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Functional characterisation and cell wall interactions of peptidoglycan

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Chapter 8

References

References

1. **Altschul, S. F., T. L. Madden, A. A. Schaffer, J. Zhang, Z. Zhang, W. Miller, and D. J. Lipman.** 1997. Gapped BLAST and PSI-BLAST: a new generation of protein database search programs. *Nucleic Acids Res.* **25**:3389-3402.
2. **Araki, Y. and E. Ito.** 1989. Linkage units in cell walls of gram-positive bacteria. *Crit Rev.Microbiol.* **17**:121-135.
3. **Archibald, A. R. and J. Baddiley.** 1966. The teichoic acids. *Adv.Carbohydr.Chem.Biochem.* **21**:323-375.
4. **Archibald, A. R., J. Baddiley, and S. Heptinstall.** 1973. The alanine ester content and magnesium binding capacity of walls of *Staphylococcus aureus* H grown at different pH values. *Biochim.Biophys.Acta* **291**:629-634.
5. **Archibald, A. R., I. C. Hancock, and C. R. Harwood.** 1993. Cell wall structure, synthesis and turnover, p. 381-410. *In* A. L. Sonenshein, J. A. Hoch, and R. Losick (eds.), *Bacillus subtilis* and other Gram-positive bacteria: Biochemistry, Physiology and Molecular Genetics. American Society for Microbiology, Washington DC.
6. **Atrih, A., G. Bacher, G. Allmaier, M. P. Williamson, and S. J. Foster.** 1999. Analysis of peptidoglycan structure from vegetative cells of *Bacillus subtilis* 168 and role of PBP 5 in peptidoglycan maturation. *J.Bacteriol.* **181**:3956-3966.
7. **Atrih, A., G. Bacher, R. Korner, G. Allmaier, and S. J. Foster.** 1999. Structural analysis of *Bacillus megaterium* KM spore peptidoglycan and its dynamics during germination. *Microbiology* **145**:1033-1041.
8. **Avall-Jaaskelainen, S., K. Kyla-Nikkila, M. Kahala, T. Miikkulainen-Lahti, and A. Palva.** 2002. Surface display of foreign epitopes on the *Lactobacillus brevis* S-layer. *Appl.Environ.Microbiol.* **68**:5943-5951.
9. **Avall-Jaaskelainen, S., A. Lindholm, and A. Palva.** 2003. Surface display of the receptor-binding region of the *Lactobacillus brevis* S-layer protein in *Lactococcus lactis* provides nonadhesive lactococci with the ability to adhere to intestinal epithelial cells. *Appl.Environ.Microbiol.* **69**:2230-2236.
10. **Baba, T. and O. Schneewind.** 1998. Targeting of muralytic enzymes to the cell division site of Gram-positive bacteria: repeat domains direct autolysin to the equatorial surface ring of *Staphylococcus aureus*. *EMBO J.* **17**:4639-4646.
11. **Barrett, J. F. and G. D. Shockman.** 1984. Isolation and characterization of soluble peptidoglycan from several strains of *Streptococcus faecium*. *J.Bacteriol.* **159**:511-519.
12. **Bateman, A. and M. Bycroft.** 2000. The structure of a LysM domain from *E. coli* membrane-bound lytic murein transglycosylase D (MltD). *J.Mol.Biol.* **299**:1113-1119.
13. **Baumeister, W., I. Wildhaber, and B. M. Phipps.** 1989. Principles of organization in eubacterial and archaeobacterial surface proteins. *Can.J.Microbiol.* **35**:215-227.
14. **Beliveau, C., C. Potvin, J. Trudel, A. Asselin, and G. Bellemare.** 1991. Cloning, sequencing, and expression in *Escherichia coli* of a *Streptococcus faecalis* autolysin. *J.Bacteriol.* **173**:5619-5623.

15. **Berberich, R., M. Kaback, and E. Freese.** 1968. D-amino acids as inducers of L-alanine dehydrogenase in *Bacillus subtilis*. *J.Biol.Chem.* **243**:1006-1011.
16. **Beveridge, T. J., P. H. Pouwels, M. Sara, A. Kotiranta, K. Lounatmaa, K. Kari, E. Kerosuo, M. Haapasalo, E. M. Egelseer, I. Schocher, U. B. Sleytr, L. Morelli, M. L. Callegari, J. F. Nomellini, W. H. Bingle, J. Smit, E. Leibovitz, M. Lemaire, I. Miras, S. Salamatou, P. Beguin, H. Ohayon, P. Gounon, M. Matuschek, and S. F. Koval.** 1997. Functions of S-layers. *FEMS Microbiol.Rev.* **20**:99-149.
17. **Bierbaum, G. and H. G. Sahl.** 1985. Induction of autolysis of staphylococci by the basic peptide antibiotics Pep 5 and nisin and their influence on the activity of autolytic enzymes. *Arch.Microbiol.* **141**:249-254.
18. **Birkeland, N. K.** 1994. Cloning, molecular characterization, and expression of the genes encoding the lytic functions of lactococcal bacteriophage phi LC3: a dual lysis system of modular design. *Can.J.Microbiol.* **40**:658-665.
19. **Blackman, S. A., T. J. Smith, and S. J. Foster.** 1998. The role of autolysins during vegetative growth of *Bacillus subtilis* 168. *Microbiology* **144**:73-82.
20. **Boels, I. C., M. Kleerebezem, and W. M. de Vos.** 2003. Engineering of carbon distribution between glycolysis and sugar nucleotide biosynthesis in *Lactococcus lactis*. *Appl.Environ.Microbiol.* **69**:1129-1135.
21. **Bolotin, A., P. Wincker, S. Mauger, O. Jaillon, K. Malarme, J. Weissenbach, S. D. Ehrlich, and A. Sorokin.** 2001. The complete genome sequence of the lactic acid bacterium *Lactococcus lactis* ssp. *lactis* IL1403. *Genome Res.* **11**:731-753.
22. **Boot, H. J., C. P. Kolen, J. M. van Noort, and P. H. Pouwels.** 1993. S-layer protein of *Lactobacillus acidophilus* ATCC 4356: purification, expression in *Escherichia coli*, and nucleotide sequence of the corresponding gene. *J.Bacteriol.* **175**:6089-6096.
23. **Boot, H. J. and P. H. Pouwels.** 1996. Expression, secretion and antigenic variation of bacterial S-layer proteins. *Mol.Microbiol.* **21**:1117-1123.
24. **Braun, L., S. Dramsi, P. Dehoux, H. Bierne, G. Lindahl, and P. Cossart.** 1997. InlB: an invasion protein of *Listeria monocytogenes* with a novel type of surface association. *Mol.Microbiol.* **25**:285-294.
25. **Braun, L., B. Ghebrehwet, and P. Cossart.** 2000. gC1q-R/p32, a C1q-binding protein, is a receptor for the InlB invasion protein of *Listeria monocytogenes*. *EMBO J.* **19**:1458-1466.
26. **Brechtel, E., M. Matuschek, A. Hellberg, E. M. Egelseer, R. Schmid, and H. Bahl.** 1999. Cell wall of *Thermoanaerobacterium thermosulfurigenes* EM1: isolation of its components and attachment of the xylanase XynA. *Arch.Microbiol.* **171**:159-165.
27. **Brockl, G., M. Behr, S. Fabry, R. Hensel, H. Kaudewitz, E. Biendl, and H. Konig.** 1991. Analysis and nucleotide sequence of the genes encoding the surface-layer glycoproteins of the hyperthermophilic methanogens *Methanothermus fervidus* and *Methanothermus sociabilis*. *Eur.J.Biochem.* **199**:147-152.

