

6 LITERATURVERZEICHNIS

6 Literaturverzeichnis

- Albert, M.L., Pearce, S.F., Francisco, L.M., Sauter, B., Roy, P., Silverstein, R.L. and Bhardwaj, N. (1998) Immature dendritic cells phagocytose apoptotic cells via alphavbeta5 and CD36, and cross-present antigens to cytotoxic T lymphocytes. *J Exp Med*, **188**, 1359-1368.
- Alderton, F., Rakhit, S., Kong, K.C., Palmer, T., Sambhi, B., Pyne, S. and Pyne, N.J. (2001) Tethering of the platelet-derived growth factor beta receptor to G-protein-coupled receptors. A novel platform for integrative signaling by these receptor classes in mammalian cells. *J Biol Chem*, **276**, 28578-28585.
- Anderson, R.G. and Jacobson, K. (2002) A role for lipid shells in targeting proteins to caveolae, rafts, and other lipid domains. *Science*, **296**, 1821-1825.
- Anjuere, F., Martin, P., Ferrero, I., Fraga, M.L., del Hoyo, G.M., Wright, N. and Ardavin, C. (1999) Definition of dendritic cell subpopulations present in the spleen, Peyer's patches, lymph nodes, and skin of the mouse. *Blood*, **93**, 590-598.
- Aragay, A.M., Mellado, M., Frade, J.M., Martin, A.M., Jimenez-Sainz, M.C., Martinez, A.C. and Mayor, F., Jr. (1998) Monocyte chemoattractant protein-1-induced CCR2B receptor desensitization mediated by the G protein-coupled receptor kinase 2. *Proc Natl Acad Sci U S A*, **95**, 2985-2990.
- Ashcroft, G.S., Yang, X., Glick, A.B., Weinstein, M., Letterio, J.L., Mizel, D.E., Anzano, M., Greenwell-Wild, T., Wahl, S.M., Deng, C. and Roberts, A.B. (1999) Mice lacking Smad3 show accelerated wound healing and an impaired local inflammatory response. *Nat Cell Biol*, **1**, 260-266.
- Attisano, L., Carcamo, J., Ventura, F., Weis, F.M., Massague, J. and Wrana, J.L. (1993) Identification of human activin and TGF beta type I receptors that form heteromeric kinase complexes with type II receptors. *Cell*, **75**, 671-680.
- Attisano, L. and Wrana, J.L. (1996) Signal transduction by members of the transforming growth factor-beta superfamily. *Cytokine Growth Factor Rev*, **7**, 327-339.
- Bajjalieh, S.M., Martin, T.F. and Floor, E. (1989) Synaptic vesicle ceramide kinase. A calcium-stimulated lipid kinase that co-purifies with brain synaptic vesicles. *J Biol Chem*, **264**, 14354-14360.
- Banchereau, J. and Steinman, R.M. (1998) Dendritic cells and the control of immunity. *Nature*, **392**, 245-252.
- Bandhuvula, P., Tam, Y.Y., Oskouian, B. and Saba, J.D. (2005) The immune modulator FTY720 inhibits sphingosine-1-phosphate lyase activity. *J Biol Chem*.
- Barlic, J., Khandaker, M.H., Mahon, E., Andrews, J., DeVries, M.E., Mitchell, G.B., Rahimpour, R., Tan, C.M., Ferguson, S.S. and Kelvin, D.J. (1999) beta-arrestins regulate interleukin-8-induced CXCR1 internalization. *J Biol Chem*, **274**, 16287-16294.
- Bauvois, B., Rouillard, D., Sanceau, J. and Wietzerbin, J. (1992) IFN-gamma and transforming growth factor-beta 1 differently regulate fibronectin and laminin receptors of human differentiating monocytic cells. *J Immunol*, **148**, 3912-3919.
- Bernardo, K., Hurwitz, R., Zenk, T., Desnick, R.J., Ferlinz, K., Schuchman, E.H. and Sandhoff, K. (1995) Purification, characterization, and biosynthesis of human acid ceramidase. *J Biol Chem*, **270**, 11098-11102.

- Borkowski, T.A., Letterio, J.J., Farr, A.G. and Udey, M.C. (1996) A role for endogenous transforming growth factor beta 1 in Langerhans cell biology: the skin of transforming growth factor beta 1 null mice is devoid of epidermal Langerhans cells. *J Exp Med*, **184**, 2417-2422.
- Borkowski, T.A., Letterio, J.J., Mackall, C.L., Saitoh, A., Wang, X.J., Roop, D.R., Gress, R.E. and Udey, M.C. (1997) A role for TGFbeta1 in langerhans cell biology. Further characterization of the epidermal Langerhans cell defect in TGFbeta1 null mice. *J Clin Invest*, **100**, 575-581.
- Brinkmann, V., Cyster, J.G. and Hla, T. (2004) FTY720: sphingosine 1-phosphate receptor-1 in the control of lymphocyte egress and endothelial barrier function. *Am J Transplant*, **4**, 1019-1025.
- Brinkmann, V., Davis, M.D., Heise, C.E., Albert, R., Cottens, S., Hof, R., Bruns, C., Prieschl, E., Baumruker, T., Hiestand, P., Foster, C.A., Zollinger, M. and Lynch, K.R. (2002) The immune modulator FTY720 targets sphingosine 1-phosphate receptors. *J Biol Chem*, **277**, 21453-21457.
- Brinkmann, V., Pinschewer, D., Chiba, K. and Feng, L. (2000) FTY720: a novel transplantation drug that modulates lymphocyte traffic rather than activation. *Trends Pharmacol Sci*, **21**, 49-52.
- Brocker, T., Riedinger, M. and Karjalainen, K. (1997) Targeted expression of major histocompatibility complex (MHC) class II molecules demonstrates that dendritic cells can induce negative but not positive selection of thymocytes in vivo. *J Exp Med*, **185**, 541-550.
- Buelens, C., Verhasselt, V., De Groote, D., Thielemans, K., Goldman, M. and Willems, F. (1997) Human dendritic cell responses to lipopolysaccharide and CD40 ligation are differentially regulated by interleukin-10. *Eur J Immunol*, **27**, 1848-1852.
- Caux, C., Vanbervliet, B., Massacrier, C., Dezutter-Dambuyant, C., de Saint-Vis, B., Jacquet, C., Yoneda, K., Imamura, S., Schmitt, D. and Banchereau, J. (1996) CD34+ hematopoietic progenitors from human cord blood differentiate along two independent dendritic cell pathways in response to GM-CSF+TNF alpha. *J Exp Med*, **184**, 695-706.
- Cella, M., Engering, A., Pinet, V., Pieters, J. and Lanzavecchia, A. (1997) Inflammatory stimuli induce accumulation of MHC class II complexes on dendritic cells. *Nature*, **388**, 782-787.
- Cerwenka, A., Bevec, D., Majdic, O., Knapp, W. and Holter, W. (1994) TGF-beta 1 is a potent inducer of human effector T cells. *J Immunol*, **153**, 4367-4377.
- Cinamon, G., Matloubian, M., Lesneski, M.J., Xu, Y., Low, C., Lu, T., Proia, R.L. and Cyster, J.G. (2004) Sphingosine 1-phosphate receptor 1 promotes B cell localization in the splenic marginal zone. *Nat Immunol*, **5**, 713-720.
- Cohen, M.M., Jr. (2003) TGF beta/Smad signaling system and its pathologic correlates. *Am J Med Genet A*, **116**, 1-10.
- Cuvillier, O., Pirianov, G., Kleuser, B., Vanek, P.G., Coso, O.A., Gutkind, S. and Spiegel, S. (1996) Suppression of ceramide-mediated programmed cell death by sphingosine-1-phosphate. *Nature*, **381**, 800-803.
- Czeloth, N., Bernhardt, G., Hofmann, F., Genth, H. and Forster, R. (2005) Sphingosine-1-phosphate mediates migration of mature dendritic cells. *J Immunol*, **175**, 2960-2967.
- De Larco, J.E., Reynolds, R., Carlberg, K., Engle, C. and Todaro, G.J. (1980) Sarcoma growth factor from mouse sarcoma virus-transformed cells. Purification by binding and elution from epidermal growth factor receptor-rich cells. *J Biol Chem*, **255**, 3685-3690.

