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Basic Concept of Cell: A Narrative Review

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A B S T R A C T

All body functions depend on cell integrity. Therefore, understanding cell biology is intrinsically important for understanding disease. A vast amount of information reveals how the cell behaves like an organism with many social cells. At the heart of cell biology is cell communication—how messages originate and are transmitted, received, interpreted, and used by cells. This efficient communication between, and within the cell maintains the function of the cell and its specialization. Intercellular signals enable each cell to determine its position and specific role. Cells must demonstrate a "chemical preference" for other cells and the environment that surrounds them to maintain the integrity of the whole organism. When they no longer tolerate this preference, the conversation ends and the cell adapts (sometimes changes in function) or becomes vulnerable to isolation, injury, illness, or even death. This review explains the function of each component in the cell and its role in life.

1. Introduction

Living cells are generally divided into two broad classes—eukaryotes and prokaryotes. Cells in higher animals and plants are eukaryotes, as are single-cell organisms, fungi, protozoa, and most algae. Prokaryotes include cyanobacteria (blue-green algae), bacteria, and rickettsia. Prokaryotes were studied as a core subject of molecular biology. The current suppression lies in eukaryotic cells; many of their structures and functions have no counterpart in bacterial cells.

Eukaryotes (*eu* = good; *karyon* = nucleus; also spelled "eukaryotes") are broader and have broader intracellular anatomy and organization than prokaryotes. Eukaryotic cells have characteristic membrane-bound intracellular compartments, called *organelles*, which include a well-defined nucleus. Prokaryotes do not have organelles, and their nuclear material is not enclosed by a nuclear membrane. Prokaryotic cells are characterized by a distinct lack of a nucleus.[1,2]

Apart from having structural differences, prokaryotic and eukaryotic cells differ in their chemical composition and biochemical activity. The nuclei of prokaryotic cells carry genetic information in a single circular chromosome, and they lack a class of proteins called *histones*, which in eukaryotic cells bind to deoxyribonucleic acid (DNA) and are involved in the *supercoiling* of DNA (figure 1). We now understand that the *loops* and *coils* of DNA are important for many diseases. Eukaryotic cells have several chromosomes. Protein production, or synthesis, in the two classes of cells also differs due to major structural differences in ribonucleic acid (RNA)—the protein complex. Other differences include differences in transport

mechanisms across the outer cell membrane and differences in enzyme content.[3]

Functions of cells

Cells become specialized through the process of differentiation, or maturation so that some cells eventually perform one function and other cells perform another. cells with well-developed functions, such as migration, often lack other functions, such as hormone production, which are more developed in some other specialized cell types.[1,4]

The eight main functions of cells are transport, conductivity, metabolic absorption, secretion, excretion, respiration, reproduction, and communication. Muscle cells can produce forces that cause movement. Muscles attached to bones move the limbs, whereas those that cover hollow organs or cavities move or empty the contents of organs when they contract. For example, contraction of smooth muscle cells surrounding blood vessels changes the diameter of blood vessels; bladder wall muscle contractions produce urine. Conduction in response to a stimulus is characterized by an excitation wave, an electric potential that travels through the cell surface to reach its interior. Conductivity is the main function of nerve cells.[5]

All cells take in and use nutrients and other substances from their surroundings. Cells in the intestines and kidneys are specialized to absorb out. Cells in the renal tubules reabsorb fluid and synthesize protein. Intestinal epithelial cells reabsorb fluids and synthesize protein enzymes. Certain cells, such as mucous gland cells, can produce new substances from the substances they absorb and then secrete these new substances for delivery to those in need. Adrenal gland cells, testes, and ovaries can secrete steroid hormones.

All cells can rid themselves of the waste products of the metabolic breakdown of nutrients. The membrane-bound sacs (lysosomes) in cells contain enzymes that break down, or digest, large molecules, turning them into waste products that are released from the cell. Cells absorb oxygen, which is used for the transformation of nutrients into energy in the form of ATP. Cellular respiration, or oxidation, occurs in organelles called mitochondria.

Tissue growth occurs when cells enlarge and reproduce. Even without growth, tissue maintenance requires new cells to be produced to replace cells that are naturally lost through cell death. Not all cells are capable of dividing continuously. Communication is very important for cells to survive in the cell environment. Pancreatic cells, for example, secrete and release insulin, which is important for signaling muscle cells to absorb sugar from the blood for energy. Constant communication enables the maintenance of a stable dynamic state.

Structure and function of cell components

Figure 1 shows a typical eukaryotic cell. It consists of 3 components: an outer membrane called the plasma membrane, or plasmalemma; contains a fluid called cytoplasm; and intracellular organs, or organelles, that are membrane-bound and encompass the nucleus. Researchers have been astonished by the development of microscopes and computer software that enable resolution down to the nanoscale—cells come alive with a more visible molecular world. Understanding structure and function will reveal, for example, how cells respond to mechanical forces or the coupling of different patterns of gene expression. The overall impact on biology is extraordinary.

The nucleus

The nucleus which is surrounded by cytoplasm and generally located in the center of the cell, is the largest membrane-bound organelle. Two flexible membranes cover the nuclear envelope (figure 2A*).* The nuclear envelope appears pockmarked with holes, called nuclear fissures, in which the nuclear fissure complex (NPC) is located in positions that allow molecules to move between the nucleus and the cytosol (figures 2, A, B, and D*).* The outer membrane continues to become the membrane of the endoplasmic reticulum (Figure 1). The inner membrane covers the nucleus. The nucleus contains

the nucleolus, a small, dense structure composed of mostly RNA; most of the cell's DNA; and DNA-bound proteins, histones, which regulate their action. The DNA chain in eukaryotic cells is so extensive that the risk of damage is high. Therefore, histone binding to DNA causes DNA to fold into chromosomes (figure 2, C). Packaging of DNA into strong chromosomes is important for cell division in eukaryotes.[6]

The main function of the nucleus is cell division and control of genetic information. Other functions include DNA replication and repair and transcription of the information stored in DNA. Genetic information is transcribed into RNA, which can be processed into messenger, transport, and ribosomal RNA and introduced into the cytoplasm, where it directs cellular activity. Most of the formation of RNA takes place in the nucleolus.

