Purification of caveolae in gradients prepared from OptiPrep™

- The principal aim of this OptiPrep™ Mini-Review is to present a bibliography of all of the current papers reporting the use of an iodixanol gradient to purify and analyse caveolae from vertebrate cells/tissues (see Section 2). Section 1 contains a brief survey of the technique; it has its own short reference list distinct from the comprehensive reference list in Section 2.

1. Background

Early methods for the purification of lipid-rich plasma membrane domains largely relied on their insolubility in Triton X-110 (or some other non-ionic detergent) relative to that of the bulk plasma membrane or that of all the other subcellular membranes. Sometimes detergent was added to the whole homogenate or more frequently a partially-purified plasma membrane fraction was first isolated before treating with detergent. Smart et al [1] however pointed out that, while use of a non-ionic detergent did permit the isolation of a lipid-rich membrane domain, that some characteristic caveolar proteins can be lost in the procedure. These workers therefore developed a method that avoids the use of Triton X-100. After isolation of a plasma membrane fraction from either human skin fibroblasts or MA104 cells, the caveolae are released by sonication in a standard cell homogenization medium. The first part of the isolation procedure is a flotation through a continuous iodixanol gradient (0-20%); this gradient is essentially a resolving gradient in which the caveolin-rich vesicles are concentrated in the top third of the gradient, while the predominantly caveolin-poor vesicles band in denser regions. A second discontinuous gradient is essentially a concentration gradient to band the caveolin-rich vesicles sharply at an interface.

Smart et al [1] used a Percoll™-based method for the initial purification of the plasma membrane, but there is no obvious requirement that such a method must be used. Kumanogoh et al [2] for example used a sucrose gradient to purify a synaptic plasma membrane before using the method devised by Smart et al [1]. There are many examples in the literature of iodixanol gradients being used to purify plasma membrane from a homogenate. The McDonald and Pike [3] method for the isolation of lipid rafts incorporates elements of both the detergent and the sonicated plasma membrane approaches. It involves performing two rounds of homogenization of CHO cells using multiple passages through a syringe needle. A post-nuclear supernatant is then adjusted to 25% (w/v) iodixanol and loaded under a 0-20% iodixanol gradient for floating the lipid-rich plasma membrane fragments. In effect it resembles a Smart et al [3] method without a plasma membrane purification step. It also omits the final iodixanol caveolae concentration gradient. Occasionally the Percoll™ gradient is omitted, for example ref 4.

1. Smart, E.J., Mineo, C. and Anderson, R.G.W. (1996) *Clustered folate receptors deliver 5-methyltetra-hydrofolate to cytoplasm of MA104 cells* J. Cell Biol., **134**, 1169-1177
2. Kumanogoh, H., Miyata, S., Sokawa, Y. and Maekawa, S. (2001) *Biochemical and morphological analysis on the localization of Rac1 in neurons* Neurosci. Res., **39**, 189-196
3. Macdonald, J.L. and Pike, L.J. (2005) *A simplified method for the preparation of detergent-free lipid rafts* J. Lipid Res., **46**, 1061-1067
4. Tome, M.E., Schaefer, C.P., Jacobs, L.M., Zhang, Y., Hemdon, J.M., Matty, F.O. and Davis, T.P. (2015) *Identification of P- glycoprotein co-fractionating proteins and specific binding partners in rat brain microvessels* J. Neurochem., **134**, 200-210

Detailed descriptions of the OptiPrep™-based techniques for isolation of caveolae and lipid rafts can be found in the following OptiPrep™ Application Sheets:

- Application Sheet S34: Isolation of caveolae
- Application Sheet S32: Isolation of lipid rafts (detergent strategy)
- Application Sheet S33: Isolation of lipid rafts (detergent-free strategy)

These can be found on the OptiPrep™ Applications flash-drive or on the following website: www.axis-shield-density-gradient-media.com (click on “Methodology”, then “Organelles and Subcellular Membranes”). Scroll down the Index to “Plasma membrane domains”. There is also a large literature on the fractionation of plasma membrane, endoplasmic reticulum, Golgi and endosomes and several Application Sheets, based on this literature, may be accessed from the Index entry for “Endoplasmic reticulum”.

2. Comprehensive bibliography

Papers have been divided into **cell or tissue type** (or occasionally **tissue**); and additionally, when required, into **research topic**. Within each group papers are listed alphabetically according to **first author**. To facilitate identification of references of interest key words in titles are highlighted in light blue. When a paper reports the study of more than one cell type, reference to that paper will appear under all relevant cell headings.

All publications reporting brain-derived caveolae are listed under **"21. Neural and related cells"**. Papers reporting on heart-derived caveolae are listed under **"3. Cardiac muscle"** but see **"25. Smooth muscle and smooth muscle cells"** for related cells. Cultured cell and tissue-derived caveolae will generally have been prepared from a partially purified plasma membrane fraction. An exception to this is a paper on "signalosomes", cytoplasmic organelles, that resemble caveolae and which have been purified from cardiac muscle (see **Quinlan et al in Section 3**). Review articles are listed in **Section 27**.

1. Caco-2 cells

Delmas, O., Breton, M., Sapin, C., Le Bivic, A., Colard, O. and Trugnan, G. (2007) *Heterogeneity of raft-type membrane micrdomains associated with VP4, the rotavirus spike protein, in Caco-2 and MA 104 cells* J. Virol., **81**, 1610-1618

2. Carcinoma cells

Cai, C., Zhu, H. and Chen, J. (2004) *Overexpression of caveolin-1 increases plasma membrane fluidity and reduces P-glycoprotein function in Hs578T/Dox* Biochem. Biophys Res. Commun., **320**, 868-874
Chaterjee, S., Cao, S., Peterson, T.E., Simari, et al (2003) *Inhibition of GTP-dependent vesicle trafficking impairs internalization of plasmalemmal eNOS and cellular nitric oxide production* J. Cell Sci., **116**, 3645-3655
Grądzka I., Sochanowicz, B., Brzóska, K., Wójciuk, G., et al (2013) *Cis-9,trans-11-conjugated linoleic acid affects lipid raft composition and sensitizes human colorectal adenocarcinoma HT-29 cells to X-radiation* Biochim. Biophys. Acta, **1830**, 2233–2242
Huhtakangas, J.A., Olivera, C.J., Bishop, J.E., Zanello, L.P. et al (2004) *The vitamin D receptor is present in caveolae-enriched plasma membranes and binds $1\alpha,25(OH)_2$-vitamin D_3 in vivo and in vitro* Mol. Endocrinol., **18**, 2660-2671
McDonald, J.F., Zheleznyak, A. and Frazier, W.A. (2004) *Cholesterol-independent interactions with CD47 enhance $\alpha_v\beta_3$ activity* J. Biol. Chem., **279**, 17301-17311
Nion, S., Briand, O., Lestavel, S., Torpier, G., et al (1997) *High-density-lipoprotein subfraction 3 interaction with glycosylphosphatidyl-inositol-anchored proteins* Biochem. J., **328**, 415-423
Piazza, T.M., Lu, J-C., Carver, K.C. and Schuler, L.A. (2009) *Src family kinases accelerate prolactin receptor internalization, modulating trafficking and signaling in breast cancer cells* Mol. Endocrinol., **23**, 202-212
Pitto, M., Parenti, M., Guzzi, F., Magni, F., et al (2002) *Palmitic is the main fatty acid carried by lipids of detergent-resistant membrane fractions from neural and non-neural cells* Neurochem. Res., **27**, 729-734
Sitaraman, S.V., Wang, L., Wong, M., Bruewer, M., et al (2002) *The adenosine 2b receptor is required to the plasma membrane and associates with E3KARP and ezrin upon agonist stimulation* J. Biol. Chem., **277**, 33188-33195
Sun, J., Nanjundan, M., Pike, L.J., Wiedmer, T., et al (2002) *Plasma membrane phospholipid scramblase 1 is enriched in lipid rafts and interacts with the epidermal growth factor receptor* Biochemistry, **41**, 6338-6345
Thiel, K.W. and Carpenter, G. (2006) *ErbB-4 and TNF-α converting enzyme localization to membrane microdomains* Biochem. Biophys. Res. Commun., **350**, 629-633
Turk, H.F., Barhoumi, R. and Chapkin, R.S. (2012) *Alteration of EGFR spatiotemporal dynamics suppresses signal transduction* PLoS One, **7**: e39682
Waugh, M.G., Lawson, D., Tan, S.K. and Hsuan, J.J. (1998) *Phosphatidylinositol 4-phosphate synthesis in immunoisolated caveolae-like vesicles and low buoyant non-caveolar membranes* J. Biol. Chem., **273**, 17115-17121