- Derynck, R. and Feng, X.H. (1997) TGF-beta receptor signaling. *Biochim Biophys Acta*, **1333**, F105-150.
- Derynck, R. and Zhang, Y.E. (2003) Smad-dependent and Smad-independent pathways in TGF-beta family signalling. *Nature*, **425**, 577-584.
- Di Guglielmo, G.M., Le Roy, C., Goodfellow, A.F. and Wrana, J.L. (2003) Distinct endocytic pathways regulate TGF-beta receptor signalling and turnover. *Nat Cell Biol*, **5**, 410-421.
- Dorsam, G., Graeler, M.H., Seroogy, C., Kong, Y., Voice, J.K. and Goetzl, E.J. (2003) Transduction of multiple effects of sphingosine 1-phosphate (S1P) on T cell functions by the S1P1 G protein-coupled receptor. *J Immunol*, **171**, 3500-3507.
- El Bawab, S., Roddy, P., Qian, T., Bielawska, A., Lemasters, J.J. and Hannun, Y.A. (2000) Molecular cloning and characterization of a human mitochondrial ceramidase. *J Biol Chem*, **275**, 21508-21513.
- Fahlen, L., Read, S., Gorelik, L., Hurst, S.D., Coffman, R.L., Flavell, R.A. and Powrie, F. (2005) T cells that cannot respond to TGF-beta escape control by CD4(+)CD25(+) regulatory T cells. *J Exp Med*, **201**, 737-746.
- Fan, G.H., Yang, W., Wang, X.J., Qian, Q. and Richmond, A. (2001) Identification of a motif in the carboxyl terminus of CXCR2 that is involved in adaptin 2 binding and receptor internalization. *Biochemistry*, **40**, 791-800.
- Fanayan, S., Firth, S.M. and Baxter, R.C. (2002) Signaling through the Smad pathway by insulin-like growth factor-binding protein-3 in breast cancer cells. Relationship to transforming growth factor-beta 1 signaling. *J Biol Chem*, **277**, 7255-7261.
- Fanayan, S., Firth, S.M., Butt, A.J. and Baxter, R.C. (2000) Growth inhibition by insulin-like growth factor-binding protein-3 in T47D breast cancer cells requires transforming growth factor-beta (TGF-beta) and the type II TGF-beta receptor. *J Biol Chem*, **275**, 39146-39151.
- Fayette, J., Dubois, B., Vandenabeele, S., Bridon, J.M., Vanbervliet, B., Durand, I., Banchereau, J., Caux, C. and Briere, F. (1997) Human dendritic cells skew isotype switching of CD40-activated naive B cells towards IgA1 and IgA2. *J Exp Med*, **185**, 1909-1918.
- Fazekas de St Groth, B. (1998) The evolution of self-tolerance: a new cell arises to meet the challenge of self-reactivity. *Immunol Today*, **19**, 448-454.
- Forster, R., Schubel, A., Breitfeld, D., Kremmer, E., Renner-Muller, I., Wolf, E. and Lipp, M. (1999) CCR7 coordinates the primary immune response by establishing functional microenvironments in secondary lymphoid organs. *Cell*, **99**, 23-33.
- Fujita, T., Hamamichi, N., Kiuchi, M., Matsuzaki, T., Kitao, Y., Inoue, K., Hirose, R., Yoneta, M., Sasaki, S. and Chiba, K. (1996a) Determination of absolute configuration and biological activity of new immunosuppressants, mycostericins D, E, F and G. *J Antibiot (Tokyo)*, **49**, 846-853.
- Fujita, T., Hirose, R., Yoneta, M., Sasaki, S., Inoue, K., Kiuchi, M., Hirase, S., Chiba, K., Sakamoto, H. and Arita, M. (1996b) Potent immunosuppressants, 2-alkyl-2-aminopropane-1,3-diols. *J Med Chem*, **39**, 4451-4459.
- Galvin, K.M., Donovan, M.J., Lynch, C.A., Meyer, R.I., Paul, R.J., Lorenz, J.N., Fairchild-Huntress, V., Dixon, K.L., Dunmore, J.H., Gimbrone, M.A., Jr., Falb, D. and Huszar, D. (2000) A role for smad6 in development and homeostasis of the cardiovascular system. *Nat Genet*, **24**, 171-174.
- Geissmann, F., Dieu-Nosjean, M.C., Dezutter, C., Valladeau, J., Kayal, S., Leborgne, M., Brousse, N., Saeland, S. and Davoust, J. (2002) Accumulation of

