

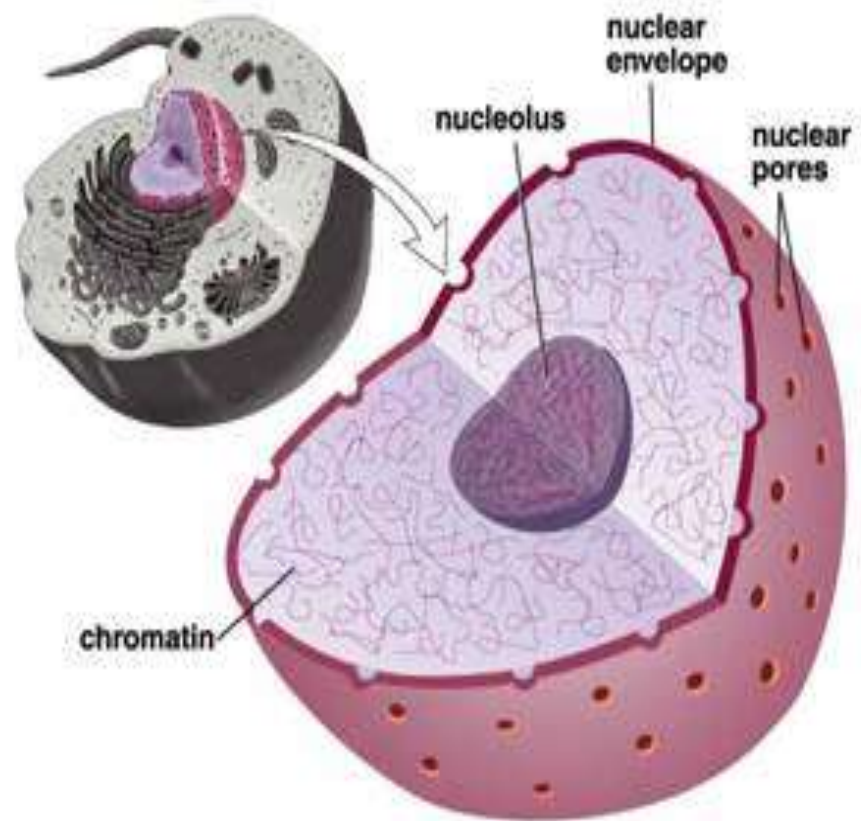
NUCLEOLUS

Dr. Indrani Das



The Nucleolus

The round granular structure within the nucleus of a cell, and composed of protein and RNA



STRUCTURE OF NUCLEOLUS:

- ◉ Estable and Sotelo (1951) described the structure of a nucleolus under the light microscope.
- ◉ According to them, nucleolus consists of a continuous coiled filament called the nucleolonema embedded in a homogenous matrix, the **pars amorpha**.
- ◉ The first description of nucleolar ultra structure was given by Borysko and Bang (1951) and Bernhard (1952).
- ◉ They described two main nucleolar components, a filamentous one corresponding to the nucleolonema and a homogenous one corresponding to the pars amorpha (matrix).

CONTD....

- ◎ Later on, Gonzales- Remirez (1961) and Izard & Bernhard (1962) demonstrated that the nucleolonema consists of a spongy net work in place of a continuous filament.
- ◎ The ultra structure of the nucleolus have been reviewed by Day (1968), Bernhard and Granboulan (1968) and Bush and Smetana (1970).

