

University of Groningen

Development of genomic array footprinting for identification of conditionally essential genes in *Streptococcus pneumoniae*

Bijlsma, Jetta J. E.; Burghout, Peter; Moosterman, Tomas G.; Bootsma, Flester J.; de Jong, Anne; Hermans, Peter W. M.; Kuipers, Oscar; Kloosterman, Tomas G.; Bootsma, Hester J.

Published in:
Applied and Environmental Microbiology

DOI:
[10.1128/AEM.01900-06](https://doi.org/10.1128/AEM.01900-06)

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2007

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Bijlsma, J. J. E., Burghout, P., Moosterman, T. G., Bootsma, F. J., de Jong, A., Hermans, P. W. M., ... Bootsma, H. J. (2007). Development of genomic array footprinting for identification of conditionally essential genes in *Streptococcus pneumoniae*. *Applied and Environmental Microbiology*, 73(5), 1514-1524. DOI: 10.1128/AEM.01900-06

Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

1 **Supplementary Table S1:** Not-detected ORFs in the analysis of the three restriction
2 digests of the mariner library after application of the filter based on the TIGR4-
3 specific ORFS, their putative function (4) and whether they are reported as essential
4 or adjacent to one (y) or not (n). If the gene is reported as essential the reference is
5 given in the last column.

6

Gene ID	Function	essential	reference
SP0003	hypothetical protein	y	(3)
SP0007	S4 domain protein	n	
SP0009	hypothetical protein	n	
SP0011	tRNA(Ile)-lysidine synthetase	y	(6)
SP0012	hypoxanthine-guanine phosphoribosyltransferase	y	(5)
SP0018	hypothetical protein	n	
SP0025	hypothetical protein	n	
SP0029	hypothetical protein	n	
SP0037	fatty acid/phospholipid synthesis protein PlsX	n	
SP0038	acyl carrier protein, putative	n	
SP0040	hypothetical protein	n	
SP0045	phosphoribosylformylglycinamide synthase, putative	y	
SP0052	hypothetical protein	n	
SP0055	hypothetical protein	n	
SP0059	hypothetical protein	n	

SP0065	sugar isomerase domain protein AgaS	n	
SP0068	hypothetical protein	n	
SP0070	hypothetical protein	n	
SP0072	hypothetical protein	n	
SP0073	conserved hypothetical protein	n	
SP0076	hypothetical protein	n	
SP0077	hypothetical protein	n	
SP0080	hypothetical protein	n	
SP0087	hypothetical protein	n	
SP0088	hypothetical protein	n	
SP0089	hypothetical protein	y	
SP0092	ABC transporter, substrate-binding protein	n	
SP0093	hypothetical protein	n	
SP0094	hypothetical protein	n	
SP0100	conserved hypothetical protein	n	
SP0109	bacteriocin, putative	n	
SP0116	hypothetical protein	n	
SP0117	pneumococcal surface protein A	n	
SP0122	conserved hypothetical protein	y	(5)
SP0123	competence-induced protein Ccs1	y	
SP0124	hypothetical protein	n	
SP0125	hypothetical protein	n	
SP0126	hypothetical protein	y	

SP0134	hypothetical protein	n	
SP0142	hypothetical protein	n	
SP0147	hypothetical protein	y	
SP0158	NrdI family protein	y	(3)
SP0160	conserved domain protein	n	
SP0161	conserved domain protein	n	
SP0162	hypothetical protein	n	
SP0164	hypothetical protein	n	
SP0170	hypothetical protein	n	
SP0171	ROK family protein	n	
SP0172	hypothetical protein	n	
SP0174	hypothetical protein	n	
SP0183	hypothetical protein	n	
SP0188	hypothetical protein	y	
SP0189	conserved hypothetical protein	y	(3)
SP0190	hypothetical protein	y	
SP0192	conserved hypothetical protein	y	(5)
SP0194	conserved hypothetical protein	y	
SP0195	hypothetical protein	n	
SP0196	hypothetical protein	n	
SP0201	hypothetical protein	n	
SP0203	hypothetical protein	n	
SP0206	hypothetical protein	n	

