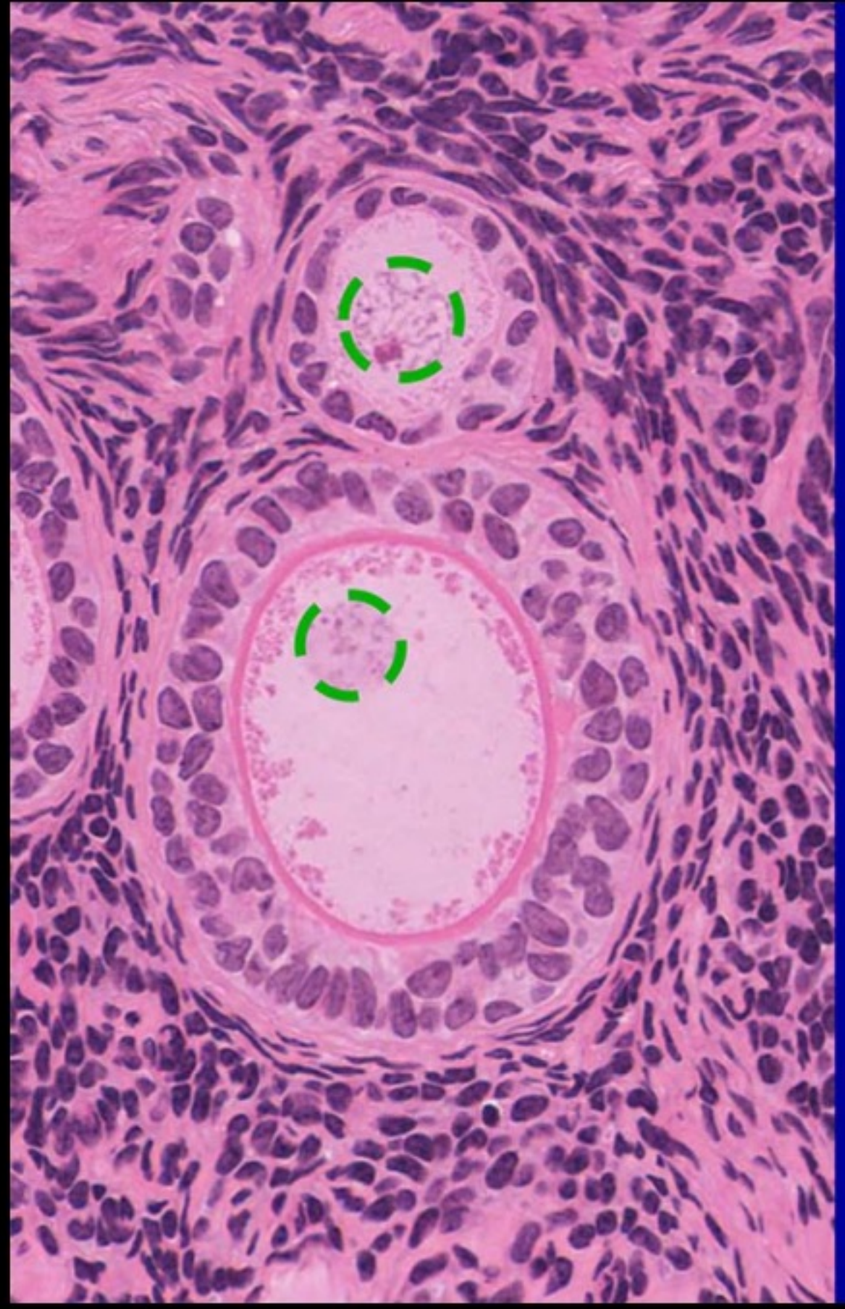
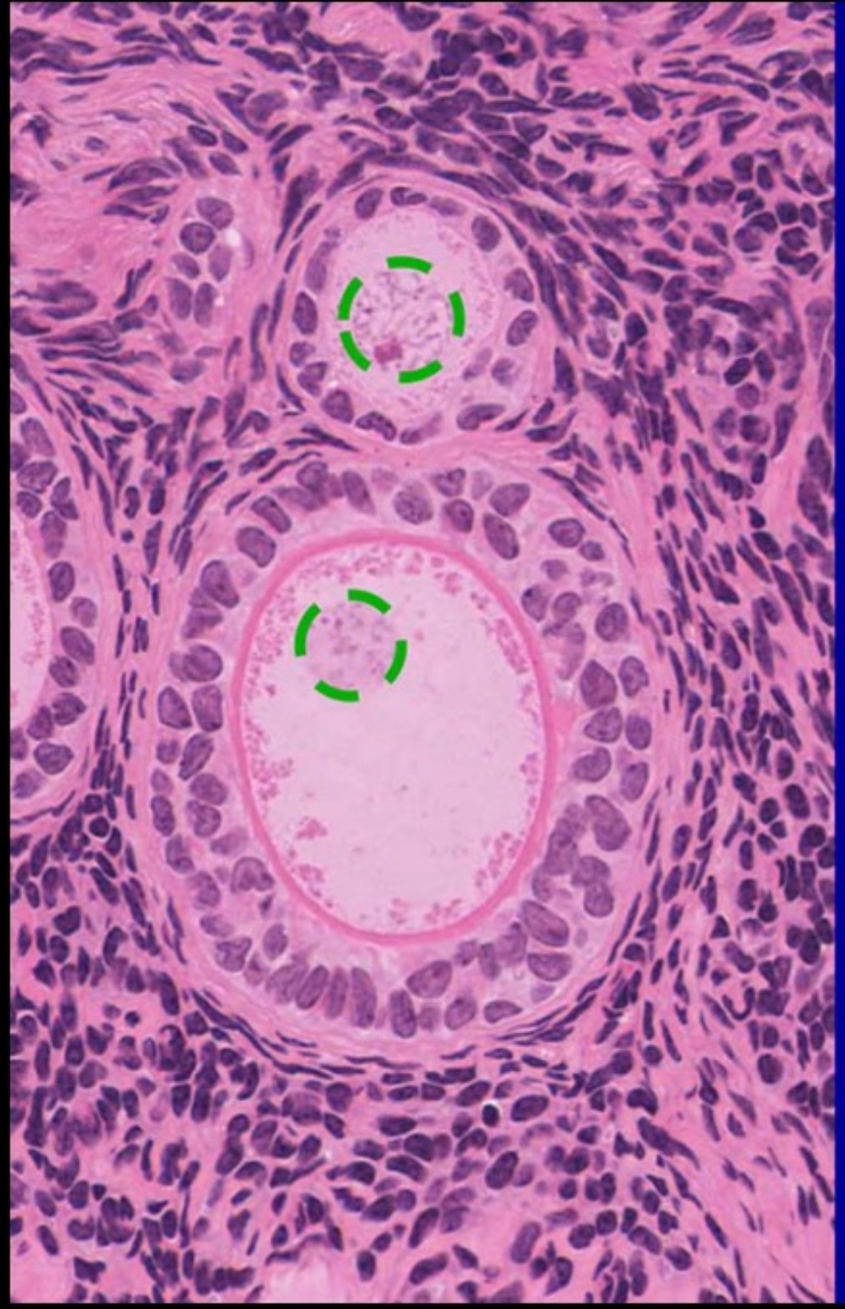


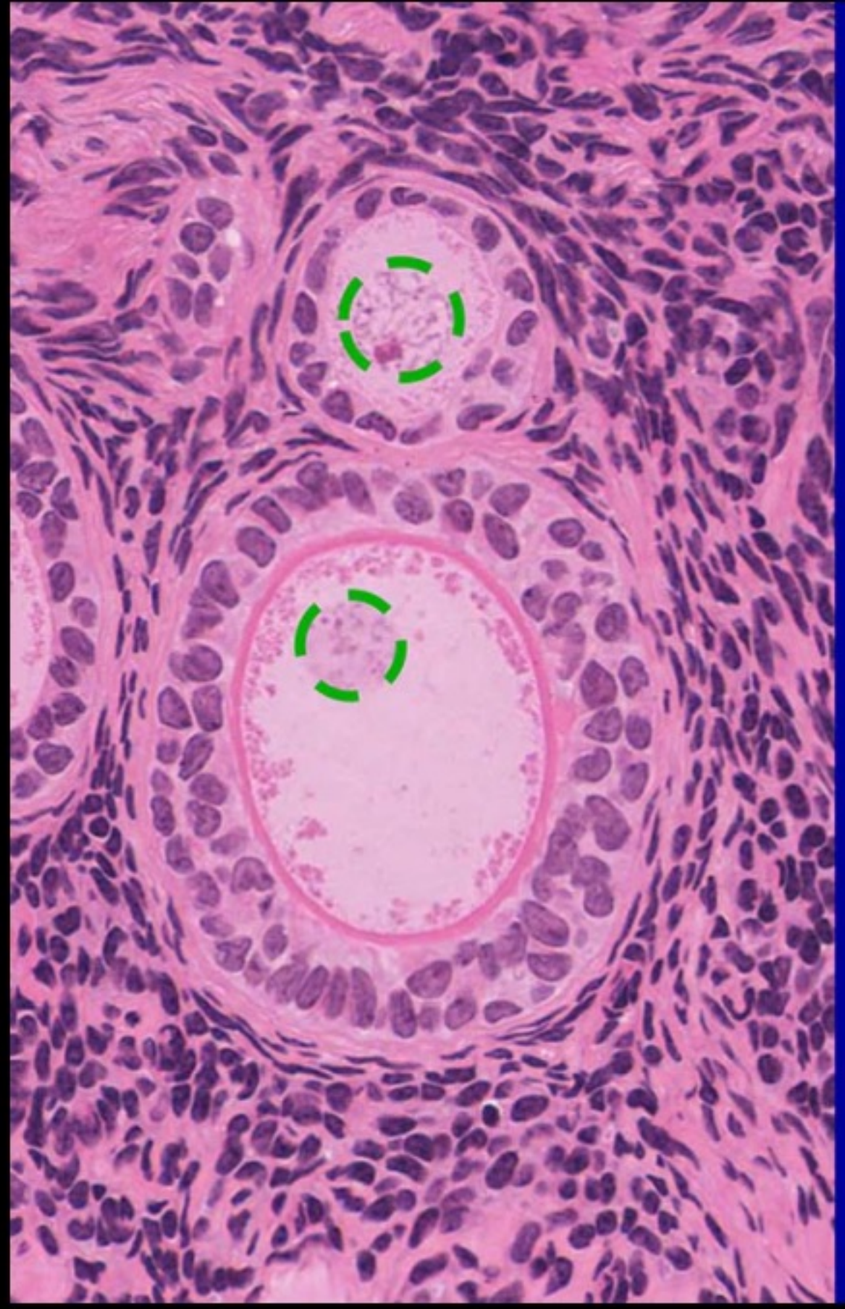
Identify the cell organelles indicated by the green dashed lines.



Identify the cell organelles indicated by the green dashed lines.

Nuclei (here of two monkey oocytes)

Which general types of biological polymers are synthesized in this cell organelle, which are not?



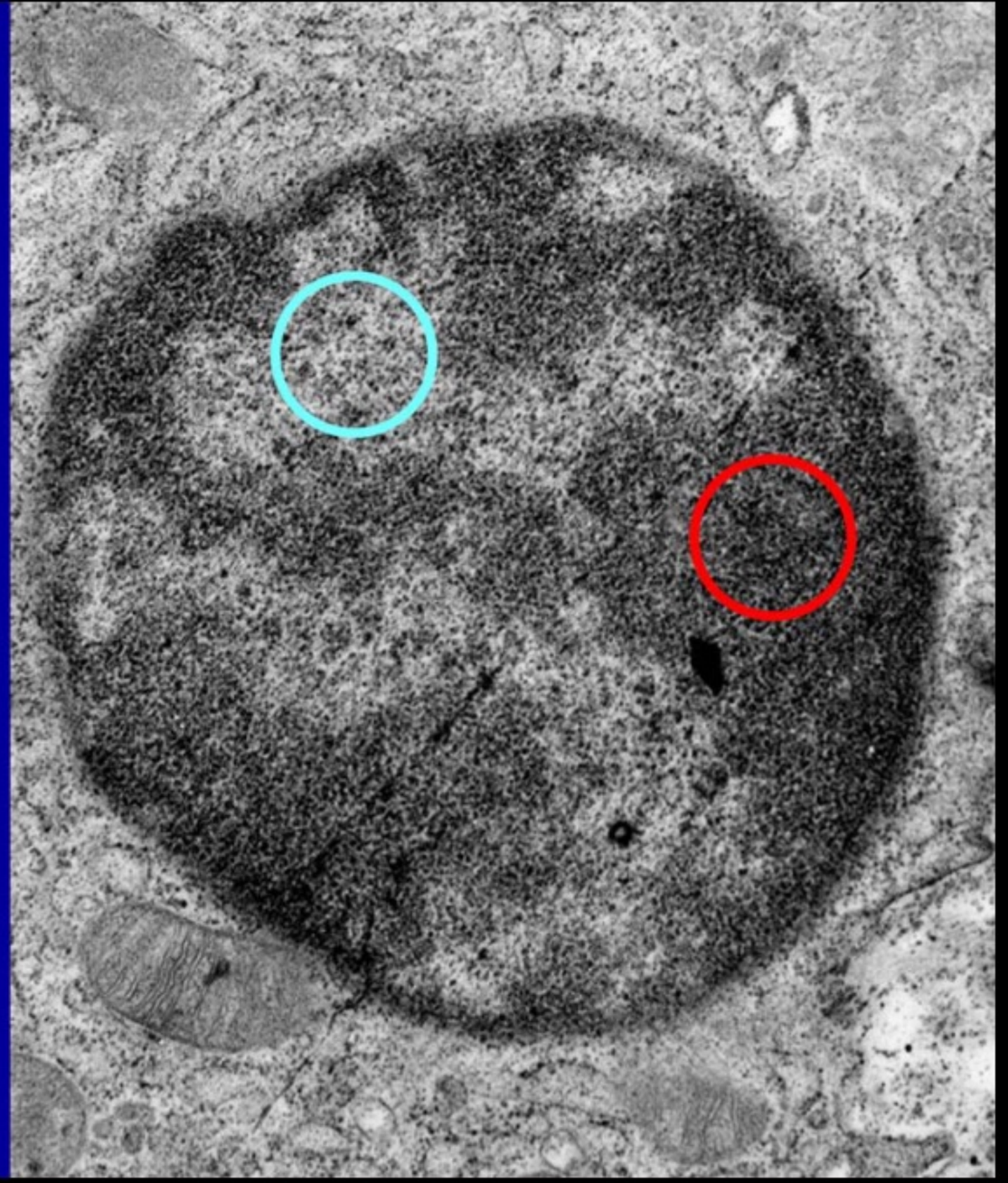
Identify the cell organelles indicated by the green dashed lines.

Nuclei (here of two monkey oocytes)

Which general types of biological polymers are synthesized in this cell organelle, which are not?

Mainly DNA and RNA; the syntheses of proteins, polysaccharides and lipids are associated with the cytosol and cytoplasmic cell organelles.

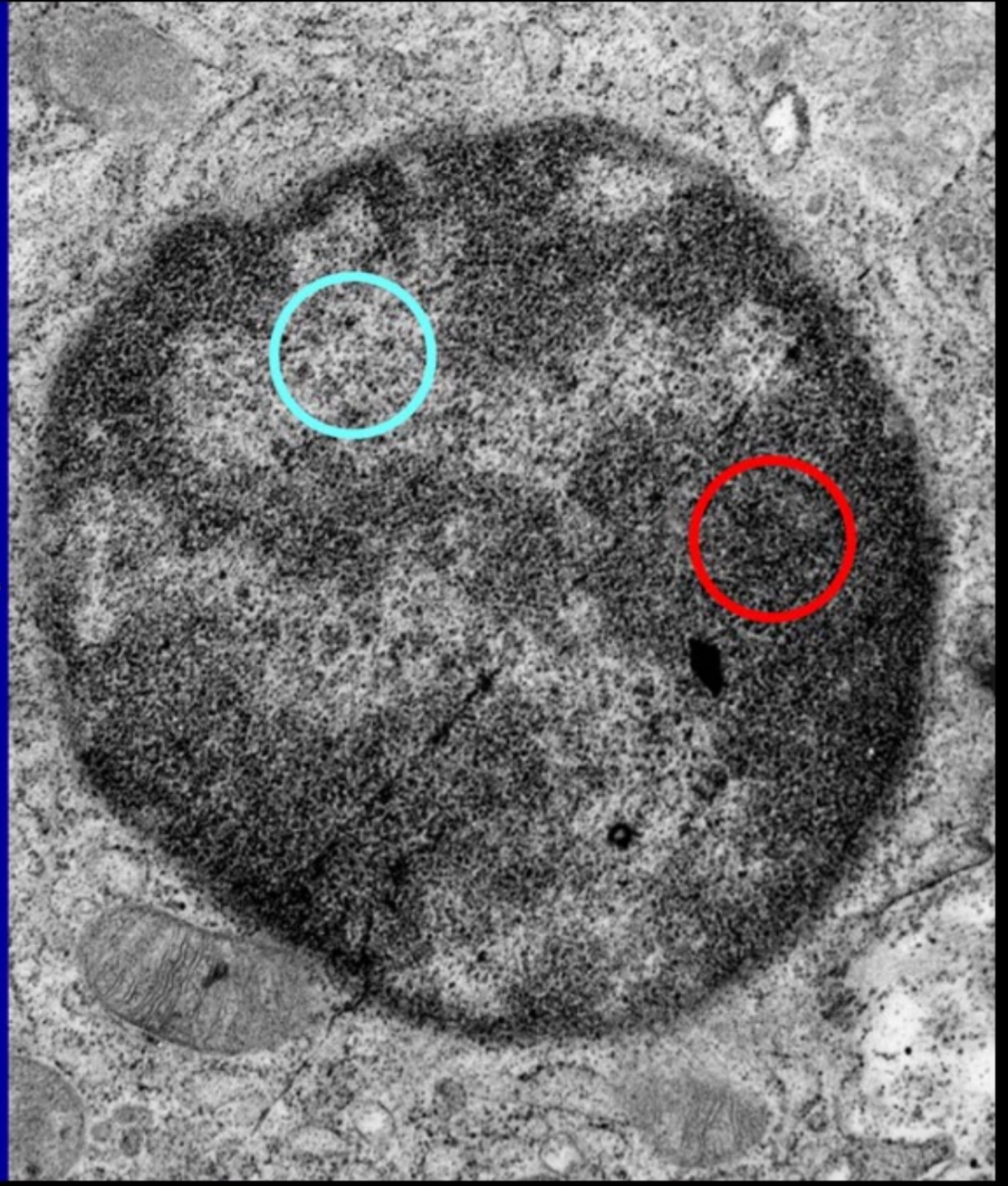
Shown is the nucleus of a plasma cell. Name the DNA content of the two nuclear areas marked by the red and blue circles.



Shown is the nucleus of a plasma cell. Name the DNA content of the two nuclear areas marked by the red and blue circles.

Heterochromatin and euchromatin

Which of the two areas is more likely to contain DNA that encodes genes which are actively engaged in transcription and why?

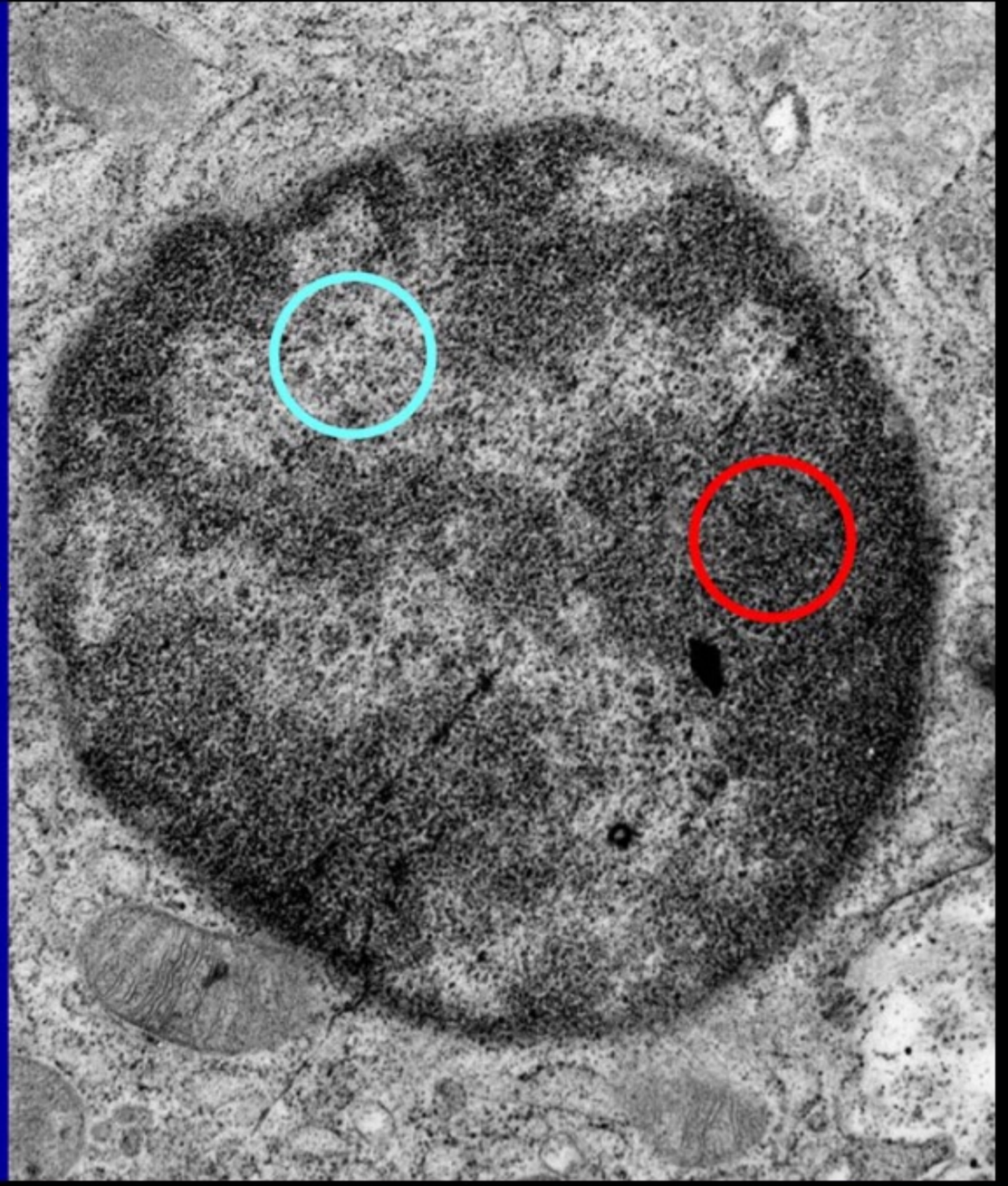


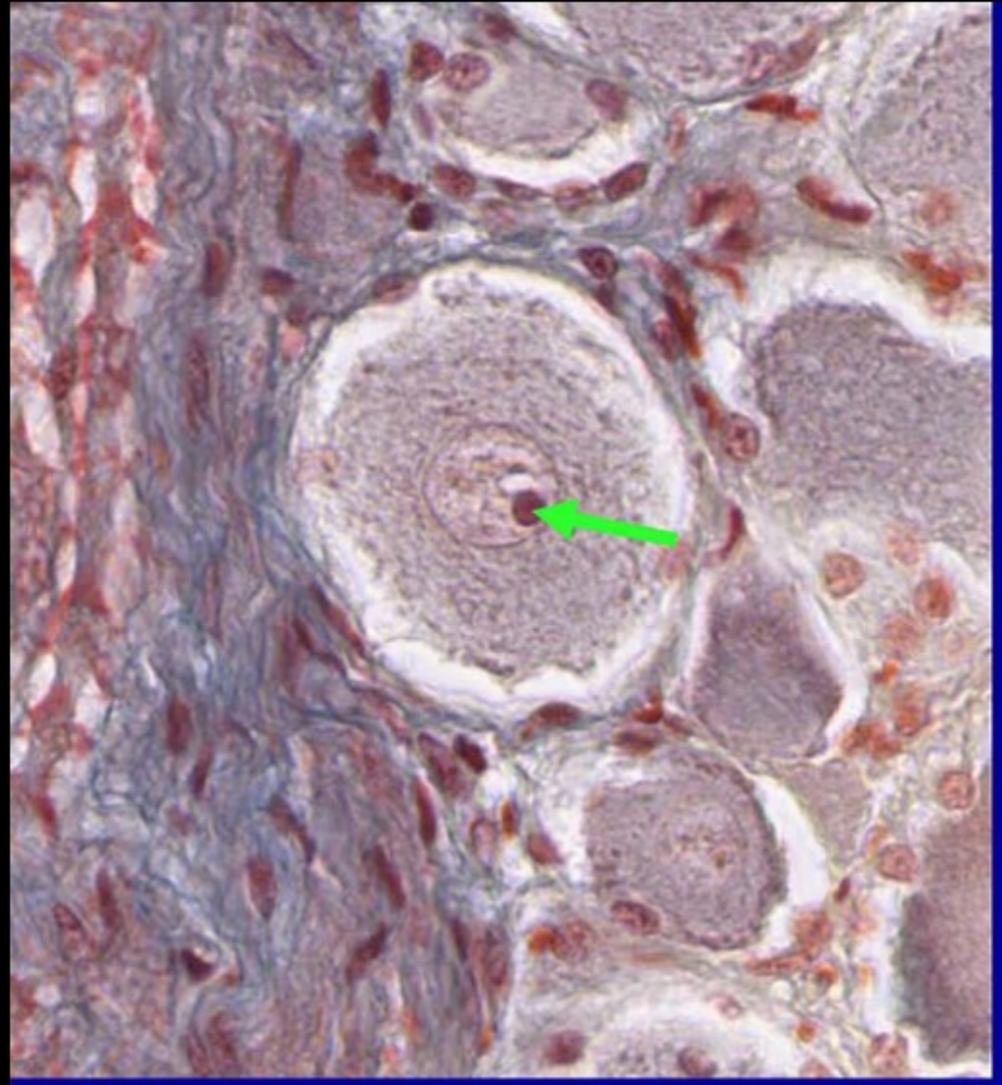
Shown is the nucleus of a plasma cell. Name the DNA content of the two nuclear areas marked by the red and blue circles.

Heterochromatin and euchromatin

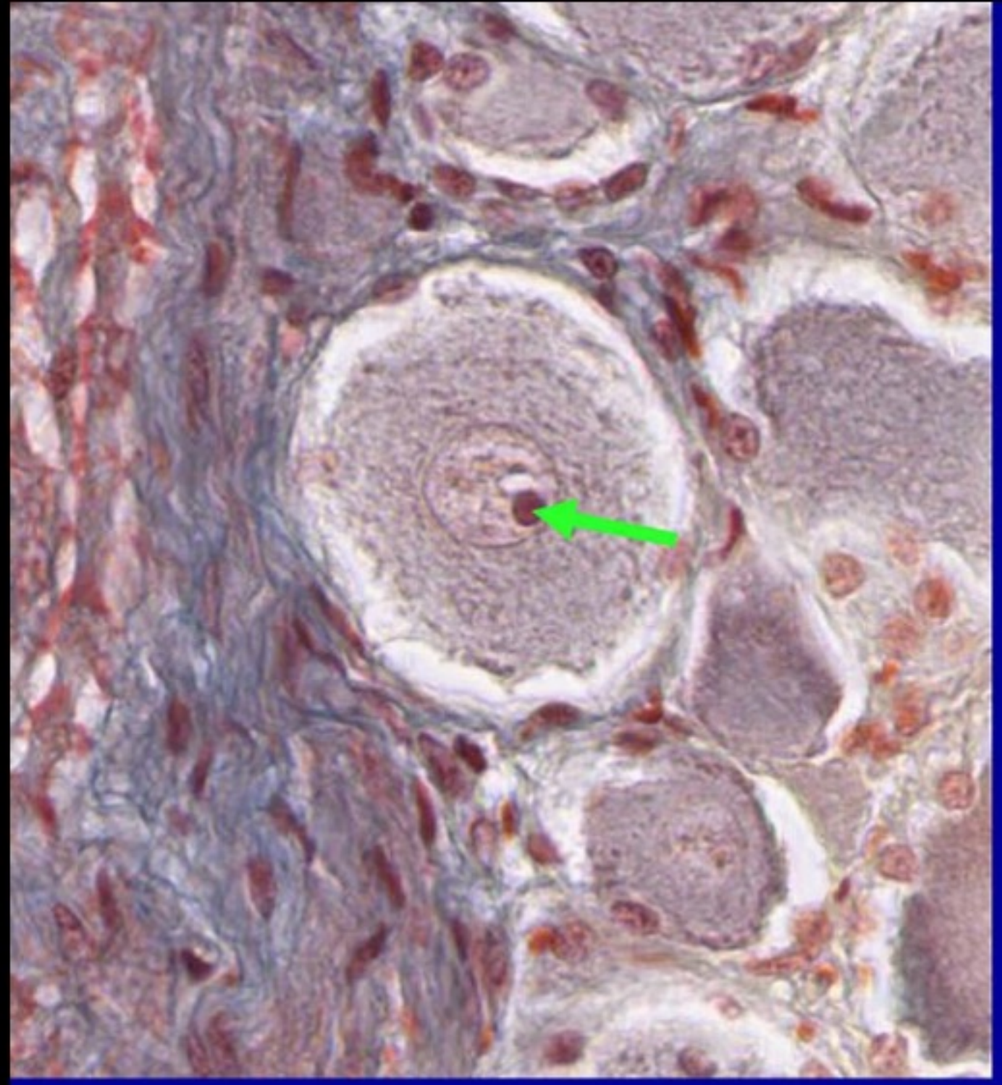
Which of the two areas is more likely to contain DNA that encodes genes which are actively engaged in transcription and why?

Euchromatin areas contain genomic DNA in a more open configuration and consequently stain more lightly. It is also gene-rich and therefore more likely to engage in transcription.





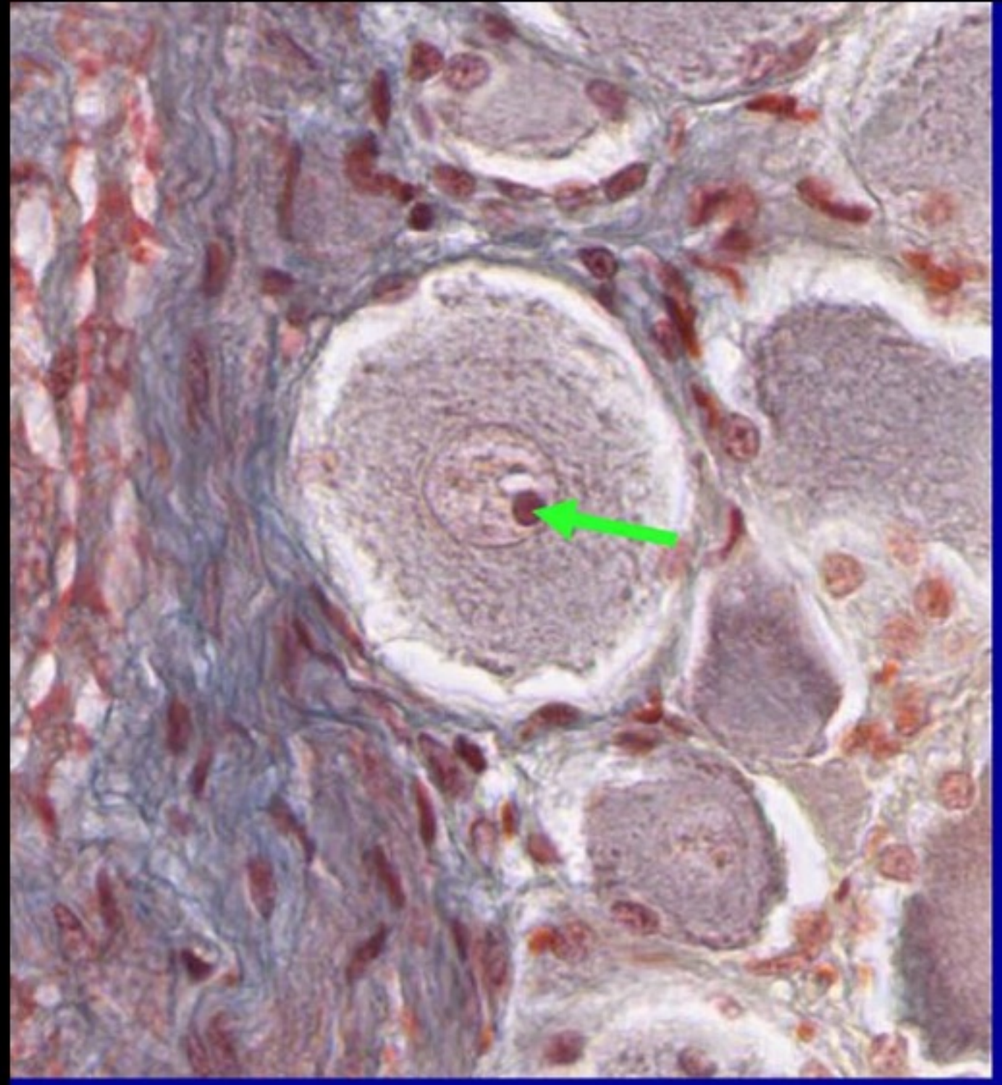
Identify the dark cell structure indicated by the green arrow.



