

# **BIO 5833 MEMBRANE STRUCTURE AND FUNCTION**

University of Texas at San Antonio, Spring, 2015  
Monday & Wednesday, 2:30-3:45 PM, MS 2.03.02

**Instructor:** Dr. Robert Renthal

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Office hours by appointment.

**Course goals:** A study of the composition, organization, and functions of biomembranes. Topics include membrane structural principles, membrane transport, and membrane receptor functions. The course will also introduce students to the basis of experimental manipulation of membranes.

**Format:** Two sessions per week, consisting of lectures and discussions of reading assignments. The lecture topics and the reading assignments are on the list below.

**Reading:** Reading will consist of assigned journal articles. Copies of assigned reading will be made available on the Blackboard web site. Students are expected to read assignments prior to class and formulate questions and comments.

**Written work:** Each student will be assigned an additional journal article on a topic related to one of the scheduled lectures. The student will briefly write a paper summarizing the article (2-3 pages) and explain how it relates to the lecture topic. Each paper will be posted on the Blackboard web site. The list of assignments will be distributed in February, with the first paper due in March.

**Exams and grades:** Two midterm exams and one final exam (each 28% of grade). Exams will stress understanding of facts and concepts from the articles and lectures. Papers will be 16% of the grade. When exam dates conflict with activities that can't be rescheduled (e.g. student is presenting a paper at a scientific meeting, or has an invitation to a medical school interview, etc.), a make-up exam can be arranged if the instructor is notified in writing two weeks prior to the expected absence. In case of emergencies on the day of an exam, notify the instructor by phone or email as soon as possible. A make-up exam may be scheduled, depending on circumstances.

<i>Date</i>	<i>Lecture topic</i>	<i>Article</i>
Jan. 12	Fluid mosaic model	1
14	Lipids	2, 3
21	Vesicles and detergents	4, 5
26	Membrane-spanning sequences	6, 7
28	Membrane fluidity	8, 9
Feb. 2	Membranes and the cytoskeleton	10, 11
4	Membrane-bound enzymes	12
9	no class	-
11	Exam I (Jan. 12-Feb. 4)	-
16	Electrical properties of membranes	13
18	Proton pumps	14
23	Respiratory chain	15, 16
25	ATP synthase	17
Mar. 2	Vacuolar ATPase	18
4	P-ATPases	19
16	ABC transporters	20
18*	Symport and antiport	21, 22
23	Protein translocation	23
25	Nuclear membrane	24
30	Exam II (Feb. 16-Mar. 25)	-
Apr. 1	Ligand-gated channels	25
6	Voltage-gated channels	26
8	Gap junctions & water channels	27, 28
13	Coated vesicles and endocytosis	29
15	Membrane fusion and exocytosis	30
20	Receptor Y kinases	31
22	G-protein-coupled receptors	32
27	Recruitment and desensitization	33, 34
29	Lipid rafts	35
May 7 (Thursday)	Exam III (3:15 -5:45 PM) (Apr. 1-29)	-

\*March 20: last day to drop a course with grade of W

## ARTICLES

1. Singer, S. J. & Nicolson, G. (1972) "The fluid mosaic model of the structure of cell membranes." *Science* 175, 720-731
2. Gennis, R. B. (1989) "The structures and properties of membrane lipids." in *Biomembranes*, Springer-Verlag, pp 36-84
3. Holthius, J.C.M. & Menon, A.K. (2014) "Lipid landscapes and pipelines in membrane homeostasis." *Nature* 510, 48-57 {Lipid review 14.pdf}
4. Linke, D. (2009) "Detergents: an overview." *Methods in Enzymol.* 463, 603-617
5. Mimms, L.T., Zampighi, G., Nozaki, Y., Tanford, C., & Reynolds, J.A. (1981) "Phospholipid vesicle formation and transmembrane protein incorporation using octyl glucoside." *Biochemistry* 20, 833-840
6. Norholm, M.H.H., Shulga, Y.V., Aoki, S., Epand, R., von Heijne, G. (2011) "Flanking residues help determine whether a hydrophobic segment adopts a monotopic or bitopic topology in the endoplasmic reticulum membrane." *J. Biol. Chem.* 286, 25284-25290
7. Lundin, C., Kall, L., Kreherc, S.A., Kapp, K., Sonnhammer, E.L., Carlson, J.R., von Heijne, G., Nilsson, I. (2007) "Membrane topology of the *Drosophila* OR83b odorant receptor." *FEBS Letters* 581, 5601-5604
8. Poo, M. & Cone, R. (1974) "Lateral diffusion of rhodopsin in the photoreceptor membrane." *Nature* 247, 438-441
9. Dupuy, A. & Engelman, D.M. (2008) "Protein area occupancy at the center of the red blood cell membrane." *Proc. Nat. Aca. Sci. USA* 105, 2848-2852
10. Bennett, V. & Healy, J. (2008) "Organizing the fluid membrane bilayer: diseases linked to spectrin and ankyrin." *Trends Mol. Med.* 14, 28-36
11. Nakada, C., Ritchie, K., Oba, Y., Nakamura, M., Hotta, Y., Iino, R., Kasai, R.S., Yamaguchi, K., Fujiwara, T. & Kusumi, A. (2003) "Accumulation of anchored proteins forms membrane diffusion barriers during neuronal polarization." *Nature Cell Biology* 5, 626-632
12. Tomita, T., Iwatsubo, T. (2013) "Structural biology of presenilins and signal peptide peptidases." *J. Biol. Chem.* 288, 14673-14680
13. Harold, F.M (1986) "Energy coupling by ion currents," in *The Vital Force*, Freeman, pp. 57-90
14. Lanyi, J.K. & Schobert, B. (2004) "Local-global conformational coupling in a heptahelical membrane protein: transport mechanism from crystal structures of the nine states in the bacteriorhodopsin photocycle." *Biochemistry* 43, 3-8
15. Mitchell, P. & Moyle, J. (1965) "Stoichiometry of proton translocation through the respiratory chain and adenosine triphosphatase systems of rat liver mitochondria." *Nature* 208, 147-151
16. Sato, M., Sinha, P., Torres-Bacete, J., Matsuno-Yagi, A., Yagi, T. (2013) "Energy transducing roles of antiporter-like subunits in *Escherichia coli* NDH-1 with main focus on subunit NuoN (ND2)." *J. Biol. Chem.* 288, 24705-24716.
17. Usukura, E., Suzuki, T., Furuike, S., Soga, N., Saita, E., Hisabori, T., Kinoshita, K., Yoshida, M. (2012) "Torque generation and utilization in motor enzyme F<sub>0</sub>F<sub>1</sub>-ATP synthase." *J. Biol. Chem.* 287, 1884-1891