SP0210	ribosomal protein L4	n	
SP0213	ribosomal protein S19	n	
SP0214	ribosomal protein L22	n	
SP0216	ribosomal protein L16	n	
SP0217	ribosomal protein L29	n	
SP0218	ribosomal protein S17	n	
SP0220	ribosomal protein L24	n	
SP0221	ribosomal protein L5	n	
SP0222	ribosomal protein S14	n	
SP0223	hypothetical protein	n	
SP0224	ribosomal protein S8	n	
SP0225	ribosomal protein L6	n	
SP0226	ribosomal protein L18	y	
SP0228	ribosomal protein L30	y	(6)
SP0229	ribosomal protein L15	y	
SP0230	preprotein translocase, SecY subunit	y	(6)
SP0231	adenylate kinase	y	(3)
SP0232	translation initiation factor IF-1	y	
SP0233	ribosomal protein L36	n	
SP0234	ribosomal protein S13	n	
SP0235	ribosomal protein S11	n	
SP0236	DNA-directed RNA polymerase, alpha subunit	n	
SP0237	ribosomal protein L17	n	

SP0238	ACT domain protein	n	
SP0244	hypothetical protein	n	
SP0248	PTS system, IIA component	n	
SP0249	PTS system, IIB component	n	
SP0255	acetyltransferase, GNAT family	y	
SP0256	acetyltransferase, GNAT family	n	
SP0258	hypothetical protein	y	
SP0260	conserved hypothetical protein	y	
SP0262	phosphatidate cytidylyltransferase	y	
	glucosamine--fructose-6-phosphate aminotransferase,		
	isomerizing	y	(5)
SP0266	isomerizing	y	
SP0269	hypothetical protein	n	
SP0270	hypothetical protein	n	
SP0271	ribosomal protein S12	n	
SP0272	ribosomal protein S7	y	
SP0275	conserved hypothetical protein	n	
SP0276	conserved hypothetical protein	n	
SP0277	hypothetical protein	n	
SP0278	aminopeptidase PepS	n	
SP0279	conserved hypothetical protein	n	
SP0291	GTP cyclohydrolase I	y	(3)
SP0293	hypothetical protein	y	
SP0296	hypothetical protein	n	

SP0297	hypothetical protein	n	
SP0304	conserved hypothetical protein	n	
SP0307	PTS system, IIA component	n	
SP0308	PTS system, IIA component	n	
SP0311	hypothetical protein	n	
SP0316	hypothetical protein	n	
SP0332	hypothetical protein	n	
SP0333	transcriptional regulator, putative	y	
SP0335	cell division protein FtsL	y	
	phospho-N-acetylmuramoyl-pentapeptide-		
SP0337	transferase	y	(5)
	ATP-dependent Clp protease, ATP-binding subunit,		
SP0338	putative	y	
SP0348	capsular polysaccharide biosynthesis protein Cps4C	y	
SP0359	capsular polysaccharide biosynthesis protein Cps4K	n	
SP0360	UDP-N-acetylglucosamine 2-epimerase	n	
SP0367	hypothetical protein	n	
SP0370	recombination protein U	n	(5)
SP0372	conserved hypothetical protein	n	
SP0389	hypothetical protein	n	
SP0394	PTS system, mannitol-specific IIBC components	n	(3)
SP0398	hypothetical protein	y	
SP0404	hypothetical protein	n	

SP0407	hypothetical protein	n	
SP0412	conserved hypothetical protein	y	
SP0414	hypothetical protein	n	
SP0418	acyl carrier protein	y	
	acetyl-CoA carboxylase, bitoin carboxyl carrier		
SP0423	protein	y	(5)
	(3R)-hydroxymyristoyl-(acyl-carrier-protein)		
SP0424	dehydratase	y	(2,5)
	acetyl-CoA carboxylase, carboxyl transferase subunit		
SP0426	beta	y	(2,5)
SP0428	hypothetical protein	y	
SP0429	hypothetical protein	n	
SP0431	conserved domain protein	n	
SP0434	conserved hypothetical protein	y	
SP0435	translation elongation factor P	y	(5)
SP0438	glutamyl-tRNA(Gln) amidotransferase, C subunit	y	(3)
SP0441	ribosomal protein L28	n	
SP0442	conserved hypothetical protein	y	
SP0443	conserved hypothetical protein	y	(6)
SP0444	hypothetical protein	y	
SP0448	hypothetical protein	n	
SP0451	hypothetical protein	n	
SP0455	hypothetical protein	n	