References

28. **Bron, P. A., M. G. Benchimol, J. Lambert, E. Palumbo, M. Deghorain, J. Delcour, W. M. de Vos, M. Kleerebezem, and P. Hols.** 2002. Use of the *alr* Gene as a Food-Grade Selection Marker in Lactic Acid Bacteria. *Appl. Environ. Microbiol.* **68**:5663-5670.
29. **BRUMFITT, W., A. C. WARDLAW, and J. T. PARK.** 1958. Development of lysozyme-resistance in *Micrococcus lysodiecticus* and its association with an increased O-acetyl content of the cell wall. *Nature* **181**:1783-1784.
30. **Buist, G.** 1997. PhD-thesis, University of Groningen, the Netherlands.
31. **Buist, G., H. Karsens, A. Nauta, D. van Sinderen, G. Venema, and J. Kok.** 1997. Autolysis of *Lactococcus lactis* caused by induced overproduction of its major autolysin, AcmA. *Appl. Environ. Microbiol.* **63**:2722-2728.
32. **Buist, G., J. Kok, K. J. Leenhouts, M. Dabrowska, G. Venema, and A. J. Haandrikman.** 1995. Molecular cloning and nucleotide sequence of the gene encoding the major peptidoglycan hydrolase of *Lactococcus lactis*, a muramidase needed for cell separation. *J. Bacteriol.* **177**:1554-1563.
33. **Buist, G., G. Venema, and J. Kok.** 1998. Autolysis of *Lactococcus lactis* is influenced by proteolysis. *J. Bacteriol.* **180**:5947-5953.
34. **Bunthof, C. J., S. van Schalkwijk, W. Meijer, T. Abee, and J. Hugenholtz.** 2001. Fluorescent method for monitoring cheese starter permeabilization and lysis. *Appl. Environ. Microbiol.* **67**:4264-4271.
35. **Callegari, M. L., B. Riboli, J. W. Sanders, P. S. Cocconcelli, J. Kok, G. Venema, and L. Morelli.** 1998. The S-layer gene of *Lactobacillus helveticus* CNRZ 892: cloning, sequence and heterologous expression. *Microbiology* **144**:719-726.
36. **Chapot-Chartier, M. P., C. Deniel, M. Rousseau, L. Vassal, and J. C. Gripon.** 1994. Autolysis of two strains of *Lactococcus lactis* during cheese ripening. *Int. Dairy Journal* **4**:251-269.
37. **Chopin, A., M. C. Chopin, A. Moillo-Batt, and P. Langella.** 1984. Two plasmid-determined restriction and modification systems in *Streptococcus lactis*. *Plasmid* **11**:260-263.
38. **Chu, C. P., R. Kariyama, L. Daneo-Moore, and G. D. Shockman.** 1992. Cloning and sequence analysis of the muramidase-2 gene from *Enterococcus hirae*. *J. Bacteriol.* **174**:1619-1625.
39. **Cibik, R., P. Tailliez, P. Langella, and M. P. Chapot-Chartier.** 2001. Identification of Mur, an atypical peptidoglycan hydrolase derived from *Leuconostoc citreum*. *Appl. Environ. Microbiol.* **67**:858-864.
40. **Cossart, P., J. Pizarro-Cerda, and M. Lecuit.** 2003. Invasion of mammalian cells by *Listeria monocytogenes*: functional mimicry to subvert cellular functions. *Trends Cell Biol.* **13**:23-31.
41. **Coyette, J. and J. M. Ghuysen.** 1970. Structure of the walls of *Lactobacillus acidophilus* strain 63 AM Gasser. *Biochemistry* **9**:2935-2943.
42. **Croux, C., C. Ronda, R. Lopez, and J. L. Garcia.** 1993. Interchange of functional domains switches enzyme specificity: construction of a chimeric pneumococcal-clostridial cell wall lytic enzyme. *Mol. Microbiol.* **9**:1019-1025.

43. **Croux, C., C. Ronda, R. Lopez, and J. L. Garcia.** 1993. Role of the C-terminal domain of the lysozyme of *Clostridium acetobutylicum* ATCC 824 in a chimeric pneumococcal-clostridial cell wall lytic enzyme. *FEBS Lett.* **336**:111-114.
44. **De Las, R. B., J. L. Garcia, R. Lopez, and P. Garcia.** 2002. Purification and polar localization of pneumococcal LytB, a putative endo-beta-N-acetylglucosaminidase: the chain-dispersing murein hydrolase. *J.Bacteriol.* **184**:4988-5000.
45. **De Man, J. C., M. Rogosa, and M. E. Sharpe.** 1960. A medium for the cultivation of lactobacilli. *J.Appl.Bacteriol.* **23**:130-135.
46. **de Ruyter, P. G., O. P. Kuipers, M. M. Beerthuyzen, I. Alen-Boerrigter, and W. M. de Vos.** 1996. Functional analysis of promoters in the nisin gene cluster of *Lactococcus lactis*. *J.Bacteriol.* **178**:3434-3439.
47. **de Ruyter, P. G., O. P. Kuipers, W. C. Meijer, and W. M. de Vos.** 1997. Food-grade controlled lysis of *Lactococcus lactis* for accelerated cheese ripening. *Nat.Biotechnol.* **15**:976-979.
48. **Debabov, D. V., M. Y. Kiriukhin, and F. C. Neuhaus.** 2000. Biosynthesis of lipoteichoic acid in *Lactobacillus rhamnosus*: role of DltD in D-alanylation. *J.Bacteriol.* **182**:2855-2864.
49. **Delcour, J., T. Ferain, M. Deghorain, E. Palumbo, and P. Hols.** 1999. The biosynthesis and functionality of the cell-wall of lactic acid bacteria. *Antonie Van Leeuwenhoek* **76**:159-184.
50. **Diaz, E., R. Lopez, and J. L. Garcia.** 1991. Chimeric pneumococcal cell wall lytic enzymes reveal important physiological and evolutionary traits. *J.Biol.Chem.* **266**:5464-5471.
51. **Douglas, L. J. and M. J. Wolin.** 1971. Cell wall polymers and phage lysis of *Lactobacillus plantarum*. *Biochemistry* **10**:1551-1555.
52. **Duwat, P., A. Cochu, S. D. Ehrlich, and A. Gruss.** 1997. Characterization of *Lactococcus lactis* UV-sensitive mutants obtained by ISS1 transposition. *J.Bacteriol.* **179**:4473-4479.
53. **Engelhardt, H. and J. Peters.** 1998. Structural research on surface layers: a focus on stability, surface layer homology domains, and surface layer-cell wall interactions. *J.Struct.Biol.* **124**:276-302.
54. **Fernandez-Tornero, C., E. Garcia, R. Lopez, G. Gimenez-Gallego, and A. Romero.** 2002. Two new crystal forms of the choline-binding domain of the major pneumococcal autolysin: insights into the dynamics of the active homodimer. *J.Mol.Biol.* **321**:163-173.
55. **Fernandez-Tornero, C., R. Lopez, E. Garcia, G. Gimenez-Gallego, and A. Romero.** 2001. A novel solenoid fold in the cell wall anchoring domain of the pneumococcal virulence factor LytA. *Nat.Struct.Biol.* **8**:1020-1024.
56. **Ferrari, E., J. Henner, and M. Yang.** 1985. Isolation of an alanine racemase gene from *Bacillus subtilis* and its use for plasmid maintenance in *B. subtilis*. *Bio/Technology* **3**:1003-1007.
57. **Fischer, W.** 1994. Lipoteichoic acids and lipoglycans, p. 199-216. *In* J. M. Ghuyssen and R. Hakenbeck (eds.), *Bacterial cell wall*. Elsevier Science publishing B.V., Amsterdam, The Netherlands.
58. **Fischer, W., P. Rosel, and H. U. Koch.** 1981. Effect of alanine ester substitution and other structural features of lipoteichoic acids on their inhibitory activity against autolysins of *Staphylococcus aureus*. *J.Bacteriol.* **146**:467-475.

