OptiPrep™ Mini-Review MS16

Endocytosis – a bibliographical review

The following references are concerned with the pathways of the endocytic process and describe the use of iodixanol gradients for the purification of a variety of membrane compartments.

- References are primarily sorted into **cell/tissue type**, or occasionally a cell process: e.g. **virus processing**
- Each **cell/tissue type** is sorted according to the **principal analytical study**.
- In each section or subsection references are listed alphabetically according to **first author**; a particular reference may appear in more than one subsection
- Note that the companion **Mini-Review MS15** summarizes the available methods for fractionation of components of the endocytic system

There are also several Application Sheets, accessible from the "Subcellular Membranes Index", devoted to the use of cultured cells or mammalian liver:

- Cultured cells – buoyant density gradients: **Application Sheet S44**
- Cultured cells/rat liver – self-generated gradients: **Application Sheet S43**
- Rat liver – gradients for study of late endosome/lysosome events: **Application Sheet S52**
- Rat liver – sedimentation velocity gradients: **Application Sheet S42**
- **Application Sheet S54** (Lysosomes (ER/endosomes/plasma membrane)) also addresses the separation of lysosomes, plasma membrane and endosomes

There are three other **Mini-Reviews** that provide bibliographies of papers reporting the analysis of lipid-rich plasma membrane domains, which may also be relevant in the endocytic process

- **MS08** Lipid rich detergent-resistant domains from mammalian cells, tissues and organelles
- **MS09** Detergent-free strategy for lipid raft isolation from mammalian cells and tissues
- **MS10** Purification of caveolae in gradients prepared from OptiPrep™
- All of the Application Sheets and Mini-Reviews can be found in the on the OptiPrep™ Applications/Mini-Reviews flash-drive or on the following website: www.axis-shield-density-gradient-media.com. On the website click on the "Methodology" tab for the Application Sheets..

- To assist the identification of a relevant reference in the following index key words are highlighted in blue

Adipocytes

Methodology

Sadler, J.B.A., Lamb, C.A., Gould, G.W. and Bryant, N.J. (2016) *Iodixanol gradient centrifugation to separate components of the low-density membrane fraction from 3T3-L1 adipocytes* Cold Spring Harb. Protoc., doi:10.1101/pdb.prot083709

Arabidopsis

Plant receptors

Groen, A.J., de Vries, S.C. and Lilley, K.S. (2008) *A proteomics approach to membrane trafficking* Plant Physiol., **147**, 1584-1589

Airway epithelial cells

Cystic fibrosis membrane conductance regulator

Bomberger, J.M., MacEachran, D., Ye, S., Swiatecka-Urban, A., et al (2007) *CFTR inhibitory factor (CIF) reduces the plasma membrane expression of CFTR by altering intracellular trafficking of CFTR to the lysosomal pathway* FASEB J., **21**, 944.4

Bomberger, J.M., Ye, S., MacEachran, D.P., Koeppen, K., et al (2011) *A Pseudomonas aeruginosa toxin that hijacks the host ubiquitin proteolytic system* PLoS Pathog., **7**: e1001325

Bomberger, J.M., Guggino, W.B. and Stanton, B.A. (2011) *Methods to monitor cell surface expression and endocytic trafficking of CFTR in polarized epithelial cells* In Cystic Fibrosis, Methods Mol. Biol. (eds. Amaral, M.D. and Kunzelmann, K.) Springer Science+Business Media, pp 271-283

Astrocytes

Notch signalling

Valapala, M., Hose, S., Gongora, C., Dong, L., et al (2013) *Impaired endolysosomal function disrupts Notch signalling in optic nerve astrocytes* Nat. Commun., 4: 1629

Persistent fetal vasculature

Zigler Jr. J.S., Valapala, M., Shang, P., Hose, S., Goldberg, M.F. and Sinha, D. (2016) *βA3/A1-crystallin and persistent fetal vasculature (PFV) disease of the eye* Biochim. Biophys. Acta, **1860**, 287–298

Bacterial phagosomes

Li, Q., Jagannath, C., Rao, P.K., Singh, C.R. and Lostumbo, G. (2010) *Analysis of phagosomal proteomes: From latex-bead to bacterial phagosomes* Proteomics, **10**, 4098–4116

BHK cells

Helicobacter pylori toxin

Molinari, M., Galli, C., Norais, N., Telford, J.L., et al (1997) *Vacuoles induced by Helicobacter pylori toxin contain both late endosomal and lysosomal markers* J. Biol. Chem., **272**, 25339-25344

Brain tissue/neural cells (see also "Astrocytes" and "Glial cells")

Adaptins

Zizioli, D., Geumann, C., Kratzke, M., Mishra, R., Borsani, G., Finazzi, D., Candiello, E. and Schua, P. (2017) *γ2 and γ1AP-1 complexes: Different essential functions and regulatory mechanisms in clathrin-dependent protein sorting* Eur. J. Cell Biol., **96**, 356–368

β-amyloid precursor protein

Sato, N., Shinohara, M., Rakugi, H. and Morishita, R. (2012) *Dual effects of statins on Aβ metabolism: upregulation of the degradation of APP-CTF and Aβ clearance* Neurodegener. Dis., **10**, 305–308

Shinohara, M., Sato, N., Kurinami, H., Takeuchi, D., et al (2010) *Reduction of brain β-amyloid (Aβ) by fluvastatin, a hydroxymethylglutaryl-CoA reductase inhibitor, through increase in degradation of amyloid precursor protein C-terminal fragments (APP-CTFs) and Aβ clearance* J. Biol. Chem., **285**, 22091–22102

