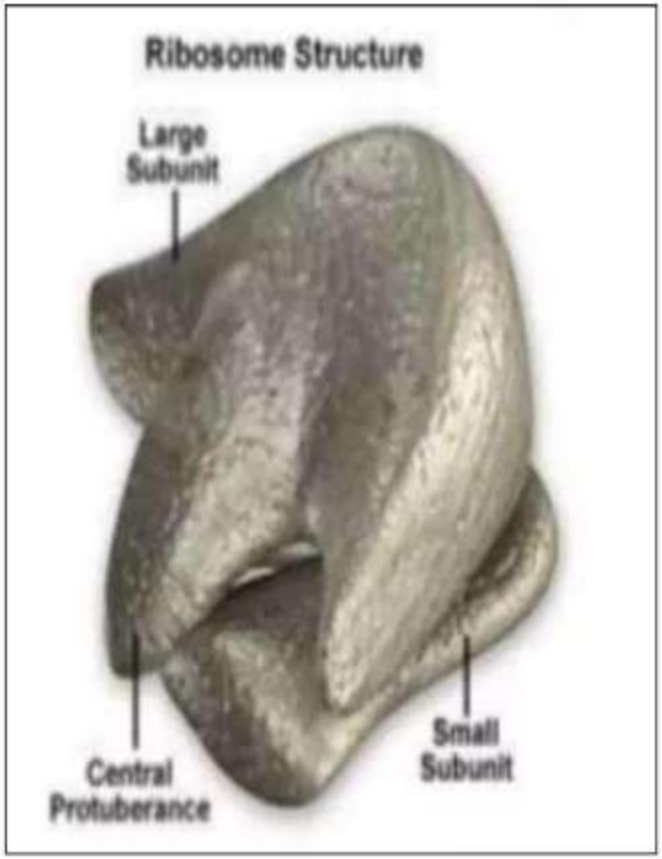
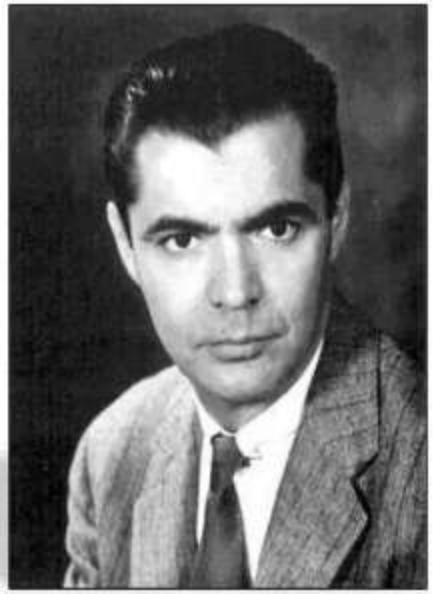
What are Ribosomes?

- Cell have a tiny (small) granular structures known as **Ribosomes**.
- Ribosomes are **Ribonucleo- Protein Particles**.
- Ribosomes are assembly shops for Protein Synthesis.



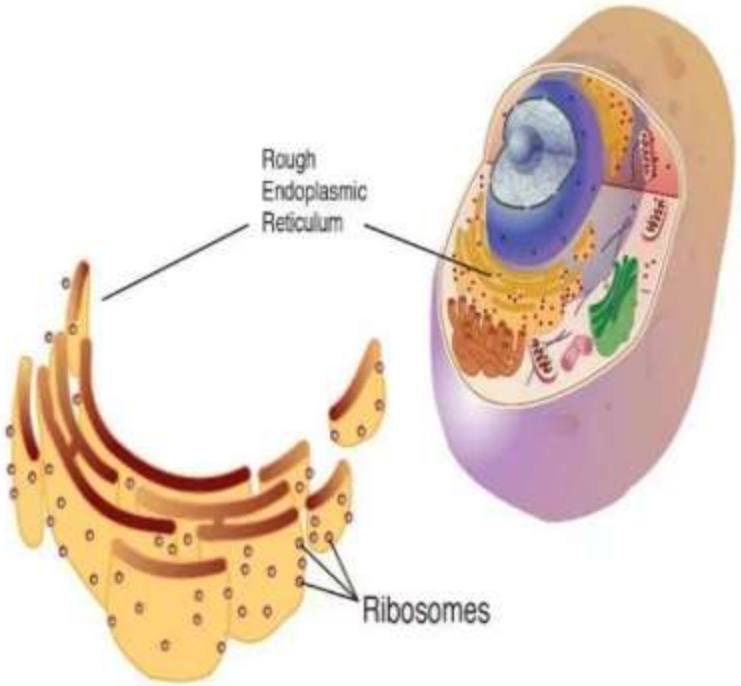
Discovery of Ribosomes

- The ribosomes are first noted in plant cells by Robinson and Brown in 1953.
- Shortly afterward **Palade** in 1955 observed them in animal cells.
- He isolated the ribosomes and detected the RNA in them in 1956.
- Albert Claude, Christian de Duve, and George Emil Palade were jointly awarded the Nobel Prize in Physiology or Medicine, in 1974, for the discovery of the ribosome.
- The Nobel Prize in Chemistry 2009 was awarded to **Venkatraman Ramakrishnan**, Thomas Steitz and



