RIBOSOME STRUCTURE AND ASSEMBLY

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RIBOSOME - STRUCTURE

- Ribosomes are non-membrane bound cell organelles made of RNA and proteins.
- Ribosomes are complex molecular machine that make proteins from amino acids in the process called protein synthesis or translation.
- Every cell needs ribosomes to manufacture proteins. Ribosomes are found in both prokaryotic and eukaryotic cells.
- Ribosomal structure and function are strikingly similar in all organisms and organelles.
- In eukaryotic organisms, ribosomes are found in cytoplasm, mitochondria and chloroplast.
- The cytoplasmic ribosomes are found free in the cytoplasm and attached to the endoplasmic reticulum. The endoplasmic reticulum associated with ribosomes are called rough endoplasmic reticulum.
- The ribosome found in mitochondria and chloroplast are structurally similar to the prokaryotic ribosomes.
- All prokaryotic ribosomes are found free in the cytoplasm of the cell.

- Each E. coli cell contains 15,000 or more ribosomes, which comprise nearly a quarter of the dry weight of the cell. Mammalian cells contain about 10 million ribosomes.
- The ribosomes are made of two subunits, the large and the small subunit which comprises ribosomal RNA (rRNA) and proteins.
- In prokaryotes, ribosomes are made up from three different rRNA molecules, whereas in eukaryotes ribosomes are made up from four different rRNA molecules.
- rRNA provides the ribosome with its basic form and function and proteins in ribosomes help fill in structural gaps and enhance the synthesis of proteins.
- The mass units of ribosomes are their Svedberg (S) values, which are based on how rapidly the subunits settle to the bottom of test tubes under the centripetal force of a centrifuge. The ribosomes of eukaryotic cells usually have Svedberg values of 80S and prokaryotes have 70S ribosomes.

RIBOSOME ASSEMBLY

- Prokaryotes have 70S ribosomes while eukaryotes have 80S ribosomes. But the structure and function of ribosomes are similar in both prokaryotes and eukaryotes.
- Bacterial ribosomes contain about 65% rRNA and 35% proteins.
- The diameter of ribosomes are about 18 nm and are composed of two unequal subunits with sedimentation coefficients of 30S and 50S and a combined sedimentation coefficient of 70S.
- In the late 1960s **Masayasu Nomura and colleagues** demonstrated that both ribosomal subunits can be broken down into their RNA and protein components, then reconstituted in vitro.
- The rRNA and proteins spontaneously reassemble to form 30S or 50S subunits nearly identical in structure and activity to native subunits.

- The first high-resolution structures of bacterial ribosomal subunits was explained by **Thomas Steitz, Ada Yonath, Venki Ramakrishnan, Harry Noller and others**.
- They elucidated that the ribosomal subunits are huge RNA molecules and the traditional focus on the protein components of ribosomes was shifted.
- In the 50S subunit, the 5S and 23S rRNAs form the structural core. The proteins are secondary elements in the complex, decorating the surface.
- There is no protein within 18 Å of the active site for peptide bond formation. The high resolution structure confirms, **the ribosome is a ribozyme**.
- In addition to the insight that the detailed structures of the ribosome and its subunits provide into the mechanism of protein synthesis, they have stimulated a new look at the evolution of life.

- The bacterial ribosome is complex, with a combined molecular weight of approx. 2.7 million.
- The two irregularly shaped ribosomal subunits fit together to form a cleft through which the mRNA passes as the ribosome moves along it during translation.
- The 57 proteins in bacterial ribosomes vary enormously in size and structure. Molecular weights range from about 6,000 to 75,000.
- Most of the proteins have globular domains arranged on the ribosome surface. Some also have snakelike extensions that protrude into the rRNA core of the ribosome, stabilizing its structure.

RNA and Protein Components of the prokaryotic ribosome (70S)

Subunit	Number of different proteins	Total number of proteins	Number and type of rRNAs
30S	21	21	1 (16S rRNA)
50S	33	36	2 (23S and 5S rRNA)