Cytoplasmic organelles

The cytoplasm is the aqueous (cytosol) fluid that fills the cytoplasmic matrix—the space between the nuclear envelope and the plasma membrane. The cytosol represents about half the volume of eukaryotic cells. It contains millions of enzymes involved and an intermediate metabolism and is jam-packed with protein-producing ribosomes. The cytosol is a major part of protein synthesis and degradation. Newly formed proteins remain in the cytosol if signals for transport to cell organelles are lacking. Organelles suspended in the cytoplasm are enclosed in a biological membrane, which enables them to perform functions that require different biochemical environments simultaneously. These functions, most of which are directly encoded by messages carried from the nucleus by RNA, include protein and hormone synthesis and transport out of the cell, isolation, and elimination of waste products from cells, metabolic processes, breakdown and removal of cell debris and foreign proteins (antigens), and maintenance of cell structure and motility. Also, the cytosol functions as a storage unit for fats, carbohydrates, and secretory vesicles.[7]

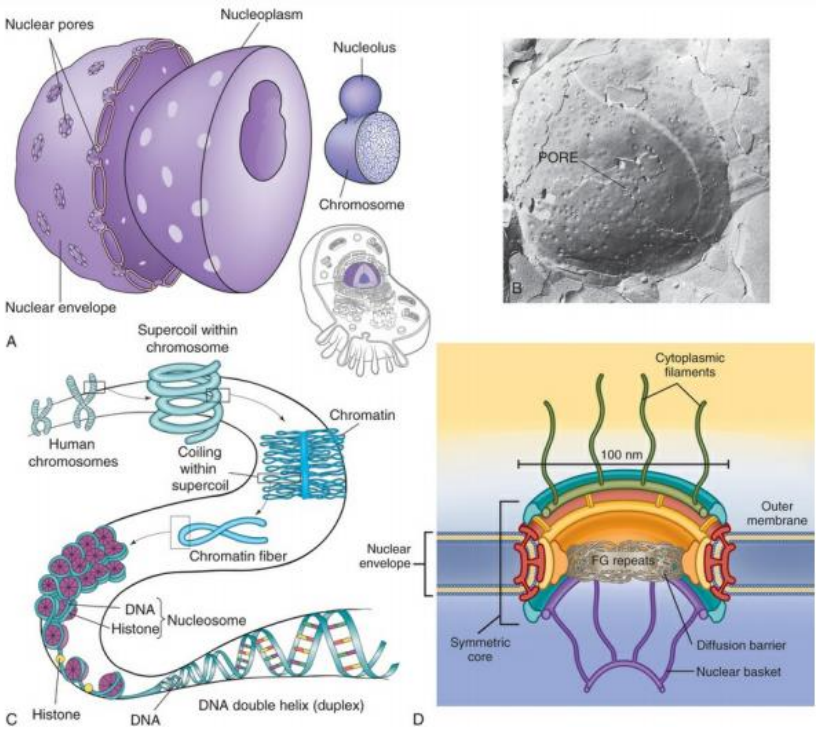

Figure 1. Nucleus. The nucleus consists of a double membrane, called the nuclear envelope, which covers a fluid-filled interior, called the nucleoplasm. Chromosomes hang in the nucleoplasm (illustrated here larger than their actual size to show dense strands of DNA). Swelling at one or more points on the chromosome, shown in figure A, occurs in the nucleolus where genes are multiplied into RNA. The nuclear envelope has gaps. B, the cracks look like dimples in the frozen etching of the nuclear envelope. C, histone-folded DNA on the chromosome. D, Nuclear cleft complex.

Ribosomes

Ribosomes are protein-RNA (nucleoprotein) complexes synthesized in the nucleolus and secreted into the cytoplasm through gaps from the nuclear envelope called nuclear cleft complexes (NPCs). These tiny ribosomes can float freely in the cytoplasm or bind themselves to the outer membrane of the endoplasmic reticulum (Figure 1A). Their main function is to provide passage for cellular protein synthesis. Newly formed ribosomes synthesize a "recognition strand," or signals, such as an address or letter. Signal recognition particles (SRP) in the cytosol bind to the ribosome after recognizing SRP. Ribophorin, a receiving protein found on the hard part of the endoplasmic reticulum (ER), acts as the "address" or binding site. The developing protein passes through the ER membrane into the lumen. The SRP is removed and the new protein chain is folded into its final conformation.[8]

Endoplasmic reticulum

The Endoplasmic Reticulum (ER) (endo = inside; plasma = cytoplasm; reticulum = tissue) is a membrane factory specialized in the synthesis and transport of proteins and lipid components of most cells organelles. It has a network of tubular or sac-like channels (sisterna) that extend through the cytoplasm and continue into the outer membrane of the nucleus (figure 3). The folded membrane surrounding the cisternae of the endoplasmic reticulum may be hard (granular) or smooth (agranular). The hard endoplasmic reticulum (rER) is tough because of the ribosomes and ribonucleoprotein particles bound to it (figure 3). Some of the proteins synthesized by these ribosomes remain in the ER, and others are used to build the membranes of other organelles (Golgi complex, lysosomes, peroxisomes, and nucleus) and the cell itself. The ER must be responsible for various cell protein synthesis and folding, and a new role for the ER is to recognize the presence of cellular stress. Understanding the mechanisms of cellular stress will aid in the diagnosis and management of the disease.[9]