Tamboli, I.Y., Hampel, H., Sandhoff, K. and Walter, J. (2006) *Accumulation of sphingolipids increases secretion of the amyloid β-peptide by stabilization of the β-amyloid precursor protein* Alzheimers Dement., **2**, Suppl. 1, S528-S529

Dendritic trafficking

Schwenk, B.M., Lang, C.M., Hogl, S., Tahirovic, S., et al (2014) *The FTLD risk factor TMEM106B and MAP6 control dendritic trafficking of lysosomes* EMBO J., **33**, 450-467

Early endosome maturation

Candiello, E., Kratzke, M., Wenzel, D., Cassel, D. and Schu, P. (2016) *AP-1/σ1A and AP-1/σ1B adaptorproteins differentially regulate neuronal early endosome maturation via the Rab5/Vps34-pathway* Sci. Rep., **6**: 29950

Glycolipids

Takamura, A., Higaki, K., Ninomiya, H., Takai, T., et al (2011) *Lysosomal accumulation of Trk protein in brain of G_{M1}-gangliosidosis mouse and its restoration by chemical chaperone* J. Neurochem., **118**, 399–406

Hereditary spastic paraplegia

Khundadze, M., Kollmann, K., Koch, N., Biskup, C., et al (2013) *A hereditary spastic paraplegia mouse model supports a role of ZFYVE26/SPASTIZIN for the endolysosomal system* PloS Genet., **9**: e1003988

Trk protein

Fu, X., Yang, Y., Xu, C., Niu, Y., et al (2011) *Retrolinkin cooperates with endophilin A1 to mediate BDNF–TrkB early endocytic trafficking and signaling from early endosomes* Mol. Biol. Cell, 22, 3684-3698

Takamura, A., Higaki, K., Ninomiya, H., Takai, T., et al (2011) *Lysosomal accumulation of Trk protein in brain of G_{M1}-gangliosidosis mouse and its restoration by chemical chaperone* J. Neurochem., **118**, 399–406

Caco-2 cells

Cholera toxin

Orlandi, P.A. (1997) *Protein-disulfide isomerase-mediated reduction of the A subunit of cholera toxin in a human intestinal cell line* J. Biol. Chem., **272**, 4591-4599

Van den Broeck, D., Lagrou, A.R. and De Wolf, M.J.S. (2007) *Distinct role of clathrin-mediated endocytosis in the functional uptake of cholera toxin* Acta Biochim. Polonica, **54**, 757-767

Methodology

Li, X. and Donowitz, M. (2008) *Fractionation of subcellular membrane vesicles of epithelial and nonepithelial cells by OptiPrep™ density gradient ultracentrifugation* In Methods Mol. Biol., **440**, Exocytosis and Endocytosis (ed. Ivanov, A.I.) Humana Press, Totowa, NJ, pp 97-110

Li, X. and Donowitz, M. (2014) *Fractionation of subcellular membrane vesicles of epithelial and non-epithelial cells by OptiPrep™ density gradient ultracentrifugation* In Exocytosis and Endocytosis, Methods in Molecular Biology, **1174** (ed. Ivanov, A,I.) Springer Science+Business Media New York 2014, pp 85-99

Caenorhabditis elegans

Lipid transport

Kobuna, H., Inoue, T., Shibata, M., Gengyo-Ando, K., Yamamoto, A., Mitani, S. and Arai, H. (2010) *Multivesicular body formation requires OSBP–related proteins and cholesterol* PloS Genet., **6**: e1001055

Carcinoma cells (incl. HeLa)

Adaptor proteins

Urbanska, A., Sadowski, L., Kalaidzidis, Y. and Miaczynska, M. (2011) *Biochemical characterization of APPL endosomes: the role of annexin A2 in APPL membrane recruitment* Traffic, **12**, 1227–1241

β-Amyloid precursor protein

Matsuda, S., Matsuda, Y., Snapp, E.L. and D'Adamioa, L. (2011) *Maturation of BRI2 generates a specific inhibitor that reduces APP processing at the plasma membrane and in endocytic vesicles* Neurobiol. Aging, **32**, 1400–1408

Vorobyeva, A.G., Lee, R., Miller, S., Longen, C., Sharoni, M. et al (2014) *Cyclopamine modulates γ-secretase-mediated cleavage of amyloid precursor protein by altering its subcellular trafficking and lysosomal degradation* J. Biol. Chem., **289**, 33258–33274

Biogenesis and cargo selection

Dengje, J., Høyer-Hansen, M., Nielsen, M.O., Eisenberg, T., et al (2012) *Identification of autophagosome-associated proteins and regulators by quantitative proteomic analysis and genetic screens* Mol. Cell. Proteom., **11:** M111.014035

Clathrin-mediated

Barroso-González, J., Machado, J-D., García-Expósito, L. and Valenzuela-Fernández, A. (2009) *Moesin regulates the trafficking of nascent clathrin-coated vesicles* J. Biol. Chem., **284**, 2419–2434

Cytokinesis

Neto, H., Kaupisch, A., Collins, L.L. and Gould, G.W, (2013) *Syntaxin 16 is a master recruitment factor for cytokinesis* Mol. Biol. Cell, **24**, 3663-3674

Endosome maturation and processing

Huotari, J., Meyer-Schaller, N., Hubner, M., Stauffer, S., et al (2012) *Cullin-3 regulates late endosome maturation* Proc. Natl. Acad. Sci. USA, **109**, 823–828

