7.61 2006 MEMBRANE STRUCTURE AND MEMBRANE PROTEINS.

Background reading

In preparation for this lecture (9/19/06) please review one or both of the following texts to (re)familiarize yourself with the basics of membrane structure.

Lodish 5th ed.
Ch. 5. pp. 147-165 Membranes
pp. 173-177 Cytoskeleton
Ch. 18. pp. 743-754 Lipids

Alberts 4th ed.
Ch. 10 Membrane structure (covers all three topics together)

In class, we will cover this material very briefly and use it as the basis for discussion of how these facts are established and to consider them in more depth.

MEMBRANE BASICS

Useful reference texts: Background information on the basics of membranes can be found in:

Gennis, R. B. Biomembranes : Molecular Structure and Function. Springer-Verlag. (1989).
Good survey. Good reference list.
Cevc, G. and Marsh, D. Phospholipid Bilayers : Physical Principles and Models. Wiley (1987).
Covers experimental methods and theory of membrane structure in some detail.
Tanford,C. The Hydrophobic Effect, Wiley and Sons, (1973).
Very good on background theory

Useful/Classical Review Articles

Singer, S.J. (1971) The Molecular organization of membranes, in Structure and Function of Biological Membranes, ed. L.I. Rothfield, Acad.Press.
The most detailed exposition of the fluid mosaic model with earlier background.
Singer, S.J. and Nicolson, G.L. (1972) Science 175:720.
A less detailed, but useful review of the fluid mosaic model.
Singer, S.J. (1990). Ann. Rev. Cell Biol. 6:247-296.
A more recent review of integral membrane proteins.
Helenius, A. and Simons, K. (1975). BBA 415:29-79.
A very useful review on detergents and their interactions with lipids, proteins and membranes.
Silvius, J.R. (1992). Solubilization and functional reconstitution of biomembrane components. Annu. Rev. Biophys. Biomol. Struct. 21:323-348.
A nice overview of the use of detergents in solubilizing and reconstituting membranes
BBA Reviews on Biomembranes vol 1376 #3 (1998) A special issue on Lipid-Protein Interactions.

Engelman DM (2005) Membranes are more mosaic than fluid. Nature 438:578-580.
A modern view – introducing a Nature Insight collection of reviews on membranes.

Bowie, JU (2005) Solving the membrane protein folding problem. Nature 438; 581-589.
One of those reviews – very nice.

Hessa…von Heijne et al (2005). Nature 433:377-381. Recognition of transmembrane helices by the ER translocon.
Elegant comparison of synthetic and thermodynamic constraints on TM segments.

Erythrocyte membranes

Bennett and Gilligan (1993). Ann. Rev. Cell Biol. 9:27-66.
Good survey pointing out parallels in other cell types.

Tse and Lux (1999) Red blood cell membrane disorders. Br. J. Haematol. 104: 2-13

MEMBRANE PROTEINS

Unwin, N. and Henderson, R. (1984). Sci. Am. 250:78-94.
Lucid description of EM/Fourier analysis of membrane protein structure.
Jennings, M.L. (1989) Ann. Rev. Biochem. 58: 999-1027.
Topography of Membrane Proteins.
White SH and Wimley WC (1999) Membrane protein folding and stability: physical principles.
Annu Rev Biophys Biomol Struct. 28: 319-365.
Discusses application of various biophysical techniques – ESR, NMR etc

Structural Analyses.

Brisson, A. and Unwin, P.N.T. (1985). Nature 315; 474-477.
Toyoshima, C. and Unwin, N. (1988). Nature 336; 247-250.
Unwin, P.N.T. (1993) J. Mol. Biol. 229 : 1101-1124.

Three papers applying EM/Fourier analysis to the nicotinic acetylcholine receptor.
The Unwin paper gives a structure at 9 A resolution with some surprising features.

Miyazawa, Fujiyoshi and Unwin (2003) Nature 423: 949-955.

Structure and gating mechanism of the acetylcholine receptor pore.
Analysis of a 4A resolution structure mostly done by EM-Fourier analyses.