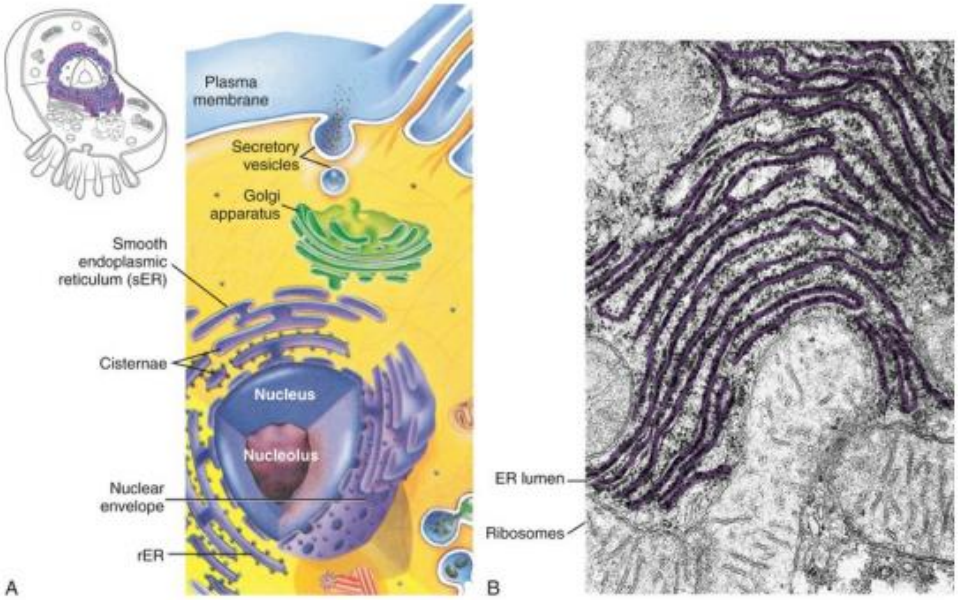

Figure 2. Endoplasmic Reticulum (ER). A, ER consists of rough ER (rER) composed of ribosomes wrapped in cisternae and vesicles of smooth ER (sER). B, Electron micrograph of rough and smooth ER.

The endoplasmic reticulum, protein folding, and ER stress

Protein folds in the ER are important to us. Like biology, proteins perform vital functions in every cell. To do this work, proteins must fold into complex three-dimensional structures (figure 3). Most secreted proteins are folded and modified in an error-free fashion, but ER or cell stress, mutation, or random errors during protein synthesis (stochastic) can reduce the number of folds or the ratio of folds. Pathophysiological processes, such as viral infection, environmental toxins, and expression of mutant proteins, can disrupt the sensitive ER environment.[9]

Natural processes can also disrupt the environment, such as the formation of large proteins that take up space in the ER. This disorder causes the accumulation of immature and abnormal cellular proteins, triggering ER stress. Fortunately, the ER has several safe ways to aid the folding process, for example, similar proteins called chaperones that facilitate the folding process and prevent the formation of out-of-travel types. Because specialized cells produce large amounts of secretory proteins, the movement or spike through the ER is severe. Therefore, unrepaired misfolded proteins in the ER are observed in several diseases and are capable of initiating apoptosis or cell death. It has been recognized recently that the endoplasmic reticulum mediates intracellular signaling pathways in response to accumulation and misfolded or misfolded proteins; This adaptive pathway is known as the unfolded protein response (UPR). Observers are studying inflammation associated with the UPR and how the UPR is multiplied by inflammation in disease. Certain diseases such as Alzheimer's, Parkinson's, Prions, amyotrophic lateral sclerosis, DM, and sepsis. Another thing that is being studied is ER stress and how it accelerates age-related cellular dysfunction. Overall, the ER is the main organelle for protein quality control.

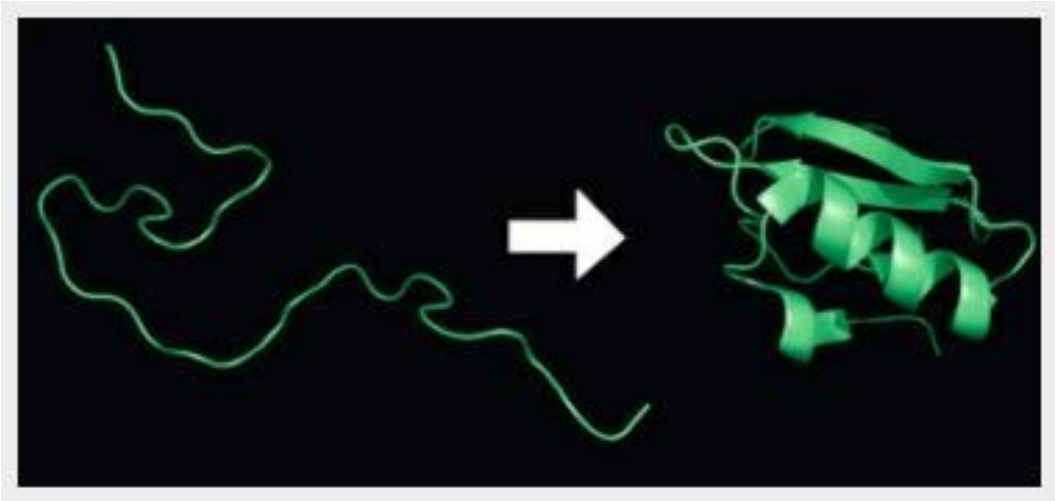

Figure 3. 3-dimensional folding structure of the RE.

Folding proteins

Each protein exists as an unfolded polypeptide (left) or random coils after translation from mRNA strands into straight chains of amino acids. From amino acids and then interacting with each other, they produce the three-dimensional structure called the folded protein (right) from which it is derived.