3. Cardiac muscle (see also "Smooth muscle")

Huhtakangas, J.A., Olivera, C.J., Bishop, J.E., Zanello, L.P., et al (2004) *The vitamin D receptor is present in caveolae-enriched plasma membranes and binds $1\alpha,25(OH)_2$-vitamin D_3 in vivo and in vitro* Mol. Endocrinol., **18**, 2660-2671
Quinlan, C.L., Costa, A.D.T., Costa, C.L., Pierre, S.V., et al *Conditioning the heart induces formation of signalosomes that interact with mitochondria to open mitoK_{ATP} channels* Am. J. Physiol. Heart Circ. Physiol., **295**, H953-H961

4. CHO cells

Babitt, J., Trigatti, B., Rigotti, A., Smart, E.J., et al (1997) *Murine SR-BI, a high density lipoprotein receptor that mediates selective lipid uptake, is N-glycosylated and fatty acylated and colocalizes with plasma membrane caveolae* J. Biol. Chem., **272**, 13242-13249

Graf, G.G., Connell, P.M., van der Westhuyzen, D.R. and Smart, E.J. (1999) *The class B, type I scavenger receptor promotes the selective uptake of high density lipoprotein cholesterol ethers into caveolae* J. Biol. Chem., **274**, 12043-12048

Guo, L., Chen, M., Song, Z., Daugherty, A., et al (2011) *C323 of SR-BI is required for SR-BI-mediated HDL binding and cholesteryl ester uptake* J. Lipid Res., **52**, 2272–2278

Uittenbogaard, A., Everson, W.V., Matveev, S.V. and Smart, E.J. (2002) *Cholesteryl ester is transported from caveolae to internal membranes as part of a caveolin-annexin II lipid-protein* J. Biol. Chem., **277**, 4925-4931

Webb, N.R., Connell, P.M., Graf, G.A., Smart, E.J., et al (1998) *SR-BII, an isoform of the scavenger receptor BI containing an alternate cytoplasmic tail, mediates lipid transfer between high density lipoprotein and cells* J. Biol. Chem., **273**, 15241-15248

Zhang, J., Chu, W. and Crandall, I. (2008) *Lipoprotein binding preference of CD36 is altered by filipin treatment* Lipids Health Dis., **7,** 23

5. Chondrocytes

Elbaradie, K.B.Y., Wang, Y., Boyan, B.D. and Schwartz, Z. (2013) *Sex-specific response of rat costochondral cartilage growth plate chondrocytes to 17β-estradiol involves differential regulation of plasma membrane associated estrogen receptors* Biochim. Biophys. Acta, **1833**, 1165–1172

6. COS cells

Grossmann, S., Higashiyama, S., Oksche, A., Schaefer, M., et al (2009) *Localisation of endothelin B receptor variants to plasma membrane microdomains and its effects on downstream signaling* Mol. Memb. Biol., **26**, 279-292

Heberden, C., Reine, F., Grosse, B., Henry, C., et al (2006) *Detection of a raft-located estrogen receptor-like protein distinct from ERα* Int. J. Biochem. Cell Biol., **38**, 376-391

Hinkovska-Galcheva, V., Boxer, L.A., Kindzelski, A., Hiraoka, M., Abe, A., Goparju, S., Spiegel, S., Petty, H.R. and Shayman, J.A. (2005) *Ceramide 1-phosphate, a mediator of phagocytosis* J. Biol. Chem., **280**, 26612-26621

Hinkovska-Galcheva, V., Clark, A., VanWay, S., Huang, J-B., et al (2008) *Ceramide kinase promotes Ca21 signaling near IgG-opsonized targets and enhances phagolysosomal fusion in COS-1 cells* J. Lipid Res., **49,** 531-542

Ikezu, T., Trapp, B.D., Song, K.S., Schlegel, A., et al (1998) *Caveolae, plasma membrane microdomains for α-secretase-mediated processing of the amyloid precursor protein* J. Biol. Chem., **273**, 10485-10495

Mansfield, P.J., Hinkovska-Galcheva, V., Borofsky, M.S., Shayman, J.A. et al (2005) *Phagocytic signaling molecules in lipid rafts of COS-1 cells transfected with FcγRIIA* Biochem. Biophys. Res. Commun., **331**, 132-138

Nishiyama, K., Trapp, B.D., Ikezu, T., Ransohoff, et al (1999) *Caveolin-3 upregulation activates β-secretase-mediated cleavage of the amyloid precursor protein in Alzheimer's disease* J. Neurosci., **19**, 6538-6548

Oh, P. and Schnitzer, J.E. (1999) *Immunoisolation of caveolae with high affinity antibody binding to the oligomeric caveolin cage* J. Biol. Chem, **274**, 23144-23154

7. Embryonic stem cells

Hernandez, V.J., Weng, J., Ly, P., Pompey, S., et al (2013) *Cavin-3 dictates the balance between ERK and Akt signaling* eLife, **2:** e00905

8. Endothelial (vascular) cells

Alzheimer's disease

David, M.A., Jones, D.R. and Tayebi, M. (2014) *Potential candidate camelid antibodies for the treatment of protein-misfolding diseases* J. Neuroimmunol., **272**, 76–85

ATP synthase

Yamamoto, K., Shimizu, N., Obi, S., Kumagaya, S., Taketani, Y., Kamiya, A. and Ando, J. (2007) *Involvement of cell surface ATP synthase in flow-induced ATP release by vascular endothelial cells* Am. J. Physiol. Heart Circ. Physiol., **293**, H1646-H1653

Caspase-3
Oxhorn, B.C. and Buxton, I.L.O. (2003) *Caveolar compartmentation of caspase-3 in cardiac endothelial cells* Cell. Signal., **15**, 489-496

Caveolin-2
Boyd, N.L., Park, H., Sun, W-P., Coleman, S.E., et al (2004) *Bovine caveolin-2 cloning and effects of shear stress on its localization in bovine aortic endothelial cells* Endothelium, **11**, 189-198

FC5
Abulrop, A., Sprong, H., Van Bergen en Henegouwen P. and Stanimirovic, D. (2005) *The blood-brain barrier transmigrating single domain antibody: mechanism of transport and antigenic epitopes in human brain endothelial cells.* J. Neurochem., **95**, 1201-1214