References

59. **Fischetti, V. A., V. Pancholi, and O. Schneewind.** 1990. Conservation of a hexapeptide sequence in the anchor region of surface proteins from gram-positive cocci. *Mol.Microbiol.* **4**:1603-1605.
60. **Foster, S. J.** 1992. Analysis of the autolysins of *Bacillus subtilis* 168 during vegetative growth and differentiation by using renaturing polyacrylamide gel electrophoresis. *J.Bacteriol.* **174**:464-470.
61. **Fox, P. F., J. M. Wallace, S. Morgan, C. M. Lynch, E. J. Niland, and J. Tobin.** 1996. Acceleration of cheese ripening. *Antonie Van Leeuwenhoek* **70**:271-297.
62. **Garcia, J. L., E. Diaz, A. Romero, and P. Garcia.** 1994. Carboxy-terminal deletion analysis of the major pneumococcal autolysin. *J.Bacteriol.* **176**:4066-4072.
63. **Garcia, P., J. L. Garcia, E. Garcia, and R. Lopez.** 1986. Nucleotide sequence and expression of the pneumococcal autolysin gene from its own promoter in *Escherichia coli*. *Gene* **43**:265-272.
64. **Garcia, P., J. L. Garcia, E. Garcia, J. M. Sanchez-Puelles, and R. Lopez.** 1990. Modular organization of the lytic enzymes of *Streptococcus pneumoniae* and its bacteriophages. *Gene* **86**:81-88.
65. **Gardiner, G. E., C. Heinemann, A. W. Bruce, D. Beurman, and G. Reid.** 2002. Persistence of *Lactobacillus fermentum* RC-14 and *Lactobacillus rhamnosus* GR-1 but not *L. rhamnosus* GG in the human vagina as demonstrated by randomly amplified polymorphic DNA. *Clin.Diagn.Lab Immunol.* **9**:92-96.
66. **Gasson, M. J.** 1983. Plasmid complements of *Streptococcus lactis* NCDO 712 and other lactic streptococci after protoplast-induced curing. *J.Bacteriol.* **154**:1-9.
67. **Geurts, R. and T. Bisseling.** 2002. Rhizobium nod factor perception and signalling. *Plant Cell* **14** Suppl:S239-S249.
68. **Ghuysen, J. M. and J. L. Strominger.** 1963. Structure of the cell wall of *Staphylococcus aureus*, strain Copenhagen. I. Preparation of fragments by enzymatic hydrolysis. *Biochemistry* **338**:1110-1119.
69. **Ghuysen, J. M. and J. L. Strominger.** 1963. Structure of the cell wall of *Staphylococcus aureus*, strain Copenhagen. II. Separation and structure of disaccharides. *Biochemistry* **338**:1119-1125.
70. **Gilbert, C., D. Atlan, B. Blanc, R. Portailer, J. E. Germond, L. Lapiere, and B. Mollet.** 1996. A new cell surface proteinase: sequencing and analysis of the *prtB* gene from *Lactobacillus delbruekii* subsp. *bulgaricus*. *J.Bacteriol.* **178**:3059-3065.
71. **Godon, J. J., K. Jury, C. A. Shearman, and M. J. Gasson.** 1994. The *Lactococcus lactis* sex-factor aggregation gene *cluA*. *Mol.Microbiol.* **12**:655-663.
72. **Gopal, P. K. and V. L. Crow.** 1993. Characterization of loosely associated material from the cell surface of *Lactococcus lactis* subsp. *cremoris* E8 and its phage-resistant variant strain 398. *Appl.Enviro.Microbiol.* **59**:3177-3182.
73. **Gopal, P. K. and K. I. Reilly.** 1995. Molecular architecture of the lactococcal cell surface as it relates to important industrial properties. *Int.Dairy Journal* **5**:1095-1111.
74. **Gram, C.** 1884. Ueber die isolirte Färbung der Schizomyceten in Schnitt- und Trockenpräparaten. *Fortschr.Med.* **2**:185-189.

75. **Grangette, C., H. Muller-Alouf, P. Hols, D. Goudercourt, J. Delcour, M. Turneer, and A. Mercenier.** 2004. Enhanced mucosal delivery of antigen with cell wall mutants of lactic acid bacteria. *Infect.Immun.* **72**:2731-2737.
76. **Greene, J. D. and T. R. Klaenhammer.** 1994. Factors involved in adherence of lactobacilli to human Caco-2 cells. *Appl.Environ.Microbiol.* **60**:4487-4494.
77. **Grossiord, B. P., E. J. Luesink, E. E. Vaughan, A. Arnaud, and W. M. de Vos.** 2003. Characterization, expression, and mutation of the *Lactococcus lactis galPMKTE* genes, involved in galactose utilization via the Leloir pathway. *J.Bacteriol.* **185**:870-878.
78. **Gutberlet, T., J. Frank, H. Bradaczek, and W. Fischer.** 1997. Effect of lipoteichoic acid on thermotropic membrane properties. *J.Bacteriol.* **179**:2879-2883.
79. **Hammes, W., K. H. Schleifer, and O. Kandler.** 1973. Mode of action of glycine on the biosynthesis of peptidoglycan. *J.Bacteriol.* **116**:1029-1053.
80. **Hancock, I. C. and I. R. Poxton.** 1988. Structure of bacteria and their envelope, p. 1-32. *In* I. C. Hancock and I. R. Poxton (eds.), *Bacterial cell surface techniques*. John Wiley & Sons, New York.
81. **Heaton, M. P., R. B. Johnston, and T. L. Thompson.** 1988. Controlled lysis of bacterial cells utilizing mutants with defective synthesis of D-alanine. *Can.J.Microbiol.* **34**:256-261.
82. **Henze, U., T. Sidow, J. Wecke, H. Labischinski, and B. Berger-Bachi.** 1993. Influence of *femB* on methicillin resistance and peptidoglycan metabolism in *Staphylococcus aureus*. *J.Bacteriol.* **175**:1612-1620.
83. **Heptinstall, S., A. R. Archibald, and J. Baddiley.** 1970. Teichoic acids and membrane function in bacteria. *Nature* **225**:519-521.
84. **Hols, P., C. Defrenne, T. Ferain, S. Derzelle, B. Delplace, and J. Delcour.** 1997. The alanine racemase gene is essential for growth of *Lactobacillus plantarum*. *J.Bacteriol.* **179**:3804-3807.
85. **Hols, P., M. Kleerebezem, A. N. Schanck, T. Ferain, J. Hugenholtz, J. Delcour, and W. M. de Vos.** 1999. Conversion of *Lactococcus lactis* from homolactic to homoalanine fermentation through metabolic engineering. *Nat.Biotechnol.* **17**:588-592.
86. **Holtje, J. V. and A. Tomasz.** 1975. Specific recognition of choline residues in the cell wall teichoic acid by the N-acetylmuramyl-L-alanine amidase of *Pneumococcus*. *J.Biol.Chem.* **250**:6072-6076.
87. **Horsburgh, G. J., A. Atrih, and S. J. Foster.** 2003. Characterization of LytH, a differentiation-associated peptidoglycan hydrolase of *Bacillus subtilis* involved in endospore cortex maturation. *J.Bacteriol.* **185**:3813-3820.
88. **Horsburgh, G. J., A. Atrih, M. P. Williamson, and S. J. Foster.** 2003. LytG of *Bacillus subtilis* is a novel peptidoglycan hydrolase: the major active glucosaminidase. *Biochemistry* **42**:257-264.
89. **Hourdou, M. L., M. Guinand, M. J. Vacheron, G. Michel, L. Denoroy, C. Duez, S. Englebert, B. Joris, G. Weber, and J. M. Ghuysen.** 1993. Characterization of the sporulation-related gamma-D-glutamyl-(L)meso- diaminopimelic-acid-hydrolysing peptidase I of *Bacillus sphaericus* NCTC 9602 as a member of the metallo(zinc) carboxypeptidase A family. Modular design of the protein. *Biochem.J.* **292**:563-570.

