BCH 610 Biochemistry of Lipids and Membranes: Spring, 2014

CLASS SCHEDULE: Tues. and Thurs. 2:00-3:15 PM is proposed, but a final decision will be discussed at the first class meeting in B231 BBSRB.

INSTRUCTORS:

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PREREQUISITES: Two semesters of organic chemistry, one semester of physical chemistry, a comprehensive general biochemistry course.

SCOPE AND OBJECTIVE: This course will cover basic concepts and technologies in membrane and lipid biochemistry. The major objective will be to critically evaluate the current literature on the biophysical properties, molecular architecture, bio-assembly, and various functions of cellular membranes, as well as the mechanisms involved in the translocation of membrane proteins and lipids from the sites of synthesis to their subcellular residence(s). Selected topics on the structure, physical state, biosynthesis, assembly, and function of membrane-associated molecules in transmembrane signaling and other cellular processes will be discussed. The course will be primarily literature-based, using both assigned reviews and original papers. The technical approaches and experimental strategies used in studies that have contributed significantly to advancing the basic understanding of important aspects of membrane biochemistry and membrane biology will be emphasized.

During the course each student will lead a 20 minute discussion of assigned papers (discuss your presentation with an instructor in advance).

During each class, all students are expected read the assignments prior to class and to participate **actively** in class.

Final grade will be based on:

Two In Class Exams	**(25% each)**
Class Presentation	**(15%)**
Class Participation	**(5%)**
Primary Reviewer's Report and Presentation	**(5%)**
Term Paper (*in lieu* of a final exam)	**(25%)**

A = 90-100; B = 80-89; C = 70-79; E = 0-69.

Lecture Topics and Exam Schedule for BCH 610-Spring 2014

Date	Day	Instructor	Topic
Jan. 16	Thurs	Whiteheart	Organization and Grant Writing
Jan. 21	Tues	Vander Kooi	Physical Properties of Lipids and Membranes
Jan. 23	Thurs	Vander Kooi	Physical Properties of Membrane Proteins
Jan. 28	Tues	Vander Kooi	Physical Properties of Biological Membranes
Jan. 30	Thurs	Rush	Structure and Isolation of Membranes
Feb. 4	Tues	Rush	Extraction and Separation of Lipids: Applications
Feb. 6	Thurs	Waechter	Flippases & Topology of Membrane Lipid Biosynthesis
Feb. 11	Tues	Waechter	Lipid-Mediated Protein N-Glycosylation in the ER
Feb. 13	Thurs	Waechter	Congenital Disorders of Glycosylation
Feb. 18	Tues	Rush	Quality Control in the ER
Feb. 20	Thurs	Whiteheart	Translocation of Proteins into the ER
Feb. 25	Tues	Dickson	Sphingolipid Signaling 1
Feb. 27	Thurs	Dickson	Sphingolipid Signaling 2
Mar. 4	**Tues**	**Exam**	
Mar. 6	Thurs	Dutch	Influenza Viral Membrane Fusion
Mar. 11	Tues	Dutch	Other Viral Membrane Fusion Systems
Mar. 13	Thurs	Galperin	Endomembrane Systems 1
Mar. 17-21	**Mon/Fri**		**UK Spring Break**
Mar. 25	Tues	Galperin	Endomembrane Systems 2
Mar. 27	Thurs	Galperin	Endomembrane Systems 3
Apr. 1	Tues	Whiteheart	The Golgi Complex
Apr. 3	Thurs	vd Westy	Regulation of Cholesterol Biosynthesis I
Apr. 8	Tues	vd Westy	Regulation of Cholesterol Biosynthesis II
Apr. 10	Thurs	vd Westy	Cholesterol Trafficking in Cells
Apr. 15	**Tues**	**Exam**	
Apr. 17	Thurs	Whiteheart	Transport Vesicle Production
Apr. 22	Tues	All	Proposal Reviews
Apr. 24	Thurs	All	Proposal Reviews
Apr. 29	Tues	Whiteheart	SNARE Hypothesis
May 1	Thurs	Whiteheart	SNARE Regulation
May 7	**Wed.**	**Faculty**	**Submission of Final Grants**

Ground Rules and Objectives for BCH 610 Term Paper (This is not the NIH format. You are requesting funding from the BCH610 Foundation, so follow our instructions.)

