

References:

1. Kadioglu, A., et al., *The role of Streptococcus pneumoniae virulence factors in host respiratory colonization and disease*. Nat Rev Micro, 2008. **6**(4): p. 288-301.
2. Argondizzo, A.P.C., et al., *Pneumococcal Predictive Proteins Selected by Microbial Genomic Approach Are Serotype Cross-Reactive and Bind to Host Extracellular Matrix Proteins*. Applied Biochemistry and Biotechnology, 2017: p. 1-22.
3. Lanie, J.A., et al., *Genome Sequence of Avery's Virulent Serotype 2 Strain D39 of Streptococcus pneumoniae and Comparison with That of Unencapsulated Laboratory Strain R6*. Journal of Bacteriology, 2007. **189**(1): p. 38-51.
4. Bogaert, D., R. de Groot, and P.W.M. Hermans, *Streptococcus pneumoniae colonisation: the key to pneumococcal disease*. The Lancet Infectious Diseases, 2004. **4**(3): p. 144-154.
5. McCool, T.L. and J.N. Weiser, *Limited Role of Antibody in Clearance of Streptococcus pneumoniae in a Murine Model of Colonization*. Infection and Immunity, 2004. **72**(10): p. 5807-5813.
6. Hausdorff, W.P., et al., *Which pneumococcal serogroups cause the most invasive disease: implications for conjugate vaccine formulation and use, part I*. Clin Infect Dis, 2000. **30**(1): p. 100-21.
7. Robinson, K.A., et al., *Epidemiology of invasive streptococcus pneumoniae infections in the united states, 1995-1998: Opportunities for prevention in the conjugate vaccine era*. JAMA, 2001. **285**(13): p. 1729-1735.
8. Weinberger, D.M., R. Malley, and M. Lipsitch, *Serotype replacement in disease after pneumococcal vaccination*. Lancet, 2011. **378**(9807): p. 1962-73.
9. Spratt, B.G. and B.M. Greenwood, *Prevention of pneumococcal disease by vaccination: does serotype replacement matter?* Lancet, 2000. **356**(9237): p. 1210-1.
10. Diawara, I., et al., *Invasive pneumococcal disease among children younger than 5 years of age before and after introduction of pneumococcal conjugate vaccine in Casablanca, Morocco*. Int J Infect Dis, 2015. **40**: p. 95-101.
11. Lehmann, D., et al., *The changing epidemiology of invasive pneumococcal disease in aboriginal and non-aboriginal western Australians from 1997 through 2007 and emergence of nonvaccine serotypes*. Clin Infect Dis, 2010. **50**(11): p. 1477-86.
12. Wenger, J.D., et al., *Invasive pneumococcal disease in Alaskan children: impact of the seven-valent pneumococcal conjugate vaccine and the role of water supply*. Pediatr Infect Dis J, 2010. **29**(3): p. 251-6.
13. Obaro, S.K., et al., *Carriage of pneumococci after pneumococcal vaccination*. Lancet, 1996. **348**(9022): p. 271-2.
14. Cheung, Y.B., et al., *Nasopharyngeal carriage of Streptococcus pneumoniae in Gambian children who participated in a 9-valent pneumococcal conjugate vaccine trial and in their younger siblings*. Pediatr Infect Dis J, 2009. **28**(11): p. 990-5.
15. Levy, C., et al., *Pneumococcal meningitis in french children before and after the introduction of pneumococcal conjugate vaccine*. Pediatr Infect Dis J, 2011. **30**(2): p. 168-70.
16. Brueggemann, A.B., et al., *Vaccine escape recombinants emerge after pneumococcal vaccination in the United States*. PLoS Pathog, 2007. **3**(11): p. e168.

17. Demczuk, W.H.B., et al., *Phylogenetic analysis of emergent Streptococcus pneumoniae serotype 22F causing invasive pneumococcal disease using whole genome sequencing*. PLoS One, 2017. **12**(5): p. e0178040.
18. Croucher, N.J., et al., *Rapid Pneumococcal Evolution in Response to Clinical Interventions*. Science, 2011. **331**(6016): p. 430-434.
19. Wyres, K.L., et al., *Pneumococcal Capsular Switching: A Historical Perspective*. The Journal of Infectious Diseases, 2013. **207**(3): p. 439-449.
20. Croucher, N.J., et al., *Population genomics of post-vaccine changes in pneumococcal epidemiology*. Nature genetics, 2013. **45**(6): p. 656-663.
21. Tettelin, H., et al., *Complete genome sequence of a virulent isolate of Streptococcus pneumoniae*. Science, 2001. **293**(5529): p. 498-506.
22. Hoskins, J., et al., *Genome of the Bacterium Streptococcus pneumoniae Strain R6*. Journal of Bacteriology, 2001. **183**(19): p. 5709-5717.
23. Brown, J.S., et al., *Immunization with components of two iron uptake ABC transporters protects mice against systemic Streptococcus pneumoniae infection*. Infect Immun, 2001. **69**(11): p. 6702-6.
24. Jomaa, M., et al., *Immunization with the iron uptake ABC transporter proteins PiaA and PiuA prevents respiratory infection with Streptococcus pneumoniae*. Vaccine, 2006. **24**(24): p. 5133-9.