Glycolipids
Czarny, M., Liu, J., Oh, P. and Schnitzer, J.E. (2003) *Transient mechanoactivation of neutral sphingomyelinase in caveolae to generate ceramide* J. Biol. Chem., **278**, 4424-4430
Shu, L. and Shayman, J.A. (2007) *Caveolin-associated accumulation of globotriaosylceramide in the vascular endothelium of α-glactosidase A null mice* J. Biol. Chem., **282**, 20960-20967

HDL uptake
Balazs, Z., Panzenboeck, U., Hammer, A., Sovic, A., et al. (2004) *Uptake and transsport of high-density lipoprotein (HDL) and HDL-associated α-tocopherol by an in vitro blood-brain barrier model* J. Neurochem., **89**, 939-950

Ion transport
Wang, X-L., Ye, D., Peterson, T.E., Cao, S., et al (2005) *Caveolae targeting and regulation of large conductance Ca^{2+} -activated K^{+} channels in vascular endothelial cells* J. Biol. Chem., **280**, 11656-11664

Lung
Jiang, Y., Sverdlov, M.S., Toth, P.T., Huang, L.S., Du, G., Liu, Y., Natarajan, V. Minshall, R,D, (2016) *Phosphatidic acid produced by RalA-activated PLD2 stimulates caveolae-mediated endocytosis and trafficking in endothelial cells* J. Biol. Chem., **291**, 20729–20738

Nitric oxide synthase
Blair, A., Shaul, P.W., Yuhanna, I.S., Conrad, P.A., et al (1999) *Oxidized low density lipoprotein displaces endothelial nitric-oxide synthase (eNOS) from plasmalemmal caveolae and impairs eNOS activation* J. Biol Chem., **274**, 32512-32519 (1999)
Joshi, M.S., Mineo, C., Shaul, P.W. and Bauer, J.A. (2007) *Biochemical consequences of the NOS3 Glu298Asp variation in human endothelium: altered caveolar localization and impaired response to shear* FASEB J., **21**, 2655-2663
Kincer, J.F., Uittenbogaard, A., Dressman, J., Guerin, T. M., et al (2002) *Hypercholesterolemia promotes a CD36-dependent and endothelial nitric oxide synthase mediated vascular dysfunction* J. Biol. Chem., **277**, 23525-23533
Peterson, T.E., Poppa, V., Ueba, H., Wu, A., et al (1999) *Opposing effects of reactive oxygen species and cholesterol on endothelial nitric oxide synthase and endothelial cell* caveolae. Circ. Res., **85**, 29-37
Peterson, T.E., d'Uscio, L.V., Cao, S., Wang, X-L., et al (2009) *Guanosine triphosphate cyclohydrolase I expression and enzymatic activity are present in caveolae of endothelial cells* Hypertension, **53**, 189-195
Shaul, P.W., Smart, E.J., Robinson, L.J., German, Z., et al (1996) *Acylation targets endothelial nitric-oxide synthase to plasmalemmal caveolae* J. Biol. Chem., **271**, 6518-6522 (1996)
Uittenbogaard, A., Shaul, P.W., Yuhanna, I.S., Blair, A. et al (2000) *High density lipoprotein prevents oxidized low density lipoprotein-induced inhibition of endothelial nitric-oxide synthase localization and activation in caveolae* J. Biol. Chem., **275**, 11278-11283

Vascular barrier/integrity
Birukova, A.A., Singleton, P.A., Gawlak, G., Tian, X., et al (2014) *GRP78 is a novel receptor initiating a vascular barrier protective response to oxidized phospholipids* Mol. Biol. Cell, **25**, 2006-2016
David, M.A., Jones, D.R. and Tayebi, M. (2014) *Potential candidate camelid antibodies for the treatment of protein-misfolding diseases* J. Neuroimmunol., **272**, 76–85

Heemskerk, N., Asimuddin, M., Oort, C., van Rijssel, J. and van Buul, J.D. (2016) *Annexin A2lLimits neutrophil transendothelial migration by organizing the spatial distribution of ICAM-1* J. Immunol., **196**, 2767–2778

VEGF Receptors

Galvagni, F., Anselmi, F., Salameh, A., Orlandini, M., et al (2007) *Vascular endothelial growth factor receptor-3 activity is modulated by its association with caveolin-1 on endothelial membrane* Biochemistry**, 46**, 3998-4005
Ikeda, S., Ushio-Fukai, M., Zuo, L., Tojo, T., et al (2005) *Novel role of ARF6 in vascular endothelial growth factor-induced signaling and angiogenesis* Circ. Res., **96**, 467-475
Labrecque, L., Royal, I., Surprenant, D.S., Patterson, C., et al (2003) *Regulation of vascular endothelial growth factor receptor-2 activity by caveolin-1 and plasma membrane cholesterol* Mol. Biol. Cell, **14**, 334-347

9. Endothelial progenitor cells

Chilla, A., Magherini, F., Margheri, F., Laurenzana, A., et al (2013) *Proteomic identification of VEGF-dependent protein enrichment to membrane caveolar-raft microdomains in endothelial progenitor cells*. Mol. Cell. Proteom., **12**, 1926-1938
Margheri, F., Chilla, A., Laurenzana, A., Serratì, S., et al (2011) *Endothelial progenitor cell–dependent angiogenesis requires localization of the full-length form of uPAR in caveolae* Blood, **118**, 3743-3755

10. Epithelial cells

Bolander Jr., F.F. (2005) *The compartmentalization of prolactin signaling in the mouse mammary gland* Mol. Cell. Endocrinol., **245**, 105-110
Bradbury, N.A., Clark, J.A., Watkins, S.C., Widnell, C.C., et al (1999) *Characterization of the internalization pathways for the cystic fibrosis transmembrane conductance regulator* Am. J. Physiol. Lung Cell. Mol. Physiol., **276**, L659-L668
Briand, O., Lestavel, S., Pilon, A., Torpier, G., et al (2003) *SR-BI does not require raft/caveola localization for cholesteryl ester selective uptake in the human adrenal cell line NCI-H295R* Biochim. Biophys. Acta, **163**, 42-50
Chen, J., Chen, J-K. and Harris, R.C. (2012) *Angiotensin II induces epithelial-to-mesenchymal transition in renal epithelial cells through reactive oxygen species/Src/caveolin-mediated activation of an epidermal growth factor receptor–extracellular signal-regulated kinase signaling pathway* Mol. Cell. Biol., **32**, 981–991
Delmas, O., Breton, M., Sapin, C., Le Bivic, A., et al (2007) *Heterogeneity of raft-type membrane micrdomains associated with VP4, the rotavirus spike protein, in Caco-2 and MA 104 cells* J. Virol., **81**, 1610-1618
Heberden, C., Reine, F., Grosse, B., Henry, C., et al (2006) *Detection of a raft-located estrogen receptor-like protein distinct from ER*α Int. J. Biochem. Cell Biol., **38**, 376-391
Huang, C., Hepler, J.R., Chen, L.T., Gilman, A.G., et al (1997) *Organization of G proteins and adenylyl cyclase at the plasma membrane* Mol. Biol. Cell, **8**, 2365-2378
Kifor, O., Diaz, R., Butters, R., Kifor, I., et al (1998) *The calcium-sensing receptor is localized in caveolin-rich plasma membrane domains of bovine parathyroid cells* J. Biol. Chem., **273**, 1708-21713
Lalor, D., Liu, P. and Hayashi, J. (2004) *Fas ligand is enriched in the caveolae membrane domains of thymic epithelial cells* Cell. Immunol., **230**, 10-16
McMahon, K-A., Zhu, M., Kwon, S.W., Liu, P., et al (2006) *Detergent-free caveolae proteome suggests an interaction with ER and mitochondria* Proteomics, **6**, 143-152
Norman, A.W., Olivera, C.J., Silva, F.R.M.B. and Bishop, J.E. (2002) *A specific binding protein/receptor for 1*α*,25-dihydroxyvitamin* D_3 *is present in an intestinal caveolae membrane fraction* Biochem. Biophys. Res. Commun., **298**, 414-419
Pike, L.J., Han, X., Chung, K-N and Gross, R.W. (2002) *Lipid rafts are enriched in arachidonic acid and plasmenylethanolamine and their composition is independent of caveolin-1 expression: a quantitative electrospray ionization/mass spectrometric analysis* Biochemistry, **41**, 2075-2088
Smart, E.J., Mineo, C. and Anderson, R.G.W. (1996) *Clustered folate receptors deliver 5-methyltetra-hydrofolate to cytoplasm of MA104 cells* J. Cell Biol., **134**, 1169-1177
Subramanian, P.S. and Johnson, H.M. (2002) *Lipid microdomains are required sites for the selective endocytosis and nuclear translocation of IFN-*γ*, its receptor chain IFN-*γ *receptor-1, and phosphorylation and nuclear translocation of STAT1*α J. Immunol, **169**, 1959-1969