The objective of the term paper is to provide a format so you can apply the knowledge you have gained in this course to solve a scientifically interesting problem in membrane biochemistry and cell biology. This experience will help graduate students in the basic sciences develop the skills needed to write an effective grant application. The proposal may be a logical extension of a currently "hot" area of research in membrane biochemistry or a novel, hypothetical problem based on topics covered during this course. Potential topics must be discussed with and approved by one of the course lecturers. The process should take the whole semester. You may not use your own research topic.

FORMAT: The paper is to be written as a mini-grant proposal.

Title: Provide a clear descriptive title. Do not exceed 56 total characters and spaces.

Hypothesis: Clearly state a hypothesis. A hypothesis can be a description or model of how you think a particular biological process can occur. It must be testable.

Specific Aims: List a small set of specific aims (2-3) that you will undertake to support your hypothesis (or not). (no more than one page)

Background and Significance: Use this section to describe how you derived your hypothesis and to support your experimental approach. State clearly the problem you will try to solve and explain why it is a significant scientific problem. Describe what pertinent information is already known and precisely what gaps in this information will be filled by your proposed research.

Experimental Design: For each specific aim give sufficient experimental details to permit the reader to evaluate the possibilities of success and your knowledge of the problem. It is wise to offer alternative experimental approaches to achieve a given Specific Aim, in case your initial plan does not work. Include, in this section, possible experimental outcomes and their interpretations. *How will your data support your hypothesis (or not)?*

References: Complete list of references cited in grant. Please include complete titles.

Text format: single line spacing with 2 cm margins (top/bottom and left//right) and 11 point Arial type font. Deviations will not be accepted. Place page numbers at the bottom of the page. Text in Figure Legends should be no smaller than 9 point.

Page limitations: Title, Introduction, Hypothesis, and Specific Aims (1 page), Background (4-5 pages), and Experimental Design (4-5 pages): **a maximum of ten pages total** (not including References). Print a separate coversheet with your name and the grant title. Do not include your name in the body of the grant but do include the title on the first page.

Review Panel Meeting and Report: Each student will be assigned to be primary reviewer of one grant proposal. The primary reviewer must evaluate the proposal and determine its scientific soundness and feasibility based on the current knowledge of the field. The reviewer will be required to write a one page critique of the proposal including a one paragraph summary of the work proposed and a description of the grant's strengths and weaknesses. The primary reviewer will also be responsible for orally presenting (in 10 min) the grant to the review panel on April 22 or 24.

Deadlines: Not meeting these deadlines will result in a loss of **5 points** from the final grade.

Jan. 30 Last date to choose a topic. You must hand in a short summary of the topic (<1 page).

Feb. 27 Have a **Hypothesis** and set of **Specific Aims** approved by the instructor familiar with the topic you have chosen. A draft of this section (1 page) must be handed in.

Apr. 3 Grant must be submitted to the review panel, by email as a PDF file before 5:00PM.

Apr. 22, 24 Review Panel Meetings

May 7 before 5:00 PM a Paper Copy of Final Grant is Due

2014 Student Presentations: This should be a ~20 minute presentation of the key points of the papers listed below. (You do not need to show all of the figures.) Discuss the presentation with the relevant instructor at least one week prior to the assigned date so that your presentation can be coordinated with the rest of the class time.

Jan. 28 vd Kooi Physical Properties of Biological Membranes
Wang Q, Navarro MV, Peng G, Molinelli E, Goh SL, Judson BL, Rajashankar KR, Sondermann H. (2009) "Molecular mechanism of membrane constriction and tubulation mediated by the F-BAR protein Pacsin/Syndapin." PNAS **106**, 12700-12705

Jan. 30 Rush Structure and Isolation of Membranes
Shakur, *et al.* (2000) "Membrane Localization of Cyclic Nucleotide Phosphodiesterase 3 (PDE3)." *J Biol Chem* **49**, 38749-38761.

Feb. 6 Waechter Flippases & Topology of Membrane Lipid Biosynthesis
Menon I., Huber T., Sanyal S., Banerjee S., Barré P., Canis S., Warren J.D., Hwa J., Sakmar T.P., Menon A.K. (2011) "Opsin is a Phospholipid Flippase." *Curr Biol* **21**, 149-53.

Feb. 27 Dickson Sphingolipid Signaling 2
Chipuk, *et al.* (2012) "Sphingolipid metabolism cooperates with BAK and BAX to promote the mitochondrial pathway of apoptosis." *Cell* **148**, 988-1000.