- immature Langerhans cells in human lymph nodes draining chronically inflamed skin. *J Exp Med*, **196**, 417-430.
- Geissmann, F., Prost, C., Monnet, J.P., Dy, M., Brousse, N. and Hermine, O. (1998) Transforming growth factor beta1, in the presence of granulocyte/macrophage colony-stimulating factor and interleukin 4, induces differentiation of human peripheral blood monocytes into dendritic Langerhans cells. *J Exp Med*, **187**, 961-966.
- Gill, J., Malin, M., Sutherland, J., Gray, D., Hollander, G. and Boyd, R. (2003) Thymic generation and regeneration. *Immunol Rev*, **195**, 28-50.
- Glick, A.B., Kulkarni, A.B., Tennenbaum, T., Hennings, H., Flanders, K.C., O'Reilly, M., Sporn, M.B., Karlsson, S. and Yuspa, S.H. (1993) Loss of expression of transforming growth factor beta in skin and skin tumors is associated with hyperproliferation and a high risk for malignant conversion. *Proc Natl Acad Sci U S A*, **90**, 6076-6080.
- Goetzl, E.J., Wang, W., McGiffert, C., Huang, M.C. and Graeler, M.H. (2004) Sphingosine 1-phosphate and its G protein-coupled receptors constitute a multifunctional immunoregulatory system. *J Cell Biochem*, **92**, 1104-1114.
- Goumans, M.J., Valdimarsdottir, G., Itoh, S., Rosendahl, A., Sideras, P. and ten Dijke, P. (2002) Balancing the activation state of the endothelium via two distinct TGF-beta type I receptors. *Embo J*, **21**, 1743-1753.
- Graeler, M. and Goetzl, E.J. (2002) Activation-regulated expression and chemotactic function of sphingosine 1-phosphate receptors in mouse splenic T cells. *Faseb J*, **16**, 1874-1878.
- Graeler, M., Shankar, G. and Goetzl, E.J. (2002) Cutting edge: suppression of T cell chemotaxis by sphingosine 1-phosphate. *J Immunol*, **169**, 4084-4087.
- Graeler, M.H., Kong, Y., Karliner, J.S. and Goetzl, E.J. (2003) Protein kinase C epsilon dependence of the recovery from down-regulation of S1P1 G protein-coupled receptors of T lymphocytes. *J Biol Chem*, **278**, 27737-27741.
- Graeler, M.H., Bernhardt, G. and Lipp, M. (1998) EDG6, a novel G-protein-coupled receptor related to receptors for bioactive lysophospholipids, is specifically expressed in lymphoid tissue. *Genomics*, **53**, 164-169.
- Graeler, M.H. and Goetzl, E.J. (2004) The immunosuppressant FTY720 down-regulates sphingosine 1-phosphate G-protein-coupled receptors. *Faseb J*, **18**, 551-553.
- Gruschwitz, M.S. and Hornstein, O.P. (1992) Expression of transforming growth factor type beta on human epidermal dendritic cells. *J Invest Dermatol*, **99**, 114-116.
- Gunn, M.D., Kyuwa, S., Tam, C., Kakiuchi, T., Matsuzawa, A., Williams, L.T. and Nakano, H. (1999) Mice lacking expression of secondary lymphoid organ chemokine have defects in lymphocyte homing and dendritic cell localization. *J Exp Med*, **189**, 451-460.
- Hacker, C., Kirsch, R.D., Ju, X.S., Hieronymus, T., Gust, T.C., Kuhl, C., Jorgas, T., Kurz, S.M., Rose-John, S., Yokota, Y. and Zenke, M. (2003) Transcriptional profiling identifies Id2 function in dendritic cell development. *Nat Immunol*, **4**, 380-386.
- Hait, N.C., Sarkar, S., Le Stunff, H., Mikami, A., Maceyka, M., Milstien, S. and Spiegel, S. (2005) Role of sphingosine kinase 2 in cell migration toward epidermal growth factor. *J Biol Chem*, **280**, 29462-29469.
- Hallak, H., Seiler, A.E., Green, J.S., Ross, B.N. and Rubin, R. (2000) Association of heterotrimeric G(i) with the insulin-like growth factor-I receptor. Release of

- G(beta gamma) subunits upon receptor activation. *J Biol Chem*, **275**, 2255-2258.
- Hannun, Y.A., Luberto, C. and Argraves, K.M. (2001) Enzymes of sphingolipid metabolism: from modular to integrative signaling. *Biochemistry*, **40**, 4893-4903.
- Hayes, S., Chawla, A. and Corvera, S. (2002) TGF beta receptor internalization into EEA1-enriched early endosomes: role in signaling to Smad2. *J Cell Biol*, **158**, 1239-1249.
- Hla, T. and Maciag, T. (1990) An abundant transcript induced in differentiating human endothelial cells encodes a polypeptide with structural similarities to G-protein-coupled receptors. *J Biol Chem*, **265**, 9308-9313.
- Hobson, J.P., Rosenfeldt, H.M., Barak, L.S., Olivera, A., Poulton, S., Caron, M.G., Milstien, S. and Spiegel, S. (2001) Role of the sphingosine-1-phosphate receptor EDG-1 in PDGF-induced cell motility. *Science*, **291**, 1800-1803.
- Idzko, M., Panther, E., Corinti, S., Morelli, A., Ferrari, D., Herouy, Y., Dichmann, S., Mockenhaupt, M., Gebicke-Haerter, P., Di Virgilio, F., Girolomoni, G. and Norgauer, J. (2002) Sphingosine 1-phosphate induces chemotaxis of immature and modulates cytokine-release in mature human dendritic cells for emergence of Th2 immune responses. *Faseb J*, **16**, 625-627.
- Igarashi, N., Okada, T., Hayashi, S., Fujita, T., Jahangeer, S. and Nakamura, S. (2003) Sphingosine kinase 2 is a nuclear protein and inhibits DNA synthesis. *J Biol Chem*, **278**, 46832-46839.
- Ignatov, A., Lintzel, J., Kreienkamp, H.J. and Schaller, H.C. (2003) Sphingosine-1-phosphate is a high-affinity ligand for the G protein-coupled receptor GPR6 from mouse and induces intracellular Ca²⁺ release by activating the sphingosine-kinase pathway. *Biochem Biophys Res Commun*, **311**, 329-336.
- Inaba, K., Inaba, M., Deguchi, M., Hagi, K., Yasumizu, R., Ikehara, S., Muramatsu, S. and Steinman, R.M. (1993) Granulocytes, macrophages, and dendritic cells arise from a common major histocompatibility complex class II-negative progenitor in mouse bone marrow. *Proc Natl Acad Sci U S A*, **90**, 3038-3042.
- Inaba, K., Turley, S., Yamaide, F., Iyoda, T., Mahnke, K., Inaba, M., Pack, M., Subklewe, M., Sauter, B., Sheff, D., Albert, M., Bhardwaj, N., Mellman, I. and Steinman, R.M. (1998) Efficient presentation of phagocytosed cellular fragments on the major histocompatibility complex class II products of dendritic cells. *J Exp Med*, **188**, 2163-2173.
- Ishii, I., Fukushima, N., Ye, X. and Chun, J. (2004) Lysophospholipid receptors: signaling and biology. *Annu Rev Biochem*, **73**, 321-354.
- Itoh, S., Itoh, F., Goumans, M.J. and Ten Dijke, P. (2000) Signaling of transforming growth factor-beta family members through Smad proteins. *Eur J Biochem*, **267**, 6954-6967.
- Iwasaki, A. and Kelsall, B.L. (2000) Localization of distinct Peyer's patch dendritic cell subsets and their recruitment by chemokines macrophage inflammatory protein (MIP)-3alpha, MIP-3beta, and secondary lymphoid organ chemokine. *J Exp Med*, **191**, 1381-1394.
- Izon, D., Rudd, K., DeMuth, W., Pear, W.S., Clendenin, C., Lindsley, R.C. and Allman, D. (2001) A common pathway for dendritic cell and early B cell development. *J Immunol*, **167**, 1387-1392.
- Jakob, T., Brown, M.J. and Udey, M.C. (1999) Characterization of E-cadherin-containing junctions involving skin-derived dendritic cells. *J Invest Dermatol*, **112**, 102-108.