Li, Q., Spencer, N.Y., Oakley, F.D., Buettner, G.R. and Engelhardt, J.F. (2009) *Endosomal Nox2 facilitates redox-dependent induction of NF-κB by TNF-α* Antioxid. Redox Signal., **11**, 1249–1263

Perini, E.D., Schaefer, R., Stöter, M., Kalaidzidis, Y. and Zerial, M. (2014) *Mammalian CORVET Is required for fusion and conversion of distinct early endosome subpopulations* Traffic, **15**, 1366–1389

Growth factors

Chin, L-S., Raynor, M.C., Wei, X., Chen, H-Q., et al (2001) *Hrs interacts with sorting nexin 1 and regulates degradation of epidermal growth factor receptor* J. Biol. Chem., **276**, 7069-7078
Yakymovych, I., Yakymovych, M., Zang, G., Mu, Y., Bergh, A., Landström, M. and Heldin, K.H. (2015) *CIN85 modulates TGF β signaling by promoting the presentation of TGF β receptors on the cell surface* J. Cell Biol., **210**, 319–332

Interleukin-1 receptor complex

Li, Q., Harraz, M.M., Zhou, W., Zhang, L.N., et al (2006) *Nox2 and Rac1 regulate H_2O_2-dependent recruitment of TRAFg to endosomal interleukin-1 receptor complexes* Mol. Cell. Biol., **26**, 140-154

Lipid droplets

Velikkakath, A.K.G., Nishimura, T., Oita, E., Ishihara, N., et al (2012) *Mammalian Atg2 proteins are essential for autophagosome formation and important for regulation of size and distribution of lipid droplets* Mol. Biol. Cell, **23**, 896-909

Notch signalling

Tagami, S., Okochi, M., Yanagida, K., Ikuta, A., et al (2008) *Regulation of Notch signaling by dynamic changes in the precision of S3 cleavage of Notch-1* Mol. Cell. Biol., **28**, 165-76

Rab GTPase

Meyers, J.M. and Prekeris, R. (2002) *Formation of mutually exclusive Rab11 complexes with members of the family of Rab11-interacting proteins regulates Rab11 endocytic targeting and function* J. Biol. Chem., **277**, 49003-49010
Proikas-Cezanne, T., Gaugel, A., Frickey, T. and Nordheim, A. (2006) *Rab14 is part of the early endosomal clathrin-coated TGN microdomain* FEBS Lett., **580**, 5241-5246
Urbanska, A., Sadowski, L., Kalaidzidis, Y. and Miaczynska, M. (2011) *Biochemical characterization of APPL endosomes: the role of annexin A2 in APPL membrane recruitment* Traffic, **12**, 1227–1241

ROS

Mumbengegwi, D.R., Li, Q., Li, C., Bear, C.E., et al (2008) *Evidence for a superoxide permeability in endosomal membranes* Mol. Cell. Biol., **28**, 3700-3712

Salmonella-containing vacuole

Santos, J.C., Duchateau, M., Fredlund, J., Weiner, A., Mallet, A., Schmitt, C., Matondo, M., Hourdel, V., Chamot-Rooke, J. and Enninga, J. (2015) *The COPII complex and lysosomal VAMP7 determine intracellular Salmonella localization and growth* Cell. Microbiol., **17**, 1699−1720

Syntaxins

Neto, H., Kaupisch, A., Collins, L.L. and Gould, G.W, (2013) *Syntaxin 16 is a master recruitment factor for cytokinesis* Mol. Biol. Cell, **24**, 3663-3674

Virus internalization and interactions

Ding, W., Zhang, L.N., Yeaman, C. and Engelhardt, J.F. (2006) *rAAV2 traffics through both the late and the recycling endosomes in a dose-dependent fashion* Mol. Ther., **13**, 671-682
Ganti, K., Massimi, P., Manzo-Merino, J., Tomaić, V., Pim, D., Playford, M.P., Lizano, M., Roberts, S., Kranjec, C., Doorbar, J. and Banks, L. (2016) *Interaction of the human papillomavirus E6 oncoprotein with sorting nexin 27 modulates endocytic cargo transport pathways* PLoS Pathog., **12**: e1005854
Su, W-C., Chen, Y-C., Tseng, C-H., Hsu, P.W-C., et al (2013) *Pooled RNAi screen identifies ubiquitin ligase Itch as crucial for influenza A virus release from the endosome during virus entry* Proc. Natl. Acad. Sci. USA, **110**, 17516–17521

Cardiac tissue

KATP channel

Hund, T.J. and Mohler, P.J. (2011) *Differential roles for SUR subunits in KATP channel membrane targeting and regulation* Am. J. Physiol. Heart Circ. Physiol., **300**, H33–H35

Yang, H.Q., Foster, M.N., Jana, K., Ho, J., Rindler, M.J. and Coetzee, W.A. (2016) *Plasticity of sarcolemmal KATP channel surface expression: relevance during ischemia and ischemic preconditioning*. Am. J. Physiol. Heart Circ. Physiol., **310**, H1558–H1566

CHO cells

β-amyloid precursor protein

Huttunen, H.J., Puglielli, L., Ellis, B.C., MacKenzie Ingano, L.A. and Kovacs, D.M. (2009) *Novel N-terminal cleavage of APP precludes Aβ generation in ACAT-defective AC29 cells* J. Mol. Neurosci., **37**, 6-15

Coatamer COPI protein

Daro, E., Sheff, D., Gomez, M., Kreis, T., et al (1997) *Inhibition of endosome function in CHO cells bearing a temperature-sensitive defect in the coatomer (COPI) component ∈-COP* J. Cell Biol., **139**, 1747-1759