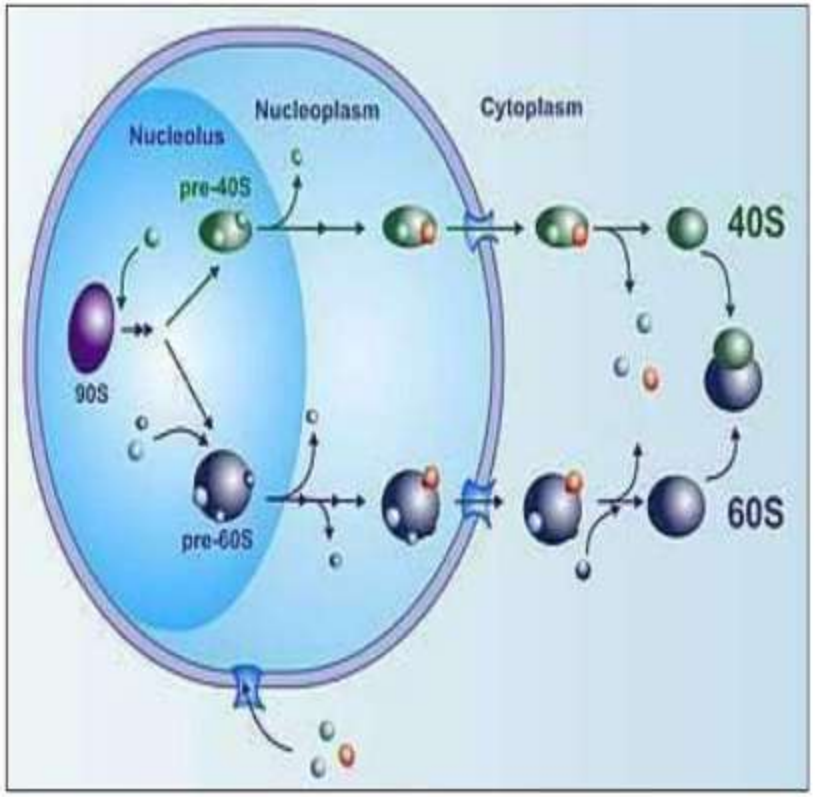
Occurrence

- Ribosomes are occur in the cells, both prokaryotic and eukaryotic cells.
- In prokaryotic cells the ribosomes often occur freely in the cytoplasm. But in eukaryotic cells attached to the outer surface of the membrane of Endoplasmic Reticulum



Ribosome Biogenesis

- It is the process of making Ribosomes in the nucleus
- The protein parts are made in the cytoplasm (Ribosome)
- Then transferred to the nucleus (Nuclear Pores)
- rRNAs are transcribed in the nucleolus
- The ribosomal proteins and rRNAs bind together
- Small and large subunits are made
- They are transported out of nucleus

