Topic: Cytoplasm

Cytoplasm refers to the fluid that fills the cell, which includes the cytosol along with filaments, proteins, ions and macromolecular structures as well as the organelles suspended in the cytosol.

In eukaryotic cells, cytoplasm refers to the contents of the cell with the exception of the nucleus. Eukaryotes have elaborate mechanisms for maintaining a distinct nuclear compartment separate from the cytoplasm. Active transport is involved in the creation of these subcellular structures and for maintaining homeostasis with the cytoplasm. For prokaryotic cells, since they do not have a defined nuclear membrane, the cytoplasm also contains the cell’s primary genetic material. These cells are usually smaller in comparison to eukaryotes, and have a simpler internal organization of the cytoplasm.

# Structure of Cytoplasm

The cytoplasm is unusual because it is unlike any other fluid found in the physical world. Liquids that are studied to understand diffusion usually contain a few solutes in an aqueous environment. However, the cytoplasm is a complex and crowded system containing a wide range of particles – from ions and small molecules, to proteins as well as giant multi protein complexes and organelles. These constituents are moved across the cell depending on the requirements of the cell along an elaborate cytoskeleton with the help of specialized motor proteins. The movement of such large particles also changes the physical properties of the cytosol.

The physical nature of the cytoplasm is variable. Sometimes, there is quick diffusion across the cell, making the cytoplasm resemble a colloidal solution. At other times, it appears to take on the properties of a gel-like or glass-like substance. It is said to have the properties of viscous as well as elastic materials – capable of deforming slowly under external force in addition to regaining its original shape with minimal loss of energy. Parts of the cytoplasm close to the plasma membrane are also ‘stiffer’ while the regions near the interior resemble free flowing liquids. These changes in the cytoplasm appear to be dependent on the metabolic processes within the cell and play an important role in carrying out specific functions and protecting the cell from stressors.

The cytoplasm can be divided into three components:

The cytoskeleton with its associated motor proteins

Organelles and other large multi-protein complexes

Cytoplasmic inclusions and dissolved solutes

Cytoskeleton and Motor Proteins

The basic shape of the cell is provided by its cytoskeleton formed primarily by three types of polymers – actin filaments, microtubules and intermediate filaments.

Actin filaments or microfilaments are 7 nm in width and are made of double stranded polymers of F-actin. These filaments are associated with a number of other proteins that help in filament assembly and are also involved in anchoring them close to the plasma membrane. This cytoplasmic location helps the microfilaments become involved in rapid responses to signal molecules from the extracellular environment and produce cellular responses through signal transduction or chemotaxis. In addition, myosin, an ATP-based motor protein transmits cargo and vesicles along the microfilament and is also involved in muscle contraction.

Microtubules are polymers of α and β tubulin, which form a hollow tube by the lateral association of 13 protofilaments. Each protofilament is a polymer of alternating α and β tubulin molecules. The inner diameter of a microtubule is 12 nm and its outer diameter is 24 nm.

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# Microtubule structure

Microtubules radiate towards the periphery of the cell from microtubule organizing centers (MTOCs) located close to the nucleus, and provide structure and shape to the cell.

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#  Fluorescent Cells

This image shows the nucleus in blue, the actin filaments on the cell periphery are labeled red and the extensive microtubule network is marked green. The cytoplasm undergoes rapid reorganization during cell division with microtubules forming the spindle, which binds to chromosomes and segregates them into two daughter cells.

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# Kinetochore

Similar to the previous image, chromosomes are stained blue and microtubules are green. Tiny red dots are kinetochores.

Microtubules are involved in cytoplasmic transport, chromosome segregation and in forming structures such as cilia and flagella for cellular movement.

Intermediate filaments are larger than microfilaments but smaller than microtubules and are formed by a group of proteins that share structural features. Though they are not involved in cell motility, they are important for cells to come together as tissues and to remain anchored to the extracellular matrix.

# Organelles and Multi-protein Complexes

Most eukaryotic cells have a number of organelles that provide compartments within the cytoplasm for specialized microenvironments. For instance, lysosomes contain a number of hydrolases in an acidic environment that is ideal for their enzymatic activity. These hydrolases are actively transported into the lysosome after being synthesized in the cytoplasm. Mitochondria, while containing their own genome, also need many enzymes synthesized in the cytosol, which are then selectively moved into the organelle. These organelles are placed in specific locations due to the physical gel-like nature of the cytoplasm and by anchoring to the cytoskeleton.