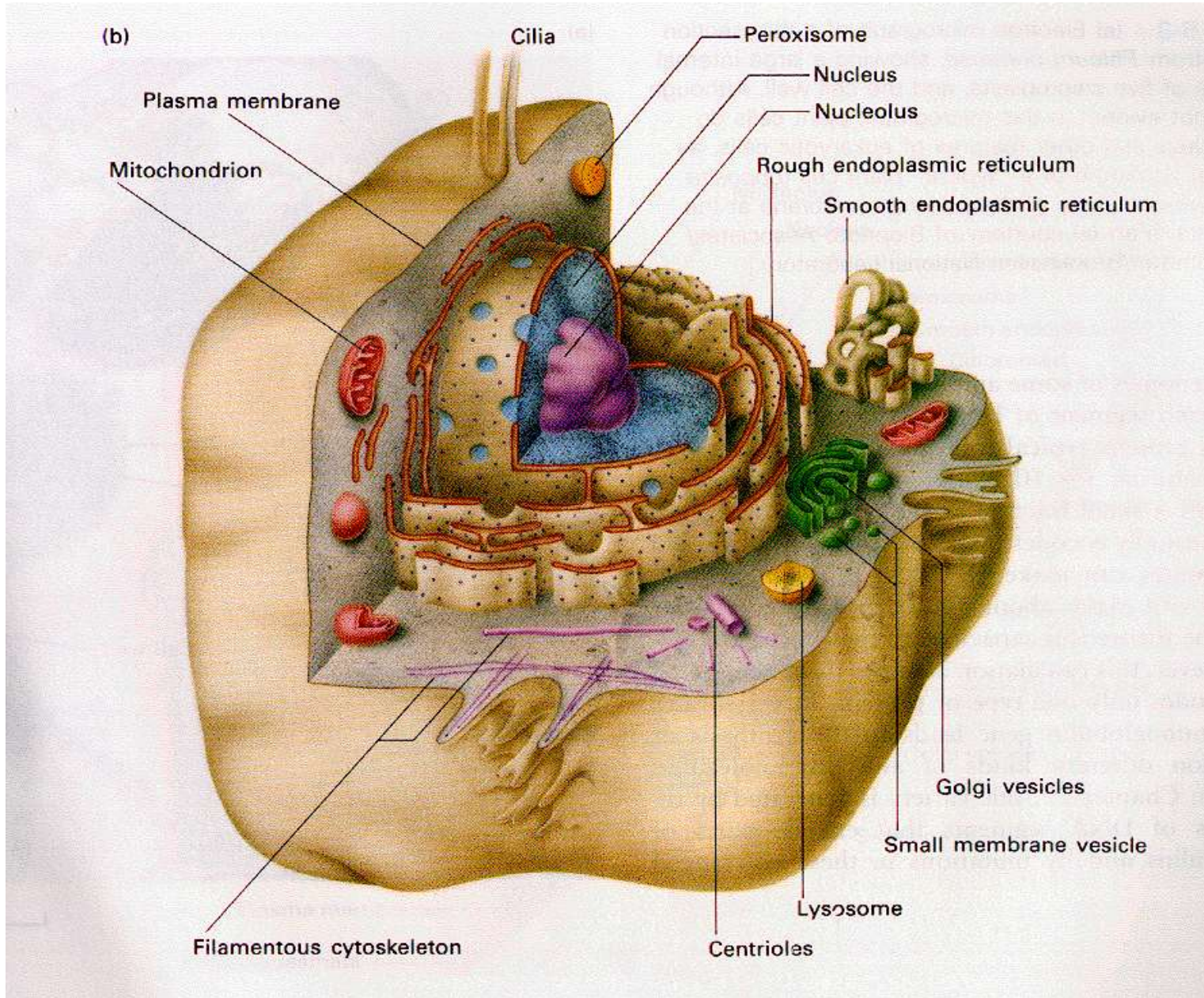
FOUR CHIEF COMPONENTS

- ⦿ (i) An amorphous matrix or **pars amorpha**.
- ⦿ (ii) Chromatin containing abundant DNA.
- ⦿ (iii) Fibrils containing RNA, 80-100 Å in diameter, precursor of granules.
- ⦿ (iv) Granules- Ribonucleoprotein granules 150-200 Å in diameter.

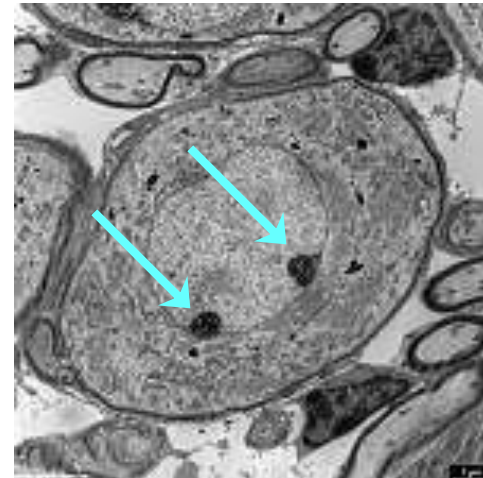
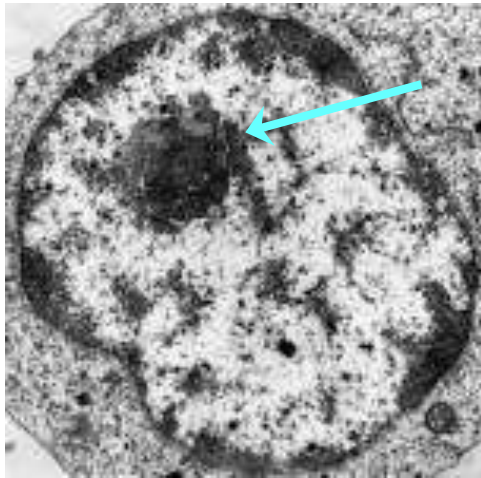
KEY CONCEPTS

