

# Integrative Illustration of a JCVI-syn3A Minimal Cell

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JCVI-syn3A is a minimal cell developed at the J. Craig Venter Institute, with a reduced genome of 493 genes. It was developed in several steps, starting from *Mycoplasma mycoides* and successively removing non-essential genes. In the most recent step, from Syn3.0 to Syn3A, 19 genes were added back to the cell resulting in more stable morphology and division of the cells. Syn3A cells provide an attractive laboratory for exploring the central processes needed for life and abundant information is available for them, including an extensively-annotated genome, a proteome with molecular abundances, and cryo-EM images of individual cells. The illustration presented here integrates this experimental data to create a cross-section through an entire JCVI-syn3A cell, showing all macromolecules.

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## Structures and Abundances

The illustration (Figure 1) builds extensively on recent experimental and modeling work on Syn3.0 and Syn3A, including systems biology modeling of metabolic and genetic networks and structural modeling with LatticeMicrobes [1-5]. This work reconciles the identity and abundance of gene products found in the proteome study [1], and provided a touchstone throughout researching and creating the illustration to define the molecular composition of the cell. Features from these studies that were included in the illustration include the ~400 nm diameter of the spherical cell, lack of supercoiled plectonemes in the nucleoid, random distribution of ribosomes, and presence of expressomes. The genome (downloaded from the NCBI site at [www.ncbi.nlm.nih.gov/nuccore/CP016816.2](http://www.ncbi.nlm.nih.gov/nuccore/CP016816.2)) provided gene location, gene name, locus tag, protein name, and protein id for gene products and non-coding RNA. Abundances were averaged for the three time points reported in the proteome, and for assemblies, abundances for all subunits were averaged. Arbitrary abundances of 20/cell were assigned for the proteins missing from the proteome. Cell surface lipoglycans were not included after a personal communication with James Daubenspeck.

Compilation of the structural proteome leveraged the recent whole-cell structural model of *Mycoplasma genitalium* [6]. Structural homologs in the *M. genitalium* proteome were found in several successive steps. Many

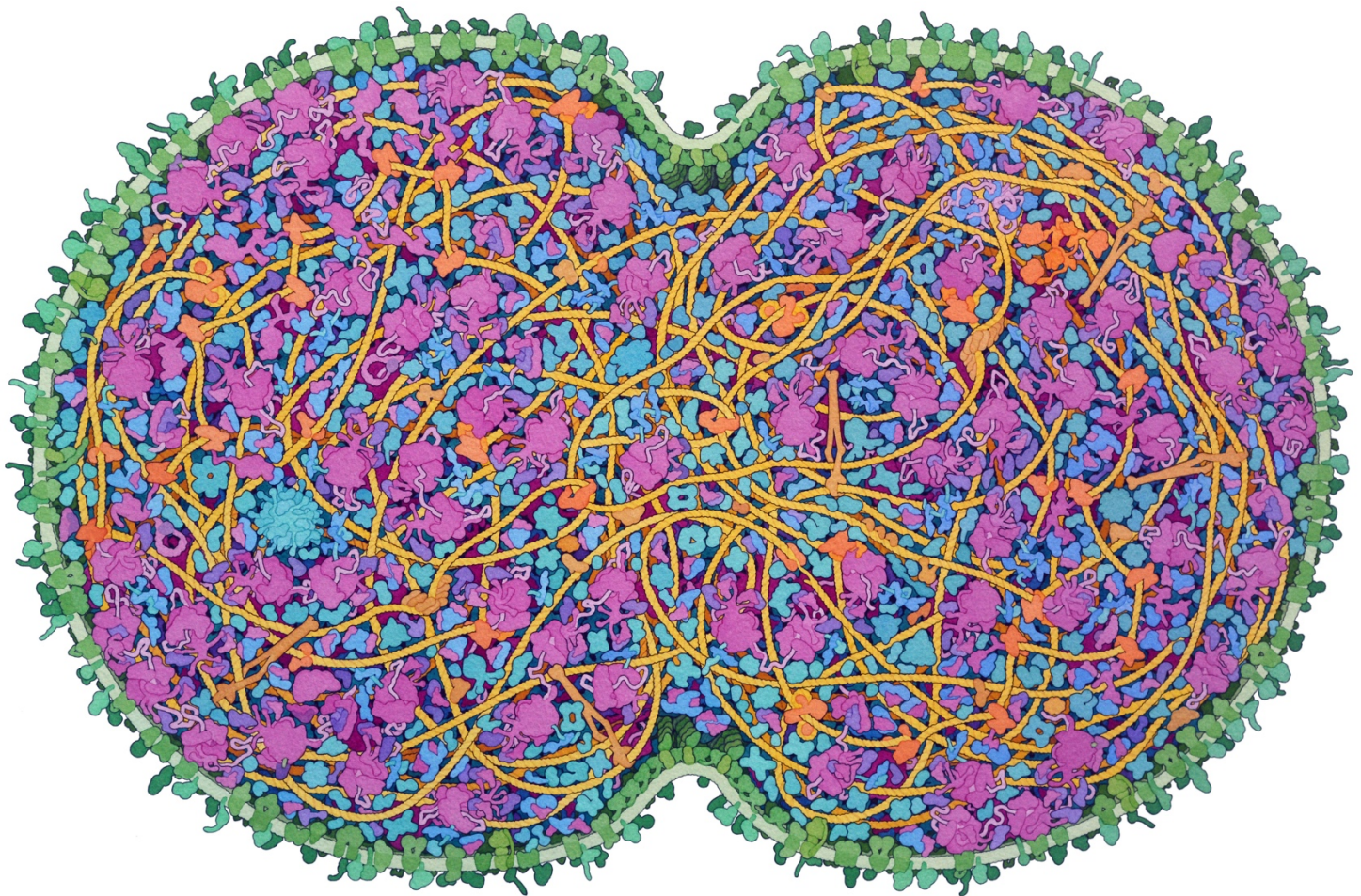
were assigned by matching gene names in UniProt. If no match was found, a BLAST search was performed at NCBI using the default parameters. In cases where this was not successful, manual search of the protein name in UniProt and RCSB Protein Data Bank was performed.