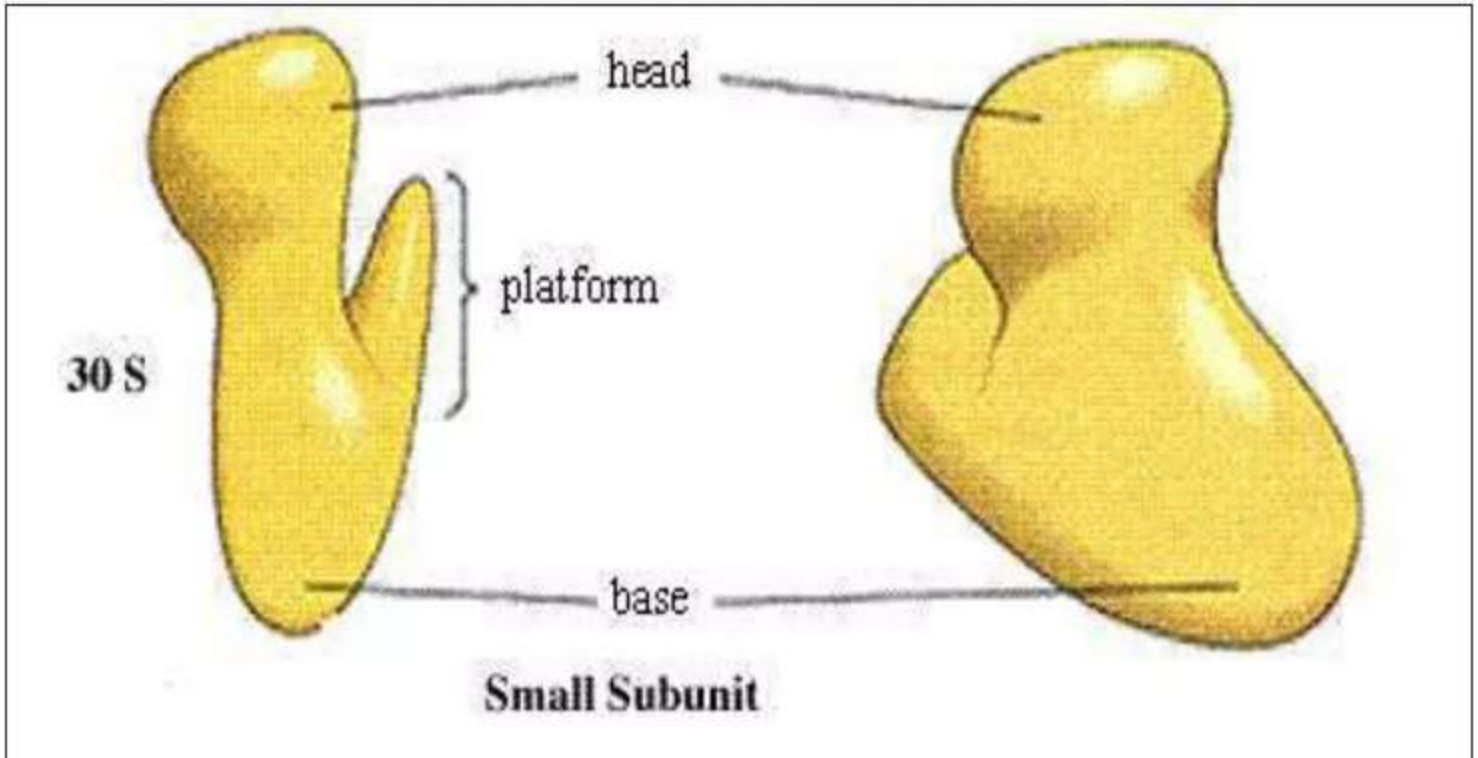


Structure of Ribosomes

- Ribosomes are spherical in shape.
- The ribosomes of prokaryotes are smaller in size and those of eukaryotes are larger in size.
  - In prokaryotes, they are 150 A° and
  - In eukaryotes, they are 250A° in diameter.
- Ribosomes are spherical bodies.
- Each ribosomes consists of two subunits, namely
  - 1.large subunits
  - 2. small subunits
- The subunits occur separately in the cytoplasm.
- They join together to form ribosomes only at the time of Protein synthesis.

30S small Subunit

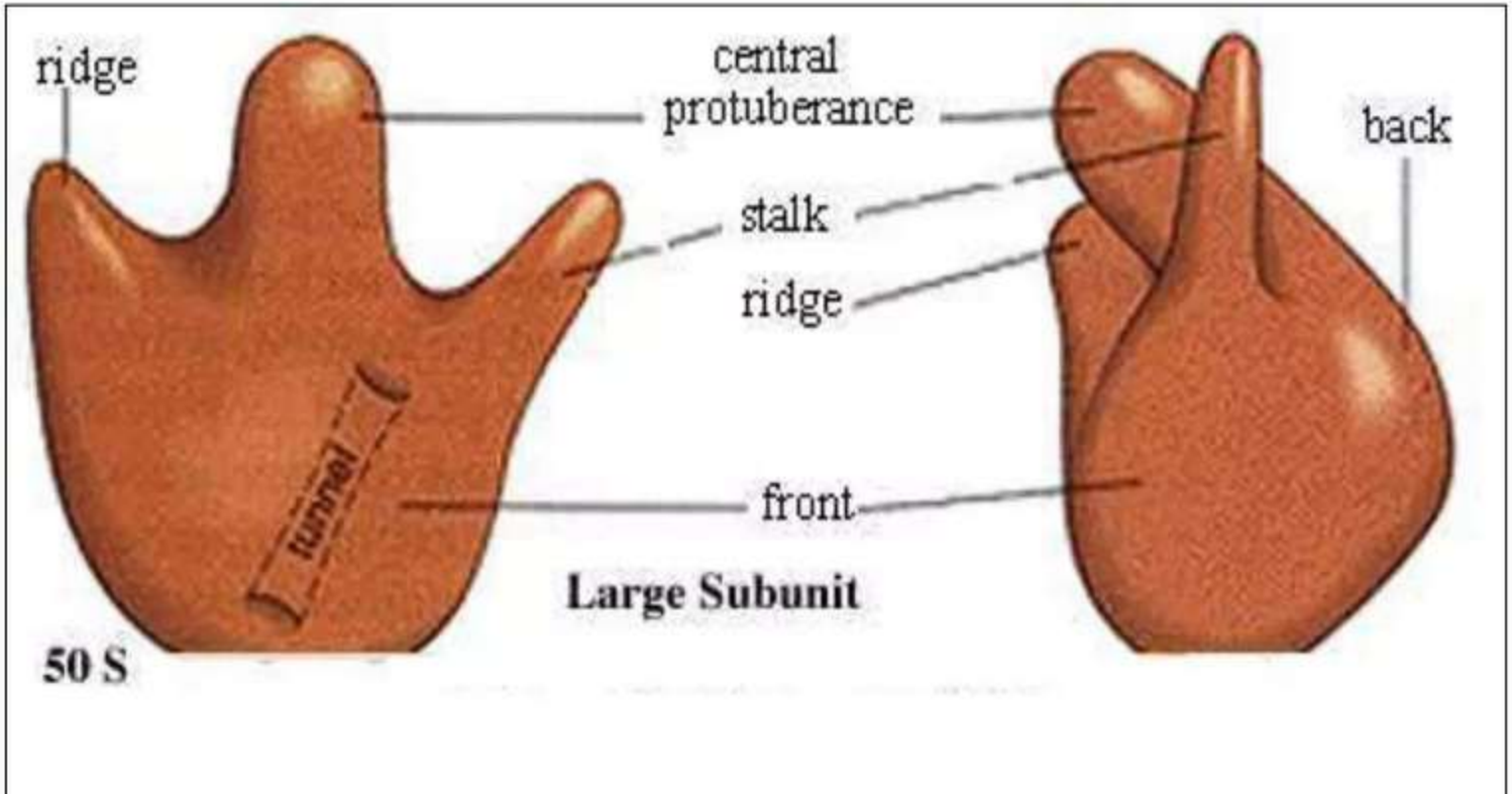
- 30S subunit is smaller and has a molecular weight of 0.9×10^6 Daltons
- it is made up of 16 S rRNA and 21 polypeptide chains



Small Subunit

50S large subunit

- The subunit is larger one and has a molecular weight of about 1.8×10^6 Daltons.
- It consists of 5S rRNA, 23S rRNA and 34 polypeptide chains