11. Fibroblasts

Cholesterol

Dufour, D., Zhao, W-Q., Ravindranath, L. and Alkon, D.L. (2003) *Abnormal cholesterol processing in Alzheimer's disease patient's fibroblasts* Neurobiol. Lipids., **1**, 34-44

Furuchi, T. and Anderson, R.G.W. (1998) *Cholesterol depletion of caveolae causes hyperactivation of extracellular signal-related kinase (ERK)* J. Biol. Chem., **273**, 21009-21104

Gallegos, A.M., McIntosh, A.L., Atshaves, B.P. and Schroeder, F. (2004) *Structure and cholesterol domain dynamics of an enriched caveolae/raft isolate* Biochem. J., **382**, 451-461

Laitinen, S., Lehto, M., Lehtonen, S., Hyvarinen, K., et al (2002) *ORP2, a homolog of oxysterol binding protein, regulates cellular cholesterol metabolism* J. Lipid Res., **43**, 245-255

Landry, Y.D., Denis, M., Nandi, S., Bell, S., et al (2006) *ATP-binding cassette transporter A1 expression disrupts raft membrane microdomains through its ATPase-related functions* J. Biol. Chem., **281**, 36091-36101

Lu, X., Kambe, F., Cao, X., Yoshida, T., et al (2006) *DHCR24-Knockout embryonic fibroblasts are susceptible to serum withdrawal-induced apoptosis because of dysfunction of caveolae and insulin-Akt-Bad signaling* Endocrinology, **147**, 3123-3132

Matthews, L.C., Taggart, M.J. and Westwood, M. (2005) *Effect of cholesterol depletion on mitogenesis and survival: the role of caveolar and noncaveolar domains in insulin-like growth factor-mediated cellular function* Endocrinology, **146**, 5463-5473

Smart, E.J., Ying, Ys., Donzell, W.C. and Anderson, R.G.W. (1996) *A role for caveolin in transport of cholesterol from endoplasmic reticulum to plasma membrane* J. Biol. Chem., **271**, 29427-29435

Uittenbogaard, A., Ying, Y.S. and Smart, E.J. (1998) *Characterization of a cytosolic heat-shock protein-caveolin chaperone complex* J. Biol. Chem., **273**, 6525-6532

Yin, Y., Liu, P., Anderson, R.G.W. and Sampson, N.S. (2002) *Construction of a catalytically inactive cholesterol oxidase mutant: inverstigation of the interplay between active site-residues glutamate 361 and histidine 447* Arch. Biochem. Biophys., **402**, 235-242

Composition and structure

Landry, Y.D., Denis, M., Nandi, S., Bell, S., et al (2006) *ATP-binding cassette transporter A1 expression disrupts raft membrane microdomains through its ATPase-related functions* J. Biol. Chem., **281**, 36091-36101

Marks, D.L., Bittman, R. and Pagano, R.E. (2008) *Use of Bodipy-labeled sphingolipid and cholesterol analogs to examine membrane microdomains in cells* Histochem. Cell. Biol., **130**, 819-832

McMahon, K-A., Zhu, M., Kwon, S.W., Liu, P., et al (2006) *Detergent-free caveolae proteome suggests an interaction with ER and mitochondria* Proteomics, **6**, 143-152

Smart, E.J., Ying, Y-S, Mineo, C. and Anderson, R.G.W. (1995) *A detergent-free method for purifying caveolae membrane from tissue culture cells* Proc. Natl. Acad. Sci. USA, **92**, 10104-10108

Westermann, M., Leutbecher, H. and Meyer, H.W. (1999) *Membrane structure of caveolae and isolated caveolin-rich vesicles* Histochem. Cell Biol., **111**, 71-81

Glycosphingolipids

Kim, S-Y., Wang, T-k., Singh, R.D., Wheatley, C.L., Marks, D.L. and Pagano, R.E. (2009) *Proteomic identification of proteins translocated to membrane microdomains upon treatment of fibroblasts with the glycosphingolipid, C8-β-D-lactosylceramide* Proteomics, **9**, 4321-4328

Growth factor receptors (see also "Protein targeting and activation" and "Signal transduction")

Boucher, P., P., Liu, P., Gotthardt, M., Hiesberger, T., et al (2002) *Platelet-derived growth factor mediates tyrosine phosphorylation of the cytoplasmic domain of the low density lipoprotein receptor-related protein in caveolae* J. Biol. Chem., **277**, 15507-15513

Liu, P., Ying, Y., Ko, Y.G and Anderson, R.G.W. (1996) *Localization of platelet-derived growth factor-stimulated phosphorylation cascade to caveolae* J. Biol. Chem., **271**, 10299-10303

Liu, P., Ying, Y-S., and Anderson. R.G.W. (1997) *Platelet-derived growth factor activates mitogen-activated protein kinase in isolated caveolae* Proc. Natl. Acad. Sci., USA, **94**, 13666-13670

Liu, P. and Anderson, R.G.W. (1999) *Spatial organization of EGF receptor transmodulation by PDGF* Biochem. Biophys. Res. Commun., **261**, 695-700

Matthews, L.C., Taggart, M.J. and Westwood, M. (2005) *Effect of cholesterol depletion on mitogenesis and survival: the role of caveolar and noncaveolar domains in insulin-like growth factor-mediated cellular function* Endocrinology, **146**, 5463-5473

Matveev, S.V. and Smart, E.J. (2002) *Heterologous desensitization of EGF receptors and PDGF receptors by sequestration in caveolae* Am. J. Physiol Cell Physiol, **282**, C935-C946

Mineo, C., James, G.L., Smart, E.J. and Anderson, R.G.W. (1996) *Localization of epidermal growth factor-stimulated Ras/Raf-1 interaction to caveolae membrane* J. Biol. Chem., **271**, 11930-11935

Mineo, C., Gill, G.N. and Anderson, R.G.W. (1999) *Regulated migration of epidermal growth factor receptor from caveolae* J. Biol. Chem., **274**, 30636-30643
Yamabhai, M. and Anderson, R.G.W. (2002) *Second cysteine-rich region of epidermal growth factor receptor contains targeting information for caveolae/rafts* J. Biol. Chem., **277**, 24843-24846
Yang, N., Huang, Y., Jiang, J. and Frank, S.J. (2004) *Caveolar and lipid raft localization of the growth hormone receptor ans its signaling elements* J. Biol. Chem., **279** 20898-20905