GLUT8 transporter

Augustin, R., Riley, J. and Moley, K.H. (2005) *GLUT8 contains a [DE]XXXL[LI] sorting motif and localizes to a late endosomal/lysosomal compartment* Traffic, **6**, 1196-1212

LDL receptor

Sugii, S., Reid, P.C., Ohgami, N., Du, H. et al (2003) *Distinct endosomal compartments in early trafficking of low density lipoprotein-derived cholesterol* J. Biol. Chem., **278**, 27180-27189

NCAM

Westphal, N., Loers, G., Lutz, D., Theis, T., Kleene, R. and Schachner, M. (2017) *Generation and intracellular trafficking of a polysialic acid carrying fragment of the neural cell adhesion molecule* NCAM to the cell nucleus Sci. Rep., **7**: 8622

Corneal epithelial cells

Clathrin-mediated

Argueso, P., Guzman-Aranguez, A., Woodward, A. and Pintor, J.J. (2011) *Inhibition of mucin O-glycosylation promotes endocytosis and nanopartical uptake in corneal epithelial cells* Invest. Ophthalmol. Vis. Sci., **52**, E-Abstr. 4394

COS cells

Calmodulin

Cao, Q., Zhong, X.Z., Zou, Y., Murrell-Lagnado, R., Zhu. M.X. and Dong, X-P. (2015) *Calcium release through P2X4 activates calmodulin to promote endolysosomal membrane fusion* J. Cell Biol., **209**, 879–894

Sialidase

Lukong, K.E., Seyrantepe, V., Landry, K., Trudel, S., et al (2001) *Intracellular distribution of lysosomal sialidase is controlled by the internalisation signal in its cytoplasmic tail* J. Biol. Chem., **276**, 46172-46181

Transferrin receptor

Shen, X., Xu, K-F., Fan, Q., Pacheco-Rodriguez, G., et al (2006) *Association of brefeldin A-inhibited guanine nucleotide-exchange protein 2 (BIG2) with recycling endosomes during transferrin uptake* Proc. Natl. Acad. Sci. USA, **103**, 2635-2640

Cytokinesis

Chen, X-W., Inoue, M., Hsu, S. and Saltiel, A.R. (2006) *RalA-exocyst-dependent recycling endosome trafficking is required for the completion of cytokinesis* J. Biol. Chem., **281**, 38609-38616

Dendritic cells

Phagosomes

Romao, S., Gasser, N., Becker, A.C., Guhl, B., Bajagic, M., Vanoaica, D., Ziegler, U., Roesler, J., Dengjel, J., Reichenbach, J. and Münz, C. (2013) *Autophagy proteins stabilize pathogen-containing phagosomes for prolonged MHC II antigen processing* J. Cell Biol., **203**, 757–766

Dictyostelium

Phagosomes

Shevchuk, O., Batzilla, C., Hägele, S., Kusch, H., Engelmann, S., Hecker, M., Haas, A., Heuner, K., Glöckner, G., Steinert, M. (2009) *Proteomic analysis of Legionella-containing phagosomes isolated from Dictyostelium* Int. J. Med. Microbiol., **299**, 489–508

Drosophila

Epithelial septate junction

Tiklová, K., Senti, K-A., Wang, S., Gräslund, A., et al (2010) *Epithelial septate junction assembly relies on melanotransferrin iron binding and endocytosis in Drosophila* Nature Cell. Biol., **12**, 1071-1078

Photoreceptor cells

Lee, J., Song, M. and Hong, S. (2013) *Negative regulation of the novel norpAP24 suppressor, diehard4, in the endo-lysosomal trafficking underlies photoreceptor cell degeneration* PLoS Genet., **9**: e1003559

sRNA

Lee, Y.S., Pressman, S., Andress, A.P., Kim, K., et al (2009) *Silencing by small RNAs is linked to endosomal trafficking* Nat. Cell Biol., **11**, 1150-1157

Endothelial cells

Growth factor receptors

Lampugnani, M.G., Orsenigo, F., Gagliani, M.C., Tacchetti, C. et al (2006) *Vascular endothelial cadherin controls VEGFR-2 internalization and signaling from intracellular compartments* J. Cell Biol., **174**, 593-604

Enterocytes

Intestinal chylomicron output

Siddiqi, S. and Mansbach II, C.M. (2015) *Dietary and biliary phosphatidylcholine activates PKCξ in rat intestine* J. Lipid Res., **56**, 859–870

Fish (rainbow trout) cells

AgNPprotein corona complexes

Yue, Y., Behra, R., Sigg, L., Suter, M, J-F., Pillai, S and Schirmer, K. (2016) *Silver nanoparticle–protein interactions in intact rainbow trout gill cells* Environ. Sci. Nano, **3**, 1174

Glial/glioma cells

Proteoglycans

Podyma-Inoue, K.A., Moriwaki, T, Rajapakshe, A.R., Terasawa, K. and Hara-Yokoyama, M. (2016) *Characterization of heparan sulfate proteoglycan-positive recycling endosomes isolated from glioma cells* Canc. Genom. Proteom., **13**, 443-452

Virus processing

Querbes, W., O'Hara, B.A., Williams, G. and Atwood, W.J. (2006) *Invasion of host cells by JC virus identifies a novel role for caveolae in endosomal sorting of noncaveolar ligands* J. Virol., **80**, 9402-9413

