FIFTH SEM GENERAL : CELL-BIOLOGY—DR. LUNA PHUKAN.

CELL BIOLOGY

1. STRUCTURE AND FUNCTION OF PRO AND EUKARYOTIC CELL.
2. VIRUS;STRUCTURE AND ASSEMBLY
3. CELL THEORY
4. STRUCTURE AND FUNCTION OF PLASMA MEMBRANE, GOLGI BODIES,ENDOPLASMIC RETICULUM,AND RIBOSOMES.CHROSOMES..ULTRASTRUCTURE AND ORGANIZATION.
5. GIANT CHROMOSOME TYPES AND SIGNIFICANCE

STRUCTURE AND FUNCTION OF PRO AND EUKARYOTIC CELL.

During the 1950s, scientists developed the concept that all organisms may be classified as prokaryotes or eukaryotes.

The cells of all prokaryotes and eukaryotes possess two basic features: a plasma membrane, also called a cell membrane, and cytoplasm.

However, the cells of prokaryotes are simpler than those of eukaryotes. For example, prokaryotic cells lack a nucleus, while eukaryotic cells have a nucleus.

Prokaryotic cells lack internal cellular bodies (organelles), while eukaryotic cells possess them. Examples of prokaryotes are bacteria and archaea. Examples of eukaryotes are protists, fungi, plants, and animals (everything except prokaryotes).

Plasma membrane

All prokaryote and eukaryote cells have plasma membranes. The plasma membrane (also known as the cell membrane) is the outermost cell surface, which separates the cell from the external environment. The plasma membrane is composed primarily of proteins and lipids, especially phospholipids.

The lipids occur in two layers (a bilayer). Proteins embedded in the bilayer appear to float within the lipid, so the membrane is constantly in flux. The membrane is therefore referred to as a fluid mosaic structure. Within the fluid mosaic structure, proteins carry out most of the membrane's functions.

The "Movement through the Plasma Membrane" section later in this chapter describes the process by which materials pass between the interior and exterior of a cell.

Cytoplasm and organelles

All prokaryote and eukaryote cells also have cytoplasm (or cytosol), a semiliquid substance that composes the volume of a cell. Essentially, cytoplasm is the gel-like material enclosed by the plasma membrane.

Within the cytoplasm of eukaryote cells are a number of membrane-bound bodies called organelles ("little organs") that provide a specialized function within the cell.

One example of an organelle is the endoplasmic reticulum (ER). The ER is a series of membranes extending throughout the cytoplasm of eukaryotic cells.

In some places, the ER is studded with submicroscopic bodies called ribosomes. This type of ER is called rough ER. In other places, there are no ribosomes.

This type of ER is called smooth ER. The rough ER is the site of protein synthesis in a cell because it contains ribosomes; however, the smooth ER lacks ribosomes and is responsible for producing lipids.

Within the ribosomes, amino acids are actually bound together to form proteins. Cisternae are spaces within the folds of the ER membranes.

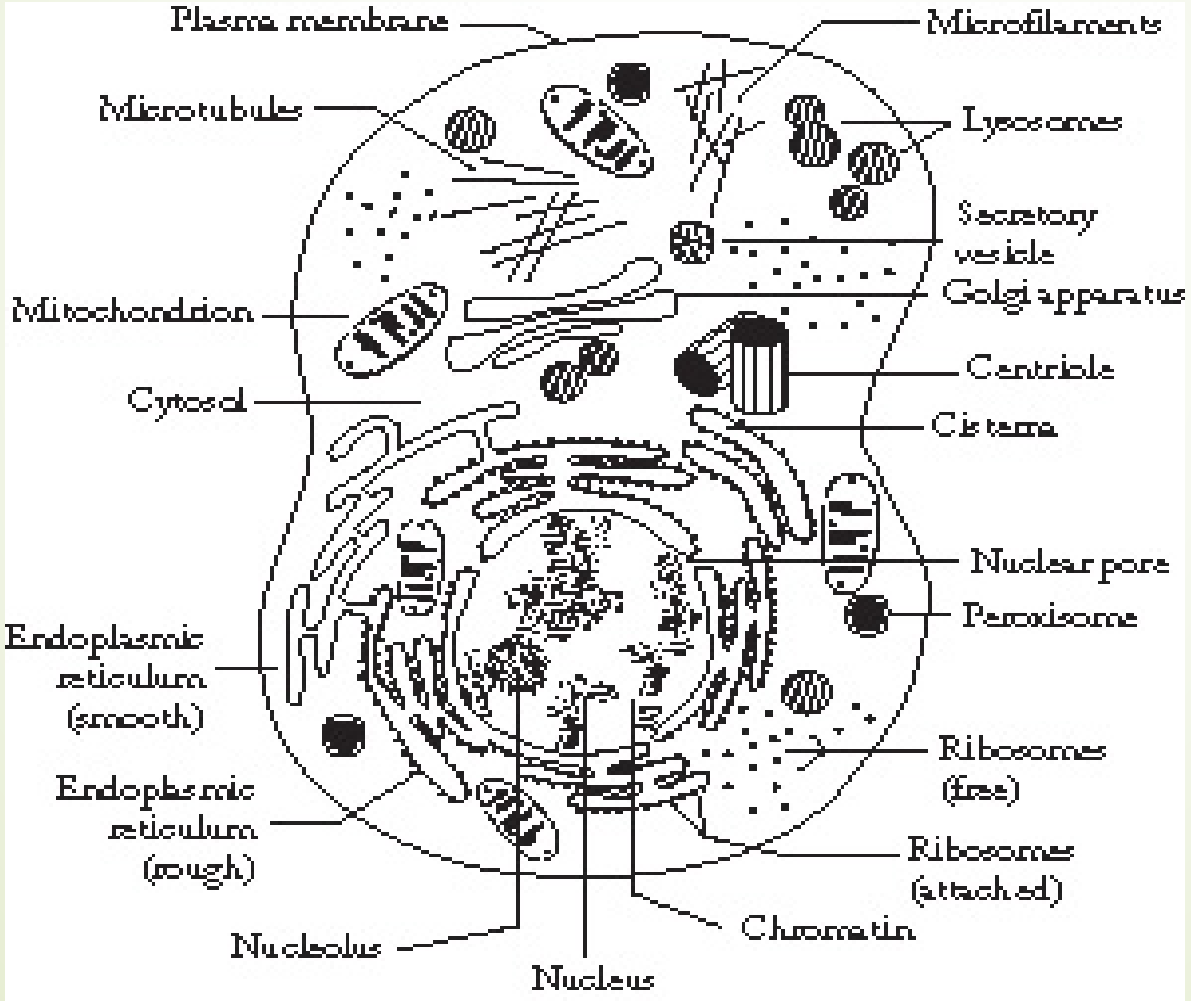
Another organelle is the Golgi apparatus (also called Golgi body). The Golgi apparatus is a series of flattened sacs, usually curled at the edges.

In the Golgi body, the cell's proteins and lipids are processed and packaged before being sent to their final destination.

To accomplish this function, the outermost sac of the Golgi body often bulges and breaks away to form droplike vesicles known as secretory vesicles.

An organelle called the lysosome (see Figure) is derived from the Golgi body. It is a droplike sac of enzymes in the cytoplasm. These enzymes are used for digestion within the cell.

They break down particles of food taken into the cell and make the products available for use; they also help break down old cell organelles. Enzymes are also contained in a cytoplasmic body called the peroxisome.



The components of an idealized eukaryotic cell. The diagram shows the relative sizes and locations of the cell parts.

The organelle that releases quantities of energy to form adenosine triphosphate (ATP) is the mitochondrion (the plural form is mitochondria).

Because mitochondria are involved in energy release and storage, they are called the "powerhouses of the cells."

Green plant cells, for example, contain organelles known as chloroplasts, which function in the process of photosynthesis.

Within chloroplasts, energy from the sun is absorbed and transformed into the energy of carbohydrate molecules.

Plant cells specialized for photosynthesis contain large numbers of chloroplasts, which are green because the

chlorophyll pigments within the chloroplasts are green. Leaves of a plant contain numerous chloroplasts.

Plant cells not specializing in photosynthesis (for example, root cells) are not green.

An organelle found in mature plant cells is a large, fluid-filled central vacuole. The vacuole may occupy more than 75 percent of the plant cell. In the vacuole, the plant stores nutrients, as well as toxic wastes. Pressure within the growing vacuole may cause the cell to swell.

The cytoskeleton is an interconnected system of fibers, threads, and interwoven molecules that give structure to the cell. The main components of the cytoskeleton are microtubules, microfilaments, and intermediate filaments. All are assembled from subunits of protein.

The centriole organelle is a cylinderlike structure that occurs in pairs. Centrioles function in cell division.

Many cells have specialized cytoskeletal structures called flagella and cilia. Flagella are long, hairlike organelles that extend from the cell, permitting it to move. In prokaryotic cells, such as bacteria, the flagella rotate like the propeller of a motorboat. In eukaryotic cells, such as certain protozoa and sperm cells,

the flagella whip about and propel the cell. Cilia are shorter and more numerous than flagella. In moving cells, the cilia wave in unison and move the cell forward.

Paramecium is a well-known ciliated protozoan. Cilia are also found on the surface of several types of cells, such as those that line the human respiratory tract.

Nucleus

Prokaryotic cells lack a nucleus; the word prokaryotic means “primitive nucleus.” Eukaryotic cells, on the other hand, have a distinct nucleus.

The nucleus of eukaryotic cells is composed primarily of protein and deoxyribonucleic acid, or DNA. The DNA is tightly wound around special proteins called histones; the mixture of DNA and histone proteins is called chromatin. The chromatin is folded even further into distinct threads called chromosomes. Functional segments of the chromosomes are referred to as genes. Approximately 21,000 genes are located in the nucleus of all human cells.

The nuclear envelope, an outer membrane, surrounds the nucleus of a eukaryotic cell. The nuclear envelope is a double membrane, consisting of two lipid layers (similar to the plasma membrane). Pores in the nuclear envelope allow the internal nuclear environment to communicate with the external nuclear environment.

Within the nucleus are two or more dense organelles referred to as nucleoli (the singular form is nucleolus). In nucleoli, submicroscopic particles known as ribosomes are assembled before their passage out of the nucleus into the cytoplasm.

Although prokaryotic cells have no nucleus, they do have DNA. The DNA exists freely in the cytoplasm as a closed loop. It has no protein to support it and no membrane covering it. A bacterium typically has a single looped chromosome.

Cell wall

Many kinds of prokaryotes and eukaryotes contain a structure outside the cell membrane called the cell wall. With only a few exceptions, all prokaryotes have thick, rigid cell walls that give them their shape. Among the eukaryotes, some protists, and a

fungi and plants, have cell walls. Cell walls are not identical in these organisms, however.

In fungi, the cell wall contains a polysaccharide called chitin.

Plant cells, in contrast, have no chitin; their cell walls are composed exclusively of the polysaccharide cellulose.

Cell walls provide support and help cells resist mechanical pressures, but they are not solid, so materials are able to pass through rather easily.

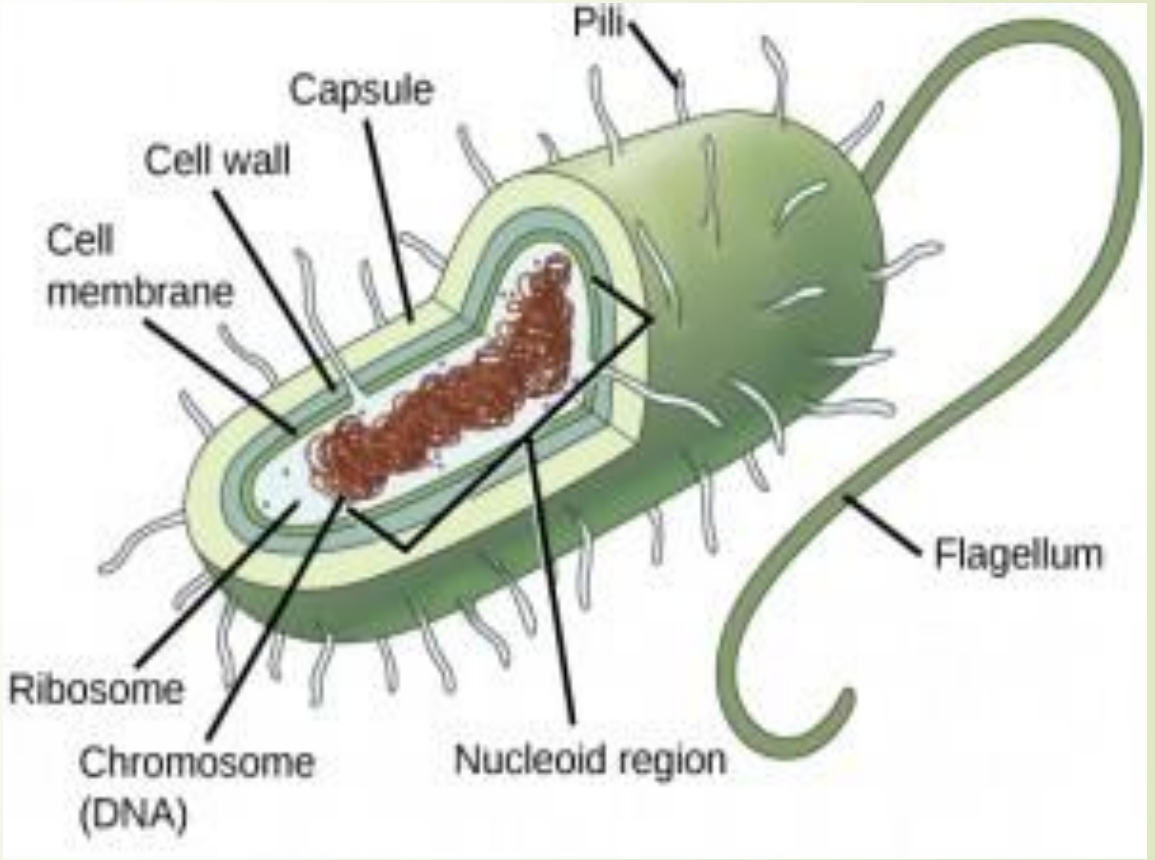
Cell walls are not selective devices, as plasma membranes are.

Cells fall into one of two broad categories: prokaryotic and eukaryotic. The predominantly single-celled organisms of the domains Bacteria and Archaea are classified as prokaryotes (pro– = before; –karyon– = nucleus). Animal cells, plant cells, fungi, and protists are eukaryotes (eu– = true).

Components of Prokaryotic Cells

All cells share four common components: 1) a plasma membrane, an outer covering that separates the cell's interior from its surrounding environment; 2) cytoplasm, consisting of a jelly-like region within the cell in which other cellular components are found; 3) DNA, the genetic material of the cell; and 4) ribosomes, particles that synthesize proteins. However, prokaryotes differ from eukaryotic cells in several ways.

A prokaryotic cell is a simple, single-celled (unicellular) organism that lacks a nucleus, or any other membrane-bound organelle. We will shortly come to see that this is significantly different in eukaryotes. Prokaryotic DNA is found in the central part of the cell: a darkened region called the nucleoid.



Prokaryotes are predominantly single-celled organisms of the domains Bacteria and Archaea. All prokaryotes have plasma membranes, cytoplasm, ribosomes, a cell wall, DNA, and lack membrane-bound organelles. Many also have polysaccharide capsules. Prokaryotic cells range in diameter from 0.1–5.0 µm.

Like a prokaryotic cell, a eukaryotic cell has a plasma membrane, cytoplasm, and ribosomes, but a eukaryotic cell is typically larger than a prokaryotic cell, has a true nucleus (meaning its DNA is surrounded by a membrane), and has other membrane-bound organelles that allow for compartmentalization of functions. Eukaryotic cells tend to be 10 to 100 times the size of prokaryotic cells.

Exercises

2.VIRUS;STRUCTURE AND ASSEMBLY

A virus is a submicroscopic infectious agent that replicates only inside the living cells of an organism.Viruses infect all types of life forms, from animals and plants to microorganisms, including bacteria and archaea. Since Dmitri Ivanovsky's 1892 article describing a non-bacterial pathogen infecting tobacco plants and the discovery of the tobacco mosaic virus by Martinus Beijerinck in 1898, more than 6,000 virus species have been described in detailof the millions of types of viruses in the environment.

Viruses are found in almost every ecosystem on Earth and are the most numerous type of biological entity. The study of viruses is known as virology, a subspeciality of microbiology.

viruses exist in the form of independent particles, or virions, consisting of:

(i) the genetic material, i.e., long molecules of DNA or RNA that encode the structure of the proteins by which the virus acts;

(ii) a protein coat, the capsid, which surrounds and protects the genetic material; and in some cases

(iii) an outside envelope of lipids. The shapes of these virus particles range from simple helical and icosahedral forms to more complex structures. Most virus species have virions too small to be seen with an optical microscope, as they are one-hundredth the size of most bacteria.

All viruses contain the following two components:

1) a nucleic acid genome and

2) a protein capsid that covers the genome. Together this is called the nucleocapsid. In addition, many animal viruses contain a

3) lipid envelope. The entire intact virus is called the virion. The structure and composition of these components can vary widely.

A: Viral Genomes: While the genomes of all known cells are comprised of double stranded DNA, the genomes of viruses can be comprised of single or double stranded DNA or RNA. They can vary greatly in size, from approximately 5-10 kb (Papovaviridae, Parvoviridae, etc.) to greater than 100-200 kb (Herpesviridae, Poxviridae). The known structures of viral genomes are summarized below

DNA: Double Stranded - linear or circular

Single Stranded - linear or circular

Other Structures - gapped circles

RNA: Double Stranded - linear

Single Stranded - linear : These single stranded genomes can be either + sense, - sense, or ambisense The sense strand is the one that can serve directly as mRNA and code for protein, so for these viruses, the viral RNA is infectious. The viral mRNA from - strand viruses is not infectious, since it needs to be copied into the + strand before it can be translated. In an ambisense virus, part of the genome is the sense strand, and part is the antisense.

The genome of some RNA viruses is segmented, meaning that a virus particle contains several different molecules of RNA, like different chromosomes.

B: Protein Capsid

Viral genomes are surrounded by protein shells known as capsids. One interesting question is how capsid proteins recognize viral, but not cellular RNA or DNA. The answer is that there is often some type of "packaging" signal (sequence) on the viral genome that is recognized by the capsid proteins

A capsid is almost always made up of repeating structural subunits that are arranged in one of two symmetrical structures, a helix or an icosahedron. In the simplest case, these "subunits" consist of a single polypeptide. In many cases, however, these structural subunits (also called protomers) are made up of several polypeptides. Both helical and icosahedral structures are described in more detail below.

1) Helical Capsids: The first and best studied example is the plant tobacco mosaic virus (TMV), which contains a SS RNA genome and a protein coat made up of a single, 17.5 kd protein.

2) This protein is arranged in a helix around the viral RNA, with 3 nt of RNA fitting into a groove in each subunit.

3) Helical capsids can also be more complex, and involve more than one protein subunit.

A helix can be defined by two parameters, its amplitude (diameter) and pitch, where pitch is defined as the distance covered by each turn of the helix. P = m x p, where m is the number of subunits per turn and p is the axial rise per subunit.

For TMV, m = 16.3 and p= 0.14 nm, so P=2.28 nm. This structure is very stable, and can be dissociated and re-associated readily by changing ionic strength, pH, temperature, etc.

The interactions that hold these molecules together are non-covalent, and involve H-bonds, salt bridges, hydrophobic interactions, and vander Waals forces.

Several families of animal virus contain helical nucleocapsids, including the Orthomyxoviridae (influenza), the Paramyxoviridae (bovine respiratory syncytial virus), and the Rhabdoviridae (rabies).

All of these are enveloped viruses (see below).

2) Icosahedral Capsids: In these structures, the subunits are arranged in the form of a hollow, quasi spherical structure, with the genome within.

An icosahedron is defined as being made up of 20 equilateral triangular faces arranged around the surface of a sphere. They display 2-3-5 fold symmetry as follows:

- an axis of 2 fold rotational symmetry through the center of each edge.

- an axis of 3 fold rotational symmetry through the center of each face.

- an axis of 5 fold rotational symmetry through the center of each corner.

These corners are also called Vertices, and each icosahedron has 12.

Since proteins are not equilateral triangles, each face of an icosahedron contains more than one protein subunit. The simplest icosahedron is made by using 3 identical subunits to form each face, so the minimum # of subunits is 60 (20 x 3). Remember, that each of these subunits could be a single protein or, more likely, a complex of several polypeptides.

Many viruses have too large a genome to be packaged inside an icosahedron made up of only 60 polypeptides (or even 60 subunits), so many are more complicated.

In these cases, each of the 20 triangular faces is divided into smaller triangles; and each of these smaller triangles is defined by 3 subunits. However, the total number of subunits is always a multiple of 60.

The total number of subunits can be defined as 60 X N, where N is sometimes called the Triangulation Number, or T. Values for T of 1,3,4,7,9, 12 and more are permitted.

When virus nucleocapsids are observed in the electron microscope, one often sees apparent "lumps" or clusters on the surface of the particle. These are usually protein subunits clustered around an axis of symmetry, and have been called "morphological units" or capsomers.

C: Viral Envelope

In some animal viruses, the nucleocapsid is surrounded by a membrane, also called an envelope.

This envelope is made up of a lipid bilayer, and is comprised of host-cell lipids. It also contains virally encoded proteins, often glycoproteins which are trans-membrane proteins

These viral proteins serve many purposes, such as binding to receptors on the host cell, playing a role in membrane fusion and cell entry, etc. They can also form channels in the viral membrane.

Many enveloped viruses also contain matrix proteins, which are internal proteins that link the nucleocapsid to the envelope.

They are very abundant (ie, many copies per virion), and are usually not glycosylated. Some virions also contain other, non-structural proteins that are used in the viral life cycle. Examples of this are replicases, transcription factors, etc. These non-structural proteins are present in low amounts in the virion.

Enveloped viruses are formed by budding through cellular membranes, usually the plasma membrane but sometimes an internal membrane such as the ER, golgi, or nucleus.

In these cases, the assembly of viral components (genome, capsid, matrix) occurs on the inside face of the membrane, the envelope glycoproteins cluster in that region of the membrane, and the virus buds out.

This ability to bud allows the virus to exit the host cell without lysing, or killing the host. In contrast, non-enveloped viruses, and some enveloped viruses, kill the host cell in order to escape.

D: Virus Classification/Nomenclature

Viruses are classified using a combination of characteristics, including the following

1) Morphology: size, shape, presence of envelope, etc.

2) Physicochemical properties: thermal stability, detergent stability, molecular mass, etc.

3) Genome: size, type of nucleic acid, strandedness, etc.

4) Proteins: number, size, sequence, etc.

5) Lipids: content, character, etc.

6) Carbohydrates: content, character, etc.

7) Genome organization and replication: strategy of replication, number and position of open reading frames, transcriptional and translational strategies, site of virion assembly and release.

8) Antigenic properties: serological relationships.

9) Biological properties: Host range, mode of transmission, pathogenicity, tissue tropisms, geographic distribution, etc.

Using these and other criteria, the International Committee on Nomenclature of Viruses (ICTV) produced the following the hierarchical system for viral classification.

1) Orders (virales): Groupings of families of viruses that share common characteristics and are distinct from other orders and families.

2) Families (-viridae): Groupings of genera of viruses that share common characteristics and are distinct from the member viruses of other families.

3) Subfamilies (-virinae): Not used in all families, but allows for more complex hierarchy of taxa.

4) Genera (-virus): Groupings of species of viruses that share common characteristics and are distinct from the member viruses of other species.

5) Species (virus); The definition accepted by ICTV is "a virus species is defined as a polythetic class of viruses that constitutes a replicating lineage and occupies a particular ecological niche". A species can be further broken down into strains, variants, etc.

In addition to this formal taxonomy, David Baltimore proposed that viruses be classified according to the nature of their genome and the relationship between the genome and the viral mRNA. The classes that he proposed are the following:

Class I: Double Stranded DNA Genomes

Class II: Single Stranded DNA Genomes

Class III: Double Stranded RNA Genomes

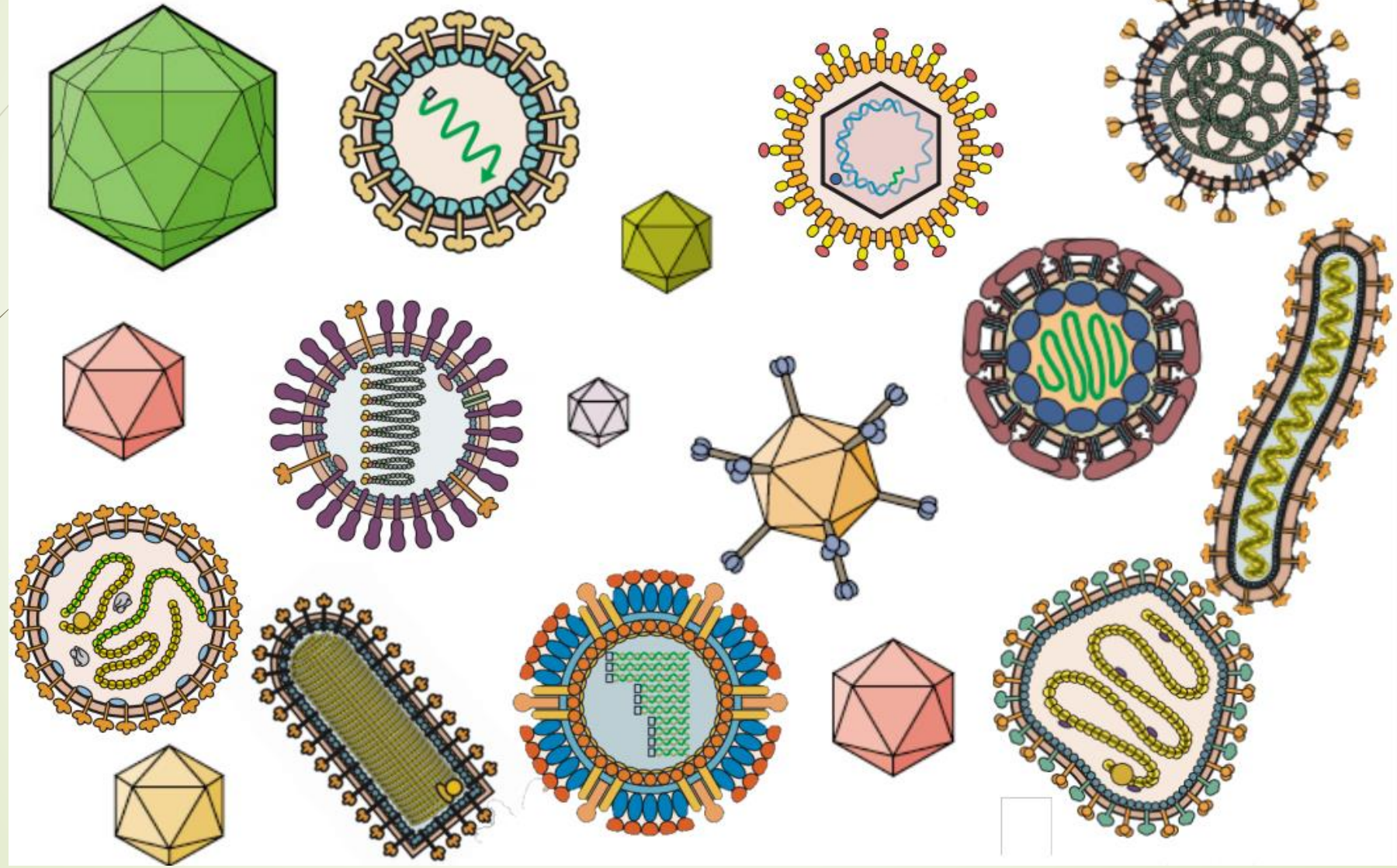
Class IV: Positive Strand RNA Genomes

Class V: Negative Strand RNA Genomes

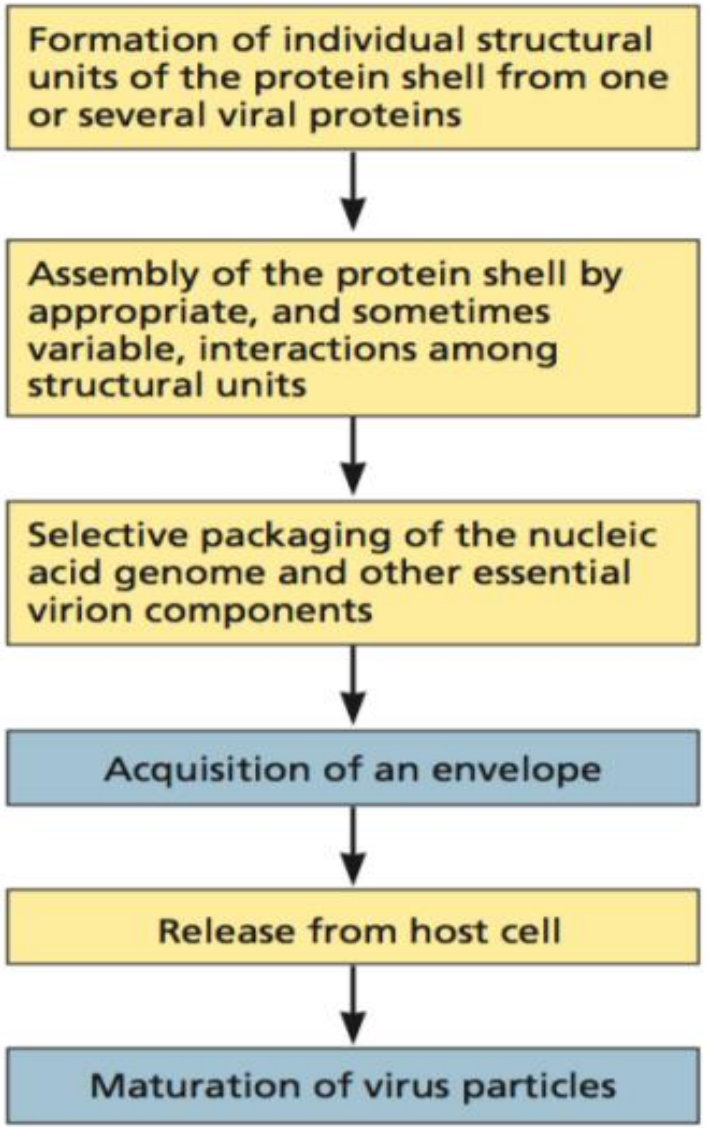
Class VI: Retroviruses

ASSEMBLY OF VIRUS

The structure of a virus particle determines how it is formed

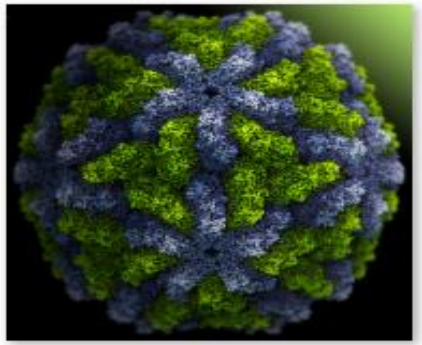


All virions complete a common set of assembly reactions



common to all viruses

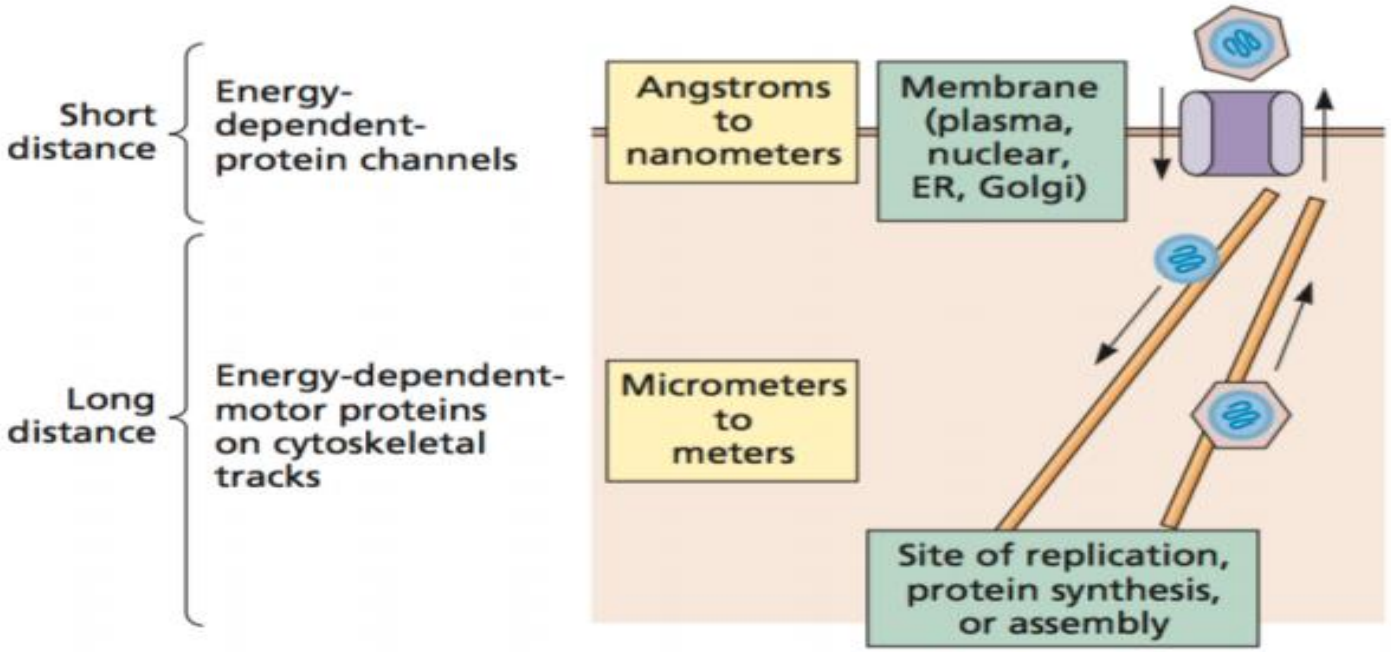
common to many viruses

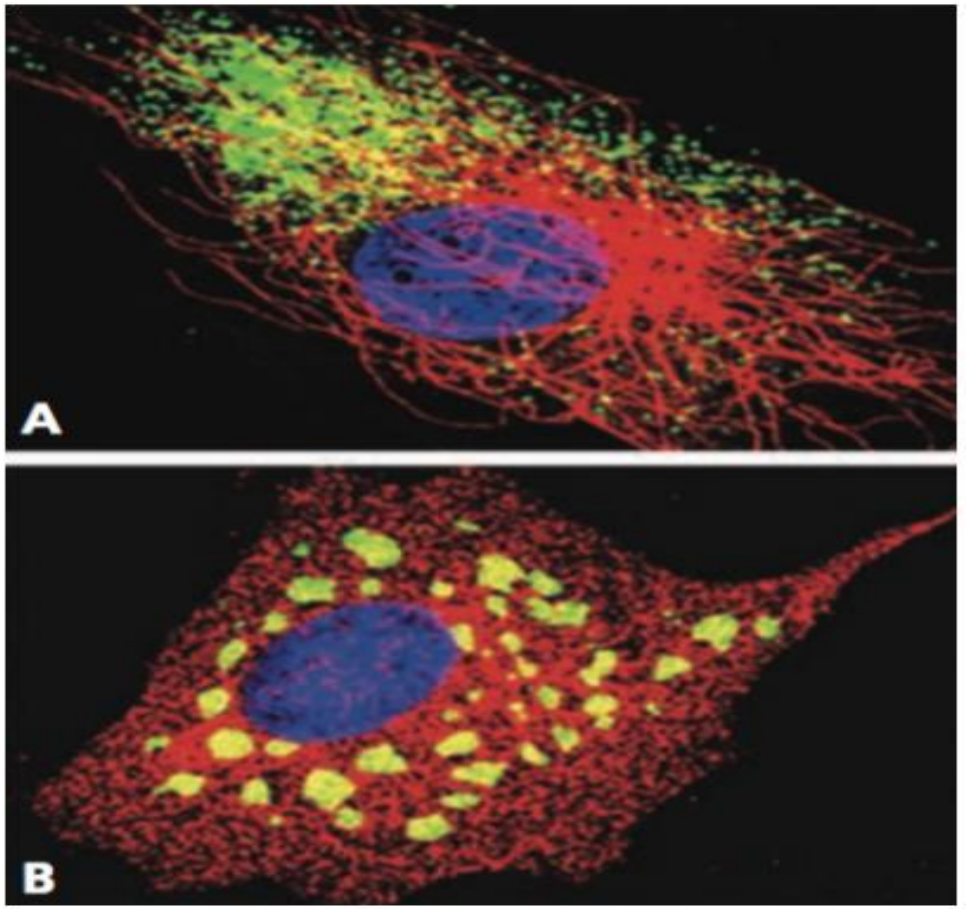


Assembly is dependent on host cell machinery

- Cellular chaperones
- Transport systems
- Secretory pathway
- Nuclear import and export machinery

