Genome Size Determination and Coding Capacity of Sodalis glossinidius, an Enteric Symbiont of Tsetse Flies, as Revealed by Hybridization to Escherichia coli Gene Arrays

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Recent molecular characterization of various microbial genomes has revealed differences in genome size and coding capacity between obligate symbionts and intracellular pathogens versus free-living organisms. Multiple symbiotic microorganisms have evolved with tsetse fly, the vector of African trypanosomes, over long evolutionary times. Although these symbionts are indispensable for tsetse fecundity, the biochemical and molecular basis of their functional significance is unknown. Here, we report on the genomic aspects of the secondary symbiont Sodalis glossinidius. The genome size of Sodalis is approximately 2 Mb. Its DNA is subject to extensive methylation and based on some of its conserved gene sequences has an A+T content of only 45%, compared to the typically AT-rich genomes of endosymbionts. Sodalis also harbors an extrachromosomal plasmid about 134 kb in size. We used a novel approach to gain insight into Sodalis genomic contents, i.e., hybridizing its DNA to macroarrays developed for Escherichia coli, a closely related enteric bacterium. In this analysis we detected 1,800 orthologous genes, corresponding to about 85% of the Sodalis genome. The Sodalis genome has apparently retained its genes for DNA replication, transcription, translation, transport, and the biosynthesis of amino acids, nucleic acids, vitamins, and cofactors. However, many genes involved in energy metabolism and carbon compound assimilation are apparently missing, which may indicate an adaptation to the energy sources available in the only nutrient of the tsetse host, blood. We present gene arrays as a rapid tool for comparative genomics in the absence of whole genome sequence to advance our understanding of closely related bacteria.

Tsetse flies are important insect vectors that transmit African trypanosomes, the causative agents of sleeping sickness disease in humans and nagana in animals. In addition to the parasites they transmit, tsetses harbor three different symbiotic microorganisms (2). Two of these organisms are members of the Enterobacteriaceae family and live in the gut tissue: the obligate primary symbiont (genus Wigglesworthia) (3, 5) and the secondary symbiont (genus Sodalis) (5, 12, 14). A third symbiont, a member of the Rickettsiaceae family, resides mainly in reproductive tissues and belongs to genus Wolbachia (28). The primary symbiont Wigglesworthia lives within the specialized epithelial cells (bacteriocytes) in the bacteriome tissue in the anterior midgut. Phylogenetic analysis has shown that Wigglesworthia displays concordant evolution with its host species, and its association with the tsetse ancestor is predicted to be about 50 to 80 million years old (11). Conversely, Sodalis is harbored both inter- and intracellularly in the tsetse midgut as well as in muscle, fat body, hemolymph, milk gland, and salivary gland tissues of certain species (12). While Sodalis is present in all tsetse species analyzed, its density in somatic tissues increases with the age of the fly and its prevalence varies in different species (12). Phylogenetic analysis has shown

that *Sodalis* isolates from different tsetse species are almost identical, indicating either horizontal transfer events between tsetse species or recent independent acquisition of the bacterium by each species (11). During its intrauterine life, the tsetse larva receives nutrients along with both gut symbionts from its mother via milk gland secretions (4, 20), while *Wolbachia* is transmitted transovarially (28).

It has been difficult to study the functional role of the obligate endosymbionts in tsetse, as attempts to eliminate them have resulted in retarded growth of the insect and a decrease in egg production, preventing the aposymbiotic host from reproducing (19, 26, 32). The ability to reproduce, however, could be partially restored when the aposymbiotic flies were given a blood meal supplemented with B-complex vitamins (thiamine, pantothenic acid, pyridoxine, folic acid, and biotin), suggesting that the endosymbionts may play a role in metabolism that involves these compounds (25). While the functional significance of Sodalis is unknown, it has been implicated in the susceptibility of tsetse for trypanosome transmission (34). Unlike obligate symbionts, it has been possible to culture Sodalis in vitro and achieve genetic transformation using the broadhost-range replicon oriV derived from a Pseudomonas aeruginosa plasmid (6, 14, 35). The recombinant Sodalis transformed with the green fluorescent protein marker gene was acquired successfully by the intrauterine progeny when microinjected into the mother's hemolymph. The symbionts were also transmitted to F₁ and F₂ flies, where they expressed the green fluorescent protein (12). Since Sodalis lives in close proximity to the pathogenic trypanosomes in the tsetse gut, the constitutive expression of foreign antitrypanosomal gene products in

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Sodalis could provide a unique approach to interfere with trypanosome viability.

Recent characterization of intracellular genomes has shown that they have undergone significant size reductions and presumably loss of gene function. To date, the only mutualistic genome that has been completely sequenced is that of Buchnera, the symbiont of aphids (31). Its genome is about 640 kb, significantly smaller than those of the free-living enteric bacteria such as Escherichia coli (7). In addition, analysis of the genome sequences of intracellular organisms has shown a high A+T bias, with Buchnera being about 65 to 70% A+T rich. Recently, we have shown that the mutualist Wigglesworthia in tsetse also has a reduced genome size of less than 740 kb and a high A+T content (1). Here we report on the genomic characteristics of Sodalis, in particular on its genome size, A+T bias, and overall coding capacity. We determined the size of the Sodalis genome and the large plasmid it harbors by contour-clamped homogeneous electric field (CHEF) gel electrophoresis analysis and evaluated its DNA methylation status. Since the free-living bacterium E. coli is a close relative of Sodalis, we used the gene arrays which contain the 4,290 PCRamplified open reading frames (ORFs) identified in the sequenced E. coli genome to examine the overall coding capability of Sodalis. We discuss both the size and the nature of the contents of Sodalis genome in the light of the symbiotic life it has established in tsetse and in comparison to those of intracellular obligate bacteria as well as free-living organisms closely related to Sodalis.

MATERIALS AND METHODS

Maintenance of Sodalis culture in vitro. Sodalis was cultured from tsetse as described previously (6, 35) and maintained in vitro in Mitsuhashi-Maramorosch medium (Sigma, St. Louis, Mo.) supplemented with 5% heat-inactivated fetal bovine serum (American Bioanalytical, Natick, Mass.) at 25°C.

Determination of Sodalis genomic and plasmid DNA size. Genomic DNA was prepared as described by Charles and Ishikawa (10). Approximately 10⁹ Sodalis cells/ml were embedded in agarose plugs. The plugs were treated overnight in EC solution (6 mM Tris-HCl [pH 7.6], 100 mM EDTA, 1 M NaCl, 0.5% Brij 58, 0.2% deoxycholate, and 0.5% N-lauroylsarcosine in the presence of lysozyme [1 mg/ml] and RNase [20 µg/ml]) at 37°C as described for Buchnera (10). The EC solution was replaced with ESP (0.5 M EDTA [pH 8], 1% N-lauroylsarcosine, 1 mg of proteinase K per ml) and incubated at 50°C for 2 days. These plugs contained both the genomic and plasmid DNAs. To obtain pure chromosomal DNA devoid of plasmids, the plugs were subjected to CHEF gel electrophoresis (Bio-Rad, Hercules, Calif.) using a 150- to 200-s pulse time for 20 h at 200 V. Under these conditions, the plasmid(s) migrates into the gel while intact genomic DNA remains in the plug. Subsequently, the plugs were removed from the wells and incubated overnight with PmeI and PacI at 37°C and with SwaI at 25°C. CHEF gel electrophoresis was performed at 200 V at various ramping pulse and run times, depending on the resolution requirements. Plasmid DNA was prepared by the alkaline extraction protocol (29), further purified on CsCl gradients, digested overnight with EcoRI, HindIII, and PstI at 37°C, and analyzed by CHEF gel electrophoresis at 170 V, using a 2-s pulse time for 12 h.

Sequencing of *Sodalis* **DNA.** Two protein-coding genes in *Sodalis, groEL* and *ftsZ*, were PCR amplified using *E. coli*-specific primers (Genosys Biotechnologies Inc., The Woodlands, Tex.). The amplification products were cloned into pGEM-T vector (Promega) and sequenced at the Keck Sequencing Center at Yale University.

Hybridization to *E. coli* macroarrays. *Sodalis* genomic DNA was separated from plasmids as described above, using CHEF electrophoresis. The agarose plugs were then digested with *Fsel*, and the digested DNA was purified using a QIAquick gel extraction kit (Qiagen Inc. Chatsworth, Calif.). DNA was radioactively labeled with $[\alpha^{-33}P]$ ATP by using a polymerase I/DNase I nick translation kit (GIBCO catalog no. 18160-010). Panorama macroarrays (Genosys Biotechnologies) were prehybridized and hybridized in a 45% formamide–5× Denhardt's solution–5× SSC (1× SSC is 0.15 M NaCl plus 0.015 M sodium



FIG. 1. Sodalis genome size determination. (A) Bacterial DNA samples embedded in agarose plugs were subjected to CHEF electrophoresis using pulse times of 150 to 200 s for 20 h at 200 V and 14°C to obtain chromosomal DNA devoid of plasmids. Sizes on the left are indicated in kilobases. (B) Sodalis genomic DNA devoid of its plasmid was analyzed by CHEF gel electrophoresis. *PmeI* and *PacI* fragments were resolved at pulse times of 18.3 to 26.3 s over 35 h at 200 V. Three different pulse times were used to resolve the *SwaI* fragments in different size ranges: 18.3 to 26.3 s for 35 h (a), 6.8 to 12.9 s for 33 h (b), and 1 to 6 s and 6 to 15 s for 15 h each (c).

citrate)–0.5% sodium dodecyl sulfate (SDS) buffer at 45°C. The arrays were washed at 42°C in $2\times$ SSC–0.1% SDS and $0.1\times$ SSC–0.1% SDS followed by $0.1\times$ SSC–0.5% SDS. Arrays were exposed to maximum-resolution films (BMR; Eastman Kodak Company, Rochester, N.Y.), and signals were scored as strong (53%), medium (44%), or weak (3%). There were no cases where duplicate spots gave contradictory results.

Analysis of DNA modifications associated with chromosomal and plasmid DNAs. Total *Sodalis* DNA was purified according to standard protocols, using proteinase K (100 μ g/ml) and SDS (1%). The plasmid DNA was purified via ultracentrifugation on CsCl gradients. All purified DNAs were digested overnight with *Eco*RII, *Sau*3AI, and *Mbo*I at 37°C and with *Bst*NI at 60°C, respectively. The digestion products were analyzed by conventional agarose gel electrophoresis.

Nucleotide sequence accession numbers. The GenBank accession numbers are AF326971 for *groEL* and AY024353 for *ftsZ*.

RESULTS

Size of *Sodalis* **genome and plasmid(s).** Since *Sodalis* contains multicopy extrachromosomal DNAs, agarose plugs containing total bacterial DNA were subjected to an initial CHEF electrophoresis that allowed the plasmid DNA to enter the gel while the intact chromosomal DNA remained in the wells (Fig. 1A). Subsequently, the plugs were removed from the wells, and chromosomal DNA was digested with one of the restriction enzymes *PmeI*, *PacI*, and *SwaI*. The restriction fragments were analyzed by CHEF electrophoresis at different pulse times to achieve resolution of desired size ranges (Fig. 1B). The sizes of all restriction fragments were determined and compiled to obtain the total size of *Sodalis* chromosome, which was found to be approximately 2.11, 2.07, and 2.02 Mb by *PmeI*, *PacI*, and *SwaI* digestions, respectively.

The total sizes of the generated plasmid DNA restriction fragments analyzed by CHEF elecrophoresis indicated the plasmid size to be about 134 kb (Fig. 2). Based on the intensity of the DNA fragments after staining with ethidium bromide,



FIG. 2. *Sodalis* plasmid size determination. Plasmid DNA fragments were resolved by CHEF gel electrophoresis at 2-s pulse time for 12 h at 170 V. Lanes 1 and 5, molecular weight markers (lambda ladder and lambda/*Hind*III, respectively); lanes 2 to 4, purified *Sodalis* plasmid DNA digested with restriction enzymes *Eco*RI, *Hind*III, and *Pst*I, respectively.

two fragments were consistently observed to be less abundant. Hence, *Sodalis* may contain at least one additional plasmid around 10 kb in size that is present in fewer copies (data not shown).

A+T content of *Sodalis* **genome.** We analyzed the coding sequences for two conserved genes, *groEL* and *ftsZ*, to examine the A+T content of the *Sodalis* genome. Both gene sequences have been extensively studied in other bacteria and hence can be used in comparative analysis with related organisms. Anal-

ysis of the *groEL* gene from *Sodalis* has shown that it is 44% A+T, while the *ftsZ* gene was found to be 41% A+T rich. The same loci characterized from *E. coli* are 47 and 46% A+T, respectively. In comparison, the *groEL* sequences characterized from the strict intracellular symbionts *Wigglesworthia* and *Buchnera* are 63% A+T in both organisms (GenBank accession no. AF321516 and AP001118, respectively). The *ftsZ* sequences from *Wigglesworthia* and *Buchnera* were similarly high in A+T content, i.e., 66% (GenBank accession no. AY024354 and AF012886, respectively).

Genome contents of Sodalis inferred from E. coli macroarray hybridizations. Hybridization of Sodalis genomic DNA devoid of plasmids to E. coli macroarrays revealed the presence of 1,800 orthologs (Fig. 3) which represent about 85% of the Sodalis genome, assuming an average size of 1 kb per gene (31). There are 4,290 ORFs represented on the E. coli array, and functional roles have been assigned to 1,938 of these. Of the 1,800 genes detected from Sodalis, 1,158 had functional roles assigned in E. coli, while the remaining 642 genes detected corresponded to genes with hypothetical functions (Fig. 4). Orthologs were grouped according to their known functions, and the number of genes in each group was compared to those present in the E. coli genome (Fig. 5). Although the Sodalis genome is about half the size of that of E. coli, this comparative analysis has revealed that it contains a high proportion of the genes for amino acid biosynthesis, regulatory functions, translation, transcription, and nucleic acid biosynthesis. Almost all of the genes necessary to synthesize each amino acid and for the de novo synthesis of nucleic acids could be detected in Sodalis via array hybridization. We were able to detect a complete set of genes involved in many metabolic pathways such as those associated with amino acid biosynthesis (e.g., trpABCDE for tryptophan, hisABCDFGHI for histidine,



FIG. 3. *E. coli* gene array hybridization analysis of *Sodalis* DNA. The autoradiogram shows the 1,800 signals detected by hybridization of *Sodalis* chromosomal DNA to Panorama macroarrays containing 4,290 *E. coli* ORFs. Each gene is spotted in duplicate over three panels.

