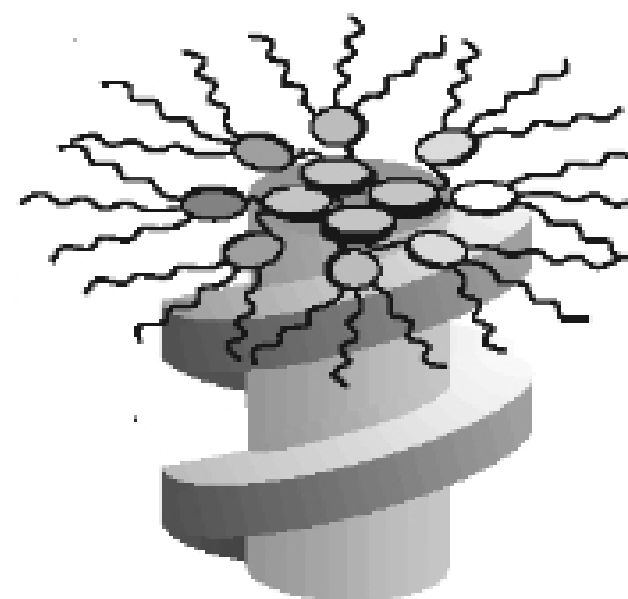


4. (6 min) The authors of the *Nature* paper suggests that molecules of the type shown in Question 3 pack together with the flat portion on the left (the part with all the NO_2 s) stacked in the middle to form a cylinder and the "hairy" part on the right arranged as a helical wrapping around the cylinder, denoted by the spiral around their rough figure shown on the right

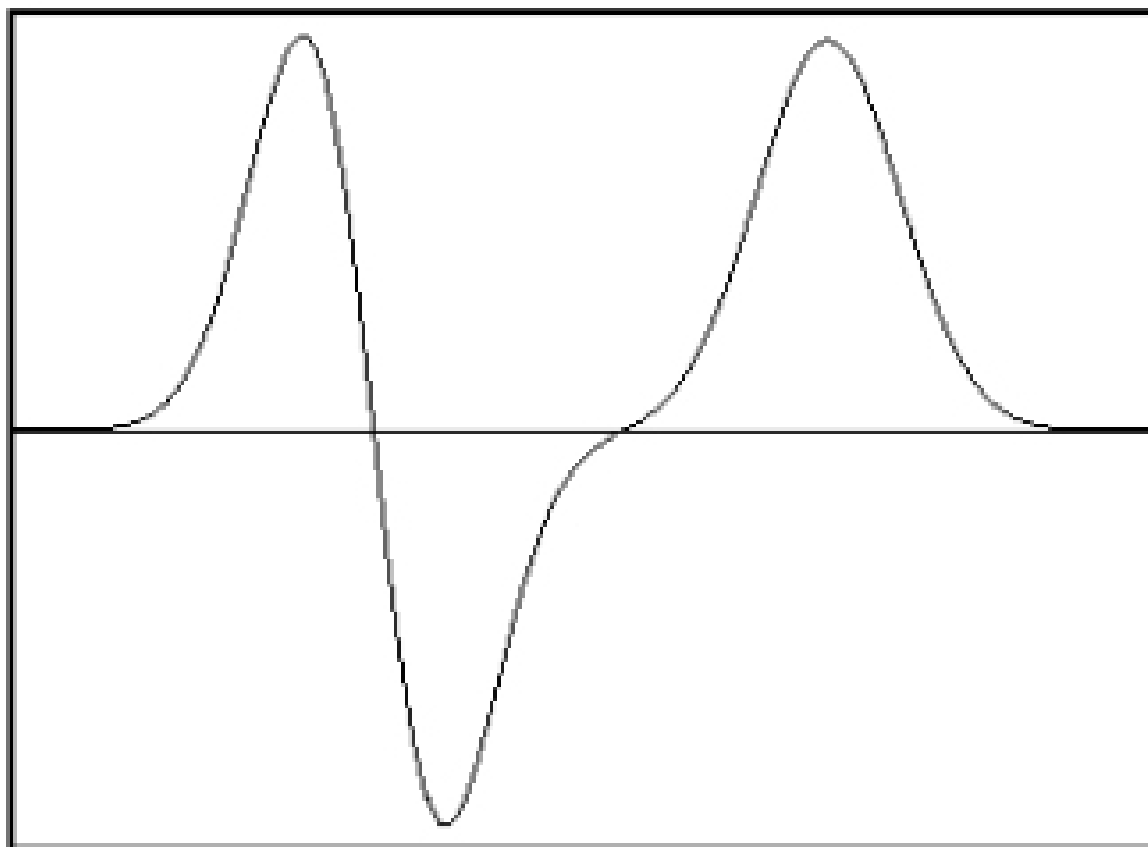
As evidence to support the stacking and the helical wrapping of this material they show a fiber's x-ray scattering pattern, six spots of which are shown below right.

(The open circle in the middle shows where the undeflected x-ray beam would hit the film.)

Explain how the six spots support the existence of stacking and helix, and explain how the pattern shows the spacing of the stacking and the pitch (steepness) of the helix. Is the pattern consistent with the rough figure showing the packing?



5. (9 minutes) The top frame shows a wave function ψ (horizontal line is at 0). ψ is a solution to the Schrödinger equation for a particle in one dimension with a certain potential energy as a function of position and a certain total energy. In the lower frame sketch an appropriate potential energy for this ψ (the central horizontal line represents the total energy). You may wish to comment and/or use lines or arrows to show correspondence in position between the wave function and the potential energy function.



6. (2 minutes) Could the wave function shown in question 5 be the lowest-energy solution for this Schrödinger equation. If not, how many solutions of lower energy should there be? Explain your thinking.