25. Bentley, S.D., et al., *Genetic analysis of the capsular biosynthetic locus from all 90 pneumococcal serotypes*. PLoS Genet, 2006. **2**(3): p. e31.
26. Lloyd-Evans, N., et al., *Nasopharyngeal carriage of pneumococci in Gambian children and in their families*. Pediatr Infect Dis J, 1996. **15**(10): p. 866-71.
27. Hill, P.C., et al., *Nasopharyngeal carriage of Streptococcus pneumoniae in Gambian infants: a longitudinal study*. Clin Infect Dis, 2008. **46**(6): p. 807-14.
28. Chaguza, C., et al., *Understanding pneumococcal serotype 1 biology through population genomic analysis*. BMC Infect Dis, 2016. **16**(1): p. 649.
29. Brueggemann, A.B. and B.G. Spratt, *Geographic Distribution and Clonal Diversity of Streptococcus pneumoniae Serotype 1 Isolates*. Journal of Clinical Microbiology, 2003. **41**(11): p. 4966-4970.
30. Dawid, S., M.E. Sebert, and J.N. Weiser, *Bacteriocin Activity of Streptococcus pneumoniae Is Controlled by the Serine Protease HtrA via Posttranscriptional Regulation*. Journal of Bacteriology, 2009. **191**(5): p. 1509-1518.
31. Moore, M.R., et al., *Population Snapshot of Emergent Streptococcus pneumoniae Serotype 19A in the United States, 2005*. The Journal of Infectious Diseases, 2008. **197**(7): p. 1016-1027.
32. Paterson, G.K. and C.J. Orihuela, *Pneumococci: immunology of the innate host response*. Respirology (Carlton, Vic.), 2010. **15**(7): p. 1057-1063.
33. Tuomanen, E.I. and H.R. Masure, *Molecular and cellular biology of pneumococcal infection*. Microb Drug Resist, 1997. **3**(4): p. 297-308.
34. O'Brien, K.L., et al., *Burden of disease caused by Streptococcus pneumoniae in children younger than 5 years: global estimates*. The Lancet. **374**(9693): p. 893-902.
35. Malley, R. and P.W. Anderson, *Serotype-independent pneumococcal experimental vaccines that induce cellular as well as humoral immunity*. Proceedings of the National Academy of Sciences, 2012. **109**(10): p. 3623-3627.
36. Lu, Y.J., et al., *Interleukin-17A mediates acquired immunity to pneumococcal colonization*. PLoS Pathog, 2008. **4**(9): p. e1000159.

37. Zhang, Z., T.B. Clarke, and J.N. Weiser, *Cellular effectors mediating Th17-dependent clearance of pneumococcal colonization in mice*. The Journal of Clinical Investigation, 2009. **119**(7): p. 1899-1909.
38. Kadioglu, A., et al., *CD4-T-Lymphocyte Interactions with Pneumolysin and Pneumococci Suggest a Crucial Protective Role in the Host Response to Pneumococcal Infection*. Infection and Immunity, 2004. **72**(5): p. 2689-2697.
39. Malley, R., et al., *CD4+ T cells mediate antibody-independent acquired immunity to pneumococcal colonization*. Proceedings of the National Academy of Sciences of the United States of America, 2005. **102**(13): p. 4848-4853.
40. O'Brien, K.L., et al., *Burden of disease caused by Streptococcus pneumoniae in children younger than 5 years: global estimates*. The Lancet. **374**(9693): p. 893-902.
41. Inostroza, J., et al., *Capsular Serotype and Antibiotic Resistance of Streptococcus pneumoniae Isolates in Two Chilean Cities*. Clinical and Diagnostic Laboratory Immunology, 1998. **5**(2): p. 176-180.
42. Boken, D.J., et al., *Colonization with penicillin-nonsusceptible Streptococcus pneumoniae in urban and rural child-care centers*. Pediatr Infect Dis J, 1996. **15**(8): p. 667-72.
43. del Amo, E., et al., *Serotypes and Clonal Diversity of Streptococcus pneumoniae Causing Invasive Disease in the Era of PCV13 in Catalonia, Spain*. PLoS ONE, 2016. **11**(3): p. e0151125.
44. Forgie, I.M., et al., *Etiology of acute lower respiratory tract infections in Gambian children: II. Acute lower respiratory tract infection in children ages one to nine years presenting at the hospital*. Pediatr Infect Dis J, 1991. **10**(1): p. 42-7.
45. Lim, C., et al., *Epidemiology and burden of multidrug-resistant bacterial infection in a developing country*. eLife, 2016. **5**: p. e18082.
46. Chang, B., et al., *Capsule Switching and Antimicrobial Resistance Acquired during Repeated Streptococcus pneumoniae Pneumonia Episodes*. Journal of Clinical Microbiology, 2015. **53**(10): p. 3318-3324.
47. Welte, T., A. Torres, and D. Nathwani, *Clinical and economic burden of community-acquired pneumonia among adults in Europe*. Thorax, 2012. **67**(1): p. 71-9.
48. Ikeogu, M.O., *Acute pneumonia in Zimbabwe: bacterial isolates by lung aspiration*. Archives of Disease in Childhood, 1988. **63**(10): p. 1266-1267.
