

Cell types:

Muscle cell

Adipocyte

Liver cell

Pancreatic cell

Example: Neuron

Outline of the presentation

1. Description of the cell type: basic functions, tissue/organ where it can be found

Neurons:

The main cell type of the nervous system.

Neurons perceive outside information, integrate them and innervate muscles, induce hormone, enzyme secretion, DNA transcription.

They receive inputs via their synapses summate them and generate action potentials.

2. Morphology, types:

many types:

cortical pyramidal cell: typical in the neocortex, hippocampus, paleocortex, pyramidal shaped soma, thick apical dendrites and thin basal dendrites.

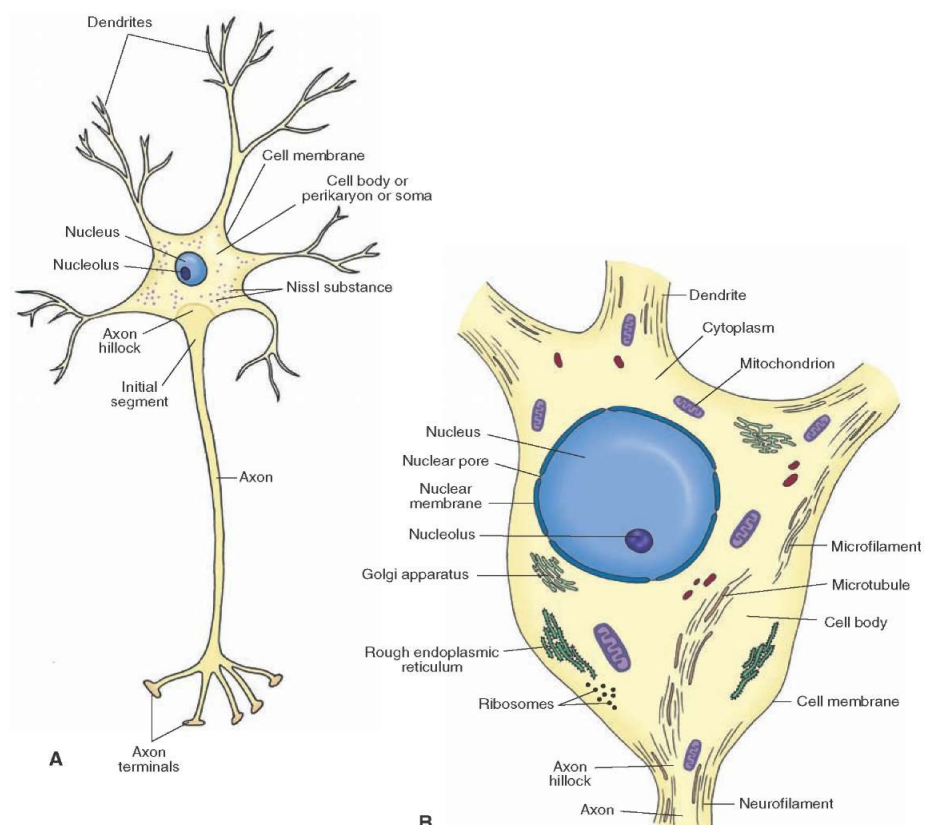
motoneurons: in the spinal cord; multipolar soma, thick dendrites, axons innervate different muscles

interneurons. coordinates the output of the pyramidal cells in different brain structures diverse dendritic arborization patterns, synaptic terminals could be on special parts of the pyramidal cell, like chandelier cells innervate pyramidal cell axon initials.

etc

3. Organelles:

(basic description of each organelle, and special features)



Cell membrane:

The neuronal membrane serves as a barrier to enclose the cytoplasm inside the neuron, and to exclude certain substances that float in the fluid that bathes the neuron.

Main functions:

- keeping Na^+ and other ions and small molecules out of the cell,
- rejecting harmful substances,
- conducting an impulse,
- catalyzing enzymatic reactions,
- membrane carriers accumulate nutrients,
- membrane receptors, ion channels perceive signals and establish electrical potentials,
- transporters, ATPases maintains resting ion concentrations.

Nucleus:

It is large and round and is centrally located.

In some cells, masses of deeply staining chromatin are visible in the nucleus.

The nuclear membrane - a double membrane punctuated by pores (nuclear pores) which are involved in nuclear-cytoplasmic interactions.

Neurons with long axons have a larger cell body and nucleus.

The principal component of the nucleus is deoxyribonucleic acid (DNA) forming chromosomes and genes.

From the DNA there is mRNA syntheses, but neurons do not divide do there is no DNA syntheses

Nucleolus:

It is in the center of the nuclei of all neurons.

The nucleolus synthesizes ribosomal RNA.

Cytoskeleton:

This cytoplasmic component, the cytoskeleton, is the main determinant of the shape of a neuron. It consists of three filamentous elements: microtubules, neurofilaments, and microfilaments.

