Lecture 2 part 1 Physiology of receptors, nervous fibers, synapses.
Lecture 3 part2 Excitation and inhibition in CNS. Principles of reflectory activity coordination.

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DIVISIONS OF NERVOUS SYSTEM

Nervous and endocrine system controls all activities of the body. Primarily, nervous system is divided into two parts:

1) central nervous system;

2) peripheral nervous system.

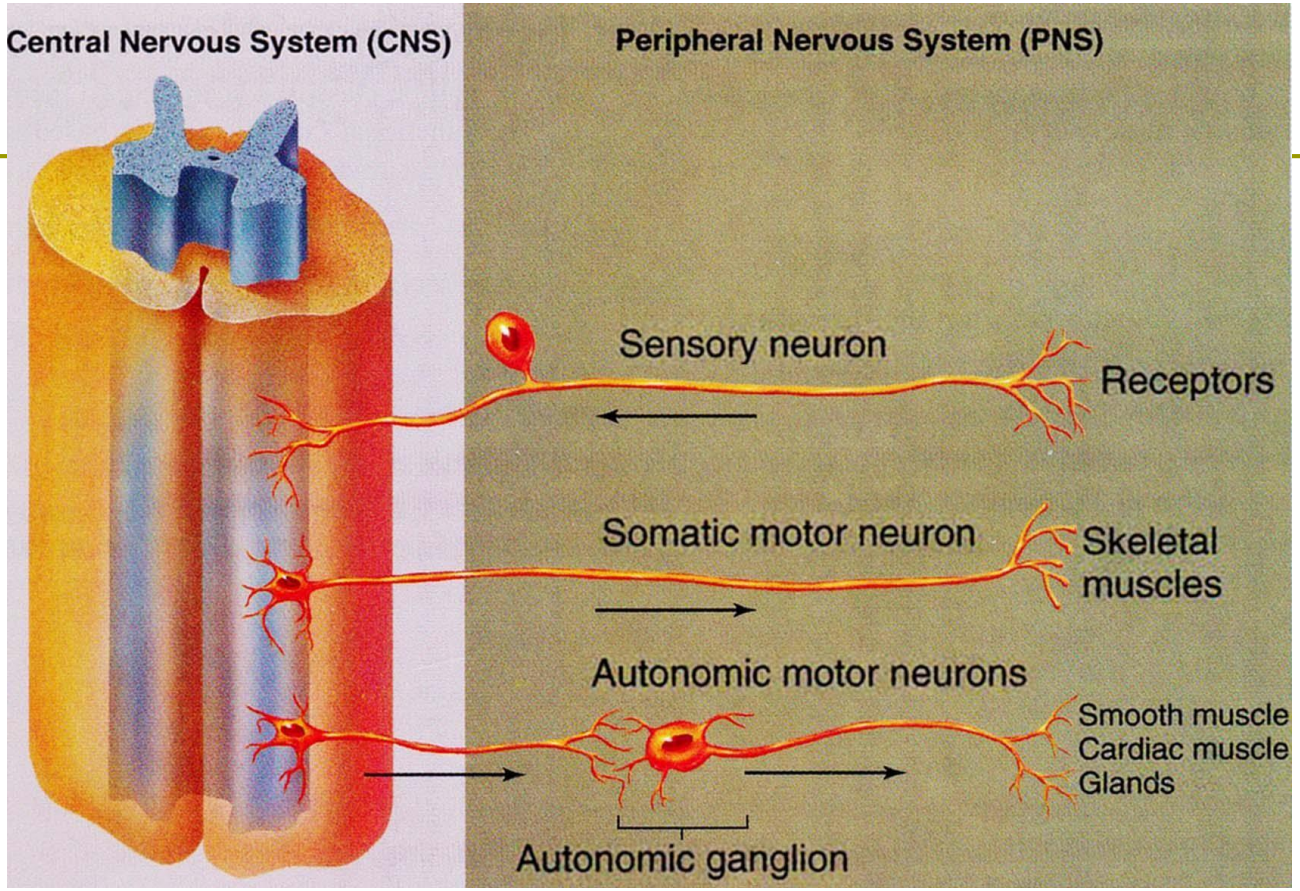
- CENTRAL NERVOUS SYSTEM

It includes brain and spine. It is formed by neurons and the supporting cells called neuroglia.