A.A	.B.&M.	b3772	ilvA	b2907	ubiH	b3600	mtlD	b2661	gabD	b0111	ampE	b3247	cafA	b2701	mltB	b2565	recO
b0002	thrA	b3773	ilvY	b2947	gshB	b3902	rhaD	b2662	gabT	b0141	yadN	b3266	acrF	b2813	mltA	b2567	rnc
b0003	thrB	b3774	ilvC	b2955	yggW	b3903	rhaA	b2675	nrdE	b0188	mes]	b3462	ftsX	b2817	amiC	b2580	ung
b0004	thrC	b3809	dapF_	b3041	ribB	b3904	rhaB	b2676	nrdF	b0229	fhiA	b3463	ftsE	b2893	dsbC	b2699	recA
b0031	dapB	b3828	metR	b3187	ispB	b4322	uxuA	b2750	cysC	60230	mbhA	b3464	ftsY	b3144	yra]	b2733	mutS
b0071	leuD	b3829	metE	b3360	pabA	b4323	ихиВ	b2751	cysN	b0311	betA	b3495	uspA	b3182	dacB	b2894	xerD
60072	leuC	b3868	glnG	b3368	cysG	b4324	uxuR	b2752	cysD	b0312	betB	b3502	arsB	b3189	murA	b2916	ıcıA
60073	leuB	b3869	ginL	b3412	bioH			b2762	cysH	b0427	yajR	b3514	yhiV	b3208	yrbM	b2961	mutY
60074	leuA	b3870	glnA	b3447	88t	C	.I.M.	b2763	cysI	60433	ampG	b3638	radC	b3224	nanT	63019	parC
b0077	ilvl	b3938	met]	b3500	gor	b0120	speD	b2764	cys]	b0436	tig	b3673	emrD	b3249	mreD	63030	parE
60078	ilvH	b3939	metB	b3610	grxC	b0121	speE	b2765	ygcM	b0462	acrB	b3686	hslS	63250	mreC	63066	dnaG
60166	dapD	63940	metL	63781	trxA	b0160	dgt	62808	gcvA	b0473	htpG	b3706	that	b3251	mreB	b3261	fis ID
60167	ginD	63957	argE	63803	hemX	60171	pyrH	b2842	kduD	60479	fsr	63908	soaA	D3358	ynfK	03283	yraD
60242	proB	b3958	argC	b3805	hemC	60200	yaeD	62903	gcvP	b0533	sfmH	b3931	nsiU	D3396	mrcA	D3387	aam
60243	proA	D3959	argB	b3867	hemN	60219	yaf V	62904	gcvн	b0578	nfnB	b4082	ујск	03428	gigp	D3635	mutivi
b0269	yagF	D3960	argH	b3929	menG	b0221	faaF	62905	gcvi	b0623	CSPE	D4142	торв	D3429	gigA	D3039	агр
DU273	argr	D4013	metA	D3930	menA	D0260	укј	D2927	ера	DU812	ups	D4143	mopA	D3431	gign	b3043	rpn
DU388	arol	D4019	metri	D3973	DIFA	D0262	yage	D2937	speь	DU007	yojk	D4334	yji i	b3432	yiyo	b3602	necG
b0390	acmP	b4024	tyse ture	b2001		b0200	yuy E waiM	D2930	sper	60000	uspD HeV	04555	157	b3613	vibD	b3700	xecE
b0754	ushD aroC	b4004	adi	b3007	iniG ihiC	b0355	yuuvi touB	b2124	agaM	60070 60074	JISK		~ c	b3610	yini rfaD	b3700	dnaM
b00734	uroG corC	b4131	cad A	b3997	homF	b0383	nhoA	b3134	agas	b0924	uchR	b0082	uahC	b3620	rfaE	b3702	dnaA
b0908	aroA	b4254	aral	b4040	uhiA	b0303	alnK	b3176	mrs A	b0990	csnG	b0085	murF	b3621	rfaC	h3704	rnnA
b0928	asnC	b4388	serB	h4390	nadR	b0450	amtR	b3213	altD	b1048	mdoG	b0086	murF	b3625	rfaY	h3741	oid A
b1014	nut A	04500	5010	04070	man	b0431	ushA	b3355	nrkB	b1049	mdoH	b0087	mraY	b3632	rfaO	b3778	ren
h1189	dad A	BC	P&C	C	CC	b0482	uhaP	h3388	dam X	b1054	htrB	60088	murD	b3633	kdtA	b3811	xerC
b1260	trnA	b0009	moo	b0061	araD	b0507	ocl	h3403	nckA	b1068	mviM	b0000	murG	b3644	vicC	b3813	uvrD
b1261	trnR	b0048	folA	b0062	ara A	b0508	ain	h3438	ontR	b1069	mniN	b0091	murC	b3785	wzzE	b3822	recO
b1262	trnC	b0052	ndrA	b0063	araR	b0512	δ.γ vhhX	h3449	uon()	b1072	floA	b0096	InxC	b3793	rffT	b3863	polA
b1263	trvD	b0068	tbpA	b0124	ocd	b0517	allD	b3617	kbl	b1073	floB	b0149	mrcB	b3832	vigN	b4000	hupA
b1264	trvE	b0109	nadC	b0270	vagG	b0564	avvY	b3729	elmS	b1074	flgC	b0163	vaeH	b3842	rfaH	b4052	dnaB
b1275	cusB	b0133	panC	b0271	vagH	b0599	vbdH	b3730	glmU	b1076	flgE	b0179	lpxD	b3972	murB	b4058	uvrA
b1704	aroH	b0134	panB	b0344	lacZ	b0600	vbdL	b3786	rffE	b1078	flgG	b0181	lpxA	b4159	yjeP	b4059	ssb
b1748	argM	b0142	folK	b0345	lacI	b0676	nagC	b3787	rffD	b1079	flgH	b0182	lpxB	b4169	amiB	b4170	mutL
b1814	sdaA	b0154	hemL	b0352	mhpE	b0677	nagA	b3788	rffG	b1080	flgI	b0196	rcsF	b4233	yjfG	b4201	priB
b2019	hisG	b0414	ribD	b0688	pgm	b0678	nagB	b3789	rffH	b1082	flgK	b0197	yaeC	b4234	yjgA	b4259	holC
Ь2020	hisD	b0415	ribH	b0757	galK	b0693	speF	b3821	pldA	b1174	minE	Ь0222	gmhA	b4314	fimA	b4349	hsdM
b2021	hisC	Ь0421	ispA	b0758	galT	b0711	ybg]	b3926	glpK	b1175	minD	b0381	ddlA	b4317	fimD	b4361	dnaC
h2022	hicR	b0475	homH	b0759	aalF	b0712	what	h3941	matE	b1197	tro A	b0404	vaiB	h/318	ConT	h4396	rah
02022	nışD	00170	nemiii	00107	8 ^{uiL}	00714	yogn	00741	men	01177	11111		gujo	04510	JIME	04070	100
b2023	hisH	b0529	folD	b0871	poxB	b0718	ybgQ	b3945	gldA	b1482	osmC	b0463	acrA	b4392	slt	04070	100
b2023 b2024	hisH hisA	b0529 b0593	folD entC	b0871 b0904	poxB focA	b0718 b0756	ybgQ galM	b3945 b4014	gldA aceB	b1482 b1557	osmC cspB	b0463 b0632	acrA dacA	b4392	slt	E	E.M.
b2023 b2024 b2025	hisH hisA hisF	b0529 b0593 b0594	folD entC entE	b0705 b0871 b0904 b1106	poxB focA ycfN	b0718 b0756 b0766	ybgQ galM ybhA	b3945 b4014 b4015	gldA aceB aceA	b1482 b1557 b1558	osmC cspB cspF	b0463 b0632 b0634	acrA dacA mrdB	b4392 D.R.F	slt R.M.&R.	64570 E 60008	E.M. talB
b2023 b2024 b2025 b2026	hisH hisA hisF hisI	b0529 b0593 b0594 b0595	folD entC entE entB	b0871 b0904 b1106 b1236	poxB focA ycfN galU	b0718 b0756 b0766 b0767	ybgQ galM ybhA ybhE	b3945 b4014 b4015 b4018	gldA aceB aceA iclR	b1482 b1557 b1558 b1732	osmC cspB cspF katE	b0463 b0632 b0634 b0635	acrA dacA mrdB pbpA	D.R.F b0060	slt slt R.M.&R. polB	E 50008 50041	iot talB fixA
b2023 b2024 b2024 b2025 b2026 b2026 b2329	hisH hisA hisF hisI aroC	b0529 b0593 b0594 b0595 b0596	folD entC entE entB entA	b0705 b0871 b0904 b1106 b1236 b1594	poxB focA ycfN galU mlc	b0718 b0756 b0766 b0767 b0772	ybgQ galM ybhA ybhE ybhC	b3945 b4014 b4015 b4018 b4092	gldA aceB aceA iclR phnP	b1482 b1557 b1558 b1732 b1823	osmC cspB cspF katE cspC	b0463 b0632 b0634 b0635 b0640	acrA dacA mrdB pbpA dsbC	b4392 D.R.F b0060 b0145	slt slt R.M.&R. polB dksA	E b0008 b0041 b0042	E. M . talB fixA fixB
b2023 b2024 b2025 b2026 b2329 b2366	hisH hisA hisF hisI aroC dsdA	b0529 b0593 b0594 b0595 b0596 b0628	folD entC entE entB entA lipA	b0871 b0904 b1106 b1236 b1594 b1613	poxB focA ycfN galU mlc manA	b0718 b0756 b0766 b0767 b0772 b0789	ybgQ galM ybhA ybhE ybhC ybhO	b3945 b4014 b4015 b4018 b4092 b4093	gldA aceB aceA iclR phnP phnO	b1482 b1557 b1558 b1732 b1823 b1828	osmC cspB cspF katE cspC o494	b0463 b0632 b0634 b0635 b0640 b0643	acrA dacA mrdB pbpA dsbC ybeL	b4392 D.R.F b0060 b0145 b0183	slt slt R.M.&R. polB dksA rnhB	E b0008 b0041 b0042 b0079 b0080	E.M. talB fixA fixB fruL fruL
b2023 b2024 b2025 b2026 b2329 b2366 b2414	hisH hisA hisF hisI aroC dsdA cysK	b0529 b0593 b0594 b0595 b0596 b0628 b0630	folD entC entE entB entA lipA lipB	b0705 b0871 b0904 b1106 b1236 b1594 b1613 b2095	poxB focA ycfN galU mlc manA gatZ	b0718 b0756 b0766 b0767 b0772 b0789 b0825	ybgQ galM ybhA ybhE ybhC ybhO ybhZ	b3945 b4014 b4015 b4018 b4092 b4093 b4094	gldA aceB aceA iclR phnP phnO phnN	b1482 b1557 b1558 b1732 b1823 b1828 b1829	osmC cspB cspF katE cspC o494 htpX metP	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780	acrA dacA mrdB pbpA dsbC ybeL pal	D.R.F b0060 b0145 b0183 b0184	slt slt R.M.&R. polB dksA rnhB dnaE makA	E b0008 b0041 b0042 b0079 b0080 b0112	talB fixA fixB fruL fruR
b2023 b2024 b2025 b2026 b2329 b2366 b2414 b2421 b2448	hisH hisA hisF hisI aroC dsdA cysK cysM	b0529 b0593 b0594 b0595 b0596 b0628 b0630 b0774	folD entC entE entB entA lipA lipB bioA bioA	b0705 b0871 b0904 b1106 b1236 b1594 b1613 b2095 b2132 b2132	poxB focA ycfN galU mlc manA gatZ bglX	b0718 b0756 b0766 b0767 b0772 b0789 b0825 b0889 b0825	ybgQ galM ybhA ybhE ybhC ybhO ybiZ lrp	b3945 b4014 b4015 b4018 b4092 b4093 b4094 b4095	gldA aceB aceA iclR phnP phnO phnN phnM	b1482 b1557 b1558 b1732 b1823 b1828 b1829 b1855 b1880	osmC cspB cspF katE cspC o494 htpX msbB gbp	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0814	acrA dacA mrdB pbpA dsbC ybeL pal ybhK avmY	D.R.F b0060 b0145 b0183 b0184 b0214 b0215	sit sit R.M.&R. polB dksA rnhB dnaE rnhA dnaC	E b0008 b0041 b0042 b0079 b0080 b0113 b0114	E.M. talB fixA fixB fruL fruR pdhR
b2023 b2024 b2025 b2026 b2329 b2366 b2414 b2421 b2468 b2472	hisH hisA hisF hisI aroC dsdA cysK cysK yffG damF	b0529 b0529 b0593 b0594 b0595 b0596 b0628 b0630 b0774 b0775 b0776	folD entC entE entB entA lipA lipB bioA bioB	b0871 b0904 b1106 b1236 b1594 b1613 b2095 b2132 b2167 b2172	poxB focA ycfN galU mlc manA gatZ bglX fruA	b0718 b0756 b0766 b0767 b0772 b0789 b0825 b0889 b0969 b0969	yogR ybgQ galM ybhA ybhC ybhC ybhC ybhO ybiZ lrp yccK	b3945 b4014 b4015 b4018 b4092 b4093 b4094 b4095 b4096 b4097	gldA aceB aceA iclR phnP phnO phnN phnM phnM phnL vhnK	b1482 b1557 b1558 b1732 b1823 b1823 b1828 b1829 b1855 b1880 b1881	osmC cspB cspF katE cspC o494 htpX msbB flhB choZ	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0814 b0814	yafD acrA dacA mrdB pbpA dsbC ybeL pal ybhK ompX dacC	D.R.F b0060 b0145 b0183 b0184 b0214 b0215 b0247	sit sit R.M.&R. polB dksA rnhB dnaE rnhA dnaQ ukfC	E b0008 b0041 b0042 b0079 b0080 b0113 b0114 b0115	talB fixA fixB fruL fruR pdhR aceE aceE
b2023 b2024 b2025 b2026 b2329 b2366 b2414 b2421 b2468 b2472 b2478	hisH hisA hisF hisI aroC dsdA cysK cysK cysK gyfG dapE davA	b0529 b0593 b0594 b0595 b0596 b0628 b0630 b0774 b0775 b0776 b07778	folD entC entE entB entA lipA lipB bioA bioB bioF bioP	b0871 b0904 b1106 b1236 b1594 b1613 b2095 b2132 b2167 b2172 b2297	gail poxB focA ycfN galU mlc manA gatZ bglX fruA yeiQ yeta	b0718 b0756 b0766 b0767 b0772 b0789 b0825 b0889 b0969 b0980 b1020	yogQ yobQ galM yohA yohC yohC yohC yohC yohZ lrp yccK appA H	b3945 b4014 b4015 b4018 b4092 b4093 b4094 b4095 b4096 b4097 b4099	gldA aceB aceA iclR phnP phnO phnN phnM phnL phnK phnK	b1482 b1557 b1558 b1732 b1823 b1823 b1828 b1829 b1855 b1880 b1881 b1883	osmC cspB cspF katE cspC o494 htpX msbB flhB cheZ cheB	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0814 b0839 b0929	acrA dacA mrdB pbpA dsbC ybeL pal ybhK ompX dacC ompF	D.R.F b0060 b0145 b0183 b0184 b0214 b0215 b0247 b0354	slt slt R.M.&R. polB dksA mhB dnaE mhA dnaQ ykfG ykfG uail	E b0008 b0041 b0042 b0079 b0080 b0113 b0114 b0115 b0116	<i>talB</i> <i>fixA</i> <i>fixB</i> <i>fruL</i> <i>fruR</i> <i>pdhR</i> <i>aceE</i> <i>aceF</i> <i>lndA</i>
b2023 b2024 b2025 b2026 b2329 b2366 b2414 b2421 b2468 b2472 b2478 b2551	his his his his his aro ds dA cys K cys M yff dap E dap A alu A	b0529 b0593 b0594 b0595 b0596 b0628 b0630 b0774 b0775 b0776 b0778	folD entC entE entB entA lipA lipB bioA bioB bioF bioD	b0871 b0904 b1106 b1236 b1594 b1613 b2095 b2132 b2167 b2172 b2297 b2452	poxB focA ycfN galU mlc manA gatZ bglX fruA yeiQ pta cutH	b0718 b0756 b0766 b0767 b0772 b0789 b0825 b0889 b0969 b0980 b1020 b1302	ybgQ galM ybhA ybhE ybhC ybhC ybhO ybiZ lrp yccK appA phoH gogG	b3945 b4014 b4015 b4018 b4092 b4093 b4094 b4095 b4096 b4097 b4099 b4101	gldA aceB aceA iclR phnP phnO phnN phnM phnL phnL phnK phnI phnG	b1482 b1557 b1558 b1732 b1823 b1823 b1828 b1829 b1855 b1880 b1881 b1883 b1885	osmC cspB cspF katE cspC o494 htpX msbB flhB cheZ cheB tap	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0814 b0839 b0929 b0957	acrA dacA mrdB pbpA dsbC ybeL pal ybhK ompX daCC ompF ompA	D.R.F b0060 b0145 b0183 b0184 b0214 b0215 b0247 b0354 b0440	slm slt 2.M.&R. polB dksA rnhB dnaE rnhA dnaQ ykfG yaiL bumB	E b0008 b0041 b0042 b0079 b0080 b0113 b0114 b0115 b0116 b0118	talB fixA fixB fruL fruR pdhR aceE aceF lpdA acuB
b2023 b2024 b2024 b2025 b2026 b2329 b2366 b2414 b2421 b2468 b2472 b2478 b2475 b2478	his his his his his aro ds dA cys K cys M yff dap A dap A gly A s ly A s ly A s ly A	b0529 b0593 b0594 b0595 b0596 b0628 b0630 b0774 b0775 b0776 b0778 b07781 b0781 b0783	folD entC entE entB entA lipA lipB bioA bioB bioF bioD moaA moaC	b0871 b0904 b1106 b1236 b1594 b1613 b2095 b2132 b2167 b2172 b2297 b2452 b2452	gaiL poxB focA ycfN galU mlc manA gatZ bgIX fruA yeiQ pta eutH eutG	b0718 b0756 b0756 b0766 b0767 b0772 b0789 b0825 b0889 b0969 b0980 b1020 b1302 b1479	ybgQ galM ybhA ybhE ybhC ybhC ybhO ybiZ lrp yccK appA phoH goaG sfcA	b3941 b3945 b4014 b4015 b4018 b4092 b4093 b4094 b4095 b4096 b4097 b4097 b4097 b4097	gldA aceB aceA iclR phnP phnO phnN phnM phnL phnK phnI phnG phnF	b1482 b1557 b1558 b1732 b1823 b1823 b1829 b1855 b1880 b1881 b1883 b1885 b1886	osmC cspB cspF katE cspC o494 htpX msbB flhB cheZ cheB tap tap	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0814 b0839 b0929 b0957 b0987	acrA dacA mrdB pbpA dsbC ybeL pal ybhK ompX dacC ompF ompA yccZ	b4392 D.R.F b0060 b0145 b0183 b0184 b0215 b0247 b0354 b0440 b0467	slm slt X.M.&R. polB dksA rnhB dnaE rnhA dnaQ ykfG yaiL hupB nriC	E b0008 b0041 b0042 b0079 b0080 b0113 b0114 b0115 b0116 b0118 b0186	E.M. talB fixA fixB fruL fruR pdhR aceE aceF lpdA acnB fdcC
b2023 b2024 b2024 b2025 b2026 b2329 b2366 b2414 b2421 b2468 b2472 b2478 b2478 b2551 b2553	hisH hisA hisF hisI aroC dsdA cysK cysM yffG dapE dapA glyA glyA glyA glyA	b0529 b0593 b0593 b0594 b0595 b0596 b0628 b0630 b0774 b0776 b0776 b0778 b0781 b0781 b0783 b0784	folD folD entC entE entB entA lipB bioA bioB bioF bioD moaA moaC moaD	b0871 b0904 b1106 b1236 b1594 b1613 b2095 b2132 b2152 b2132 b2152 b2453 b2453	gaiL poxB focA ycfN galU mlc manA gatZ bglX fruA yeiQ pta eutH eutG eutI	b0718 b0756 b0766 b0767 b0772 b0789 b0825 b0889 b0825 b0889 b0969 b0980 b1020 b1302 b1479 b1602	ybgQ ybgQ ybhA ybhA ybhC ybhC ybhC Irp ybcK appA phoH goaG sfcA pntB	b3945 b4014 b4015 b4018 b4092 b4093 b4094 b4095 b4096 b4097 b4099 b4101 b4102	gldA aceB aceA iclR phnP phnO phnO phnM phnL phnK phnI phnG phnF dshD	b1482 b1557 b1558 b1732 b1823 b1823 b1823 b1823 b1825 b1880 b1881 b1883 b1885 b1886 b1887	osmC cspB cspF katE cspC o494 htpX msbB flhB cheZ cheB tar cheW	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0814 b0839 b0929 b0957 b0983 b1215	acrA acrA mrdB pbpA dsbC ybeL pal ybhK ompX dacC ompF ompA yccZ kdsA	b4392 b4392 D.R.F b0060 b0145 b0183 b0184 b0214 b0214 b0247 b0354 b0440 b0467	slm slt R.M.&R. polB dksA rnhB dnaE rnhA dnaQ ykfG yaiL hupB priC dnaX	E 50008 50008 50041 50042 50079 50080 50113 50114 50116 50116 50116 50118 50186 50211	E.M. talB fixA fixB fruL fruR pdhR aceE aceF lpdA acnB fdcC dniR
b2023 b2024 b2025 b2026 b2026 b2329 b2366 b2414 b2421 b2468 b2472 b2478 b2478 b2551 b2553 b2599 b2600	hisH hisH hisF hisI aroC dsdA cysK cysK cysM yffG dapE dapA glyA glnB pheA hurA	b0529 b0593 b0594 b0595 b0596 b0630 b0774 b0775 b0776 b07775 b0776 b0778 b0781 b0783 b0784 b0784	nenni folD entC entE entB entA lipB bioA bioB bioB bioB bioF bioD moaA moaD moaF	b0871 b0904 b1106 b1236 b1594 b1613 b2095 b2132 b2132 b2167 b2172 b2297 b2452 b2453 b2454 b2455	gant poxB focA ycfN galU mic manA gatZ bglX fruA yeiQ pta eutH eutG eutF	b0718 b0756 b0766 b0767 b0772 b0789 b0825 b0889 b0989 b0980 b1020 b1302 b1302 b1479 b1602 b1603	ybgQ ybgQ ybhA ybhE ybhC ybhC ybhC ybhC ybhC ybhC ybhC ybhC	b3945 b4014 b4015 b4018 b4092 b4093 b4094 b4095 b4096 b4097 b4099 b4101 b4102 b4136	gldA aceB aceA iclR phmP phmO phmN phmN phmL phmK phmI phmG phmF dsbD asnA	b1482 b1482 b1557 b1558 b1732 b1823 b1823 b1823 b1828 b1882 b1885 b1883 b1885 b1886 b1887 b1888	osmC cspB cspF katE cspC o494 htpX msbB flhB cheZ cheB tap tar cheW cheA	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0814 b0839 b0929 b0957 b0983 b1215 b1377	acrA dacA mrdB pbpA dsbC ybeL pal ybhK ompX dacC ompF ompA yccZ kdsA omnN	b4392 b4392 D.R.F b0060 b0145 b0183 b0184 b0214 b0215 b0247 b0354 b0440 b0467 b0470	Jimr slt 2.M.&R. polB dksA rnhB dnaE rnhA dnaQ ykfG yaiL hupB priC dnaX recR	E b0008 b0041 b0042 b0079 b0080 b0113 b0114 b0115 b0116 b0118 b0186 b0211 b0328	E.M. talB fixA fixB fruL fruR pdhR aceE aceF lpdA accB fdcC dniR tahN
b2023 b2024 b2025 b2026 b2329 b2366 b2414 b2421 b2468 b2472 b2478 b2478 b2478 b2478 b2553 b2599 b2600	hisH hisH hisF hisI aroC dsdA cysK cysM yffG dapE dapE dapA glnB pheA glnB pheA aroF	b0529 b0593 b0594 b0595 b0596 b0630 b0774 b0775 b0776 b0777 b0776 b0778 b0781 b0783 b0784 b0783	nemn folD entC entE entB entA lipA lipB bioA bioB bioA bioD moaA moaC moaD moeA	b0871 b0904 b1106 b1236 b1594 b1613 b2095 b2132 b2132 b2167 b2132 b2167 b2172 b2297 b2452 b2453 b2453 b2454 b2458	poxB focA ycfN galU mlc manA gatZ bglX fruA gatZ bglX fruA geutH eutH eutG eutI eutE eutI	b0718 b0756 b0766 b0767 b0772 b0789 b0829 b0889 b0980 b1020 b1302 b1479 b1602 b1603 b1702	ybgQ ybgQ ybhA ybhA ybhC ybhC ybhC ybhO ybbZ lrp yccK appA yhoH goaG sfcA pntB pntA pvsA	b3945 b4014 b4015 b4018 b4092 b4093 b4094 b4095 b4096 b4096 b4097 b4099 b4101 b4102 b4136 b4136 b4134	aceB aceB aceA iclR phnP phnO phnN phnM phnL phnM phnI phnI phnF dsbD aspA cvsO	b1482 b14557 b1558 b1732 b1823 b1823 b1828 b1829 b1855 b1880 b1881 b1883 b1885 b1886 b1887 b1888	norm cspB cspF katE cspF katE cspC od94 htpX msbB flhB cheZ cheB tap tar cheW cheA motB	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0814 b0839 b0929 b0957 b0983 b1215 b1377 b1424	acrA dacA mrdB pbpA dsbC ybeL pal ybhK ompX dacC ompF ompA yccZ kdsA ompN wdcG	b4392 D.R.F b0060 b0145 b0183 b0184 b0214 b0214 b0215 b0247 b0354 b0440 b0467 b0470 b0470 b0472	Jimr slt 2.M.&R. polB dksA rnhB dnaE rnhA dnaQ ykfG yaiL hupB priC dnaX recR ybfD	E 50008 50008 50041 50042 50079 50080 50113 50114 50116 50116 50116 50211 50328 50428	E.M. talB fixA fixB fruL fruR pdhR aceE aceF lpdA fdcC dniR tahN ccyoE
b2023 b2024 b2025 b2026 b2329 b2366 b2414 b2421 b2468 b2472 b2478 b2478 b2478 b2551 b2553 b2599 b2600 b2601 b2797	hisH hisH hisF hisI aroC dsdA cysK cysM yffG dapE dapA glyA glyB pheA tyrA aroF sdaB	b0529 b0593 b0593 b0594 b0595 b0596 b0628 b0628 b0628 b0630 b0774 b0775 b0776 b0776 b0778 b0778 b0781 b0783 b0784 b0785 b0827	neurit folD entC entE entB entB lipA lipA lipB bioA bioB bioF bioD moaA moaC moaD moeA pmcB	b0871 b0904 b1106 b1236 b1594 b1613 b2095 b2132 b2167 b2132 b2167 b2132 b2297 b2452 b2453 b2454 b2455 b2458 b2458 b2708	yant poxB focA ycfN galU mlc manA gatZ bglX fruA yeiQ pta eutH eutG eutH eutG eutI eutE eutI gutO	b0718 b0756 b0766 b0767 b0772 b0789 b0825 b0889 b0969 b0980 b1020 b1020 b1302 b1479 b1602 b1603 b1702 b1850	ybgQ ybgQ ybhA ybhA ybhE ybhC ybhO ybbO ybbZ lrp yccK appA yboH goaG sfcA pntB pntA ppsA eda	b3945 b4014 b4015 b4018 b4092 b4093 b4094 b4095 b4095 b4096 b4097 b4099 b4101 b4102 b4136 b4139 b4214	aceB aceA iclR phnP phnO phnN phnM phnL phnK phnI phnG phnF dsbD aspA cysQ ppa	b1482 b1482 b1557 b1558 b1732 b1823 b1823 b1823 b1825 b1880 b1885 b1880 b1881 b1883 b1885 b1886 b1887 b1888 b1889 b1820	norm cspB cspF katE cspF katE cspC od94 htpX msbB flhB cheZ cheB tap tar cheW cheA motB fliY	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0814 b0839 b0929 b0957 b0983 b1215 b1377 b1424 b1433	acrA dacA mrdB pbpA dsbC ybeL pal ybhK ompX dacC ompA yccZ kdsA ompN ydcO	b4392 D.R.F b0060 b0145 b0183 b0184 b0214 b0215 b0247 b0354 b0470 b0470 b0472 b0706 b0708	Jimr slt 2.M.&R. polB dksA rnhB dnaE rnhA dnaQ ykfG priC dnaX recR ybfD phrB	E 50008 50008 50041 50042 50079 50080 50113 50114 50116 50116 50118 50186 50211 50328 50428 50429	E.M. talB fixA fixB fruL fruR pdhR aceE aceF lpdA acnB fdcC dniR tahN cyoE cyoD
b2023 b2024 b2025 b2026 b2329 b2366 b2414 b2421 b2468 b2472 b2478 b2553 b2553 b2553 b2599 b2600 b2601 b2797 b2818	hisH hisH hisF hisI aroC dsdA cysK cysM yffG dapE dapA glyA glyA glnB pheA tyrA aroF sdaB argA	b0529 b0593 b0594 b0595 b0596 b0628 b0628 b0630 b0774 b0775 b0776 b0778 b0778 b0778 b0783 b0783 b0784 b0785 b0827 b0931	nemn folD entC entE entB entA lipA lipA lipB bioA bioB bioF bioD moaA moaC moaD moaE pmcB grxB	b0871 b0904 b1106 b1236 b1594 b1613 b2095 b2132 b2167 b2152 b2297 b2452 b2453 b2454 b2455 b2454 b2455 b2458 b2708 b2714	panb poxB focA ycfN galU mlc manA gatZ bglX fruA yeiQ pta eutH eutG eutI eutE eutI gutQ ascG	b0718 b0756 b0766 b0767 b0772 b0789 b0825 b0889 b0969 b0980 b1020 b1302 b1479 b1602 b1479 b1603 b1702 b1850	ybgQ ybgQ ybhA ybhA ybhE ybhC ybhO ybiZ irp yccK appA phOH goaG sfcA pntB pntA ppsA eda	b3945 b4014 b4015 b4018 b4092 b4093 b4094 b4095 b4094 b4095 b4096 b4097 b4099 b4101 b4102 b4136 b4139 b4214 b4226	aceB aceA iclR phnP phnN phnN phnM phnL phnK phnG phnG phnF dsbD aspA cysQ ppa fbp	b1482 b1482 b1557 b1558 b1732 b1823 b1823 b1823 b1829 b1855 b1880 b1885 b1886 b1885 b1886 b1887 b1888 b1888 b1888 b1889 b1920	norm cspB cspF katE cspC o494 htpX msbB flhB cheZ cheB tap tar cheW cheA motB fliY fliI	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0814 b0780 b0927 b0927 b0927 b09257 b0983 b1215 b1377 b1424 b1637	acrA dacA mrdB pbpA dsbC ybeL pal ybhK ompX dacC ompF ompA yccZ ompN ydcG ydcG jbp	b4392 D.R.F b0060 b0145 b0183 b0184 b0214 b0214 b0214 b0214 b0247 b0354 b0440 b0470 b0472 b0706 b0706 b0708	Jumr slt 2.M.&R. polB dksA rnhB dnaE rnhA dnaQ ykfG dnaX recR ybfD phrB dinG	E b0008 b0041 b0042 b0079 b0080 b0113 b0114 b0115 b0116 b0118 b0186 b0211 b0328 b0429 b0429 b0420	E.M. talB fixA fixB fruL fruR pdhR aceE aceF lpdA aceB fdcC dniR tahN cyoD cyoD cyoC
b2023 b2024 b2025 b2026 b2326 b2366 b2414 b2421 b2468 b2472 b2478 b2553 b2553 b2559 b2600 b2601 b2797 b2818 b2839	hisH hisH hisF hisI aroC dsdA cysK cysK cysK cysK dapE dapA glyB glnB pheA tyrA aroF sdaB argA lysR	b0529 b0593 b0594 b0595 b0596 b0596 b0596 b0596 b0596 b0774 b0775 b0775 b0778 b0778 b0778 b0781 b0783 b0781 b0783 b0781 b0783 b0781 b0782 b0781 b0782 b0781 b0783 b0794 b0795 b0794 b0795 b0795 b0774 b0776 b0776 b0778 b0778 b0793 b0794 b0795 b0795 b0795 b0795 b0795 b0795 b0795 b0795 b0795 b0795 b0796 b0796 b0796 b0796 b0796 b0796 b0796 b0796 b0774 b0776 b0778 b0778 b0778 b0783 b0798 b0797 b0776 b0778 b0798 b0796 b0776 b0778 b0798 b0796 b0776 b0776 b0778 b0783 b0781 b0783 b0781 b0783 b0781 b0783 b0781 b0783 b0781 b0783 b0783 b0781 b0783 b0781 b0783 b0781 b0783 b0781 b0782 b0781 b0782 b0781 b0782 b0782 b0781 b0782	nemii folD entC entE entB entA lipA lipB bioA bioB bioF bioD moaA moaC moaA grxB hemA	b0871 b0904 b1106 b1294 b1613 b2095 b2167 b2172 b2297 b2452 b2453 b2454 b2455 b2455 b2458 b2714 b2787	poxB focA ycfN galU mlc manA gatZ bglX fruA yeiQ pta eutH eutG eutE eutE eutE gutQ gscG gudD	b0718 b0756 b0766 b0767 b0772 b0789 b0825 b0889 b0969 b0969 b1020 b1302 b1302 b1402 b1603 b1603 b1603 b1603 b1851 b2042	ybgQ ybgQ yalM ybhA ybhA ybhC ybhC ybhO ybiZ lrp yccK appA phoH goaG sfcA pntB pntA ppsA eda edd galF	b3945 b4014 b4015 b4018 b4093 b4093 b4094 b4095 b4096 b4097 b4099 b4100 b4109 b4102 b4130 b4139 b4214 b4226 b4232	nici aceB aceA iclR phnP phnN phnN phnM phnK phnI phnK phnI phnG phnG phnG phnG phnG phnG phnG phnG	b1482 b1482 b1557 b1558 b1732 b1823 b1828 b1829 b1855 b1880 b1881 b1883 b1885 b1885 b1885 b1885 b1885 b1888 b1887 b1888 b1889 b1920 b1943	norm cspB cspF katE cspC od94 htpX msbB flhB cheZ cheB hap tar cheA motB fliY fliI fliK	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0814 b0780 b0839 b0929 b0957 b0983 b1215 b1377 b1424 b1433 b1677 b1879	acrA dacA mrdB dsbC ybeL pal ybhK ompX dacC ompF ompA yccZ ompN ydcG ydcG lpp fhA	b4318 b4392 D.R.F b0060 b0145 b0183 b0183 b0184 b0215 b0247 b0354 b0440 b0467 b0470 b0472 b0470 b0472 b0706 b0708 b0799 b0892	Jimr slt 2.M.&R. polB dksA rnhB dnaE rnhA dnaE rnhA dnaQ ykfG yaiL hupB priC dnaX recR ybfD phrB dinG yca]	E b0008 b0041 b0042 b0079 b0080 b0113 b0114 b0115 b0116 b0116 b0118 b0186 b0211 b0328 b0428 b0428 b0429 b0430	E.M. talB fixA fixA fruL fruR pdhR aceE aceF lpdA acnB dniR tahN cyoE cyoC cyoC cyoB
b2023 b2024 b2025 b2026 b2329 b2366 b2414 b2421 b2482 b2472 b2472 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2479 b2600 b2601 b2797 b2818 b2839 b2913	hisH hisH hisF hisF aroC dsdA cysK cysM glsA dapE dapA glyA glyA glyB pheA tyrA aroF sdaB argA ysR serA	b0529 b0593 b0594 b0595 b0596 b0596 b0596 b0596 b0596 b0776 b0777 b0775 b07775 b0778 b0778 b0778 b0778 b0778 b0781 b0783 b0784 b0785 b0827 b0931 b1064 b1212	nemii folD entC entE entB entA lipA lipB bioA bioB bioF bioD moaA moaC moaD moaE moeA pncB grxB hemA hemK	b0871 b0904 b1106 b1294 b1613 b2095 b2132 b2167 b2172 b2297 b2452 b2453 b2453 b2453 b2455 b2458 b2458 b2458 b2714 b2788	poxB focA ycfN galU mlc manA gatZ bglX fruA yeiQ pta eutH eutG eutI gutQ ascG gudD gudD gudX	b0718 b0756 b0766 b0767 b0772 b0772 b0772 b0772 b0722 b0825 b0889 b0969 b0960 b1020 b1302 b1479 b1603 b1702 b1603 b1702 b1850 b1850 b1851 b2042 b2048	ybgQ ybgQ yalM ybhA ybhA ybhC ybhO ybiZ lrp yccK appA yhoH goaG sfcA pntB pntA ppsA eda edd galF cpsG	b3945 b4014 b4015 b4015 b4093 b4093 b4094 b4095 b4096 b4097 b4099 b4101 b4102 b4102 b4102 b4139 b4214 b4226 b4232	gldA aceB aceA iclR phnP phnO phnN phnN phnN phnK phnI phnG phnF dsbD aspA cysQ ppa fbp C.P.	b1482 b1482 b1557 b1558 b1732 b1823 b1828 b1829 b1855 b1880 b1881 b1883 b1885 b1886 b1885 b1886 b1885 b1886 b1885 b1888 b1888 b1888 b1888 b1888 b1898 b1920 b1941 b1943	norm cspB cspF cspF katE cspC od94 htpX msbB flhB thpX thpX thpX thpX thpX thpX thpX thpX	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0839 b0929 b0957 b0983 b1215 b1377 b1424 b1433 b1677 b1879 b1891	acrA dacA mrdB pbpA dsbC ybeL pal ybhK ompX dacC ompF ompA yccZ kdsA ompN ydcG ydcO lpp flhA flhC	b4316 b4392 D.R.F b0060 b0145 b0183 b0184 b0214 b0215 b0247 b0354 b0420 b0470 b0472 b0470 b0472 b0706 b0472 b0706 b0708 b0799 b0892	Jimr slt 2.M.&R. polB dksA rnhB dnaE rnhA dnaQ ykfG yaiL hupB priC dnaX recR ybfD phrB dinG ycaJ himD	E b0008 b0041 b0042 b0079 b0080 b0113 b0114 b0115 b0116 b0118 b01211 b0328 b0428 b0429 b0430 b0431 b0432	E.M. talB fixA fixB fruC fruR pdhR aceE aceF lpdA acnB facC dniR tahN cyoE cyoD cyoC cyoB cyoA