Lipoproteins
Boucher, P., P., Liu, P., Gotthardt, M., Hiesberger, T., et al (2002) *Platelet-derived growth factor mediates tyrosine phosphorylation of the cytoplasmic domain of the low density lipoprotein receptor-related protein in caveolae* J. Biol. Chem., **277**, 15507-15513
Nion, S., Briand, O., Lestavel, S., Torpier, G., et al (1997) *High-density-lipoprotein subfraction 3 interaction with glycosylphosphatidyl-inositol-anchored proteins* Biochem. J., **328**, 415-423

Protein targeting and activation
Li, W-P., Liu, P., Pilcher, B.K. and Anderson, R.G.W. (2001) *Cell-specific targeting of caveolin-1 to caveolae, secretory vesicles, cytoplasm or mitochondria* J. Cell Sci., **114**, 1397-1408
Michaely, P.A., Mineo, C. Ying, Y-S. and Anderson, R.G.W. (1999) *Polarized distribution of endogenous Racl and RhoA at the cell surface* J. Biol. Chem., **274**, 21430-21436
Mineo, C., James, G.L., Smart, E.J. and Anderson, R.G.W. (1996) *Localization of epidermal growth factor-stimulated Ras/Raf-1 interaction to caveolae membrane* J. Biol. Chem., **271**, 11930-11935
Mineo, C., Anderson, R.G.W. and White, M.A. (1997) *Physical association with Ras enhances activation of membrane-bound Raf (RafCAAX)* J. Biol. Chem., **272**, 10345-10348
Shu, L., Lee, L., Chang, Y., Holzman, L.B., et al (2000) *Caveolar structure and protein sorting are maintained in NIH cells independent of glycosphingolipid depletion* Arch. Biochem. Biophys., **373**, 83-90
Uittenbogaard, A., Ying, Y.S. and Smart, E.J. (1998) *Characterization of a cytosolic heat-shock protein-caveolin chaperone complex* J. Biol. Chem., **273**, 6525-6532

Signal transduction
Bilderback, T.R., Gazula, V-R., Lisanti, M.P. and Dobrowsky, R.T. (1999) *Caveolin interacts with Trk A and* $p75^{NTR}$ *and regulates neurotrophin signaling pathways* J. Biol. Chem., **274**, 257-263
Chen, J., Doroudi, M., Cheung, J., Grozier, A.L., et al (2013) *Plasma membrane Pdia3 and VDR interact to elicit rapid responses to* $1\alpha,25(OH)_2D_3$ Cell. Signal., **25**, 2362–2373
Huang, C., Hepler, J.R., Chen, L.T., Gilman, et al (1997) *Organization of G proteins and adenylyl cyclase at the plasma membrane* Mol. Biol. Cell, **8**, 2365-2378
Liu, P., Wang, P-y., Michaely, P., Zhu, M., et al (2000) *Presence of oxidized cholesterol in caveolae uncouples active platelet-derived growth factor receptors from tyrosine kinase substrates* J. Biol. Chem., **275**, 31648-31654
Lu, X., Kambe, F., Cao, X., Yoshida, T., et al (2006) *DHCR24-Knockout embryonic fibroblasts are susceptible to serum withdrawal-induced apoptosis because of dysfunction of caveolae and insulin-Akt-Bad signaling* Endocrinology, **147**, 3123-3132
Mineo, C., Ying, Y-S, Chapline, C., Jaken, S., et al (1998) *Targeting of protein kinase Cα to caveolae* J. Cell Biol., **141**, 601-610
Yin, Y., Liu, P., Anderson, R.G.W. and Sampson, N.S. (2002) *Construction of a catalytically inactive cholesterol oxidase mutant: inverstigation of the interplay between active site-residues glutamate 361 and histidine 447* Arch. Biochem. Biophys., **402**, 235-242

11. HEK cells
Balijepalli, R.C., Delisle, B.P., Balijepalli, S.Y., Foell, J.D., et al (2007) *Kv11.1 (ERH1)* K^+ *channels localize in cholesterol and sphingolipid enriched membranes and are modulated by cholesterol* Channels, **1**, 263-272
Fortin, J-P., Rivard, G.E., Adam, A. and Marceau, F. (2005) *Studies on rabbit natural and recombinant tissue factors: intracellular retention and regulation of surface expression in cultured cells* Am. J. Physiol., **288**, H2192-H2202
Ikezu, T., Trapp, B.D., Song, K.S., Schlegel, A., et al (1998) *Caveolae, plasma membrane microdomains for α-secretase-mediated processing of the amyloid precursor protein* J. Biol. Chem., **273**, 10485-10495
Lamb, M.E., de Weerd, W.F.C. and Leeb-Lundberg, L.M.F. (2001) *Agonist-promoted trafficking of human bradykinin receptors: arrestin- and dynamin-independent sequestration of the* B_2 *receptor and bradykinin in HEK293 cells* Biochem. J., **355**, 741-750
Lamb, M.E., Zhang, C., Shea, T., Kyle, D.J., et al (2002) *Human B1 and B2 bradykinin receptors and their agonists target caveolae-related lipid rafts to different degrees in HEK293 cells* Biochemistry, **41**, 14340-14347

Sabourin, T., Bastien, L., Bachvarov, D.R., and Marceau, F. (2002) *Agonist-induced translocation of the kinin B_1 receptor to caveolae-related rafts* Mol. Pharmacol., **61,** 546-553
Sorci-Thomas, M.G., Owen, J.S., Fulp, B., Bhat, S., Zhu, X., Parks, J.S., Shah, D., Jerome, W.G., Gerelus, M., Zabalawi, M. and Thomas, M.J. (2012) *Nascent high density lipoproteins formed by ABCA1 resemble lipid rafts and are structurally organized by three apoA-I monomers* J. Lipid Res., **53**, 1890–1909

12. Hepatoma cells

Smith, R.M., Harada, S., Smith, J.A., Zhang, S., et al (1998) *Insulin-induced protein tyrosine phosphorylation cascade and signalling molecules are localized in a caveolin-enriched cell membrane domain* Cell. Signalling, **10**, 355-362
Truong, T.Q., Aubin, D., Bourgeois, P., Falstrault, L., et al (2006) *Opposite effect of caveolin-1 in the metabolism of high-density and low-density lipoproteins* Biochim. Biophys. Acta, **1761**, 24-36
Yanase, K. and Madaio, M.P. (2005) *Nuclear localization anti-DNA antibodies enter cells via caveoli and modulate expression of caveolin and p53* J. Autoimmun., **24**, 145-151

13. Intestine

Huhtakangas, J.A., Olivera, C.J., Bishop, J.E., Zanello, L.P., et al (2004) *The vitamin D receptor is present in caveolae-enriched plasma membranes and binds $1\alpha,25(OH)_2$-vitamin D_3 in vivo and in vitro* Mol. Endocrinol., **18**, 2660-2671