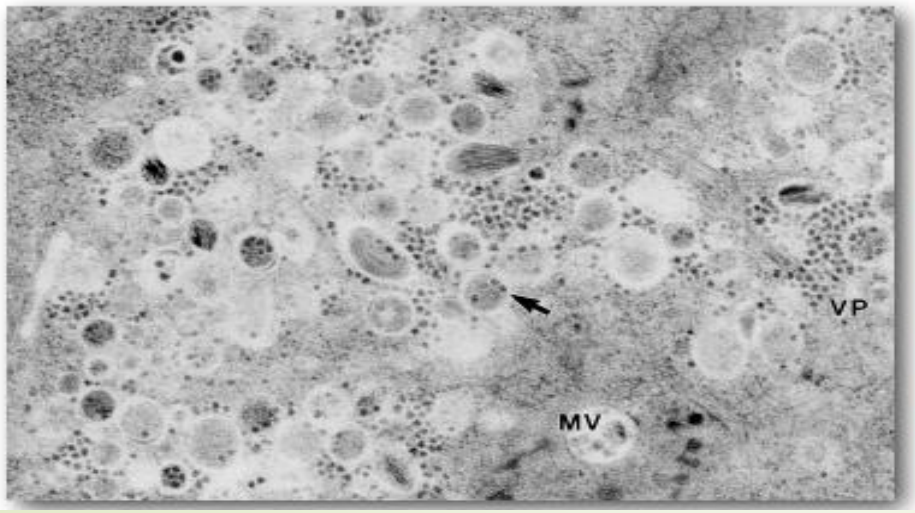
Moving in heavy traffic

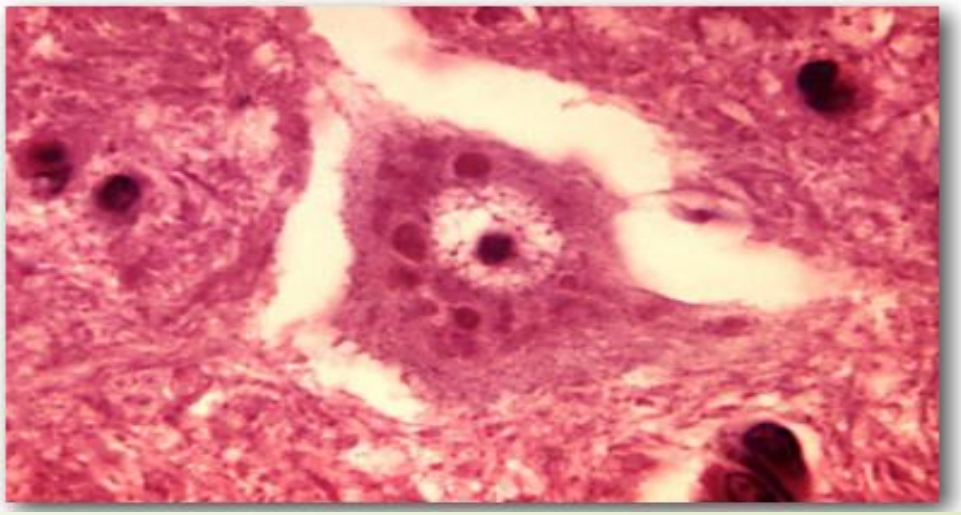




Nothing happens fast in dilute solutions

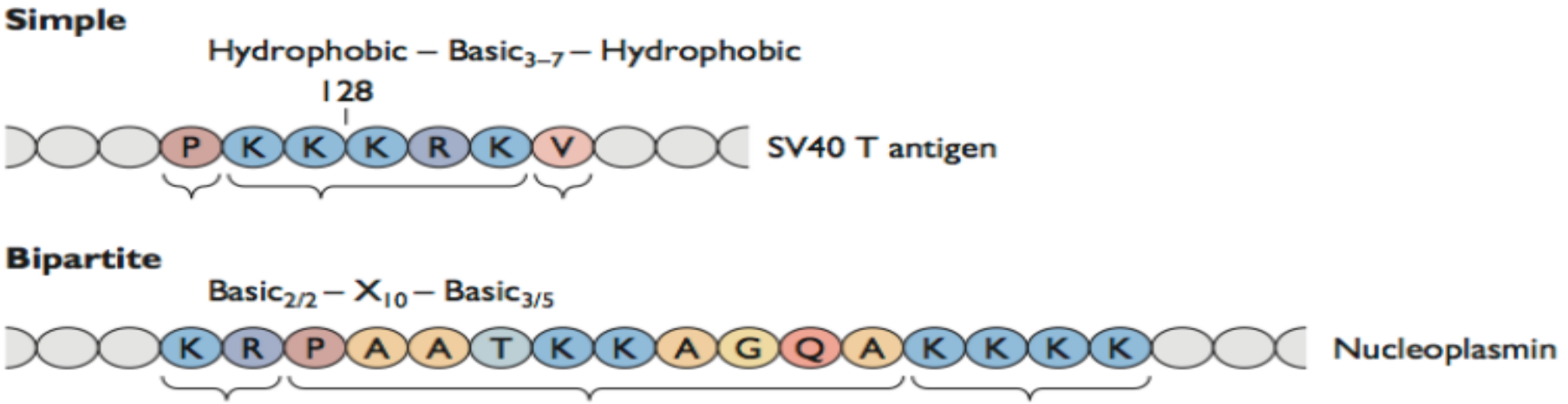
- Viral components often visible by light microscopy ('factories' or 'inclusions')
- Concentrate proteins on internal membranes *(poliovirus)*
- Negri bodies *(rabies virus)*



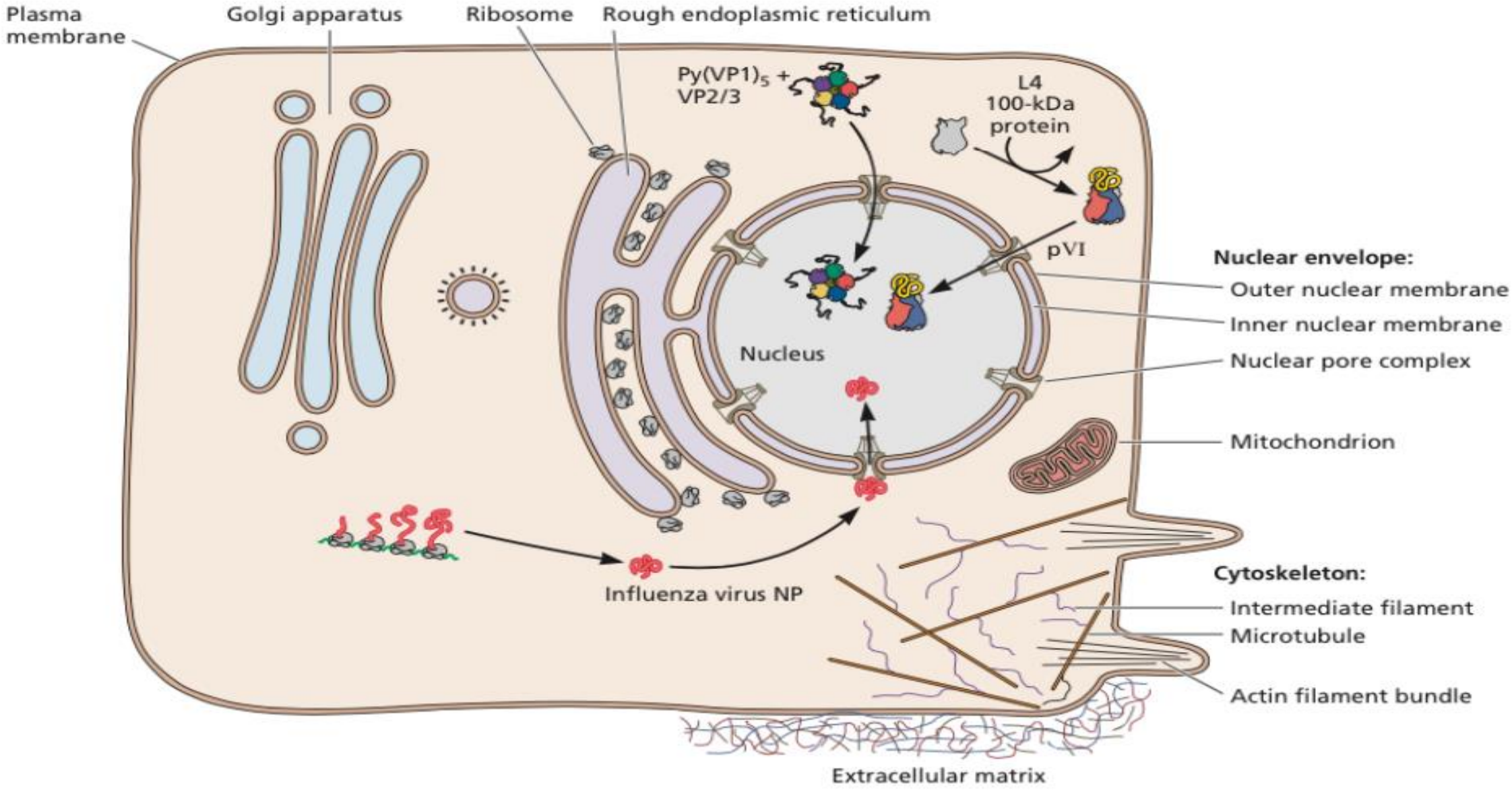


Viral proteins have 'addresses'

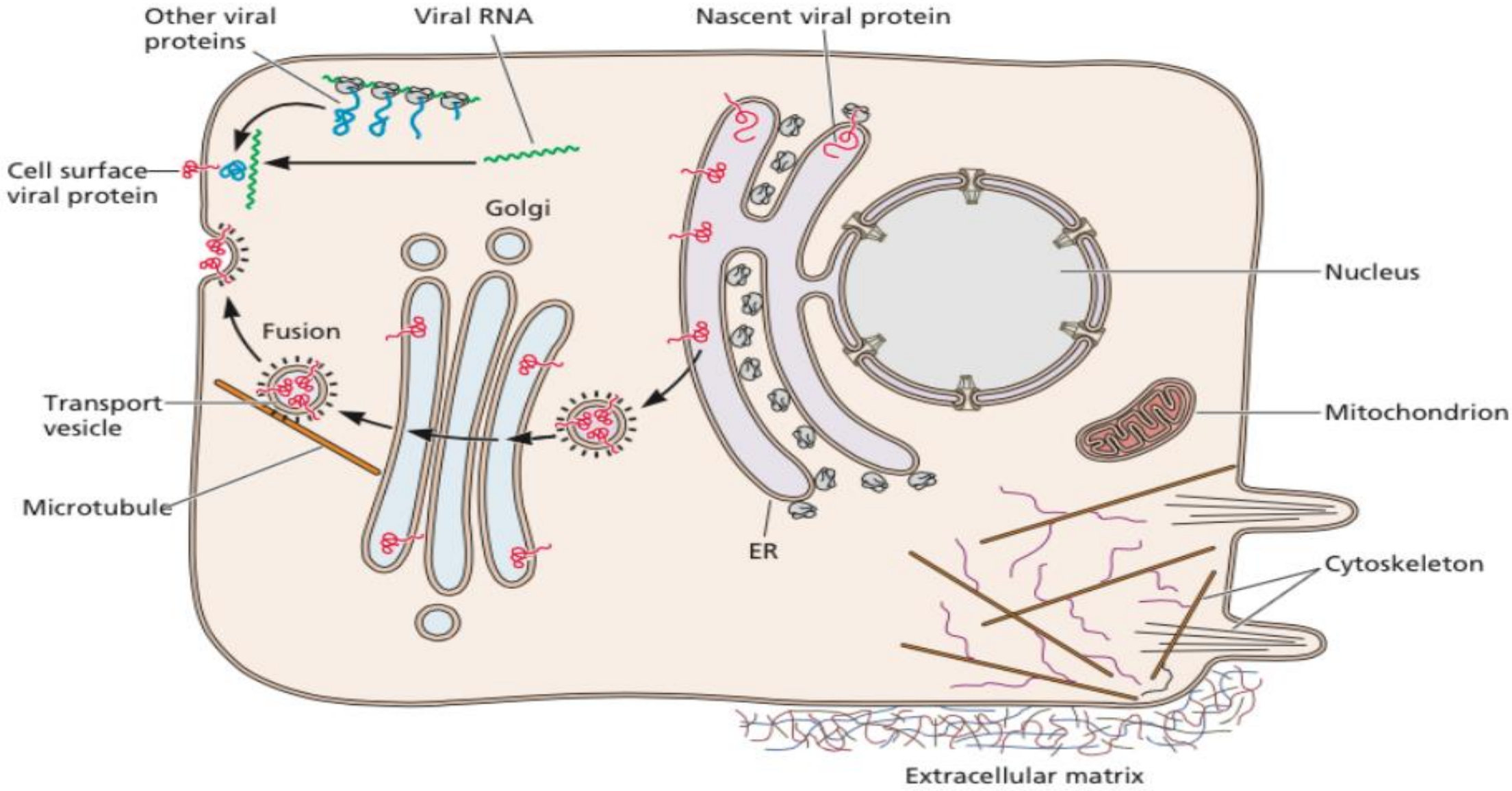
- Membrane targeting: Signal sequences, fatty acid modifications
- Membrane retention signals
- Nuclear localization sequences (NLS)
- Nuclear export signals



Localization of viral proteins to nucleus

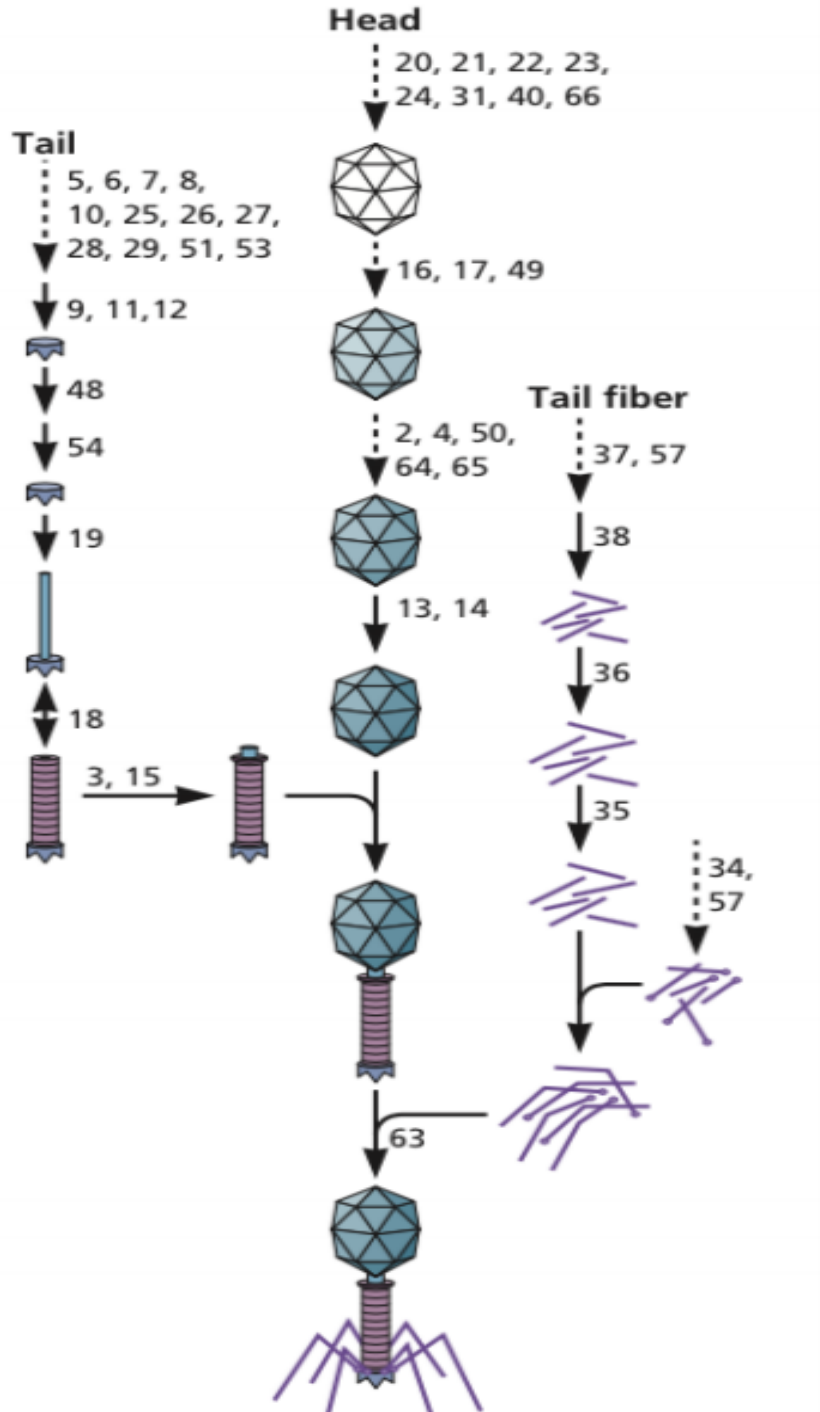


Localization of viral proteins to plasma membrane

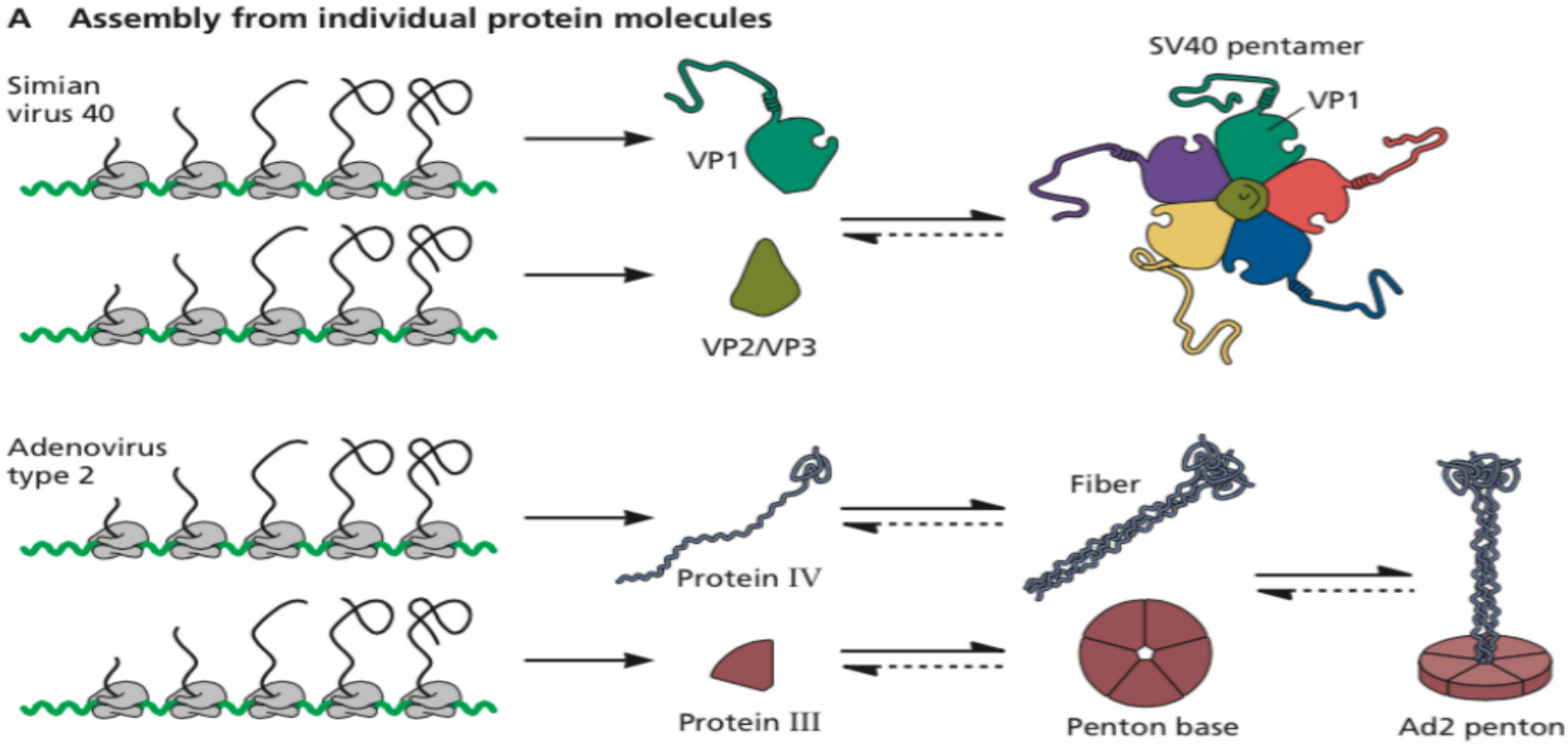


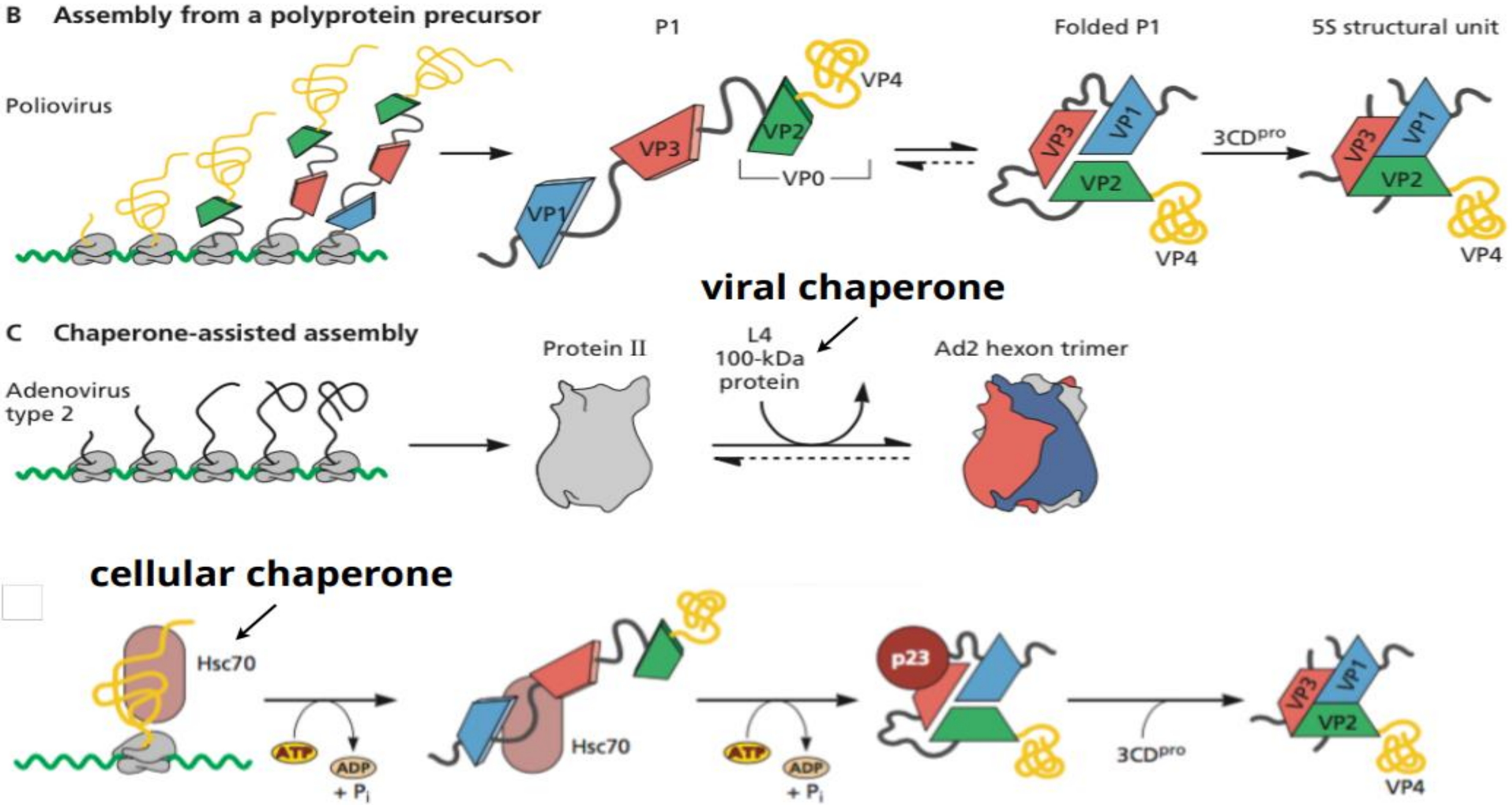
Sub-assemblies

- Ensure orderly formation of viral particles and virion subunits
- Formation of discrete intermediate structures
- Can't proceed unless previous structure is formed: *quality control*

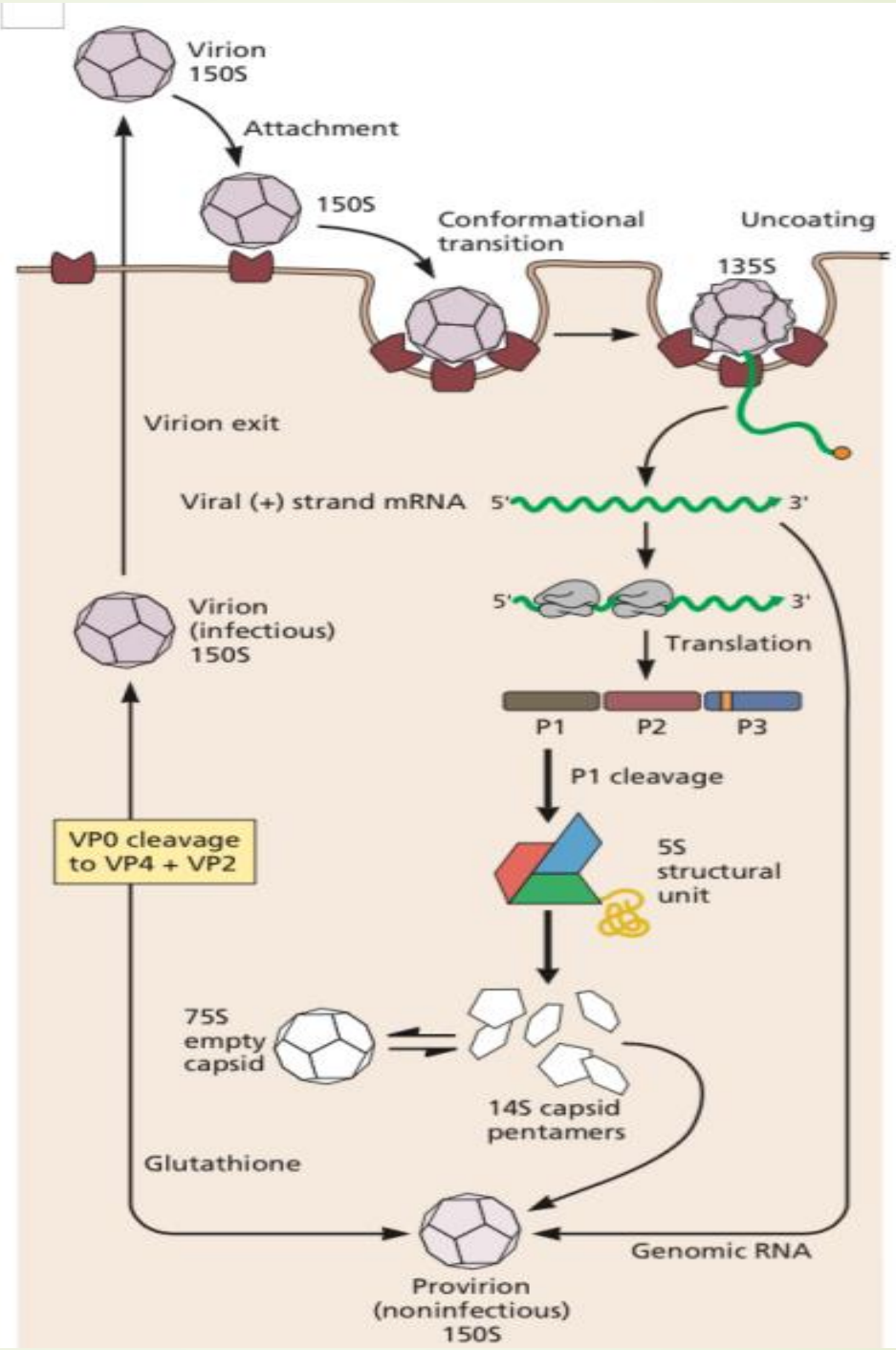


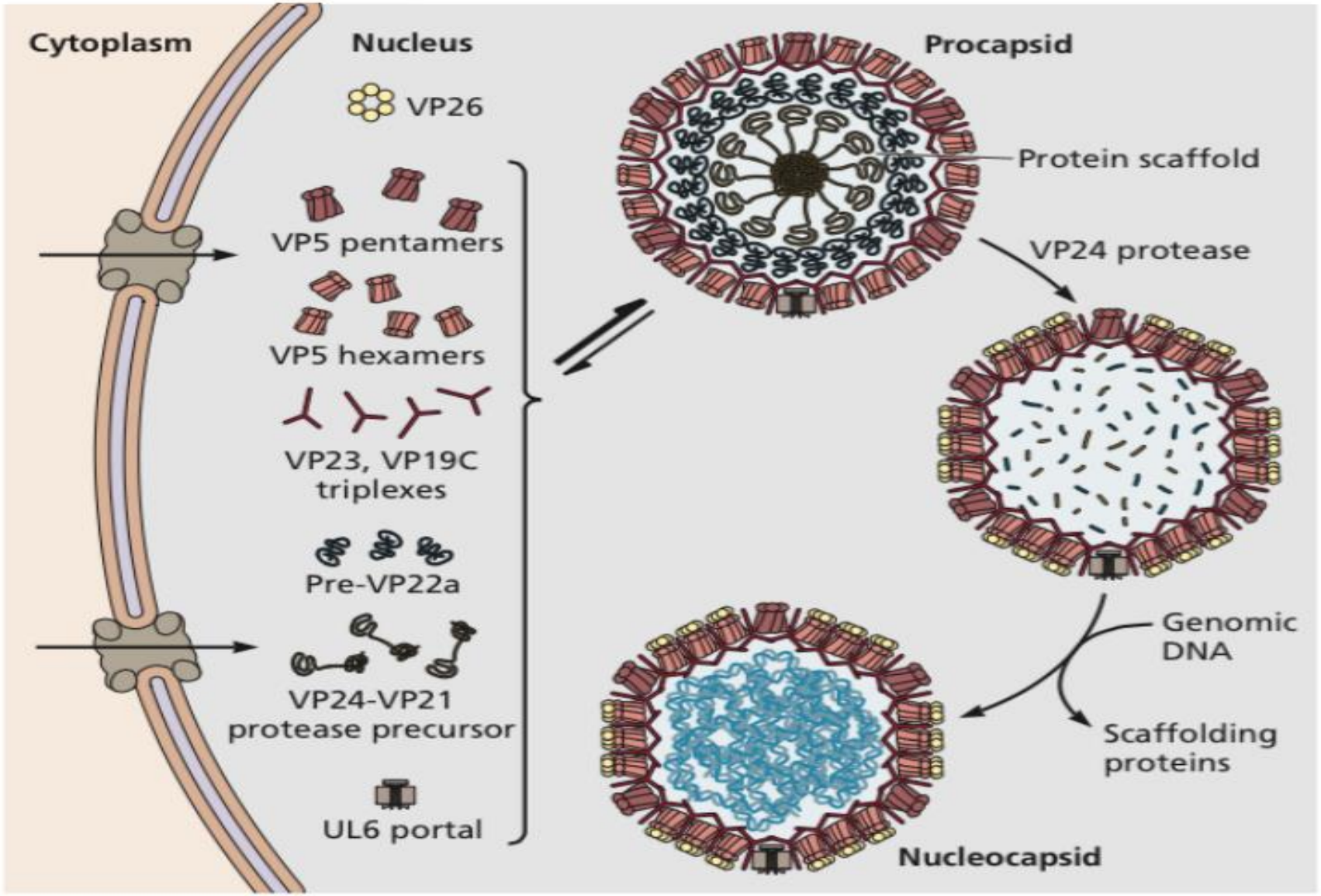
Three strategies for making sub-assemblies




B Assembly from a polyprotein precursor
Poliovirus
P1
VP4
VP2
VP3
VP1
VP0
Folded P1
VP3
VP1
VP2
VP4
3CDpro
5S structural unit
VP3
VP1
VP2
VP4
viral chaperone
C Chaperone-assisted assembly
Adenovirus type 2
Protein II
L4 100-kDa protein
Ad2 hexon trimer
cellular chaperone
Hsc70
ATP
ADP + Pi
Hsc70
ATP
ADP + Pi
p23
3CDpro
VP3
VP1
VP2
VP4