Identify the dark cell structure indicated by the green arrow.

Nucleolus (here of a sensory neuron nucleus in a dorsal root ganglion)

What is synthesized and assembled in this cell organelle?



Identify the dark cell structure indicated by the green arrow.

Nucleolus (here of a sensory neuron nucleus in a dorsal root ganglion)

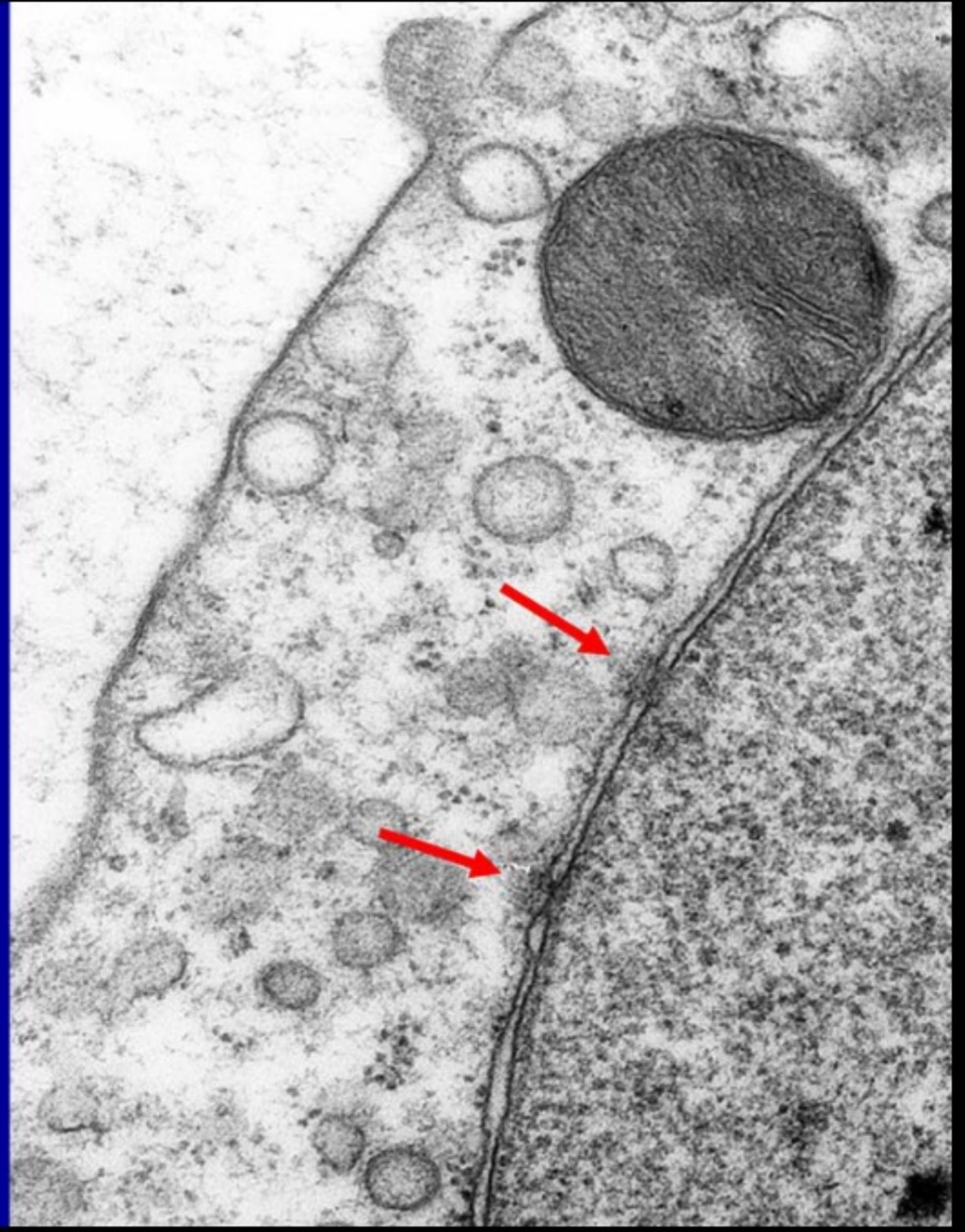
What is synthesized and assembled in this cell organelle?

The nucleolus is the location of ribosomal RNA synthesis and the assembly of ribosomal subunits. Ribosomal proteins are synthesized in the cytoplasm by free polysomes and imported into the nucleus via nuclear pores.

Identify the structures marked by the red arrows.

Nuclear pores

Describe the energy requirement for transport processes through nuclear pores.

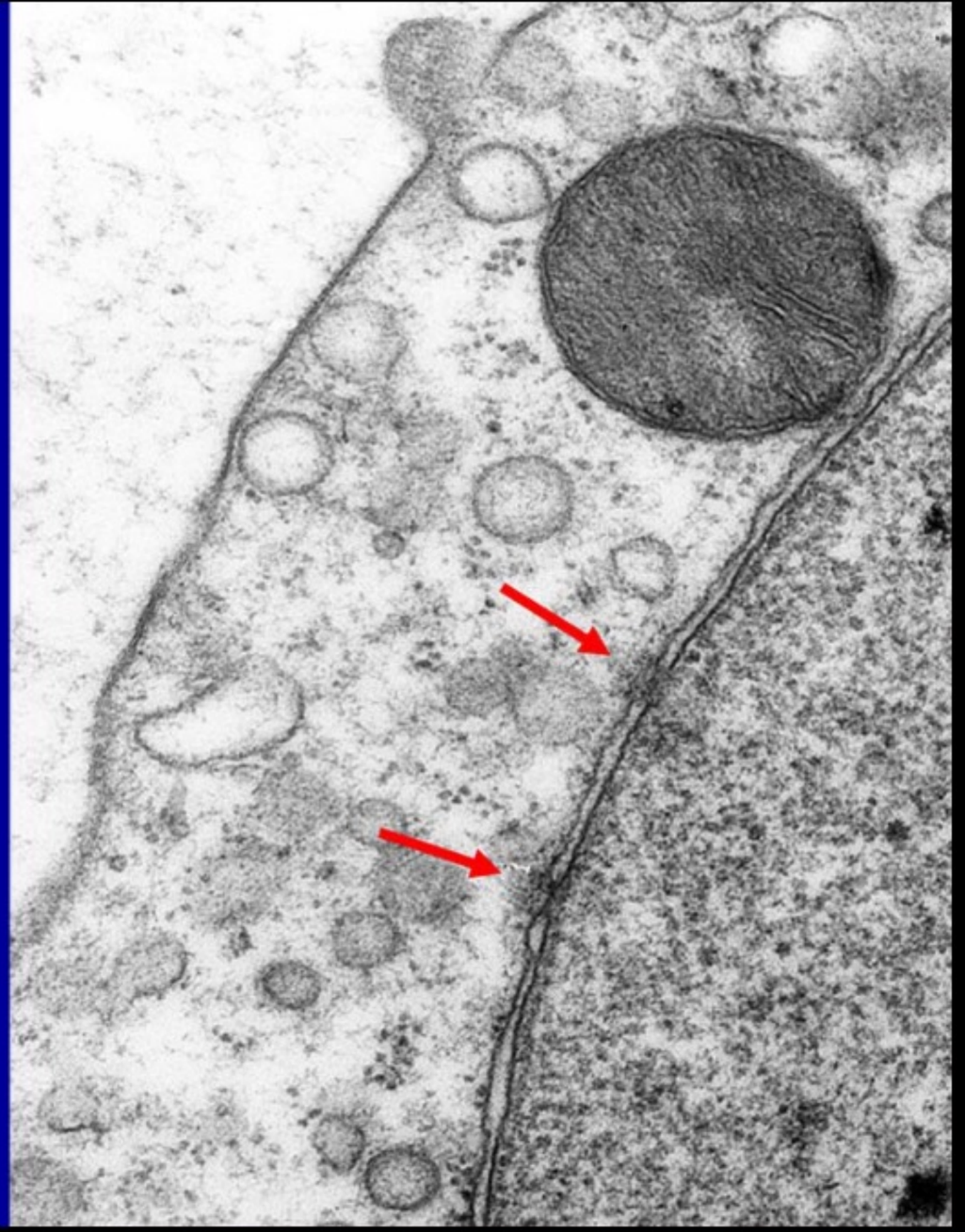


Identify the structures marked by the red arrows.

Nuclear pores

Describe the energy requirement for transport processes through nuclear pores. Transport processes through nuclear pores can be either energy-dependent (requiring GTP) or energy-independent.

How many membranes form the nuclear envelope?



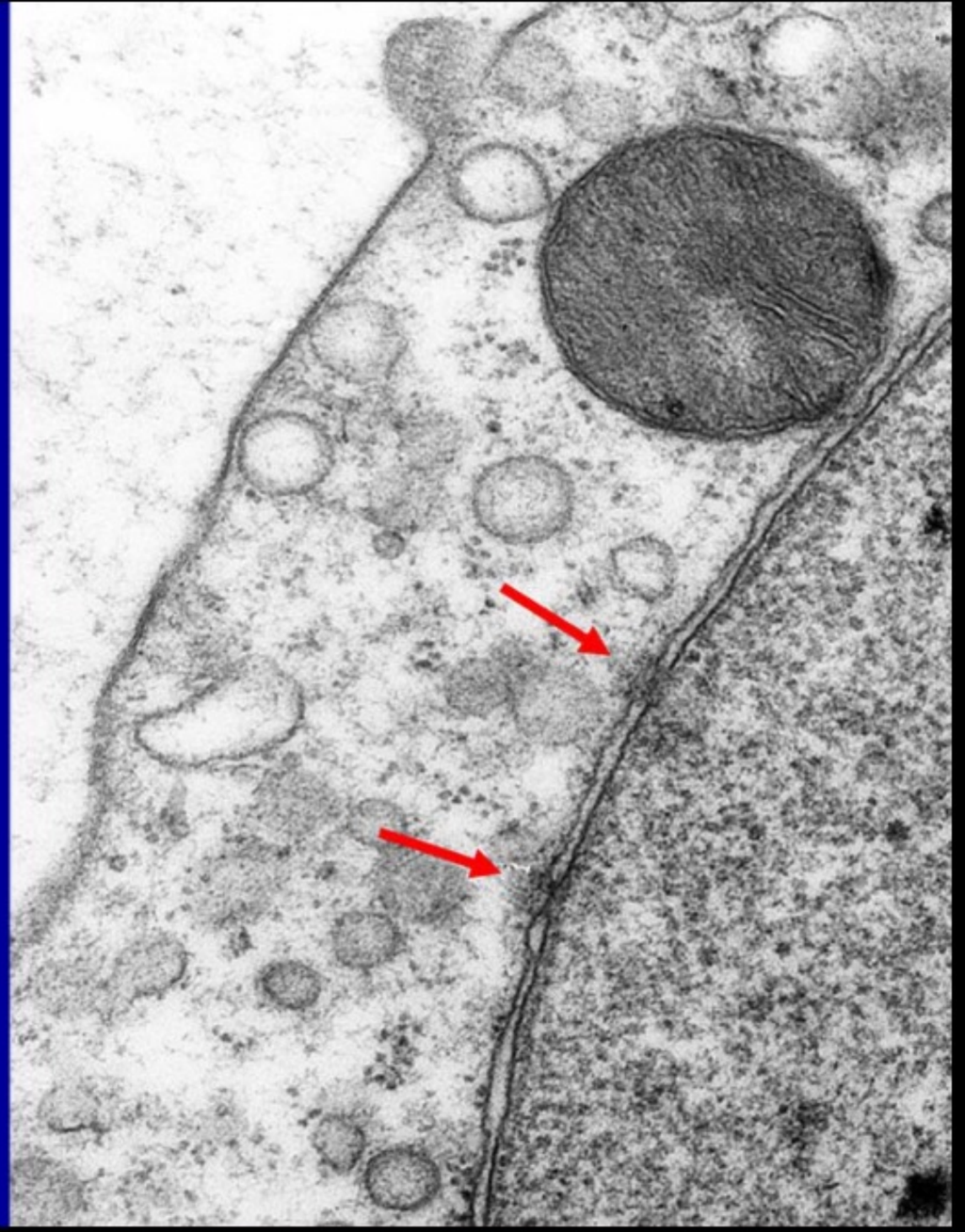
Identify the structures marked by the red arrows.

Nuclear pores

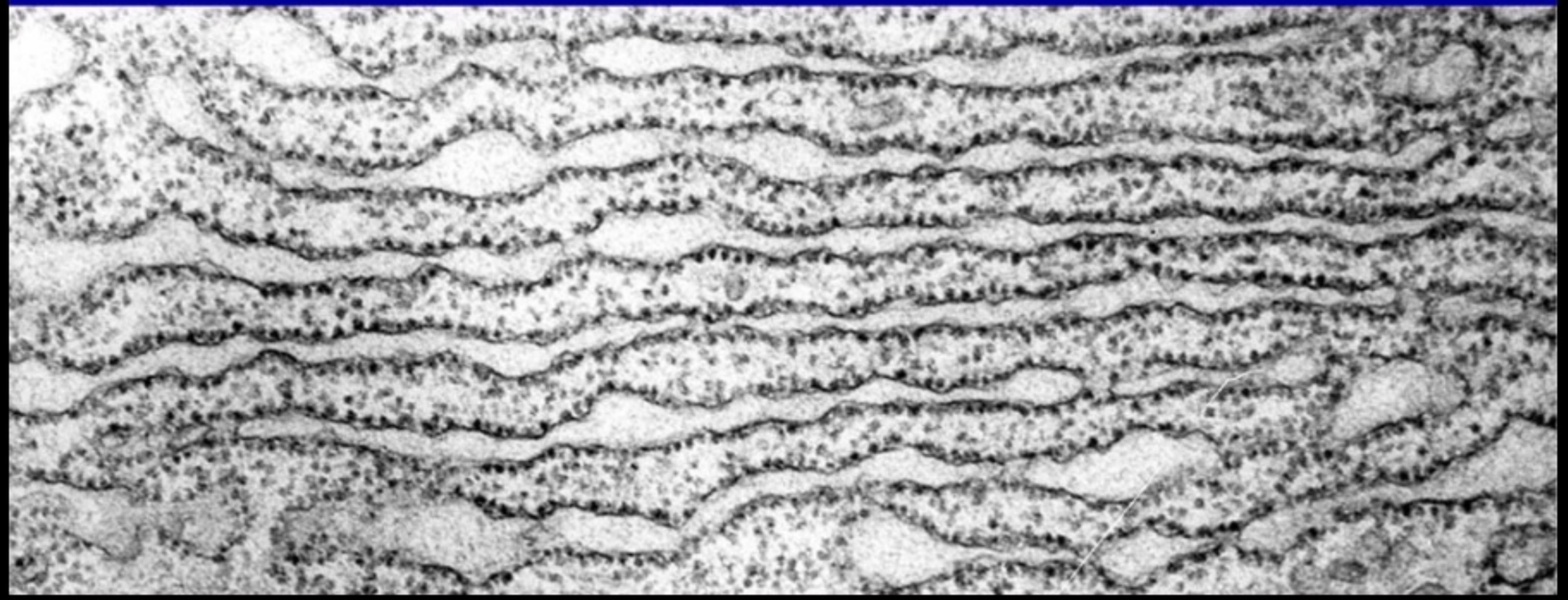
Describe the energy requirement for transport processes through nuclear pores. Transport processes through nuclear pores can be either energy-dependent (requiring GTP) or energy-independent.

How many membranes form the nuclear envelope?

The nuclear envelope consists of two lipid bilayers. The outer nuclear membrane is contiguous with the membrane of the endoplasmic reticulum.



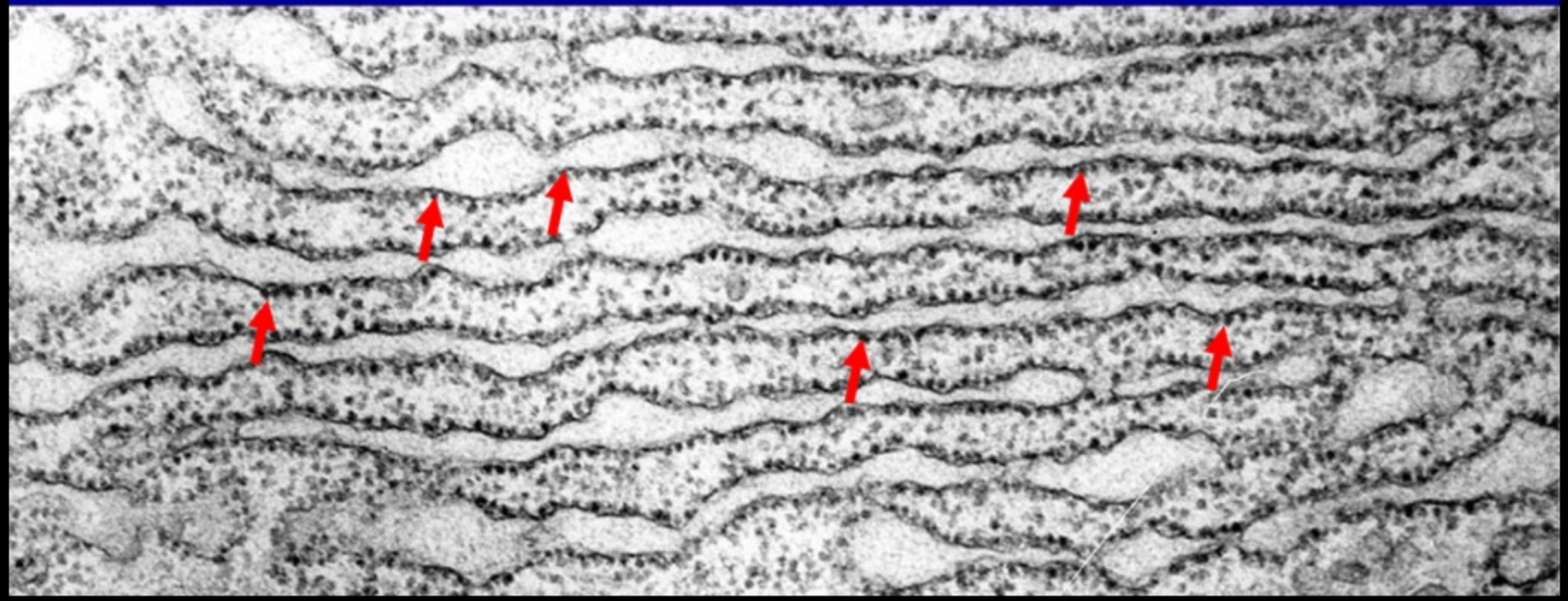
Identify the cell organelle in the picture below. Be specific!



Identify the cell organelle in the picture below. Be specific!

Rough endoplasmic reticulum (rER)

The dark spots marked by the red arrows represent what cell structure?



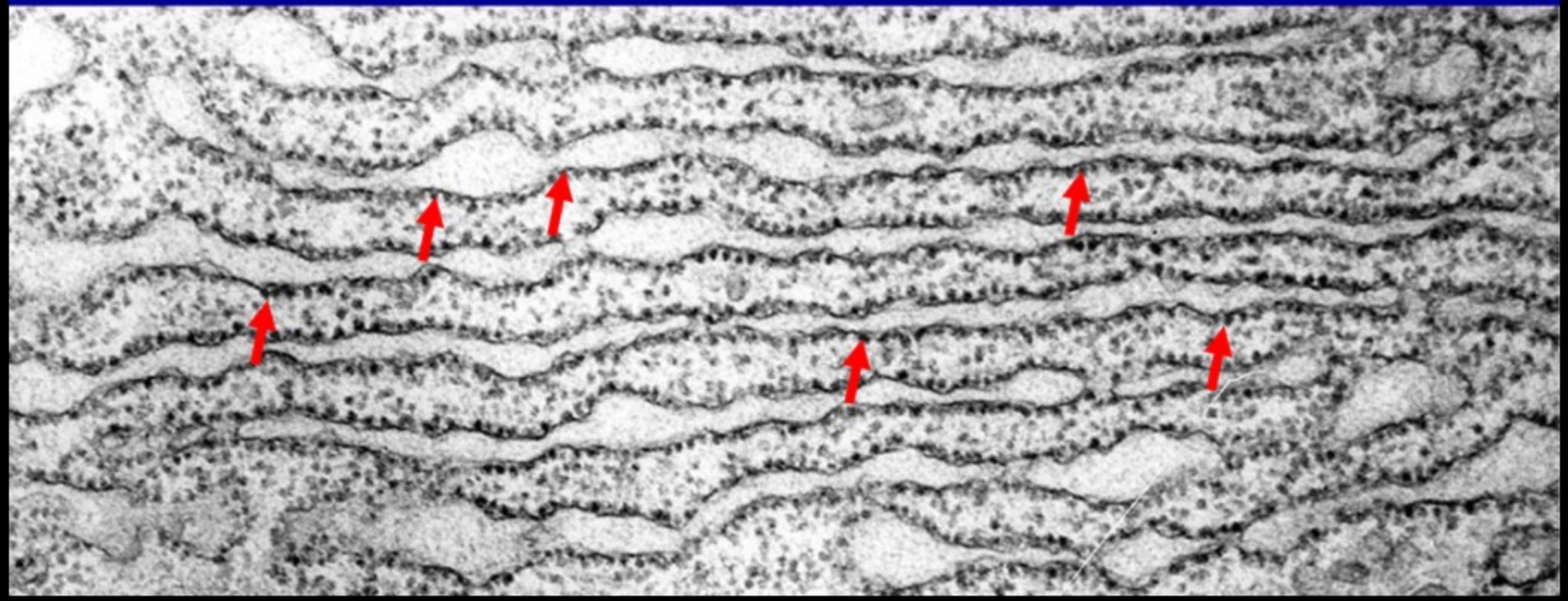
Identify the cell organelle in the picture below. Be specific!

Rough endoplasmic reticulum (rER)

The dark spots marked by the red arrows represent what cell structure?

Membrane-bound ribosomes

Which general types of proteins are synthesized by ribosomes associated with the rER?



Identify the cell organelle in the picture below. Be specific!

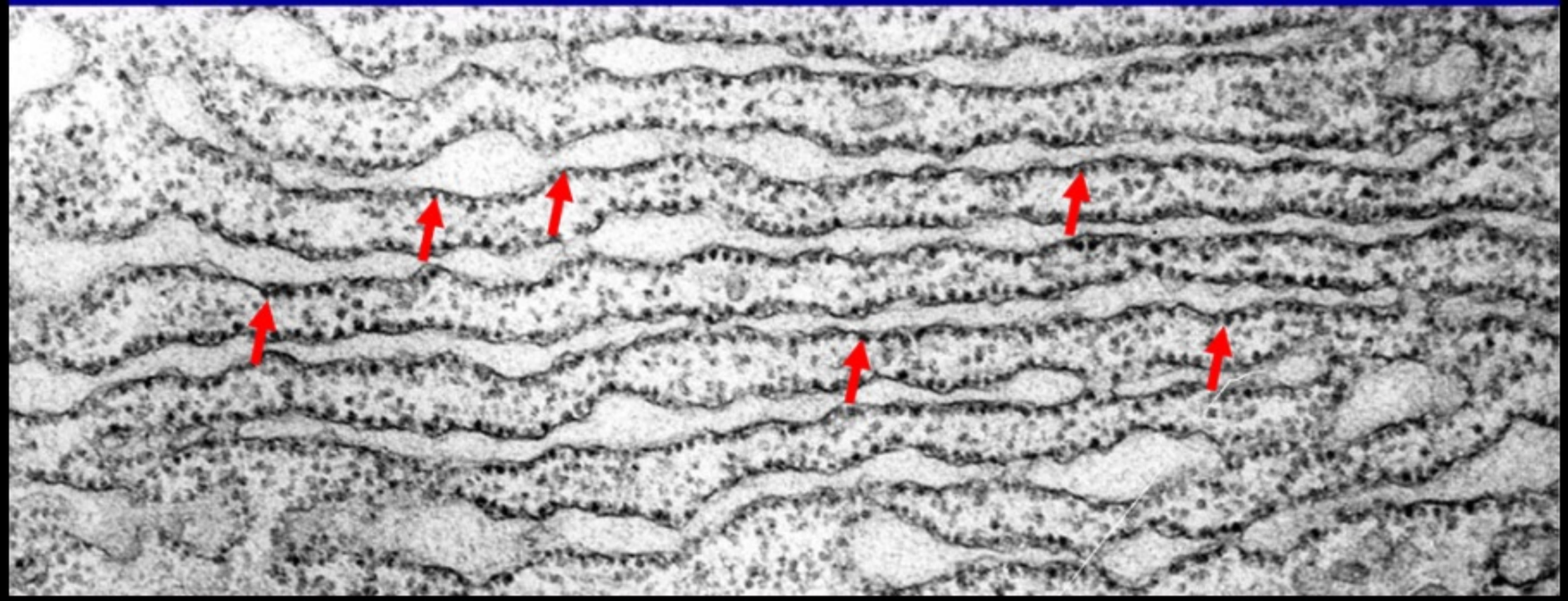
Rough endoplasmic reticulum (rER)

The dark spots marked by the red arrows represent what cell structure?

Membrane-bound ribosomes

Which general types of proteins are synthesized by ribosomes associated with the rER?

Membrane-bound polysomes synthesize secretory proteins, integral membrane proteins, as well as lysosomal proteins.



Shown is a high magnification electron micrograph of a liver cell. Identify the two areas that are marked by the red and blue dashed lines.

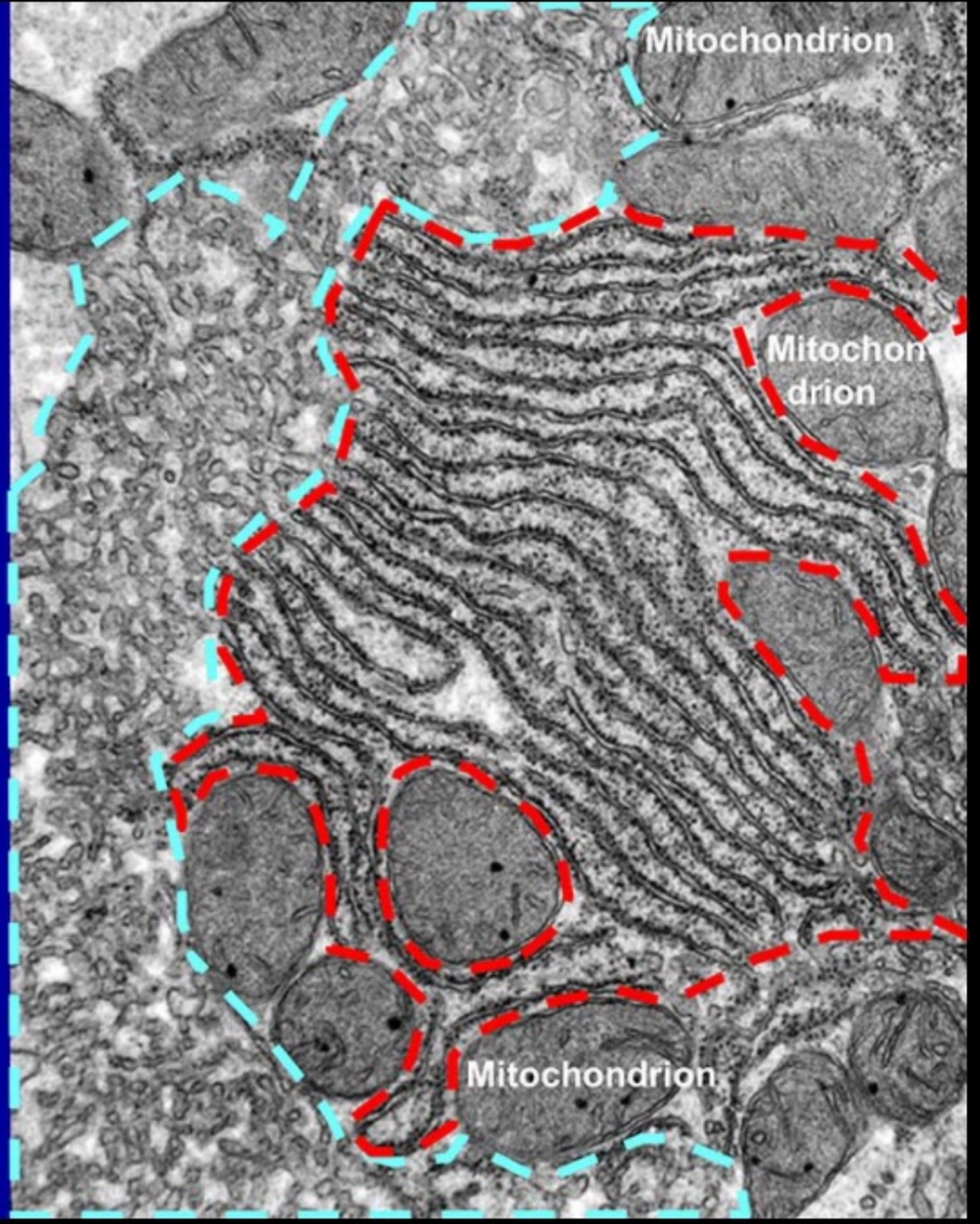


Image courtesy of A.K. Christensen, University of Michigan

Shown is a high magnification electron micrograph of a liver cell. Identify the two areas that are marked by the red and blue dashed lines.