- ◉ The nucleolus, whose primary function is to assemble ribosomes, is the largest structure in the cell nucleus.
- ◉ The nucleolus organiser regions of chromosomes, which harbour the genes for pre-rRNA, are the foundation for the nucleolus.
- ◉ All active nucleoli contain at least two ultrastructural components, the nucleolar dense fibrillar component representing early pre-ribosomal complexes and the granular component containing more mature pre-ribosomal particles.
- ◉ Most nucleoli in higher eukaryotes also contain fibrillar centres, which are the interphase equivalents of the nucleolus organiser regions.
- ◉ The nucleolus disassembles at the beginning of mitosis and begins to reassemble in telophase.
- ◉ Ribosome assembly begins with the transcription of pre-rRNA by RNA polymerase I.
- ◉ Ribosomal and non-ribosomal proteins and 5S RNA associate with the pre-rRNA during and after transcription.
- ◉ The pre-rRNA is modified and processed into rRNA with the aid of non-ribosomal proteins and small nucleolar RNAs.
- ◉ The nucleolus has numerous other functions including assembly of signal recognition particles, modification of transfer RNAs and sensing cellular stress.

NUCLEOLUS



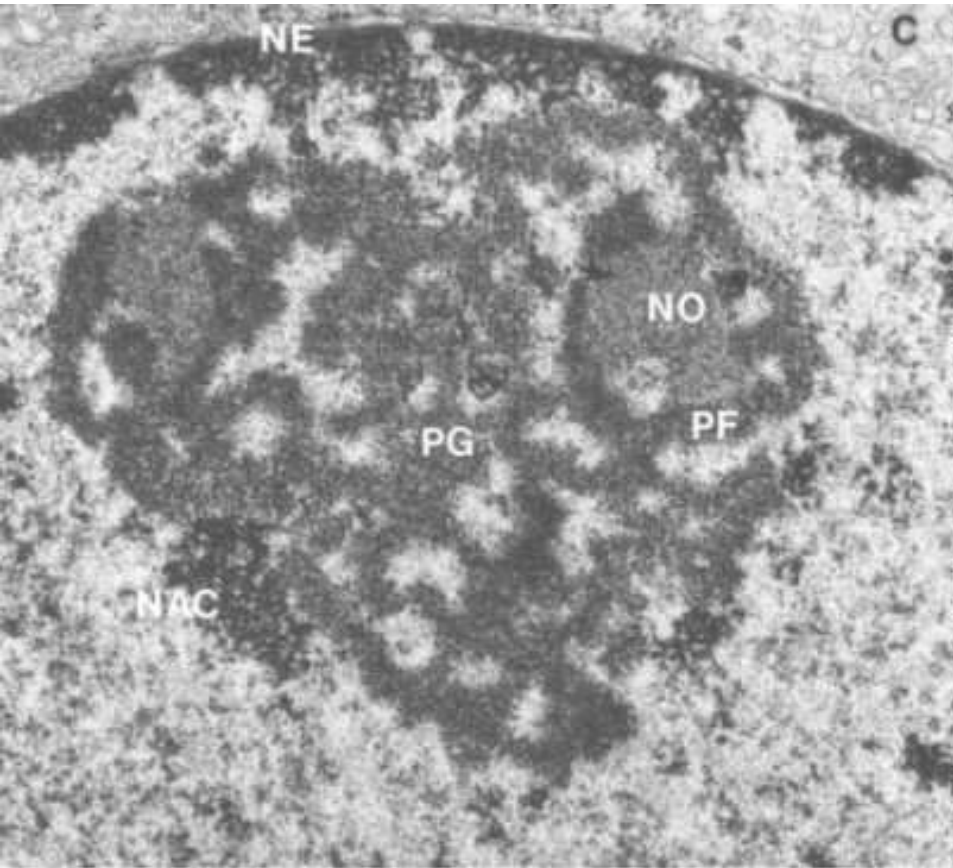
THE NUCLEOLUS IN ELECTRON MICROGRAPHS



Spherical structures within the nucleus, ~1-2 μm .