- PERIPHERAL NERVOUS SYSTEM

It is formed by neurons and their processes present in all regions of the body. This is again divided into two subdivisions.

DIVISIONS OF NERVOUS SYSTEM



The relationship between CNS and PNS. Sensory and motor neurons of the peripheral nervous system carry information into and out of, respectively, the central nervous system (brain and spinal cord).

DIVISIONS OF NERVOUS SYSTEM

PERIPHERAL NERVOUS SYSTEM

1. Somatic Nervous System

It includes the nerves supplying the skeletal muscles. Somatic nervous system controls movements of the body by acting on skeletal muscles.

2. Autonomic Nervous System

It is concerned with regulation of visceral or vegetative functions. So, it is called vegetative or involuntary nervous system with other words. Autonomic nervous system consists of three parts:

a) sympathetic,

b) parasympathetic and

c) metasympathetic.

Structural and functional unit of nervous system is defined as neuron or nerve cell.

NEURONS CLASSIFICATION

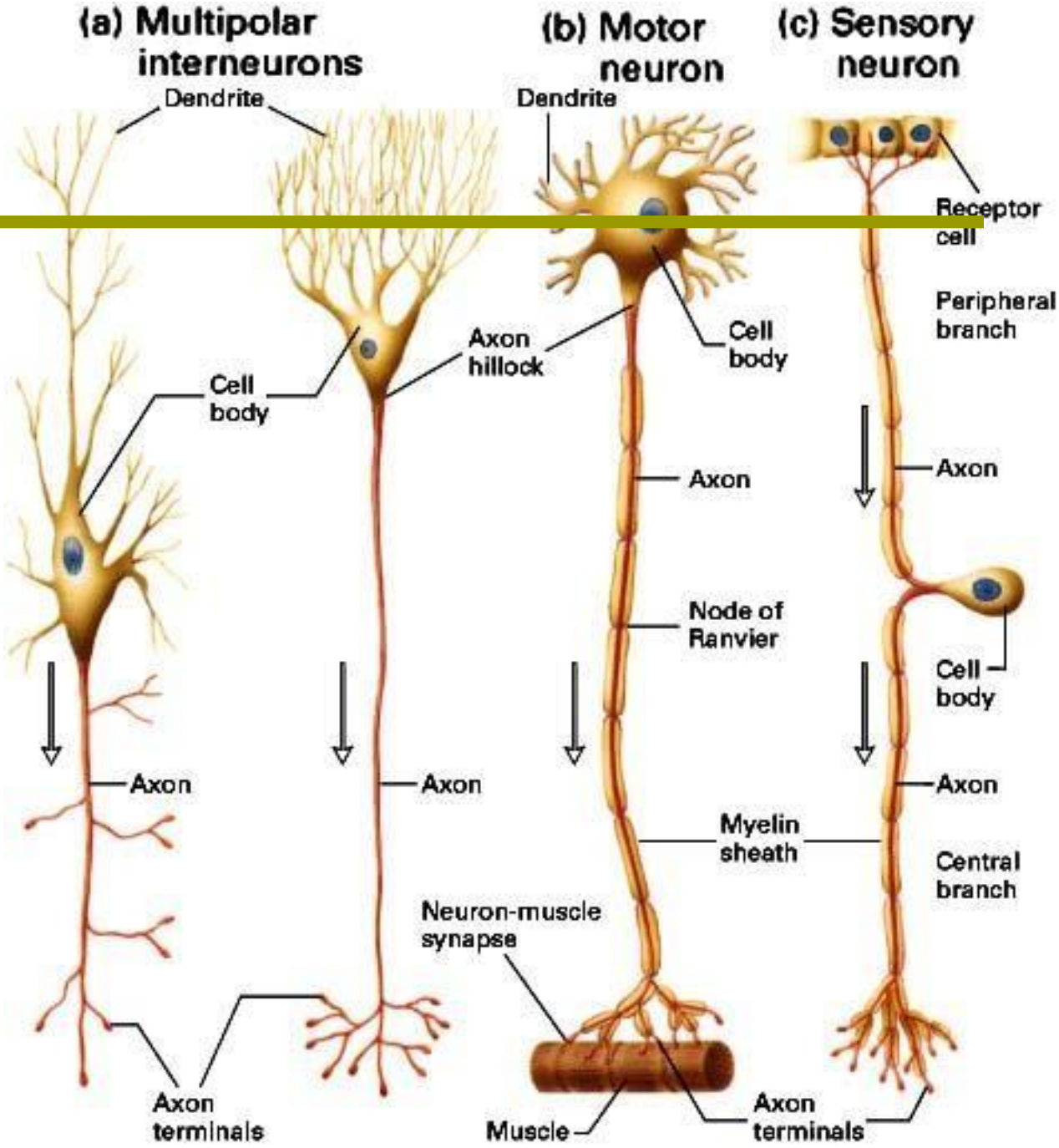
1. Depending on number of poles:
   a) unipolar neurons;
   b) bipolar neurons;
   c) multipolar neurons.
2. Depending on function:
   a) motor or efferent neurons ;
   b) sensory or afferent neurons.
3. Depending on length of axon:
   a)Golgi Type I Neurons — have long axons; are in central nervous system and their axons reach peripheral organs.
   b)Golgi Type II Neurons — have short axons, are present in cerebral cortex and spinal cord.