49. Brouwer, M.C., A.R. Tunkel, and D. van de Beek, *Epidemiology, Diagnosis, and Antimicrobial Treatment of Acute Bacterial Meningitis*. Clinical Microbiology Reviews, 2010. **23**(3): p. 467-492.
50. Nuoh, R.D., et al., *Review of meningitis surveillance data, upper West Region, Ghana 2009-2013*. The Pan African Medical Journal, 2016. **25**(Suppl 1): p. 9.
51. Leimkugel, J., et al., *An outbreak of serotype 1 Streptococcus pneumoniae meningitis in northern Ghana with features that are characteristic of Neisseria meningitidis meningitis epidemics*. J Infect Dis, 2005. **192**(2): p. 192-9.
52. Yaro, S., et al., *Epidemiological and Molecular Characteristics of a Highly Lethal Pneumococcal Meningitis Epidemic in Burkina Faso*. Clinical Infectious Diseases, 2006. **43**(6): p. 693-700.
53. Molyneux, E., F.A. Riordan, and A. Walsh, *Acute bacterial meningitis in children presenting to the Royal Liverpool Children's Hospital, Liverpool, UK and the Queen*

- Elizabeth Central Hospital in Blantyre, Malawi: a world of difference.* Ann Trop Paediatr, 2006. **26**(1): p. 29-37.
54. Kwambana-Adams, B.A., et al., *An outbreak of pneumococcal meningitis among older children (≥ 5 years) and adults after the implementation of an infant vaccination programme with the 13-valent pneumococcal conjugate vaccine in Ghana.* BMC Infectious Diseases, 2016. **16**(1): p. 575.
 55. Traore, Y., et al., *Incidence, Seasonality, Age Distribution, and Mortality of Pneumococcal Meningitis in Burkina Faso and Togo.* Clinical Infectious Diseases, 2009. **48**(Supplement_2): p. S181-S189.
 56. The Kenyan Bacteraemia Study, G., et al., *Polymorphism in a lincRNA Associates with a Doubled Risk of Pneumococcal Bacteremia in Kenyan Children.* American Journal of Human Genetics, 2016. **98**(6): p. 1092-1100.
 57. Laupland, K.B., *Incidence of bloodstream infection: a review of population-based studies.* Clin Microbiol Infect, 2013. **19**(6): p. 492-500.
 58. Berkley , J.A., et al., *Bacteremia among Children Admitted to a Rural Hospital in Kenya.* New England Journal of Medicine, 2005. **352**(1): p. 39-47.
 59. Rosenblut, A., et al., *Etiology of acute otitis media and serotype distribution of Streptococcus pneumoniae and Haemophilus influenzae in Chilean children <5 years of age.* Medicine, 2017. **96**(6): p. e5974.
 60. Paradise, J.L., et al., *Language, speech sound production, and cognition in three-year-old children in relation to otitis media in their first three years of life.* Pediatrics, 2000. **105**(5): p. 1119-30.
 61. Valenzuela, M.T., et al., *The burden of pneumococcal disease among Latin American and Caribbean children: review of the evidence.* Rev Panam Salud Publica, 2009. **25**(3): p. 270-9.
 62. Aguilar, L., et al., *Microbiology of the middle ear fluid in Costa Rican children between 2002 and 2007.* Int J Pediatr Otorhinolaryngol, 2009. **73**(10): p. 1407-11.
 63. Beekmann, S.E., et al., *Antimicrobial resistance in Streptococcus pneumoniae, Haemophilus influenzae, Moraxella catarrhalis and group A β -haemolytic streptococci in 2002–2003: Results of the multinational GRASP Surveillance Program.* International Journal of Antimicrobial Agents, 2005. **25**(2): p. 148-156.
 64. Friedland, I.R. and K.P. Klugman, *Antibiotic-resistant pneumococcal disease in South African children.* Am J Dis Child, 1992. **146**(8): p. 920-3.
 65. Jedrzejas, M.J., *Pneumococcal Virulence Factors: Structure and Function.* Microbiology and Molecular Biology Reviews, 2001. **65**(2): p. 187-207.
 66. Adegbola, R.A., et al., *Serotype and antimicrobial susceptibility patterns of isolates of Streptococcus pneumoniae causing invasive disease in The Gambia 1996-2003.* Trop Med Int Health, 2006. **11**(7): p. 1128-35.
 67. *Pneumococcal vaccines WHO position paper - 2012 - recommendations.* Vaccine, 2012. **30**(32): p. 4717-8.
 68. Tai, S.S., *Streptococcus pneumoniae protein vaccine candidates: properties, activities and animal studies.* Crit Rev Microbiol, 2006. **32**(3): p. 139-53.
 69. Rigden, D.J., M.Y. Galperin, and M.J. Jedrzejas, *Analysis of structure and function of putative surface-exposed proteins encoded in the Streptococcus pneumoniae genome: a bioinformatics-based approach to vaccine and drug design.* Crit Rev Biochem Mol Biol, 2003. **38**(2): p. 143-68.