Rough and smooth endoplasmic reticulum

List the most important functions of these two cellular organelles, which constitute a connected membrane system:

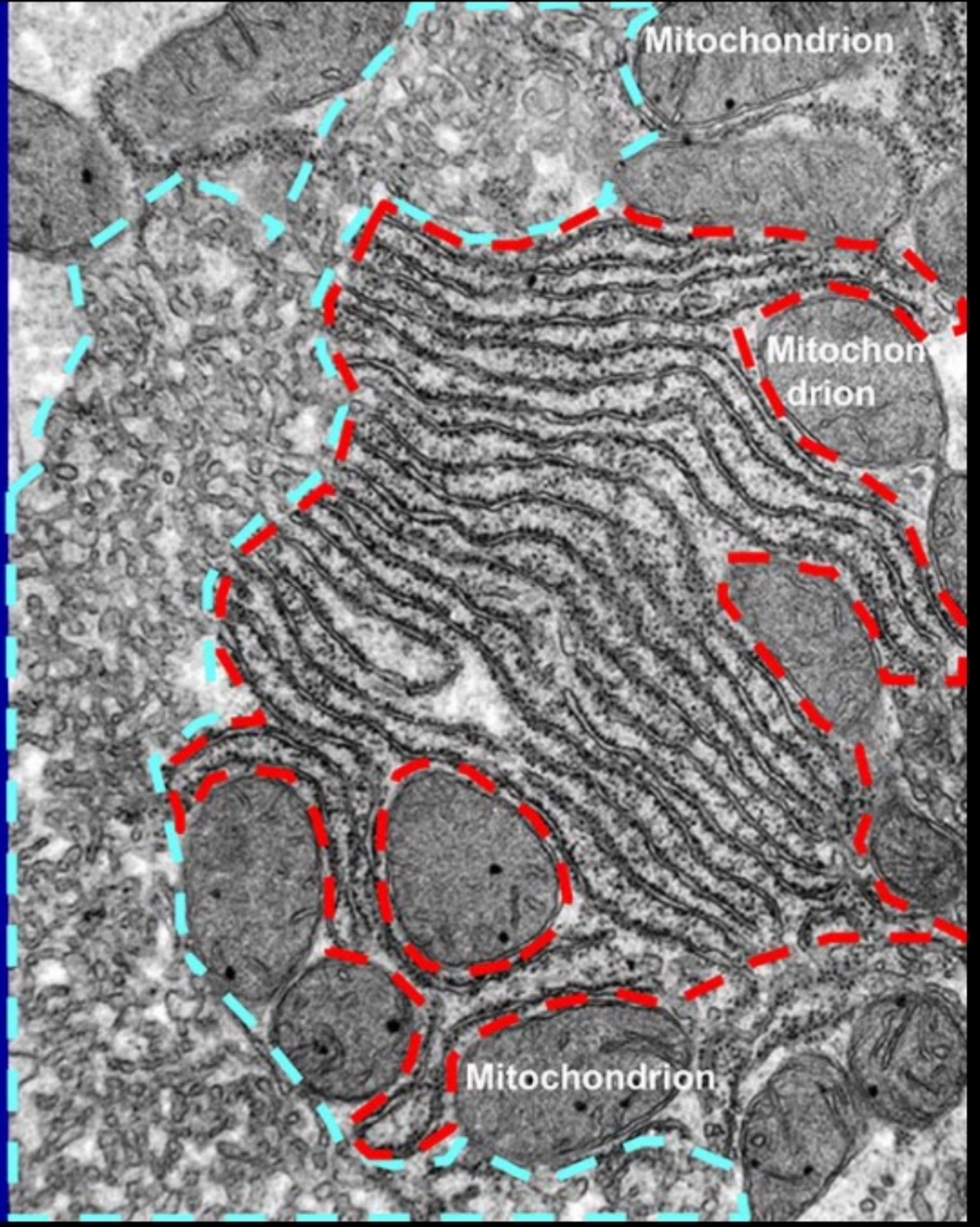


Image courtesy of A.K. Christensen, University of Michigan

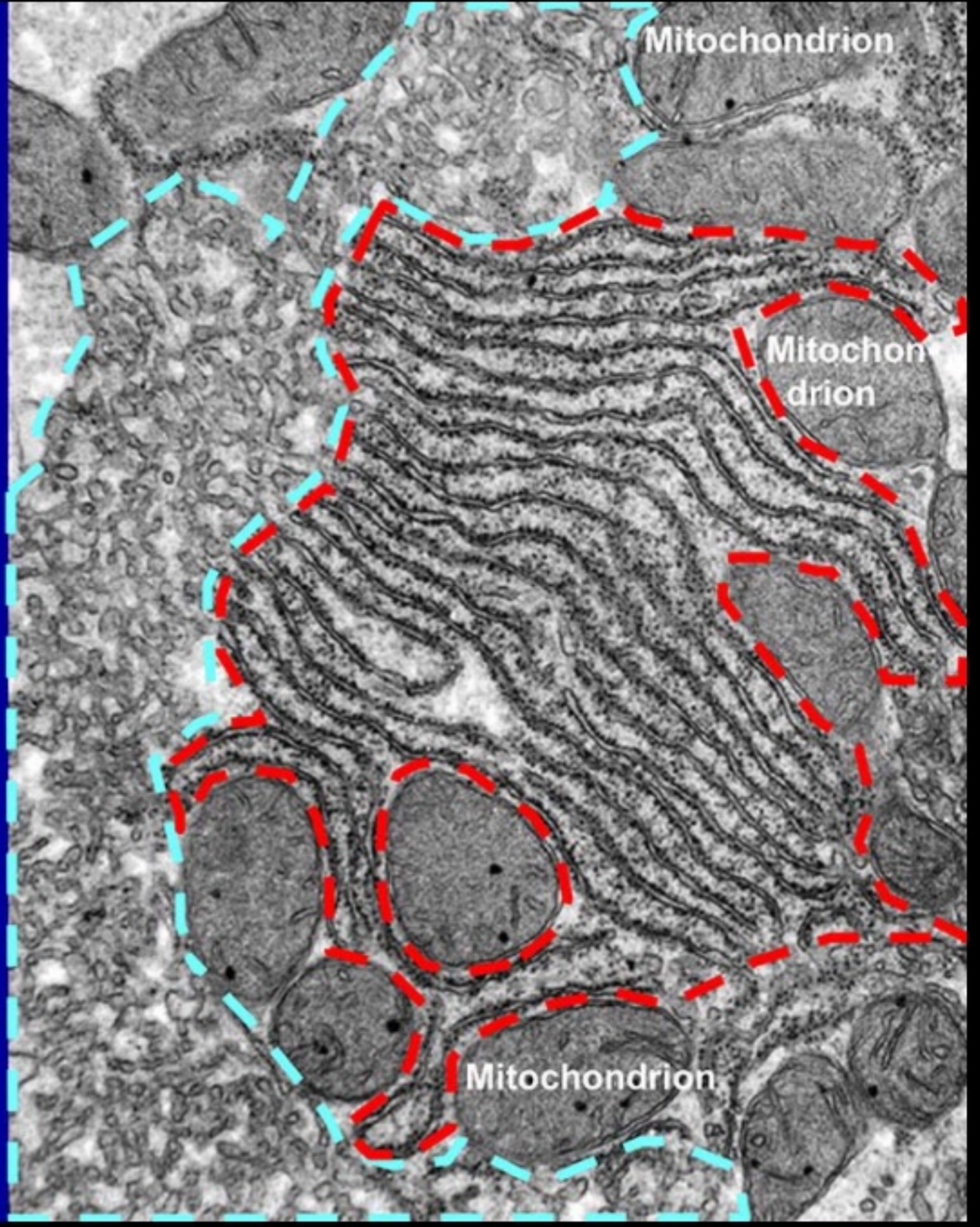
Shown is a high magnification electron micrograph of a liver cell. Identify the two areas that are marked by the red and blue dashed lines.

Rough and smooth endoplasmic reticulum

List the most important functions of these two cellular organelles, which constitute a connected membrane system:

Co-translational insertion or membrane translocation of proteins containing a signal sequence (rER only), N-linked glycosylation (rER only), lipid and steroid metabolism (mainly sER), detoxification processes (mainly sER), Ca^{2+} storage (mainly sER).

Image courtesy of A.K. Christensen, University of Michigan



Identify the cell organelle indicated by the blue dashed line.

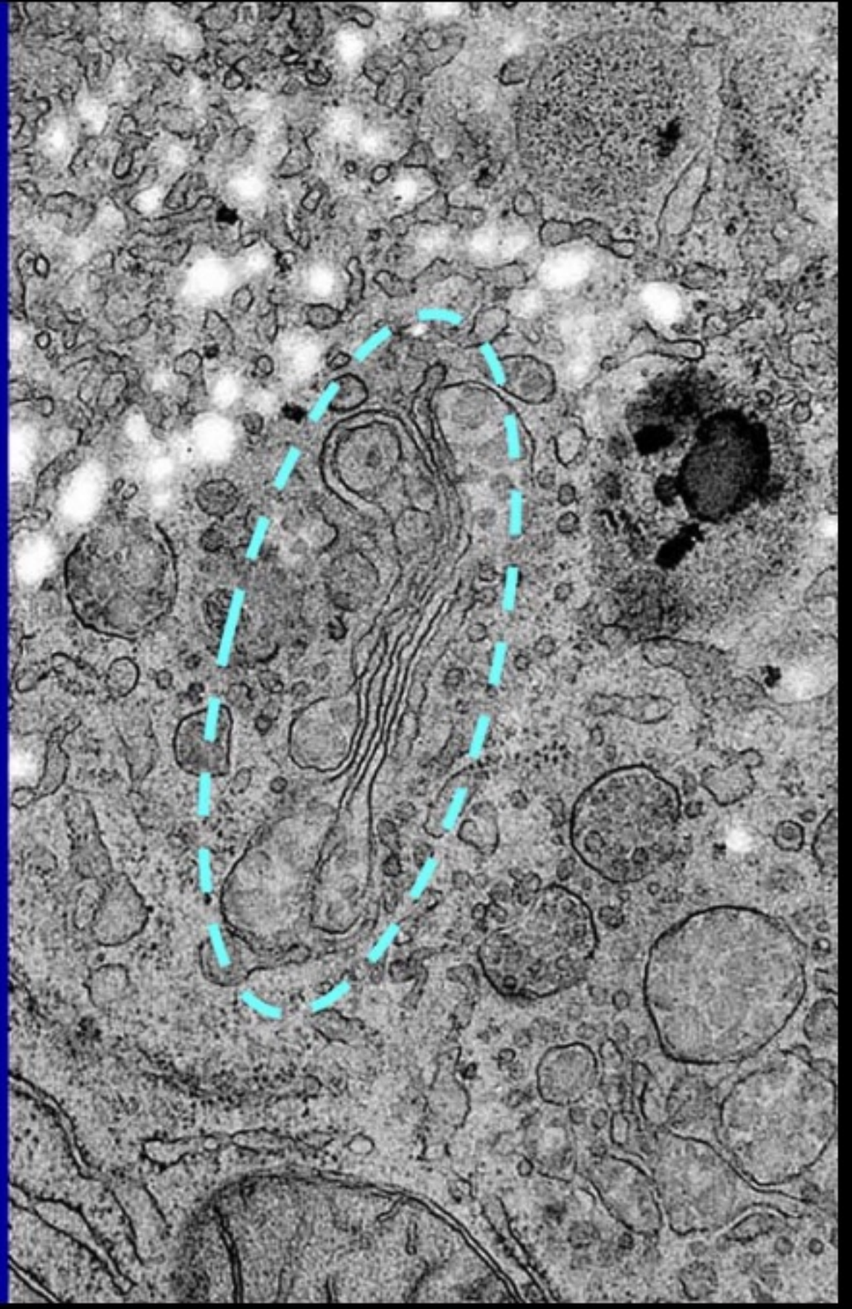


Image courtesy of A.K. Christensen, University of Michigan

Identify the cell organelle indicated by the blue dashed line.

Golgi apparatus or Golgi complex

Outline some major functions of the Golgi complex and processes that reside in this cell organelle.

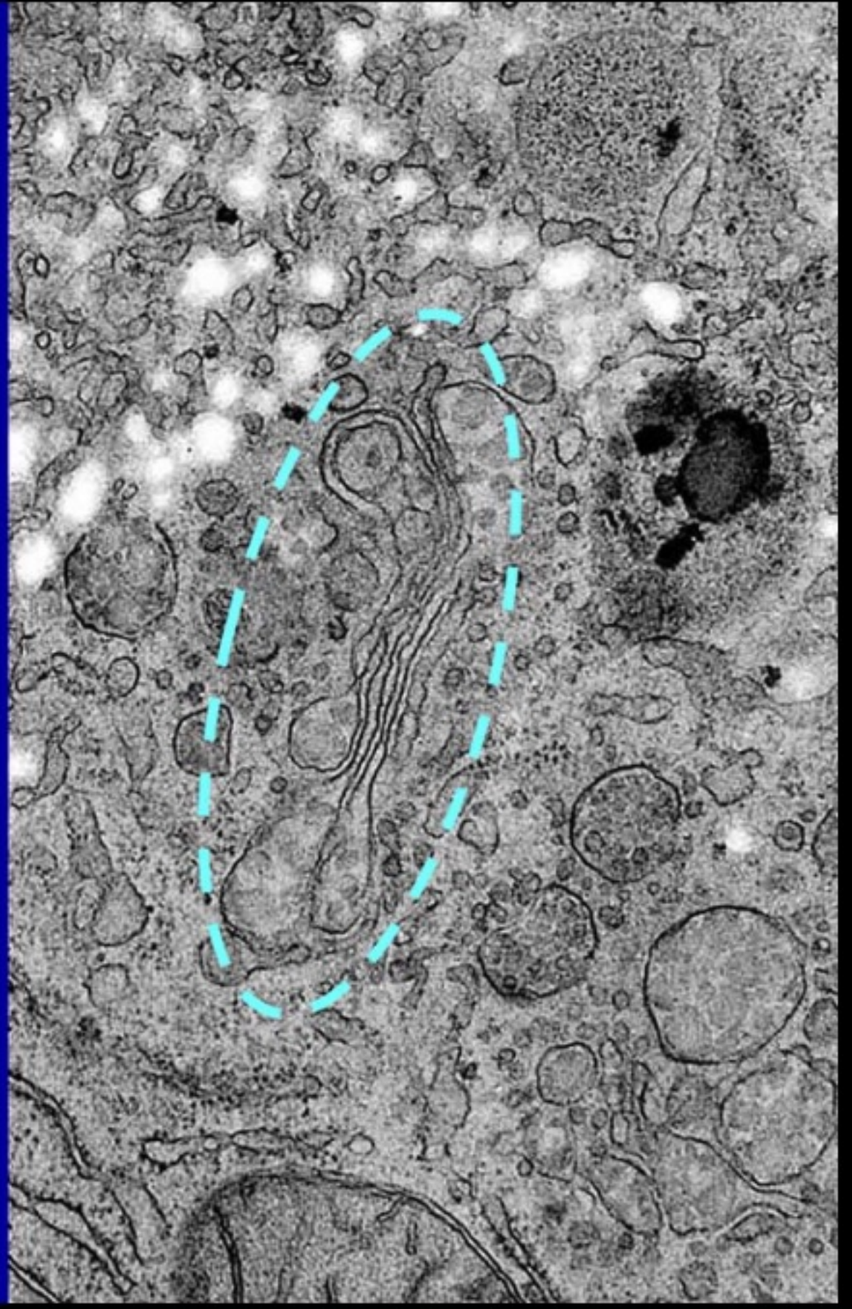


Image courtesy of A.K. Christensen, University of Michigan

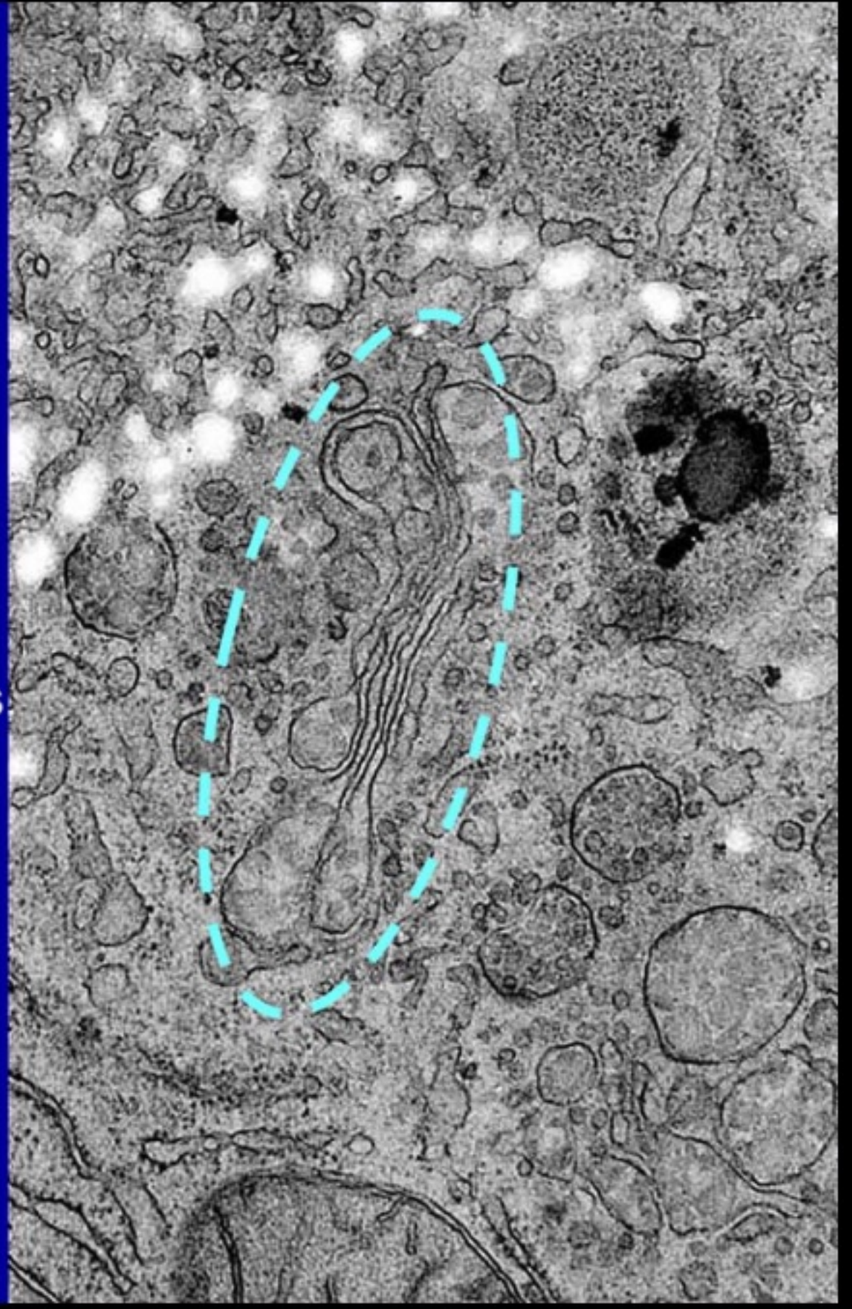
Identify the cell organelle indicated by the blue dashed line.

Golgi apparatus or Golgi complex

Outline some major functions of the Golgi complex and processes that reside in this cell organelle.

O-linked protein glycosylation, modifications of N- and O-linked carbohydrate moieties, protein phosphorylation processes and proteolytic processing of certain proteins

Describe how proteins are transferred between different Golgi membrane stacks.



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Identify the cell organelle indicated by the blue dashed line.

Golgi apparatus or Golgi complex

Outline some major functions of the Golgi complex and processes that reside in this cell organelle.

O-linked protein glycosylation, modifications of N- and O-linked carbohydrate moieties, protein phosphorylation processes and proteolytic processing of certain proteins

Describe how proteins are transferred between different Golgi membrane stacks.

Transport processes from the ER to the cis-Golgi cisterna, between Golgi cisternae and from the trans-Golgi cisterna to the final destination are all based on membranous vesicles.

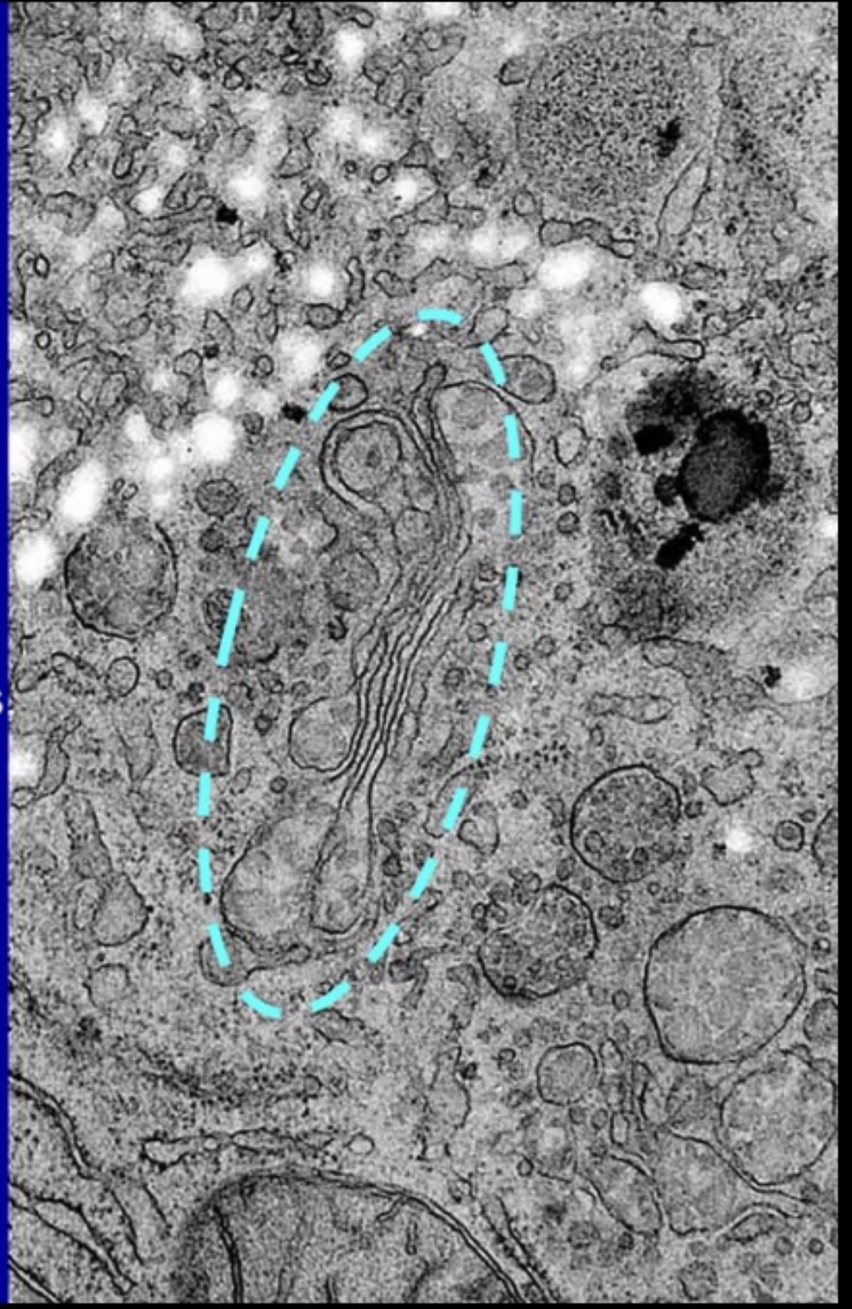
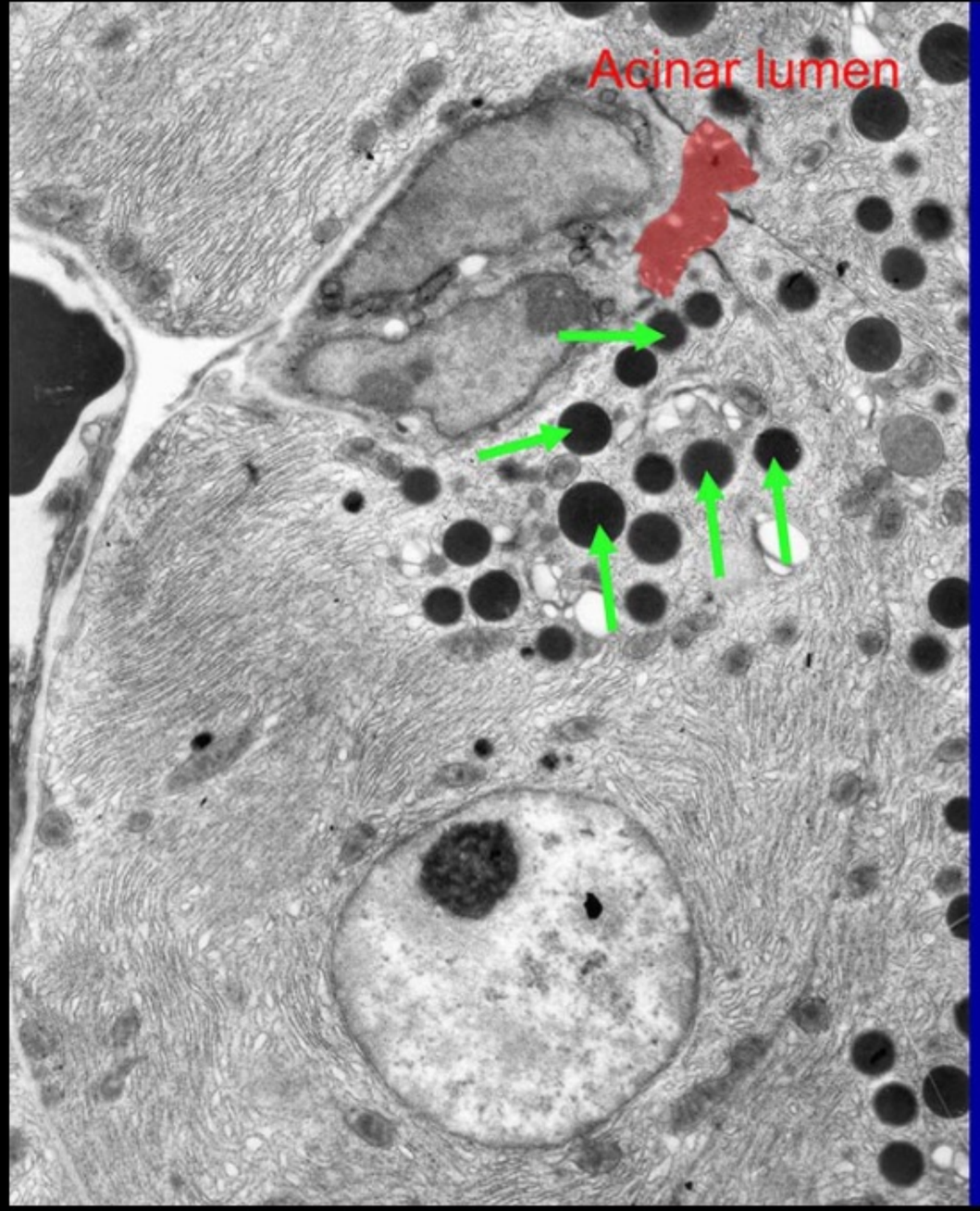
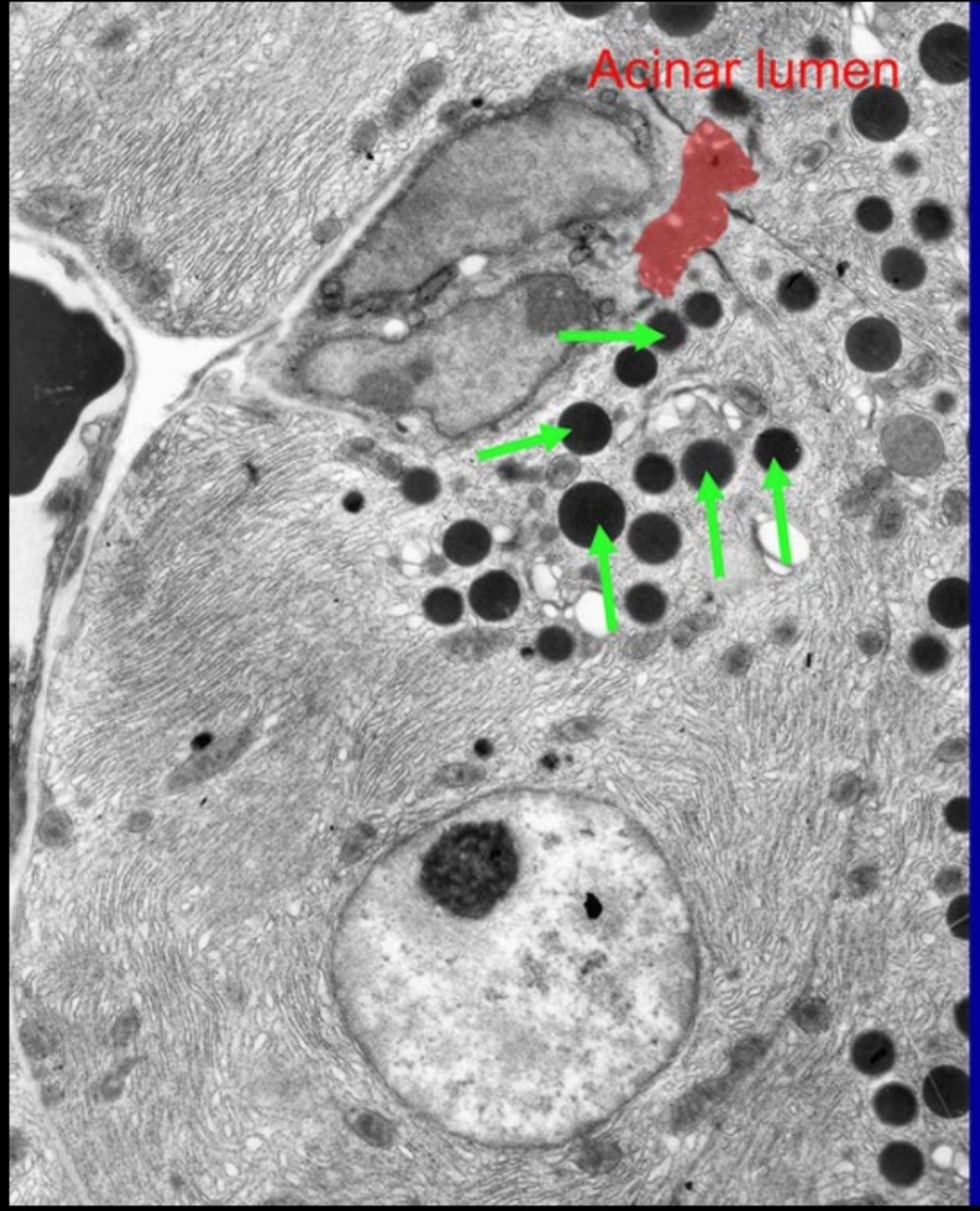


Image courtesy of A.K. Christensen, University of Michigan



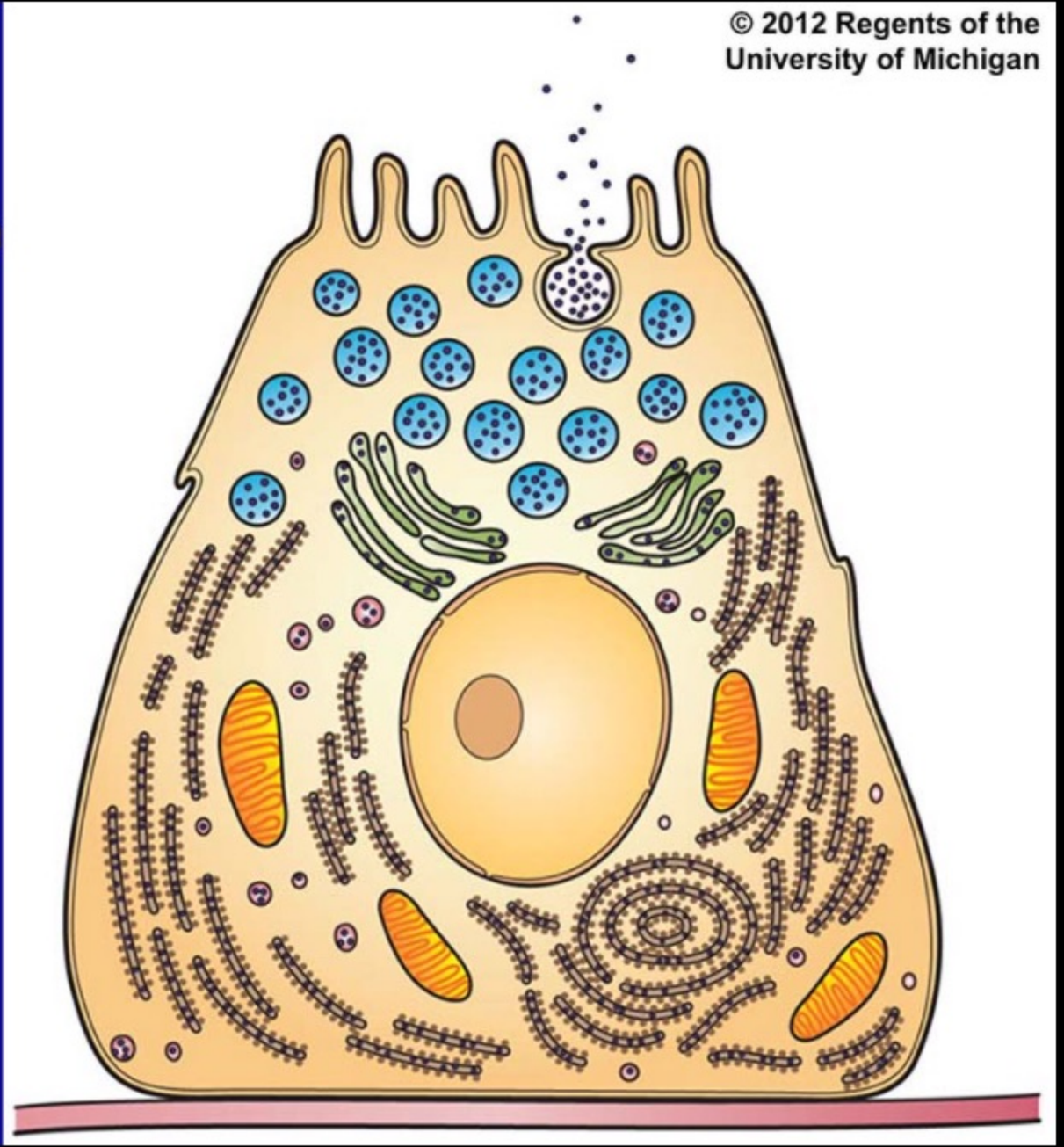
Shown are cells forming a pancreatic secretory acinus. The acinar lumen that receives the secreted proteins is shaded in red. Name the cellular organelles indicated by the green arrows.