In interphase cells: nucleolus is normally not readily recognisable or absent, except in neurons, where a large, prominent nucleolus is present.

MAIN PARTS OF THE NUCLEOLUS:



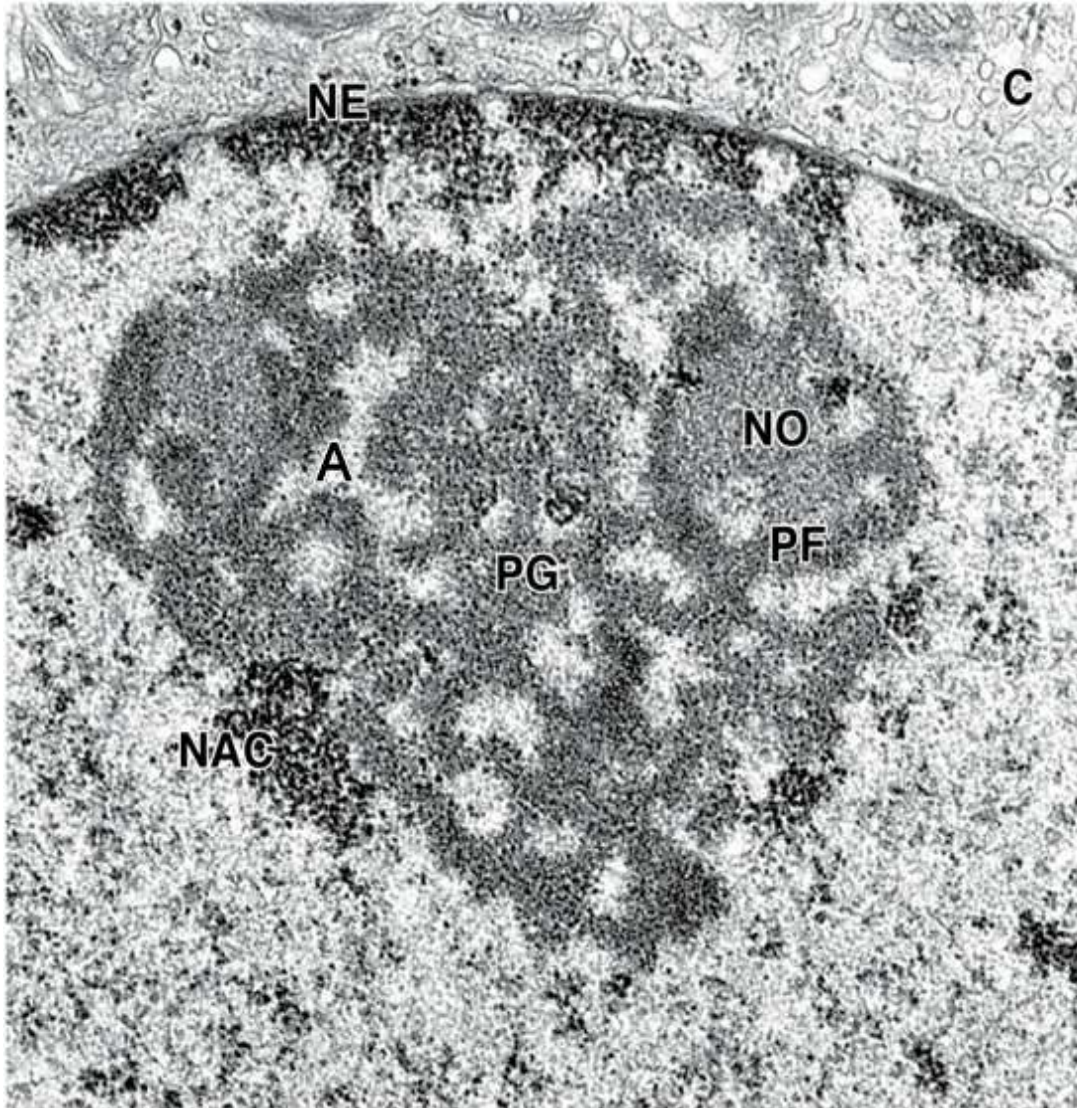
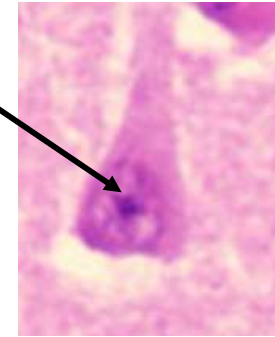
NO: nucleolar organizer region of those chromosomes possessing nucleolar genes