References

90. **Huard, C., G. Miranda, Y. Redko, F. Wessner, S. J. Foster, and M. P. Chapot-Chartier.** 2004. Analysis of the peptidoglycan hydrolase complement of *Lactococcus lactis*: identification of a third N-acetylglucosaminidase, AcmC. *Appl. Environ. Microbiol.* **70**:3493-3499.
91. **Huard, C., G. Miranda, F. Wessner, A. Bolotin, J. Hansen, S. J. Foster, and M. P. Chapot-Chartier.** 2003. Characterization of AcmB, an N-acetylglucosaminidase autolysin from *Lactococcus lactis*. *Microbiology* **149**:695-705.
92. **Hughes, A. H., I. C. Hancock, and J. Baddiley.** 1973. The function of teichoic acids in cation control in bacterial membranes. *Biochem. J.* **132**:83-93.
93. **Husson-Kao, C., J. Mengaud, L. Benbadis, and M. P. Chapot-Chartier.** 2000. MurI, a *Streptococcus thermophilus* peptidoglycan hydrolase devoid of a specific cell wall binding domain. *FEMS Microbiol. Lett.* **187**:69-76.
94. **Hyyrylainen, H. L., Pietiainen, M, Gardemeister, M, Murtomaki-Repo, S, Kontinen, V. P., and Sarvas, M.** 2003. D-alanylation of teichoic acids affects the signal transduction via CsaRS and YvqCE two-component systems. Poster abstract 12th International conference on Bacilli, Baveno, Italy.
95. **Hyyrylainen, H. L., M. Vitikainen, J. Thwaite, H. Wu, M. Sarvas, C. R. Harwood, V. P. Kontinen, and K. Stephenson.** 2000. D-Alanine substitution of teichoic acids as a modulator of protein folding and stability at the cytoplasmic membrane/cell wall interface of *Bacillus subtilis*. *J. Biol. Chem.* **275**:26696-26703.
96. **Ilk, N., P. Kosma, M. Puchberger, E. M. Egelseer, H. F. Mayer, U. B. Sleytr, and M. Sara.** 1999. Structural and functional analyses of the secondary cell wall polymer of *Bacillus sphaericus* CCM 2177 that serves as an S-layer-specific anchor. *J. Bacteriol.* **181**:7643-7646.
97. **Ishikawa, S., Y. Hara, R. Ohnishi, and J. Sekiguchi.** 1998. Regulation of a new cell wall hydrolase gene, *cwlF*, which affects cell separation in *Bacillus subtilis*. *J. Bacteriol.* **180**:2549-2555.
98. **Jedrzejas, M. J.** 2001. Pneumococcal virulence factors: structure and function. *Microbiol. Mol. Biol. Rev.* **65**:187-207.
99. **Jonquieres, R., H. Bierne, F. Fiedler, P. Gounon, and P. Cossart.** 1999. Interaction between the protein InlB of *Listeria monocytogenes* and lipoteichoic acid: a novel mechanism of protein association at the surface of gram-positive bacteria. *Mol. Microbiol.* **34**:902-914.
100. **Joris, B., S. Englebert, C. P. Chu, R. Kariyama, L. Daneo-Moore, G. D. Shockman, and J. M. Ghuyssen.** 1992. Modular design of the *Enterococcus hirae* muramidase-2 and *Streptococcus faecalis* autolysin. *FEMS Microbiol. Lett.* **70**:257-264.
101. **Kariyama, R. and G. D. Shockman.** 1992. Extracellular and cellular distribution of muramidase-2 and muramidase-1 of *Enterococcus hirae* ATCC 9790. *J. Bacteriol.* **174**:3236-3241.
102. **Kemper, M. A., M. M. Urrutia, T. J. Beveridge, A. L. Koch, and R. J. Doyle.** 1993. Proton motive force may regulate cell wall-associated enzymes of *Bacillus subtilis*. *J. Bacteriol.* **175**:5690-5696.
103. **Kiriukhin, M. Y. and F. C. Neuhaus.** 2001. D-alanylation of lipoteichoic acid: role of the D-alanyl carrier protein in acylation. *J. Bacteriol.* **183**:2051-2058.

104. **Knowles, J. P., P. Lehtovaara, and T. Teeri.** 1987. Cellulase families and their genes. *Tibtech* **5**:255-261.
105. **Kobayashi, G., J. Toida, T. Akamatsu, H. Yamamoto, T. Shida, and J. Sekiguchi.** 2000. Accumulation of an artificial cell wall-binding lipase by *Bacillus subtilis wprA* and/or *sigD* mutants. *FEMS Microbiol.Lett.* **188**:165-169.
106. **Kodama, T., H. Takamatsu, K. Asai, K. Kobayashi, N. Ogasawara, and K. Watabe.** 1999. The *Bacillus subtilis yaaH* gene is transcribed by SigE RNA polymerase during sporulation, and its product is involved in germination of spores. *J.Bacteriol.* **181**:4584-4591.
107. **Kodama, T., H. Takamatsu, K. Asai, N. Ogasawara, Y. Sadaie, and K. Watabe.** 2000. Synthesis and characterization of the spore proteins of *Bacillus subtilis* YdhD, YkuD, and YkvP, which carry a motif conserved among cell wall binding proteins. *J.Biochem.(Tokyo)* **128**:655-663.
108. **Kohler, S., M. Leimeister-Wachter, T. Chakraborty, F. Lottspeich, and W. Goebel.** 1990. The gene coding for protein p60 of *Listeria monocytogenes* and its use as a specific probe for *Listeria monocytogenes*. *Infect.Immun.* **58**:1943-1950.
109. **Kok, J.** 1992. Special-purpose vectors for lactococci, p. 97-102. *In* G. M. Dunny, P. P. Cleary, and L. L. McKay (eds.), *Genetics and molecular biology of Streptococci, Lactococci, and Enterococci.* American Society for Microbiology, Washington, D.C.
110. **Kok, J., J. M. van Dijl, J. M. van der Vossen, and G. Venema.** 1985. Cloning and expression of a *Streptococcus cremoris* proteinase in *Bacillus subtilis* and *Streptococcus lactis*. *Appl.Environ.Microbiol.* **50**:94-101.
111. **Kuipers, O. P., M. M. Beerthuyzen, R. J. Siezen, and W. M. de Vos.** 1993. Characterization of the nisin gene cluster *nisABTCIPR* of *Lactococcus lactis*. Requirement of expression of the *nisA* and *nisI* genes for development of immunity. *Eur.J.Biochem.* **216**:281-291.
112. **Kuipers, O. P., P. G. G. A. de Ruyter, M. Kleerebezem, and W. M. de Vos.** 1998. Quorum sensing-controlled gene expression in lactic acid bacteria. *J.Biotechnol.* **64**:15-21.
113. **Kunst, F., N. Ogasawara, I. Moszer, A. M. Albertini, G. Alloni, V. Azevedo, M. G. Bertero, P. Bessieres, A. Bolotin, S. Borchert, R. Borriss, L. Boursier, A. Brans, M. Braun, S. C. Brignell, S. Bron, S. Brouillet, C. V. Bruschi, B. Caldwell, V. Capuano, N. M. Carter, S. K. Choi, J. J. Codani, I. F. Connerton, A. Danchin, and .** 1997. The complete genome sequence of the gram-positive bacterium *Bacillus subtilis*. *Nature* **390**:249-256.
114. **Kuriyan, J. and D. Cowburn.** 1997. Modular peptide recognition domains in eukaryotic signaling. *Annu.Rev.Biophys.Biomol.Struct.* **26**:259-288.
115. **Laemmli, U. K.** 1970. Cleavage of structural proteins during the assembly of the head of bacteriophage T4. *Nature* **227**:680-685.
116. **Lambert, P. A., I. C. Hancock, and J. Baddiley.** 1975. Influence of alanyl ester residues on the binding of magnesium ions to teichoic acids. *Biochem.J.* **151**:671-676.
117. **Law, B. A., M. E. Sharpe, and B. Reiter.** 1974. The release of intracellular dipeptidase from starter streptococci during Cheddar cheese ripening. *J.Dairy.Res.* **76**:2455-2467.