Mar. 11 Dutch Other Viral Membrane Fusion Systems
McLellan, J. S. *et al.* (2013) "Structure-based design of a fusion glycoprotein vaccine for respiratory syncytial virus." *Science* **342**: 592-8.

Mar. 27 Galperin Endomembrane Systems 2
Dozynkiewicz MA, Jamieson NB, Macpherson I, Grindlay J, *et al.* (2012) "Rab25 and CLIC3 collaborate to promote integrin recycling from late endosomes/lysosomes and drive cancer progression." *Dev. Cell* **22**, 131-45.

Apr. 8 vd Westy Regulation of Cholesterol Biosynthesis II
Sever, N., *et al.* (2003) "Accelerated degradation of HMGCoA reductase by binding of insig-1 to its sterol-sensing domain." *Mol. Cell* **11**, 25-33.

Apr. 29 Whiteheart SNARE Hypothesis
Han X, Wang CT, Bai J, Chapman ER, Jackson MB. (2004) "Transmembrane segments of syntaxin line the fusion pore of Ca^{2+}-triggered exocytosis." *Science* **304**, 289-92.

2014 Class Reading List: Most of the assigned papers are now online. However, there are a few that are not. Those can be "borrowed" from the lecturer. We recommend (**strongly** encourage!!) that you download the papers and read as many as you can prior to the class session. Get a ring-binder to keep them in.

Jan. 21 Vander Kooi Physical Properties of Lipids and Membranes

Singer, S.J., and Nicolson, G.L. (1972) "The Fluid Mosaic Model of the Structure of Cell Membranes." *J. Mol. Biol.* **296**, 911-919. (Influential working model for the membrane, cited >4000 times!)

Cronan, J.E., and Gelmann, E.P. (1975) "Physical Properties of Membrane Lipids: Biological Relevance and Regulation." *Bacteriological Reviews* **39**, 232-256

Jan. 23 Vander Kooi Physical Properties of Membrane Proteins

Russ, W. P. and Engelman, D. M. (2000) "The GxxxG motif: a framework for transmembrane helix-helix association." *J Mol Biol.* **296**, 911-919. (Motif and detection mechanism for transmembrane oligomerization.)

Oldham, M. L., Khare, D., Quiocho, F. A., Davidson, A. L., and Chen, J. (2007) "Crystal structure of a catalytic intermediate of the maltose transporter." *Nature* **450**, 515-521. (A complete ABC transporter showing the complex membrane topology and conformational changes required for membrane interaction and maltose transport.)

Fernandez, C., Hilty, C., Wider, G., and Wuthrich, K. (2002) "Lipid-protein interactions in DHPC micelles containing the integral membrane protein OmpX investigated by NMR spectroscopy." *PNAS.* **99**, 13533-13537. (Experimental determination of the nature and extent of protein/lipid interactions for an integral membrane protein.)

Lee D., Walter, K.F.A., Bruckner, A-K., Hilty, C., Becker, S., and Griesinger C. (2008) "Bilayer in Small Bicelles Revealed by Lipid−Protein Interactions Using NMR Spectroscopy." *J. Am. Chem. Soc.*,**130**, 13822–13823. (Implications of extending beyond a detergent micelle)

Jan. 28 Vander Kooi Physical Properties of Biological Membranes

Essen, L., Siegert, R., Lehmann, W. D., and Oesterhelt, D. (1998) "Lipid patches in membrane protein oligomers: crystal structure of the bacteriorhodopsin-lipid complex." *PNAS* **95**, 11673-11678. (Lipid selectivity and membrane thickness modulation as seen in bacteriorhodopsin.)

Zimmerberg, J. and Kozlov, M.M. (2006) "How proteins produce cellular membrane curvature." *Nat. Rev. Mol. Cell Bio.* **7**, 9-19. (Measurement of membrane shape and physical properties and mechanisms of protein mediated modulation.)

Wang Q, Navarro MV, Peng G, Molinelli E, Goh SL, Judson BL, Rajashankar KR, Sondermann H. (2009) "Molecular mechanism of membrane constriction and tubulation mediated by the F-BAR protein Pacsin/Syndapin." PNAS **106**, 12700-12705 (An example of the complex physical mechanisms underlying vesiculation)

Jan. 30 Rush Structure and Isolation of Membranes

Gennis, R. B. (1989) "Introduction: The Structure and Composition of Biomembranes." in Chapter 1, pp.1-35. *Biomembranes: Molecular Structure and Function* Springer-Verlag (Handout: Read through section 1.5. Be familiar with the information in the remainder).

