Wisdom
Dentistry 2023

SHEET NUMBER : 1

2023

PHYSIOLOGY

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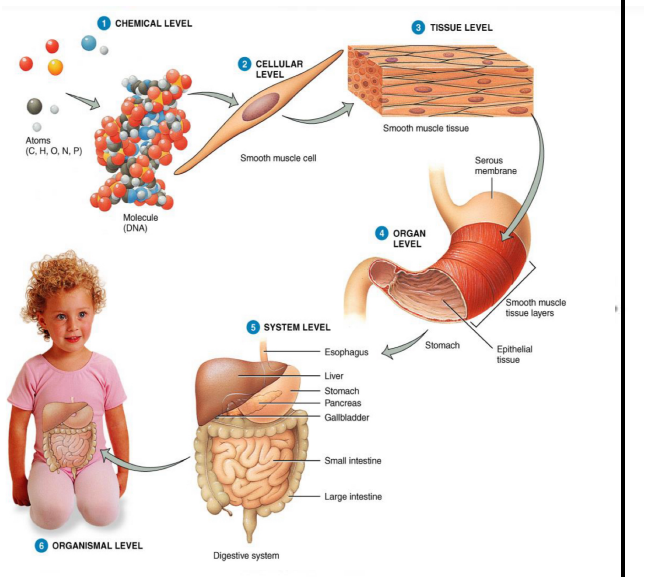
Introduction:

The body consists of several systems, each system consists of several organs and organs consist of several tissues, until we finally reach the basic unit of the body, which is ***the cell***.



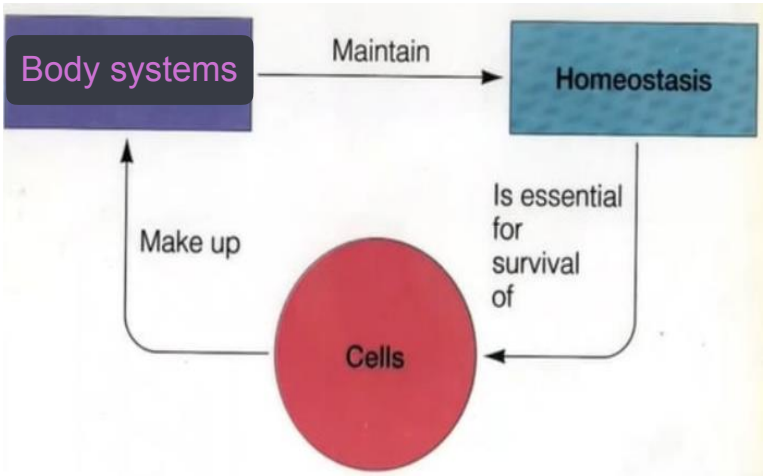
As we know, there are many systems in the body like the respiratory system, nervous system, gastrointestinal system which is our example here.

This system consists of many organs like the small intestine, large intestine, and the stomach.

The stomach consists of many tissues like the muscular tissue, epithelial tissue, etc. Each type of tissue serve a certain function.

As we mentioned, the basic unit of the body which maintain the functions of the body is **the cell**, so we have to keep it in a condition of *equilibrium* (balance) in the body's internal environment, where it's maintained at an <u>almost constant level</u>, which is known as **Homeostasis**.

Homeostasis is **dynamic not static**, the body has a normal range of values for each variable (within narrow variation), these variables are like, Blood pressure (BP), Blood Glucose Level (BGL), body temperature, PH of the blood, the concentration of [CO2, O2, Na+, K+, Ca2+]. So, any change in these variables will disrupt homeostasis and cause problems to the body, thus, the body systems will try to restore homeostasis.



For example, while running, the body demand for oxygen **increases**, and the oxygen concentration in the blood will **decrease**, so the respiratory system and the cardiovascular system will try to restore homeostasis by certain mechanisms. If there is a problem in one of these systems, a disease will develop.

Another example is when we have a problem in the pancreas, so there is a decrease in insulin release, thus, not enough glucose will enter the cells, the blood glucose concentration will increase and that will lead to diabetes.

Note: The example in this sheet are not for memorizing, only understand the general concept.

To Sum Up !

What is the homeostasis ?

Kind of balance state in our body function if there any change or shift , it will be adjusted or controlled by our body (constancy of substance).

Cells are found in media called extracellular matrix (ECM).

ECM has specified substance such as : sodium ,potassium and glucose must be kept in constant concentrations.

Homeostasis is not the same as Hemostasis

Hemostasis is process of blood clotting to stop blood static .

Homeostasis is dynamic not static and found in any process in our body .

Cells make the body systems. → Body systems maintain homeostasis

→ Homeostasis is essential for survival of cells

Steps of homeostasis :

-homeostasis is disrupted by any mechanism

-receptors sense the disruption and send massages(nerve impulses or chemical signals) to control center , this called input .

Control center :part of the body that control our organs (e.g. Nervous system)

-input integrated inside control system then sends an output to effectors organs(by nerve impulses or chemical signals).

-effectors organs receives the output and change the body depending o n it.

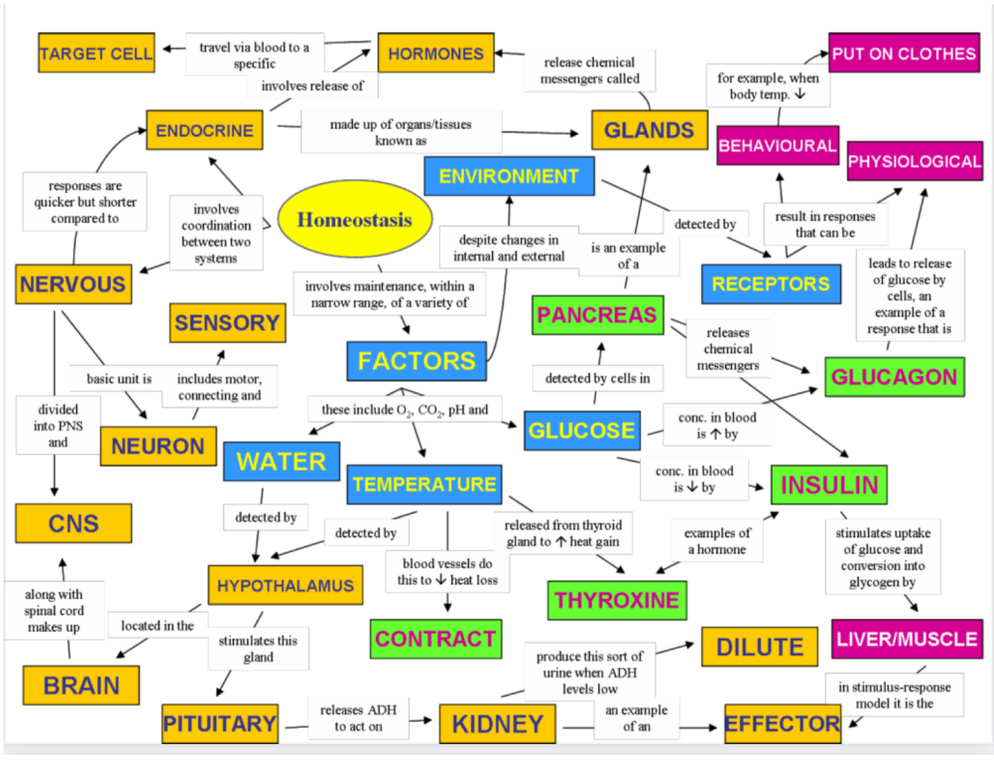
•Homeostasis is achieved

Examples of the homeostasis :

blood pressure

calcium level

environment temperature



Homeostasis is necessary for survival, and it is regulated by many ways in the body, it is a very complex process, so, **How the body will sense and deal if there is a disturbance in homeostasis?**

Feedback system

There are three Basic components:

1. Receptors:

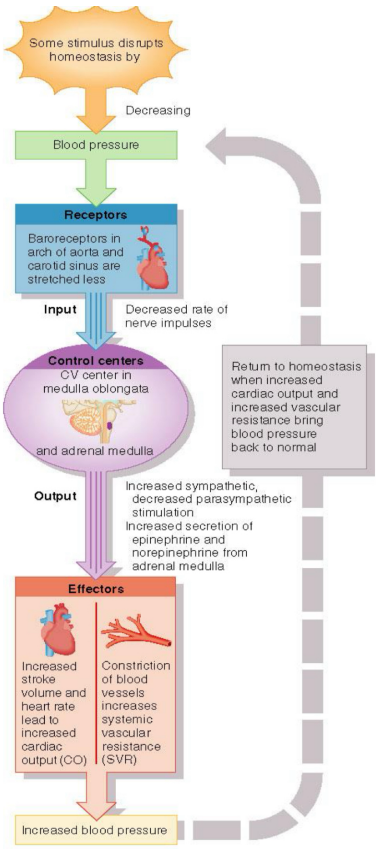
- Body structures that monitor changes in a controlled condition.
- Sends input to the control center (the brain).
- Example: Baroreceptors in the blood vessels that sense the blood pressure.

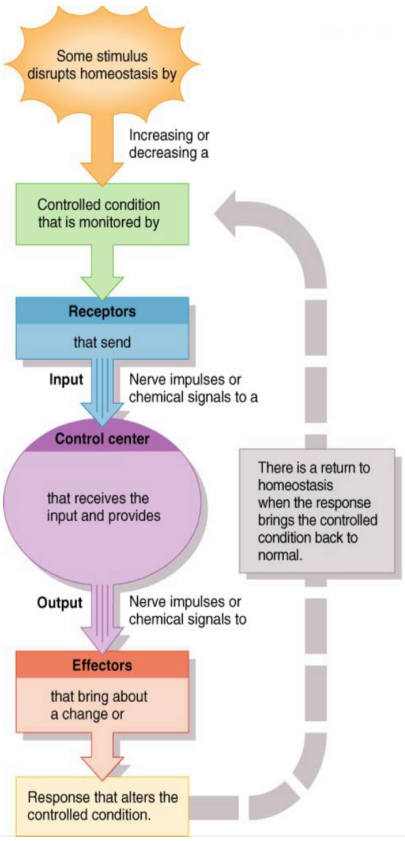
2. Control center:

- **Brain**
- Sets the range of values to be maintained.
- Evaluates input received from receptors and generates output command.
- The brain output command are done by the Nervous system (nerve impulses) and endocrine system (hormones).
- Example: Brain acts as a control center by receiving nerve impulses from baroreceptors.

