Regulators of integrin α6β4 function

Molder, L. te

Author: Molder, L. te
Title: Regulators of integrin α6β4 function
Issue Date: 2021-02-25

ADDENDUM

References
Nederlandse samenvatting voor leken
Curriculum Vitae
List of Publications
Dankwoord

References

[1] S.H.M. Litjens, J.M. de Pereda, A. Sonnenberg, Current insights into the formation and breakdown of hemidesmosomes, Trends Cell Biol. 16 (2006) 376–383. https://doi.org/10.1016/j.tcb.2006.05.004.

[2] G. Walko, M.J. Castañón, G. Wiche, Molecular architecture and function of the hemidesmosome, Cell Tissue Res. (2015). https://doi.org/10.1007/s00441-015-2216-6.

[3] L.M. Sterk, C.A. Geuijen, L.C. Oomen, J. Calafat, H. Janssen, A. Sonnenberg, The tetraspan molecule CD151, a novel constituent of hemidesmosomes, associates with the integrin alpha6beta4 and may regulate the spatial organization of hemidesmosomes, J. Cell Biol. 149 (2000) 969–982.

[4] L. Fontao, J. Stutzmann, P. Gendry, J.F. Launay, Regulation of the type II hemidesmosomal plaque assembly in intestinal epithelial cells, Exp. Cell Res. 250 (1999) 298–312. https://doi.org/10.1006/excr.1999.4549.

[5] C. Margadant, R.A. Charafeddine, A. Sonnenberg, Unique and redundant functions of integrins in the epidermis, FASEB J. 24 (2010) 4133–4152. https://doi.org/10.1096/fj.09-151449.

[6] C. Margadant, E. Frijns, K. Wilhelmsen, A. Sonnenberg, Regulation of hemidesmosome disassembly by growth factor receptors, Curr. Opin. Cell Biol. 20 (2008) 589–596. https://doi.org/10.1016/j.ceb.2008.05.001.

[7] G.A. Rezniczek, J.M. de Pereda, S. Reipert, G. Wiche, Linking integrin alpha6beta4-based cell adhesion to the intermediate filament cytoskeleton: direct interaction between the beta4 subunit and plectin at multiple molecular sites, J. Cell Biol. 141 (1998) 209–225.

[8] C.M. Niessen, E.H. Hulsman, L.C. Oomen, I. Kuikman, A. Sonnenberg, A minimal region on the integrin beta4 subunit that is critical to its localization in hemidesmosomes regulates the distribution of HD1/plectin in COS-7 cells, J. Cell Sci. 110 (Pt 15) (1997) 1705–1716.

[9] D. Geerts, L. Fontao, M.G. Nievers, R.Q. Schaapveld, P.E. Purkis, G.N. Wheeler, E.B. Lane, I.M. Leigh, A. Sonnenberg, Binding of integrin alpha6beta4 to plectin prevents plectin association with F-actin but does not interfere with intermediate filament binding, J. Cell Biol. 147 (1999) 417–434.

[10] S.H.M. Litjens, J. Koster, I. Kuikman, S. van Wilpe, J.M. de Pereda, A. Sonnenberg, Specificity of Binding of the Plectin Actin-binding Domain to β4 Integrin, Mol. Biol. Cell. 14 (2003) 4039–4050. https://doi.org/10.1091/mbc.E03-05-0268.

[11] J. Koster, D. Geerts, B. Favre, L. Borradori, A. Sonnenberg, Analysis of the interactions between BP180, BP230, plectin and the integrin alpha6beta4 important for hemidesmosome assembly, J. Cell Sci. 116 (2003) 387–399.

[12] J.A. Manso, M. Gómez-Hernández, A. Carabias, N. Alonso-García, I. García-Rubio, M. Kreft, A. Sonnenberg, J.M. de Pereda, Integrin α6β4 Recognition of a Linear Motif of Bullous Pemphigoid Antigen BP230 Controls Its Recruitment to Hemidesmosomes, Struct. Lond. Engl. 1993. 27 (2019) 952-964.e6. https://doi.org/10.1016/j.str.2019.03.016.

[13] R.Q. Schaapveld, L. Borradori, D. Geerts, M.R. van Leusden, I. Kuikman, M.G. Nievers, C.M. Niessen, R.D. Steenbergen, P.J. Snijders, A. Sonnenberg, Hemidesmosome formation is initiated by the beta4 integrin subunit, requires complex formation of beta4 and HD1/plectin, and involves a direct interaction between beta4 and the bullous pemphigoid antigen 180, J. Cell Biol. 142 (1998) 271–284.

[14] L. Borradori, P.J. Koch, C.M. Niessen, S. Erkeland, M.R. van Leusden, A. Sonnenberg, The localization of bullous pemphigoid antigen 180 (BP180) in hemidesmosomes is mediated by its cytoplasmic domain and seems to be regulated by the beta4 integrin subunit, J. Cell Biol. 136 (1997) 1333–1347.

[15] S.B. Hopkinson, K. Findlay, G.W. deHart, J.C. Jones, Interaction of BP180 (type XVII collagen) and alpha6 integrin is necessary for stabilization of hemidesmosome structure, J. Invest. Dermatol. 111 (1998) 1015–1022. https://doi.org/10.1046/j.1523-1747.1998.00452.x.

[16] S.B. Hopkinson, J.C. Jones, The N terminus of the transmembrane protein BP180 interacts with the N-terminal domain of BP230, thereby mediating keratin cytoskeleton anchorage to the cell surface at the site of the hemidesmosome, Mol. Biol. Cell. 11 (2000) 277–286. https://doi.org/10.1091/mbc.11.1.277.

[17] C.M. Niessen, E.H. Hulsman, E.S. Rots, P. Sánchez-Aparicio, A. Sonnenberg, Integrin alpha 6 beta 4 forms a complex with the cytoskeletal protein HD1 and induces its redistribution in transfected COS-7 cells., Mol. Biol. Cell. 8 (1997) 555–566.

[18] A. Sonnenberg, R.K.H. Liem, Plakins in development and disease, Exp. Cell Res. 313 (2007) 2189–2203. https://doi.org/10.1016/j.yexcr.2007.03.039.

[19] C.M. Niessen, F. Hogervorst, L.H. Jaspars, A.A. de Melker, G.O. Delwel, E.H. Hulsman, I. Kuikman, A. Sonnenberg, The alpha 6 beta 4 integrin is a receptor for both laminin and kalinin, Exp. Cell Res. 211 (1994) 360–367. https://doi.org/10.1006/excr.1994.1099.

[20] K. Tasanen, L. Tunggal, G. Chometon, L. Bruckner-Tuderman, M. Aumailley, Keratinocytes from patients lacking collagen XVII display a migratory phenotype, Am. J. Pathol. 164 (2004) 2027–2038. https://doi.org/10.1016/S0002-9440(10)63762-5.

[21] C. Has, J. Fischer, Inherited epidermolysis bullosa: New diagnostics and new clinical phenotypes, Exp. Dermatol. 28 (2019) 1146–1152. https://doi.org/10.1111/exd.13668.

[22] A. Tabor, J.V. Pergolizzi, G. Marti, J. Harmon, B. Cohen, J.A. Lequang, Raising Awareness Among Healthcare Providers about Epidermolysis Bullosa and Advancing Toward a Cure, J. Clin. Aesthetic Dermatol. 10 (2017) 36–48.

[23] G.H. Ashton, P. Sorelli, J.E. Mellerio, F.M. Keane, R.A. Eady, J.A. McGrath, Alpha 6 beta 4 integrin abnormalities in junctional epidermolysis bullosa with pyloric atresia, Br. J. Dermatol. 144 (2001) 408–414.

[24] C.M. Niessen, M.H. van der Raaij-Helmer, E.H. Hulsman, R. van der Neut, M.F. Jonkman, A. Sonnenberg, Deficiency of the integrin beta 4 subunit in junctional epidermolysis bullosa with pyloric atresia: consequences for hemidesmosome formation and adhesion properties, J. Cell Sci. 109 (Pt 7) (1996) 1695–1706.

[25] F. Vidal, D. Aberdam, C. Miquel, A.M. Christiano, L. Pulkkinen, J. Uitto, J.P. Ortonne, G. Meneguzzi, Integrin beta 4 mutations associated with junctional epidermolysis bullosa with pyloric atresia, Nat. Genet. 10 (1995) 229–234. https://doi.org/10.1038/ng0695-229.

[26] M. Durbeej, Laminins, Cell Tissue Res. 339 (2010) 259–268. https://doi.org/10.1007/s00441-009-0838-2.

[27] R. Zent, A. Pozzi, eds., Cell-Extracellular Matrix Interactions in Cancer, Springer-Verlag, New York, 2010. https://doi.org/10.1007/978-1-4419-0814-8.

[28] R. Nishiuchi, J. Takagi, M. Hayashi, H. Ido, Y. Yagi, N. Sanzen, T. Tsuji, M. Yamada, K. Sekiguchi, Ligand-binding specificities of laminin-binding integrins: a comprehensive survey of laminin-integrin interactions using recombinant alpha3beta1, alpha6beta1, alpha7beta1 and alpha6beta4 integrins, Matrix Biol. J. Int. Soc. Matrix Biol. 25 (2006) 189–197. https://doi.org/10.1016/j.matbio.2005.12.001.

[29] Y. Kikkawa, N. Sanzen, H. Fujiwara, A. Sonnenberg, K. Sekiguchi, Integrin binding specificity of laminin-10/11: laminin-10/11 are recognized by alpha 3 beta 1, alpha 6 beta 1 and alpha 6 beta 4 integrins, J. Cell Sci. 113 (Pt 5) (2000) 869–876.

[30] G.O. Delwel, A.A. de Melker, F. Hogervorst, L.H. Jaspars, D.L. Fles, I. Kuikman, A. Lindblom, M. Paulsson, R. Timpl, A. Sonnenberg, Distinct and overlapping ligand specificities of the alpha 3A beta 1 and alpha 6A beta 1 integrins: recognition of laminin isoforms, Mol. Biol. Cell. 5 (1994) 203–215. https://doi.org/10.1091/mbc.5.2.203.

[31] A.A. de Melker, A. Sonnenberg, Integrins: alternative splicing as a mechanism to regulate ligand binding and integrin signaling events, BioEssays. 21 (1999) 499–509. https://doi.org/10.1002/(SICI)1521-1878(199906)21:6<499::AID-BIES6>3.0.CO;2-D.

[32] M. Kääriäinen, L. Nissinen, S. Kaufman, A. Sonnenberg, M. Järvinen, J. Heino, H. Kalimo, Expression of α7β1 Integrin Splicing Variants during Skeletal Muscle Regeneration, Am. J. Pathol. 161 (2002) 1023–1031.

[33] N. Vignier, B. Moghadaszadeh, F. Gary, J. Beckmann, U. Mayer, P. Guicheney, Structure, genetic localization, and identification of the cardiac and skeletal muscle transcripts of the human integrin alpha7 gene (ITGA7), Biochem. Biophys. Res. Commun. 260 (1999) 357–364. https://doi.org/10.1006/bbrc.1999.0916.

[34] C.M. DiPersio, J. Trevithick, R. Hynes, Functional Comparison of the α3A and α3B Cytoplasmic Domain Variants of the Chicken α3 Integrin Subunit, Exp. Cell Res. 268 (2001) 45–60. https://doi.org/10.1006/excr.2001.5273.

[35] A.A. de Melker, L.M. Sterk, G.O. Delwel, D.L. Fles, H. Daams, J.J. Weening, A. Sonnenberg, The A and B variants of the alpha 3 integrin subunit: tissue distribution and functional characterization, Lab. Investig. J. Tech. Methods Pathol. 76 (1997) 547–563.

[36] G.O. Delwel, I. Kuikman, A. Sonnenberg, An alternatively spliced exon in the extracellular domain of the human alpha 6 integrin subunit--functional analysis of the alpha 6 integrin variants, Cell Adhes. Commun. 3 (1995) 143–161. https://doi.org/10.3109/15419069509081283.

[37] F. Hogervorst, L.G. Admiraal, C. Niessen, I. Kuikman, H. Janssen, H. Daams, A. Sonnenberg, Biochemical characterization and tissue distribution of the A and B variants of the integrin alpha 6 subunit, J. Cell Biol. 121 (1993) 179–191.

[38] F. Hogervorst, I. Kuikman, A.G. van Kessel, A. Sonnenberg, Molecular cloning of the human alpha 6 integrin subunit. Alternative splicing of alpha 6 mRNA and chromosomal localization of the alpha 6 and beta 4 genes, Eur. J. Biochem. FEBS. 199 (1991) 425–433.

[39] B.L. Ziober, M.P. Vu, N. Waleh, J. Crawford, C.S. Lin, R.H. Kramer, Alternative extracellular and cytoplasmic domains of the integrin alpha 7 subunit are differentially expressed during development., J. Biol. Chem. 268 (1993) 26773–26783.

[40] S. Thorsteinsdóttir, B.A. Roelen, E. Freund, A.C. Gaspar, A. Sonnenberg, C.L. Mummery, Expression patterns of laminin receptor splice variants alpha 6A beta 1 and alpha 6B beta 1 suggest different roles in mouse development, Dev. Dyn. Off. Publ. Am. Assoc. Anat. 204 (1995) 240–258. https://doi.org/10.1002/aja.1002040304.

[41] R.N. Tamura, H.M. Cooper, G. Collo, V. Quaranta, Cell type-specific integrin variants with alternative alpha chain cytoplasmic domains, Proc. Natl. Acad. Sci. U. S. A. 88 (1991) 10183–10187.

[42] C. Gimond, C. Baudoin, R. van der Neut, D. Kramer, J. Calafat, A. Sonnenberg, Cre-loxP-mediated inactivation of the alpha6A integrin splice variant in vivo: evidence for a specific functional role of alpha6A in lymphocyte migration but not in heart development, J. Cell Biol. 143 (1998) 253–266. https://doi.org/10.1083/jcb.143.1.253.

[43] T. Velling, G. Collo, L. Sorokin, M. Durbeej, H. Zhang, D. Gullberg, Distinct alpha 7A beta 1 and alpha 7B beta 1 integrin expression patterns during mouse development: alpha 7A is restricted to skeletal muscle but alpha 7B is expressed in striated muscle, vasculature, and nervous system, Dev. Dyn. Off. Publ. Am. Assoc. Anat. 207 (1996) 355–371. https://doi.org/10.1002/(SICI)1097-0177(199612)207:4<355::AID-AJA1>3.0.CO;2-G.

[44] J.V. Welser-Alves, A. Boroujerdi, U. Tigges, L. Wrabetz, M.L. Feltri, R. Milner, Endothelial β4 integrin is predominantly expressed in arterioles, where it promotes vascular remodeling in the hypoxic brain, Arterioscler. Thromb. Vasc. Biol. 33 (2013) 943–953. https://doi.org/10.1161/ATVBAHA.112.300566.

[45] C.M. Niessen, O. Cremona, H. Daams, S. Ferraresi, A. Sonnenberg, P.C. Marchisio, Expression of the integrin alpha 6 beta 4 in peripheral nerves: localization in Schwann and perineural cells and different variants of the beta 4 subunit, J. Cell Sci. 107 (Pt 2) (1994) 543–552.

[46] A. Sonnenberg, C.J. Linders, J.H. Daams, S.J. Kennel, The alpha 6 beta 1 (VLA-6) and alpha 6 beta 4 protein complexes: tissue distribution and biochemical properties, J. Cell Sci. 96 (Pt 2) (1990) 207–217.

[47] R. van der Neut, P. Krimpenfort, J. Calafat, C.M. Niessen, A. Sonnenberg, Epithelial detachment due to absence of hemidesmosomes in integrin β4 null mice, Nat. Genet. 13 (1996) 366–369. https://doi.org/10.1038/ng0796-366.

[48] J. Dowling, Q.C. Yu, E. Fuchs, Beta4 integrin is required for hemidesmosome formation, cell adhesion and cell survival, J. Cell Biol. 134 (1996) 559–572.

[49] E. Georges-Labouesse, N. Messaddeq, G. Yehia, L. Cadalbert, A. Dierich, M. Le Meur, Absence of integrin alpha 6 leads to epidermolysis bullosa and neonatal death in mice, Nat. Genet. 13 (1996) 370–373. https://doi.org/10.1038/ng0796-370.

[50] N. Nicolaou, C. Margadant, S.H. Kevelam, M.R. Lilien, M.J.S. Oosterveld, M. Kreft, A.M. van Eerde, R. Pfundt, P.A. Terhal, B. van der Zwaag, P.G.J. Nikkels, N. Sachs, R. Goldschmeding, N.V.A.M. Knoers, K.Y. Renkema, A. Sonnenberg, Gain of glycosylation in integrin α3 causes lung disease and nephrotic syndrome, J. Clin. Invest. 122 (2012) 4375–4387. https://doi.org/10.1172/JCI64100.

[51] E.G. Yalcin, Y. He, D. Orhan, C. Pazzagli, N. Emiralioglu, C. Has, Crucial role of posttranslational modifications of integrin α3 in interstitial lung disease and nephrotic syndrome, Hum. Mol. Genet. 24 (2015) 3679–3688. https://doi.org/10.1093/hmg/ddv111.

[52] C. Has, G. Spartà, D. Kiritsi, L. Weibel, A. Moeller, V. Vega-Warner, A. Waters, Y. He, Y. Anikster, P. Esser, B.K. Straub, I. Hausser, D. Bockenhauer, B. Dekel, F. Hildebrandt, L. Bruckner-Tuderman, G.F. Laube, Integrin α3 mutations with kidney, lung, and skin disease, N. Engl. J. Med. 366 (2012) 1508–1514. https://doi.org/10.1056/NEJMoa1110813.

[53] J.A. Kreidberg, M.J. Donovan, S.L. Goldstein, H. Rennke, K. Shepherd, R.C. Jones, R. Jaenisch, Alpha 3 beta 1 integrin has a crucial role in kidney and lung organogenesis, Dev. Camb. Engl. 122 (1996) 3537–3547.

[54] C.M. DiPersio, K.M. Hodivala-Dilke, R. Jaenisch, J.A. Kreidberg, R.O. Hynes, alpha3beta1 Integrin is required for normal development of the epidermal basement membrane, J. Cell Biol. 137 (1997) 729–742.

[55] C. Margadant, K. Raymond, M. Kreft, N. Sachs, H. Janssen, A. Sonnenberg, Integrin α3β1 inhibits directional migration and wound re-epithelialization in the skin, J. Cell Sci. 122 (2009) 278–288. https://doi.org/10.1242/jcs.029108.

[56] Y.K. Hayashi, F.L. Chou, E. Engvall, M. Ogawa, C. Matsuda, S. Hirabayashi, K. Yokochi, B.L. Ziober, R.H. Kramer, S.J. Kaufman, E. Ozawa, Y. Goto, I. Nonaka, T. Tsukahara, J.Z. Wang, E.P. Hoffman, K. Arahata, Mutations in the integrin alpha7 gene cause congenital myopathy, Nat. Genet. 19 (1998) 94–97. https://doi.org/10.1038/ng0598-94.

[57] U. Mayer, G. Saher, R. Fässler, A. Bornemann, F. Echtermeyer, H. von der Mark, N. Miosge, E. Pöschl, K. von der Mark, Absence of integrin alpha 7 causes a novel form of muscular dystrophy, Nat. Genet. 17 (1997) 318–323. https://doi.org/10.1038/ng1197-318.

[58] E. Georges-Labouesse, M. Mark, N. Messaddeq, A. Gansmüller, Essential role of alpha 6 integrins in cortical and retinal lamination, Curr. Biol. CB. 8 (1998) 983–986.

[59] R. Fässler, M. Meyer, Consequences of lack of beta 1 integrin gene expression in mice, Genes Dev. 9 (1995) 1896–1908. https://doi.org/10.1101/gad.9.15.1896.

[60] C.S. Chen, J.L. Alonso, E. Ostuni, G.M. Whitesides, D.E. Ingber, Cell shape provides global control of focal adhesion assembly, Biochem. Biophys. Res. Commun. 307 (2003) 355–361. https://doi.org/10.1016/s0006-291x(03)01165-3.

[61] L. Borradori, A. Sonnenberg, Structure and function of hemidesmosomes: more than simple adhesion complexes, J. Invest. Dermatol. 112 (1999) 411–418. https://doi.org/10.1046/j.1523-1747.1999.00546.x.

[62] J.C. Jones, S.B. Hopkinson, L.E. Goldfinger, Structure and assembly of hemidesmosomes, BioEssays News Rev. Mol. Cell. Dev. Biol. 20 (1998) 488–494. https://doi.org/10.1002/(SICI)1521-1878(199806)20:6<488::AID-BIES7>3.0.CO;2-I.

[63] K. Seltmann, F. Cheng, G. Wiche, J.E. Eriksson, T.M. Magin, Keratins Stabilize Hemidesmosomes Through Regulation of β4-Integrin Turnover, J. Invest. Dermatol. (2015). https://doi.org/10.1038/jid.2015.46.

[64] S.-O. Yoon, S. Shin, A.M. Mercurio, Hypoxia stimulates carcinoma invasion by stabilizing microtubules and promoting the Rab11 trafficking of the alpha6beta4 integrin, Cancer Res. 65 (2005) 2761–2769. https://doi.org/10.1158/0008-5472.CAN-04-4122.

[65] P. Rousselle, K. Beck, Laminin 332 processing impacts cellular behavior, Cell Adhes. Migr. 7 (2013) 122–134. https://doi.org/10.4161/cam.23132.

[66] M.E. Werner, F. Chen, J.V. Moyano, F. Yehiely, J.C.R. Jones, V.L. Cryns, Caspase proteolysis of the integrin beta4 subunit disrupts hemidesmosome assembly, promotes apoptosis, and inhibits cell migration, J. Biol. Chem. 282 (2007) 5560–5569. https://doi.org/10.1074/jbc.M603669200.

[67] F.G. Giancotti, M.A. Stepp, S. Suzuki, E. Engvall, E. Ruoslahti, Proteolytic processing of endogenous and recombinant beta 4 integrin subunit, J. Cell Biol. 118 (1992) 951–959.

[68] E. Frijns, N. Sachs, M. Kreft, K. Wilhelmsen, A. Sonnenberg, EGF-induced MAPK signaling inhibits hemidesmosome formation through phosphorylation of the integrin {beta}4, J. Biol. Chem. 285 (2010) 37650–37662. https://doi.org/10.1074/jbc.M110.138818.

[69] E. Frijns, I. Kuikman, S. Litjens, M. Raspe, K. Jalink, M. Ports, K. Wilhelmsen, A. Sonnenberg, Phosphorylation of threonine 1736 in the C-terminal tail of integrin β4 contributes to hemidesmosome disassembly, Mol. Biol. Cell. 23 (2012) 1475–1485. https://doi.org/10.1091/mbc.E11-11-0957.

[70] E.C. Germain, T.M. Santos, I. Rabinovitz, Phosphorylation of a novel site on the {beta}4 integrin at the trailing edge of migrating cells promotes hemidesmosome disassembly, Mol. Biol. Cell. 20 (2009) 56–67. https://doi.org/10.1091/mbc.E08-06-0646.

[71] J.-E. Bouameur, Y. Schneider, N. Begré, R.P. Hobbs, P. Lingasamy, L. Fontao, K.J. Green, B. Favre, L. Borradori, Phosphorylation of serine 4,642 in the C-terminus of plectin by MNK2 and PKA modulates its interaction with intermediate filaments, J. Cell Sci. 126 (2013) 4195–4207. https://doi.org/10.1242/jcs.127779.

[72] I. Rabinovitz, L. Tsomo, A.M. Mercurio, Protein kinase C-alpha phosphorylation of specific serines in the connecting segment of the beta 4 integrin regulates the dynamics of type II hemidesmosomes, Mol. Cell. Biol. 24 (2004) 4351–4360.

[73] I. Rabinovitz, A.M. Mercurio, The integrin alpha6beta4 functions in carcinoma cell migration on laminin-1 by mediating the formation and stabilization of actin-containing motility structures, J. Cell Biol. 139 (1997) 1873–1884.

[74] I. Rabinovitz, A. Toker, A.M. Mercurio, Protein kinase C-dependent mobilization of the alpha6beta4 integrin from hemidesmosomes and its association with actin-rich cell protrusions drive the chemotactic migration of carcinoma cells, J. Cell Biol. 146 (1999) 1147–1160.

[75] R.O. Hynes, Integrins: Bidirectional, Allosteric Signaling Machines, Cell. 110 (2002) 673–687. https://doi.org/10.1016/S0092-8674(02)00971-6.

[76] C. Kim, F. Ye, M.H. Ginsberg, Regulation of integrin activation, Annu. Rev. Cell Dev. Biol. 27 (2011) 321–345. https://doi.org/10.1146/annurev-cellbio-100109-104104.