18. Saroussi, S. & Nelson, N. (2009) "The little we know on the structure and machinery of V-ATPase." *J. Exp. Biol.* 212, 1604-1610
19. Palmgren, M.F., Nissen, P. (2011) "P-type ATPases." *Ann. Rev. Biophys.* 40, 243-266
20. Mehmood, S., Domene, C., Forest, E., Jault, J.-M. (2012) "Dynamics of a bacterial multidrug ABC transporter in the inward- and outward-facing conformations." *Proc. Nat. Acad. Sci. USA* 109, 10832-10836
21. Guan, L. & Kaback, H.R. (2006) "Lessons from lactose permease." *Annu. Rev. Biophys. Biomol. Struct.* 35, 67-91
22. Jiang, X., Driessen, A.J.M., Feringa, B.L., Kaback, H.R. (2013) "The periplasmic cavity of LacY mutant Cys154-Gly: how open is open?" *Biochemistry* 52, 6568-6574
23. Park, E. & Rapaport, T.A. (2012) "Mechanisms of Sec61/SecY-mediated protein translocation across membranes." *Annu. Rev. Biophys.* 41, 1-20
24. Wälde, S. & Kehlenbach, R.H. (2010) "The part and the whole: functions of nucleoporins in nucleocytoplasmic transport." *Trends in Cell Biol.* 20, 461-469
25. Unwin, N., Fujiyoshi, Y. (2012) "Gating movement of acetylcholine receptor caught by plunge-freezing." *J. Mol. Biol.* 422, 617-634
26. Hong, L., Pathak, M.M., Kim, I.H., Ta, D., Tombola, F. (2013) "Voltage-sensing domain of voltage-gated proton channel Hv1 shares mechanism of block with pore domains." *Neuron* 77, 274-287
27. Smith, T.D., Mohankumar, A., Minogue, P.J., Beyer, E.C., Berthoud, V.M., Koval, M. (2012) "Cytoplasmic amino acids within the membrane interface region influence connexin oligomerization." *J. Mem. Biol.* 245, 221-230
28. Savage, D.F., O'Connell, J.D., Miercke, L.J.W., Finer-Moore, J. & Stroud, R.M. (2010) "Structural context shapes the aquaporin selectivity filter." *Proc. Nat. Acad. Sci. USA* 107, 17164-17169
29. Edeling, M.A., Smith, C. & Owen, D. (2006) "Life of a clathrin coat: insights from clathrin and AP structures." *Nature Rev. Mol. Cell Biol.* 7, 32-44
30. Jahn, R., Fasshauer, D. (2012) "Molecular machines governing exocytosis of synaptic vesicles." *Nature* 490, 201-207
31. Ferguson, K.M. (2008) "Structure-based view of epidermal growth factor receptor regulation." *Annu. Rev. Biophys.* 37, 353-373
32. Hiller, C., Kuhhorn, J., Gmeiner, P. (2013) "Class A G-protein-coupled receptor (GPCR) dimers and bivalent ligands." *J. Med. Chem.* 56, 6542-6559
33. Lemmon, M.A. (2008) "Membrane recognition by phospholipid-binding domains." *Nature Rev. Mol. Cell Biol.* 9, 99-111
34. Shukla, A.K., Xiao, K. & Lefkowitz, R.J. (2011) "Emerging paradigms of  $\beta$ -arrestin-dependent seven transmembrane receptor signaling." *Trends Biochem. Sci.* 36, 457-469
35. Lingwood, D. & Simons, K. (2010) "Lipid rafts as a membrane-organizing principle." *Science* 327, 46-50