The smooth endoplasmic reticulum (sER) has no ribosomes or ribonucleoprotein particles (figure 1). Presumably, the membrane surface of the smooth endoplasmic reticulum contains enzymes that are involved in the synthesis of steroid hormones and are responsible for various reactions required to remove toxic substances from cells. The endoplasmic reticulum communicates with the Golgi complex and interacts with other organelles, especially lysosomes and peroxisomes.

Golgi complex

The Golgi complex or Golgi Apparatus is a network of flat, smooth membranes and vesicles that are often located in the cell nucleus (figure 4). Proteins from the ER are processed and packaged into tiny membrane-bound pouches or vesicles called secretory vesicles, which collect in the last membrane folds of the Golgi complex—called cisternae (like stacks of pita bread). Secretory vesicles then disintegrate from the Goli bodies and migrate to several intracellular and extracellular destinations, including the plasma membrane. The vesicles fuse with the plasma membrane, and their contents are released from the cell. The best-known vesicles are those that have a coat and make the protein clathrine extensively and are called clathrine vesicles. They sprout from the Golgi complex in the outer secretory pathway and the plasma membrane in the inner endocytic pathway. Newly formed proteins by the ER are carried from the Golgi network to the endosome by clathrine-coat vesicle transport before being processed into lysosomes. Many molecules, including lipids, proteins, glycoproteins, and enzymes from lysosomes, cross the Golgi complex through several stages in their maturation. The Golgi complex is a refining plant and directs traffic (e.g. protein molecules, polynucleotides, polysaccharides) in cells (figure 5).[10,11]

Lysosomes

Lysosomes (lyso = dissolution; soma = body) are membrane-enclosed organelles (such as pouches) filled with enzymes that digest macromolecules and kill intracellular organelles and particles that are ingested from outside the cell by endocytosis (figure 1A). They contain more than 60 digestive enzymes called hydrolases, which catalyze the bonding in proteins, lipids, nucleic acids, and carbohydrates. Hydrolases function optimally at acidic pH. Lysosomes function as an intracellular digestive system (figure 6, A). Lysosomal enzymes can completely digest most cellular elements into their basic components, such as amino acids, nucleotides, and carbohydrates. Transport proteins in the lysosomal membrane carry these final components to the cytosol where the cell can reuse them or dispose of them. Recent data have changed the view that lysosomes are not only litter boxes and recycling agents but evoke a central role of lysosomes in nutrient-dependent signal transduction for cellular adaptation.

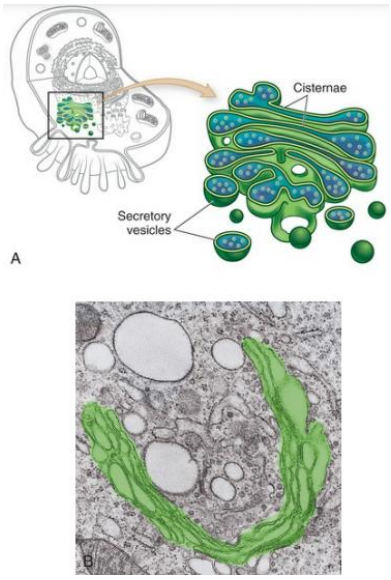

Figure 4. Golgi apparatus. A Schematic representation of the Golgi apparatus showing stacks of flat pouches, or cisternae, and several tiny membrane balls, or secretory vesicles. B, Transmission electron micrograph showing the Golgi Bodies highlighted in color.

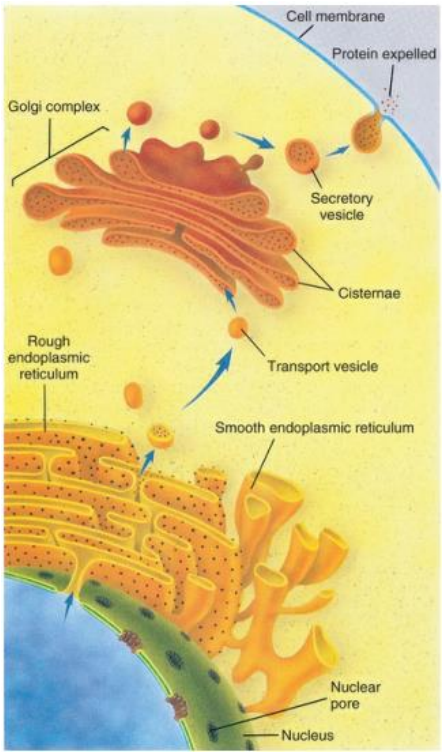

Figure 5. How is the Internal Membrane System of a Protein Cell Pile for Export? Instructions for making proteins intended for export out of cells, such as digestive enzymes made by pancreatic cells, are first transcribed from DNA by RNA in the nucleus. The RNA then leaves the nucleus through the nuclear gap and is processed towards the ribosome site in the rough ER. There, it provides instructions for the proper sequence of a mino acids for the synthesis of specific digestive enzymes. When enzyme synthesis is complete, the enzyme travels across the ER and is encapsulated in a transport vesicle. Transport vesicles fuse with Golgi bodies, releasing enzymes. In the Golgi complex, the enzymes are further modified and then blocked towards flat stacks or cisternae. There, enzymes wait for secretory vesicles, which will carry them out toward the cell's perimeter, the cell membrane. The secretory vesicle membrane then fuses with the cell membrane, and enzymes are released out of the cell.