[77] F. Ye, A.K. Snider, M.H. Ginsberg, Talin and kindlin: the one-two punch in integrin activation, Front. Med. 8 (2014) 6–16. https://doi.org/10.1007/s11684-014-0317-3.

[78] K.R. Legate, S.A. Wickström, R. Fässler, Genetic and cell biological analysis of integrin outside-in signaling, Genes Dev. 23 (2009) 397–418. https://doi.org/10.1101/gad.1758709.

[79] K.R. Legate, R. Fässler, Mechanisms that regulate adaptor binding to beta-integrin cytoplasmic tails, J. Cell Sci. 122 (2009) 187–198. https://doi.org/10.1242/jcs.041624.

[80] E.M. Morse, N.N. Brahme, D.A. Calderwood, Integrin cytoplasmic tail interactions, Biochemistry. 53 (2014) 810–820. https://doi.org/10.1021/bi401596q.

[81] S. Liu, D.A. Calderwood, M.H. Ginsberg, Integrin cytoplasmic domain-binding proteins, J. Cell Sci. 113 (Pt 20) (2000) 3563–3571.

[82] S.K. Mitra, D.D. Schlaepfer, Integrin-regulated FAK-Src signaling in normal and cancer cells, Curr. Opin. Cell Biol. 18 (2006) 516–523. https://doi.org/10.1016/j.ceb.2006.08.011.

[83] C.S. Stipp, Laminin-binding integrins and their tetraspanin partners as potential antimetastatic targets, Expert Rev. Mol. Med. 12 (2010). https://doi.org/10.1017/S1462399409001355.

[84] E.A. Lipscomb, A.M. Mercurio, Mobilization and activation of a signaling competent alpha6beta4integrin underlies its contribution to carcinoma progression, Cancer Metastasis Rev. 24 (2005) 413–423. https://doi.org/10.1007/s10555-005-5133-4.

[85] F. Mainiero, A. Pepe, M. Yeon, Y. Ren, F.G. Giancotti, The intracellular functions of alpha6beta4 integrin are regulated by EGF, J. Cell Biol. 134 (1996) 241–253.

[86] C. Chao, M.M. Lotz, A.C. Clarke, A.M. Mercurio, A function for the integrin alpha6beta4 in the invasive properties of colorectal carcinoma cells, Cancer Res. 56 (1996) 4811–4819.

[87] Y.H. Soung, H.J. Gil, J.L. Clifford, J. Chung, Role of α6β4 integrin in cell motility, invasion and metastasis of mammary tumors, Curr. Protein Pept. Sci. 12 (2011) 23–29.

[88] K. Wilhelmsen, S.H.M. Litjens, A. Sonnenberg, Multiple functions of the integrin alpha6beta4 in epidermal homeostasis and tumorigenesis, Mol. Cell. Biol. 26 (2006) 2877–2886. https://doi.org/10.1128/MCB.26.8.2877-2886.2006.

[89] M. Dans, L. Gagnoux-Palacios, P. Blaikie, S. Klein, A. Mariotti, F.G. Giancotti, Tyrosine phosphorylation of the beta 4 integrin cytoplasmic domain mediates Shc signaling to extracellular signal-regulated kinase and antagonizes formation of hemidesmosomes, J. Biol. Chem. 276 (2001) 1494–1502. https://doi.org/10.1074/jbc.M008663200.

[90] L.M. Shaw, Identification of insulin receptor substrate 1 (IRS-1) and IRS-2 as signaling intermediates in the alpha6beta4 integrin-dependent activation of phosphoinositide 3-OH kinase and promotion of invasion, Mol. Cell. Biol. 21 (2001) 5082–5093. https://doi.org/10.1128/MCB.21.15.5082-5093.2001.

[91] A. Bertotti, P.M. Comoglio, L. Trusolino, Beta4 integrin activates a Shp2-Src signaling pathway that sustains HGF-induced anchorage-independent growth, J. Cell Biol. 175 (2006) 993–1003. https://doi.org/10.1083/jcb.200605114.

[92] M.E. Hemler, Tetraspanin functions and associated microdomains, Nat. Rev. Mol. Cell Biol. 6 (2005) 801–811. https://doi.org/10.1038/nrm1736.

[93] H.W. Smith, C.J. Marshall, Regulation of cell signalling by uPAR, Nat. Rev. Mol. Cell Biol. 11 (2010) 23–36. https://doi.org/10.1038/nrm2821.

[94] W. Guo, F.G. Giancotti, Integrin signalling during tumour progression, Nat. Rev. Mol. Cell Biol. 5 (2004) 816–826. https://doi.org/10.1038/nrm1490.

[95] M.P. Marinkovich, Tumour microenvironment: laminin 332 in squamous-cell carcinoma, Nat. Rev. Cancer. 7 (2007) 370–380. https://doi.org/10.1038/nrc2089.

[96] N. Pouliot, N. Kusuma, Laminin-511: a multi-functional adhesion protein regulating cell migration, tumor invasion and metastasis, Cell Adhes. Migr. 7 (2013) 142–149. https://doi.org/10.4161/cam.22125.

[97] L. Seguin, J.S. Desgrosellier, S.M. Weis, D.A. Cheresh, Integrins and cancer: regulators of cancer stemness, metastasis, and drug resistance, Trends Cell Biol. 25 (2015) 234–240. https://doi.org/10.1016/j.tcb.2014.12.006.

[98] S. Subbaram, C.M. Dipersio, Integrin α3β1 as a breast cancer target, Expert Opin. Ther. Targets. 15 (2011) 1197–1210. https://doi.org/10.1517/14728222.2011.609557.

[99] J.S. Desgrosellier, D.A. Cheresh, Integrins in cancer: biological implications and therapeutic opportunities, Nat. Rev. Cancer. 10 (2010) 9–22. https://doi.org/10.1038/nrc2748.

[100] S. Cabodi, M. del Pilar Camacho-Leal, P. Di Stefano, P. Defilippi, Integrin signalling adaptors: not only figurants in the cancer story, Nat. Rev. Cancer. 10 (2010) 858–870. https://doi.org/10.1038/nrc2967.

[101] Y. Su, X.-Q. Guan, F.-Q. Liu, Y.-L. Wang, The effects of MIBG on the invasive properties of HepG2 hepatocellular carcinoma cells, Int. J. Mol. Med. 34 (2014) 842–848. https://doi.org/10.3892/ijmm.2014.1819.

[102] I.C. Sroka, T.A. Anderson, K.M. McDaniel, R.B. Nagle, M.B. Gretzer, A.E. Cress, The laminin binding integrin alpha6beta1 in prostate cancer perineural invasion, J. Cell. Physiol. 224 (2010) 283–288. https://doi.org/10.1002/jcp.22149.

[103] D. Hanahan, R.A. Weinberg, Hallmarks of cancer: the next generation, Cell. 144 (2011) 646–674. https://doi.org/10.1016/j.cell.2011.02.013.

[104] D.S. Missan, S.V. Chittur, C.M. DiPersio, Regulation of fibulin-2 gene expression by integrin α3β1 contributes to the invasive phenotype of transformed keratinocytes, J. Invest. Dermatol. 134 (2014) 2418–2427. https://doi.org/10.1038/jid.2014.166.

[105] K. Schramm, K. Krause, A. Bittroff-Leben, P. Goldin-Lang, E. Thiel, E.D. Kreuser, Activated K-ras is involved in regulation of integrin expression in human colon carcinoma cells, Int. J. Cancer. 87 (2000) 155–164. https://doi.org/10.1002/1097-0215(20000715)87:2<155::aid-ijc1>3.0.co;2-j.

[106] P.G. Natali, M.R. Nicotra, A. Bartolazzi, R. Cavaliere, A. Bigotti, Integrin expression in cutaneous malignant melanoma: association of the alpha 3/beta 1 heterodimer with tumor progression, Int. J. Cancer. 54 (1993) 68–72. https://doi.org/10.1002/ijc.2910540112.

[107] D. Schumacher, G. Schaumburg-Lever, Ultrastructural localization of alpha-3 integrin subunit in malignant melanoma and adjacent epidermis, J. Cutan. Pathol. 26 (1999) 321–326. https://doi.org/10.1111/j.1600-0560.1999.tb01853.x.

[108] N. Sachs, P. Secades, L. van Hulst, M. Kreft, J.-Y. Song, A. Sonnenberg, Loss of integrin α3 prevents skin tumor formation by promoting epidermal turnover and depletion of slow-cycling cells, Proc. Natl. Acad. Sci. 109 (2012) 21468–21473. https://doi.org/10.1073/pnas.1204614110.

[109] R.G. da Silva, B. Tavora, S.D. Robinson, L.E. Reynolds, C. Szekeres, J. Lamar, S. Batista, V. Kostourou, M.A. Germain, A.R. Reynolds, D.T. Jones, A.R. Watson, J.L. Jones, A. Harris, I.R. Hart, M.L. Iruela-Arispe, C.M. Dipersio, J.A. Kreidberg, K.M. Hodivala-Dilke, Endothelial alpha3beta1-integrin represses pathological angiogenesis and sustains endothelial-VEGF, Am. J. Pathol. 177 (2010) 1534–1548. https://doi.org/10.2353/ajpath.2010.100043.

[110] W. Xiao, N. Yao, L. Peng, R. Liu, K.S. Lam, Near-infrared optical imaging in glioblastoma xenograft with ligand-targeting alpha 3 integrin, Eur. J. Nucl. Med. Mol. Imaging. 36 (2009) 94–103. https://doi.org/10.1007/s00259-008-0920-0.

[111] P. Zhou, S. Erfani, Z. Liu, C. Jia, Y. Chen, B. Xu, X. Deng, J.E. Alfaro, L. Chen, D. Napier, M. Lu, J.-A. Huang, C. Liu, O. Thibault, R. Segal, B.P. Zhou, N. Kyprianou, C. Horbinski, X.H. Yang, CD151-α3β1 integrin complexes are prognostic markers of glioblastoma and cooperate with EGFR to drive tumor cell motility and invasion, Oncotarget. (2015).

[112] T. Kawataki, T. Yamane, H. Naganuma, P. Rousselle, I. Andurén, K. Tryggvason, M. Patarroyo, Laminin isoforms and their integrin receptors in glioma cell migration and invasiveness: Evidence for a role of alpha5-laminin(s) and alpha3beta1 integrin, Exp. Cell Res. 313 (2007) 3819–3831. https://doi.org/10.1016/j.yexcr.2007.07.038.

[113] M. Nakada, E. Nambu, N. Furuyama, Y. Yoshida, T. Takino, Y. Hayashi, H. Sato, Y. Sai, T. Tsuji, K. -i Miyamoto, A. Hirao, J. -i Hamada, Integrin α3 is overexpressed in glioma stem-like cells and promotes invasion, Br. J. Cancer. 108 (2013) 2516–2524. https://doi.org/10.1038/bjc.2013.218.

[114] J. Chen, X. Xu, H. Wang, Expression of integrin-alpha(3) mRNA in meningiomas and its correlation with proliferation and invasion, J. Huazhong Univ. Sci. Technol. Med. Sci. Hua Zhong Ke Ji Xue Xue Bao Yi Xue Ying Wen Ban Huazhong Keji Daxue Xuebao Yixue Yingdewen Ban. 29 (2009) 94–96. https://doi.org/10.1007/s11596-009-0120-6.

[115] S. Ghosh, J. Koblinski, J. Johnson, Y. Liu, A. Ericsson, J.W. Davis, Z. Shi, M.J. Ravosa, S. Crawford, S. Frazier, M.S. Stack, Urinary-type plasminogen activator receptor/alpha 3 beta 1 integrin signaling, altered gene expression, and oral tumor progression, Mol. Cancer Res. MCR. 8 (2010) 145–158. https://doi.org/10.1158/1541-7786.MCR-09-0045.

[116] M. Shinohara, S. Nakamura, M. Sasaki, S. Kurahara, T. Ikebe, T. Harada, K. Shirasuna, Expression of integrins in squamous cell carcinoma of the oral cavity. Correlations with tumor invasion and metastasis, Am. J. Clin. Pathol. 111 (1999) 75–88. https://doi.org/10.1093/ajcp/111.1.75.

[117] M. Nagata, H. Fujita, H. Ida, H. Hoshina, T. Inoue, Y. Seki, M. Ohnishi, T. Ohyama, S. Shingaki, M. Kaji, T. Saku, R. Takagi, Identification of potential biomarkers of lymph node metastasis in oral squamous cell carcinoma by cDNA microarray analysis, Int. J. Cancer. 106 (2003) 683–689. https://doi.org/10.1002/ijc.11283.

[118] A. Kurokawa, M. Nagata, N. Kitamura, A.A. Noman, M. Ohnishi, T. Ohyama, T. Kobayashi, S. Shingaki, R. Takagi, Oral, Maxillofacial Pathology, and Surgery Group, Diagnostic value of integrin alpha3, beta4, and beta5 gene expression levels for the clinical outcome of tongue squamous cell carcinoma, Cancer. 112 (2008) 1272–1281. https://doi.org/10.1002/cncr.23295.

[119] H.M. Romanska, P. Potemski, S.I. Collins, H. Williams, S. Parmar, F. Berditchevski, Loss of CD151/Tspan24 from the complex with integrin α3β1 in invasive front of the tumour is a negative predictor of disease-free survival in oral squamous cell carcinoma, Oral Oncol. 49 (2013) 224–229. https://doi.org/10.1016/j.oraloncology.2012.09.013.

[120] M. Nagata, A.A. Noman, K. Suzuki, H. Kurita, M. Ohnishi, T. Ohyama, N. Kitamura, T. Kobayashi, K. Uematsu, K. Takahashi, N. Kodama, T. Kawase, H. Hoshina, N. Ikeda, S. Shingaki, R. Takagi, ITGA3 and ITGB4 expression biomarkers estimate the risks of locoregional and hematogenous dissemination of oral squamous cell carcinoma, BMC Cancer. 13 (2013) 410. https://doi.org/10.1186/1471-2407-13-410.

[121] J. Peixoto da-Silva, S. Lourenço, M. Nico, F.H. Silva, M.T. Martins, A. Costa-Neves, Expression of laminin-5 and integrins in actinic cheilitis and superficially invasive squamous cell carcinomas of the lip, Pathol. Res. Pract. 208 (2012) 598–603. https://doi.org/10.1016/j.prp.2012.07.004.

[122] T. Ohara, S. Kawashiri, A. Tanaka, N. Noguchi, H. Kitahara, A. Okamune, K. Kato, T. Hase, H. Nakaya, K. Yoshizawa, Integrin expression levels correlate with invasion, metastasis and prognosis of oral squamous cell carcinoma, Pathol. Oncol. Res. POR. 15 (2009) 429–436. https://doi.org/10.1007/s12253-008-9142-9.

[123] Y. Zhao, X. Liu, L. Zhong, M. He, S. Chen, T. Wang, S. Ma, The combined use of miRNAs and mRNAs as biomarkers for the diagnosis of papillary thyroid carcinoma, Int. J. Mol. Med. 36 (2015) 1097–1103. https://doi.org/10.3892/ijmm.2015.2305.

[124] O.H. Dyce, A.F. Ziober, R.S. Weber, K. Miyazaki, S.S. Khariwala, M. Feldman, B.L. Ziober, Integrins in head and neck squamous cell carcinoma invasion, The Laryngoscope. 112 (2002) 2025–2032. https://doi.org/10.1097/00005537-200211000-00021.

[125] M.C. Boelens, A. van den Berg, I. Vogelzang, J. Wesseling, D.S. Postma, W. Timens, H.J.M. Groen, Differential expression and distribution of epithelial adhesion molecules in non-small cell lung cancer and normal bronchus, J. Clin. Pathol. 60 (2007) 608–614. https://doi.org/10.1136/jcp.2005.031443.

[126] G. Alì, N. Borrelli, G. Riccardo, A. Proietti, S. Pelliccioni, C. Niccoli, L. Boldrini, M. Lucchi, A. Mussi, G. Fontanini, Differential expression of extracellular matrix constituents and cell adhesion molecules between malignant pleural mesothelioma and mesothelial hyperplasia, J. Thorac. Oncol. Off. Publ. Int. Assoc. Study Lung Cancer. 8 (2013) 1389–1395. https://doi.org/10.1097/JTO.0b013e3182a59f45.

[127] T. Yoshimasu, T. Sakurai, S. Oura, I. Hirai, H. Tanino, Y. Kokawa, Y. Naito, Y. Okamura, I. Ota, N. Tani, N. Matsuura, Increased expression of integrin alpha3beta1 in highly brain metastatic subclone of a human non-small cell lung cancer cell line, Cancer Sci. 95 (2004) 142–148. https://doi.org/10.1111/j.1349-7006.2004.tb03195.x.

[128] H. Wang, W. Fu, J.H. Im, Z. Zhou, S.A. Santoro, V. Iyer, C.M. DiPersio, Q.-C. Yu, V. Quaranta, A. Al-Mehdi, R.J. Muschel, Tumor cell alpha3beta1 integrin and vascular laminin-5 mediate pulmonary arrest and metastasis, J. Cell Biol. 164 (2004) 935–941. https://doi.org/10.1083/jcb.200309112.

[129] C.S. Boosani, A.P. Mannam, D. Cosgrove, R. Silva, K.M. Hodivala-Dilke, V.G. Keshamouni, A. Sudhakar, Regulation of COX-2 mediated signaling by alpha3 type IV noncollagenous domain in tumor angiogenesis, Blood. 110 (2007) 1168–1177. https://doi.org/10.1182/blood-2007-01-066282.

[130] M. Adachi, T. Taki, C. Huang, M. Higashiyama, O. Doi, T. Tsuji, M. Miyake, Reduced integrin alpha3 expression as a factor of poor prognosis of patients with adenocarcinoma of the lung, J. Clin. Oncol. Off. J. Am. Soc. Clin. Oncol. 16 (1998) 1060–1067. https://doi.org/10.1200/JCO.1998.16.3.1060.

[131] K. Mitchell, K.B. Svenson, W.M. Longmate, K. Gkirtzimanaki, R. Sadej, X. Wang, J. Zhao, A.G. Eliopoulos, F. Berditchevski, C.M. Dipersio, Suppression of integrin alpha3beta1 in breast cancer cells reduces cyclooxygenase-2 gene expression and inhibits tumorigenesis, invasion, and cross-talk to endothelial cells, Cancer Res. 70 (2010) 6359–6367. https://doi.org/10.1158/0008-5472.CAN-09-4283.

[132] T. Shirakihara, T. Kawasaki, A. Fukagawa, K. Semba, R. Sakai, K. Miyazono, K. Miyazawa, M. Saitoh, Identification of integrin α3 as a molecular marker of cells undergoing epithelial-mesenchymal transition and of cancer cells with aggressive phenotypes, Cancer Sci. 104 (2013) 1189–1197. https://doi.org/10.1111/cas.12220.

[133] V. Novitskaya, H. Romanska, R. Kordek, P. Potemski, R. Kusińska, M. Parsons, E. Odintsova, F. Berditchevski, Integrin α3β1-CD151 complex regulates dimerization of ErbB2 via RhoA, Oncogene. 33 (2014) 2779–2789. https://doi.org/10.1038/onc.2013.231.

[134] A. Aggarwal, R.N. Al-Rohil, A. Batra, P.J. Feustel, D.M. Jones, C.M. DiPersio, Expression of integrin $\alpha3\beta1$ and cyclooxygenase-2 (COX2) are positively correlated in human breast cancer, BMC Cancer. 14 (2014) 459. https://doi.org/10.1186/1471-2407-14-459.

[135] S. Cagnet, M.M. Faraldo, M. Kreft, A. Sonnenberg, K. Raymond, M.A. Glukhova, Signaling events mediated by $\alpha3\beta1$ integrin are essential for mammary tumorigenesis, Oncogene. 33 (2014) 4286–4295. https://doi.org/10.1038/onc.2013.391.

[136] B. Zhou, K.N. Gibson-Corley, M.E. Herndon, Y. Sun, E. Gustafson-Wagner, M. Teoh-Fitzgerald, F.E. Domann, M.D. Henry, C.S. Stipp, Integrin $\alpha3\beta1$ can function to promote spontaneous metastasis and lung colonization of invasive breast carcinoma, Mol. Cancer Res. MCR. 12 (2014) 143–154. https://doi.org/10.1158/1541-7786.MCR-13-0184.

[137] H.M. Romanska, P. Potemski, M. Krakowska, M. Mieszkowska, S. Chaudhri, R. Kordek, R. Kubiak, V. Speirs, A.M. Hanby, R. Sadej, F. Berditchevski, Lack of CD151/integrin $\alpha3\beta1$ complex is predictive of poor outcome in node-negative lobular breast carcinoma: opposing roles of CD151 in invasive lobular and ductal breast cancers, Br. J. Cancer. (2015). https://doi.org/10.1038/bjc.2015.344.

[138] M. Morini, M. Mottolese, N. Ferrari, F. Ghiorzo, S. Buglioni, R. Mortarini, D.M. Noonan, P.G. Natali, A. Albini, The alpha 3 beta 1 integrin is associated with mammary carcinoma cell metastasis, invasion, and gelatinase B (MMP-9) activity, Int. J. Cancer. 87 (2000) 336–342.

[139] G.P. Gui, C.A. Wells, P.D. Browne, P. Yeomans, S. Jordan, J.R. Puddefoot, G.P. Vinson, R. Carpenter, Integrin expression in primary breast cancer and its relation to axillary nodal status, Surgery. 117 (1995) 102–108. https://doi.org/10.1016/s0039-6060(05)80236-3.

[140] G.P. Gui, C.A. Wells, P. Yeomans, S.E. Jordan, G.P. Vinson, R. Carpenter, Integrin expression in breast cancer cytology: a novel predictor of axillary metastasis, Eur. J. Surg. Oncol. J. Eur. Soc. Surg. Oncol. Br. Assoc. Surg. Oncol. 22 (1996) 254–258. https://doi.org/10.1016/s0748-7983(96)80013-8.

[141] M. Pignatelli, A.M. Hanby, G.W. Stamp, Low expression of beta 1, alpha 2 and alpha 3 subunits of VLA integrins in malignant mammary tumours, J. Pathol. 165 (1991) 25–32. https://doi.org/10.1002/path.1711650106.

[142] J. Pontes-Júnior, S.T. Reis, L.C.N. de Oliveira, A.C. Sant'anna, M.F. Dall'oglio, A.A. Antunes, L.A. Ribeiro-Filho, P.A. Carvalho, J. Cury, M. Srougi, K.R.M. Leite, Association between integrin expression and prognosis in localized prostate cancer, The Prostate. 70 (2010) 1189–1195. https://doi.org/10.1002/pros.21153.

[143] S. Dedhar, R. Saulnier, R. Nagle, C.M. Overall, Specific alterations in the expression of alpha 3 beta 1 and alpha 6 beta 4 integrins in highly invasive and metastatic variants of human prostate carcinoma cells selected by in vitro invasion through reconstituted basement membrane, Clin. Exp. Metastasis. 11 (1993) 391–400. https://doi.org/10.1007/bf00132982.

[144] A. Timmer, J.W. Oosterhuis, H. Schraffordt Koops, D.T. Sleijfer, B.G. Szabo, W. Timens, The tumor microenvironment: possible role of integrins and the extracellular matrix in tumor biological behavior of intratubular germ cell neoplasia and testicular seminomas, Am. J. Pathol. 144 (1994) 1035–1044.

[145] S. Miyamoto, A. Maruyama, K. Okugawa, K. Akazawa, H. Baba, Y. Maehara, E. Mekada, Loss of motility-related protein 1 (MRP1/CD9) and integrin alpha3 expression in endometrial cancers, Cancer. 92 (2001) 542–548. https://doi.org/10.1002/1097-0142(20010801)92:3<542::aid-cncr1353>3.0.co;2-8.

[146] M. Schmelz, A.E. Cress, K.M. Scott, F. Bürger, H. Cui, K. Sallam, K.M. McDaniel, B.L. Dalkin, R.B. Nagle, Different phenotypes in human prostate cancer: alpha6 or alpha3 integrin in cell-extracellular adhesion sites, Neoplasia N. Y. N. 4 (2002) 243–254. https://doi.org/10.1038/sj.neo.7900223.

[147] L.A. Baldwin, J.T. Hoff, J. Lefringhouse, M. Zhang, C. Jia, Z. Liu, S. Erfani, H. Jin, M. Xu, Q.-B. She, J.R. van Nagell, C. Wang, L. Chen, R. Plattner, D.M. Kaetzel, J. Luo, M. Lu, D. West, C. Liu, F.R. Ueland, R. Drapkin, B.P. Zhou, X.H. Yang, CD151-$\alpha3\beta1$ integrin complexes suppress ovarian tumor growth by repressing slug-mediated EMT and canonical Wnt signaling, Oncotarget. 5 (2014) 12203–12217. https://doi.org/10.18632/oncotarget.2622.