Types of neurons

(a)Multipolar neurons;

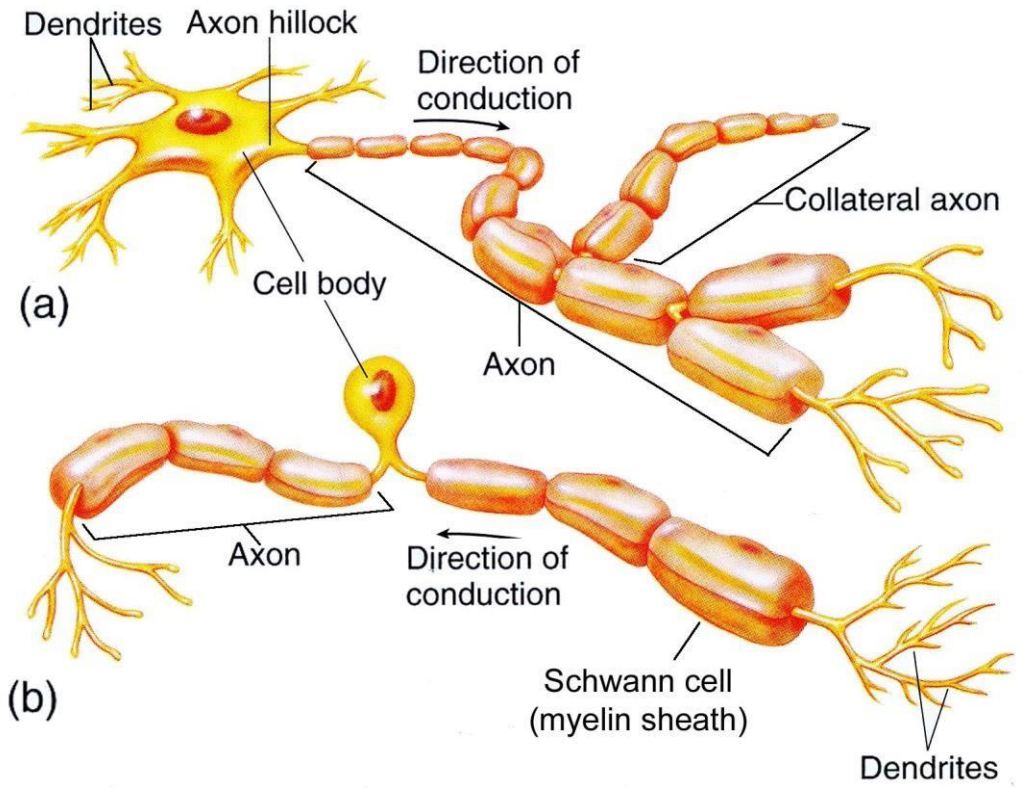
(b)Motor neuron (unipolar);

(c)Sensory neuron.