Evans, H. W. (1987) "Organelles and membranes of Animal Cells." in *Biological Membranes: a practical approach* (ed. J. B. C. Findlay and W. H. Evans) IRL Press. (Handout)

Fleischer, S., and Packer, L., eds. (1974) "Biomembranes." *Methods in Enzymology* Vol. XXXI (For use as a good general reference for the isolation of subcellular fractions from mammalian and prokaryotic cells, read sections as appropriate for your use.).

Brunet, S. *et al.* (2003) "Organelle Proteomics: looking at less to See more." *Trends in Cell Biol.* **13**, 629-638.

Feb. 4 Rush Extraction and Separation of Lipids: Applications

Higgins, J. A. (1987) "Separation and Analysis of Membrane Lipid Components." Chapter 4, pp. 103-137 in *Biological Membranes: a practical approach* (ed. J. B. C. Findlay and W. H. Evans) IRL Press. (Handout. Read through section 1.3 in detail, be familiar with the specific examples in the remainder of the chapter; the chapter contains some very useful examples of the application of classic techniques of lipid extraction, separation and analysis to study membrane lipids).

Kates, M. (1986) "Lipid Extraction Procedures." Chapter 3, in pp. 100-111, in *Techniques of Lipidology: Isolation, Analysis and Identification of Lipids* Elsevier (New York). (Handout)

Lowenstein, J. M. (ed.) (1969) *Methods in Enzymology* Vol. XIV (Good basic reference source for extraction and analysis of membrane lipids, read sections as appropriate for your use.).

Feb. 6 Waechter Flipases and Topology of Membrane Lipid Biosynthesis

Kornberg, R. D., and McConnell, H. M. (1971) "Inside-Outside Transitions of Phospholipids in Vesicle Membranes." *Biochem.* **10**, 1111-1120. (a classic)

Rothman, J. E., and Kennedy, E. P. (1977) "Rapid Transmembrane Movement of Newly Synthesized Phospholipids During Membrane Assembly." *PNAS* **74**, 1821-1825. (another classic)

Bell, R. M., Ballas, L. M., and Coleman, R. A. (1981) "Lipid Topogenesis." *J Lipid Res.* **22**, 391-403. (Describes the basics for protease-sensitivity approach)

Sanyal S, and Menon AK. (2009) "Flipping Lipids: Why An' What's the Reason For?" *ACS Chem. Biol.* **4**, 895-909. (Another excellent review of function of various flippases)

Menon I., Huber T., Sanyal S., Banerjee S., Barré P., Canis S., Warren J.D., Hwa J., Sakmar T.P., Menon A.K. (2011) "Opsin is a Phospholipid Flippase." *Curr. Biol.* **21**, 149-53.

Feb. 11 Waechter Lipid-Mediated Protein N-Glycosylation in the ER

Schenk, B., Fernandez, F., and Waechter, C. J. (2001) "The Ins(ide) and Outs(ide) of Dolichyl Phosphate Biosynthesis and Recycling in the Endoplasmic Reticulum." *Glycobiology* **11**, 61R-70R. (Overview of polyisoprenoid biosynthesis and protein N-glycosylation in the ER)

Larkin A., Imperiali B. (2011) "The Expanding Horizons of Asparagine-Linked Glycosylation". *Biochemistry*. **50,** 4411-4426. (Good general review of lipid-mediated glycosylation in prokaryotes and eukaryotes)

Rush, J. S., Gao, N., Lehrman, M. A. and Waechter, C. J. (2007) “Recycling of Dolichyl Monophosphate to the Cytoplasmic Leaflet of the ER after the Cleavage of Dolichyl Pyrophosphate on the Lumenal Monolayer.” *J Biol Chem.* **283**, 4087-4093.

Sanyal S, Menon AK. (2010) “Stereoselective Transbilayer Translocation of Mannosyl Phosphoryl Dolichol by an Endoplasmic Reticulum Flippase.” PNAS **107,** 11289-94.