SP0462	cell wall surface anchor family protein	n
SP0464	cell wall surface anchor family protein	n
SP0465	hypothetical protein	n
SP0470	hypothetical protein	n
SP0471	conserved hypothetical protein	n
SP0472	hypothetical protein	n
SP0487	hypothetical protein	n
SP0491	hypothetical protein	n
SP0497	hypothetical protein	n
SP0503	hypothetical protein	n
SP0504	hypothetical protein	n
SP0511	hypothetical protein	n
SP0512	hypothetical protein	n
SP0513	hypothetical protein	n
SP0517	dnaK protein	n
SP0518	hypothetical protein	n
SP0520	hypothetical protein	n
SP0525	blpS protein	n
SP0527	putative histidine kinase BlpH	n
SP0528	peptide pheromone BlpC	n
SP0531	bacteriocin BlpI	n
SP0532	bacteriocin BlpJ	n
SP0533	bacteriocin BlpK	n

SP0534	hypothetical protein	n	
SP0535	hypothetical protein	n	
SP0536	immunity protein BlpL	n	
SP0540	blpN protein	n	
SP0541	bacteriocin BlpO	n	
SP0542	hypothetical protein	n	
SP0543	hypothetical protein	n	
SP0546	BlpZ protein, fusion	n	
SP0548	hypothetical protein	n	
SP0552	conserved hypothetical protein	y	(1)
SP0554	conserved hypothetical protein	y	(5)
SP0555	ribosomal protein L7A family	y	(1)
SP0559	hypothetical protein	n	
SP0560	hypothetical protein	n	
SP0563	hypothetical protein	n	
SP0566	acetyltransferase, GNAT family	n	
SP0567	conserved domain protein	n	
SP0570	conserved domain protein	n	
SP0573	hypothetical protein	n	
SP0575	helicase, putative	n	
SP0576	transcription antiterminator Lict	n	
SP0580	acetyltransferase, GNAT family	y	(5)
SP0584	transcriptional regulator, putative	n	

SP0587	hypothetical protein	n
SP0590	acetyltransferase, GNAT family	n
SP0594	hypothetical protein, fusion	n
SP0595	hypothetical protein	n
SP0596	hypothetical protein	n
SP0598	hypothetical protein	n
SP0602	pep27 protein	n
SP0607	amino acid ABC transporter, permease protein	n
SP0612	hypothetical protein	y
SP0619	conserved hypothetical protein	n
	amino acid ABC transporter, amino acid-binding	
SP0620	protein, putative	n
SP0621	hypothetical protein	n
SP0630	ribosomal protein L11	n
SP0633	hypothetical protein	n
SP0634	conserved domain protein	n
SP0635	hypothetical protein	n
SP0639	hypothetical protein	n
SP0640	hypothetical protein	n
SP0645	PTS system IIA component, putative	n
SP0646	PTS system, IIB component, putative	n
SP0653	hypothetical protein	n
SP0654	hypothetical protein	n

SP0656	hypothetical protein	n	
SP0670	hypothetical protein	y	
SP0679	hypothetical protein	y	
SP0683	hypothetical protein	n	
SP0684	hypothetical protein	n	
SP0685	hypothetical protein	n	
SP0691	hypothetical protein	n	
SP0692	hypothetical protein	n	
SP0693	hypothetical protein	n	
SP0699	hypothetical protein	n	
SP0728	hypothetical protein	n	
SP0730	pyruvate oxidase	n	
SP0738	conserved domain protein	n	
SP0747	hypothetical protein	n	
SP0748	conserved hypothetical protein	n	
	cell division ABC transporter, ATP-binding protein		
SP0756	FtsE	y	(3)
SP0757	cell division ABC transporter, permease protein FtsX	y	
SP0758	PTS system, IIABC components	n	
SP0759	hypothetical protein	n	
SP0760	hypothetical protein	y	
SP0762	S-adenosylmethionine synthetase	y	(3)
SP0763	hypothetical protein	y	

SP0765	DNA polymerase III, delta subunit	n	
SP0767	conserved hypothetical protein	n	
SP0772	hypothetical protein	n	
SP0773	hypothetical protein	n	
SP0774	hypothetical protein	n	
SP0775	ribosomal protein S16	n	
SP0776	KH domain protein	n	
SP0777	hypothetical protein	n	
SP0778	16S rRNA processing protein RimM	y	(5)
SP0788	methionyl-tRNA synthetase	n	
SP0790	conserved domain protein	n	
SP0791	oxidoreductase, aldo/keto reductase family	n	
SP0792	hypothetical protein	n	
SP0800	hypothetical protein	n	
SP0805	hydrolase, haloacid dehalogenase-like family	y	
SP0815	hypothetical protein	n	
SP0816	hypothetical protein	n	
SP0821	hypothetical protein	n	
SP0822	conserved hypothetical protein	n	
SP0829	phosphopentomutase	n	
SP0832	hypothetical protein	n	
SP0837	DNA topology modulation protein FlaR, putative	n	
SP0838	ribosomal protein S20	y	

