Nucleolus
Structure and Functions

Structure of the Nucleolus

The nucleolus is the most prominent organelle in the mammalian nucleus, and was first observed more than 200 years ago.

It was first described in the early 1830s as a “nucleus within the nucleus,” with the name “nucleolus” coined by the German physiologist Gabriel Gustav Valentin

Nucleoli are small basophilic spherical bodies located in the nucleus. Usually they can be found in the central nuclear region but may also be close to the nuclear membrane. A nucleolus is built by a nucleolus organizing region (NOR) of a specific chromosome. These regions contain the genes for ribosomal RNA subunits that build the protein synthesis machinery.

Structure of the Nucleolus

In eukaryotic cells, nucleolus has a well-ordered structure with four main ultrastructural components.

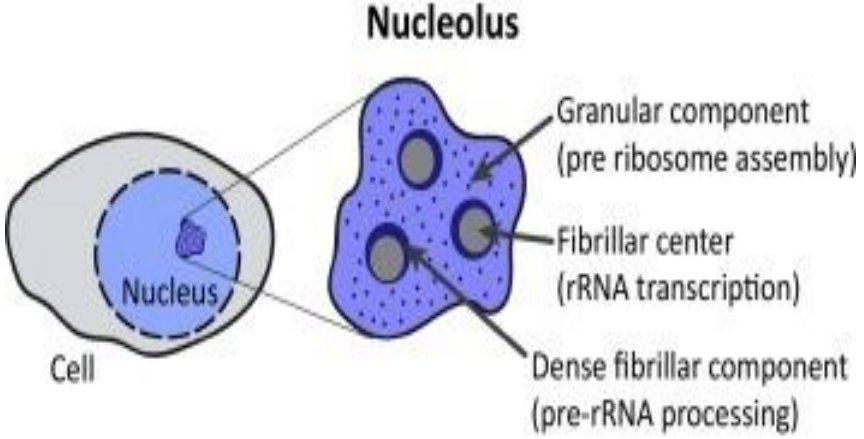
Fibrillar Centers: It is the place where the ribosomal proteins are formed.
Granular Components: Before ribosomes are formed, these components have rRNA that binds to ribosomal proteins.
Dense Fibrillar Components: It has new transcribed RNA, which connects to the ribosomal proteins.
Nucleolar vacuoles: It is present only in plant cells.

Morphologically, nucleoli consist of three distinguishable regions:

the **fibrillar center,**

dense fibrillar component, and

granular component .



These different regions are thought to represent the sites of progressive stages of rRNA transcription, processing, and ribosome assembly.

The rRNA genes are located in the fibrillar centers, with transcription occurring primarily at the boundary of the fibrillar centers and dense fibrillar component.

Processing of the pre-rRNA is initiated in the dense fibrillar component and continues in the granular component, where the rRNA is assembled with ribosomal proteins to form nearly completed preribosomal subunits, ready for export to the cytoplasm.

Nucleoli have two distinctive regions, the pars fibrosa that contains the proteins required for transcription and the pars granulosa that contains the ribosomal precursors. During mitosis, nucleoli disappear and are reconstituted in the daughter cells. Shortly after cell division, a larger number of nucleoli that fuse gradually can be observed.

The most prominent substructure within the nucleus is the nucleolus , which is the site of rRNA transcription and processing, and of ribosome assembly.

cells require large numbers of ribosome to meet their needs for protein synthesis. Actively growing mammalian cells, for example, contain 5 million to 10 million ribosomes that must be synthesized each time the cell divides.

The nucleolus is a ribosome production factory, designed to fulfill the need for large-scale production of rRNAs and assembly of the ribosomal subunits.

Ribosomal RNA Genes and the Organization of the Nucleolus

The nucleolus, which is not surrounded by a membrane, is organized around the chromosomal regions that contain the genes for the 5.8S, 18S, and 28S rRNAs.

Eukaryotic ribosome contain four types of RNA, designated the 5S, 5.8S, 18S, and 28S rRNAs. The 5.8S, 18S, and 28S rRNAs are transcribed as a single unit within the nucleolus by RNA polymerase I, yielding a 45S ribosomal precursor RNA. The 45S pre-rRNA is processed to the 18S rRNA of the 40S (small) ribosomal subunit and to the 5.8S and 28S rRNAs of the 60S (large) ribosomal subunit.

Transcription of the 5S rRNA, which is also found in the 60S ribosomal subunit, takes place outside of the nucleolus and is catalyzed by RNA polymerase III.

To meet the need for transcription of large numbers of rRNA molecules, all cells contain multiple copies of the rRNA genes.

The human genome, for example, contains about 200 copies of the gene that encodes the 5.8S, 18S, and 28S rRNAs and approximately 2000 copies of the gene that encodes 5S rRNA.

The genes for 5.8S, 18S, and 28S rRNAs are clustered in tandem arrays on five different human chromosomes (chromosomes 13, 14, 15, 21, and 22); the 5S rRNA genes are present in a single tandem array on chromosome 1.

Following each cell division, nucleoli form around the chromosomal regions that contain the 5.8S, 18S, and 28S rRNA genes, which are therefore called **nucleolar organizing regions**.

The formation of nucleoli requires the transcription of 45S pre-rRNA, which appears to lead to the fusion of small prenucleolar bodies that contain processing factors and other components of the nucleolus.

In most cells, the initially separate nucleoli then fuse to form a single nucleolus. The size of the nucleolus depends on the metabolic activity of the cell, with large nucleoli found in cells that are actively engaged in protein synthesis.

This variation is due primarily to differences in the size of the granular component, reflecting the levels of ribosome synthesis.