1. Microtubules: consist of helical cylinders made up of 13 protofilaments, which, in turn, are linearly arranged pairs of alpha and beta subunits of tubulin. They are 25 to 28 nm in diameter and are required in the development and maintenance of the neuron's processes.

2. Neurofilaments: are composed of fibers that twist around each other to form coils. Two thin proto-filaments form a protofibril. Three protofibrils form a neurofilament that is about 10 nm in diameter. Neuro-filaments are most abundant in the axon. In Alzheimer's disease, neurofilaments

become modified and form a neurofibrillary tangle.

3. Microfilaments: are usually 3 to 7 nm in diameter and consist of two strands of polymerized globular actin monomers arranged in a helix. They play an important role in the motility of growth cones during development and in the formation of presynaptic and postsynaptic specializations.

Endoplasmatic reticulum ER:

Two parts: Rough Endoplasmic Reticulum (RER) with ribosomes on its surface and Smooth Endoplasmic Reticulum (SER)

A system of tubes for the synthesis and transportation of materials within the cytoplasm.

RER is important for protein synthesis, SER is involved in Ca^{2+} buffering and in the biosynthesis and recycling of synaptic vesicles.

Nissl Substance or Bodies:

Polyribosomes - there are several free ribosomes attached by a thread. The thread is a single strand of mRNA (messenger RNA, a molecule involved in the synthesis of proteins outside the nucleus).

The associated ribosomes work on it to make multiple copies of the same protein.

Granular material is present in the entire cell body and proximal portions of the dendrites.

Mitochondria:

Spherical or rod-shaped structures, their inner membrane consists of folds projecting into the interior of the mitochondria. They are involved in the generation of energy for the neuron.

Enzymes involved in the tricarboxylic cycle and cytochrome chains of respiration are located on the inner membrane.

The mitochondria are present in the soma, dendrites, and the axon of the neuron and are involved

Golgi Apparatus:

membrane-bound structure that plays a role in packaging peptides and proteins (including neurotransmitters) into vesicles.

Protein-containing vesicles that bud off from the rough endoplasmic reticulum are transported to the Golgi apparatus where the proteins are modified (with processes such as glycosylation or phosphorylation), packaged into vesicles, and transported to other intracellular locations (such as nerve terminals).

Lysosomes:

Lysosomes are small (300-500 nm) membrane-bound vesicles formed from the Golgi apparatus that contain hydro-lytic enzymes. They serve as scavengers in the neurons.

Dendrites:

Dendrites are short processes arise that from the cell body. Their diameter tapers distally, and they branch extensively.

Small projections, called dendritic spines, extend from dendritic branches of some neurons.

The primary function of dendrites is to increase the surface area for receiving signals from axonal projections of other neurons. The presence of dendritic spines further enhances the synaptic surface area of the neuron. The dendritic spines are usually the sites of synaptic contacts. The cytoplasmic composition in the dendrites is similar to that of the neuronal cell body: Nissl granules (ribosomes), smooth endoplasmic reticulum, neurofilaments, microfilaments, microtubules, and mitochondria are found in the dendrites.

Axon:

A single, long, cylindrical and slender process arising usually from the soma of a neuron is called an axon. The axon usually arises from a small conical elevation on the soma of a neuron that does not contain Nissl substance and is called an axon hillock. The plasma membrane of the axon is called the axolemma, and the cytoplasm contained in it is called axoplasm. The axoplasm does not contain the Nissl substance or Golgi apparatus, but it does contain mitochondria, microtubules, and neurofilaments.

The action potential originates at the axon hillock. Axons are either myelinated or unmyelinated, their terminal ends are called synaptic terminals (synaptic boutons).

Synapses:

Synapses are specialized junctions between neurons that facilitate the transmission of impulses from one (presynaptic) neuron to another (postsynaptic) neuron. Synapses also occur between axons and effector (target) cells, such as muscle and gland cells. Synapses between neurons may be classified morphologically as: axodendritic, occurring between axons and dendrites; axosomatic, occurring between axons and the cell body; axoaxonic, occurring between axons and axons.

4. Cell functions:

Action potential (AP) generation:

AP generation is the process by which a neuron rapidly depolarizes from a negative resting potential to a more positive potential, and is achieved by influx of mainly Na^+ ions and Ca^{2+} ions through ion channels. It occurs at the action potential initiation zone region of the soma, and is propagated along the axon to downstream targets.

AP comprises an initial explosive increase in membrane Na^+ ion permeability which allows these ions to flood down their concentration gradient into the cell, thereby depolarizing the membrane such that the potential difference is transiently reversed to a positive value. It lasts for only a

millisecond, then the membrane potential is rapidly restored to its resting negative value (repolarization). These events are controlled by the brief opening and closing of a transient, voltage-activated sodium channel and then the opening of the delayed rectifier potassium channel and later other potassium channels in the membrane.