Shown are cells forming a pancreatic secretory acinus. The acinar lumen that receives the secreted proteins is shaded in red. Name the cellular organelles indicated by the green arrows.

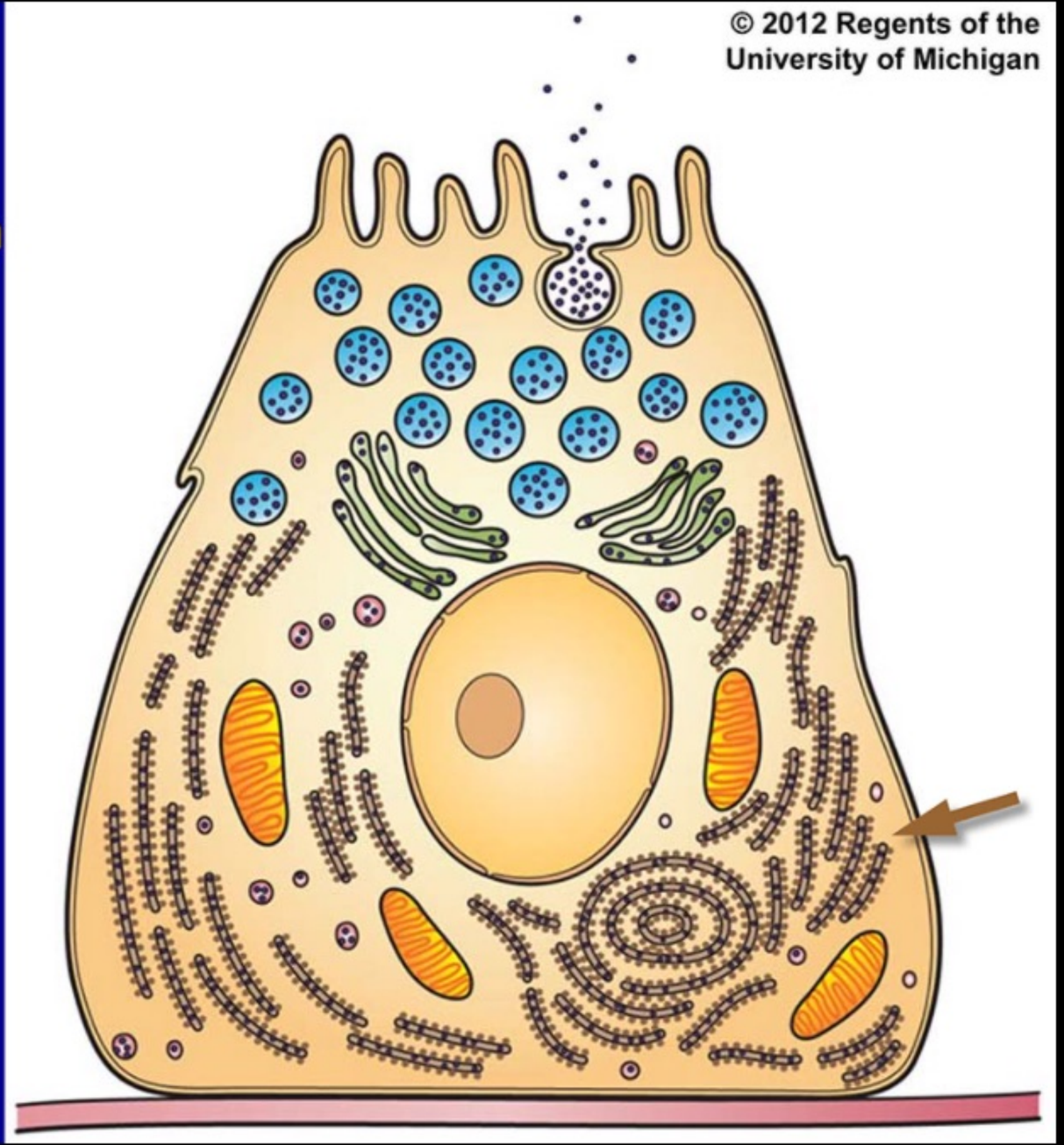
These are secretory vesicles/granules awaiting a trigger to fuse with the apical plasma membrane facing the acinar lumen and to release their protein content of secretory proteins. This process is the final step of the secretory pathway.

Name the major organelles of the secretory pathway in their correct order.



Name the major organelles of the secretory pathway in their correct order.

Rough endoplasmic reticulum



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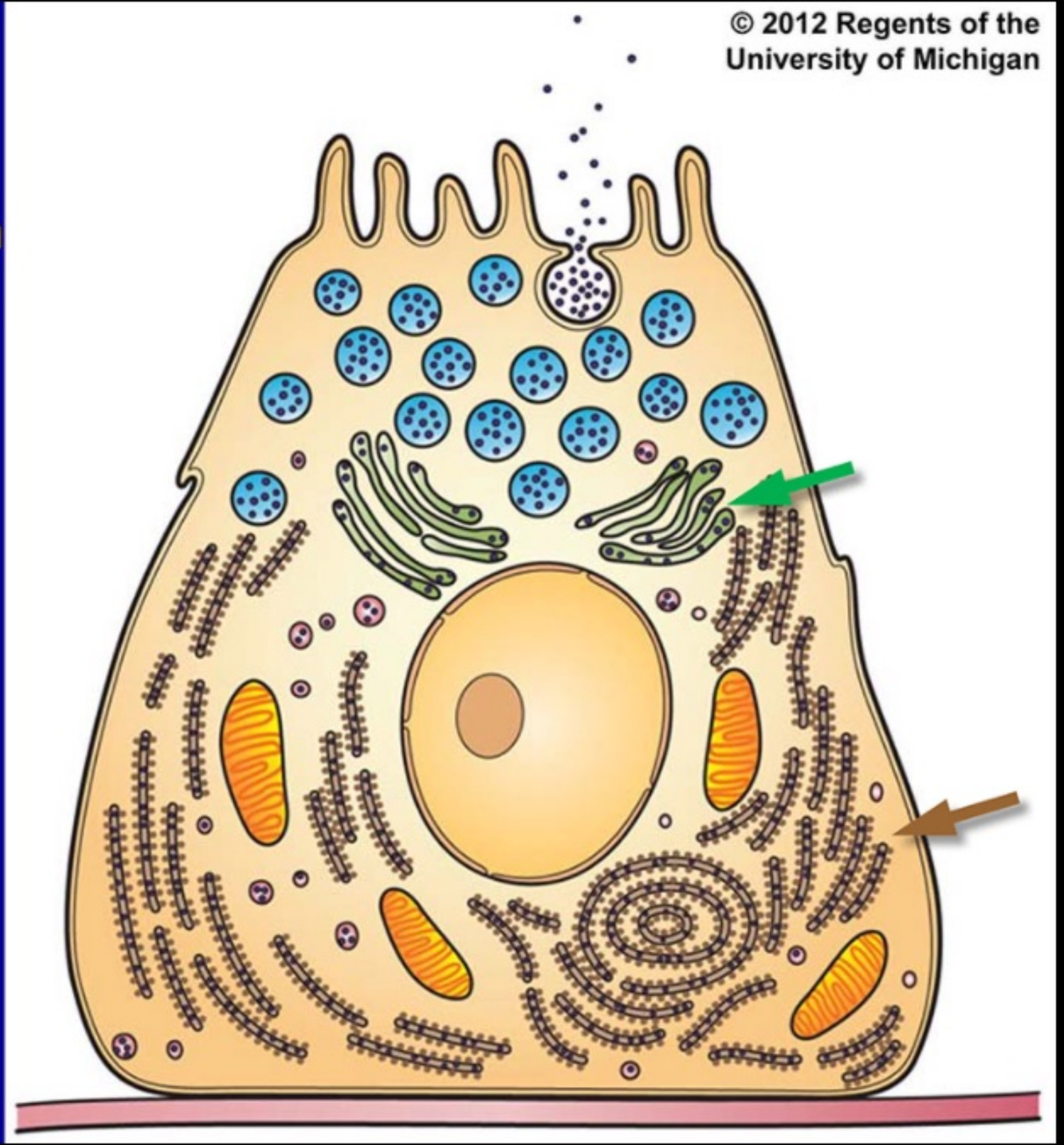
Rough endoplasmic reticulum

Golgi complex

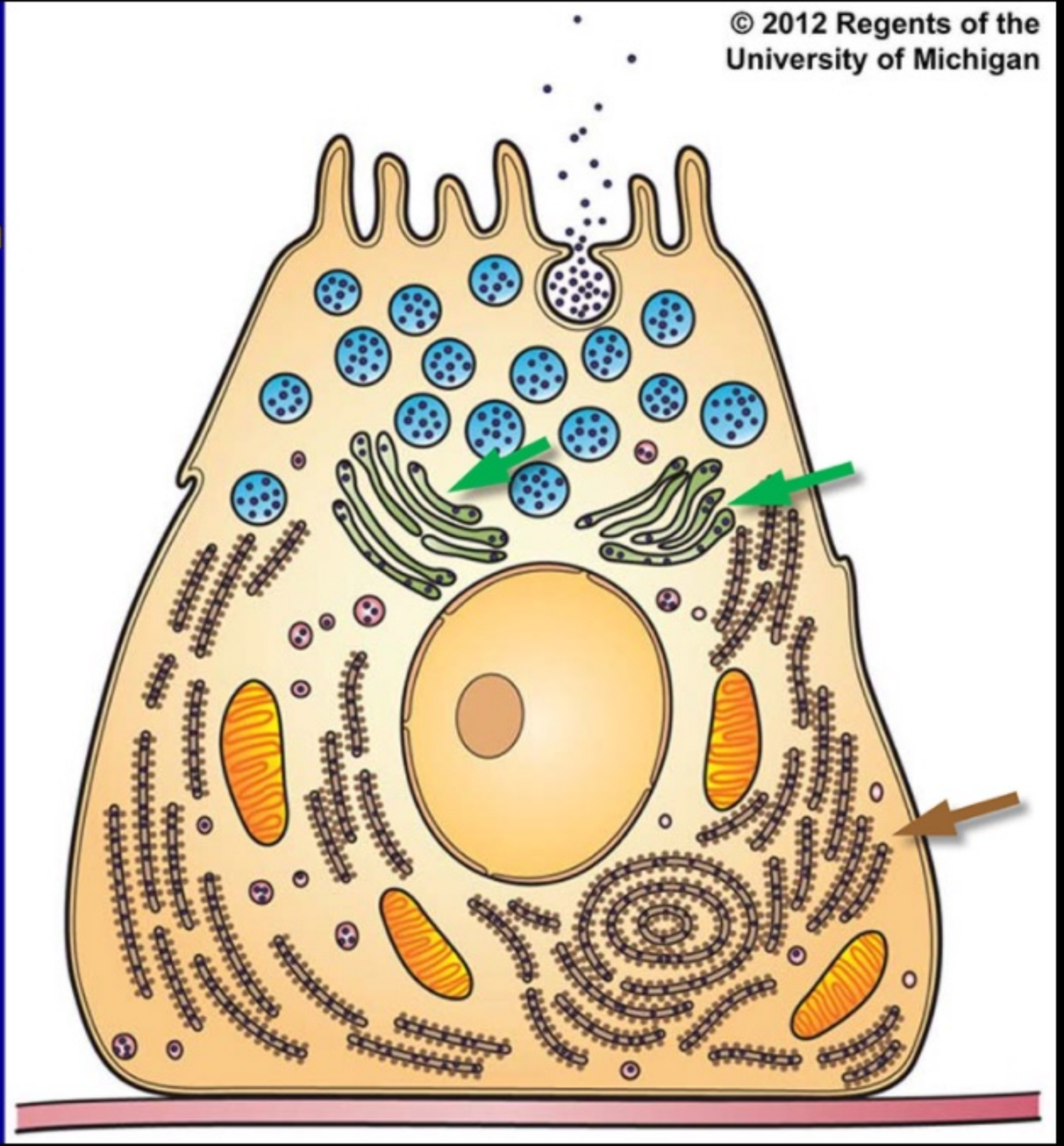


Name the major organelles of the secretory pathway in their correct order.

Rough endoplasmic reticulum

Golgi complex

trans-Golgi network



Name the major organelles of the secretory pathway in their correct order.

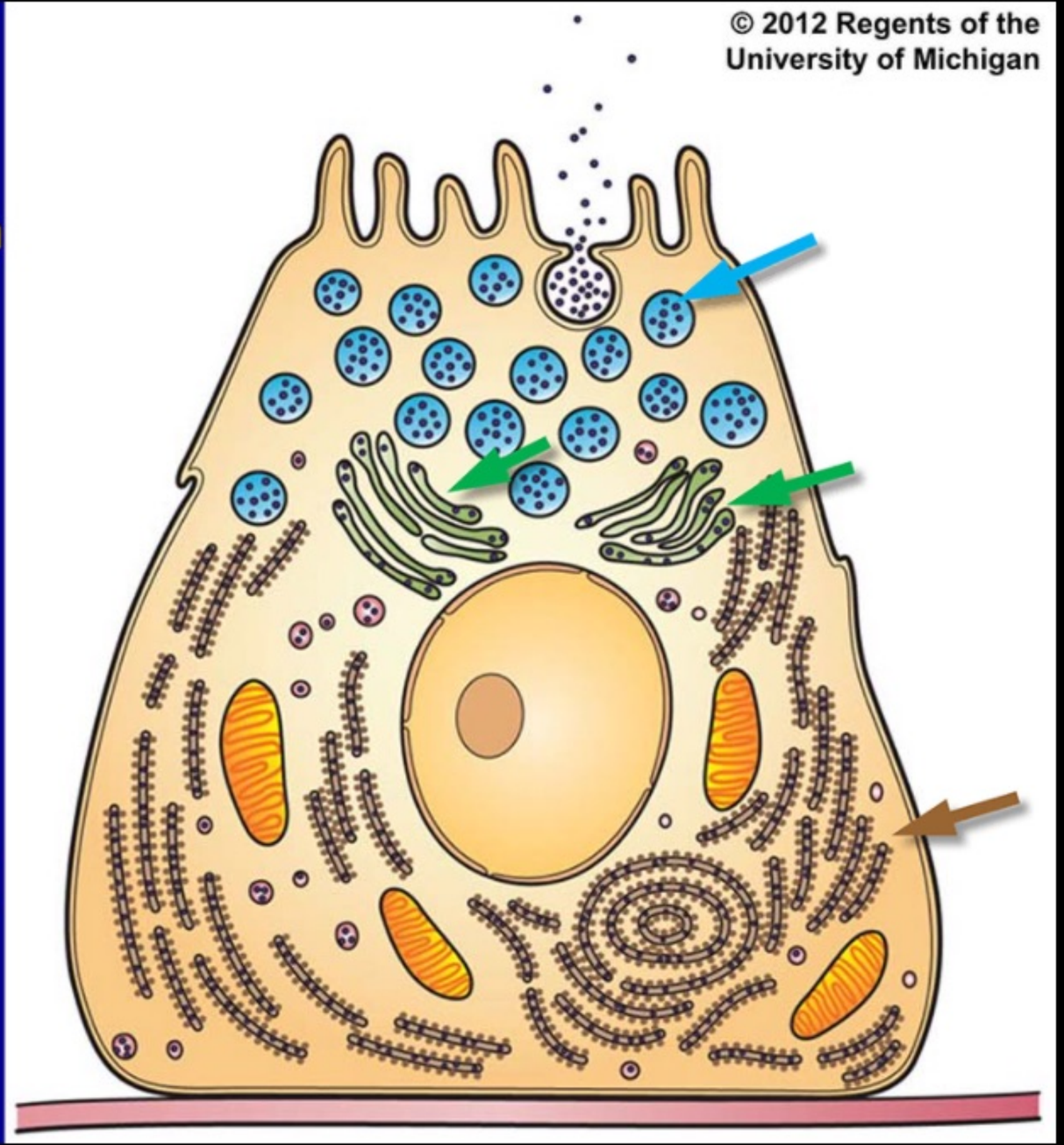
Rough endoplasmic reticulum

Golgi complex

trans-Golgi network

Secretory vesicles

How do secretory proteins pass between these cell organelles?



Name the major organelles of the secretory pathway in their correct order.

Rough endoplasmic reticulum

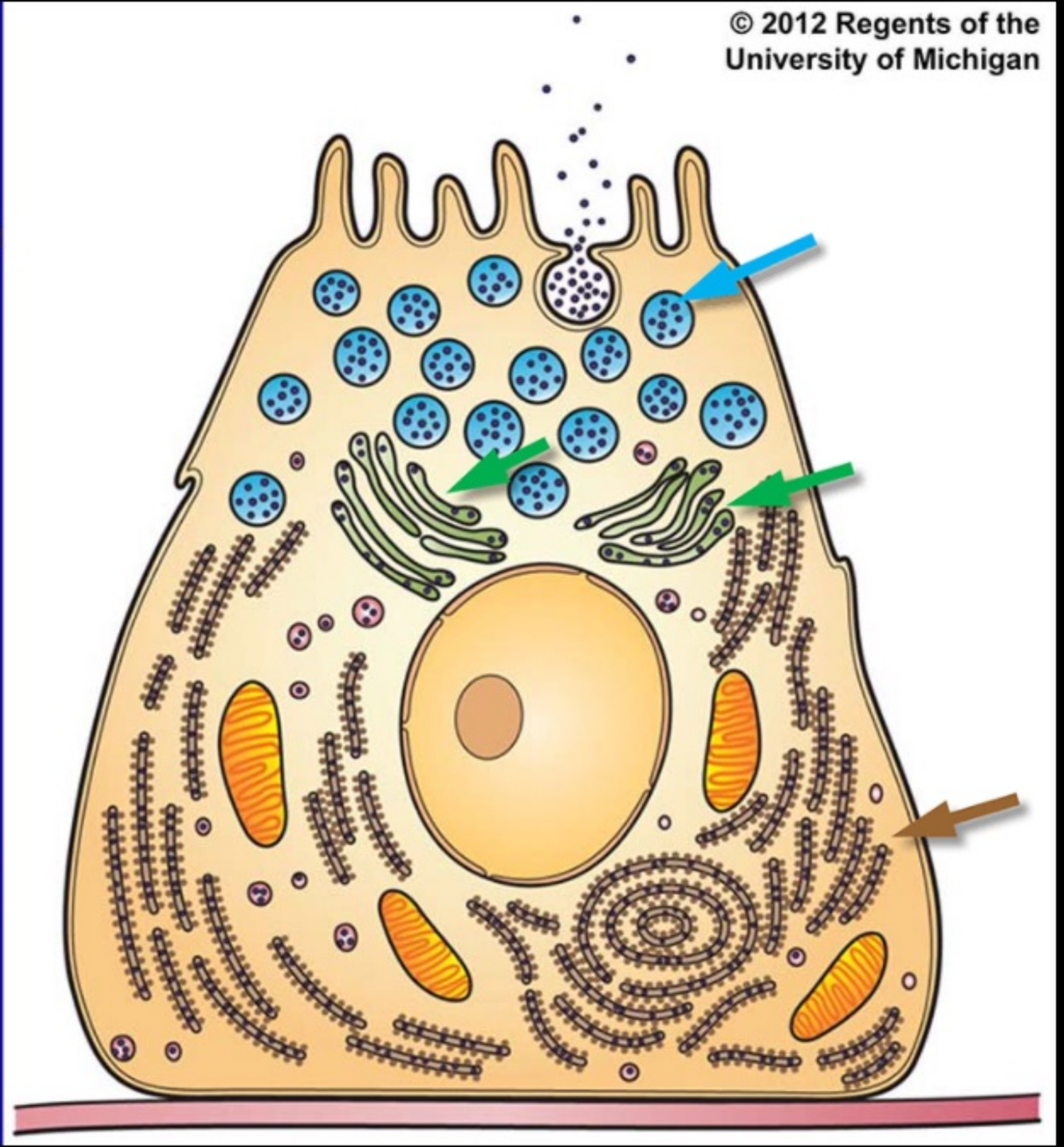
Golgi complex

trans-Golgi network

Secretory vesicles

How do secretory proteins pass between these cell organelles?

By vesicular transport



Identify the cell organelle that is occupying most the electron micrograph on the right.

Identify the cell organelle that is occupying most the electron micrograph on the right. Mitochondrion

List the most important functions and processes associated with mitochondria:

Identify the cell organelle that is occupying most the electron micrograph on the right. Mitochondrion

List the most important functions and processes associated with mitochondria:

ATP synthesis, oxidative phosphorylation, Krebs cycle and fatty-acid oxidation.

How many different membranes are found in a mitochondrion?

Identify the cell organelle that is occupying most the electron micrograph on the right. Mitochondrion

List the most important functions and processes associated with mitochondria:

ATP synthesis, oxidative phosphorylation, Krebs cycle and fatty-acid oxidation.

How many different membranes are found in a mitochondrion?

Two separate lipid bilayers

Which membrane is the place of ATP synthesis?

Identify the cell organelle that is occupying most the electron micrograph on the right. Mitochondrion

List the most important functions and processes associated with mitochondria:

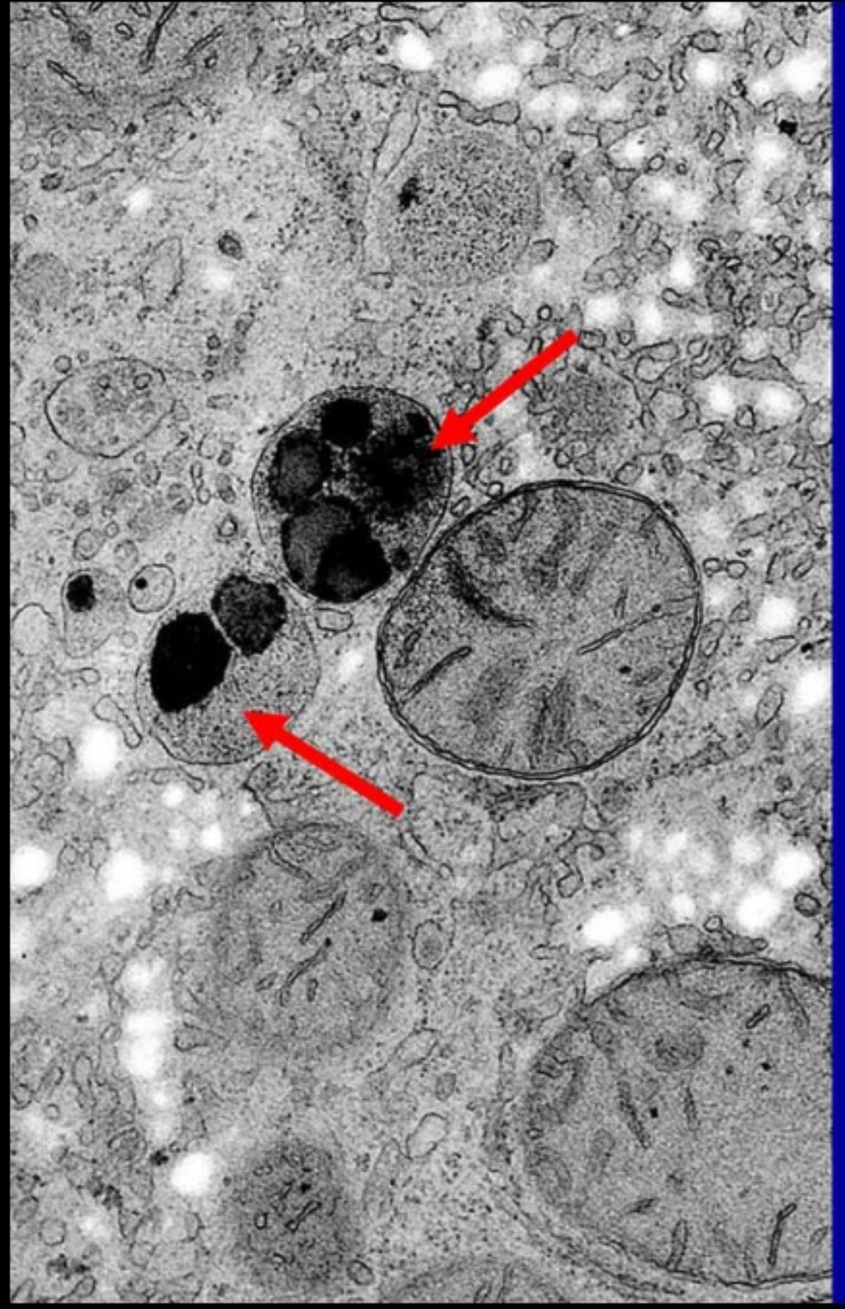
ATP synthesis, oxidative phosphorylation, Krebs cycle and fatty-acid oxidation.

How many different membranes are found in a mitochondrion?

Two separate lipid bilayers

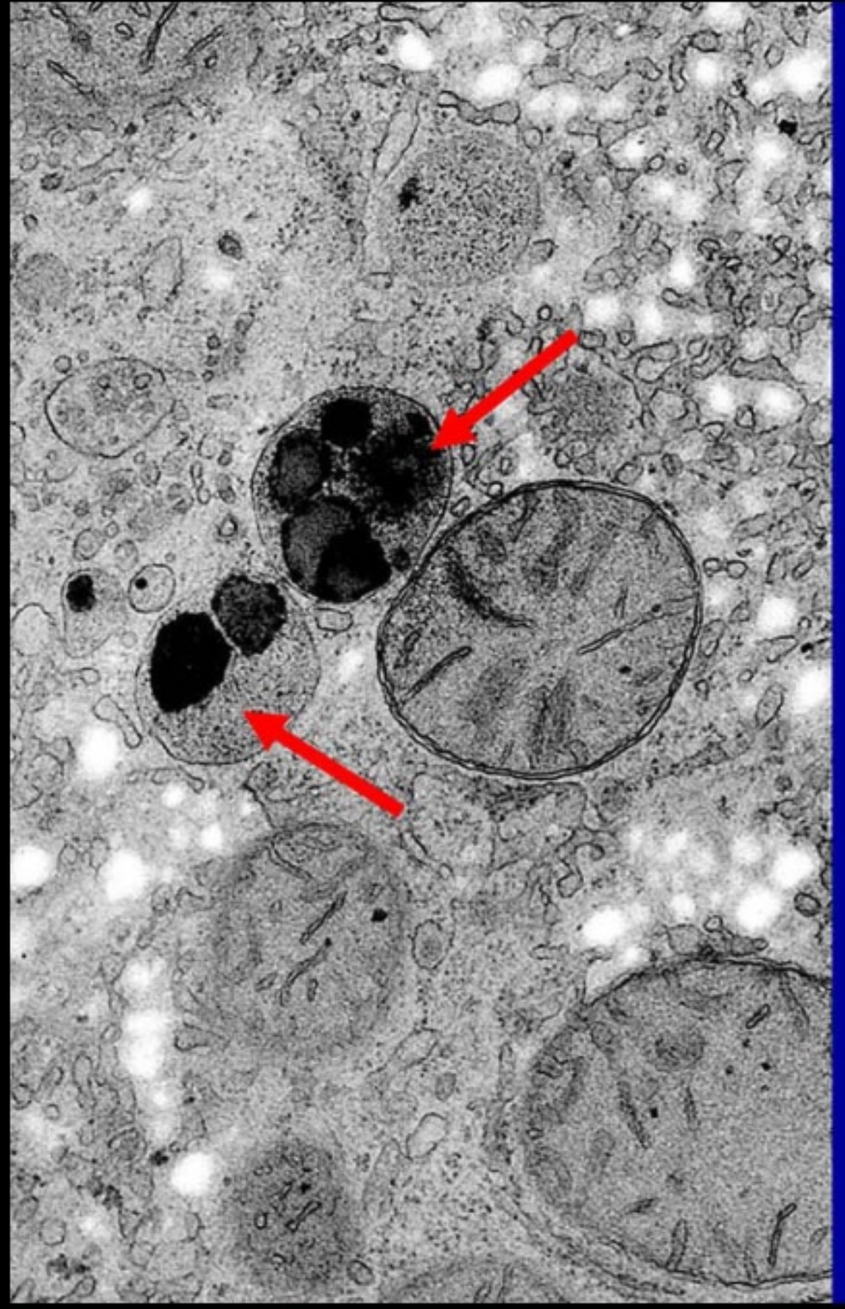
Which membrane is the place of ATP synthesis?

The inner membrane contains ATP Synthetase complexes and is the location of ATP synthesis.



Identify the membranous cell organelle that is marked by the red arrows and which participates in the degradation of macromolecules.

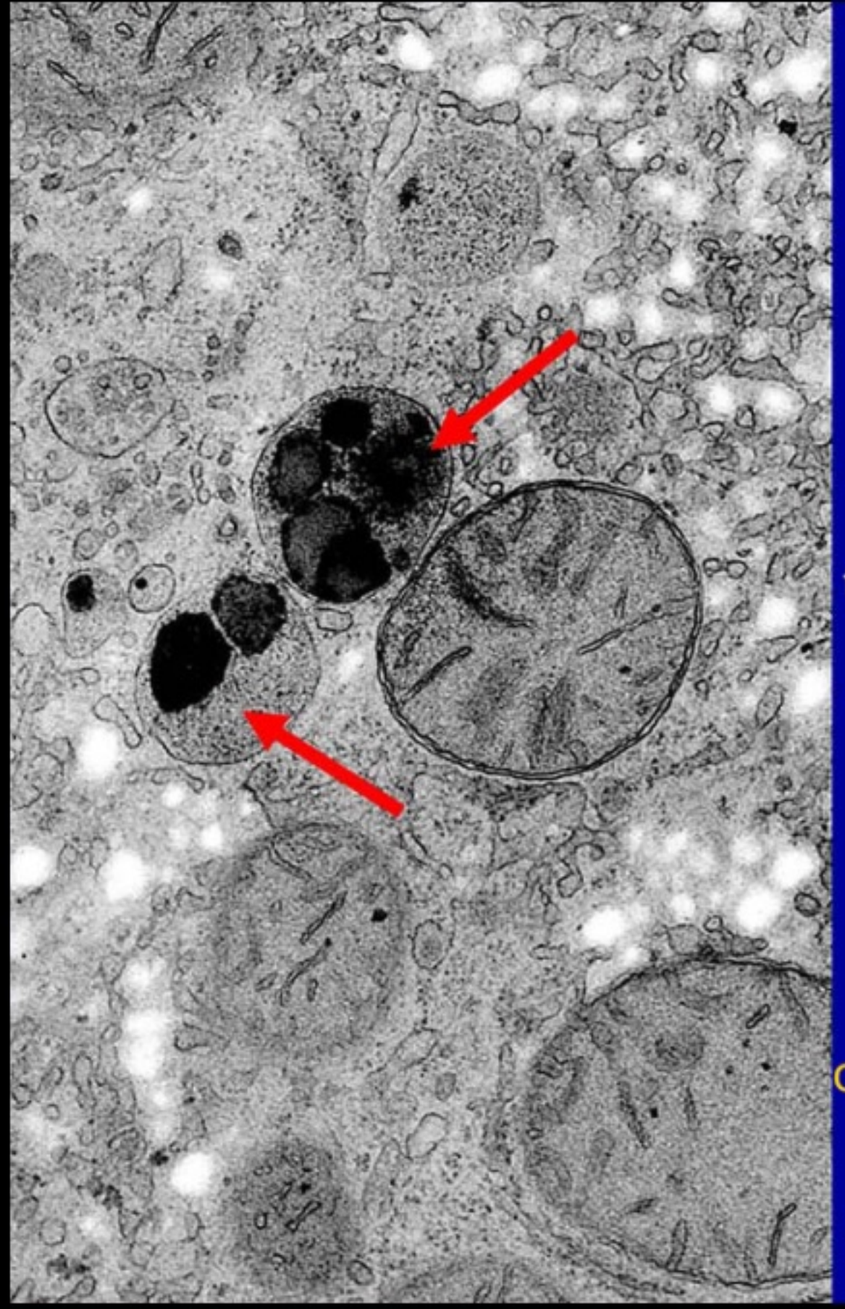
Image courtesy of A.K. Christensen, University of Michigan



Identify the membranous cell organelle that is marked by the red arrows and which participates in the degradation of macromolecules. Lysosomes

Name processes that deliver material to the lysosomal compartment.

