Nuclear Envelope:

Under electron microscope, the nuclear envelope appears to consist of two membranes, outer and inner nuclear membranes, separated by a perinuclear space of 20 nm. Each of the two nuclear membranes appears to have trilaminar unit membrane structure of 7-10 nm thickness. The outer membrane communicates with endoplasmic reticulum at several points and has ribosomes on the outer side (Fig. 2.64 and Fig. 2.65).

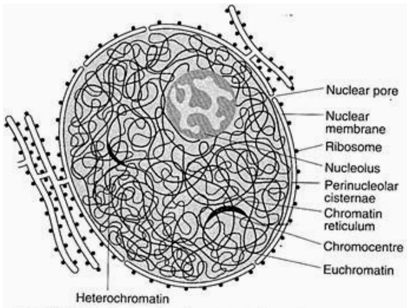

Fig. 2.64: Ultrastructure of nucleus (sectional view) showing its parts

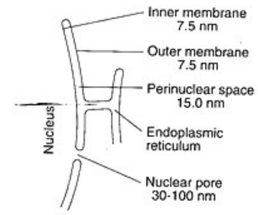

Fig. 2.65: Nuclear membrane showing double structure

Nuclear envelope is perforated by many circular apertures called nuclear pores. Each pore shows the presence of an electron- dense ring or cylinder called the annulus. Actual opening of nuclear pore is thus confined to the cavity of the annulus which annulus extends both into the cytoplasm and the nucleoplasm. Annulus typically consists of eight subunits arranged in radial symmetry around the periphery of the pore. Subunits have been variously interpreted as micro-cylinders, filaments, spheres or ovoid. A central ribonucleoprotein granule of 10-15 nm size may be present in some pore complexes and may be absent in adjacent ones. On the inner side of the envelope of many cell types is present fibrous material which has been called fibrous lamina which extends into the nucleoplasm.

Nuclear lamina:

Inner nuclear membrane is lined on the inner surface by the nuclear lamina, which is a protein fibrous network of 30-100 nm thick that connects inner nuclear membrane with chromatin. It is composed of three principal extrinsic membrane proteins- lamins A, B and C. Lamins are made up of two parts, one is rod like tail of 52 nm long and the other is two globular heads at one end. Lamins are highly similar in sequence and structure with the cytoplasmic intermediate filament. Inner nuclear membrane contains lamin B receptors that bind to lamin B; and lamin A and C bind with lamin B and with interactions between the lamina and chromatin (Fig. 2.66).

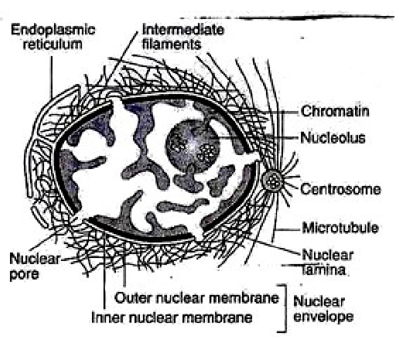

Fig. 2.66: Structure of nuclear envelope

The nuclear lamina and its polypeptide carry out the following functions:
(a) Regulating assembly and disassembly of the nuclear membrane during cell division.
(b) Attachment of chromatin to the nuclear envelope.
(c) Helps to form micronuclei when the cells are left for a long time in colchicine.

Nuclear Pore Complex:
Nuclear pore is a structure of 125 million Daltons with 120 nm diameter and 50 nm thick. Electron micrograph has shown that nuclear pore complexes have an 8-fold symmetry. It consists of annuli and a structure is formed from a set of large protein granules arranged in octagonal patterns. The hole in the centre of each complex often appears to be plugged by a large central granule. Eight radial spokes also extends from plug to rings (Fig. 2.67 & 2.68).