b2023 b2024 b2025 b2026 b2329 b2366 b2414 b2421 b2468 b2472 b2478 b2478 b2478 b2478 b2478 b2479 b2478 b2479 b2600 b2601 b2797 b2818 b2893 b2913 b2957	hisH hisH hisF hisI aroC dsdA cysK cysM dsdA cysK cysM glsA dapE dapE dapA glyA glnB pheA glyA glnB pheA aroF sdaB argA lysR serA ansB	b0529 b0593 b0594 b0595 b0596 b0596 b0628 b0628 b0628 b0774 b0775 b0776 b0776 b0778 b0778 b0778 b0781 b0781 b0783 b0784 b0783 b0784 b0827 b0931 b1064 b1212 b1270	nemn folD entC entE entB entA lipA lipB bioA bioB bioF bioD moaA moaC moaA moaC moaB grxB hemK btuR	b0871 b0904 b1106 b1236 b1594 b1613 b2095 b2132 b2167 b2172 b2297 b2452 b2453 b2453 b2453 b2454 b2455 b2458 b2458 b2708 b2714 b2787 b2788	poxB focA ycfN galU mlc manA gatZ bglX fruA gatZ bglX fruA gatZ bglX fruA gutQ eutH eutH eutG eutH gutQ ascG gudD gudX gudP	b0718 b0756 b0766 b0767 b0772 b0772 b0772 b0722 b0889 b0980 b1020 b1020 b1302 b1479 b1602 b1479 b1602 b1603 b1702 b1850 b1851 b2042 b2048	ybgQ ybgQ yalM ybhA ybhA ybhC ybhC ybhC ybhC ybhC ybhC ybhC ybhC	b3945 b4014 b4015 b4018 b4092 b4093 b4094 b4095 b4095 b4095 b4095 b4095 b4099 b4101 b4102 b4106 b4139 b4214 b4226 b4232 b4012	gldA aceB aceA icIR phnP phnO phnN phnM phnM phnK phnK phnF dsbD aspA cysQ ppa fbp C.P. htgA	b1482 b1482 b1557 b1558 b1732 b1823 b1828 b1829 b1855 b1880 b1881 b1883 b1885 b1886 b1887 b1888 b1887 b1888 b1887 b1888 b1889 b1920 b1941 b1943 b1981	nerf cspB cspF katE cspC cspC cspC cspC cspC ch24 htpX msbB flhB cheZ cheB tap tar cheW cheA motB fliY fliI fliK shiA yegD	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0814 b0839 b0929 b0957 b0983 b1215 b1377 b1424 b1433 b1677 b1879 b1891 b1922	acrA dacA mrdB pbpA dsbC ybeL pal ybhK ompK ompF ompA yccZ kdsA ompN ydcG ydcO lpp flhA flhC flhC fliA	b4392 b4392 D.R.F b0060 b0145 b0183 b0183 b0184 b0214 b0215 b0247 b0354 b0247 b0354 b0467 b0470 b0470 b0470 b0472 b0706 b0708 b0799 b0892 b0912	Jumr slt 2.M.&R. polB dksA rnhB dnaE rnhA dnaQ ykfG yaiL hupB priC dnaX yejD phrB dinG ycaJ himD helD	E b0008 b0041 b0042 b0079 b0080 b0113 b0114 b0115 b0116 b0118 b0186 b0211 b0328 b0428 b0429 b0430 b0431 b0432 b0684	E.M. talB fixA fixB fruL fruR pdhR aceF aceF aceB facC dniR tahN cyoE cyoD cyoC cyoC cyoA fidA
b2023 b2024 b2025 b2026 b2329 b2366 b2414 b2421 b2468 b2472 b2478 b2472 b2478 b2472 b2478 b2472 b2478 b2472 b2478 b2479 b2600 b2601 b2797 b2818 b2839 b2913 b2953 b2903 b2004	hisH hisH hisF hisI aroC dsdA cysK cysM yffG dapE dapE dapA glnB pheA glnB pheA aroF sdaB argA lysR serA ansB metC	b0529 b0593 b0594 b0595 b0596 b0628 b0628 b0630 b0774 b0775 b0776 b0776 b0776 b0778 b0778 b0778 b0778 b0781 b0783 b0784 b0783 b0784 b0785 b0827 b0931 b1064 b1210 b1277	nemn folD entC entE entB entA lipA lipB bioA bioB bioD moaA moaC moaD moaC moaD grxB hemA hemK btuR ribA	b0871 b0904 b1106 b1236 b1594 b1613 b2095 b2132 b2167 b2172 b2297 b2452 b2453 b2454 b2453 b2454 b2455 b2458 b2714 b2787 b2788 b2789 b2802	yent poxB focA yefN galU mlc manA gatZ bglX fruA gatZ bglX fruA gutQ pta eutH eutG eutH eutG eutI gutQ gudZ gudD gudZ gudP fucl	b0718 b0756 b0766 b0767 b0772 b0789 b0825 b0889 b0980 b1020 b1020 b1302 b1479 b1602 b1479 b1602 b1479 b1602 b1450 b1851 b2042 b2048 b2049 b2066	ybgQ ybgQ ybhA ybhA ybhE ybhC ybhC ybhO ybbZ lrp yccK appA ybhO ybbZ lrp yccK appA phoH posA eda eda eda galF cpsB udk	b3945 b4014 b4015 b4018 b4092 b4093 b4094 b4095 b4095 b4095 b4095 b4095 b4096 b4097 b4101 b4102 b4136 b4139 b4214 b4226 b4232	nici gldA accB accA iclR phmP phmO phmN phmM phmL phmL phmI phmI phmF dsbD aspD cysQ ppa fbp C.P. htgA dmaK	b1482 b1482 b1557 b1558 b1732 b1823 b1828 b1829 b1855 b1880 b1881 b1883 b1885 b1886 b1887 b1888 b1889 b1920 b1941 b1943 b1941 b2069 b2144	norm cspB cspF cspF katE cspC od94 htpX msbB flhB cheZ cheB tap tar cheW cheA motB fliY fliI fliK shiA yegD sanA	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0843 b0741 b0780 b0839 b0927 b0983 b1927 b1424 b1433 b1677 b1424	acrA dacA mrdB pbpA dsbC ybeL pal ybhK ompX dacC ompF ompA yccZ kdsA ompN ydcG ypf fhA fhC fhiA fliD	b4392 b4392 D.R.F b0060 b0145 b0145 b0145 b0145 b0145 b0145 b0145 b0145 b0145 b0145 b0214 b0214 b0247 b0470 b0470 b0470 b0470 b0470 b0470 b0470 b0706 b0708 b0709 b0892 b0912 b0962 b0962 b0984	Jump slt 2.M.&R. polB dksA rnhB dnaE rnhA dnaQ ykfG yaiL hupB priC dnaX recR ybfD phrB dinG ycaJ himD helD rne	E b0008 b0041 b0042 b0079 b0080 b0113 b0114 b0115 b0116 b0116 b0118 b0186 b0211 b0328 b0428 b0429 b0430 b0431 b0432 b0684 b0720	E.M. talB fixA fixB fruL fruR pdhR aceE aceE lpdA acnB fdcC dniR tahN cyoD cyoD cyoC cyoB cyoA fldA
b2023 b2024 b2024 b2025 b2026 b2329 b2366 b2414 b2421 b2468 b2472 b2478 b2553 b2599 b2600 b2601 b2797 b2818 b2839 b2913 b2957 b3008 b3172	hisH hisH hisF hisI aroC dsdA cysK cysM dfG dapE dapA glyA glyA glyA glyA glyA aroF sdaB argA lysR serA ansB metC argG	b0529 b0593 b0594 b0595 b0596 b0596 b0628 b0628 b0774 b0775 b0776 b0778 b0778 b07781 b0781 b0783 b0784 b0783 b0784 b0785 b0827 b0931 b1026 b1210 b12277 b1638	nemn folD entC entE entB entA lipA lipB bioA bioB bioF bioD moaA moaC moaD moaC moaA grxB hemA hemK btuR pdxH	b0871 b0904 b1106 b1294 b1613 b2095 b2167 b2172 b2297 b2452 b2453 b2453 b2453 b2453 b2455 b2458 b2714 b2787 b2788 b2788 b2788 b2788	panb poxB focA ycfN galU manA gatZ bglX fruA yeiQ pta eutH eutG eutI gutQ gudD gudD gudZ gudD gudZ gudD gudZ	b0718 b0756 b0766 b0767 b0772 b0789 b0825 b0889 b0980 b1020 b1020 b1020 b1020 b1602 b1603 b1702 b1670 b1851 b2042 b2048 b2048 b2049 b2066 b2113	ybgQ ybgQ ybhA ybhA ybhE ybhC ybhC ybhO ybbZ lrp yccK appA ybhO ybbZ lrp yccK appA phoH goaG sfcA pntB pntB pnsA eda eda galF cpsB udk mrp	b3945 b4014 b4015 b4018 b4092 b4093 b4094 b4095 b4096 b4097 b4099 b4097 b4099 b4101 b4102 b4136 b4139 b4214 b4136 b4232 b4036 b4232 b4030 b4214 b426 b4232 b4030 b4214 b426 b4232 b4030 b4214 b405 b4014 b405 b4095 b4101 b4102 b405 b4095 b405 b405 b405 b405 b405 b405 b405 b40	aceB aceA iclR phnP phnO phnN phnM phnL phnK phnI phnG phnF dsbD aspA cysQ ppa fbp C.P. htgA dnaK dnaJ	b1482 b1482 b1557 b1558 b1732 b1823 b1823 b1828 b1829 b1855 b1880 b1881 b1883 b1883 b1885 b1885 b1886 b1887 b1888 b1889 b1920 b1941 b1943 b1981 b2044 b2182	norm cspB cspF katE cspC o494 htpX msbB flhB cheZ cheB tap tar cheW cheA motB fli1 fli1 fli1 fli1 fli1 fli1 sanA bcr	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0814 b0780 b0814 b0780 b0814 b0780 b0814 b0780 b0929 b0957 b0983 b1215 b1377 b1424 b1437 b1677 b1879 b1891 b1922 b1924 b1938	acrA dacA mrdB pbpA dsbC ybeL pal ybhK ompX dacC ompF ompA yccG ydcG ydcG ydcG flhA flhC fliA fliF	b4392 b4392 D.R.F b0060 b0145 b0145 b0145 b0145 b0145 b0145 b0145 b0145 b0145 b0145 b0145 b0214 b0214 b0247 b0354 b0470 b0470 b0470 b0470 b0470 b0470 b0470 b0706 b0708 b0708 b0709 b0892 b0912 b0962 b1184 b1114	Jimr slt 2.M.&R. polB dksA rnhB dnaE rnhA dnaQ ykfG yaiL hupB priC dnaX recR ybfD phrB dinG ycaJ himD helD rne mfd	E b0008 b0041 b0042 b0079 b0080 b0113 b0114 b0115 b0116 b0116 b0118 b0186 b0211 b0328 b0428 b0429 b0430 b0431 b0431 b0432 b0684 b0720 b0721	E.M. talB fixA fixB fruR pdhR aceE aceE lpdA acnB fdcC dniR tahN cyoE cyoD cyoC cyoB cyoA fidA gltA gltA
b2023 b2024 b2024 b2025 b2026 b2329 b2366 b2414 b2421 b2468 b2472 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2472 b2478 b2553 b2593 b2590 b2600 b2601 b2797 b2818 b2839 b2813 b2957 b3008 b3172	hisH hisH hisF hisI aroC dsdA cysK cysK cysM dapE dapA glyA glnB pheA tyrA aroF sdaB argA lysR serA ansB metC argG argR	b0529 b0593 b0594 b0595 b0596 b0596 b0596 b0596 b0774 b0775 b0777 b0778 b0778 b0778 b0778 b0781 b0783 b0781 b0783 b0781 b0783 b0781 b0783 b0781 b1064 b1210 b1212 b1212 b1277 b1638 b1662	nemn folD entC entE entB entA lipA lipB bioA bioB bioF bioD moaA moaC moaA grxB hemA hemK btuR ribE	b0871 b0904 b1106 b1294 b1613 b2095 b2167 b2172 b2297 b2452 b2453 b2454 b2455 b2458 b2714 b2455 b2458 b2714 b2787 b2788 b2883 b2883 b2888 b2788 b2788 b2883 b2888 b2788 b2888 b2788 b2888 b2788 b2888 b2888 b2788 b2888 b2888 b2888 b2888 b2888 b2788 b28888 b2888 b2888 b2888 b2888 b2888 b2888 b2888 b2888 b2888 b2888 b2888	gail2 poxB focA ycfN galU mlc manA gatZ bglX fruA yeiQ pta eutH eutG eutE eutI gutQ gudD gudZ gudD gudZ gudP fucK galR	b0718 b0756 b0766 b0767 b0772 b0789 b0825 b0889 b0969 b1020 b1302 b1302 b1402 b1603 b1603 b1603 b1603 b1851 b2042 b2048 b2048 b2048 b2048 b2048 b2048	ybgQ ybgQ ybhA ybhA ybhA ybhC ybhC ybhC ybhO ybiZ lrp yccK appA phoH goaG sfcA pntB pntA ppsA eda edd galF cpsB udk cpsB udk mrp yejM	b3945 b4014 b4015 b4018 b4093 b4093 b4094 b4095 b4096 b4097 b4099 b4100 b4109 b4102 b4136 b4139 b4214 b4126 b4226 b4232	nici gldA aceB aceA iclR phnP phnO phnN phnM phnL phnK phnI phnG phnF aspA cysQ ppa fbp C.P. htgA dnaK dnaJ gefL	b1482 b1482 b1557 b1558 b1732 b1823 b1828 b1829 b1855 b1880 b1881 b1883 b1885 b1885 b1885 b1885 b1885 b1885 b1888 b1887 b1888 b1889 b1920 b1941 b1943 b1943 b1981 b2069 b2144 b2182 b2319	norm cspB cspF katE cspC od94 htpX msbB flhB cheZ cheB hap tar cheA motB fliY fliI fliK shiA yegD sanA bcr usg	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0814 b0839 b0929 b0957 b0983 b1215 b1377 b1424 b1433 b1677 b1879 b1891 b1922 b1924 b1938 b1939	acrA dacA mrdB pbpA dsbC ybeL pal ybhK ompA yccC ompF ompA yccA ompN ydcG ydcO lpp flhA fliC fliA fliF fliG	b4318 b4392 D.R.F b0060 b0145 b0183 b0183 b0184 b0215 b0247 b0354 b0440 b0467 b0470 b0472 b0470 b0472 b0706 b0708 b0799 b0892 b0912 b0912 b0962 b1014 b1114 b1235	Jimr slt 2.M.&R. polB dksA rnhB dnaE rnhA dnaE rnhA dnaE ykfG yaiL hupB priC dnaX recR ybfD phrB dinG ycca] himD helD rne mfd hnr	E b0008 b0041 b0042 b0079 b0080 b0113 b0114 b0115 b0116 b0116 b0118 b0186 b0211 b0328 b0428 b0428 b0429 b0430 b0431 b0432 b0684 b0720 b0722	E.M. talB fixA fruC fruC fruC fruC fruC fruC fruC aceF lpdA aceF lpdA aceF lpdA aceF lpdA aceF lpdA aceF lpdA aceF lpdA aceF lpdA aceB fdcC dniR tahN cyoE cyoD cyoC cyoB cyoA fldA gltA sdhC sdhD sdhC sdhC sdhC sdhC sdhC sdhC sdhC sdhC
b2023 b2024 b2024 b2025 b2026 b2329 b2366 b2414 b2421 b2468 b2472 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2472 b2478 b2472 b2478 b2472 b2478 b2472 b2478 b2571 b2573 b2597 b2600 b2601 b2797 b2818 b2937 b2937 b2937 b2937 b2937 b2937 b2600 b2601 b2797 b2818 b2957 b2937	hisH hisH hisF hisI aroC dsdA cysK cysM dapE dapA glyA glnB pheA tyrA aroF sdaB argA lysR serA ansB metC argg argD	b0529 b0593 b0594 b0595 b0596 b0596 b0596 b0596 b0776 b0775 b0775 b0775 b0778 b0778 b0778 b0778 b0781 b0783 b0781 b0783 b0784 b0783 b0784 b0785 b0827 b0931 b1064 b1210 b1212 b1270 b1212 b1668 b1640 b1277	nemn folD entC entE entB entA lipA lipB bioA bioB bioF bioD moaA moaC moaD moaE moeA pncB hemA hemK btuR ribE nadE nadE	b0871 b0904 b1106 b1294 b1613 b2095 b2167 b2172 b2297 b2452 b2453 b2454 b2455 b2458 b2454 b2455 b2458 b2708 b2708 b2787 b2787 b2788 b2789 b2802 b2803 b2803 b2803	poxB focA ycfN galU mlc manA gatZ bglX fruA yeiQ pta eutH eutG gutQ gutQ gutQ gutQ gudD gudD gudD gudA gudP fucI fucK galR kduI	b0718 b0756 b0766 b0767 b0772 b0772 b0772 b0825 b0889 b0969 b0980 b1020 b1302 b1402 b1402 b1402 b1403 b1702 b1850 b1851 b2048 b20888 b2088 b2088 b2088 b2088 b2088 b2088 b2088 b2088 b2088 b2088	ybgQ ybgQ yalM ybhA ybhA ybhC ybhO ybiZ lrp yccK appA yhoH yoaG sfcA pntB pntA ppsA eda edd galF cpsB udk mrp yejM hisQ	b3945 b4014 b4015 b4018 b4093 b4093 b4094 b4095 b4096 b4097 b4099 b4101 b4102 b4136 b4139 b4214 b4139 b4214 b4226 b4232 b0012 b0014 b0015 b0018 b0015	nici gldA aceB aceA iciR phnP phnO phnN phnM phnM phnK phnF phnG phnF dsbD aspA cysQ ppa fbp C.P. htgA dnaK dnaK gefL caiE	b1482 b1482 b1557 b1558 b1732 b1823 b1828 b1829 b1825 b1880 b1881 b1883 b1885 b1886 b1887 b1888 b1888 b1888 b1888 b1888 b1889 b1920 b1941 b1943 b1981 b2069 b2144 b2182 b2319 b2470	nerformer cspB cspF cspF katE cspC od94 htpX msbB flhB cheZ cheB hap lar cheW cheZ cheB hap lar cheW fliY fliI fliK sanA bcr usg acrD sarA	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0839 b0929 b0957 b0983 b1215 b1377 b1424 b1377 b1424 b1433 b1677 b1879 b1891 b1892 b1891 b1922 b1924 b1938 b1935	acrA dacA mrdB dsbC ybeL pal ybhK ompF ompA yccZ kdsA ompN ydcG ydcO lpp fhhA fhC fhiA fhiG fhiG fhiM	b4392 b4392 D.R.F b0060 b0145 b0183 b0184 b0214 b0214 b0215 b0247 b0354 b0420 b0470 b0470 b0470 b0470 b0472 b0706 b0708 b0799 b0892 b0912 b0962 b10184 b1114 b1235 b1237	Jimr slt 2.M.&R. polB dksA rnhB dnaE rnhA dnaE rnhA dnaE ykfG yaiL hupB priC dnaX recR ybfD phrB dinG ycaJ himD helD rne mfd hnr hns	E b0008 b0041 b0042 b0079 b0080 b0113 b0114 b0115 b0116 b0116 b0118 b0186 b0211 b0328 b0429 b0430 b0421 b0422 b0431 b0432 b0684 b0720 b0722 b0723	E.M. talB fixA fruC fruC fruC fruC fruC fruC fruC aceF lpdA aceF lpdA aceF lpdA aceF lpdA aceF lpdA aceF lpdA aceF lpdA aceB fdcC dniR cyoE cyoD cyoC cyoA fldA gltA sdhD sdhA sdhA
b2023 b2024 b2024 b2025 b2026 b2329 b2366 b2414 b2421 b2482 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2551 b2590 b2600 b2601 b2797 b2818 b2913 b2957 b308 b3172 b3237 b3389 b3389	hisH hisH hisF hisI aroC dsdA cysK cysM dsdA cysK cysM dspE dapE dapE dapA glyA glyA glyA glyA glyA glyA glyA gly	b0529 b0593 b0594 b0595 b0596 b0596 b0628 b0628 b0628 b0774 b0775 b0776 b0776 b0778 b0778 b0781 b0783 b0784 b0783 b0784 b0783 b0784 b0783 b0784 b0783 b0784 b0783 b0784 b1210 b1212 b1270 b1217 b1638 b1662 b1740 b12153	nemin folD entC entE entB entA lipA lipB bioA bioB bioF bioD moaA moaC moaA moaC moaA moaC moaA pncB grxB hemA hemK btuR ribA pdxH ribA folD folD folD folD folD folD folD folD	b0871 b0904 b1106 b1294 b1613 b2095 b2132 b2167 b2172 b2297 b2452 b2453 b2454 b2455 b2458 b2458 b2458 b2708 b2714 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2789 b2802 b2803 b2837 b2843 b2902	poxB focA ycfN galU mlc manA gatZ bgIX fruA yeiQ pta eutH eutG gutQ ascG gudD gutQ gutQ ascGD gudZ gudP fucl fucL fucL gutR kduI ygfF	b0718 b0756 b0766 b0767 b0772 b0772 b0825 b0889 b0980 b1020 b1302 b1479 b1603 b1479 b1603 b1702 b1603 b1702 b1850 b1851 b2042 b2048 b2056 b2087 b20827 b2087 b2087 b2087 b2087 b2087 b	ybgQ ybgQ yalM ybhA ybhA ybhC ybhC ybhC ybhC ybhC ybhC ybhC ybhC	b3945 b4014 b4015 b4014 b4093 b4093 b4094 b4095 b4096 b4097 b4099 b4101 b4102 b4106 b4139 b4214 b4226 b4139 b4214 b4226 b4232	nici aceB aceA iciR phnP phnO phnN phnM phnM phnK phnK phnI phnG phnF dsbD aspA cysQ ppa fbp C.P. htgA dnaK dnaJ gefL caiE caiE caiD	b1482 b1482 b1557 b1558 b1732 b1823 b1828 b1829 b1855 b1880 b1881 b1883 b1885 b1886 b1885 b1886 b1887 b1888 b1888 b1888 b1888 b1888 b1889 b1920 b1941 b1941 b1941 b2069 b2144 b2182 b2319 b2470 b2470	nerf cspB cspF cspF katE cspC od94 htpX msbB flhB tap tar cheB tap tar cheB tap tar cheW cheA motB fliY fliK shiA yegD sanA bcr usg acrD hscA	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0839 b0929 b0957 b0983 b1215 b1377 b1424 b1377 b1424 b1433 b1677 b1879 b1891 b1922 b1924 b1938 b1935 b1945 b1946	acrA dacA mrdB pbpA dsbC ybeL pal ybhK dacC ompF ompA yccZ kdsA ompN ydcG ydcO lpp flhA fliC fliA fliG fliG fliM fliN	b4318 b4392 D.R.F b0060 b0145 b0143 b0144 b0214 b0214 b0247 b0354 b0440 b0467 b0470 b0470 b0472 b0706 b0708 b0008 b0008 b0008 b0008 b00080	Jimr slt 2.M.&R. polB dksA rnhB dnaE rnhA dnaQ ykfG yaiL hupB priC dnaX recR ybfD phrB dinG himD helD rne mfd hnr hns topA	E b0008 b0041 b0042 b0079 b0080 b0113 b0114 b0115 b0116 b0118 b0116 b0118 b0121 b0211 b0328 b0429 b0430 b0431 b0432 b0684 b0432 b0684 b0720 b0721 b0723 b0724	E.M. talB fixA fruR pdhR aceF acnB facC dniR tahN cyoE cyoD cyoC cyoC cyoC cyoA fidA gltA sdhD sdhA sdhB
b2023 b2024 b2025 b2026 b2329 b2366 b2414 b2421 b2468 b2472 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2479 b2401 b2423 b2530 b2957 b308 b3327 b33389 b33390 b33390b33390	hisH hisH hisF hisI aroC dsdA cysK cysM dapE dapE dapE dapA glyA glnB pheA tyrA glyA glnB pheA tyrA aroF sdaB argA lysR eargA argB aroB aroB aroK	b0529 b0593 b0594 b0595 b0596 b0628 b0628 b0628 b0628 b0774 b0775 b0776 b0776 b0778 b0778 b0781 b0783 b0784 b0783 b0784 b0783 b0784 b0783 b0784 b0783 b0784 b0783 b0784 b0783 b0784 b0784 b0784 b0783 b0784 b0785 b0784 b0785 b0784 b0784 b0785 b0784 b0775 b0775 b0775 b0776 b0775 b0776 b0775 b0776 b0778 b0778 b0784 b0775 b0778 b0778 b0784 b0775 b0775 b0775 b0775 b0775 b0775 b0775 b0775 b0775 b0776 b0778 b0784 b0784 b0784 b0784 b0775 b0775 b0775 b0775 b0775 b0776 b0778 b0784 b0784 b0784 b0784 b0784 b0785 b0784 b0785 b0784 b0785 b0784 b0785 b0784 b0775 b0755	nemin folD entC entE entB entA lipA lipB bioA bioB bioF bioD moaA moaC moaA moaC moaA grxB hemA btuR ribA pdxH ribA pdxH ribA folE ubiG	b0871 b0904 b1106 b1296 b1594 b1613 b2095 b2132 b2167 b2172 b2297 b2452 b2453 b2453 b2453 b2454 b2455 b2458 b2708 b2714 b2787 b2788 b2708 b2714 b2787 b2788 b2708 b2802 b2803 b2803 b2802 b2802 b2980	poxB focA ycfN galU mlc manA gatZ bglX fruA gatZ bglX fruA gatZ bglX fruA gutQ eutH eutH eutG eutH gutQ gutQ gudQ gudQ gudQ gudQ gudQ gudQ gudQ gud	b0718 b0756 b0766 b0767 b0772 b0772 b0722 b0889 b0825 b0889 b0980 b1020 b1302 b1479 b1602 b1479 b1602 b1479 b1602 b1479 b1602 b1851 b2048 b2042 b2048 b2049 b2046 b2049 b2048 b2049 b2048 b2049 b2048 b2049 b2048 b2049 b2048 b2049 b2048 b2049 b2048 b2049 b2048 b2048 b2049 b2048 b2088 b2388	ybgQ ybgQ yalM ybhA ybhA ybhC ybhC ybhC ybhC ybhC ybhC ybhC ybhC	b3945 b4014 b4015 b4018 b4093 b4093 b4093 b4094 b4095 b4096 b4097 b4099 b4101 b4102 b4106 b4139 b4214 b4226 b4232 b4012 b4015 b4015 b4018 b403 b4096 b4109 b4105 b4096 b4099 b4101 b4105 b4096 b4099 b4101 b4105 b4096 b4099 b4101 b4105 b4099 b4091 b4095 b4096 b4099 b4091 b4095 b4096 b4099 b4091 b4095 b4096 b4099 b4091 b4095 b4096 b4099 b4090 b4099 b4090 b4099 b4090 b4090 b4095 b4099 b4090 b4095 b4096 b4099 b4090 b4090 b4095 b4099 b4090 b4090 b4099 b4090 b4099 b4009 b4099 b4000 b4009 b4000 b400 b4000 b4	nici aceB aceA iclR phnO phnN phnM phnM phnI phnG phnF phnI phnG phnF phnG phnF phnG phnF phnG phnF phnG phnF phnG phnA phnA phnA phnA phnA phnA phnA phnA	b1482 b1482 b1557 b1558 b1732 b1823 b1828 b1829 b1855 b1880 b1881 b1883 b1885 b1886 b1887 b1888 b1887 b1888 b1887 b1888 b1887 b1888 b18920 b1941 b1943 b1920 b1941 b2069 b2144 b2182 b2370 b2470 b2526 b2639	nerformer cspB cspF katE cspC cspC cspC cspC cspC cspC cspC cspC	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0839 b0929 b0957 b0983 b1925 b1377 b1424 b1433 b1677 b1879 b1891 b1922 b1924 b1938 b1946 b1948	acrA dacA mrdB pbpA dsbC ybeL pal ybhK dacC ompF ompA yccZ kdsA ompN ydcG ydcO lpp flhA fliD fliF fliG fliM fliN fliP	b4318 b4392 D.R.F b0060 b0145 b0183 b0184 b0214 b0215 b0247 b0354 b0247 b0354 b0467 b0470 b0470 b0470 b0470 b0470 b0472 b0706 b0708 b0799 b0892 b0799 b0892 b0799 b0892 b0795 b0716 b0708 b0799 b0892 b0706 b0708 b0799 b0892 b0706 b0708	Jumr slt 2.M.&R. polB dksA rnhB dnaE rnhA dnaQ ykfG yaiL hupB priC dnaX recR ybfD phrB dinG ycaJ himD heD rne mfd hnr hns topA rnb	E b0008 b0041 b0042 b0079 b0080 b0113 b0114 b0115 b0116 b0118 b0186 b0211 b0328 b0428 b0429 b0430 b0431 b0432 b0431 b0422 b0684 b0722 b0684 b0722 b0723 b0724 b0724 b0726	E.M. talB fixA fixB fruL fruR pdhR aceF aceB facC dniR tahN facC dniR tahN cyoE cyoD cyoC cyoC cyoC cyoA fidA gltA sdhC sdhD sdhA
b2023 b2024 b2025 b2026 b2329 b2366 b2414 b2421 b2468 b2472 b2478 b2478 b2478 b2477 b2478 b2477 b2478 b2477 b2478 b2477 b2600 b2600 b2600 b2601 b2797 b2600 b2601 b2797 b2818 b2957 b3008 b3172 b3359 b3389 b3389 b3389 b3390 b3433	hisH hisH hisF hisI aroC dsdA cysK cysM dsdA cysK cysM dsdP dapE dapE dapE dapE dapE dapE dapA glyA glnB pheA aroF sdaB argA lysR serA ansB metC argG aroB aroB aroK asd	b0529 b0593 b0594 b0595 b0596 b0628 b0628 b0630 b0774 b0775 b0776 b0776 b0778 b0778 b0778 b0778 b0778 b0781 b0783 b0784 b0783 b0784 b0783 b0784 b0827 b0931 b1064 b1212 b1270 b1227 b1638 b1662 b1740 b2153 b2232 b2260	nemni folD entC entE entB entA lipA lipB bioA bioB bioD moaA moaC moaD moaC moaD moaE grxB hemA btuR ribA pdxH ribE natE folE ubiG menE_ tubiG menE_ tubiG menE_ tubiG	b0871 b0904 b1106 b1236 b1594 b1613 b2095 b2132 b2167 b2172 b2297 b2452 b2453 b2453 b2453 b2455 b2453 b2455 b2458 b2708 b2714 b2787 b2788 b2708 b2789 b2803 b2803 b2802 b2803 b2802 b2803 b2802 b2803 b2803	poxB focA ycfN galU mlc manA gatZ bglX fruA gatZ bglX fruA gutQ eutH eutG eutH eutG eutH gutQ gutQ gudQ gudQ gudQ gudQ gudQ gudQ gudQ gud	b0718 b0756 b0766 b0767 b0772 b0789 b0825 b0889 b0980 b1020 b1302 b1602 b1603 b1702 b1603 b1702 b1479 b1602 b14551 b2042 b18551 b2042 b2048 b2048 b2048 b2048 b2048 b2048 b2048 b2088 b2379 b2383 b2383 b2464	ybgQ ybgQ ybgQ ybhA ybhA ybhC ybhC ybhC ybhO ybbZ lrp yccK appA ybhO ybbZ ybhO ybbZ ybhO ybbC ybhO ybbC ybhO ybbC ybhO ybhO ybhO ybhO ybhO ybhO ybhO ybhO	b3945 b4014 b4015 b4018 b4093 b4093 b4094 b4095 b4096 b4097 b4099 b4101 b4109 b4109 b4109 b4109 b4109 b4104 b4139 b4214 b4226 b4232 b0014 b0015 b0018 b0018 b0035 b0038 b0039	aceB aceA iclR phnP phnO phnN phnM phnL phnK phnF dsbD aspA cysQ ppa fbp C.P. htgA dnaK dnaJ gefL caiE caiB caiA	b1482 b1482 b1557 b1558 b1732 b1823 b1828 b1829 b1855 b1880 b1881 b1883 b1885 b1886 b1887 b1888 b1885 b1886 b1887 b1888 b1885 b1886 b1887 b1888 b1889 b1920 b1941 b1943 b1981 b2069 b2144 b2182 b2319 b2470 b2526 b2639 b2679	nerf cspB cspF katE cspC cspC cspC cspC cspC cspC cspC cspC	b0463 b0632 b0632 b0634 b0643 b0643 b0741 b0780 b0814 b0780 b0929 b0957 b0983 b1215 b1377 b1424 b1433 b1677 b1879 b1891 b1922 b1924 b1938 b1945 b1945 b1948 b1949	acrA dacA mrdB pbpA dsbC ybeL pal ybhK ompX dacC ompA yccZ kdsA ompF fhA fhA fhiA fhiA fhiA fhiA fhiP fhiP fhiQ	b4392 b4392 D.R.F b0060 b0145 b0145 b0145 b0145 b0145 b0145 b0147 b0247 b0247 b0247 b0247 b0247 b0247 b0470 b0470 b0470 b0470 b0470 b0470 b0470 b0470 b0470 b0472 b0708 b0708 b0708 b0799 b0892 b0912 b0912 b1084 b1114 b1135 b1237 b1274 b1286 b1335	Jume slt 2.M.&R. polB dksA rnhB dnaE rnhA dnaQ ykfG yaiL hupB priC dnaX recR ybfD phrB dinG ycaJ himD heID rne mfd hnr hns topA rnb ogt	E 50008 50008 50041 50042 50079 50080 50113 50114 50115 50116 50116 50116 50116 50118 50126 50428 50429 50430 50428 50429 50430 50428 50429 50430 50421 50722 50722 50722 50724 50726 50727 50726 50756	E.M. talB fixA fixB fruL fruR pdhR aceE aceE lpdA acnB fdcC dniR tahN cyoE cyoD cyoC cyoB cyoC cyoB fldA sdhC sdhD sdhA suCA suCA