Image courtesy of A.K. Christensen, University of Michigan



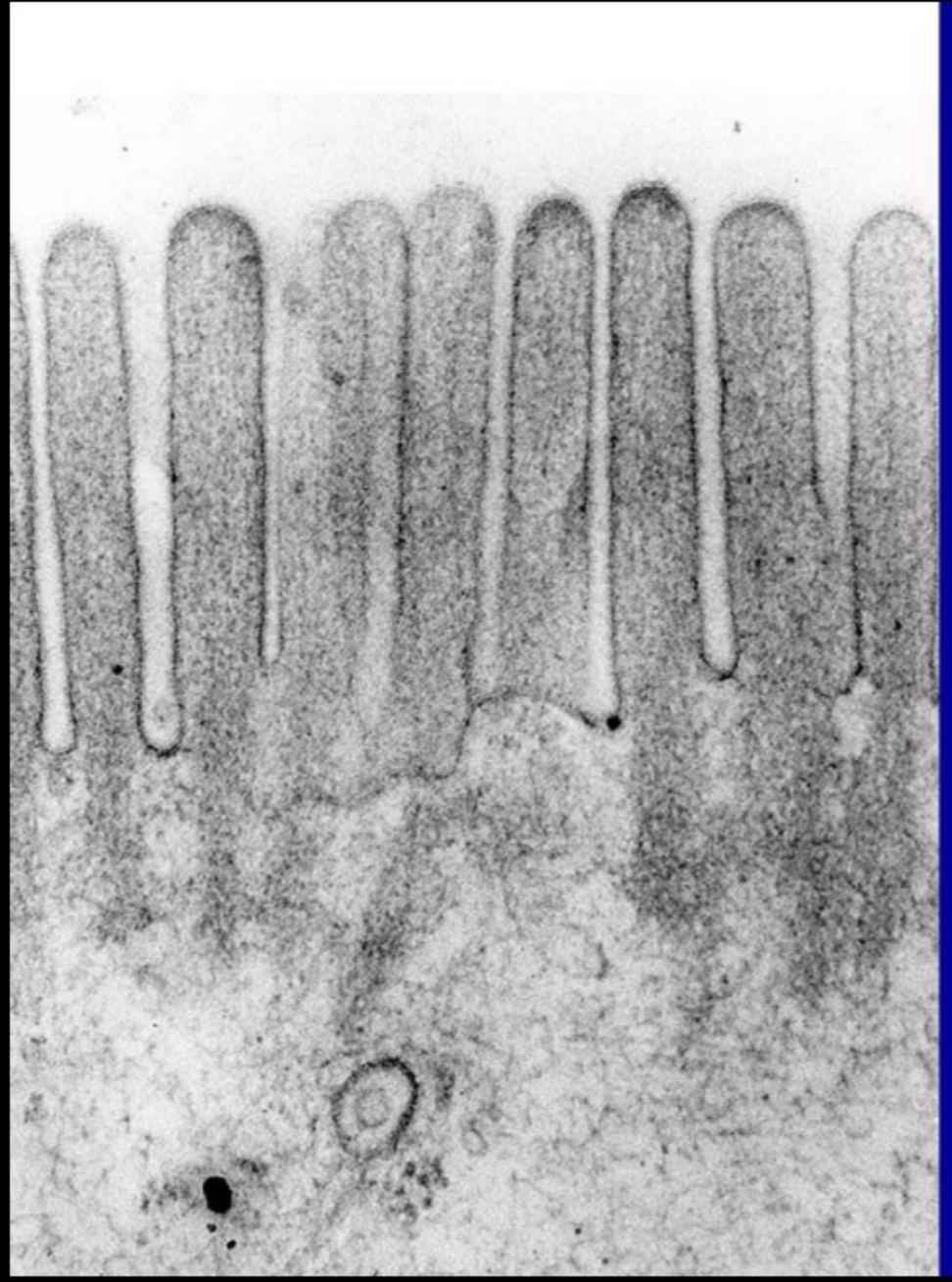
Identify the membranous cell organelle that is marked by the red arrows and which participates in the degradation of macromolecules. Lysosomes

Name processes that deliver material to the lysosomal compartment.

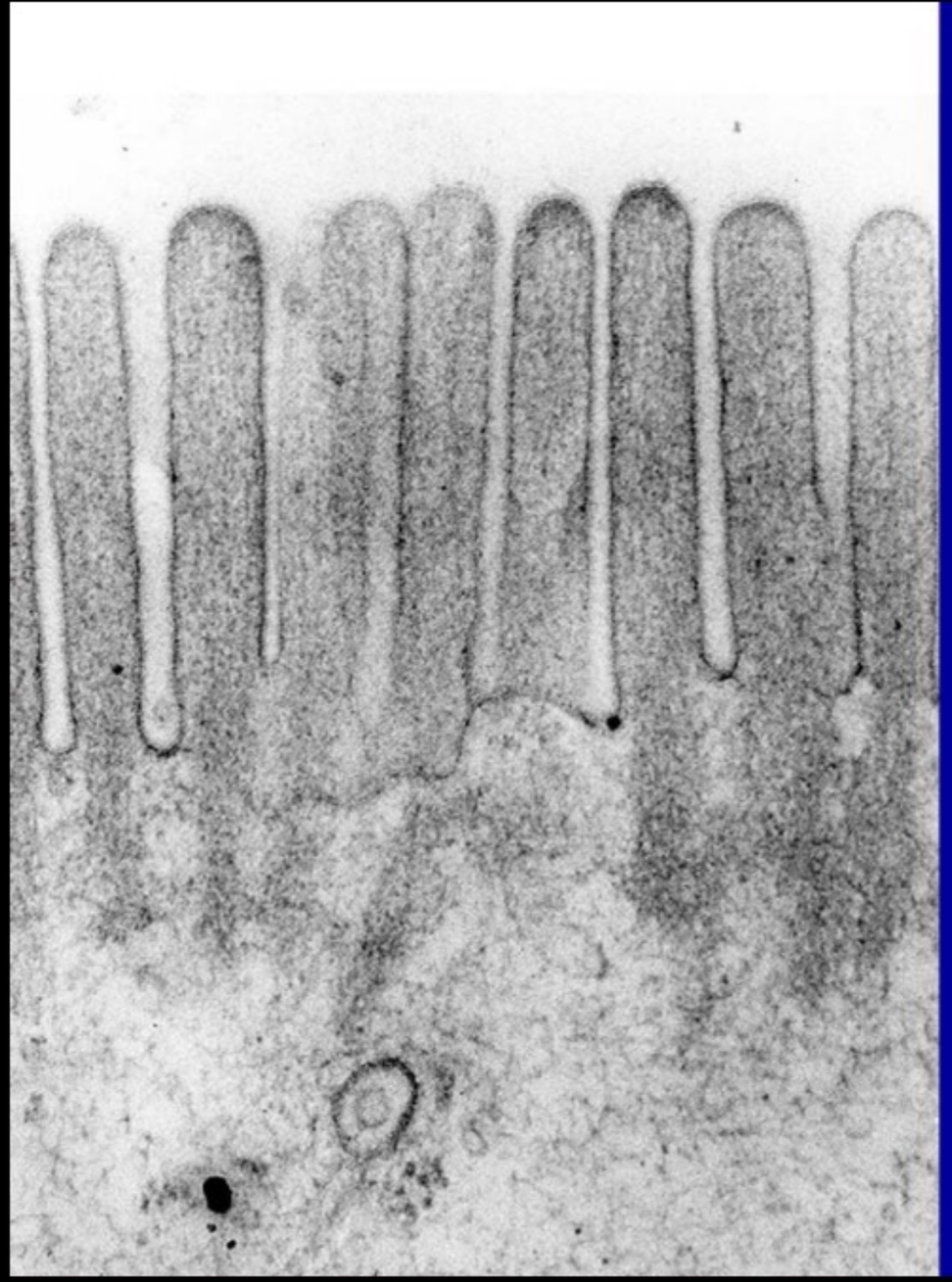
Most lysosomal proteins carry a mannose-6-phosphate signal and are delivered via the trans-Golgi network. Extracellular large particles are delivered by phagocytosis, small extracellular particles by endocytosis and intracellular particles by autophagy.

Name a second, non-membranous structure in the cytoplasm that is also involved in protein degradation and name the signal that marks proteins destined to be degraded by this pathway.

Image courtesy of A.K. Christensen, University of Michigan



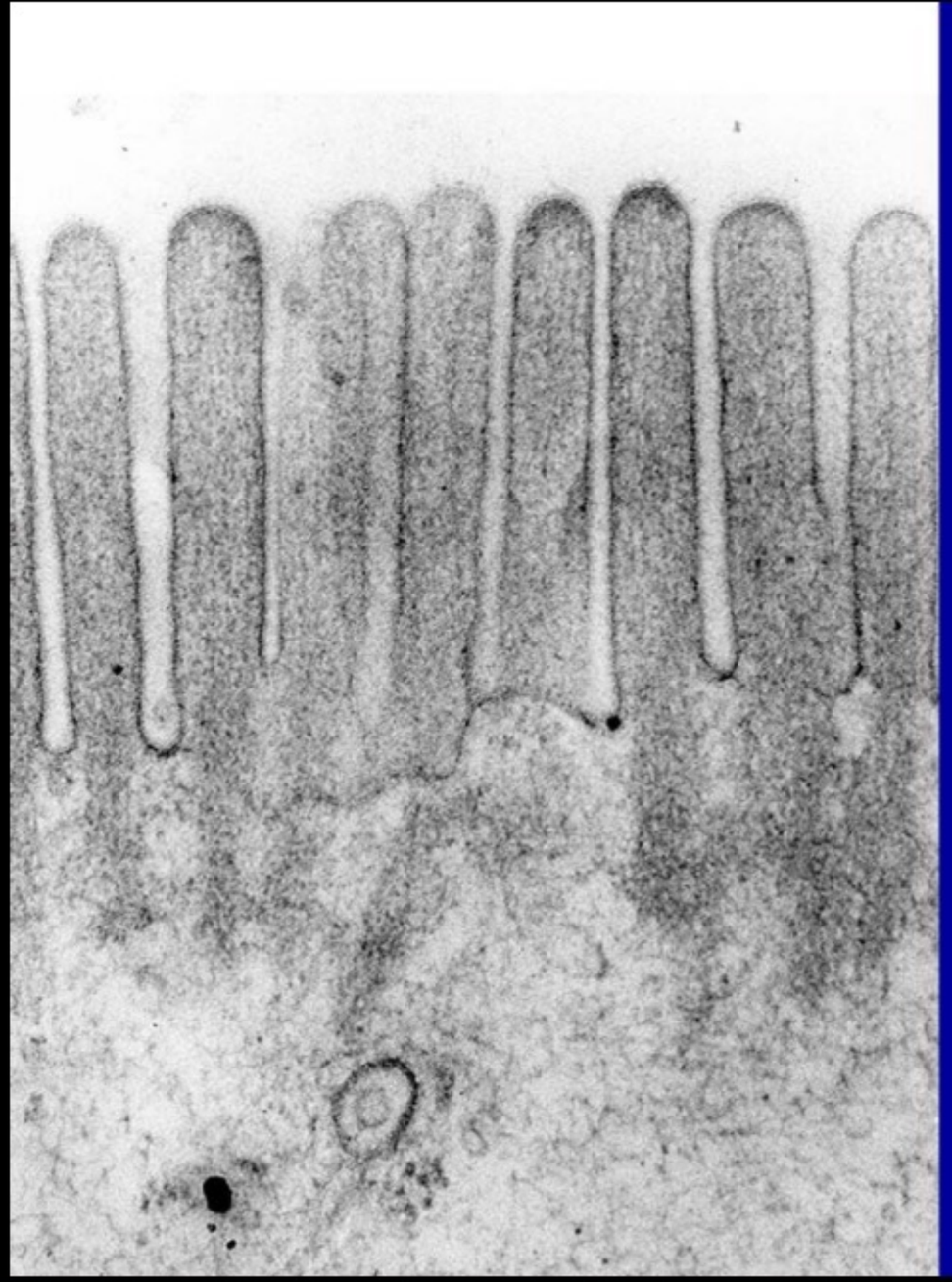
Identify these cellular structures and and name the epithelial cell surface at which they are usually found.



Identify these cellular structures and and name the epithelial cell surface at which they are usually found.

Microvilli are usually found on the apical surface of many epithelial cells.

What is the general function of microvilli?



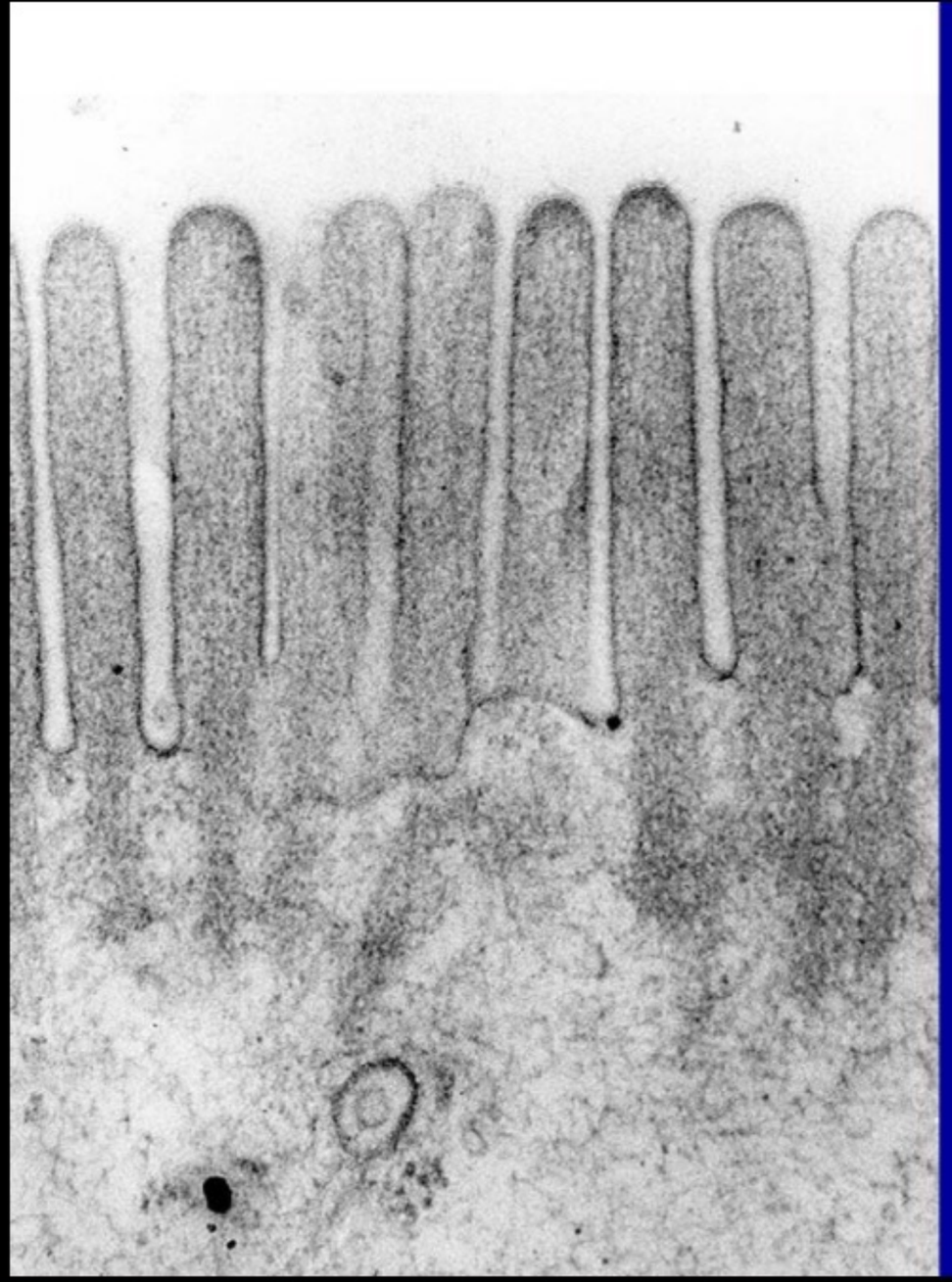
Identify these cellular structures and and name the epithelial cell surface at which they are usually found.

Microvilli are usually found on the apical surface of many epithelial cells.

What is the general function of microvilli?

Microvilli increase the surface area and thereby support epithelial transport processes.

Name the cytoskeletal element that is present in microvilli.



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What is the general function of microvilli?

Microvilli increase the surface area and thereby support epithelial transport processes.

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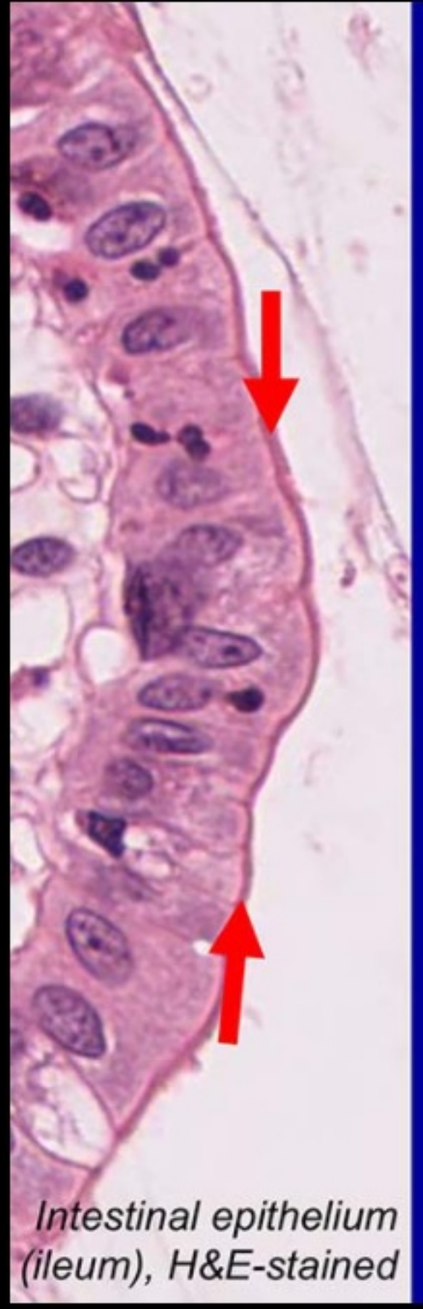
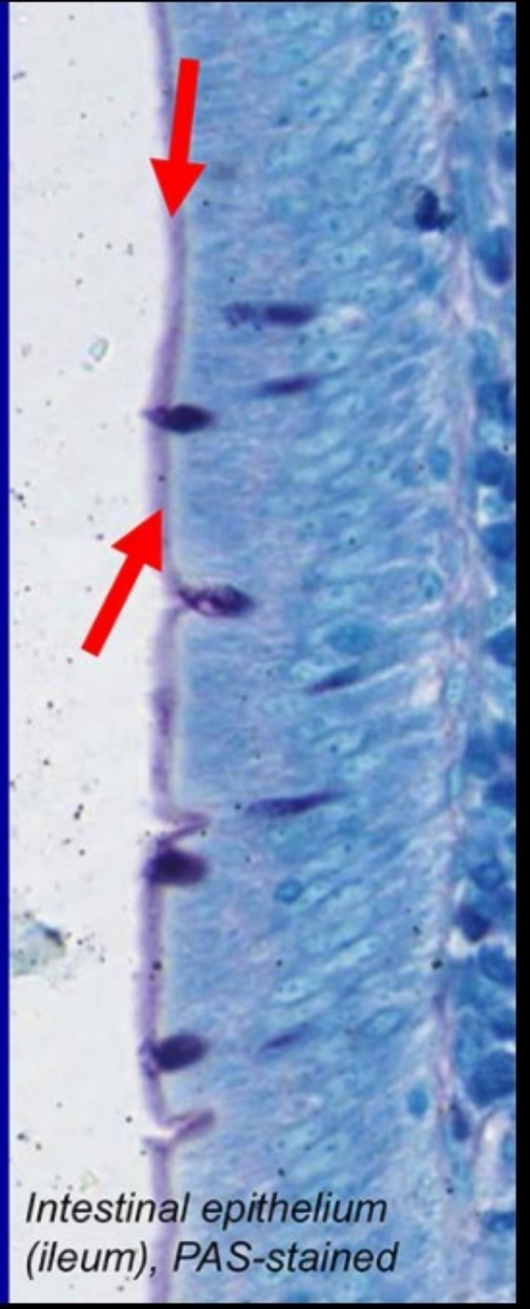
Microvilli contain actin filaments.

Do these actin filaments make microvilli actively motile?

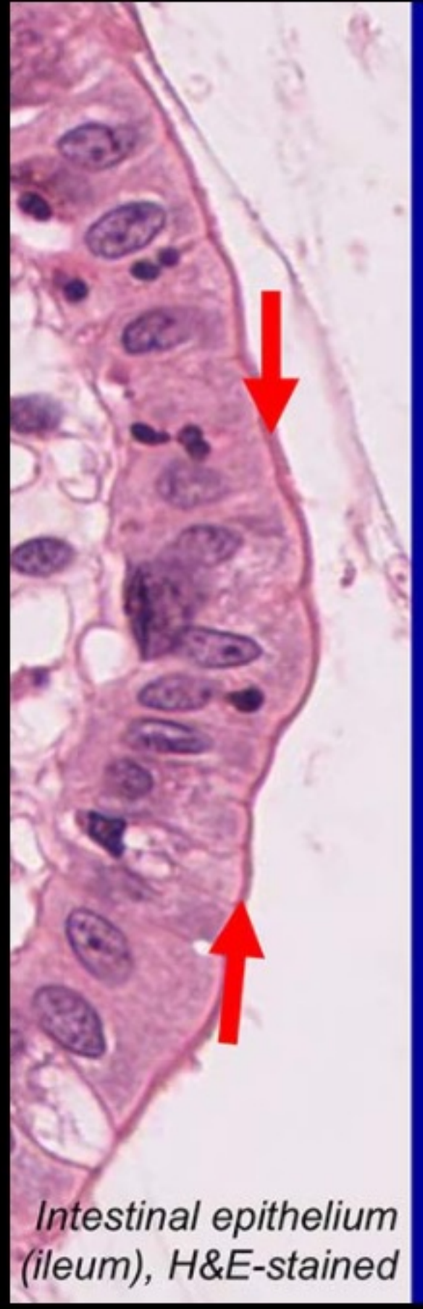
Identify the structure that is indicated by the red arrows.



Intestinal epithelium (ileum), H&E-stained



Intestinal epithelium (ileum), PAS-stained

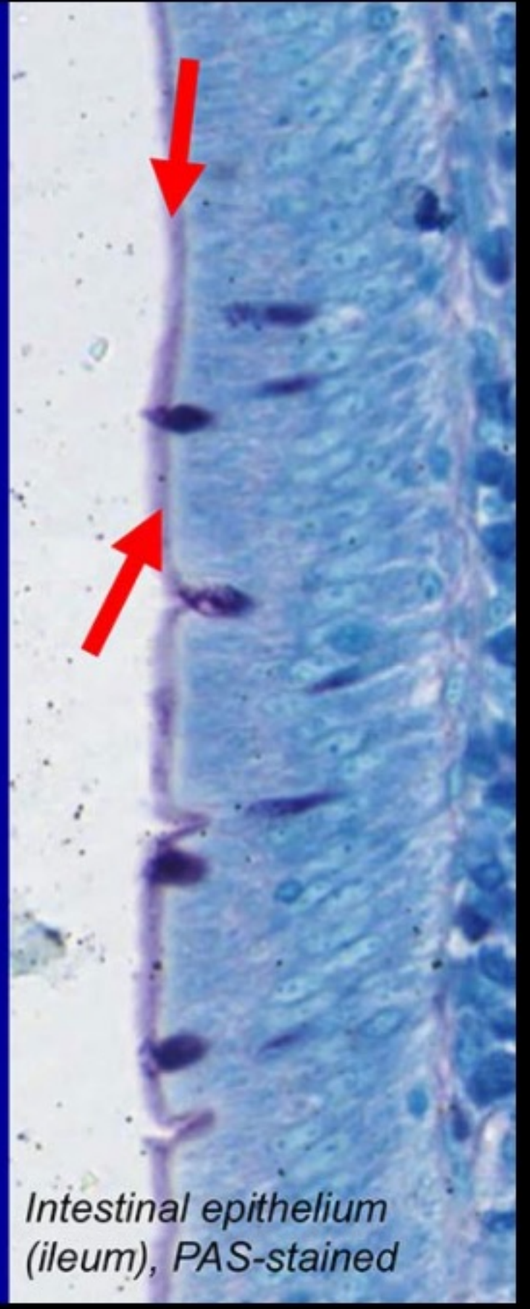


Intestinal epithelium (ileum), H&E-stained

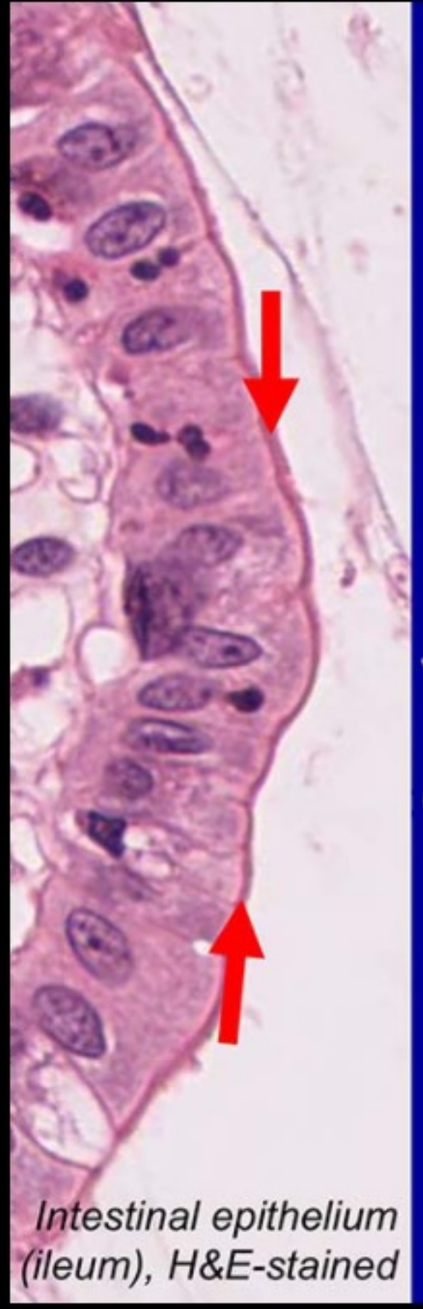
Identify the structure that is indicated by the red arrows.

The arrow marks the brush or striated border.

Which cellular structure forms a brush or striated border?



Intestinal epithelium (ileum), PAS-stained



Intestinal epithelium (ileum), H&E-stained

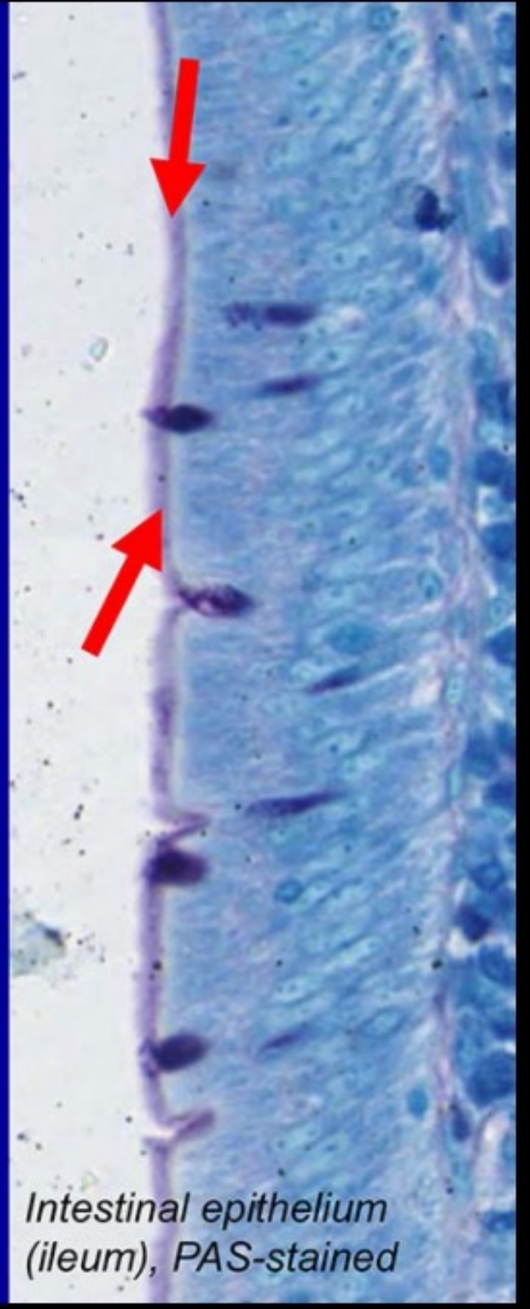
Identify the structure that is indicated by the red arrows.

The arrow marks the brush or striated border.

Which cellular structure forms a brush or striated border?

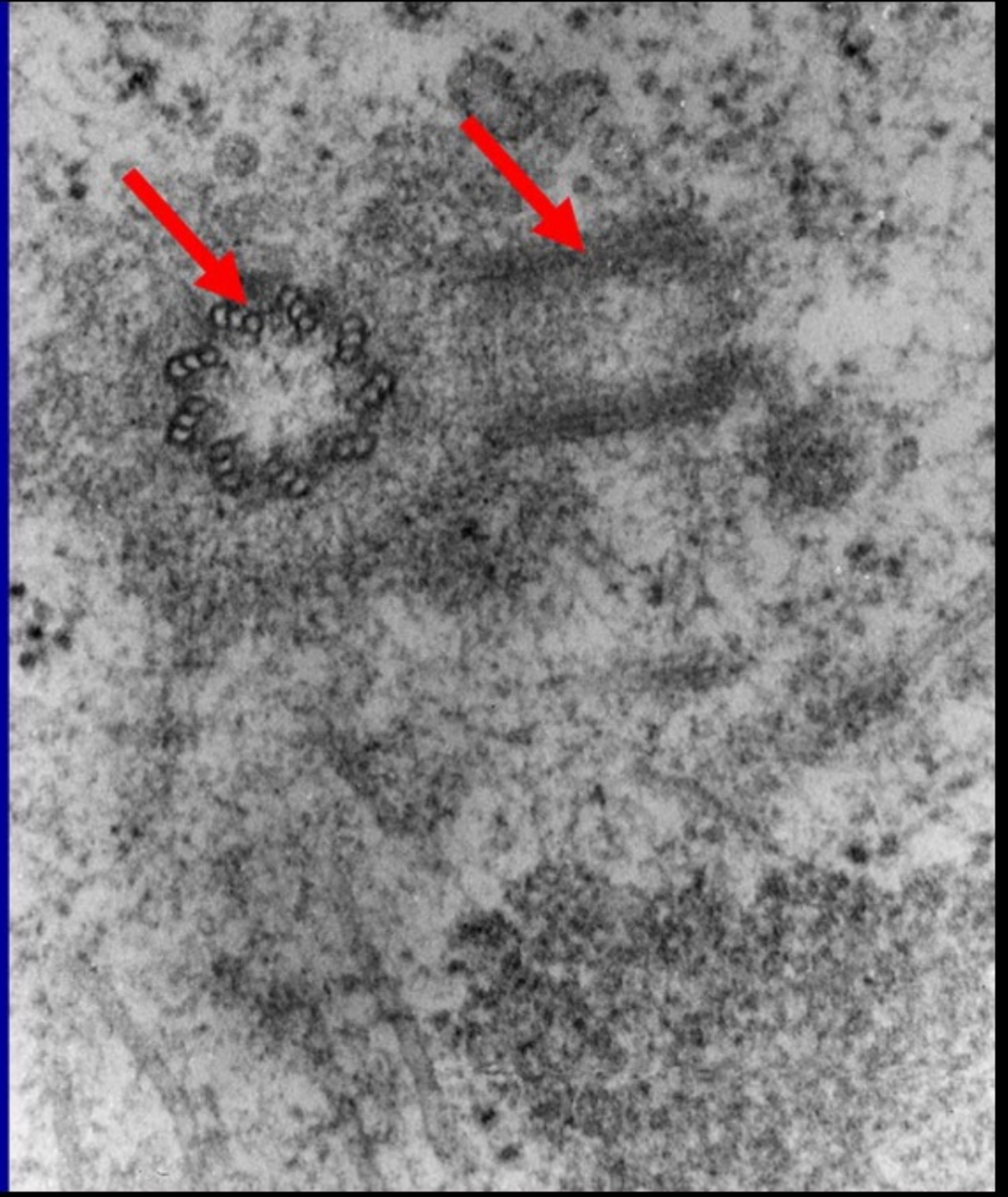
This structure is made up of thousands of microvilli. A single microvillus is too small to be visible by regular light microscopy. As they are coated by a dense carbohydrate-rich glycocalyx, they appear purple in a PAS-stained specimen (see its appearance in the right image. The dark spots represent mucus-filled goblet cells).