70. Pavia, M., et al., *Efficacy of pneumococcal vaccination in children younger than 24 months: a meta-analysis*. Pediatrics, 2009. **123**(6): p. e1103-10.
71. Picazo, J., et al., *Effect of the different 13-valent pneumococcal conjugate vaccination uptakes on the invasive pneumococcal disease in children: Analysis of a hospital-based and population-based surveillance study in Madrid, Spain, 2007-2015*. PLoS One, 2017. **12**(2): p. e0172222.
72. Silfverdal, S.A., et al., *Immunogenicity of a 2-dose priming and booster vaccination with the 10-valent pneumococcal nontypeable *Haemophilus influenzae* protein D conjugate vaccine*. Pediatr Infect Dis J, 2009. **28**(10): p. e276-82.
73. Dagan, R., et al., *Efficacy of 13-valent pneumococcal conjugate vaccine (PCV13) versus that of 7-valent PCV (PCV7) against nasopharyngeal colonization of antibiotic-nonsusceptible *Streptococcus pneumoniae**. J Infect Dis, 2015. **211**(7): p. 1144-53.
74. Kwambana-Adams, B.A., et al., *An outbreak of pneumococcal meningitis among older children (>/=5 years) and adults after the implementation of an infant vaccination programme with the 13-valent pneumococcal conjugate vaccine in Ghana*. BMC Infect Dis, 2016. **16**(1): p. 575.
75. Mackenzie, G.A., et al., *Effect of the introduction of pneumococcal conjugate vaccination on invasive pneumococcal disease in The Gambia: a population-based surveillance study*. Lancet Infect Dis, 2016. **16**(6): p. 703-11.
76. Huang, S.S., et al., *Post-PCV7 changes in colonizing pneumococcal serotypes in 16 Massachusetts communities, 2001 and 2004*. Pediatrics, 2005. **116**(3): p. e408-13.
77. Pirez, M.C., et al., *Impact of universal pneumococcal vaccination on hospitalizations for pneumonia and meningitis in children in Montevideo, Uruguay*. Pediatr Infect Dis J, 2011. **30**(8): p. 669-74.
78. Weatherholtz, R., et al., *Invasive Pneumococcal Disease a Decade after Pneumococcal Conjugate Vaccine Use in an American Indian Population at High Risk for Disease*. Clinical Infectious Diseases, 2010. **50**(9): p. 1238-1246.
79. Richter, S.S., et al., *Changes in Pneumococcal Serotypes and Antimicrobial Resistance after Introduction of the 13-Valent Conjugate Vaccine in the United States*. Antimicrobial Agents and Chemotherapy, 2014. **58**(11): p. 6484-6489.
80. Wizemann, T.M., et al., *Use of a whole genome approach to identify vaccine molecules affording protection against *Streptococcus pneumoniae* infection*. Infect Immun, 2001. **69**(3): p. 1593-8.
81. Yamaguchi, K., F. Yu, and M. Inouye, *A single amino acid determinant of the membrane localization of lipoproteins in *E. coli**. Cell, 1988. **53**(3): p. 423-432.
82. Juncker, A.S., et al., *Prediction of lipoprotein signal peptides in Gram-negative bacteria*. Protein Science, 2003. **12**(8): p. 1652-1662.
83. Jomaa, M., et al., *Antibodies to the iron uptake ABC transporter lipoproteins PiaA and PiuA promote opsonophagocytosis of *Streptococcus pneumoniae**. Infect Immun, 2005. **73**(10): p. 6852-9.
84. Odutola, A., et al., *Efficacy of a novel, protein-based pneumococcal vaccine against nasopharyngeal carriage of *Streptococcus pneumoniae* in infants: A phase 2, randomized, controlled, observer-blind study*. Vaccine, 2017. **35**(19): p. 2531-2542.
85. Kaur, R., et al., *Human Antibodies to PhtD, PcpA, and Ply Reduce Adherence to Human Lung Epithelial Cells and Murine Nasopharyngeal Colonization by *Streptococcus pneumoniae**. Infection and Immunity, 2014. **82**(12): p. 5069-5075.

86. Verhoeven, D., Q. Xu, and M.E. Pichichero, *Vaccination with a Streptococcus pneumoniae trivalent recombinant PcpA, PhtD and PlyD1 protein vaccine candidate protects against lethal pneumonia in an infant murine model*. Vaccine, 2014. **32**(26): p. 3205-3210.
87. Goulart, C., et al., *Recombinant BCG expressing a PspA-PdT fusion protein protects mice against pneumococcal lethal challenge in a prime-boost strategy*. Vaccine, 2017. **35**(13): p. 1683-1691.
88. Ren, B., et al., *The Absence of PspA or Presence of Antibody to PspA Facilitates the Complement-Dependent Phagocytosis of Pneumococci In Vitro*. Clinical and Vaccine Immunology, 2012. **19**(10): p. 1574-1582.
89. *Current status and perspectives on protein-based pneumococcal vaccines*. Critical Reviews in Microbiology, 2015. **41**(2): p. 190-200.
90. Khan, M.N., et al., *PcpA of Streptococcus pneumoniae mediates adherence to nasopharyngeal and lung epithelial cells and elicits functional antibodies in humans*. Microbes and Infection, 2012. **14**(12): p. 1102-1110.