- Jeckel, D., Karrenbauer, A., Burger, K.N., van Meer, G. and Wieland, F. (1992) Glucosylceramide is synthesized at the cytosolic surface of various Golgi subfractions. *J Cell Biol*, **117**, 259-267.
- Jolly, P.S., Bektas, M., Olivera, A., Gonzalez-Espinosa, C., Proia, R.L., Rivera, J., Milstien, S. and Spiegel, S. (2004) Transactivation of sphingosine-1-phosphate receptors by FcepsilonRI triggering is required for normal mast cell degranulation and chemotaxis. *J Exp Med*, **199**, 959-970.
- Kamath, A.T., Pooley, J., O'Keeffe, M.A., Vremec, D., Zhan, Y., Lew, A.M., D'Amico, A., Wu, L., Tough, D.F. and Shortman, K. (2000) The development, maturation, and turnover rate of mouse spleen dendritic cell populations. *J Immunol*, **165**, 6762-6770.
- Katzmann, D.J., Babst, M. and Emr, S.D. (2001) Ubiquitin-dependent sorting into the multivesicular body pathway requires the function of a conserved endosomal protein sorting complex, ESCRT-I. *Cell*, **106**, 145-155.
- Kehrl, J.H., Wakefield, L.M., Roberts, A.B., Jakowlew, S., Alvarez-Mon, M., Derynck, R., Sporn, M.B. and Fauci, A.S. (1986) Production of transforming growth factor beta by human T lymphocytes and its potential role in the regulation of T cell growth. *J Exp Med*, **163**, 1037-1050.
- Kim, J., Ahn, S., Guo, R. and Daaka, Y. (2003) Regulation of epidermal growth factor receptor internalization by G protein-coupled receptors. *Biochemistry*, **42**, 2887-2894.
- Kingsley, D.M. (1994) The TGF-beta superfamily: new members, new receptors, and new genetic tests of function in different organisms. *Genes Dev*, **8**, 133-146.
- Kleuser, B., Cuvillier, O. and Spiegel, S. (1998) 1Alpha,25-dihydroxyvitamin D3 inhibits programmed cell death in HL-60 cells by activation of sphingosine kinase. *Cancer Res*, **58**, 1817-1824.
- Kluepfel, D., Bagli, J., Baker, H., Charest, M.P. and Kudelski, A. (1972) Myriocin, a new antifungal antibiotic from *Myriococcum albomyces*. *J Antibiot (Tokyo)*, **25**, 109-115.
- Koch, J., Gartner, S., Li, C.M., Quintern, L.E., Bernardo, K., Levran, O., Schnabel, D., Desnick, R.J., Schuchman, E.H. and Sandhoff, K. (1996) Molecular cloning and characterization of a full-length complementary DNA encoding human acid ceramidase. Identification Of the first molecular lesion causing Farber disease. *J Biol Chem*, **271**, 33110-33115.
- Kon, J., Sato, K., Watanabe, T., Tomura, H., Kuwabara, A., Kimura, T., Tamama, K., Ishizuka, T., Murata, N., Kanda, T., Kobayashi, I., Ohta, H., Ui, M. and Okajima, F. (1999) Comparison of intrinsic activities of the putative sphingosine 1-phosphate receptor subtypes to regulate several signaling pathways in their cDNA-transfected Chinese hamster ovary cells. *J Biol Chem*, **274**, 23940-23947.
- Kostenis, E. (2004) Novel clusters of receptors for sphingosine-1-phosphate, sphingosylphosphorylcholine, and (lyso)-phosphatidic acid: new receptors for "old" ligands. *J Cell Biochem*, **92**, 923-936.
- Kowanetz, M., Valcourt, U., Bergstrom, R., Heldin, C.H. and Moustakas, A. (2004) Id2 and Id3 define the potency of cell proliferation and differentiation responses to transforming growth factor beta and bone morphogenetic protein. *Mol Cell Biol*, **24**, 4241-4254.
- Kranenburg, O. and Moolenaar, W.H. (2001) Ras-MAP kinase signaling by lysophosphatidic acid and other G protein-coupled receptor agonists. *Oncogene*, **20**, 1540-1546.

- Kretzschmar, M., Doody, J. and Massague, J. (1997) Opposing BMP and EGF signalling pathways converge on the TGF-beta family mediator Smad1. *Nature*, **389**, 618-622.
- Kretzschmar, M., Doody, J., Timokhina, I. and Massague, J. (1999) A mechanism of repression of TGFbeta/ Smad signaling by oncogenic Ras. *Genes Dev*, **13**, 804-816.
- Kulkarni, A.B., Huh, C.G., Becker, D., Geiser, A., Lyght, M., Flanders, K.C., Roberts, A.B., Sporn, M.B., Ward, J.M. and Karlsson, S. (1993) Transforming growth factor beta 1 null mutation in mice causes excessive inflammatory response and early death. *Proc Natl Acad Sci U S A*, **90**, 770-774.
- Lan, Y.Y., De Creus, A., Colvin, B.L., Abe, M., Brinkmann, V., Coates, P.T. and Thomson, A.W. (2005) The sphingosine-1-phosphate receptor agonist FTY720 modulates dendritic cell trafficking in vivo. *Am J Transplant*, **5**, 2649-2659.
- Le Stunff, H., Galve-Roperh, I., Peterson, C., Milstien, S. and Spiegel, S. (2002) Sphingosine-1-phosphate phosphohydrolase in regulation of sphingolipid metabolism and apoptosis. *J Cell Biol*, **158**, 1039-1049.
- Le Stunff, H., Milstien, S. and Spiegel, S. (2004) Generation and metabolism of bioactive sphingosine-1-phosphate. *J Cell Biochem*, **92**, 882-899.
- Lee, M.J., Thangada, S., Claffey, K.P., Ancellin, N., Liu, C.H., Kluk, M., Volpi, M., Sha'afi, R.I. and Hla, T. (1999) Vascular endothelial cell adherens junction assembly and morphogenesis induced by sphingosine-1-phosphate. *Cell*, **99**, 301-312.
- Letterio, J.J. and Bottinger, E.P. (1998) TGF-beta knockout and dominant-negative receptor transgenic mice. *Miner Electrolyte Metab*, **24**, 161-167.
- Letterio, J.J. and Roberts, A.B. (1998) Regulation of immune responses by TGF-beta. *Annu Rev Immunol*, **16**, 137-161.
- Levade, T. and Jaffrezou, J.P. (1999) Signalling sphingomyelinases: which, where, how and why? *Biochim Biophys Acta*, **1438**, 1-17.
- Lindahl, P., Johansson, B.R., Leveen, P. and Betsholtz, C. (1997) Pericyte loss and microaneurysm formation in PDGF-B-deficient mice. *Science*, **277**, 242-245.
- Liu, C.H., Thangada, S., Lee, M.J., Van Brocklyn, J.R., Spiegel, S. and Hla, T. (1999) Ligand-induced trafficking of the sphingosine-1-phosphate receptor EDG-1. *Mol Biol Cell*, **10**, 1179-1190.
- Liu, H., Sugiura, M., Nava, V.E., Edsall, L.C., Kono, K., Poulton, S., Milstien, S., Kohama, T. and Spiegel, S. (2000a) Molecular cloning and functional characterization of a novel mammalian sphingosine kinase type 2 isoform. *J Biol Chem*, **275**, 19513-19520.
- Liu, Y., Wada, R., Yamashita, T., Mi, Y., Deng, C.X., Hobson, J.P., Rosenfeldt, H.M., Nava, V.E., Chae, S.S., Lee, M.J., Liu, C.H., Hla, T., Spiegel, S. and Proia, R.L. (2000b) Edg-1, the G protein-coupled receptor for sphingosine-1-phosphate, is essential for vascular maturation. *J Clin Invest*, **106**, 951-961.
- Liu, Z. and Armant, D.R. (2004) Lysophosphatidic acid regulates murine blastocyst development by transactivation of receptors for heparin-binding EGF-like growth factor. *Exp Cell Res*, **296**, 317-326.
- Lo, C.G., Xu, Y., Proia, R.L. and Cyster, J.G. (2005) Cyclical modulation of sphingosine-1-phosphate receptor 1 surface expression during lymphocyte recirculation and relationship to lymphoid organ transit. *J Exp Med*, **201**, 291-301.
- Luft, T., Maraskovsky, E., Schnurr, M., Knebel, K., Kirsch, M., Gorner, M., Skoda, R., Ho, A.D., Nawroth, P. and Bierhaus, A. (2004) Tuning the volume of the