Most of the structures from the *M. genitalium* structural proteome were used as-is, however alternative decisions were made in several cases. For proteins interacting with tRNA (such as amino acid--tRNA ligases and EF-Tu), the protein is depicted as a complex with tRNA. Ribosomes in multiple states are depicted similarly to previous work with *Escherichia coli* (doi: 10.2210/rcsb\_pdb/goodsell-gallery-028). Several DNA-associated proteins were based on published reports: DNA gyrase [7], DNA topoisomerase IV [8], and RNA polymerase and the expressome [9].

Structural homologs were not found for 89 proteins, most of which are annotated as uncharacterized proteins in the genome. Structures were predicted with AlphaFold2 [10]. These were then manually examined in Jmol [11] using a representation that highlights surface hydrophobicity, and compared with predictions of membrane-spanning regions from UniProt. In most cases, the predicted structure matched the prediction, and membrane portions showed as prominent a prominent hydrophobic alpha helix or a hydrophobic belt around globular proteins. Lipoproteins were modeled with signal sequences, and in all cases, the signal sequence was predicted to be disordered and was removed for the final model and replaced by lipidation.

## Narrative Decisions

The cell is depicted just after beginning division, to underscore the role of several cell division proteins (ftsZ, ftsA, and sepF), two of which are key elements included in the move from Syn3.0 to Syn3A. Long filaments of ftsZ are thought to mediate the division septum through interactions of membrane-binding proteins ftsA and sepF. In order to highlight the shape of the septum, ftsZ filaments are depicted perpendicular to the plane of the page. Recent study of sepF indicates that it forms rings with the membrane-interacting surface on the inner face [12], so it is depicted as forming a C-shaped assembly cupping around the septum. Uncharacterized protein JCVISYN3A\_0239 was predicted to have a single transmembrane segment and several spectrin repeats, and



**Figure 1. Artistic conception of a cross-section through a dividing JCVI-syn3A cell**

is included in a speculative interaction with *ftsZ*/*ftsA* similar to *EzrA* [13]. The illustration assumes entropic segregation of the daughter DNA strands and depicts two topoisomerases resolving entanglements.

One overarching goal of this illustration is to depict an entire proteome. This is possible due to the limited size of the Syn3A genome, and the abundance of data that is currently available. The genome of Syn3A annotates 452 proteins and 38 RNA, plus two additional proteins needed for cloning in yeast. After structure assignment, these yielded 329 molecular assemblies (Table 1 and Figure 2). Functional RNA (ribosomal subunits, tRNA, tmRNA, RNase P, and signal recognition particle) are also included with their protein partners in the assembly list. Fourteen gene products were omitted from the illustration (bottom of Table 1). They are small chains annotated as “uncharacterized protein” that did not fold into a globular structure with AlphaFold2. These are assumed to be subunits of larger assemblies, also not depicted in the illustration. The illustration also includes DNA and a lipid membrane, but small molecules, ions, and water are omitted for clarity.

Several features of ribosomes are highlighted in the illustration, based on current conceptions of ribosome structure and function. In both daughter cells, ribosomal

RNA is being transcribed by multiple RNA polymerases from rRNA operons. Ribosomes are depicted with stalk proteins associated with EF-G and EF-Tu/tRNA complexes, and in some cases, are further associated into polysomes. Given the presence of antitermination proteins *nusG* and *nusA* in the genome, several expressomes are included. Several ribosomes are also shown associating or associated with transport channels at the cell surface.

### Aesthetic Decisions

As in previous work, artistic license is taken in several aspects of the illustration to improve clarity and comprehensibility. Fibrous molecules (DNA, RNA, and disordered protein) are shown in the plane of the page, never clipped by the cross-section. The membrane, on the other hand, is positioned perpendicular to the clipping plane, providing a smooth outer contour for the cell. Canonical views are chosen for each molecule and used throughout, to highlight symmetry and functional features, and improve recognizability. Abundances were approximated in the following manner: ribosomes were added first based on distribution in cryoEM images and the nucleoid sketched around them; multiple copies of abundant translation factors, tRNA, chaperones, and

metabolic enzymes were then added; the remaining space was filled with one or two copies of less abundant proteins to complete the proteome. The original watercolor illustration was rendered at 1 million times magnification, which required a slight exaggeration of the width of RNA and disordered protein chains, so that they would not be lost in the ink outlining.