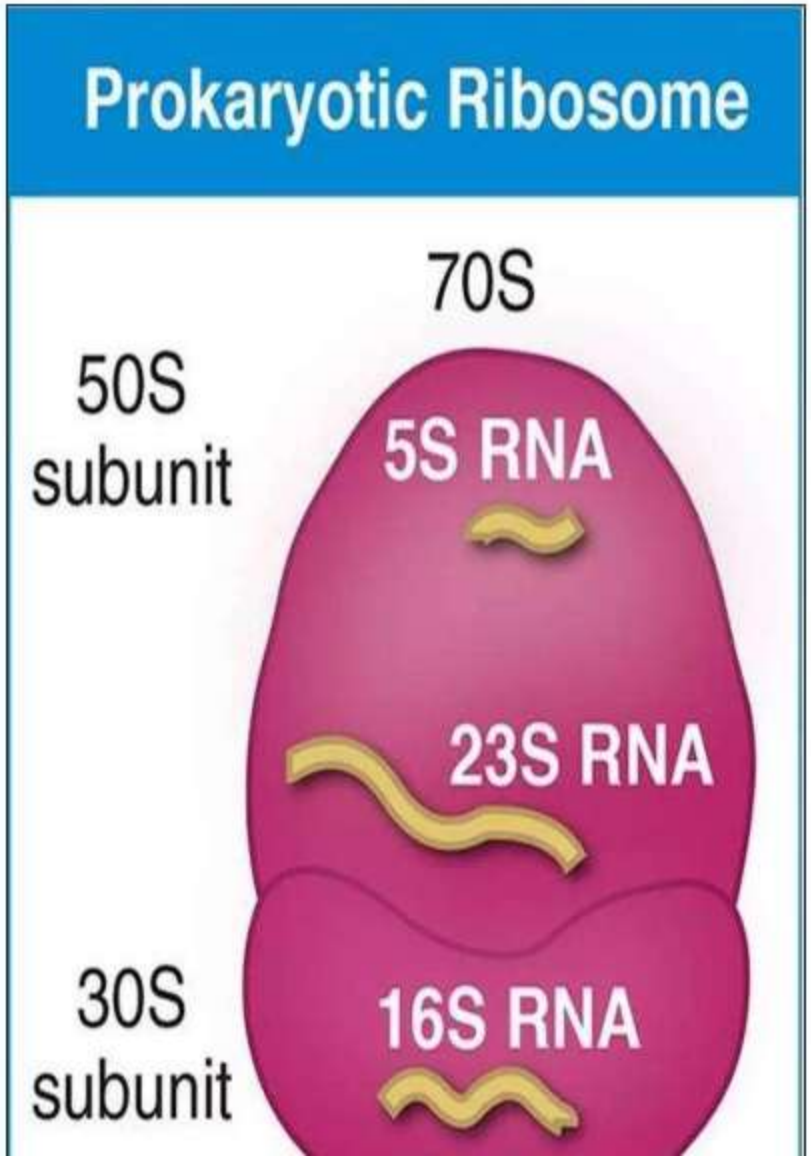


Svedberg unit

- The S in 70S and similar values stand for **Svedberg units**
- The faster a particle travels when centrifuged, the greater its Svedberg value or Sedimentation coefficient
- The sedimentation coefficient is a function of a particles molecular weight, volume and shape
- Heavier and more compact particles normally have larger Svedberg