- immune response: strength and persistence of stimulation determine migration and cytokine secretion of dendritic cells. *Blood*, **104**, 1066-1074.
- Luttrell, L.M., van Biesen, T., Hawes, B.E., Koch, W.J., Touhara, K. and Lefkowitz, R.J. (1995) G beta gamma subunits mediate mitogen-activated protein kinase activation by the tyrosine kinase insulin-like growth factor 1 receptor. *J Biol Chem*, **270**, 16495-16498.
- MacLennan, A.J., Carney, P.R., Zhu, W.J., Chaves, A.H., Garcia, J., Grimes, J.R., Anderson, K.J., Roper, S.N. and Lee, N. (2001) An essential role for the H218/AGR16/Edg-5/LP(B2) sphingosine 1-phosphate receptor in neuronal excitability. *Eur J Neurosci*, **14**, 203-209.
- MacLennan, A.J., Marks, L., Gaskin, A.A. and Lee, N. (1997) Embryonic expression pattern of H218, a G-protein coupled receptor homolog, suggests roles in early mammalian nervous system development. *Neuroscience*, **79**, 217-224.
- MacPherson, G.G., Jenkins, C.D., Stein, M.J. and Edwards, C. (1995) Endotoxin-mediated dendritic cell release from the intestine. Characterization of released dendritic cells and TNF dependence. *J Immunol*, **154**, 1317-1322.
- Maldonado-Lopez, R., De Smedt, T., Michel, P., Godfroid, J., Pajak, B., Heirman, C., Thielemans, K., Leo, O., Urbain, J. and Moser, M. (1999) CD8alpha+ and CD8alpha- subclasses of dendritic cells direct the development of distinct T helper cells in vivo. *J Exp Med*, **189**, 587-592.
- Malek, R.L., Toman, R.E., Edsall, L.C., Wong, S., Chiu, J., Letterle, C.A., Van Brocklyn, J.R., Milstien, S., Spiegel, S. and Lee, N.H. (2001) Nrg-1 belongs to the endothelial differentiation gene family of G protein-coupled sphingosine-1-phosphate receptors. *J Biol Chem*, **276**, 5692-5699.
- Mandala, S., Hajdu, R., Bergstrom, J., Quackenbush, E., Xie, J., Milligan, J., Thornton, R., Shei, G.J., Card, D., Keohane, C., Rosenbach, M., Hale, J., Lynch, C.L., Rupprecht, K., Parsons, W. and Rosen, H. (2002) Alteration of lymphocyte trafficking by sphingosine-1-phosphate receptor agonists. *Science*, **296**, 346-349.
- Martin-Fontecha, A., Sebastiani, S., Hopken, U.E., Ugucioni, M., Lipp, M., Lanzavecchia, A. and Sallusto, F. (2003) Regulation of dendritic cell migration to the draining lymph node: impact on T lymphocyte traffic and priming. *J Exp Med*, **198**, 615-621.
- Massague, J. (1998) TGF-beta signal transduction. *Annu Rev Biochem*, **67**, 753-791.
- Massague, J. (2000) How cells read TGF-beta signals. *Nat Rev Mol Cell Biol*, **1**, 169-178.
- Matloubian, M., Lo, C.G., Cinamon, G., Lesneski, M.J., Xu, Y., Brinkmann, V., Allende, M.L., Proia, R.L. and Cyster, J.G. (2004) Lymphocyte egress from thymus and peripheral lymphoid organs is dependent on S1P receptor 1. *Nature*, **427**, 355-360.
- Matzinger, P. (1994) Tolerance, danger, and the extended family. *Annu Rev Immunol*, **12**, 991-1045.
- Medzhitov, R. and Janeway, C., Jr. (2000) Innate immune recognition: mechanisms and pathways. *Immunol Rev*, **173**, 89-97.
- Melendez, A., Floto, R.A., Gillooly, D.J., Harnett, M.M. and Allen, J.M. (1998) Fc gamma RI coupling to phospholipase D initiates sphingosine kinase-mediated calcium mobilization and vesicular trafficking. *J Biol Chem*, **273**, 9393-9402.
- Mellman, I. and Steinman, R.M. (2001) Dendritic cells: specialized and regulated antigen processing machines. *Cell*, **106**, 255-258.