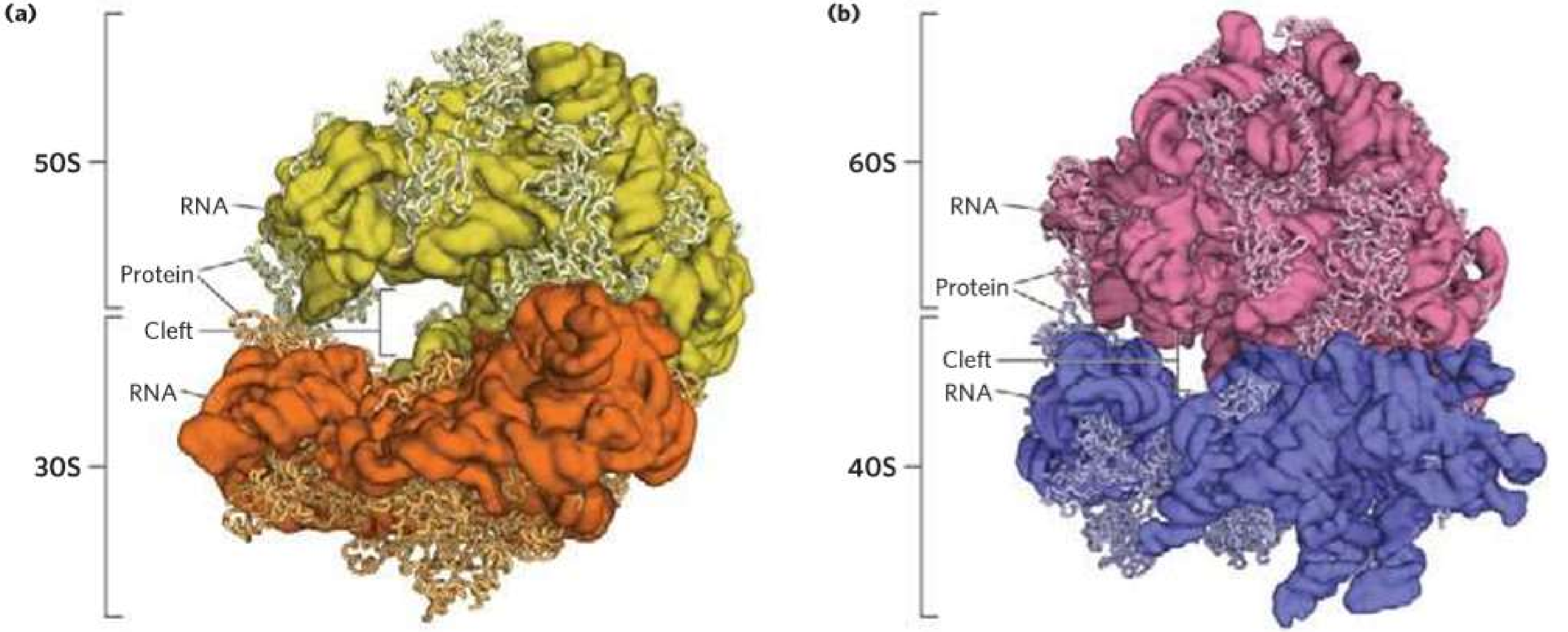


FIGURE 27–14 The structure of ribosomes. Our understanding of ribosome structure has been greatly enhanced by multiple high-resolution images of the ribosomes from bacteria and yeast. **(a)** The bacterial ribosome (derived from PDB ID 2OW8 and PDB ID 1VSA). The 50S and 30S subunits come together to form the 70S ribosome. A cleft between them is where protein synthesis occurs. **(b)** The yeast ribosome has a similar structure with somewhat increased complexity (derived from PDB ID 3O58 and PDB ID 3O2Z).

- The ribosomes of eukaryotic cells (other than mitochondrial and chloroplast ribosomes) are larger and more complex than bacterial ribosomes, with a diameter of about 23 nm and a sedimentation coefficient of about 80S.
- They also have two subunits, which vary in size among species but on average are 60S and 40S.
- Eukaryotic ribosomes contain more than 80 different proteins. The ribosomes of mitochondria and chloroplasts are somewhat smaller and simpler than bacterial ribosomes.

RNA and Protein Components of the Eukaryotic ribosome (80S)

Subunit	Number of different proteins	Total number of proteins	Number and type of rRNAs
40S	33	33	1 (18S rRNA)
60S	47	47	3 (28S, 5.8S and 5S rRNA)