The color palette is chosen to highlight the functional categories of each molecule. This coloring scheme is consistent with previous work, allowing direct comparison with other integrative illustrations. Given the primacy of the genome, DNA is in bright yellow, DNA-associated proteins are in tan, and DNA-associated enzymes (polymerases and topoisomerases) are in orange. The membrane is in green, with membrane-spanning proteins in a darker shade and lipoproteins in bluer green. RNA, including ribosomes, tRNA and mRNA, are in shades of magenta, and protein synthesis factors are in purple. Enzymes are in shades of blue, with a cooler cobalt blue for enzymes interacting with the protein synthesis machinery, and metabolic enzymes in shades of turquoise.

The color palette is built almost entirely from Windsor and Newton watercolors cadmium yellow, yellow ochre, Windsor red, viridian hue, cobalt blue, and Old Holland magenta, painted on Arches 300 lb Rough Natural White paper. Background molecules are depth-cued to darker shades using Vandyke brown for warm colors and ivory black for cool colors. Outlines are rendered in India ink with a 00 (0.3 mm) Rapidograph technical pen.

### Availability

The illustration is freely available under a Creative Commons CC-BY-4.0 license at PDB-101, the outreach and education portal of the RCSB Protein Data Bank ([pdb101.rcsb.org/sci-art/goodsell-gallery/](http://pdb101.rcsb.org/sci-art/goodsell-gallery/)). Please cite this document as: Goodsell DS (2022) Integrative illustration of a JCVI\_syn3A minimal cell. RCSB Protein Data Bank, doi: 10.2210/rcsb\_pdb/goodsell-gallery-042.

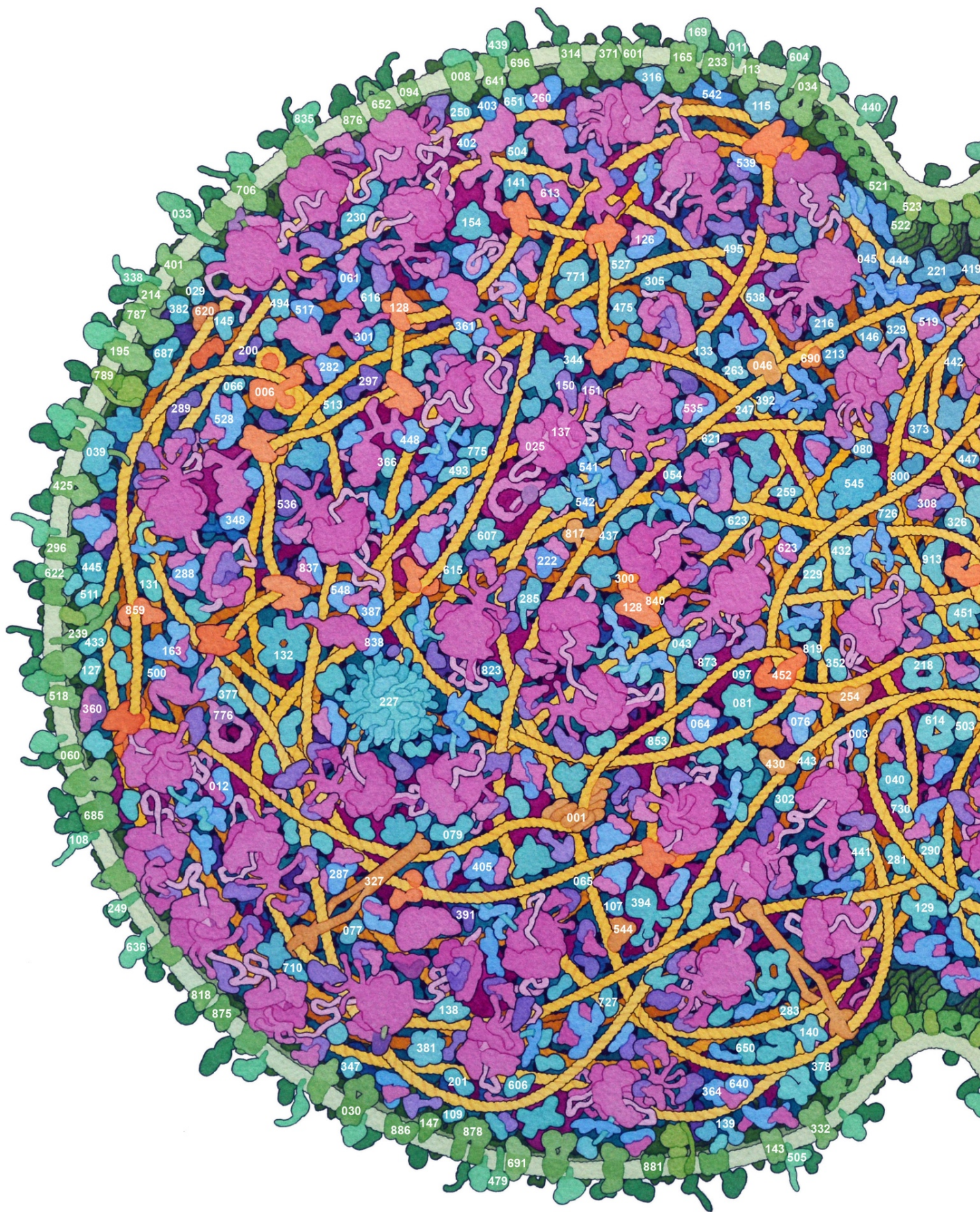
### Acknowledgments

I gratefully acknowledge the RCSB Protein Data Bank (National Science Foundation DBI-1832184, National Institutes of Health GM133198, and US Department of Energy DE-SC0019749) for ongoing support of my education and outreach work, the Department of Integrative Structural and Computational Biology at Scripps Research, and NIH grant GM120604. I thank John Glass, Elizabeth Villa, Markus Covert and Zaida Luthey-Schulten for helpful discussions.