On which cell side will you find microvilli/a brush border?



Intestinal epithelium (ileum), PAS-stained

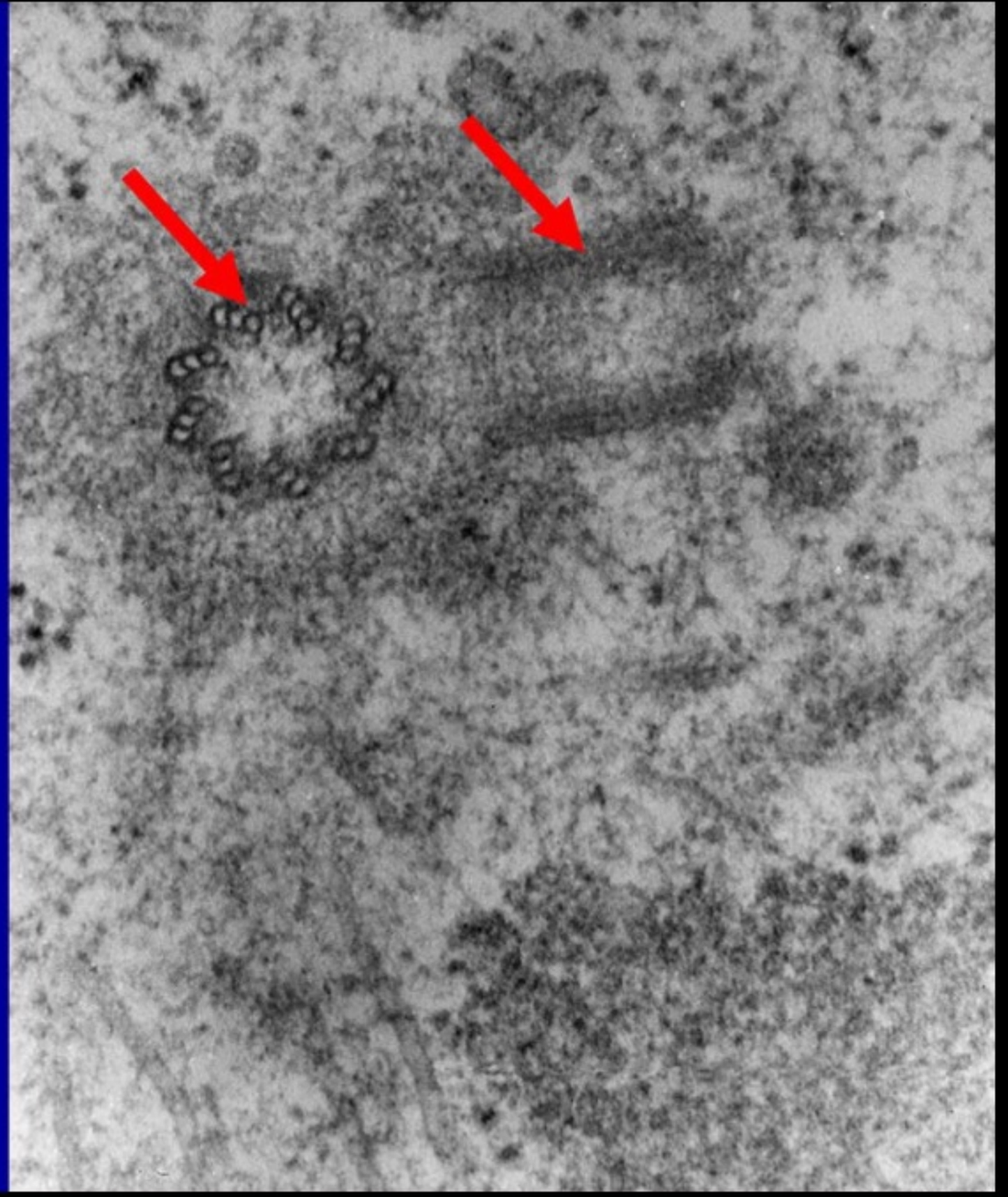
Identify this cell organelle indicated by the red arrows.



Identify this cell organelle indicated by the red arrows.

A centriole

Outline the major functional attributes of centrioles.

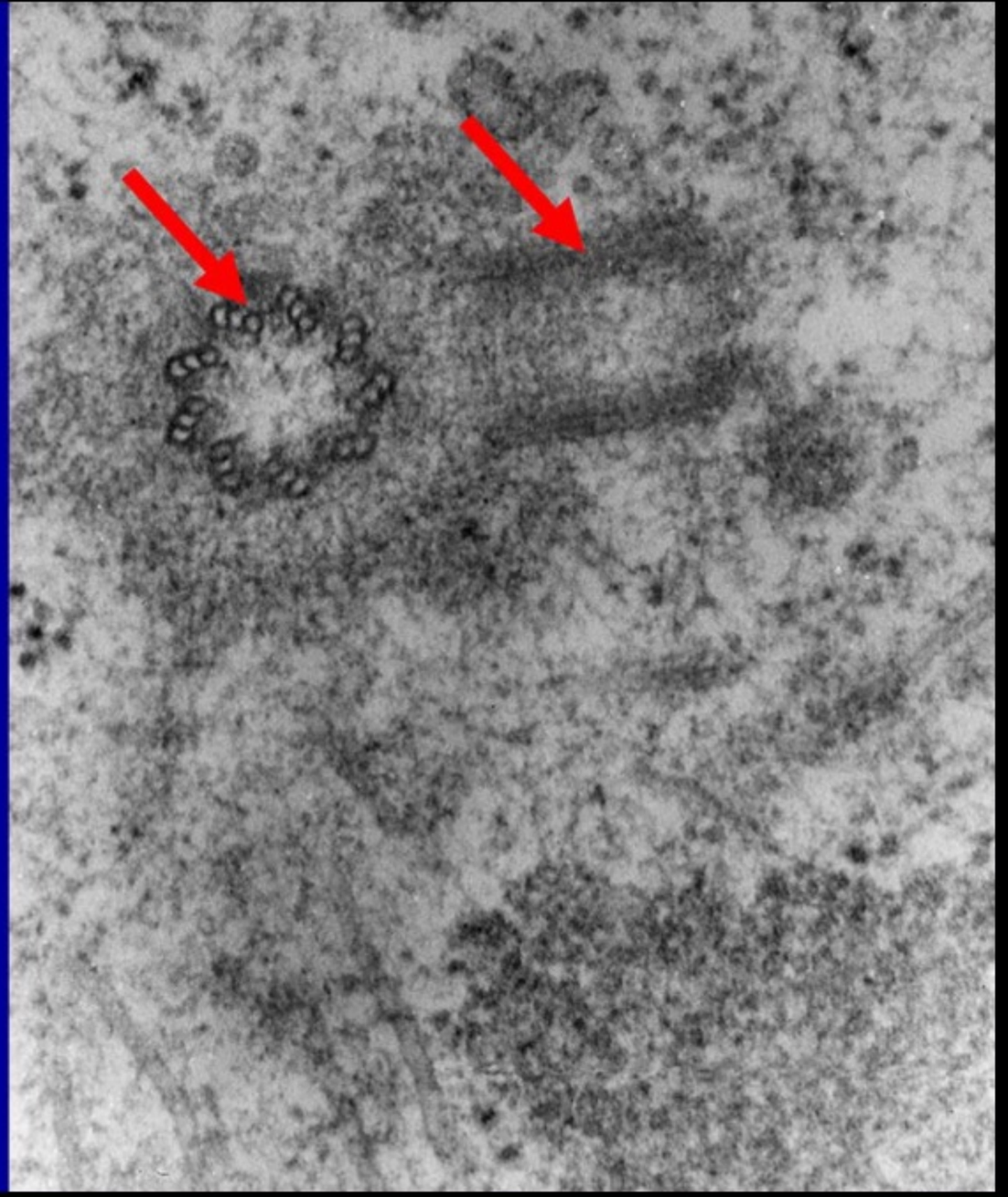


Identify this cell organelle indicated by the red arrows.

A centriole

Outline the major functional attributes of centrioles.

Centrioles together with the pericentriolar material form the microtubule-organizing center or centrosome. They also provide the template for basal body formation (associated with cilia and flagella). Furthermore, during mitosis they position and organize the mitotic spindle.



Identify these cellular structures and and name the epithelial cell surface at which they are usually found.

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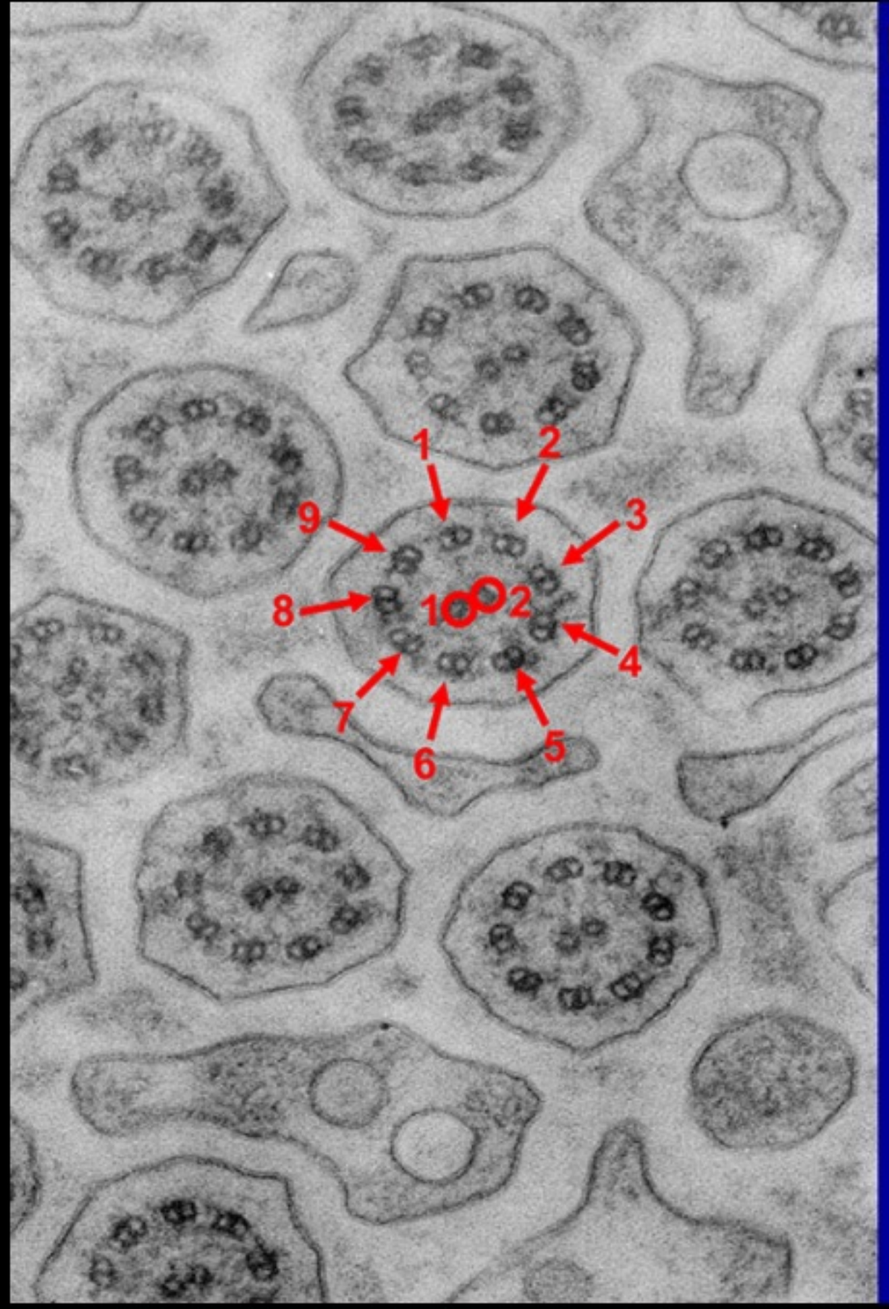
Cilia are usually found on the apical surface of epithelial cells.

Cilia contain which type of cytoskeletal element? Does this cytoskeletal core make cilia actively motile?



Identify these cellular structures and and name the epithelial cell surface at which they are usually found.

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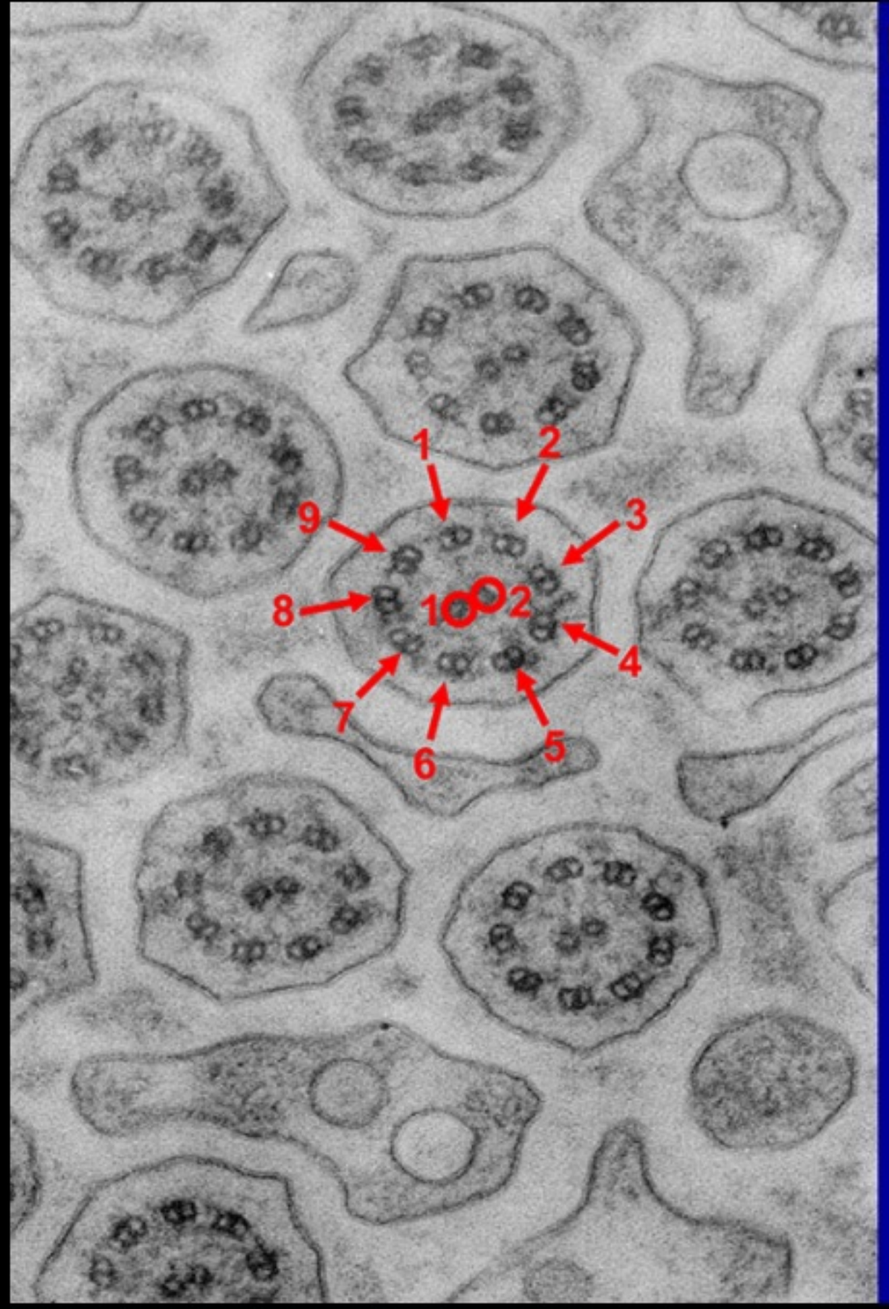
Motile cilia contain microtubules, which are clearly identifiable by their typical 9+2 pattern in electron micrographs. Yes, this 9+2 tubulin core usually conveys active motility.

What are the general functions of cilia?



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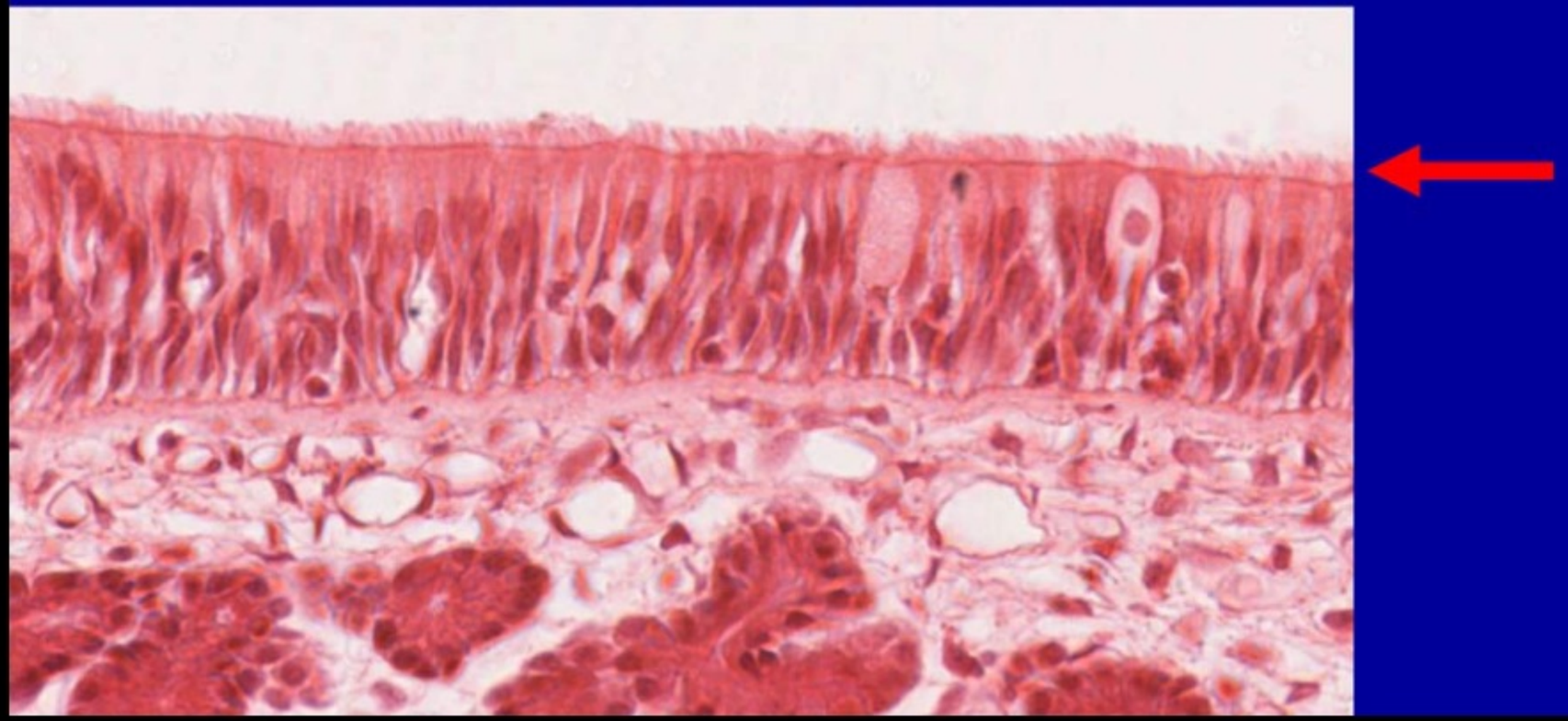
Motile cilia contain microtubules, which are clearly identifiable by their typical 9+2 pattern in electron micrographs. Yes, this 9+2 tubulin core usually conveys active motility.

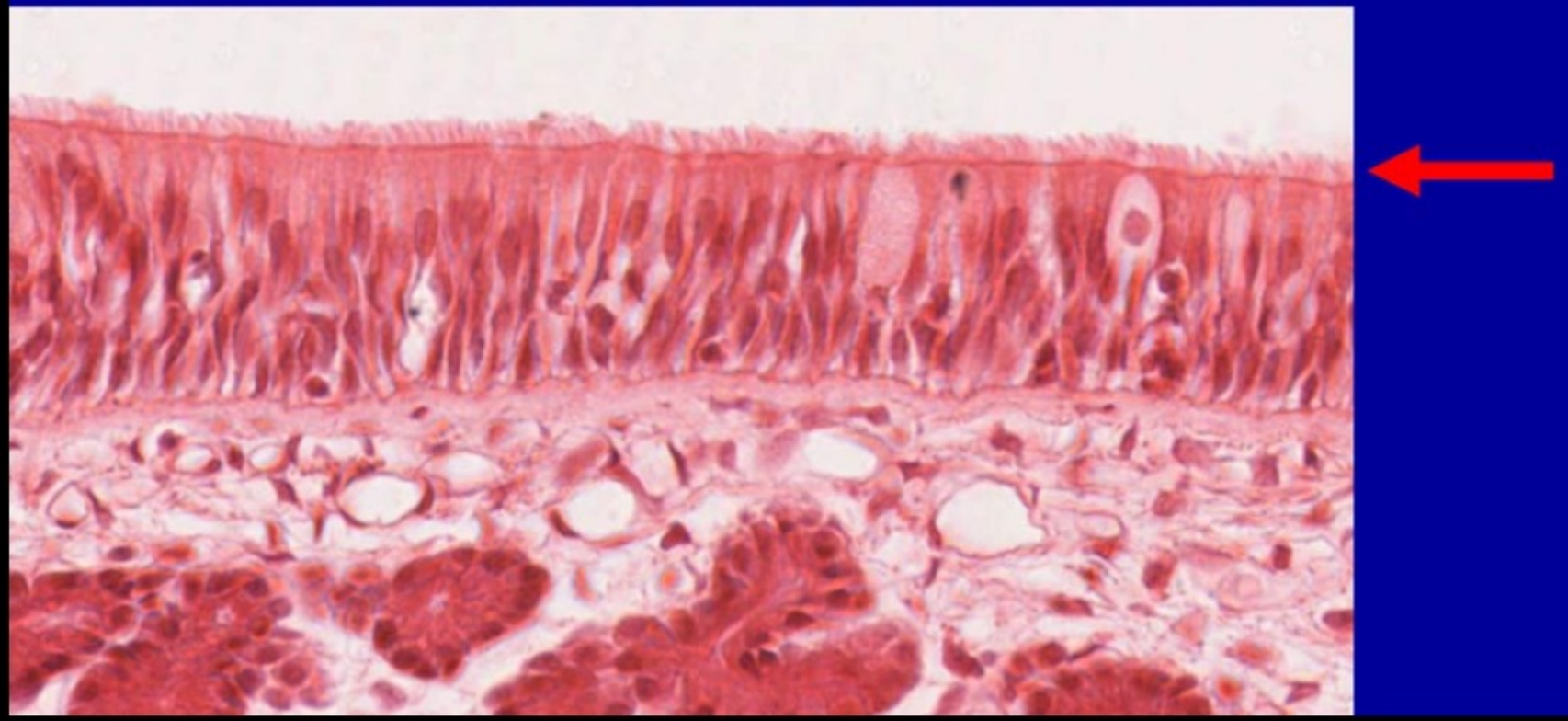
What are the general functions of cilia? Motile cilia participate in moving material along cellular surfaces (such as mucus, sperm or an oocyte). Non-motile cilia also contain microtubules (9+0) and have sensory functions.

Identify the cellular structures that are indicated by the red arrow.



Identify the cellular structures that are indicated by the red arrow. The arrow marks motile cilia in a respiratory epithelium. Cilia are large enough to be visible by regular light microscopy.

Cilia contain which type of cytoskeletal element?

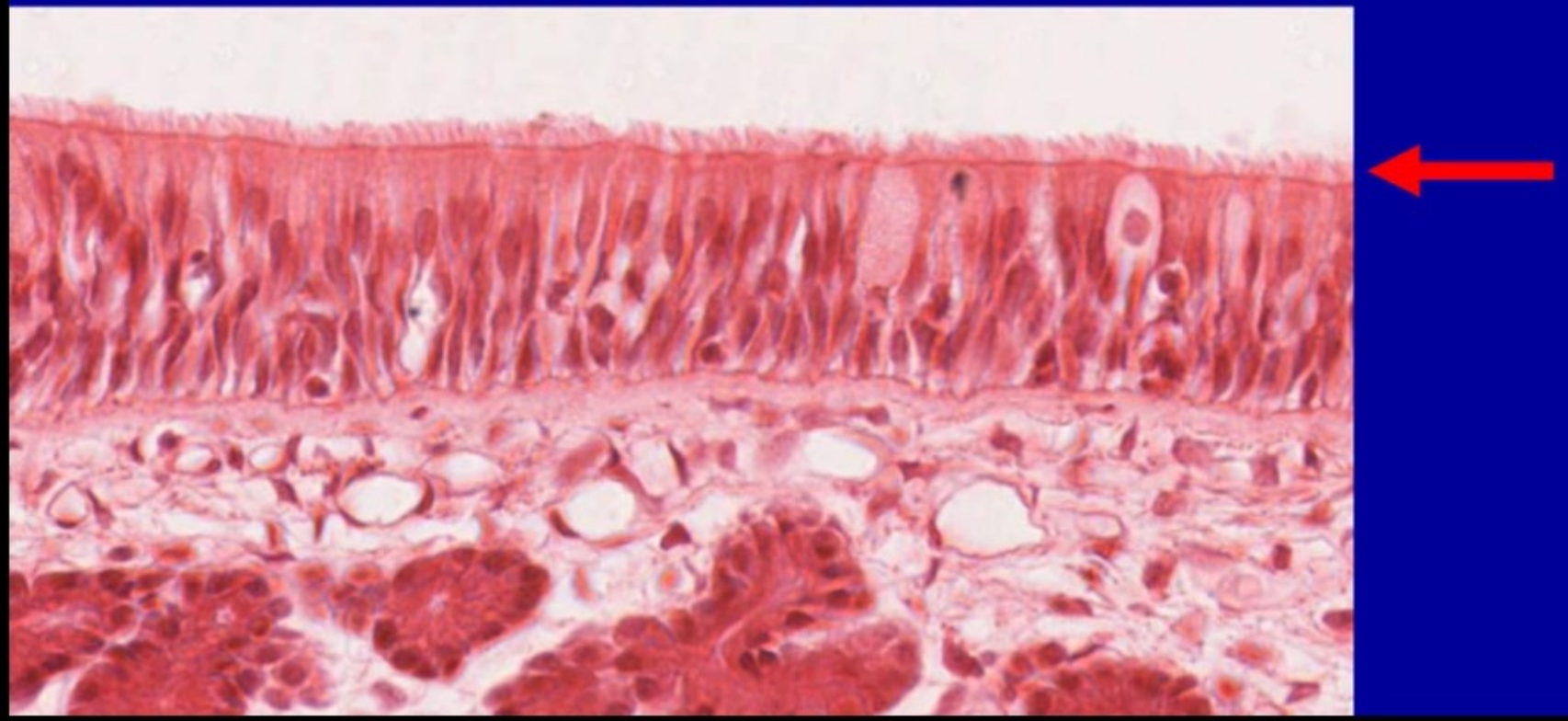


Identify the cellular structures that are indicated by the red arrow. The arrow marks motile cilia in a respiratory epithelium. Cilia are large enough to be visible by regular light microscopy.

Cilia contain which type of cytoskeletal element?

Microtubules (here in a 9+2 pattern)

On which cell side will you usually find cilia?



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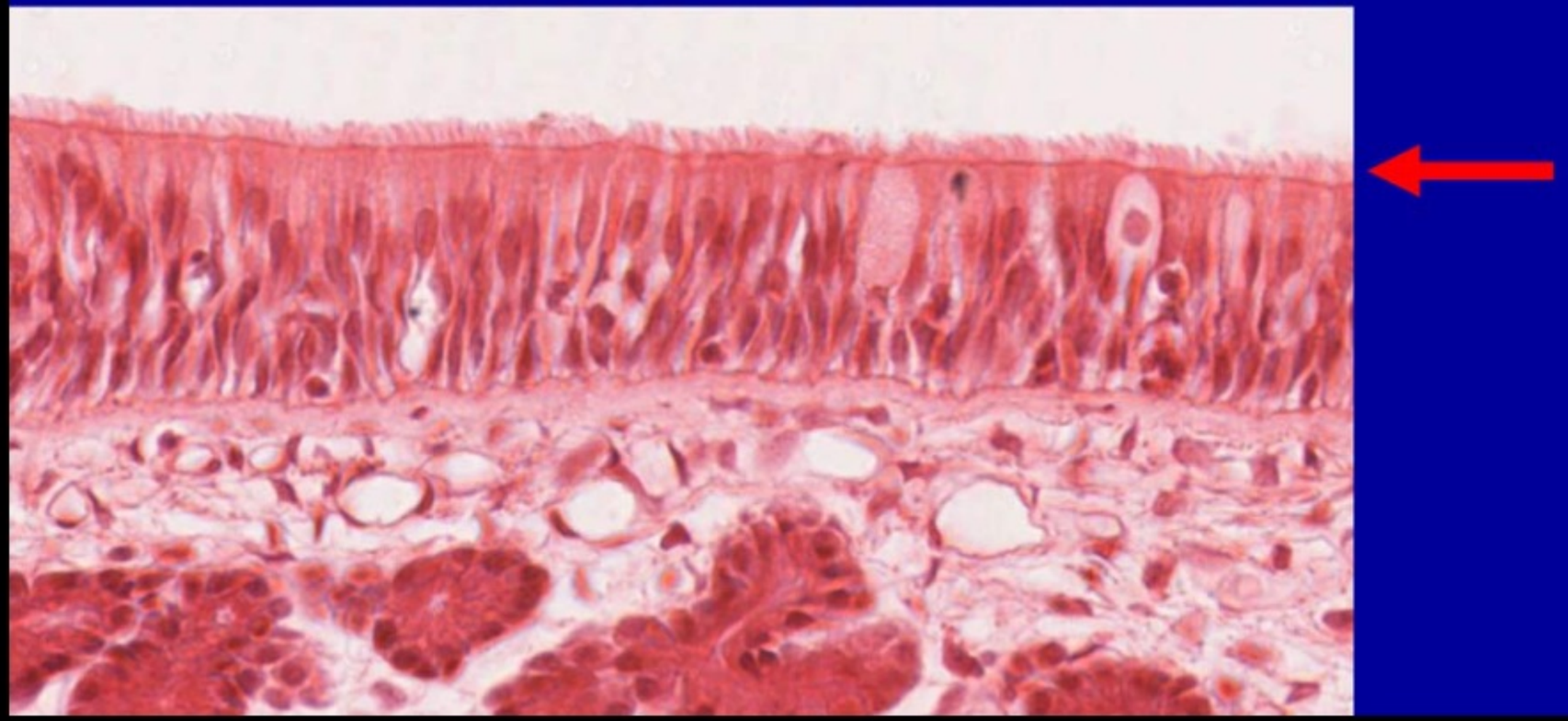
Cilia contain which type of cytoskeletal element?

Microtubules (here in a 9+2 pattern)

On which cell side will you usually find cilia?