- Meyer zu Heringdorf, D., Lass, H., Kuchar, I., Alemany, R., Guo, Y., Schmidt, M. and Jakobs, K.H. (1999) Role of sphingosine kinase in Ca(2+) signalling by epidermal growth factor receptor. *FEBS Lett*, **461**, 217-222.
- Miyake, Y., Kozutsumi, Y., Nakamura, S., Fujita, T. and Kawasaki, T. (1995) Serine palmitoyltransferase is the primary target of a sphingosine-like immunosuppressant, ISP-1/myriocin. *Biochem Biophys Res Commun*, **211**, 396-403.
- Miyasaka, M. and Tanaka, T. (2004) Lymphocyte trafficking across high endothelial venules: dogmas and enigmas. *Nat Rev Immunol*, **4**, 360-370.
- Moser, M. and Murphy, K.M. (2000) Dendritic cell regulation of TH1-TH2 development. *Nat Immunol*, **1**, 199-205.
- Moughal, N.A., Waters, C., Sambhi, B., Pyne, S. and Pyne, N.J. (2004) Nerve growth factor signaling involves interaction between the Trk A receptor and lysophosphatidate receptor 1 systems: nuclear translocation of the lysophosphatidate receptor 1 and Trk A receptors in pheochromocytoma 12 cells. *Cell Signal*, **16**, 127-136.
- Muller, H., Hofer, S., Kaneider, N., Neuwirt, H., Mosheimer, B., Mayer, G., Konwalinka, G., Heufler, C. and Tiefenthaler, M. (2005) The immunomodulator FTY720 interferes with effector functions of human monocyte-derived dendritic cells. *Eur J Immunol*, **35**, 533-545.
- Noguchi, Y., Okamoto, A., Kasama, T., Imajoh-Ohmi, S., Karatsu, T. and Nogawa, H. (2006) Lysophosphatidic acid cooperates with EGF in inducing branching morphogenesis of embryonic mouse salivary epithelium. *Dev Dyn*, **235**, 403-410.
- Nomura, M. and Li, E. (1998) Smad2 role in mesoderm formation, left-right patterning and craniofacial development. *Nature*, **393**, 786-790.
- Ogawa, C., Kihara, A., Gokoh, M. and Igarashi, Y. (2003) Identification and characterization of a novel human sphingosine-1-phosphate phosphohydrolase, hSPP2. *J Biol Chem*, **278**, 1268-1272.
- Okamoto, H., Takuwa, N., Yokomizo, T., Sugimoto, N., Sakurada, S., Shigematsu, H. and Takuwa, Y. (2000) Inhibitory regulation of Rac activation, membrane ruffling, and cell migration by the G protein-coupled sphingosine-1-phosphate receptor EDG5 but not EDG1 or EDG3. *Mol Cell Biol*, **20**, 9247-9261.
- Okazaki, T., Bell, R.M. and Hannun, Y.A. (1989) Sphingomyelin turnover induced by vitamin D3 in HL-60 cells. Role in cell differentiation. *J Biol Chem*, **264**, 19076-19080.
- Olivera, A., Kohama, T., Tu, Z., Milstien, S. and Spiegel, S. (1998) Purification and characterization of rat kidney sphingosine kinase. *J Biol Chem*, **273**, 12576-12583.
- Olivera, A. and Rivera, J. (2005) Sphingolipids and the balancing of immune cell function: lessons from the mast cell. *J Immunol*, **174**, 1153-1158.
- Olivera, A. and Spiegel, S. (1993) Sphingosine-1-phosphate as second messenger in cell proliferation induced by PDGF and FCS mitogens. *Nature*, **365**, 557-560.
- Olsson, N., Piek, E., ten Dijke, P. and Nilsson, G. (2000) Human mast cell migration in response to members of the transforming growth factor-beta family. *J Leukoc Biol*, **67**, 350-356.
- Panther, E., Idzko, M., Corinti, S., Ferrari, D., Herouy, Y., Mockenhaupt, M., Dichmann, S., Gebicke-Haerter, P., Di Virgilio, F., Girolomoni, G. and Norgauer, J. (2002) The influence of lysophosphatidic acid on the functions of human dendritic cells. *J Immunol*, **169**, 4129-4135.

- Pierre, P. and Mellman, I. (1998) Developmental regulation of invariant chain proteolysis controls MHC class II trafficking in mouse dendritic cells. *Cell*, **93**, 1135-1145.
- Pierre, P., Turley, S.J., Gatti, E., Hull, M., Meltzer, J., Mirza, A., Inaba, K., Steinman, R.M. and Mellman, I. (1997) Developmental regulation of MHC class II transport in mouse dendritic cells. *Nature*, **388**, 787-792.
- Pinschewer, D.D., Ochsenbein, A.F., Odermatt, B., Brinkmann, V., Hengartner, H. and Zinkernagel, R.M. (2000) FTY720 immunosuppression impairs effector T cell peripheral homing without affecting induction, expansion, and memory. *J Immunol*, **164**, 5761-5770.
- Pulendran, B., Banchereau, J., Maraskovsky, E. and Maliszewski, C. (2001) Modulating the immune response with dendritic cells and their growth factors. *Trends Immunol*, **22**, 41-47.
- Pyne, N.J., Waters, C., Moughal, N.A., Sambhi, B.S. and Pyne, S. (2003) Receptor tyrosine kinase-GPCR signal complexes. *Biochem Soc Trans*, **31**, 1220-1225.
- Radeke, H.H., von Wenckstern, H., Stoldtner, K., Sauer, B., Hammer, S. and Kleuser, B. (2005) Overlapping signaling pathways of sphingosine 1-phosphate and TGF-beta in the murine Langerhans cell line XS52. *J Immunol*, **174**, 2778-2786.
- Randolph, G.J. (2002) Is maturation required for Langerhans cell migration? *J Exp Med*, **196**, 413-416.
- Rastellini, C., Lu, L., Ricordi, C., Starzl, T.E., Rao, A.S. and Thomson, A.W. (1995) Granulocyte/macrophage colony-stimulating factor-stimulated hepatic dendritic cell progenitors prolong pancreatic islet allograft survival. *Transplantation*, **60**, 1366-1370.
- Regnault, A., Lankar, D., Lacabanne, V., Rodriguez, A., They, C., Rescigno, M., Saito, T., Verbeek, S., Bonnerot, C., Ricciardi-Castagnoli, P. and Amigorena, S. (1999) Fc-gamma receptor-mediated induction of dendritic cell maturation and major histocompatibility complex class I-restricted antigen presentation after immune complex internalization. *J Exp Med*, **189**, 371-380.
- Renkl, A., Berod, L., Mockenhaupt, M., Idzko, M., Panther, E., Termeer, C., Elsner, P., Huber, M. and Norgauer, J. (2004) Distinct effects of sphingosine-1-phosphate, lysophosphatidic acid and histamine in human and mouse dendritic cells. *Int J Mol Med*, **13**, 203-209.
- Robbiani, D.F., Finch, R.A., Jager, D., Muller, W.A., Sartorelli, A.C. and Randolph, G.J. (2000) The leukotriene C(4) transporter MRP1 regulates CCL19 (MIP-3beta, ELC)-dependent mobilization of dendritic cells to lymph nodes. *Cell*, **103**, 757-768.
- Romani, N., Holzmann, S., Tripp, C.H., Koch, F. and Stoitzner, P. (2003) Langerhans cells - dendritic cells of the epidermis. *Apmis*, **111**, 725-740.
- Roncarolo, M.G., Levings, M.K. and Traversari, C. (2001) Differentiation of T regulatory cells by immature dendritic cells. *J Exp Med*, **193**, F5-9.
- Rosbottom, A., Scudamore, C.L., von der Mark, H., Thornton, E.M., Wright, S.H. and Miller, H.R. (2002) TGF-beta 1 regulates adhesion of mucosal mast cell homologues to laminin-1 through expression of integrin alpha 7. *J Immunol*, **169**, 5689-5695.
- Rosen, H. and Goetzl, E.J. (2005) Sphingosine 1-phosphate and its receptors: an autocrine and paracrine network. *Nat Rev Immunol*, **5**, 560-570.
- Rosenfeldt, H.M., Hobson, J.P., Maceyka, M., Olivera, A., Nava, V.E., Milstien, S. and Spiegel, S. (2001) EDG-1 links the PDGF receptor to Src and focal