b2023 b2024 b2024 b2025 b2026 b2329 b2366 b2414 b2421 b2468 b2472 b2478 b2478 b2478 b2478 b2478 b2553 b2593 b2593 b2593 b2593 b2593 b2593 b2597 b2818 b2839 b2913 b2913 b2977 b3089 b3172 b3237 b3389 b3389 b3433 b3572	hisH hisH hisA hisF hisI aroC dsdA cysK cysK cysK cysK dapE dapA glyA glnB pheA tyrA aroF sdaB pheA tyrA argF argB argB argB argB argB aroK asg azgA azgA azgA azgA azgA azgA azgA azg	b0529 b0593 b0594 b0595 b0596 b0596 b0596 b0774 b0775 b0776 b0778 b0778 b0781 b0783 b0781 b0783 b0781 b0783 b0781 b0783 b0781 b0783 b0781 b0783 b0781 b0783 b0781 b0783 b0781 b0783 b0783 b0783 b0781 b0783 b0783 b0783 b0783 b0783 b0783 b0783 b0783 b0783 b0783 b0783 b0783 b0784 b0795 b0794 b0776 b0776 b0776 b0776 b0778 b0783 b0783 b0783 b0783 b0783 b0783 b0783 b0784 b0783 b0784 b0783 b0784 b0785 b0784 b0785 b0784 b0785 b0784 b0785 b0784 b0785 b0784 b0785	nemii folD entC entE entB entA lipA lipB bioA bioF bioD moaA moaC moaA moaC moaA grxB hemA hemK btuR ribA pdxH ribE nadE folE ubiG menE ubiG menE	b0871 b0904 b1106 b1294 b1613 b2095 b2167 b2172 b2297 b2452 b2452 b2453 b2455 b2458 b2708 b2714 b2455 b2458 b2708 b2712 b2452 b2453 b2458 b2708 b2803	panb poxB focA ycfN galU mlc manA gatZ bglX fruA yeiQ pta eutH eutG eutE eutI gutQ gudD gudX gudD gudX gudZ gu	b0718 b0756 b0766 b0767 b0772 b0789 b0825 b0889 b0980 b1020 b1302 b1402 b1402 b1402 b1402 b1402 b1402 b1402 b1450 b1450 b1851 b2042 b2048 b2048 b2048 b2048 b2049 b2086 b2113 b2188 b2308 b2383 b2464 b2484 b2484	ybgQ ygalM ybhA ybhA ybhC ybhC ybbC ybbZ lrp yccK appA phoH goaG yntB pntA posA eda edd fcpsB udk pntA ppsA eda galF cpsB udk ypdD ybQ ybQ ybD ybD ybD ybD ybD ybD ybD ybD ybD ybD	b3945 b4014 b4015 b4018 b4093 b4093 b4094 b4095 b4096 b4097 b4099 b4101 b4102 b4136 b4139 b4214 b4136 b4139 b4214 b4226 b4136 b4125 b4012 b0012 b0012 b0014 b0015 b0035 b0036 b0039 b0039 b0040	nicia aceB accA iclR phmP phmO phmN phmM phmL phmK phmI phmF phmF phmF aspA cysQ ppa fbp C.P. htgA dnaJ gefL caiE caiE caiB caiB caiB caiB caiB	b1482 b1482 b1557 b1558 b1732 b1823 b1823 b1828 b1829 b1855 b1886 b1885 b1885 b1885 b1886 b1887 b1888 b1887 b1888 b1887 b1888 b1887 b1888 b1889 b1941 b1943 b1941 b2049 b2144 b2182 b2319 b2470 b2526 b2639 b2679 b2686	nerf cspB cspF katE cspC cspC cspC ch24 htpX msbB flhB thpZ theZ cheB tap tar cheZ cheB tap tar cheZ cheB tap tar tar cheZ cheB tap tar tar cheZ cheB tap tar tar cheZ cheB tap tar tar cheB tap tar cheZ cheB tap tar cheZ cheB tap tar cheZ cheB tap tar cheZ cheB tap tar cheZ cheB tap tar cheZ cheB tar tar cheZ cheB tar tar cheZ cheB tar tar cheZ	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0814 b0780 b0814 b0780 b0814 b0780 b0814 b0780 b0814 b0780 b0929 b0957 b1927 b1927 b1879 b1879 b1879 b1922 b1928 b1938 b1938 b1938 b1945 b1946 b1946 b1949 b1950	acrA dacA mrdB pbpA dsbC ybeL pal ybhK ompA yccA ompF ydcG ompA ydcG ydcO lfhA fliA fliA fliF fliG fliM fliP fliQ fliR	b4318 b4392 D.R.F b0060 b0145 b0183 b0183 b0184 b0215 b0247 b0215 b0247 b0354 b0440 b0467 b0470 b0472 b0470 b0472 b0470 b0472 b0706 b0708 b0796 b0792 b0912 b0922 b0912 b0962 b1084 b1114 b1235 b1237 b1274 b1286 b1335 b1610	Jume slt 2.M.&R. polB dksA rnhB dnaE rnhA dnaQ ykfG yaiL hupB priC dnaX recR ybfD phrB dinG ycaJ himD helD rne mfd hnr hns topA rnb ogt tus	E 1990 E	E.M. talB fixA fruC fruC fruC fruC fruC fruC fruC aceF lpdA aceF lpdA aceF lpdA aceF lpdA aceB fdcC cyoD cyoD cyoD cyoD cyoD cyoD cyoD cyoA fldA gltA sdhD sdhA sdhA sdhA sdbD sdhA sdbD suCA suCB suCC suC suCC sdbD suCA suCB suCC suCC suCC sdbD suCC suCC suCC suCC suCC suCC suCC suC
b2023 b2024 b2024 b2025 b2026 b2329 b2366 b2414 b2421 b2468 b2472 b2478 b2478 b2478 b2478 b2478 b2472 b2478 b2478 b2472 b2478 b2472 b2478 b2472 b2478 b2472 b2478 b2472 b2478 b2472 b2473 b2573 b2593 b2390 b2337 b3359 b3433 b3572 b3430 b3433 b3572 b3467	hisH hisH hisA hisF hisI aroC dsdA cysK cysK cysK cysK dapE dapA glyA glnB pheA tyrA aroF sdaB argA lysR serA argB argB argB aroB aroB aroB aroB asd acgB aroB asd acgB aroB asd acgB aroB asd acgB aroB asd acgB acgB aroB acgB acgB aroB acgB acgB acgB acgB acgB acgB acgB acg	b0529 b0593 b0594 b0595 b0596 b0596 b0596 b0774 b0775 b0775 b0778 b0778 b0778 b0778 b0778 b0778 b0781 b0778 b0781 b0778 b0781 b0783 b0781 b0783 b0781 b0783 b0781 b0785 b0827 b0931 b1064 b1210 b1212 b1277 b1638 b1662 b1740 b1253 b2262 b2261 b2262	nemni folD entC entE entB entA lipA lipB bioA bioF bioD moaA bioF bioD moaA moaC moaA grxB hemA hemK btuR ribE nadE folE ubiG menE menC menC menC	b0871 b0904 b1106 b1294 b1613 b2095 b2167 b2172 b2297 b2452 b2453 b2454 b2455 b2458 b2714 b2455 b2458 b2714 b2787 b2788 b2714 b2787 b2788 b2714 b2787 b2788 b2714 b2787 b2802 b2803 b2802 b2803 b2802 b2803 b2802 b2803 b2802 b2803 b2802 b2803 b2802 b2803 b2802 b2803 b2802 b2803 b2802 b2803 b2802 b2803 b2802 b2803 b2802 b2803 b2803 b2802 b2803 b2802 b2803 b2803 b2803 b2803 b2803 b2803 b2803 b2803 b2804 b2805 b2803	poxB focA ycfN galU mlc manA gatZ bglX fruA yeiQ pta eutF eutF eutE eutE eutE eutE gudD gudZ gudZ gudZ gudZ gudZ gudZ gudZ gudZ	b0718 b0756 b0766 b0767 b0772 b0789 b0825 b0889 b0969 b1020 b1302 b1302 b1302 b1402 b1603 b1603 b1603 b1603 b1603 b1851 b2042 b2048 b2048 b2048 b2048 b2048 b2048 b2113 b2188 b2308 b2308 b2379 b2383 b2464 b2484 b2484 b2484	ybgQ ybgQ ybgQ ybhA ybhA ybhA ybhC ybhO ybiZ lrp yccK aphoH goaG yccK aphoH goaG yccK aphoH goaG yccK aphoH goaG yccK aphoH goaG yccK aphoH goaG yccK aphoH goaG yccK aphoH goaG yccK aphoH goaG yccK aphoH goaG yccK aphoH goaG yccK ybhO ybhO ybhO ybhO ybhO ybhO ybhO ybhO	b3945 b4014 b4015 b4018 b4093 b4093 b4094 b4095 b4096 b4097 b4099 b4101 b4102 b4136 b4139 b4214 b4139 b4214 b4126 b4134 b4226 b4134 b4226 b4135 b4097 b4099 b4101 b4102 b4136 b4035 b4097 b4099 b4101 b4102 b4136 b4037 b4099 b4101 b4105 b4099 b4101 b4097 b4099 b4101 b4095 b4099 b4097 b4099 b4101 b4097 b4099 b4097 b4099 b4097 b4099 b4097 b4099 b4101 b4097 b4099 b4101 b4097 b4099 b4101 b4102 b4036 b4037 b4099 b4097 b4099 b4097 b4099 b4097 b4099 b4097 b4099 b4097 b4099 b4097 b4099 b4010 b4097 b4099 b4012 b4036 b4036 b4039 b4020 b4036 b4039 b4097 b4099 b4014 b4026 b4036 b4039 b4097 b4099 b4004 b4036 b4036 b4039 b4004 b4005 b4099 b4014 b4005 b4099 b4004 b4005 b4099 b4004 b4005 b4099 b4004 b4005 b4005 b4004 b4005 b4004 b4005 b4005 b4004 b4005	nicia aceB aceA iclR phnP phnO phnN phnM phnM phnI phnF dsbD aspA cysQ ppa fbp C.P. htgA dnaK dnaJ gefL caiB caiB caiT ksgA.	b1482 b1482 b1557 b1558 b1732 b1823 b1828 b1829 b1855 b1880 b1881 b1883 b1885 b1886 b1887 b1888 b1887 b1887 b1888 b1887 b1888 b1887 b1888 b1887 b1888 b1887 b1888 b1887 b1886 b1887 b1888 b1887 b1886 b1887 b1886 b1887 b1886 b1887 b1886 b1887 b1886 b1887 b1886 b1887 b1886 b1887 b1886 b1887 b1886 b1887 b1886 b1886 b1887 b1896 b1921 b1943 b2069 b2470 b2526 b2679 b2674 b2679 b2679 b2679 b2674 b2679 b2674 b2679 b2674 b2679 b2674 b2679 b2674 b2679 b2674 b2679 b2674 b2679 b2674 b2679 b2674 b2679 b2674 b2679 b2674 b2679 b2674 b2679 b2674 b2679 b2674 b2674 b2679 b2674 b2774 b2774 b2774 b2774 b2774 b2774 b2774 b2774 b2774 b2774 b2774 b2774 b2774 b2774 b2774	nerformer cspB cspF katE cspC cspC od94 htpX msbB flhB thPX msbB flhB thPX thPX msbB flhB thPX thPX thPX thPX thPX thPX thPX thPX	b0463 b0632 b0634 b0634 b0643 b0741 b0780 b0839 b0929 b0957 b0983 b1215 b1377 b1424 b1433 b1677 b1879 b1891 b1922 b1924 b1938 b1939 b1945 b1946 b1948 b1949 b1950 b2007	acrA dacA mrdB dsbC ybeL pal ybhK ompF ompA yccZ ompN ydcG ydcO flhA fliG fliA fliG fliA fliG fliR fliR fliR yeeX	b4318 b4392 D.R.F b0060 b0145 b0183 b0183 b0184 b0215 b0247 b0215 b0247 b0354 b0440 b0467 b0470 b0472 b0706 b0790 b0472 b0706 b0790 b0472 b0706 b0790 b0892 b0912 b0962 b1084 b1114 b1235 b1237 b1274 b1235 b1610 b1712 b1722	Jimr slt 2.M.&R. polB dksA rnhB dnaE rnhA dnaE rnhA dnaE ykfG ykfG ykfG ykfG ykfG ykfG hupB priC dnaX recR ybfD phrB dinG yca] himD helD rne mfd hnr hns topA rnh bur kfG yca] himD helD rne himD helD rne himD helD rne himD helD rne himD himD himD himD himD himD himD himD	E 1990 E b0008 b0041 b0042 b0079 b0080 b0113 b0114 b0115 b0116 b0115 b0116 b0118 b01211 b0328 b0429 b0430 b0431 b0432 b0431 b0432 b04331 b0432 b04331 b0432 b0428 b0429 b04331 b0432 b0428 b0422 b0727 b0722 b0727 b0728 b0729	E.M. talB fixA fruC fruC fruC fruC fruC fruC fruC fruC
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b2023 b2024 b2024 b2025 b2026 b2329 b2366 b2414 b2421 b2468 b2472 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2497 b2601 b2797 b2601 b2797 b2818 b2957 b3008 b3172 b3359 b3389 b3389 b3389 b3372 b3607 b3616 b3743 b2757 b277 b277 b277 b277 b277 b277 b27	hisH hisH hisF hisI aroC dsdA cysK cysM dapE dapA dapE dapA glyA glyA glyA glyA glyA glyA glyA gly	b0529 b0593 b0594 b0595 b0595 b0596 b0628 b0628 b0628 b0774 b0775 b0776 b0778 b0781 b0783 b0784 b0778 b0783 b0784 b0778 b0783 b0784 b0775 b0783 b0784 b0778 b0783 b0784 b0778 b0783 b0784 b0778 b0783 b0784 b0778 b0783 b0784 b0783 b0784 b0778 b0783 b0784 b0778 b0783 b0784 b0775 b0783 b0784 b0775 b0784 b0775 b0783 b0784 b0775 b0783 b0784 b0775 b0783 b0784 b0775 b0784 b0775 b0784 b0775 b0784 b0775 b0783 b0784 b0775 b0783 b0784 b0775 b0784 b0775 b0784 b0775 b0784 b0775 b0784 b0776 b0778 b0784 b0776 b0778 b0784 b0776 b0778 b0784 b0776 b0726 b0726 b0778 b0784 b0778 b0784 b0726 b0726 b0726 b0726 b0778 b0784 b0784 b0726 b0776 b0726	nemn folD entC entE entB entA lipA lipB bioA bioB bioF bioD moaA moaC moaA moaC moaA moaC moaA moaC moaA moaC moaA moaC moaA pncB grxB hemA hemK btuR ribA tibA tibA tibA bioF bioD moaA moaC moaA moaC moaA folD tibA tibA tibA tibA tibA tibA tibA tibA	b0871 b0904 b1106 b1296 b1594 b1613 b2095 b2132 b2167 b2172 b2297 b2452 b2453 b2453 b2454 b2455 b2458 b2458 b2708 b2714 b2787 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2789 b2802 b2803 b2837 b2843 b2802 b2803 b2837 b2843 b2902 b2803 b2837 b2843 b2902 b2803 b2837 b2843 b2902 b2803 b2837 b2843 b2902 b2803 b2837 b2843 b2902 b2803 b2837 b2843 b2902 b2803 b2837 b2843 b2902 b2803 b2837 b2843 b2902 b2803 b2837 b2843 b2902 b2803 b2837 b2843 b2902 b2803 b2837 b2843 b2902 b2803 b2837 b2843 b2902 b2803 b2837 b2843 b2902 b2803 b2837 b2843 b2902 b2803 b2837 b2843 b2832	poxB focA ycfN galU mlc manA gatZ bglX fruA yeiQ pta eutH eutG gutQ ascG gudD gutQ fucl fucK galR kdul ygfF glcC icc ebgR uxaA exuR yhaZ	b0718 b0756 b0766 b0767 b0772 b0789 b0825 b0889 b0969 b0980 b1020 b1302 b1479 b1603 b1020 b1302 b1479 b1603 b1702 b1603 b1702 b1603 b1702 b1850 b1850 b1851 b2042 b2048 b2048 b2048 b2049 b2383 b2388 b2379 b2383 b2464 b2491 b2501 b2502 b2502	ybgQ ybgQ ybgQ ybhA ybhA ybhA ybhC ybhO ybiZ lrp yccK appA ybhO ybbO ybbO ybbO ybbO ybbO ybbO ybbO	b3945 b4014 b4015 b4014 b4093 b4093 b4094 b4095 b4096 b4097 b4099 b4101 b4102 b4106 b4139 b4214 b4226 b4139 b4214 b4226 b4139 b4214 b4226 b4139 b4214 b4226 b4035 b4095 b4095 b4096 b4097 b4007 b4097 b40007 b4007 b4007 b4007 b4007 b4000	aceB aceB aceA iclR phnP phnO phnN phnM phnM phnI phnG phnF dsbD aspA cySQ ppa fbp C.P. htgA dnaK dnaJ gefL caiB caiA caiT ksgA surA imp	b1482 b1482 b1557 b1558 b1732 b1823 b1828 b1829 b1855 b1880 b1881 b1883 b1885 b1886 b1885 b1886 b1885 b1886 b1885 b1886 b1885 b1888 b1885 b1888 b1885 b1888 b1885 b1888 b1888 b1888 b1889 b1920 b1941 b1943 b1981 b2069 b2144 b2319 b2470 b2526 b2470 b2526 b2470 b2526 b2470 b2526 b2470 b2526 b2470 b2526 b2470 b2526 b2470 b2526 b2470 b2526 b2470 b2526 b2744 b2830 b2685 b2744 b2835 b2685 b2744 b2835 b2685 b2744 b2835 b2685 b2744 b2835 b2685 b2744 b2835 b2685 b2744 b2835 b2685 b2744 b2835 b2685 b2744 b2835 b2685 b2744 b2835 b2685 b2744 b2835 b2685 b2744 b2835 b2685 b2744 b2835 b2685 b2744 b2835 b2679 b2674 b2679 b2679 b2674 b2679 b2679 b2674 b2679 b2679 b2674 b2679 b2679 b2674 b2679 b2679 b2674 b2679 b2679 b2679 b2679 b2674 b2679 b2679 b2674 b2679 b2679 b2674 b2679 b2679 b2674 b2679 b2679 b2679 b2674 b2679 b2674 b2679 b2679 b2674 b2679 b2679 b2674 b2679 b2674 b2679 b2674 b2679 b2679 b2674 b2679 b2674 b2679 b2674 b2679 b2674 b2679 b2674 b2679 b2674 b2679 b2674 b2679 b2674 b2679 b2674 b2679 b2674 b2679 b2674 b2674 b2679 b2674 b2676 b2766 b2766 b27676 b2766 b2766 b2766 b2766 b2766 b2766 b2766 b2766 b2766 b2766 b276	nerf cspB cspF cspF cspF cspC cspC cspC cspC cspC cspC cspC cspC cspC che3 tap tar che8 tap tar che7	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0839 b0929 b0957 b0983 b1215 b1377 b1424 b1377 b1424 b1377 b1424 b1377 b1879 b1891 b1922 b1924 b1938 b1945 b1945 b1946 b1948 b1945 b1946 b1948 b1945 b1945 b1946 b1945	acrA dacA mrdB pbpA dsbC ybeL pal ybhK ompF ompA yccZ kdsA ompF flhQ fliA fliD fliF fliA fliA fliB fliB fliB fliR fliR fliR fliR fliR fliR fliR fliR	b4392 b4392 D.R.F b0060 b0145 b0145 b0143 b0184 b0214 b0215 b0247 b0354 b0440 b0467 b0470 b0470 b0472 b0706 b0708 b0708 b0708 b0708 b0708 b0706 b0708 b0708 b0708 b0708 b0708 b0706 b0708 b0708 b0708 b0708 b0708 b0706 b0708 b0708 b0706 b0708 b008 b0	Jimr slt 2.M.&R. polB dksA dnaE rnhA dnaQ ykfG yaiL hupB priC dnaX recR ybfD phrB dinG himD helD rne mfd hnr hns topA rnb ogt tus himA topB yoaA	E 1930 E 1930	E.M. talB fixA fixB fruL fruR pdhR aceE lpdA acnB facC dniR tahN cyoE cyoD cyoC cyoC cyoC cyoC cyoC sdhA sdhA sdhB sucA sucC cydA cydA cydA
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gudZ gudZ gudZ gudZ gudZ gudZ gudZ manA gudZ manA gudZ manA gudZ	b0718 b0756 b0766 b0767 b0772 b0789 b0825 b0889 b0969 b1020 b1302 b1302 b1302 b1302 b1402 b1302 b1402 b1603 b1702 b1850 b1850 b1850 b2048 b2049 b2048 b2048 b2049 b2048 b2048 b2048 b2048 b2048 b2048 b2048 b2048 b2050 b2538 b2501 b2502 b2523 b2530 b2536 b2538	ybgQ ybgQ ybgQ ybhA ybhA ybhA ybhC ybhO ybiZ lrp ycK appA ybhO ybiZ lrp ycK appA ybhO ybiZ ybhO ybiZ ybhO ybiZ ybhO ybhC ybhO ybhC ybhO ybhC ybhO ybhC ybhO ybhC ybhO ybhC ybhO ybhO ybhO ybhO ybhO ybhO ybhO ybhO	b3945 b4014 b4015 b4014 b4015 b4093 b4093 b4094 b4095 b4096 b4097 b4099 b4101 b4102 b4136 b4139 b4114 b4122 b4136 b4139 b4214 b4226 b4134 b4226 b4139 b4214 b4226 b4135 b4014 b4226 b4135 b4097 b4012 b4035 b0012 b0014 b0035 b0035 b0055 b0055 b0055 b0084 b0055 b0084 b0097 b0097 b0097 b0098 b0097 b0098 b0097 b0098 b0097 b0098 b0097 b0098 b0097 b0098 b0097 b0098 b0097 b0098 b0097 b0098 b0097 b0098 b0097 b0098 b0098 b0097 b0098 b0098 b0098 b0098 b0098 b0098 b0098 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tap tar cheZ cheZ tap tar cheZ cheZ cheB tap tar cheZ cheZ cheB tap tar cheZ	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0834 b0929 b0957 b0983 b1215 b1377 b1424 b1433 b1677 b1424 b1433 b1677 b1879 b1891 b1922 b1924 b1939 b1945 b1946 b1948 b1949 b1950 b2007 b2007 b2007 b2015 b2218 b2218 b2218 b2221	acrA dacA mrdB dsbC ybeL pal ybhK ompF ompA yccZ dacC ompF ompA yccZ dacC ompF filhC fliA fliD fliF fliQ fliR fliR fliR fliR fliR fliR yfcA yfcA yfcA yfcA yfcA yfcA yfcA yfcA	b43192 b43192 b43192 b01455 b0183 b0183 b0184 b0214 b0215 b0247 b0354 b0247 b0354 b0440 b0467 b0470 b0470 b0472 b0706 b0470 b0472 b0706 b0708 b0708 b0708 b0708 b0708 b0706 b0708 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0708 b0706 b0708 b0	Jimr slt 2.M.&R. polB dksA rnhB dnaE rnhA dnaQ ykfG yaiL hupB priC dnaX recR ybfD phrB dinG ycaJ himD helD rne mfd hnr hns topA rnb dns tus himA topB yoaA holE ruvB ruvC dcm tus	E 1990 E 1990	E.M. talB fixA fruC fruC fruC fruC fruC fruC fruC dniR aceF lpdA aceF lpdA aceF lpdA aceF lpdA aceF lpdA aceF lpdA aceF lpdA aceF lpdA aceF lpdA aceF lpdA aceF lpdA aceF lpdA aceF lpdA aceF lpdA aceB fdcC cyoE cyoC cyoC cyoC cyoC cyoC cyoA fldA sdhD sdhA sdhB sucC sucC sucC sucC sucC sucC sucC sucC
b2023 b2024 b2024 b2025 b2026 b2329 b2366 b2414 b2421 b2482 b2472 b2478 b2472 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2478 b2479 b2601 b2797 b2601 b2797 b2601 b2797 b2818 b2937 b2839 b3389 b3359 b3389 b3359 b3389 b3357 b3667 b3667 b3667 b36767 b36767 b3768 b3767 b3768 b3767 b3768 b3767	hisH hisH hisF hisI aroC dsdA cysK cysM dapE dapA glyA glyB pheA tyrA aroF sdaB argB argB argB argB argB argB argB ar	b0529 b0593 b0594 b0595 b0595 b0596 b0628 b0628 b0628 b0774 b0775 b0776 b0778 b0783 b0785 b0227 b0231 b1206 b1212 b1230 b2260 b2264 b2301 b231 b2320 b2364 b2374 b2326 b2364 b2364 b2374 b2364 b2376 b2364 b	nemni folD entC entE entB entA lipA lipB bioA bioB bioF bioD moaA moaA moaA moaA moaA moaA moaA moaA	b0871 b0904 b1106 b1294 b1106 b1594 b1613 b2095 b2167 b2172 b2297 b2452 b2453 b2454 b2455 b2454 b2455 b2458 b2714 b2455 b2458 b2714 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2789 b2802 b2803 b2802 b2803 b2802 b2803 b2843 b2902 b2803 b3032 b3091 b3094 b3094 b3032 b3091 b3094 b3127 b3127 b3127 b3126 b3056 b3516 b3564 b3564 b3564 b3564 b3564 b3564	panb poxB focA ycfN galU mlc manA gatZ bglX fruA yeiQ pta eutH eutG gutQ gutQ gutQ gutZ gudD gudZ gudP fucl fucK galR kduI ygfF glcC ebgR uxaA exuR ydaU treF kdgK xylB	b0718 b0756 b0766 b0767 b0772 b0789 b0825 b0889 b0960 b1020 b1302 b1479 b1603 b1020 b1302 b1479 b1603 b1702 b1603 b1702 b1850 b1850 b1851 b2042 b2048 b2048 b2048 b2048 b2048 b2048 b2048 b2048 b2048 b2048 b2048 b2048 b2048 b2048 b2048 b2048 b2050 b2530 b2530 b2530 b2530 b2536 b2538 b2548	ybgQ ybgQ ybgQ ybhA ybhA ybhA ybhC ybhO ybiZ lrp yccK appA phoH goaG sfcA pntB pntA posA eda edd galF cpsB udk mrp ypgA yfdZ ypdD talA hyfR ppk ypkI ypkD yfdZ ypdD talA hyfR ppk ppx yfaC ybhO yfR ppk ppx yfaC ybhO yfR ppk ppx yfaC ybhO ybhO ybhO ybhO ybhO ybhO ybhO ybhO	b3945 b4014 b4015 b4014 b4015 b4093 b4093 b4094 b4095 b4096 b4097 b4099 b4101 b4102 b4106 b4139 b4214 b4126 b4139 b4214 b4226 b4232 b0012 b0014 b0015 b0035 b0035 b0036 b0035 b0036 b0051 b0053 b0054 b0055 b0054 b0055 b0054 b0055 b0054 b0055 b0054 b0055 b0054 b0055 b0054 b0055 b0054 b0055 b0054 b0055 b0054 b0055 b0054 b0055 b0054 b0055 b0054 b0055	aceB aceB aceA iclR phnO phnN phnM phnN phnN phnK phnF dsbA cysQ ppa fbp C.P. htgA dnaK dnaF caiB caiC caiB ftsU ftsI ftsW ftsQ ftsA ftsQ ftsA ftsQ ftsA	b1482 b1482 b1557 b1558 b1732 b1823 b1828 b1829 b1855 b1880 b1881 b1883 b1885 b1886 b1885 b1886 b1885 b1886 b1887 b1888 b1885 b1886 b1887 b1888 b1889 b1920 b1941 b1943 b1981 b2069 b2144 b2182 b2319 b2470 b2526 b2639 b2470 b2526 b2639 b2679 b2669 b2695 b3077 b3057 b3072 b3057 b3072 b3057 b3072 b3057 b3072	nerformer cspB cspF cspF cspF cspC cspC co494 htpX msbB flhB tar cheZ cheB tap tar cheW cheZ cheB tap tar cheW flhB fliK shiA yegD sanA bcr usg sanA bcr usg sanA bcr ygdP ygeD sufE sufE cheZ cheA motB fliK sinA yegD sanA bcr ygdP ygeD sufE sufE sufE cheZ cheA sanA bcr yrather ygdP ygeD sufE sufE sufE sufE cheZ cheA sufE sanA bcr ygeD sufE sufE sufE sufE cheZ cheA sufE sanA bcr ygeD sufE sufE sufE sufE sufE cheA sufE sufE sufE cheA sufE sufE cheA sufE	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0814 b0789 b0929 b0957 b0983 b1215 b1377 b1424 b1377 b1424 b1377 b1424 b1377 b1879 b1891 b1922 b1924 b1938 b1945 b1945 b1946 b1948 b1949 b1950 b2007 b2062 b2175 b2215 b25 b25 b25 b25 b25 b25 b25 b25 b25 b2	acrA dacA mrdB dbbC ybbL pal ybbK ompF ompA yccZ kdsA ompN ydcG ydcO lpp flhA fliG fliA fliF fliA fliF fliR fliR fliR fliR fliR fliR fliR fliR	b4316 b4392 D.R.F b0060 b0145 b0183 b0184 b0214 b0215 b0247 b0247 b0247 b0354 b0440 b0467 b0470 b0472 b0706 b0708 b0708 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0708 b0706 b0708 b0708 b0706 b0708 b0708 b0706 b0708 b0708 b0706 b0708 b0708 b0706 b0708 b0702 b0708 b0702 b0708 b0702 b0708 b0702 b0708 b0702 b0702 b0708 b0702 b0708 b0702	Jumr slt 2.M.&R. polB dksA dnaE rnhB dnaE rnhA dnaQ ykfG yaiL hupB priC dnaX recR ybfD phrB dinG ycaJ himD helD rne mfd hmr hns topA rnb ogt tus himA topB yoaA hoiE ruvC dcm ycaJ himA	E 1990 E 1990	E.M. talB fixA fruR fruR pdhR aceE lpdA acnB fdcC dniR cyoE cyoD cyoC cyoD cyoC cyoC cyoC cyoC sdhA sdhA sdhB sucA sdhB sucA sucC cydA acnC flA msB dmsC pflA neB
b2023 b2024 b2024 b2025 b2026 b2329 b2366 b2414 b2421 b2468 b2472 b2478 b2551 b2590 b2600 b2601 b2797 b2818 b2590 b2600 b2601 b2797 b2818 b2957 b3008 b3172 b3359 b3389 b3389 b3389 b3389 b3389 b3374 b3572 b3677 b3616 b3776 b3768 b3767 b3768 b3769 b3770	hisH hisH hisF hisI aroC dsdA cysK cysM dapE dapA dapA dapA dapA dapA dapA dapA dapA	b0529 b0529 b0593 b0594 b0595 b0596 b0628 b0628 b0628 b0774 b0775 b0776 b0778 b0783 b0784 b0778 b0783 b0784 b0778 b0783 b0784 b0778 b0783 b0784 b0778 b0783 b0784 b0778 b0783 b0784 b0778 b0783 b0784 b0778 b0783 b0784 b0778 b0783 b0784 b0778 b0783 b0784 b0778 b0783 b0784 b0775 b0783 b0784 b0775 b0783 b0784 b0775 b0784 b0775 b0783 b0784 b0775 b0783 b0784 b0775 b0783 b0784 b0775 b0783 b0784 b0778 b0784 b0726 b0727 b0277 b1638 b1200 b1212 b1270 b1213 b2260 b2264 b2264 b2311 b2312 b2326 b2364 b2364 b2376 b2364	nemni folD entC entE entB lipA lipB bioA bioB bioF bioD moaA moaC moaA moaC moaA moaC moaA moaC moaA moaC moaA moaC moaA moaC moaA moaC moaA moaC moaA bioF bioD moaA moaC moaA moaC moaA moaC moaA bioF bioD moaA moaC moaA bioF bioD moaA moaC moaA bioF bioD moaA moaC moaA bioR bioF bioD moaA moaC moaA bioR bioA bioF bioD moaA moaC moaA bioR bioR bioF bioD moaA moaC moaA bioR bioR bioR bioA bioF bioD moaA moaC moaA bioR bioR bioR bioR bioR bioD moaA moaC moaA moaC moaA bioR bioR bioR bioR bioR bioR bioR bioR	b0871 b0904 b1106 b1294 b1106 b1294 b1613 b2095 b2132 b2167 b2172 b2297 b2452 b2453 b2453 b2454 b2455 b2458 b2458 b2458 b2708 b2714 b2787 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2788 b2789 b2802 b2803 b2837 b2843 b2837 b2843 b2902 b2880 b3032 b3091 b3094 b3127 b3132 b3416 b3526 b3546 b3564 b3566 b3566	poxB focA ycfN galU mlc manA gatZ bglX fruA yeta eutH eutG gutQ gutQ fucl fucK gutQ gudD gudZ gudP fucl fucR kduI ygfF glcC icc ebgR uxaA exuR yaaQ treF kdgK xylB xylR	b0718 b0756 b0766 b0767 b0772 b0789 b0825 b0889 b0980 b1020 b1302 b1479 b1603 b1020 b1302 b1479 b1603 b1702 b1603 b1702 b1850 b1851 b2042 b1850 b1851 b2042 b2048 b2048 b2048 b2049 b2066 b2113 b2048 b2049 b2066 b2138 b2388 b2379 b2383 b2484 b2501 b2532 b2536 b2536 b2538 b2584 b2584b2584 b2584	ybgQ ygalM ybhA ybhA ybhA ybhC ybhC ybhC ybhC ybhC ybhC ybhC ybhC	b3945 b4014 b4015 b4014 b4093 b4093 b4093 b4094 b4095 b4096 b4097 b4099 b4101 b4102 b4106 b4139 b4214 b4226 b4139 b4214 b4226 b4139 b4214 b4226 b4139 b4214 b4226 b4139 b4214 b4226 b4035 b4095 b4095 b4095 b4096 b4099 b4097 b4096 b4099 b4097 b4096 b4099 b4096 b4099 b4096 b4099 b4096 b4099 b4096 b4099 b4096 b4099 b4096 b4099 b4096 b4099 b4096 b4099 b4096 b4099 b40096 b4099 b40096 b4099 b40096 b4099 b40096 b4099 b40096 b4099 b40096 b4099 b4096 b4099 b4096 b4099 b40096 b4099 b40096 b4099 b40096 b4099 b40096 b4099 b40096 b4099 b40096 b4099 b40096 b4099 b40096 b40096 b4099 b40096 b4099 b40096 b4099 b40096 b4099 b40096 b4099 b40096 b4099 b40096 b4099 b40096 b4005 b0016 b00036 b00036 b00056 b0056	aceB aceB aceA iclR phnO phnN phnM phnL phnM phnI phnG phnF dsbD dsbA cysQ ppa fbp C.P. htgA dnaK dnaJ gefL caiB caiA caiT ksgA surA imp ftsU ftsU ftsQ ftsA ftsZ amp	b1482 b1482 b1557 b1558 b1732 b1823 b1828 b1829 b1825 b1880 b1881 b1883 b1885 b1886 b1885 b1886 b1885 b1886 b1885 b1886 b1885 b1888 b1885 b1888 b1885 b1888 b1885 b1888 b1885 b1888 b1885 b1888 b1889 b1920 b1941 b1943 b1941 b1943 b1941 b2069 b2144 b2319 b2470 b2526 b2470 b2526 b2470 b2526 b2470 b2526 b2470 b2526 b2470 b2526 b2470 b2526 b2470 b2526 b2470 b2526 b2744 b2830 b2685 b3077 b3057 b3072 b3150 b3178	nerf cspB cspF cspF cspF katE cspC cspG d94 htpX msbB flhB cheZ cheB tap tar cheW cheZ cheB tap tar cheW cheZ cheB flhB fliX fliIK shiA yegD sanA bcr usg acrD hscA yfjV proX emrB suF ygdP ygeD sufE toiC t	b0463 b0632 b0634 b0635 b0640 b0643 b0741 b0780 b0814 b0780 b0814 b0780 b0814 b0780 b0814 b1075 b1215 b1377 b1424 b1377 b1424 b1377 b1424 b1377 b1424 b1377 b1879 b1891 b1922 b1924 b1945 b1955 b2017 b2017 b2017 b2017 b2215 b2216 b2519 b2215 b2215 b2215 b2216 b2519	acrA dacA mrdB dbbC ybbL pal ybbK ybbL pal ybbK dompF dacC ompA yccZ kdsA ompF fliA fliD fliF fliA fliD fliF fliA fliB fliB fliB fliB fliB fliB fliB fliB	b4316 b4392 D.R.F b0060 b0145 b0143 b0183 b0184 b0214 b0215 b0247 b0354 b0440 b0467 b0470 b0470 b0472 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0706 b0708 b0708 b0706 b0708	Jimr slt 2.M.&R. polB dksA dnaE rnhA dnaQ ykfG yaiL hupB priC dnaX recR ybfD phrB dinG hupB priC dnaX recR ybfD phrB dinG hupB priC topA rnb ogt tus himA topB yoaA hoi tus himA topB yoaA hoi tus himA topB yoaA hoi tus himA topB yoaA hoi tus himA topB yoaA hoi tus himA topB yoaA hoi tus himA himA tus himA tus	E 1930 E 1930	E.M. talB fixA fixB fruL fruR pdhR aceE acnB facC dniR tahR aceE dniR takN cyoE cyoD cyoD cyoC cyoC cyoC cyoC cyoC cyoC cyoC cyoC