91. Bologa, M., et al., *Safety and immunogenicity of pneumococcal protein vaccine candidates: Monovalent choline-binding protein A (PcpA) vaccine and bivalent PcpA-pneumococcal histidine triad protein D vaccine*. Vaccine, 2012. **30**(52): p. 7461-7468.
92. Pimenta, F.C., et al., *Intranasal Immunization with the Cholera Toxin B Subunit-Pneumococcal Surface Antigen A Fusion Protein Induces Protection against Colonization with Streptococcus pneumoniae and Has Negligible Impact on the Nasopharyngeal and Oral Microbiota of Mice*. Infection and Immunity, 2006. **74**(8): p. 4939-4944.
93. Glover, D.T., S.K. Hollingshead, and D.E. Briles, *Streptococcus pneumoniae Surface Protein PcpA Elicits Protection against Lung Infection and Fatal Sepsis*. Infection and Immunity, 2008. **76**(6): p. 2767-2776.
94. Feil, E.J. and B.G. Spratt, *Recombination and the Population Structures of Bacterial Pathogens*. Annual Review of Microbiology, 2001. **55**(1): p. 561-590.
95. Croucher, N.J., et al., *Bacterial genomes in epidemiology—present and future*. Philosophical Transactions of the Royal Society B: Biological Sciences, 2013. **368**(1614): p. 20120202.
96. Croucher, N.J., et al., *Rapid pneumococcal evolution in response to clinical interventions*. Science, 2011. **331**(6016): p. 430-4.
97. Dowson, C.G., et al., *Horizontal gene transfer and the evolution of resistance and virulence determinants in Streptococcus*. Soc Appl Bacteriol Symp Ser, 1997. **26**: p. 42s-51s.
98. Argondizzo, A.P.C., et al., *Identification of Proteins in Streptococcus pneumoniae by Reverse Vaccinology and Genetic Diversity of These Proteins in Clinical Isolates*. Applied Biochemistry and Biotechnology, 2015. **175**(4): p. 2124-2165.
99. Reglier-Poupet, H., et al., *Maturation of lipoproteins by type II signal peptidase is required for phagosomal escape of Listeria monocytogenes*. J Biol Chem, 2003. **278**(49): p. 49469-77.
100. Hammerschmidt, S., et al., *Identification of Pneumococcal Surface Protein A as a Lactoferrin-Binding Protein of Streptococcus pneumoniae*. Infection and Immunity, 1999. **67**(4): p. 1683-1687.

101. Plumptre, C.D., et al., *AdcA and AdcAll employ distinct zinc acquisition mechanisms and contribute additively to zinc homeostasis in Streptococcus pneumoniae*. Molecular Microbiology, 2014. **91**(4): p. 834-851.
102. Maeda, Y., et al., *Novel 33-kilodalton lipoprotein from Mycobacterium leprae*. Infect Immun, 2002. **70**(8): p. 4106-11.
103. Sutcliffe, I.C. and R.R. Russell, *Lipoproteins of gram-positive bacteria*. Journal of Bacteriology, 1995. **177**(5): p. 1123-1128.
104. Countrymeters, *Gambia Population*. 2017.
105. Ceesay, S.J., et al., *Changes in malaria indices between 1999 and 2007 in The Gambia: a retrospective analysis*. The Lancet. **372**(9649): p. 1545-1554.
106. O'Brien, K.L. and H. Nohynek, *Report from a WHO Working Group: standard method for detecting upper respiratory carriage of Streptococcus pneumoniae*. Pediatr Infect Dis J, 2003. **22**(2): p. e1-11.
107. Page, A.J., et al., *Robust high-throughput prokaryote de novo assembly and improvement pipeline for Illumina data*. Microb Genom, 2016. **2**(8): p. e000083.
108. Zerbino, D.R. and E. Birney, *Velvet: algorithms for de novo short read assembly using de Bruijn graphs*. Genome Res, 2008. **18**(5): p. 821-9.
109. Boetzer, M., et al., *Scaffolding pre-assembled contigs using SSPACE*. Bioinformatics, 2011. **27**(4): p. 578-9.
110. Boetzer, M. and W. Pirovano, *Toward almost closed genomes with GapFiller*. Genome Biology, 2012. **13**(6): p. R56.
111. Seemann, T., *Prokka: rapid prokaryotic genome annotation*. Bioinformatics, 2014. **30**(14): p. 2068-9.
112. Wood, D.E. and S.L. Salzberg, *Kraken: ultrafast metagenomic sequence classification using exact alignments*. Genome Biology, 2014. **15**(3): p. R46.
113. Page, A.J., Taylor B., Keane J.A., *Multilocus sequence typing by blast from de novo assemblies against PubMLST*. The Journal of Open Source Software, 2016.
114. Kapatai, G., et al., *Whole genome sequencing of Streptococcus pneumoniae: development, evaluation and verification of targets for serogroup and serotype prediction using an automated pipeline*. PeerJ, 2016. **4**: p. e2477.
115. Cheng, L., et al., *Hierarchical and Spatially Explicit Clustering of DNA Sequences with BAPS Software*. Molecular Biology and Evolution, 2013. **30**(5): p. 1224-1228.