SP0840	hypothetical protein	y	
SP0844	cytidine deaminase	n	
SP0845	lipoprotein	n	
SP0854	hypothetical protein	n	
SP0860	pyrrolidone-carboxylate peptidase	n	
SP0861	hypothetical protein	n	
SP0862	ribosomal protein S1	n	
SP0866	hypothetical protein	y	
SP0873	membrane protein	y	(5)
SP0874	hypothetical protein	n	
SP0875	lactose phosphotransferase system repressor	n	
SP0876	1-phosphofructokinase, putative	n	
SP0877	PTS system, fructose specific IIABC components	n	
SP0888	hypothetical protein	n	
SP0889	hypothetical protein	n	
SP0901	hypothetical protein	n	
SP0903	hypothetical protein	n	
SP0906	hypothetical protein	n	
SP0910	conserved hypothetical protein	n	
SP0911	hypothetical protein	n	
SP0924	hypothetical protein	n	
SP0926	hypothetical protein	n	
SP0934	hypothetical protein	n	

SP0937	conserved hypothetical protein	y	
SP0945	ribosome recycling factor	y	(5)
SP0947	conserved hypothetical protein	n	
SP0951	conserved hypothetical protein	n	
SP0956	hypothetical protein	n	
SP0959	translation initiation factor IF-3	y	(3)
SP0960	ribosomal protein L35	y	
SP0968	diacylglycerol kinase	y	
SP0974	preprotein translocase, SecG subunit, putative	y	(5)
SP0978	competence protein CoiA	y	(3)
SP0984	phosphoglycerate mutase family protein	n	
SP0986	conserved hypothetical protein	n	
SP0987	hypothetical protein	y	
SP0988	UDP-N-acetylglucosamine pyrophosphorylase	y	(5)
SP0989	MutT/nudix family protein	y	
	5-methylthioadenosine/S-adenosylhomocysteine		
SP0991	nucleosidase	n	
SP0992	conserved hypothetical protein	n	
SP0997	hypothetical protein	n	
SP1006	hypothetical protein	n	
	large conductance mechanosensitive channel protein		
SP1010	MscL	n	
SP1017	4-oxalocrotonate tautomerase	y	

SP1018	thymidine kinase	n
SP1019	acetyltransferase, GNAT family	y
SP1022	Sua5/YciO/YrdC family protein	n
SP1023	acetyltransferase, GNAT family	n
SP1024	serine hydroxymethyltransferase	n
SP1025	hypothetical protein	n
SP1028	hypothetical protein	n
SP1030	conserved hypothetical protein	n
SP1031	hypothetical protein	n
SP1033	iron-compound ABC transporter, permease protein	n
SP1036	hypothetical protein	n
SP1037	type II restriction endonuclease, putative	n
SP1038	hypothetical protein	n
SP1039	hypothetical protein	n
SP1042	hypothetical protein	n
SP1044	hydrolase, putative	n
SP1048	hypothetical protein	n
SP1049	hypothetical protein	n
SP1054	Tn5252, Orf 10 protein	n
SP1058	hypothetical protein	n
SP1060	hypothetical protein	n
SP1065	hypothetical protein	n
SP1068	phosphoenolpyruvate carboxylase	y

SP1074	conserved hypothetical protein	y	
SP1077	conserved domain protein	y	
SP1078	hypothetical protein	y	
SP1080	hypothetical protein	y	
SP1091	hypothetical protein	n	
SP1092	hypothetical protein	n	
SP1093	hypothetical protein	n	
SP1094	aminotransferase, class-V	y	(3)
SP1102	conserved hypothetical protein TIGR00103	n	
SP1103	hypothetical protein	n	
SP1107	ribosomal protein L27	n	
SP1108	hypothetical protein	n	
SP1109	hypothetical protein	n	
SP1111	conserved hypothetical protein	n	
SP1113	DNA-binding protein HU	y	(5)
SP1118	pullulanase, putative	n	
SP1120	hypothetical protein	n	
SP1121	1,4-alpha-glucan branching enzyme	n	
SP1122	glucose-1-phosphate adenylyltransferase	n	
SP1123	glycogen biosynthesis protein GlgD	n	
SP1124	glycogen synthase	n	
SP1127	hypothetical protein	y	
SP1131	transcriptional regulator, putative	n	