In addition, the cytoplasm also plays host to multi-protein complexes like the proteasome and ribosomes. Ribosomes are large complexes of RNA and protein that are important for the translation of mRNA code into amino acid sequences of proteins. Proteasomes are giant molecular structures about 20,000 kilodaltons in mass and 15 nm in diameter. Proteasomes are important for targeted destruction of proteins that are no longer needed by the cell.

# Cytoplasmic Inclusions

Cytoplasmic inclusions can include a wide range of biochemicals – from small crystals of proteins, to pigments, carbohydrates and fats. All cells, especially in tissue like the adipose, contain droplets of lipids in their triglyceride form. These are used to create cellular membranes and are an excellent energy store. Lipids can generate twice as many ATP molecules per gram when compared to carbohydrates. However, the process of releasing this energy from triglycerides in intensive in oxygen consumption and therefore the cell also contains stores of glycogen as cytoplasmic inclusions. Glycogen inclusions are particularly important in cells like the skeletal and cardiac muscle cells where there can be a sudden increase in demand for glucose. Glycogen can be quickly broken down into individual molecules of glucose and used in cellular respiration before the cell can obtain more glucose reserves from the body.

Crystals are another type of cytoplasmic inclusion found in many cells, and have special function in cells of the inner ear (maintaining balance). Presence of crystals in cells of the testis appears to be linked with morbidity and infertility. Finally, the cytoplasm also contains pigments such as melanin, which lead to the pigmented cells of the skin. These pigments protect the cell and internal body structures from the deleterious effects of ultraviolet radiation. Pigments are also prominent in the cells of the iris that surround the pupil of the eye.

Each of these components affects the functioning of the cytoplasm in different ways, making it a dynamic region that plays a role in, and is influenced by the cell’s overall metabolic activity.

# Functions of Cytoplasm

The cytoplasm is the site for most of the enzymatic reactions and metabolic activity of the cell. Cellular respiration begins in the cytoplasm with anaerobic respiration or glycolysis. This reaction provides the intermediates that are used by the mitochondria to generate ATP. In addition, the translation of mRNA into proteins on ribosomes also occurs mostly in the cytoplasm. Some of it happens on free ribosomes suspended in the cytosol while the rest happens on ribosomes anchored on the endoplasmic reticulum.

The cytoplasm also contains the monomers that go on to generate the cytoskeleton. The cytoskeleton, in addition to being important for the normal activities of the cell is crucial for cells that have a specialized shape. For instance, neurons with their long axons need the presence of intermediate filaments, microtubules, and actin filaments in order to provide a rigid framework for the action potential to be transmitted to the next cell. Additionally, some epithelial cells contain small cilia or flagella to move the cell or remove foreign particles through coordinated activity of cytoplasmic extrusions formed through the cytoskeleton.

The cytoplasm also plays a role in creating order within the cell with specific locations for different organelles. For instance, the nucleus is usually seen towards the center of the cell, with a centrosome nearby. The extensive endoplasmic reticulum and Golgi network are also placed in relation to the nucleus, with the vesicles radiating out towards the plasma membrane.

# Cytoplasmic Streaming

Movement within the cytoplasm also occurs in bulk, through the directed movement of cytosol around the nucleus or vacuole. This is particularly important in large single celled organisms such as some species of green algae, which can be nearly 10 cm in length. Cytoplasmic streaming is also important for positioning chloroplasts close to the plasma membrane to optimize photosynthesis and for distributing nutrients through the entire cell. In some cells, such as mouse oocytes, cytoplasmic streaming is expected to have a role in the formation of cellular sub-compartments and in organelle positioning as well.

# Cytoplasmic Inheritance

The cytoplasm plays hosts to two organelles that contain their own genomes – the chloroplast and mitochondria. These organelles are inherited directly from the mother through the oocyte and therefore constitute genes that are inherited outside the nucleus. These organelles replicate independent of the nucleus and respond to the needs of the cell. Cytoplasmic or extranuclear inheritance, therefore, forms an unbroken genetic line that has not undergone mixing or recombination with the male parent.

# Types of cytoplasmic inclusions

# Ribosomes:

Ribosomes in bacteria (prokaryotes) are small granular bodies of 10-20 nm in diameter freely lying in the cytoplasm and composed of ribosomal ribonucleic acid (rRNA) and proteins. Bacterial ribosomes are thought to contain about 80-85% of the bacterial RNA.