[148] A. Varzavand, J.M. Drake, R.U. Svensson, M.E. Herndon, B. Zhou, M.D. Henry, C.S. Stipp, Integrin α3β1 regulates tumor cell responses to stromal cells and can function to suppress prostate cancer metastatic colonization, Clin. Exp. Metastasis. 30 (2013) 541–552. https://doi.org/10.1007/s10585-012-9558-1.

[149] T.D. Palmer, C.H. Martínez, C. Vasquez, K.E. Hebron, C. Jones-Paris, S.A. Arnold, S.M. Chan, V. Chalasani, J.A. Gomez-Lemus, A.K. Williams, J.L. Chin, G.A. Giannico, T. Ketova, J.D. Lewis, A. Zijlstra, Integrin-free tetraspanin CD151 can inhibit tumor cell motility upon clustering and is a clinical indicator of prostate cancer progression, Cancer Res. 74 (2014) 173–187. https://doi.org/10.1158/0008-5472.CAN-13-0275.

[150] M.M. Linhares, R.J. Affonso, L. de S. Viana, S.R.M. Silva, M.V.A. Denadai, S.R.C. de Toledo, D. Matos, Genetic and Immunohistochemical Expression of Integrins ITGAV, ITGA6, and ITGA3 As Prognostic Factor for Colorectal Cancer: Models for Global and Disease-Free Survival, PloS One. 10 (2015) e0144333. https://doi.org/10.1371/journal.pone.0144333.

[151] H. Ura, R. Denno, K. Hirata, K. Yamaguchi, T. Yasoshima, Separate functions of alpha2beta1 and alpha3beta1 integrins in the metastatic process of human gastric carcinoma, Surg. Today. 28 (1998) 1001–1006. https://doi.org/10.1007/bf02483952.

[152] H. Takatsuki, S. Komatsu, R. Sano, Y. Takada, T. Tsuji, Adhesion of gastric carcinoma cells to peritoneum mediated by alpha3beta1 integrin (VLA-3), Cancer Res. 64 (2004) 6065–6070. https://doi.org/10.1158/0008-5472.CAN-04-0321.

[153] M.V. Denadai, L.S. Viana, R.J. Affonso, S.R. Silva, I.D. Oliveira, S.R. Toledo, D. Matos, Expression of integrin genes and proteins in progression and dissemination of colorectal adenocarcinoma, BMC Clin. Pathol. 13 (2013) 16. https://doi.org/10.1186/1472-6890-13-16.

[154] H. Hashida, A. Takabayashi, T. Tokuhara, T. Taki, K. Kondo, N. Kohno, Y. Yamaoka, M. Miyake, Integrin alpha3 expression as a prognostic factor in colon cancer: association with MRP-1/CD9 and KAI1/CD82, Int. J. Cancer. 97 (2002) 518–525. https://doi.org/10.1002/ijc.1625.

[155] H. Hashida, A. Takabayashi, M. Adachi, T. Imai, K. Kondo, N. Kohno, Y. Yamaoka, M. Miyake, The novel monoclonal antibody MH8-4 inhibiting cell motility recognizes integrin alpha 3: inverse of its expression withmetastases in colon cancer, Int. J. Oncol. 18 (2001) 89–95. https://doi.org/10.3892/ijo.18.1.89.

[156] G.-H. Zhu, C. Huang, Z.-J. Qiu, J. Liu, Z.-H. Zhang, N. Zhao, Z.-Z. Feng, X.-H. Lv, Expression and prognostic significance of CD151, c-Met, and integrin alpha3/alpha6 in pancreatic ductal adenocarcinoma, Dig. Dis. Sci. 56 (2011) 1090–1098. https://doi.org/10.1007/s10620-010-1416-x.

[157] G. Giannelli, E. Fransvea, F. Marinosci, C. Bergamini, S. Colucci, O. Schiraldi, S. Antonaci, Transforming growth factor-beta1 triggers hepatocellular carcinoma invasiveness via alpha3beta1 integrin, Am. J. Pathol. 161 (2002) 183–193. https://doi.org/10.1016/s0002-9440(10)64170-3.

[158] C. Li, Z. Yang, Y. Du, H. Tang, J. Chen, D. Hu, Z. Fan, BCMab1, a monoclonal antibody against aberrantly glycosylated integrin α3β1, has potent antitumor activity of bladder cancer in vivo, Clin. Cancer Res. Off. J. Am. Assoc. Cancer Res. 20 (2014) 4001–4013. https://doi.org/10.1158/1078-0432.CCR-13-3397.

[159] H.M. Behnsawy, H. Miyake, M.A. Abdalla, M.A. Sayed, A.E.-F.I. Ahmed, M. Fujisawa, Expression of integrin proteins in non-muscle-invasive bladder cancer: significance of intravesical recurrence after transurethral resection, BJU Int. 107 (2011) 240–246. https://doi.org/10.1111/j.1464-410X.2010.09534.x.

[160] M. Bockhorn, S. Roberge, C. Sousa, R.K. Jain, L.L. Munn, Differential gene expression in metastasizing cells shed from kidney tumors, Cancer Res. 64 (2004) 2469–2473. https://doi.org/10.1158/0008-5472.can-03-0256.

[161] F. de Nigris, C. Botti, R. Rossiello, E. Crimi, V. Sica, C. Napoli, Cooperation between Myc and YY1 provides novel silencing transcriptional targets of alpha3beta1-integrin in tumour cells, Oncogene. 26 (2007) 382–394. https://doi.org/10.1038/sj.onc.1209804.

[162] A.K. Fournier, L.E. Campbell, P. Castagnino, W.F. Liu, B.M. Chung, V.M. Weaver, C.S. Chen, R.K. Assoian, Rac-dependent cyclin D1 gene expression regulated by cadherin- and integrin-mediated adhesion, J. Cell Sci. 121 (2008) 226–233. https://doi.org/10.1242/jcs.017012.

[163] M. Gonzales, K. Haan, S.E. Baker, M. Fitchmun, I. Todorov, S. Weitzman, J.C.R. Jones, A Cell Signal Pathway Involving Laminin-5, α3β1 Integrin, and Mitogen-activated Protein Kinase Can Regulate Epithelial Cell Proliferation, Mol. Biol. Cell. 10 (1999) 259–270.
[164] C. Bergamini, C. Sgarra, P. Trerotoli, L. Lupo, A. Azzariti, S. Antonaci, G. Giannelli, Laminin-5 stimulates hepatocellular carcinoma growth through a different function of alpha6beta4 and alpha3beta1 integrins, Hepatol. Baltim. Md. 46 (2007) 1801–1809. https://doi.org/10.1002/hep.21936.
[165] N. Ahmed, C. Riley, G. Rice, M. Quinn, Role of integrin receptors for fibronectin, collagen and laminin in the regulation of ovarian carcinoma functions in response to a matrix microenvironment, Clin. Exp. Metastasis. 22 (2005) 391–402. https://doi.org/10.1007/s10585-005-1262-y.
[166] H.J. Yoon, Y.-R. Cho, J.-H. Joo, D.-W. Seo, Knockdown of integrin α3β1 expression induces proliferation and migration of non-small cell lung cancer cells, Oncol. Rep. 29 (2013) 662–668. https://doi.org/10.3892/or.2012.2169.
[167] A. Manohar, S.G. Shome, J. Lamar, L. Stirling, V. Iyer, K. Pumiglia, C.M. DiPersio, Alpha 3 beta 1 integrin promotes keratinocyte cell survival through activation of a MEK/ERK signaling pathway, J. Cell Sci. 117 (2004) 4043–4054. https://doi.org/10.1242/jcs.01277.
[168] A. Steglich, A. Vehlow, I. Eke, N. Cordes, α integrin targeting for radiosensitization of three-dimensionally grown human head and neck squamous cell carcinoma cells, Cancer Lett. 357 (2015) 542–548. https://doi.org/10.1016/j.canlet.2014.12.009.
[169] K. Mitchell, C. Szekeres, V. Milano, K.B. Svenson, M. Nilsen-Hamilton, J.A. Kreidberg, C.M. DiPersio, Alpha3beta1 integrin in epidermis promotes wound angiogenesis and keratinocyte-to-endothelial-cell crosstalk through the induction of MRP3, J. Cell Sci. 122 (2009) 1778–1787. https://doi.org/10.1242/jcs.040956.
[170] H.-J. Kim, Y.-R. Cho, S.H. Kim, D.-W. Seo, TIMP-2-derived 18-mer peptide inhibits endothelial cell proliferation and migration through cAMP/PKA-dependent mechanism, Cancer Lett. 343 (2014) 210–216. https://doi.org/10.1016/j.canlet.2013.10.037.
[171] D.-W. Seo, H. Li, L. Guedez, P.T. Wingfield, T. Diaz, R. Salloum, B. Wei, W.G. Stetler-Stevenson, TIMP-2 mediated inhibition of angiogenesis: an MMP-independent mechanism, Cell. 114 (2003) 171–180. https://doi.org/10.1016/s0092-8674(03)00551-8.
[172] S. Subbaram, S.P. Lyons, K.B. Svenson, S.L. Hammond, L.G. McCabe, S.V. Chittur, C.M. DiPersio, Integrin α3β1 controls mRNA splicing that determines Cox-2 mRNA stability in breast cancer cells, J. Cell Sci. 127 (2014) 1179–1189. https://doi.org/10.1242/jcs.131227.
[173] H.I. Kim, H.-S. Lee, T.H. Kim, J.-S. Lee, S.-T. Lee, S.-J. Lee, Growth-stimulatory activity of TIMP-2 is mediated through c-Src activation followed by activation of FAK, PI3-kinase/AKT, and ERK1/2 independent of MMP inhibition in lung adenocarcinoma cells, Oncotarget. 6 (2015) 42905–42922. https://doi.org/10.18632/oncotarget.5466.
[174] N. Guo, N.S. Templeton, H. Al-Barazi, J.A. Cashel, J.M. Sipes, H.C. Krutzsch, D.D. Roberts, Thrombospondin-1 promotes alpha3beta1 integrin-mediated adhesion and neurite-like outgrowth and inhibits proliferation of small cell lung carcinoma cells, Cancer Res. 60 (2000) 457–466.
[175] D. Ndishabandi, C. Duquette, G.E.-M. Billah, M. Reyes, M. Duquette, J. Lawler, S. Kazerounian, Thrombospondin-1 Modulates Actin Filament Remodeling and Cell Motility in Mouse Mammary Tumor cells in Vitro, Discov. Craiova Rom. 2 (2014). https://doi.org/10.15190/d.2014.23.
[176] R. Sadej, H. Romanska, G. Baldwin, K. Gkirtzimanaki, V. Novitskaya, A.D. Filer, Z. Krcova, R. Kusinska, J. Ehrmann, C.D. Buckley, R. Kordek, P. Potemski, A.G. Eliopoulos, E.-N. Lalani, F. Berditchevski, CD151 regulates tumorigenesis by modulating the communication between tumor cells and endothelium, Mol. Cancer Res. MCR. 7 (2009) 787–798. https://doi.org/10.1158/1541-7786.MCR-08-0574.
[177] E.M. Pinatel, F. Orso, E. Penna, D. Cimino, A.R. Elia, P. Circosta, P. Dentelli, M.F. Brizzi, P. Provero, D. Taverna, miR-223 is a coordinator of breast cancer progression as revealed by bioinformatics predictions, PloS One. 9 (2014) e84859. https://doi.org/10.1371/journal.pone.0084859.

[178] A. Kurozumi, Y. Goto, R. Matsushita, I. Fukumoto, M. Kato, R. Nishikawa, S. Sakamoto, H. Enokida, M. Nakagawa, T. Ichikawa, N. Seki, Tumor-suppressive microRNA-223 inhibits cancer cell migration and invasion by targeting ITGA3/ITGB1 signaling in prostate cancer, Cancer Sci. 107 (2016) 84–94. https://doi.org/10.1111/cas.12842.

[179] A. Melchiori, R. Mortarini, S. Carlone, P.C. Marchisio, A. Anichini, D.M. Noonan, A. Albini, The alpha 3 beta 1 integrin is involved in melanoma cell migration and invasion, Exp. Cell Res. 219 (1995) 233–242. https://doi.org/10.1006/excr.1995.1223.

[180] N. Suzuki, A. Higashiguchi, Y. Hasegawa, H. Matsumoto, S. Oie, K. Orikawa, S. Ezawa, N. Susumu, K.-I. Miyashita, D. Aoki, Loss of integrin alpha3 expression associated with acquisition of invasive potential by ovarian clear cell adenocarcinoma cells, Hum. Cell. 18 (2005) 147–155. https://doi.org/10.1111/j.1749-0774.2005.tb00005.x.

[181] K. Katabami, H. Mizuno, R. Sano, Y. Saito, M. Ogura, S. Itoh, T. Tsuji, Transforming growth factor-beta1 upregulates transcription of alpha3 integrin gene in hepatocellular carcinoma cells via Ets-transcription factor-binding motif in the promoter region, Clin. Exp. Metastasis. 22 (2005) 539–548. https://doi.org/10.1007/s10585-005-5260-x.

[182] K. Zhang, R.H. Kramer, Laminin 5 deposition promotes keratinocyte motility, Exp. Cell Res. 227 (1996) 309–322. https://doi.org/10.1006/excr.1996.0280.

[183] D.P. Choma, V. Milano, K.M. Pumiglia, C.M. DiPersio, Integrin alpha3beta1-dependent activation of FAK/Src regulates Rac1-mediated keratinocyte polarization on laminin-5, J. Invest. Dermatol. 127 (2007) 31–40. https://doi.org/10.1038/sj.jid.5700505.

[184] A. Kwiatkowska, M. Symons, Signaling determinants of glioma cell invasion, Adv. Exp. Med. Biol. 986 (2013) 121–141. https://doi.org/10.1007/978-94-007-4719-7_7.

[185] Y. Fukushima, T. Ohnishi, N. Arita, T. Hayakawa, K. Sekiguchi, Integrin alpha3beta1-mediated interaction with laminin-5 stimulates adhesion, migration and invasion of malignant glioma cells, Int. J. Cancer. 76 (1998) 63–72. https://doi.org/10.1002/(sici)1097-0215(19980330)76:1<63::aid-ijc11>3.0.co;2-h.

[186] R. Mahesparan, T.-A. Read, M. Lund-Johansen, K.O. Skaftnesmo, R. Bjerkvig, O. Engebraaten, Expression of extracellular matrix components in a highly infiltrative in vivo glioma model, Acta Neuropathol. (Berl.). 105 (2003) 49–57. https://doi.org/10.1007/s00401-002-0610-0.

[187] R.C. Ireton, J. Chen, EphA2 receptor tyrosine kinase as a promising target for cancer therapeutics, Curr. Cancer Drug Targets. 5 (2005) 149–157. https://doi.org/10.2174/1568009053765780.

[188] A. Makarov, I. Ylivinkka, T.A. Nyman, M. Hyytiäinen, J. Keski-Oja, Ephrin-As, Eph receptors and integrin α3 interact and colocalise at membrane protrusions of U251MG glioblastoma cells, Cell Biol. Int. 37 (2013) 1080–1088. https://doi.org/10.1002/cbin.10134.

[189] H. Mizuno, M. Ogura, Y. Saito, W. Sekine, R. Sano, T. Gotou, T. Oku, S. Itoh, K. Katabami, T. Tsuji, Changes in adhesive and migratory characteristics of hepatocellular carcinoma (HCC) cells induced by expression of alpha3beta1 integrin, Biochim. Biophys. Acta. 1780 (2008) 564–570. https://doi.org/10.1016/j.bbagen.2007.09.007.

[190] J. Lohi, J. Oivula, E. Kivilaakso, T. Kiviluoto, K. Fröjdman, Y. Yamada, R.E. Burgeson, I. Leivo, I. Virtanen, Basement membrane laminin-5 is deposited in colorectal adenomas and carcinomas and serves as a ligand for alpha3beta1 integrin, APMIS Acta Pathol. Microbiol. Immunol. Scand. 108 (2000) 161–172. https://doi.org/10.1034/j.1600-0463.2000.d01-40.x.

[191] N. Pouliot, E.C. Nice, A.W. Burgess, Laminin-10 mediates basal and EGF-stimulated motility of human colon carcinoma cells via alpha(3)beta(1) and alpha(6)beta(4) integrins, Exp. Cell Res. 266 (2001) 1–10. https://doi.org/10.1006/excr.2001.5197.

[192] T. Tsuji, Y. Kawada, M. Kai-Murozono, S. Komatsu, S.A. Han, K. Takeuchi, H. Mizushima, K. Miyazaki, T. Irimura, Regulation of melanoma cell migration and invasion by laminin-5 and alpha3beta1 integrin (VLA-3), Clin. Exp. Metastasis. 19 (2002) 127–134. https://doi.org/10.1023/a:1014573204062.

[193] I.G. Yoshinaga, J. Vink, S.K. Dekker, M.C. Mihm, H.R. Byers, Role of alpha 3 beta 1 and alpha 2 beta 1 integrins in melanoma cell migration, Melanoma Res. 3 (1993) 435–441. https://doi.org/10.1097/00008390-199311000-00006.

[194] H.-M. Yu, D.E. Frank, J. Zhang, X. You, W.G. Carter, B.S. Knudsen, Basal prostate epithelial cells stimulate the migration of prostate cancer cells, Mol. Carcinog. 41 (2004) 85–97. https://doi.org/10.1002/mc.20041.

[195] H. Zhou, R.H. Kramer, Integrin engagement differentially modulates epithelial cell motility by RhoA/ROCK and PAK1, J. Biol. Chem. 280 (2005) 10624–10635. https://doi.org/10.1074/jbc.M411900200.

[196] Y. Saito, W. Sekine, R. Sano, S. Komatsu, H. Mizuno, K. Katabami, K. Shimada, T. Oku, T. Tsuji, Potentiation of cell invasion and matrix metalloproteinase production by alpha3beta1 integrin-mediated adhesion of gastric carcinoma cells to laminin-5, Clin. Exp. Metastasis. 27 (2010) 197–205. https://doi.org/10.1007/s10585-010-9314-3.

[197] A. Wright, Y.-H. Li, C. Zhu, The differential effect of endothelial cell factors on in vitro motility of malignant and non-malignant cells, Ann. Biomed. Eng. 36 (2008) 958–969. https://doi.org/10.1007/s10439-008-9489-9.

[198] T. Okada, H. Okuno, Y. Mitsui, A novel in vitro assay system for transendothelial tumor cell invasion: significance of E-selectin and alpha 3 integrin in the transendothelial invasion by HT1080 fibrosarcoma cells, Clin. Exp. Metastasis. 12 (1994) 305–314. https://doi.org/10.1007/bf01753837.

[199] O.V. Glinskii, F. Li, L.S. Wilson, S. Barnes, K. Rittenhouse-Olson, J.J. Barchi, K.J. Pienta, V.V. Glinsky, Endothelial integrin $\alpha3\beta1$ stabilizes carbohydrate-mediated tumor/endothelial cell adhesion and induces macromolecular signaling complex formation at the endothelial cell membrane, Oncotarget. 5 (2014) 1382–1389. https://doi.org/10.18632/oncotarget.1837.

[200] B.-H. Fu, Z.-Z. Wu, J. Qin, Effects of integrins on laminin chemotaxis by hepatocellular carcinoma cells, Mol. Biol. Rep. 37 (2010) 1665–1670. https://doi.org/10.1007/s11033-009-9790-1.

[201] J. Chia, N. Kusuma, R. Anderson, B. Parker, B. Bidwell, L. Zamurs, E. Nice, N. Pouliot, Evidence for a role of tumor-derived laminin-511 in the metastatic progression of breast cancer, Am. J. Pathol. 170 (2007) 2135–2148. https://doi.org/10.2353/ajpath.2007.060709.

[202] N. Kusuma, D. Denoyer, J.A. Eble, R.P. Redvers, B.S. Parker, R. Pelzer, R.L. Anderson, N. Pouliot, Integrin-dependent response to laminin-511 regulates breast tumor cell invasion and metastasis, Int. J. Cancer. 130 (2012) 555–566. https://doi.org/10.1002/ijc.26018.

[203] N.J. Tawil, V. Gowri, M. Djoneidi, J. Nip, S. Carbonetto, P. Brodt, Integrin alpha3beta1 can promote adhesion and spreading of metastatic breast carcinoma cells on the lymph node stroma, Int. J. Cancer. 66 (1996) 703–710. https://doi.org/10.1002/(SICI)1097-0215(19960529)66:5<703::AID-IJC20>3.0.CO;2-3.

[204] K.T. Chan, C.L. Cortesio, A. Huttenlocher, FAK alters invadopodia and focal adhesion composition and dynamics to regulate breast cancer invasion, J. Cell Biol. 185 (2009) 357–370. https://doi.org/10.1083/jcb.200809110.

[205] S. Liu, H. Yamashita, B. Weidow, A.M. Weaver, V. Quaranta, Laminin-332-beta1 integrin interactions negatively regulate invadopodia, J. Cell. Physiol. 223 (2010) 134–142. https://doi.org/10.1002/jcp.22018.

[206] M.E. Hemler, Tetraspanin functions and associated microdomains, Nat. Rev. Mol. Cell Biol. 6 (2005) 801–811. https://doi.org/10.1038/nrm1736.

[207] I. Sordat, C. Decraene, T. Silvestre, O. Petermann, C. Auffray, G. Piétu, B. Sordat, Complementary DNA arrays identify CD63 tetraspanin and alpha3 integrin chain as differentially expressed in low and high metastatic human colon carcinoma cells, Lab. Investig. J. Tech. Methods Pathol. 82 (2002) 1715–1724. https://doi.org/10.1097/01.lab.0000044350.18215.0d.

[208] E. Gustafson-Wagner, C.S. Stipp, The CD9/CD81 Tetraspanin Complex and Tetraspanin CD151 Regulate $\alpha3\beta1$ Integrin-Dependent Tumor Cell Behaviors by Overlapping but Distinct Mechanisms, PLoS ONE. 8 (2013) e61834. https://doi.org/10.1371/journal.pone.0061834.

[209] K. Mitsuzuka, K. Handa, M. Satoh, Y. Arai, S. Hakomori, A specific microdomain ("glycosynapse 3") controls phenotypic conversion and reversion of bladder cancer cells through GM3-mediated interaction of alpha3beta1 integrin with CD9, J. Biol. Chem. 280 (2005) 35545–35553. https://doi.org/10.1074/jbc.M505630200.

[210] S.-J. Pan, S.-K. Zhan, Y.-X. Pan, W. Liu, L.-G. Bian, B. Sun, Q.-F. Sun, Tetraspanin 8-rictor-integrin α3 complex is required for glioma cell migration, Int. J. Mol. Sci. 16 (2015) 5363–5374. https://doi.org/10.3390/ijms16035363.

[211] L.M.T. Sterk, C.A.W. Geuijen, J.G. van den Berg, N. Claessen, J.J. Weening, A. Sonnenberg, Association of the tetraspanin CD151 with the laminin-binding integrinsα 3β1, α6β1, α6β4 and α7β1 in cells in culture and in vivo, J. Cell Sci. 115 (2002) 1161–1173.

[212] R.L. Yauch, F. Berditchevski, M.B. Harler, J. Reichner, M.E. Hemler, Highly Stoichiometric, Stable, and Specific Association of Integrin α3β1 with CD151 Provides a Major Link to Phosphatidylinositol 4-Kinase, and May Regulate Cell Migration, Mol. Biol. Cell. 9 (1998) 2751–2765.

[213] N. Sachs, N. Claessen, J. Aten, M. Kreft, G.J.D. Teske, A. Koeman, C.J. Zuurbier, H. Janssen, A. Sonnenberg, Blood pressure influences end-stage renal disease of Cd151 knockout mice, J. Clin. Invest. 122 (2012) 348–358. https://doi.org/10.1172/JCI58878.

[214] N.E. Winterwood, A. Varzavand, M.N. Meland, L.K. Ashman, C.S. Stipp, A Critical Role for Tetraspanin CD151 in α3β1 and α6β4 Integrin–dependent Tumor Cell Functions on Laminin-5, Mol. Biol. Cell. 17 (2006) 2707–2721. https://doi.org/10.1091/mbc.E05-11-1042.

[215] S. Zevian, N.E. Winterwood, C.S. Stipp, Structure-function analysis of tetraspanin CD151 reveals distinct requirements for tumor cell behaviors mediated by α3β1 versus α6β4 integrin, J. Biol. Chem. 286 (2011) 7496–7506. https://doi.org/10.1074/jbc.M110.173583.

[216] W. Yang, P. Li, J. Lin, H. Zuo, P. Zuo, Y. Zou, Z. Liu, CD151 promotes proliferation and migration of PC3 cells via the formation of CD151-integrin α3/α6 complex, J. Huazhong Univ. Sci. Technol. Med. Sci. Hua Zhong Ke Ji Xue Xue Bao Yi Xue Ying Wen Ban Huazhong Keji Daxue Xuebao Yixue Yingdewen Ban. 32 (2012) 383–388. https://doi.org/10.1007/s11596-012-0066-y.

