Golgi apparatus

Golgi Apparatus

- Golgi apparatus or golgi complex, or golgi body, or ‘the ‘Golgi’): is found in all plant and animal cells
- the term golgi apparatus is given to groups of flattened disc-like structures located close to the endoplasmic reticulum.
- The number of ‘Golgi apparatus’ within a cell is variable. Animal cells tend to have fewer and larger Golgi apparatus. Plant cells can contain as many as several hundred smaller versions.
- The Golgi apparatus receives proteins and lipids (fats) from the rough endoplasmic reticulum. It modifies some of them and sorts, concentrates and packs them into sealed droplets called vesicles.
- Depending on the contents these are despatched to one of three destinations:
    Destination 1: within the cell, to organelles called lysosomes.
    Destination 2: the plasma membrane of the cell
    Destination 3: outside of the cell.

The name behind the apparatus

The Golgi apparatus is the only cell organelle to be named after a scientist. The visible characteristics of the organelle were first reported by Camillo Golgi (1843-1926) at a meeting of the Medical Society of Pavia on 19 April 1898 when he named it the ‘internal reticular apparatus’.

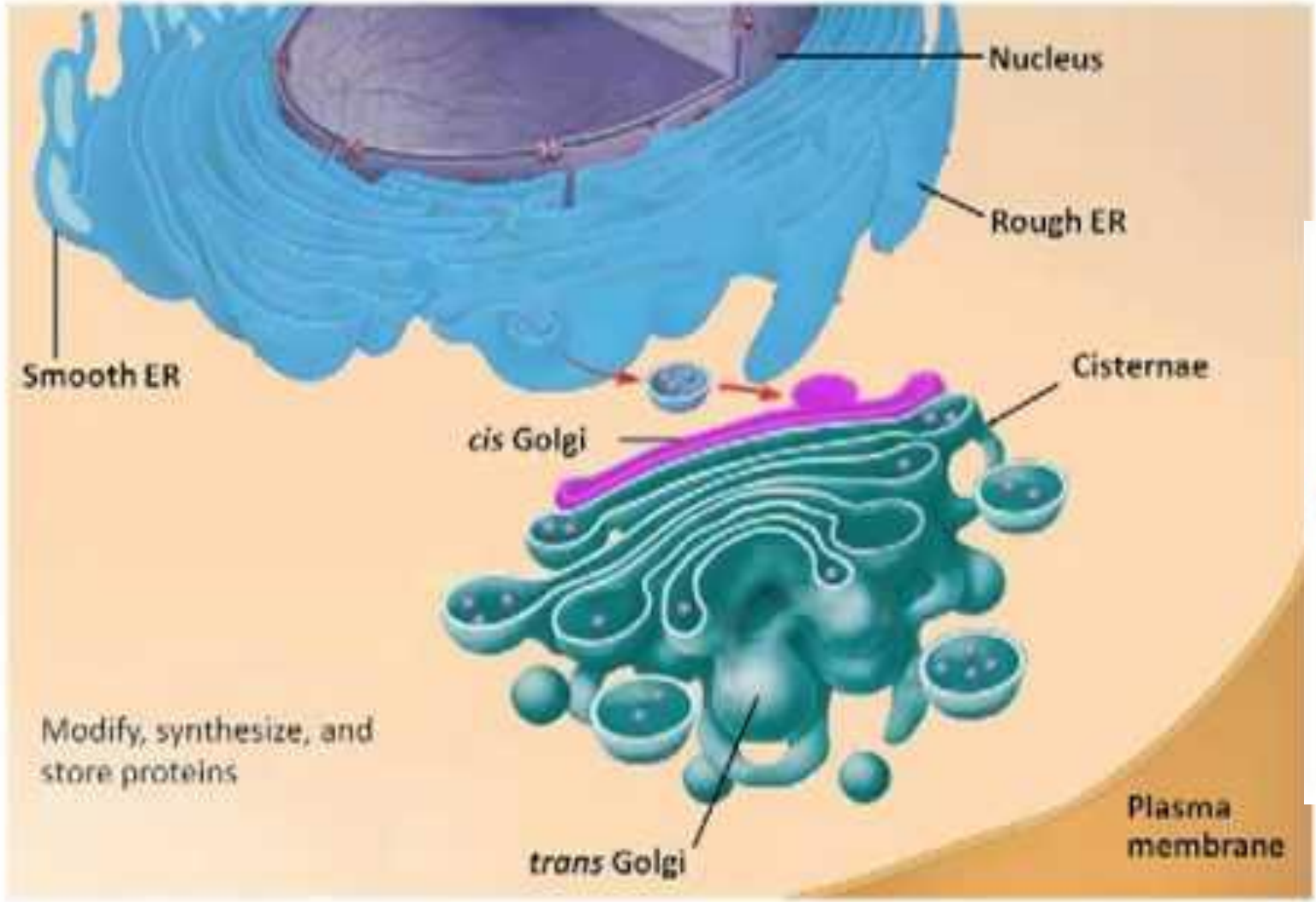
The Golgi Apparatus

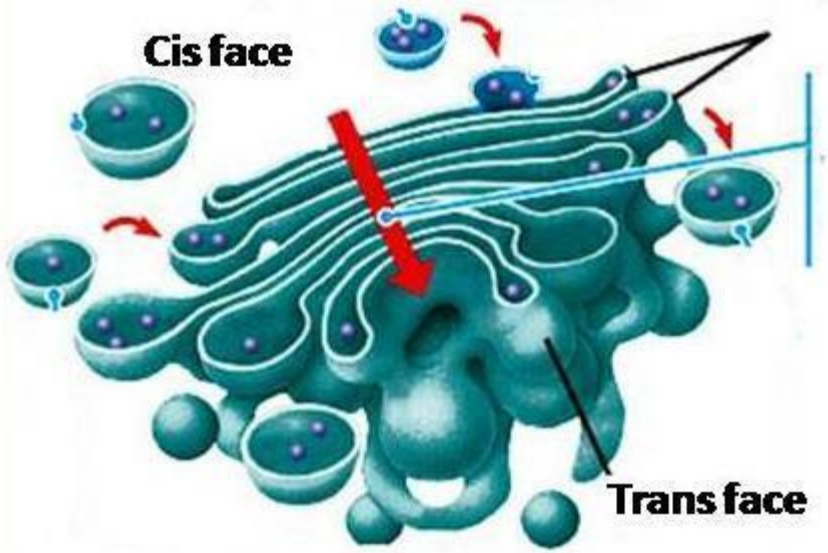
- The Golgi apparatus, or **Golgi complex**, functions as a factory in which proteins received from the ER are further processed and sorted for transport to their eventual destinations: lysosomes, the plasma membrane, or secretion.
- In addition, glycolipids and sphingomyelin are synthesized within the Golgi.
- In plant cells, the Golgi apparatus further serves as the site at which the complex polysaccharides of the cell wall are synthesized.
- The Golgi apparatus is thus involved in processing the broad range of cellular constituents that travel along the secretory pathway.