This recent finding of signaling function cooperates with the known degradative role of lysosomes to mediate basic cellular functions, such as metabolic adaptation of nutrient taste, and control of protein and organelle quality. The transcriptional complex program controls the synthesis, composition, and quantity of lysosomes and regulates their work to match the evolving needs of the cell. These changes in essential functions are central to the pathophysiology of a wide range of conditions and include storage disease, neurodegenerative disease, and cancer. Lysosomes maintain cellular health due to efficient removal of cellular toxic components, removal of useless organelles, termination of signal transduction, and maintenance of metabolic balance. Aging can lead to a progressive loss of lysosomal efficiency and decreased regenerating capacity of organs and tissues. Lysosomes are the signaling key of sophisticated networks for cellular adaptation, and these networks include ion and nutrient transporters, protein kinases and phosphatases, and transcription factors and transcriptional regulators. Together, these components integrate functions, such as nutrient abundance, energy levels, and cell stressors, and translate them into instructions that regulate cellular metabolism leading to either proliferation or inactivation. The signaling function has far-reaching implications for metabolic regulation in health and disease.

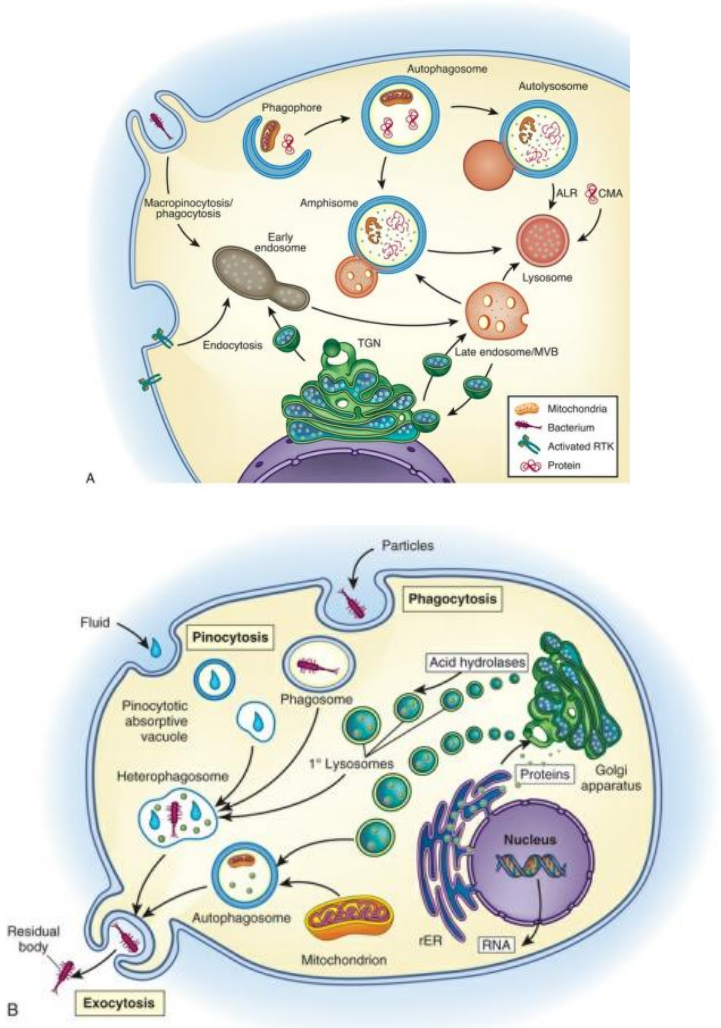

Figure 6. The Endolysosomal System and Four Pathways for Degradation in Lysosomes. An Endolysosomal system. B, Four pathways for degradation in lysosomes, and in all of these pathways the final step is lysosomal fusion.

The lysosomal membrane acts as a protective shield between the powerful digestive enzymes in the lysosomes and the cytoplasm, preventing their leakage into the cytoplasmic matrix. Membrane damage by various medications or cellular injury triggers the release of lysosomal enzymes, which can then react with their specific substrates, leading to their digestion by the cell. Lysosomal abnormalities are implicated in several conditions involving cellular injury and death.[12]

Lysosomal storage disease (LSD) may be the result of a genetic defect or deficiency of one or more lysosomal enzymes.[13] For example, lysosomal -1,4-glucosidase deficiency triggers the accumulation of glycogen in lysosomes known as Pompe's disease. Tay-Sachs disease is characterized by the accumulation of ganglioside GM2 (a lipid) in lysosomes as a result of deficiency or absence of lysosomal hexosaminidase A. In gout, undigested uric acid accumulates in lysosomes, damaging the lysosomal membrane. Continued enzyme leakage results in cell death and tissue injury. The four lysosomal degradation pathways include endocytosis, phagocytosis, macropinocytosis, and autophagy (figure 7A).

Endocytosis is the uptake of macromolecules from the extracellular fluid; phagocytosis is the process of engulfing large particles or microorganisms in phagocytic cells, such as macrophages or neutrophils; macropinocytosis is the nonspecific uptake of fluids, membranes, and particles bound to the plasma

membrane; and autophagy (self-eating) begins in the cytosol and is used to digest ineffective cytosol and organelles. The extracellular substance is taken up into the cell and enclosed in a membrane-bound vesicle (see discussion on endocytosis). Lysosomes fuse with vesicles to form digestive vacuoles. Lysosomes remain fully active by maintaining a low internal pH. They do this by pumping hydrogen ions into their interior. Hydrolytic enzymes are only maximally active at acidic pH. Inactive lysosomes do not maintain such an internal acidic pH. Lysosomes in this "survival pattern" are called primary lysosomes. When primary lysosomes fuse with vacuoles or other organelles, their pH decreases, and hydrolytic enzymes are activated. When active, they are called secondary lysosomes, or heterophagosomes (figure 6B).[12,13]

As cells complete their lifespan and die, lysosomes digest the resulting debris or worn-out parts by autophagy. Lysosomes involved in this process, called autodigestion, are also called autolysosomes, or autophagosomes (figures 7, A, and B). In living cells, cellular debris is enclosed in vesicles which react with lysosomes to complete their degradation. Autophagy promotes balance as it is involved in continuous biosynthesis and cell turnover. Therefore, autophagy plays an important role in health. Defects in autophagy can challenge the removal mechanisms of microbial disposal, aggregation of unnecessary proteins, and abnormal proteins, resulting in contributions to disease from infectious disorders to neurodegeneration and cancer.