b0975	hyaD	b3062	ttdB	M.P	b 088	4 inf/	4 b3311	rpsQ	b2820	recB	b1246	oppD	b3542	dppC	b4043	texA
b0977	hyaF	b3103	yhaH	b0198 ya	иеЕ b089	3 ser	5 b3312	rpmC	b2822	recC	b1247	oppF	b3543	dppB	b4401	arcA
b0978	appC	b3115	yhaA	b0489 yb	<i>bK</i> b09	1 rps.	4 b3313	rplP	b2892	rec]	b1250	kch	b3544	dppA		
60979	appB	b3236	mdh	b0786 yb	hL = 6092	2 mu	kF b3314	rpsC	b2945	endA	61290	sapF	b3566	xylF	P.	.K.P.
b0993	torS	b3365	nirB	b2346 va	icJ b093	0 asn	5 b3315	rplV	b3067	rpoD	b1291	sapD	b3567	xylG	60162	yaeG
b1017	o243	b3367	nirC	b2477 nl	pB 6093	2 pep	N 63316	rpsS	b3162	deaD	b1292	sapC	b3599	mtlA	60272	yagi
61109	ndh	63386	rpe	62742 nt	pD 5100	6 rim	J 53317	rpiB	b3164	рпр	b1293	<i>sap</i> В	b3609	secB	D0417	thiL
b1136	ıcdA	63423	glpR	N D 4	6108	9 rpn	IF 53318	rpiw	b3169	nusA	b1294	sap A	b3666	unpi	b05/1	yicA webT
b1226	nar]	63424	gipG	N.B.&	M. 511	7 рер	1 63319	rpiD	b3295	rpoA	b1323	tyrk	D3667	unpC	D0933	YCOE 1124 A
b1227	nari	b3425	gipe	60032 ca	TA 6120	4 ptn	D3320	rpic	D3406	greв	D1329	тррА	D3008	ипрь	D1000	TSTA
b1241	aanE	03426	gipD	b0033 ca	7B D12.	$1 pr_{f}$	1 D3321	rpsj	D3401	rpoH	D1485	aapr	D3009	unpA	b1914	uori
b1276	acnA	03518	ynjA	b0049 ap	ari bizi	Z SON	D D3339	nijA Gur A	D3049	rpoz.	D1404	uupD	D3003	gioc har	02140 b2056	yoni
D1300	alaH	D3583	yias LuD	b0104 gu	ac D16.	2 ryrs	D334U	fusA	D3780	rniD	D1092	ynjj	D3722	Ugir	b2000	what
D1415	aiaA warV	D3605	ICID	b0125 np	7 D17.	5 pne	1 D3341 C b2241	rpsG	D3/03	THU THUC	D1021 h1711	muiA htuC	b3725	psib net A	b2299	yjcD ufcM
D1465	narv	D3608	gpsA	60238 gp	dA = b17	4 pne	5 D3342 F h2345	fpsL fm A	D3962 b2087	nusG moR	b1/11 b1917	manY	b3720	psiA netC	b2320	yjcivi zin A
D1400	narvv Gasti	D3731 h2722	atpC	b0357 (0)	$h_{A} = 017.$	5 rpi	1 62340	JKPA	D3907	троБ rnoC	b1017	manV	b3727	psiC netS	b2412	21pA ufel I
D1475	junn sumfE	b3732	atnC	b0409 up	h = 017	info	n 00047	siyD mi 4	03900	TPOC	b1810	man7	b3747	kun	b2556	yje U ufbK
D1007	ynj£ unfE	b3733	atn A	b0522 m	K = 017	0 H_{12}	- 00000 - 63384	trnS	т	<i>e</i> -R P	b1898	oroH	b3748	rhcD	b2550	yoa A
b1500	ynyr fumC	b3734	atnU	b0522 pu	r = b17	5 1111. 6 cm	A h3/99	nrlC	50007	unal	b1900	araC	b3740	rhsA	b2869	yzur naeV
b1611	fum A	b3735	atoE	b0888 tri	$r_{R}^{TL} = b183$	0 spp.	h3550	aluS	b0007	len A	b1901	araF	b3816	corA	b2974	yac v whoS
b1676	jumA mikE	b3730	atnF	b0910 cm	$h = \frac{100}{18}$	5 ntri	3 b3560	g_{igO}	60027 60047	kefC	b2148	malC	b3849	trkH	b3105	vhal
b1697	udiO	b3738	atnB	b0945 m	urD b186	6 asn	5 b3590	selR	b0098	sec A	b2140	malA	b3897	frnR	b3110	yha()
b1758	yuiQ uniF	b3739	atnI	b1062 m	rC b18	6 ara	s b3591	selA	b0000	aroP	b2150	molB	b3899	frvB	b3163	vhhM
b1750	gngi gan A	b3844	uhiB	h1098 tr	k b21	4 met	G b3636	rnmG	b0112	fhuC	b2156	lusP	b3907	rhaT	b3243	0309
b1852	710f	b3891	fdhF	b1131 pu	rB = b218	5 ml	(b3637	rnnR	b0153	fhuB	b2179	veiE	b3909	kdoT	b3422	vhgB
b1854	nukA	h3892	fdol	$b1207 \ pr$	sA b210	0 veil	D b3703	romH	b0100	ahc	b2180	veiF	b3917	shn	b3662	vicM
b2029	and	b3895	fdhD	b1623 ad	ld b220	9 eco	b3765	<i>vif</i> B	b0314	hetT	b2240	oInT	b3927	ølnF	b3692	vidU
b2133	did	b3916	nfkA	b1658 nu	rR b23	8 tru	4 b3775	miC	b0341	cun X	b2306	hisP	b3947	ntsA	b3694	dooR
b2168	fruK	b3919	tni A	b1849 pu	T b23	5 und	F b3847	nenO	b0401	brnO	b2307	hisM	b3966	btuB	b3791	vifl
b2100	narP	b3924	fnr	$b_{2065} d_{c}$	d b240	0 voi	5 b3860	dshA	b0408	secD	b2309	hisI	b3981	secE	b3912	coxR
b2193	ccmH	b3951	nfID	b2143 cd	d b249	0 huf	b3871	wihK	b0409	secF	b2310	aroT	b4031	xulE	b4191	vifO
b2195	dshF	b3952	nflC	b2234 nr	dA = b25	4 his	5 b3932	hslV	b0411	tsx	b2393	nunC	b4033	malF	b4340	viiR
b2196	ccmF	b3956	nnc	b2235 nr	dB = b256	9 len	4 b3936	rpmE	b0448	mdlA	b2415	ptsH	b4035	malK	b4172	hfa
b2197	ccmE	b4003	hvdH	b2312 pu	urF b259	2 clpl	3 b3965	trmA	b0449	mdlB	b2416	ptsI	b4077	gltP	b4271	intB
b2199	ccmC	b4004	hvdG	b2476 pu	urC b260	6 rvl	5 b3980	tufB	b0478	ubaL	b2417	crr	b4104	phnE		
b2205	navG	b4025	pei	b2498 up	w b260	7 trm	D b3983	rolK	b0484	ybaR	b2422	cysA	b4106	phnC	Р.	Т./Р.
b2206	navA	b4051	aor	b2499 pu	irM b260	9 ros	P b3984	rolA	b0495	ubbA	b2423	cusW	b4111	proP	b0257	0141
b2242	olnB	b4070	nrfA	b2500 pu	urN b269	7 alas	5 b3985	roll	b0576	pheP	b2424	cusU	b4123	dcuB	b0360	vi21-1
b2276	nuoN	b4071	nrfB	b2507 gu	uaA b274	3 pcn	i b3986	rolL	b0584	fevA	b2425	cusP	b4208	cycA	b0361	yi22
b2277	nuoM	b4072	nrfC	b2508 gu	uaB b278	5 190	A b4129	lusU	b0588	fepC	b2480	bcv	b4240	treB	b0372	tra5-1
b2278	nuol.	b4073	nrfD	b2518 nd	$k b_{282}$	$1 \ ntr$	b4147	' efv	b0589	fevG	b2568	levB	b4287	fecE	b0553	nmpC
b2279	nuoK	b4074	nrfE	b2557 pu	urL b289	0 lus	5 b4171	miaA	b0590	fevD	b2610	ffh	b4288	fecD	b0737	tolÓ
b2280	nuol	b4079	fdhF	b2780 pu	rG b289	1 prfl	3 b4173	hflX	b0652	gltL	b2663	gabP	b4289	fecC	b0738	tolR
b2281	nuoI	b4085	vicU	b2827 th	vA b290	8 vev	P b4174	hflK	b0653	gltK	b2677	proV	b4291	fecA	b0739	tolA
b2282	nuoH	b4122	fumB	b3640 du	<i>it</i> b302	0 f53	5 b4175	hflC	b0654	gltI	b2678	proW	b4292	fecR	b0740	tolB
b2283	nuoG	b4151	frdD	b3642 pv	rE b305	3 gln	E 64200	rpsF	b0657	Int	b2715	ascF	b4 321	gntP	b1303	pspF
b2284	nuoF	b4153	, frdB	b3648 gn	nk b305	6 cca	b4202	rpsR	b0679	nagE	b2796	sdaC		0	b1304	pspA
b2285	nuoE	b4154	frdA	b3831 ud	<i>lp</i> b306	4 vgji	D b4203	rplI	b0696	kdpC	b2801	fucP]	R.F.	b1402	yi22-2
b2287	пиоВ		<i>.</i>	b4005 pu	irD b306	5 rps	U b4207	fkIB	b0697	kdpВ	b2829	ptsP	b0029	lytB	b1403	yi21-2
b2288	nuoA	F.A.	&P.M.	b4006 pu	<i>arH</i> b302	4 ygji	Н 64219	msrA	b0698	kdpA	b2841	araE	b0400	phoR	b1362	rzpR
b2289	lrhA	b0175	cdsA	b4177 pu	urA b312	9 soh.	A b4235	pmbA	b0761	modE	b2933	cmtA	b0439	lon	b1994	yi52-6
b2296	ackA	b0180	fabZ	b4238 nr	dD b315	8 yhb	U b4258	valS	b0765	modC	b2943	galP	b0683	fur	b1996	yi22-3
b2465	tktB	b0185	accA	b4244 py	<i>rI</i> b310	5 rps	Э b4260	pepA	Ь0809	glnQ	b2987	pitB	b0694	kdpE	b1997	yi21-3
b2469	narQ	b0954	fabA	b4245 py	rB b310	6 trui	B b4373	rimI	b0810	glnP	b3006	exbB	b0695	kdpD	b2089	tra5-4
b2482	hyfB	b1090	plsX	b4381 de	oC b310	7 rbf/	4 b4375	prfC	b0829	yliA	b3175	secG	b1129	phoQ	b2192	yi52 - 8
b2486	hyfF	b1091	fabH	b4382 de	wA b316	8 infE	3 b4386	lplA	b0831	yliC	b3204	ptsN	b1334	fnr	b2313	cvpA
b2487	hyfG	b1092	fabD	b4383 de	oB b318	1 gre.	4 b4389	sms	b0854	potF	b3206	ptsO	b1609	<i>rstB</i>	b2860	yi22-4
b2488	hyfH	b1093	fabG	b4384 de	wD b318	5 rpn	1A		b0855	potG	b3258	panF	b2533	suhB	b2861	yi21-4
b2489	hyfl	b1094	acpP		b318	6 rpll	. T.	R.P.&D.	b0856	potH	b3290	trkA	b2566	era	b3044	yi21-5
b2552	hmpA	b1095	fabF	T.&P.1	.M . b323	0 rps	b0059	hepA	b0857	potI	b3300	prlA	b2570	rseC	b3045	yi22-5
b2579	yfiD	b1249	cls	b0023 rp	sT b323	1 rpll	И 60143	рспВ	b0860	artJ	b3350	kefB	b2571	rseB	b4 273	0301
b2718	hycH	b1278	pgpB	b0026 ile	eS b323	4 hho	A b0148	hrpB	b0861	artM	b3391	hofQ	b2572	rseE	b4285	o198
b2719	hycG	b1288	fabI	b0161 ht	rA b323	5 hho	В 60397	sbcC	b0862	artQ	b3409	feoB	b2573	rpoE		
b2722	hycD	b1412	acpD	b0168 m	ap b325	9 prn	iA b0416	nusB	b0863	artI	b3415	gntT	b2696	csrA	H	.U.U.
b2723	hycC	b1661	cfa	b0169 rp	sB b329	4 rpl(д 60779	uvrB	b0864	artP	b3436	gntU	b2784	relA	b0005	yaa X
b2724	hycB	b1912	psgA	b0170 tsf	f b329	6 rpsi	D b0797	rhlE	b0886	cydC	b3450	ugpC	b2786	barA	b0043	fixC
b2727	hypB	b2316	accD	b0194 pr	<i>vS</i> b329	7 <i>rps</i> i	K b1159	mcrA	b0887	cydD	b3451	ugpE	b3202	rpoN	b0055	yabH
b2731	fhlA	b2323	fabB	b0237 pe	pD b329	8 rpsi	M b1343	dbpA	b0891	lolA	b3452	ugpA	b3210	arcB	b0066	yabJ
b2749	ygbE	b2585	pssA	b0405 qu	ueA b329	9 rpn	ıJ b1413	hrpA	b0914	msbA	b3453	ugpB	b3228	sspB	b0067	yabK
b2769	uacO	b2828	lgt	b0406 tg	t b330	1 rpl(D b1633	nth	b1015	putB	b3455	livG	b3229	sspA	b0069	yabN
	98° ×	1.2010	plsC	b0437 ch	pP b330	2 rpn	ıD b1749	xthA	b1101	ptsG	b3456	livM	b3357	crp	b0081	yabB
b2779	eno	03018				2	E h1913	uvrC	b1123	potD	b3457	livH	b3404	ennZ	1 0007	NOG A
b2779 b2886	9800 eno ygfS	b3255	accB	b0438 clp	pX b330	o ipsi				,				011045	D0097	ушен
b2779 b2886 b2895	980Q eno ygfS fldB	b3255 b3256	accB accC	b0438 cl ₄ b0441 pp	pX b330 piD b330	4 rpll	R b1960	vsr	b1125	potB	b3460	livJ	b3405	ompR	b0097 b0126	yadF
b2779 b2886 b2895 b2914	9800 eno ygfS fldB rpiA	b3255 b3256 b3845	accB accC fadA	b0438 <i>cl</i> b0441 <i>pp</i> b0525 <i>pp</i>	vX b330 viD b330 viB b330	14 rpl1 14 rpl1 15 rpl1	R b1960	vsr evgS	b1125 b1216	potB chaA	b3460 b3478	liv] nikC	b3405 b3650	ompR spoT	b0126 b0127	yadF yadG
b2779 b2886 b2895 b2914 b2925	9802 eno ygfS fldB rpiA fba	b3255 b3256 b3845 b3846	accB accC fadA fadB	b0438 cl b0441 pp b0525 pp b0526 cy	pX b330 piD b330 piB b330 psS b330	15 rps 14 rpl1 15 rpl1 16 rps	R b1960 F b2370 H b2509	vsr evgS xseA	b1125 b1216 b1218	potB chaA chaC	b3460 b3478 b3479	liv] nikC nikD	b3405 b3650 b3724	ompR spoT phoU	b0097 b0126 b0127 b0128	yadF yadG yadH
b2779 b2886 b2895 b2914 b2925 b2926	9800 eno ygfS fldB rpiA fba pgk	b3018 b3255 b3256 b3845 b3846 b4041	accB accC fadA fadB plsB	b0438 cl b0441 pp b0525 pp b0526 cy b0642 let	vX b330 viD b330 viB b330 vsS b330 uS b330	15 rps1 14 rp11 15 rp11 16 rps1 17 rps1	R b1960 F b2370 H b2509 V b2576	vsr evgS xseA srmB	b1125 b1216 b1218 b1223	potB chaA chaC narK	b3460 b3478 b3479 b3480	liv] nikC nikD nikE	b3405 b3650 b3724 b3779	ompR spoT phoU gppA	b0097 b0126 b0127 b0128 b0130	yadF yadG yadH yadE
b2779 b2886 b2895 b2914 b2925 b2926 b2935	9800 eno ygfS fldB rpiA fba pgk tktA	b3018 b3255 b3256 b3845 b3846 b4041 b4069	accB accC fadA fadB plsB acs	b0438 cl b0441 pp b0525 pp b0526 cy b0642 lei b0680 gli	vX b330 viD b330 viB b330 vsS b330 uS b330 nS b330	15 rps 14 rp11 15 rp11 16 rps 16 rps 18 rp11	R b1960 F b2370 H b2509 N b2576 E b2741	vsr evgS xseA srmB rpoS	b1125 b1216 b1218 b1223 b1243	potB chaA chaC narK oppA	b3460 b3478 b3479 b3480 b3493	liv] nikC nikD nikE pitA	b3405 b3650 b3724 b3779 b3806	ompR spoT phoU gppA cyaC	b0097 b0126 b0127 b0128 b0130 b0132	yadF yadG yadH yadE yadD
b2779 b2886 b2895 b2914 b2925 b2926 b2935 b2995	980 eno ygfS fldB rpiA fba pgk tktA hybB	b3018 b3255 b3256 b3845 b3846 b4041 b4069 b4160	accB accC fadA fadB plsB acs psd	b0438 clµ b0441 pp b0525 pp b0526 cy b0642 let b0680 gli b0852 rin	vX b330 viD b330 viB b330 vsS b330 vsS b330 vs b330 vs b330 vs b330 vs b330	13 rp5 14 rp11 15 rp11 16 rp5 16 rp5 18 rp11 18 rp11	R b1960 F b2370 H b2509 V b2576 E b2741 X b2798	vsr evgS xseA srmB rpoS exo	b1125 b1216 b1218 b1223 b1243 b1244	potB chaA chaC narK oppA oppB	b3460 b3478 b3479 b3480 b3493 b3540	liv] nikC nikD nikE pitA dppF	b3405 b3650 b3724 b3779 b3806 b3911	ompR spoT phoU gppA cyaC cpxA	b0097 b0126 b0127 b0128 b0130 b0132 b0147	yacA yadF yadG yadH yadE yadD yadP
b2779 b2886 b2895 b2914 b2925 b2926 b2935 b2995 b3061	980 eno ygfS fldB rpiA fba pgk tktA hybB ttdA	b3255 b3256 b3845 b3846 b4041 b4069 b4160	accB accC fadA fadB plsB acs psd	b0438 clµ b0441 pp b0525 pp b0526 cy b0642 let b0680 gh b0852 rin b0882 clµ	vX b33 niD b33 niB b33 vsS b33 uS b33 nS b33 mK b33 vA b33	15 rps 14 rpl1 15 rpl1 16 rps 16 rps 18 rpl1 19 rpl2 0 rpl1	K b1960 F b2370 H b2509 N b2576 E b2741 X b2798 N b2819	vsr evgS xseA srmB rpoS exo recD	b1125 b1216 b1218 b1223 b1243 b1244 b1245	potB chaA chaC narK oppA oppB oppC	b3460 b3478 b3479 b3480 b3493 b3540 b3541	liv] nikC nikD nikE pitA dppF dppD	b3405 b3650 b3724 b3779 b3806 b3911 b3961	ompR spoT phoU gppA cyaC cpxA oxyR	b0097 b0126 b0127 b0128 b0130 b0132 b0147 b0155	yadF yadG yadH yadH yadD yadP yadQ