Sequential capsid assembly: poliovirus

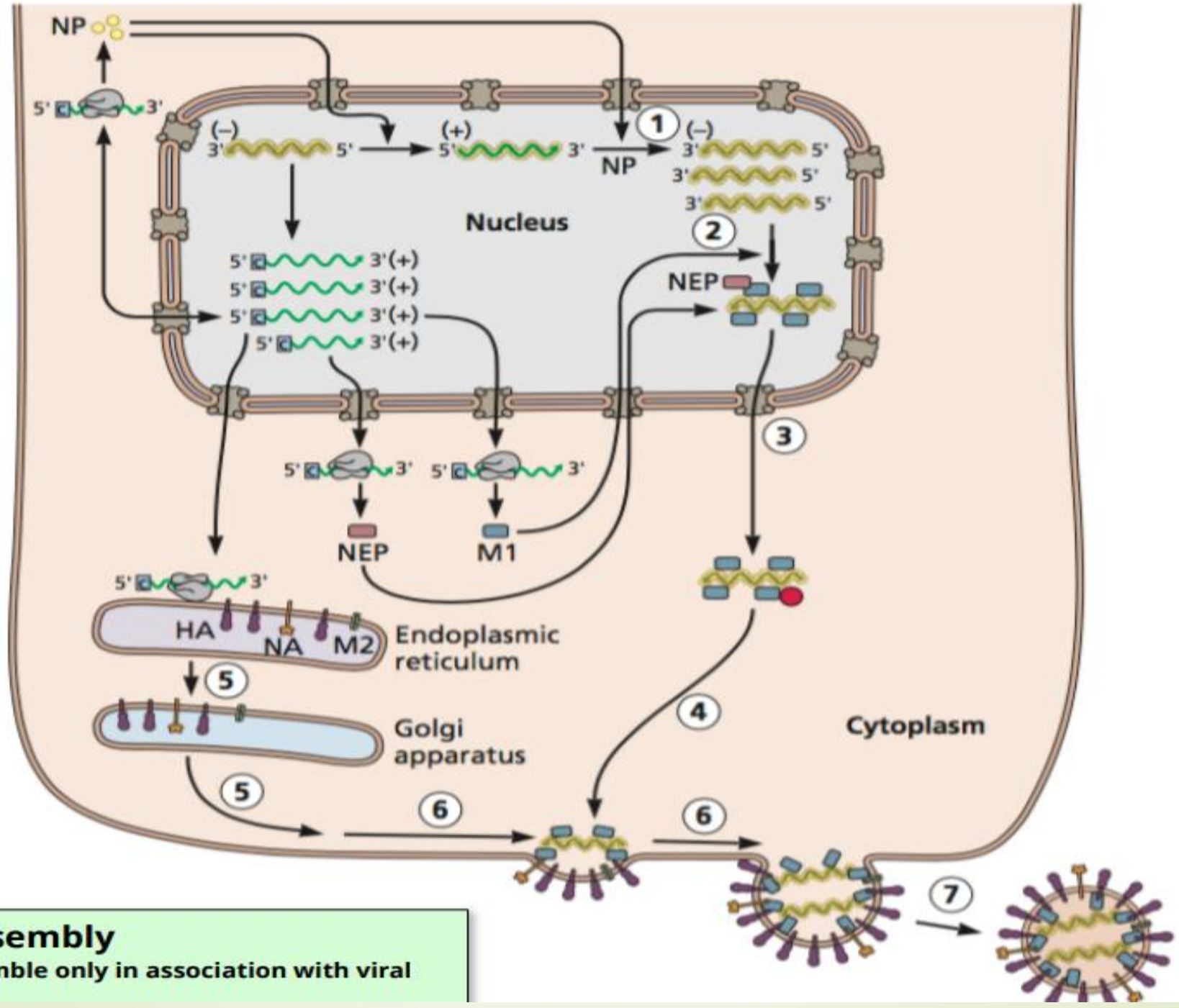




Viral scaffolding proteins

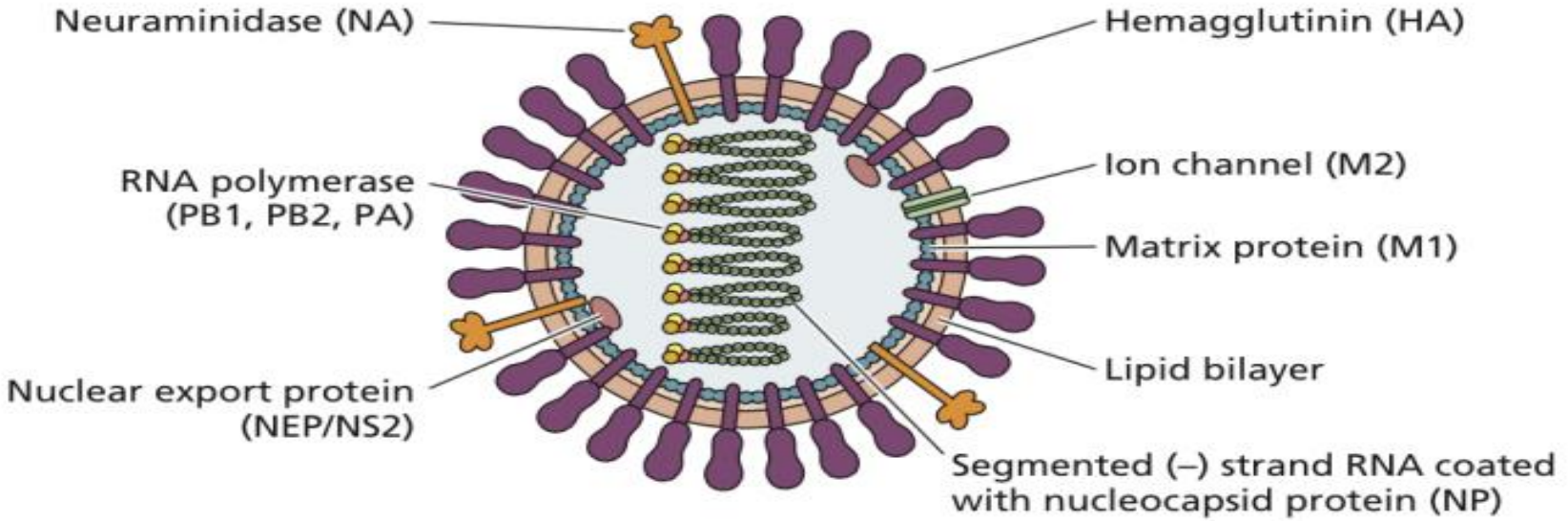
- establish transient intermediate structures
- viral proteases packaged in these intermediate structures become activated to finalize structure

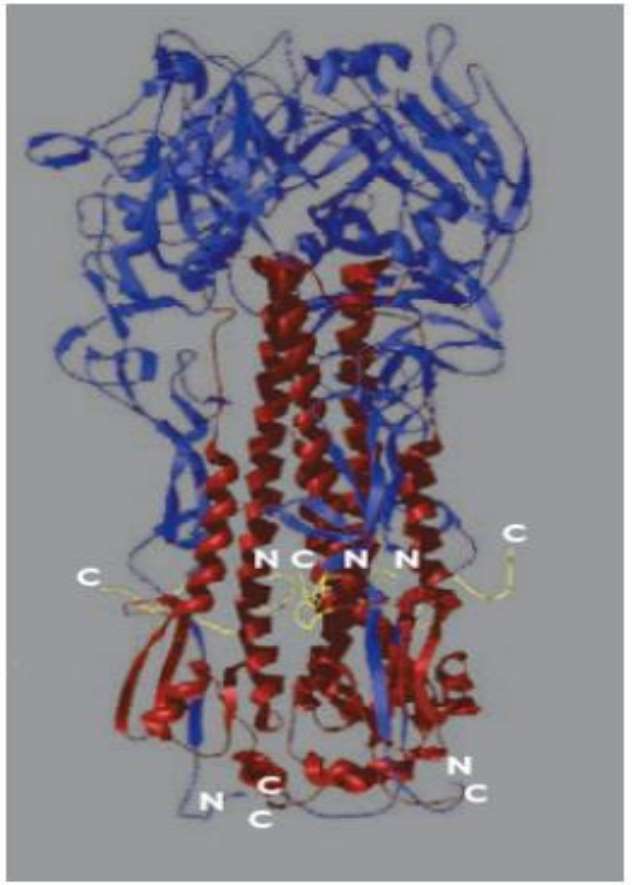
{sequential}



Concerted Assembly

Virus particles assemble only in association with viral genome


Neuraminidase (NA)
Hemagglutinin (HA)
RNA polymerase
(PB1, PB2, PA)
Ion channel (M2)
Matrix protein (M1)
Nuclear export protein
(NEP/NS2)
Lipid bilayer
Segmented (–) strand RNA coated
with nucleocapsid protein (NP)


N
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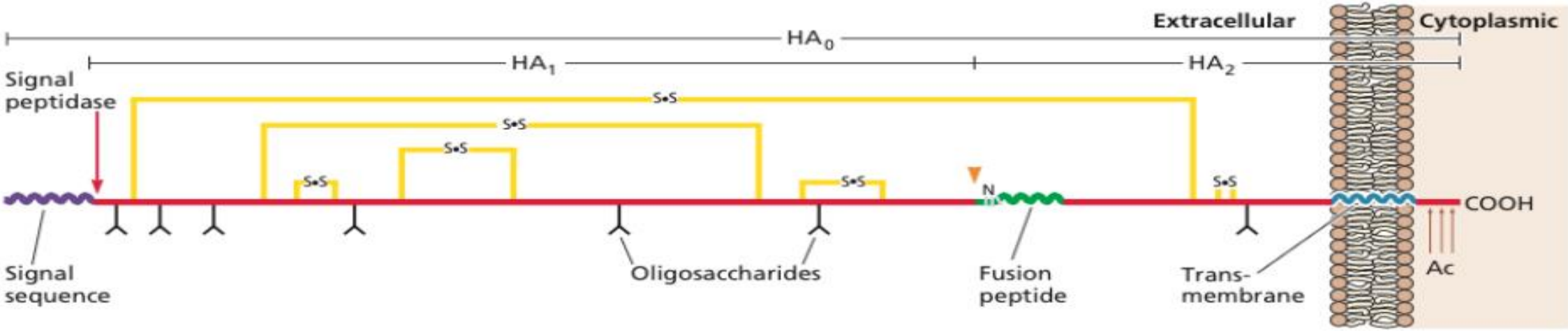
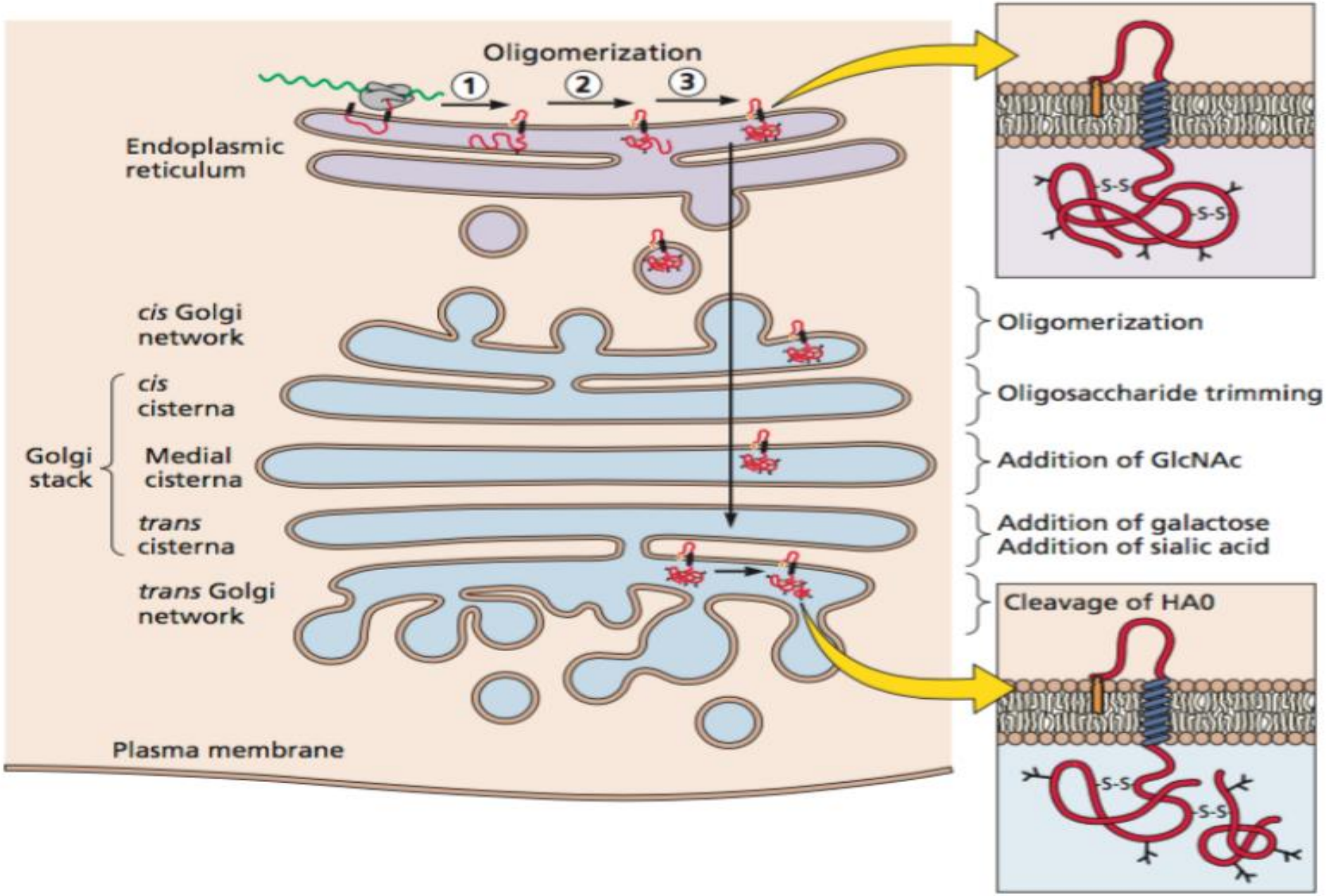

Extracellular
Cytoplasmic
HA0
HA1
HA2
Signal
peptidase
S•S
S•S
S•S
S•S
S•S
S•S
N
COOH
Signal
sequence
Oligosaccharides
Fusion
peptide
Trans-
membrane
Ac

Maturation of influenza HA0



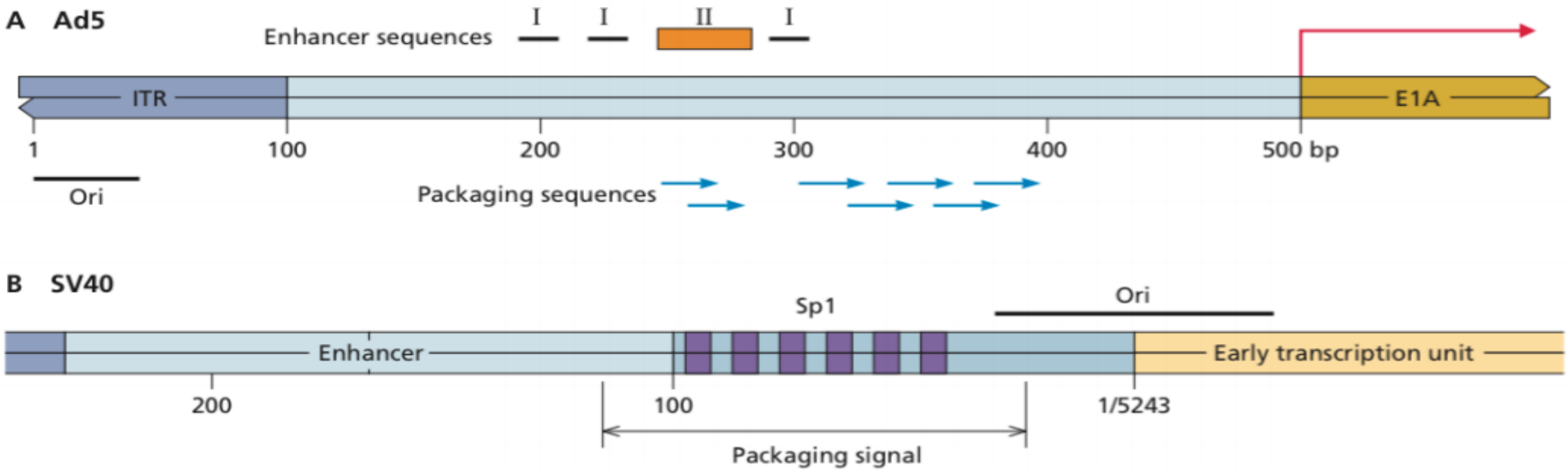
Subassemblies are involved in which of the following types of virus particle production?

1. Concerted assembly
2. Sequential assembly
3. Assembly lines
4. Chaperone-assisted assembly
5. All of the above

Genome packaging

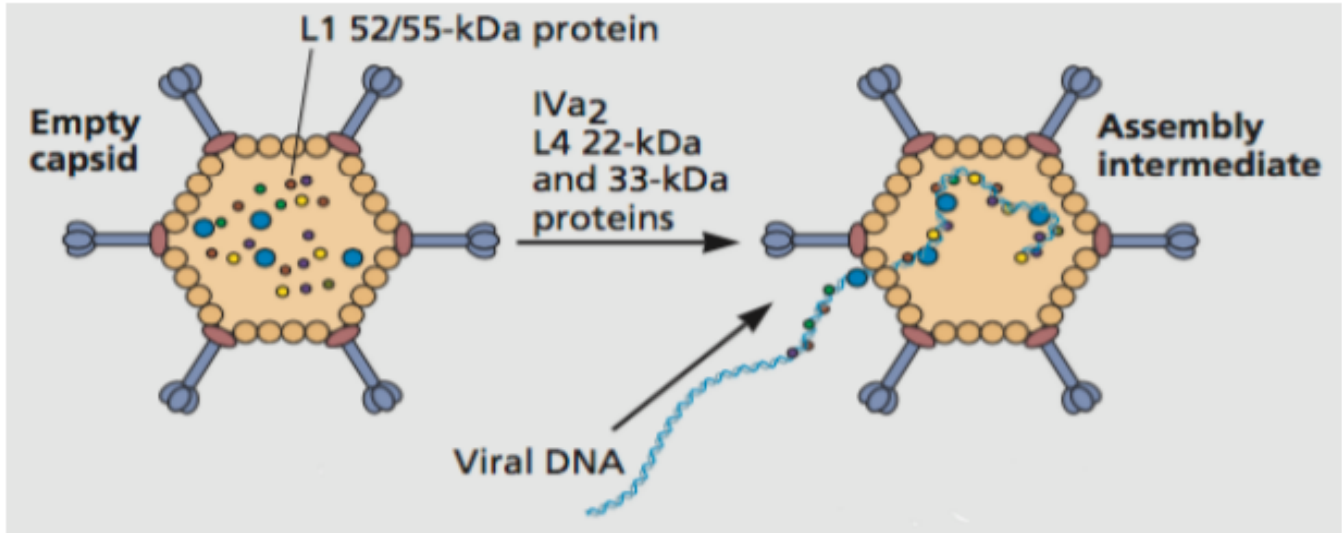
- Problem: Viral genomes must be distinguished from cellular DNA or RNA molecules where assembly takes place
- Solution: **Packaging signals** in the viral genome

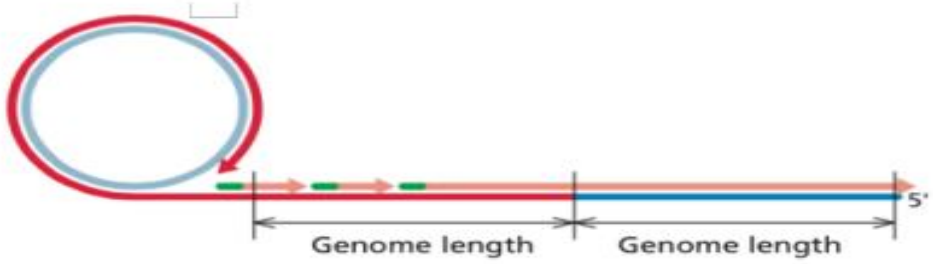
Packaging signals - DNA genomes

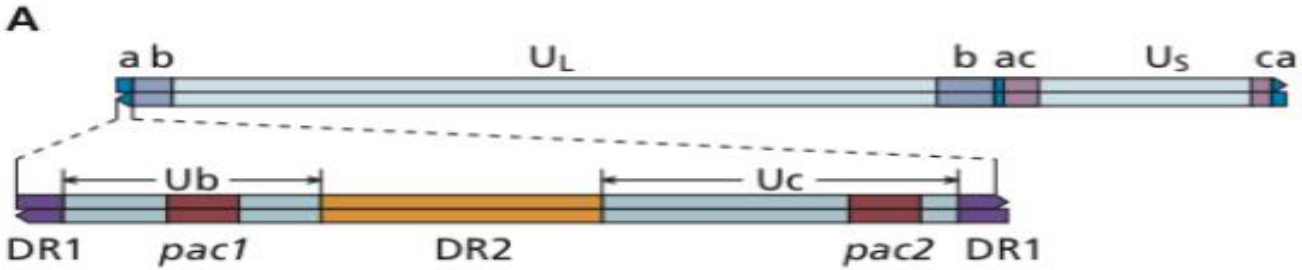


Adenovirus

- Packaging signal near left inverted repeat and origin
- Signal is complex: a set of repeated sequences; overlapping with enhancers that stimulate late transcription
- Recognized by viral protein IV2a

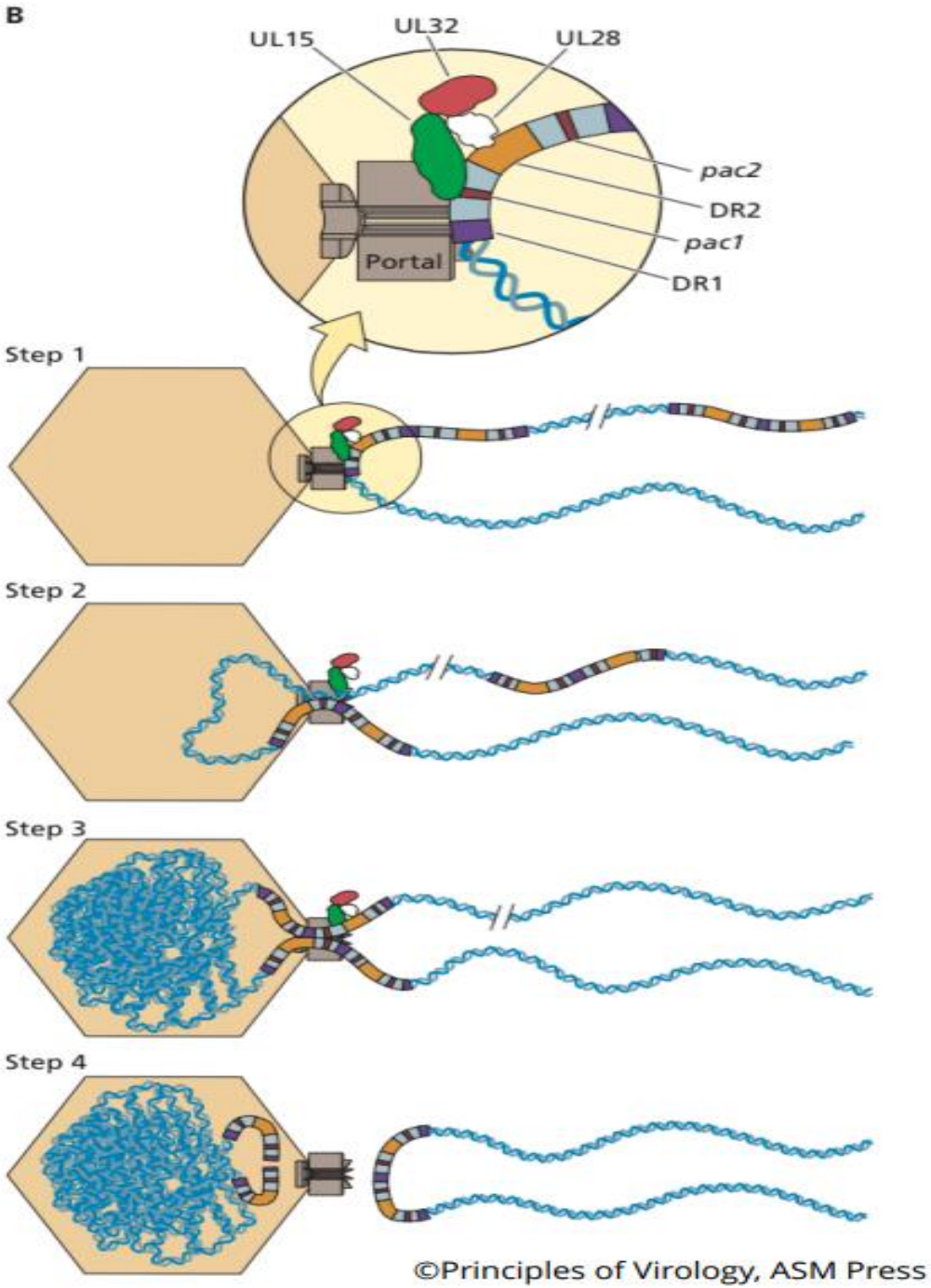




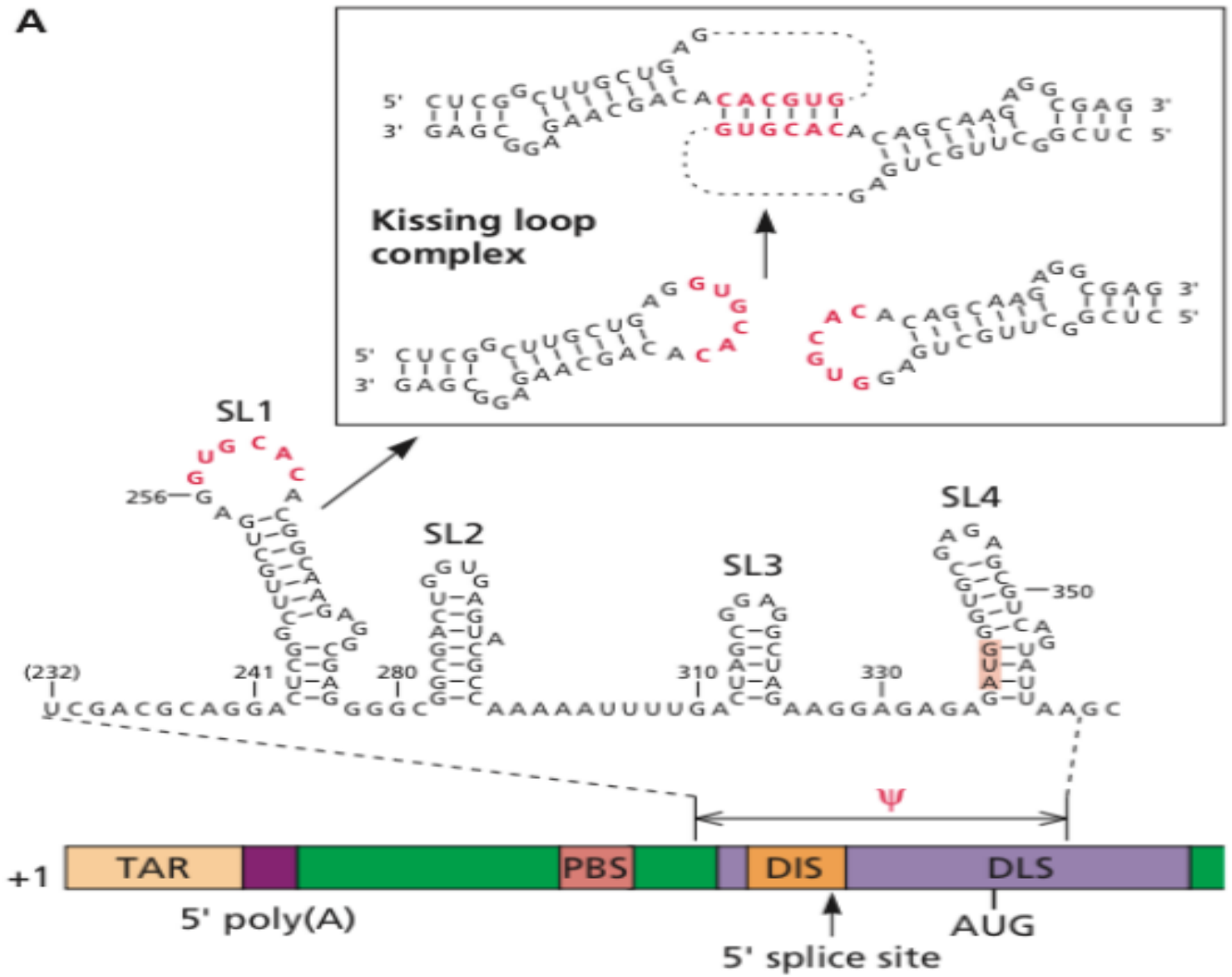


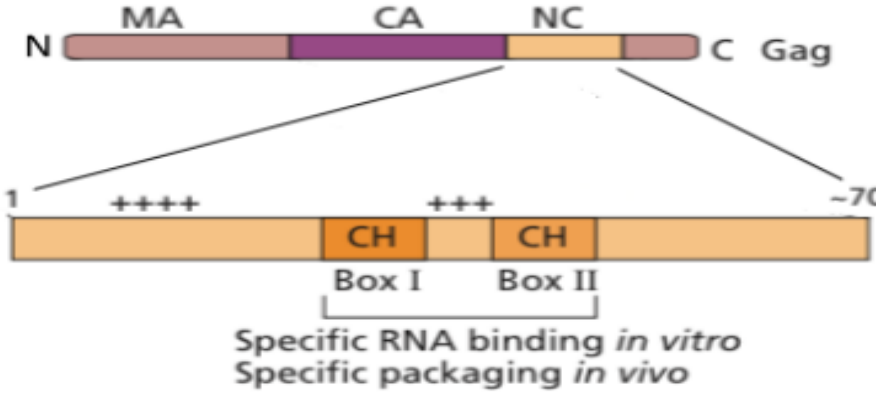
- Herpesvirus genome replication produces concatemers with head-to-tail copies of viral genome

- HSV-1 packaging signals *pac1* and *pac2* needed for recognition of viral DNA and cleavage within DR1



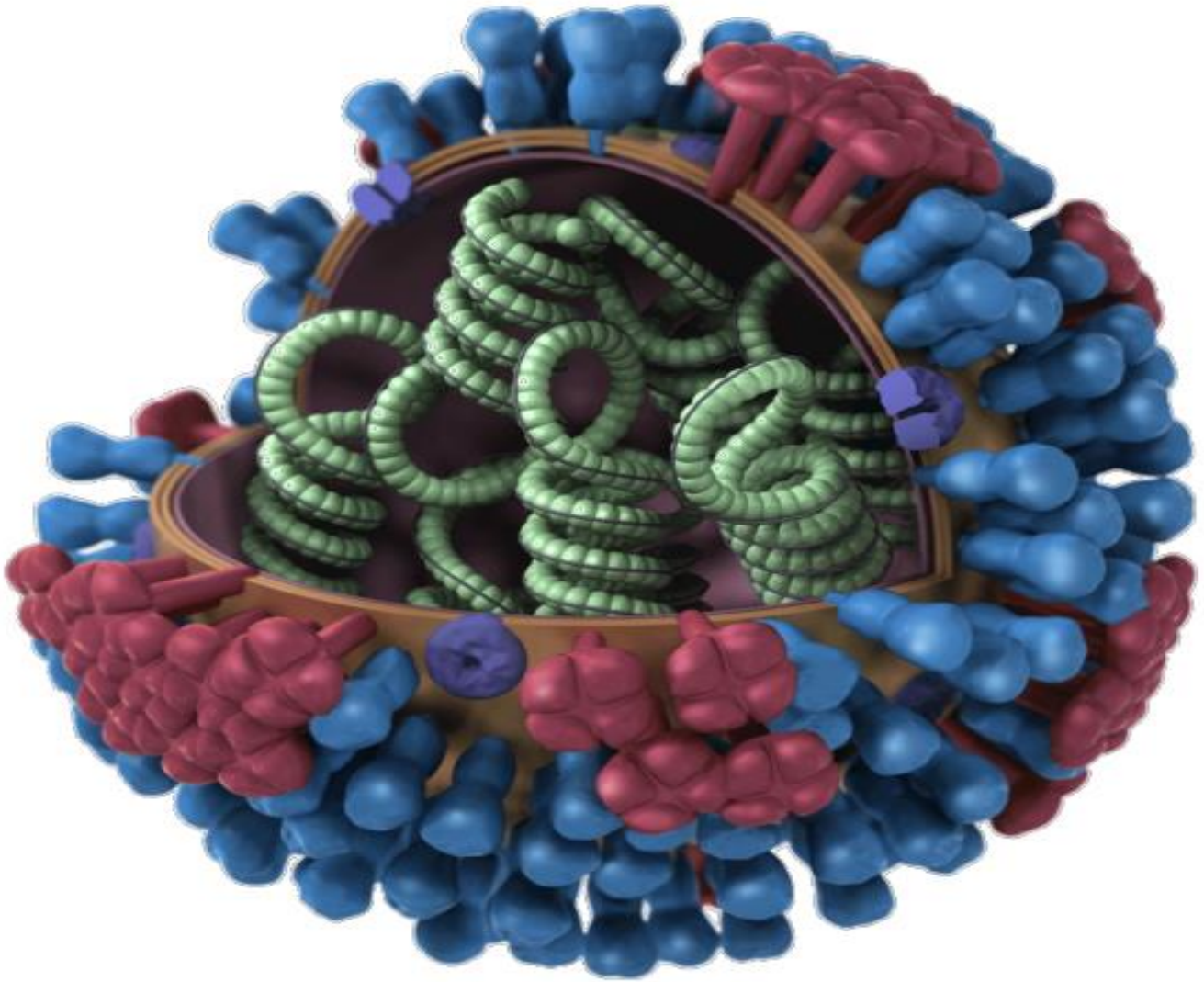
Packaging signals - RNA genomes





Necessary but not sufficient for HIV-1 genome packaging

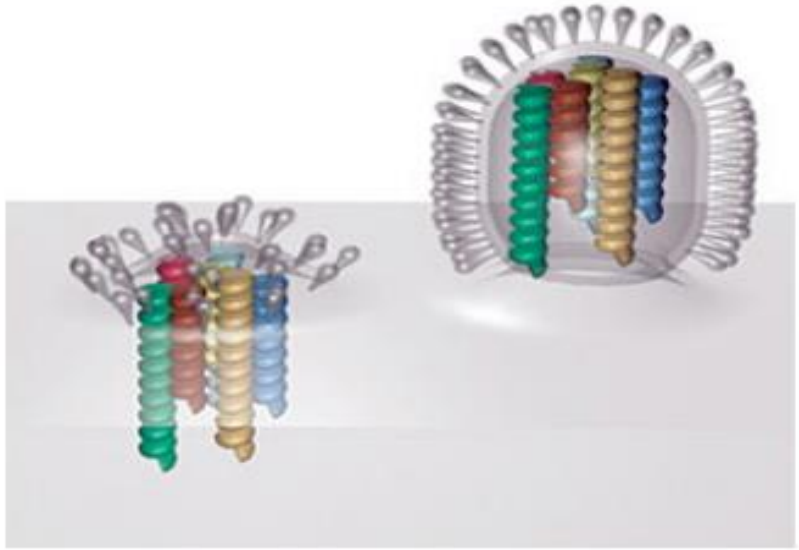
Packaging of segmented genomes

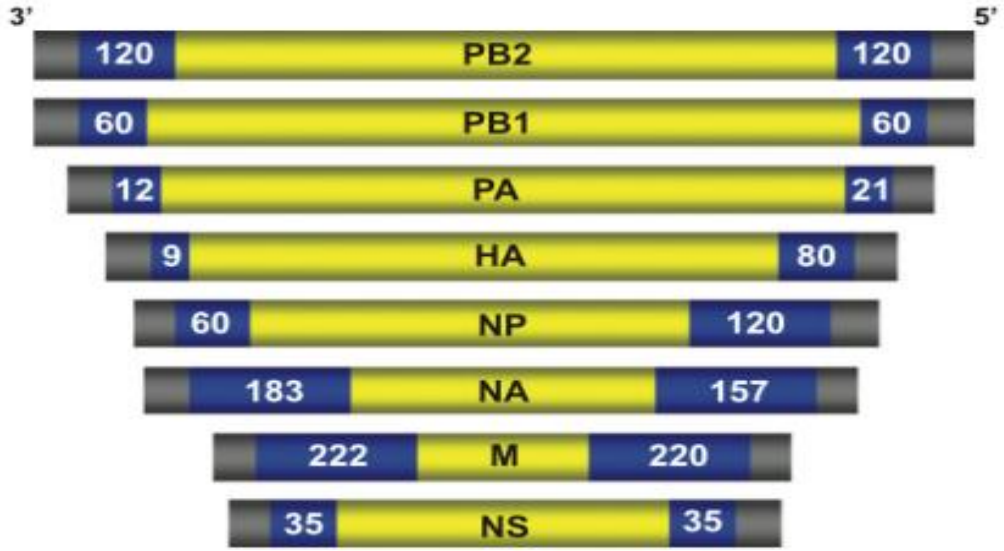


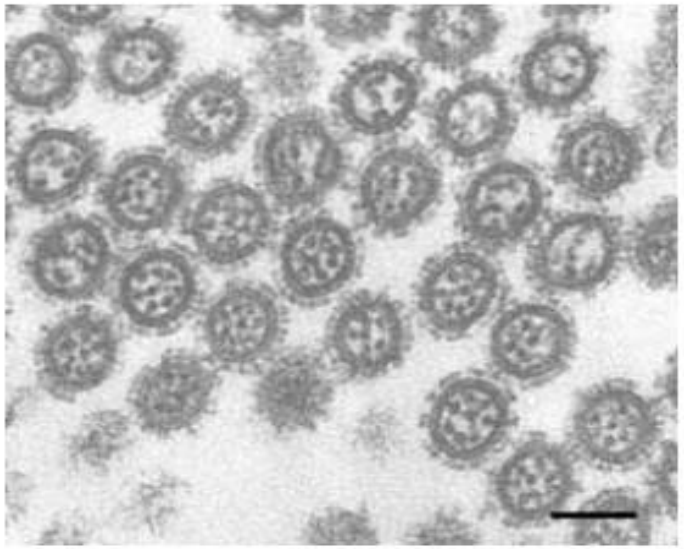
- *Random* mechanism would yield 1 infectious particle per 400 assembled - within known particle:pfu ratio

- Evidence for *specific* packaging sequence on each RNA segment

Influenza virus RNA packaging

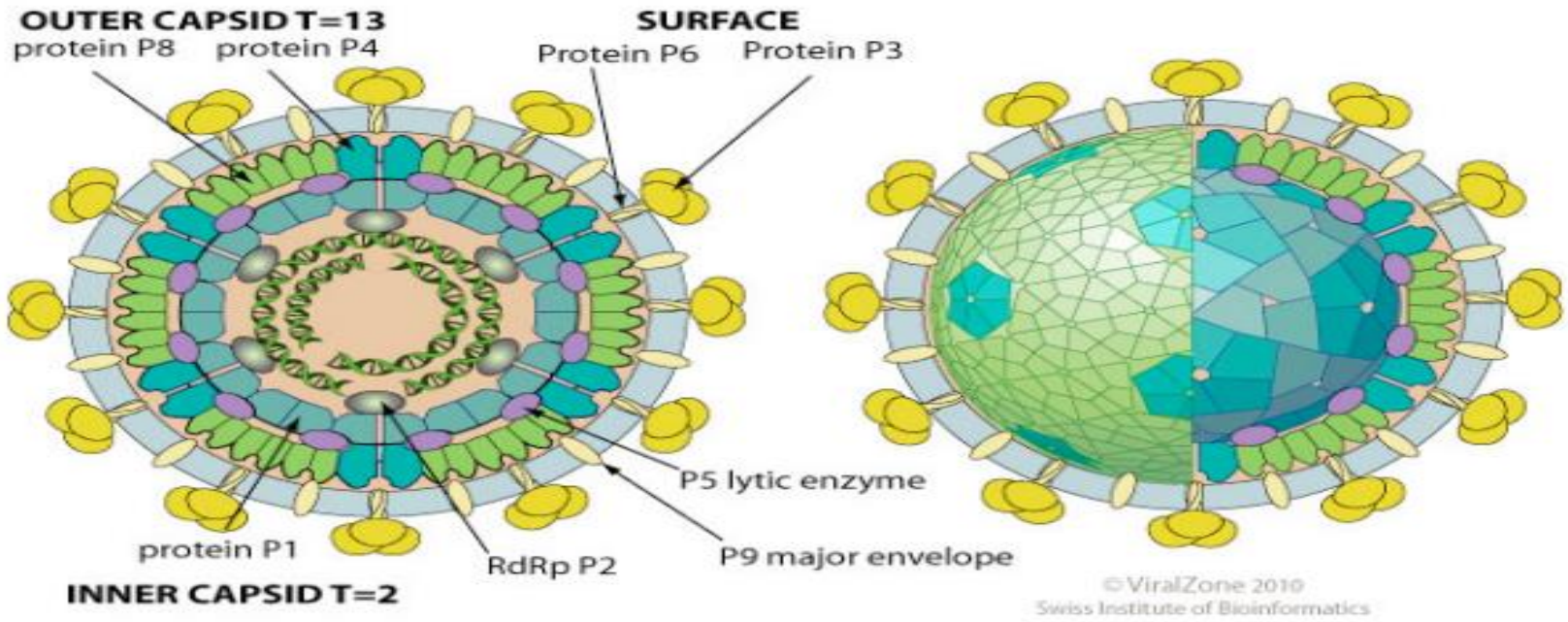






- Always 8 RNA segments
- Segments oriented perpendicular to budding tip
- HA, NS signals swapped
- RNA-RNA or RNA-protein interactions

Selective packaging



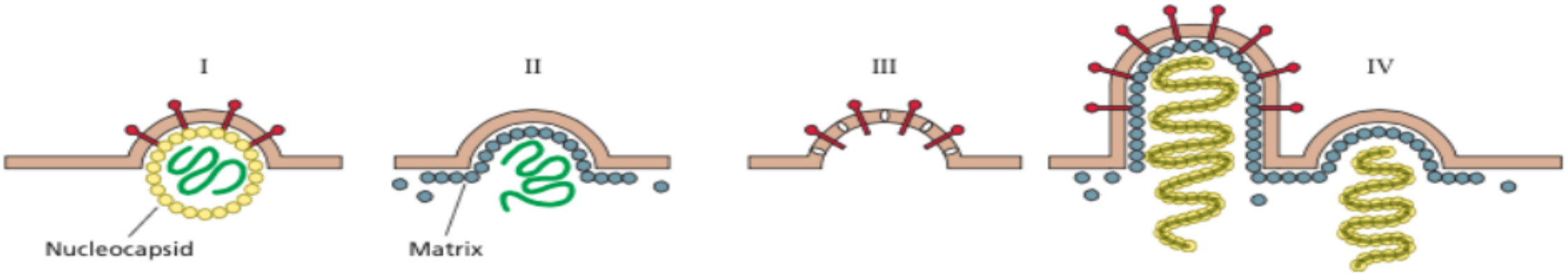
- Bacteriophage ϕ6 - 3 dsRNA segments S, M, L
- Serial dependence of packaging: S-M-L
- Particle:pfu ratio ~1
- Rotavirus

Packaging signals on viral ____ interact with viral ___ during virus assembly.