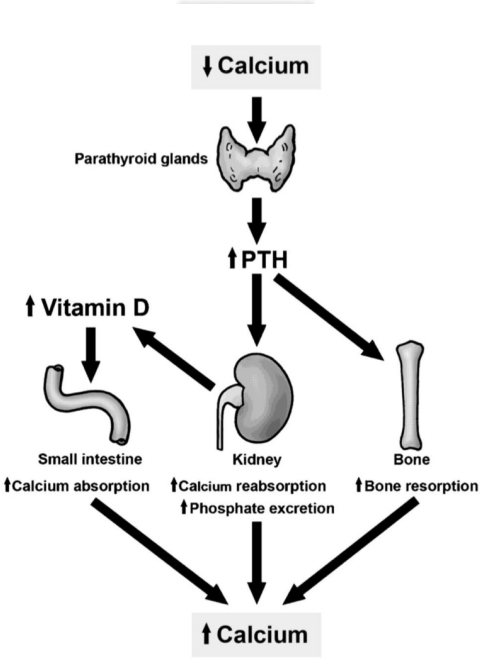
3. Effectors:

- Receive output from the control center.
- Produce a response or effect that changes the controlled condition.
- Found in nearly every organ or tissue.
- Example: if the baroreceptors sense a decrease in blood pressure, they will send signals to the control center which is the brain, and the brain will send signals to the effectors to solve this problem and increase the blood pressure back to normal, by increasing the contractility of the heart muscle to pump more blood, **or** by sending signals to kidney to increase the absorption of water, **in either cases**, that will lead to increase the blood pressure back to normal.





Another example of feedback system is when calcium concentration gets below the normal range, the body will sense that decrease by certain receptors, these receptors will send signals to the brain, and the brain will respond to that signals by stimulating the **parathyroid gland** to release more parathyroid hormone (**PTH**), this hormone will increase the calcium concentration by;



1. Increasing bone **resorption** (breakdown).

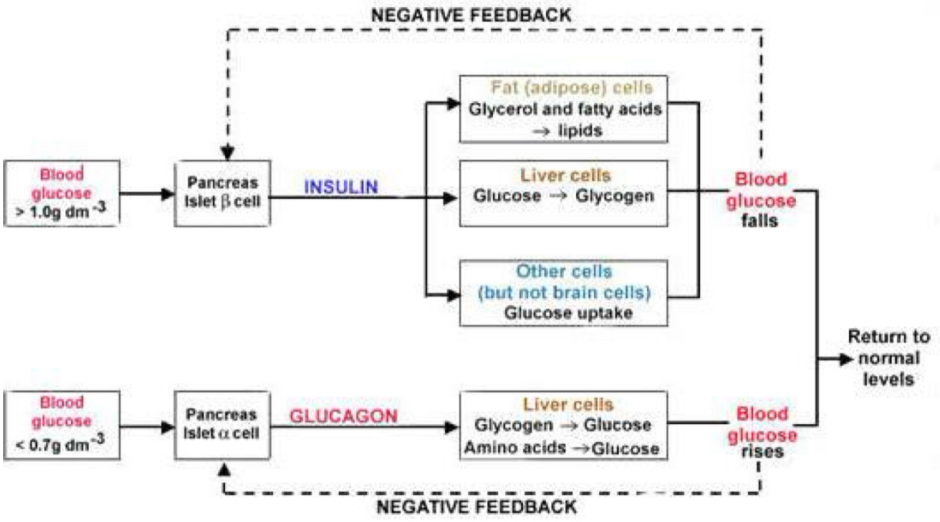
2. Increasing calcium **reabsorption** by the kidneys

3. Stimulating the kidney to transform the inactive form of vitamin D to the active form, which will increase the absorption of calcium from the intestine.

- ✓ There are two types of feedback system, negative feedback system and positive feedback system.

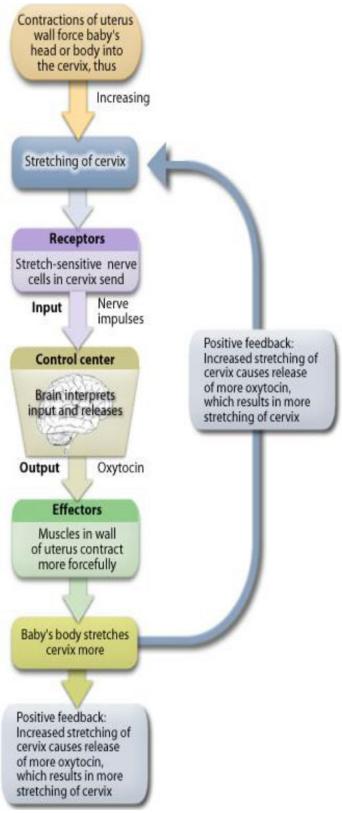
The two examples that we discussed above and the example below are examples of negative feedback system, so **what is negative feedback system**?

The negative feedback system means that when something gets higher than the normal range, the body will try to decrease it, and vice versa. In this example, when blood glucose concentration gets higher than the normal range, the brain sends signals to the islets beta cells in the **pancreas** to produce **more insulin**, the insulin by certain mechanisms (you will take them next year) will **decrease the blood glucose back to normal**, and if there is a decrease in blood glucose, the signals from the brain will stimulate the pancreas to produce **more glucagon** which will **increase the glucose in the blood**. So this is the negative feedback system!



The negative feedback system indicates that the final event (response) will be **opposite** to the initial event that took place (stimulus), while in the **positive feedback system** the final event will be similar to the initial event that took place, if there is something that increased, the body will **further increase it**. This happens in emergency situations and we have two examples in our body.

1. **Normal childbirth**: During the process of delivering a new-born, the uterus **starts contracting** (also known as labour), the contraction starts as slow and infrequent but when signals reach the brain, the brain will stimulate the **pituitary gland** to produce a hormone known as ***oxytocin***, this hormone will increase the contraction of the uterus even further, until delivery of baby takes place. Once the delivery is finished, everything will return to its normal condition.



- Notice that the response (increase in contractions) is in the same direction as the stimulus (which is the beginning of the contractions).

2. **Blood loss in cases of injury**: When someone is bleeding, the blood coagulates (stimulus), the (response) will be an increase in coagulation to prevent blood loss. (The doctor didn't mention it but know it for further understanding).

To Sum Up!

NEGATIVE FEEDACK

when the direction of the stimulus is opposite to the direction of the effect or Reverses a change in a controlled condition(final event that is a result of the first event and reverse to it).

Example given: hypertension and hypotension (regulation of blood pressure).

Example: After Insulin is secreted because of raised blood glucose level, blood glucose falls, this send a message to the pancreas to stop secreting insulin ▪

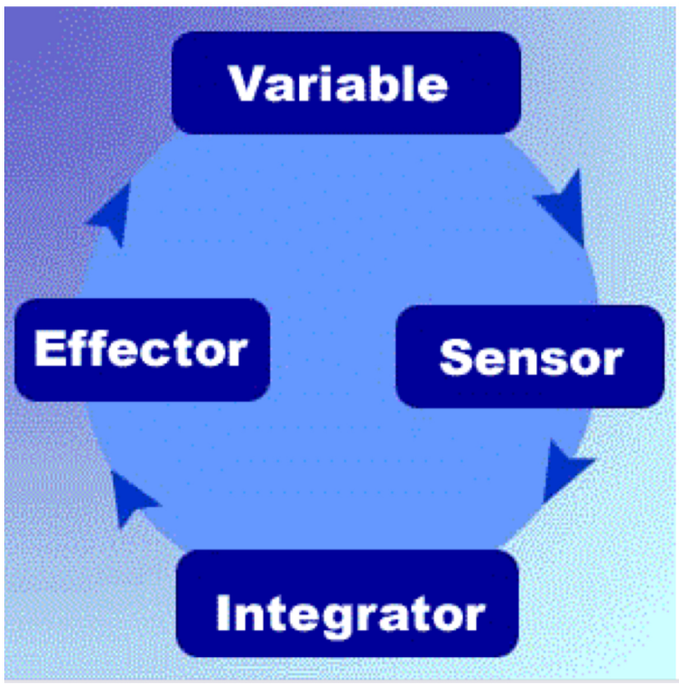
Another example: After Glucagon is secreted because of decreased blood glucose level, blood glucose rises, this send a message to the pancreas to stop secreting glucagon .

POSITIVE FEEDBACK

when the response is in the same direction with the stimulus in a good or bad way (Final event that is a result of the first event and same to it).

Example: Normal childbirth

The cervix start stretching when the baby is about to be delivered, stretching is sensed by certain receptors and signal is sent to the control center, which will integrate the input and send an output to the cervix to contract more, contraction is sensed again and the circuit repeats until the baby is born .



The more oxytocin the .more stretch
The more stretch the more .stimulation of oxytocin

Most of feedbacks are negative not positive ! Positive feedback can be harmful !

Please check on the professor's handout,
Very Important ..

The University of Jordan
Department of Physiology and Biochemistry
Medical and Dental students

Introduction to Homeostasis and Control systems

Follow the links:

https://www.youtube.com/watch?v=LSgEJSlk6W4

https://letstalkscience.ca/educational-resources/backgrounders/introduction-homeostasis-and-regulation

Questions:

What we mean by baroreceptors?

Introduction

Homeostasis refers to the inclination to oppose alteration in order to uphold a steady and relatively unchanging internal environment. Typically, homeostasis entails the utilization of negative feedback loops that counterbalance deviations from the desired values, also known as set points. In contrast, positive feedback loops intensify the initial stimuli, thereby steering the system away from its initial state.

Homeostasis, the tendency to uphold a stable internal environment, encompasses more than just temperature regulation. The body also ensures the steady concentration of various ions, pH levels, and glucose concentration in the blood. Deviations from these values can lead to severe illness.

Homeostasis operates at multiple levels, not limited to the entire body's temperature regulation. For instance, the stomach maintains a distinct pH compared to surrounding organs, and individual cells maintain different ion concentrations than the surrounding fluid. Maintaining homeostasis at each level is crucial for the overall functioning of the body.