Organization of the Golgi

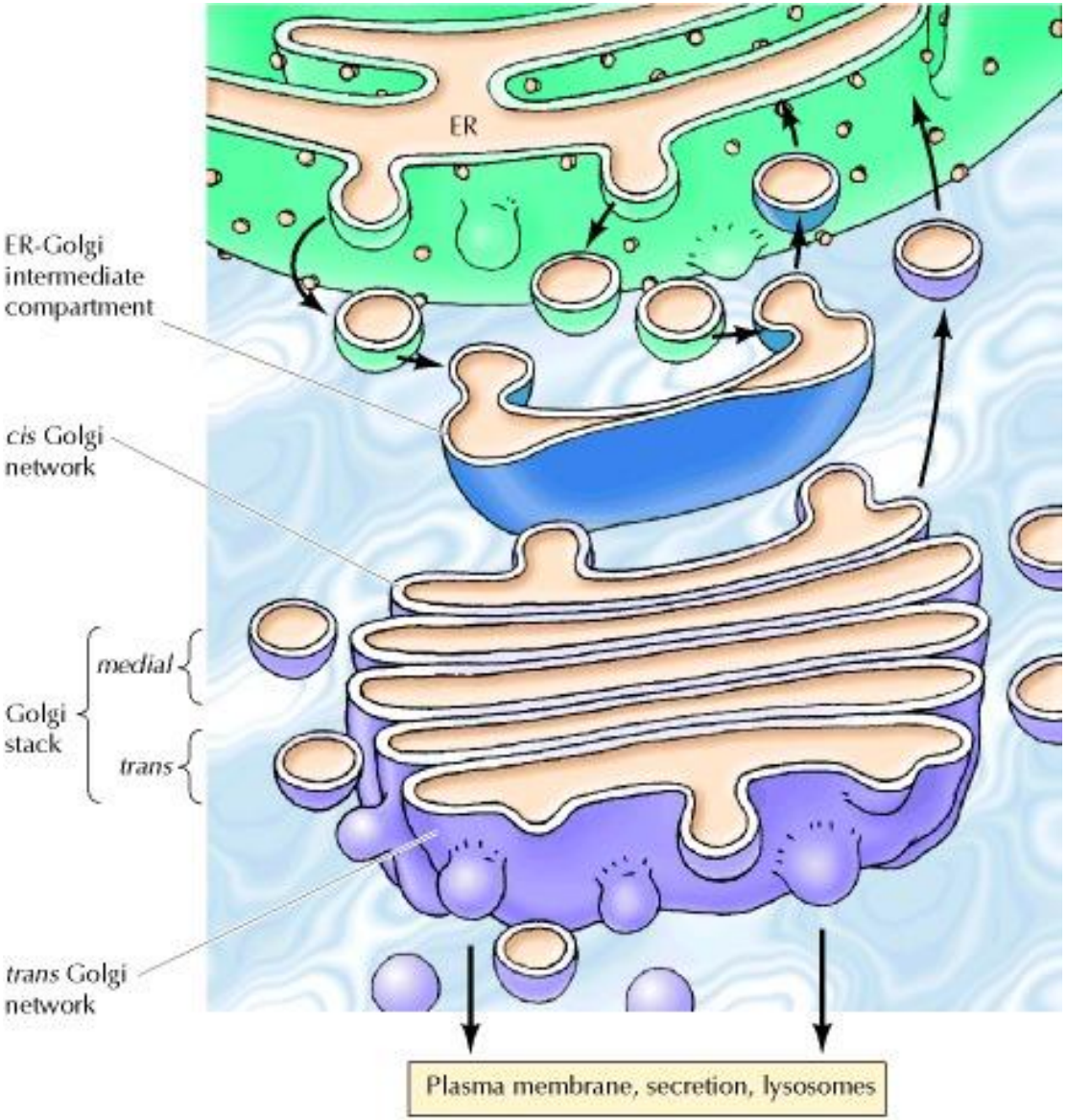
- Morphologically the Golgi is composed of flattened membrane-enclosed sacs (cisternae) and associated vesicles.
- A striking feature of the Golgi apparatus is its distinct polarity in both structure and function.
- Proteins from the ER enter at its *cis* face (entry face), which is convex and usually oriented toward the nucleus.
- They are then transported through the Golgi and exit from its concave *trans* face (exit face).
- As they pass through the Golgi, proteins are modified and sorted for transport to their eventual destinations within the cell.

Golgi Apparatus





- The Golgi is most commonly viewed as consisting of four functionally distinct regions: the ***cis*Golgi network**, the **Golgi stack** (which is divided into the *medial* and *trans* subcompartments), and the ***trans*Golgi network.**
- Proteins from the ER are transported to the ER-Golgi intermediate compartment and then enter the Golgi apparatus at the *cis* Golgi network.
- They then progress to the *medial* and *trans* compartments of the Golgi stack, within which most metabolic activities of the Golgi apparatus take place.
- The modified proteins, lipids, and polysaccharides then move to the *trans* Golgi network, which acts as a sorting and distribution center, directing them to lysosomes, the plasma membrane, or the cell exterior.