[217] L. Liu, B. He, W.M. Liu, D. Zhou, J.V. Cox, X.A. Zhang, Tetraspanin CD151 promotes cell migration by regulating integrin trafficking, J. Biol. Chem. 282 (2007) 31631–31642. https://doi.org/10.1074/jbc.M701165200.

[218] I.-K. Hong, D.-I. Jeoung, K.-S. Ha, Y.-M. Kim, H. Lee, Tetraspanin CD151 stimulates adhesion-dependent activation of Ras, Rac, and Cdc42 by facilitating molecular association between β1 integrins and small GTPases, J. Biol. Chem. 287 (2012) 32027–32039. https://doi.org/10.1074/jbc.M111.314443.

[219] T.M.E. Scales, A. Jayo, B. Obara, M.R. Holt, N.A. Hotchin, F. Berditchevski, M. Parsons, α3β1 integrins regulate CD151 complex assembly and membrane dynamics in carcinoma cells within 3D environments, Oncogene. 32 (2013) 3965–3979. https://doi.org/10.1038/onc.2012.415.

[220] G. Chometon, Z.-G. Zhang, E. Rubinstein, C. Boucheix, C. Mauch, M. Aumailley, Dissociation of the complex between CD151 and laminin-binding integrins permits migration of epithelial cells, Exp. Cell Res. 312 (2006) 983–995. https://doi.org/10.1016/j.yexcr.2005.12.034.

[221] A. Ranjan, S.M. Bane, R.D. Kalraiya, Glycosylation of the laminin receptor (α3β1) regulates its association with tetraspanin CD151: Impact on cell spreading, motility, degradation and invasion of basement membrane by tumor cells, Exp. Cell Res. 322 (2014) 249–264. https://doi.org/10.1016/j.yexcr.2014.02.004.

[222] H.M. Romanska, P. Potemski, R. Kusinska, J. Kopczynski, R. Sadej, R. Kordek, Expression of CD151/Tspan24 and integrin alpha 3 complex in aid of prognostication of HER2-negative high-grade ductal carcinoma in situ, Int. J. Clin. Exp. Pathol. 8 (2015) 9471–9478.

[223] X.H. Yang, L.M. Flores, Q. Li, P. Zhou, F. Xu, I.E. Krop, M.E. Hemler, Disruption of laminin-integrin-CD151-focal adhesion kinase axis sensitizes breast cancer cells to ErbB2 antagonists, Cancer Res. 70 (2010) 2256–2263. https://doi.org/10.1158/0008-5472.CAN-09-4032.

[224] B. Weigelt, F.C. Geyer, R. Natrajan, M.A. Lopez-Garcia, A.S. Ahmad, K. Savage, B. Kreike, J.S. Reis-Filho, The molecular underpinning of lobular histological growth pattern: a genome-wide transcriptomic analysis of invasive lobular carcinomas and grade- and molecular subtype-matched invasive ductal carcinomas of no special type, J. Pathol. 220 (2010) 45–57. https://doi.org/10.1002/path.2629.

[225] N. Chattopadhyay, Z. Wang, L.K. Ashman, S.M. Brady-Kalnay, J.A. Kreidberg, alpha3beta1 integrin-CD151, a component of the cadherin-catenin complex, regulates PTPmu expression and cell-cell adhesion, J. Cell Biol. 163 (2003) 1351–1362. https://doi.org/10.1083/jcb.200306067.

[226] J.L. Johnson, N. Winterwood, K.A. DeMali, C.S. Stipp, Tetraspanin CD151 regulates RhoA activation and the dynamic stability of carcinoma cell-cell contacts, J. Cell Sci. 122 (2009) 2263–2273. https://doi.org/10.1242/jcs.045997.

[227] S.C. Zevian, J.L. Johnson, N.E. Winterwood, K.S. Walters, M.E. Herndon, M.D. Henry, C.S. Stipp, CD151 Promotes α3β1 Integrin-Dependent Organization of Carcinoma Cell Junctions and Restrains Collective Cell Invasion, Cancer Biol. Ther. (2015) 0. https://doi.org/10.1080/15384047.2015.1095396.

[228] S. Ghosh, J.J. Johnson, R. Sen, S. Mukhopadhyay, Y. Liu, F. Zhang, Y. Wei, H.A. Chapman, M.S. Stack, Functional relevance of urinary-type plasminogen activator receptor-alpha3beta1 integrin association in proteinase regulatory pathways, J. Biol. Chem. 281 (2006) 13021–13029. https://doi.org/10.1074/jbc.M508526200.

[229] Z. Shi, Y. Liu, J.J. Johnson, M.S. Stack, Urinary-type plasminogen activator receptor (uPAR) modulates oral cancer cell behavior with alteration in p130cas, Mol. Cell. Biochem. 357 (2011) 151–161. https://doi.org/10.1007/s11010-011-0885-3.

[230] W. Yang, W. Han, S. Ye, D. Liu, J. Wu, H. Liu, C. Li, H. Chen, Fibroblast activation protein-α promotes ovarian cancer cell proliferation and invasion via extracellular and intracellular signaling mechanisms, Exp. Mol. Pathol. 95 (2013) 105–110. https://doi.org/10.1016/j.yexmp.2013.06.007.

[231] Y. Wei, J.A. Eble, Z. Wang, J.A. Kreidberg, H.A. Chapman, Urokinase receptors promote beta1 integrin function through interactions with integrin alpha3beta1, Mol. Biol. Cell. 12 (2001) 2975–2986. https://doi.org/10.1091/mbc.12.10.2975.

[232] G.M.S. Ferraris, C. Schulte, V. Buttiglione, V. De Lorenzi, A. Piontini, M. Galluzzi, A. Podestà, C.D. Madsen, N. Sidenius, The interaction between uPAR and vitronectin triggers ligand-independent adhesion signalling by integrins, EMBO J. 33 (2014) 2458–2472. https://doi.org/10.15252/embj.201387611.

[233] C. Schulte, G.M.S. Ferraris, A. Oldani, M. Galluzzi, A. Podestà, L. Puricelli, V. de Lorenzi, C. Lenardi, P. Milani, N. Sidenius, Lamellipodial tension, not integrin/ligand binding, is the crucial factor to realise integrin activation and cell migration, Eur. J. Cell Biol. 95 (2016) 1–14. https://doi.org/10.1016/j.ejcb.2015.10.002.

[234] J. Gu, N. Taniguchi, Regulation of integrin functions by N-glycans, Glycoconj. J. 21 (2004) 9–15. https://doi.org/10.1023/B:GLYC.0000043741.47559.30.

[235] M.E. Janik, M. Przybyło, E. Pocheć, M. Pokrywka, A. Lityńska, Effect of alpha3beta1 and alphavbeta3 integrin glycosylation on interaction of melanoma cells with vitronectin, Acta Biochim. Pol. 57 (2010) 55–61.

[236] M.E. Kremser, M. Przybyło, D. Hoja-Łukowicz, E. Pocheć, A. Amoresano, A. Carpentieri, M. Bubka, A. Lityńska, Characterisation of alpha3beta1 and alpha(v)beta3 integrin N-oligosaccharides in metastatic melanoma WM9 and WM239 cell lines, Biochim. Biophys. Acta. 1780 (2008) 1421–1431. https://doi.org/10.1016/j.bbagen.2008.07.011.

[237] H. Yamamoto, A. Oviedo, C. Sweeley, T. Saito, J.R. Moskal, Alpha2,6-sialylation of cell-surface N-glycans inhibits glioma formation in vivo, Cancer Res. 61 (2001) 6822–6829.

[238] A. Lityńska, M. Przybyło, D. Ksiazek, P. Laidler, Differences of alpha3beta1 integrin glycans from different human bladder cell lines, Acta Biochim. Pol. 47 (2000) 427–434.

[239] E. Pocheć, A. Lityńska, M. Bubka, A. Amoresano, A. Casbarra, Characterization of the oligosaccharide component of alpha3beta1 integrin from human bladder carcinoma cell line T24 and its role in adhesion and migration, Eur. J. Cell Biol. 85 (2006) 47–57. https://doi.org/10.1016/j.ejcb.2005.08.010.

[240] G. Baldwin, V. Novitskaya, R. Sadej, E. Pochec, A. Litynska, C. Hartmann, J. Williams, L. Ashman, J.A. Eble, F. Berditchevski, Tetraspanin CD151 regulates glycosylation of (alpha)3(beta)1 integrin, J. Biol. Chem. 283 (2008) 35445–35454. https://doi.org/10.1074/jbc.M806394200.

[241] C. Saravanan, F.-T. Liu, I.K. Gipson, N. Panjwani, Galectin-3 promotes lamellipodia formation in epithelial cells by interacting with complex N-glycans on alpha3beta1 integrin, J. Cell Sci. 122 (2009) 3684–3693. https://doi.org/10.1242/jcs.045674.

[242] Y. Ren, P. Hao, S.K.A. Law, S.K. Sze, Hypoxia-induced changes to integrin α 3 glycosylation facilitate invasion in epidermoid carcinoma cell line A431, Mol. Cell. Proteomics MCP. 13 (2014) 3126–3137. https://doi.org/10.1074/mcp.M114.038505.

[243] D. Saito, S. Kyakumoto, N. Chosa, M. Ibi, N. Takahashi, N. Okubo, S. Sawada, A. Ishisaki, M. Kamo, Transforming growth factor-β1 induces epithelial-mesenchymal transition and integrin α3β1-mediated cell migration of HSC-4 human squamous cell carcinoma cells through Slug, J. Biochem. (Tokyo). 153 (2013) 303–315. https://doi.org/10.1093/jb/mvs144.

[244] Y. Li, K. Yang, Q. Mao, X. Zheng, D. Kong, L. Xie, Inhibition of TGF-beta receptor I by siRNA suppresses the motility and invasiveness of T24 bladder cancer cells via modulation of integrins and matrix metalloproteinase, Int. Urol. Nephrol. 42 (2010) 315–323. https://doi.org/10.1007/s11255-009-9620-3.

[245] J.M. Lamar, K.M. Pumiglia, C.M. DiPersio, An immortalization-dependent switch in integrin function up-regulates MMP-9 to enhance tumor cell invasion, Cancer Res. 68 (2008) 7371–7379. https://doi.org/10.1158/0008-5472.CAN-08-1080.

[246] V. Iyer, K. Pumiglia, C.M. DiPersio, Alpha3beta1 integrin regulates MMP-9 mRNA stability in immortalized keratinocytes: a novel mechanism of integrin-mediated MMP gene expression, J. Cell Sci. 118 (2005) 1185–1195. https://doi.org/10.1242/jcs.01708.

[247] J.M. Lamar, V. Iyer, C.M. DiPersio, Integrin alpha3beta1 potentiates TGFbeta-mediated induction of MMP-9 in immortalized keratinocytes, J. Invest. Dermatol. 128 (2008) 575–586. https://doi.org/10.1038/sj.jid.5701042.

[248] D.S. Missan, K. Mitchell, S. Subbaram, C.M. DiPersio, Integrin α3β1 signaling through MEK/ERK determines alternative polyadenylation of the MMP-9 mRNA transcript in immortalized mouse keratinocytes, PloS One. 10 (2015) e0119539. https://doi.org/10.1371/journal.pone.0119539.

[249] W.M. Longmate, R. Monichan, M.-L. Chu, T. Tsuda, M.G. Mahoney, C.M. DiPersio, Reduced fibulin-2 contributes to loss of basement membrane integrity and skin blistering in mice lacking integrin α3β1 in the epidermis, J. Invest. Dermatol. 134 (2014) 1609–1617. https://doi.org/10.1038/jid.2014.10.

[250] S.J. Kennel, L.J. Foote, R. Falcioni, A. Sonnenberg, C.D. Stringer, C. Crouse, M.E. Hemler, Analysis of the tumor-associated antigen TSP-180. Identity with alpha 6-beta 4 in the integrin superfamily, J. Biol. Chem. 264 (1989) 15515–15521.

[251] C. Van Waes, K.F. Kozarsky, A.B. Warren, L. Kidd, D. Paugh, M. Liebert, T.E. Carey, The A9 antigen associated with aggressive human squamous carcinoma is structurally and functionally similar to the newly defined integrin alpha 6 beta 4, Cancer Res. 51 (1991) 2395–2402.

[252] R.L. Stewart, K.L. O'Connor, Clinical significance of the integrin α6β4 in human malignancies, Lab. Investig. J. Tech. Methods Pathol. 95 (2015) 976–986. https://doi.org/10.1038/labinvest.2015.82.

[253] L.K. Diaz, M. Cristofanilli, X. Zhou, K.L. Welch, T.L. Smith, Y. Yang, N. Sneige, A.A. Sahin, M.Z. Gilcrease, Beta4 integrin subunit gene expression correlates with tumor size and nuclear grade in early breast cancer, Mod. Pathol. Off. J. U. S. Can. Acad. Pathol. Inc. 18 (2005) 1165–1175. https://doi.org/10.1038/modpathol.3800411.

[254] Y. Masugi, K. Yamazaki, K. Emoto, K. Effendi, H. Tsujikawa, M. Kitago, O. Itano, Y. Kitagawa, M. Sakamoto, Upregulation of integrin β4 promotes epithelial-mesenchymal transition and is a novel prognostic marker in pancreatic ductal adenocarcinoma, Lab. Investig. J. Tech. Methods Pathol. 95 (2015) 308–319. https://doi.org/10.1038/labinvest.2014.166.

[255] J.D. Aplin, S. Dawson, M.W. Seif, Abnormal expression of integrin alpha 6 beta 4 in cervical intraepithelial neoplasia, Br. J. Cancer. 74 (1996) 240–245.

[256] T. Tennenbaum, A.K. Weiner, A.J. Belanger, A.B. Glick, H. Hennings, S.H. Yuspa, The suprabasal expression of alpha 6 beta 4 integrin is associated with a high risk for malignant progression in mouse skin carcinogenesis, Cancer Res. 53 (1993) 4803–4810.

[257] C.V. Waes, D.M. Surh, Z. Chen, M. Kirby, J.S. Rhim, R. Brager, R.B. Sessions, J. Poore, G.T. Wolf, T.E. Carey, Increase in Suprabasilar Integrin Adhesion Molecule Expression in Human Epidermal Neoplasms Accompanies Increased Proliferation Occurring with Immortalization and Tumor Progression, Cancer Res. 55 (1995) 5434–5444.

[258] E. Carico, D. French, B. Bucci, R. Falcioni, A. Vecchione, R. Mariani-Costantini, Integrin beta 4 expression in the neoplastic progression of cervical epithelium, Gynecol. Oncol. 49 (1993) 61–66. https://doi.org/10.1006/gyno.1993.1087.

[259] H.B. Grossman, R.W. Washington, T.E. Carey, M. Liebert, Alterations in antigen expression in superficial bladder cancer, J. Cell. Biochem. 50 (1992) 63–68. https://doi.org/10.1002/jcb.240501313.

[260] A.E. Cress, I. Rabinovitz, W. Zhu, R.B. Nagle, The alpha 6 beta 1 and alpha 6 beta 4 integrins in human prostate cancer progression, Cancer Metastasis Rev. 14 (1995) 219–228.

[261] T.L. Davis, A.E. Cress, B.L. Dalkin, R.B. Nagle, Unique expression pattern of the alpha6beta4 integrin and laminin-5 in human prostate carcinoma, The Prostate. 46 (2001) 240–248.

[262] R.B. Nagle, J. Hao, J.D. Knox, B.L. Dalkin, V. Clark, A.E. Cress, Expression of hemidesmosomal and extracellular matrix proteins by normal and malignant human prostate tissue, Am. J. Pathol. 146 (1995) 1498–1507.

[263] M.V. Allen, G.J. Smith, R. Juliano, S.J. Maygarden, J.L. Mohler, Downregulation of the beta4 integrin subunit in prostatic carcinoma and prostatic intraepithelial neoplasia, Hum. Pathol. 29 (1998) 311–318.

[264] K. Rossen, K.K. Dahlstrøm, A.M. Mercurio, U.M. Wewer, Expression of the alpha 6 beta 4 integrin by squamous cell carcinomas and basal cell carcinomas: possible relation to invasive potential?, Acta Derm. Venereol. 74 (1994) 101–105.

[265] D.M. Owens, M.R. Romero, C. Gardner, F.M. Watt, Suprabasal alpha6beta4 integrin expression in epidermis results in enhanced tumourigenesis and disruption of TGFbeta signalling, J. Cell Sci. 116 (2003) 3783–3791. https://doi.org/10.1242/jcs.00725.

[266] C.S. Yoon, K.D. Kim, S.N. Park, S.W. Cheong, alpha(6) Integrin is the main receptor of human papillomavirus type 16 VLP, Biochem. Biophys. Res. Commun. 283 (2001) 668–673. https://doi.org/10.1006/bbrc.2001.4838.

[267] H.-S. Huang, P.F. Lambert, Use of an in vivo animal model for assessing the role of integrin α(6)β(4) and syndecan-1 in early steps in papillomavirus infection, Virology. 433 (2012) 395–400. https://doi.org/10.1016/j.virol.2012.08.032.

[268] P. Aksoy, C.Y. Abban, E. Kiyashka, W. Qiang, P.I. Meneses, HPV16 infection of HaCaTs is dependent on β4 integrin, and α6 integrin processing, Virology. 449 (2014) 45–52. https://doi.org/10.1016/j.virol.2013.10.034.

[269] M. Oldak, R.B. Maksym, T. Sperling, M. Yaniv, H. Smola, H.J. Pfister, J. Malejczyk, S. Smola, Human papillomavirus type 8 E2 protein unravels JunB/Fra-1 as an activator of the beta4-integrin gene in human keratinocytes, J. Virol. 84 (2010) 1376–1386. https://doi.org/10.1128/JVI.01220-09.

[270] M. Oldak, H. Smola, M. Aumailley, F. Rivero, H. Pfister, S. Smola-Hess, The human papillomavirus type 8 E2 protein suppresses beta4-integrin expression in primary human keratinocytes, J. Virol. 78 (2004) 10738–10746. https://doi.org/10.1128/JVI.78.19.10738-10746.2004.

[271] W. Guo, Y. Pylayeva, A. Pepe, T. Yoshioka, W.J. Muller, G. Inghirami, F.G. Giancotti, Beta 4 integrin amplifies ErbB2 signaling to promote mammary tumorigenesis, Cell. 126 (2006) 489–502. https://doi.org/10.1016/j.cell.2006.05.047.

[272] R. Falcioni, A. Antonini, P. Nisticò, S. Di Stefano, M. Crescenzi, P.G. Natali, A. Sacchi, Alpha 6 beta 4 and alpha 6 beta 1 integrins associate with ErbB-2 in human carcinoma cell lines, Exp. Cell Res. 236 (1997) 76–85.

[273] M.M. Santoro, G. Gaudino, P.C. Marchisio, The MSP Receptor Regulates α6β4 and α3β1 Integrins via 14-3-3 Proteins in Keratinocyte Migration, Dev. Cell. 5 (2003) 257–271. https://doi.org/10.1016/S1534-5807(03)00201-6.

[274] A. Bertotti, P.M. Comoglio, L. Trusolino, β4 Integrin Is a Transforming Molecule that Unleashes Met Tyrosine Kinase Tumorigenesis, Cancer Res. 65 (2005) 10674–10679. https://doi.org/10.1158/0008-5472.CAN-05-2827.

[275] M. Fujita, K. Ieguchi, P. Davari, S. Yamaji, Y. Taniguchi, K. Sekiguchi, Y.K. Takada, Y. Takada, Cross-talk between integrin α6β4 and insulin-like growth factor-1 receptor (IGF1R) through direct α6β4 binding to IGF1 and subsequent α6β4-IGF1-IGF1R ternary complex formation in anchorage-independent conditions, J. Biol. Chem. 287 (2012) 12491–12500. https://doi.org/10.1074/jbc.M111.304170.

[276] F.G. Giancotti, Targeting integrin beta4 for cancer and anti-angiogenic therapy, Trends Pharmacol. Sci. 28 (2007) 506–511. https://doi.org/10.1016/j.tips.2007.08.004.

[277] A. Mariotti, P.A. Kedeshian, M. Dans, A.M. Curatola, L. Gagnoux-Palacios, F.G. Giancotti, EGF-R signaling through Fyn kinase disrupts the function of integrin alpha6beta4 at hemidesmosomes: role in epithelial cell migration and carcinoma invasion, J. Cell Biol. 155 (2001) 447–458. https://doi.org/10.1083/jcb.200105017.

[278] Y.-L. Tai, P.-Y. Chu, I.-R. Lai, M.-Y. Wang, H.-Y. Tseng, J.-L. Guan, J.-Y. Liou, T.-L. Shen, An EGFR/Src-dependent β4 integrin/FAK complex contributes to malignancy of breast cancer, Sci. Rep. 5 (2015) 16408. https://doi.org/10.1038/srep16408.

[279] L. Trusolino, A. Bertotti, P.M. Comoglio, A signaling adapter function for alpha6beta4 integrin in the control of HGF-dependent invasive growth, Cell. 107 (2001) 643–654.

[280] M.Z. Gilcrease, X. Zhou, X. Lu, W.A. Woodward, B.E. Hall, P.J. Morrissey, Alpha6beta4 integrin crosslinking induces EGFR clustering and promotes EGF-mediated Rho activation in breast cancer, J. Exp. Clin. Cancer Res. CR. 28 (2009) 67. https://doi.org/10.1186/1756-9966-28-67.

[281] H. Wang, L. Leavitt, R. Ramaswamy, A.C. Rapraeger, Interaction of syndecan and alpha6beta4 integrin cytoplasmic domains: regulation of ErbB2-mediated integrin activation, J. Biol. Chem. 285 (2010) 13569–13579. https://doi.org/10.1074/jbc.M110.102137.

[282] H. Wang, H. Jin, D.M. Beauvais, A.C. Rapraeger, Cytoplasmic Domain Interactions of Syndecan-1 and Syndecan-4 with α6β4 Integrin Mediate Human Epidermal Growth Factor Receptor (HER1 and HER2)-dependent Motility and Survival, J. Biol. Chem. 289 (2014) 30318–30332. https://doi.org/10.1074/jbc.M114.586438.

[283] F. Mainiero, C. Murgia, K.K. Wary, A.M. Curatola, A. Pepe, M. Blumemberg, J.K. Westwick, C.J. Der, F.G. Giancotti, The coupling of alpha6beta4 integrin to Ras-MAP kinase pathways mediated by Shc controls keratinocyte proliferation, EMBO J. 16 (1997) 2365–2375. https://doi.org/10.1093/emboj/16.9.2365.

[284] L. Gagnoux-Palacios, M. Dans, W. van't Hof, A. Mariotti, A. Pepe, G. Meneguzzi, M.D. Resh, F.G. Giancotti, Compartmentalization of integrin alpha6beta4 signaling in lipid rafts, J. Cell Biol. 162 (2003) 1189–1196. https://doi.org/10.1083/jcb.200305006.

[285] J. Chung, R.E. Bachelder, E.A. Lipscomb, L.M. Shaw, A.M. Mercurio, Integrin (alpha 6 beta 4) regulation of eIF-4E activity and VEGF translation: a survival mechanism for carcinoma cells, J. Cell Biol. 158 (2002) 165–174. https://doi.org/10.1083/jcb.200112015.

[286] A.M. Mercurio, R.E. Bachelder, R.C. Bates, J. Chung, Autocrine signaling in carcinoma: VEGF and the α6β4 integrin, Semin. Cancer Biol. 14 (2004) 115–122. https://doi.org/10.1016/j.semcancer.2003.09.016.

[287] L.M. Shaw, I. Rabinovitz, H.H. Wang, A. Toker, A.M. Mercurio, Activation of phosphoinositide 3-OH kinase by the alpha6beta4 integrin promotes carcinoma invasion, Cell. 91 (1997) 949–960.

[288] V. Gabarra, S. Cho, M. Ramirez, Y. Ren, L.L. Chen, A. Cheung, X. Cao, R. Rennard, K.R. Unruh, C.P. Graff, B. Browning, H.A. Huet, K. McLachlan, Antibodies directed to alpha6beta4 highlight the adhesive and signaling functions of the integrin in breast cancer cell lines, Cancer Biol. Ther. 9 (2010) 437–445.

[289] G. Bon, V. Folgiero, G. Bossi, L. Felicioni, A. Marchetti, A. Sacchi, R. Falcioni, Loss of beta4 integrin subunit reduces the tumorigenicity of MCF7 mammary cells and causes apoptosis upon hormone deprivation, Clin. Cancer Res. Off. J. Am. Assoc. Cancer Res. 12 (2006) 3280–3287. https://doi.org/10.1158/1078-0432.CCR-05-2223.

