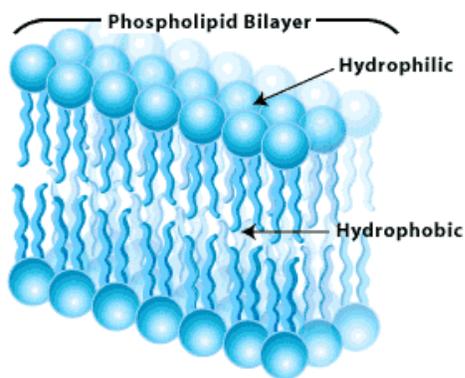


High stakes assignments for What is nanoscience ? course

Topic: Self assembly

Example 1

The cell membrane is essentially a lipid bilayer structure (see Figure), and is an example of self assembly resulting in functional nanostructures. In this case lipid molecules undergo self assembly into a lipid bilayer. Lipid molecules have a hydrophobic tail and a phosphate containing hydrophilic head group (see Figure).



http://www.biologycorner.com/APbiology/cellular/notes_cell_membrane.html

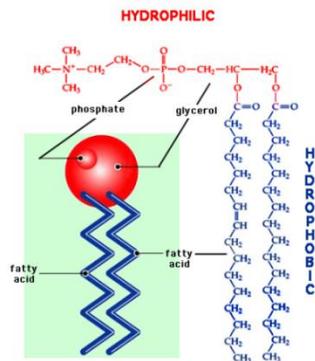


Figure 25. Molecular structure of a phospholipid, the building block of membranes. Inset - the usual depiction of a membrane phospholipid containing a phosphatidyl-glycerol "head" attached to two fatty acid "tails".

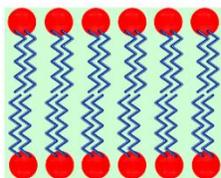


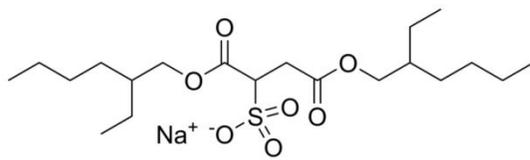
Figure 26. Organization of phospholipids in aqueous solution to form a bilayer. The hydrophilic phosphatidyl glycerols form the inner and outer faces of the membrane. The fatty acids orient themselves towards one another to form the hydrophobic interior of the membrane.

<http://textbookofbacteriology.net/themicrobialworld/Structure.html>

Design a drug delivery vehicle that will encapsulate water soluble drugs for intravenous injection. Additionally, in your design do you think there is room available to accommodate hydrophobic drugs to co-deliver to disease site. Explain and defend your design in a paper written in journal article format (abstract, introduction, experimental, discussion, conclusion) aimed at a scientific audience.

Example 2

Quantum dots (QDs) such as CdS are made from salts (e.g. cadmium and sulphur salts for CdS QDs) that are highly water soluble. The preparation method is based on using a mix of oil and water with anionic surfactant such as AOT (Dioctyl sodium sulfosuccinate).



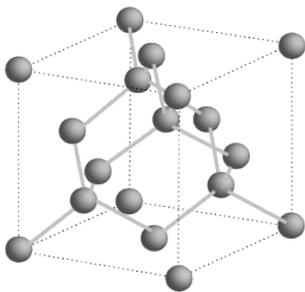
Chemical structure of AOT.

Write a paper that addresses the following: (i) Discuss your view of the mechanism by which QDs could be formed in such a system. (ii) What should be the general ratio of oil vs. water (high, equal, low) to create a nanoreactor filled with water for QD synthesis? (iii) QDs are insoluble in water, but remain stabilized in the microemulsion. Explain why this is the case.

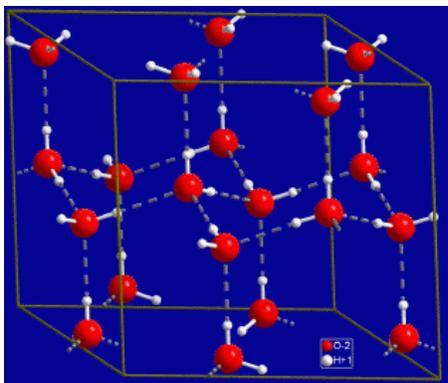
Explain and defend your conclusions in arguments aimed at a scientific audience.

Topic: Solids

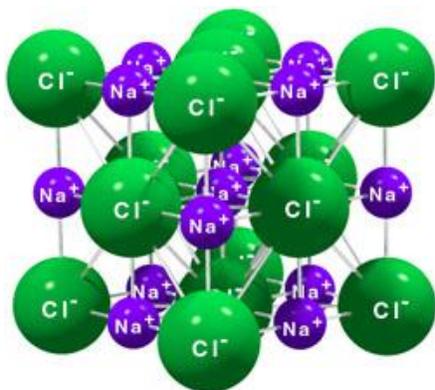
In solid state crystals atoms are periodically arranged into a lattice. Typical crystal types are elemental crystals (e.g. Si crystal), molecular crystals (e.g. ice), or ionic crystals (e.g. NaCl, salt crystals).



Si crystal (<http://hyperphysics.phy-astr.gsu.edu/hbase/solids/sili2.html>)



Ice crystal (http://www.meta-synthesis.com/webbook/13_lab-matrix/matrix.php?id=1388)



NaCl crystal (<http://www.chemistry.wustl.edu/~edudev/LabTutorials/Water/PublicWaterSupply/PublicWaterSupply.html>)

Discuss the following topics in a paper aimed at a scientific audience. (i) What is the difference between these solids in terms of the building blocks and the fundamental interactions between the building blocks in the solid? (ii) How many and in which way can you assemble water molecules around a central water molecule (building block for how water crystallizes). Focus your discussion on the types basic building blocks and on the interactions that lead to assembly of the building blocks into matter.

Topic: Periodic table in relation to matter

Consider CdS quantum dots (QDs) of ~ 5 nm size. Due to surface defects the QD does not emit light efficiently. By applying another crystalline coating (passivating shell) we can fix those defects, but the crystal coating lattice constant has to closely match that of the CdS QD.

Pick two of the following elements that you deem appropriate for use in a passivating shell around a CdS core QD: Zn, Ti, Na, C, S, O, Se.

Write a paper discussing your choice. Your paper should argue your case to a scientific audience, and should involve discussion based on your knowledge of atomic size in the periodic table.