SP1132	hypothetical protein	n	
SP1133	hypothetical protein	n	
SP1138	hypothetical protein	n	
SP1140	hypothetical protein	n	
SP1142	hypothetical protein	n	
SP1144	conserved hypothetical protein	n	
SP1145	hypothetical protein	n	
SP1146	hypothetical protein	n	
SP1148	IS630-Spn1, transposase Orf2	n	
SP1150	hypothetical protein	n	
SP1151	exonuclease RexB	n	
SP1158	hypothetical protein	n	
SP1165	hypothetical protein	n	
SP1172	hypothetical protein	n	
SP1176	phosphoenolpyruvate-protein phosphotransferase	y	
SP1177	phosphocarrier protein HPr	y	(3)
SP1178	NrdH-redoxin	y	(3)
SP1181	hypothetical protein	n	
SP1183	hypothetical protein	n	
SP1186	PTS system, lactose-specific IIA component	n	
SP1188	hypothetical protein	n	
SP1201	serine/threonine protein phosphatase	n	
SP1206	exodeoxyribonuclease VII, small subunit	n	

SP1209	hypothetical protein	n	
SP1210	hypothetical protein	n	
SP1211	hypothetical protein	n	
SP1216	hypothetical protein	n	
SP1217	hypothetical protein	n	
SP1223	conserved hypothetical protein	n	
SP1224	conserved domain protein	n	
SP1231	flavoprotein	y	(6),(3)
SP1234	transcriptional regulator, biotin repressor family	n	
SP1238	excinuclease ABC, subunit B	n	
SP1252	hypothetical protein	n	
SP1254	hypothetical protein	n	
SP1256	conserved hypothetical protein	n	
SP1259	conserved hypothetical protein	n	
SP1265	hypothetical protein	n	
SP1276	carbamoyl-phosphate synthase, small subunit	n	
SP1288	conserved hypothetical protein	y	(5)
SP1293	ribosomal protein L19	n	
SP1294	crcB protein	n	
SP1296	chorismate mutase, putative	n	
SP1299	ribosomal protein L31	n	
SP1300	hypothetical protein	n	
SP1302	conserved hypothetical protein	n	

SP1304	hypothetical protein	n
SP1305	hypothetical protein	n
SP1307	hypothetical protein	n
SP1314	IS66 family element, Orf1	n
SP1315	v-type sodium ATP synthase, subunit D	n
SP1318	v-type sodium ATP synthase, subunit G	n
SP1323	hypothetical protein	n
SP1327	conserved hypothetical protein	n
SP1328	sodium:solute symporter family protein	n
SP1333	hypothetical protein	n
SP1334	conserved hypothetical protein	n
SP1338	hypothetical protein	n
SP1339	hypothetical protein	n
SP1345	hypothetical protein	n
SP1349	hypothetical protein	n
SP1353	hypothetical protein	n
SP1354	ribosomal protein L7/L12	n
SP1356	Atz/Trz family protein	n
SP1375	3-dehydroquinate synthase	n
SP1379	hypothetical protein	n
SP1385	hypothetical protein	n
SP1401	hypothetical protein	n
SP1414	ribosomal protein S21	n

SP1423	transcriptional repressor, putative	n	
SP1425	hypothetical protein	n	
SP1432	hypothetical protein	n	
SP1452	hypothetical protein	n	
SP1453	conserved domain protein	n	
SP1454	hypothetical protein	n	
SP1455	hypothetical protein	y	
SP1459	hypothetical protein	y	
SP1462	conserved hypothetical protein	n	
SP1473	conserved hypothetical protein	n	
SP1475	glycyl-tRNA synthetase, alpha subunit	y	(3)
SP1476	hypothetical protein	y	
SP1480	hypothetical protein	n	
SP1481	hypothetical protein	n	
SP1485	IS3-Spn1, transposase	n	
SP1487	hypothetical protein	n	
SP1490	hypothetical protein	n	
SP1494	hypothetical protein	n	
SP1495	hypothetical protein	n	
SP1507	ATP synthase F1, epsilon subunit	y	(3)
SP1511	ATP synthase F1, delta subunit	y	
SP1514	ATP synthase F0, C subunit	n	
SP1528	hypothetical protein	y	