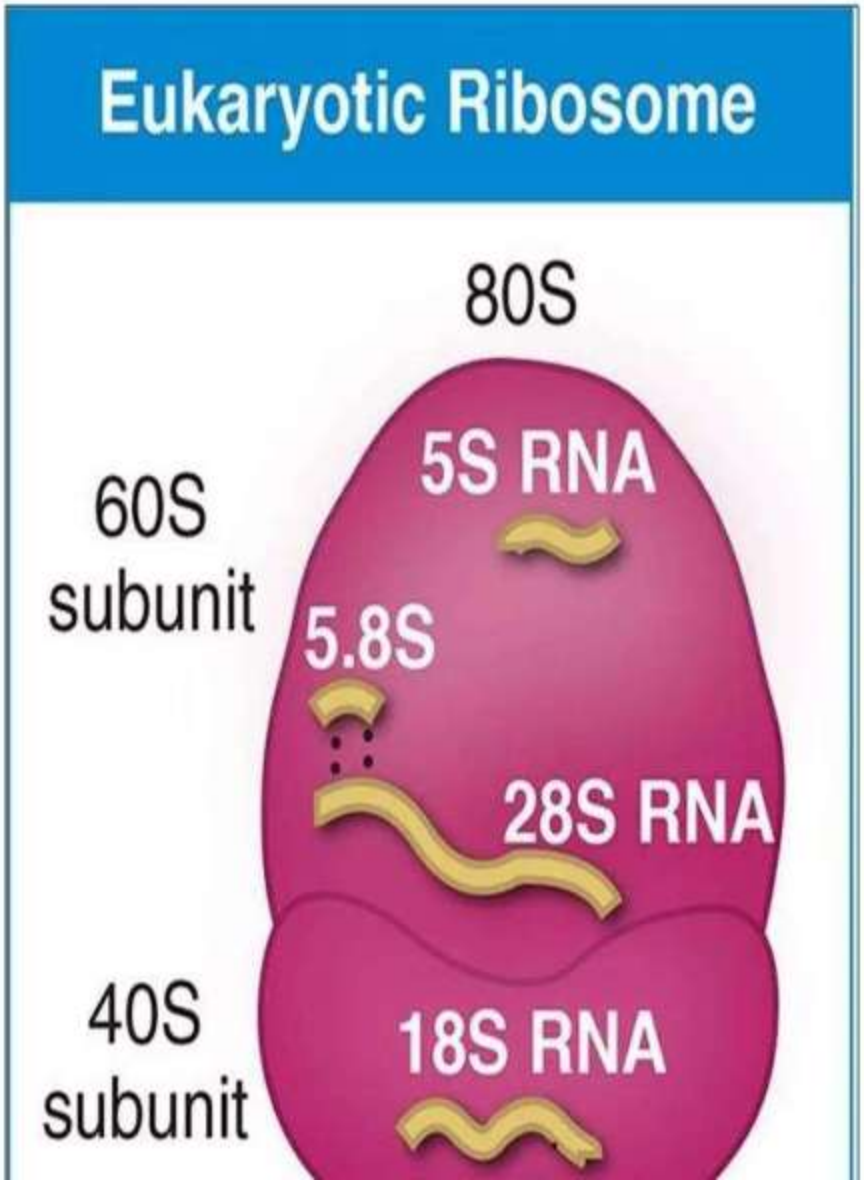
70S Ribosomes

- The 70S ribosomes is found in prokaryotic cells.
- Its very smaller in size and it has a sedimentation co-efficient of 70S.
- It has a molecular weight of 3×10^6 Daltons. It is composed of rRNA proteins.
- The 70S ribosomes made up of two subunits, namely a large 50S and a small 30S.
- Each subunits made up of rRNA and ribosomal proteins. The 50S subunit is composed of 23S rRNA, 5S rRNA and about 30 different proteins.



80S Ribosomes

- The 80S ribosomes are eukaryotes.
- It is larger in size and has a sedimentation co-efficient of 80S.
- It has a molecular weight of 5×10^6 Daltons.
- It is composed of rRNA and Ribosomal proteins.
- The 80S ribosomes made up of two subunits, namely a large 60S and a small 40S.
- Each subunits composed of ribosomal proteins and rRNA. The 60S sub unit has 28S rRNA, 5.8S rRNA, 5S rRNA and about 50 different proteins.



Types of ribosomes

- **Matrix Ribosomes (Mitochondrial Ribosomes):**
  - Smaller than cytoplasmic ones
  - Sedimentation coefficient of 55S with 35S and 25S subunit
  - More similar to bacterial ribosome
  - Protein synthesis takes place in mitochondria with the help of mitochondrial ribosome
  - These synthesize proteins destined to remain within the cell.
- **Plasma membrane Ribosomes or Cytoribosomes:**

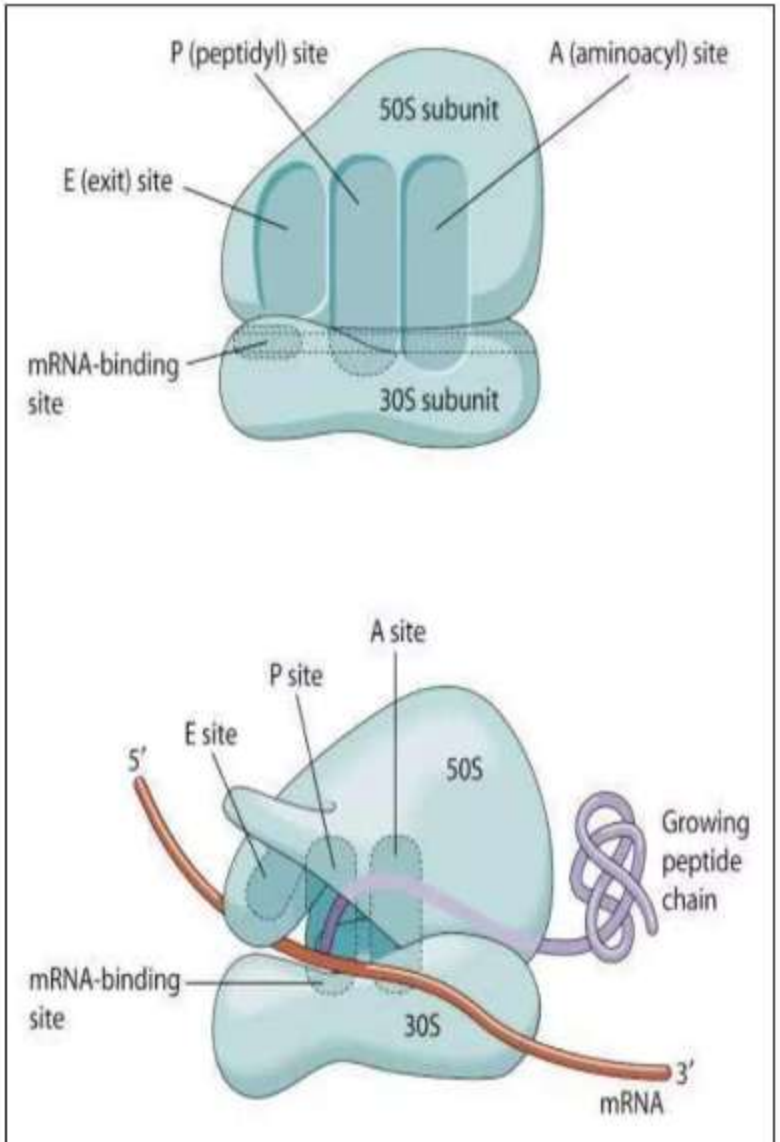
Domains of Ribosomes

There are two domains of Ribosomes

- **Translational domain:**
  - The region responsible for translation is called the Translational domain
  - Both subunits contribute to this domain, located in the upper half of the small subunit and in the associated areas of the large subunit
- **Exit Domain:**
  - The growing peptide chain emerges from the large subunit at the exit domain
  - This is located on the side of the subunit.

Sites of Ribosomes

- The ribosomes has three sites for binding t-RNA
- **The peptidyl or donor site (P site)** – Which holds the tRNA with the nascent peptide chain
- **The Aminoacyl or Acceptor Site (the A site)** – Which accepts the incoming aminoacylated tRNA
- **The exit site (the E site)** – which holds the deacylated tRNA before it leaves the ribosome.



Chemical Composition

The ribosomes contain RNAs, proteins and metal ions.