Maintaining homeostasis: EXAMPLES

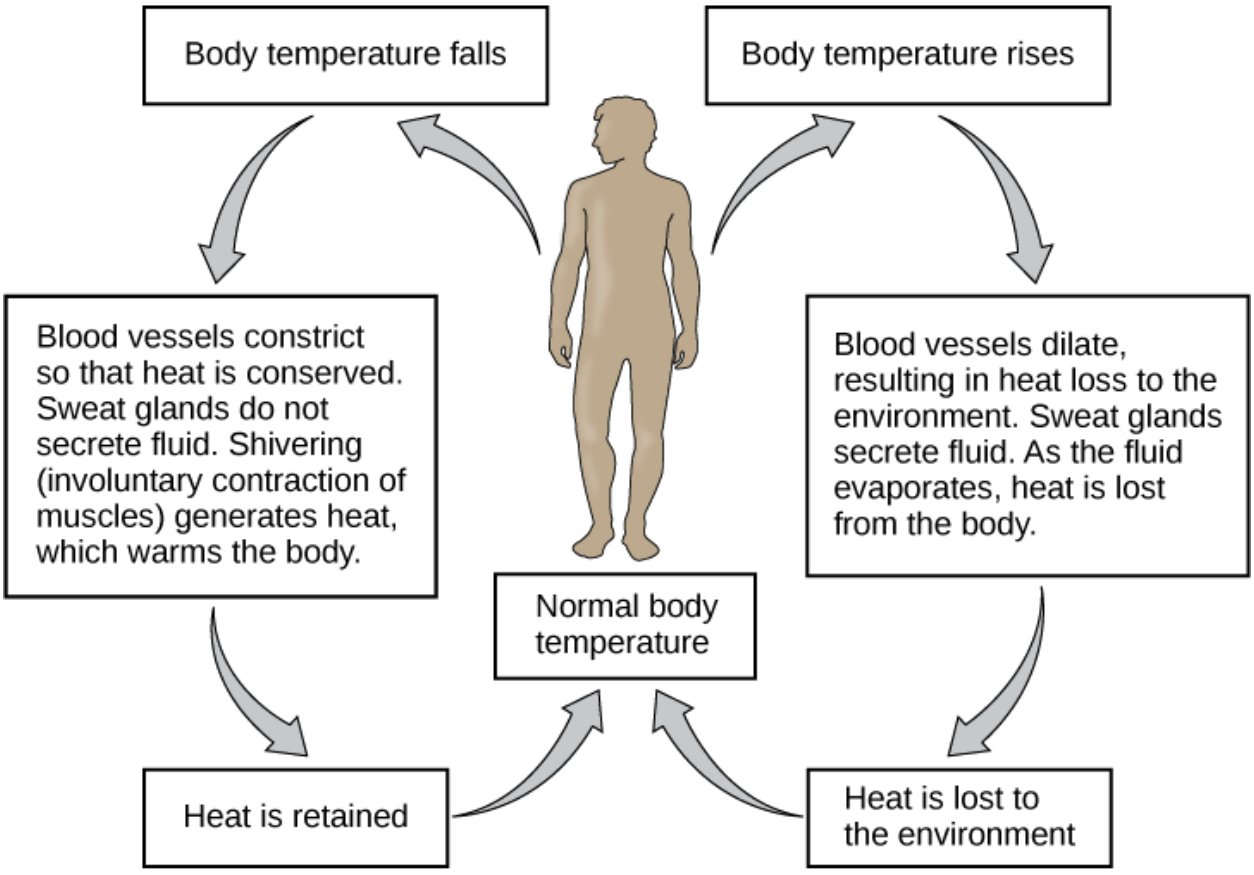
Biological systems, such as the human body, are constantly being pushed away from their equilibrium points. When you engage in physical activity, for example, your muscles generate more heat, causing your body temperature to rise. Similarly, consuming a glass of fruit juice leads to an increase in blood glucose levels. The maintenance of homeostasis relies on your body's ability to detect and counteract these changes.

The preservation of homeostasis typically involves negative feedback loops, which work to counter the initial stimulus or cue that triggers them. If your body temperature becomes too high, a negative feedback loop will be activated to bring it back towards the desired set point or target value.

So, how does this process work? Initially, sensors, primarily nerve cells located in your skin and brain, detect the elevated temperature and transmit this information to a temperature-regulatory control center in your brain. The control center then processes the data and initiates a response through effectors, such as sweat glands, which work to counteract the stimulus by reducing body temperature.

1. A negative feedback loop consists of four fundamental components: a stimulus, a sensor, a control, and an effector.

2. Negative feedback is responsible for regulating body temperature. The stimulus occurs when the body temperature surpasses 37 degrees Celsius, the sensors are nerve endings located in the skin and brain, the control is the temperature regulatory center in the brain, and the effector refers to the sweat glands distributed throughout the body.



Source: https://storymd.com/asset/VdKXDmuwqK-homeostasis

Certainly, body temperature does not only exceed its target value, but it can also fall below this value. Typically, homeostatic circuits involve at least two negative feedback loops:

One is activated when a parameter, such as body temperature, surpasses the set point and aims to lower it.

One is activated when the parameter falls below the set point and aims to raise it.

To illustrate this concept further, let's examine the opposing feedback loops that govern body temperature control.

Temperature regulation in homeostatic responses

If there is an increase or a decrease in body temperature, sensors in both the periphery and the brain inform the temperature regulation center of your brain, specifically the hypothalamus region, that your temperature has deviated from its set point.

For example, in the event that you have been engaging in rigorous physical activity, your body temperature may exceed its designated level, necessitating the activation of cooling mechanisms. This involves an increase in blood flow to your skin to expedite heat dissipation into the surrounding environment. Additionally, you may experience sweating, as the evaporation of sweat from your skin aids in cooling you down. Furthermore, heavy breathing can contribute to the loss of heat.

When the body temperature becomes excessively high, the blood vessels expand, sweat glands release fluid, and the body dissipates heat. Consequently, as heat is released into the surroundings, the body temperature gradually reverts back to its normal state.

However, in the event that you find yourself in a chilly environment without adequate clothing, the brain's temperature center will activate mechanisms to warm you up. This includes reducing blood flow to the skin, causing shivering to generate additional heat in the muscles. Additionally, you may experience goose bumps, which raise the hair on your body and create a layer of air near the skin, as well as an increase in the release of heat-producing hormones.

Disruptions to feedback disrupt homeostasis.

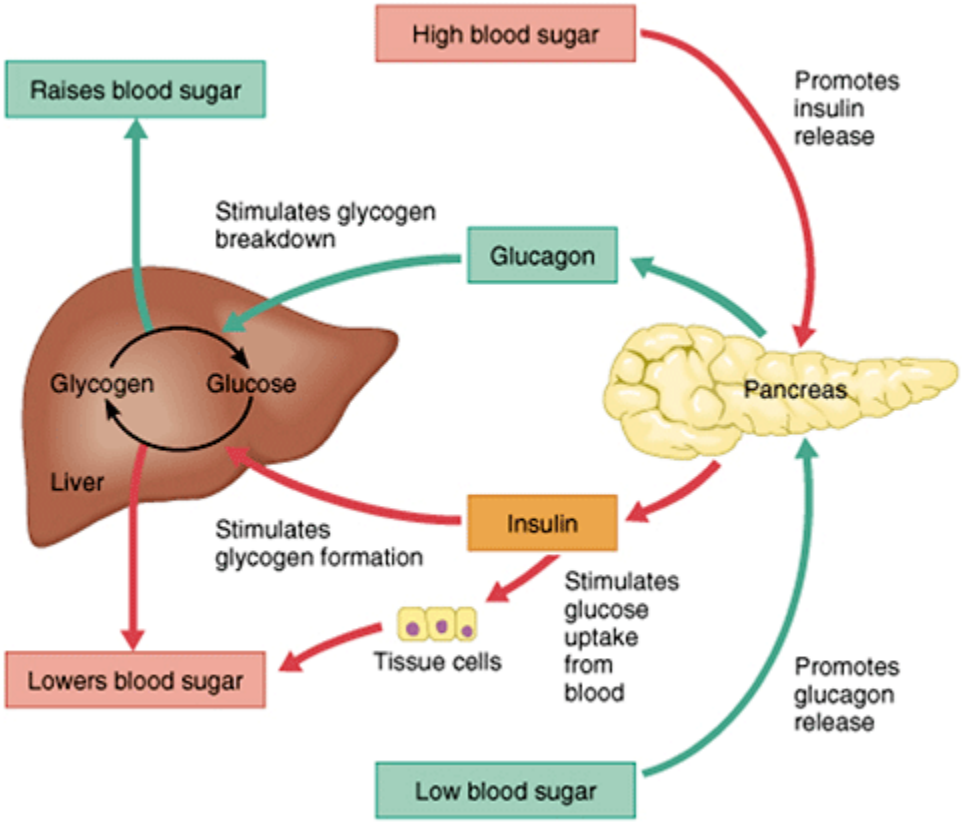
Disruptions to the feedback mechanisms can have a significant impact on homeostasis. Homeostasis relies on negative feedback loops, and any interference with these loops can disrupt the balance. This disruption can lead to various diseases, such as diabetes.

Diabetes is a prime example of a disease that arises from a malfunctioning feedback loop involving insulin. When this feedback loop is broken, the body struggles to regulate high blood sugar levels effectively, making it challenging to bring them down to a healthy level.

To understand how diabetes develops, it's essential to grasp the fundamentals of blood sugar regulation. In a healthy individual, insulin and glucagon, two hormones, work together to control blood sugar levels.

Insulin plays a crucial role in reducing glucose concentration in the blood. After a meal, blood glucose levels increase, prompting the pancreas's β cells to secrete insulin. This hormone acts as a signal, prompting cells throughout the body, including fat and muscle cells, to absorb glucose for energy. Additionally, insulin facilitates the conversion of glucose into glycogen, a storage molecule found in the liver. Both processes help remove sugar from the blood, lowering blood sugar levels, reducing insulin secretion, and restoring overall homeostasis.

When blood glucose concentration exceeds the normal range, insulin is released to stimulate body cells to remove excess glucose from the blood. Conversely, if blood glucose concentration falls below the normal range, glucagon is released to encourage body cells to release glucose into the bloodstream.



Sources: https://www.atrainceu.com/content/4-regulation-blood-glucose

Glucagon functions in the opposite manner, as it elevates the concentration of glucose in the bloodstream. In the absence of food intake for an extended period, the decline in blood glucose levels triggers the release of glucagon from the α cells in the pancreas. Glucagon then acts upon the liver, prompting the breakdown of glycogen into glucose, which is subsequently released into the bloodstream. This process effectively raises blood sugar levels, leading to a reduction in glucagon secretion and the restoration of homeostasis within the system.

Diabetes occurs when the pancreas fails to produce sufficient insulin, or when the body's cells become unresponsive to insulin, or both. Consequently, under these circumstances, the cells in the body do not efficiently absorb glucose, resulting in prolonged high blood sugar levels following a meal. This occurs due to two primary reasons:

1. Insufficient glucose uptake by muscle and fat cells, leading to fatigue and potential wasting of muscle and fat tissues.