Green monkey kidney (Vero) cells

Toxins

McKenzie, J., Johannes, L., Taguchi, T.and Sheff, D. (2009) *Passage through the Golgi is necessary for Shiga toxin B subunit to reach the endoplasmic reticulum* FEBS J., **276**, 1581–1595

Majoul, I.V., Bastiaens, P.I.H. and Soling H-D (1996) *Transport of an external Lys-Asp-Glu-Leu (KDEL) protein from the plasma membrane to the endoplasmic reticulum: studies with cholera toxin in Vero cells* J. Cell Biol., **133**, 777-789

HEK cells

β-Catenin

Layton, M.J., Faux, M.C., Church, N.L., Catimel, B., et al (2012) *Identification of a Wnt-induced protein complex by affinity proteomics using an antibody that recognizes a sub-population of β-catenin* Biochim. Biophys. Acta, **1824**, 925–937

Clathrin-mediated
Idkowiak-Baldys, J., Becker, K.P., Kitatani, K. and Hannum, Y.A. (2006) *Dynamic sequestration of the recycling compartment by classical protein kinase C* J. Biol. Chem., **281**, 22321-22331
Neel, N.F., Lapierre, L.A., Goldenring, J.R. and Richmond, A. (2007) *RhoB plays an essential role in CXCR2 sorting decisions* J. Cell Sci., **120**, 1559-1571

Dopamine transporter
Keith, D.J., Wolfrum, K., Eshleman, A.J. and Janowsky, A. (2012) *Melittin initiates dopamine transporter internalization and recycling in transfected HEK-293 cells* Eur. J. Pharmacol., **690**, 13–21

GLUT8 transporter
Augustin, R., Riley, J. and Moley, K.H. (2005) *GLUT8 contains a [DE]XXXL[LI] sorting motif and localizes to a late endosomal/lysosomal compartment* Traffic, **6**, 1196-1212

Immune receptors
Qi, R., Singh, D. and Kao, C.C. (2012) *Proteolytic processing regulates toll-like receptor 3 stability and endosomal localization* J. Biol. Chem., **287**, 32617–32629

Neimann-Pick disease
Kim, H., Chun, Y., Che, L. Kim, J., Lee, S. and Lee, S. (2017) *The new obesity-associated protein, neuronal growth regulator 1 (NEGR1), is implicated in Niemann-Pick disease Type C (NPC2)-mediated cholesterol trafficking* Biochem. Biophys. Res. Comm., **482**, 1367-1374

Notch signalling
Tagami, S., Okochi, M., Yanagida, K., Ikuta, A., et al (2008) *Regulation of Notch signaling by dynamic changes in the precision of S3 cleavage of Notch-1* Mol. Cell. Biol., **28**, 165-76

Pericentrion
El-Osta, M.A., Idkowiak-Baldys, J. and Hannun, Y.A. (2011) *Delayed phosphorylation of classical protein kinase C (PKC) substrates requires PKC internalization and formation of the pericentrion in a phospholipase D (PLD)-dependent manner* J. Biol. Chem., **286**, 19340–19353

Phosphatidylinositol
Sbrissa, D., Ikonomov, O.C., Fu, Z., Ijuin, T., et al (2007) *Core protein machinery for mammalian phosphatidylinositol 3,5-bisphosphate synthesis and turnover that regulates the progression of endosomal transport* J. Biol. Chem., **282**, 23878-23891

mRNA, mi-RNA targetting
Barman, B. and Bhattacharyya, S.N. (2015) *mRNA targeting to endoplasmic reticulum precedes Ago protein interaction and microRNA (miRNA)-mediated translation repression in mammalian cells* J. Biol. Chem., **290**, 24650–24656
Bose, M., Barman, B., Goswami, A., Bhattacharyya, S.N., (2017) *Spatiotemporal uncoupling of microRNA-mediated translational repression and target RNA degradation controls microRNP recycling in mammalian cells* Mol. Cell. Biol., **37:** e00464-16

Rab GTPase
Urbanska, A., Sadowski, L., Kalaidzidis, Y. and Miaczynska, M. (2011) *Biochemical characterization of APPL endosomes: the role of annexin A2 in APPL membrane recruitment* Traffic, **12**, 1227–1241

Stotmatin
Mairhofer, M., Steiner, M., Salzer, U. and Prohaska, R. (2009) *Stomatin-like protein-1 interacts with stomatin and is targeted to late endosomes* J. Biol. Chem., **284**, 29218-29229

Tau protein
Simón, D., García-García, E., Royo, F., Falcón-Pérez, J.M. et al (2012) *Proteostasis of tau. Tau overexpression results in its secretion via membrane vesicles* FEBS Lett., **586**, 47–54

Virus internalization

Su, W-C., Chen, Y-C., Tseng, C-H., Hsu, P.W-C., et al (2013) *Pooled RNAi screen identifies ubiquitin ligase Itch as crucial for influenza A virus release from the endosome during virus entry* Proc. Natl. Acad. Sci. USA, **110**, 17516–17521

HeLa cells (see "Carcinoma cells")

Hepatocytes

Autophagosomes/phagosomes

Berg, T.O., Fengsrud, M., Stromhaug, P.E., Berg, T., et al (1998) *Isolation and characterization of rat liver amphisomes* J. Biol. Chem., **273**, 21883-21892

Fengsrud, M., Erichsen, E.S., Berg, T.O., Raiborg, C. et al (2000) *Ultrastructural characterization of the delimiting membranes of isolated autophagosomes and amphisomes by freeze-fracture electron microscopy* Eur. J. Cell Biol., **79**, 871-882