1. Ribosomal RNA.
2. Ribosomal proteins.
3. Metal ions.

1. Ribosomal RNA

- The RNA present in the ribosomes are called rRNA.
- In eukaryotic cells, rRNAs are found in four forms, namely 28S rRNA, 18S rRNA, 5S rRNA and 5.8S rRNA. 18S rRNA present in small subunit and others are found in the larger subunit.
- In prokaryotic cells, they are form of 23S rRNA, 16S rRNA and 5S rRNA. 5S rRNA

2. Ribosomal proteins:

- The 70S ribosomes contain 50 to 60 proteins.
- The 80S ribosomes has 70 to 80 proteins. These proteins are two types, namely
  a. core proteins (CP)
  b. Spilt proteins (SP)

3. Metal ions

Ribosomes contain a number of metal ions such Mg, Ca, Mn, Fe, etc.

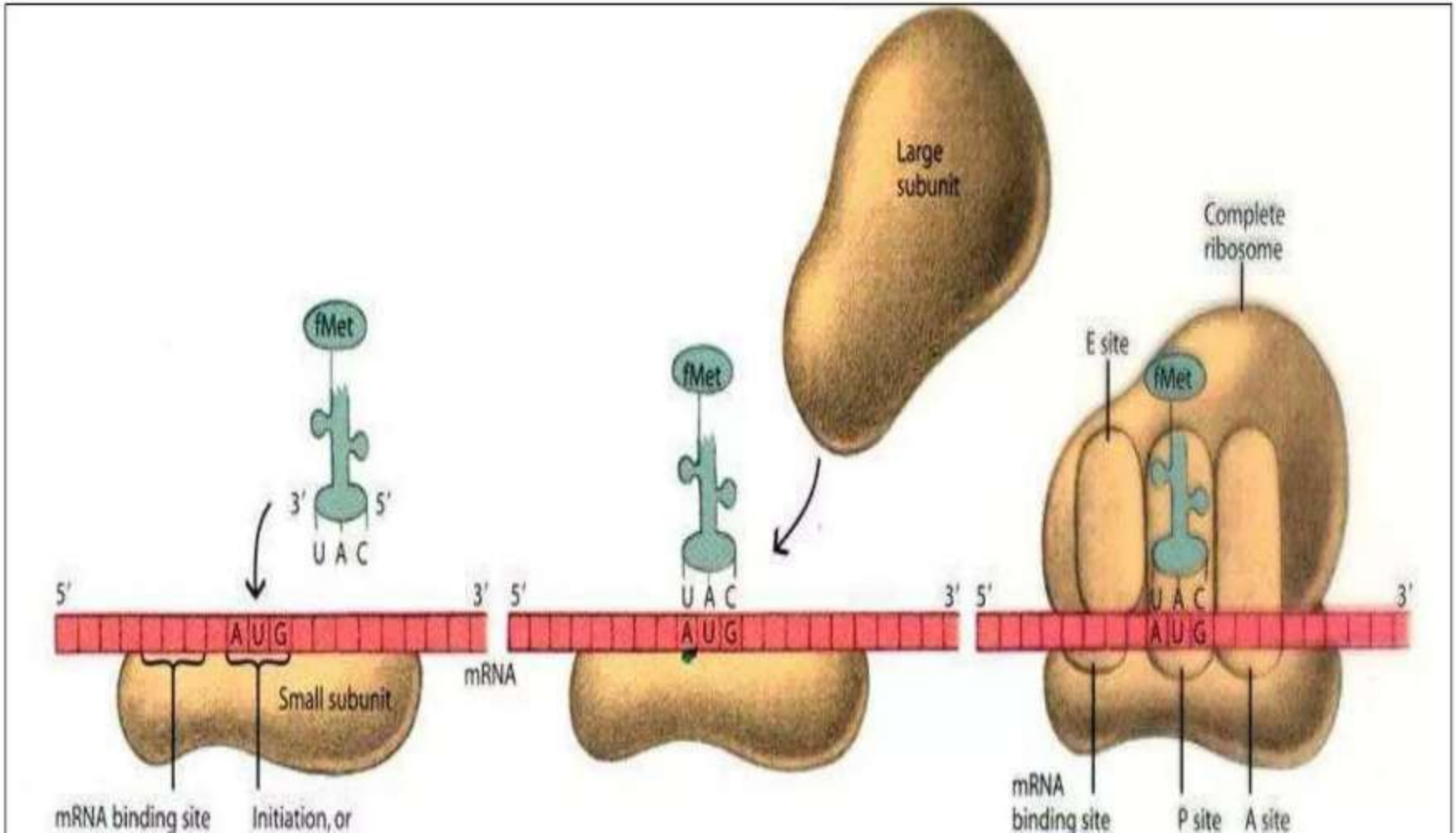
Functions of Ribosomes

- Main function of the Ribosome is involved in the process of **Protein Synthesis**
- Protein Synthesis is divided into three stages:
  1. Initiation
  2. Elongation
  3. Termination