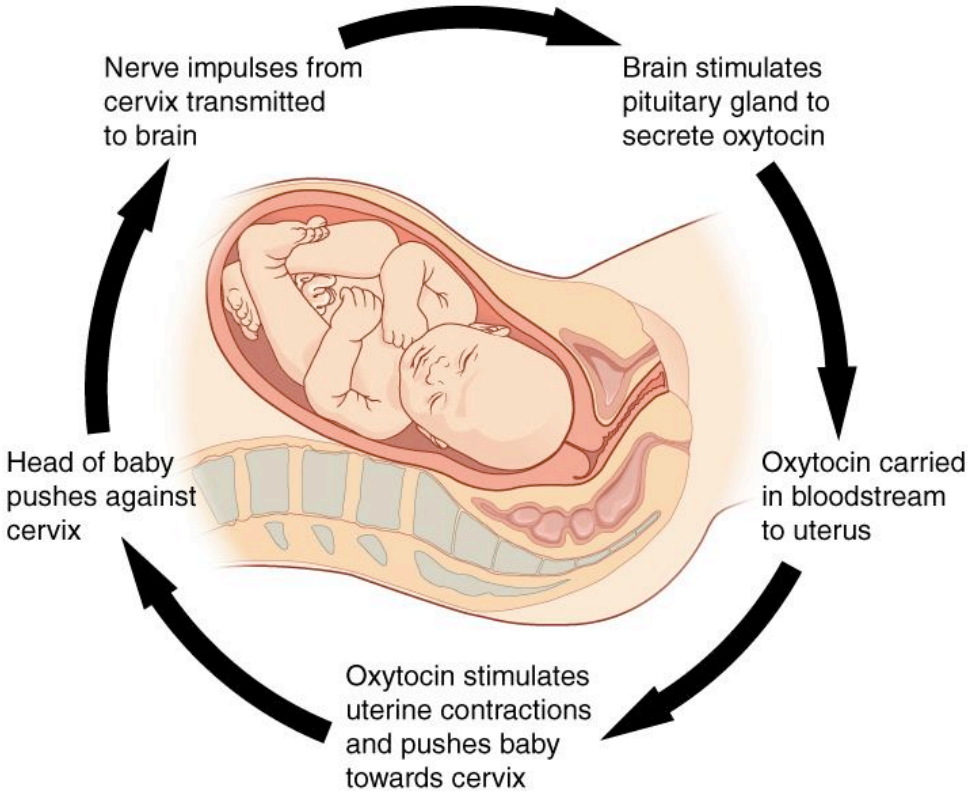
2. Elevated blood sugar levels causing symptoms such as frequent urination, increased thirst, and even dehydration. Over time, this can give rise to more severe complications.

Positive Feedback

Homeostatic circuits typically involve negative feedback loops, which are characterized by their ability to counteract changes and bring a parameter back towards its set point. However, there are some biological systems that utilize positive feedback loops. Unlike negative feedback loops, positive feedback loops amplify the initial signal and are commonly found in processes that require completion rather than maintaining the original status.

One example of a positive feedback loop is observed during childbirth. When the baby's head presses on the cervix, it activates neurons that send a signal to the brain. This signal triggers the release of **oxytocin** from the pituitary gland. Oxytocin **then increases uterine contractions**, leading to more pressure on the cervix. This, in turn, causes the release of even more oxytocin and stronger contractions. The positive feedback loop continues until the baby is born.

It is important to note that normal childbirth is driven by a positive feedback loop, which results in a change in the body's status rather than a return to homeostasis. The feedback loop in this case is drawn clockwise.



Source: OpenStax College, Anatomy & Physiology, CC BY 4.0

1. The transmission of nerve impulses from the cervix to the brain initiates a series of events.

2. Subsequently, the brain triggers the pituitary gland to release oxytocin into the bloodstream.

3. The oxytocin then travels through the bloodstream and reaches the uterus.

4. Once in the uterus, oxytocin stimulates contractions, which in turn push the baby towards the cervix.

5. As the baby's head presses against the cervix, the process continues in a repetitive cycle.

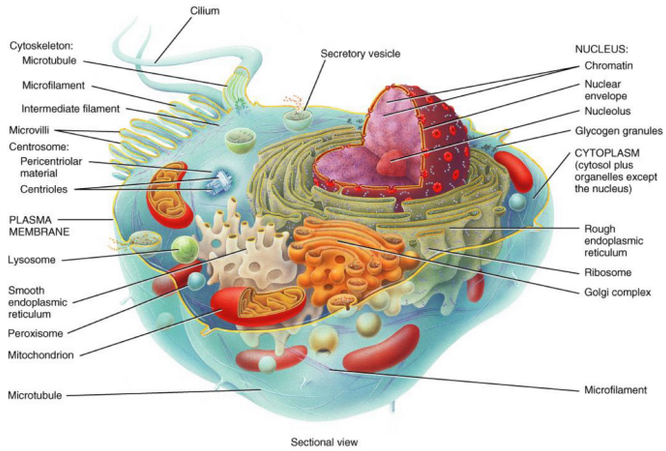
Summary:

Negative feedbacks serve as the body's mechanism to maintain normalcy or stability,

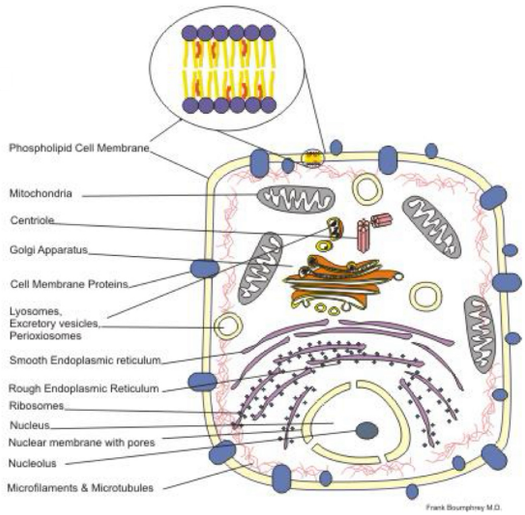
While the positive feedbacks intensify specific effects on the body by ensuring repetition of functions.

Moving to another subject that you already have taken in biology, which is **cell and organelles.**

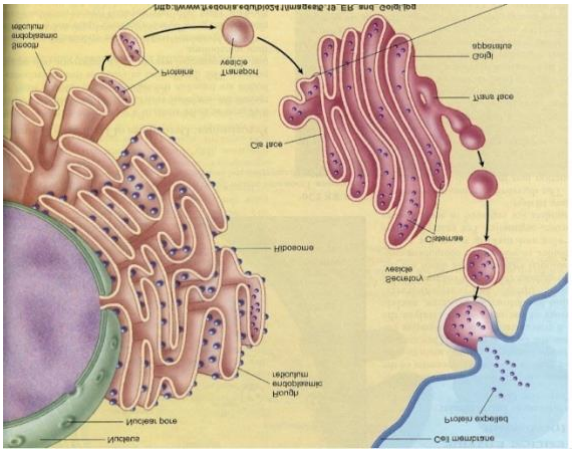
As the importance of the cell in the body's function, it is important to know the cells' organelles and their function, and that any disturbance in these organelles will lead to a disease.

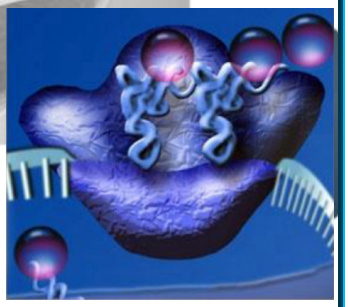


The cell consists of several compartments; for regulation purposes, i.e. lysosomes, endoplasmic reticulum, Golgi apparatus and mitochondria. These organelles contain membranes in their structure which help in separating their **own environment** from the cytoplasm of the cell, this **compartmentalization** helps in controlling the function of the cell, for example; the smooth endoplasmic reticulum contains high concentration of calcium ion in its compartment, which is important in many processes, like **muscle contraction** and **cell signalling**. So by controlling the permeability of the ER membrane, you are controlling the cell function!



Cell is the smallest functional unit of our body .
We have two types of cells : prokaryotic and eukaryotic cells
Eukaryotic cell has nucleus and it's organelles have membrane that separates
them from the cytoplasm and they contain different molecular concentration than cytoplasm, that is important to remain the cell in live.
Its DNA locates in nucleus
Prokaryotic cell doesn't have nucleus and the DNA locates in cytoplasm.
The organelles that have membrane is :
•Endoplasmic reticulum: rough and smooth
The function of the rough endoplasmic reticulum is synthesis of protein
•Golgi
•Lysosomes and peroxisome

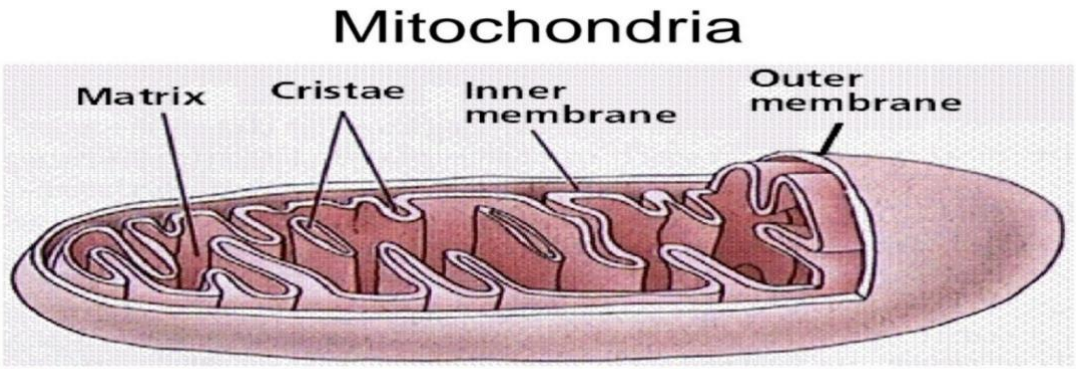




These pictures show the endoplasmic reticulum which contains ribosomes, the vesicle formation process, and the translation process done by ribosomes .and the Lysosomes contain digestive enzymes ..