NEURONS STRUCTURE

1. Nerve cell body
2. Dendrite
3. Axon
4. Myelin sheath or membrane
5. Neurilemma



The structure of two kinds of neurons.
(a) A motor neuron and
(b) a sensory neuron.

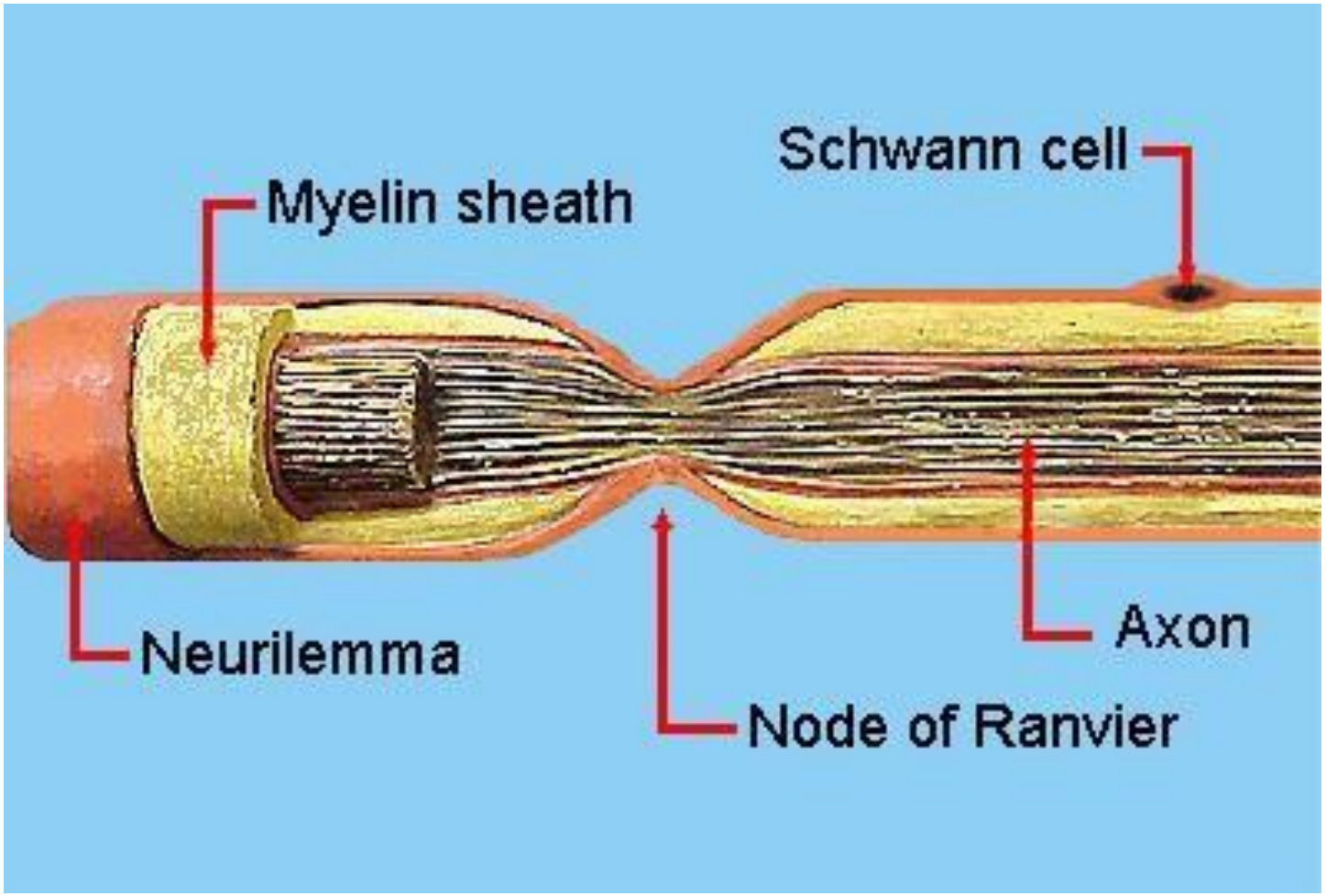
NERVOUS FIBERS PHYSIOLOGY

Structure of Myelinated Nerve Fiber.