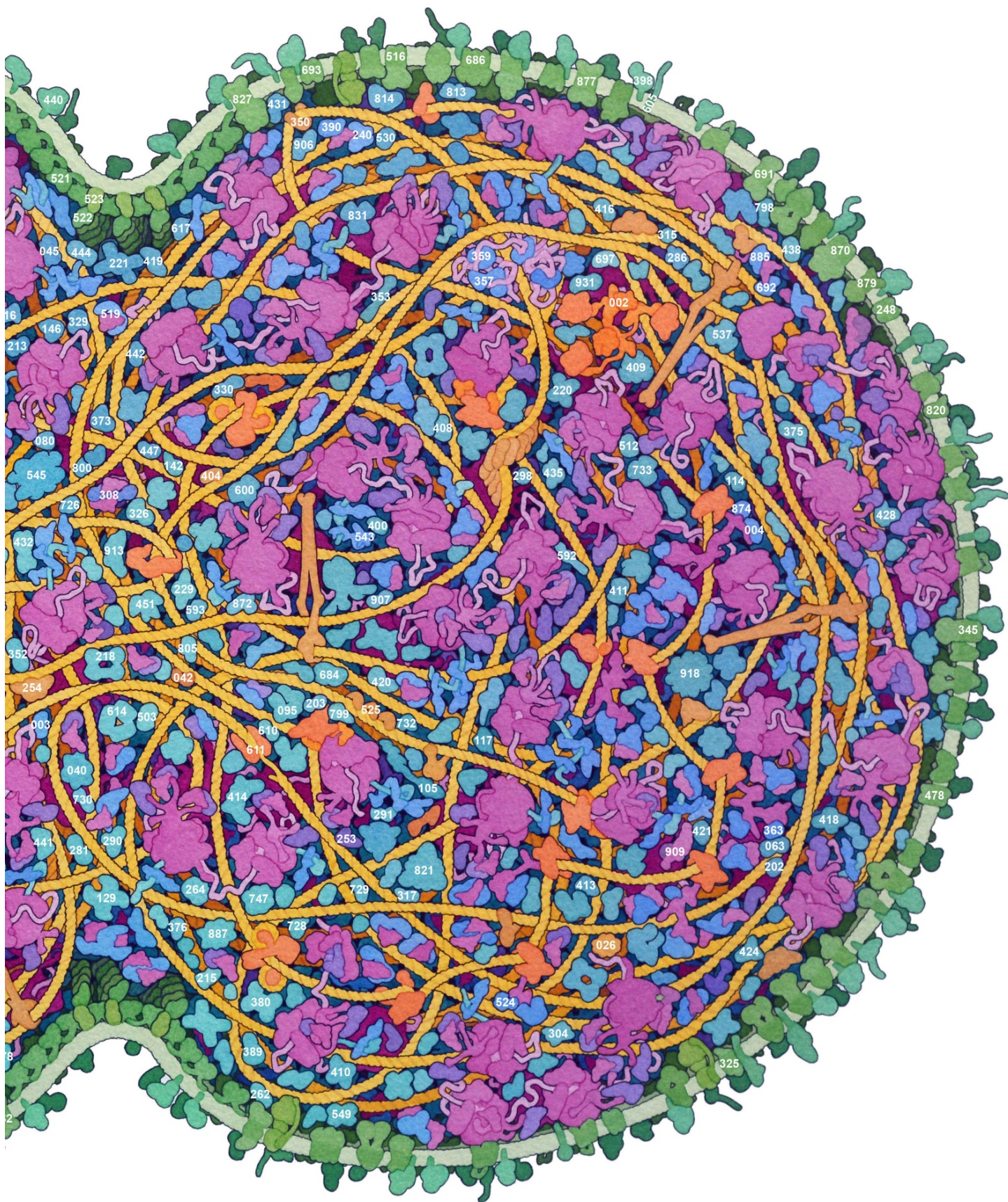
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**Figure 2. Key for molecules in the illustration**

Numbers are shortened versions of the locus tag from the cellular genome, including only the last three digits. Only one instance of each type of protein is labeled. For assemblies, the number represents the subunit with the lowest locus id.