Somteime , they are found in small groups callef polyribosomes or polysomes, which are formed when several ribosomes begin to translate a single mRNA molecule.

Generally, the ribosomes are a few hundred in number in each bacterial cell, but when the cell undertakes active protein synthesis , they increase in number to as many as 15,000-20,000 per cell about 15% of the cell mass.

# Sulphur globules:

Sulphur globules are present in the bacterial cells growing such as photosynthetuc purple sulfur bacteria and filamentous non phitosynthetic bacteria. These bacteria oxidize into elemental sulfut which accumulates inside the cell in visible sulfur globules.

These sulfur globuled of elemental sulfur remain until the H2S source is reduced . .In the latter condition the stored sulfur in these granules is oxidized to sulfate and the globules slowly disappear.

It is reported that the sulfur globules occur in the periplasm rather than the cytoplasm of the bacterial cell.

# Glycogen:

Glycogen like PHB , is another storage product formed by prokaryotes. It is a polymer of glucose units composed of long chains formed by (1-4) glycosidic bonds and branching chains connected to them by alpha (1-6) glycosidic bonds.

Glycogen is dispersed more evenly throughout the cytoplasmic matrix as small (about 20-100nm) in diameter and is a storage reservoir for carbon and energy .

Glycogen also known as ‘animal starch’ and, besides prokaryoted, is found in fungi.

# Carboxysomes:

Carboxysomes are polyhedral bodies surrounded by thin, non unit membrane and range about 100 nm in diameter. They contain apart from a little DNA , the enzyme ribulose-1,5 – bisphosphate carboxylase (RUBISCO) in a para crystalline arrangement.

It is thougjt that carbixysomes are a mechanism to increase the amount of RUBISCO in the bacterial cell to allow for mire rapid carbon dioxide , fixation without causing any effect on the osmolarity of thr cytoplasm ; the osmotic pressure of the cytoplasm is not affected as the carboxysome is insoluble.

# Magnetosomes:

Magnetosomes are the inorganic inclusions bodies of iron usually in the form of intracellular chains of magnitite (Fe3O4). Sone species rom sulfidic habitays possess magnetosomes containing greigite(Fe3S4) and pyrite(FeS2). Magnetosomes containing bacteria are called magnetotactic bacteria.

Magnetosomes vary in shape from square to rectangular to spike shaped as their morphology is species specific. They are around 40 to 100 nm in diameter and bounded by a monolayer membrane made up of phospholipids, proteins , and glycoproteins.

# Vacuoles:

Gas vacuoles, the most remarkable organic inclusions bodies , are formed as a result of the aggregation of large number of small, hollow, cylindrical structures called gas vesicles. These structures confer buoyamcy on cells by decreasing their density and live a floating existence within the water column of lakes and the oceans.

Each gas vacuole appears about 75 nm in diameter with conical ends and about 200-1,000 nm in length. The most dramatic instances of floatation due to gas vacuolrs are seen in cyano bacteria that form massivr accumulation in lakes.

# What is called cortex of cytoplasm?

1. Ectoplasm
2. Medulla
3. Tonoplasm
4. Protoplasm

# Ectoplasm

# 2.which of the following is not an organelle?

1. Golgi body
2. Centrosome
3. Matrix
4. Lysosome

# C.Matrix

# 3.what type of material is the cytoplasm?

1. Water soluble material
2. Permeable material
3. Fat soluble material
4. Colloidal material

# D. Colloidal material

# 5. The translucant fluid part of cytoplasm is called?

1. Cytosol
2. Matrix
3. Organelles
4. Cell protein

# Matrix

# 6. The biochemical reactions and proper functioning pf organelles takes place in?

1. Cytoplasm
2. Nucleus
3. Golgi complex
4. Vacuoles

# Cytoplasm

# 7. Cytoplasm present in axon is called?

1. Neuroplasm
2. Protoplasm
3. Axoplasm
4. Dendroplasm

# Axoplasm

# 8. The exchange of materials take place between nucleus and cytoplasm with the help of?

1. Nuclear pores
2. Nuclear membrane
3. Nucleus
4. Chromatin network

# Nuclear pores

# 9. The fusion of cytoplasm is known as?

1. Plasmogamy
2. Karyogamy
3. Progamy
4. Microgamy

# Plasmogamy

# 10. Pseudopodia is specialized cytoplasmic projections which are the attribute of ?

1. Paramecium
2. Amoeba
3. Hydra
4. Chlamydomonas

# A.paramecium