Initiation

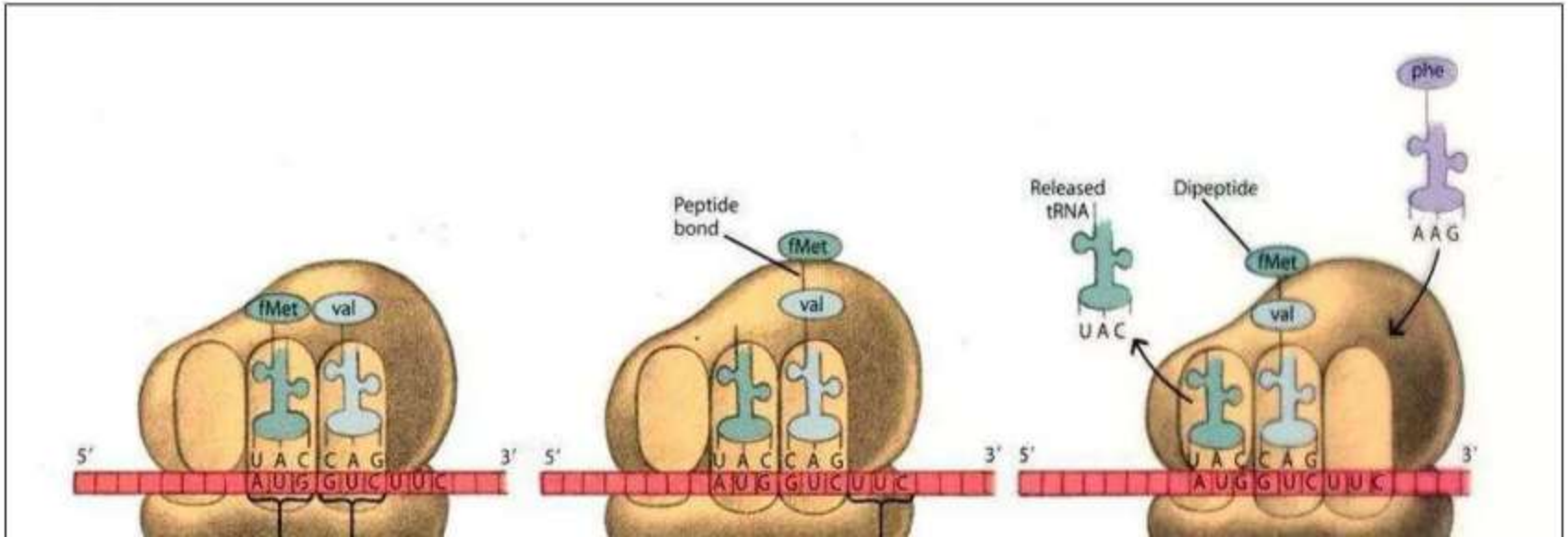
- The necessary Components Assemble:
  - The two ribosomal subunits
  - A tRNA with the anticodon UAC
  - The mRNA molecule to be translated
  - Along with several additional protein factors
- In E.coli and most bacteria translation begin with specially modified aminoacyl tRNA, N-formylmethionyl tRNA
- Because the α-amino is blocked by a formyl group, this aminoacyl tRNA can be used only for initiation
- This N-formylmethionyl-tRNA attaches itself to the P Site of ribosome(Peptidyl Site)
- mRNA have a special "Initiation Codon" (AUG) that specifically binds with the fMet tRNA anticodon
- Finally, the 50S subunit binds to the 30S subunit mRNA, forming an active ribosome mRNA complex

Initiation


Large subunit
Complete ribosome
fMet
E site
3'
5'
U A C
5'
3'
A U G
Small subunit
mRNA
mRNA binding site
Initiation, or
P site
A site