**Table 1. JCVI-syn3A Proteins Depicted in the Illustration**

Locus Tag	Product
JCVISYN3A_0001	Chromosomal replication initiator protein dnaA
JCVISYN3A_0002, 0044,0047,0303, 0406,0608,0609, 0612,0695,0826, 0834	DNA polymerase
JCVISYN3A_0003	Ribonuclease M5
JCVISYN3A_0004	16S rRNA (adenine(1518)-N(6)/adenine(1519)-N(6))-dimethyltransferase
JCVISYN3A_0006,0007	DNA gyrase
JCVISYN3A_0008-0011	Ribose/galactose ABC transporter
JCVISYN3A_0011	Nucleoside ABC transporter substrate-binding
JCVISYN3A_0012	Methionine--tRNA ligase
JCVISYN3A_0025, 0027,0082,0148, 0149,0238,0294, 0362,0482,0540, 0637,0646,0647, 0654,0657,0658, 0662,0665,0667, 0672	30S ribosome
JCVISYN3A_0026	Single-stranded DNA-binding protein
JCVISYN3A_0029	Uncharacterized FMN-dependent NADH-azoreductase
JCVISYN3A_0030	Uncharacterized ABC transporter
JCVISYN3A_0034	Uncharacterized ABC transporter
JCVISYN3A_0033	Uncharacterized protein
JCVISYN3A_0039	Membrane anchored AAA+ protease ftsH
JCVISYN3A_0040	tRNA lysidine(34) synthetase
JCVISYN3A_0042	Uncharacterized transcriptional regulator
JCVISYN3A_0043	Uncharacterized methyltransferase
JCVISYN3A_0045	dTMP kinase
JCVISYN3A_0046	Recombination protein recR
JCVISYN3A_0054	Uncharacterized peroxiredoxin
JCVISYN3A_0060	Uncharacterized protein
JCVISYN3A_0061	Serine--tRNA ligase
JCVISYN3A_0063	Uncharacterized tRNA dihydrouridine synthase
JCVISYN3A_0064	Lysine--tRNA ligase
JCVISYN3A_0065	Thioredoxin
JCVISYN3A_0066	Low specificity hydrolase
JCVISYN3A_0076	Asparagine--tRNA ligase
JCVISYN3A_0077	Uncharacterized hydrolase
JCVISYN3A_0079, 0144,0270,0271	tRNA (N6-adenosine(37)-N6)-threonylcarbamoyltransferase complex
JCVISYN3A_0080	Uncharacterized protein
JCVISYN3A_0081,0434	tRNA uridine 5-carboxymethylaminomethyl modification enzyme
JCVISYN3A_0094	Uncharacterized protein
JCVISYN3A_0095	Preprotein translocase subunit A
JCVISYN3A_0097	Uncharacterized 5'-3' exonuclease
JCVISYN3A_0105,0106	Exodeoxyribonuclease VII
JCVISYN3A_0107	Transcription antitermination factor
JCVISYN3A_0108	Uncharacterized lipoprotein
JCVISYN3A_0109	Deoxyribonuclease IV
JCVISYN3A_0113	Glycolipid synthase A
JCVISYN3A_0114	Glycolipid synthase B
JCVISYN3A_0115	UTP--glucose-1-phosphate uridylyltransferase
JCVISYN3A_0117	Acyl-phosphate glycerol 3-phosphate acyltransferase
JCVISYN3A_0126	Glutamate--tRNA ligase
JCVISYN3A_0127	Uncharacterized phosphohydrolase
JCVISYN3A_0128, 0407,0645,0803, 0804	RNA polymerase
JCVISYN3A_0129	CTP synthase
JCVISYN3A_0131	Fructose-1,6-bisphosphate aldolase
JCVISYN3A_0132	Toxin-antitoxin AAA ATPase
JCVISYN3A_0133	Toxin-antitoxin serine protease
JCVISYN3A_0137, 0198,0199,0365, 0422,0499,0501, 0526,0638,0644, 0648,0653,0655, 0656,0659,0660, 0661,0663,0664, 0666,0668,0669, 0670,0671,0806,	50S ribosome