SP1531	hypothetical protein	y	
SP1539	ribosomal protein S18	y	
SP1541	ribosomal protein S6	y	
SP1545	conserved hypothetical protein	y	(5)
SP1556	hypothetical protein	y	
SP1558	hypothetical protein	y	
SP1562	hypothetical protein	y	
SP1579	hypothetical protein	n	
SP1581	hypothetical protein	n	
SP1583	isochorismatase family protein	y	
SP1585	hypothetical protein	y	
SP1587	oxalate:formate antiporter	n	
SP1592	conserved domain protein	n	
SP1596	IS3-Spn1, hypothetical protein, interruption	n	
SP1605	ferredoxin	y	(3)
SP1611	hypothetical protein	y	
SP1612	conserved domain protein	n	
SP1623	cation-transporting ATPase, E1-E2 family	y	
SP1628	hypothetical protein	y	
SP1629	hypothetical protein	n	
SP1635	hypothetical protein	n	
SP1638	iron-dependent transcriptional regulator	n	
SP1639	IS1167, transposase	n	

SP1642	hypothetical protein	n	
SP1643	hypothetical protein	n	
	manganese ABC transporter, manganese-binding		
SP1650	adhesion liprotein	y	
SP1651	thiol peroxidase	n	
SP1652	hypothetical protein	n	
SP1653	ABC transporter, ATP-binding protein	n	
SP1656	hypothetical protein	n	
SP1657	hypothetical protein	n	
SP1658	hypothetical protein	y	
SP1660	hypothetical protein	y	
	UDP-N-acetylmuramoylalanyl-D-glutamyl-2,6-		
SP1670	diaminopimelate--D-alanyl-D-alanyl ligase	y	(3)
SP1678	hypothetical protein	n	
SP1679	hypothetical protein	n	
SP1683	sugar ABC transporter, sugar-binding protein	n	
SP1694	hypothetical protein	n	
SP1696	hypothetical protein	n	
SP1697	ATP-dependent DNA helicase RecG	n	
SP1698	alanine racemase	y	(3)
SP1699	holo-(acyl-carrier protein) synthase	y	(3)
SP1700	phospho-2-dehydro-3-deoxyheptonate aldolase	n	
SP1703	conserved domain protein	n	

SP1710	nitroreductase family protein	y	
SP1718	hypothetical protein	n	
SP1723	hypothetical protein	n	
SP1724	sucrose-6-phosphate hydrolase	n	
SP1725	sucrose operon repressor	y	
SP1726	3-hydroxy-3-methylglutaryl-CoA reductase	y	(5)
SP1728	hypothetical protein	y	
SP1730	hypothetical protein	n	
SP1732	serine/threonine protein kinase	y	(5)
SP1736	primosomal protein N	y	
	DNA-directed RNA polymerase, omega subunit,		
SP1737	putative	y	(5)
SP1739	KH domain protein	n	
SP1740	conserved hypothetical protein	n	
SP1741	conserved hypothetical protein	n	
SP1742	conserved hypothetical protein	n	
SP1744	iojap-related protein	y	(6)
SP1745	isochorismatase family protein	y	
SP1748	conserved hypothetical protein	y	(5)
SP1749	GTP-binding protein	y	(6)
SP1750	conserved hypothetical protein	y	(5)
SP1752	conserved domain protein	n	
SP1756	conserved domain protein	n	

SP1767	glycosyl transferase, family 8	n
SP1768	conserved hypothetical protein	n
SP1775	conserved domain protein	n
SP1776	thioredoxin	y
SP1783	MutT/nudix family protein	n
SP1787	hypothetical protein	n
SP1788	hypothetical protein	n
SP1789	hypothetical protein	n
SP1791	integrase-related protein	n
SP1794	hypothetical protein	y
SP1798	ABC transporter, permease protein	n
SP1799	sugar-binding transcriptional regulator, LacI family	n
SP1801	conserved hypothetical protein	n
SP1803	conserved hypothetical protein	n
SP1805	hypothetical protein	n
SP1806	conserved domain protein	n
SP1814	indole-3-glycerol phosphate synthase	n
SP1818	hypothetical protein	n
SP1819	hypothetical protein	n
SP1820	hypothetical protein	n
SP1822	conserved domain protein	n
SP1832	hypothetical protein	n
SP1834	hypothetical protein	n

SP1835	hypothetical protein	n	
SP1836	hypothetical protein	y	
SP1842	hypothetical protein	n	
SP1843	hypothetical protein	n	
SP1844	hypothetical protein	n	
SP1859	conserved domain protein	y	(3)
SP1860	choline transporter	n	
SP1864	conserved hypothetical protein	n	
SP1866	hypothetical protein	n	
SP1868	conserved domain protein	n	
SP1873	conserved hypothetical protein	n	
SP1875	conserved hypothetical protein	n	
SP1876	conserved hypothetical protein	n	
SP1878	CBS domain protein	n	
SP1879	conserved hypothetical protein	n	
SP1881	glutamate racemase	y	(3)
SP1882	conserved hypothetical protein	y	(3)
	oligopeptide ABC transporter, permease protein		
SP1889	AmiD	y	(5)
	oligopeptide ABC transporter, oligopeptide-binding		
SP1891	protein AmiA	n	
SP1892	hypothetical protein	n	
SP1900	BirA bifunctional protein	y	(3)