14. Kidney

Chen, J., Chen, J-K. and Harris, R.C. (2012) *Angiotensin II induces epithelial-to-mesenchymal transition in renal epithelial cells through reactive oxygen species/Src/caveolin-mediated activation of an epidermal growth factor receptor–extracellular signal-regulated kinase signaling pathway* Mol. Cell. Biol., **32**, 981–991
Hill, W.G., Butterworth, M.B., Wang, H. Edinger, R.S., et al (2007) *The epithelial sodium channel (ENaC) traffics to apical membrane in lipid rafts in mouse cortical collecting duct cells* J. Biol. Chem., 282, 37402-37411
Huhtakangas, J.A., Olivera, C.J., Bishop, J.E., Zanello, L.P et al (2004) *The vitamin D receptor is present in caveolae-enriched plasma membranes and binds $1\alpha,25(OH)_2$-vitamin D_3 in vivo and in vitro* Mol. Endocrinol., **18**, 2660-2671
Yosef, E., Katz, A., Peleg, Y., Mehlman, T. and Karlish, S.J.D. (2016) *Do Src kinase and caveolin interact directly with Na,K-ATPase?* J. Biol. Chem., **291**, 11736–11750

15. Liver (fish)

Zehmer, J.K. and Hazel, J.R. (2004) *Membrane order conservation in raft and non-raft regions of hepatocyte plasma membranes from thermally acclimated rainbow trout* Biochim, Biophys. Acta., **1664**, 108-116
Zehmer, J.K. and Hazel, J.R. (2005) *Thermally induced changes in lipid composition of raft and non-raft regions of hepatocyte plasma membranes of rainbow trout* J. Exp. Biol., **208**, 4283-4290

16. Liver (rodent)

Huhtakangas, J.A., Olivera, C.J., Bishop, J.E., Zanello, L.P. et al (2004) *The vitamin D receptor is present in caveolae-enriched plasma membranes and binds $1\alpha,25(OH)_2$-vitamin D_3 in vivo and in vitro* Mol. Endocrinol., **18**, 2660-2671
Wang, Y., Posner, B.I. and Balbis, A. (2009) *Compartmentalization of epidermal growth factor receptor in liver plasma membrane* J. Cell. Biochem., **107**, 96-103

17. Lung

Hill, W.G., Almasri, E., Ruiz, W.G., Apodaca, G., et al (2005) *Water and solute permeability of rat lung caveolae: high permeabilities explained by acyl chain unsaturation* Am. J. Physiol., **289**, C33-C41
Huhtakangas, J.A., Olivera, C.J., Bishop, J.E., Zanello, L.P., et al (2004) *The vitamin D receptor is present in caveolae-enriched plasma membranes and binds $1\alpha,25(OH)_2$-vitamin D_3 in vivo and in vitro* Mol. Endocrinol., **18**, 2660-2671
Oh, P. and Schnitzer, J.E. (1999) *Immunoisolation of caveolae with high affinity antibody binding to the oligomeric caveolin cage* J. Biol. Chem, **274**, 23144-23154
Oh, P. and Schnitzer, J.E. (2001) *Segregation of heterotrimeric G proteins in cell surface microdomains* Mol. Biol. Cell, **12**, 685-698

18. Lymphoid/monocytic cells

Huhtakangas, J.A., Olivera, C.J., Bishop, J.E., Zanello, L.P., et al (2004) *The vitamin D receptor is present in caveolae-enriched plasma membranes and binds $1\alpha,25(OH)_2$-vitamin D_3 in vivo and in vitro* Mol. Endocrinol., **18**, 2660-2671

Matveev, S., van der Westhuyzen, D.R. and Smart, E.J. (1999) *Co-expression of scavenger receptor-BI and caveolin-1 is associated with enhanced selective cholesterol ester uptake in THP-1 macrophages* J. Lipid Res., **40**, 1647-1654

McMahon, K-A., Zhu, M., Kwon, S.W., Liu, P., et al (2006) *Detergent-free caveolae proteome suggests an interaction with ER and mitochondria* Proteomics, **6**, 143-152

Poussin, C., Foti, M., Carpentier, J.L. and Pugin, J. (1998) *CD14-dependent endotoxin internalization via a macropinocytic pathway* J. Biol. Chem., **273**, 20285-20291

Uittenbogaard, A. and Smart, E.J. (2000) *Palmitoylation of caveolin-1 is required for cholesterol binding, chaperone complex formation, and rapid transport of cholesterol to caveolae* J. Biol. Chem., **275**, 25595-25599

19. Macrophages

Sorci-Thomas, M.G., Owen, J.S., Fulp, B., Bhat, S., et al (2012) *Nascent high density lipoproteins formed by ABCA1 resemble lipid rafts and are structurally organized by three apoA-I monomers* J. Lipid Res., **53**, 1890–1909

Zhu, X., Owen, J.S., Wilson, M.D., Li, H., et al (2010) *Macrophage ABCA1 reduces MyD88-dependent Toll-like receptor trafficking to lipid rafts by reduction of lipid raft cholesterol* J. Lipid Res., **51**, 3196–3206

MC3T3-E1 cells (see "Fibroblasts")

20. MDCK (and other kidney cells)

Gallegos, A.M., Storey, S.M., Kier, A.B., Schroeder, F., et al (2006) *Structure and cholesterol dynamics of caveolae/raft and nonraft plasma membrane domains* Biochemistry, **45**, 12100-12116

Heller, B., Adu-Gyamfi, E., Smith-Kinnaman, W., Babbey, C., et al (2010) *Amot recognizes a juxtanuclear endocytic recycling compartment via a novel lipid binding domain* J. Biol. Chem., **285**, 12308-12320

Huang, C., Hepler, J.R., Chen, L.T., Gilman, A.G., et al (1997) *Organization of G proteins and adenylyl cyclase at the plasma membrane* Mol. Biol. Cell, **8**, 2365-2378

Huang, C., Duncan, J.A., Gilman, A.G. and Mumby, S.M (1999) *Persistent membrane association of activated and depalmitoylated G protein α subunits* Proc. Natl. Acad. Sci. USA, **96**, 412-417

Ikezu, T., Trapp, B.D., Song, K.S., Schlegel, A., Lisanti, M.P. and Okamoto, T. (1998) *Caveolae, plasma membrane microdomains for α-secretase-mediated processing of the amyloid precursor protein* J. Biol. Chem., **273**, 10485-10495

McMahon, K-A., Zhu, M., Kwon, S.W., Liu, P., et al (2006) *Detergent-free caveolae proteome suggests an interaction with ER and mitochondria* Proteomics, **6**, 143-152

Nashiki, K., Taketani, Y., Takeichi, T., Sawada, N., et al (2005) *Role of membrane microdomains in PTH-mediated down-regulation of NaPi-Iia in opossum kidney cells* Kidney Int., **68**, 1137-1147

21. Neural tissue and cells

Abulrob, A., Giuseppin, S., Andrade, M.F., McDermid, A., et al (2004) *Interactions of EGFR and caveolin-1 in human glioblastoma cells: evidence that tyrosine phosphorylation regulates EGFR association with caveolae* Oncogene, **23**, 6967-6979

Brouillett, E., Trembleau, A., Galanaud, D., Volovitch, M., et al (1999) *The amyloid precursor protein interacts with G_o heterotrimeric protein within a cell compartment specialized in signal transduction* J. Neurosci., **19**, 1717-1727

Cameron, P.L., Ruffin, J.W., Bollag, R., Rasmussen, H., et al (1997) *Identification of caveolin and caveolin-related proteins in the brain* J. Neurosci., **17**, 9520-9535

Kelly, J.F., Storie, K., Skamra, C., Bienias, J., et al (2005) *Relationship between Alzheimer's disease clinical stage and Gq/11 in subcellular fractions of frontal cortex* J. Neural Transm., **112**, 1049-1056