[290] C. Fan, H. Su, J. Zhao, B. Zhao, S. Zhang, J. Miao, A novel copper complex of salicylaldehyde pyrazole hydrazone induces apoptosis through up-regulating integrin beta4 in H322 lung carcinoma cells, Eur. J. Med. Chem. 45 (2010) 1438–1446. https://doi.org/10.1016/j.ejmech.2009.12.048.

[291] C. Fan, J. Zhao, B. Zhao, S. Zhang, J. Miao, Novel complex of copper and a salicylaldehyde pyrazole hydrazone derivative induces apoptosis through up-regulating integrin beta 4 in vascular endothelial cells, Chem. Res. Toxicol. 22 (2009) 1517–1525. https://doi.org/10.1021/tx900111y.

[292] X. Liu, J. Zhao, J. Xu, B. Zhao, Y. Zhang, S. Zhang, J. Miao, Protective effects of a benzoxazine derivative against oxidized LDL-induced apoptosis and the increases of integrin beta4, ROS, NF-kappaB and P53 in human umbilical vein endothelial cells, Bioorg. Med. Chem. Lett. 19 (2009) 2896–2900. https://doi.org/10.1016/j.bmcl.2009.03.070.

[293] L. Su, B. Zhao, X. Lv, N. Wang, J. Zhao, S. Zhang, J. Miao, Safrole oxide induces neuronal apoptosis through inhibition of integrin beta4/SOD activity and elevation of ROS/NADPH oxidase activity, Life Sci. 80 (2007) 999–1006. https://doi.org/10.1016/j.lfs.2006.11.041.

[294] K.-W. Zhao, Q.-T. Zhao, S.-L. Zhang, J.-Y. Miao, Integrin beta4 mAb inhibited apoptosis induced by deprivation of growth factors in vascular endothelial cells, Acta Pharmacol. Sin. 25 (2004) 733–737.

[295] Y. Ishii, A. Ochiai, T. Yamada, S. Akimoto, K. Yanagihara, M. Kitajima, S. Hirohashi, Integrin alpha6beta4 as a suppressor and a predictive marker for peritoneal dissemination in human gastric cancer, Gastroenterology. 118 (2000) 497–506.

[296] R.E. Bachelder, A. Marchetti, R. Falcioni, S. Soddu, A.M. Mercurio, Activation of p53 function in carcinoma cells by the alpha6beta4 integrin, J. Biol. Chem. 274 (1999) 20733–20737.

[297] G. Bon, S.E. Di Carlo, V. Folgiero, P. Avetrani, C. Lazzari, G. D'Orazi, M.F. Brizzi, A. Sacchi, S. Soddu, G. Blandino, M. Mottolese, R. Falcioni, Negative regulation of beta4 integrin transcription by homeodomain-interacting protein kinase 2 and p53 impairs tumor progression, Cancer Res. 69 (2009) 5978–5986. https://doi.org/10.1158/0008-5472.CAN-09-0244.

[298] R.E. Bachelder, M.J. Ribick, A. Marchetti, R. Falcioni, S. Soddu, K.R. Davis, A.M. Mercurio, p53 inhibits alpha 6 beta 4 integrin survival signaling by promoting the caspase 3-dependent cleavage of AKT/PKB, J. Cell Biol. 147 (1999) 1063–1072.

[299] J.-G. Lee, J.-H. Ahn, T. Jin Kim, J. Ho Lee, J.-H. Choi, Mutant p53 promotes ovarian cancer cell adhesion to mesothelial cells via integrin β4 and Akt signals, Sci. Rep. 5 (2015) 12642. https://doi.org/10.1038/srep12642.

[300] M. Dajee, M. Lazarov, J.Y. Zhang, T. Cai, C.L. Green, A.J. Russell, M.P. Marinkovich, S. Tao, Q. Lin, Y. Kubo, P.A. Khavari, NF-kappaB blockade and oncogenic Ras trigger invasive human epidermal neoplasia, Nature. 421 (2003) 639–643. https://doi.org/10.1038/nature01283.

[301] E.A. Lipscomb, K.J. Simpson, S.R. Lyle, J.E. Ring, A.S. Dugan, A.M. Mercurio, The alpha6beta4 integrin maintains the survival of human breast carcinoma cells in vivo, Cancer Res. 65 (2005) 10970–10976. https://doi.org/10.1158/0008-5472.CAN-05-2327.

[302] J.C. Friedland, J.N. Lakins, M.G. Kazanietz, J. Chernoff, D. Boettiger, V.M. Weaver, alpha6beta4 integrin activates Rac-dependent p21-activated kinase 1 to drive NF-kappaB-dependent resistance to apoptosis in 3D mammary acini, J. Cell Sci. 120 (2007) 3700–3712. https://doi.org/10.1242/jcs.03484.

[303] N. Zahir, J.N. Lakins, A. Russell, W. Ming, C. Chatterjee, G.I. Rozenberg, M.P. Marinkovich, V.M. Weaver, Autocrine laminin-5 ligates alpha6beta4 integrin and activates RAC and NFkappaB to mediate anchorage-independent survival of mammary tumors, J. Cell Biol. 163 (2003) 1397–1407. https://doi.org/10.1083/jcb.200302023.

[304] R. Derynck, R.J. Akhurst, A. Balmain, TGF-beta signaling in tumor suppression and cancer progression, Nat. Genet. 29 (2001) 117–129. https://doi.org/10.1038/ng1001-117.

[305] L.M. Wakefield, A.B. Roberts, TGF-beta signaling: positive and negative effects on tumorigenesis, Curr. Opin. Genet. Dev. 12 (2002) 22–29.

[306] T.S. Hiran, J.E. Mazurkiewicz, P. Kreienberg, F.L. Rice, S.E. LaFlamme, Endothelial expression of the alpha6beta4 integrin is negatively regulated during angiogenesis, J. Cell Sci. 116 (2003) 3771–3781. https://doi.org/10.1242/jcs.00681.

[307] D. Desai, P. Singh, L. Van De Water, S.E. Laflamme, Dynamic Regulation of Integrin α6β4 During Angiogenesis: Potential Implications for Pathogenic Wound Healing, Adv. Wound Care. 2 (2013) 401–409. https://doi.org/10.1089/wound.2013.0455.

[308] T.-H. Lee, S. Seng, H. Li, S.J. Kennel, H.K. Avraham, S. Avraham, Integrin regulation by vascular endothelial growth factor in human brain microvascular endothelial cells: role of alpha6beta1 integrin in angiogenesis, J. Biol. Chem. 281 (2006) 40450–40460. https://doi.org/10.1074/jbc.M607525200.

[309] S.N. Nikolopoulos, P. Blaikie, T. Yoshioka, W. Guo, F.G. Giancotti, Integrin beta4 signaling promotes tumor angiogenesis, Cancer Cell. 6 (2004) 471–483. https://doi.org/10.1016/j.ccr.2004.09.029.

[310] C. Feng, C. Ye, X. Liu, H. Ma, M. Li, Beta4 integrin is involved in statin-induced endothelial cell death, Biochem. Biophys. Res. Commun. 323 (2004) 858–864. https://doi.org/10.1016/j.bbrc.2004.08.171.

[311] L. Wang, Z. Dong, Y. Zhang, J. Miao, The roles of integrin β4 in vascular endothelial cells, J. Cell. Physiol. 227 (2012) 474–478. https://doi.org/10.1002/jcp.22769.

[312] A.M. Mercurio, E.A. Lipscomb, R.E. Bachelder, Non-angiogenic functions of VEGF in breast cancer, J. Mammary Gland Biol. Neoplasia. 10 (2005) 283–290. https://doi.org/10.1007/s10911-006-9001-9.

[313] A.M. Mercurio, I. Rabinovitz, Towards a mechanistic understanding of tumor invasion--lessons from the alpha6beta 4 integrin, Semin. Cancer Biol. 11 (2001) 129–141. https://doi.org/10.1006/scbi.2000.0364.

[314] G. Giannelli, S. Astigiano, S. Antonaci, M. Morini, O. Barbieri, D.M. Noonan, A. Albini, Role of the alpha3beta1 and alpha6beta4 integrins in tumor invasion, Clin. Exp. Metastasis. 19 (2002) 217–223.

[315] C.A.W. Geuijen, A. Sonnenberg, Dynamics of the alpha6beta4 integrin in keratinocytes, Mol. Biol. Cell. 13 (2002) 3845–3858. https://doi.org/10.1091/mbc.02-01-0601.

[316] K. Raymond, M. Kreft, H. Janssen, J. Calafat, A. Sonnenberg, Keratinocytes display normal proliferation, survival and differentiation in conditional beta4-integrin knockout mice, J. Cell Sci. 118 (2005) 1045–1060. https://doi.org/10.1242/jcs.01689.

[317] J. Uematsu, Y. Nishizawa, A. Sonnenberg, K. Owaribe, Demonstration of type II hemidesmosomes in a mammary gland epithelial cell line, BMGE-H, J. Biochem. (Tokyo). 115 (1994) 469–476.

[318] J.F. Beaulieu, Extracellular matrix components and integrins in relationship to human intestinal epithelial cell differentiation, Prog. Histochem. Cytochem. 31 (1997) 1–78.

[319] A.M. Mercurio, I. Rabinovitz, L.M. Shaw, The α6β4 integrin and epithelial cell migration, Curr. Opin. Cell Biol. 13 (2001) 541–545. https://doi.org/10.1016/S0955-0674(00)00249-0.

[320] J. Tang, G. Wang, M. Zhang, F. Li, Y. Sang, B. Wang, K. Hu, Y. Wu, R. Luo, D. Liao, J. Cao, X. Wang, L. Wang, R. Zhang, X. Zhang, W. Deng, D. Xie, R. Xu, T. Kang, Paradoxical role of CBX8 in proliferation and metastasis of colorectal cancer, Oncotarget. 5 (2014) 10778–10790. https://doi.org/10.18632/oncotarget.2502.

[321] C.D. Lawson, K. Burridge, The on-off relationship of Rho and Rac during integrin-mediated adhesion and cell migration, Small GTPases. 5 (2014) e27958. https://doi.org/10.4161/sgtp.27958.

[322] B.P. Nguyen, S.G. Gil, W.G. Carter, Deposition of laminin 5 by keratinocytes regulates integrin adhesion and signaling, J. Biol. Chem. 275 (2000) 31896–31907. https://doi.org/10.1074/jbc.M006379200.

[323] C.E. Pullar, B.S. Baier, Y. Kariya, A.J. Russell, B.A.J. Horst, M.P. Marinkovich, R.R. Isseroff, beta4 integrin and epidermal growth factor coordinately regulate electric field-mediated directional migration via Rac1, Mol. Biol. Cell. 17 (2006) 4925–4935. https://doi.org/10.1091/mbc.E06-05-0433.

[324] Z. Cruz-Monserrate, K.L. O'Connor, Integrin alpha 6 beta 4 promotes migration, invasion through Tiam1 upregulation, and subsequent Rac activation, Neoplasia N. Y. N. 10 (2008) 408–417.

[325] R.V. Mula, V. Bhatia, M. Falzon, PTHrP promotes colon cancer cell migration and invasion in an integrin α6β4-dependent manner through activation of Rac1, Cancer Lett. 298 (2010) 119–127. https://doi.org/10.1016/j.canlet.2010.06.009.

[326] K.L. O'Connor, M. Chen, L.N. Towers, Integrin α6β4 cooperates with LPA signaling to stimulate Rac through AKAP-Lbc-mediated RhoA activation, Am. J. Physiol. Cell Physiol. 302 (2012) C605-614. https://doi.org/10.1152/ajpcell.00095.2011.

[327] A.J. Russell, E.F. Fincher, L. Millman, R. Smith, V. Vela, E.A. Waterman, C.N. Dey, S. Guide, V.M. Weaver, M.P. Marinkovich, Alpha 6 beta 4 integrin regulates keratinocyte chemotaxis through differential GTPase activation and antagonism of alpha 3 beta 1 integrin, J. Cell Sci. 116 (2003) 3543–3556. https://doi.org/10.1242/jcs.00663.

[328] S.N. Nikolopoulos, P. Blaikie, T. Yoshioka, W. Guo, C. Puri, C. Tacchetti, F.G. Giancotti, Targeted deletion of the integrin beta4 signaling domain suppresses laminin-5-dependent nuclear entry of mitogen-activated protein kinases and NF-kappaB, causing defects in epidermal growth and migration, Mol. Cell. Biol. 25 (2005) 6090–6102. https://doi.org/10.1128/MCB.25.14.6090-6102.2005.

[329] K.L. O'Connor, B.K. Nguyen, A.M. Mercurio, RhoA function in lamellae formation and migration is regulated by the alpha6beta4 integrin and cAMP metabolism, J. Cell Biol. 148 (2000) 253–258.

[330] S. Jauliac, C. López-Rodriguez, L.M. Shaw, L.F. Brown, A. Rao, A. Toker, The role of NFAT transcription factors in integrin-mediated carcinoma invasion, Nat. Cell Biol. 4 (2002) 540–544. https://doi.org/10.1038/ncb816.

[331] T.H. Kim, H.I. Kim, Y.H. Soung, L.A. Shaw, J. Chung, Integrin (alpha6beta4) signals through Src to increase expression of S100A4, a metastasis-promoting factor: implications for cancer cell invasion, Mol. Cancer Res. MCR. 7 (2009) 1605–1612. https://doi.org/10.1158/1541-7786.MCR-09-0102.

[332] M. Chen, K.L. O'Connor, Integrin alpha6beta4 promotes expression of autotaxin/ENPP2 autocrine motility factor in breast carcinoma cells, Oncogene. 24 (2005) 5125–5130. https://doi.org/10.1038/sj.onc.1208729.

[333] Y. Kishi, S. Okudaira, M. Tanaka, K. Hama, D. Shida, J. Kitayama, T. Yamori, J. Aoki, T. Fujimaki, H. Arai, Autotaxin is overexpressed in glioblastoma multiforme and contributes to cell motility of glioblastoma by converting lysophosphatidylcholine to lysophosphatidic acid, J. Biol. Chem. 281 (2006) 17492–17500. https://doi.org/10.1074/jbc.M601803200.

[334] M. Chen, M. Sinha, B.A. Luxon, A.R. Bresnick, K.L. O'Connor, Integrin alpha6beta4 controls the expression of genes associated with cell motility, invasion, and metastasis, including S100A4/metastasin, J. Biol. Chem. 284 (2009) 1484–1494. https://doi.org/10.1074/jbc.M803997200.

[335] S. Tarabykina, T.R.L. Griffiths, E. Tulchinsky, J.K. Mellon, I.B. Bronstein, M. Kriajevska, Metastasis-associated protein S100A4: spotlight on its role in cell migration, Curr. Cancer Drug Targets. 7 (2007) 217–228.

[336] R. Barraclough, Calcium-binding protein S100A4 in health and disease, Biochim. Biophys. Acta. 1448 (1998) 190–199.

[337] A. Miyazaki, T. Ohkubo, M. Hatta, H. Ishikawa, J. Yamazaki, Integrin α6β4 and TRPV1 channel coordinately regulate directional keratinocyte migration, Biochem. Biophys. Res. Commun. 458 (2015) 161–167. https://doi.org/10.1016/j.bbrc.2015.01.086.

[338] Q. Chen, R. Xu, C. Zeng, Q. Lu, D. Huang, C. Shi, W. Zhang, L. Deng, R. Yan, H. Rao, G. Gao, S. Luo, Down-regulation of Gli transcription factor leads to the inhibition of migration and invasion of ovarian cancer cells via integrin β4-mediated FAK signaling, PloS One. 9 (2014) e88386. https://doi.org/10.1371/journal.pone.0088386.

[339] M. Abdel-Ghany, H.-C. Cheng, R.C. Elble, B.U. Pauli, Focal adhesion kinase activated by beta(4) integrin ligation to mCLCA1 mediates early metastatic growth, J. Biol. Chem. 277 (2002) 34391–34400. https://doi.org/10.1074/jbc.M205307200.

[340] I. Lakshmanan, S. Rachagani, R. Hauke, S.R. Krishn, S. Paknikar, P. Seshacharyulu, S. Karmakar, R.K. Nimmakayala, G. Kaushik, S.L. Johansson, G.B. Carey, M.P. Ponnusamy, S. Kaur, S.K. Batra, A.K. Ganti, MUC5AC interactions with integrin β4 enhances the migration of lung cancer cells through FAK signaling, Oncogene. (2016). https://doi.org/10.1038/onc.2015.478.

[341] B.U. Sehgal, P.J. DeBiase, S. Matzno, T.-L. Chew, J.N. Claiborne, S.B. Hopkinson, A. Russell, M.P. Marinkovich, J.C.R. Jones, Integrin beta4 regulates migratory behavior of keratinocytes by determining laminin-332 organization, J. Biol. Chem. 281 (2006) 35487–35498. https://doi.org/10.1074/jbc.M606317200.

[342] I. Rabinovitz, I.K. Gipson, A.M. Mercurio, Traction forces mediated by alpha6beta4 integrin: implications for basement membrane organization and tumor invasion, Mol. Biol. Cell. 12 (2001) 4030–4043. https://doi.org/10.1091/mbc.12.12.4030.

[343] B.L. Carpenter, M. Chen, T. Knifley, K.A. Davis, S.M.W. Harrison, R.L. Stewart, K.L. O'Connor, Integrin α6β4 Promotes Autocrine Epidermal Growth Factor Receptor (EGFR) Signaling to Stimulate Migration and Invasion toward Hepatocyte Growth Factor (HGF), J. Biol. Chem. 290 (2015) 27228–27238. https://doi.org/10.1074/jbc.M115.686873.
[344] N. Daemi, N. Thomasset, J.C. Lissitzky, J. Dumortier, M.F. Jacquier, C. Pourreyron, P. Rousselle, J.A. Chayvialle, L. Remy, Anti-beta4 integrin antibodies enhance migratory and invasive abilities of human colon adenocarcinoma cells and their MMP-2 expression, Int. J. Cancer J. Int. Cancer. 85 (2000) 850–856.
[345] R. Sadej, A. Grudowska, L. Turczyk, R. Kordek, H.M. Romanska, CD151 in cancer progression and metastasis: a complex scenario, Lab. Investig. J. Tech. Methods Pathol. 94 (2014) 41–51. https://doi.org/10.1038/labinvest.2013.136.
[346] M. Zöller, Tetraspanins: push and pull in suppressing and promoting metastasis, Nat. Rev. Cancer. 9 (2009) 40–55. https://doi.org/10.1038/nrc2543.
[347] M. Hasegawa, M. Furuya, Y. Kasuya, M. Nishiyama, T. Sugiura, T. Nikaido, Y. Momota, M. Ichinose, S. Kimura, CD151 dynamics in carcinoma-stroma interaction: integrin expression, adhesion strength and proteolytic activity, Lab. Investig. J. Tech. Methods Pathol. 87 (2007) 882–892. https://doi.org/10.1038/labinvest.3700657.
[348] D.E. White, W.J. Muller, Multifaceted roles of integrins in breast cancer metastasis, J. Mammary Gland Biol. Neoplasia. 12 (2007) 135–142. https://doi.org/10.1007/s10911-007-9045-5.
[349] R. Shi, J. Li, F. Tang, Y.I. Luo, C.-Q. Tu, Identification and functional study of osteosarcoma metastasis marker genes, Oncol. Lett. 10 (2015) 1848–1852. https://doi.org/10.3892/ol.2015.3444.
[350] M.Z. Gilcrease, S.K. Kilpatrick, W.A. Woodward, X. Zhou, M.M. Nicolas, L.J. Corley, G.N. Fuller, S.L. Tucker, L.K. Diaz, T.A. Buchholz, J.A. Frost, Coexpression of alpha6beta4 integrin and guanine nucleotide exchange factor Net1 identifies node-positive breast cancer patients at high risk for distant metastasis, Cancer Epidemiol. Biomark. Prev. Publ. Am. Assoc. Cancer Res. Cosponsored Am. Soc. Prev. Oncol. 18 (2009) 80–86. https://doi.org/10.1158/1055-9965.EPI-08-0842.
[351] T.-H. Lee, H.K. Avraham, S. Jiang, S. Avraham, Vascular endothelial growth factor modulates the transendothelial migration of MDA-MB-231 breast cancer cells through regulation of brain microvascular endothelial cell permeability, J. Biol. Chem. 278 (2003) 5277–5284. https://doi.org/10.1074/jbc.M210063200.
[352] S. Shen, J. Fan, B. Cai, Y. Lv, M. Zeng, Y. Hao, F.G. Giancotti, B.M. Fu, Vascular endothelial growth factor enhances cancer cell adhesion to microvascular endothelium in vivo, Exp. Physiol. 95 (2010) 369–379. https://doi.org/10.1113/expphysiol.2009.050260.
[353] B.M. Fu, S. Shen, Acute VEGF effect on solute permeability of mammalian microvessels in vivo, Microvasc. Res. 68 (2004) 51–62. https://doi.org/10.1016/j.mvr.2004.03.004.
[354] J. Fan, B. Cai, M. Zeng, Y. Hao, F.G. Giancotti, B.M. Fu, Integrin β4 signaling promotes mammary tumor cell adhesion to brain microvascular endothelium by inducing ErbB2-mediated secretion of VEGF, Ann. Biomed. Eng. 39 (2011) 2223–2241. https://doi.org/10.1007/s10439-011-0321-6.
[355] A. Hoshino, B. Costa-Silva, T.-L. Shen, G. Rodrigues, A. Hashimoto, M. Tesic Mark, H. Molina, S. Kohsaka, A. Di Giannatale, S. Ceder, S. Singh, C. Williams, N. Soplop, K. Uryu, L. Pharmer, T. King, L. Bojmar, A.E. Davies, Y. Ararso, T. Zhang, H. Zhang, J. Hernandez, J.M. Weiss, V.D. Dumont-Cole, K. Kramer, L.H. Wexler, A. Narendran, G.K. Schwartz, J.H. Healey, P. Sandstrom, K. Jørgen Labori, E.H. Kure, P.M. Grandgenett, M.A. Hollingsworth, M. de Sousa, S. Kaur, M. Jain, K. Mallya, S.K. Batra, W.R. Jarnagin, M.S. Brady, O. Fodstad, V. Muller, K. Pantel, A.J. Minn, M.J. Bissell, B.A. Garcia, Y. Kang, V.K. Rajasekhar, C.M. Ghajar, I. Matei, H. Peinado, J. Bromberg, D. Lyden, Tumour exosome integrins determine organotropic metastasis, Nature. 527 (2015) 329–335. https://doi.org/10.1038/nature15756.
[356] P.T. Yu, M. Babicky, D. Jaquish, R. French, K. Marayuma, E. Mose, S. Niessen, H. Hoover, D. Shields, D. Cheresh, B.F. Cravatt, A.M. Lowy, The RON-receptor regulates pancreatic cancer cell migration through phosphorylation-dependent breakdown of the hemidesmosome, Int. J. Cancer J. Int. Cancer. 131 (2012) 1744–1754. https://doi.org/10.1002/ijc.27447.