116. Price, M.N., P.S. Dehal, and A.P. Arkin, *FastTree 2--approximately maximum-likelihood trees for large alignments*. PLoS One, 2010. **5**(3): p. e9490.
117. Page, A.J., et al., *SNP-sites: rapid efficient extraction of SNPs from multi-FASTA alignments*. Microbial Genomics, 2016. **2**(4).
118. Page, A.J., et al., *Roary: rapid large-scale prokaryote pan genome analysis*. Bioinformatics, 2015.
119. Cock, P.J.A., et al., *Biopython: freely available Python tools for computational molecular biology and bioinformatics*. Bioinformatics, 2009. **25**(11): p. 1422-1423.
120. de Castro, E., et al., *ScanProsite: detection of PROSITE signature matches and ProRule-associated functional and structural residues in proteins*. Nucleic Acids Research, 2006. **34**(suppl_2): p. W362-W365.
121. Sutcliffe, I.C. and D.J. Harrington, *Pattern searches for the identification of putative lipoprotein genes in Gram-positive bacterial genomes*. Microbiology, 2002. **148**(Pt 7): p. 2065-77.

122. Rahman, O., et al., *Methods for the bioinformatic identification of bacterial lipoproteins encoded in the genomes of Gram-positive bacteria*. World Journal of Microbiology and Biotechnology, 2008. **24**(11): p. 2377.
123. Camacho, C., et al., *BLAST+: architecture and applications*. BMC Bioinformatics, 2009. **10**(1): p. 421.
124. Petersen, T.N., et al., *SignalP 4.0: discriminating signal peptides from transmembrane regions*. Nat Methods, 2011. **8**(10): p. 785-6.
125. Käll, L., A. Krogh, and E.L.L. Sonnhammer, *A Combined Transmembrane Topology and Signal Peptide Prediction Method*. Journal of Molecular Biology, 2004. **338**(5): p. 1027-1036.
126. Madan Babu, M. and K. Sankaran, *DOLOP--database of bacterial lipoproteins*. Bioinformatics, 2002. **18**(4): p. 641-3.
127. Babu, M.M., et al., *A Database of Bacterial Lipoproteins (DOLOP) with Functional Assignments to Predicted Lipoproteins*. Journal of Bacteriology, 2006. **188**(8): p. 2761-2773.
128. Terada, M., et al., *Lipoprotein sorting signals evaluated as the *LolA*-dependent release of lipoproteins from the cytoplasmic membrane of *Escherichia coli**. J Biol Chem, 2001. **276**(50): p. 47690-4.
129. Gouy, M., S. Guindon, and O. Gascuel, *SeaView Version 4: A Multiplatform Graphical User Interface for Sequence Alignment and Phylogenetic Tree Building*. Molecular Biology and Evolution, 2010. **27**(2): p. 221-224.
130. Edgar, R.C., *MUSCLE: multiple sequence alignment with high accuracy and high throughput*. Nucleic Acids Res, 2004. **32**(5): p. 1792-7.
131. Stamatakis, A., *RAxML version 8: a tool for phylogenetic analysis and post-analysis of large phylogenies*. Bioinformatics, 2014. **30**(9): p. 1312-1313.
132. Hadfield, J., et al., *Phandango: an interactive viewer for bacterial population genomics*. bioRxiv, 2017.
133. Letunic, I. and P. Bork, *Interactive tree of life (iTOL) v3: an online tool for the display and annotation of phylogenetic and other trees*. Nucleic Acids Research, 2016. **44**(Web Server issue): p. W242-W245.
134. Haste Andersen, P., M. Nielsen, and O. Lund, *Prediction of residues in discontinuous B-cell epitopes using protein 3D structures*. Protein Sci, 2006. **15**(11): p. 2558-67.
135. Larsen, J.E.P., O. Lund, and M. Nielsen, *Improved method for predicting linear B-cell epitopes*. Immunome Research, 2006. **2**: p. 2-2.
136. Parker, J.M., D. Guo, and R.S. Hodges, *New hydrophilicity scale derived from high-performance liquid chromatography peptide retention data: correlation of predicted surface residues with antigenicity and X-ray-derived accessible sites*. Biochemistry, 1986. **25**(19): p. 5425-32.
137. Hopp, T.P. and K.R. Woods, *Prediction of protein antigenic determinants from amino acid sequences*. Proceedings of the National Academy of Sciences of the United States of America, 1981. **78**(6): p. 3824-3828.
138. Welling, G.W., et al., *Prediction of sequential antigenic regions in proteins*. FEBS Lett, 1985. **188**(2): p. 215-8.
139. Levitt, M., *Conformational preferences of amino acids in globular proteins*. Biochemistry, 1978. **17**(20): p. 4277-85.

140. Pellequer, J.L., E. Westhof, and M.H. Van Regenmortel, *Correlation between the location of antigenic sites and the prediction of turns in proteins*. Immunol Lett, 1993. **36**(1): p. 83-99.
141. Chou, P.Y. and G.D. Fasman, *Prediction of the secondary structure of proteins from their amino acid sequence*. Adv Enzymol Relat Areas Mol Biol, 1978. **47**: p. 45-148.