Strømhaug, P.E., Berg, T.O. and Seglen, P.O. (1998) *Purification and characterization of autophagosomes from rat hepatocytes* Biochem. J., **335**, 217-224

Sætre, F., Hagen, L.K., Engedal, N. and Seglen, P.O. (2015) *Novel steps in the autophagic-lysosomal pathway* FEBS J., **282**, 2202–2214

Szalaia, P., Korseberg Hagen, L., Sætre, F., Luhr, M., Sponheim, M., Øverbye, A., Mills, I.G., Seglen, P.O. and Engedal, N. (2015) *Autophagic bulk sequestration of cytosolic cargo is independent of LC3, but requires GABARAPs* Exp. Cell Res., 333, 21-38

Lipid droplets

Schulze, R.J., Weller, S.G., Schroeder, B., Krueger, E.W., et al (2013) *Lipid droplet breakdown requires Dynamin 2 for vesiculation of autolysosomal tubules in hepatocytes* J. Cell Biol., **203**, 315–326

miRNA / siRNA

Ghosh, S., Bose, M., Ray, A. and Bhattacharyya, S.N. (2015) *Polysome arrest restricts miRNA turnover by preventing exosomal export of miRNA in growth-retarded mammalian cells* Mol. Biol. Cell, **26**, 1072-1083

Xu, Y., Ou, M., Keough, E., Roberts, J., et al (2014) *Quantitation of physiological and biochemical barriers to siRNA liver delivery via lipid nanoparticle platform* Mol. Pharmaceutics, **11**, 1424-434

Reactive oxygen species

Oakley, F.D., Abbott, D., Li, Q. and Engelhardt, J.F. (2009) *Signaling components of redox active endosomes: the redoxosomes* Antioxid. Redox Signal., **11**, 1313–1333

Hepatoma/hepatocarcinoma cells

Alpha-1-antitrypsin deficiency

Khodayari, N., Marek, G., Lu, Y., Krotova, K., Wang, R.L. and Brantly, M. (2017) *Erdj3 has an essential role for Z variant alpha-1-antitrypsin degradation* J. Cell. Biochem., **118**, 3090–3101

Lipid droplets

Li, Z., Schulze, R.J., Weller, S.G., Krueger, E.W., Schott, M.B., Zhang, X., Casey, C.A., Liu, J., Stöckli, J., James, D.E. and McNiven, M.A. (2016) *A novel Rab10-EHBP1-EHD2 complex essential for the autophagic engulfment of lipid droplets* Sci. Adv., **2**: e1601470

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Lysosomal acid lipase

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mRNA, mi-RNA

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Manunta, M., Izzo, L., Duncan, R. and Jones, A.T. (2007) *Establishment of subcellular fractionation techniques to monitor the intracellular fate of polymer therapeutics II: Identification of endosomal and lysosomal compartments in HepG2 cells combining single-step subcellular fractionation and fluorescent imaging* J. Drug Target., **15**, 37-50

Virus interactions

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Human skin fibroblasts

Niemann-Pick C1

Nakasone, N., Nakamura, Y.S., Higaki, K., Oumi, N., Ohno, K. and Ninomiya, H. (2014) *Endoplasmic reticulum-associated degradation of Niemann-Pick C1: evidence for the role of heat shock proteins and identification of lysine residues that accept ubiquitin* J. Biol. Chem., **289**, 9714–19725

Ileal brush border

Na^+-H^+ exchanger

Li, X. and Donowitz, M. (2008) *Fractionation of subcellular membrane vesicles of epithelial and nonepithelial cells by OptiPrep™ density gradient ultracentrifugation* In Methods Mol. Biol., **440**, Exocytosis and Endocytosis (ed. Ivanov, A.I.) Humana Press, Totowa, NJ, pp 97-110

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Jurkat cells

Transferrin receptor

Shakor, A.B.A., Atia, M.M., Kwiatkowska, K. and Sobota, A. (2012) *Cell surface ceramide controls translocation of transferrin receptor to clathrin-coated pits* Cell. Signal., **24**, 677–684

Keratinocytes

Clathrin-mediated

Guzman-Aranguez, A., Woodward, A.M., Pintor, J. and Argüeso, P. (2012) *Targeted disruption of core 1 β1,3-galactosyltransferase (C1galt1) induces apical endocytic trafficking in human corneal keratinocytes* PLoS One, **7**: e36628

Kidney

Aquaporin

Procino, G., Barbieri, C., Carmosino, M., Rizzo, F., et al M. (2010) *Lovastatin-induced cholesterol depletion affects both apical sorting and endocytosis of aquaporin-2 in renal cells* Am. J. Physiol. Renal Physiol., **298**, F266–F278

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Biemesderfer, D., Mentone, S.A., Mooseker, M. and Hasson, T. (2002) *Expression of myosin VI within the early endocytic pathway in adult and developing proximal tubules* Am. J. Physiol., Ren. Physiol**.**, **282**, F785-F794

LD9 cells

Prion protein

Graham, J.F., Agarwal, S., Kurian, D., Kirby, L., et al (2010) *Low density subcellular fractions enhance disease-specific prion protein misfolding* J. Biol. Chem., **285**, 9868–9880

Liver (rodent)

Late endosomal/lysosomal sorting

Pribasnig, M.A., Mrak I., Grabner, G.F., Taschler, U., Knittelfelder, O., Scherz, B., Eichmann, T.O., Heier, C., Grumet, L. et al (2015) *α/β Hydrolase domain-containing 6 (ABHD6) degrades the late endosomal/ lysosomal lipid bis(monoacylglycero)phosphate* J. Biol. Chem., **290**, 29869–29881