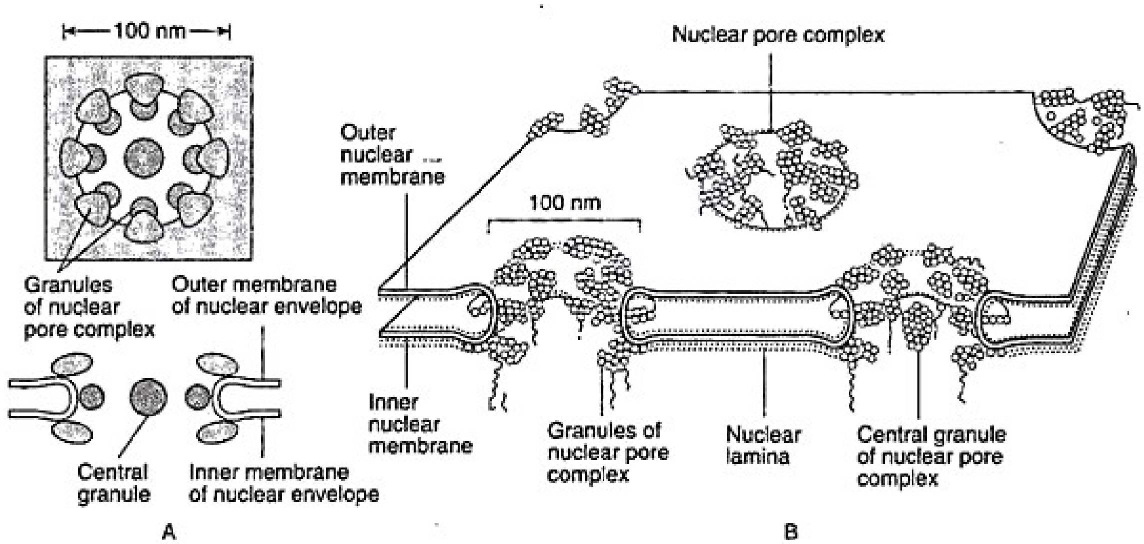

Fig. 2.67: The arrangement of the nuclear pore complexes in the nuclear envelope. A. A top view and a central vertical section. The "central granule" is seen in some pores but not in others; these granules may be a part of the pore, or they may be large complexes caught in transit through it. B. Three-dimensional sketch of a small region of the nuclear evelope (from Roy and De)

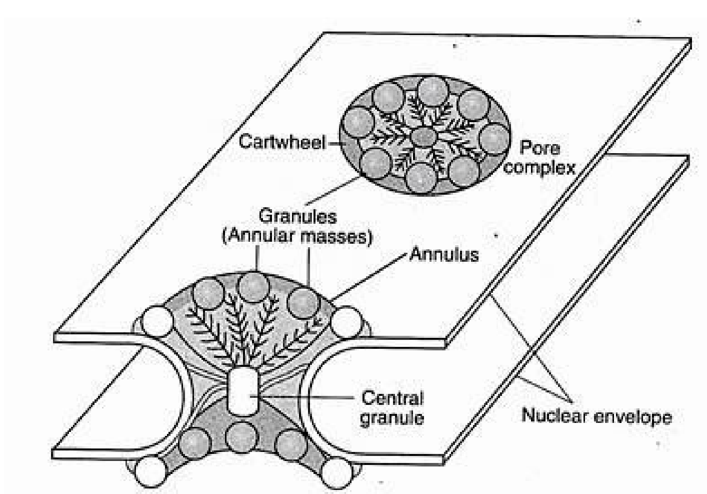

Fig. 2.68: The pore complex, Franke (1970)

It consists of four separate elements:

(i) Scaffold, which included majority of the pore.

(ii) Transporter, the central hub which carries out active transport of proteins and RNAs.

(iii) Short thick filaments attached to the cytoplasmic side of the pore.

(iv) A basket attached to the nucleo-cytoplasmic side of the pore (Fig. 2.69).

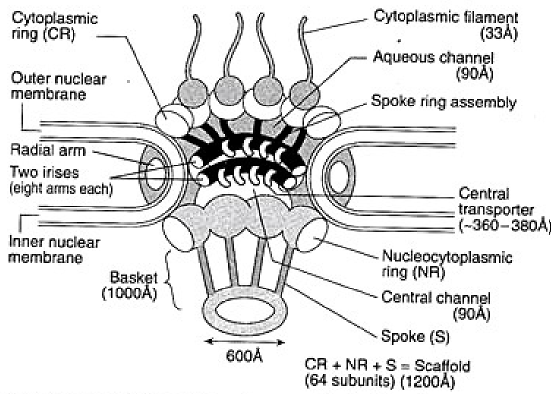

Fig. 2.69: Detailed structure of the nuclear pore, showing iris and transporter

The scaffold is a stack of three closely apposed rings- cytoplasmic ring, nucleo-cytoplasmic ring and a central ring of thick spokes.