142. Karplus, P.A. and G.E. Schulz, *Prediction of chain flexibility in proteins*. Naturwissenschaften, 1985. **72**(4): p. 212-213.
143. Ponomarenko, J., et al., *ElliPro: a new structure-based tool for the prediction of antibody epitopes*. BMC Bioinformatics, 2008. **9**(1): p. 514.
144. Thornton, J.M., et al., *Location of 'continuous' antigenic determinants in the protruding regions of proteins*. The EMBO Journal, 1986. **5**(2): p. 409-413.
145. Berman, H.M., et al., *The Protein Data Bank*. Nucleic Acids Research, 2000. **28**(1): p. 235-242.
146. Yang, J., et al., *The I-TASSER Suite: protein structure and function prediction*. Nat Methods, 2015. **12**(1): p. 7-8.
147. Roy, A., A. Kucukural, and Y. Zhang, *I-TASSER: a unified platform for automated protein structure and function prediction*. Nature protocols, 2010. **5**(4): p. 725-738.
148. Zhang, Y., *I-TASSER server for protein 3D structure prediction*. BMC Bioinformatics, 2008. **9**: p. 40.
149. Kelley, L.A., et al., *The Phyre2 web portal for protein modeling, prediction and analysis*. Nat. Protocols, 2015. **10**(6): p. 845-858.
150. Fiser, A. and A. Šali, *Modeller: Generation and Refinement of Homology-Based Protein Structure Models*, in *Methods in Enzymology*. 2003, Academic Press. p. 461-491.
151. Geno, K.A., J.S. Saad, and M.H. Nahm, *Discovery of novel pneumococcal serotype, 35D: a natural WciG-deficient variant of serotype 35B*. Journal of Clinical Microbiology, 2017.
152. *Jmol: an open-source Java viewerfor chemical structures in 3D*.
153. Romero-Steiner, S., et al., *Inhibition of Pneumococcal Adherence to Human Nasopharyngeal Epithelial Cells by Anti-PsaA Antibodies*. Clinical and Diagnostic Laboratory Immunology, 2003. **10**(2): p. 246-251.
154. Claverys, J.P., *A new family of high-affinity ABC manganese and zinc permeases*. Res Microbiol, 2001. **152**(3-4): p. 231-43.
155. Moore, C.M. and J.D. Helmann, *Metal ion homeostasis in Bacillus subtilis*. Curr Opin Microbiol, 2005. **8**(2): p. 188-95.
156. Loisel, E., et al., *AdcAll, A New Pneumococcal Zn-Binding Protein Homologous with ABC Transporters: Biochemical and Structural Analysis*. Journal of Molecular Biology, 2008. **381**(3): p. 594-606.
157. Dintilhac, A., et al., *Competence and virulence of Streptococcus pneumoniae: Adc and PsaA mutants exhibit a requirement for Zn and Mn resulting from inactivation of putative ABC metal permeases*. Mol Microbiol, 1997. **25**(4): p. 727-39.
158. Bayle, L., et al., *Zinc uptake by Streptococcus pneumoniae depends on both AdcA and AdcAll and is essential for normal bacterial morphology and virulence*. Mol Microbiol, 2011. **82**(4): p. 904-16.
159. Brown, L.R., et al., *AdcAll of Streptococcus pneumoniae Affects Pneumococcal Invasiveness*. PLOS ONE, 2016. **11**(1): p. e0146785.

160. Berry, A.M. and J.C. Paton, *Sequence heterogeneity of PsaA, a 37-kilodalton putative adhesin essential for virulence of Streptococcus pneumoniae*. Infect Immun, 1996. **64**(12): p. 5255-62.
161. Wilson, R., et al., *Protection against Streptococcus pneumoniae lung infection after nasopharyngeal colonization requires both humoral and cellular immune responses*. Mucosal Immunology, 2015. **8**(3): p. 627-639.
162. Ogunniyi, A.D., et al., *Immunization of mice with combinations of pneumococcal virulence proteins elicits enhanced protection against challenge with Streptococcus pneumoniae*. Infect Immun, 2000. **68**(5): p. 3028-33.
163. Gor, D.O., et al., *Enhanced immunogenicity of pneumococcal surface adhesin A by genetic fusion to cytokines and evaluation of protective immunity in mice*. Infect Immun, 2002. **70**(10): p. 5589-95.
164. Sampson, J.S., et al., *Limited diversity of Streptococcus pneumoniae psaA among pneumococcal vaccine serotypes*. Infect Immun, 1997. **65**(5): p. 1967-71.
165. Goodell, E.W. and C.F. Higgins, *Uptake of cell wall peptides by Salmonella typhimurium and Escherichia coli*. Journal of Bacteriology, 1987. **169**(8): p. 3861-3865.
166. Claverys, J.-P., B. Grossiord, and G. Alloing, *Is the Ami-AliA/B oligopeptide permease of Streptococcus pneumoniae involved in sensing environmental conditions?* Research in Microbiology, 2000. **151**(6): p. 457-463.
167. Alloing, G., M.C. Trombe, and J.P. Claverys, *The ami locus of the Gram-positive bacterium Streptococcus pneumoniae is similar to binding protein-dependent transport operons of Gram-negative bacteria*. Molecular Microbiology, 1990. **4**(4): p. 633-644.