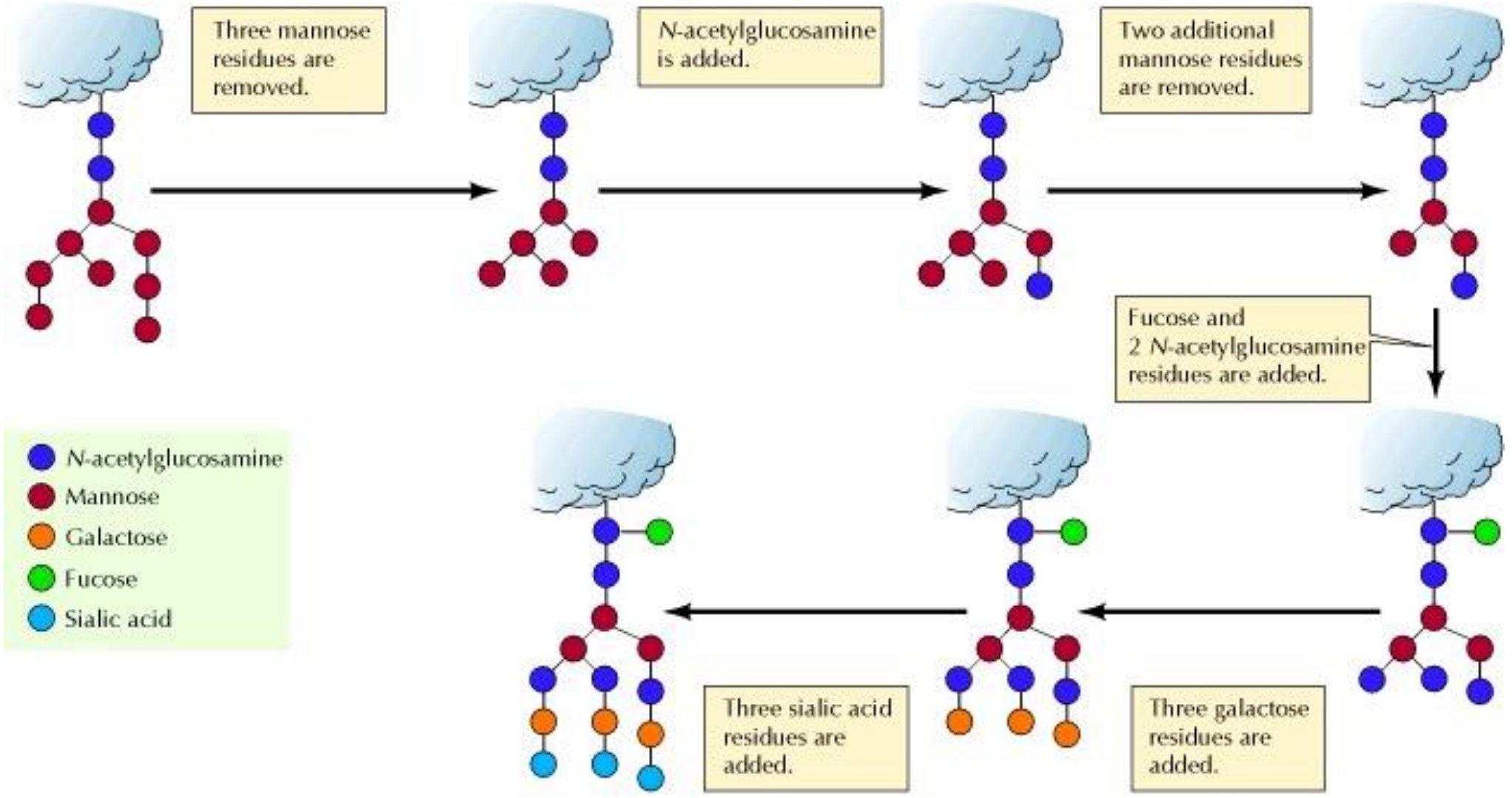
Regions of the Golgi apparatus

Vesicles from the ER fuse to form the ER-Golgi intermediate compartment, and proteins from the ER are then transported to the *cis* Golgi network. Resident ER proteins are returned from the ER-Golgi intermediate compartment and the *cis* Golgi network via the recycling pathway.

The *medial* and *trans* compartments of the Golgi stack correspond to the cisternae in the middle of the Golgi complex and are the sites of most protein modifications. Proteins are then carried to the *trans* Golgi network, where they are sorted for transport to the plasma membrane, secretion, or lysosomes.