[357] D. Gambaletta, A. Marchetti, L. Benedetti, A.M. Mercurio, A. Sacchi, R. Falcioni, Cooperative signaling between alpha(6)beta(4) integrin and ErbB-2 receptor is required to promote phosphatidylinositol 3-kinase-dependent invasion, J. Biol. Chem. 275 (2000) 10604–10610.
[358] V. Folgiero, P. Avetrani, G. Bon, S.E. Di Carlo, A. Fabi, C. Nisticò, P. Vici, E. Melucci, S. Buglioni, L. Perracchio, I. Sperduti, L. Rosanò, A. Sacchi, M. Mottolese, R. Falcioni, Induction of ErbB-3 expression by alpha6beta4 integrin contributes to tamoxifen resistance in ERbeta1-negative breast carcinomas, PloS One. 3 (2008) e1592. https://doi.org/10.1371/journal.pone.0001592.
[359] Y.H. Soung, J.L. Clifford, J. Chung, Crosstalk between integrin and receptor tyrosine kinase signaling in breast carcinoma progression, BMB Rep. 43 (2010) 311–318.
[360] C.H. Streuli, N. Akhtar, Signal co-operation between integrins and other receptor systems, Biochem. J. 418 (2009) 491–506. https://doi.org/10.1042/BJ20081948.
[361] C. Schreider, G. Peignon, S. Thenet, J. Chambaz, M. Pinçon-Raymond, Integrin-mediated functional polarization of Caco-2 cells through E-cadherin--actin complexes, J. Cell Sci. 115 (2002) 543–552.
[362] E. Hintermann, N. Yang, D. O'Sullivan, J.M.G. Higgins, V. Quaranta, Integrin alpha6beta4-erbB2 complex inhibits haptotaxis by up-regulating E-cadherin cell-cell junctions in keratinocytes, J. Biol. Chem. 280 (2005) 8004–8015. https://doi.org/10.1074/jbc.M406301200.
[363] X. Yang, B. Pursell, S. Lu, T.-K. Chang, A.M. Mercurio, Regulation of beta 4-integrin expression by epigenetic modifications in the mammary gland and during the epithelial-to-mesenchymal transition, J. Cell Sci. 122 (2009) 2473–2480. https://doi.org/10.1242/jcs.049148.
[364] M. Takkunen, R. Grenman, M. Hukkanen, M. Korhonen, A. García de Herreros, I. Virtanen, Snail-dependent and -independent epithelial-mesenchymal transition in oral squamous carcinoma cells, J. Histochem. Cytochem. Off. J. Histochem. Soc. 54 (2006) 1263–1275. https://doi.org/10.1369/jhc.6A6958.2006.
[365] M. Emadi Baygi, Z.-S. Soheili, F. Essmann, A. Deezagi, R. Engers, W. Goering, W.A. Schulz, Slug/SNAI2 regulates cell proliferation and invasiveness of metastatic prostate cancer cell lines, Tumour Biol. J. Int. Soc. Oncodevelopmental Biol. Med. 31 (2010) 297–307. https://doi.org/10.1007/s13277-010-0037-5.
[366] J. Du, S. Hong, L. Dong, B. Cheng, L. Lin, B. Zhao, Y.-G. Chen, X. Chen, Dynamic Sialylation in Transforming Growth Factor-β (TGF-β)-induced Epithelial to Mesenchymal Transition, J. Biol. Chem. 290 (2015) 12000–12013. https://doi.org/10.1074/jbc.M115.636969.
[367] T. Uemura, K. Shiozaki, K. Yamaguchi, S. Miyazaki, S. Satomi, K. Kato, H. Sakuraba, T. Miyagi, Contribution of sialidase NEU1 to suppression of metastasis of human colon cancer cells through desialylation of integrin beta4, Oncogene. 28 (2009) 1218–1229. https://doi.org/10.1038/onc.2008.471.
[368] J.-Y. Ho, F.-W. Chang, F.S. Huang, J.-M. Liu, Y.-P. Liu, S.-P. Chen, Y.-L. Liu, K.-C. Cheng, C.-P. Yu, R.-J. Hsu, Estrogen Enhances the Cell Viability and Motility of Breast Cancer Cells through the ERα-ΔNp63-Integrin β4 Signaling Pathway, PloS One. 11 (2016) e0148301. https://doi.org/10.1371/journal.pone.0148301.
[369] V. Bhatia, R.V. Mula, N.L. Weigel, M. Falzon, Parathyroid hormone-related protein regulates cell survival pathways via integrin alpha6beta4-mediated activation of phosphatidylinositol 3-kinase/Akt signaling, Mol. Cancer Res. MCR. 7 (2009) 1119–1131. https://doi.org/10.1158/1541-7786.MCR-08-0568.
[370] L. Bonaccorsi, V. Carloni, M. Muratori, A. Salvadori, A. Giannini, M. Carini, M. Serio, G. Forti, E. Baldi, Androgen receptor expression in prostate carcinoma cells suppresses alpha6beta4 integrin-mediated invasive phenotype, Endocrinology. 141 (2000) 3172–3182. https://doi.org/10.1210/endo.141.9.7640.
[371] O. Nagakawa, T. Akashi, Y. Hayakawa, A. Junicho, K. Koizumi, Y. Fujiuchi, Y. Furuya, T. Matsuda, H. Fuse, I. Saiki, Differential expression of integrin subunits in DU-145/AR prostate cancer cells, Oncol. Rep. 12 (2004) 837–841.
[372] J.G. Baust, D.P. Klossner, R.G. Vanbuskirk, A.A. Gage, V. Mouraviev, T.J. Polascik, J.M. Baust, Integrin involvement in freeze resistance of androgen-insensitive prostate cancer, Prostate Cancer Prostatic Dis. 13 (2010) 151–161. https://doi.org/10.1038/pcan.2009.59.

[373] K. Raymond, M. Kreft, J.-Y. Song, H. Janssen, A. Sonnenberg, Dual Role of alpha6beta4 integrin in epidermal tumor growth: tumor-suppressive versus tumor-promoting function, Mol. Biol. Cell. 18 (2007) 4210–4221. https://doi.org/10.1091/mbc.E06-08-0720.

[374] T. Mohri, Y. Adachi, S. Ikehara, K. Hioki, R. Tokunaga, S. Taketani, Activated Rac1 selectively up-regulates the expression of integrin alpha6beta4 and induces cell adhesion and membrane ruffles of nonadherent colon cancer Colo201 cells, Exp. Cell Res. 253 (1999) 533–540. https://doi.org/10.1006/excr.1999.4720.

[375] G. Niu, T. Ye, L. Qin, P.M. Bourbon, C. Chang, S. Zhao, Y. Li, L. Zhou, P. Cui, I. Rabinovitz, A.M. Mercurio, D. Zhao, H. Zeng, Orphan nuclear receptor TR3/Nur77 improves wound healing by upregulating the expression of integrin β4, FASEB J. Off. Publ. Fed. Am. Soc. Exp. Biol. 29 (2015) 131–140. https://doi.org/10.1096/fj.14-257550.

[376] X. Shen, M. Falzon, PTH-related protein upregulates integrin alpha6beta4 expression and activates Akt in breast cancer cells, Exp. Cell Res. 312 (2006) 3822–3834. https://doi.org/10.1016/j.yexcr.2006.08.011.

[377] X. Shen, M. Falzon, PTH-related protein modulates PC-3 prostate cancer cell adhesion and integrin subunit profile, Mol. Cell. Endocrinol. 199 (2003) 165–177.

[378] W. Xuan, Y.-J. Li, G. Liu, Y. Ben-David, M.C. Archer, Interleukin-24 induces expression of beta4 integrin but suppresses anchorage-independent growth of rat mammary tumor cells by a mechanism that is independent of beta4, Mol. Cancer Res. MCR. 7 (2009) 433–442. https://doi.org/10.1158/1541-7786.MCR-08-0252.

[379] S.-O. Yoon, S. Shin, A.M. Mercurio, Ras stimulation of E2F activity and a consequent E2F regulation of integrin alpha6beta4 promote the invasion of breast carcinoma cells, Cancer Res. 66 (2006) 6288–6295. https://doi.org/10.1158/0008-5472.CAN-06-0826.

[380] K.M. Draheim, H.-B. Chen, Q. Tao, N. Moore, M. Roche, S. Lyle, ARRDC3 suppresses breast cancer progression by negatively regulating integrin beta4, Oncogene. 29 (2010) 5032–5047. https://doi.org/10.1038/onc.2010.250.

[381] J.M. Drake, J.M. Barnes, J.M. Madsen, F.E. Domann, C.S. Stipp, M.D. Henry, ZEB1 coordinately regulates laminin-332 and {beta}4 integrin expression altering the invasive phenotype of prostate cancer cells, J. Biol. Chem. 285 (2010) 33940–33948. https://doi.org/10.1074/jbc.M110.136044.

[382] C. Sharma, I. Rabinovitz, M.E. Hemler, Palmitoylation by DHHC3 is critical for the function, expression, and stability of integrin α6β4, Cell. Mol. Life Sci. CMLS. 69 (2012) 2233–2244. https://doi.org/10.1007/s00018-012-0924-6.

[383] A. Ferraro, C.K. Kontos, T. Boni, I. Bantounas, D. Siakouli, V. Kosmidou, M. Vlassi, Y. Spyridakis, I. Tsipras, G. Zografos, A. Pintzas, Epigenetic regulation of miR-21 in colorectal cancer: ITGB4 as a novel miR-21 target and a three-gene network (miR-21-ITGB4-PDCD4) as predictor of metastatic tumor potential, Epigenetics. 9 (2014) 129–141. https://doi.org/10.4161/epi.26842.

[384] P. Dentelli, M. Traversa, A. Rosso, G. Togliatto, C. Olgasi, C. Marchiò, P. Provero, A. Lembo, G. Bon, L. Annaratone, A. Sapino, R. Falcioni, M.F. Brizzi, miR-221/222 control luminal breast cancer tumor progression by regulating different targets, Cell Cycle Georget. Tex. 13 (2014) 1811–1826. https://doi.org/10.4161/cc.28758.

[385] P. Gandellini, V. Profumo, A. Casamichele, N. Fenderico, S. Borrelli, G. Petrovich, G. Santilli, M. Callari, M. Colecchia, S. Pozzi, M. De Cesare, M. Folini, R. Valdagni, R. Mantovani, N. Zaffaroni, miR-205 regulates basement membrane deposition in human prostate: implications for cancer development, Cell Death Differ. 19 (2012) 1750–1760. https://doi.org/10.1038/cdd.2012.56.

[386] A. Stallmach, B. von Lampe, H. Matthes, G. Bornhöft, E.O. Riecken, Diminished expression of integrin adhesion molecules on human colonic epithelial cells during the benign to malign tumour transformation, Gut. 33 (1992) 342–346.

[387] I. Sordat, F.T. Bosman, G. Dorta, P. Rousselle, D. Aberdam, A.L. Blum, B. Sordat, Differential expression of laminin-5 subunits and integrin receptors in human colorectal neoplasia, J. Pathol. 185 (1998) 44–52. https://doi.org/10.1002/(SICI)1096-9896(199805)185:1<44::AID-PATH46>3.0.CO;2-A.

[388] A.B. Dydensborg, I.C. Teller, J.-F. Groulx, N. Basora, F. Paré, E. Herring, R. Gauthier, D. Jean, J.-F. Beaulieu, Integrin alpha6Bbeta4 inhibits colon cancer cell proliferation and c-Myc activity, BMC Cancer. 9 (2009) 223. https://doi.org/10.1186/1471-2407-9-223.

[389] T. Tennenbaum, A.J. Belanger, A.B. Glick, R. Tamura, V. Quaranta, S.H. Yuspa, A splice variant of alpha 6 integrin is associated with malignant conversion in mouse skin tumorigenesis, Proc. Natl. Acad. Sci. U. S. A. 92 (1995) 7041–7045. https://doi.org/10.1073/pnas.92.15.7041.

[390] K. Friedrichs, P. Ruiz, F. Franke, I. Gille, H.J. Terpe, B.A. Imhof, High expression level of alpha 6 integrin in human breast carcinoma is correlated with reduced survival, Cancer Res. 55 (1995) 901–906.

[391] H.L. Goel, T. Gritsko, B. Pursell, C. Chang, L.D. Shultz, D.L. Greiner, J.H. Norum, R. Toftgard, L.M. Shaw, A.M. Mercurio, Regulated Splicing of the α6 Integrin Cytoplasmic Domain Determines the Fate of Breast Cancer Stem Cells, Cell Rep. 7 (2014) 747–761. https://doi.org/10.1016/j.celrep.2014.03.059.

[392] C. Chang, H.L. Goel, H. Gao, B. Pursell, L.D. Shultz, D.L. Greiner, S. Ingerpuu, M. Patarroyo, S. Cao, E. Lim, J. Mao, K.K. McKee, P.D. Yurchenco, A.M. Mercurio, A laminin 511 matrix is regulated by TAZ and functions as the ligand for the α6Bβ1 integrin to sustain breast cancer stem cells, Genes Dev. 29 (2015) 1–6. https://doi.org/10.1101/gad.253682.114.

[393] M.E. Hemler, C. Crouse, A. Sonnenberg, Association of the VLA alpha 6 subunit with a novel protein. A possible alternative to the common VLA beta 1 subunit on certain cell lines, J. Biol. Chem. 264 (1989) 6529–6535.

[394] X. Deng, Q. Li, J. Hoff, M. Novak, H. Yang, H. Jin, S.F. Erfani, C. Sharma, P. Zhou, I. Rabinovitz, A. Sonnenberg, Y. Yi, P. Zhou, C.S. Stipp, D.M. Kaetzel, M.E. Hemler, X.H. Yang, Integrin-Associated CD151 Drives ErbB2-Evoked Mammary Tumor Onset and Metastasis, Neoplasia N. Y. N. 14 (2012) 678–689.

[395] M. Franco, C. Muratori, S. Corso, E. Tenaglia, A. Bertotti, L. Capparuccia, L. Trusolino, P.M. Comoglio, L. Tamagnone, The tetraspanin CD151 is required for Met-dependent signaling and tumor cell growth, J. Biol. Chem. 285 (2010) 38756–38764. https://doi.org/10.1074/jbc.M110.145417.

[396] Q. Li, X.H. Yang, F. Xu, C. Sharma, H.-X. Wang, K. Knoblich, I. Rabinovitz, S.R. Granter, M.E. Hemler, Tetraspanin CD151 plays a key role in skin squamous cell carcinoma, Oncogene. 32 (2013) 1772–1783. https://doi.org/10.1038/onc.2012.205.

[397] K. Wilhelmsen, S.H.M. Litjens, I. Kuikman, C. Margadant, J. van Rheenen, A. Sonnenberg, Serine phosphorylation of the integrin beta4 subunit is necessary for epidermal growth factor receptor induced hemidesmosome disruption, Mol. Biol. Cell. 18 (2007) 3512–3522. https://doi.org/10.1091/mbc.E07-04-0306.

[398] M. Herlevsen, D.-S. Schmidt, K. Miyazaki, M. Zöller, The association of the tetraspanin D6.1A with the alpha6beta4 integrin supports cell motility and liver metastasis formation, J. Cell Sci. 116 (2003) 4373–4390. https://doi.org/10.1242/jcs.00760.

[399] B. Baudoux, D. Castanares-Zapatero, M. Leclercq-Smekens, N. Berna, Y. Poumay, The tetraspanin CD9 associates with the integrin alpha6beta4 in cultured human epidermal keratinocytes and is involved in cell motility, Eur. J. Cell Biol. 79 (2000) 41–51.

[400] S. Huang, C.S. Chen, D.E. Ingber, Control of cyclin D1, p27(Kip1), and cell cycle progression in human capillary endothelial cells by cell shape and cytoskeletal tension, Mol. Biol. Cell. 9 (1998) 3179–3193. https://doi.org/10.1091/mbc.9.11.3179.

[401] A.E. Aplin, S.A. Stewart, R.K. Assoian, R.L. Juliano, Integrin-mediated adhesion regulates ERK nuclear translocation and phosphorylation of Elk-1, J. Cell Biol. 153 (2001) 273–282. https://doi.org/10.1083/jcb.153.2.273.

[402] A.E. Aplin, B.P. Hogan, J. Tomeu, R.L. Juliano, Cell adhesion differentially regulates the nucleocytoplasmic distribution of active MAP kinases, J. Cell Sci. 115 (2002) 2781–2790.

[403] U. Dutta, L.M. Shaw, A key tyrosine (Y1494) in the beta4 integrin regulates multiple signaling pathways important for tumor development and progression, Cancer Res. 68 (2008) 8779–8787. https://doi.org/10.1158/0008-5472.CAN-08-2125.

[404] N. Alonso-García, I. García-Rubio, J.A. Manso, R.M. Buey, H. Urien, A. Sonnenberg, G. Jeschke, J.M. de Pereda, Combination of X-ray crystallography, SAXS and DEER to obtain the structure of the FnIII-3,4 domains of integrin α6β4, Acta Crystallogr. D Biol. Crystallogr. 71 (2015) 969–985. https://doi.org/10.1107/S1399004715002485.

[405] J. Koster, I. Kuikman, M. Kreft, A. Sonnenberg, Two different mutations in the cytoplasmic domain of the integrin beta 4 subunit in nonlethal forms of epidermolysis bullosa prevent interaction of beta 4 with plectin, J. Invest. Dermatol. 117 (2001) 1405–1411. https://doi.org/10.1046/j.0022-202x.2001.01567.x.

[406] J. Uitto, L. Pulkkinen, Molecular genetics of heritable blistering disorders, Arch. Dermatol. 137 (2001) 1458–1461. https://doi.org/10.1001/archderm.137.11.1458.

[407] R. van der Neut, P. Krimpenfort, J. Calafat, C.M. Niessen, A. Sonnenberg, Epithelial detachment due to absence of hemidesmosomes in integrin beta 4 null mice, Nat. Genet. 13 (1996) 366–369. https://doi.org/10.1038/ng0796-366.

[408] K. Andrä, H. Lassmann, R. Bittner, S. Shorny, R. Fässler, F. Propst, G. Wiche, Targeted inactivation of plectin reveals essential function in maintaining the integrity of skin, muscle, and heart cytoarchitecture, Genes Dev. 11 (1997) 3143–3156.

[409] K. Ohkura, H. Hori, H. Terada, Effect of extracellular calcium on the intracellular calcium level of newborn rat skin basal cells, Biol. Pharm. Bull. 21 (1998) 1–4. https://doi.org/10.1248/bpb.21.1.

[410] T. Kashyap, I. Rabinovitz, The calcium/calcineurin pathway promotes hemidesmosome stability through inhibition of β4 integrin phosphorylation, J. Biol. Chem. 287 (2012) 32440–32449. https://doi.org/10.1074/jbc.M112.385245.

[411] E. Rozengurt, O. Rey, R.T. Waldron, Protein kinase D signaling, J. Biol. Chem. 280 (2005) 13205–13208. https://doi.org/10.1074/jbc.R500002200.

[412] G.P. Sapkota, L. Cummings, F.S. Newell, C. Armstrong, J. Bain, M. Frodin, M. Grauert, M. Hoffmann, G. Schnapp, M. Steegmaier, P. Cohen, D.R. Alessi, BI-D1870 is a specific inhibitor of the p90 RSK (ribosomal S6 kinase) isoforms in vitro and in vivo, Biochem. J. 401 (2007) 29–38. https://doi.org/10.1042/BJ20061088.

[413] P. Storz, H. Döppler, A. Toker, Protein kinase Cdelta selectively regulates protein kinase D-dependent activation of NF-kappaB in oxidative stress signaling, Mol. Cell. Biol. 24 (2004) 2614–2626. https://doi.org/10.1128/mcb.24.7.2614-2626.2004.

[414] J.L. Zugaza, J. Sinnett-Smith, J. Van Lint, E. Rozengurt, Protein kinase D (PKD) activation in intact cells through a protein kinase C-dependent signal transduction pathway., EMBO J. 15 (1996) 6220–6230.

[415] R.T. Waldron, T. Iglesias, E. Rozengurt, The pleckstrin homology domain of protein kinase D interacts preferentially with the eta isoform of protein kinase C, J. Biol. Chem. 274 (1999) 9224–9230. https://doi.org/10.1074/jbc.274.14.9224.

[416] A. Alt, M. Gartsbein, M. Ohba, T. Kuroki, T. Tennenbaum, Differential regulation of alpha6beta4 integrin by PKC isoforms in murine skin keratinocytes, Biochem. Biophys. Res. Commun. 314 (2004) 17–23. https://doi.org/10.1016/j.bbrc.2003.12.053.

[417] R. Anjum, J. Blenis, The RSK family of kinases: emerging roles in cellular signalling, Nat. Rev. Mol. Cell Biol. 9 (2008) 747–758. https://doi.org/10.1038/nrm2509.

[418] S. Kamakura, T. Moriguchi, E. Nishida, Activation of the protein kinase ERK5/BMK1 by receptor tyrosine kinases. Identification and characterization of a signaling pathway to the nucleus, J. Biol. Chem. 274 (1999) 26563–26571.

[419] K. Dokladda, K.A. Green, D.A. Pan, D.G. Hardie, PD98059 and U0126 activate AMP-activated protein kinase by increasing the cellular AMP:ATP ratio and not via inhibition of the MAP kinase pathway, FEBS Lett. 579 (2005) 236–240. https://doi.org/10.1016/j.febslet.2004.11.084.

[420] F. Rusnak, P. Mertz, Calcineurin: form and function, Physiol. Rev. 80 (2000) 1483–1521. https://doi.org/10.1152/physrev.2000.80.4.1483.

[421] Q.S. Ji, G. Carpenter, Role of basal calcium in the EGF activation of MAP kinases, Oncogene. 19 (2000) 1853–1856. https://doi.org/10.1038/sj.onc.1203517.

[422] T.A. Millward, S. Zolnierowicz, B.A. Hemmings, Regulation of protein kinase cascades by protein phosphatase 2A, Trends Biochem. Sci. 24 (1999) 186–191. https://doi.org/10.1016/s0968-0004(99)01375-4.
[423] K. Seltmann, W. Roth, C. Kröger, F. Loschke, M. Lederer, S. Hüttelmaier, T.M. Magin, Keratins mediate localization of hemidesmosomes and repress cell motility, J. Invest. Dermatol. 133 (2013) 181–190. https://doi.org/10.1038/jid.2012.256.
[424] D.J. Giard, S.A. Aaronson, G.J. Todaro, P. Arnstein, J.H. Kersey, H. Dosik, W.P. Parks, In vitro cultivation of human tumors: establishment of cell lines derived from a series of solid tumors, J. Natl. Cancer Inst. 51 (1973) 1417–1423. https://doi.org/10.1093/jnci/51.5.1417.
[425] S. Bolte, F.P. Cordelières, A guided tour into subcellular colocalization analysis in light microscopy, J. Microsc. 224 (2006) 213–232. https://doi.org/10.1111/j.1365-2818.2006.01706.x.
[426] Mechanisms of receptor tyrosine kinase activation in cancer | Molecular Cancer | Full Text, (2018) 58. https://doi.org/10.1186/s12943-018-0782-4.
[427] H. Hamidi, J. Ivaska, Every step of the way: integrins in cancer progression and metastasis, Nat. Rev. Cancer. 18 (2018) 533–548. https://doi.org/10.1038/s41568-018-0038-z.
[428] S. Kajiji, R.N. Tamura, V. Quaranta, A novel integrin (alpha E beta 4) from human epithelial cells suggests a fourth family of integrin adhesion receptors, EMBO J. 8 (1989) 673–680.
[429] A. Sonnenberg, J. Calafat, H. Janssen, H. Daams, L.M. van der Raaij-Helmer, R. Falcioni, S.J. Kennel, J.D. Aplin, J. Baker, M. Loizidou, Integrin alpha 6/beta 4 complex is located in hemidesmosomes, suggesting a major role in epidermal cell-basement membrane adhesion, J. Cell Biol. 113 (1991) 907–917. https://doi.org/10.1083/jcb.113.4.907.
[430] V. Ramovs, L. Te Molder, A. Sonnenberg, The opposing roles of laminin-binding integrins in cancer, Matrix Biol. J. Int. Soc. Matrix Biol. (2016). https://doi.org/10.1016/j.matbio.2016.08.007.
[431] R.L. Stewart, K.L. O'Connor, Clinical significance of the integrin α6β4 in human malignancies, Lab. Investig. J. Tech. Methods Pathol. 95 (2015) 976–986. https://doi.org/10.1038/labinvest.2015.82.
[432] X. Meng, P. Liu, Y. Wu, X. Liu, Y. Huang, B. Yu, J. Han, H. Jin, X. Tan, Integrin beta 4 (ITGB4) and its tyrosine-1510 phosphorylation promote pancreatic tumorigenesis and regulate the MEK1-ERK1/2 signaling pathway, Bosn. J. Basic Med. Sci. (2019). https://doi.org/10.17305/bjbms.2019.4255.
[433] M. Dans, L. Gagnoux-Palacios, P. Blaikie, S. Klein, A. Mariotti, F.G. Giancotti, Tyrosine phosphorylation of the beta 4 integrin cytoplasmic domain mediates Shc signaling to extracellular signal-regulated kinase and antagonizes formation of hemidesmosomes, J. Biol. Chem. 276 (2001) 1494–1502. https://doi.org/10.1074/jbc.M008663200.
[434] F.G. Giancotti, E. Ruoslahti, Integrin signaling, Science. 285 (1999) 1028–1032.
[435] C. Murgia, P. Blaikie, N. Kim, M. Dans, H.T. Petrie, F.G. Giancotti, Cell cycle and adhesion defects in mice carrying a targeted deletion of the integrin beta4 cytoplasmic domain, EMBO J. 17 (1998) 3940–3951. https://doi.org/10.1093/emboj/17.14.3940.
[436] F. Mainiero, A. Pepe, K.K. Wary, L. Spinardi, M. Mohammadi, J. Schlessinger, F.G. Giancotti, Signal transduction by the alpha 6 beta 4 integrin: distinct beta 4 subunit sites mediate recruitment of Shc/Grb2 and association with the cytoskeleton of hemidesmosomes, EMBO J. 14 (1995) 4470–4481.
[437] L.M. Shaw, Identification of insulin receptor substrate 1 (IRS-1) and IRS-2 as signaling intermediates in the alpha6beta4 integrin-dependent activation of phosphoinositide 3-OH kinase and promotion of invasion, Mol. Cell. Biol. 21 (2001) 5082–5093. https://doi.org/10.1128/MCB.21.15.5082-5093.2001.
[438] F.G. Giancotti, Signal transduction by the $\alpha_6\beta_4$ integrin: charting the path between laminin binding and nuclear events, J. Cell Sci. 109 (1996) 1165.
[439] K. Oda, Y. Matsuoka, A. Funahashi, H. Kitano, A comprehensive pathway map of epidermal growth factor receptor signaling, Mol. Syst. Biol. 1 (2005) 2005.0010. https://doi.org/10.1038/msb4100014.
[440] F.-L. Zhao, C.-F. Qin, EGF promotes HIF-1α expression in colorectal cancer cells and tumor metastasis by regulating phosphorylation of STAT3, Eur. Rev. Med. Pharmacol. Sci. 23 (2019) 1055–1062. https://doi.org/10.26355/eurrev_201902_16993.