Neogalactosylalbumin uptake

Billington, D., Maltby, P.J. Jackson, A.P. and Graham, J.M. (1998) *Dissection of hepatic receptor-mediated endocytic pathways using self-generated gradients of iodixanol (OptiPrep)* Anal. Biochem., **258**, 251-258

Sialidase

Lukong, K.E., Seyrantepe, V., Landry, K., Trudel, S., et al (2001) *Intracellular distribution of lysosomal sialidase is controlled by the internalisation signal in its cytoplasmic tail* J. Biol. Chem., **276**, 46172-46181

Lymphocytes, leukeamia and lymphoma cells

Anaplasma infection/Beclin-1

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Antigen processing

Vaithilingam, A., Lai, N.Y., Duong, E., Boucau, J., et al (2013) *A simple methodology to assess endolysosomal protease activity involved in antigen processing in human primary cells* BMC Cell Biol., **14**: 35

Cysteine proteases

Kung Sutherland, M.S., Sanderson, R.J., Gordon, K.A., Andreyka, J., Cerveny, C.G., Yu, C., Lewis, T.S., Meyer, D.L., Zabinski, R.F., Doronina, S.D., Senter, P.D., Law, C-L., Wahl, A.F. (2006) *Lysosomal trafficking and cysteine protease metabolism confer target-specific cytotoxicity by peptide-linked anti-CD30-auristatin conjugates* J. Biol. Chem., **281**, 10540-10547

Granzyme B

Baginska, J., Viry, E., Berchem, G., Poli, A., et al (2013) *Granzyme B degradation by autophagy decreases tumor cell susceptibility to natural killer-mediated lysis under hypoxia* Proc. Natl. Acad. Sci. USA, **110**,17450–17455

Interferon receptor (Type-1)

Payelle-Brogard, B. and Pellegrini, S. (2010) *Biochemical monitoring of the early endocytic traffic of the type I interferon receptor* J. Interferon Cytokine Res., **30**, 89-98

Lymphoma-targetting antibody-polymer conjugates

Berguig, G.Y., Convertine, A.J., Shi, J., Palanca-Wessels, M.C., et al (2012) *Intracellular delivery and trafficking dynamics of a lymphoma-targeting antibody-polymer conjugate* Mol. Pharm., **9**, 3506−3514

Lytic granules

Tuli, A., Thiery, J., James, A.M., Michelet, X., et al (2013) *Arf-like GTPase Arl8b regulates lytic granule polarization and natural killer cell–mediated cytotoxicity* Mol. Biol. Cell, **24**, 3721-3735

Macrophages

Derlin-dependent proteins

Schaheen, B., Dang, H. and Fares, H. (2009) *Derlin-dependent accumulation of integral membrane proteins at cell surfaces* J. Cell Sci., **122**, 228-2239

Leishmania-infected

Chakrabarty, T. and Bhattacharyya, S.N. (2017) *Leishmania donovani restricts mitochondrial dynamics to enhance miRNP stability and target RNA repression in host macrophages* Mol. Biol. Cell, **28**, 2091-2105

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Schapansky, J., Nardozzi. J.D., Felizia, F. and LaVoie, M.J. (2014) *Membrane recruitment of endogenous LRRK2 precedes its potent regulation of autophagy* Hum. Mol. Genet., **23**, 4201–4214

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miRNA

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Phagosomes

Romao, S., Gasser, N., Becker, A.C., Guhl, B., Bajagic, M., Vanoaica, D., Ziegler, U., Roesler, J., Dengjel, J., Reichenbach, J. and Münz, C. (2013) *Autophagy proteins stabilize pathogen-containing phagosomes for prolonged MHC II antigen processing* J. Cell Biol., **203**, 757–766

Toll-like receptors

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Yersinia pestis V antigen

DiMezzo, T.L., Ruthel, G., Brueggemann, E.E., Hines, et al (2009) *In vitro intracellular trafficking of virulence antigen during infection by Yersinia pestis* PLoS One, **4**:e6281

MDCK cells

Transferrin receptor

Sheff, D.R., Daro, E.A., Hull, M. and Mellmann, I. (1999) *The receptor recycling pathway contains two distinct populations of early endosomes with different sorting functions* J. Cell Biol., **145**, 123-139

Virus internalization

Su, W-C., Chen, Y-C., Tseng, C-H., Hsu, P.W-C., et al (2013) *Pooled RNAi screen identifies ubiquitin ligase Itch as crucial for influenza A virus release from the endosome during virus entry* Proc. Natl. Acad. Sci. USA, **110**, 17516–17521

Monocytic cells

Autophagosomes

Kimura, T., Jia, J., Kumar, S., Choi, S.W., Gu, Y., Mudd, M., Dupont, N., Jiang, S., et al (2017) *Dedicated SNAREs and specialized TRIM cargo receptors mediate secretory autophagy* EMBO J., **36**, 42-60

Mouse embryo fibroblasts

Autophagosomes

Ganley, I.G., Wong, P-M., Gammoh, N. and Jiang, X. (2011) *Distinct autophagosomal-lysosomal fusion mechanism revealed by thapsigargin-induced autophagy arrest* Mol. Cell, **42**, 731–743

Young, M.M., Takahashi, Y., Fox, T.E., Yun, J.K., Kester, M. and Wang, H-G. (2016) *Sphingosine kinase 1 cooperates with autophagy to maintain endocytic membrane trafficking* Cell Rep., **17**, 1532–1545