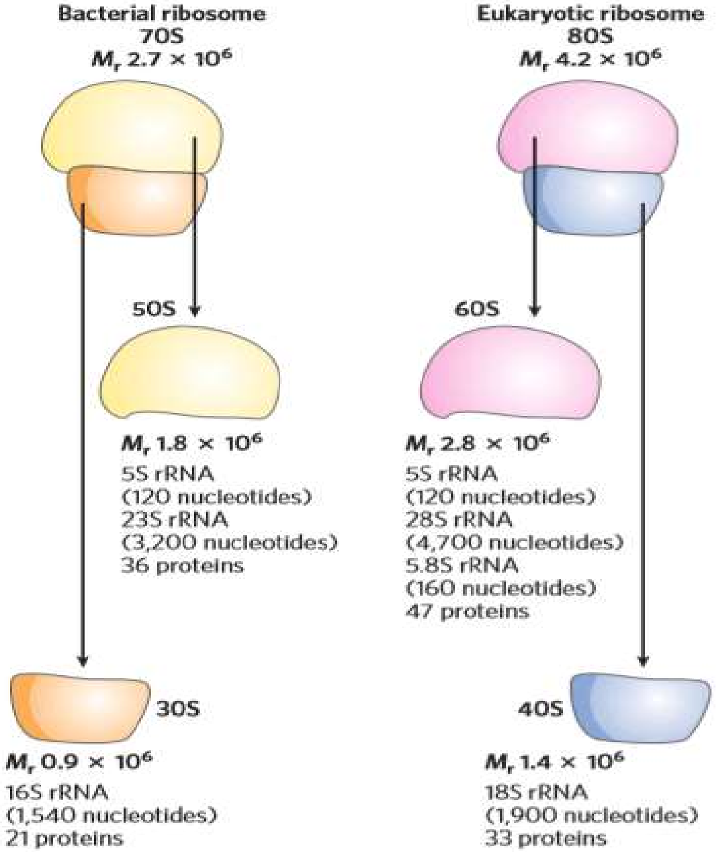
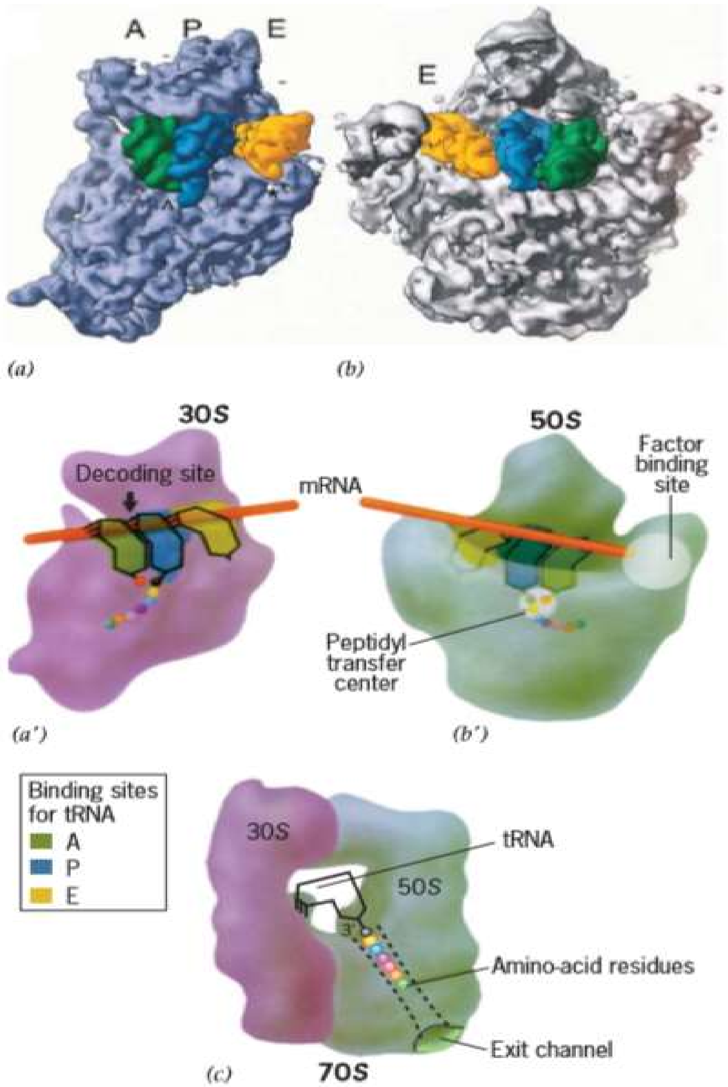


FIGURE 27–16 Summary of the composition and mass of ribosomes in bacteria and eukaryotes. Ribosomal subunits are identified by their S (Svedberg unit) values, sedimentation coefficients that refer to their rate of sedimentation in a centrifuge. The S values are not additive when subunits are combined, because S values are approximately proportional to the ⅔ power of molecular weight and are also slightly affected by shape.

- Each ribosome has three sites for association with transfer RNA molecules. These sites, termed the A (aminoacyl) site, the P (peptidyl) site, and the E (exit) site, receive each tRNA in successive steps of the elongation cycle.
- The interface between the small and large subunits forms a relatively spacious cavity that is lined almost exclusively by RNA.
- The surfaces of the two subunits that face one another contain the binding sites for the mRNA and incoming tRNAs and, thus, are of key importance for the function of the ribosome.
- The active site, where amino acids are covalently linked to one another, also consists of RNA. This catalytic portion of the large subunit resides in a deep cleft, which protects the newly formed peptide bond from hydrolysis by the aqueous solvent.
- The mRNA is situated in a narrow groove that winds around the neck of the small subunit, passing through the A, P, and E sites. Prior to entering the A site, the mRNA is stripped of any secondary structure it might possess by an apparent helicase activity of the ribosome.
- A tunnel runs completely through the core of the large subunit beginning at the active site. This tunnel provides a passageway for translocation of the elongating polypeptide through the ribosome
- Most of the proteins of the ribosomal subunits have multiple RNA-binding sites and are ideally situated to stabilize the complex tertiary structure of the rRNAs.



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Thank You