168. Alloing, G., P. de Philip, and J.P. Claverys, *Three highly homologous membrane-bound lipoproteins participate in oligopeptide transport by the Ami system of the gram-positive Streptococcus pneumoniae*. J Mol Biol, 1994. **241**(1): p. 44-58.
169. Gilson, E., et al., *Evidence for high affinity binding-protein dependent transport systems in gram-positive bacteria and in Mycoplasma*. Embo j, 1988. **7**(12): p. 3971-4.
170. Abbott, D.W., et al., *The molecular basis of glycogen breakdown and transport in Streptococcus pneumoniae*. Molecular Microbiology, 2010. **77**(1): p. 183-199.
171. Orihuela, C.J., et al., *Microarray Analysis of Pneumococcal Gene Expression during Invasive Disease*. Infection and Immunity, 2004. **72**(10): p. 5582-5596.
172. Yang, X.Y., et al., *Integrated Translatomics with Proteomics to Identify Novel Iron-Transporting Proteins in Streptococcus pneumoniae*. Front Microbiol, 2016. **7**: p. 78.
173. Brown, J.S., et al., *Characterization of Pit, a Streptococcus pneumoniae Iron Uptake ABC Transporter*. Infection and Immunity, 2002. **70**(8): p. 4389-4398.
174. Brown, J.S., S.M. Gilliland, and D.W. Holden, *A Streptococcus pneumoniae pathogenicity island encoding an ABC transporter involved in iron uptake and virulence*. Mol Microbiol, 2001. **40**(3): p. 572-85.
175. Whalan, R.H., et al., *Distribution and genetic diversity of the ABC transporter lipoproteins PiuA and PiaA within Streptococcus pneumoniae and related streptococci*. J Bacteriol, 2006. **188**(3): p. 1031-8.
176. Croucher, N.J., et al., *Diverse evolutionary patterns of pneumococcal antigens identified by pan-genome-wide immunological screening*. Proc Natl Acad Sci U S A, 2017. **114**(3): p. E357-e366.

177. UniProt: the universal protein knowledgebase. Nucleic Acids Research, 2017. **45**(D1): p. D158-D169.
178. Scientific, T., *Amino Acid Physical Properties*. 2017.
179. Culurgioni, S., M. Tang, and M.A. Walsh, *Structural characterization of the Streptococcus pneumoniae carbohydrate substrate-binding protein SP0092*. Acta crystallographica. Section F, Structural biology communications, 2017. **73**(Pt 1): p. 54-61.
180. Bidossi, A., et al., *A functional genomics approach to establish the complement of carbohydrate transporters in Streptococcus pneumoniae*. PLoS One, 2012. **7**(3): p. e33320.
181. I. Sillitoe, N.D., T. Lewis, D. Lee, J. Lees, C. Orengo, *CATH: Protein Structure Classification Database*. 2017.
182. Novak, R., et al., *Identification of a Streptococcus pneumoniae Gene Locus Encoding Proteins of an ABC Phosphate Transporter and a Two-Component Regulatory System*. Journal of Bacteriology, 1999. **181**(4): p. 1126-1133.
183. Soualhine, H., et al., *A proteomic analysis of penicillin resistance in Streptococcus pneumoniae reveals a novel role for PstS, a subunit of the phosphate ABC transporter*. Mol Microbiol, 2005. **58**(5): p. 1430-40.
184. Abdullah, M.R., et al., *Structure of the pneumococcal l,d-carboxypeptidase DacB and pathophysiological effects of disabled cell wall hydrolases DacA and DacB*. Mol Microbiol, 2014. **93**(6): p. 1183-206.
185. Barendt, S.M., L.-T. Sham, and M.E. Winkler, *Characterization of Mutants Deficient in the l,d-Carboxypeptidase (DacB) and WalRK (VicRK) Regulon, Involved in Peptidoglycan Maturation of Streptococcus pneumoniae Serotype 2 Strain D39*. Journal of Bacteriology, 2011. **193**(9): p. 2290-2300.
186. Deka, R.K., et al., *The PnrA (Tp0319; TmpC) lipoprotein represents a new family of bacterial purine nucleoside receptor encoded within an ATP-binding cassette (ABC)-like operon in Treponema pallidum*. J Biol Chem, 2006. **281**(12): p. 8072-81.
187. Saleh, M., et al., *Molecular architecture of Streptococcus pneumoniae surface thioredoxin-fold lipoproteins crucial for extracellular oxidative stress resistance and maintenance of virulence*. EMBO Molecular Medicine, 2013. **5**(12): p. 1852.
188. Whalan, R.H., et al., *PiuA and PiaA, iron uptake lipoproteins of Streptococcus pneumoniae, elicit serotype independent antibody responses following human pneumococcal septicaemia*. FEMS Immunol Med Microbiol, 2005. **43**(1): p. 73-80.
189. Giefing, C., et al., *Discovery of a novel class of highly conserved vaccine antigens using genomic scale antigenic fingerprinting of pneumococcus with human antibodies*. The Journal of Experimental Medicine, 2008. **205**(1): p. 117-131.