PF: pars fibrosa, dense fibrillary component

PG: pars granulosa, or nucleolonema: ribonucleo-protein particles

NAC: nucleolus-associated chromatin

The structure of the nucleolus



NE - nuclear envelope

NO - nucleolar organizer, parts of the chromosomes that organize the nucleolus after division

A - pars amorpha: DNA encoding rRNA

PF - pars fibrosa, primary rRNA transcripts

PG - pars granule, maturing ribosomal subunits

NAC - nucleolus-associated chromatin

FUNCTIONS OF NUCLEOLUS:

- ⦿ **(i) Ribosome formation or biogenesis of ribosomes.**

- ⦿ **(ii) Synthesis and storage of RNA:**

It produces 70-90% of cellular RNA in many cells. It is source of RNA. The chromatin in nucleolus contains genes or ribosomal DNA (rDNA) for coding ribosomal RNA. Chromatin containing DNA gives rise to fibrils containing RNA. Granules containing RNA already produces ribosomes.

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○ iii) Protein synthesis:

Maggis (1960) and others have suggested that protein synthesis takes place in nucleolus. Other studies confirm the above views. **In eukaryotes the gene coding for RNA contains a chain of at least 100-1000 repeating copies of DNA.** This DNA is given off from the chromosomal fibre in the forms of loops. The DNA loops are associated with proteins to form nucleoli.

The DNA seems as a template for 45S rRNA. Half the 45S rRNA is broken down to form 28S and 18S RNA. The other half is broken down further to nucleotide level. Within the nucleolus the 28S rRNA combines with proteins made in cytoplasm to form the 60S ribosomal sub-unit. The 18S rRNA also associates with proteins to form the 40 S subunit of the ribosome.