Feb. 13 Waechter Congenital Disorders of Glycosylation

Haeuptle M. A, and Hennet T. (2009) “Congenital Disorders of Glycosylation: An Update on Defects Affecting the Biosynthesis of Dolichol-Linked Oligosaccharides.” *Hum Mutat* **30**,1628-1641. (Current Review of CDGs)

Vleugels W, *et al*. (2009) “Rft1 deficiency in three novel CDG patients.” *Hum Mutat.* **30**, 1428-1434.

Feb. 18 Rush Quality Control in the ER

Walter, P. and Ron, D. (2011) “The Unfolded Protein Response: From Stress Pathway to Homeostatic Regulation.” *Science* **334**, 1081-1086.

Brodsky, J. L. and Skach, W. R. (2011) “Protein Folding and Quality Control in the Endoplasmic Reticulum: Recent Lessons from Yeast and Mammalian Cell Systems.” *Cur Op in Cell Biology* **23**, 464-475.

Hedge, R. S. and Ploegh, H. L. (2010) “Quality and quantity control at the endoplasmic reticulum.” *Cur Op in Cell Biology* **22**, 437-446.

Aebi, M., Bernasconi, R., Cler, S. and Molinari, M. (2009) “N-glycan structures: recognition and processing in the ER.” *Trends in Biochemical Sciences* **35**, 74-82.

Molinari, M. and Helenius, A. (2000) “Chaperone Selection During Glycoprotein Translocation into the Endoplasmic Reticulum.” *Science* **288**, 331-333.

Feb. 20 Whiteheart Translocation of Proteins into the ER

Egea PF, Stroud RM, and Walter P. (2005) “Targeting proteins to membranes: structure of the signal recognition particle.” *Cur Op Struct Biol.* **15,** 213-20. (Review)

Rapoport, TA. (2007) “Protein translocation across the eukaryotic endoplasmic reticulum and bacterial plasma membranes.” *Nature* **450**, 663-669. (Review)

Shao, S. and Hegde, R.S. (2011) “Membrane protein insertion at the endoplasmic reticulum.” *Annu Rev Cell Dev Biol.* **27**, 25-56. (Review)

Van den Berg, B., Clemons, W.M., Collinson, I., Modis, Y., Hartmann, E., Harrison, S.C., and Rapoport, T.A. (2004) “X-ray structure of a protein-conducting channel.” *Nature* **427,** 36-44.

Lam VQ, Akopian D, Rome M, Henningsen D, Shan SO. (2010) “Lipid activation of the signal recognition particle receptor provides spatial coordination of protein targeting.” *J Cell Biol.* **190**, 623-35.

Heinrich, S.U., Mothes, W., Brunner, J., and Rapoport, T.A. (2000) “The Sec61p complex mediates the integration of a membrane protein by allowing lipid partitioning of the transmembrane domain.“ *Cell* **102**, 233-44.

Feb. 25/27 Dickson Sphingolipid Signaling 1 / 2

Futerman and Hannun (2004) "The complex life of simple sphingolipids." *EMBO Rep.* **5,** 777-782. (A brief, but informative and insightful overview of current cutting-edge areas of sphingolipid research.)

Ponnusamy *et al.* (2010) "Sphingolipids and cancer: ceramide and sphingosine-1-phosphate in the regulation of cell death and drug resistance." *Future Oncology* **6**, 603-1624 (A good overview of ceramide signaling and its role in the pathogenesis of cancers and chemotherapy. Nice diagrams.)

Maceyka *et al.* (2012) "Sphingosine-1-phosphate signaling and its role in disease." *Trends in Cell Biology* **22**, 50-59. (An overview by Spiegel who first revealed the signal transduction functions of sphingosine-1-phosphate).

Mar. 6 Dutch Influenza Viral Membrane Fusion

Hamilton, B.S. *et al.* (2012) "Influenza virus-mediated membrane fusion: determinants of hemagglutinin fusogenic activity and experimental approaches for assessing virus fusion." *Viruses* **4**, 1144-1168.

Carr, C. M., and Kim, P. S. (1993) "A spring-loaded mechanism for the conformational change of influenza hemagglutinin." *Cell* **73,** 823-832.

Chernomordik, L. V., Leikina, E., Frolov, V., Bronk, P., and Zimmerberg, J. (1997) "An early stage of membrane fusion mediated by the low pH conformation of influenza hemagglutinin depends upon membrane lipids." *J Cell Biol.* **136,** 81-93.

Lee, K. K. (2010) "Architecture of a nascent viral fusion pore" *EMBO J.* **29,** 1299 – 1311.