Deisenhofer, J. and Michel, H. (1989). Science 245: 1463-1473.
Feher, G., Allen, J.P., Okamura, M.Y., and Rees,D.C. (1989).Nature 339: 111-116.
Rees et al Ann. Rev. Biochem. 58: 607-633 (1989)

Three articles summarizing the structure of the photosynthetic reaction center determined by X-ray diffraction.

Jap, B.K., Walian, P.J. and Gehring, W. (1991). Nature 350:167-170.
EM-Fourier analysis of a bacterial porin.

Cowan et al (1992) Nature 358: 727-733.
Crystal structures explain functional properties of two *E.coli* porins.

Walz et al, (1997) Nature 387: 624-627
Cheng et al (1997) Nature 387: 627-630
Two papers using electron crystallography to analyze water channels (aquaporins) at 6-7A resolution

Henderson et al. (1990). J. Mol. Biol. 213:899-929.
Electron diffraction structure of bacteriorhodopsin at 3.5 Å resolution.

Pebay-Peyroula et al (1994) Science 277: 1676- 1681
X-ray structure of bacteriorhodopsin at 2.5 A from microcrystals grown in lipidic cubic phases.

Palczewski K, Kumasaka T, Hori T, Behnke CA, Motoshima H, Fox BA, Le Trong I, Teller DC, Okada T, Stenkamp, RE, Yamamoto M, Miyano M (2000)
Crystal structure of rhodopsin: A G protein-coupled receptor. Science 289: 739-745.

McDermott et all (1995) Nature 374: 517-521
X-ray structure of the light-harvesting complex of photosynthetic bacteria

Murata et al Structural determinants of water permeation through aquaporin. (2000) Nature 407: 599-605.
An electron crystallography model at 3.8A resolution

**Current Opinion in Structural Biology Vol. 3 #4 (1993).
Several short reviews on membrane protein structures.

__Lateral Mobility of membrane proteins__

Application of single particle tracking methods and optical tweezers are revealing details of the restrictions on lateral mobility of membrane proteins.

Jacobson K, Sheets ED, and Simson R (1995) Revisiting the fluid mosaic model of membranes. Science 268: 1441-2
Brief review of methods and results showing that membrane protein mobility is restricted in various ways. The following review (Sheetz) gives a more extensive treatment.

Sheetz, M.P. (1993). Glycoprotein motility and dynamic domains in fluid plasma membranes. Annu. Rev. Biophys. Biomol. Struct. 22:417-431.

Sheets, E., Simson, R. and Jacobson, K. (1995) New insights into membrane dynamics from the analysis of cell surface interactions by physical methods.
Curr. Opin. Cell Biol. 7: 707-714

Kusumi, A. and Sako, Y. (1996) Cell surface organization by the membrane skeleton. Curr. Opin. Cell Biol. 8: 566-574.

__Rafts and Caveolae__

Simons, K. and Ikonen, E. (1997) Functional rafts in cell membranes. Nature 387: 569-572.

Kurzchalia, T.V. and Parton, R.G. (1999) Membrane microdomains and caveolae. Curr. Opin. Cell Biol. 11: 424-431.

Brown, D.A. and London, E. (1998) Functions of lipid rafts in biological membranes. Annu. Rev. Cell Dev. Biol. 14:111-136.

Anderson RG. (1998). The caveolae membrane system. Annu Rev Biochem.;67:199-225.

Simons and Toomre (2000) Nat Rev Mol Cell Biol 1: 31-40.

Van Meer (2002) The different hues of lipid rafts. Science 296: 855-856

Anderson, RGW and Jacobson, K. (2002) Science 296: 1821-1825.

Lai (2003) Lipid rafts make for slippery platforms. J. Cell Biol. 162:365-370

Parton (2003) Nat Rev Mol Cell Biol. 4: 162-167

Munro, S. (2003) Lipid refts: Elusive or Illusive? Cell 115: 377-388

Zacharias, Violin, Newton and Tsien (2002) Partitioning of lipid-modified monomeric GFPs into membrane microdomains of live cells. Science 296: 913-916.

Lane and Beese (2006) Thematic review series: lipid posttranslational modifications.
.J. Lipid Res. 2006;47:681-699 One review in a series on this topic.