- adhesion kinase activation leading to lamellipodia formation and cell migration. *Faseb J*, **15**, 2649-2659.
- Rot, A. and von Andrian, U.H. (2004) Chemokines in innate and adaptive host defense: basic chemokine grammar for immune cells. *Annu Rev Immunol*, **22**, 891-928.
- Ruzinova, M.B. and Benezra, R. (2003) Id proteins in development, cell cycle and cancer. *Trends Cell Biol*, **13**, 410-418.
- Saeki, H., Moore, A.M., Brown, M.J. and Hwang, S.T. (1999) Cutting edge: secondary lymphoid-tissue chemokine (SLC) and CC chemokine receptor 7 (CCR7) participate in the emigration pathway of mature dendritic cells from the skin to regional lymph nodes. *J Immunol*, **162**, 2472-2475.
- Sallusto, F. and Lanzavecchia, A. (1994) Efficient presentation of soluble antigen by cultured human dendritic cells is maintained by granulocyte/macrophage colony-stimulating factor plus interleukin 4 and downregulated by tumor necrosis factor alpha. *J Exp Med*, **179**, 1109-1118.
- Sallusto, F., Schaerli, P., Loetscher, P., Schaniel, C., Lenig, D., Mackay, C.R., Qin, S. and Lanzavecchia, A. (1998) Rapid and coordinated switch in chemokine receptor expression during dendritic cell maturation. *Eur J Immunol*, **28**, 2760-2769.
- Sanchez, T., Estrada-Hernandez, T., Paik, J.H., Wu, M.T., Venkataraman, K., Brinkmann, V., Claffey, K. and Hla, T. (2003) Phosphorylation and action of the immunomodulator FTY720 inhibits vascular endothelial cell growth factor-induced vascular permeability. *J Biol Chem*, **278**, 47281-47290.
- Sarkar, S., Maceyka, M., Hait, N.C., Paugh, S.W., Sankala, H., Milstien, S. and Spiegel, S. (2005) Sphingosine kinase 1 is required for migration, proliferation and survival of MCF-7 human breast cancer cells. *FEBS Lett*, **579**, 5313-5317.
- Sato, N., Ahuja, S.K., Quinones, M., KostECKI, V., Reddick, R.L., Melby, P.C., Kuziel, W.A. and Ahuja, S.S. (2000) CC chemokine receptor (CCR)2 is required for langerhans cell migration and localization of T helper cell type 1 (Th1)-inducing dendritic cells. Absence of CCR2 shifts the Leishmania major-resistant phenotype to a susceptible state dominated by Th2 cytokines, b cell outgrowth, and sustained neutrophilic inflammation. *J Exp Med*, **192**, 205-218.
- Sauer, B., Vogler, R., von Wenckstern, H., Fujii, M., Anzano, M.B., Glick, A.B., Schafer-Korting, M., Roberts, A.B. and Kleuser, B. (2004a) Involvement of Smad signaling in sphingosine 1-phosphate-mediated biological responses of keratinocytes. *J Biol Chem*, **279**, 38471-38479.
- Sauer, B., Vogler, R., Zimmermann, K., Fujii, M., Anzano, M.B., Schafer-Korting, M., Roberts, A.B. and Kleuser, B. (2004b) Lysophosphatidic acid interacts with transforming growth factor-beta signaling to mediate keratinocyte growth arrest and chemotaxis. *J Invest Dermatol*, **123**, 840-849.
- Scandella, E., Men, Y., Gillessen, S., Forster, R. and Groettrup, M. (2002) Prostaglandin E2 is a key factor for CCR7 surface expression and migration of monocyte-derived dendritic cells. *Blood*, **100**, 1354-1361.
- Schmitt, E., Hoehn, P., Huels, C., Goedert, S., Palm, N., Rude, E. and Germann, T. (1994) T helper type 1 development of naive CD4+ T cells requires the coordinate action of interleukin-12 and interferon-gamma and is inhibited by transforming growth factor-beta. *Eur J Immunol*, **24**, 793-798.
- Schwab, S.R., Pereira, J.P., Matloubian, M., Xu, Y., Huang, Y. and Cyster, J.G. (2005) Lymphocyte sequestration through S1P lyase inhibition and disruption of S1P gradients. *Science*, **309**, 1735-1739.

- Shah, B.H., Neithardt, A., Chu, D.B., Shah, F.B. and Catt, K.J. (2006) Role of EGF receptor transactivation in phosphoinositide 3-kinase-dependent activation of MAP kinase by GPCRs. *J Cell Physiol*, **206**, 47-57.
- Shakushiro, K., Yamasaki, Y., Nishikawa, M. and Takakura, Y. (2004) Efficient scavenger receptor-mediated uptake and cross-presentation of negatively charged soluble antigens by dendritic cells. *Immunology*, **112**, 211-218.
- Sharma, P., Sabharanjak, S. and Mayor, S. (2002) Endocytosis of lipid rafts: an identity crisis. *Semin Cell Dev Biol*, **13**, 205-214.
- Shortman, K. and Liu, Y.J. (2002) Mouse and human dendritic cell subtypes. *Nat Rev Immunol*, **2**, 151-161.
- Shull, M.M., Ormsby, I., Kier, A.B., Pawlowski, S., Diebold, R.J., Yin, M., Allen, R., Sidman, C., Proetzel, G., Calvin, D. and et al. (1992) Targeted disruption of the mouse transforming growth factor-beta 1 gene results in multifocal inflammatory disease. *Nature*, **359**, 693-699.
- Simons, K. and Toomre, D. (2000) Lipid rafts and signal transduction. *Nat Rev Mol Cell Biol*, **1**, 31-39.
- Spiegel, S. and Milstien, S. (2002) Sphingosine 1-phosphate, a key cell signaling molecule. *J Biol Chem*, **277**, 25851-25854.
- Steinman, R.M. (2003) Some interfaces of dendritic cell biology. *Apmis*, **111**, 675-697.
- Strobl, H., Riedl, E., Scheinecker, C., Bello-Fernandez, C., Pickl, W.F., Rappersberger, K., Majdic, O. and Knapp, W. (1996) TGF-beta 1 promotes in vitro development of dendritic cells from CD34+ hemopoietic progenitors. *J Immunol*, **157**, 1499-1507.
- Suss, G. and Shortman, K. (1996) A subclass of dendritic cells kills CD4 T cells via Fas/Fas-ligand-induced apoptosis. *J Exp Med*, **183**, 1789-1796.
- Swain, S.L., Huston, G., Tonkonogy, S. and Weinberg, A. (1991) Transforming growth factor-beta and IL-4 cause helper T cell precursors to develop into distinct effector helper cells that differ in lymphokine secretion pattern and cell surface phenotype. *J Immunol*, **147**, 2991-3000.
- Taipale, J., Saharinen, J. and Keski-Oja, J. (1998) Extracellular matrix-associated transforming growth factor-beta: role in cancer cell growth and invasion. *Adv Cancer Res*, **75**, 87-134.
- Takashima, A., Xu, S., Ariizumi, K. and Bergstresser, P.R. (1995) Establishment and characterization of antigen-presenting cell lines (XS series) derived from newborn mouse epidermis. *Adv Exp Med Biol*, **378**, 159-162.
- Tang, A., Amagai, M., Granger, L.G., Stanley, J.R. and Udey, M.C. (1993) Adhesion of epidermal Langerhans cells to keratinocytes mediated by E-cadherin. *Nature*, **361**, 82-85.
- Thudichum, J.L.W. (1884) *A Treatise on the Chemical Constitution of Brain*. Bailliere, Tindall and Cox, London.
- Tsukazaki, T., Chiang, T.A., Davison, A.F., Attisano, L. and Wrana, J.L. (1998) SARA, a FYVE domain protein that recruits Smad2 to the TGFbeta receptor. *Cell*, **95**, 779-791.
- Turner, M., Chantry, D. and Feldmann, M. (1990) Transforming growth factor beta induces the production of interleukin 6 by human peripheral blood mononuclear cells. *Cytokine*, **2**, 211-216.
- Uhlenbrock, K., Gassenhuber, H. and Kostenis, E. (2002) Sphingosine 1-phosphate is a ligand of the human gpr3, gpr6 and gpr12 family of constitutively active G protein-coupled receptors. *Cell Signal*, **14**, 941-953.