References

118. **Leenhouts, K., G. Buist, and J. Kok.** 1999. Anchoring of proteins to lactic acid bacteria. *Antonie Van Leeuwenhoek* **76**:367-376.
119. **Leenhouts, K. J. and G. Venema.** 1992. Molecular cloning and expression in *Lactococcus*. *Med.Fac.Landbouw.Univ.Gent.* **57**:2031-2043.
120. **Lerouge, P., P. Roche, C. Faucher, F. Maillet, G. Truchet, J. C. Prome, and J. Denarie.** 1990. Symbiotic host-specificity of *Rhizobium meliloti* is determined by a sulphated and acylated glucosamine oligosaccharide signal. *Nature* **344**:781-784.
121. **Limpens, E., C. Franken, P. Smit, J. Willemse, T. Bisseling, and R. Geurts.** 2003. LysM domain receptor kinases regulating rhizobial Nod factor-induced infection. *Science* **302**:630-633.
122. **Loessner, M. J., K. Kramer, F. Ebel, and S. Scherer.** 2002. C-terminal domains of *Listeria monocytogenes* bacteriophage murein hydrolases determine specific recognition and high-affinity binding to bacterial cell wall carbohydrates. *Mol.Microbiol.* **44**:335-349.
123. **Longchamp, P. F., C. Mauel, and D. Karamata.** 1994. Lytic enzymes associated with defective prophages of *Bacillus subtilis*: sequencing and characterization of the region comprising the N-acetylmuramoyl-L-alanine amidase gene of prophage PBSX. *Microbiology* **140 (Pt 8)**:1855-1867.
124. **Lopez, R., M. P. Gonzalez, E. Garcia, J. L. Garcia, and P. Garcia.** 2000. Biological roles of two new murein hydrolases of *Streptococcus pneumoniae* representing examples of module shuffling. *Res.Microbiol.* **151**:437-443.
125. **Madsen, E. B., L. H. Madsen, S. Radutoiu, M. Olbryt, M. Rakwalska, K. Szczyglowski, S. Sato, T. Kaneko, S. Tabata, N. Sandal, and J. Stougaard.** 2003. A receptor kinase gene of the LysM type is involved in legume perception of rhizobial signals. *Nature* **425**:637-640.
126. **Margot, P. and D. Karamata.** 1992. Identification of the structural genes for N-acetylmuramoyl-L-alanine amidase and its modifier in *Bacillus subtilis* 168: inactivation of these genes by insertional mutagenesis has no effect on growth or cell separation. *Mol.Gen.Genet.* **232**:359-366.
127. **Margot, P., M. Pagni, and D. Karamata.** 1999. *Bacillus subtilis* 168 gene *lytF* encodes a gamma-D-glutamate-meso-diaminopimelate muropeptidase expressed by the alternative vegetative sigma factor, sigmaD. *Microbiology* **145**:57-65.
128. **Margot, P., M. Wahlen, A. Gholamhoseinian, P. Piggot, D. Karamata, and A. Gholamhuseinian.** 1998. The *lytE* gene of *Bacillus subtilis* 168 encodes a cell wall hydrolase. *J.Bacteriol.* **180**:749-752.
129. **Marino, M., M. Banerjee, R. Jonquieres, P. Cossart, and P. Ghosh.** 2002. GW domains of the *Listeria monocytogenes* invasion protein InlB are SH3-like and mediate binding to host ligands. *EMBO J.* **21**:5623-5634.
130. **Matuschek, M., K. Sahn, A. Zibat, and H. Bahl.** 1996. Characterization of genes from *Thermoanaerobacterium thermosulfurigenes* EM1 that encode two glycosyl hydrolases with conserved S-layer-like domains. *Mol.Gen.Genet.* **252**:493-496.
131. **Meijer, W., B. B. van de, M. Twigt, B. de Jonge, G. Smit, and J. Hugenholtz.** 1998. Lysis of *Lactococcus lactis* subsp. *cremoris* SK110 and its nisin-immune transconjugant in relation to flavor development in cheese. *Appl.Environ.Microbiol.* **64**:1950-1953.

132. **Mesnager, S., T. Fontaine, T. Mignot, M. Delepierre, M. Mock, and A. Fouet.** 2000. Bacterial SLH domain proteins are non-covalently anchored to the cell surface via a conserved mechanism involving wall polysaccharide pyruvylation. *EMBO J.* **19**:4473-4484.
133. **Mesnager, S., E. Tosi-Couture, and A. Fouet.** 1999. Production and cell surface anchoring of functional fusions between the SLH motifs of the *Bacillus anthracis* S-layer proteins and the *Bacillus subtilis* levansucrase. *Mol.Microbiol.* **31**:927-936.
134. **Mesnager, S., E. Tosi-Couture, M. Mock, and A. Fouet.** 1999. The S-layer homology domain as a means for anchoring heterologous proteins on the cell surface of *Bacillus anthracis*. *J.Appl.Microbiol.* **87**:256-260.
135. **Mesnager, S., E. Tosi-Couture, M. Mock, P. Gounon, and A. Fouet.** 1997. Molecular characterization of the *Bacillus anthracis* main S-layer component: evidence that it is the major cell-associated antigen. *Mol.Microbiol.* **23**:1147-1155.
136. **Milohanic, E., R. Jonquieres, P. Cossart, P. Berche, and J. L. Gaillard.** 2001. The autolysin Ami contributes to the adhesion of *Listeria monocytogenes* to eukaryotic cells via its cell wall anchor. *Mol.Microbiol.* **39**:1212-1224.
137. **Milward, C. P. and N. A. Jacques.** 1990. Secretion of fructosyltransferase by *Streptococcus salivarius* involves the sucrose-dependent release of the cell-bound form. *J.Gen.Microbiol.* **136**:165-169.
138. **Mou, L., J. J. Sullivan, and G. R. Jago.** 1976. Autolysis of *Streptococcus cremoris*. *Journal of Dairy Science* **43**:275-282.
139. **Murazumi, N., Y. Araki, and E. Ito.** 1986. Biosynthesis of the wall neutral polysaccharide in *Bacillus cereus* AHU 1356. *Eur.J.Biochem.* **161**:51-59.
140. **Nakao, A., S. Imai, and T. Takano.** 2000. Transposon-mediated insertional mutagenesis of the D-alanyl-lipoteichoic acid (*dlt*) operon raises methicillin resistance in *Staphylococcus aureus*. *Res.Microbiol.* **151**:823-829.
141. **Nambu, T., T. Minamino, R. M. Macnab, and K. Kutsukake.** 1999. Peptidoglycan-hydrolyzing activity of the FlgJ protein, essential for flagellar rod formation in *Salmonella typhimurium*. *J.Bacteriol.* **181**:1555-1561.
142. **Navarre, W. W. and O. Schneewind.** 1999. Surface proteins of gram-positive bacteria and mechanisms of their targeting to the cell wall envelope. *Microbiol.Mol.Biol.Rev.* **63**:174-229.
143. **Neuhaus, F. C.** 1985. Inter-chain transacylation of D-alanine ester residues of lipoteichoic acid: a unique mechanism of membrane communication. *Biochem.Soc.Trans.* **13**:987-990.
144. **Neuhaus, F. C. and J. Baddiley.** 2003. A continuum of anionic charge: structures and functions of D-alanyl-teichoic acids in gram-positive bacteria. *Microbiol.Mol.Biol.Rev.* **67**:686-723.
145. **Neuhaus, F. C., M. P. Heaton, D. V. Debatov, and Q. Zhang.** 1996. The *dlt* operon in the biosynthesis of D-alanyl-lipoteichoic acid in *Lactobacillus casei*. *Microb.Drug Resist.* **2**:77-84.
146. **Noone, D., A. Howell, R. Collery, and K. M. Devine.** 2001. YkdA and YvtA, HtrA-like serine proteases in *Bacillus subtilis*, engage in negative autoregulation and reciprocal cross-regulation of *ykdA* and *yvtA* gene expression. *J.Bacteriol.* **183**:654-663.