[441] M. Duan, X. Du, G. Ren, Y. Zhang, Y. Zheng, S. Sun, J. Zhang, Obovatol inhibits the growth and aggressiveness of tongue squamous cell carcinoma through regulation of the EGF-mediated JAK-STAT signaling pathway, Mol. Med. Rep. 18 (2018) 1651–1659. https://doi.org/10.3892/mmr.2018.9078.

[442] S.L.J. Knudsen, A.S.W. Mac, L. Henriksen, B. van Deurs, L.M. Grøvdal, EGFR signaling patterns are regulated by its different ligands, Growth Factors Chur Switz. 32 (2014) 155–163. https://doi.org/10.3109/08977194.2014.952410.

[443] PhosphoSitePlus, 2014: mutations, PTMs and recalibrations. - PubMed - NCBI, (n.d.). https://www.ncbi.nlm.nih.gov/pubmed/25514926 (accessed January 11, 2020).

[444] E. Dellambra, S. Prislei, A.L. Salvati, M.L. Madeddu, O. Golisano, E. Siviero, S. Bondanza, S. Cicuzza, A. Orecchia, F.G. Giancotti, G. Zambruno, M. De Luca, Gene correction of integrin beta4-dependent pyloric atresia-junctional epidermolysis bullosa keratinocytes establishes a role for beta4 tyrosines 1422 and 1440 in hemidesmosome assembly, J. Biol. Chem. 276 (2001) 41336–41342. https://doi.org/10.1074/jbc.M103139200.

[445] W. Guo, Y. Pylayeva, A. Pepe, T. Yoshioka, W.J. Muller, G. Inghirami, F.G. Giancotti, Beta 4 integrin amplifies ErbB2 signaling to promote mammary tumorigenesis, Cell. 126 (2006) 489–502. https://doi.org/10.1016/j.cell.2006.05.047.

[446] S.M. Thomas, J.S. Brugge, Cellular functions regulated by Src family kinases, Annu. Rev. Cell Dev. Biol. 13 (1997) 513–609. https://doi.org/10.1146/annurev.cellbio.13.1.513.

[447] K.B. Runkle, A. Kharbanda, E. Stypulkowski, X.-J. Cao, W. Wang, B.A. Garcia, E.S. Witze, Inhibition of DHHC20-Mediated EGFR Palmitoylation Creates a Dependence on EGFR Signaling, Mol. Cell. 62 (2016) 385–396. https://doi.org/10.1016/j.molcel.2016.04.003.

[448] M. Koegl, P. Zlatkine, S.C. Ley, S.A. Courtneidge, A.I. Magee, Palmitoylation of multiple Src-family kinases at a homologous N-terminal motif, Biochem. J. 303 (Pt 3) (1994) 749–753. https://doi.org/10.1042/bj3030749.

[449] T. Honda, S. Soeda, K. Tsuda, C. Yamaguchi, K. Aoyama, T. Morinaga, R. Yuki, Y. Nakayama, N. Yamaguchi, N. Yamaguchi, Protective role for lipid modifications of Src-family kinases against chromosome missegregation, Sci. Rep. 6 (2016) 38751. https://doi.org/10.1038/srep38751.

[450] X. Yang, C. Claas, S.-K. Kraeft, L.B. Chen, Z. Wang, J.A. Kreidberg, M.E. Hemler, Palmitoylation of Tetraspanin Proteins: Modulation of CD151 Lateral Interactions, Subcellular Distribution, and Integrin-dependent Cell Morphology, Mol. Biol. Cell. 13 (2002) 767–781. https://doi.org/10.1091/mbc.01-05-0275.

[451] K.D. Merdek, X. Yang, C.A. Taglienti, L.M. Shaw, A.M. Mercurio, Intrinsic signaling functions of the beta4 integrin intracellular domain, J. Biol. Chem. 282 (2007) 30322–30330. https://doi.org/10.1074/jbc.M703156200.

[452] P. Chen, H. Xie, A. Wells, Mitogenic signaling from the egf receptor is attenuated by a phospholipase C-gamma/protein kinase C feedback mechanism, Mol. Biol. Cell. 7 (1996) 871–881. https://doi.org/10.1091/mbc.7.6.871.

[453] T. Kawamoto, J.D. Sato, A. Le, J. Polikoff, G.H. Sato, J. Mendelsohn, Growth stimulation of A431 cells by epidermal growth factor: identification of high-affinity receptors for epidermal growth factor by an anti-receptor monoclonal antibody, Proc. Natl. Acad. Sci. U. S. A. 80 (1983) 1337–1341. https://doi.org/10.1073/pnas.80.5.1337.

[454] D.W. Barnes, Epidermal growth factor inhibits growth of A431 human epidermoid carcinoma in serum-free cell culture, J. Cell Biol. 93 (1982) 1–4. https://doi.org/10.1083/jcb.93.1.1.

[455] M. Silvy, P.M. Martin, N. Chajry, Y. Berthois, Differential dose-dependent effects of epidermal growth factor on gene expression in A431 cells: evidence for a signal transduction pathway that can bypass Raf-1 activation, Endocrinology. 139 (1998) 2382–2391. https://doi.org/10.1210/endo.139.5.5981.

[456] W. Wang, A. Zuidema, L. Te Molder, L. Nahidiazar, L. Hoekman, T. Schmidt, S. Coppola, A. Sonnenberg, Hemidesmosomes modulate force generation via focal adhesions, J. Cell Biol. 219 (2020). https://doi.org/10.1083/jcb.201904137.

[457] A. Riedl, M. Schlederer, K. Pudelko, M. Stadler, S. Walter, D. Unterleuthner, C. Unger, N. Kramer, M. Hengstschläger, L. Kenner, D. Pfeiffer, G. Krupitza, H. Dolznig, Comparison of cancer cells in 2D vs 3D culture reveals differences in AKT-mTOR-S6K signaling and drug responses, J. Cell Sci. 130 (2017) 203–218. https://doi.org/10.1242/jcs.188102.

[458] S.N. Nikolopoulos, P. Blaikie, T. Yoshioka, W. Guo, F.G. Giancotti, Integrin beta4 signaling promotes tumor angiogenesis, Cancer Cell. 6 (2004) 471–483. https://doi.org/10.1016/j.ccr.2004.09.029.

[459] A. Plotnikov, E. Zehorai, S. Procaccia, R. Seger, The MAPK cascades: signaling components, nuclear roles and mechanisms of nuclear translocation, Biochim. Biophys. Acta. 1813 (2011) 1619–1633. https://doi.org/10.1016/j.bbamcr.2010.12.012.

[460] M. Korc, C.A. Haussler, N.S. Trookman, Divergent effects of epidermal growth factor and transforming growth factors on a human endometrial carcinoma cell line, Cancer Res. 47 (1987) 4909–4914.

[461] R.A. Klinghoffer, C. Sachsenmaier, J.A. Cooper, P. Soriano, Src family kinases are required for integrin but not PDGFR signal transduction, EMBO J. 18 (1999) 2459–2471. https://doi.org/10.1093/emboj/18.9.2459.

[462] J. Mitchell, S.J. Kim, A. Seelmann, B. Veit, B. Shepard, E. Im, S.H. Rhee, Src family kinase tyrosine phosphorylates Toll-like receptor 4 to dissociate MyD88 and Mal/Tirap, suppressing LPS-induced inflammatory responses, Biochem. Pharmacol. 147 (2018) 119–127. https://doi.org/10.1016/j.bcp.2017.11.015.

[463] J. Bain, L. Plater, M. Elliott, N. Shpiro, C.J. Hastie, H. McLauchlan, I. Klevernic, J.S.C. Arthur, D.R. Alessi, P. Cohen, The selectivity of protein kinase inhibitors: a further update, Biochem. J. 408 (2007) 297–315. https://doi.org/10.1042/BJ20070797.

[464] H.J. Shim, H.I. Kim, S.-T. Lee, The associated pyrazolopyrimidines PP1 and PP2 inhibit protein tyrosine kinase 6 activity and suppress breast cancer cell proliferation, Oncol. Lett. 13 (2017) 1463–1469. https://doi.org/10.3892/ol.2017.5564.

[465] L. Te Molder, J. Juksar, R. Harkes, W. Wang, M. Kreft, A. Sonnenberg, Tetraspanin CD151 and integrin α3β1 contribute to the stabilization of integrin α6β4-containing cell-matrix adhesions, J. Cell Sci. 132 (2019). https://doi.org/10.1242/jcs.235366.

[466] L. Te Molder, A. Sonnenberg, PKD2 and RSK1 Regulate Integrin β4 Phosphorylation at Threonine 1736, PloS One. 10 (2015) e0143357. https://doi.org/10.1371/journal.pone.0143357.

[467] L. Fontao, S. Dirrig, K. Owaribe, M. Kedinger, J.F. Launay, Polarized expression of HD1: relationship with the cytoskeleton in cultured human colonic carcinoma cells, Exp. Cell Res. 231 (1997) 319–327. https://doi.org/10.1006/excr.1996.3465.

[468] W.H. McLean, L. Pulkkinen, F.J. Smith, E.L. Rugg, E.B. Lane, F. Bullrich, R.E. Burgeson, S. Amano, D.L. Hudson, K. Owaribe, J.A. McGrath, J.R. McMillan, R.A. Eady, I.M. Leigh, A.M. Christiano, J. Uitto, Loss of plectin causes epidermolysis bullosa with muscular dystrophy: cDNA cloning and genomic organization, Genes Dev. 10 (1996) 1724–1735.

[469] H. Nakamura, D. Sawamura, M. Goto, H. Nakamura, J.R. McMillan, S. Park, S. Kono, S. Hasegawa, S. Paku, T. Nakamura, Y. Ogiso, H. Shimizu, Epidermolysis bullosa simplex associated with pyloric atresia is a novel clinical subtype caused by mutations in the plectin gene (PLEC1), J. Mol. Diagn. JMD. 7 (2005) 28–35. https://doi.org/10.1016/S1525-1578(10)60005-0.

[470] R.W. Groves, L. Liu, P.J. Dopping-Hepenstal, H.S. Markus, P.A. Lovell, L. Ozoemena, J.E. Lai-Cheong, J. Gawler, K. Owaribe, T. Hashimoto, J.E. Mellerio, J.B. Mee, J.A. McGrath, A homozygous nonsense mutation within the dystonin gene coding for the coiled-coil domain of the epithelial isoform of BPAG1 underlies a new subtype of autosomal recessive epidermolysis bullosa simplex, J. Invest. Dermatol. 130 (2010) 1551–1557. https://doi.org/10.1038/jid.2010.19.

[471] M.F. Jonkman, M.C. de Jong, K. Heeres, H.H. Pas, J.B. van der Meer, K. Owaribe, A.M. Martinez de Velasco, C.M. Niessen, A. Sonnenberg, 180-kD bullous pemphigoid antigen (BP180) is deficient in generalized atrophic benign epidermolysis bullosa, J. Clin. Invest. 95 (1995) 1345–1352. https://doi.org/10.1172/JCI117785.

[472] L. Liu, P.J. Dopping-Hepenstal, P.A. Lovell, M. Michael, H. Horn, K. Fong, J.E. Lai-Cheong, J.E. Mellerio, M. Parsons, J.A. McGrath, Autosomal recessive epidermolysis bullosa simplex due to loss of BPAG1-e expression, J. Invest. Dermatol. 132 (2012) 742–744. https://doi.org/10.1038/jid.2011.379.

[473] J.R. McMillan, J.A. McGrath, M.J. Tidman, R.A. Eady, Hemidesmosomes show abnormal association with the keratin filament network in junctional forms of epidermolysis bullosa, J. Invest. Dermatol. 110 (1998) 132–137. https://doi.org/10.1046/j.1523-1747.1998.00102.x.

[474] V.K. Crew, N. Burton, A. Kagan, C.A. Green, C. Levene, F. Flinter, R.L. Brady, G. Daniels, D.J. Anstee, CD151, the first member of the tetraspanin (TM4) superfamily detected on erythrocytes, is essential for the correct assembly of human basement membranes in kidney and skin, Blood. 104 (2004) 2217–2223. https://doi.org/10.1182/blood-2004-04-1512.

[475] A. Kagan, S. Feld, J. Chemke, Y. Bar-Khayim, Occurrence of hereditary nephritis, pretibial epidermolysis bullosa and beta-thalassemia minor in two siblings with end-stage renal disease, Nephron. 49 (1988) 331–332. https://doi.org/10.1159/000185086.

[476] H. Vahidnezhad, L. Youssefian, A.H. Saeidian, H. Mahmoudi, A. Touati, M. Abiri, A.-M. Kajbafzadeh, S. Aristodemou, L. Liu, J.A. McGrath, A. Ertel, E. Londin, A. Kariminejad, S. Zeinali, P. Fortina, J. Uitto, Recessive mutation in tetraspanin CD151 causes Kindler syndrome-like epidermolysis bullosa with multi-systemic manifestations including nephropathy, Matrix Biol. J. Int. Soc. Matrix Biol. 66 (2018) 22–33. https://doi.org/10.1016/j.matbio.2017.11.003.

[477] J. Dowling, Q.C. Yu, E. Fuchs, Beta4 integrin is required for hemidesmosome formation, cell adhesion and cell survival, J. Cell Biol. 134 (1996) 559–572. https://doi.org/10.1083/jcb.134.2.559.

[478] L. Guo, L. Degenstein, J. Dowling, Q.C. Yu, R. Wollmann, B. Perman, E. Fuchs, Gene targeting of BPAG1: abnormalities in mechanical strength and cell migration in stratified epithelia and neurologic degeneration, Cell. 81 (1995) 233–243. https://doi.org/10.1016/0092-8674(95)90333-x.

[479] N. Sachs, M. Kreft, M.A. van den Bergh Weerman, A.J. Beynon, T.A. Peters, J.J. Weening, A. Sonnenberg, Kidney failure in mice lacking the tetraspanin CD151, J. Cell Biol. 175 (2006) 33–39. https://doi.org/10.1083/jcb.200603073.

[480] M.D. Wright, S.M. Geary, S. Fitter, G.W. Moseley, L.-M. Lau, K.-C. Sheng, V. Apostolopoulos, E.G. Stanley, D.E. Jackson, L.K. Ashman, Characterization of Mice Lacking the Tetraspanin Superfamily Member CD151, Mol. Cell. Biol. 24 (2004) 5978–5988. https://doi.org/10.1128/MCB.24.13.5978-5988.2004.

[481] F. Berditchevski, Complexes of tetraspanins with integrins: more than meets the eye, J. Cell Sci. 114 (2001) 4143–4151.

[482] C.M. Termini, J.M. Gillette, Tetraspanins Function as Regulators of Cellular Signaling, Front. Cell Dev. Biol. 5 (2017) 34. https://doi.org/10.3389/fcell.2017.00034.

[483] R.A. Underwood, W.G. Carter, M.L. Usui, J.E. Olerud, Ultrastructural Localization of Integrin Subunits β4 and α3 Within the Migrating Epithelial Tongue of In Vivo Human Wounds, J. Histochem. Cytochem. 57 (2009) 123–142. https://doi.org/10.1369/jhc.2008.952176.

[484] X.P. Zhang, W. Puzon-McLaughlin, A. Irie, N. Kovach, N.L. Prokopishyn, S. Laferté, K. Takeuchi, T. Tsuji, Y. Takada, Alpha 3 beta 1 adhesion to laminin-5 and invasin: critical and differential role of integrin residues clustered at the boundary between alpha 3 N-terminal repeats 2 and 3, Biochemistry. 38 (1999) 14424–14431. https://doi.org/10.1021/bi990323b.

[485] X. Yang, C. Claas, S.-K. Kraeft, L.B. Chen, Z. Wang, J.A. Kreidberg, M.E. Hemler, Palmitoylation of tetraspanin proteins: modulation of CD151 lateral interactions, subcellular distribution, and integrin-dependent cell morphology, Mol. Biol. Cell. 13 (2002) 767–781. https://doi.org/10.1091/mbc.01-05-0275.

[486] F. Berditchevski, E. Odintsova, S. Sawada, E. Gilbert, Expression of the palmitoylation-deficient CD151 weakens the association of alpha 3 beta 1 integrin with the tetraspanin-enriched microdomains and affects integrin-dependent signaling, J. Biol. Chem. 277 (2002) 36991–37000. https://doi.org/10.1074/jbc.M205265200.

[487] M.G. Nievers, I. Kuikman, D. Geerts, I.M. Leigh, A. Sonnenberg, Formation of hemidesmosome-like structures in the absence of ligand binding by the (alpha)6(beta)4 integrin requires binding of HD1/plectin to the cytoplasmic domain of the (beta)4 integrin subunit, J. Cell Sci. 113 (Pt 6) (2000) 963–973.
[488] E. Puklin-Faucher, M.P. Sheetz, The mechanical integrin cycle, J. Cell Sci. 122 (2009) 179–186. https://doi.org/10.1242/jcs.042127.
[489] D. Boettiger, Quantitative measurements of integrin-mediated adhesion to extracellular matrix, Methods Enzymol. 426 (2007) 1–25. https://doi.org/10.1016/S0076-6879(07)26001-X.
[490] P.M. Sincock, G. Mayrhofer, L.K. Ashman, Localization of the transmembrane 4 superfamily (TM4SF) member PETA-3 (CD151) in normal human tissues: comparison with CD9, CD63, and alpha5beta1 integrin, J. Histochem. Cytochem. Off. J. Histochem. Soc. 45 (1997) 515–525. https://doi.org/10.1177/002215549704500404.
[491] M. Michael, R. Begum, K. Fong, C. Pourreyron, C. Pourreyrone, A.P. South, J.A. McGrath, M. Parsons, BPAG1-e restricts keratinocyte migration through control of adhesion stability, J. Invest. Dermatol. 134 (2014) 773–782. https://doi.org/10.1038/jid.2013.382.
[492] X. Yang, O.V. Kovalenko, W. Tang, C. Claas, C.S. Stipp, M.E. Hemler, Palmitoylation supports assembly and function of integrin-tetraspanin complexes, J. Cell Biol. 167 (2004) 1231–1240. https://doi.org/10.1083/jcb.200404100.
[493] F.J.A. Conti, R.J. Rudling, A. Robson, K.M. Hodivala-Dilke, alpha3beta1-integrin regulates hair follicle but not interfollicular morphogenesis in adult epidermis, J. Cell Sci. 116 (2003) 2737–2747. https://doi.org/10.1242/jcs.00475.
[494] C. Brakebusch, R. Grose, F. Quondamatteo, A. Ramirez, J.L. Jorcano, A. Pirro, M. Svensson, R. Herken, T. Sasaki, R. Timpl, S. Werner, R. Fässler, Skin and hair follicle integrity is crucially dependent on beta 1 integrin expression on keratinocytes, EMBO J. 19 (2000) 3990–4003. https://doi.org/10.1093/emboj/19.15.3990.
[495] H. Qu, T. Wen, M. Pesch, M. Aumailley, Partial loss of epithelial phenotype in kindlin-1-deficient keratinocytes, Am. J. Pathol. 180 (2012) 1581–1592. https://doi.org/10.1016/j.ajpath.2012.01.005.
[496] S. Raghavan, C. Bauer, G. Mundschau, Q. Li, E. Fuchs, Conditional ablation of beta1 integrin in skin. Severe defects in epidermal proliferation, basement membrane formation, and hair follicle invagination, J. Cell Biol. 150 (2000) 1149–1160.
[497] V.A. Blomen, P. Májek, L.T. Jae, J.W. Bigenzahn, J. Nieuwenhuis, J. Staring, R. Sacco, F.R. van Diemen, N. Olk, A. Stukalov, C. Marceau, H. Janssen, J.E. Carette, K.L. Bennett, J. Colinge, G. Superti-Furga, T.R. Brummelkamp, Gene essentiality and synthetic lethality in haploid human cells, Science. 350 (2015) 1092–1096. https://doi.org/10.1126/science.aac7557.
[498] J. Kirfel, T.M. Magin, J. Reichelt, Keratins: a structural scaffold with emerging functions, Cell. Mol. Life Sci. CMLS. 60 (2003) 56–71. https://doi.org/10.1007/s000180300004.
[499] L. Blanchoin, R. Boujemaa-Paterski, C. Sykes, J. Plastino, Actin dynamics, architecture, and mechanics in cell motility, Physiol. Rev. 94 (2014) 235–263. https://doi.org/10.1152/physrev.00018.2013.
[500] C. Has, L. Bruckner-Tuderman, The genetics of skin fragility, Annu. Rev. Genomics Hum. Genet. 15 (2014) 245–268. https://doi.org/10.1146/annurev-genom-090413-025540.
[501] E.R. Horton, A. Byron, J.A. Askari, D.H.J. Ng, A. Millon-Frémillon, J. Robertson, E.J. Koper, N.R. Paul, S. Warwood, D. Knight, J.D. Humphries, M.J. Humphries, Definition of a consensus integrin adhesome and its dynamics during adhesion complex assembly and disassembly, Nat. Cell Biol. 17 (2015) 1577–1587. https://doi.org/10.1038/ncb3257.
[502] Y. Mimori-Kiyosue, I. Grigoriev, G. Lansbergen, H. Sasaki, C. Matsui, F. Severin, N. Galjart, F. Grosveld, I. Vorobjev, S. Tsukita, A. Akhmanova, CLASP1 and CLASP2 bind to EB1 and regulate microtubule plus-end dynamics at the cell cortex, J. Cell Biol. 168 (2005) 141–153. https://doi.org/10.1083/jcb.200405094.
[503] G. Lansbergen, I. Grigoriev, Y. Mimori-Kiyosue, T. Ohtsuka, S. Higa, I. Kitajima, J. Demmers, N. Galjart, A.B. Houtsmuller, F. Grosveld, A. Akhmanova, CLASPs attach microtubule plus ends to the cell cortex through a complex with LL5beta, Dev. Cell. 11 (2006) 21–32. https://doi.org/10.1016/j.devcel.2006.05.012.