- Valladeau, J., Ravel, O., Dezutter-Dambuyant, C., Moore, K., Kleijmeer, M., Liu, Y., Duvert-Frances, V., Vincent, C., Schmitt, D., Davoust, J., Caux, C., Lebecque, S. and Saeland, S. (2000) Langerin, a novel C-type lectin specific to Langerhans cells, is an endocytic receptor that induces the formation of Birbeck granules. *Immunity*, **12**, 71-81.
- Valladeau, J. and Saeland, S. (2005) Cutaneous dendritic cells. *Semin Immunol*, **17**, 273-283.
- Vogler, R., Sauer, B., Kim, D.S., Schafer-Korting, M. and Kleuser, B. (2003) Sphingosine-1-phosphate and its potentially paradoxical effects on critical parameters of cutaneous wound healing. *J Invest Dermatol*, **120**, 693-700.
- Wahl, S.M., Allen, J.B., Weeks, B.S., Wong, H.L. and Klotman, P.E. (1993) Transforming growth factor beta enhances integrin expression and type IV collagenase secretion in human monocytes. *Proc Natl Acad Sci U S A*, **90**, 4577-4581.
- Wallet, M.A., Sen, P. and Tisch, R. (2005) Immunoregulation of dendritic cells. *Clin Med Res*, **3**, 166-175.
- Wang, F., Van Brocklyn, J.R., Hobson, J.P., Movafagh, S., Zukowska-Grojec, Z., Milstien, S. and Spiegel, S. (1999) Sphingosine 1-phosphate stimulates cell migration through a G(i)-coupled cell surface receptor. Potential involvement in angiogenesis. *J Biol Chem*, **274**, 35343-35350.
- Wang, W., Graeler, M.H. and Goetzl, E.J. (2005) Type 4 sphingosine 1-phosphate G protein-coupled receptor (S1P4) transduces S1P effects on T cell proliferation and cytokine secretion without signaling migration. *Faseb J*.
- Waters, C., Sambhi, B., Kong, K.C., Thompson, D., Pitson, S.M., Pyne, S. and Pyne, N.J. (2003) Sphingosine 1-phosphate and platelet-derived growth factor (PDGF) act via PDGF beta receptor-sphingosine 1-phosphate receptor complexes in airway smooth muscle cells. *J Biol Chem*, **278**, 6282-6290.
- Wrana, J.L. and Attisano, L. (2000) The Smad pathway. *Cytokine Growth Factor Rev*, **11**, 5-13.
- Wu, L., D'Amico, A., Hochrein, H., O'Keeffe, M., Shortman, K. and Lucas, K. (2001) Development of thymic and splenic dendritic cell populations from different hemopoietic precursors. *Blood*, **98**, 3376-3382.
- Xin, C., Ren, S., Kleuser, B., Shabahang, S., Eberhardt, W., Radeke, H., Schafer-Korting, M., Pfeilschifter, J. and Huwiler, A. (2004) Sphingosine 1-phosphate cross-activates the Smad signaling cascade and mimics transforming growth factor-beta-induced cell responses. *J Biol Chem*, **279**, 35255-35262.
- Xu, H., Guan, H., Zu, G., Bullard, D., Hanson, J., Slater, M. and Elmets, C.A. (2001) The role of ICAM-1 molecule in the migration of Langerhans cells in the skin and regional lymph node. *Eur J Immunol*, **31**, 3085-3093.
- Xu, S., Ariizumi, K., Caceres-Dittmar, G., Edelbaum, D., Hashimoto, K., Bergstresser, P.R. and Takashima, A. (1995a) Successive generation of antigen-presenting, dendritic cell lines from murine epidermis. *J Immunol*, **154**, 2697-2705.
- Xu, S., Bergstresser, P.R. and Takashima, A. (1995b) Phenotypic and functional heterogeneity among murine epidermal-derived dendritic cell clones. *J Invest Dermatol*, **105**, 831-836.
- Yamaguchi, H., Kitayama, J., Takuwa, N., Arikawa, K., Inoki, I., Takehara, K., Nagawa, H. and Takuwa, Y. (2003) Sphingosine-1-phosphate receptor subtype-specific positive and negative regulation of Rac and haematogenous metastasis of melanoma cells. *Biochem J*, **374**, 715-722.
- Yang, L., Yatomi, Y., Miura, Y., Satoh, K. and Ozaki, Y. (1999a) Metabolism and functional effects of sphingolipids in blood cells. *Br J Haematol*, **107**, 282-293.

- Yang, X., Castilla, L.H., Xu, X., Li, C., Gotay, J., Weinstein, M., Liu, P.P. and Deng, C.X. (1999b) Angiogenesis defects and mesenchymal apoptosis in mice lacking SMAD5. *Development*, **126**, 1571-1580.
- Yang, X., Letterio, J.J., Lechleider, R.J., Chen, L., Hayman, R., Gu, H., Roberts, A.B. and Deng, C. (1999c) Targeted disruption of SMAD3 results in impaired mucosal immunity and diminished T cell responsiveness to TGF-beta. *Embo J*, **18**, 1280-1291.
- Yang, X., Li, C., Xu, X. and Deng, C. (1998) The tumor suppressor SMAD4/DPC4 is essential for epiblast proliferation and mesoderm induction in mice. *Proc Natl Acad Sci U S A*, **95**, 3667-3672.
- Yatomi, Y., Ozaki, Y., Ohmori, T. and Igarashi, Y. (2001) Sphingosine 1-phosphate: synthesis and release. *Prostaglandins Other Lipid Mediat*, **64**, 107-122.
- Yoshimoto, T., Furuhashi, M., Kamiya, S., Hisada, M., Miyaji, H., Magami, Y., Yamamoto, K., Fujiwara, H. and Mizuguchi, J. (2003) Positive modulation of IL-12 signaling by sphingosine kinase 2 associating with the IL-12 receptor beta 1 cytoplasmic region. *J Immunol*, **171**, 1352-1359.
- Yu, L., Hebert, M.C. and Zhang, Y.E. (2002) TGF-beta receptor-activated p38 MAP kinase mediates Smad-independent TGF-beta responses. *Embo J*, **21**, 3749-3759.
- Zhao, Y., He, D., Saatian, B., Watkins, T., Spannhake, E.W., Pyne, N.J. and Natarajan, V. (2006) Regulation of lysophosphatidic acid- induced epidermal growth factor receptor transactivation and interleukin-8 secretion in human bronchial epithelial cells by protein kinase C delta, Lyn kinase and matrix metalloproteinases. *J Biol Chem*.