Galloway, S.E. *et al.* (2013) "Influenza HA subtypes demonstrate divergent phenotypes for cleavage activation and pH of fusion: implications for host range and adaptation." *PLoS Pathogens* **9**, e1003151.

Mar. 11 Dutch Other Viral Membrane Fusion Systems

Harrison, S. C. (2008) "Viral membrane fusion" *Nat Struct Mol Biol.* **15,** 690-8. (Review)

Melikyan, G.B., Markosyan, R.M., Hemmati, H., Delmedico, M.K., Lambert, D.M. and Cohen, F.S. (2000) "Evidence that the Transition of HIV-1 gp41 into a Six-Helix Bundle, Not the Bundle Configuration, Induces Membrane Fusion." *J Cell Biol.* **151,** 413-423.

Zaitseva, E., *et al.* (2010) "Dengue virus ensures its fusion in late endosomes using compartment-specific lipids." *PLoS Pathog.* **7**, e1001131.

Demirkhanyan, L., Marin, M., Lu, W. and Melikyan, G.B. (2013) "Sub-inhibitory concentrations of human α-defensin potentiate neutralizing antibodies against HIV-1 gp41 pre-hairpin intermediates in the presence of serum." *PloS Pathogens*: **9**, e1003431.

Li, K. *et al.* (2013) "IFITM proteins restrict viral membrane hemifusion." *PloS Pathogens*: **9**, e1003124.

Mar. 13 Galperin Endomembrane Systems 1

Clathrin-dependent, -independent endocytosis, recycling, endocytic machinery for cell motility and adhesion

Mayor, S. and Paggano, R.E. (2007) "Pathways of clathrin-independent endocytosis." *Nat. Rev. Mol. Cell Biol.* **8**, 603-612. (Review)

Huotari J, Helenius A. (2011) "Endosome maturation." *EMBO J* **30**, 3481-500. (Review)

McMahon HT, Boucrot E. (2011) “Molecular mechanism and physiological functions of clathrin-mediated endocytosis.” *Nature Rev. Mol. Cell Biol.* **12**, 517-33. (Review)

Grant BD, Donaldson JG (2009) “Pathways and mechanisms of endocytic recycling.” *Nat Rev Mol Cell Biol. **10***, 597-608. (Review)

Jacquemet G, Humphries MJ, Caswell PT. (2013) “Role of adhesion receptor trafficking in 3D cell migration.” *Curr Opin Cell Biol*. **25**, 627-32. (Review).

Bridgewater RE, Norman JC, Caswell PT. (2012) “Integrin trafficking at a glance.” *J Cell Sci.* **125**, 3695-701. (Review).

Dozynkiewicz MA, Jamieson NB, Macpherson I, Grindlay J, *et al.* “Rab25 and CLIC3 collaborate to promote integrin recycling from late endosomes/lysosomes and drive cancer progression.” *Dev. Cell* **22**, 131-45.

Damke, H., Baba, T., van der Bliek, A.M., and Schmid, S.L. (1995) “Clathrin-independent pinocytosis is induced in cells overexpressing a temperature-sensitive mutant of dynamin.” *J. Cell Biol*. **131**, 69-80.

Mar. 25 Galperin Endomembrane Systems 2

Mechanisms of receptor endocytosis and signaling: adaptor molecules and ubiquitination/endocytic machinery in receptor endocytosis: RTKs (EGF, TGFb), GPCR + β-arrestins) and NOTCH signaling).

Sorkin A, von Zastrow M. (2009) “Endocytosis and signalling: intertwining molecular networks.” *Nat Rev Mol Cell Biol.* **10**, 609-22. (Review)

Sorkin A, von Zastrow M. (2002) “Endocytosis and signalling: intertwining molecular networks”. Nat Rev *Mol Cell Biol.* **8**, 600-14. (Review)

Marchese A, Trejo J. (2013) “Ubiquitin-dependent regulation of G protein-coupled receptor trafficking and signaling.” *Cell Signal.* **3**, 707-16. (Review)

Moore CA, Milano SK, Benovic JL. (2007) “Regulation of Receptor Trafficking by GRKs and Arrestins.” *Annual Review of Physiology* **69**, 451-482 (Review)

Kandachar V, Roegiers F. (2012) “Endocytosis and control of Notch signaling.” *Curr Opin Cell Biol.* **24**, 534-40 (Review)

Ben-Zion Shilo and Eyal D Schejter (2011) “Regulation of developmental intercellular signalling by intracellular trafficking.” *EMBO J.* **30**, 3516–3526. (Review)

Nesterov A, Kurten RC, Gill GN. (1995) “Association of epidermal growth factor receptors with coated pit adaptins via a tyrosine phosphorylation-regulated mechanism.” *J Biol Chem.* **270**, 6320-7.