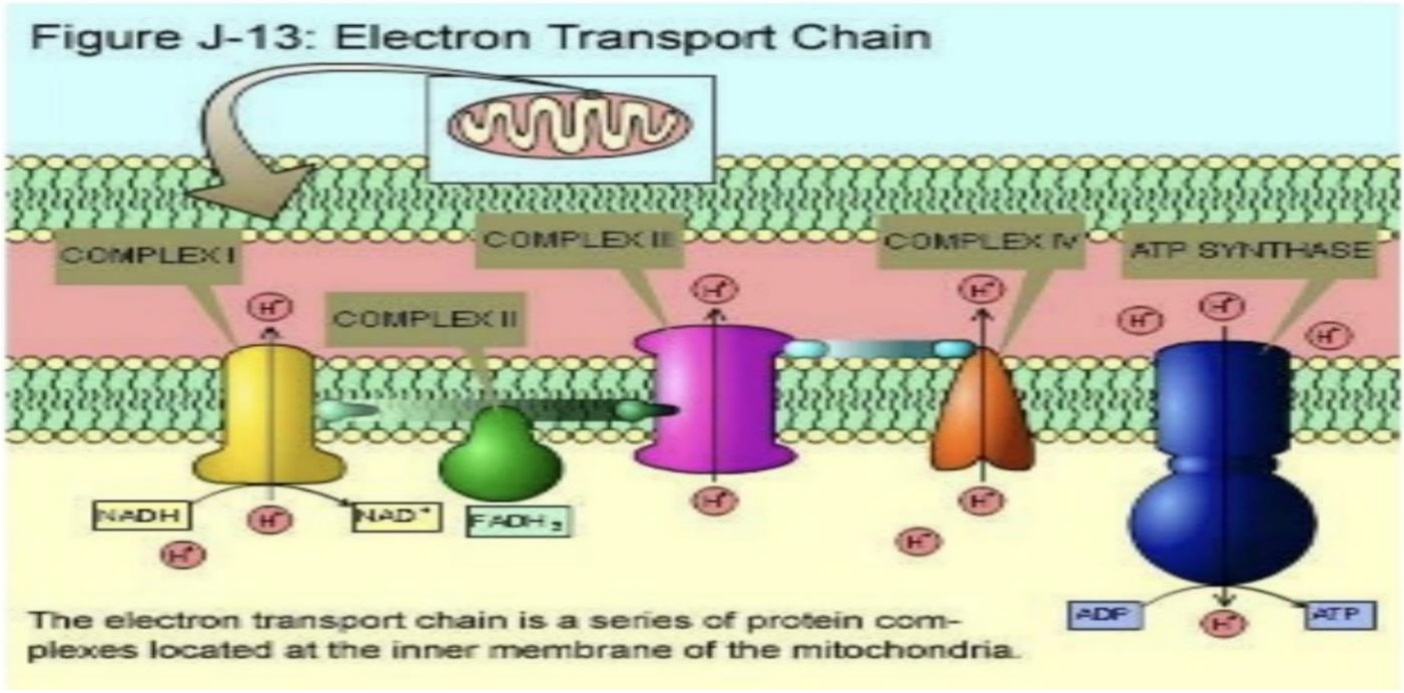
Mitochondria : its function is produce micro energetic molecule by cellular –respiration that is needed to the activity of cell.

https://www.youtube.com/watch?v=c4JsEBI9u6I

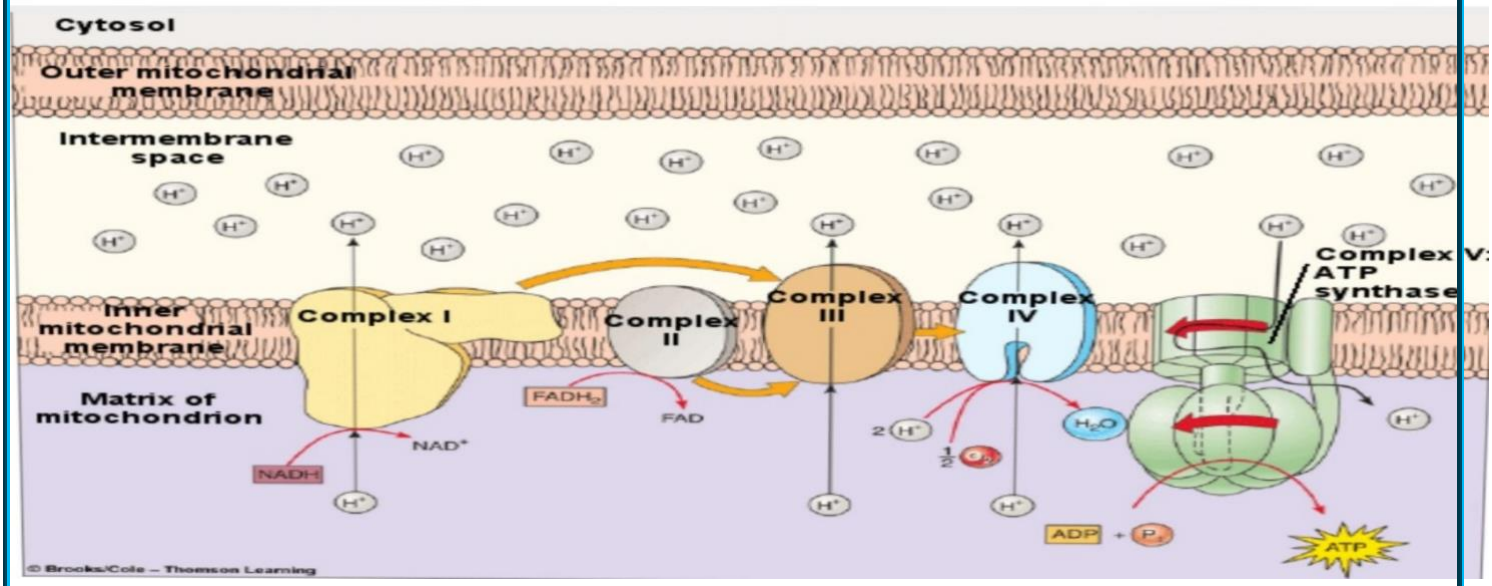


Between the inner and outer membrane of the mitochondria there is inter membranous space .

Electron transport chain is in the inner membrane of the mitochondria, its function is transport protons from the high energy state to low energy state .

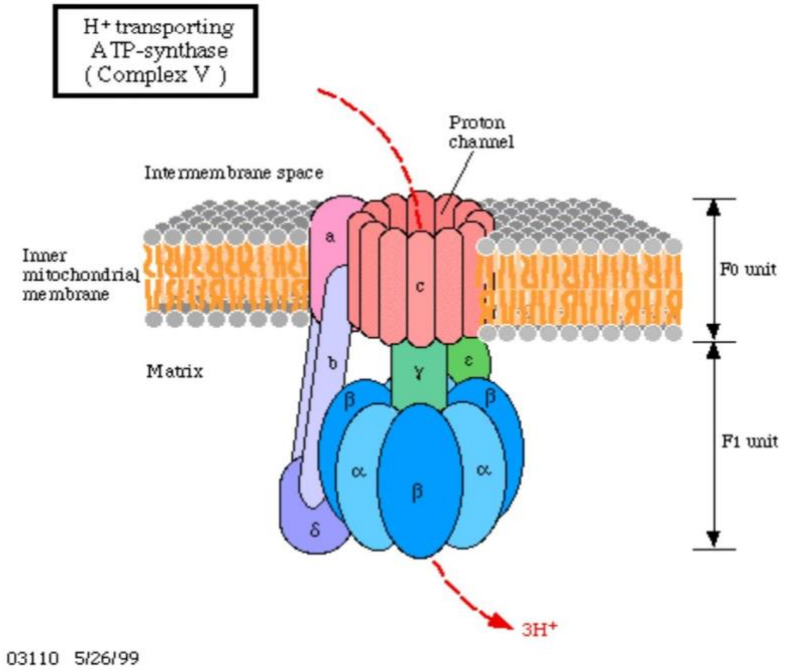


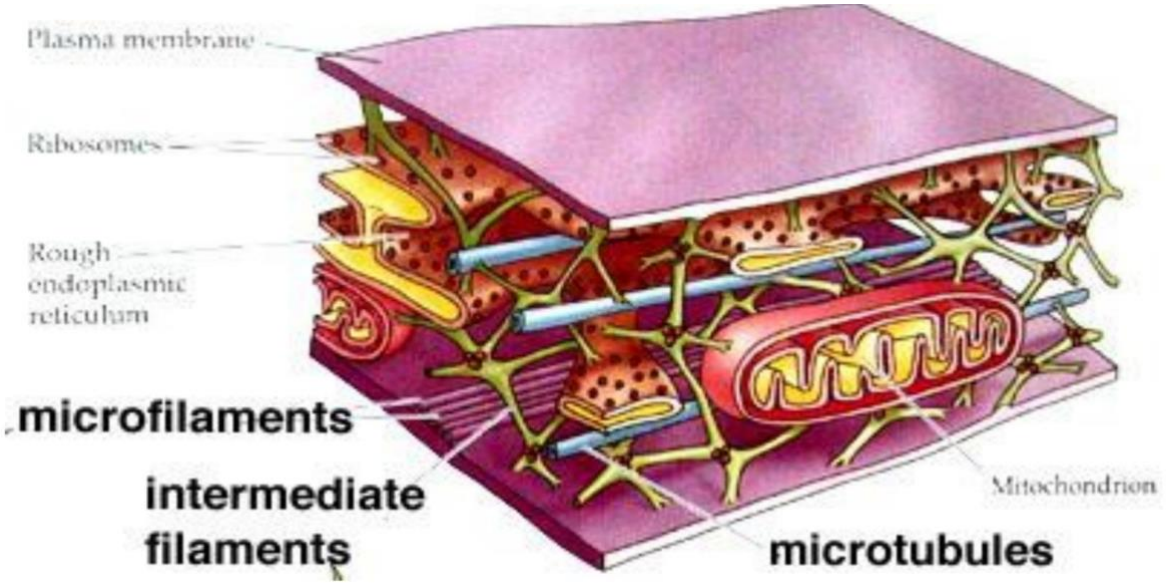
NADH and FADH2 are oxidized ,the produced electrons go to the electron transport chain and move from complex to another until to reach to oxygen. During this transportation, electrons give energy to complexes that use it to transport H+ from matrix to inter membranous space because of that the concentration of H+ in the inter membranous space will be higher .
After that protons will be transpoted into matrix by ATP synthesis enzyme(fifth complex) but there is condition and this condition is protons give this enzyme energy to go to the matrix . This energy is used to produce ATP.