References

147. **Noone, D., A. Howell, and K. M. Devine.** 2000. Expression of *ykdA*, encoding a *Bacillus subtilis* homologue of HtrA, is heat shock inducible and negatively autoregulated. *J.Bacteriol.* **182**:1592-1599.
148. **Nouaille, S., J. Commissaire, J. J. Gratadoux, P. Ravn, A. Bolotin, A. Gruss, Y. Le Loir, and P. Langella.** 2004. Influence of lipoteichoic acid D-alanylation on protein secretion in *Lactococcus lactis* as revealed by random mutagenesis. *Appl.Environ.Microbiol.* **70**:1600-1607.
149. **O'Connell-Motherway, M., D. van Sinderen, F. Morel-Deville, G. F. Fitzgerald, S. D. Ehrlich, and P. Morel.** 2000. Six putative two-component regulatory systems isolated from *Lactococcus lactis* subsp. *cremoris* MG1363. *Microbiology* **146**:935-947.
150. **O'Sullivan, L., S. M. Morgan, R. P. Ross, and C. Hill.** 2002. Elevated enzyme release from lactococcal starter cultures on exposure to the lantibiotic lacticin 481, produced by *Lactococcus lactis* DPC5552. *J.Dairy Sci.* **85**:2130-2140.
151. **Ohnishi, R., S. Ishikawa, and J. Sekiguchi.** 1999. Peptidoglycan hydrolase LytF plays a role in cell separation with CwIF during vegetative growth of *Bacillus subtilis*. *J.Bacteriol.* **181**:3178-3184.
152. **Oshida, T., M. Sugai, H. Komatsuzawa, Y. M. Hong, H. Suginaka, and A. Tomasz.** 1995. A *Staphylococcus aureus* autolysin that has an N-acetylmuramoyl-L- alanine amidase domain and an endo-beta-N-acetylglucosaminidase domain: cloning, sequence analysis, and characterization. *Proc.Natl.Acad.Sci.U.S.A* **92**:285-289.
153. **Ou, L. T. and R. E. Marquis.** 1970. Electromechanical interactions in cell walls of gram-positive cocci. *J.Bacteriol.* **101**:92-101.
154. **Ozin, A. J., A. O. Henriques, H. Yi, and C. P. Moran, Jr.** 2000. Morphogenetic proteins SpoVID and SafA form a complex during assembly of the *Bacillus subtilis* spore coat. *J.Bacteriol.* **182**:1828-1833.
155. **Palumbo, E., C. F. Favier, M. Deghorain, P. S. Cocconcelli, C. Grangette, A. Mercenier, E. E. Vaughan, and P. Hols.** 2004. Knockout of the alanine racemase gene in *Lactobacillus plantarum* results in septation defects and cell wall perforation. *FEMS Microbiol.Lett.* **233**:131-138.
156. **Pederson, J. A., G. J. Mileski, B. C. Weimer, and J. L. Steele.** 1999. Genetic characterization of a cell envelope-associated proteinase from *Lactobacillus helveticus* CNRZ32. *J.Bacteriol.* **181**:4592-4597.
157. **Pelletier, C., C. Bouley, C. Cayuela, S. Bouttier, P. Bourlioux, and M. N. Bellon-Fontaine.** 1997. Cell surface characteristics of *Lactobacillus casei* subsp. *casei*, *Lactobacillus paracasei* subsp. *paracasei*, and *Lactobacillus rhamnosus* strains. *Appl.Environ.Microbiol.* **63**:1725-1731.
158. **Perego, M., P. Glaser, A. Minutello, M. A. Strauch, K. Leopold, and W. Fischer.** 1995. Incorporation of D-alanine into lipoteichoic acid and wall teichoic acid in *Bacillus subtilis*. Identification of genes and regulation. *J.Biol.Chem.* **270**:15598-15606.
159. **Peschel, A., M. Otto, R. W. Jack, H. Kalbacher, G. Jung, and F. Gotz.** 1999. Inactivation of the *dlt* operon in *Staphylococcus aureus* confers sensitivity to defensins, protegrins, and other antimicrobial peptides. *J.Biol.Chem.* **274**:8405-8410.

160. **Plant, L. J. and P. L. Conway.** 2002. Adjuvant properties and colonization potential of adhering and non-adhering *Lactobacillus* spp following oral administration to mice. *FEMS Immunol.Med.Microbiol.* **34**:105-111.
161. **Ponting, C. P., L. Aravind, J. Schultz, P. Bork, and E. V. Koonin.** 1999. Eukaryotic signalling domain homologues in archaea and bacteria. Ancient ancestry and horizontal gene transfer. *J.Mol.Biol.* **289**:729-745.
162. **Pooley, H. M. and D. Karamata.** 1994. Teichoic acid synthesis in *Bacillus subtilis*: genetic organization and biological roles, p. 187-196. *In* J. M. Ghuysen and R. Hakenbeck (eds.), *Bacterial cell wall*. Elsevier Science B.V., Amsterdam, The Netherlands.
163. **Poquet, I., V. Saint, E. Seznec, N. Simoes, A. Bolotin, and A. Gruss.** 2000. HtrA is the unique surface housekeeping protease in *Lactococcus lactis* and is required for natural protein processing. *Mol.Microbiol.* **35**:1042-1051.
164. **Radutoiu, S., L. H. Madsen, E. B. Madsen, H. H. Felle, Y. Umehara, M. Gronlund, S. Sato, Y. Nakamura, S. Tabata, N. Sandal, and J. Stougaard.** 2003. Plant recognition of symbiotic bacteria requires two LysM receptor-like kinases. *Nature* **425**:585-592.
165. **Ramadurai, L. and R. K. Jayaswal.** 1997. Molecular cloning, sequencing, and expression of *lytM*, a unique autolytic gene of *Staphylococcus aureus*. *J.Bacteriol.* **179**:3625-3631.
166. **Ramasamy, R., S. Yasawardena, R. Kanagaratnam, E. Buratti, F. E. Baralle, and M. S. Ramasamy.** 1999. Antibodies to a merozoite surface protein promote multiple invasion of red blood cells by malaria parasites. *Parasite Immunol.* **21**:397-407.
167. **Rashid, M. H., M. Mori, and J. Sekiguchi.** 1995. Glucosaminidase of *Bacillus subtilis*: cloning, regulation, primary structure and biochemical characterization. *Microbiology* **141**:2391-2404.
168. **Rathsam, C., P. M. Giffard, and N. A. Jacques.** 1993. The cell-bound fructosyltransferase of *Streptococcus salivarius*: the carboxyl terminus specifies attachment in a *Streptococcus gordonii* model system. *J.Bacteriol.* **175**:4520-4527.
169. **Raychaudhuri, D. and A. N. Chatterjee.** 1985. Use of resistant mutants to study the interaction of triton X-100 with *Staphylococcus aureus*. *J.Bacteriol.* **164**:1337-1349.
170. **Reveneau, N., M. C. Geoffroy, C. Loch, P. Chagnaud, and A. Mercenier.** 2002. Comparison of the immune responses induced by local immunizations with recombinant *Lactobacillus plantarum* producing tetanus toxin fragment C in different cellular locations. *Vaccine* **20**:1769-1777.
171. **Riepe, H. R., C. J. Pillidge, P. K. Gopal, and L. L. McKay.** 1997. Characterization of the highly autolytic *Lactococcus lactis* subsp. *cremoris* strains CO and 2250. *Appl.Environ.Microbiol.* **63**:3757-3763.
172. **Ries, W., C. Hotzy, I. Schocher, U. B. Sleytr, and M. Sara.** 1997. Evidence that the N-terminal part of the S-layer protein from *Bacillus stearothermophilus* PV72/p2 recognizes a secondary cell wall polymer. *J.Bacteriol.* **179**:3892-3898.