1. Lipids, proteins
2. Proteins, subassemblies
3. Genomes, proteins
4. Proteases, membranes
5. Proteins, genomes

Acquisition of an envelope

- After assembly of internal structures (most enveloped viruses)
- Simultaneous with assembly of internal structures (retroviruses)



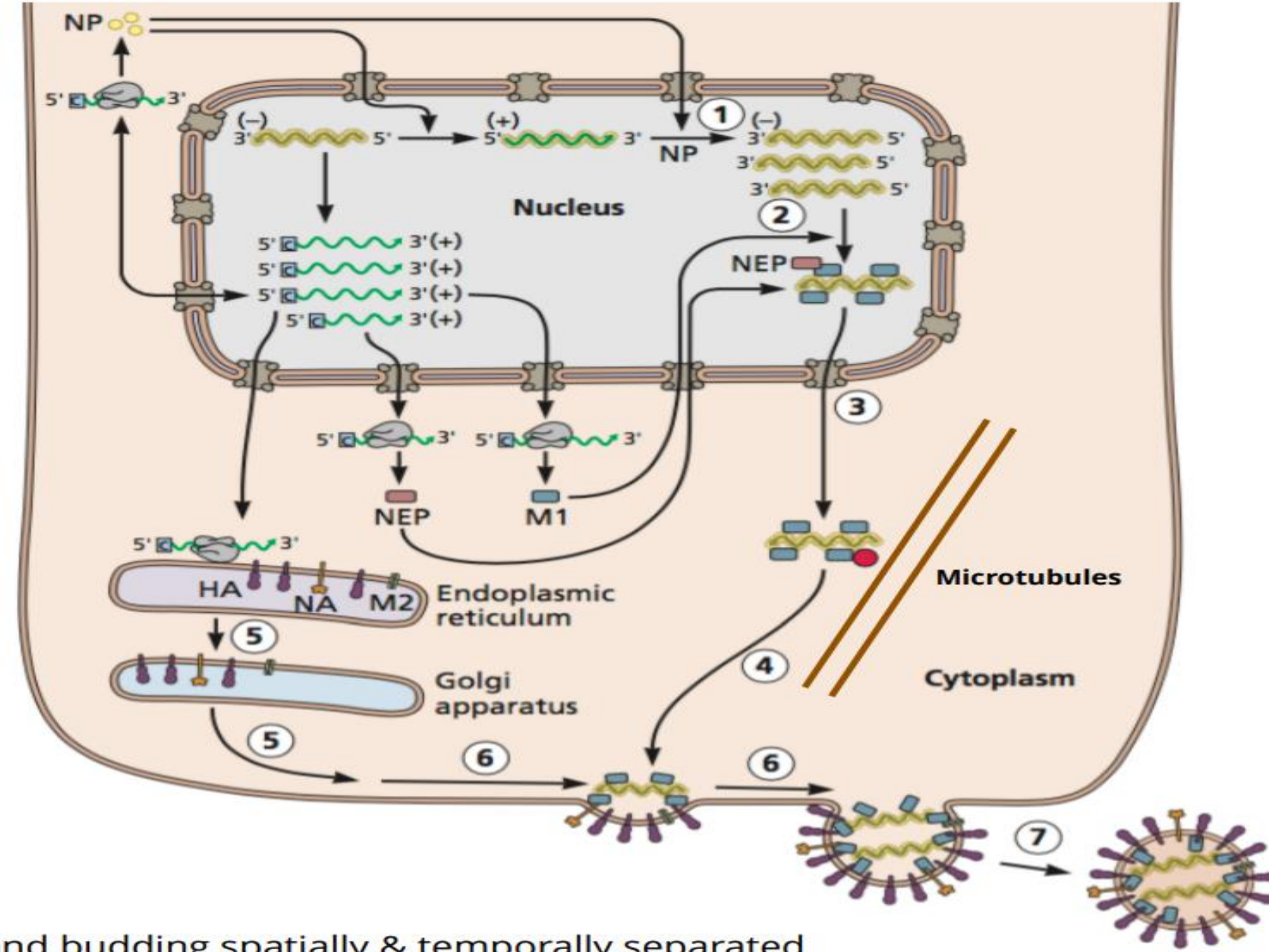
Envelope glycoproteins and capsid essential for budding - alphaviruses

Internal matrix or capsid proteins drive budding - retroviruses

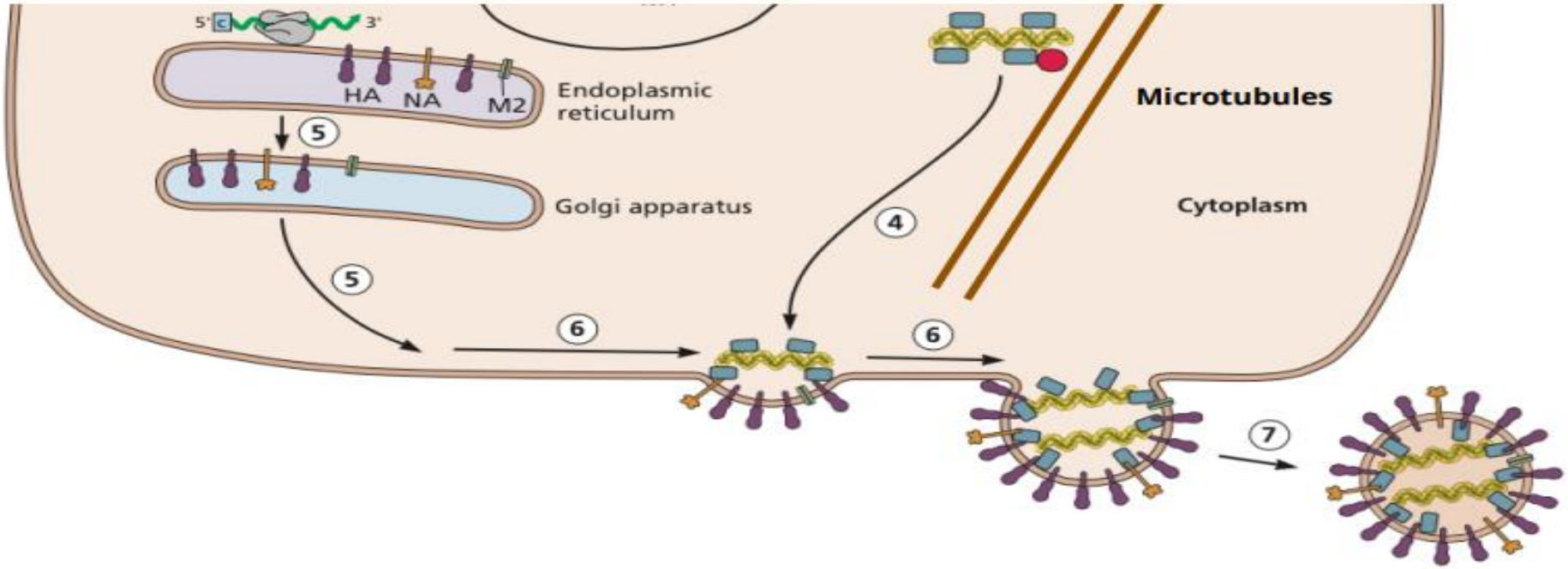
Envelope proteins drive budding - influenza virus, coronavirus

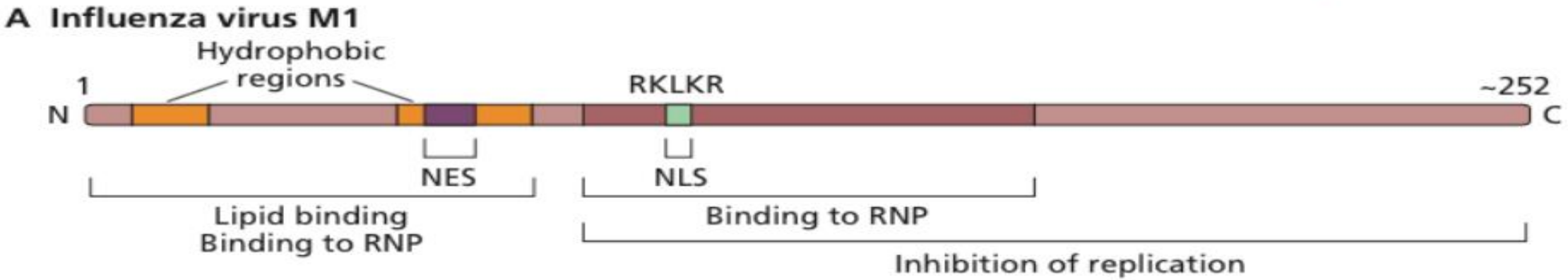
Matrix proteins drive budding, but additional components (glycoproteins, RNP) needed for efficiency or accuracy

Influenza virus budding



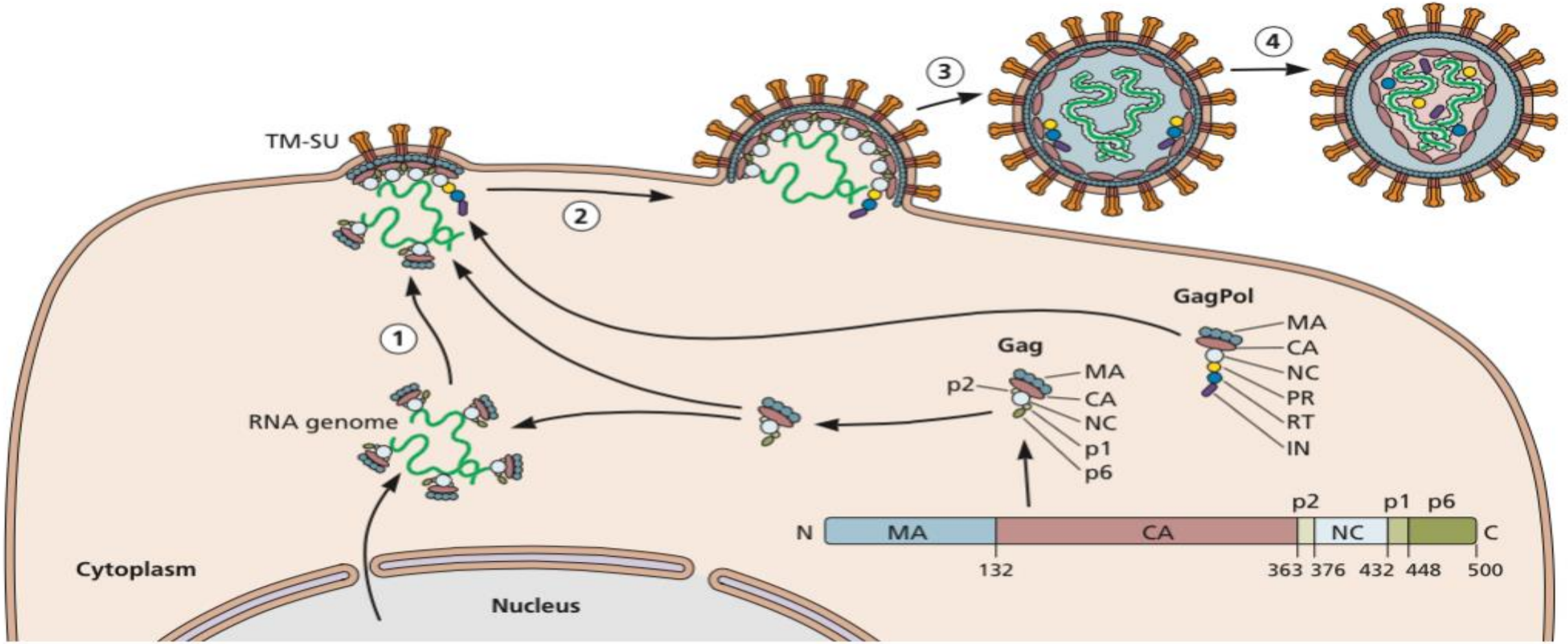
Internal structure assembly and budding spatially & temporally separated


5'
C
3'
HA
NA
M2
Endoplasmic reticulum
5
Golgi apparatus
5
4
Microtubules
Cytoplasm
6
6
7

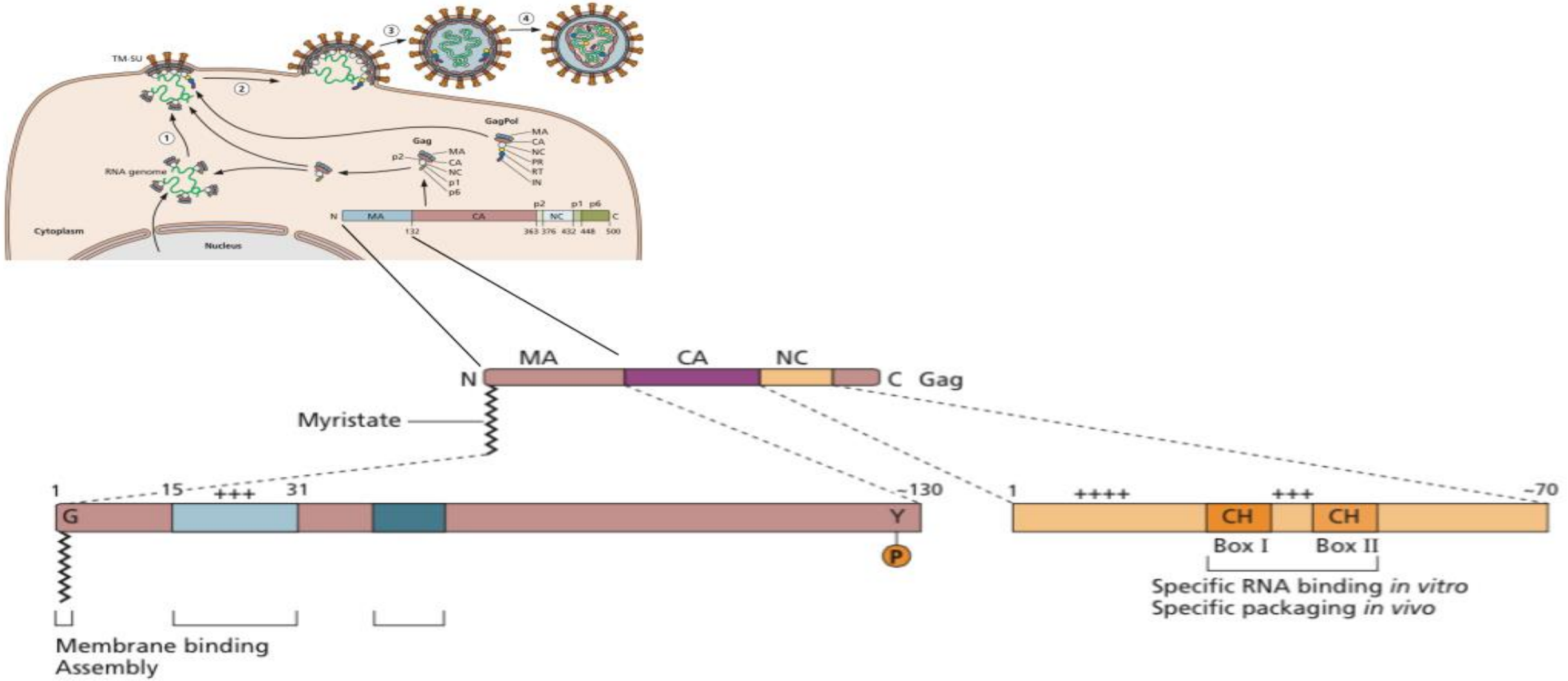

A Influenza virus M1
Hydrophobic regions
1
RKLKR
~252
N
C
NES
NLS
Lipid binding
Binding to RNP
Binding to RNP
Inhibition of replication


B VSV M
Hydrophobic region
1+++
229
N
C
Membrane binding
Binding to RNPs

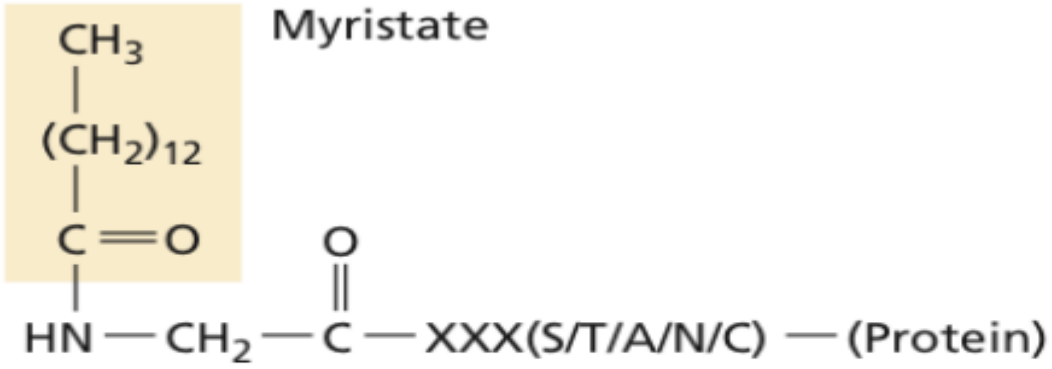
Retrovirus budding



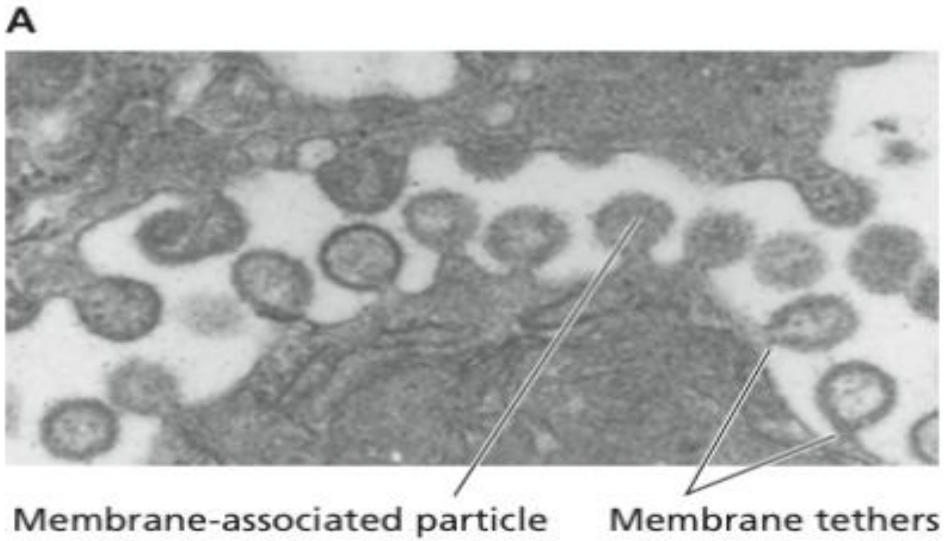
Gag alone produces virus-like particles

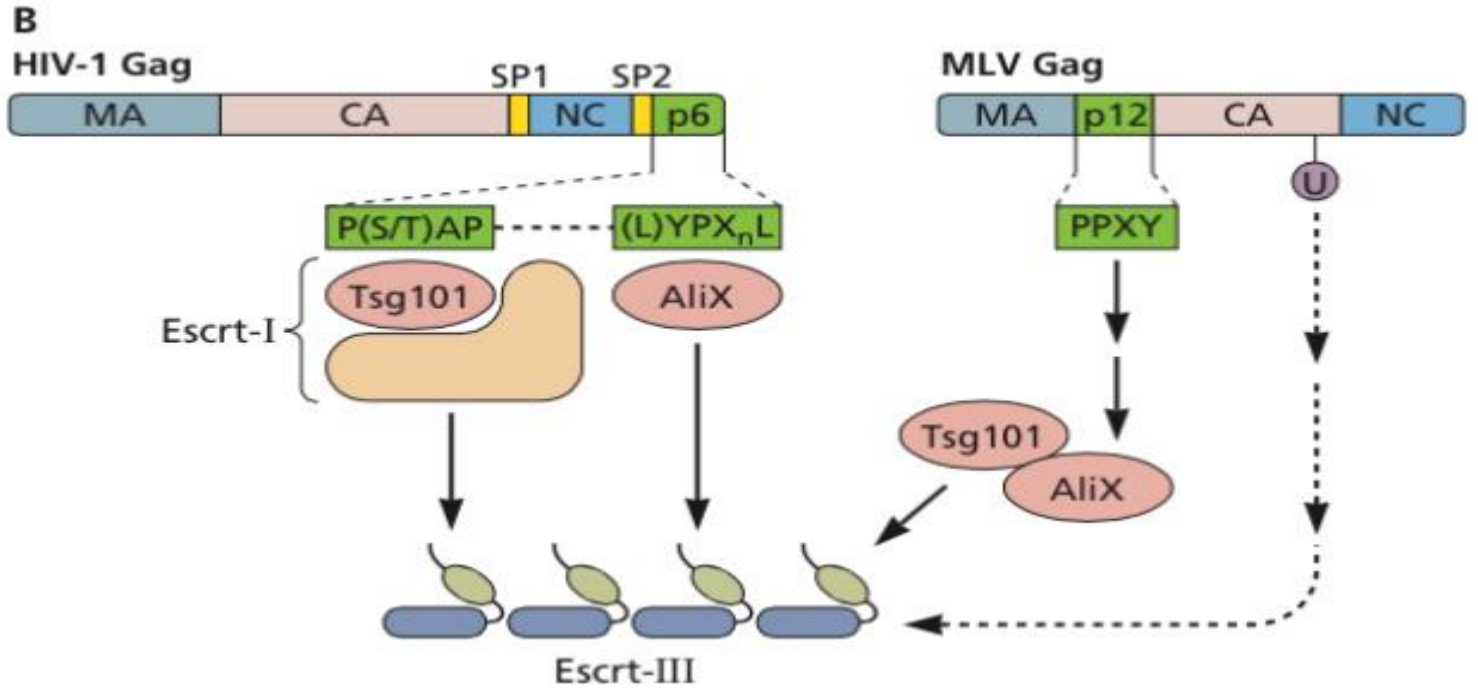


- Changes at myristoylation sequence prevent interaction of Gag with the cytoplasmic face of the plasma membrane
- Virus assembly and budding are inhibited



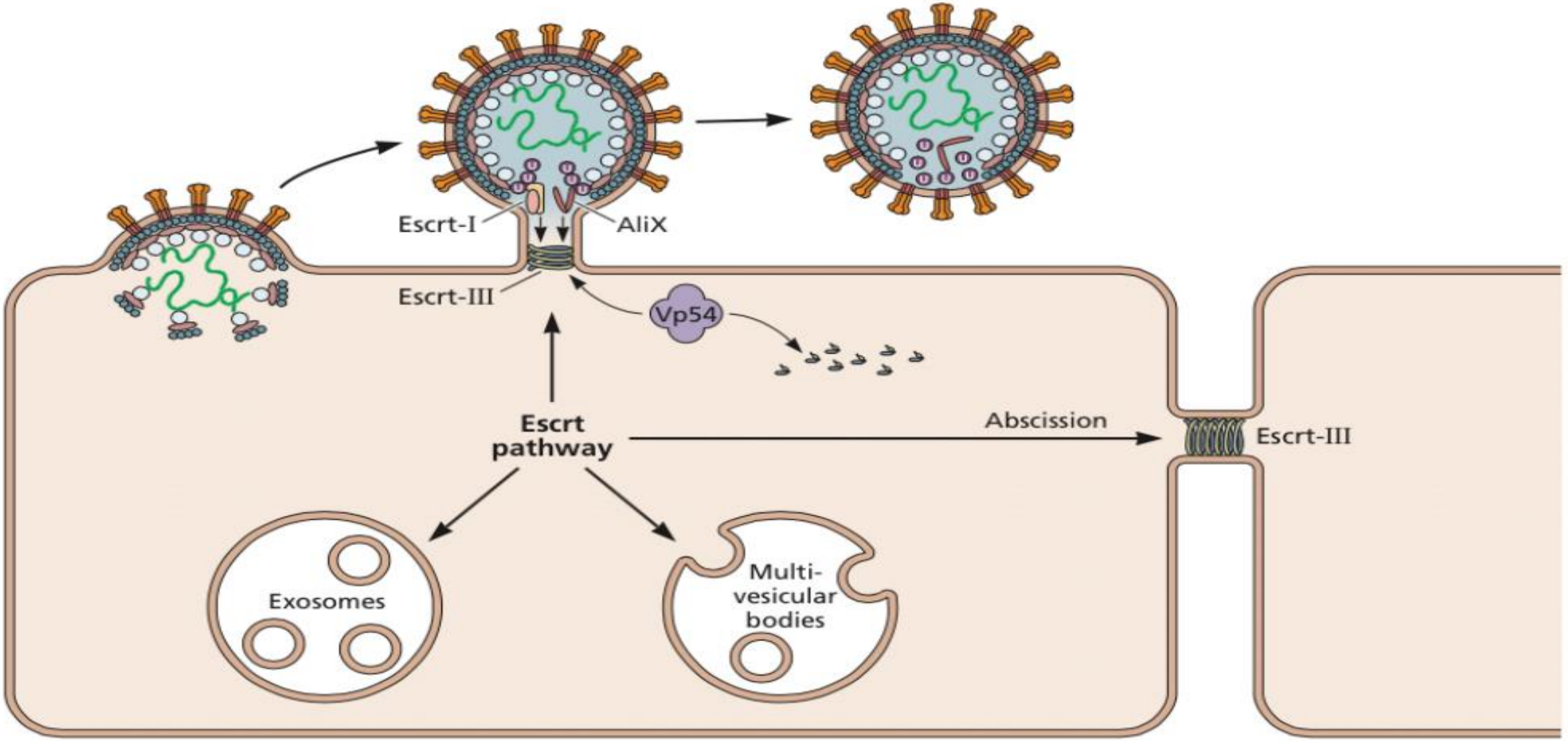
- Addition of lipid to viral proteins allows targeting to membranes independent of signal sequence
- Viral proteins are synthesized in the cytoplasm, and modified with lipids post-translationally

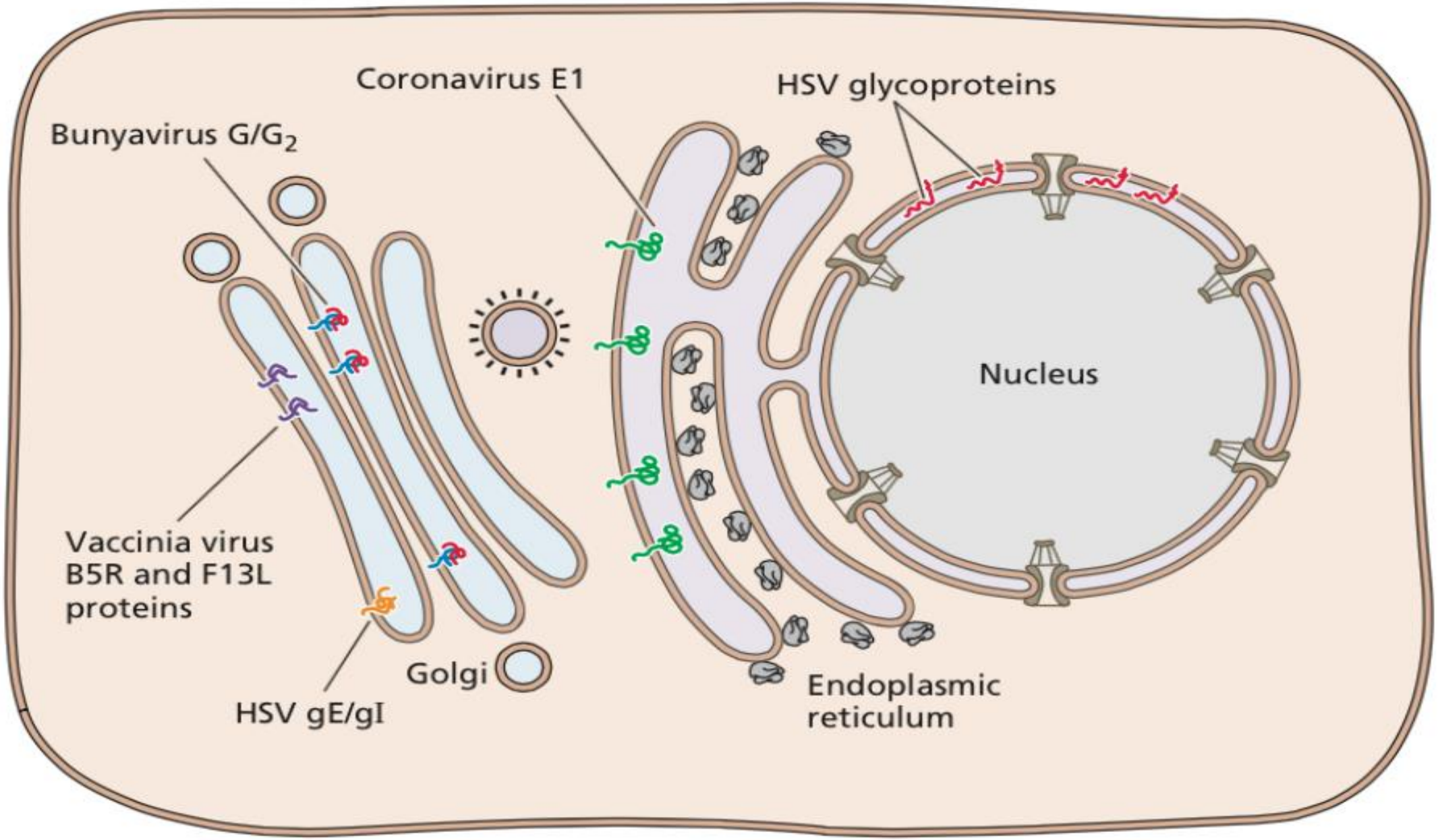




- Amino acid change in Gag cause arrest of budding at a late stage (late or L domains)
- Found in + and - strand enveloped viruses
- L domains bind cell proteins involved in vesicle trafficking, needed for virus release