Kumanogoh, H., Miyata, S., Sokawa, Y. and Maekawa, S. (2001) *Biochemical and morphological analysis on the localization of Rac1 in neurons* Neurosci. Res., **39**, 189-196

Langelier, B., Linard, A., Bordat, C., Lavialle, M., et al (2010) *Long chain-polyunsaturated fatty acids modulate membrane phospholipid composition and protein localization in lipid rafts of neural stem cell cultures* J. Cell. Biochem., **110**, 1356–1364

Nishiyama, K., Trapp, B.D., Ikezu, T., Ransohoff, R.M., et al (1999) *Caveolin-3 upregulation activates β-secretase-mediated cleavage of the amyloid precursor protein in Alzheimer's disease* J. Neurosci., **19**, 6538-6548

Ren, Q. and Bennett, V. (1998) *Palmitoylation of neurofascin at a site in the membrane-spanning domain highly conserved among the L1 family of cell adhesion molecules* J. Neurochem., **70**, 1839-1849
Rimmerman, N., Hughes, H.V., Bradshaw, H.B., Pazos, M.X., et al (2008) *Compartmentalization of endocannabinoids into lipid rafts in a dorsal root ganglion cell line* Br. J. Pharmacol., **153**, 380–389
Tome, M.E., Schaefer, C.P., Jacobs, L.M., Zhang, Y., Hemdon, J.M., Matty, F.O. and Davis, T.P. (2015) *Identification of P- glycoprotein co-fractionating proteins and specific binding partners in rat brain microvessels* J. Neurochem., **134**, 200-210
Toran-Allerand, C.D., Guan, X., MacLusky, N.J., Horvath, T.L., et al (2002) *ER-X: A novel, plasma membrane-associated, putative estrogen receptor that is regulated during development and after ischemic brain injury* J. Neurosci., **22**, 8391-8401
Vey, M., Pilkuhn, S., Wille, H., Nixon, R., et al (1996) *Subcellular colocalization of the cellular and scrapie prion proteins in caveolae-like membranous domains* Proc. Natl. Acad. Sci. USA, **93**, 14945-14949
Wu, C., Butz, S., Ying, Y-S and Anderson, R.G.W. (1997) *Tyrosine kinase receptors concentrated in caveolae-like domains from neuronal plasma membrane* J. Biol. Chem., **272**, 3554-3559
Zhai, J., Ström, A.L., Kilty, R., Venkatakrishnan, P., et al (2009) *Proteomic characterization of lipid raft proteins in amyotrophic lateral sclerosis mouse spinal cord* FEBS J., **276**, 3308-3323

22. Osteoblasts/osteoclasts

Chen, J., Olivares-Navarrete, R., Wang, Y., Herman, T.R., et al (2010) *Protein-disulfide isomerase-associated 3 (Pdia3) mediates the membrane response to 1,25-dihydroxyvitamin D3 in osteoblasts* J. Biol. Chem., **285**, 37041–37050
Chen, J., Doroudi, M., Cheung, J., Grozier, A.L., et al (2013) *Plasma membrane Pdia3 and VDR interact to elicit rapid responses to* $1\alpha,25(OH)_2D_3$ Cell. Signal., **25**, 2362–2373
Doroudi, M., Schwartz, Z., and Boyan, B.D. (2012) *Phospholipase A2 activating protein is required for 1α,25-dihydroxyvitamin D3 dependent rapid activation of protein kinase C via Pdia3* J. Steroid Biochem. Mol. Biol., **132**, 48– 56
Doroudi, M., Olivares-Navarrete, R., Hyzy, S.L., Boyan, B.D. amd Schwartz, Z. (2014) *Signaling components of the* $1\alpha,25(OH)_2D_3$*-dependent Pdia3 receptor complex are required for Wnt5a calcium-dependent signaling* Biochim. Biophys. Acta, **1843**, 2365–2375
Doroudi, M., Plaisance, M.C., Boyan, B.D. and Schwartz, Z. (2015) *Membrane actions of* $1\alpha,25(OH)_2D_3$ *are mediated by* Ca^{2+}*/calmodulin-dependent protein kinase II in bone and cartilage cells* J. Steroid Biochem. Mol. Biol., **145**, 65–74

23. Platelets

Silvagno, F., De Vivo, E., Attanasio, A., Gallo, V., et al (2010) *Mitochondrial localization of vitamin D receptor in human platelets and differentiated megakaryocytes* PLoS One **5**: e8760

24. Pre-adipocytes

Wang, X., Yang, N., Deng, L., Li, X., et al (2009) *Interruption of growth hormone signaling via SHC and ERK in 3T3-F442A preadipocytes upon knockdown of insulin receptor substrate-1* Mol. Endocrinol., **23**, 486–496

25. Smooth muscle and smooth muscle cells

25-1. Airway

Grim, K.J., Abcejo, A.J., Barnes, A., Sathish, V., Smelter, D.F., Ford, G.C., Thompson, M.A., Prakash, Y.S. and Pabelick, C.M. (2012) *Caveolae and propofol effects on airway smooth muscle* Br. J. Anaesth., **109**, 444–53
Prakash, Y.S., Thompson, M.A., Vaa, B., Matabdin, I., et al (2007) *Caveolins and intracellular calcium regulation in human airway smooth muscle* Am. J. Physiol. Lung Cell. Mol. Physiol., **293**, L1118-L1126
Sathish, V., Yang, B., Meuchel, L.W., Van Oosten, S.K., et al (2011) *Caveolin-1 and force regulation in porcine airway smooth muscle* Am. J. Physiol. Lung Cell. Mol. Physiol., **300**, L920–L929
Sathish, V., Abcejo, A.J., VanOosten, S.K., Thompson, M.A., et al (2011) *Caveolin-1 in cytokine-induced enhancement of intracellular* Ca^{2+} *in human airway smooth muscle* Am. J. Physiol. Lung Cell. Mol. Physiol., **301**, L607–L614
Sathish, V., Thompson, M.A., Sinha, S., Sieck, G.C., et al (2014) *Inflammation, caveolae and CD38-mediated calcium regulation in human airway smooth muscle* Biochim. Biophys. Acta, **1843**, 346–351

25-2. Cardiac myocytes

Doyle, D.D., Goings, G., Upshaw-Earley, J., Ambler, S.K., et al (2000) *Dystrophin associates with a caveolae of rat cardiac myocytes* Circ. Res., **87**, 480-488

Lasley, R.D., Narayan, P., Uittenbogaard, A. and Smart, E.J. (2000) *Activated cardiac adenosine A_1 receptors translocate out of caveolae* J. Biol. Chem., **275**, 4417-4421
Liu, L., Mohammadi, K., Aynafshar, B., Wang, H., et al (2003) *Role of caveolae in signal-tranducing function of cardiac Na^+/K^+ -ATPase* Am. J. Physiol. Cell Physiol., **284**, C1550-C1560
Rybin, V.O., Xu, X., Lisanti, M.P. and Steinberg, S.F. (2000) *Differential targeting of β-adrenergic receptor subtypes and adenyl cyclase to cardiomyocyte caveolae: A mechanism to functionally regulate the cAMP signaling pathway* J. Biol. Chem., **275**, 41447-41457

25-3. Gall bladder

Cong, P., Pricolo, V., Biancani, P. and Behar, J. (2010) *Effects of cholesterol on CCK-1 receptors and caveolin-3 proteins recycling in human gallbladder muscle* Am. J. Physiol. Gastrointest. Liver Physiol., **299**, G742–G750
Xiao, Z., Schmitz, F., Pricolo, V.E., Biancani, P., et al (2007) *Role of caveolae in the pathogenesis of cholesterol-induced gall bladder muscle hypomotility* Am. J. Physiol. Gastrointest. Liver Physiol., **292**, G1641-G1649