FIG. 4-Continued.

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b0156	yadR	b0491	ybbM	b1117	ycfV	b1856	yebA	b2356	yfdM	b2906	visC	b3252	yhdA	b3602	yibL	b4023	yjbD
b0157	yadS	b0496	ybbP	b1118	ycfW	b1857	yebL	b2378	lpxP	b2918	<i>ygfD</i>	b3253	yhdH	b3606	yibK	b4029	yjbH
b0173	vaeM	b0514	glxK	b1132	ycfC	b1858	znuC	b2384	ypdE	b2950	f341	b3260	yhdG	b3611	yibN	b4044	dinF
b0174	uppS	b0516	allC	b1133	<i>ucfB</i>	b1859	vebI	b2390	0108	b2952	0188	b3268	vhdW	b3641	ťtk	b4046	vibK
b0176	vaeL	b0567	vbcH	b1188	vcgB	b1867	vecD	b2420	0244	b2960	vggH	b3269	uhdX	b3646	vicG	b4049	vibN
b0177	vaeT	b0575	uhd E.	b1191	9-8- 11000	b1869	vecN	h2429	0474	b2963	1007	b3270	vhdY	b3654	vicE	b4055	vibP
b0195	vaeR	b0591	uhd A	b1203	ycg C ychF	b1870	wer	h2474	f671	b2975	188- 1560	b3271	whdZ	b3656	vicl	b4065	vicE
b0120	yacD watD	b0597	uhdR	b1206	uchM	b1871	yeeO weeD	b2475	£787	b3031	uniA	b3285	smf	b3657	vicl	b4066	vicE
b0209	yujt) vafK	60577	cot A	b1200	uchB	b1800	473A	h2402	0287	b3037	yquu	b3280	fmu	b3664	yic_j	b4067	vicC
b0224	yuj K din D	b0590	uhaC	b1200	ycnD trinLI	b1017	J234	b2492	0202	b2029	ygiD ygiC	b3246	jinu uhaO	b3664	yicO	641067	yjtG
D0231	unP	DU022	ybeG whe A	b1200	irpri	b1917	yecc	D2494	040/ E02	12020	ygic	100040 100050	yneO	b3003	yicr	D4120	yjui
D0239	yajA T	10050	ybeA what	b1200	yciQ	D2000	yeeQ	D2511 1-2512	1505	b3039	9810	100002	ynes whea	1000/9 1-0/05	yur	D4150	yjuL wiel I
b0251	yafF	D0655	ybej	D1269	yciL	D2014	yeer	02512	J392	03052	J4//	D3330	ynjA	03085	yiue.	04141	yjeri
60255	0134	60658	yve x	b1296	ycjj	b2046	wzxC	62515	gcpE	03035	yguvi	03364	ynfC	03691	yia i	D4146	ујек
60258	ykfC	60660	ybeZ	61311	ycj0	62053	yefA	62517	уfgB	63070	f254	63369	ynfL	63693	yia V	64155	yjeA
b0266	yagB	b0661	miaB	b1318	ycjV	b2074	yegM	b2531	f162	b3073	ygjG	63370	yhfM	b3695	yıdW	b4156	ујеМ
b0267	yagA	b0662	ubiF	b1336	ydaH	b2076	yegO	62532	f246	b 3080	ygjK	b3371	yhfN	63705	yidC	b4161	yjeQ
b0283	yagQ	b0663	o111	b1344	ydaO	b2077	yegB	b2542	<i>o</i> 400	b3081	ygjL	b3376	yhfS	b3714	yieG	b4162	yjeR
b0284	yagR	b0667	<i>o</i> 45	b1378	ydbK	b2098	yegT	b2545	f364	b3087	ygjR	b3381	yhfX	b3720	yieC	b4166	yjeS
b0285	yagS	b0669	o39	b1443	ydcV	b2118	yehI	b2546	f332	b3088	ygjT	b3395	yrfD	b3746	yieN	b4167	yjeF
b0287	yagU	b0671	o50	b1451	yncD	b2122	yehQ	b2558	yfhD	b3089	ygjU	b3397	yrfE	b3754	yieO	b4176	yjeT
b0307	ykgF	b0681	ybfM	b1456	rhsE	b2129	yehX	b2559	yfhC	b3109	yhaN	b3398	yrf F	b3792	yifJ	b4179	vacB
b0321	yahG	b0700	rhsC	b1487	ddpA	b2138	yohG	b2584	0886	b3111	yhaP	b3399	yrfG	b3795	yifK	b4180	yjfH
b0323	yahI	b0715	abrB	b1513	ego	b2142	yohK	b2594	sfhB	b3114	yhaS	b3400	yrfH	b3810	yigA	b4188	yjfN
b0324	yahl	b0742	ybgF	b1514	ydeY	b2145	yeiS	b2595	o245	b3124	yhaD	b3402	yhgE	b3812	yigB	b4190	vifP
b0325	yahK	b0788	ybhN	b1515	ydeZ	b2170	veiO	b2608	vfjA	b3125	yhaE	b3407	yhgF	b3819	rarD	b4218	ytfL
b0334	vrvD	b0818	ybiR	b1543	vdfl	b2173	veiR	b2611	0288	b3126	yhaF	b3414	yhgI	b3843	vigC	b4220	ytfM
b0335	prvE	b0819	ubiS	b1568	udfX	b2178	veiB	b2612	0196	b3128	vhaG	b3420	vhgK	b3859	vihE	b4221	vtfN
b0347	mhvA	b0820	ubiT	b1578	0218	b2183	veiD	b2613	vfiD	b3146	yraL	b3469	zntA	b3865	vihA	b4227	ytfO
b0353	mhvT	b0842	cmr	b1589	vnfG	b2210	voiH	b2615	vfiB	b3153	vhbO	b3470	vhhP	b3874	vihN	b4228	vtfR
b0367	tauC	b0879	ubiZ.	b1596	unfM	b2211	voil	b2620	smnB	b3159	vhbV	b3471	vhhO	b3876	vihO	b4230	vtfT
b0376	vaiH	b0898	ycaD	b1604	vdoH	b2214	voiL	b2681	0305	b3160	vhbW	b3473	vhhS	b3877	vihP	b4231	vifF
b0385	vaiC	b0905	vcaO	b1614	udoA	b2249	ufaY	b2687	ugaG	b3170	vhbC.	b3483	vhhH	b3882	vihll	b4243	vigF
b0392	ukiA	b0923	mukE	b1624	udol	b2254	nmrF	b2711	yohD	b3183	whhZ.	b3488	vhil	b3883	vihV	b4247	vigG
b0393	vaiD	b0935	ssuD	b1627	udol.	b2255	vfhG	b2746	vohB	b3184	whbE	b3490	uhil.	b3885	vihX	b4261	vigP
b0394	vaiF	b0948	uchY	b1642	sluA	b2256	ufhH	b2771	f469	b3190	wrhA	h3492	uhiN	b3886	vihY	b4262	vigO
b0402	proY	b0949	uun	b1654	udhD	b2257	ufhI	b2777	f223	b3192	vrhC	b3494	vhiO	b3888	viiD	b4266	yja∝ vi¢∐
b0407	vaiC	b0951	naiB	b1663	udhE	b2258	ufhI	b2781	mazG	b3194	wrhE	b3499	uhiR	h3915	viiP	b4279	vihB
b0410	vaiD	b0960	vccS	b1681	sufD	b2263	ufhB	b2791	£260	b3195	yrbE yrhF	h3508	uhdY	h3925	olnX	b4358	viiN
b0410	vhaD	b0970	ycc A	b1682	suff	b2267	ola A	b2806	uadE	b3196	urbG	b3523	yhäiF	h3928	viill	b4371	y))!
b0410	dre	b1055	ycert ycert	b1683	sufB	b2269	alaD	b2810	930L 0401	b3197	yrbG wrhH	b3524	yng: uluiC	b3937	viiX	b4377	9)) 1 viil I
b0420	uns Huit	b1065	ycen	b1687	udil	b2207	nuoC	b2010	6768	b3201	yhhC	b3527	yiij0 uih0	b3943	yux	b4378	wiiV
b0423	1111 11.11	b1005	yteL vioV	b1607	yui) udiV	h2200	nuoc utho	b2012	0237	b2201	ynbG yhbI	h2522	yiuo	h2067	yıjı. udb A	b4307	gjj v
b0424	uuj vaiC	b1077	yuv vcoC	b1000	yui udi A	b2270	$y_{\mu}v_{Q}$	b2002	0237	b3203	ynoj uhoC	b3530	ynj0 uhiV	b3062	uunzi uiiC	04377	UEA
E0444	yujG	L1000	ycec	b1703	yuiA udiO	b2293	9]01 1461	b2000	072	b3211	ynce	b3535	yn y v Mi IN	b3044	yıjC uiiD		
DU444	YUUA	b1007	yceD yceC	61792	yujQ vaaC	b2304	yjtri ufal	b2004	0.340	b3222	ynci whai	63540 63552	yn yw wia D	b3075	91JL) 451		
DU443	youe wheat	b109/	yceG	D1703	yeuG voaU	b2224	yjcj	D2002	040J 6644	b2227	yncL	b35552	yiuD wiaE	03973 h200/	151 110D		
DU430	ybaA	D1108	ycjr	D1/04	yeari	b2324	yJCK.	0200/ Lagoo	1044 2226	D3232	yncivi wlaeO	000000 1-2575	yur. viek	D3770	yjuD wiaT		
DU471	урав	01110	ycjj	D1816	yoae	02330 h0231	ујсв	02898 Laboo	0320	D3241	yncQ	1.2590	ylak	03998 1-4020	yjar -		
DU488	4001	D1116	IOIC	D1853	yebK	D2331	<i>ufCI</i> N	D2899	1219	D3244	naD	03389	yia Y	D4020	410B		