Protein Glycosylation within the Golgi

- Protein processing within the Golgi involves the modification and synthesis of the carbohydrate portions of glycoproteins.
- One of the major aspects of this processing is the modification of the *N*-linked oligosaccharides that were added to proteins in the ER.
- *N*-linked oligosaccharides are processed within the Golgi apparatus in an ordered sequence of reactions.
- The first modification of proteins destined for secretion or for the plasma membrane is the
  - removal of three additional mannose residues, followed by the sequential addition of an *N*-acetylglucosamine, the removal of two more mannoses, and the addition of a fucose and two more *N*-acetylglucosamines. Finally, three galactose and three sialic acid residues are added.

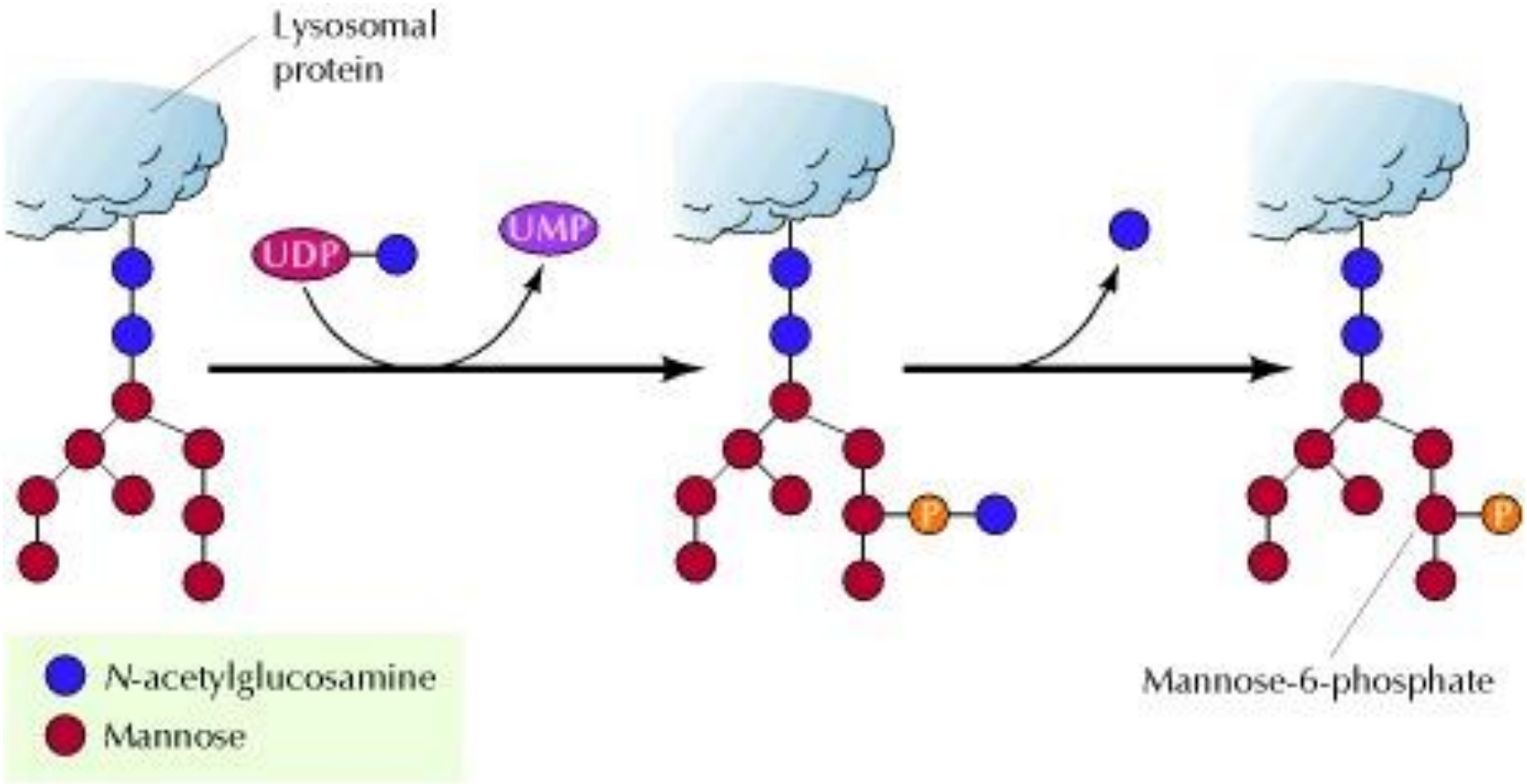


Processing of *N*-linked oligosaccharides in the Golgi

The *N*-linked oligosaccharides of glycoproteins transported from the ER are further modified by an ordered sequence of reactions in the Golgi.