25-4. MF-2 cells

De Weerd, W.F.C. and Leeb-Lundberg, L.M.F. (1997) *Bradykinin sequesters B2 bradykinin receptors and the receptor-coupled Gα subunits $G\alpha_q$ and $G\alpha_i$ in caveolae in DDT_1 MF-2 smooth muscle cells* J. Biol. Chem., **272**, 17858-17866

25-5. Vascular (primarily pulmonary artery)

Angiotensin receptors

Zuo, L., Ushio-Fukai, M., Hilenski, L.L. and Alexander, R.W. (2004) *Microtubules regulate angiotensin II type 1 receptor and Rac1 localization in caveolae/lipid rafts* Arterioscler. Thromb. Vasc. Biol., **24**, 1223-1228
Zuo, L., Ushio-Fukai, M., Ikeda, S., Hilenski, L., et al (2005) *Caveolin-1 is essential for activation of Rac1 and NAD(P)H oxidase after angiotensin II type 1 receptor stimulation in vascular smooth muscle cells* Arterioscler. Thromb. Vasc. Biol., **25**, 1824-1830

Growth factor receptors

Ashino, T., Sudhahar, V., Urao, N., Oshikawa, J., et al (2010) *Unexpected role of the copper transporter ATP7A in PDGF-induced vascular smooth muscle cell migration* Circ. Res., **107**, 787-799
Bousserouel, S., Raymondjean, M., Brouillet, A., Bereziat, G., et al (2004) *Modulation of cyclin D1 and early growth response factor-1 gene expression in interleukin-1β-treated rat smooth muscle cells by n-6 and n-3 polyunsaturated fatty acids* Eur. J. Biochem., **271**, 4462-4473

Lipoprotein receptor

Von Arnim, C.A.F., Kinoshita, A., Peltan, I.D., Tangredi, M.M., et al (2005) *The low density lipoprotein receptor-related protein (LRP) is a novel β-secretase (BACE1) substrate* J. Biol. Chem., **280**, 17777-17785

Na^+/K^+-ATPase and Ca^{2+} regulation

Ghosh, B., Kar, P., Mandal, A., Dey, K., et al (2009) *Ca^{2+} influx mechanisms in caveolae vesicles of pulmonary smooth muscle plasma membrane under inhibition of α2β1 isozyme of Na^+/K^+-ATPase by ouabain* Life Sci., **84**, 39–148
Ghosh, B., Chakraborti, T., Kar, P., Dey, K., et al (2009) *Solubilization, purification, and reconstitution of a2b1 isozyme of Na^+/K^+-ATPase from caveolae of pulmonary smooth muscle plasma membrane: comparative studies with DHPC, C12E8, and Triton X-100* Mol. Cell. Biochem., **323**, 169–184
Shaikh, S., Samanta, K., Kar, P., Roy, S., et al (2010) *m-Calpain-mediated cleavage of Na^+/Ca^{2+} exchanger-1 in caveolae vesicles isolated from pulmonary artery smooth muscle* Mol. Cell. Biochem., **341**, 167–180

Signaling pathways

Hilenski, L.L., Clempus, R.E., Quinn, M.T., Lambeth, J.D. and Griendling, K.K. (2004) *Distinct subcellular localizations of Nox1 and Nox4 in vascular smooth muscle cells* Arterioscler. Thromb. Vasc. Biol., **24**, 1-8

Tissue factors

Fortin, J-P., Rivard, G.E., Adam, A. and Marceau, F. (2005) *Studies on rabbit natural and recombinant tissue factors: intracellular retention and regulation of surface expression in cultured cells* Am. J. Physiol., **288**, H2192-H2202

25-6. Uterine

Kiss, A.L., Turi, A., Mullner, N., Kovacs, E., et al (2005) *Oestrogen-mediated tyrosine phosphorylation of caveolin-1 and its effect on the oestrogen receptor localization: an in vivo study* Mol. Cell. Endocrinol., **245**, 128-137

26. Thyroid

Lin, C-I., Barletta, J.A., Nehs, M.A., Morris, Z.S., et al (2011) *Thyroid-specific knockout of the tumor suppressor mitogen-inducible gene 6 activates epidermal growth factor receptor signaling pathways and suppresses nuclear factor-κB activity* Surgery, **150**, 1295-302

27. Review articles

Balbis, A. and Posner, B.I. (2010) *Compartmentalization of EGFR in cellular membranes: role of membrane rafts* J. Cell. Biochem., **109**, 1103–1108
Brown, D.A. and London, E. (1998) *Functions of lipid rafts in biological membranes* Annu. Rev. Cell Dev. Biol., **14**, 111-136
Casem, M.L. (2016) *Cytoskeleton and intracellular motility* In "Case studies in cell biology" Elsevier Inc, pp 127-156
Gimpl, G. and Gehrig-Burger, K. (2012) *Specific and non specific regulation of GPCR function by cholesterol* In Regulation of ion channels and receptors (Ed. Levitan, I. and Barrantes, F.J.) John Wiley & Sons, Inc., pp 205-230
Head, B.P., Patel, H.H. and Insel, P.A. (2014) *Interaction of membrane/lipid rafts with the cytoskeleton: Impact on signaling and function. Membrane/lipid rafts, mediators of cytoskeletal arrangement and cell signaling* Biochim. Biophys. Acta, **1838**, 532–545
Kim, W., Chapkin, R.S., Barhoumi, R. and Ma, D.W.L. (2009) *A novel role for nutrition in the alteration of functional microdomains on the cell surface* In Methods Mol. Biol., **579**, Lipidomics (ed. Armstrong, D) Humana Press, Totowa, NJ, pp 261-270
Landry, A. and Xavier, R. (2006) *Isolation and analysis of lipid rafts in cell-cell interactions* Methods Mol. Biol., **341**, 251-282
Lasley, R.D. (2011) *Adenosine receptors and membrane microdomains* Biochim. Biophys. Acta, **1808**, 1284–1289
Matveev, S., Li, X., Everson, W. and Smart, E.J. (2001) *The role of caveolae and caveolin in vesicle-dependent and vesicle-independent trafficking* Adv. Drug. Deliver. Rev., **49**, 237-240
Mingpeng, S. and Zongli, W. (1999) *The protective role of high-density lipoproteins in atherosclerosis* Exp. Gerontol., **34**, 539-548
Minogue, S. and Waugh, M.G. (2012) *Lipid rafts, microdomain heterogeneity and inter-organelle contacts: Impacts on membrane preparation for proteomic studies* Biol. Cell, **104**, 618–627
Pilch, P.F., Souto, R.P., Liu, L., Jedrycjowski, M.P., et al (2007) *Cellular spelunking: exploring adipocyte caveolae* J. Lipid Res., **48**, 2103-2111
Shaul, P.W. and Anderson, R.G.W. (1998) *Role of plasmalemmal caveolae in signal transduction* Am. J. Physiol., **275**, 843-851
Stillwell, W. (2016) *Membrane isolation methods* In "An Introduction to Biological Membranes" Elsevier Inc, pp 247-271
Svobada, P. and Novotny, J. (2002) *Hormone-induced subcellular redistribution of trimeric G proteins* Cell. Mol. Life Sci., **59**, 501-512
Thomas, C.M. and Smart, E.J. (2008) *Caveolae structure and function* J. Cell Mol. Med., **12**, 796-809

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