SP1904	hypothetical protein	n	
SP1906	chaperonin, 60 kDa	n	
SP1907	chaperonin, 10 kDa	y	(5)
SP1910	conserved hypothetical protein	y	
SP1911	thioredoxin, putative	n	
SP1912	hypothetical protein	n	
SP1915	hypothetical protein	n	
SP1921	hypothetical protein	n	
SP1924	hypothetical protein	n	
SP1929	hypothetical protein	n	
SP1930	hypothetical protein	n	
SP1932	hypothetical protein	n	
SP1935	hypothetical protein	n	
	type II restriction-modification system regulatory		
SP1936	protein, putative	n	
SP1938	hypothetical protein	n	
SP1939	MATE efflux family protein DinF	n	
SP1940	recA protein	n	
SP1942	transcriptional regulator, putative	n	
SP1944	conserved hypothetical protein TIGR00150	y	(6)
SP1945	hypothetical protein	y	
SP1947	hypothetical protein	n	
SP1948	conserved domain protein	n	

SP1949	hypothetical protein	n	
SP1955	hypothetical protein	n	
SP1958	hypothetical protein	n	
SP1959	nucleoside diphosphate kinase	y	
SP1961	DNA-directed RNA polymerase, beta subunit	y	(2)
SP1962	hypothetical protein	y	
SP1963	CBS domain protein	n	
SP1965	hypothetical protein	n	
SP1967	conserved hypothetical protein	y	
SP1968	phosphopantetheine adenylyltransferase	y	(5)
SP1969	type II DNA modification methyltransferase, putative	y	
SP1970	aspartate--ammonia ligase	n	
SP1971	hypothetical protein	n	
SP1972	membrane protein	n	
SP1973	SpoU rRNA Methylase family protein	n	
SP1974	acylphosphatase	y	
SP1975	spoIIIJ family protein	y	(6)
SP1976	pyruvate formate-lyase-activating enzyme	y	
SP1977	hypothetical protein	n	
SP1980	cmp-binding-factor 1	n	
SP1981	competence-induced protein Ccs50	n	
SP1983	ribulose-phosphate 3-epimerase	y	(3)
SP1986	hypothetical protein	n	

SP1990	primase-related protein	y	(3)
SP1991	hydrolase, putative	y	
SP1993	ribosomal protein L34	n	
SP1995	conserved hypothetical protein	n	
SP1996	universal stress protein family	n	
SP2003	ABC transporter, ATP-binding protein	n	
SP2004	hypothetical protein	n	
SP2005	hypothetical protein	n	
SP2006	transcriptional regulator ComX1	n	
SP2007	transcription antitermination protein NusG	n	
SP2008	preprotein translocase, SecE subunit, putative	n	
SP2009	ribosomal protein L33	n	
SP2010	penicillin-binding protein 2A	y	
	ribosomal large subunit pseudouridine synthase,		
SP2011	RluD subfamily	y	(3)
SP2024	PTS system, IIA component	n	
SP2025	hypothetical protein	n	
SP2028	phosphotyrosine protein phosphatase	n	
SP2037	PTS system, IIB component	n	
SP2042	ribonuclease P protein component	y	(3)
SP2043	hypothetical protein	y	
SP2049	conserved hypothetical protein	n	
SP2050	competence protein CglD	n	

SP2056	N-acetylglucosamine-6-phosphate deacetylase	n	
SP2061	conserved hypothetical protein	n	
SP2068	cytidine/deoxycytidylate deaminase family protein	y	
SP2071	conserved domain protein	y	
SP2083	sensor histidine kinase PnpS	n	
SP2092	UTP-glucose-1-phosphate uridylyltransferase	n	
SP2093	hypothetical protein	n	
SP2094	conserved hypothetical protein	y	
SP2095	5-formyltetrahydrofolate cyclo-ligase family protein	y	(6)
SP2102	hypothetical protein	n	
SP2104	hypothetical protein	y	(3)
SP2114	aspartyl-tRNA synthetase	y	(2)
SP2115	hypothetical protein	y	
SP2118	hypothetical protein	n	
SP2120	hypothetical protein	n	
SP2124	hypothetical protein	n	
SP2130	PTS system, IIB component, putative	n	
SP2133	conserved domain protein	n	
SP2134	ribosomal protein L32	n	
SP2135	ribosomal protein L33	n	
SP2139	hypothetical protein	n	
SP2140	hypothetical protein	n	
SP2147	hypothetical protein	n	