Valapala M, Hose S, Gongora C, Dong L, Wawrousek EF, Samuel Zigler J Jr, Sinha D. (2013) “Impaired endolysosomal function disrupts Notch signalling in optic nerve astrocytes.” *Nat Commun.***4**, 1629.

Mar. 27 Galperin Endomembrane Systems 2

Post-endocytic receptor trafficking: sustained signaling in endosomes (EGFR and TrkA), signaling attenuation, ESCORT complex, late endosomes and exosomes

Piper, R.C. and Luzio, J.P. (2001) “Late Endosomes: Sorting and Partitioning in Multivesicular Bodies.” *Traffic* **2**, 612-621. (Review)

Fevrier, B. and Raposo, G. (2004) “Exosomes: endosomal-derived vesicles shipping extracellular messages.” *Cur. Opin. Cell Biol.* **16**, 415-421. (Review)

Henne WM, Buchkovich NJ, Emr SD (2011) “The ESCRT pathway.” *Dev Cell.* **21**,77-91. (Review)

Babst M. (2011) “MVB vesicle formation: ESCRT-dependent, ESCRT-independent and everything in between.” *Curr Opin Cell Biol.* **23**, 452-7. (Review)

Katzmann, D.J., Babst, M., and Emr, S.D. (2001) “Ubiquitin-Dependent Sorting into Multivesicular Body Pathway Requires the Function of a Conserved Endosomal Protein Sorting Complex, ESCRT-1.” *Cell* **106**, 145-155.

Mittelbrunn M, Gutiérrez-Vázquez C, Villarroya-Beltri C, González S, Sánchez-Cabo F, González MÁ, Bernad A, Sánchez-Madrid F. (2011) “Unidirectional transfer of microRNA-loaded exosomes from T cells to antigen-presenting cells.” **Nat Commun 2**, 282.

Apr. 1 Whiteheart The Golgi Complex

Munro, S. (2011) “What is the Golgi apparatus, and why are we asking?” *BMC Biol.* **9**, 63-67.

Lowe, M. (2011) “Structural organization of the Golgi apparatus.” *Curr Opin Cell Biol.* **23**, 85-93.

Wilson C, Venditti R, Rega LR, Colanzi A, D'Angelo G, De Matteis MA (2011) “The Golgi apparatus: an organelle with multiple complex functions.” *Biochem J* **433**, 1-9. (Review)

Tu L, and Banfield DK (2010) “Localization of Golgi-resident glycosyltransferases.” *Cell Mol Life Sci* **67**, 29-41. (Review)

Bankaitis, V.A., Garcia-Mata, R., and Mousley, C.J. (2012) “Golgi membrane dynamics and lipid metabolism.” *Curr Biol.* **22**, R414-24.

Ladinsky MS, Mastronarde DN, McIntosh JR, Howell KE, Staehelin LA. (1999) “Golgi Structure In Three Dimensions: Functional Insights form the Normal Rat Kidney Cell.” *J Cell Biol.* **144**, 1135-1149.

Bonfanti L, Mironov AA Jr, Martínez-Menárguez JA, Martella O, Fusella A, Baldassarre M, Buccione R, Geuze HJ, Mironov AA, Luini A. (1998) “Procollagen Traverses the Golgi Stack without Leaving the Lumen of Cisternae: Evidence for Cisternal Maturation.” *Cell* **95**, 993-1003.

Apr. 3/8 Westy Regulation of Cholesterol Biosynthesis I/II

Tabas I (2002) “Cholesterol in health and disease.” *J Clin Invest.* **110,** 583-590. (Review)

Maxfield FR and Tabas I (2005) “Role of Cholesterol in Health and Disease.” *Nature* **438,** 612-621. (Review)

Brown MS, and Goldstein JL. (2009) “Cholesterol feedback: from Schoenheimer's bottle to Scap's MELADL.” *J Lipid Res.* **50**, S15-27. (Review)

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