processing of the *N*-linked oligosaccharide of lysosomal proteins

- The processing of the *N*-linked oligosaccharide of lysosomal proteins differs from that of secreted and plasma membrane proteins.
- Rather than the initial removal of three mannose residues, proteins destined for incorporation into lysosomes are modified by mannose phosphorylation.
- In the first step of this reaction, *N*-acetylglucosamine phosphates are added to specific mannose residues, probably while the protein is still in the *cis* Golgi network.
- This is followed by removal of the *N*-acetylglucosamine group, leaving **mannose-6-phosphate** residues on the *N*-linked oligosaccharide. Because of this modification, these residues are not removed during further processing. Instead, these phosphorylated mannose residues are specifically recognized by a mannose-6-phosphate receptor in the *trans* Golgi network, which directs the transport of these proteins to lysosomes.

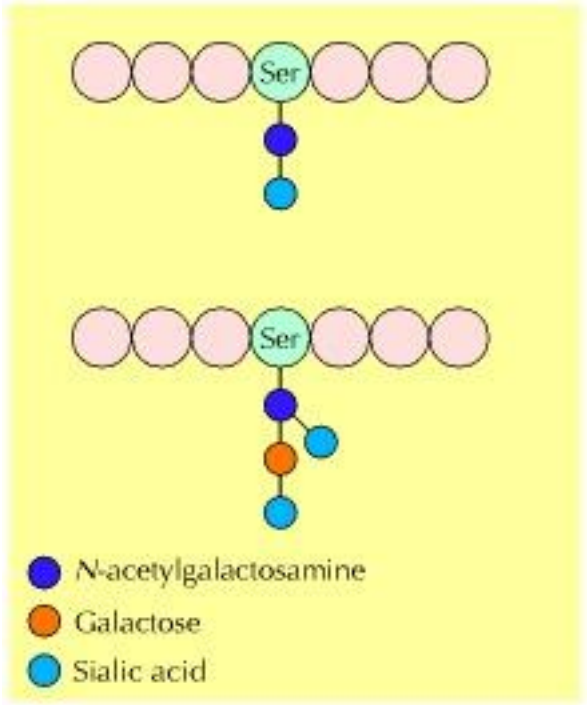


Targeting of lysosomal proteins by phosphorylation of mannose residues

Proteins destined for incorporation into lysosomes are specifically recognized and modified by the addition of phosphate groups to the 6 position of mannose residues. In the first step of the reaction, *N*-acetylglucosamine phosphates are transferred to mannose residues from UDP-*N*-acetylglucosamine. The *N*-acetylglucosamine groups are then removed, leaving mannose-6-phosphates.