This process called oxidative phosphorylation

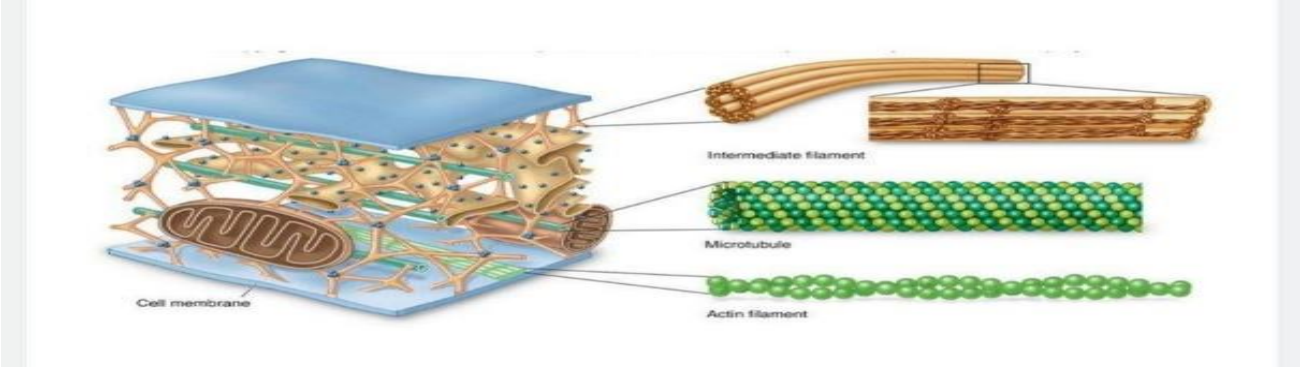
Supportive video: https://www.youtube.com/watch?v=fHoL-vcMENw





We have three types of the cytoskeletons :

- Microfilaments
- Intermediate filaments
- Microtubules



There are functions of cytoskeleton:

By microtubules:-

- Formation of cilia
- Transporting vesicles
- Formation of mitotic spindle

By actin filament:-

- Formation of pseudopods
- Contraction of muscles

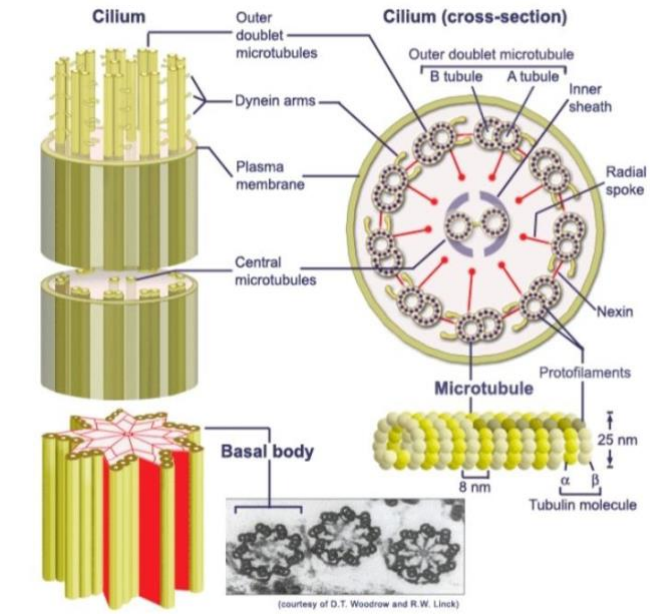
And determination the shape of cell.

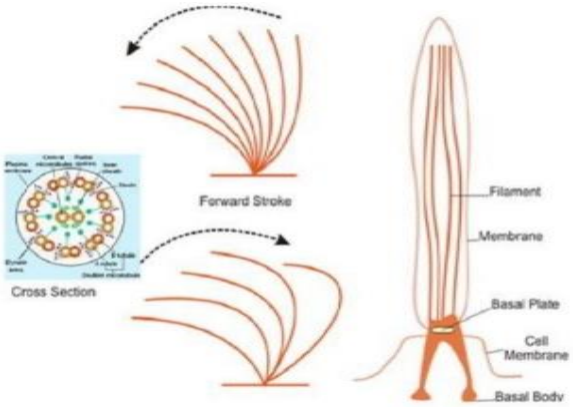
Formation of cilia:-

Respiratory system has cilia that is waving to get the movement of mucus that is secreted to be exited out of the respiratory system.

The structure of the cilia is nine pairs of microtubules in the form of ring on its tip and one pair in the middle and these are connected with each other to motor proteins .

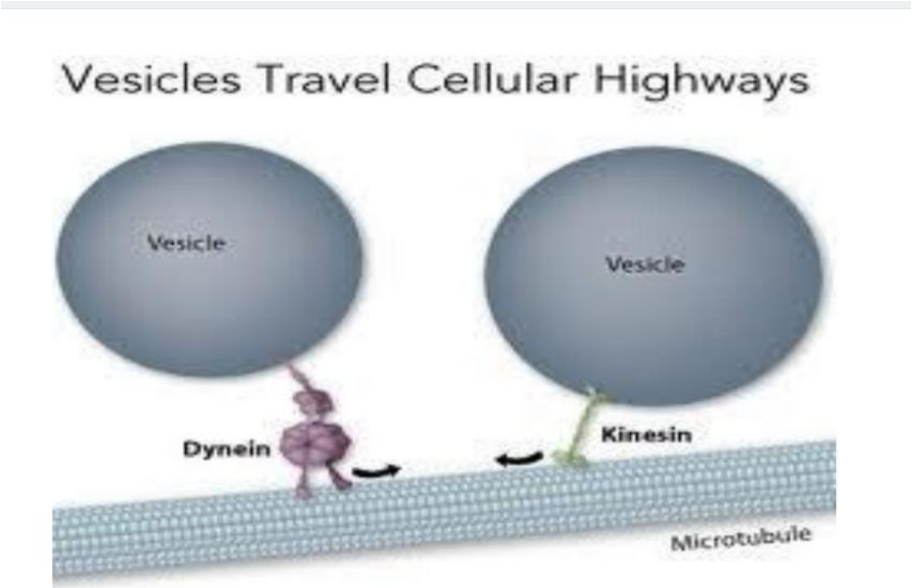
The movement of motor proteins that are connecting microtubules together sliding up and down resulting in waving of the cilia in one direction or another .

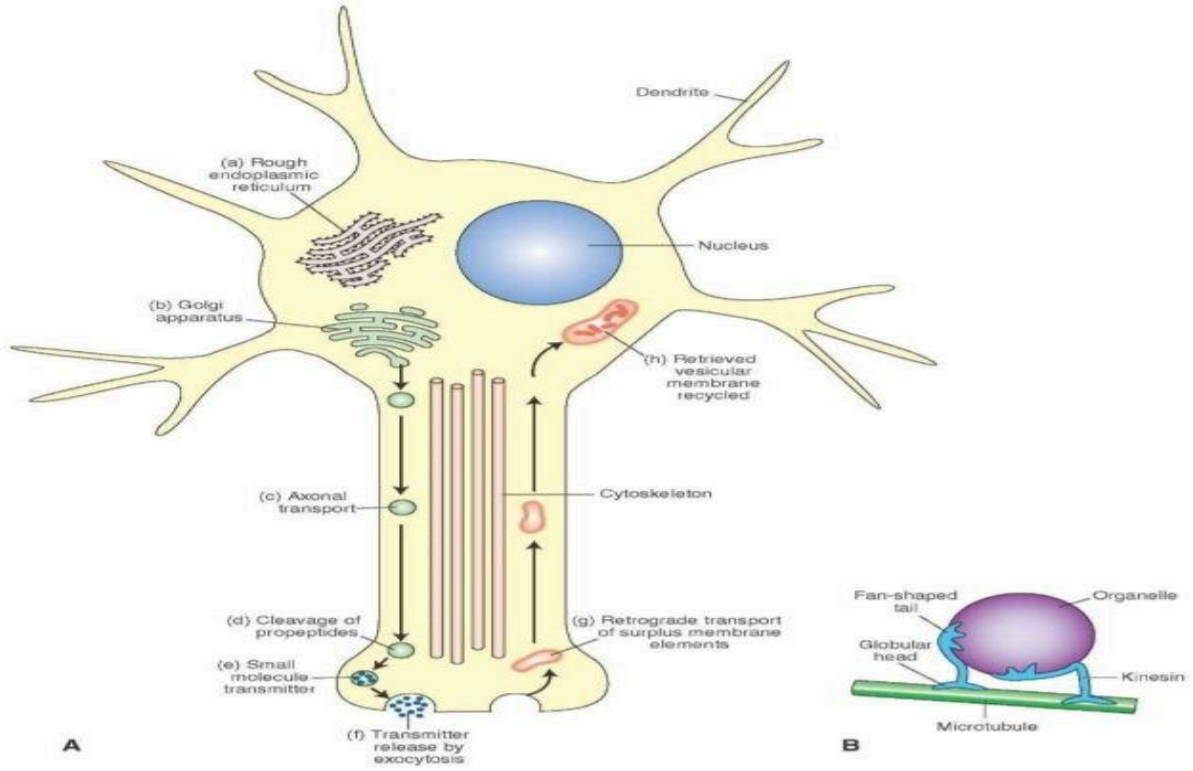




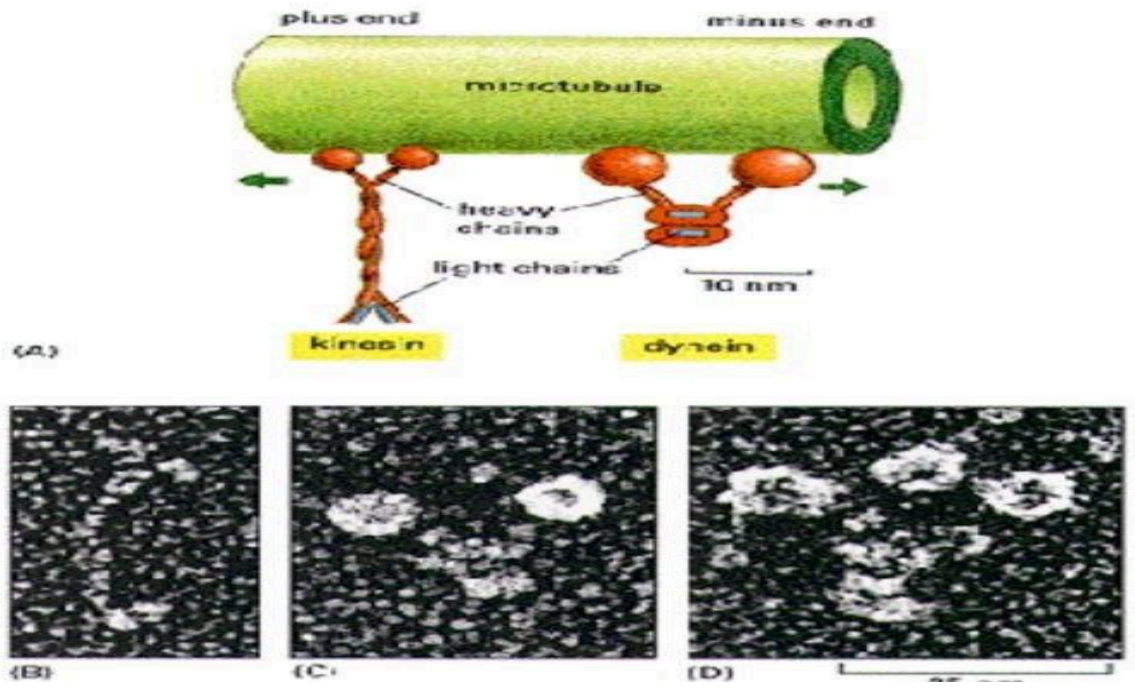
Transporting vesicles:-

Microtubules is very important for vesicles transport .we have system from microtubules and proteins perform this function . In this system microtubules act as street that certain types of proteins which act as vehicles carry vesicles walk on this street. Each type of proteins is specialized to sent vesicle to particular destination. We have plenty of vesicles transport inside the cells which is achieved with the help of the microtubules, vesicles are linked to these microtubules by motor proteins are walking along this microtubules to transport vesicles.