Endosomal sorting complexes required for transport (ESCRT) machinery

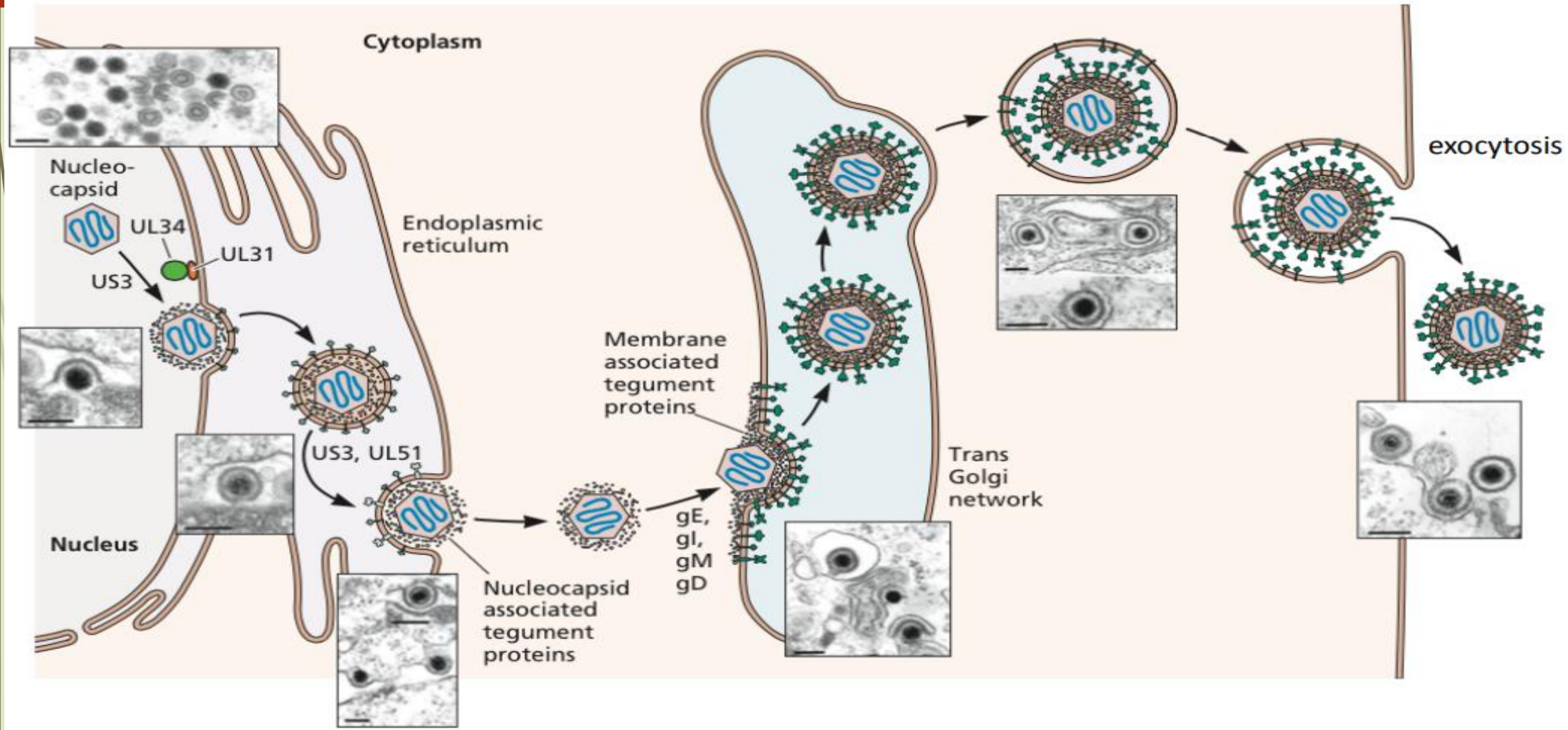



Coronavirus E1
HSV glycoproteins
Bunyavirus G/G2
Nucleus
Vaccinia virus
B5R and F13L
proteins
Golgi
HSV gE/gI
Endoplasmic
reticulum

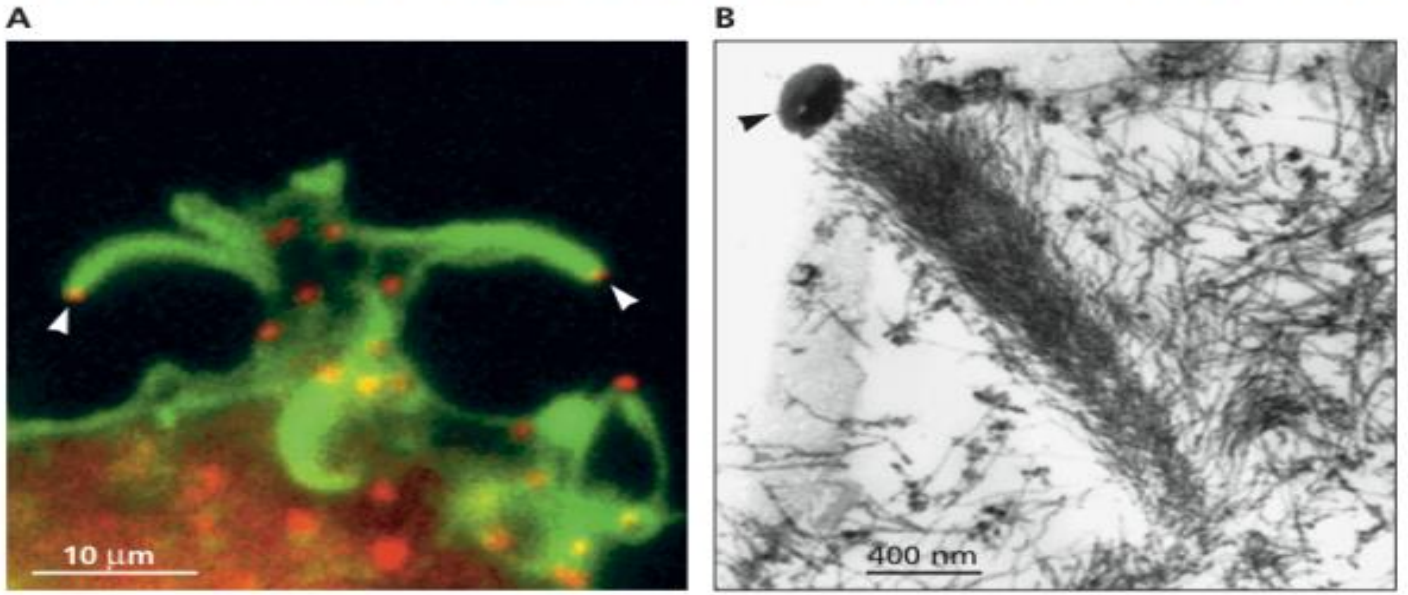
Which statement about viral budding is incorrect?

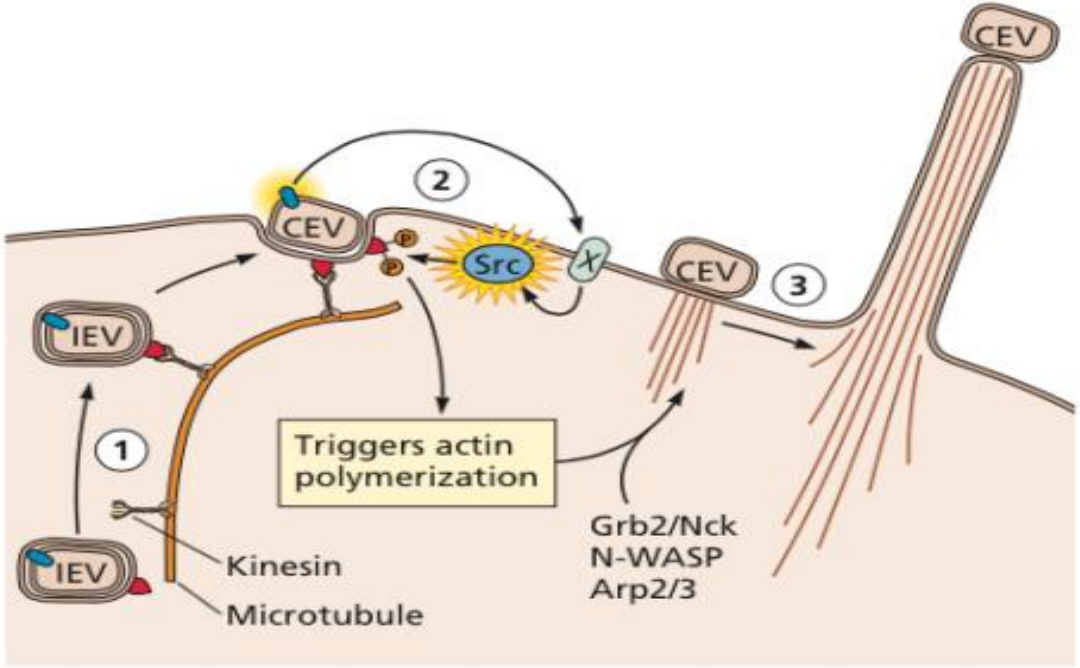
1. The envelope can be acquired before or simultaneous with assembly of internal components
2. The viral spike glycoprotein can drive budding
3. No host proteins are involved in the budding process
4. Lipids assist structural proteins to interact with the membrane
5. Budding can occur from the nucleus, ER, Golgi, or plasma membrane

Herpesvirus assembly and egress

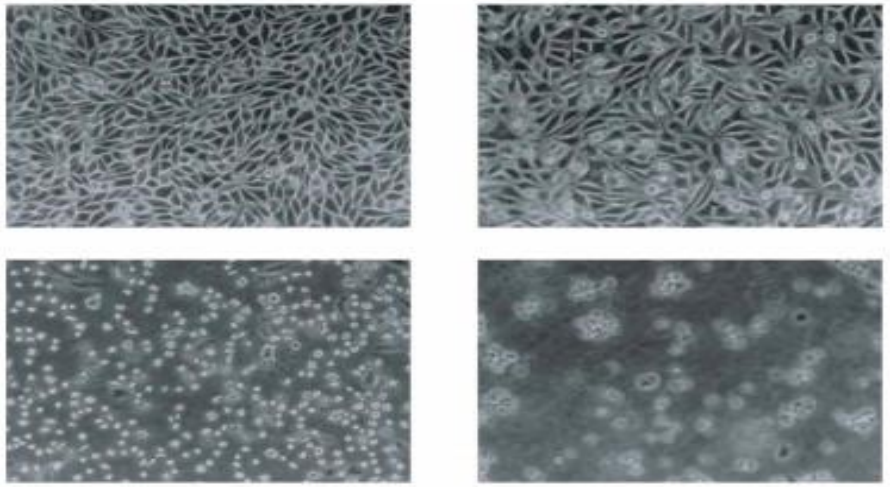


Propulsion of vaccinia virus on actin tails



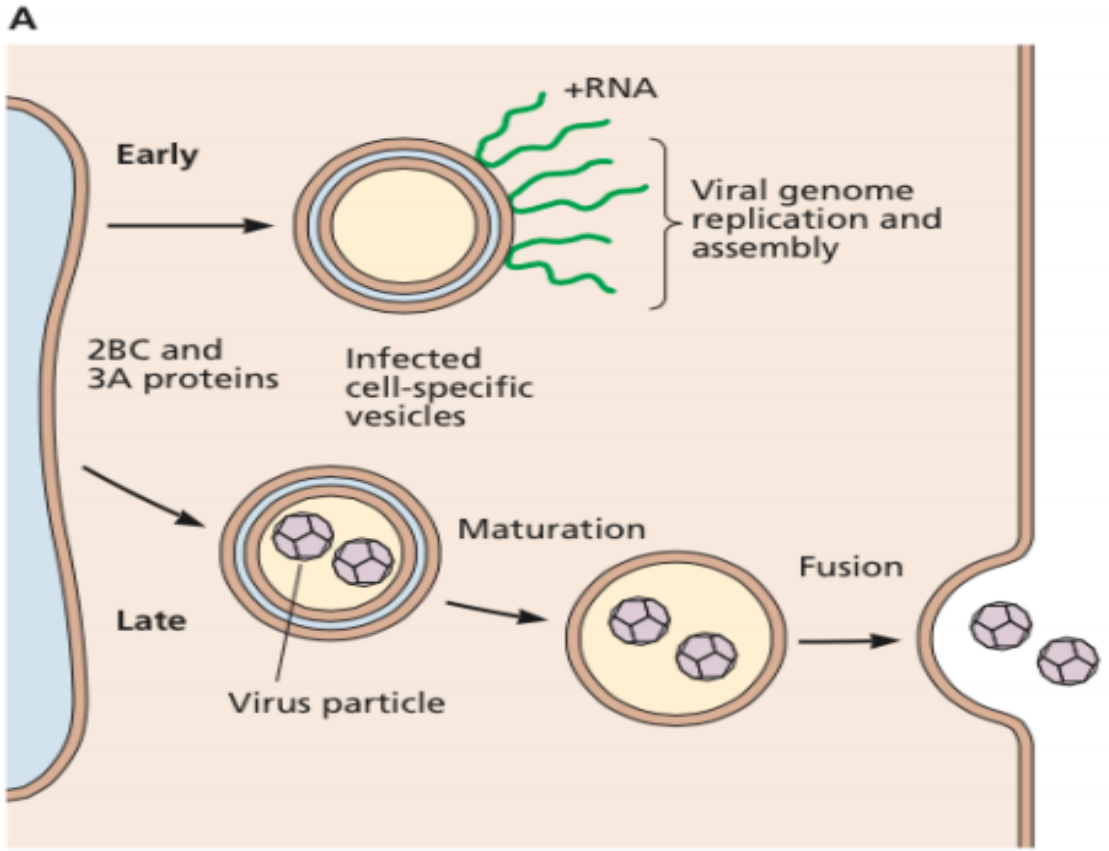


Release of nonenveloped viruses



- Cell lysis: apoptosis, necroptosis
- Viral proteins that induce rupture of cell membranes
  - Viroporins form pores in cell membranes (polyomavirus)
- Loss of membrane integrity with inhibition of protein synthesis

Non-lytic release of nonenveloped viruses



3.CELL THEORY

In biology, cell theory is the historic scientific theory, now universally accepted, that living organisms are made up of cells, that they are the basic structural/organizational unit of all organisms, and that all cells come from pre-existing cells.

Cells are the basic unit of structure in all organisms and also the basic unit of reproduction.

The three tenets to the cell theory are as described below:

All living organisms are composed of one or more cells.
The cell is the basic unit of structure and organization in organisms.

Cells arise from pre-existing cells

Key Points

The cell theory describes the basic properties of all cells.

The three scientists that contributed to the development of cell theory are Matthias Schleiden, Theodor Schwann, and Rudolf Virchow.

A component of the cell theory is that all living things are composed of one or more cells.

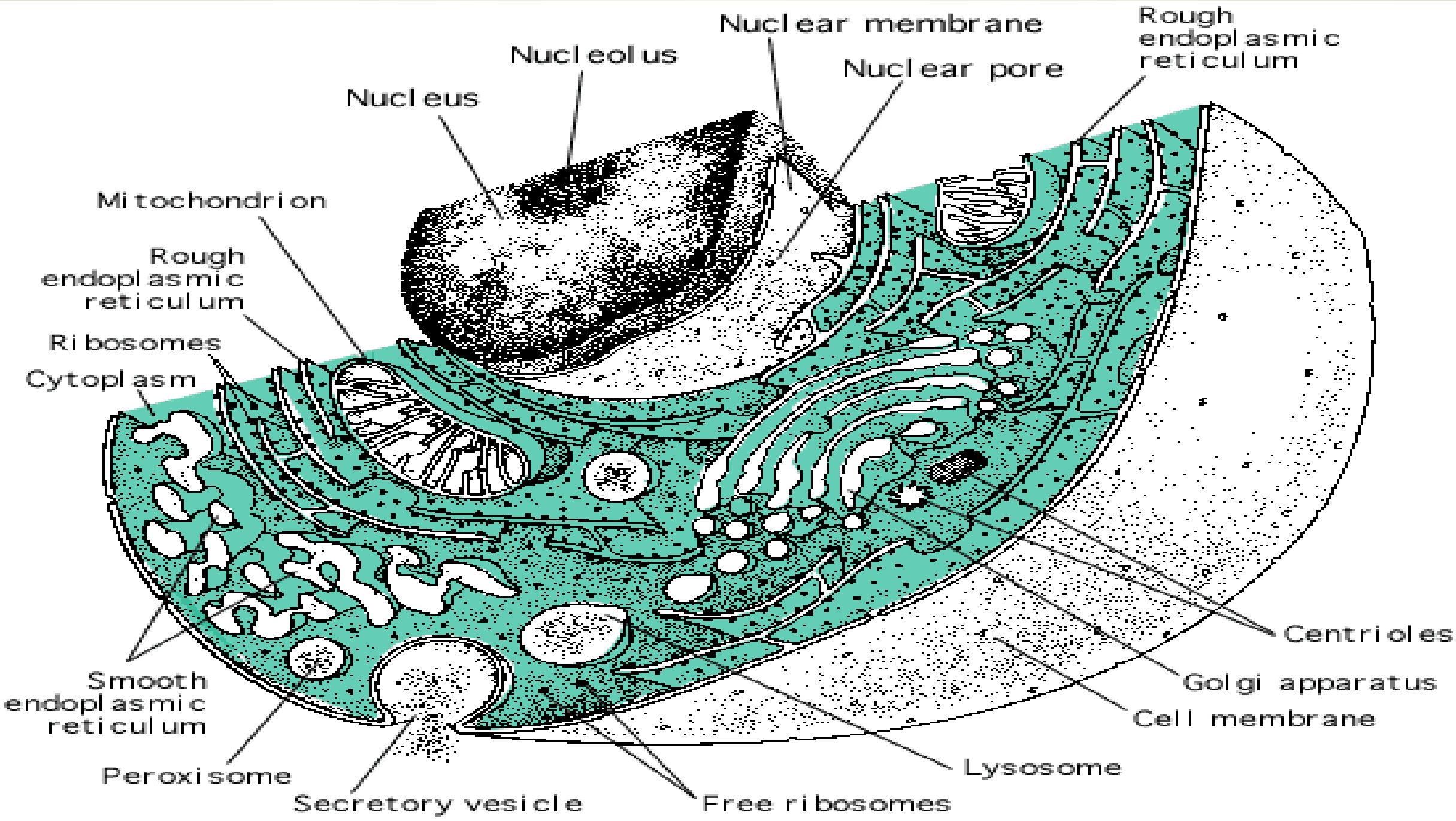
A component of the cell theory is that the cell is the basic unit of life.

A component of the cell theory is that all new cells arise from existing cells.

cell theory: The scientific theory that all living organisms are made of cells as the smallest functional unit.

The microscopes we use today are far more complex than those used in the 1600s by Antony van Leeuwenhoek, a Dutch shopkeeper who had great skill in crafting lenses. Despite the limitations of his now-ancient lenses, van Leeuwenhoek observed the movements of protista (a type of single-celled organism) and sperm, which he collectively termed "animalcules. "

In a 1665 publication called Micrographia, experimental scientist Robert Hooke coined the term “cell” for the box-like structures he observed when viewing cork tissue through a lens. In the 1670s, van Leeuwenhoek discovered bacteria and protozoa. Later advances in lenses, microscope construction, and staining techniques enabled other scientists to see some components inside cells.


Nuclear membrane
Rough endoplasmic reticulum
Nucleolus
Nuclear pore
Nucleus
Mitochondrion
Rough endoplasmic reticulum
Ribosomes
Cytoplasm
Centrioles
Golgi apparatus
Cell membrane
Smooth endoplasmic reticulum
Lysosome
Peroxisome
Secretory vesicle
Free ribosomes

By the late 1830s, botanist Matthias Schleiden and zoologist Theodor Schwann were studying tissues and proposed the unified cell theory. The unified cell theory states that: all living things are composed of one or more cells; the cell is the basic unit of life; and new cells arise from existing cells. Rudolf Virchow later made important contributions to this theory.

Schleiden and Schwann proposed spontaneous generation as the method for cell origination, but spontaneous generation (also called abiogenesis) was later disproven. Rudolf Virchow famously stated "Omnis cellula e cellula"… "All cells only arise from pre-existing cells. "The parts of the theory that did not have to do with the origin of cells, however, held up to scientific scrutiny and are widely agreed upon by the scientific community today. The generally accepted portions of the modern Cell Theory are as follows:

- The cell is the fundamental unit of structure and function in living things.
- All organisms are made up of one or more cells.
- Cells arise from other cells through cellular division.
- **The expanded version of the cell theory can also include:**
- Cells carry genetic material passed to daughter cells during cellular division
- All cells are essentially the same in chemical composition
- Energy flow (metabolism and biochemistry) occurs within cells

Modern interpretation

The generally accepted parts of modern cell theory include:

All known living things are made up of one or more cells
All living cells arise from pre-existing cells by division.
The cell is the fundamental unit of structure and function in all living organisms.
The activity of an organism depends on the total activity of independent cells.[citation needed]
Energy flow (metabolism and biochemistry) occurs within cells.

Cells contain DNA which is found specifically in the chromosome and RNA found in the cell nucleus and cytoplasm.
All cells are basically the same in chemical composition in organisms of similar species.

Modern version

The modern version of the cell theory includes the ideas that:

Energy flow occurs within cells.

Heredity information (DNA) is passed on from cell to cell.

All cells have the same basic chemical composition

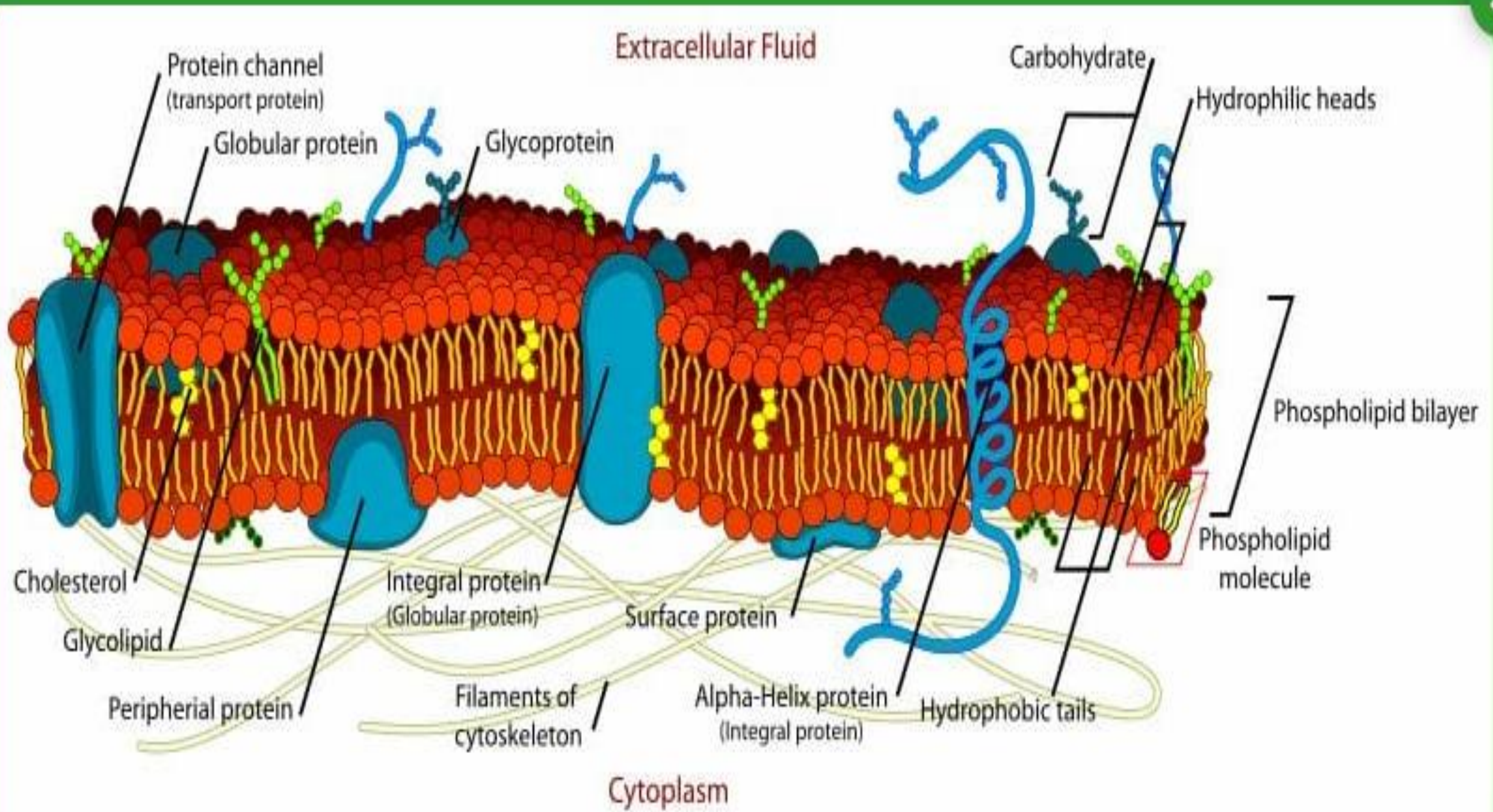
4.STRUCTURE AND FUNCTION OF PLASMA MEMBRANE, GOLGI BODIES,ENDOPLASMIC RETICULUM,AND RIBOSOMES

4.STRUCTURE AND FUNCTION OF PLASMA MEMBRANE

Plasma Membrane Definition

The plasma membrane of a cell is a network of lipids and proteins that forms the boundary between a cell's contents and the outside of the cell. It is also simply called the cell membrane.

The main function of the plasma membrane is to protect the cell from its surrounding environment. It is semi-permeable and regulates the materials that enter and exit the cell. The cells of all living things have plasma membranes.


Extracellular Fluid
Protein channel
(transport protein)
Globular protein
Glycoprotein
Carbohydrate
Hydrophilic heads
Phospholipid bilayer
Phospholipid
molecule
Cholesterol
Glycolipid
Peripherial protein
Integral protein
(Globular protein)
Surface protein
Filaments of
cytoskeleton
Alpha-Helix protein
(Integral protein)
Hydrophobic tails
Cytoplasm

Phospholipids

The membrane is partially made up of molecules called phospholipids, which spontaneously arrange themselves into a double layer with hydrophilic ("water loving") heads on the outside and hydrophobic ("water hating") tails on the inside. These interactions with water are what allow plasma membranes to form.

Proteins

Proteins are wedged between the lipids that make up the membrane, and these transmembrane proteins allow molecules that couldn't enter the cell otherwise to pass through by forming channels, pores or gates. In this way, the cell controls the flow of these molecules as they enter and exit. Proteins in the cell membrane play a role in many other functions, such as cell signaling, cell recognition, and enzyme activity.

Carbohydrates

Carbohydrates are also found in the plasma membrane; specifically, most carbohydrates in the membrane are part of glycoproteins, which are formed when a carbohydrate attaches to a protein. Glycoproteins play a role in the interactions between cells, including cell adhesion, the process by which cells attach to each other.

Fluid Mosaic Model

Technically, the cell membrane is a liquid. At room temperature, it has about the same consistency as vegetable oil. Lipids, proteins, and carbohydrates in the plasma membrane can diffuse freely throughout the cell membrane; they are essentially floating across its surface. This is known as the fluid mosaic model, which was coined by S.J. Singer and G.L. Nicolson in 1972.

Functions of the Plasma Membrane

A Physical Barrier

The plasma membrane surrounds all cells and physically separates the cytoplasm, which is the material that makes up the cell, from the extracellular fluid outside the cell. This protects all the components of the cell from the outside environment and allows separate activities to occur inside and outside the cell.

The plasma membrane provides structural support to the cell. It tethers the cytoskeleton, which is a network of protein filaments inside the cell that hold all the parts of the cell in place. This gives the cell its shape. Certain organisms such as plants and fungi have a cell wall in addition to the membrane. The cell wall is composed of molecules such as cellulose. It provides additional support to the cell, and it is why plant cells do not burst like animal cells do if too much water diffuses into them.

Selective Permeability

Plasma membranes are selectively permeable (or semi-permeable), meaning that only certain molecules can pass through them. Water, oxygen, and carbon dioxide can easily travel through the membrane.

Generally, ions (e.g. sodium, potassium) and polar molecules cannot pass through the membrane; they must go through specific channels or pores in the membrane instead of freely diffusing through.

This way, the membrane can control the rate at which certain molecules can enter and exit the cell.

Endocytosis and Exocytosis

Endocytosis is when a cell ingests relatively larger contents than the single ions or molecules that pass through channels. Through endocytosis, a cell can take in large quantities of molecules or even whole bacteria from the extracellular fluid.

Exocytosis is when the cell releases these materials. The cell membrane plays an important role in both of these processes. The shape of the membrane itself changes to allow molecules to enter or exit the cell. It also forms vacuoles, small bubbles of membrane that can transport many molecules at once, in order to transport materials to different places in the cell.

Cell Signaling

Another important function of the membrane is to facilitate communication and signaling between cells. It does so through the use of various proteins and carbohydrates in the membrane. Proteins on the cell “mark” that cell so that other cells can identify it. The membrane also has receptors that allow it to carry out certain tasks when molecules such as hormones bind to those receptors.

5.STRUCTURE AND FUNCTION OF GOLGI BODIES,

Golgi Apparatus Definition
The Golgi apparatus is an organelle in eukaryotic organisms that moves molecules from the endoplasmic reticulum to their destination.

The organelle also modifies products of the endoplasmic reticulum to their final form. The Golgi apparatus is comprised of a series of flattened sacs that extend from the endoplasmic reticulum.

Golgi Apparatus Overview

The main function of the Golgi apparatus is the ability to deliver vesicles, or packets of various cell products, to different locations throughout the cell. The Golgi also has important functions in tagging vesicles with proteins and sugar molecules, which serve as identifiers for the vesicles so they can be delivered to the proper target. The organelle is also called the Golgi complex or Golgi body.

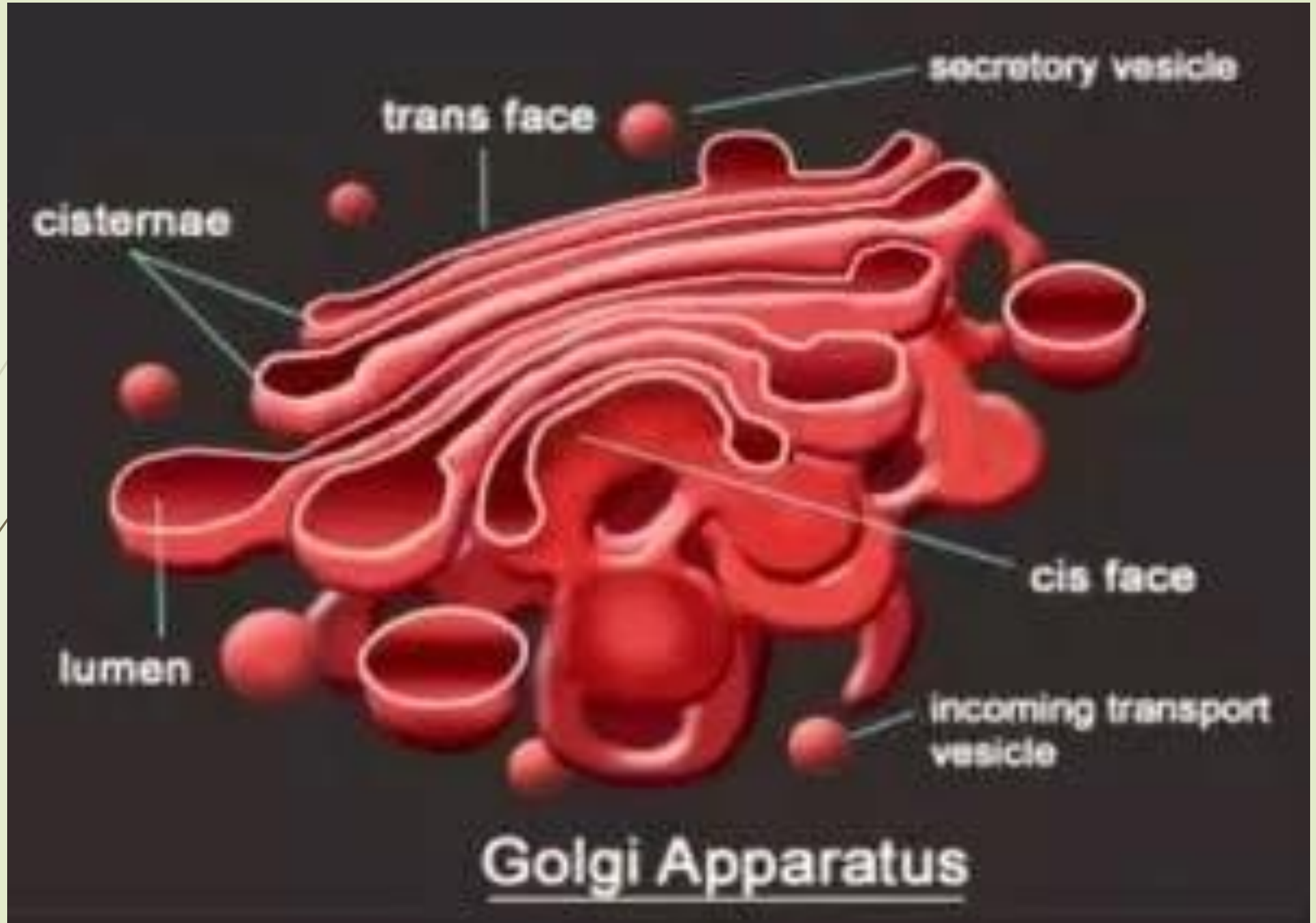
Typically, proteins and cellular products are manufactured in the endoplasmic reticulum. The rough endoplasmic reticulum has a number of ribosomes, which assemble proteins from instructions contained in messenger RNA. Throughout the rest of the endoplasmic reticulum, these protein products are folded and modified. As they reach the Golgi apparatus, more modifications are made. Finally, the products are packaged within vesicles which are “labeled” by other proteins and molecules. The vesicles are released and based on their tags or labels they are carried to the appropriate location within the cell by the cytoskeleton.

Golgi Apparatus Structure

The image below shows the structure of the Golgi apparatus. The cis face of the organelle is closest to the endoplasmic reticulum.

The trans face is the side furthest from the nucleus, which secretes vesicles to various parts of the cell. Further, there are a number of lumens and cisternae through which products flow.

These appear as a series of flattened sacs stack on each other, much like the endoplasmic reticulum.


secretory vesicle
trans face
cisternae
cis face
lumen
incoming transport vesicle
Golgi Apparatus

Golgi Apparatus Location

The Golgi apparatus is situated in between the endoplasmic reticulum and the cell membrane.

Most often, the Golgi appears to be an extension of the endoplasmic reticulum which is slightly smaller and smoother in appearance.

However, the Golgi apparatus can be easily mistaken for smooth endoplasmic reticulum. Although they look similar, the Golgi is an independent organelle which has different functions.

Golgi Apparatus Functions

The Golgi apparatus has many discrete functions. But, all functions are associated with moving molecules from the endoplasmic reticulum to their final destination and modifying certain products along the way. The multiple sacs of the Golgi serve as different chambers for chemical reactions.

As the products of the endoplasmic reticulum move through the Golgi apparatus, they are continuously transferred into new environments, and the reactions that can take place are different.

In this way, a product can be given modifications, or multiple products can be combined to form large macromolecules. The many sacs and folds of the Golgi apparatus allow for many reactions to take place at the same time, increasing the speed at which an organism can produce products.

Tagging Cellular Products

Regardless of the product, the vesicles containing the product move from the endoplasmic reticulum and into the cis face of the Golgi apparatus. In layman's terms, this is the side facing the endoplasmic reticulum.

The side furthest from the endoplasmic reticulum is known as the trans face of the Golgi apparatus, and this is where products are headed.

After having any modifications or additions to their structure, the products are packaged in vesicles and tagged with markers that indicate where the vesicle needs to end up.

These tags can be molecules, such as phosphate groups, or special proteins on the surface of the vesicle. Once tagged, the vesicle is excreted from the Golgi apparatus, on its way to its final destination.

Finalizing Cellular Products

There are many products that are produced by eukaryotes, from proteins that can carry out chemical reactions to lipid molecules that can build new cell membranes. Some products are meant for the endoplasmic reticulum or the Golgi apparatus itself and travel in the opposite direction of most vesicles.

While the endoplasmic reticulum produces most of the products and bases used, it is the Golgi apparatus that is responsible for the final presentation and assembly of products. Often, the environment must be slightly different from that present in the endoplasmic reticulum to obtain certain end products.

The many sacs of the Golgi apparatus function to provide many different areas in which reactions can take place in the most favorable of conditions.

In secretory cells, or cells which produce large amounts of a substance that your body needs, the Golgi apparatus will be very large. Consider the cells in your stomach that secrete acid.

The acid is produced by reactions in the endoplasmic reticulum and is modified as is goes through the Golgi apparatus.

Once to the trans side of the Golgi apparatus, the acid is packaged in a vesicle and sent towards the cell's surface.