References

173. **Roche, P., P. Lerouge, C. Ponthus, and J. C. Prome.** 1991. Structural determination of bacterial nodulation factors involved in the *Rhizobium meliloti*-alfalfa symbiosis. *J.Biol.Chem.* **266**:10933-10940.
174. **Rogers, H. J., H. R. Perkins, and J. B. Ward.** 1980. The bacterial autolysins, p. 437-460. *In* H. J. Rogers, H. R. Perkins, and J. B. Ward (eds.), *Microbial cell walls and membranes*. Chapman and Hall, London.
175. **Rosenow, C., P. Ryan, J. N. Weiser, S. Johnson, P. Fontan, A. Ortqvist, and H. R. Masure.** 1997. Contribution of novel choline-binding proteins to adherence, colonization and immunogenicity of *Streptococcus pneumoniae*. *Mol.Microbiol.* **25**:819-829.
176. **Ruhland, G. J., M. Hellwig, G. Wanner, and F. Fiedler.** 1993. Cell-surface location of *Listeria*-specific protein p60--detection of *Listeria* cells by indirect immunofluorescence. *J.Gen.Microbiol.* **139**:609-616.
177. **Sambrook, J., E. F. Fritsch, and T. Maniatis.** 1989. *Molecular cloning: a laboratory manual*. Cold Spring Harbor laboratory Press, Cold Spring Harbor, N.Y.
178. **Sanchez-Puelles, J. M., J. M. Sanz, J. L. Garcia, and E. Garcia.** 1990. Cloning and expression of gene fragments encoding the choline-binding domain of pneumococcal murein hydrolases. *Gene* **89**:69-75.
179. **Sanders, J. W., G. Venema, and J. Kok.** 1997. A chloride-inducible gene expression cassette and its use in induced lysis of *Lactococcus lactis*. *Appl.Environ.Microbiol.* **63**:4877-4882.
180. **Sanger, F., S. Nicklen, and A. R. Coulson.** 1977. DNA sequencing with chain-terminating inhibitors. *Proc.Natl.Acad.Sci.U.S.A* **74**:5463-5467.
181. **Sara, M., C. Dekitsch, H. F. Mayer, E. M. Egelseer, and U. B. Sleytr.** 1998. Influence of the secondary cell wall polymer on the reassembly, recrystallization, and stability properties of the S-layer protein from *Bacillus stearothermophilus* PV72/p2. *J.Bacteriol.* **180**:4146-4153.
182. **Sara, M. and U. B. Sleytr.** 2000. S-Layer proteins. *J.Bacteriol.* **182**:859-868.
183. **Sauve, D. M., D. T. Ho, and M. Roberge.** 1995. Concentration of dilute protein for gel electrophoresis. *Analytical Biochemistry* **226**:382-383.
184. **Saxton, W. O. and W. Baumeister.** 1986. Principles of organization in S layers. *J.Mol.Biol.* **187**:251-253.
185. **Schafer, A., A. Geis, H. Neve, and M. Teuber.** 1991. Bacteriophage receptors of *Lactococcus lactis* subsp. '*diacetylactis*' F7/2 and *Lactococcus lactis* subsp. *cremoris* Wg2-1. *FEMS Microbiol.Lett.* **62**:69-73.
186. **Schleifer, K. H. and O. Kandler.** 1972. Peptidoglycan types of bacterial cell walls and their taxonomic implications. *Bacteriological Reviews* **36**:407-477.
187. **Schneewind, O., D. Mihaylova-Petkov, and P. Model.** 1993. Cell wall sorting signals in surface proteins of gram-positive bacteria. *EMBO J.* **12**:4803-4811.
188. **Schneewind, O., P. Model, and V. A. Fischetti.** 1992. Sorting of protein A to the staphylococcal cell wall. *Cell* **70**:267-281.

189. **Seegers, J. F., S. Bron, C. M. Franke, G. Venema, and R. Kiewiet.** 1994. The majority of lactococcal plasmids carry a highly related replicon. *Microbiology* **140**:1291-1300.
190. **Shida, T., H. Hattori, F. Ise, and J. Sekiguchi.** 2001. Mutational analysis of catalytic sites of the cell wall lytic N-acetylmuramoyl-L-alanine amidases CwlC and CwlV. *J.Biol.Chem.* **276**:28140-28146.
191. **Shockman, G. D. and J. F. Barrett.** 1983. Structure, function, and assembly of cell walls of gram-positive bacteria. *Annu.Rev.Microbiol.* **37**:501-527.
192. **Shockman, G. D. and J. V. Holtje.** 1994. Microbial peptidoglycan (murein) hydrolases, p. 131-166. *In* J. M. Ghuysen and R. Hakenbeck (eds.), *Bacterial cell wall*. Elsevier Science B.V., Amsterdam, The Netherlands.
193. **Siezen, R. J.** 1999. Multi-domain, cell-envelope proteinases of lactic acid bacteria. *Antonie Van Leeuwenhoek* **76**:139-155.
194. **Sijtsma, L., J. T. Wouters, and K. J. Hellingwerf.** 1990. Isolation and characterization of lipoteichoic acid, a cell envelope component involved in preventing phage adsorption, from *Lactococcus lactis* subsp. *cremoris* SK110. *J.Bacteriol.* **172**:7126-7130.
195. **Sillanpaa, J., B. Martinez, J. Antikainen, T. Toba, N. Kalkkinen, S. Tankka, K. Lounatmaa, J. Keranen, M. Hook, B. Westerlund-Wikstrom, P. H. Pouwels, and T. K. Korhonen.** 2000. Characterization of the collagen-binding S-layer protein CbsA of *Lactobacillus crispatus*. *J.Bacteriol.* **182**:6440-6450.
196. **Sleytr, U. B. and T. J. Beveridge.** 1999. Bacterial S-layers. *Trends Microbiol.* **7**:253-260.
197. **Sleytr, U. B. and P. Messner.** 1983. Crystalline surface layers on bacteria. *Annu.Rev.Microbiol.* **37**:311-339.
198. **Smit, E., F. Oling, R. Demel, B. Martinez, and P. H. Pouwels.** 2001. The S-layer protein of *Lactobacillus acidophilus* ATCC 4356: identification and characterisation of domains responsible for S-protein assembly and cell wall binding. *J.Mol.Biol.* **305**:245-257.
199. **Smith, T. J., S. A. Blackman, and S. J. Foster.** 1996. Peptidoglycan hydrolases of *Bacillus subtilis* 168. *Microb.Drug Resist.* **2**:113-118.
200. **Smith, T. J., S. A. Blackman, and S. J. Foster.** 2000. Autolysins of *Bacillus subtilis*: multiple enzymes with multiple functions. *Microbiology* **146**:249-262.
201. **Smith, T. J. and S. J. Foster.** 1995. Characterization of the involvement of two compensatory autolysins in mother cell lysis during sporulation of *Bacillus subtilis* 168. *J.Bacteriol.* **177**:3855-3862.
202. **Snowden, M. A. and H. R. Perkins.** 1990. Peptidoglycan cross-linking in *Staphylococcus aureus*. An apparent random polymerisation process. *Eur.J.Biochem.* **191**:373-377.
203. **Spaink, H. P.** 2004. Specific recognition of bacteria by plant LysM domain receptor kinases. *Trends Microbiol.* **12**:201-204.
204. **Steen, A., G. Buist, G. J. Horsburgh, G. Venema, O. P. Kuipers, S. J. Foster, and J. Kok.** 2005. AcmA of *Lactococcus lactis* is an N-acetylglucosaminidase with an optimal number of LysM domains for proper functioning. *FEBS J.* **272**:2854-2868.

References

205. **Steen, A., G. Buist, K. J. Leenhouts, M. E. Khattabi, F. Grijpstra, A. L. Zomer, G. Venema, O. P. Kuipers, and J. Kok.** 2003. Cell wall attachment of a widely distributed peptidoglycan binding domain is hindered by cell wall constituents. *J.Biol.Chem.* **278**:23874-23881.
206. **Steen, A., E. Palumbo, M. Deghorain, P. S. Cocconcelli, J. Delcour, O. P. Kuipers, J. Kok, G. Buist, and P. Hols.** 2005. Autolysis of *Lactococcus lactis* is increased upon D-alanine depletion of peptidoglycan and lipoteichoic acids. *J.Bacteriol.* **187**:114-124.
207. **Steidler, L., J. Viaene, W. Fiers, and E. Remaut.** 1998. Functional display of a heterologous protein on the surface of *Lactococcus lactis* by means of the cell wall anchor of *Staphylococcus aureus* protein A. *Appl.Environ.Microbiol.* **64**:342-345.
208. **Studier, F. W. and B. A. Moffatt.** 1986. Use of bacteriophage T7 RNA polymerase to direct selective high-level expression of cloned genes. *J.Mol.Biol.* **189**:113-130.
209. **Sugai, M., S. Yamada, S. Nakashima, H. Komatsuzawa, A. Matsumoto, T. Oshida, and H. Suginaka.** 1997. Localized perforation of the cell wall by a major autolysin: *atl* gene products and the onset of penicillin-induced lysis of *Staphylococcus aureus*. *J.Bacteriol.* **179**:2958-2962.
210. **Takahashi, J., H. Komatsuzawa, S. Yamada, T. Nishida, H. Labischinski, T. Fujiwara, M. Ohara, J. Yamagishi, and M. Sugai.** 2002. Molecular characterization of an *atl* null mutant of *Staphylococcus aureus*. *Microbiol.Immunol.* **46**:601-612.
211. **Tan, P. S., T. A. van Kessel, F. L. van de Veerdonk, P. F. Zuurendonk, A. P. Bruins, and W. N. Konings.** 1993. Degradation and debittering of a tryptic digest from beta-casein by aminopeptidase N from *Lactococcus lactis* subsp. *cremoris* Wg2. *Appl.Environ.Microbiol.* **59**:1430-1436.
212. **Thwaite, J. E., L. W. Baillie, N. M. Carter, K. Stephenson, M. Rees, C. R. Harwood, and P. T. Emmerson.** 2002. Optimization of the cell wall microenvironment allows increased production of recombinant *Bacillus anthracis* protective antigen from *B. subtilis*. *Appl.Environ.Microbiol.* **68**:227-234.
213. **Tipper, D. J. and J. L. Strominger.** 1966. Isolation of 4-O-beta-N-acetylmuramyl-N-acetylglucosamine and 4-O-beta-N, 6-O-diacetylmuramyl-N-acetylglucosamine and the structure of the cell wall polysaccharide of *Staphylococcus aureus*. *Biochem.Biophys.Res.Comm.* **22**:48-56.
214. **Tomasz, A.** 1984. Building and breaking bonds in the cell wall of bacteria-the role for autolysins, p. 3-12. *In* C. Nombela (ed.), *Microbial cell wall synthesis and autolysis*. Elsevier Science publishers, Amsterdam.
215. **Tomasz, A., M. Westphal, E. B. Briles, and P. Fletcher.** 1975. On the physiological functions of teichoic acids. *J.Supramol.Struct.* **3**:1-16.
216. **Towbin, H., T. Staehelin, and J. Gordon.** 1992. Electrophoretic transfer of proteins from polyacrylamide gels to nitrocellulose sheets: procedure and some applications. 1979. *Biotechnology* **24**:145-149.
217. **Turner, M. S., L. M. Hafner, T. Walsh, and P. M. Giffard.** 2004. Identification and characterization of the novel LysM domain-containing surface protein Sep from *Lactobacillus fermentum* BR11 and its