The products of autophagy (and phagocytosis) exit the lysosomes and are reused by the cell. Undigested material is stored in vesicles called residue bodies, the contents of which are actively removed from the cell (figure 7). High concentrations of lipids can accumulate in residual bodies and remain there for a long time. Lipids are finally oxidized, and pigmented substances dependent on polyunsaturated fatty acids and proteins accumulate in the cells. This pigmented substance, called lipofuscin, is often called the “age pigment” or “age spot”, and is known in older individuals.

Peroxisomes

Peroxisomes (microbodies) are membrane-bound organelles that contain several oxidative enzymes such as catalase and urate oxidase. These oxidative enzymes can detoxify compounds and fatty acids. Similar to lysosomes under a microscope, peroxisomes are larger and oval or irregular in shape. Like mitochondria, peroxisomes are a major part of using oxygen. Peroxisomes are so named because they usually contain enzymes that use oxygen to remove hydrogen atoms from specific substrates in an oxidation reaction that produces hydrogen peroxide (H_2O_2). Hydrogen peroxide is a strong oxidant, potentially devastating if it accumulates or escapes from peroxisomes. Catalase, an antioxidant enzyme, uses H_2O_2 for the oxidation of various other substrates—phenol, formic acid, formaldehyde, and alcohols—by a peroxidative reaction:

$$H_2O_2 + R^1H_2 \rightarrow R^1 + 2H_2O$$

Thus, the solution of H_2O_2 produces H_2O and O_2. Peroxisomes also have an important role in the synthesis of specialized phospholipids that are important for myelination of nerve cells. Such reactions are important in the detoxification of various wastes in the cell or foreign components that enter the cell, such as ethanol. Damage to peroxisomes can lead to disease.

Mitochondria

Mitochondria (mito = woven; chondros = granules), organelles found in large numbers in most cells, are responsible for cellular respiration and energy production. These cytoplasmic organelles appear as balls, rods, or fibrous bodies bound by a double membrane (figure 7). The outer membrane is smooth and surrounded by the mitochondria itself; the inner membrane is coiled within the mitochondrial matrix to form partitions called cristae. The inner membrane

contains enzymes for the respiratory chain—the name given to the electron transport chain. This enzyme is important in the process of oxidative phosphorylation that produces most of the cell's ATP. Metabolic pathways involve the metabolism of carbohydrates, lipids, and amino acids, and special pathways involving urea and heme synthesis are located in the mitochondrial matrix.[14]

The outer membrane is permeable to many substances, but the inner membrane is highly selective and contains many transport systems between membranes. The inner membrane contains a transporter to electrically move calcium (calcium ions). Mitochondria have their DNA that codes for the enzymes required for oxidative phosphorylation.

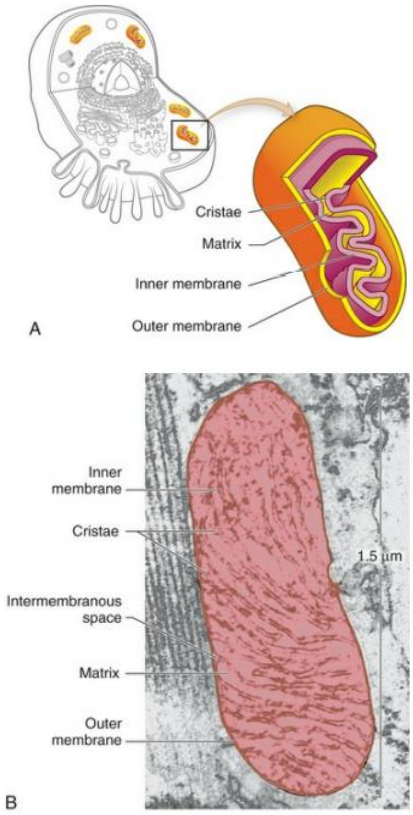

Figure 7. Mitochondrion. A Sectional sketch showing the outer and inner membranes. Note that there are many folds (crista) of the inner membrane. B, Transmission electron micrograph of the mitochondria. Although some mitochondria have a capsule shape shown here, most are round or oval.

Cytosol

The cytosol is the gelatinous, semi-liquid portion of the cytoplasm which accounts for about 55% of the total cell volume. Cytosol functions include intermediate metabolism involving enzymatic biochemical reactions; ribosomal protein synthesis; and storage of carbohydrates, fats, and secretory vesicles.

Intermediate metabolism refers to the intracellular chemical reactions that involve the synthesis, degradation, and transformation of small organic molecules (e.g. simple sugars, fatty acids, and amino acids). All of these intermediate metabolisms occur in the cytoplasm or the interior of the cell that is not occupied by the nucleus—with most of the metabolism occurring in the cytosol. These reactions enable energy to be used to maintain cellular activity and provide substrates for maintaining cell integrity. Ribosomal protein synthesis takes place on free ribosomes in the cytosol. Cytosolic ribosomes that synthesize identical proteins are collected in “factories” known as polyribosomes.[3]

Excess stored nutrients that are not immediately used for ATP production are converted in the cytosol into stored forms; for example, excess glucose is stored as glycogen. These temporary masses are known as inclusions. Secretory vesicles processed and packaged by the ER and the Golgi complex also persist in the cytosol. By signaling, vesicles transport and empty their contents of the cell.