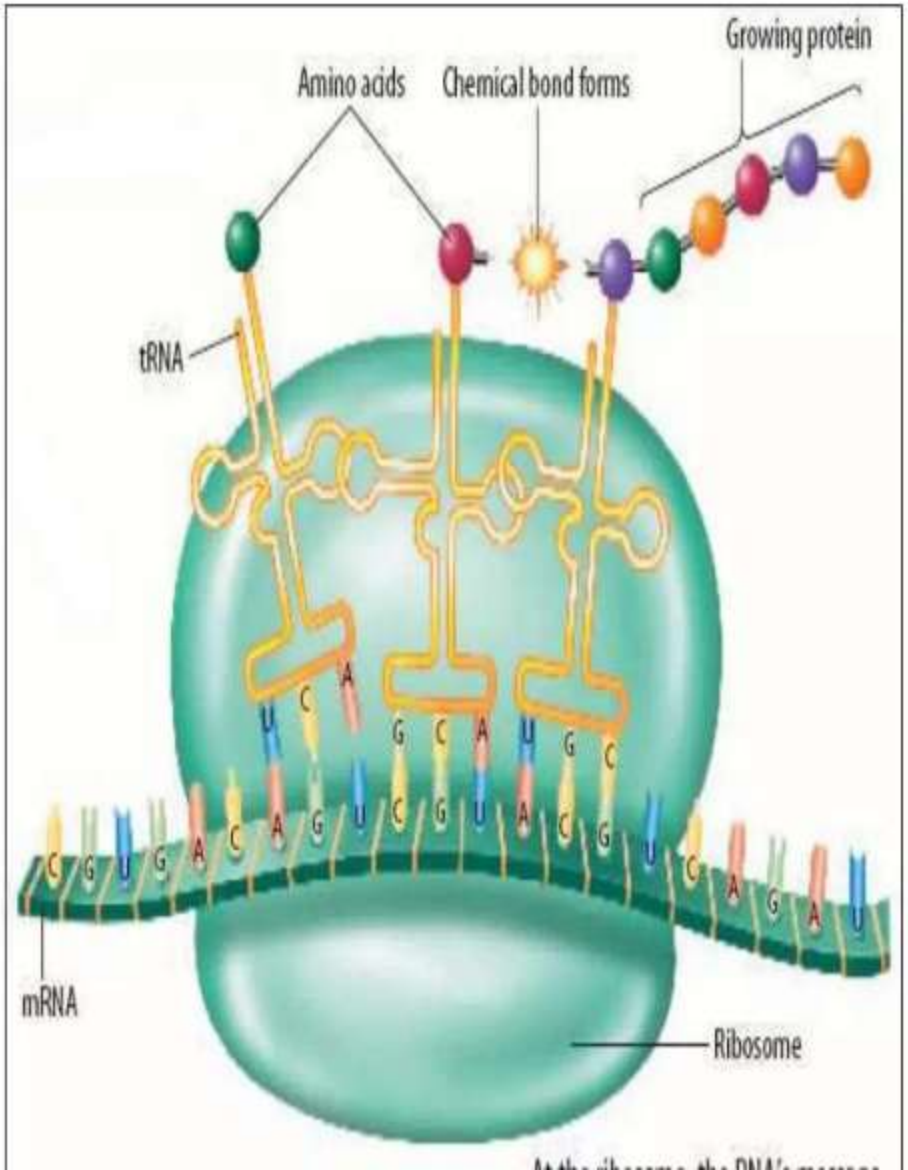
Elongation

- At the beginning of elongation cycle, the Peptide Site (P Site) is filled with N-formymethionyl- tRNA and aminoacyl(A Site) with Exit Site(E Site) are empty
- Aminoacyl-tRNA Binding: The next codon is located with A site and is ready to direct the binding of an aminoacyl-tRNA
- GTP and Elongation factor donate the aminoacyl-tRNA to ribosomes



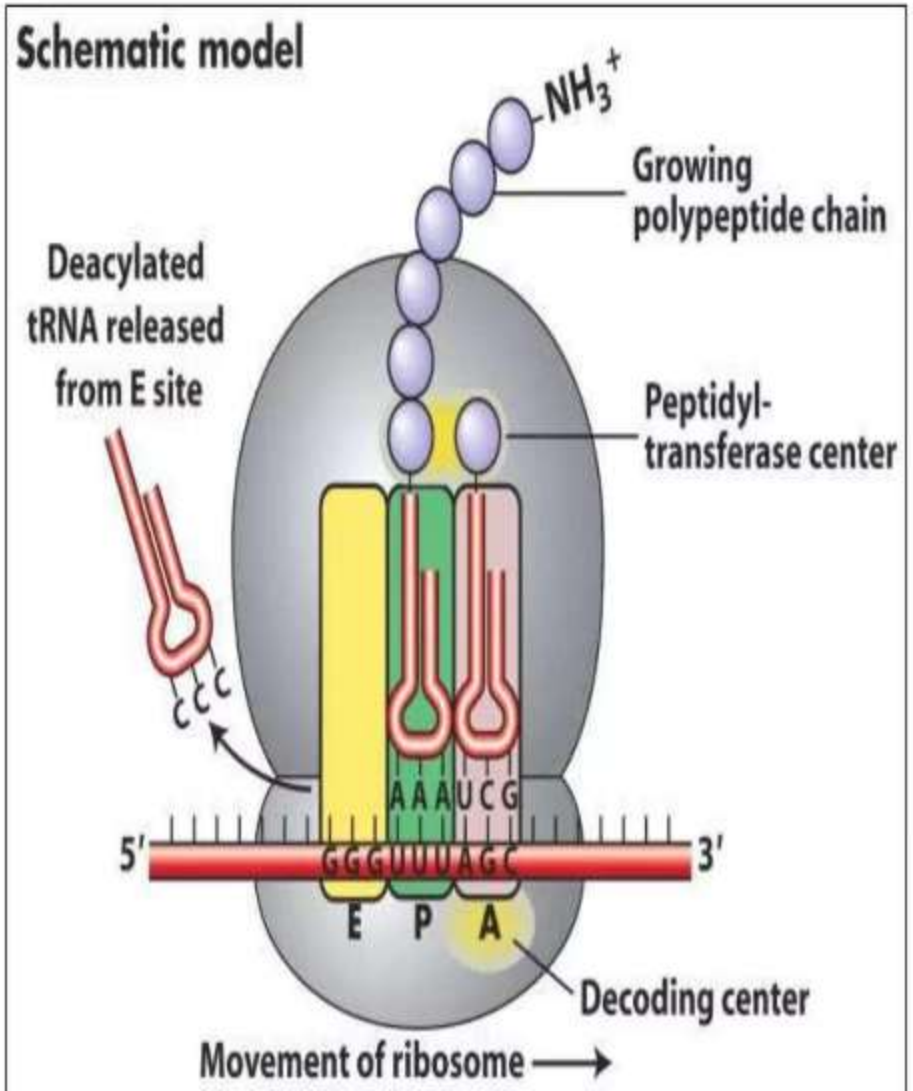
Transpeptidation Reaction:

- Peptidyl transferase, located on 50S Subunit catalyse the transpeptidation reaction
- The α-amino group of A site amino acid attacks α-carboxyl group of C-terminal amino acid on P site tRNA in this reaction resulting in peptide bond formation
- A specific adenine base seems to participate in catalyzing peptide bond



Translocation:

- Movement of Ribosome on mRNA is called Translocation
- There are three Phases of Translocation
  - The peptidyl-tRNA moves from the A site to P site
  - The ribosome moves one codon along mRNA so that a new codon is positioned in the A site
  - The empty tRNA leaves the P site
- Translocation requires GTP and elongation factor complex to proceed



Termination

- Protein Synthesis stops when the ribosomes reaches one of three special non-sense codons- UAA, UAG, UGA
- Three release factors(RF-1, RF-2, RF-3) aid the ribosomes in recognizing these codons
- After the ribosome has stopped, peptidyl transferase hydrolyzes the peptide free from its tRNA, and the empty tRNA is released GTP hydrolyzes required for this process
- Last tRNA leaves ribosomes, leaving behind completed peptide.
- Next the ribosome dissociates from its mRNA and separates into 30S and 50S subunits and will remain this way until another mRNA comes along to restart the process.