- use as a peptide fusion partner in *Lactobacillus* and *Lactococcus*. *Appl.Environ.Microbiol.* **70**:3673-3680.
218. **Umeda, A., S. Yokoyama, T. Arizono, and K. Amako.** 1992. Location of peptidoglycan and teichoic acid on the cell wall surface of *Staphylococcus aureus* as determined by immunoelectron microscopy. *J.Electron Microsc.(Tokyo)* **41**:46-52.
219. **Valyasevi, R., W. E. Sandine, and B. L. Geller.** 1990. The bacteriophage kh receptor of *Lactococcus lactis* subsp. *cremoris* KH is the rhamnose of the extracellular wall polysaccharide. *Appl.Environ.Microbiol.* **56**:1882-1889.
220. **van Asseldonk, M., G. Rutten, M. Oteman, R. J. Siezen, W. M. de Vos, and G. Simons.** 1990. Cloning of *usp45*, a gene encoding a secreted protein from *Lactococcus lactis* subsp. *lactis* MG1363. *Gene* **95**:155-160.
221. **van de Guchte, M., J. Kodde, J. M. van der Vossen, J. Kok, and G. Venema.** 1990. Heterologous gene expression in *Lactococcus lactis* subsp. *lactis*: synthesis, secretion, and processing of the *Bacillus subtilis* neutral protease. *Appl.Environ.Microbiol.* **56**:2606-2611.
222. **van Sinderen, D., H. Karsens, J. Kok, P. Terpstra, M. H. Ruiters, G. Venema, and A. Nauta.** 1996. Sequence analysis and molecular characterization of the temperate lactococcal bacteriophage rlt. *Mol.Microbiol.* **19**:1343-1355.
223. **van, d. M., Jr., J. Polman, M. M. Beerthuyzen, R. J. Siezen, O. P. Kuipers, and W. M. de Vos.** 1993. Characterization of the *Lactococcus lactis* nisin A operon genes *nisP*, encoding a subtilisin-like serine protease involved in precursor processing, and *nisR*, encoding a regulatory protein involved in nisin biosynthesis. *J.Bacteriol.* **175**:2578-2588.
224. **Vaughan, E. E., B. Mollet, and W. M. deVos.** 1999. Functionality of probiotics and intestinal lactobacilli: light in the intestinal tract tunnel. *Curr.Opin.Biotechnol.* **10**:505-510.
225. **Ventura, M., M. L. Callegari, and L. Morelli.** 2000. S-layer gene as a molecular marker for identification of *Lactobacillus helveticus*. *FEMS Microbiol.Lett.* **189**:275-279.
226. **Vidgren, G., I. Palva, R. Pakkanen, K. Lounatmaa, and A. Palva.** 1992. S-layer protein gene of *Lactobacillus brevis*: cloning by polymerase chain reaction and determination of the nucleotide sequence. *J.Bacteriol.* **174**:7419-7427.
227. **Vieira, J. and J. Messing.** 1991. New pUC-derived cloning vectors with different selectable markers and DNA replication origins. *Gene* **100**:189-194.
228. **Vollmer, W., H. Pils, K. Hantke, J. V. Holtje, and V. Braun.** 1997. Pesticin displays muramidase activity. *J.Bacteriol.* **179**:1580-1583.
229. **von Heijne, G.** 1990. The signal peptide. *J.Membr.Biol.* **115**:195-201.
230. **Walstra, P., A. Noomen, and T. J. Geurts.** 1987. Dutch-type varieties, p. 45-92. *In* P. F. Fox (ed.), *Cheese: chemistry, physics and microbiology*. Elsevier Applied Science Publishers, London.
231. **Ward, J. B.** 1981. Teichoic and teichuronic acids: biosynthesis, assembly, and location. *Microbiol.Rev.* **45**:211-243.

References

232. **Ward, J. B. and R. Williamson.** 1984. Bacterial autolysins: specificity and function, p. 159-175. In C. Nombela (ed.), *Microbial cell wall synthesis and autolysis*. Elsevier Science Publishers, Amsterdam.
233. **Wecke, J., M. Perego, and W. Fischer.** 1996. D-alanine deprivation of *Bacillus subtilis* teichoic acids is without effect on cell growth and morphology but affects the autolytic activity. *Microb. Drug Resist.* **2**:123-129.
234. **Wilkinson, M. G., T. P. Guinee, D. M. O'Callaghan, and P. F. Fox.** 1994. Autolysis and proteolysis in different strains of starter bacteria during Cheddar cheese ripening. *J. Dairy. Res.* **61**:249-262.
235. **Wittenberger, C. L. and N. Angelo.** 1970. Purification and properties of a fructose-1,6-diphosphate-activated lactate dehydrogenase from *Streptococcus faecalis*. *J. Bacteriol.* **101**:717-724.
236. **Wood, W. A. and I. C. Gunsalus.** 1951. D-Alanine formation: a racemase in *Streptococcus faecalis*. *J. Biol. Chem.* **190**:403-416.
237. **Wren, B. W.** 1991. A family of clostridial and streptococcal ligand-binding proteins with conserved C-terminal repeat sequences. *Mol. Microbiol.* **5**:797-803.
238. **Yamamoto, H., S. Kurosawa, and J. Sekiguchi.** 2003. Localization of the vegetative cell wall hydrolases LytC, LytE, and LytF on the *Bacillus subtilis* cell surface and stability of these enzymes to cell wall-bound or extracellular proteases. *J. Bacteriol.* **185**:6666-6677.
239. **Yamashita, Y., Y. Tsukioka, Y. Nakano, K. Tomihisa, T. Oho, and T. Koga.** 1998. Biological functions of UDP-glucose synthesis in *Streptococcus mutans*. *Microbiology* **144**:1235-1245.
240. **Yother, J. and D. E. Briles.** 1992. Structural properties and evolutionary relationships of PspA, a surface protein of *Streptococcus pneumoniae*, as revealed by sequence analysis. *J. Bacteriol.* **174**:601-609.
241. **Yother, J. and J. M. White.** 1994. Novel surface attachment mechanism of the *Streptococcus pneumoniae* protein PspA. *J. Bacteriol.* **176**:2976-2985.
242. **Young, F. E.** 1967. Requirement of glucosylated teichoic acid for adsorption of phage in *Bacillus subtilis* 168. *Proc. Natl. Acad. Sci. U.S.A* **58**:2377-2384.
243. **Young, R.** 1992. Bacteriophage lysis: mechanism and regulation. *Microbiol. Rev.* **56**:430-481.
244. **Zabarovsky, E. R. and G. Winberg.** 1990. High efficiency electroporation of ligated DNA into bacteria. *Nucleic Acids Res.* **18**:5912.