Insulin receptor

Pedersen, D.J., Diakanastasis, B., Stöckli, J., Schmitz-Peiffer, C. (2013) *Protein kinase Cε modulates insulin receptor localization and trafficking in mouse embryonic fibroblasts* PLoS One, **8**: e58046

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Öhrvik, H., Nose, Y., Wood, L.K., Kim, B-E., et al (2013) *Ctr2 regulates biogenesis of a cleaved form of mammalian Ctr1 metal transporter lacking the copper- and cisplatin-binding ecto-domain* Proc. Natl. Acad. Sci. USA, **110**, E4279-E4288

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Mycobacterium
Phagosome proteome
Lee, B-Y., Jethwaney, D., Schilling, B., Clemens, D.L., Gibson, B.W. and Horwitz, M.A. (2010) *The Mycobacterium bovis bacilli Calmette-Guérin phagosome proteome* Mol. Cell. Proteom., **9**, 32–53

Nerve tissue/neurons
Growth factor receptors
Weible II, M.W., Ozsarac, N., Grimes, M.L. and Hendry, I.A. (2004) *Comparison of nerve terminal events in vivo effecting retrograde transport of vesicles containing neurotrophins or synaptic vesicle components* J. Neurosci. Res., **75**, 771-781

Neuronal signalling
Ammar, M.R., Thahouly, T., Hanauer, A., Stegner, D., Nieswandt, B. and Vitale, N. (2015) *PLD1 participates in BDNF-induced signalling in cortical neurons* Sci. Rep., **5**: 14778

Neuroblastoma cells
Alzheimer's disease
Burg, V.K., Grimm, H.S., Rothhaar, T.L., Grösgen, S., et al (2013) *Plant sterols the better cholesterol in Alzheimer's disease? A mechanistical study* J. Neruosci., **33**, 16072-16087
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vATPase
Kratzke, M., Candiello, E., Schmidt, B., Jahn, O. and Schu, P. (2015) *AP-1/σ1B-dependent SV protein recycling is regulated in early endosomes and is coupled to AP-2 endocytosis* Mol. Neurobiol., **52**, 142–161

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Osaka, M., Ito, D. and Suzuki, N. (2016) *Disturbance of proteasomal and autophagic protein degradation pathways by amyotrophic lateral sclerosis-linked mutations in ubiquilin 2* Biochem. Biophys. Res. Comm., **472**, 324-331

Dopamine receptor
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Xin, X., Gfeller, D., Cheng, J., Tonikian, R., et al (2013) *SH3 interactome conserves general function over specific form* Mol. Systems Biol., **9**: 652

Transferrin receptor
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NRK cells
Caveolin
Pol, A., Lu, A., Pons, M., Peiro, S., et al (2000) *Epidermal growth factor-mediated caveolin recruitment to early endosomes and MAPK activation* J. Biol. Chem., **275**, 30566-30572

Nanotube formation

Su, Q.P., Du, W., Ji, Q., Xue, B., Jiang, D., Zhu, Y., Lou, J., Yu, L. and Sun, Y. (2016) *Vesicle size regulates nanotube formation in the cell* Sci. Rep., **6**: 24002

Osteosarcoma cells

Autophagy

Merrill, N.M., Schipper, J.L., Kames, J.B., Kauffman, A.L., Martin, K.R. and MacKeigan, J.P. (2017) *PI3K-C2a knockdown decreases autophagy and maturation of endocytic vesicles* PLoS One, **12**: e0184909

PC12 cells

Neurotrophin receptor

Lin, D.C., Quevedo, C., Brewer, N.E., Bell, A., et al (2006) *APPL1 associates with TrkA and GIPC1 and is required for nerve growth factor-mediated signal transduction* Mol. Cell. Biol., **26**, 8928-8941

Receptors (various)

McCaffrey, G., Welker, J., Scott, J., van der Salm, L., et al (2009) *High-resolution fractionation of signaling endosomes containing different receptors* Traffic, **10**, 938–950

Growth factor receptors

Li, Y., Chin, L-S., Levey, A.L. and Li, L. (2002) *Huntingtin-associated protein 1 interacts with hepatocyte growth factor-regulated tyrosine kinase substrate and functions in endosomal trafficking* J. Biol. Chem., **277**, 28212-28221

Pryor, S., McCaffrey, G., Young. L.R. and Grimes, M.L. (2012) *NGF causes TrkA to specifically attract microtubules to lipid rafts* PLoS One **7**: e35163

Neurotrophin receptor

Fu, X., Zang, K., Zhou, Z., Reichardt, L.F., et al (2010) *Retrograde neurotrophic signaling requires a protein interacting with receptor tyrosine kinases via C2H2 zinc fingers* Mol. Biol. Cell, **21**, 36-49

PS120 cells

Gradient methodology

Li, X. and Donowitz, M. (2008) *Fractionation of subcellular membrane vesicles of epithelial and non-epithelial cells by OptiPrep™ density gradient ultracentrifugation* In Methods Mol. Biol., **440**, Exocytosis and Endocytosis (ed. Ivanov, A.I.) Humana Press, Totowa, NJ, pp 97-110

Yeast

Multivesicular body

Mitsui, K., Koshimura, Y., Yoshikawa, Y., Matsushita, M., et al (2011) *The endosomal Na^+/H^+ exchanger contributes to multivesicular body formation by regulating the recruitment of ESCRT-0 Vps27p to the endosomal membrane* J. Biol. Chem., **286**, 37625–37638

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