0807,0809,0810,	
0833,0930,0932	
JCVISYN3A_0138	Uncharacterized protein
JCVISYN3A_0139	NanoRNase
JCVISYN3A_0140	Thymidine kinase
JCVISYN3A_0141	Peptide chain release factor 1
JCVISYN3A_0142	Protein-(glutamine-N5) methyltransferase
JCVISYN3A_0143	Uncharacterized protein
JCVISYN3A_0145	Uncharacterized acetyltransferase
JCVISYN3A_0146	Uncharacterized protein
JCVISYN3A_0147	Cardiolipin synthase
JCVISYN3A_0150	Translation elongation factor G
JCVISYN3A_0151	Translation elongation factor Tu
JCVISYN3A_0154	Uncharacterized peptidase
JCVISYN3A_0163	Alanine--tRNA ligase
JCVISYN3A_0165-0168	oligopeptide ABC transporter
JCVISYN3A_0169	Oligopeptide ABC transporter substrate-binding
JCVISYN3A_0195-0197	Spermidine/putrescine ABC transporter
JCVISYN3A_0200	Translation initiation factor IF-3
JCVISYN3A_0201	Peptide deformylase
JCVISYN3A_0202	16S rRNA (guanine(966)-N(2))-methyltransferase
JCVISYN3A_0203	Guanylate kinase
JCVISYN3A_0213	Phosphopyruvate hydratase
JCVISYN3A_0214	Phosphatidylglycerophosphatase
JCVISYN3A_0215	Putative pre-16S rRNA nuclease
JCVISYN3A_0216	Hypoxanthine phosphoribosyltransferase
JCVISYN3A_0218	Glycerol kinase
JCVISYN3A_0220	6-Phosphofructokinase
JCVISYN3A_0221	Pyruvate kinase
JCVISYN3A_0222	Threonine--tRNA ligase
JCVISYN3A_0227,0228	Pyruvate dehydrogenase complex
JCVISYN3A_0229	Phosphate acetyltransferase
JCVISYN3A_0230	Acetate kinase
JCVISYN3A_0233,	PTS system
0234,0694,0779	
JCVISYN3A_0239	Uncharacterized protein
JCVISYN3A_0240	tRNA 4-thiouridine(8) synthase
JCVISYN3A_0247	Ribosome biogenesis GTP-binding protein
JCVISYN3A_0248	Uncharacterized protein
JCVISYN3A_0249	Uncharacterized protein
JCVISYN3A_0250	Uncharacterized protein
JCVISYN3A_0253	Transcription elongation factor greA
JCVISYN3A_0254,	uvrAB repair complex
0824,0825	
JCVISYN3A_0257	RNase J family beta-CASP ribonuclease
JCVISYN3A_0259	NAD(+) kinase
JCVISYN3A_0260	Valine--tRNA ligase
JCVISYN3A_0262	Ribulose-phosphate 3-epimerase
JCVISYN3A_0263	Ribosome small subunit-dependent GTPase A
JCVISYN3A_0264	Uncharacterized serine/threonine protein kinase
JCVISYN3A_0281	Uncharacterized protein
JCVISYN3A_0282	Proline--tRNA ligase
JCVISYN3A_0283	Double-stranded RNA binding RNase HI
JCVISYN3A_0285	Elongation factor 4
JCVISYN3A_0286	Uncharacterized protein
JCVISYN3A_0287	Aspartate--tRNA ligase
JCVISYN3A_0288	Histidine--tRNA ligase
JCVISYN3A_0289	Ribosome-binding factor A
JCVISYN3A_0290	tRNA pseudouridine(55) synthase
JCVISYN3A_0291	FAD synthetase
JCVISYN3A_0296	Uncharacterized protein
JCVISYN3A_0297	Translation initiation factor IF-2
JCVISYN3A_0298	Uncharacterized L7Ae family protein
JCVISYN3A_0299	Uncharacterized protein
JCVISYN3A_0300	Transcription termination/antitermination nusA
JCVISYN3A_0301	Ribosome assembly cofactor rimP
JCVISYN3A_0302	Flavin reductase
JCVISYN3A_0304	Phosphatidate cytidylyltransferase
JCVISYN3A_0305	Uncharacterized metallopeptidase
JCVISYN3A_0308	Tryptophan--tRNA ligase
JCVISYN3A_0314	Uncharacterized ECF transporter S component
JCVISYN3A_0315	Uncharacterized protein
JCVISYN3A_0316	Transketolase
JCVISYN3A_0317	Uncharacterized protein
JCVISYN3A_0325	Uncharacterized protein
JCVISYN3A_0326	Uncharacterized protein
JCVISYN3A_0327,	Structural maintenance of chromosomes complex
0328,0415	
JCVISYN3A_0329	Uncharacterized pseudouridine synthase

JCVISYN3A_0330	Deoxyguanosine kinase
JCVISYN3A_0332	Uncharacterized protein
JCVISYN3A_0338	Uncharacterized lipoprotein
JCVISYN3A_0344	Inorganic diphosphatase
JCVISYN3A_0345	Uncharacterized ECF transporter S component
JCVISYN3A_0347	Cytidylate kinase
JCVISYN3A_0348	Ribosome biogenesis GTPase
JCVISYN3A_0350	DNA-binding protein HU
JCVISYN3A_0352	Uncharacterized protein
JCVISYN3A_0353	Uncharacterized protein
JCVISYN3A_0359	Ribonuclease Y
JCVISYN3A_0360,0429	Signal recognition particle
JCVISYN3A_0361	23S rRNA
JCVISYN3A_0363	16S rRNA processing protein
JCVISYN3A_0364	tRNA (guanosine(37)-N1)-methyltransferase
JCVISYN3A_0366	L16-binding dependent 50S subunit-maturation
JCVISYN3A_0371,0372	Flippase
JCVISYN3A_0373	Uncharacterized protein
JCVISYN3A_0375	Uncharacterized protein
JCVISYN3A_0376	Uncharacterized protein
JCVISYN3A_0377	Ribosome GTPase
JCVISYN3A_0378	NAD(+) synthase
JCVISYN3A_0380	Nicotinate (nicotinamide) nucleotide adenyllyltransferase
JCVISYN3A_0381	5'-Methylthioadenosine nucleosidase
JCVISYN3A_0382	Deoxynucleoside kinase
JCVISYN3A_0387	tRNA 2-thiouridine(34) synthase
JCVISYN3A_0389	Uncharacterized protein
JCVISYN3A_0390	Methionyl-tRNA formyltransferase
JCVISYN3A_0391	Elongation factor P
JCVISYN3A_0392	Uncharacterized protein
JCVISYN3A_0394	Endopeptidase La
JCVISYN3A_0398	Uncharacterized lipoprotein
JCVISYN3A_0400	Uncharacterized protease
JCVISYN3A_0401	Uncharacterized peptidase
JCVISYN3A_0402	rRNA maturation RNase
JCVISYN3A_0403	Ribosome GTPase
JCVISYN3A_0404	DNA repair protein recO
JCVISYN3A_0405	Glycine--tRNA ligase
JCVISYN3A_0408	Uncharacterized methyltransferase
JCVISYN3A_0409	Uncharacterized protein
JCVISYN3A_0410	Uncharacterized helicase
JCVISYN3A_0411	Uncharacterized protein
JCVISYN3A_0413	Adenine phosphoribosyltransferase
JCVISYN3A_0414	Guanosine-3',5'-bis(diphosphate) 3'-pyrophosphohydrolase
JCVISYN3A_0416	Uncharacterized protein
JCVISYN3A_0418	Ribonuclease III
JCVISYN3A_0419	Phosphate acyltransferase
JCVISYN3A_0420	Fatty acid kinase subunit A
JCVISYN3A_0421	Uncharacterized protein
JCVISYN3A_0424	Uncharacterized protein
JCVISYN3A_0425,0426,0427	Phosphate ABC transporter
JCVISYN3A_0428	Phosphate transport system regulatory protein
JCVISYN3A_0430	Uncharacterized DNA-binding protein
JCVISYN3A_0431	Uncharacterized metallophosphoesterase
JCVISYN3A_0432	Methionine adenosyltransferase
JCVISYN3A_0433	Uncharacterized protein
JCVISYN3A_0435	Mannose-6-phosphate isomerase
JCVISYN3A_0437	Putative 3'-5' exoribonuclease
JCVISYN3A_0438	Uncharacterized protein
JCVISYN3A_0439	Uncharacterized lipoprotein
JCVISYN3A_0440	Uncharacterized lipoprotein
JCVISYN3A_0441	Cysteine desulfurase
JCVISYN3A_0442	Iron-sulfur cluster assembly scaffold protein
JCVISYN3A_0443	5-Formyltetrahydrofolate cyclo-ligase
JCVISYN3A_0444	Uncharacterized peptidase
JCVISYN3A_0445	Glucose-6-phosphate isomerase
JCVISYN3A_0447	dUTP diphosphatase
JCVISYN3A_0448	Uncharacterized rRNA methyltransferase
JCVISYN3A_0451	Glyceraldehyde-3-phosphate dehydrogenase
JCVISYN3A_0452,0453	DNA topoisomerase IV
JCVISYN3A_0475	L-lactate dehydrogenase
JCVISYN3A_0478	Uncharacterized protein
JCVISYN3A_0479	Uncharacterized peptidase
JCVISYN3A_0481	Uncharacterized lipoprotein
JCVISYN3A_0493	Uncharacterized peptidase
JCVISYN3A_0494	N-acetylmannosamine-6-phosphate 2-epimerase
JCVISYN3A_0495	Uncharacterized kinase
JCVISYN3A_0500	Maturation protease for ribosomal protein L27