[504] A. Akhmanova, M.O. Steinmetz, Tracking the ends: a dynamic protein network controls the fate of microtubule tips, Nat. Rev. Mol. Cell Biol. 9 (2008) 309–322. https://doi.org/10.1038/nrm2369.
[505] S.J. Stehbens, M. Paszek, H. Pemble, A. Ettinger, S. Gierke, T. Wittmann, CLASPs link focal-adhesion-associated microtubule capture to localized exocytosis and adhesion site turnover, Nat. Cell Biol. 16 (2014) 561–573. https://doi.org/10.1038/ncb2975.
[506] M. Dogterom, G.H. Koenderink, Actin-microtubule crosstalk in cell biology, Nat. Rev. Mol. Cell Biol. 20 (2019) 38–54. https://doi.org/10.1038/s41580-018-0067-1.
[507] A. Akhmanova, S.J. Stehbens, A.S. Yap, Touch, grasp, deliver and control: functional cross-talk between microtubules and cell adhesions, Traffic Cph. Den. 10 (2009) 268–274. https://doi.org/10.1111/j.1600-0854.2008.00869.x.
[508] O.C. Rodriguez, A.W. Schaefer, C.A. Mandato, P. Forscher, W.M. Bement, C.M. Waterman-Storer, Conserved microtubule-actin interactions in cell movement and morphogenesis, Nat. Cell Biol. 5 (2003) 599–609. https://doi.org/10.1038/ncb0703-599.
[509] K.J. Roux, D.I. Kim, M. Raida, B. Burke, A promiscuous biotin ligase fusion protein identifies proximal and interacting proteins in mammalian cells, J. Cell Biol. 196 (2012) 801–810. https://doi.org/10.1083/jcb.201112098.
[510] J.-M. Dong, F.P.-L. Tay, H.L.-F. Swa, J. Gunaratne, T. Leung, B. Burke, E. Manser, Proximity biotinylation provides insight into the molecular composition of focal adhesions at the nanometer scale, Sci. Signal. 9 (2016) rs4. https://doi.org/10.1126/scisignal.aaf3572.
[511] C.M. Van Itallie, A.J. Tietgens, A. Aponte, K. Fredriksson, A.S. Fanning, M. Gucek, J.M. Anderson, Biotin ligase tagging identifies proteins proximal to E-cadherin, including lipoma preferred partner, a regulator of epithelial cell-cell and cell-substrate adhesion, J. Cell Sci. 127 (2014) 885–895. https://doi.org/10.1242/jcs.140475.
[512] C.M. Van Itallie, A. Aponte, A.J. Tietgens, M. Gucek, K. Fredriksson, J.M. Anderson, The N and C termini of ZO-1 are surrounded by distinct proteins and functional protein networks, J. Biol. Chem. 288 (2013) 13775–13788. https://doi.org/10.1074/jbc.M113.466193.
[513] K. Fredriksson, C.M. Van Itallie, A. Aponte, M. Gucek, A.J. Tietgens, J.M. Anderson, Proteomic analysis of proteins surrounding occludin and claudin-4 reveals their proximity to signaling and trafficking networks, PloS One. 10 (2015) e0117074. https://doi.org/10.1371/journal.pone.0117074.
[514] S.-M. Myllymäki, U.-R. Kämäräinen, X. Liu, S.P. Cruz, S. Miettinen, M. Vuorela, M. Varjosalo, A. Manninen, Assembly of the β4-Integrin Interactome Based on Proximal Biotinylation in the Presence and Absence of Heterodimerization, Mol. Cell. Proteomics MCP. 18 (2019) 277–293. https://doi.org/10.1074/mcp.RA118.001095.
[515] C. Asperti, E. Pettinato, I. de Curtis, Liprin-alpha1 affects the distribution of low-affinity beta1 integrins and stabilizes their permanence at the cell surface, Exp. Cell Res. 316 (2010) 915–926. https://doi.org/10.1016/j.yexcr.2010.01.017.
[516] V. Astro, S. Chiaretti, E. Magistrati, M. Fivaz, I. de Curtis, Liprin-α1, ERC1 and LL5 define polarized and dynamic structures that are implicated in cell migration, J. Cell Sci. 127 (2014) 3862–3876. https://doi.org/10.1242/jcs.155663.
[517] G. Mana, F. Clapero, E. Panieri, V. Panero, R.T. Böttcher, H.-Y. Tseng, F. Saltarin, E. Astanina, K.I. Wolanska, M.R. Morgan, M.J. Humphries, M.M. Santoro, G. Serini, D. Valdembri, PPFIA1 drives active α5β1 integrin recycling and controls fibronectin fibrillogenesis and vascular morphogenesis, Nat. Commun. 7 (2016) 13546. https://doi.org/10.1038/ncomms13546.
[518] N. Balasubramanian, D.W. Scott, J.D. Castle, J.E. Casanova, M.A. Schwartz, Arf6 and microtubules in adhesion-dependent trafficking of lipid rafts, Nat. Cell Biol. 9 (2007) 1381–1391. https://doi.org/10.1038/ncb1657.
[519] N. Osmani, J. Pontabry, J. Comelles, N. Fekonja, J.G. Goetz, D. Riveline, E. Georges-Labouesse, M. Labouesse, An Arf6- and caveolae-dependent pathway links hemidesmosome remodeling and mechanoresponse, Mol. Biol. Cell. 29 (2018) 435–451. https://doi.org/10.1091/mbc.E17-06-0356.
[520] Y. Nakaya, E.W. Sukowati, Y. Wu, G. Sheng, RhoA and microtubule dynamics control cell-basement membrane interaction in EMT during gastrulation, Nat. Cell Biol. 10 (2008) 765–775. https://doi.org/10.1038/ncb1739.

[521] A. Hotta, T. Kawakatsu, T. Nakatani, T. Sato, C. Matsui, T. Sukezane, T. Akagi, T. Hamaji, I. Grigoriev, A. Akhmanova, Y. Takai, Y. Mimori-Kiyosue, Laminin-based cell adhesion anchors microtubule plus ends to the epithelial cell basal cortex through LL5alpha/beta, J. Cell Biol. 189 (2010) 901–917. https://doi.org/10.1083/jcb.200910095.

[522] O.E. Nekrasova, E.V. Amargo, W.O. Smith, J. Chen, G.E. Kreitzer, K.J. Green, Desmosomal cadherins utilize distinct kinesins for assembly into desmosomes, J. Cell Biol. 195 (2011) 1185–1203. https://doi.org/10.1083/jcb.201106057.

[523] A. Akhmanova, C.C. Hoogenraad, Microtubule plus-end-tracking proteins: mechanisms and functions, Curr. Opin. Cell Biol. 17 (2005) 47–54. https://doi.org/10.1016/j.ceb.2004.11.001.

[524] Y. Wen, C.H. Eng, J. Schmoranzer, N. Cabrera-Poch, E.J.S. Morris, M. Chen, B.J. Wallar, A.S. Alberts, G.G. Gundersen, EB1 and APC bind to mDia to stabilize microtubules downstream of Rho and promote cell migration, Nat. Cell Biol. 6 (2004) 820–830. https://doi.org/10.1038/ncb1160.

[525] S. Sakamoto, T. Ishizaki, K. Okawa, S. Watanabe, T. Arakawa, N. Watanabe, S. Narumiya, Liprin-α controls stress fiber formation by binding to mDia and regulating its membrane localization, J. Cell Sci. 125 (2012) 108–120. https://doi.org/10.1242/jcs.087411.

[526] S.A. Wickström, A. Lange, M.W. Hess, J. Polleux, J.P. Spatz, M. Krüger, K. Pfaller, A. Lambacher, W. Bloch, M. Mann, L.A. Huber, R. Fässler, Integrin-linked kinase controls microtubule dynamics required for plasma membrane targeting of caveolae, Dev. Cell. 19 (2010) 574–588. https://doi.org/10.1016/j.devcel.2010.09.007.

[527] A. Kodama, I. Karakesisoglou, E. Wong, A. Vaezi, E. Fuchs, ACF7: An essential integrator of microtubule dynamics, Cell. 115 (2003) 343–354. https://doi.org/10.1016/S0092-8674(03)00813-4.

[528] J.J. Moffat, M. Ka, E.-M. Jung, A.L. Smith, W.-Y. Kim, The role of MACF1 in nervous system development and maintenance, Semin. Cell Dev. Biol. 69 (2017) 9–17. https://doi.org/10.1016/j.semcdb.2017.05.020.

[529] B.P. Bouchet, R.E. Gough, Y.-C. Ammon, D. van de Willige, H. Post, G. Jacquemet, A.M. Altelaar, A.J. Heck, B.T. Goult, A. Akhmanova, Talin-KANK1 interaction controls the recruitment of cortical microtubule stabilizing complexes to focal adhesions, ELife. 5 (2016). https://doi.org/10.7554/eLife.18124.

[530] E.R. Horton, J.D. Humphries, J. James, M.C. Jones, J.A. Askari, M.J. Humphries, The integrin adhesome network at a glance, J. Cell Sci. (2016). https://doi.org/10.1242/jcs.192054.

[531] B. Favre, L. Fontao, J. Koster, R. Shafaatian, F. Jaunin, J.H. Saurat, A. Sonnenberg, L. Borradori, The hemidesmosomal protein bullous pemphigoid antigen 1 and the integrin beta 4 subunit bind to ERBIN. Molecular cloning of multiple alternative splice variants of ERBIN and analysis of their tissue expression, J. Biol. Chem. 276 (2001) 32427–32436. https://doi.org/10.1074/jbc.M011005200.

[532] I. Izawa, M. Nishizawa, Y. Tomono, K. Ohtakara, T. Takahashi, M. Inagaki, ERBIN associates with p0071, an armadillo protein, at cell-cell junctions of epithelial cells, Genes Cells Devoted Mol. Cell. Mech. 7 (2002) 475–485. https://doi.org/10.1046/j.1365-2443.2002.00533.x.

[533] C. Sharma, I. Rabinovitz, M.E. Hemler, Palmitoylation by DHHC3 is critical for the function, expression, and stability of integrin α6β4, Cell. Mol. Life Sci. CMLS. 69 (2012) 2233–2244. https://doi.org/10.1007/s00018-012-0924-6.

[534] J.L. Johnson, N. Winterwood, K.A. DeMali, C.S. Stipp, Tetraspanin CD151 regulates RhoA activation and the dynamic stability of carcinoma cell-cell contacts, J. Cell Sci. 122 (2009) 2263–2273. https://doi.org/10.1242/jcs.045997.

[535] A. Alt, M. Ohba, L. Li, M. Gartsbein, A. Belanger, M.F. Denning, T. Kuroki, S.H. Yuspa, T. Tennenbaum, Protein kinase Cdelta-mediated phosphorylation of alpha6beta4 is associated with reduced integrin localization to the hemidesmosome and decreased keratinocyte attachment, Cancer Res. 61 (2001) 4591–4598.

[536] Y. Kitajima, Y. Aoyama, M. Seishima, Transmembrane signaling for adhesive regulation of desmosomes and hemidesmosomes, and for cell-cell datachment induced by pemphigus IgG in cultured keratinocytes: involvement of protein kinase C, J. Investig. Dermatol. Symp. Proc. 4 (1999) 137–144. https://doi.org/10.1038/sj.jidsp.5640197.

[537] Y. Ni, X. Wang, X. Yin, Y. Li, X. Liu, H. Wang, X. Liu, J. Zhang, H. Gao, B. Shi, S. Zhao, Plectin protects podocytes from adriamycin-induced apoptosis and F-actin cytoskeletal disruption through the integrin α6β4/FAK/p38 MAPK pathway, J. Cell. Mol. Med. 22 (2018) 5450–5467. https://doi.org/10.1111/jcmm.13816.

[538] E.Y. Seo, S.-P. Jin, Y.K. Kim, H. Lee, S. Han, D.H. Lee, J.H. Chung, Integrin-β4-TNS4-Focal Adhesion Kinase Signaling Mediates Keratinocyte Proliferation in Human Skin, J. Invest. Dermatol. 137 (2017) 763–766. https://doi.org/10.1016/j.jid.2016.10.039.

[539] P.R. Sudhakaran, R.I. Viji, M.S. Kiran, V.B. Sameer Kumar, Endothelial cell-laminin interaction: modulation of LDH expression involves alpha6beta4 integrin-FAK-p38MAPK pathway, Glycoconj. J. 26 (2009) 697–704. https://doi.org/10.1007/s10719-008-9188-7.

[540] J. Payne, H. Gong, V. Trinkaus-Randall, Tyrosine phosphorylation: a critical component in the formation of hemidesmosomes, Cell Tissue Res. 300 (2000) 401–411.

[541] J.M. de Pereda, M.P. Lillo, A. Sonnenberg, Structural basis of the interaction between integrin alpha6beta4 and plectin at the hemidesmosomes, EMBO J. 28 (2009) 1180–1190. https://doi.org/10.1038/emboj.2009.48.

[542] L. te Molder, L. Hoekman, M. Kreft, O. Bleijerveld, A. Sonnenberg, Comparative interactomics analysis reveals potential regulators of α6β4 distribution in keratinocytes, Biol. Open. (2020). https://doi.org/10.1242/bio.054155.

[543] A. Kharbanda, D.M. Walter, A.A. Gudiel, N. Schek, D.M. Feldser, E.S. Witze, Blocking EGFR palmitoylation suppresses PI3K signaling and mutant KRAS lung tumorigenesis, Sci. Signal. 13 (2020). https://doi.org/10.1126/scisignal.aax2364.

[544] C. Sharma, X.H. Yang, M.E. Hemler, DHHC2 affects palmitoylation, stability, and functions of tetraspanins CD9 and CD151, Mol. Biol. Cell. 19 (2008) 3415–3425. https://doi.org/10.1091/mbc.e07-11-1164.

[545] S. Charrin, F. le Naour, O. Silvie, P.-E. Milhiet, C. Boucheix, E. Rubinstein, Lateral organization of membrane proteins: tetraspanins spin their web, Biochem. J. 420 (2009) 133–154. https://doi.org/10.1042/BJ20082422.

[546] M. Yáñez-Mó, O. Barreiro, M. Gordon-Alonso, M. Sala-Valdés, F. Sánchez-Madrid, Tetraspanin-enriched microdomains: a functional unit in cell plasma membranes, Trends Cell Biol. 19 (2009) 434–446. https://doi.org/10.1016/j.tcb.2009.06.004.

[547] N. Sachs, A. Sonnenberg, Cell–matrix adhesion of podocytes in physiology and disease, Nat. Rev. Nephrol. 9 (2013) 200–210. https://doi.org/10.1038/nrneph.2012.291.

[548] M.C. Ryan, K. Lee, Y. Miyashita, W.G. Carter, Targeted Disruption of the LAMA3 Gene in Mice Reveals Abnormalities in Survival and Late Stage Differentiation of Epithelial Cells, J. Cell Biol. 145 (1999) 1309–1324.

[549] L.E. Goldfinger, S.B. Hopkinson, G.W. deHart, S. Collawn, J.R. Couchman, J.C. Jones, The alpha3 laminin subunit, alpha6beta4 and alpha3beta1 integrin coordinately regulate wound healing in cultured epithelial cells and in the skin, J. Cell Sci. 112 (Pt 16) (1999) 2615–2629.

[550] E. Hintermann, V. Quaranta, Epithelial cell motility on laminin-5: regulation by matrix assembly, proteolysis, integrins and erbB receptors, Matrix Biol. J. Int. Soc. Matrix Biol. 23 (2004) 75–85. https://doi.org/10.1016/j.matbio.2004.03.001.

[551] T. Sadowski, S. Dietrich, F. Koschinsky, A. Ludwig, E. Proksch, B. Titz, R. Sedlacek, Matrix metalloproteinase 19 processes the laminin 5 gamma 2 chain and induces epithelial cell migration, Cell. Mol. Life Sci. CMLS. 62 (2005) 870–880. https://doi.org/10.1007/s00018-005-4478-8.

[552] L.E. Goldfinger, M.S. Stack, J.C. Jones, Processing of laminin-5 and its functional consequences: role of plasmin and tissue-type plasminogen activator, J. Cell Biol. 141 (1998) 255–265.

[553] C. Baudoin, L. Fantin, G. Meneguzzi, Proteolytic processing of the laminin alpha3 G domain mediates assembly of hemidesmosomes but has no role on keratinocyte migration, J. Invest. Dermatol. 125 (2005) 883–888. https://doi.org/10.1111/j.0022-202X.2005.23881.x.

[554] M.G. Nievers, R.Q. Schaapveld, L.C. Oomen, L. Fontao, D. Geerts, A. Sonnenberg, Ligand-independent role of the beta 4 integrin subunit in the formation of hemidesmosomes, J. Cell Sci. 111 (Pt 12) (1998) 1659–1672.

[555] S.M. Homan, A.M. Mercurio, S.E. LaFlamme, Endothelial cells assemble two distinct alpha6beta4-containing vimentin-associated structures: roles for ligand binding and the beta4 cytoplasmic tail, J. Cell Sci. 111 (Pt 18) (1998) 2717–2728.

[556] M. Sonawane, Y. Carpio, R. Geisler, H. Schwarz, H.-M. Maischein, C. Nuesslein-Volhard, Zebrafish penner/lethal giant larvae 2 functions in hemidesmosome formation, maintenance of cellular morphology and growth regulation in the developing basal epidermis, Dev. Camb. Engl. 132 (2005) 3255–3265. https://doi.org/10.1242/dev.01904.

[557] V. Vasioukhin, Lethal giant puzzle of Lgl, Dev. Neurosci. 28 (2006) 13–24. https://doi.org/10.1159/000090749.

[558] X. Zhang, P. Wang, A. Gangar, J. Zhang, P. Brennwald, D. TerBush, W. Guo, Lethal giant larvae proteins interact with the exocyst complex and are involved in polarized exocytosis, J. Cell Biol. 170 (2005) 273–283. https://doi.org/10.1083/jcb.200502055.

[559] P. Elias, S. Ahn, B. Brown, D. Crumrine, K.R. Feingold, Origin of the epidermal calcium gradient: regulation by barrier status and role of active vs passive mechanisms, J. Invest. Dermatol. 119 (2002) 1269–1274. https://doi.org/10.1046/j.1523-1747.2002.19622.x.

[560] S.E. Lee, S.H. Lee, Skin Barrier and Calcium, Ann. Dermatol. 30 (2018) 265–275. https://doi.org/10.5021/ad.2018.30.3.265.

[561] S.H. Lee, P.M. Elias, E. Proksch, G.K. Menon, M. Mao-Quiang, K.R. Feingold, Calcium and potassium are important regulators of barrier homeostasis in murine epidermis, J. Clin. Invest. 89 (1992) 530–538. https://doi.org/10.1172/JCI115617.

[562] S.H. Yuspa, A.E. Kilkenny, P.M. Steinert, D.R. Roop, Expression of murine epidermal differentiation markers is tightly regulated by restricted extracellular calcium concentrations in vitro, J. Cell Biol. 109 (1989) 1207–1217. https://doi.org/10.1083/jcb.109.3.1207.

[563] J. Kostan, M. Gregor, G. Walko, G. Wiche, Plectin isoform-dependent regulation of keratin-integrin alpha6beta4 anchorage via Ca2+/calmodulin, J. Biol. Chem. 284 (2009) 18525–18536. https://doi.org/10.1074/jbc.M109.008474.

[564] V. Trinkaus-Randall, I.K. Gipson, Role of calcium and calmodulin in hemidesmosome formation in vitro, J. Cell Biol. 98 (1984) 1565–1571. https://doi.org/10.1083/jcb.98.4.1565.

[565] E.M. Schwarz, S. Benzer, Calx, a Na-Ca exchanger gene of Drosophila melanogaster, Proc. Natl. Acad. Sci. U. S. A. 94 (1997) 10249–10254.

[566] N. Alonso-García, A. Inglés-Prieto, A. Sonnenberg, J.M. de Pereda, Structure of the Calx-beta domain of the integrin beta4 subunit: insights into function and cation-independent stability, Acta Crystallogr. D Biol. Crystallogr. 65 (2009) 858–871. https://doi.org/10.1107/S0907444909018745.

[567] M. Jin, C. Guan, Y. Jiang, G. Chen, C. Zhao, K. Cui, Y. Song, C. Wu, M. Poo, X. Yuan, Ca2+-Dependent Regulation of Rho GTPases Triggers Turning of Nerve Growth Cones, J. Neurosci. 25 (2005) 2338–2347. https://doi.org/10.1523/JNEUROSCI.4889-04.2005.

[568] P. Aspenström, Integration of signalling pathways regulated by small GTPases and calcium, Biochim. Biophys. Acta BBA - Mol. Cell Res. 1742 (2004) 51–58. https://doi.org/10.1016/j.bbamcr.2004.09.029.

[569] J.-G. Song, J. Kostan, F. Drepper, B. Knapp, E. de Almeida Ribeiro, P.V. Konarev, I. Grishkovskaya, G. Wiche, M. Gregor, D.I. Svergun, B. Warscheid, K. Djinović-Carugo, Structural Insights into Ca(2+)-Calmodulin Regulation of Plectin 1a-Integrin β4 Interaction in Hemidesmosomes, Struct. Lond. Engl. 1993. 23 (2015) 558–570. https://doi.org/10.1016/j.str.2015.01.011.

[570] E.J. Wilkinson, A.M. Woodworth, M. Parker, J.L. Phillips, R.C. Malley, J.L. Dickinson, A.F. Holloway, Epigenetic regulation of the ITGB4 gene in prostate cancer, Exp. Cell Res. 392 (2020) 112055. https://doi.org/10.1016/j.yexcr.2020.112055.

[571] Y. Kariya, J. Gu, N-glycosylation of ß4 integrin controls the adhesion and motility of keratinocytes, PloS One. 6 (2011) e27084. https://doi.org/10.1371/journal.pone.0027084.

[572] Y. Kariya, C. Kawamura, T. Tabei, J. Gu, Bisecting GlcNAc residues on laminin-332 down-regulate galectin-3-dependent keratinocyte motility, J. Biol. Chem. 285 (2010) 3330–3340. https://doi.org/10.1074/jbc.M109.038836.

[573] Y. Sakumura, Y. Tsukada, N. Yamamoto, S. Ishii, A Molecular Model for Axon Guidance Based on Cross Talk between Rho GTPases, Biophys. J. 89 (2005) 812–822. https://doi.org/10.1529/biophysj.104.055624.

[574] D.P. Choma, K. Pumiglia, C.M. DiPersio, Integrin alpha3beta1 directs the stabilization of a polarized lamellipodium in epithelial cells through activation of Rac1, J. Cell Sci. 117 (2004) 3947–3959. https://doi.org/10.1242/jcs.01251.

[575] M. Amano, M. Ito, K. Kimura, Y. Fukata, K. Chihara, T. Nakano, Y. Matsuura, K. Kaibuchi, Phosphorylation and activation of myosin by Rho-associated kinase (Rho-kinase), J. Biol. Chem. 271 (1996) 20246–20249. https://doi.org/10.1074/jbc.271.34.20246.

[576] E.C. Lessey, C. Guilluy, K. Burridge, From mechanical force to RhoA activation, Biochemistry. 51 (2012) 7420–7432. https://doi.org/10.1021/bi300758e.

[577] Y. Jiu, J. Peränen, N. Schaible, F. Cheng, J.E. Eriksson, R. Krishnan, P. Lappalainen, Vimentin intermediate filaments control actin stress fiber assembly through GEF-H1 and RhoA, J. Cell Sci. 130 (2017) 892–902. https://doi.org/10.1242/jcs.196881.

[578] N. Bonakdar, A. Schilling, M. Spörrer, P. Lennert, A. Mainka, L. Winter, G. Walko, G. Wiche, B. Fabry, W.H. Goldmann, Determining the mechanical properties of plectin in mouse myoblasts and keratinocytes, Exp. Cell Res. 331 (2015) 331–337. https://doi.org/10.1016/j.yexcr.2014.10.001.

[579] S. Osmanagic-Myers, S. Rus, M. Wolfram, D. Brunner, W.H. Goldmann, N. Bonakdar, I. Fischer, S. Reipert, A. Zuzuarregui, G. Walko, G. Wiche, Plectin reinforces vascular integrity by mediating crosstalk between the vimentin and the actin networks, J. Cell Sci. 128 (2015) 4138–4150. https://doi.org/10.1242/jcs.172056.

[580] K. Andrä, B. Nikolic, M. Stöcher, D. Drenckhahn, G. Wiche, Not just scaffolding: plectin regulates actin dynamics in cultured cells, Genes Dev. 12 (1998) 3442–3451.

[581] I.K. Gipson, S. Spurr-Michaud, A. Tisdale, J. Elwell, M.A. Stepp, Redistribution of the hemidesmosome components alpha 6 beta 4 integrin and bullous pemphigoid antigens during epithelial wound healing, Exp. Cell Res. 207 (1993) 86–98. https://doi.org/10.1006/excr.1993.1166.

[582] A. Zuidema, W. Wang, M. Kreft, L. Te Molder, L. Hoekman, O.B. Bleijerveld, L. Nahidiazar, H. Janssen, A. Sonnenberg, Mechanisms of integrin αVβ5 clustering in flat clathrin lattices, J. Cell Sci. 131 (2018). https://doi.org/10.1242/jcs.221317.

[583] D. Riveline, E. Zamir, N.Q. Balaban, U.S. Schwarz, T. Ishizaki, S. Narumiya, Z. Kam, B. Geiger, A.D. Bershadsky, Focal contacts as mechanosensors: externally applied local mechanical force induces growth of focal contacts by an mDia1-dependent and ROCK-independent mechanism, J. Cell Biol. 153 (2001) 1175–1186. https://doi.org/10.1083/jcb.153.6.1175.

[584] P.W. Oakes, M.L. Gardel, Stressing the limits of focal adhesion mechanosensitivity, Curr. Opin. Cell Biol. 30 (2014) 68–73. https://doi.org/10.1016/j.ceb.2014.06.003.

[585] J. Stricker, Y. Aratyn-Schaus, P.W. Oakes, M.L. Gardel, Spatiotemporal constraints on the force-dependent growth of focal adhesions, Biophys. J. 100 (2011) 2883–2893. https://doi.org/10.1016/j.bpj.2011.05.023.

[586] H.A. Chapman, X. Li, J.P. Alexander, A. Brumwell, W. Lorizio, K. Tan, A. Sonnenberg, Y. Wei, T.H. Vu, Integrin α6β4 identifies an adult distal lung epithelial population with regenerative potential in mice, J. Clin. Invest. 121 (2011) 2855–2862. https://doi.org/10.1172/JCI57673.

[587] T.C. Klinowska, C.M. Alexander, E. Georges-Labouesse, R. Van der Neut, J.A. Kreidberg, C.J. Jones, A. Sonnenberg, C.H. Streuli, Epithelial development and differentiation in the mammary gland is not dependent on alpha 3 or alpha 6 integrin subunits, Dev. Biol. 233 (2001) 449–467. https://doi.org/10.1006/dbio.2001.0204.

[588] D. Tsuruta, S.B. Hopkinson, J.C.R. Jones, Hemidesmosome protein dynamics in live epithelial cells, Cell Motil. Cytoskeleton. 54 (2003) 122–134. https://doi.org/10.1002/cm.10089.