O-linked glycosylation

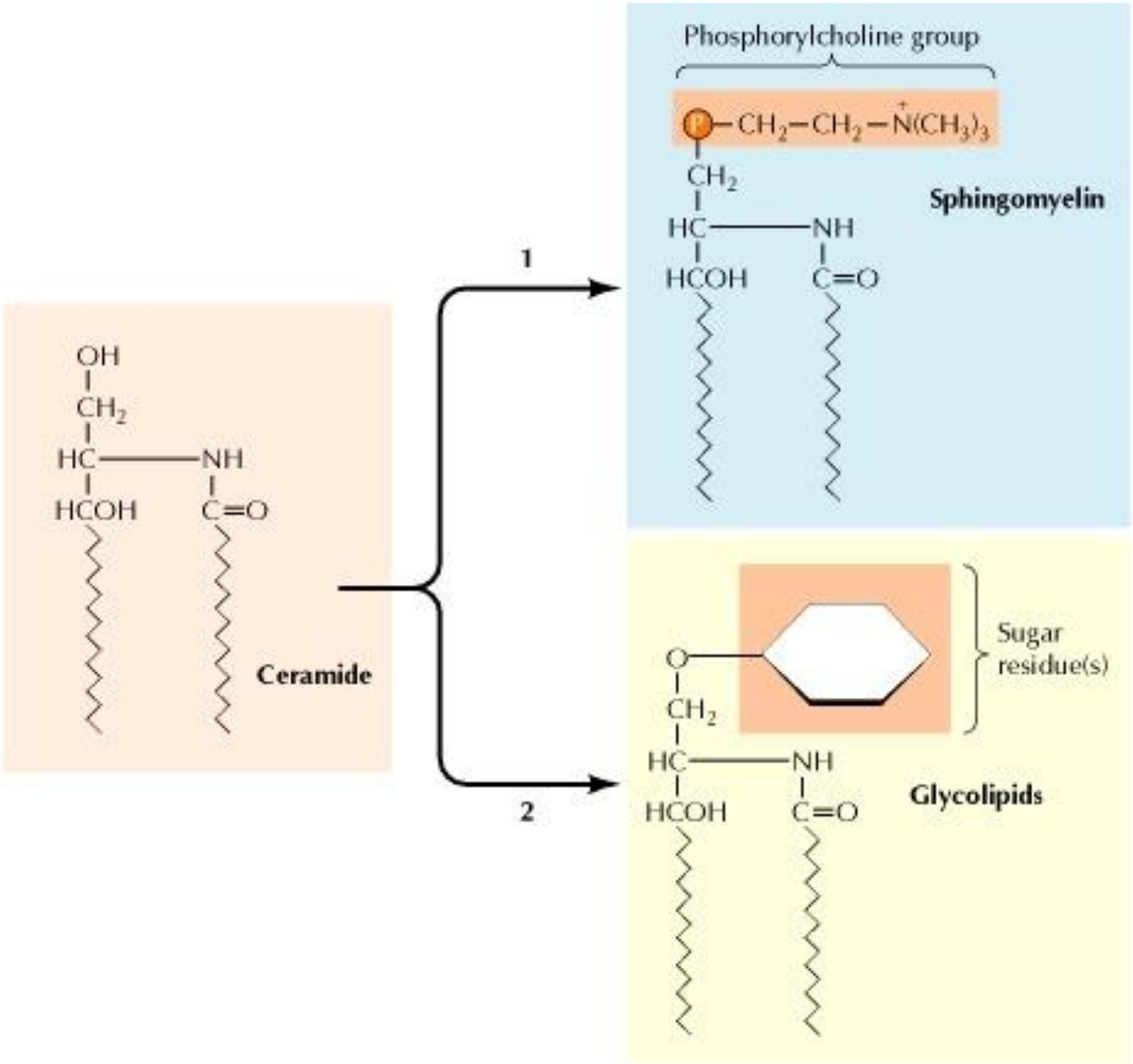
- Proteins can also be modified by the addition of carbohydrates to the side chains of acceptor serine and threonine residues within specific sequences of amino acids (*O*-linked glycosylation).
- These modifications take place in the Golgi apparatus by the sequential addition of single sugar residues. The serine or threonine is usually linked directly to *N*-acetylgalactosamine, to which other sugars can then be added.



Examples of *O*-linked oligosaccharides

O-linked oligosaccharides usually consist of only a few carbohydrate residues, which are added one sugar at a time.

- **Lipid and Polysaccharide Metabolism in the Golgi**
- In addition to its activities in processing and sorting glycoproteins, the Golgi apparatus functions in lipid metabolism—in particular, in the synthesis of glycolipids and sphingomyelin.
- The glycerol phospholipids, cholesterol, and ceramide are synthesized in the ER. Sphingomyelin and glycolipids are then synthesized from ceramide in the Golgi apparatus.
- In plant cells, synthesis of many complex polysaccharides of cell wall takes place in golgi
- In animals most of the glycosaminoglycans of the extracellular matrix are synthesized in the golgi.



Synthesis of sphingomyelin and glycolipids

Ceramide, which is synthesized in the ER, is converted either to sphingomyelin (a phospholipid) or to glycolipids in the Golgi apparatus. In the first reaction, a phosphorylcholine group is transferred from phosphatidylcholine to ceramide. Alternatively, a variety of different glycolipids can be synthesized by the addition of one or more sugar residues (e.g., glucose).