On the apical surface



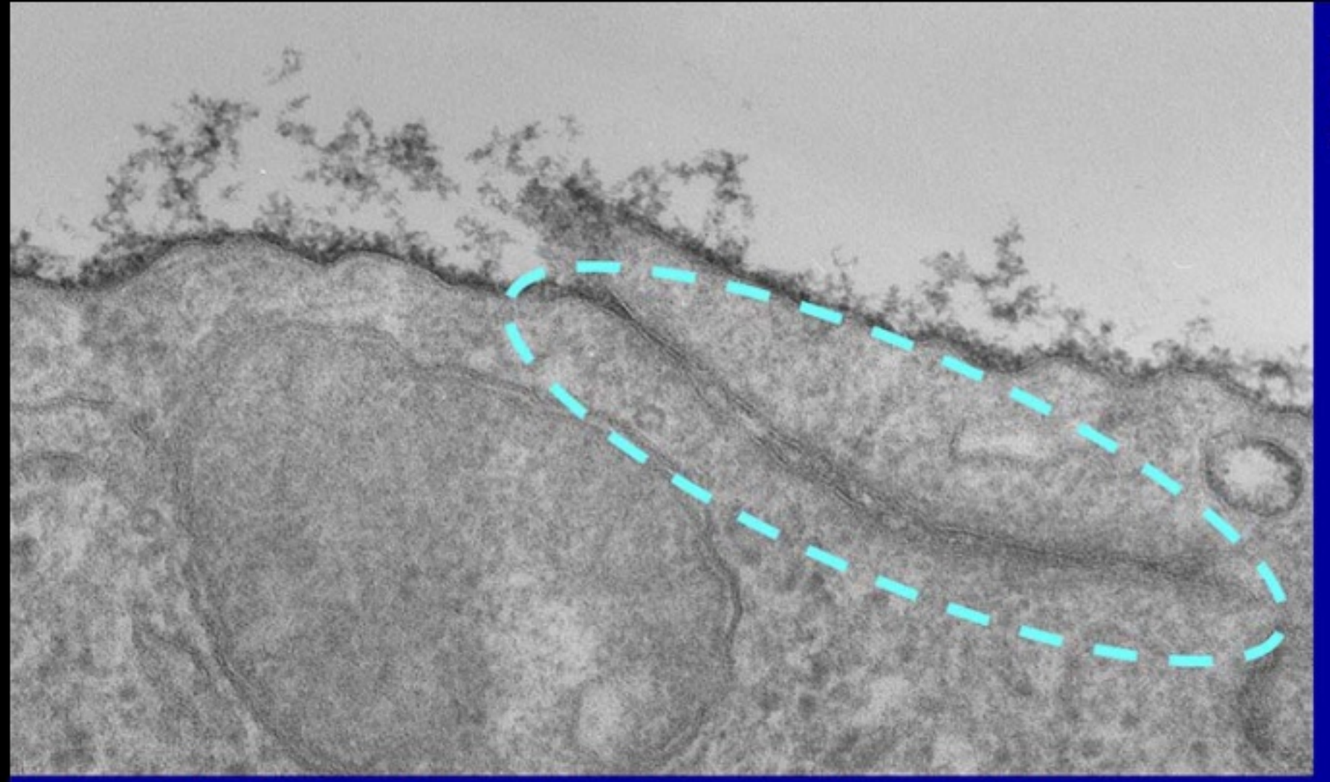


Image courtesy of
Dorothy Sorensen,
University of Michigan

Identify the cell contact area in the blue oval.

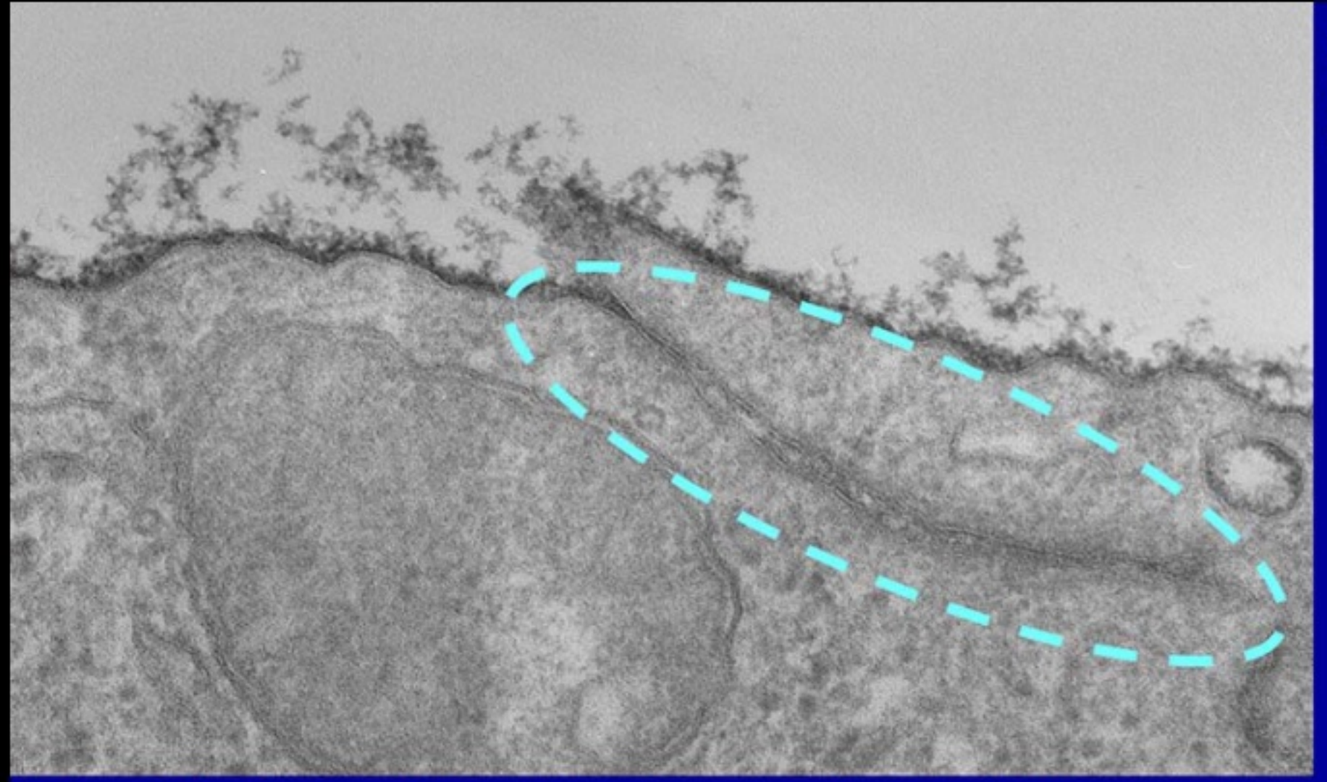


Image courtesy of
Dorothy Sorensen,
University of Michigan

Identify the cell contact area in the blue oval.

Tight or
occluding junction

Name the major membrane proteins that are associated with tight junctions.

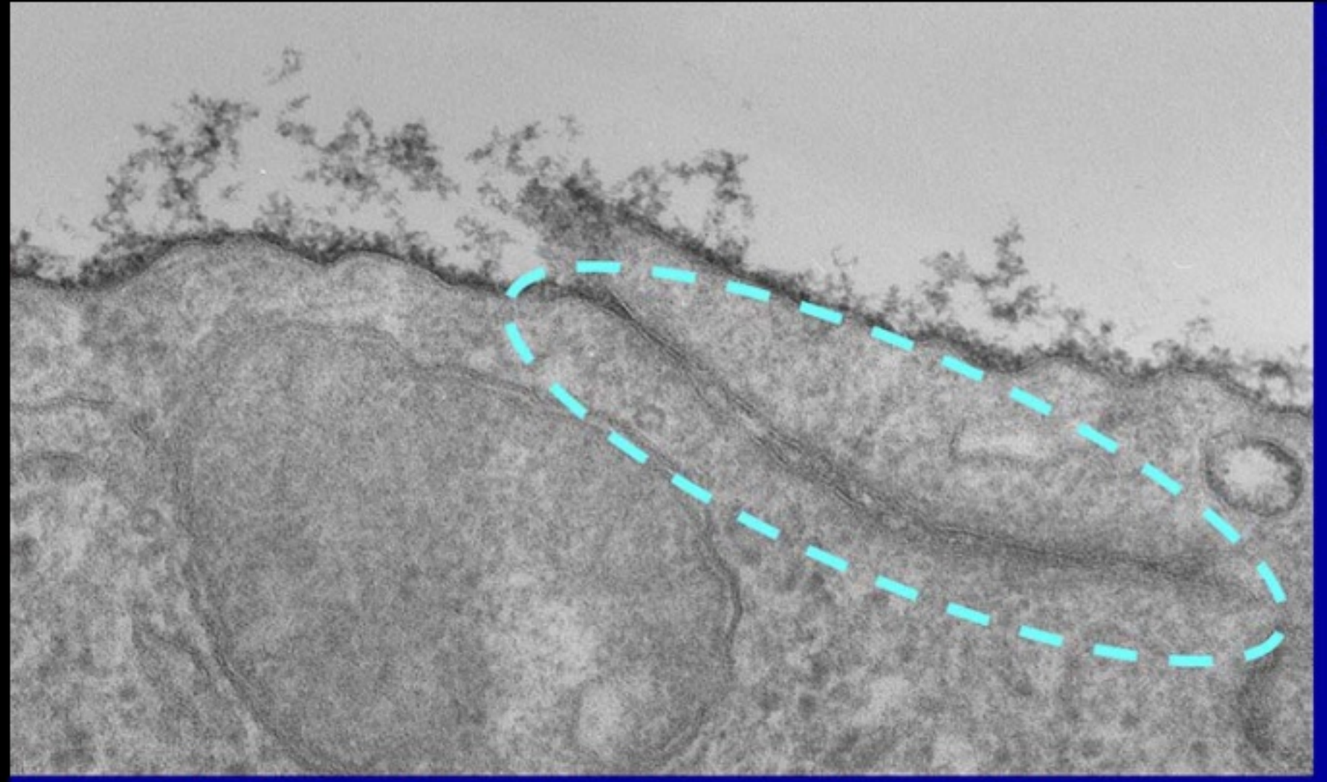


Image courtesy of Dorothy Sorensen, University of Michigan

Identify the cell contact area in the blue oval.

Tight or occluding junction

Name the major membrane proteins that are associated with tight junctions.

Occludin and claudins

Briefly outline the main functional attributes of tight junctions.

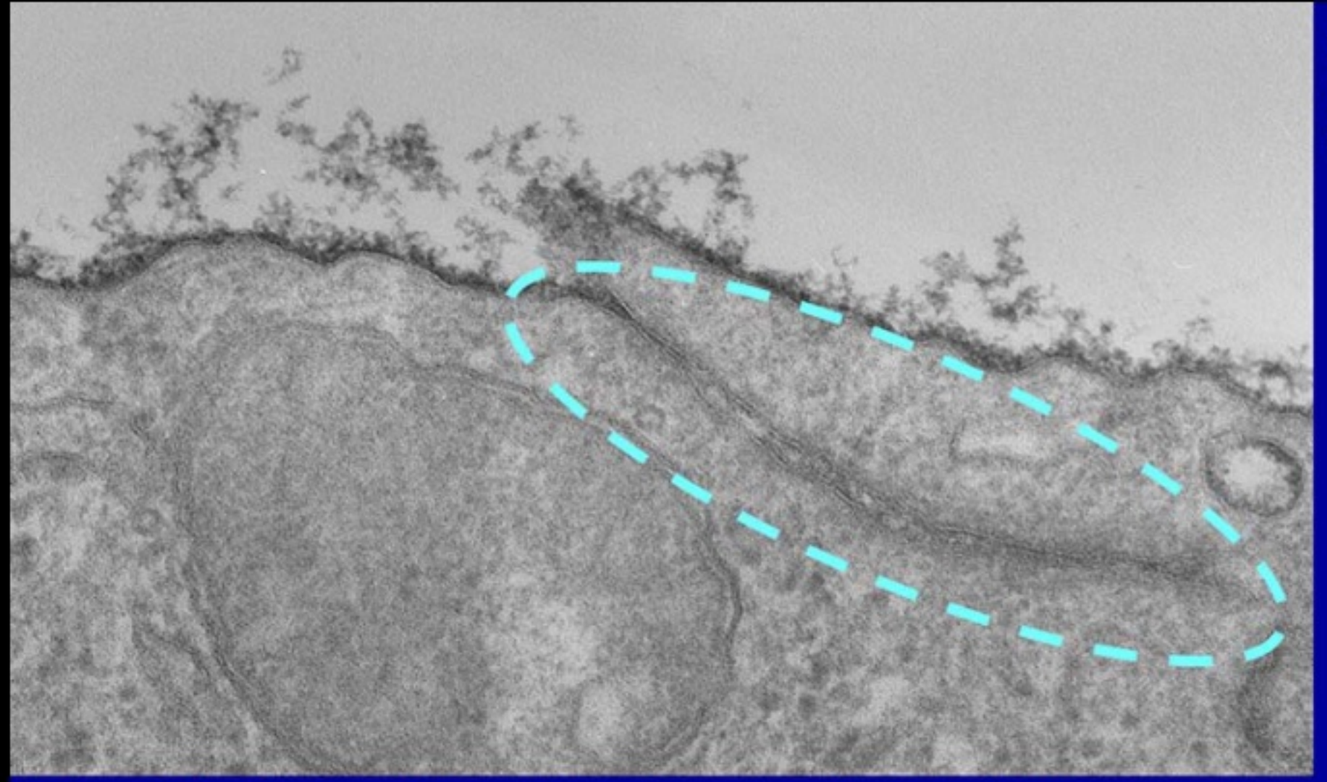


Image courtesy of
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Identify the cell contact area in the blue oval.

Tight or
occluding junction

Name the major membrane proteins that are associated with tight junctions.

Occludin and claudins

Briefly outline the main functional attributes of tight junctions.

Tight junctions act as seals in epithelial cell sheets, usually isolating and separating the apical from the basolateral environment.

Identify and name this cell to cell contact.

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Desmosome or macula adherens

Name the membrane proteins that are associated with desmosomes.

Identify and name this cell to cell contact.

Desmosome or macula adherens

Name the membrane proteins that are associated with desmosomes.

Desmosomes contain desmogleins and desmocollins, which are cadherin-type proteins

Name the main function of desmosomes.

Identify and name this cell to cell contact.

Desmosome or macula adherens

Name the membrane proteins that are associated with desmosomes.

Desmosomes contain desmogleins and desmocollins, which are cadherin-type proteins

Name the main function of desmosomes. Desmosomes are spot-like cell contacts that provide structural stability.

Which cytoskeletal structures are associated with desmosomes?

Identify and name this cell to cell contact.

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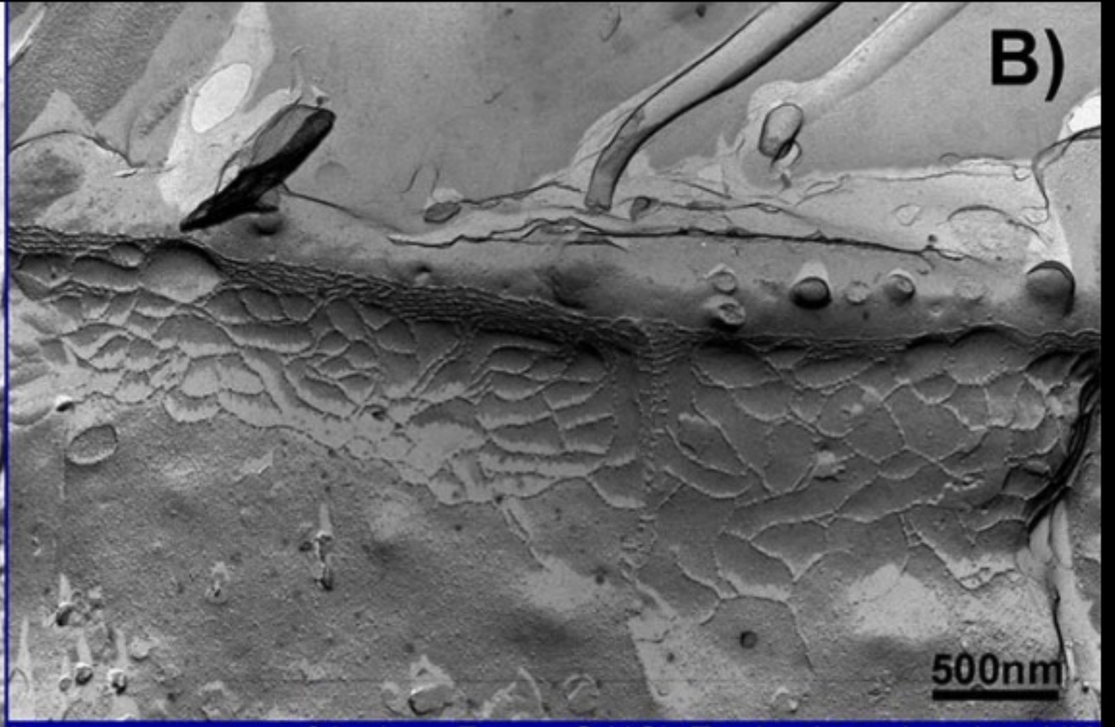
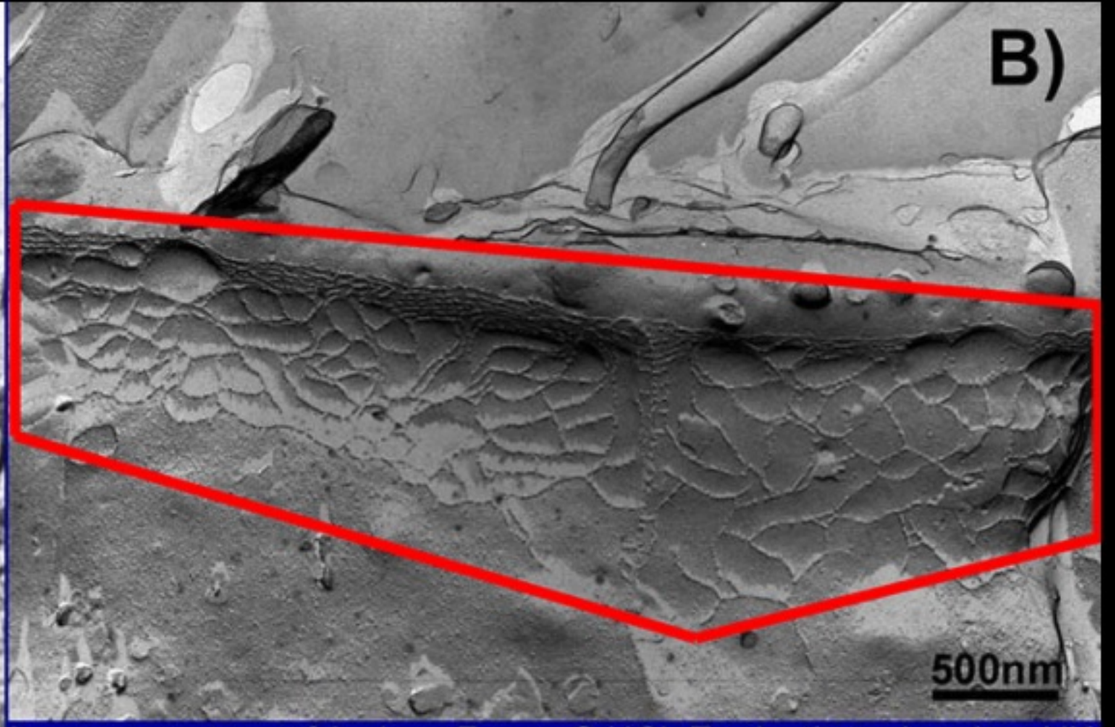
Which cytoskeletal structures are associated with desmosomes?

On the cytoplasmic side, desmosome are linked to intermediate filaments.



Images courtesy of Andrew Forge, © UCL Ear Institute, London, UK

These two images were taken using two different microscope techniques.
Name the two techniques.

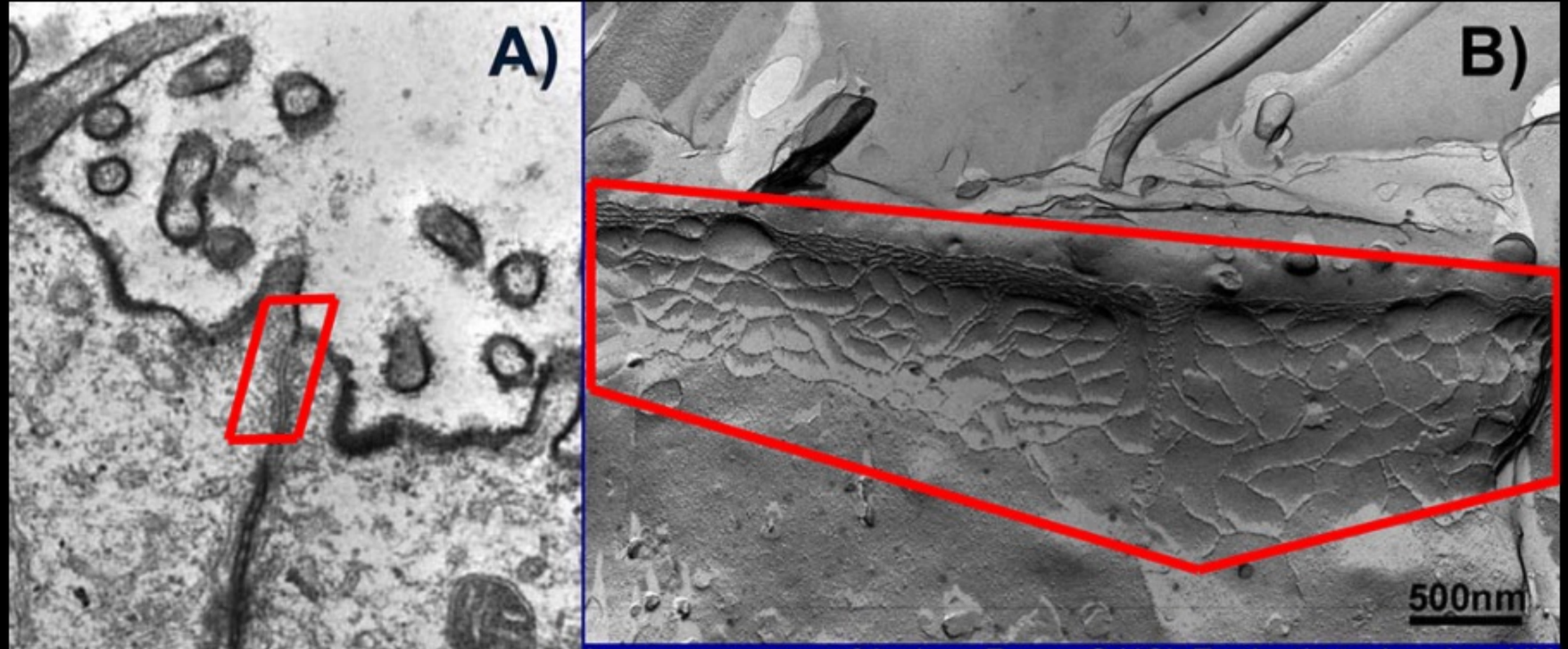


Images courtesy of Andrew Forge, © UCL Ear Institute, London, UK

These two images were taken using two different microscope techniques.
Name the two techniques.

A) Transmission electron microscopy (TEM)
and B) Freeze fracture electron microscopy

The two red boxes outline a specific type of cell junction. Identify this cell junction and briefly outline its general function.



Images courtesy of Andrew Forge, © UCL Ear Institute, London, UK

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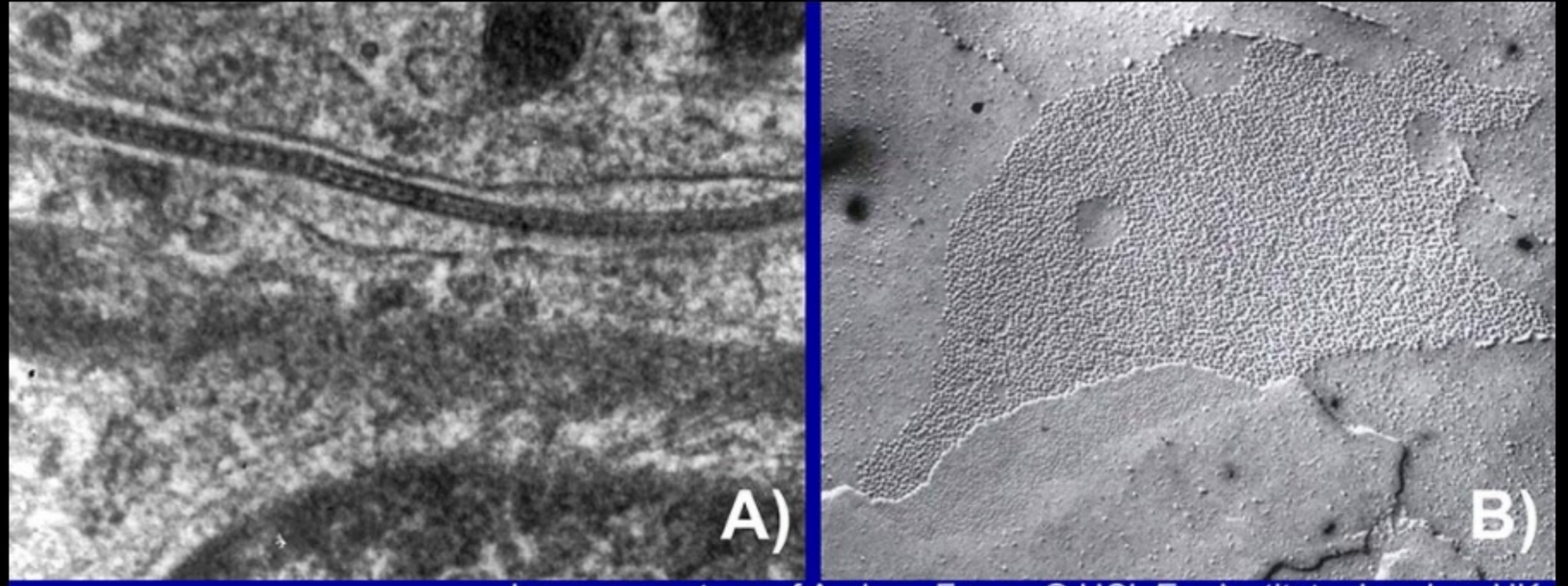
Name the two techniques.

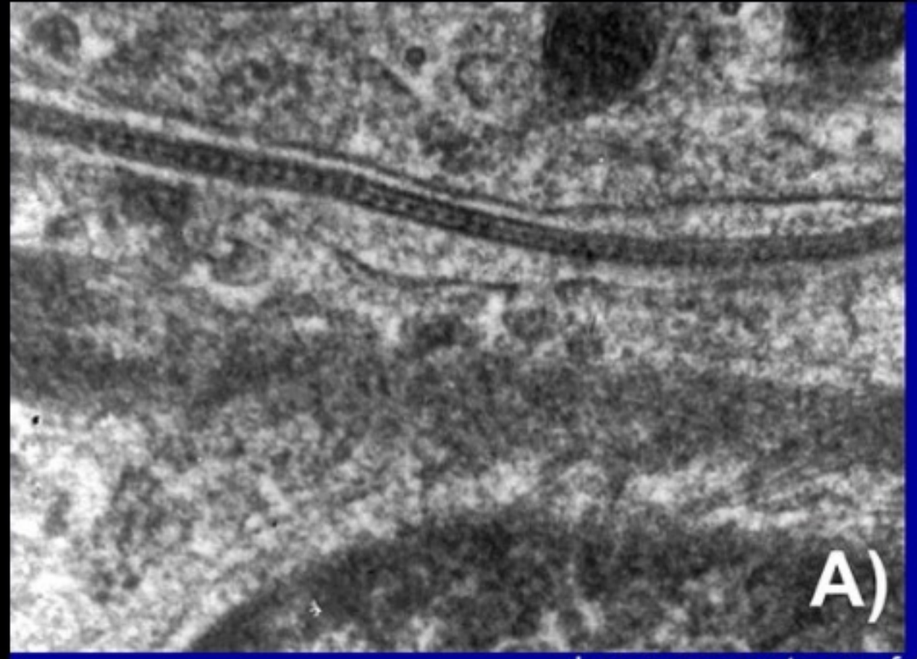
A) Transmission electron microscopy (TEM)
and B) Freeze fracture electron microscopy

The two red boxes outline a specific type of cell junction. Identify this cell junction and briefly outline its general function. Tight or occluding junction restricting diffusion across a cell layer/epithelium.



Images courtesy of Andrew Forge, © UCL Ear Institute, London, UK

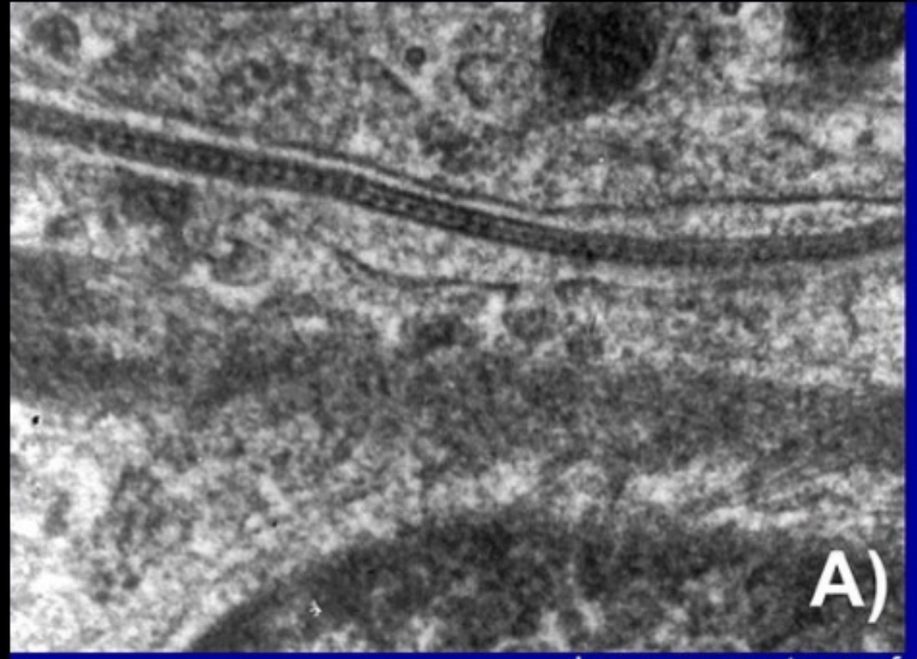
These two images show a specific cell junction between two cells. A) is a transmission EM and B) a freeze fraction electron micrograph. Identify this type of cell junction.



These two images show a specific cell junction between two cells. A) is a transmission EM and B) a freeze fraction electron micrograph. Identify this type of cell junction.

Shown are fields of GAP or communicating junctions.

Name the family of membrane proteins that forms these cell junctions.



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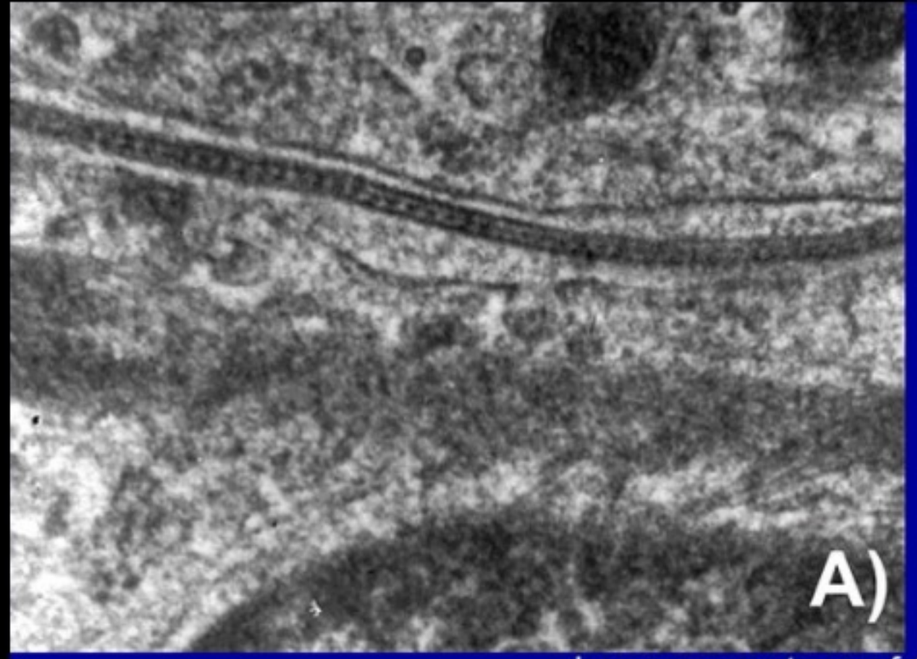
Connexin proteins

Name the general function that is carried out by Gap junctions.