Cytoskeleton

All eukaryotic cells contain a complex and specialized internal structure in the cytosol that provides the "muscle and bone" of the cell—the cytoskeleton. The cytoskeleton maintains the cell's shape and internal organization and permits the movement of substances within the cell and the movement of external projections (cilia or microvilli; flagella in sperm) out of the plasma membrane. The internal skeleton is composed of a network of protein filaments; The three main types of filaments include actin filaments, microtubules, and intermediate filaments. These filaments collectively promote cell strength, shape, and movement.[3,4]

By translating mechanical forces and deformations into biochemical signals, cells sense their physical environment including the extracellular matrix, neighboring cells, and physical stress. The cytoskeleton is involved with the extracellular matrix and the interior of the nucleus in the transmission of forces (mechanical forces) called mechanotransduction. Mechanotransduction describes the cellular processes that translate mechanical stimuli into biochemical signals, enabling cells to adapt to their surroundings. Cell tearing, however, involves the adaptation of mechanotransduction and is associated with several changes and diseases including hearing loss, cardiovascular disease, muscular dystrophy, and cancer.

Microtubules are small, hollow, cylindrical, unbranched tubules made of protein. When found together, microtubules exhibit rigidity, unlike the rest of the cytoplasm. The microtubules then add strength to the cell structure (figures 8A and B). Within the cell, microtubules support and move organelles from one part of the cytoplasm to another, facilitate the transport of impulses along with the nerve cell, and have roles in inflammatory and immune responses and hormone secretion (figure 8C). Microtubules are also involved in the external movement, or motility, of some cells.

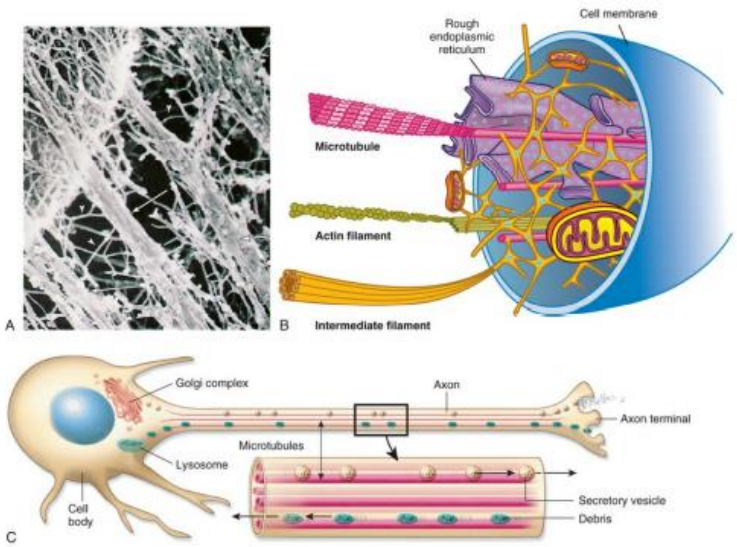

Figure 8. Cytoskeleton. A, Electron micrograph of the inner frame of a cell. The arrowheads mark the intermediate filaments, and the intact arrowheads mark the microtubules. B, Artist's interpretation of the frame in the cell. Note that ribosomes are "free" and other organelles are not completely free. C, Microtubules are important for maintaining asymmetrical cell shapes, such as in nerve cells. In addition, specific chemicals are released at the ends of the axon terminals to influence neural transmission.

Microtubules are arranged in a thick base, or ground body, of a protrusion of the cell's plasma membrane. This arrangement occurs in the base bodies of the sperm flagella and the cilia of certain other cells. Long, whip-like flagella are capable of moving sperm cells. Cilia normally move substances through the cell, which remains stationary. For example, the cilia in cells along the respiratory tract move together to “push” mucus toward the throat so that it can be expelled through coughing.

While the cell is not dividing, only a few microtubules are assembled; cell division (mitosis) or cell defense (phagocytosis) also do, however, induce an immediate cycle of assembly and destruction. Microtubules involved in cell division are arranged in centrioles. Centrioles are always composed of nine groups of three microtubules each. During division, the centriole pairs separate and migrate to the opposite side of the cell.

Actin filaments (microfilaments) These are smaller fibrils that usually occur in clusters rather than as singular forms (Figure 9B). They are concentrated in the cortex of the cell, just below the plasma membrane. The actin cortical tissue is the primary driver for many cell functions including cell movement, endocytosis, and maintaining cell and tissue shape. Actin filaments connect the interior of the cell to bring the cell closer together through cell junctions.

In addition, microfilaments are important in the regulation of cell growth and promote the pinching of one cell in two. Cellular locomotion relies on contractile properties involving both microtubules and actin filaments. The actin cytoskeleton of motile cells has recently been described as an “excitation wave” that might explain the spontaneous migration of cells.

The intermediate filament is a braided, cable car-like fiber made of several protein filaments. The different filaments form a web called the nuclear lamina under the inner nuclear membrane, providing a protective space for the cell's DNA. The other forms cross the cytoplasm, providing mechanical strength. In epithelial tissue, these filaments bridge the cytoplasm from one cell to another, supporting and strengthening the epithelial layer.

Plasma membrane

Membrane means the boundary of the cell. Whether they surround the cell or enclose intracellular organelles, membranes are crucial for normal physiological function because they control the composition of the spaces, or compartments, they cover. They can expel a wide variety of molecules, and because of their selective transport system, they can move molecules into or out of spaces (figure 10). By controlling the movement of substances from one compartment to another, membranes exert a strong influence on metabolic pathways. Direct transport is facilitated by polarized domains, distinct apical and basolateral domains. The direction of the cell-cell polarity—maintains normal cell and tissue structure for a variety of functions, the most important of which is the transport of nutrients into and out of cells, and is altered by diseases such as cancer (figure 11). In addition to this function, the plasma membrane has an important role in cell-to-cell recognition. For example, protein receptors for hormones and other chemical signals are bound to membranes and act as markers that recognize cells from their neighbors. Other functions of the plasma membrane include assisting with cellular mobility and maintaining cell shape.