SP2170	zinc ABC transporter, permease protein	n	
SP2174	D-alanyl carrier protein	n	
SP2177	hypothetical protein	n	
SP2179	IS1380-Spn1, transposase	n	
SP2183	hypothetical protein	y	(3)
SP2195	transcriptional regulator CtsR	n	
SP2199	conserved hypothetical protein	n	
SP2200	hypothetical protein	n	
SP2202	conserved hypothetical protein	y	
SP2207	competence protein ComF, putative	y	(3)
SP2210	cysteine synthase	n	
SP2215	ribosomal protein S2	y	
SP2219	conserved hypothetical protein	y	
	CDP-diacylglycerol--glycerol-3-phosphate 3-		
SP2222	phosphatidyltransferase	y	(3)
SP2226	conserved hypothetical protein	n	
SP2237	competence stimulating peptide 2	n	
SP2239	serine protease	n	

1

2

3

References

4

- 1 **1. Akerley, B. J., E. J. Rubin, A. Camilli, D. J. Lampe, H. M. Robertson, and J. J.**
2 **Mekalanos.** 1998. Systematic identification of essential genes by *in vitro mariner*
3 mutagenesis. Proc. Natl. Acad. Sci. U. S. A **95**:8927-8932.

- 4 **2. Lee, M. S., B. A. Dougherty, A. C. Madeo, and D. A. Morrison.** 1999.
5 Construction and analysis of a library for random insertional mutagenesis in
6 *Streptococcus pneumoniae*: use for recovery of mutants defective in genetic
7 transformation and for identification of essential genes. Appl. Environ.
8 Microbiol. **65**:1883-1890.

- 9 **3. Song, J. H., K. S. Ko, J. Y. Lee, J. Y. Baek, W. S. Oh, H. S. Yoon, J. Y. Jeong, and**
10 **J. Chun.** 2005. Identification of essential genes in *Streptococcus pneumoniae* by
11 allelic replacement mutagenesis. Mol. Cells **19**:365-374.

- 12 **4. Tettelin, H., K. E. Nelson, I. T. Paulsen, J. A. Eisen, T. D. Read, S. Peterson, J.**
13 **Heidelberg, R. T. DeBoy, D. H. Haft, R. J. Dodson, A. S. Durkin, M. Gwinn, J.**
14 **F. Kolonay, W. C. Nelson, J. D. Peterson, L. A. Umayam, O. White, S. L.**
15 **Salzberg, M. R. Lewis, D. Radune, E. Holtzapple, H. Khouri, A. M. Wolf, T. R.**
16 **Utterback, C. L. Hansen, L. A. McDonald, T. V. Feldblyum, S. Angiuoli, T.**
17 **Dickinson, E. K. Hickey, I. E. Holt, B. J. Loftus, F. Yang, H. O. Smith, J. C.**
18 **Venter, B. A. Dougherty, D. A. Morrison, S. K. Hollingshead, and C. M.**
19 **Fraser.** 2001. Complete genome sequence of a virulent isolate of *Streptococcus*
20 *pneumoniae*. Science **293**:498-506.

- 21 **5. Thanassi, J. A., S. L. Hartman-Neumann, T. J. Dougherty, B. A. Dougherty,**
22 **and M. J. Pucci.** 2002. Identification of 113 conserved essential genes using a

1 high-throughput gene disruption system in *Streptococcus pneumoniae*. Nucleic
2 Acids Res. **30**:3152-3162.

3 6. **Zalacain, M., S. Biswas, K. A. Ingraham, J. Ambrad, A. Bryant, A. F. Chalker,**
4 **S. Iordanescu, J. Fan, F. Fan, R. D. Lunsford, K. O'Dwyer, L. M. Palmer, C. So,**
5 **D. Sylvester, C. Volker, P. Warren, D. McDevitt, J. R. Brown, D. J. Holmes,**
6 **and M. K. Burnham.** 2003. A global approach to identify novel broad-spectrum
7 antibacterial targets among proteins of unknown function. J. Mol. Microbiol.
8 Biotechnol. **6**:109-126.

9

10