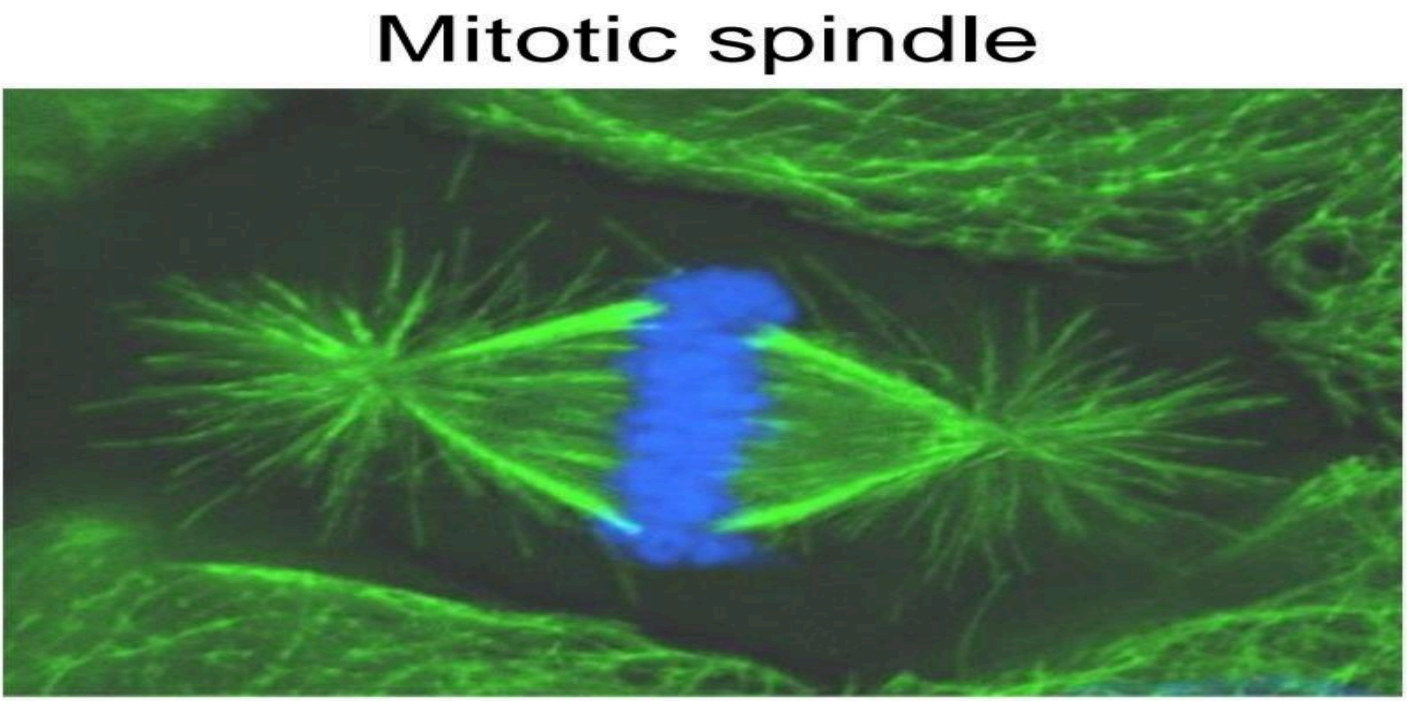


Example of that is neural cell, neurotransmitters are synthesized in the cell body but their function is at the terminals and we have very long distance between the cell body and terminals (0.5-1) meters .How we are transport these?
The answer is by vesicle transport after packing them in vesicles we have along axles of microtubules and these vesicles use these microtubules to get transporting of the neurotransmitters from the cell body toward the terminals of the neural cell .



Formation of the mitotic spindle:-

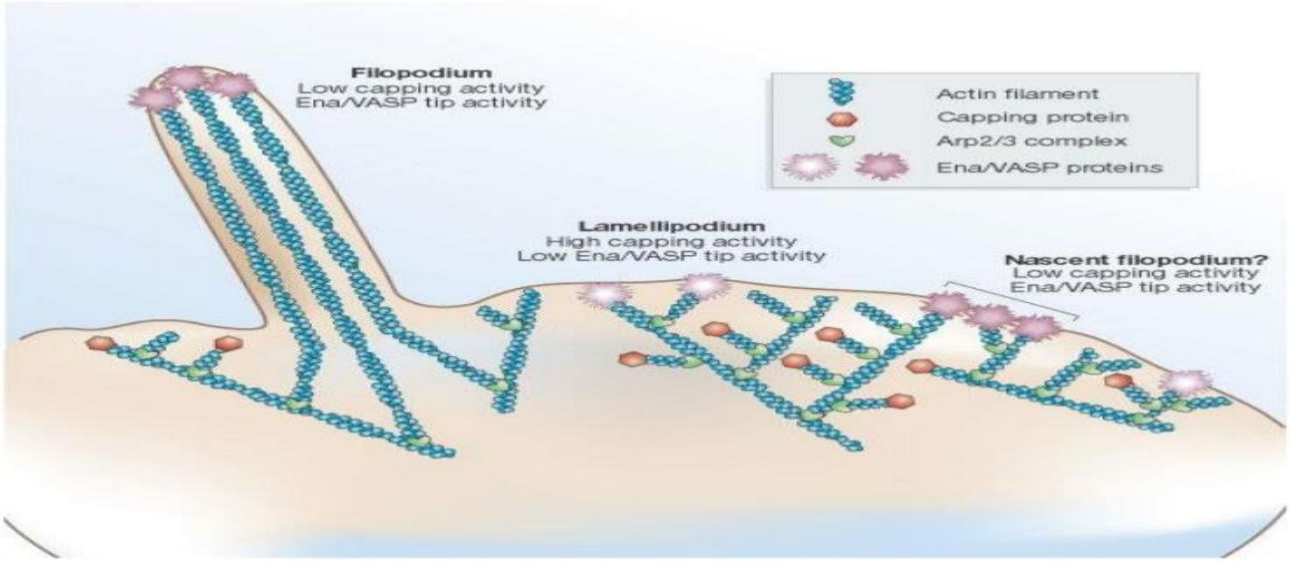
Microtubules have function during division of the cell by formation of the mitotic spindles . They can polymerize and connect to chromatids and by their connections they can shrink and get separation of these chromatids with the help of mitotic spindles.



Formation of the pseudopods:-

Some cells are moving by process of forming pseudopods that attached to some points and this process is done by polymerization of actin filaments to get longer actin filaments in that direction after binding of that pseudopods that is trapping the rest of the cell to that location , so it's important for movement of this cell.

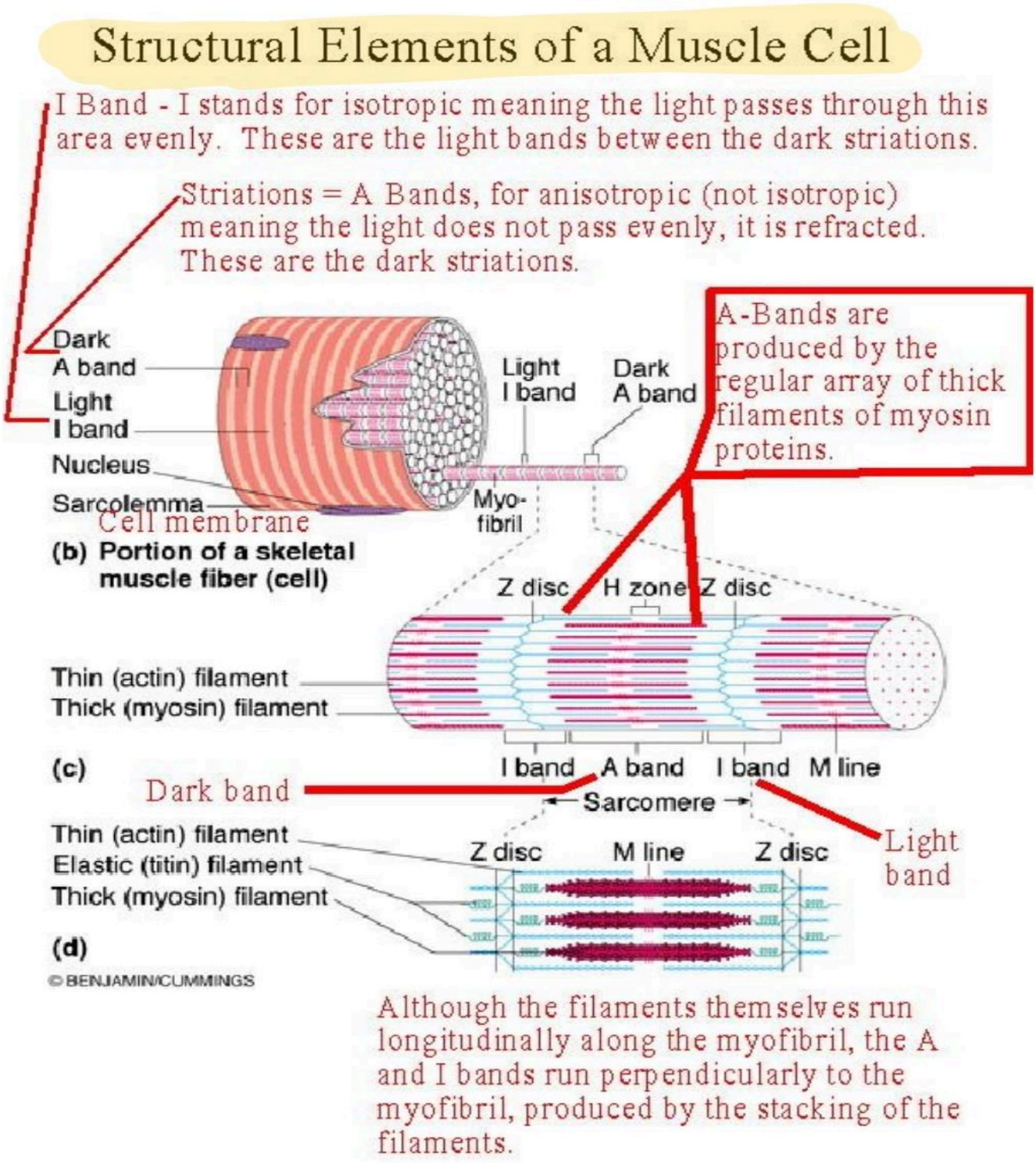
Pseudopods is hidden by depolymerizing .