FIG. 4. List of genes detected in *Sodalis* by *E. coli* array hybridization analysis. A.A.B.&M., amino acid biosynthesis and metabolism; B.C.P.&C., biosynthesis of cofactors, prosthetic groups, and carriers; C.C.C., carbon compound catabolism; C.I.M., central intermediary metabolism; C.P., cell processes; C.S., cell structure; D.R.R.M.&R., DNA replication, recombination, modification, and repair; E.M., energy metabolism; F.A.&P.M., fatty acid and phospholipid metabolism; M.P., membrane proteins; N.B.&M., nucleotide biosynthesis and metabolism; T.&P.T.M., translation and posttranslational modification; T.R.P.&D., transcription, RNA processing, and degradation; T.&B.P., transport and binding proteins, R.F., regulatory function; P.R.P., putative regulatory proteins; P.T./P., phage, transposon, or plasmid; H.U.U., hypothetical, unclassified, unknown.

and *thrABC*, *metL*, *lysC*, and *asd* for threonine biosynthesis) and the tricarboxylic acid cycle (*sdhABCD*, *sucABCD*, *fum-ABC*, *acnAB*, *gltA*, *icdA*, and *mdh*) in addition to all of the genes coding for ribosomal subunit proteins, further validating the results of the orthologous array analysis (Fig. 4). Many genes involved in the biosynthesis of cofactors, replication, and transport functions were also found to be present. Most of the DNA repair and recombinase orthologs of *E. coli* involved in direct damage reversal, base excision repair, mismatch repair, recombinase pathways, and nucleotide excision repair were found to be retained. However, genes involved in carbon compound catabolism, central intermediary metabolism, fatty acid phospholipid metabolism, cell processes, and cell structure were fewer in numbers in comparison to the *E. coli* genome. Based on hybridization analysis, *Sodalis* appears to have respi-