As the vesicle joins with the plasma membrane, the acid is released into the stomach, so it can digest your food.

Theory of Golgi Apparatus Function

The most prevalent theory of how the Golgi apparatus forms is the cisternal maturation model.

This model suggests that the sacs themselves tend to move from the cis face to the trans face of the Golgi apparatus over time. New sacs are formed closest to the endoplasmic reticulum.

These sacs “age” as they move towards the trans face of the Golgi apparatus and their product becomes fully mature.

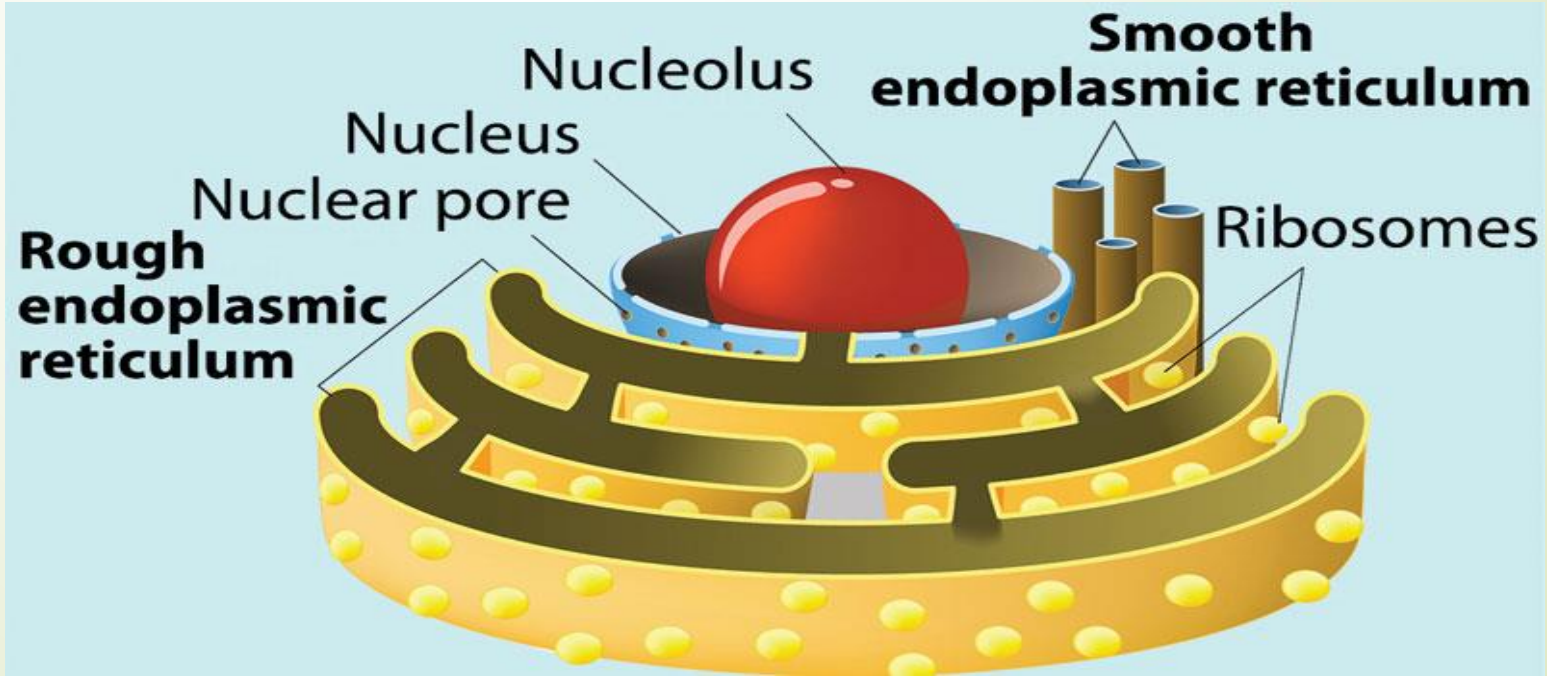
Specific Products

It may seem like there could never be enough lipids to produce the continual flow of cell membrane needed to continually make transport vesicles between the endoplasmic reticulum and the Golgi apparatus. However, there are constantly segments of cell membrane being produced and recycled by the endoplasmic reticulum, Golgi apparatus, lysosomes, and other organelles in the cell, as well as the outer cell membrane itself. The Golgi apparatus and endoplasmic reticulum work together to produce new cell membrane, as well as recycle the cell membranes of vesicles by merging two membranes when vesicles are absorbed.

The Golgi also creates lysosomes. These sacs contain digestive materials. The sacs are pinched off from the Golgi apparatus, and they are used to process materials which have been phagocytized or to digest organelles which no longer function. The lysosome delivers raw ingredients to the endoplasmic reticulum.

,ENDOPLASMIC RETICULUM,

Endoplasmic reticulum (ER), in biology, a continuous membrane system that forms a series of flattened sacs within the cytoplasm of eukaryotic cells and serves multiple functions, being important particularly in the synthesis, folding, modification, and transport of proteins



The endoplasmic reticulum (ER) is a type of organelle made up of two subunits – rough endoplasmic reticulum (RER), and smooth endoplasmic reticulum (SER).

The endoplasmic reticulum is found in most eukaryotic cells and forms an interconnected network of flattened, membrane-enclosed sacs known as cisternae (in the RER), and tubular structures in the SER.

The membranes of the ER are continuous with the outer nuclear membrane. The endoplasmic reticulum is not found in red blood cells, or spermatozoa. It is, in essence, the transportation system of the eukaryotic cell, and has many other important functions such as protein folding.

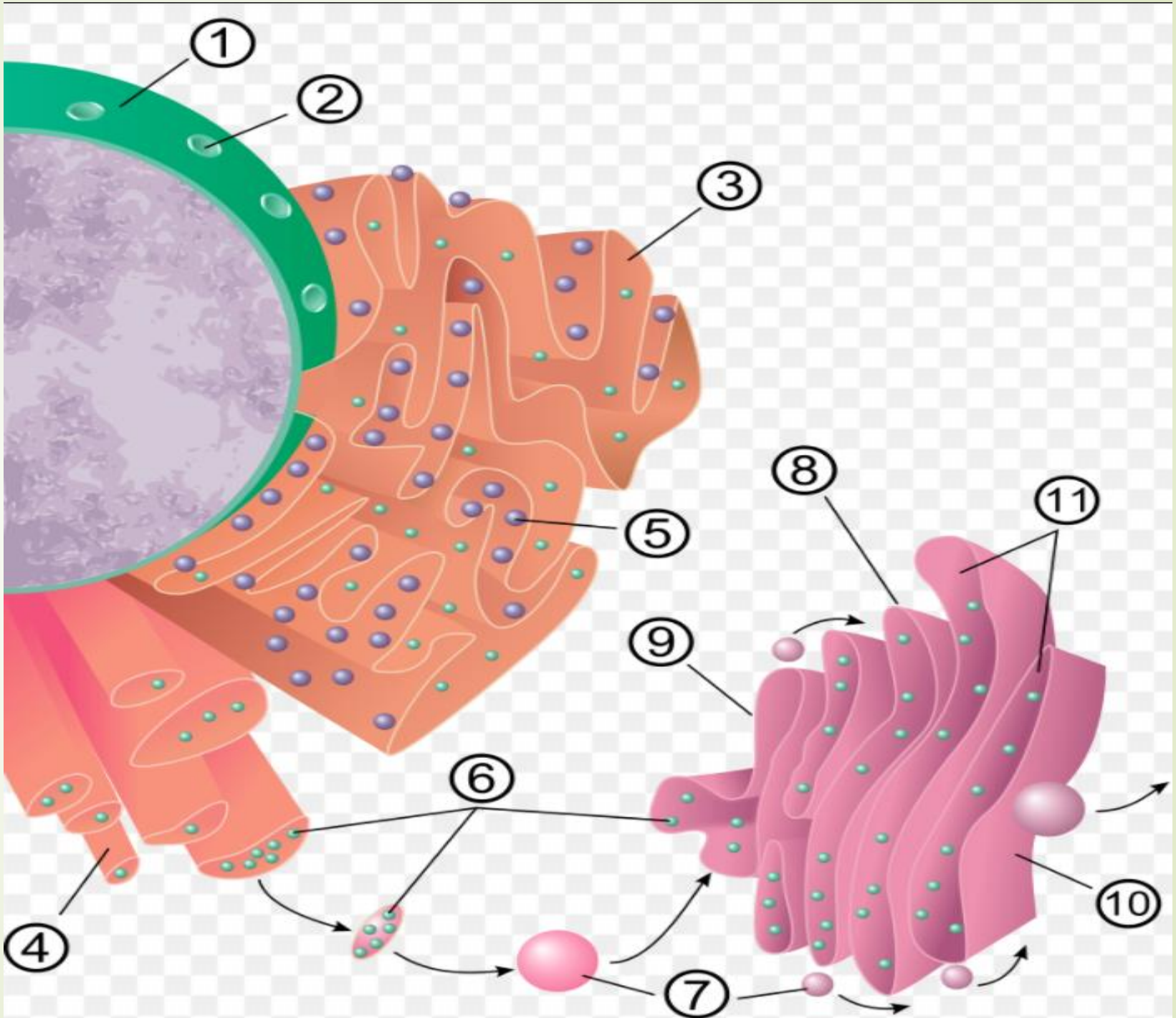
The two types of ER share many of the same proteins and engage in certain common activities such as the synthesis of certain lipids and cholesterol.

Different types of cells contain different ratios of the two types of ER depending on the activities of the cell.

The outer (cytosolic) face of the rough endoplasmic reticulum is studded with ribosomes that are the sites of protein synthesis. The rough endoplasmic reticulum is especially prominent in cells such as hepatocytes. The smooth endoplasmic reticulum lacks ribosomes and functions in lipid synthesis but not metabolism, the production of steroid hormones, and detoxification.[1] The smooth endoplasmic reticulum is especially abundant in mammalian liver and gonad cells.

structure of the endoplasmic reticulum is a network of membranes called cisternae. These sac-like structures are held together by the cytoskeleton. The phospholipid membrane encloses the cisternal space (or lumen), which is continuous with the perinuclear space but separate from the cytosol. The functions of the endoplasmic reticulum can be summarized as the synthesis and export of proteins and membrane lipids, but varies between ER and cell type and cell function. The quantity of both rough and smooth endoplasmic reticulum in a cell can slowly interchange from one type to the other, depending on the changing metabolic activities of the cell. Transformation can include embedding of new proteins in membrane as well as structural changes. Changes in protein content may occur without noticeable structural changes

1 Nucleus2Nuclear pore3 Rough endoplasmic reticulum (RER)4 Smooth endoplasmic reticulum (SER)5Ribosome on the rough ER6Proteins that are transported7 Transport vesicle8Golgi apparatus9 Cis face of the Golgi apparatus10 Trans face of the Golgi apparatus11 Cisternae of the Golgi apparatus



Rough endoplasmic reticulum

A 2-minute animation showing how a protein destined for the secretory pathway is synthesized into the rough endoplasmic reticulum, which appears at the upper right approximately halfway through the animation.

The surface of the rough endoplasmic reticulum (often abbreviated RER or rough ER; also called granular endoplasmic reticulum) is studded with protein-manufacturing ribosomes giving it a "rough" appearance (hence its name).

The binding site of the ribosome on the rough endoplasmic reticulum is the translocon. However, the ribosomes are not a stable part of this organelle's structure as they are constantly being bound and released from the membrane. A ribosome only binds to the RER once a specific protein-nucleic acid complex forms in the cytosol.

This special complex forms when a free ribosome begins translating the mRNA of a protein destined for the secretory pathway.The first 5–30 amino acids polymerized encode a signal peptide, a molecular message that is recognized and bound by a signal recognition particle (SRP).

Translation pauses and the ribosome complex binds to the RER translocon where translation continues with the nascent (new) protein forming into the RER lumen and/or membrane. The protein is processed in the ER lumen by an enzyme (a signal peptidase), which removes the signal peptide. Ribosomes at this point may be released back into the cytosol; however, non-translating ribosomes are also known to stay associated with translocons.

The membrane of the rough endoplasmic reticulum forms large double-membrane sheets that are located near, and continuous with, the outer layer of the nuclear envelope.

The double membrane sheets are stacked and connected through several right- or left-handed helical ramps, the "Terasaki ramps", giving rise to a structure resembling a multi-story car park.

Although there is no continuous membrane between the endoplasmic reticulum and the Golgi apparatus, membrane-bound transport vesicles shuttle proteins between these two compartments.

Vesicles are surrounded by coating proteins called COPI and COPII. COPII targets vesicles to the Golgi apparatus and COPI marks them to be brought back to the rough endoplasmic reticulum. The rough endoplasmic reticulum works in concert with the Golgi complex to target new proteins to their proper destinations.

The second method of transport out of the endoplasmic reticulum involves areas called membrane contact sites, where the membranes of the endoplasmic reticulum and other organelles are held closely together, allowing the transfer of lipids and other small molecules

The rough endoplasmic reticulum is key in multiple functions:

- Manufacture of lysosomal enzymes with a mannose-6-phosphate marker added in the cis-Golgi network.[citation needed]
Manufacture of secreted proteins, either secreted constitutively with no tag or secreted in a regulatory manner involving clathrin and paired basic amino acids in the signal peptide.

Integral membrane proteins that stay embedded in the membrane as vesicles exit and bind to new membranes. Rab proteins are key in targeting the membrane; SNAP and SNARE proteins are key in the fusion event.
Initial glycosylation as assembly continues. This is N-linked (O-linking occurs in the Golgi).

N-linked glycosylation: If the protein is properly folded, oligosaccharyltransferase recognizes the AA sequence NXS or NXT (with the S/T residue phosphorylated) and adds a 14-sugar backbone (2-N-acetylglucosamine, 9-branching mannose, and 3-glucose at the end) to the side-chain nitrogen of Asn.

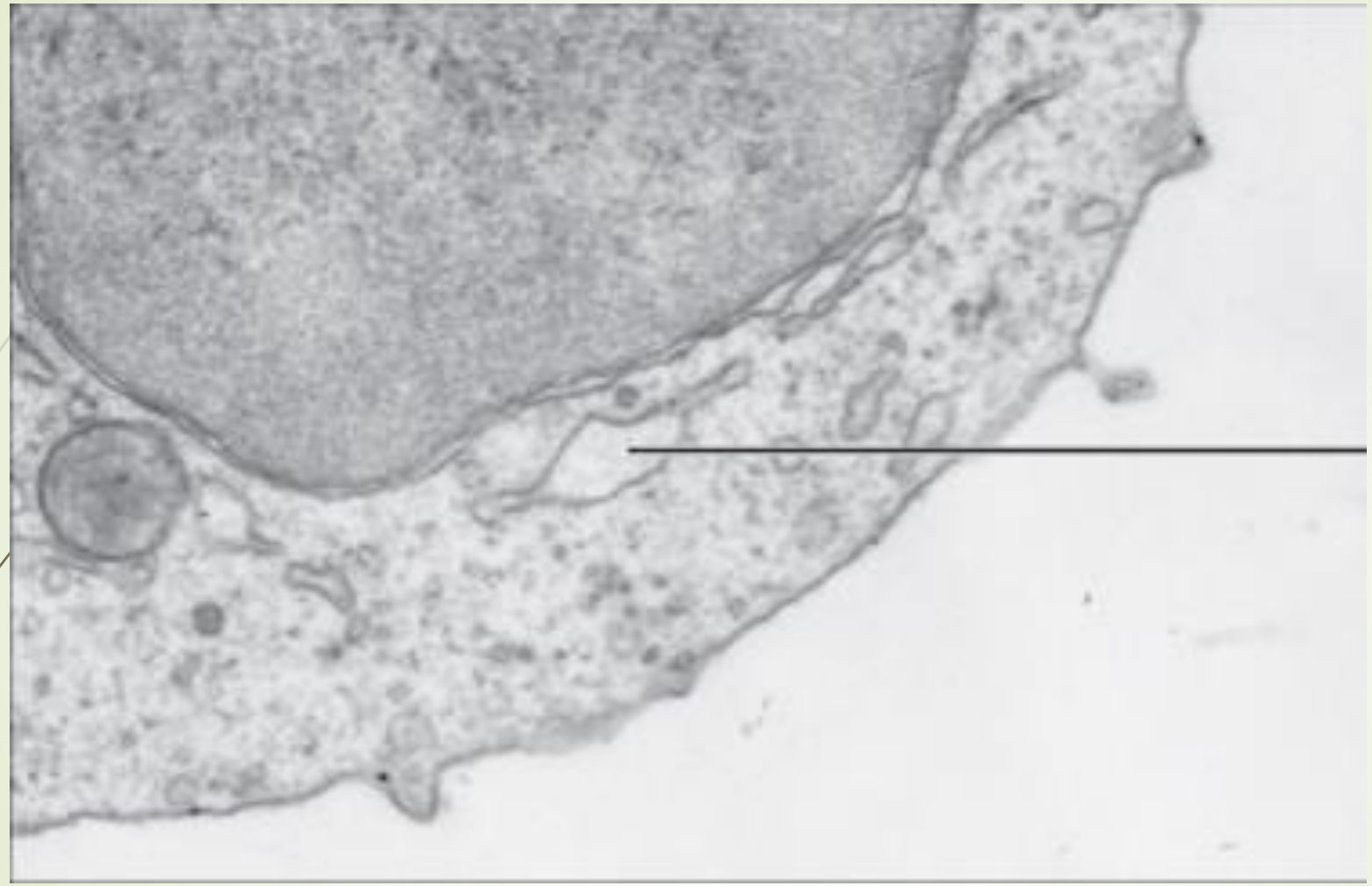
Smooth endoplasmic reticulum

In most cells the smooth endoplasmic reticulum (abbreviated SER) is scarce. Instead there are areas where the ER is partly smooth and partly rough, this area is called the transitional ER. The transitional ER gets its name because it contains ER exit sites. These are areas where the transport vesicles that contain lipids and proteins made in the ER, detach from the ER and start moving to the Golgi apparatus. Specialized cells can have a lot of smooth endoplasmic reticulum and in these cells the smooth ER has many functions. It synthesizes lipids, phospholipids, and steroids.

. Cells which secrete these products, such as those in the testes, ovaries, and sebaceous glands have an abundance of smooth endoplasmic reticulum.

It also carries out the metabolism of carbohydrates, detoxification of natural metabolism products and of alcohol and drugs, attachment of receptors on cell membrane proteins, and steroid metabolism.

In muscle cells, it regulates calcium ion concentration. Smooth endoplasmic reticulum is found in a variety of cell types (both animal and plant), and it serves different functions in each.



The smooth endoplasmic reticulum also contains the enzyme glucose-6-phosphatase, which converts glucose-6-phosphate to glucose, a step in gluconeogenesis.

It is connected to the nuclear envelope and consists of tubules that are located near the cell periphery. These tubes sometimes branch forming a network that is reticular in appearance. In some cells, there are dilated areas like the sacs of rough endoplasmic reticulum.

The network of smooth endoplasmic reticulum allows for an increased surface area to be devoted to the action or storage of key enzymes and the products of these enzymes.

Protein transport

Secretory proteins, mostly glycoproteins, are moved across the endoplasmic reticulum membrane. Proteins that are transported by the endoplasmic reticulum throughout the cell are marked with an address tag called a signal sequence.

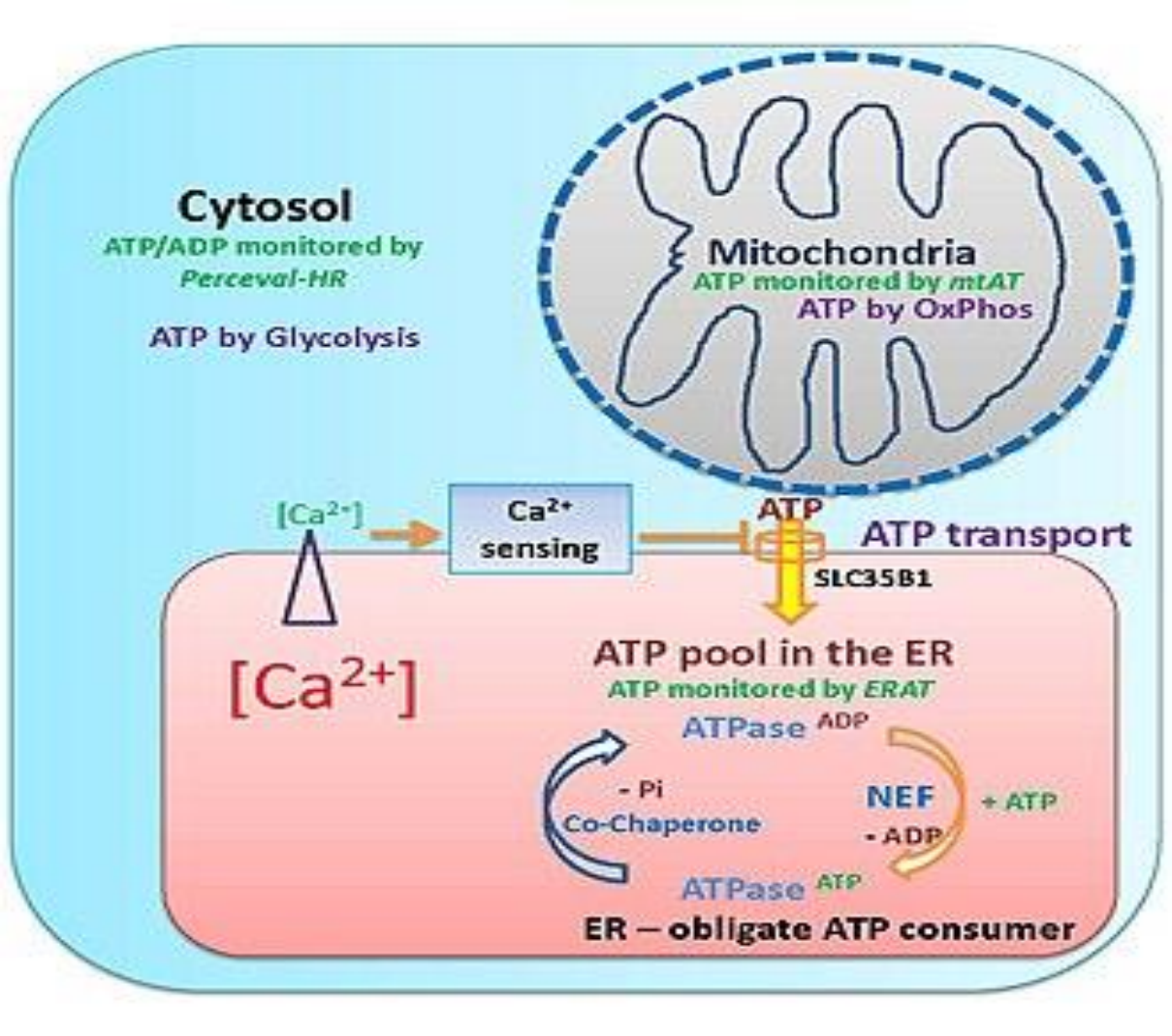
The N-terminus (one end) of a polypeptide chain (i.e., a protein) contains a few amino acids that work as an address tag, which are removed when the polypeptide reaches its destination.

Nascent peptides reach the ER via the translocon, a membrane-embedded multiprotein complex. Proteins that are destined for places outside the endoplasmic reticulum are packed into transport vesicles and moved along the cytoskeleton toward their destination. In human fibroblasts, the ER is always co-distributed with microtubules and the depolymerisation of the latter cause its co-aggregation with mitochondria, which are also associated with the ER

Bioenergetics regulation of ER ATP supply by a CaATiER mechanism

The endoplasmic reticulum does not harbor an ATP-regeneration machinery, and therefore requires ATP import from mitochondria. The imported ATP is vital for the ER to carry out its house keeping cellular functions, such as for protein folding and trafficking.

Ca2+-antagonized transport into the endoplasmic reticulum (CaATiER) model



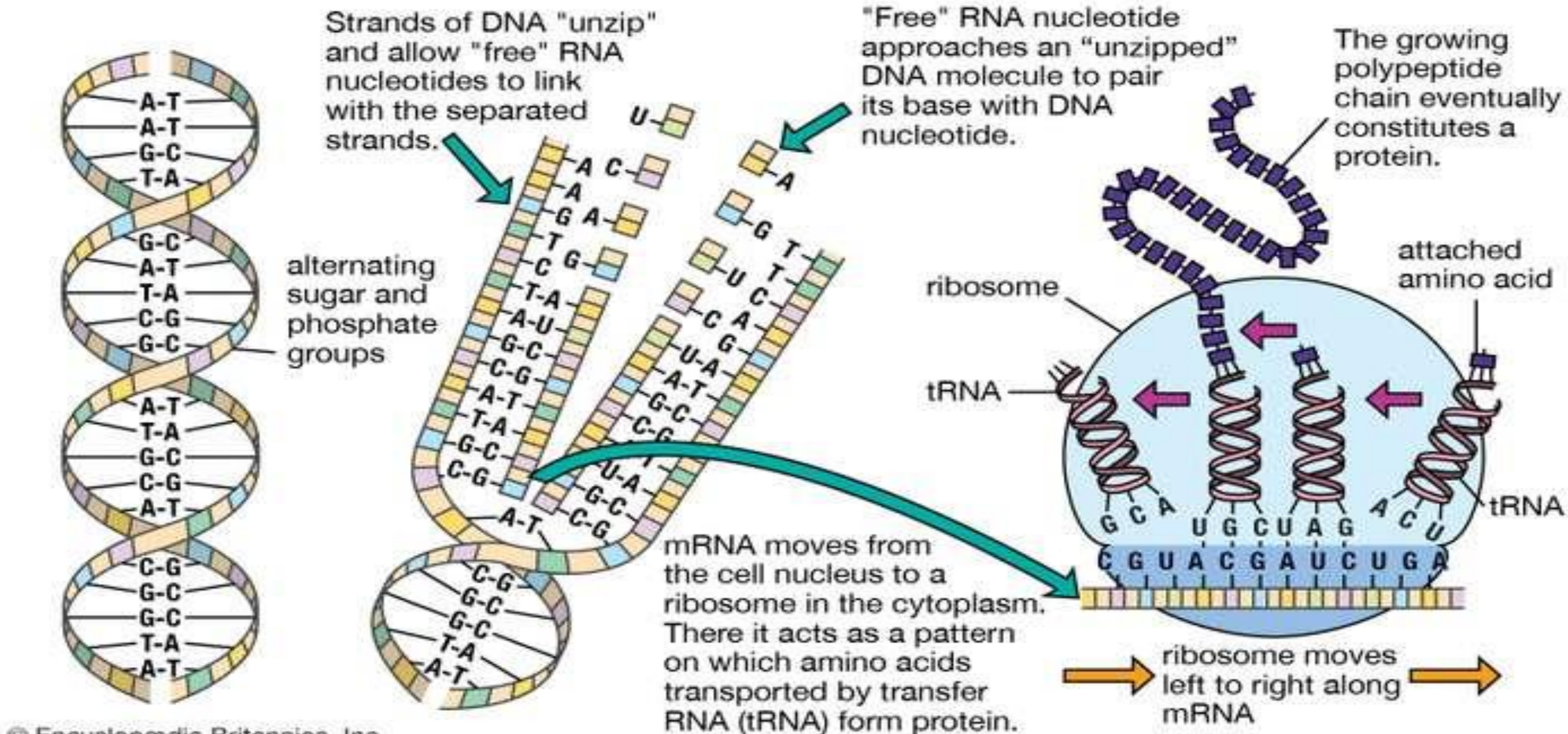
RIBOSOMES

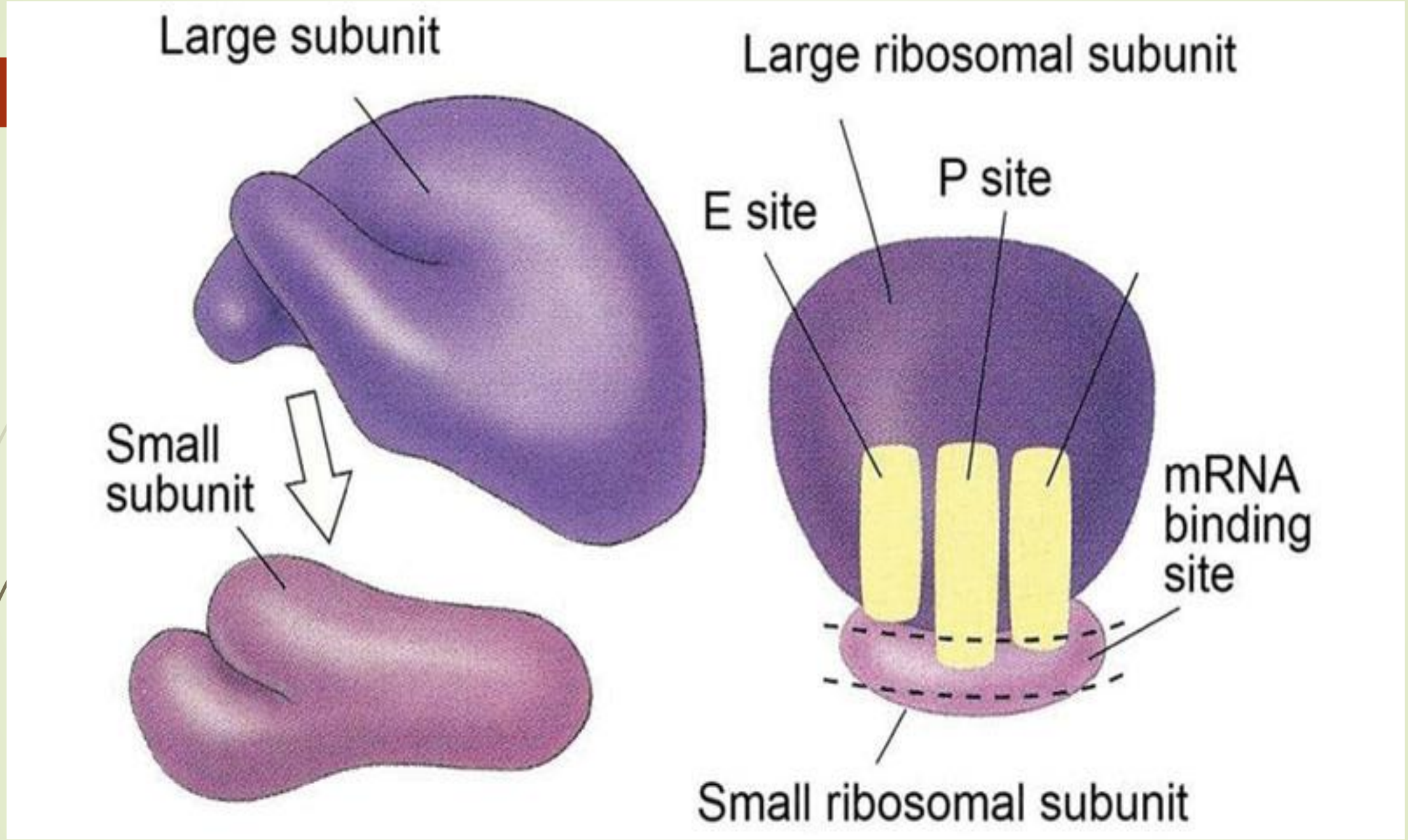
Structure

Ribosomes are made of proteins and ribonucleic acid (abbreviated as RNA), in almost equal amounts. It comprises of two sections, known as subunits. The tinier subunit is the place the mRNA binds and it decodes, whereas the bigger subunit is the place the amino acids are included.

Both subunits comprise of both ribonucleic acid and protein components and are linked to each other by interactions between the proteins in one subunit and the rRNAs in the other subunit. The ribonucleic acid is obtained from the nucleolus, at the point where ribosomes are arranged in a cell.

How DNA directs protein synthesis



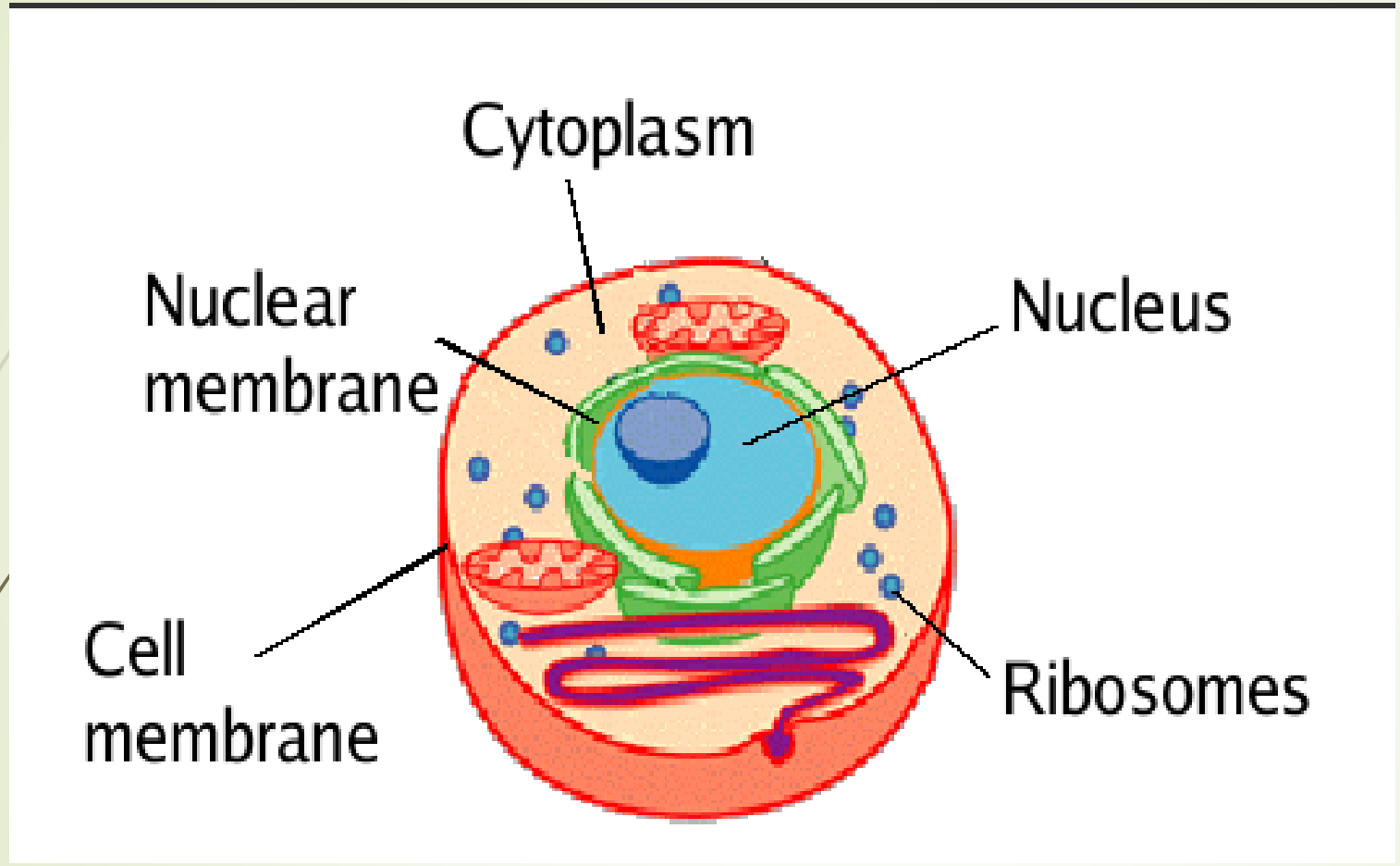

Large subunit
Small subunit
Large ribosomal subunit
E site
P site
mRNA binding site
Small ribosomal subunit

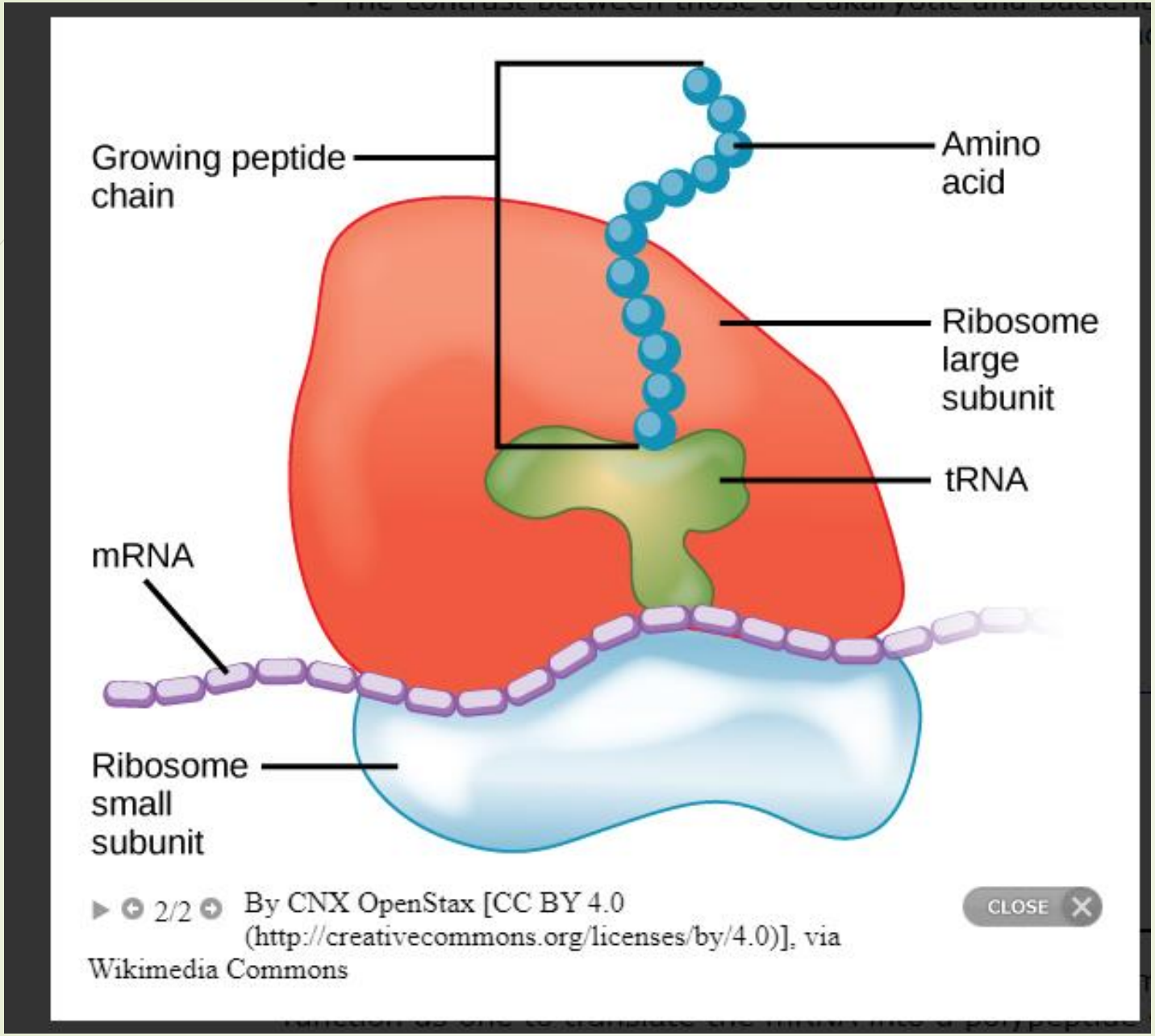
The structures of ribosomes include:

Situated in two areas of the cytoplasm.
They are seen scattered in the cytoplasm and a few are connected to the endoplasmic reticulum.
Whenever joined to the ER they are called the rough endoplasmic reticulum.
The free and the bound ribosomes are very much alike in structure and are associated with protein synthesis.
Around 37 to 62% of RNA is comprised of RNA and the rest is proteins.
Prokaryotes have 70S ribosomes respectively subunits comprising the little subunit of 30S and the bigger subunit of 50S. Eukaryotes have 80S ribosomes respectively comprising of little (40S) and substantial (60S) subunits.