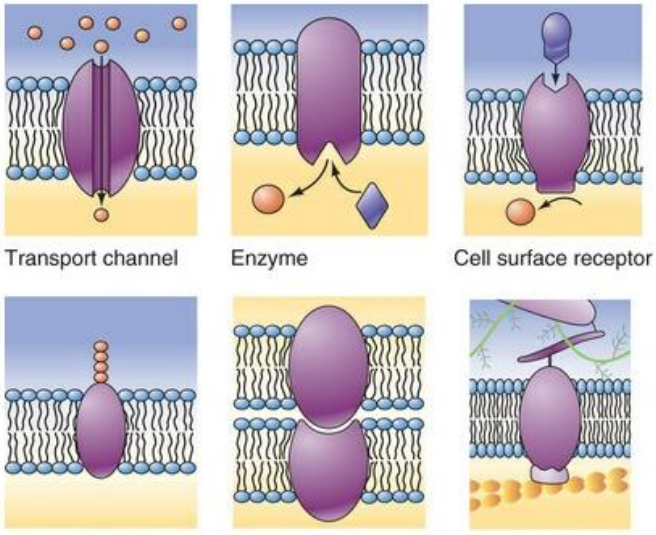

Figure 9. Functions of Plasma Membrane Proteins. The plasma membrane proteins illustrated here show the various functions performed by different types of plasma membranes.

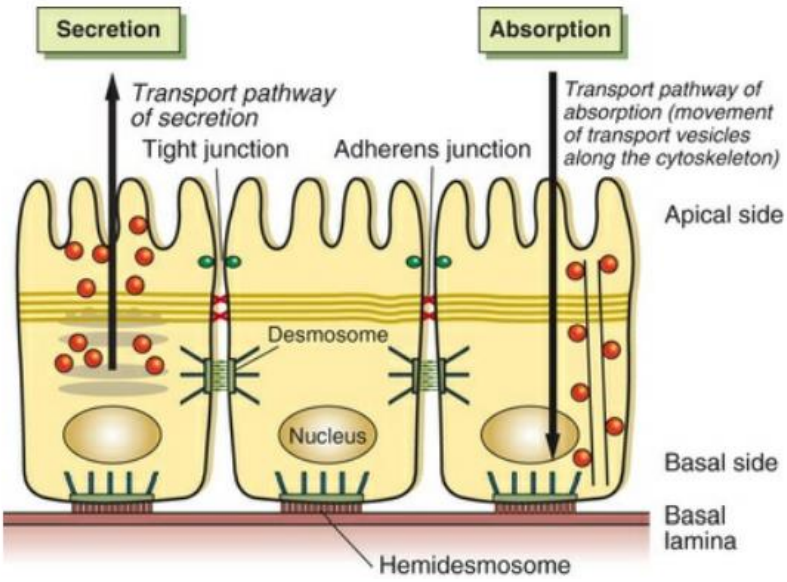

Figure 10. The polarity of Epithelial Cells. A schematic cell polarity (cell direction) of an epithelial cell. Above are directions from the base side and the apical side. Organelles and the cytoskeleton are also arranged directly to be capable of, for example, cellular secretion and absorption in intestinal cells. The red circle represents the contents of the cell.

2. Conclusion

Understanding cell biology is intrinsically important for understanding disease. At the heart of cell biology is cell communication—how messages originate and are transmitted, received, interpreted, and used by cells. Each cell undergoes a process of differentiation, or maturation so that one cell eventually performs one function and another performs another.

3. References

1. Misteli T. The concept of self-organization in cellular architecture. J Cell Biol. 2001; 155(2): 181-6.

2. Thery M, Bornens M. Cell adhesion guides cell polarity. Med Sci (Paris). 2007; 23(3):230-2.
3. Morre DJ, Mollenhauer HH. Microscopic morphology and the origins of the membrane maturation model of Golgi apparatus function. Int Rev Cytol. 2007; 262:191-218.
4. Kadzik RS, Homa KE, Kovar DR. Actin cytoskeleton network self-organization through competition and cooperation. Annu Rev Cell Dev Biol.2021; 36:35-60.
5. Pearce S, Perez-Mercader J. Chemoadaptive polymeric assemblies by integrated chemical feedback in self-assembled synthetic protocells. ACS Cent Sci. 2021; 7(9):1543-50.
6. Guo T, Fang Y. Functional organization and dynamics of the cell nucleus. FrontPlant Science. 2014; 5:378.
7. Parody A, Corbo C, Cevenini A, Molinaro R, Palomba R, et al. Enabling cytoplasmic delivery and organelle targeting by surface modification of nanocarriers. Nanomedicine (Lond). 2015; 10(12):1923-40.
8. Opron K, Burton ZF. Ribosome structure, function and early evolution. Int J Mol Sci. 2019; 20(1):40.
9. Schwarz DS, Blower MD. The endoplasmic reticulum: structure, function and response to cellular signaling. Cell Mol Life Sci. 2016; 73:79-94.
10. Machamer CE. The Golgi complex in stress and death. Front Neurosci. 2015; 421.
11. Park K, Ju S, Kim N, Park SY. The Golgi complex: a hub of the secretory pathway. BMB Rep. 2021; 54(5):246-52.
12. Ballabio A. The awesome lysosome. EMBO Mol Med.2016; 8(2):73-6.
13. Platt FM, Boland B, Spoel AC. The cell biology of disease: lysosomal storage disorders: the cellular impact of lysosomal dysfunction. J Cell Biol.2012; 199(5):723-34.
14. Magalhaes J, Venditti P, Adhihetty PJ, Ramsey JJ, Ascensao A, et al. Mitochondria in Health and Disease. Oxid Med Cell Longev. 2014; 814042.