The key features of the action potential are that it is: (1) an all-or-none event, rather than a graded response; (2) it is self-propagating, such that the wave of depolarization travels rapidly along the plasma membrane; and (3) it is transient, such that membrane excitability is quickly restored.

These features of the action potential allow rapid transfer of information along nerve axons in the nervous system.

Divisions:

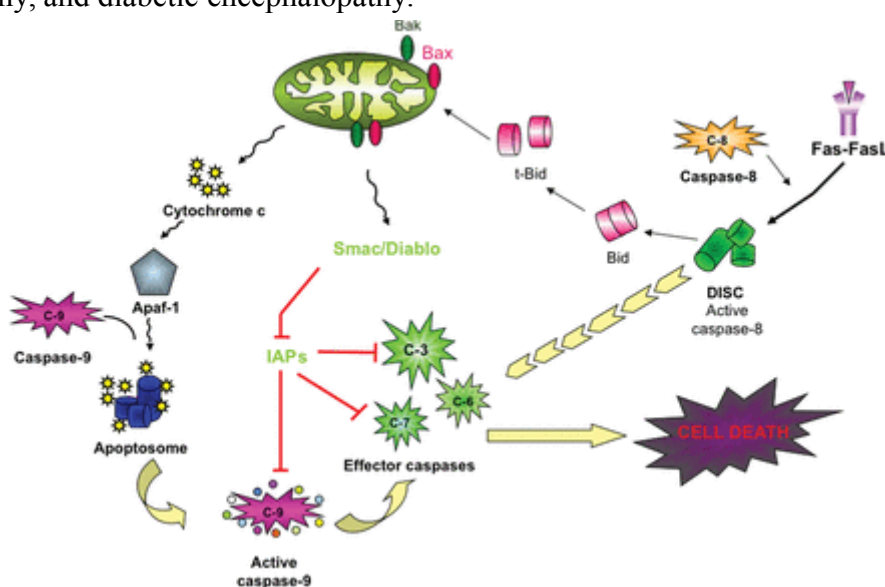
They do not divide after differentiation

Cell death:

Apoptosis:

Apoptosis mediates the precise and programmed natural death of neurons and is a physiologically important process in neurogenesis during maturation of the central nervous system. The massive overproduction of neurons that occur during the development of the brain is followed by a programmed cell death of roughly one-half of the originally formed neurons.

However, premature apoptosis and/or an aberration in apoptosis regulation is implicated in the pathogenesis of neurodegeneration, a multifaceted process that leads to various chronic disease states, such as Alzheimer's, Parkinson's, Huntington's diseases, amyotrophic lateral sclerosis, spinal muscular atrophy, and diabetic encephalopathy.



Intrinsic and extrinsic death pathways

The intrinsic pathway is illustrated on the left-hand side of the Figure. This pathway is mediated by permeabilization of mitochondria, followed by release of cytochrome c, which, in an ATP-

dependent fashion, assembles Apaf-1 (apoptotic protease-activating factor 1; the specific adaptor of caspase 9) and pro-caspase 9 into the apoptosome where caspase 9 dimerizes, resulting in a conformational change and caspase 9 activation. On the right-hand side of the Figure is the extrinsic pathway. Death receptor ligands, illustrated here with Fas ligand (FasL), bind the appropriate receptor and recruit death adaptor proteins [FADD (Fas-associated death domain)], which dimerize and activate caspase 8 in the DISC. Active caspase 8 and active caspase 9 cleave and activate effector caspases, leading to cell death. The DISC can potentiate the intrinsic pathway through the cleavage of BID to t-Bid, which enhances mitochondrial permeabilization. The cytosolic IAPs can inhibit caspases 3, 7 and 9. IAPs can be inhibited by Smac/Diablo, which is released from permeabilized mitochondria. C-, caspase.

Necrosis:

Brain ischemia often results in necrotic cell death in the infarct core and cellular dysfunction in the peri-infarct zone. Neuronal necrosis results in extensive spreading of death to adjacent cells through complicated signaling pathways, including ROS, JNK, Eiger (*Drosophila* TNF α) and other unknown signals.

Ischemic stroke, for instance, is caused by a lack of oxygen and glucose in the brain, which leads to the excessive accumulation of glutamate in the extracellular space. Glutamate then activates *N*-methyl-d-aspartate (NMDA) receptors, which trigger calcium influx and a series of detrimental events, including production of nitric oxide (NO), activation of extracellular signal-regulated kinase (ERK1/2) and calpain, swelling of organelles, rupture of plasma membrane, and irreversible necrotic cell death in neurons. Calcium overload can activate the ERK pathway, and the translocation of activated ERK1/2 into the nucleus is required for their detrimental effect in neuronal necrosis. In addition, chromatin modifications have been reported to associate with many pathological conditions of neurodegeneration.