The ribosomes seen in the chloroplasts of mitochondria of eukaryotes are comprised of big and little subunits composed of proteins inside a 70S particle.
Share a center structure which is very much alike to all ribosomes in spite of changes in its size.

The RNA is arranged in different tertiary structures. The RNA in the bigger ribosomes is into numerous continuous infusions as they create loops out of the center of the structure without disturbing or altering it.
The contrast between those of eukaryotic and bacteria are utilized to make antibiotics that can crush bacterial disease without damaging human cells.


Cytoplasm
Nuclear membrane
Nucleus
Cell membrane
Ribosomes


Growing peptide chain
Amino acid
Ribosome large subunit
tRNA
mRNA
Ribosome small subunit
2/2
By CNX OpenStax [CC BY 4.0 (http://creativecommons.org/licenses/by/4.0)], via Wikimedia Commons
CLOSE

Ribosomes Size

Ribosomes comprise of two subunits that are suitably composed and function as one to translate the mRNA into a polypeptide chain amid protein synthesis. Due to the fact that they are made from two subunits of differing size, they are a little longer in the hinge than in diameter. They vary in size between prokaryotic cells and eukaryotic cells.

The prokaryotic is comprised of a 30s (Svedberg) subunit and a 50s (Svedberg) subunit meaning 70s for the entire organelle equal to the molecular weight of 2.7×106 Daltons. Prokaryotic ribosomes are about 20 nm (200 Å) in diameter and are made of 35% ribosomal proteins and 65% rRNA.

Notwithstanding, the eukaryotic are amidst 25 and 30 nm (250–300 Å) in diameter. They comprise of a 40s (Svedberg) subunit and a 60s (Svedberg) subunit which means 80s (Svedberg) for the entire organelle which is equal to the molecular weight of 4×106 Daltons.

Location

Ribosomes are organelles located inside the animal, human cell, and plant cells.

They are situated in the cytosol, some bound and free-floating to the membrane of the coarse endoplasmic reticulum.

They are utilized in decoding DNA (deoxyribonucleic acid) to proteins and no rRNA is forever bound to the RER, they release or bind as directed by the kind of protein they proceed to combine. In an animal or human cell, there could be up to 10 million ribosomes and numerous ribosomes can be connected to the equivalent mRNA strand, this structure is known as a POLYSOME.

Function

When it comes to the main functions of ribosomes, they assume the role of bringing together amino acids to form particular proteins, which are important for completing the cell's activities.

Protein is required for numerous cell functions, for example, directing chemical processes or fixing the damage. Ribosomes can yet be discovered floating inside the cytoplasm or joined to the endoplasmic reticulum.

- The other functions include:

- The procedure of creation of proteins, the deoxyribonucleic acid makes mRNA by the step of DNA transcription.
- The hereditary information from the mRNA is converted into proteins amid DNA translation.
-
- The arrangements of protein assembly amid protein synthesis are indicated in the mRNA.
- The mRNA is arranged in the nucleus and is moved to the cytoplasm for an additional operation of protein synthesis.

- The proteins which are arranged by the ribosomes currently in the cytoplasm are utilized inside the cytoplasm by itself. The proteins created by the bound ribosomes are moved outside the cell.

Those that live inside bacteria, parasites and different creatures, for example, lower and microscopic level creatures are the ones which are called prokaryotic ribosomes. While those that live inside humans and others such as higher level creatures are those ones we call the eukaryotic ribosome.

The other major differences include:

Prokaryotes have 70S ribosomes, singly made of a 30S and a 50S subunit. While the Eukaryotes have 80S ribosomes, singly made of a 40S and 60S subunit.
70S Ribosomes are relatively smaller than 80S while the 80S Ribosomes are relatively bigger than 70S ribosomes.

- Prokaryotes have 30S subunit with a 16S RNA subunit and comprise of 1540 nucleotides bound to 21 proteins. The 50S subunit gets produced from a 5S RNA subunit that involves 120 nucleotides, a 23S RNA subunit that contains 2900 nucleotides and 31 proteins.

- Eukaryotes have 40S subunit with 18S RNA and also 33 proteins and 1900 nucleotides. The big subunit contains 5S RNA and also 120 nucleotides, 4700 nucleotides and also 28S RNA, 5.8S RNA as well as 160 nucleotides subunits and 46 proteins.
- Eukaryotic cells have mitochondria and chloroplasts as organelles and those organelles additionally have ribosomes 70S. Hence, eukaryotic cells have different kinds of ribosomes (70S and 80S), while prokaryotic cells just have 70S ribosomes.

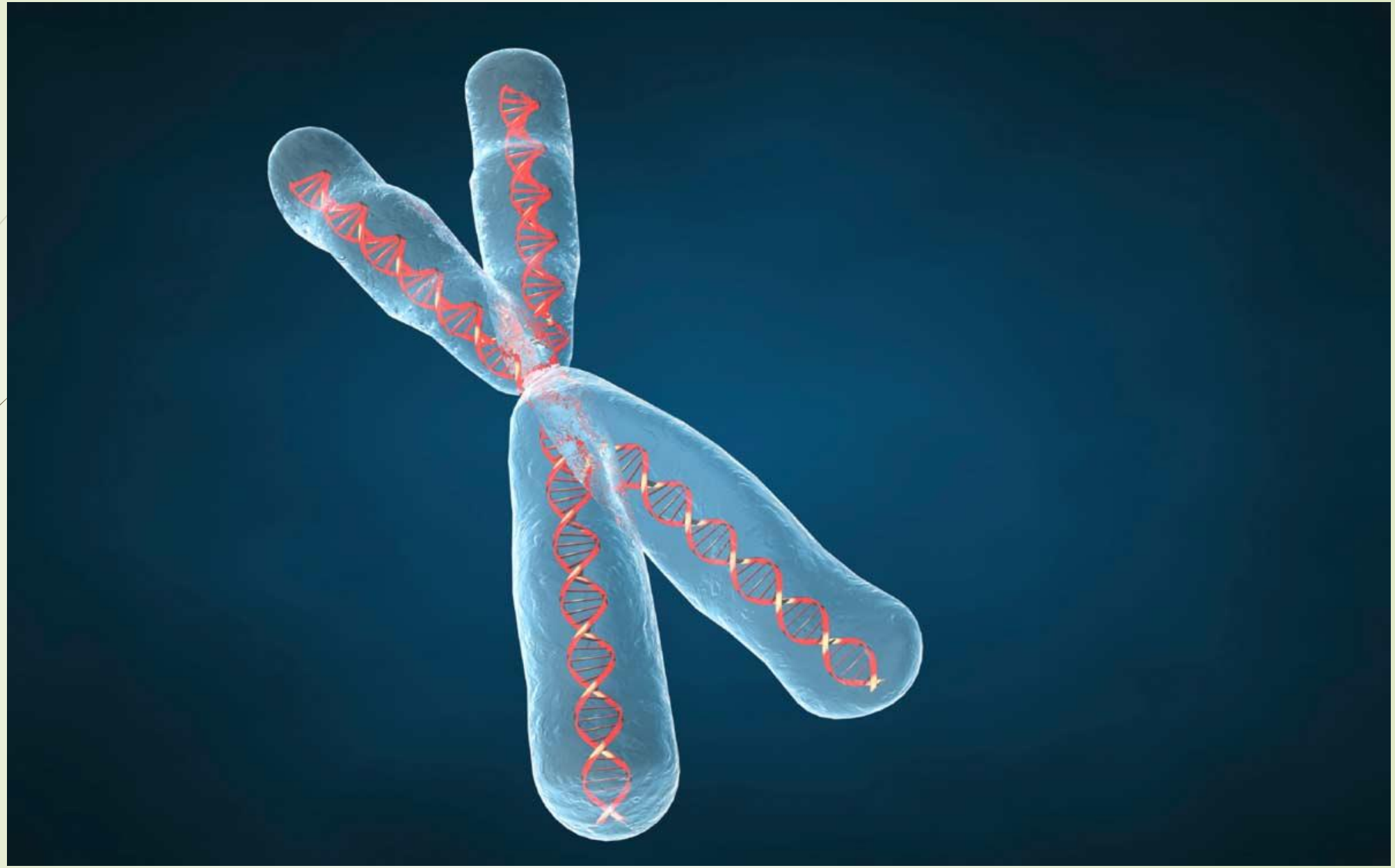
Fine or Ultrastructure of Chromosome

Chromosome is the multistranded body:

The smallest unit of chromosome (by electron microscopy) is the fibril, which is 100 A thick.

This fibril contains two DNA double helixes, separated by a space about 25 A across, and the associated protein.

The next largest unit of the chromosome is the quarter chromatid.



The quarter chromatid consists of four 100 A fibrils, so that it is about 400 A thick having eight double helixes of DNA and the associated protein. Two quarter chromatids form a half chromatid, which therefore contains 16 double helixes of DNA.

A chromatid contains two half chromatids, bringing the total number of helixes in a chromatid to 32 and its diameter is about 1600 A before DNA synthesis or replication. After replication the chromosome contains 64 double helixes of ‘DNA with an approximate diameter of 3200 A. The thickness is quite variable from cell to cell and from organism to organism due to differences in coiling of the chromosomes.

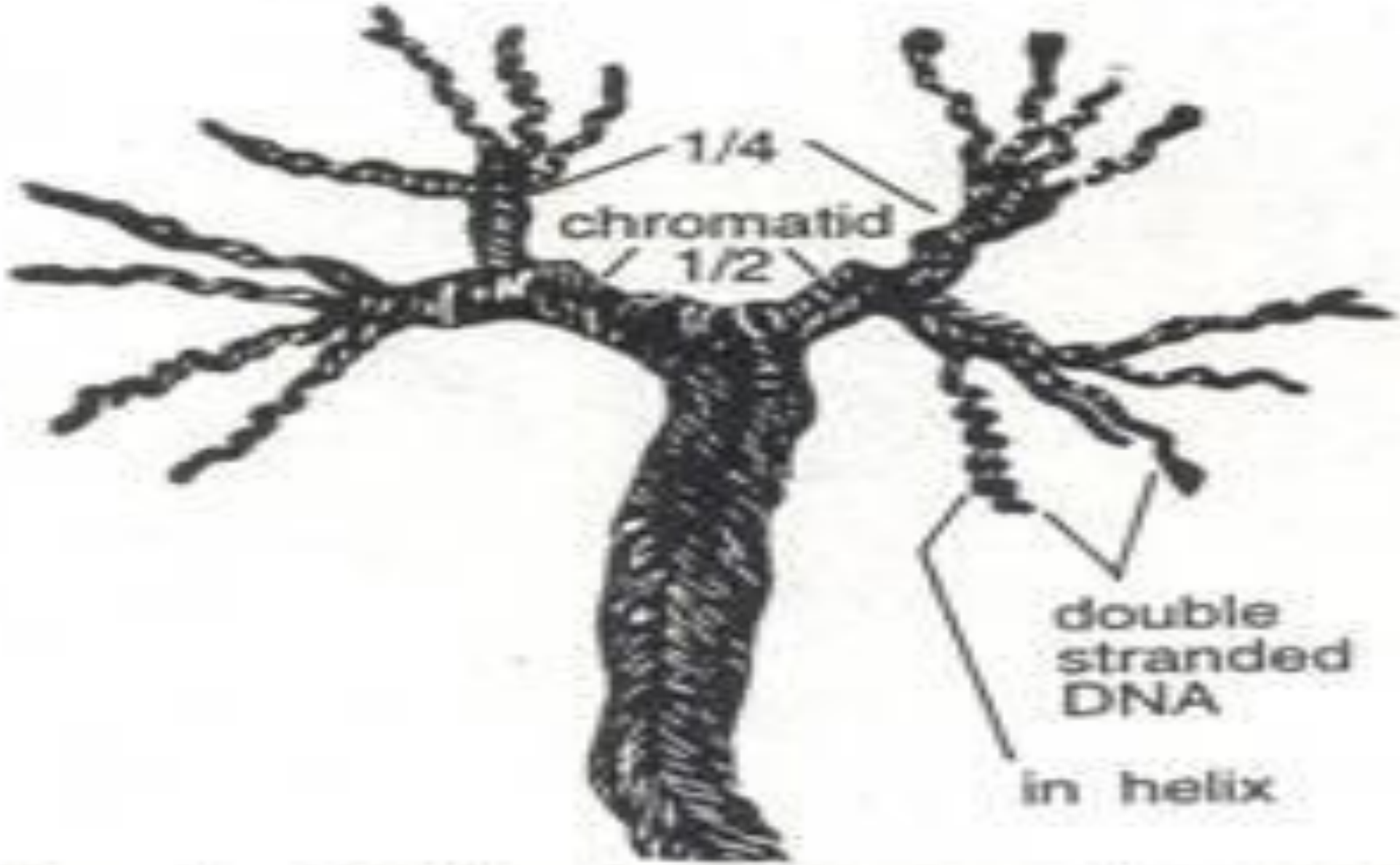


Fig. 9. Model of a metaphase chromosome based on multistranded organization.

The DNA molecule consists of one old helix and one new helix. The chromosome of a higher organism may contain eight or more double helixes, depending upon its degree of subdivision.

[II] Single continuous fibre of nucleoprotein (Folded-fibre organization):

A chromosome consists of a single long chain of DNA and protein, upto several hundred microns long. For example, the total length of DNA— protein making up 46 chromosomes of man has been estimated as 50 cm.

The fibre is extremely coiled. The lowest level is represented by 100 A superhelix. This helical fibre is then folded many times and irregularly entwined to form the body of a chromatid, and there is no subchromatid-strand structure. The packing of the fibres may depend upon Ca++ and Mg++ ions.

Thus the basic unit of chromosome is a DNA-protein superhelix having a diameter of about 100 A and these units make up 250 A fibres as seen in electron microscope. In addition, presence of histone protein and divalent cations (Ca++ and Mg++) is essential for coiling of such fibres.

[III] Folded fibre model of chromosome:

'Folded-fibre model' of chromosome structure was proposed by Du Praw (1966), in which the chromosomal unit is regarded as a single DNA-protein fibre, which is repeatedly folded back on itself both longitudinally and transversely to make up the body of the chromatid. The model defines a 'unit chromatid' as a chromatin fibre of variable length, of folding configuration and of replication mechanism.

It corresponds to one continuous Watson-Crick DNA molecule. The single DNA helix of the unit chromatid is thought to be wrapped with polypeptides in P-configurations (e.g., lysine-rich histones) and then super coiled to make up the 200 to 300 A chromatin fibres.

Presumably super coiling is induced and maintained by cross-linking with a-helical proteins, such as arginine rich histones. During interphase S period, the unit chromatid replicates sequentially at two or more replication forks, a process that involves local unwinding of the tertiary and secondary helices.

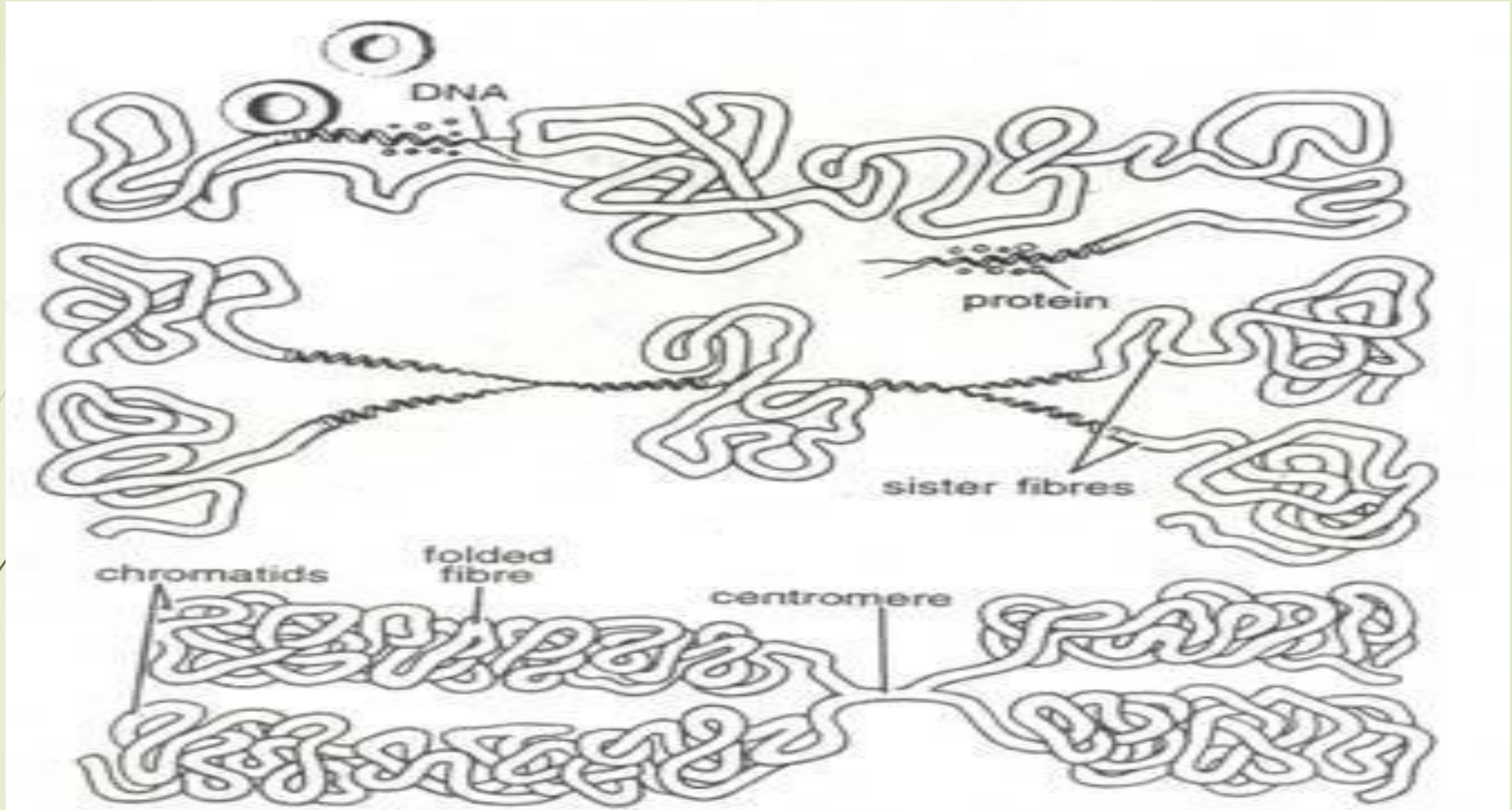


Fig. 10. Chromosome Folded — fibre model of Du Praw. A. An interphase 230 Å fibre composed of a single DNA helix. B. Replication proceed from either end toward centre (centromers) involving two replication forks. C. At metaphase sister fibres fold up as sister chromatids.

Each pair of daughter fibres corresponds to a pair of metaphase chromatids, which are held together by unreplicated portions of the fibre, especially in the centromere region (middle figure 6.10).

As proposed in the 'folded-fibre model,' the protein components of the unit chromatids are regarded having not only histones but also various DNA-linked nonhistone proteins, including such enzymes as RNA polymerase, NAD synthetase, nucleoside triphosphatase, phospho proteins, histone acetylases, and possibly DNA polymerase and enzymes of nuclear oxidative phosphorylation.

These molecules may be arranged on DNA filaments in very orderly functional arrays. Presumably histones are able to account for DNA super coiling. DNA is itself responsible for linear continuity of a chromosome. It is the DNA-linked proteins which mediate chromosome condensation.

[IV] Synaptinemal complex (SC):

In certain organisms like crayfish, locust, pigeon and rat and in early meiotic prophase of spermatogenesis shows a linear complex of three parallel strands of DNA in the central axis of the chromosome. These strands form synaptinemal complex.

A single synaptinemal complex is a ribbon-like object, consisting of two parallel dense rods (each of 450 A diameter) separated uniformly at a distance of 1000 to 1200 A, and connected to a median longitudinal element by transverse fibres. This structure was on first discovered in males of crayfish, pigeons, cats and human beings but not present in male Drosophila.

This complex appears to be associated with the synapsis of the chromosomes during meiotic prophase. The synaptinemal complex is interposed between pairing homologues and can be considered the structural basis of pairing. Lateral elements of SC start to form at leptonema, while median element appears with pairing at zygonema. During pairing, two homologues remain separated by a 0.15 to 0.2 μm space that is occupied by SC.

ORGANISATION OF CHROMOSOMES

Each chromosome is made up of DNA tightly coiled many times around proteins called histones that support its structure. Chromosomes are not visible in the cell's nucleus—not even under a microscope—when the cell is not dividing. ... DNA and histone proteins are packaged into structures called chromosomes.

Prokaryotes: Nucleoid

The prokaryotes – bacteria and archaea – typically have a single circular chromosome, but many variations exist. The chromosomes of most bacteria, which some authors prefer to call genophores, can range in size from only 130,000 base pairs in the endosymbiotic bacteria Candidatus Hodgkinia cicadicolaand Candidatus Tremblaya princeps, to more than 14,000,000 base pairs in the soil-dwelling bacterium Sorangium cellulosum. Spirochaetes of the genus Borrelia are a notable exception to this arrangement, with bacteria such as Borrelia burgdorferi, the cause of Lyme disease, containing a single linear chromosome

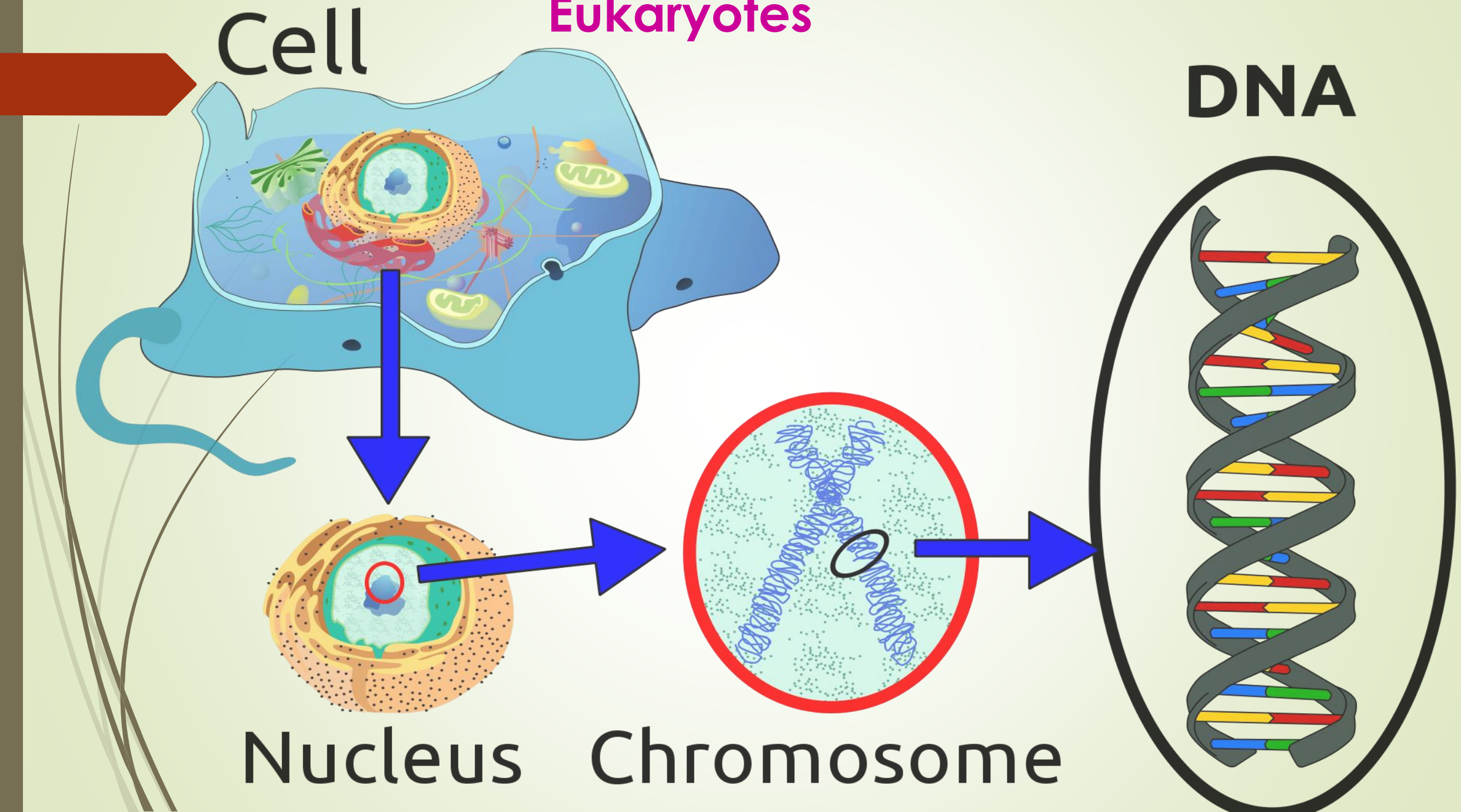
DNA packaging

Prokaryotes do not possess nuclei. Instead, their DNA is organized into a structure called the nucleoid. The nucleoid is a distinct structure and occupies a defined region of the bacterial cell.

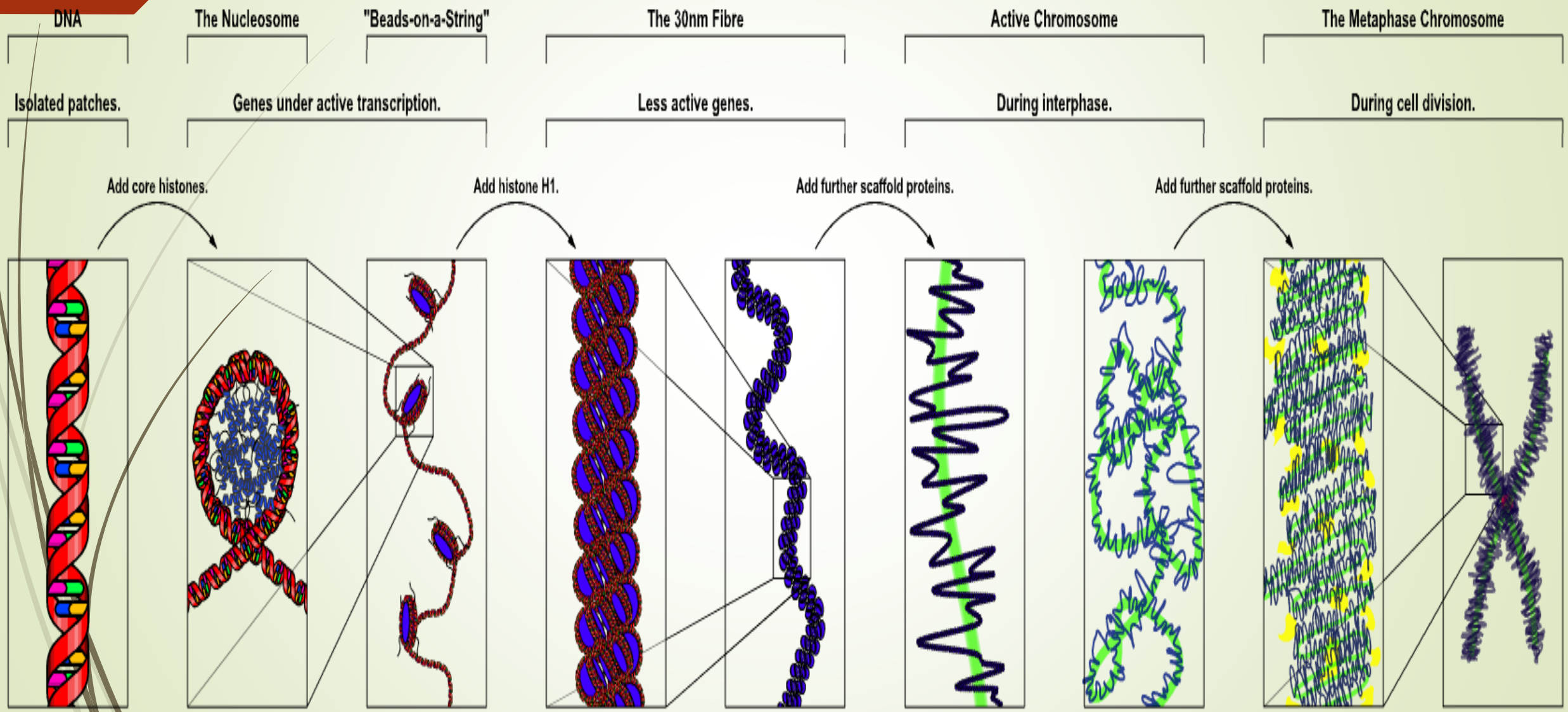
This structure is, however, dynamic and is maintained and remodeled by the actions of a range of histone-like proteins, which associate with the bacterial chromosome.

In archaea, the DNA in chromosomes is even more organized, with the DNA packaged within structures similar to eukaryotic nucleosomes.

Eukaryotes



The major structures in DNA compaction: DNA, the nucleosome, the 10 nm "beads-on-a-string" fibre, the 30 nm fibre and the metaphase chromosome.

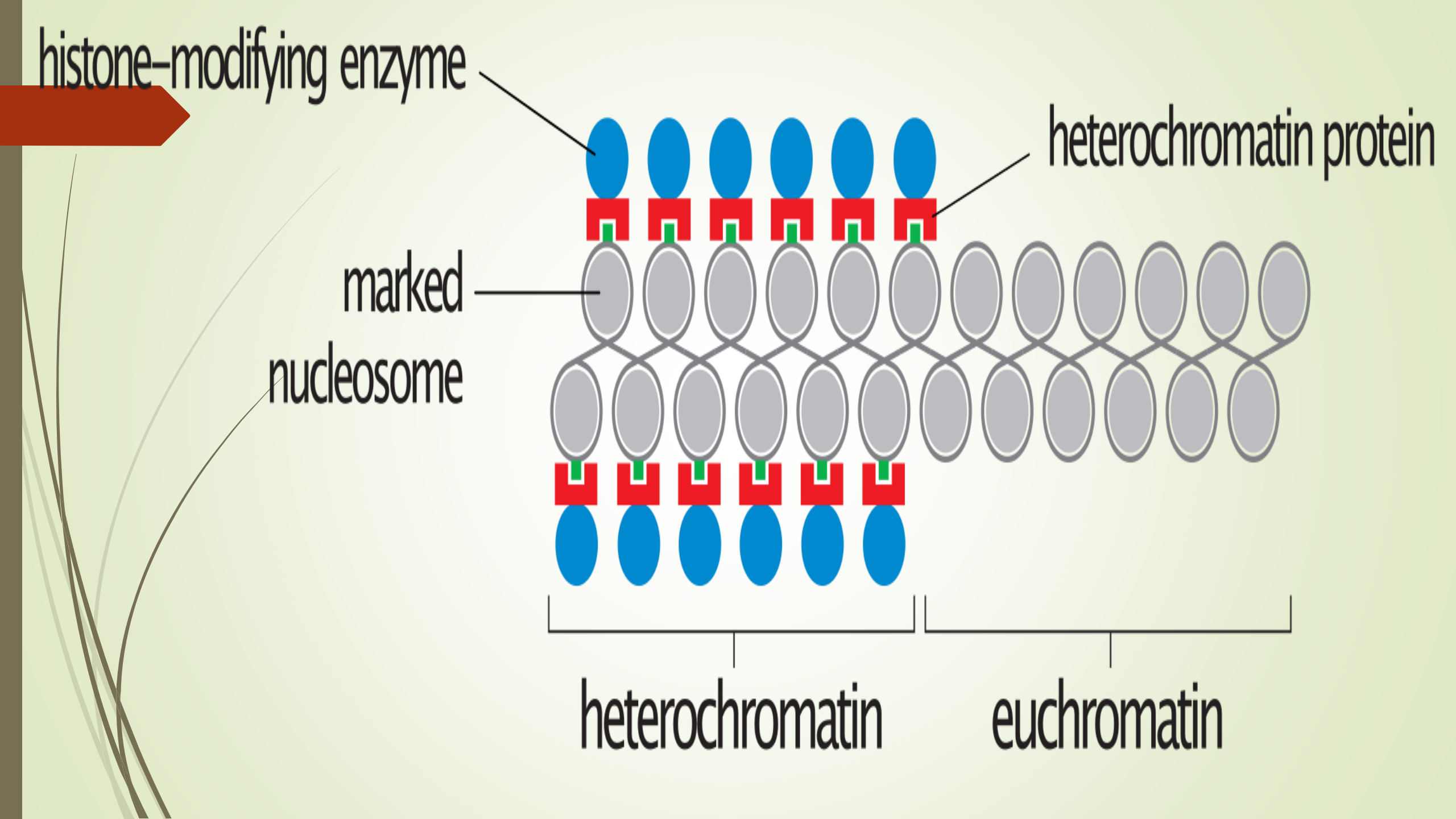


Each eukaryotic chromosome consist on a long linear DNA molecule associated with proteins, forming a compact complex of proteins and DNA called chromatin.