JCVISYN3A_0503	Uncharacterized protein
JCVISYN3A_0504	16S rRNA (cytidine(1402)-2'-O)-methyltransferase
JCVISYN3A_0505	Uncharacterized lipoprotein
JCVISYN3A_0511	Uncharacterized protein
JCVISYN3A_0512	Acyl-phosphate glycerol 3-phosphate acyltransferase
JCVISYN3A_0513	ACP synthase
JCVISYN3A_0515	Cytidine deaminase
JCVISYN3A_0516	Uncharacterized protein
JCVISYN3A_0517	Uncharacterized RNA pseudouridine synthase
JCVISYN3A_0518	Lipoprotein signal peptidase
JCVISYN3A_0519	Isoleucine--tRNA ligase
JCVISYN3A_0520	Uncharacterized hydrolase *
JCVISYN3A_0521	Cell division protein sepF *
JCVISYN3A_0522	Cell division protein ftsZ *
JCVISYN3A_0523	Cell division protein ftsA
JCVISYN3A_0524	16S rRNA (cytosine(1402)-N(4))-methyltransferase
JCVISYN3A_0525	Cell division/cell wall cluster transcriptional repressor
JCVISYN3A_0527	Uncharacterized protein *
JCVISYN3A_0528,0529	Phenylalanine--tRNA ligase
JCVISYN3A_0530	Uncharacterized protein
JCVISYN3A_0535	Arginine--tRNA ligase
JCVISYN3A_0536	Ribosome recycling factor
JCVISYN3A_0537	UMP kinase
JCVISYN3A_0538	Uncharacterized protein *
JCVISYN3A_0539	Translation elongation factor Ts
JCVISYN3A_0541	Molecular chaperone dnaJ
JCVISYN3A_0542	Molecular chaperone dnaK
JCVISYN3A_0543	Nucleotide exchange factor grpE
JCVISYN3A_0544	Heat-inducible transcription repressor
JCVISYN3A_0545	ATP-dependent Clp protease subunit B
JCVISYN3A_0548	tRNA (cytidine(34)-2'-O)-methyltransferase *
JCVISYN3A_0549	Non-canonical purine NTP pyrophosphatase *
JCVISYN3A_0592	Uncharacterized protein *
JCVISYN3A_0593	Uncharacterized protein *
JCVISYN3A_0600	Ribonuclease J
JCVISYN3A_0601	Uncharacterized protein
JCVISYN3A_0604	Uncharacterized protein *
JCVISYN3A_0605	Uncharacterized protein *
JCVISYN3A_0606	Phosphoglycerate kinase
JCVISYN3A_0607	Type I glyceraldehyde-3-phosphate dehydrogenase
JCVISYN3A_0610	DNA-formamidopyrimidine glycosylase *
JCVISYN3A_0611	DNA polymerase I
JCVISYN3A_0613	Tyrosine--tRNA ligase
JCVISYN3A_0614	Nicotinate phosphoribosyltransferase
JCVISYN3A_0615	Uncharacterized protein
JCVISYN3A_0616	Fatty acid binding protein
JCVISYN3A_0617	Fatty acid binding protein
JCVISYN3A_0620	Uncharacterized transcriptional regulator
JCVISYN3A_0621	Acyl carrier protein
JCVISYN3A_0622	Uncharacterized lipoprotein *
JCVISYN3A_0623	Uncharacterized protein *
JCVISYN3A_0634	Leucine--tRNA ligase
JCVISYN3A_0636	Uncharacterized lipoprotein
JCVISYN3A_0640	tRNA pseudouridine(38-40) synthase
JCVISYN3A_0641,0642,0643	ECF transporter
JCVISYN3A_0649	Translation initiation factor IF-1
JCVISYN3A_0650	Type I methionyl aminopeptidase
JCVISYN3A_0651	Adenylate kinase
JCVISYN3A_0652,0774,0839,0908	Preprotein translocase/insertase
JCVISYN3A_0684	5,10-Methylene-tetrahydrofolate dehydrogenase/cyclohydrolase
JCVISYN3A_0685	Ion transporter
JCVISYN3A_0685	Ion transporter
JCVISYN3A_0687,0688,0689	Glutamyl-tRNA amidotransferase
JCVISYN3A_0690	DNA ligase
JCVISYN3A_0691	Uncharacterized protein
JCVISYN3A_0692	Uncharacterized pseudouridine synthase
JCVISYN3A_0693	Uncharacterized protease
JCVISYN3A_0696	Uncharacterized transporter
JCVISYN3A_0697	Uncharacterized glycosyl transferase
JCVISYN3A_0706,0707,0708	Thiamine ABC transporter
JCVISYN3A_0710	Uncharacterized hydrolase
JCVISYN3A_0726	Glucosamine-6-phosphate deaminase
JCVISYN3A_0727	Triose-phosphate isomerase
JCVISYN3A_0728	Uncharacterized hydrolase
JCVISYN3A_0729	Phosphoglycerate mutase