ratory oxidases, NADH dehydrogenase complex enzymes and a complete tricarboxylic acid cycle. It has the capability to grow on several sugars including galactose, fructose, and raffinose as well as the amino sugars *N*-acetyl-D-glucosamine, the methylpentoses L-fucose, L-rhamnose, L-arabinose, and xylose. *Sodalis* appears to have the ability to convert fatty acids to acetyl coenzyme A using the glyoxylate cycle enzymes. Twenty-six genes detected in *Sodalis* were grouped as phage/transposon or plasmid-like sequences in *E. coli*.

The array analysis was also repeated with purified *Sodalis* plasmid DNA (data not shown). Thirty-six genes were detected, with none corresponding to the genes detected with *Sodalis* chromosomal DNA, indicating that the genes reported in Fig. 4 are indeed of chromosomal origin. Among the genes detected were those coding for a membrane usher protein



FIG. 5. Numbers of genes in different functional categories in the known genome of *E. coli* compared to the numbers of putative genes detected in *Sodalis* on the basis of gene array analysis.

(*yraJ*) and an RNA helicase (*dbpA*). The remaining genes either were hypothetical with no known functions in *E. coli* or corresponded to phage/transposon-like sequences.

DNA methylation in Sodalis. Of interest were two genes detected by array hybridization analysis, coding for DNA adenine (Dam) and cytosine (Dcm) methylase. DNA methylation in bacteria is thought to be involved in protection against foreign DNA in addition to regulatory functions for gene expression and replication. The functional presence of these genes was investigated by DNA restriction analysis using isoschizomers with different methylation requirements. Two pairs of isoschizomers that are diagnostic for Dcm (BstNI and EcoRII) and Dam (Sau3AI and MboI) methylation status of DNA were used to digest total chromosomal and plasmid DNA preparations (Fig. 6). Neither the plasmid nor the chromosomal DNA could be digested with Dam-sensitive restriction enzyme MboI (Fig. 6, lanes 5), while the same DNAs were cleaved with its isoschizomer Sau3AI (Fig. 6, lanes 4), indicating that Sodalis genomic as well as plasmid DNAs are extensively methylated at the adenine residues. Under the same digestion conditions, Wigglesworthia DNA could be completely digested with MboI (data not shown). Although both total and plasmid DNAs could be digested with BstNI (Fig. 6, lanes 2) and EcoRII (Fig. 6, lanes 3), we observed a difference in the plasmid digestion fragments, suggesting that this DNA may be hemimethylated at cytosine residues (Fig. 6B, lane 2 versus lane 3).

DISCUSSION

Symbiotic associations with microorganisms are common in insects and form a continuum from obligate relationships re-

quired for host nutrition and fecundity to parasitic infections with selfish organisms which manipulate host physiology for their own benefit. The genome analysis of mutualists and intracellular pathogens has shown several hallmarks such as reduced genome size, increased A+T bias in coding sequences, and faster polypeptide evolution (21). We studied the genomic aspects of the secondary symbiont of tsetse, *Sodalis*, to better understand the functional nature of its symbiotic association with tsetse.



FIG. 6. Methylation status of *Sodalis* DNA. Two pairs of isoschizomers that are diagnostic for Dcm (*Bst*NI and *Eco*RII) and Dam (*Sau*3AI and *Mbo*I) methylation status of DNA were used to digest total (A) and plasmid (B) DNA preparations. (A) M, lambda/*Hind*III molecular weight marker; lane 1, *Sodalis* total DNA uncut; lanes 2 to 5, *Sodalis* total DNA digested with *Bst*NI, *Eco*RII, *Sau*3AI, and *Mbo*I, respectively. (B) Lane 1, *Sodalis* plasmid DNA uncut; lanes 2 to 5, *Sodalis* plasmid DNA digested with *Bst*NI, *Eco*RII, *Sau*3AI, and *Mbo*I, respectively.

Genome size reductions have been observed for intracellular pathogens such as Chlamydia trachomatis (1.04 Mb), Treponema pallidum (1.14 Mb), Mycoplasma genitalium (0.58 kb), and Rickettsia prowazekii (1.1 Mb) (22). Recently, the genome of the obligate endosymbiont Buchnera from aphids has been characterized as 640 kb (10, 31), and the genome of the obligate Wigglesworthia from tsetse is found to be smaller than 750 kb (1), both apparently approaching the size of that of M. genitalium, the smallest bacterial genome reported thus far. Both Buchnera and Wigglesworthia are intracellular and live within specialized insect cells (bacteriocytes) which make up a defined organ (bacteriome). It has not been possible to culture either organism in vitro. The genome reductions imply genetic and presumably functional loss and may reflect the increased exploitation and dependence of these organisms on their host cells, unlike free-living organisms. In contrast, free-living bacteria such as E. coli and Salmonella have been found to have significantly larger genomes, around 4.5 Mb. The genome size of Sodalis is shown here to be about 2 Mb, significantly larger than those of the intracellular pathogens and obligate symbionts but smaller than those of the closely related free-living enterics. Genome-wide sequence analysis is necessary to understand the full spectrum of genes that have been lost from the enteric ancestor during symbiosis or to identify genes that may have been since acquired to mediate its symbiotic association. In the absence of this information, however, hybridization of its DNA to macroarrays of a closely related microorganism, E. coli, has provided rapid insight into its genome composition. While E. coli arrays have been useful for documenting gene inventories in different strains (27), data presented here show a different application which can provide a cost-effective and fast alternative to genome sequencing for broad comparative analysis of closely related organisms. The future availability of gene arrays from distant organisms and similar applications stand to improve the efficacy of this approach.

Based on its genomic composition revealed by array analysis, Sodalis has many of the capabilities of free-living bacteria. In fact, establishment of an in vitro culture for this organism supports the notion that it can synthesize all of the metabolites it needs for survival outside of host insect cells (6, 35). It appears to have retained many genes involved in transcription, translation, regulation, and nucleic acid and amino acid biosynthetic pathways. Meanwhile, Sodalis might have lost genes in carbon compound catabolism, central intermediary metabolism, and fatty acid phospholipid metabolism. While the absence of certain genes and pathways will need to be confirmed by complete genome sequencing, our findings represent an adaptation by Sodalis to its energy-rich environment, the single diet of tsetse, blood. Under in vitro conditions, Sodalis has been found to assimilate N-acetyl-D-glucosamine and raffinose (14). The symbionts of blood-feeding insects are thought to provide cofactors and vitamin metabolites to supplement the restricted diets of their host insects (8). Many genes involved in the biosynthesis of cofactors and vitamins were detected in Sodalis. Thus, Sodalis might indeed benefit its tsetse host via the synthesis of compounds such as biotin and lipoic acid, molybdenum cofactor, thiamine, riboflavin, and folic acid. In a similar study with Wigglesworthia, we have applied the E. coli arrays to understand the general aspects of its much reduced

genome contents and found that it too has maintained many of the biosynthetic pathways for vitamin and cofactor synthesis, possibly indicating their significance for host tsetse biology (1). While this study provides a general understanding of the genomic coding capacity of *Sodalis*, it lacks information on loci not represented in the *E. coli* genome. There are at least two such examples; the first is a chitinase gene characterized from *Sodalis* that is absent in the *E. coli* genome (34), and the second is the recently described pathogenicity island genes, which may help *Sodalis* invade insect cells (15).

The overall A+T contents of the genomes of intracellular pathogens R. prowazekii and M. genitalium are 71 and 68%, respectively. Similarly, the genomes of mutualists are also A+T rich; for example, that of Buchnera was found to be 75% A+T (31). Genome analysis of intracellular pathogens and obligates indicate that loci encoding for DNA repair and recombination functions have been lost or limited in many of these organisms (22), and this loss of the repair functions may have led to their high A+T bias. In contrast, the genome of the free-living bacterium E. coli does not exhibit such a bias, and its overall A+T content is about 50%. The A+T content of Sodalis groEL and ftsZ gene sequences is less than 45%, another hallmark of free-living organisms. Unlike genomes of obligate intracellular bacteria, the Sodalis genome appears to have retained almost all of the genes involved in DNA repair and recombination functions.

Phylogenetic characterization of the obligate symbionts from various insects has shown that they display concordance with their host phylogenies including the symbionts from tsetse (5), aphids (23), whiteflies (13), mealybugs (24), and carpenter ants (30). Unlike these obligates, the phylogenetic analysis of the secondary symbionts such as Sodalis from tsetse and the symbionts of psyllids and aphids has shown them to be identical among distant species of each insect taxa (11, 16, 33). Based on 16S rRNA gene analysis, Sodalis forms a distinct lineage with the primary symbiont of the rice weevil Sitophilus oryzae, SOPE (4). Comparative analysis of their groEL sequences indicates 98% identity, indicating that they are close members of one bacterial taxon. The genome size of SOPE is 3 Mb, significantly larger than those of the intracellular obligates (9), and the A+T content of its groEL gene is about 45%, similar to that of Sodalis (17). Like Sodalis, it harbors large extracellular plasmids (17). In contrast to their shared evolutionary and molecular characteristics, the biology of SOPE in its weevil host is different from that of Sodalis. SOPE has been shown to reside within bacteriocytes in the weevil (18), similar to Wigglesworthia in tsetse. Its symbiosis in the weevil host is thought to be obligate in nature, and its elimination has been found to impair many physiological traits of its host, including fecundity (18). In tsetse, it has been difficult to disassociate the functional significance of Wigglesworthia from that of Sodalis since antibiotic treatment of flies eliminates both organisms. However, since the prevalence of Sodalis varies extensively in different tsetse species, its association may be considered commensal in nature (12). The transmission modes of Sodalis and SOPE are also different. SOPE is transovarially transmitted to insect progeny (18), while Sodalis is absent in reproductive tissues but is transmitted vertically to the intrauterine larva through the mother's milk (12, 20). It appears that upon association with the hosts, the common ancestor of SOPE and

Sodalis adapted to the distinct functional biologies of the host insects. While SOPE is restricted to an intracellular association in the weevil, Sodalis can replicate in various tissues of tsetse and can replicate outside the host insect cells. It remains to be seen whether the different functional roles they display in their hosts result from host-derived factors or from variations in their genotypes. One precedent for such an association is *Wolbachia*, a parasitic *Rickettsiaceae* which has been shown to invade a wide range of insects where it displays many different phenotypes, ranging from reproductive incompatibilities to age-shortening effects. Further genome-wide comparative analysis between the closely related *Sodalis* and SOPE will undoubtedly shed light on the mechanistic as well as the functional basis of symbiosis in their hosts.

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REFERENCES

- Akman, L., and S. Aksoy. 2001. Escherichia coli gene array analysis provides insight into the biology of the obligate endosymbiont of tsetse flies, Wigglesworthia glossinidia. Proc. Natl. Acad. Sci. USA 98:7546–7551.
- Aksoy, S. 2000. Tsetse: a haven for microorganisms. Parasitol. Today 16:114– 119.
- Aksoy, S. 1995. Wigglesworthia gen. nov. and Wigglesworthia glossinidia sp. nov., taxa consisting of the mycetocyte-associated, primary endosymbionts of tsetse flies. Int. J. Syst. Bacteriol. 45:848–851.
- Aksoy, S., X. Chen, and V. Hypsa. 1997. Phylogeny and potential transmission routes of midgut-associated endosymbionts of tsetse (Diptera:Glossinidae). Insect Mol. Biol. 6:183–190.
- Aksoy, S., A. A. Pourhosseini, and A. Chow. 1995. Mycetome endosymbionts of tsetse flies constitute a distinct lineage related to *Enterobacteriaceae*. Insect Mol. Biol. 4:15–22.
- Beard, C. B., S. L. O'Neill, P. Mason, L. Mandelco, C. R. Woese, R. B. Tesh, F. F. Richards, and S. Aksoy. 1993. Genetic transformation and phylogeny of bacterial symbionts from tsetse. Insect Mol. Biol. 1:123–131.
- Blattner, F., G. R. Plunkett, C. Bloch, N. Perna, V. Burland, M. Riley, J. Collado-Vides, J. Glasner, C. Rode, G. Mayhew, G. J. N. Davis, H. Kirkpatrick, M. Goeden, D. Rose, B. Mau, and Y. Shao. 1997. The complete genome sequence of *Escherichia coli* K-12. Science 277:1453–1474.
- Buchner, P. 1965 Endosymbiosis of animals with plant micro-organisms. p. 210–338. Interscience Publishers Inc., New York, N.Y.
- Charles, H., G. Condemine, C. Nardon, and P. Nardon. 1997. Genome size characterization of the principal endocellular symbiotic bacteria of the weevil *Sitophilus oryzae*, using pulse field gel electrophoresis. Insect Biochem. Mol. Biol. 27:345–350.
- Charles, H., and H. Ishikawa. 1999. Physical and genetic map of the genome of *Buchnera*, the primary endosymbiont of the pea aphid *Acrythosiphon pisum*. J. Mol. Evol. 48:142–150.
- Chen, X., L. Song, and S. Aksoy. 1999. Concordant evolution of a symbiont with its host insect species: molecular phylogeny of genus *Glossina* and its bacteriome-associated endosymbiont, *Wigglesworthia glossinidia*. J. Mol. Evol. 48:49–58.
- Cheng, Q., and S. Aksoy. 1999. Tissue tropism, transmission and expression of foreign genes *in vivo* in midgut symbionts of tsetse flies. Insect Mol. Biol. 8:125–132.
- 13. Clark, M. A., L. Baumann, M. A. Munson, P. Baumann, B. C. Campbell,

J. E. Duffus, L. S. Osborne, and N. A. Moran. 1992. The eubacterial endosymbionts of whiteflies (Homoptera: Aleyrodoidea) constitute a lineage distinct from the endosymbionts of aphids and mealybugs. Curr. Microbiol. 25:119–123.

- Dale, C., and I. Maudlin. 1999. Sodalis gen. nov. and Sodalis glossinidius sp. nov., a microaerophilic secondary endosymbiont of the tsetse fly Glossina morsitans morsitans. Int. J. Syst. Bacteriol. 49:267–275.
- Dale, C., S. A. Young, D. T. Haydon, and S. C. Welburn. 2001. The insect endosymbiont *Sodalis glossinidius* utilizes a type III secretion system for cell invasion. Proc. Natl. Acad. Sci. USA 98:1883–1888.
- Fukatsu, T., N. Nikoh, R. Kawai, and R. Koga. 2000. The secondary endosymbiotic bacterium of the pea aphid *Acyrthosiphon pisum* (Insecta: Homoptera). Appl. Environ. Microbiol. 66:2748–2758.
- Heddi, A., H. Charles, C. Khatchadourian, G. Bonnot, and P. Nardon. 1998. Molecular characterization of the principal symbiotic bacteria of the weevil *Sitophilus oryzae*: a peculiar G+C contents of an endocytobiotic DNA. J. Mol. Evol. 47:52–61.
- Heddi, A., A. M. Grenier, C. Khatchadourian, H. Charles, and P. Nardon. 1999. Four intracellular genomes direct weevil biology: nuclear, mitochondrial, principal endosymbiont, and *Wolbachia*. Proc. Natl. Acad. Sci. USA 96:6814–6819.
- Hill, P. D. S., and J. A. Campbell. 1973. The production of symbiont-free *Glossina morsitans* and an associated loss of female fertility. Trans. R. Soc. Trop. Med. Hyg. 67:727–728.
- Ma, W.-C., and D. L. Denlinger. 1974. Secretory discharge and microflora of milk gland in tsetse flies. Nature 247:301–303.
- Moran, N., and P. Baumann. 2000. Bacterial endosymbionts in animals. Curr. Opin. Microbiol. 3:270–275.
- Moran, N., and J. Wernegreen. 2000. Lifestyle evolution in symbiotic baceria: insights from genomics. Trends Ecol. Evol. 15:321–326.
- Munson, M., P. Baumann, and M. Kinsey. 1991. Buchnera gen. nov. and Buchnera aphidicola sp. nov., a taxon consisting of the mycetocyte-associated, primary endosymbionts of aphids. Int. J. Syst. Bacteriol. 41:566–568.
- Munson, M. A., P. Baumann, and N. A. Moran. 1992. Phylogenetic relationships of the endosymbionts of mealybugs (Homoptera: Pseudococcidae) based on 16S rDNA sequences. Mol. Phylogenet. Evol. 1:26–30.
- Nogge, G. 1981. Significance of symbionts for the maintenance of an optional nutritional state for successful reproduction in hematophagous arthropods. Parasitology 82:101–104.
- Nogge, G. 1976. Sterility in tsetse flies (*Glossina morsitans* Westwood) caused by loss of symbionts. Experientia 32:995–996.
- Ochman, H., and I. B. Jones. 2000. Evolutionary dynamics of full genome content in *Escherichia coli*. EMBO J. 19:6637–6643.
- O'Neill, S. L., R. H. Gooding, and S. Aksoy. 1993. Phylogenetically distant symbiotic microorganisms reside in *Glossina* midgut and ovary tissues. Med. Vet. Entomol. 7:377–383.
- Sambrook, J., E. Fritsch, and T. Maniatis. 1989. Molecular cloning: a laboratory manual, 2nd ed. Cold Spring Harbor Laboratory Press Cold Spring Harbor, N.Y.
- Schroder, D., H. Deppisch, M. Obermayer, G. Krohne, E. Stackebrandt, B. Holldobler, W. Goebel, and R. Gross. 1996. Intracellular endosymbiotic bacteria of Camponotus species (carpenter ants): systematics, evolution and ultrastructural characterization. Mol. Microbiol. 21:479–489.
- Shigenobu, S., H. Watanabe, M. Hattori, Y. Sakaki, and H. Ishikawa. 2000. Genome sequence of the endocellular bacterial symbiont of aphids *Buchnera* sp. APS. Nature 407:81–86.
- Southwood, T. R., S. Khalaf, and R. E. Sinden. 1975. The micro-organisms of tsetse flies. Acta Trop. 32:259–266.
- Thao, M. L., M. A. Clark, L. Baumann, E. B. Brennan, N. A. Moran, and P. Baumann. 2000. Secondary endosymbionts of psyllids have been acquired multiple times. Curr. Microbiol. 41:300–304.
- Welburn, S. C., K. Arnold, I. Maudlin, and G. W. Gooday. 1993. Rickettsialike organisms and chitinase production in relation to transmission of trypanosomes by tsetse flies. Parasitology 107:141–145.
- Welburn, S. C., I. Maudlin, and D. S. Ellis. 1987. In vitro cultivation of rickettsia-like-organisms from *Glossina* spp. Ann. Trop. Med. Parasitol. 81: 331–335.