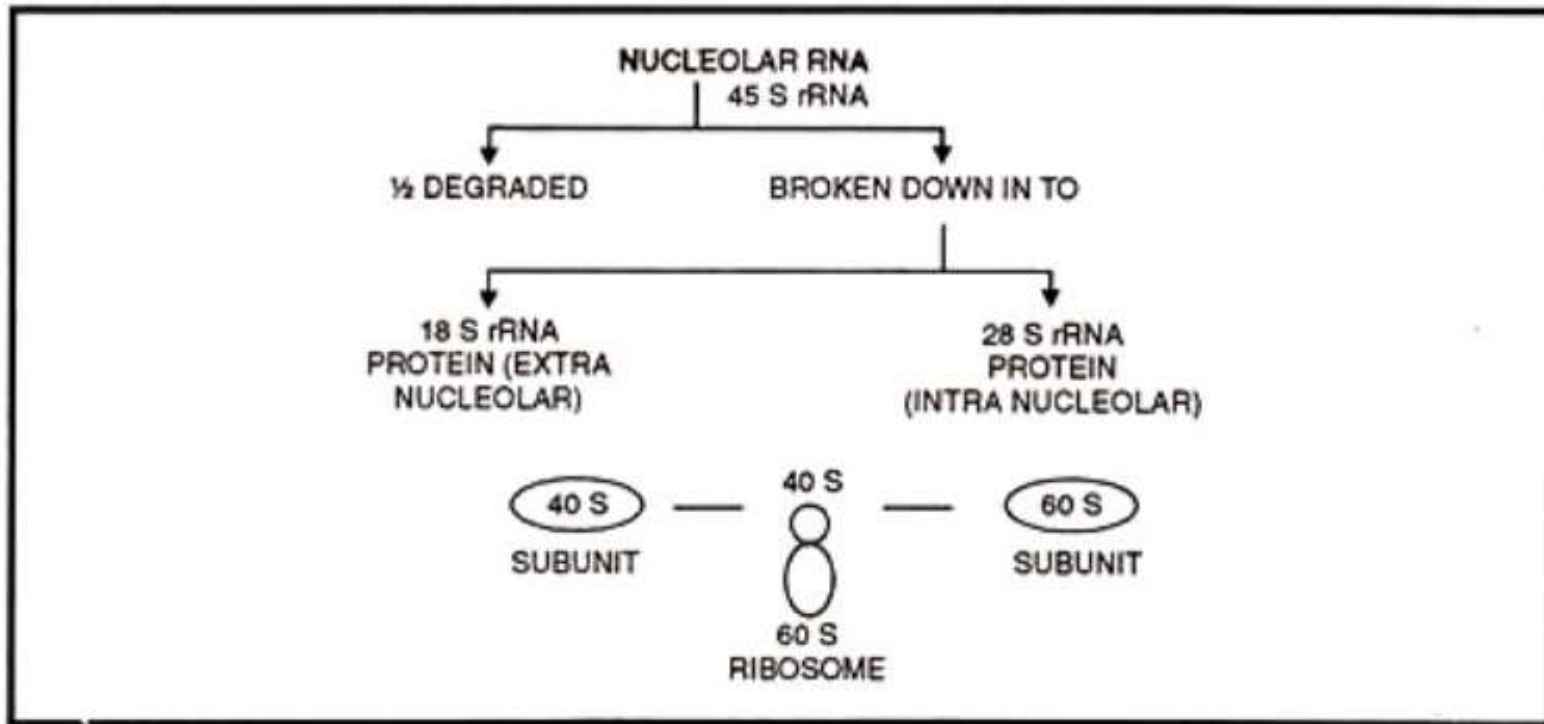


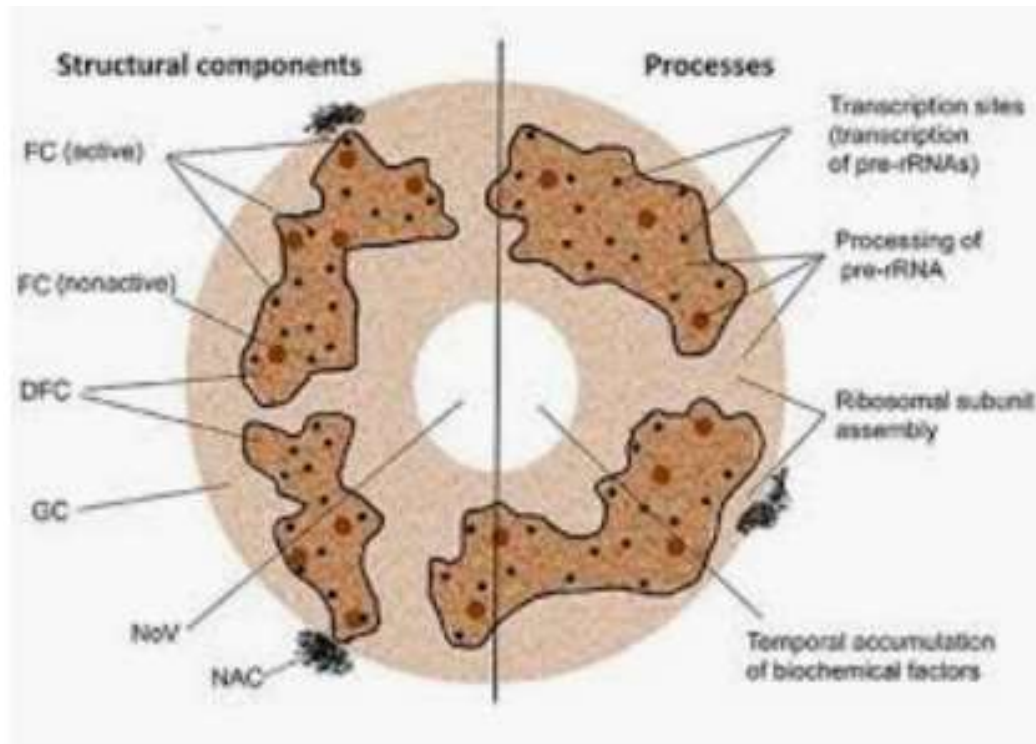
Fig. 36. Formation of Ribosome

FUNCTION OF THE NUCLEOLUS:

It produces the ribosomes.