JCVISYN3A_0730	Uncharacterized protein
JCVISYN3A_0732	Deoxyribose-phosphate aldolase
JCVISYN3A_0733	Phosphopentomutase
JCVISYN3A_0747	Purine-nucleoside phosphorylase
JCVISYN3A_0771-0773	Ribonucleotide-diphosphate reductase
JCVISYN3A_0775	Ribonuclease R
JCVISYN3A_0776	SsrA-binding protein/tmRNA
JCVISYN3A_0787	Magnesium-translocating P-type ATPase
JCVISYN3A_0789-0796	F0F1 ATP synthase
JCVISYN3A_0798	Uracil phosphoribosyltransferase
JCVISYN3A_0799	Serine hydroxymethyltransferase
JCVISYN3A_0800	Ribose 5-phosphate isomerase B
JCVISYN3A_0805	Uncharacterized protein
JCVISYN3A_0813	UDP-glucose 4-epimerase GalE
JCVISYN3A_0814	UDP-galactopyranose mutase
JCVISYN3A_0817	Uncharacterized DNA-binding protein
JCVISYN3A_0818	Diacylglyceryl transferase
JCVISYN3A_0819	Thioredoxin-disulfide reductase
JCVISYN3A_0820	Diacylglyceryl transferase
JCVISYN3A_0821	HPr(Ser) kinase/phosphatase
JCVISYN3A_0823	Dihydrofolate synthase
JCVISYN3A_0827	Uncharacterized protein
JCVISYN3A_0831	Phosphoribosylpyrophosphate synthetase
JCVISYN3A_0832	Aminoacyl-tRNA hydrolase
JCVISYN3A_0835	Uncharacterized lipoprotein
JCVISYN3A_0837	Cysteine--tRNA ligase
JCVISYN3A_0838	23S rRNA (guanosine(2251)-2'-O)-methyltransferase
JCVISYN3A_0840	Antitermination protein nusG
JCVISYN3A_0853	Uncharacterized protein
JCVISYN3A_0859	DNA topoisomerase I
JCVISYN3A_0870	Uncharacterized C4-dicarboxylate ABC transporter
JCVISYN3A_0872	Uncharacterized ATPase
JCVISYN3A_0873	Uncharacterized protein
JCVISYN3A_0874	16S rRNA (guanine(527)-N(7))-methyltransferase
JCVISYN3A_0875	CDP-diacylglycerol--glycerol-3-phosphate
JCVISYN3A_0876	Uncharacterized amino acid permease
JCVISYN3A_0877	Uncharacterized protein
JCVISYN3A_0878	Uncharacterized amino acid permease
JCVISYN3A_0879	Magnesium transporter
JCVISYN3A_0881	Uncharacterized MFS transporter
JCVISYN3A_0885	tRNA uridine(34) 5-carboxymethylaminomethyl synthesis enzyme
JCVISYN3A_0886	Proton-glutamate symporter
JCVISYN3A_0887	Coenzyme A disulfide reductase
JCVISYN3A_0906	Uncharacterized protein
JCVISYN3A_0907	Uncharacterized hydrolase
JCVISYN3A_0909	Ribonuclease P protein component
JCVISYN3A_0913	Tetracycline resistance ribosomal protection
JCVISYN3A_0918	Imidazoleglycerol-phosphate dehydratase
JCVISYN3A_0931	Adenylyl-sulfate kinase
JCVISYN3A_0005,0116, 0164,0235,0346,0379, 0388,0599,0777,0778, 0797,0830,0851,0852	Uncharacterized protein, not shown