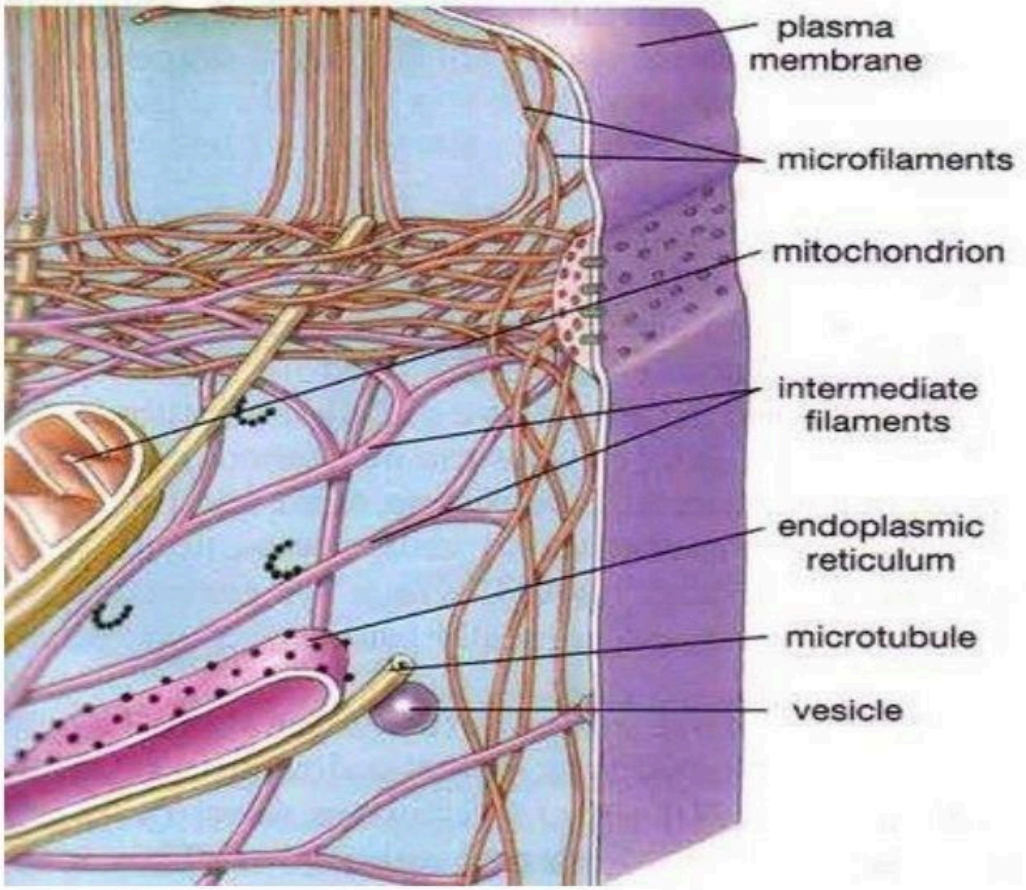


Contraction of muscles:-

We have thin and thick filaments, actually these filaments are different from each other .

The contraction of muscles is done by sliding thick filaments and thin filaments that causes shorting of them .

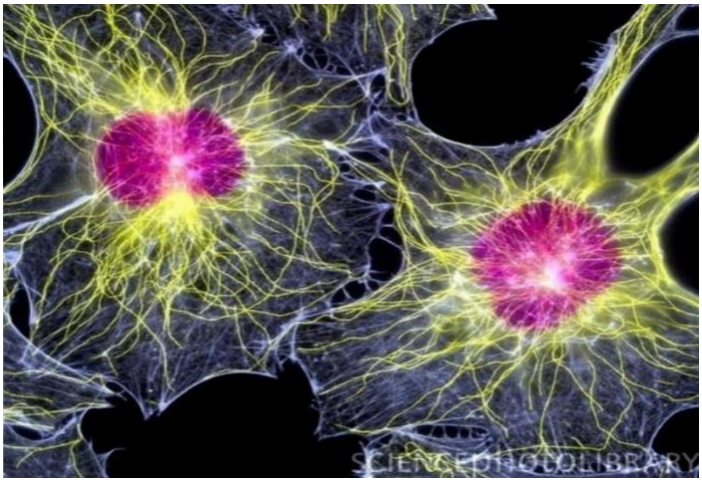


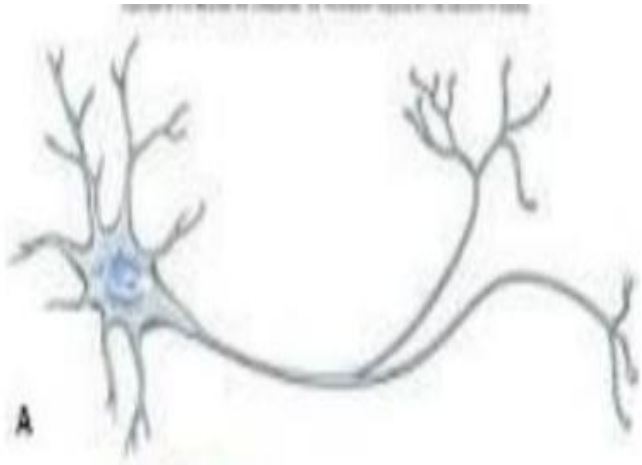


cytoskeletons are keeping the geometry and shape of cell.

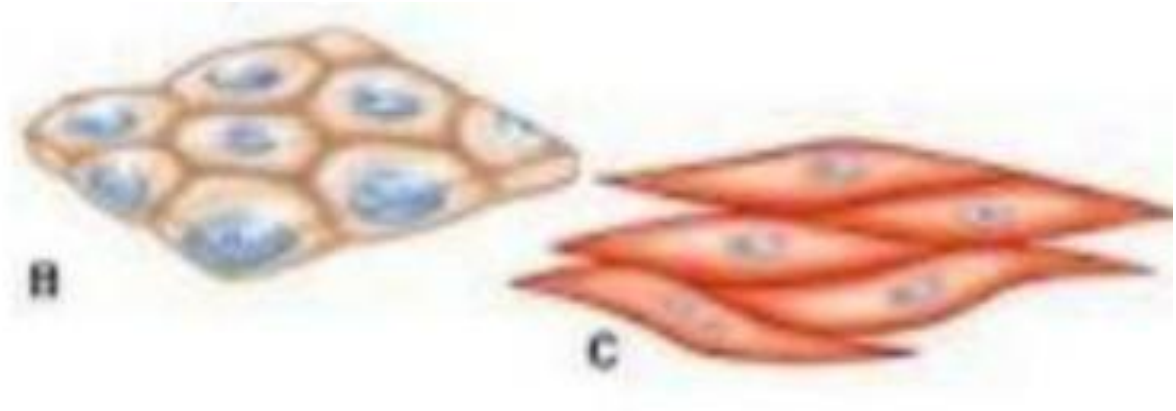
The importance of the cell shape for its function

We have different shapes of cells and these shapes are important for the functions .

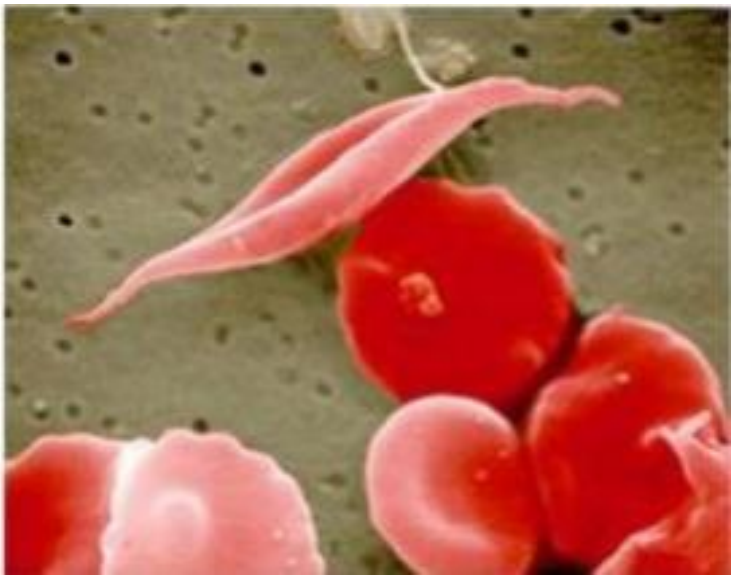




Neurons have rounded shape that is important for the function. Its shape increase the surface area to get some nutrients absorbed well ,In addition, we have a lot of factors called trophic factors that can be released by other cells around the neurons which are helping the survival of these neurons much better.



Muscles cells are elongated cells not rounded. If it is rounded , contracting won't be efficient but it is elongated structure. By contraction we are getting good shortening of that cell to get the job .



Blood cells can transport oxygen well for highest amount of paths in very short time .. They are disk shape (biconcave) to get much better loading for these cells during this short time while they passage in capillaries of the lungs to be oxygenated and in other body cells to give them the oxygen.
If they are spherical ,they can't do their function and this case considered disease because this cell will not transport oxygen well .

Good luck for all😊