Main steps:

- transcription of nucleolar genes code for ribosomal RNA occurs at the *nucleolar organizer*
- ribosomal proteins are synthesized in the *cytoplasm*
- RNA-protein assembly takes place in *pars fibrosa*
- ribonucleoprotein particles accumulate in *pars granulosa* and undergo maturation process
- completed ribosomal subunits are transported through the nuclear pores into the cytoplasm where they carry out their function



The Multiple Functions of the Nucleolus ...

REVISION

- ◉ **Discovered by Fontane and, studied by Wagner.** The nucleolus is a **membrane less**, spherical, dense colloidal body present in the **interphase nucleus**. Usually nucleolus found attached to chromatin at a specific region called nucleolar organizer region (**NOR**) which represents secondary constriction of the nucleolar organizing chromosomes, e.g., in maize chromosome 6 and 9; in human chromosome 13,14,15,20 and 21 contain NOR.
- ◉ Generally a nucleus contains 1 -4 nucleoli. However, cells of bacteria and yeast lack nucleolus. Smaller or no nucleoli found in the cells with little or no synthetic activities, e.g., sperm cells, blastomeres, muscle cells etc., while the oocytes of *Xenopus* contain up to 1600 nucleoli.

The ultrastructure of nucleolus has four parts:

- (i) Amorphous matrix,
- (ii) Granular area,
- (iii) Fibrillar portion and
- (iv) Chromatin region.

- ◉ **(i) Amorphous Matrix (Pars amorpha):**

It is the homogenous ground substance of the nucleolus which composed of proteins.

- ◉ **(ii) Granular Area (Pars granulose):**

It consists of granules of the size of 150-200 A which lie scattered in the amorphous matrix. These granules contain protein and RNA in the ratio of 2:1. These are the precursors of ribosomes.

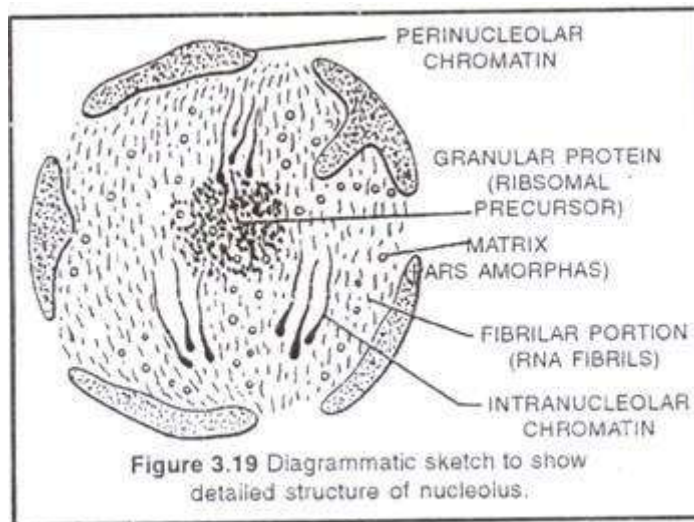
- ◉ **(iii) Fibrillar Portion (Pars fibrillosa):**

In the centre of the nucleoli, there is a region of much denser fibrous network surrounded by granular area. It composed of a large number of small fibrils that are 50-80 A long. The fibrils contain both protein and RNA and are the precursors of granules.

- ◉ **(iv) Chromatin Region:**

The chromatin (Feulgen positive) present in the nucleoli is of two types -

- (a) Perinucleolar chromatin - it surrounds nucleolus like a shell, and
- (b) Intranucleolar chromatin - its tubules project into nucleolus.



FUNCTIONS OF NUCLEOLUS:

- ⦿ 1. It is the principal site for the formation of ribosomal RNAs.
- ⦿ 2. Nucleolus is the centre for the formation of ribosomes.
- ⦿ 3. It stores nucleoproteins. These are synthesized in the cytoplasm (over the ribosomes) and transferred to nucleolus
- ⦿ 4. It is essential for spindle formation during nuclear division.