The spokes of central ring are attached to the transporter on the inner side and to the nucleo-cytoplasmic and cytoplasmic rings on the outer side. Interspersed between the spokes are aqueous channels, 9 nm wide, which allow diffusion of proteins and metabolites between the nucleus and the cytoplasm. The transporter is a proteinaceous ring, 36-38 nm in diameter and consists of two irises of eight arms each. The two irises are assumed to be stacked atop one another and open sequentially, each like the diaphragm of a camera, to let a nuclear protein or RNA pass through from the nucleus to the cytoplasm. On the cytoplasmic side of the pore, thick filaments of 3.3 nm in diameter, extend into the cytoplasm. On the nuclear side, a large basket like structure is found, which consists of eight filaments of 100 nm long, extending from nucleo-cytoplasmic ring of the pore and meeting a smaller ring of 60 nm in diameter within the nucleus. This basket plays an important role in RNA export.

The function of nuclear pore complex is the nucleo-cytoplasmic transport mediated through a number of proteins, called nucleoporin (NUP). The nuclear pore complex has a passive diffusion channel and also can diffuse many substances by active process using energy or signal sequence mediated by carrier molecules.

Function of Nuclear Envelope:

The nuclear envelope is an interface between nucleus and the cytoplasm. It serves to separate the genetic component of the cell (chromosomes) from the protein-synthesis machinery (ribosome and ER). It thus provides protection to DNA against mutagenic effects of cytoplasmic enzymes. It is concerned with the nucelo-cytoplasmic exchange, attachment of structural elements to cytoplasm, attachment of nuclear components, contribution to other cell membranes and electron transport activity.

Nucleolus:

Nucleolus is a spherical body situated within the nucleus, either in central or peripheral position. It is found in close association with the nucleolar organizer region of two or more chromosomes (Fig. 2.70). One or many nucleoli may be present in a nucleus.

Ultrastructure of Nucleolus:

The ultra-structure of the nucleolus shows four chief components: amorphous matrix, nucleolar associated chromatin, fibrils and granules (Fig. 2.71). Matrix or pars amorpha is homogenous. It contains scattered granules and fibrils. Chromatin associated with the nucleolus contains DNA which serves as a template for rRNA synthesis. Surrounding the nucleolus is perinucleolar chromatin. Projecting into the nucleolus from perinucleolar chromatin are septa like trabeculae, called intra-nucleolar chromatin. The fibrils are 80-100Å in diameter and constitute pars fibrosa. They contain RNA and are the precursors of the granules. Granules are of 150-200Å diameter which constitutes the pars granulosa. These granules contain protein, RNA and act as precursors of ribosomes. Granules appear to be vesicles with light central and dense peripheral structure. They are connected together by thin filament, forming primary nucleolonema which resembles a string of beads. The primary nucleolonema undergoes folding to form secondary nucleolonema.

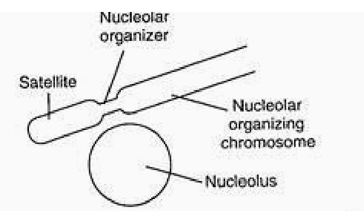

Fig. 2.70: A satellited chromosome and an attached nucleolus

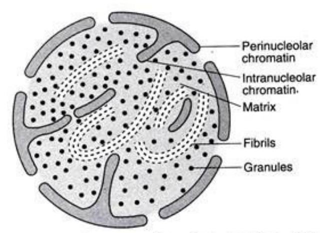

Fig. 2.71: Ultrastructure of nucleolus (sectional view) showing its parts

Function of Nucleolus:

Nucleolus is one of the most active sites of RNA synthesis and source of rRNA. Chromatin in nucleolus contains genes or ribosomal DNA for coding rRNA. Fibrils represent the origin of rRNA, and granules the next stage. Granules in turn are the precursors of ribosomes (Fig. 2.72).

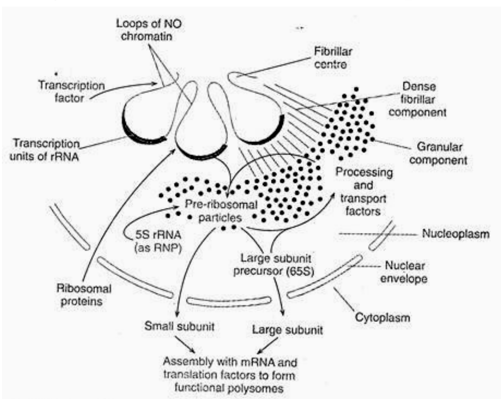

Fig. 2.72: Three different regions of the nucleolus and their involvement in ribosome assembly

Further reading: http://cytochemistry.net/cell-biology/nuclear_envelope.htm