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Connexin proteins

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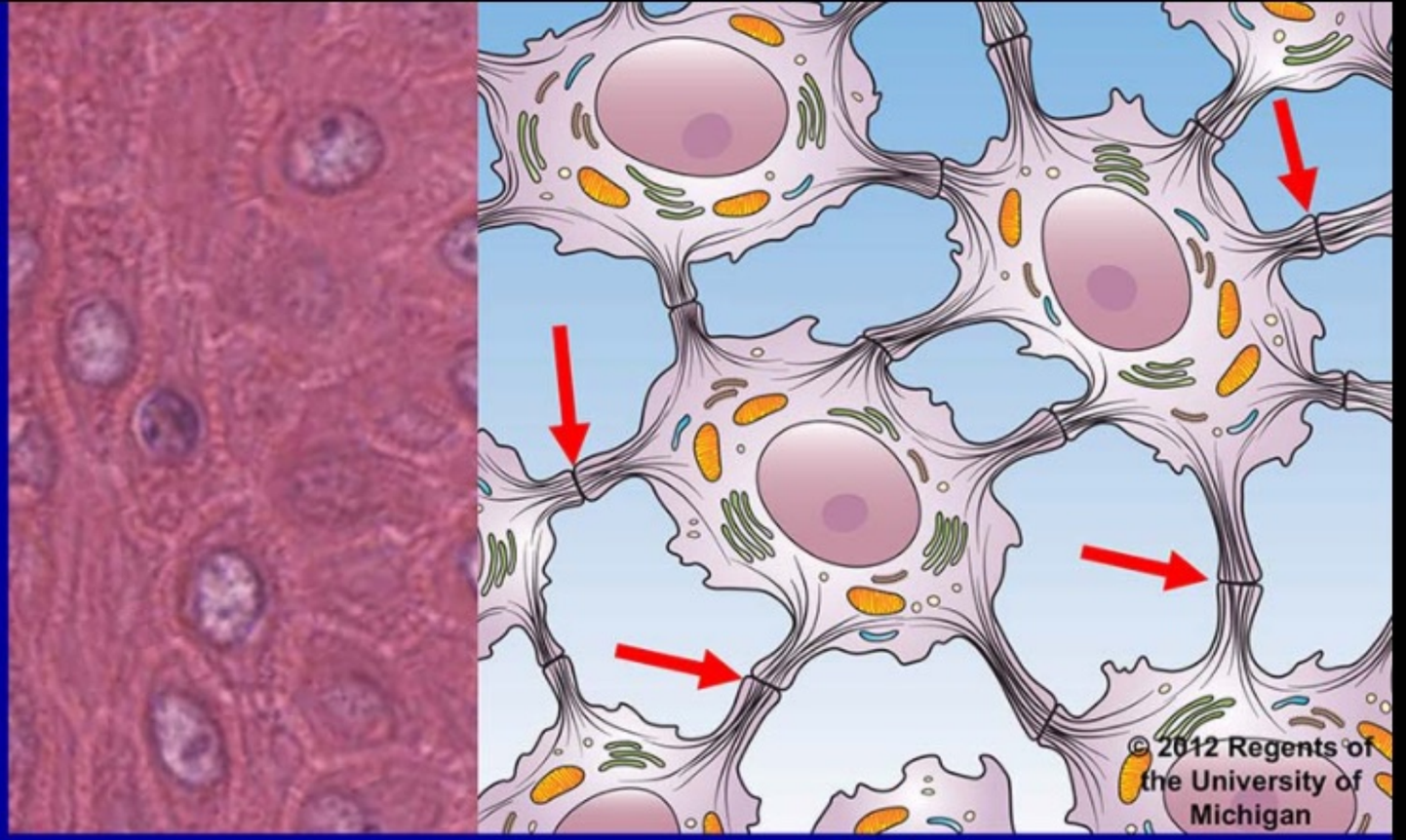
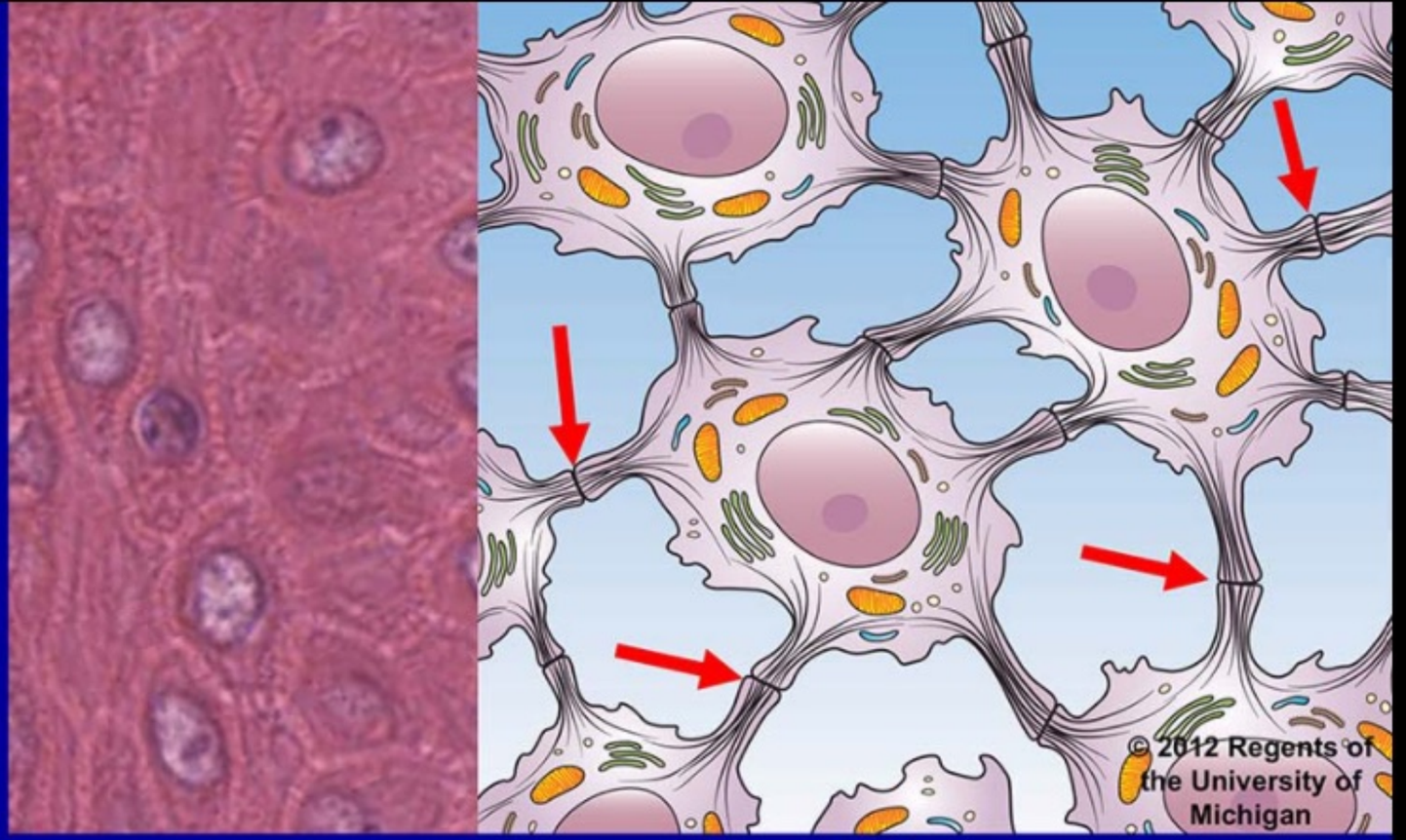
Gap junctions are proteinaceous membrane channels that connect the cytosols of adjacent cells and through which small molecules can diffuse.

Cells of the stratum spinosum in the skin are interconnected by "spinous" processes.



The left image shows cells in the stratum spinosum of the skin. The spines connecting these cells reflect a specific type of cell junction that is also marked by the red arrows in the diagram on the right. Name the cell junction.

Cells of the stratum spinosum in the skin are interconnected by "spinous" processes.



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Desmosomes or macula adherens

Is this cell junction associated with the cytoskeleton? If yes, which cytoskeletal structure?

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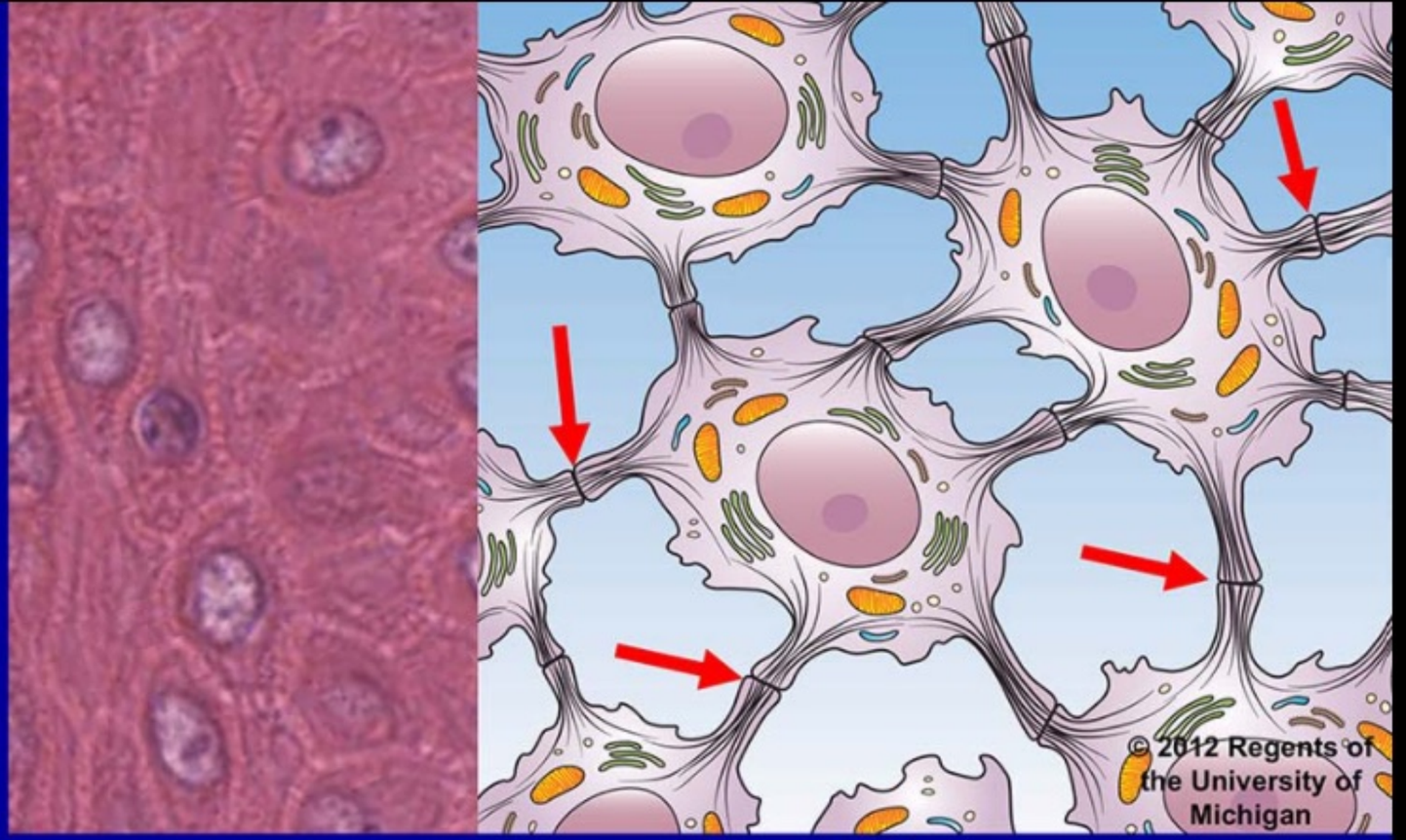

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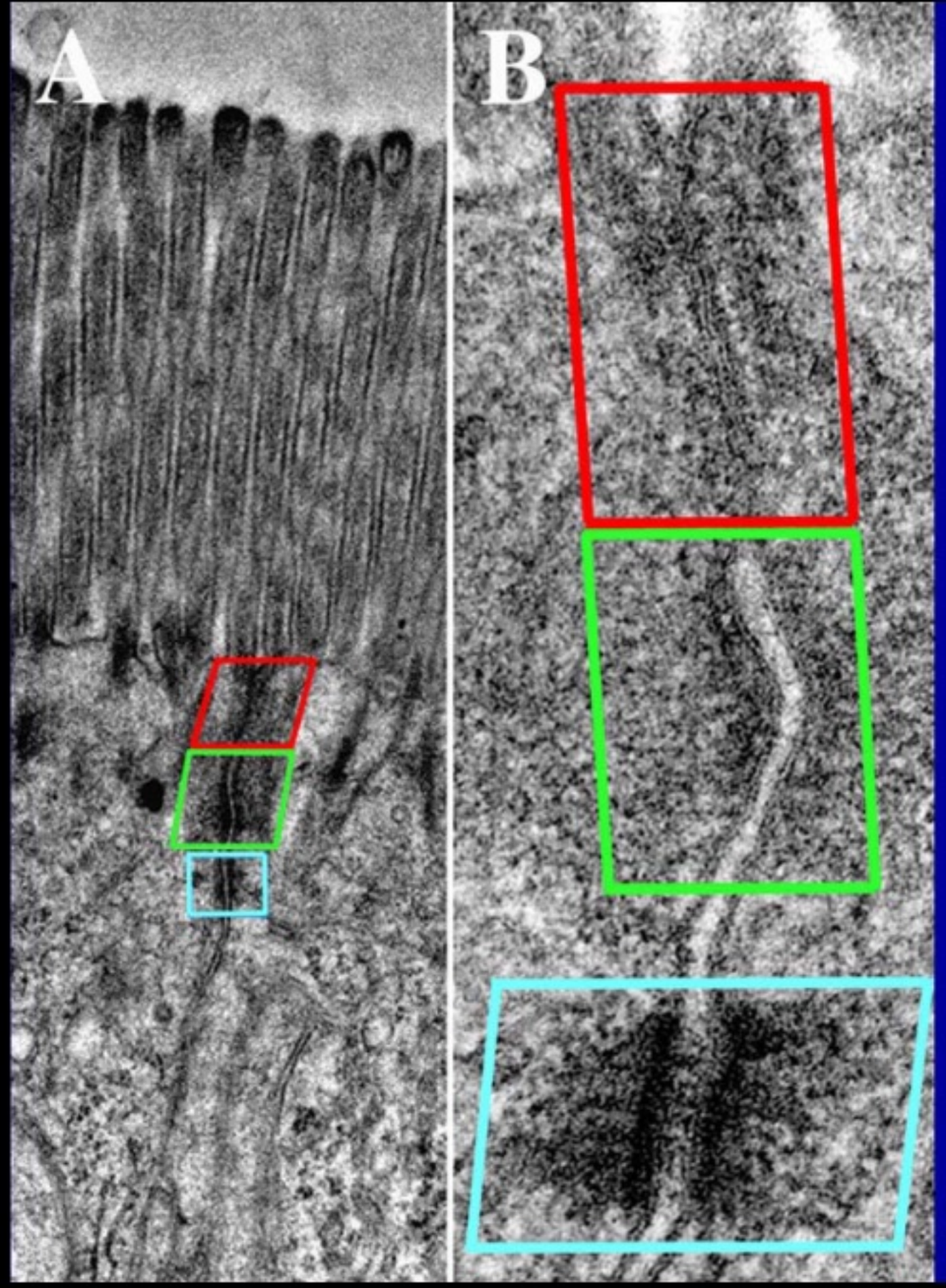
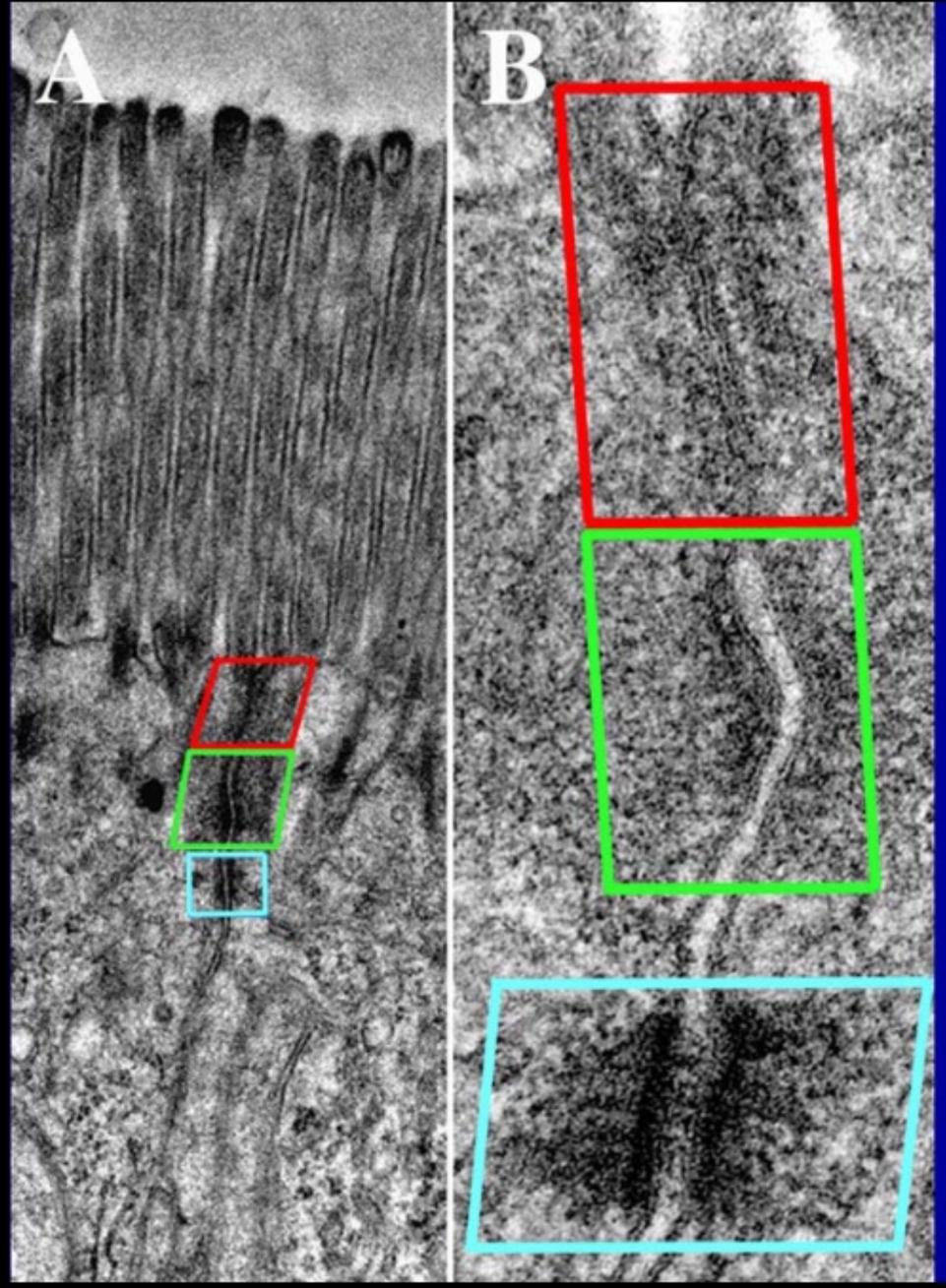
Is this cell junction associated with the cytoskeleton? If yes, which cytoskeletal structure?

Yes, desmosomes are associated with intermediate filaments, which in the case of epithelial cells are keratins (or tonofilaments).



Identify the cell junctions labeled by the red boxes.

Images courtesy of Roger C. Wagner,

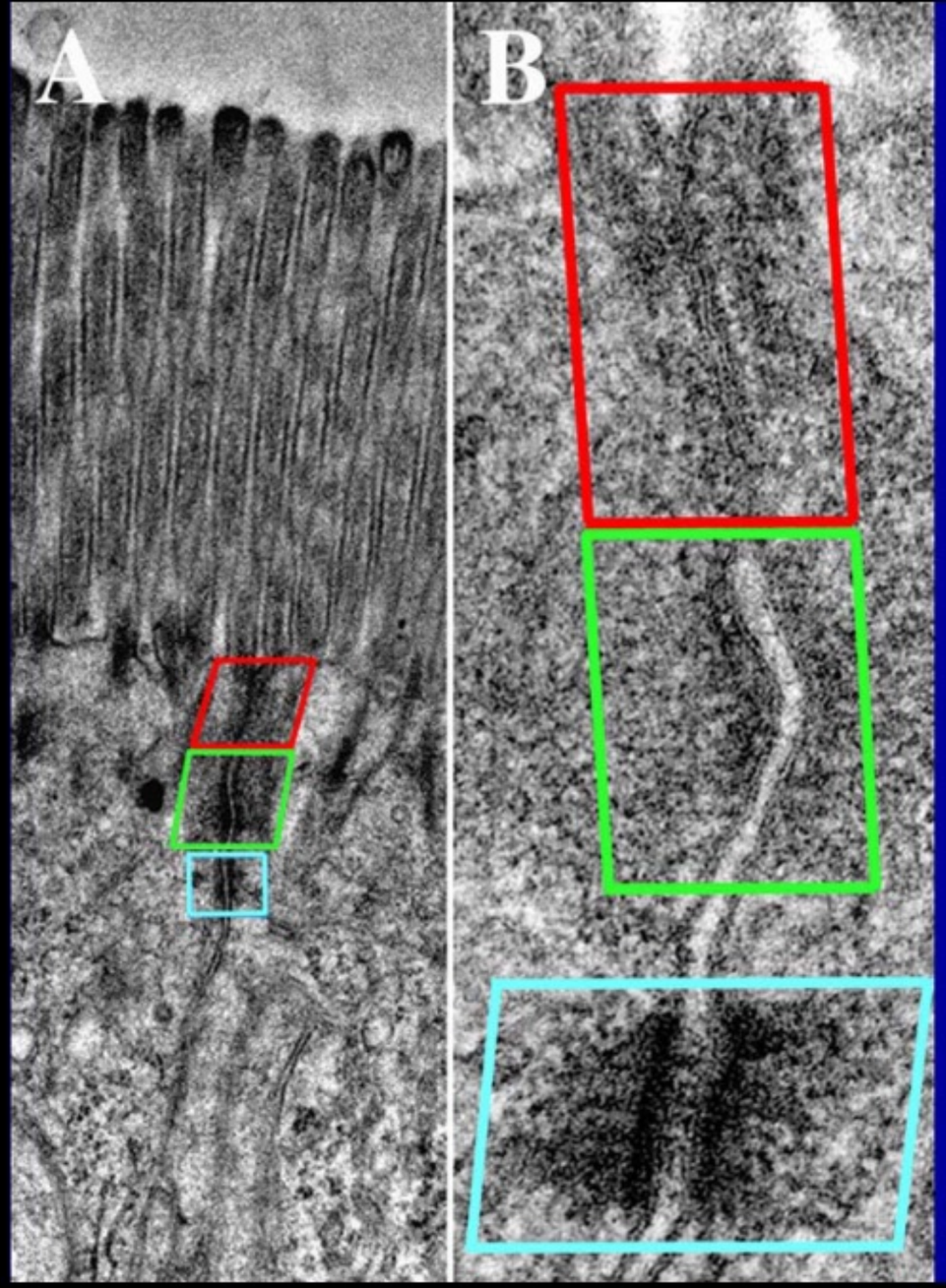


Identify the cell junctions labeled by the red boxes.

Zonula occludens or tight junction

Identify the cell junctions labeled by the green boxes.

Images courtesy of Roger C. Wagner,
© University of Delaware



Identify the cell junctions labeled by the red boxes.

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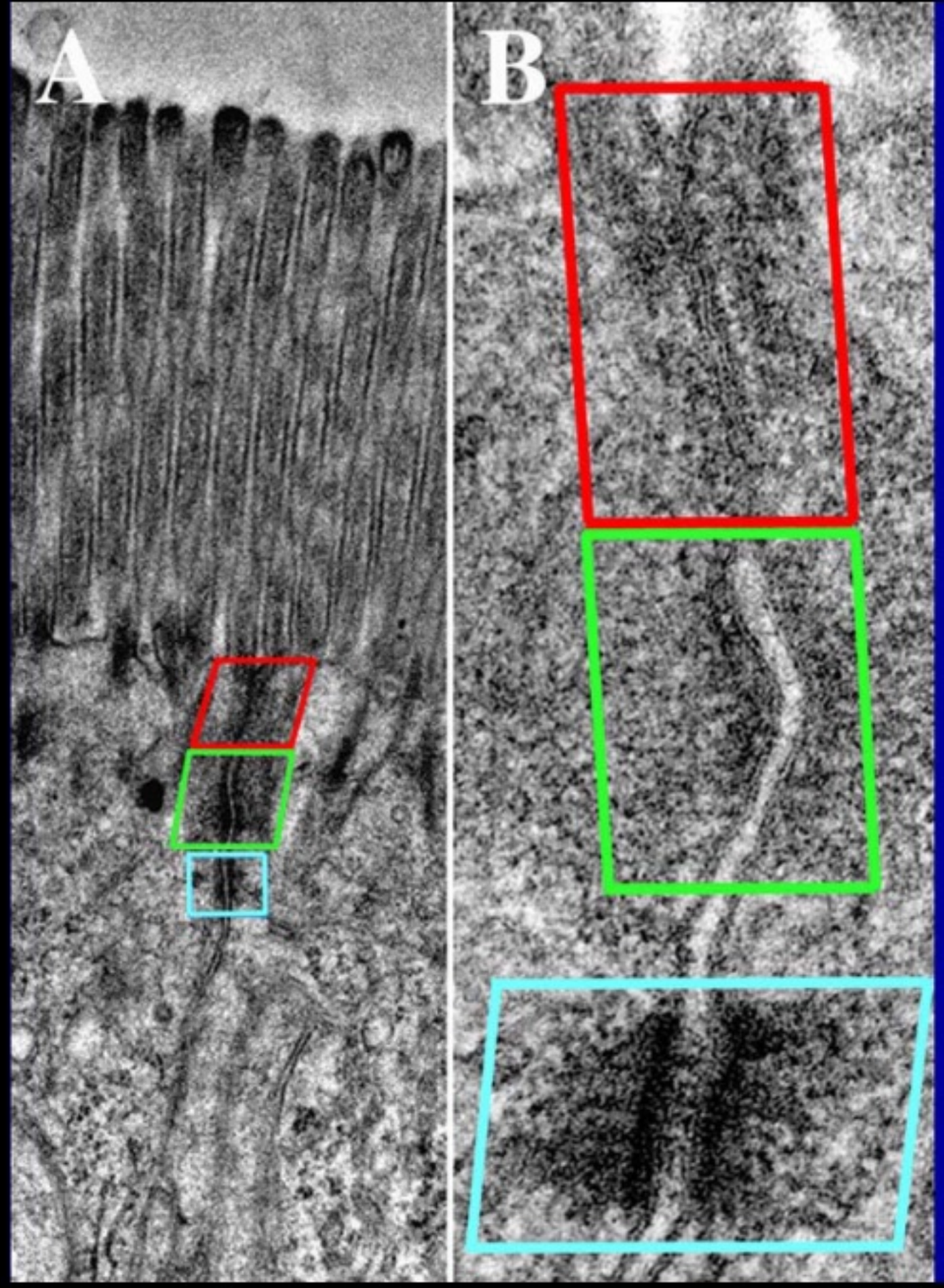
Identify the cell junctions labeled by the green boxes.

Zonula adherens or adherent junction

Identify the cell junctions labeled by the blue boxes.

Images courtesy of Roger C. Wagner,



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Zonula adherens or adherent junction

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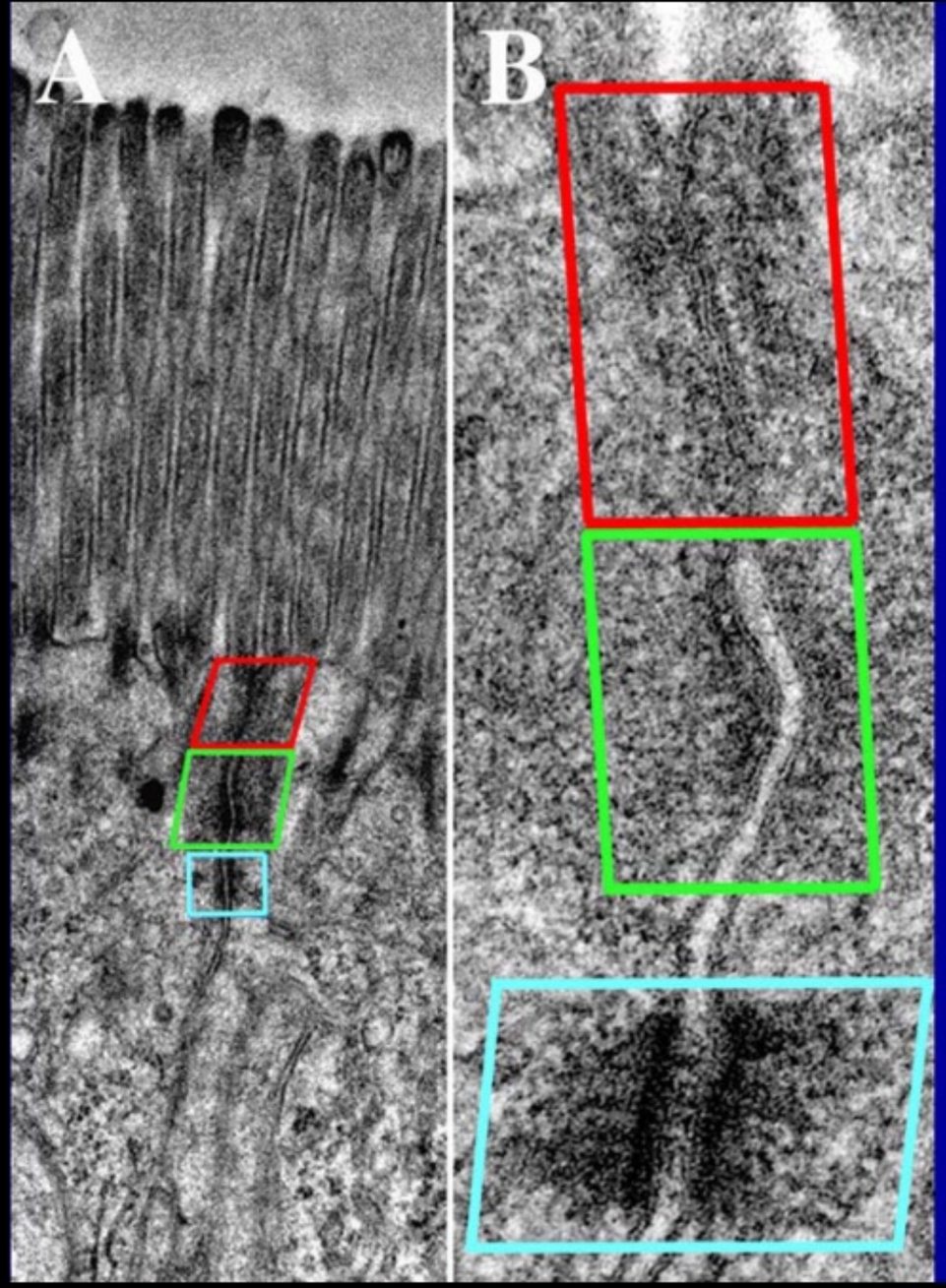
Macula adherens or desmosomes

What is this arrangement of cell junctions referred to?

Images courtesy of Roger C. Wagner,



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Junctional complex(es)

Images courtesy of Roger C. Wagner,