Chromatin contains the vast majority of the DNA of an organism, but a small amount inherited maternally, can be found in the mitochondria. It is present in most cells, with a few exceptions, for example, red blood cells.

Histones are responsible for the first and most basic unit of chromosome organization, the nucleosome.

Eukaryotes (cells with nuclei such as those found in plants, fungi, and animals) possess multiple large linear chromosomes contained in the cell's nucleus. Each chromosome has one centromere, with one or two arms projecting from the centromere, although, under most circumstances, these arms are not visible as such. In addition, most eukaryotes have a small circular mitochondrial genome, and some eukaryotes may have additional small circular or linear cytoplasmic chromosomes


histone–modifying enzyme
heterochromatin protein
marked nucleosome
heterochromatin
euchromatin

Interphase chromatin

The packaging of DNA into nucleosomes causes a 10 nanometer fibre which may further condense up to 30 nm fibres

Most of the euchromatin in interphase nuclei appears to be in the form of 30-nm fibers. Chromatin structure is the more decondensed state, i.e. the 10-nm conformation allows transcription

During interphase (the period of the cell cycle where the cell is not dividing), two types of chromatin can be distinguished:

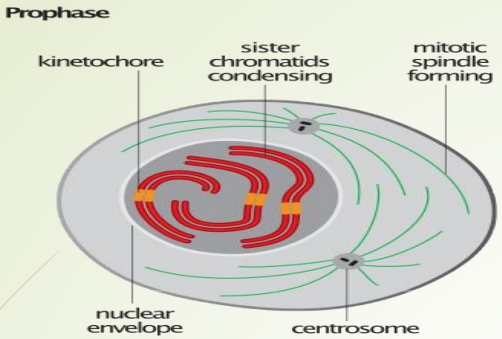
Euchromatin, which consists of DNA that is active, e.g., being expressed as protein.
Heterochromatin, which consists of mostly inactive DNA. It seems to serve structural purposes during the chromosomal stages.
Heterochromatin can be further distinguished into two types:

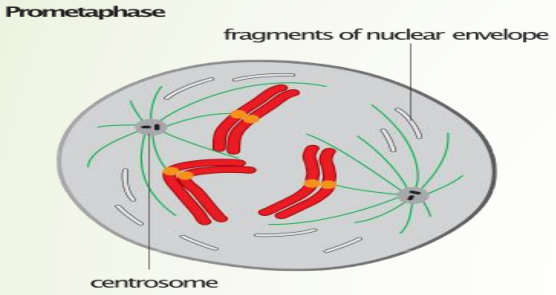
Constitutive heterochromatin, which is never expressed. It is located around the centromere and usually contains repetitive sequences.

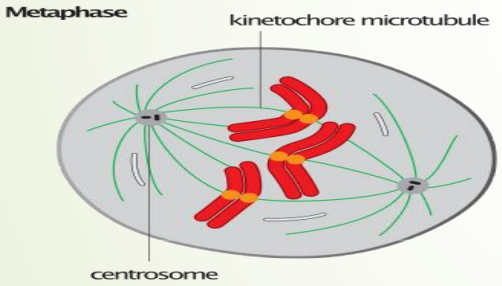
Facultative heterochromatin, which is sometimes expressed

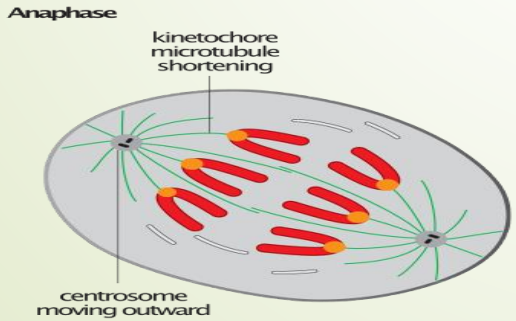
Metaphase chromatin and division

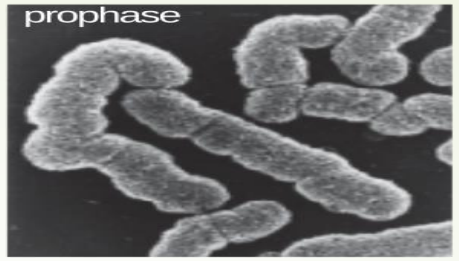
In the early stages of mitosis or meiosis (cell division), the chromatin double helix become more and more condensed. They cease to function as accessible genetic material (transcription stops) and become a compact transportable form. The loops of 30-nm chromatin fibers are thought to fold upon themselves further to form the compact metaphase chromosomes of mitotic cells. The DNA is thus condense about 10,000 fold

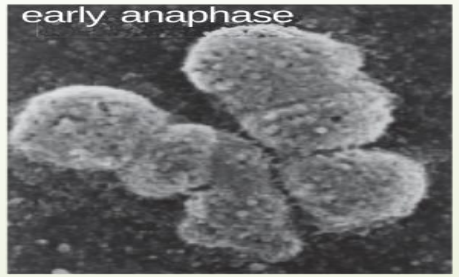












Stages of early mitosis in a vertebrate cell with micrograp hs of chromatid s

This highly compact form makes the individual chromosomes visible, and they form the classic four arm structure, a pair of sister chromatids attached to each other at the centromere. The shorter arms are called p arms (from the French petit, small) and the longer arms are called q arms (q follows p in the Latin alphabet; q-g "grande"; alternatively it is sometimes said q is short for queue meaning tail in French[35]). This is the only natural context in which individual chromosomes are visible with an optical microscope.

During mitosis, microtubules grow from centrosomes located at opposite ends of the cell and also attach to the centromere at specialized structures called kinetochores, one of which is present on each sister chromatid. A special DNA base sequence in the region of the kinetochores provides, along with special proteins, longer-lasting attachment in this region.

The microtubules then pull the chromatids apart toward the centrosomes, so that each daughter cell inherits one set of chromatids. Once the cells have divided, the chromatids are uncoiled and DNA can again be transcribed. In spite of their appearance, chromosomes are structurally highly condensed, which enables these giant DNA structures to be contained within a cell nucleus.

Normal members of a particular eukaryotic species all have the same number of nuclear chromosomes (see the table). Other eukaryotic chromosomes, i.e., mitochondrial and plasmid-like small chromosomes, are much more variable in number, and there may be thousands of copies per cell.

Asexually reproducing species have one set of chromosomes that are the same in all body cells. However, asexual species can be either haploid or diploid.

Sexually reproducing species have somatic cells (body cells), which are diploid [2n] having two sets of chromosomes (23 pairs in humans with one set of 23 chromosomes from each parent), one set from the mother and one from the father. Gametes, reproductive cells, are haploid [n]: They have one set of chromosomes. Gametes are produced by meiosis of a diploid germ line cell. During meiosis, the matching chromosomes of father and mother can exchange small parts of themselves (crossover), and thus create new chromosomes that are not inherited solely from either parent. When a male and a female gamete merge (fertilization), a new diploid organism is formed.

Some animal and plant species are polyploid [Xn]: They have more than two sets of homologous chromosomes. Plants important in agriculture such as tobacco or wheat are often polyploid, compared to their ancestral species.

Wheat has a haploid number of seven chromosomes, still seen in some cultivars as well as the wild progenitors. The more-common pasta and bread wheat types are polyploid, having 28 (tetraploid) and 42 (hexaploid) chromosomes, compared to the 14 (diploid) chromosomes in the wild wheat

Prokaryote species generally have one copy of each major chromosome, but most cells can easily survive with multiple copies.

For example, Buchnera, a symbiont of aphids has multiple copies of its chromosome, ranging from 10–400 copies per cell. However, in some large bacteria, such as Epulopiscium fishelsoni up to 100,000 copies of the chromosome can be present. Plasmids and plasmid-like small chromosomes are, as in eukaryotes, highly variable in copy number. The number of plasmids in the cell is almost entirely determined by the rate of division of the plasmid – fast division causes high copy number

Karyotype

In general, the karyotype is the characteristic chromosome complement of a eukaryote species. The preparation and study of karyotypes is part of cytogenetics.

Although the replication and transcription of DNA is highly standardized in eukaryotes, the same cannot be said for their karyotypes, which are often highly variable. There may be variation between species in chromosome number and in detailed organization. In some cases, there is significant variation within species. Often there is:

1.variation between the two sexes
2. variation between the germ-line and soma (between gametes and the rest of the body)
3. variation between members of a population, due to balanced genetic polymorphism
4. geographical variation between races
5. mosaics or otherwise abnormal individuals.
Also, variation in karyotype may occur during develo

Aberrations

Chromosomal aberrations are disruptions in the normal chromosomal content of a cell and are a major cause of genetic conditions in humans, such as Down syndrome, although most aberrations have little to no effect. Some chromosome abnormalities do not cause disease in carriers, such as translocations, or chromosomal inversions, although they may lead to a higher chance of bearing a child with a chromosome disorder. Abnormal numbers of chromosomes or chromosome sets, called aneuploidy, may be lethal or may give rise to genetic disorders. Genetic counseling is offered for families that may carry a chromosome rearrangement.

The gain or loss of DNA from chromosomes can lead to a variety of genetic disorders. Human examples include:

- Cri du chat, which is caused by the deletion of part of the short arm of chromosome 5. "Cri du chat" means "cry of the cat" in French; the condition was so-named because affected babies make high-pitched cries that sound like those of a cat. Affected individuals have wide-set eyes, a small head and jaw, moderate to severe mental health problems, and are very short.
- Down syndrome, the most common trisomy, usually caused by an extra copy of chromosome 21 (trisomy 21). Characteristics include decreased muscle tone, stockier build, asymmetrical skull, slanting eyes and mild to moderate developmental disability

- Edwards syndrome, or trisomy-18, the second most common trisomy.Symptoms include motor retardation, developmental disability and numerous congenital anomalies causing serious health problems. Ninety percent of those affected die in infancy. They have characteristic clenched hands and overlapping fingers.

- Isodicentric 15, also called idic(15), partial tetrasomy 15q, or inverted duplication 15 (inv dup 15).

- Jacobsen syndrome, which is very rare. It is also called the terminal 11q deletion disorder. Those affected have normal intelligence or mild developmental disability, with poor expressive language skills. Most have a bleeding disorder called Paris-Trousseau syndrome.

- Klinefelter syndrome (XXY). Men with Klinefelter syndrome are usually sterile and tend to be taller and have longer arms and legs than their peers. Boys with the syndrome are often shy and quiet and have a higher incidence of speech delay and dyslexia. Without testosterone treatment, some may develop gynecomastia during puberty.
- Patau Syndrome, also called D-Syndrome or trisomy-13. Symptoms are somewhat similar to those of trisomy-18, without the characteristic folded hand.
- Small supernumerary marker chromosome. This means there is an extra, abnormal chromosome. Features depend on the origin of the extra genetic material. Cat-eye syndrome and isodicentric chromosome 15 syndrome (or Idic15) are both caused by a supernumerary marker chromosome, as is Pallister–Killian syndrome

- Triple-X syndrome (XXX). XXX girls tend to be tall and thin and have a higher incidence of dyslexia.

- Turner syndrome (X instead of XX or XY). In Turner syndrome, female sexual characteristics are present but underdeveloped. Females with Turner syndrome often have a short stature, low hairline, abnormal eye features and bone development and a "caved-in" appearance to the chest.
- Wolf–Hirschhorn syndrome, which is caused by partial deletion of the short arm of chromosome 4. It is characterized by growth retardation, delayed motor skills development, "Greek Helmet" facial features, and mild to profound mental health problems.
- XYY syndrome. XYY boys are usually taller than their siblings. Like XXY boys and XXX girls, they are more likely to have learning difficulties

Sperm aneuploidy

Exposure of males to certain lifestyle, environmental and/or occupational hazards may increase the risk of aneuploid spermatozoa.

In particular, risk of aneuploidy is increased by tobacco smoking and occupational exposure to benzene, insecticides,and perfluorinated compounds.

Increased aneuploidy is often associated with increased DNA damage in spermatozoa.

GIANT CHROMOSOME TYPES AND SIGNIFICANCE

The giant chromosomes were first observed in the cells of salivary glands, gut, trachea and other body parts of dipteran insects by E.G. Balbiani in . The name polytene was assigned to these chromosomes by Kollar. ... Because of the multi-stranded condition, these chromosomes are called polytene chromosomes.

Polytene chromosomes were first reported by E.G.Balbiani in 1881. ... They are produced when repeated rounds of DNA replication without cell division forms a giant chromosome. Thus polytene chromosomes form when multiple rounds of replication produce many sister chromatids which stay fused together.

What is a giant chromosome?

Giant chromosome

Chromosomes are decondensed during interphase.

Some exception are lampbrush chromosomes of vertebrate & polytene chromosome of insect. In both these chromosome The region that are actively synthesizing RNA are least condensed. Giant chromosome are very long & thick (200 times) during metaphase.

Hence they are know as “Giant chromosomes”.

Lampbrush chromosome

INTRODUCTION First discovered by Ruckert in 1892. Occur in oocytes of vertebrates as well as in some invertebrates. Found in those cells which produce a lot of RNA and their cytoplasmic and nuclear volume increases. Their detailed structure have been studied during the diplotene stage of meiotic division. During diplotene stage, certain chr. Stretch out large loops of DNA, causing the chr to resemble a lamp brush. They are visible under the light mocroscope.

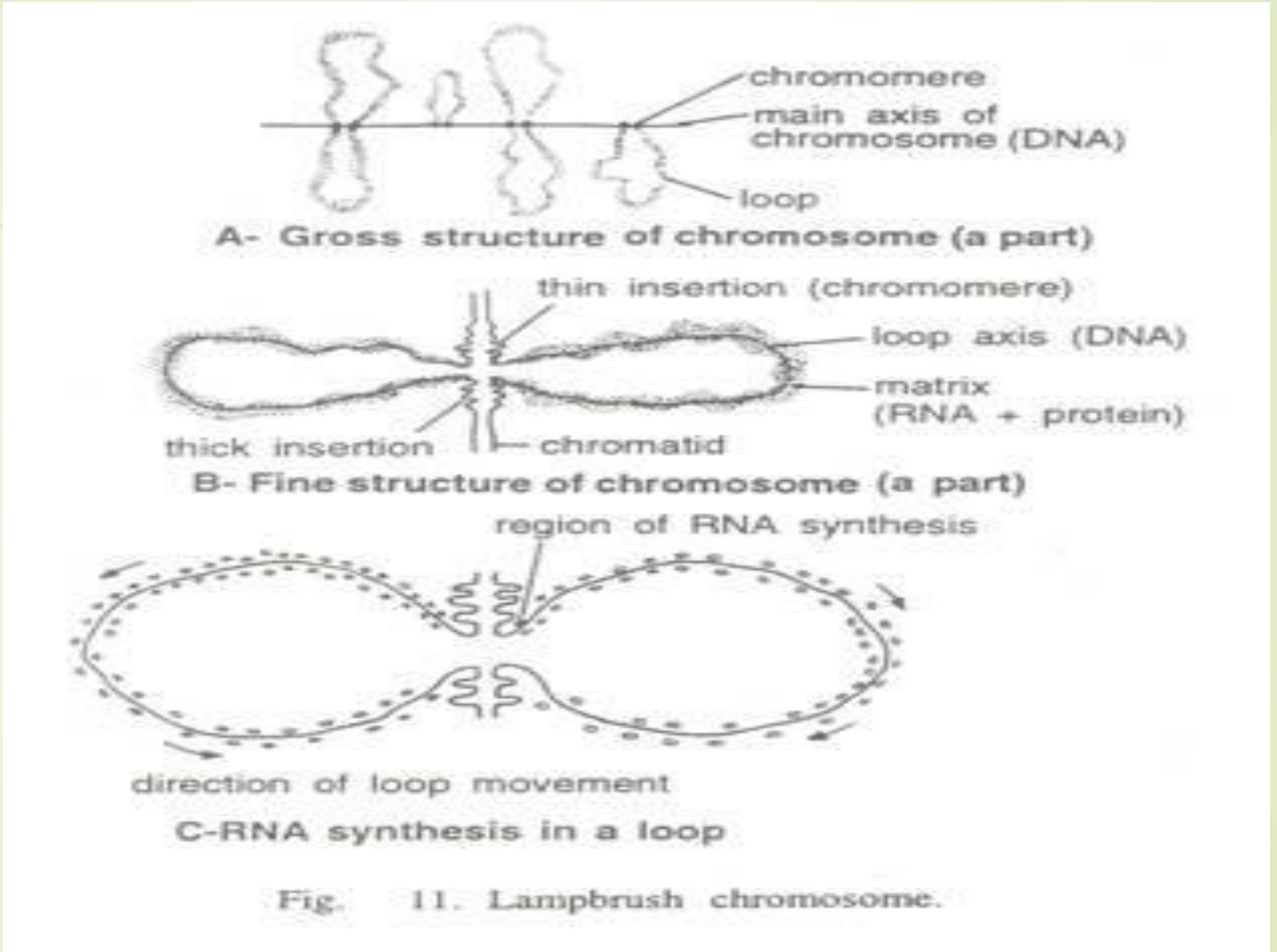
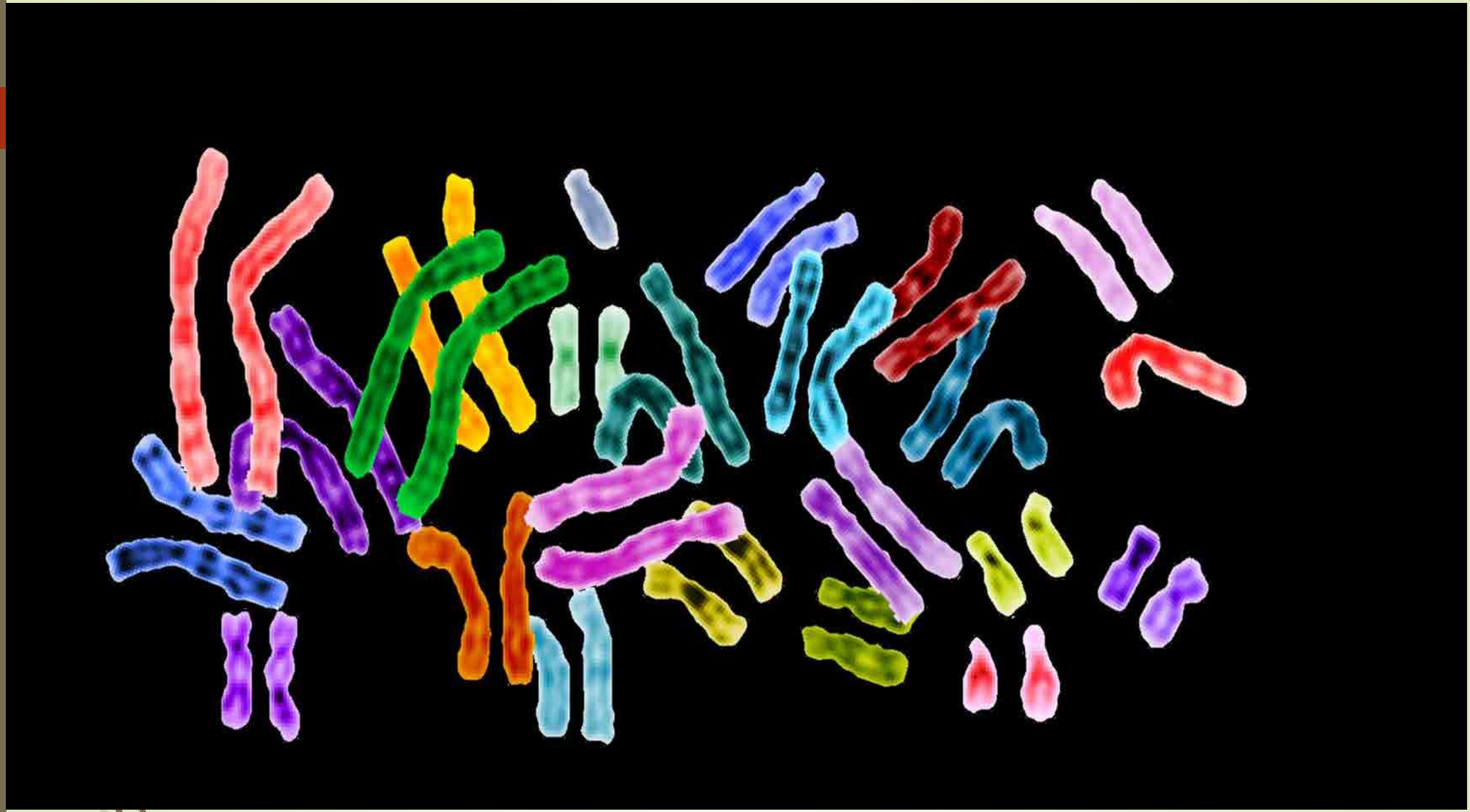


Fig. 11. Lampbrush chromosome.



These are the largest known chromosomes found in the yolk rich oocytic nuclei of certain vertebrates such as fishes, amphibians, reptiles and birds.

They can be seen with naked eye and are characterized by fine lateral loops, arising from the chromomeres, during first prophase (diplotene) of meiosis.

These loops give it a brush-like appearance; that is why these are called lampbrush chromosomes first discovered by Flemming in 1882 and were described in shark oocytes by Ruckert (1892). Lampbrush chromosomes of certain urodele oocytes may reach upto 5900μ in length.

It consists of longitudinal axis formed by a single DNA molecule along which several hundred bead-like chromomeres are distributed in a linear fashion. From each chromomere there emerge two symmetrical lateral loops (one for each chromatid), which are able to expand or contract in response to various environmental conditions.

About 5 to 10% of the DNA is in the lateral loops.

Loop formation reduces the mass of the corresponding chromomeres, implying a spinning out of chromomere material into the lateral strands.

The centromeres also have the appearance of elongate Feulgen-positive chromomeres but they characteristically lack lateral loops.

Lampbrush chromosomes can be dissected in (toto) from oocyte nucleus. Individual chromosomes are liable to stretching.

With extreme stretching, chromomeres begin to separate transversely into two halves, so that the paired loops form double stranded bridges. The axis between chromomeres is also double, which can be seen in certain special regions where two elements separate longitudinally and bear single loops (Callan, 1955).

These experiments indicate that each chromomere possesses four quadrants separated by both a transverse and a longitudinal line of division (Fig. C). Callan (1963) regards it as that the entire chromatid pair is made up of two continuous strands, which lie parallel to one another in the interchromomere regions, are tightly folded in the chromomeres, and separate as single, unfolded fibres in the loops. Each of the two fibres would correspond to one conventional metaphase chromatid.

There is fundamental similarity in the organization of amphibian lmpbrush chromosomes and dipteran giant polytene chromosomes: in both cases, very long single fibres correspond to single chromatids and are partly but not completely extended.

The substructure of the salivary chromosome ‘puffs’ also bear some similarity to that of the lampbrush lateral loops.

Lateral loops are formed of DNA, in chromomeres regions DNA is tightly folded and transcriptionally inactive. In lateral loops RNA synthesis is intense.

Each loop in turn has an axis formed by a single DNA molecule, which is coated by a matrix of nascent RNA and proteins. The matrix is asymmetrical, being thicker at one end of the loop.

RNA synthesis starts at the thinner end and progresses toward the thicker end.

1. Functions of Lampbrush chromosomes,

(a) Synthesis of RNA:

Functions of lampbrush chromosomes involve synthesis of RNA and protein by their loops. RNA is synthesized only at the thin insertion and then carried around the loops to the thick insertion. There it may be either destroyed or released into nucleus.

(b) Formation of yolk material:

There are some probabilities that lampbrush chromosomes help in the formation of certain amount of yolk material for the egg.

. Polytene chromosomes

INTRODUCTION :

First discovered by E.G Balbiani in 188, in squash of salivary cells of Chironomous. They also occur in rectal epithelium & Malphigian tubules. They are many times larger than the normal chromosomes reaching a length of 200µm and are visible even under a compound microscope. The enormous size is due to the duplication of chromonema which do not separate.

According to an estimate, the polytene chromosomes have 1000 times more DNA than the normal somatic chromosomes. Because of these chromosomes actually consist of many strands, they are called as Polytene chromosome.

Morphology: Contain 5 long & 1 short arm radiating from a central point called chromocentre, formed by the fusion of centromeres all the 8 chromosomes found in the cell. Of the 6 arms, the short arm represents the fused IV chromosome & the longest represents the fused sex chr. About 80% of the DNA is located in bands, & about 15% in interbands.

The chromatin in Darkly stained band is more condensed than chromatin in interbands. Intensely stained chromosomal segments correspond to high degree of packing & are genetically inactive (heterochromatin). Less tightly packed segments stain less distinctly & correspond to segment with genetic activity (euchromatin).

Ultrastructure of giant polytene (poly=many, tene=strands) chromosomes:

It was first investigated by Beermann and Bahr (1954), who observed numerous fine fibrils in the Balbiani rings of Chironomus and estimated that each chromosome contains 1000 to 2000 separate strands (corresponding to the degree of ploidy).

Later Gay (1956) observed strands 200 to 500 A in diameter in sectioned Drosophila salivary chromosomes. The individual fibres in band and interband regions are similar in appearance, but the fibres in the bands exhibit a considerable degree of metaphase-like folding and are much more tightly packed.

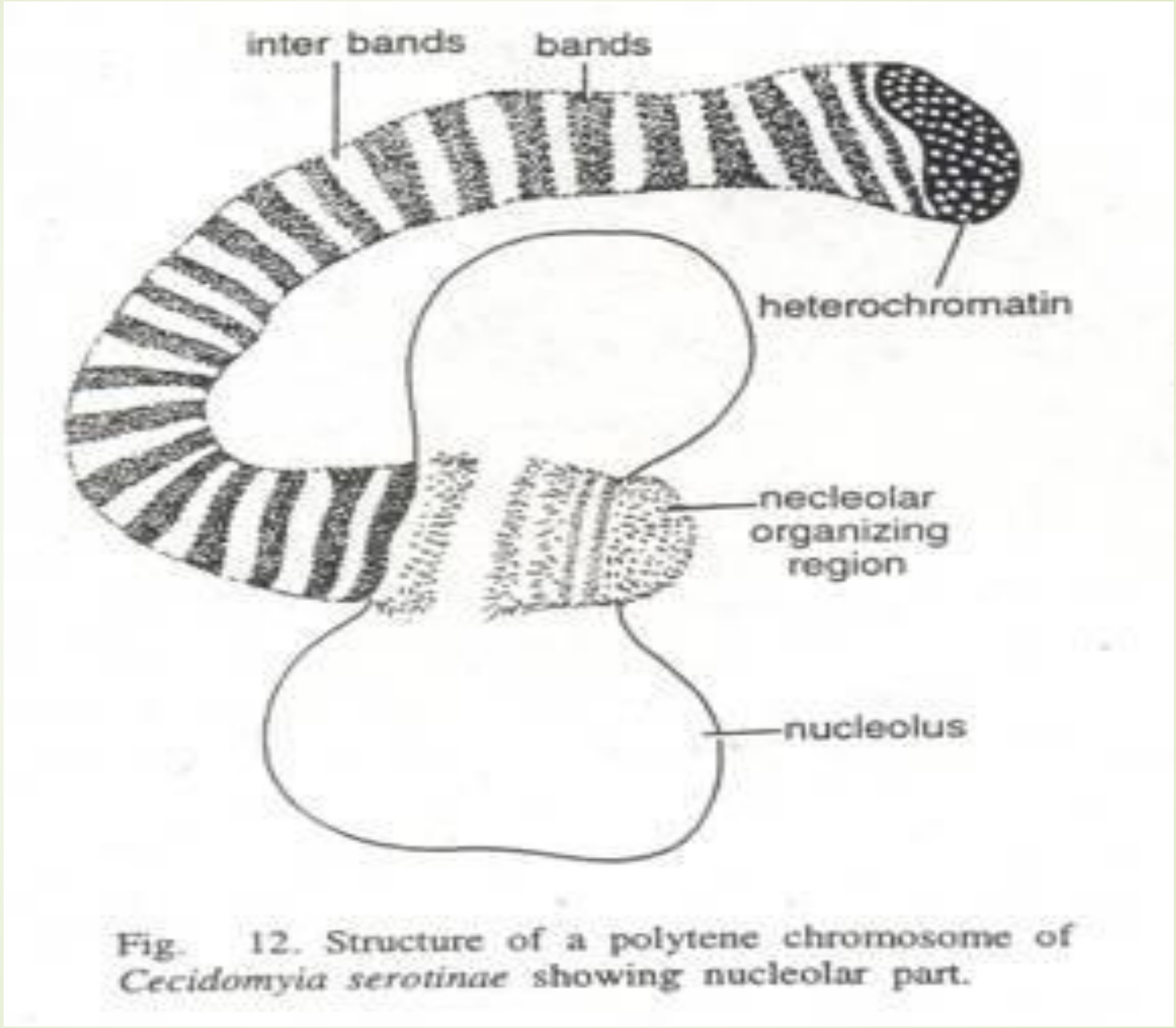


Fig. 12. Structure of a polytene chromosome of *Cecidomyia serotinae* showing nucleolar part.

Polytene chromosomes get their name from the fact that they are formed by many parallel chromatids, often more than a thousand strands, which do not separate from one another following duplication. Along each chromatid strand some regions of chromatin are tightly coiled and other regions are less coiled, with the result that polytene chromosomes appear to consist of light and dark bands when observed under a microscope.

During larval development, specific areas on polytene chromosomes become uncoiled, forming localized regions called 'pufs'. Puffs represent regions of active RNA synthesis (transcription). In the puff individual fibres remain continuous across the puff and they become extended as short lateral loops (Bahr, 1954). DNA is concentrated almost entirely in the bands. Protein and RNA is also found in puffs.

Puffing is due to the uncoiling of chromosome fibres which are usually closely folded or coiled in the dense band regions. These fibres then project in the form of loops.

Puffs and Balbiani rings:

During their initial stages of development these bands or interbands of the chromosomes exhibit swellings or puffs. Their appearance depends on the stage of larval development. It is probable that the metabolic activities, required for the formation of puffs, are related to the secretory function of the salivary glands. The formation of this is controlled by certain specific genes and the puffs are related with the active synthesis of RNA and proteins.

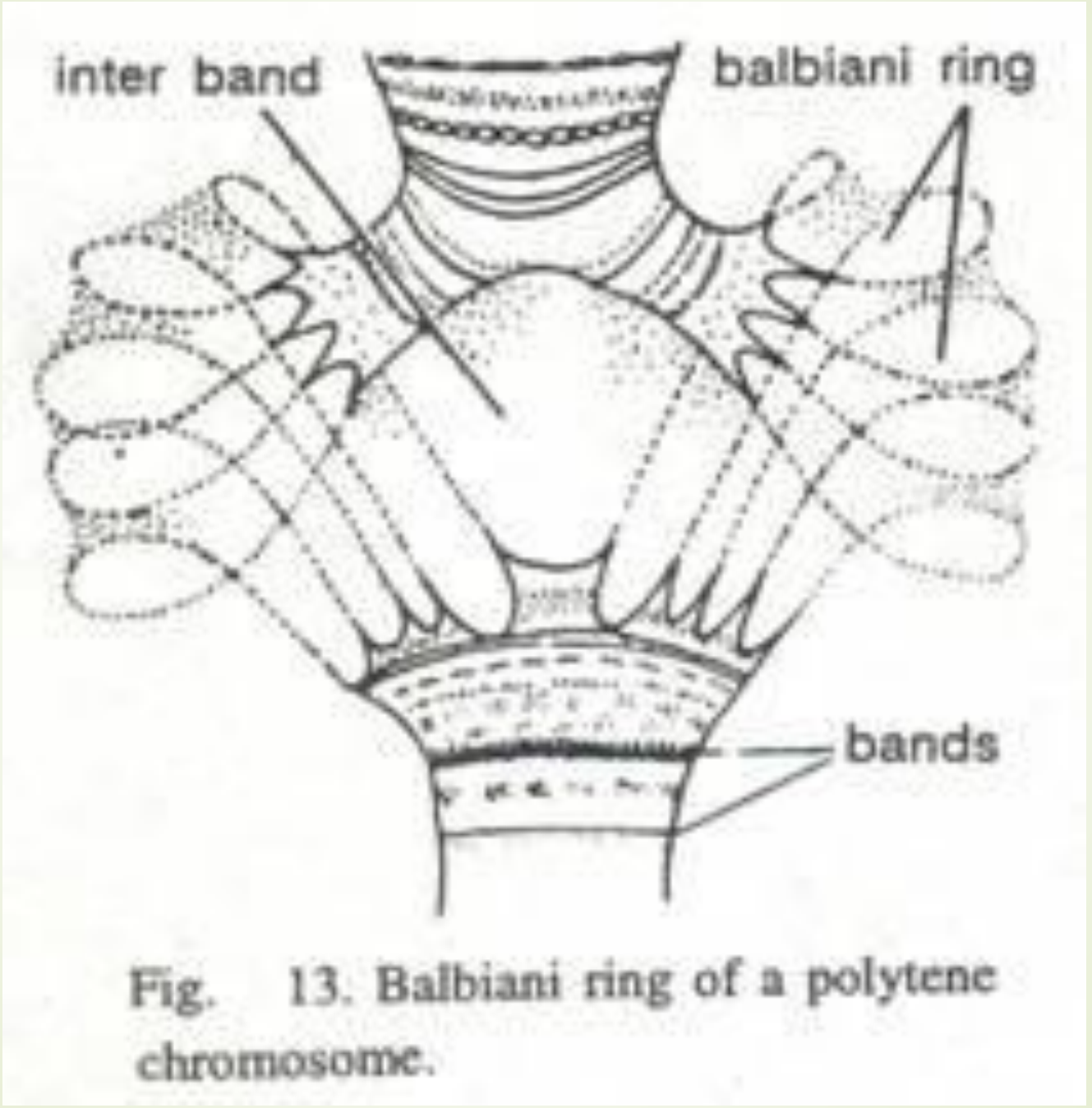


Fig. 13. Balbiani ring of a polytene chromosome.

This chromosomal RNA differs from the nucleolar and cytoplasmic RNA. The RNA of puffs is also not similar; it differs from each other in chemical composition. Some regions show larger puffs than others. These larger puffing regions are called Balbiani rings.

These rings are formed by the lateral stretching of loops caused by chromonemata. These loops of chromonemata make up Balbiani rings and give the chromosome a fuzzy outlook. The Balbiani rings are rich in DNA and mRNA, and the formation and function of the Balbiani rings are similar to the puffs.

Functions of giant polytene chromosomes:

(1) Main function of the polytene chromosome is to carry genes which ultimately control physiology of an organism. These genes are formed of DNA molecules.

(2) Shifting of heterochromatin in respect to euchromatin produces giant changes called position effects. These effects cause mutations in animals as well.

(3) Heterochromatic regions contain fewer genes than euchromatic parts. Production of nucleolar material is entirely done by heterochromatin.

(4) Chromosomes also help in protein synthesis indirectly. Nucleolus contains RNA, and this RNA serves as a means of transmission of genetic information to the cytoplasm, leading to the formation of specific protein.

Supernumerary chromosomes:

In nuclei of some plants and animals, in addition to normal chromosomes are present one or more accessory or supernumerary chromosomes. Wilson first discovered these in 1905 in hemipteran insect Metapodius.

Since then they have been found in a variety of insects and in a great many higher plants. In Metapodius these are derived from Y—chromosome. More commonly their ancestry is entirely unknown. Generally they are of smaller size and appear to be genetically inert

THANK YOU