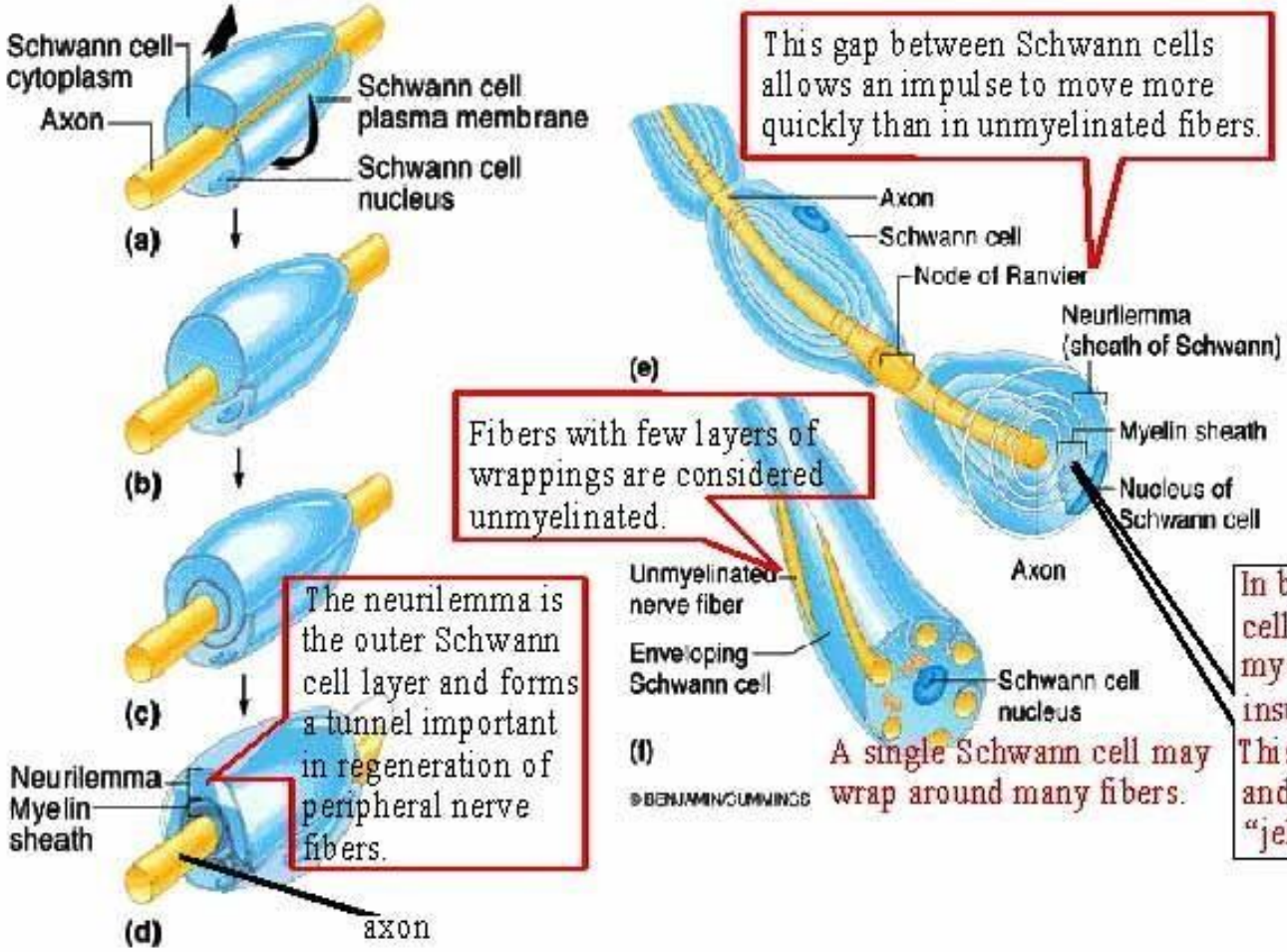
The axis cylinder of the nerve fiber is covered by a membrane called neurilemma.

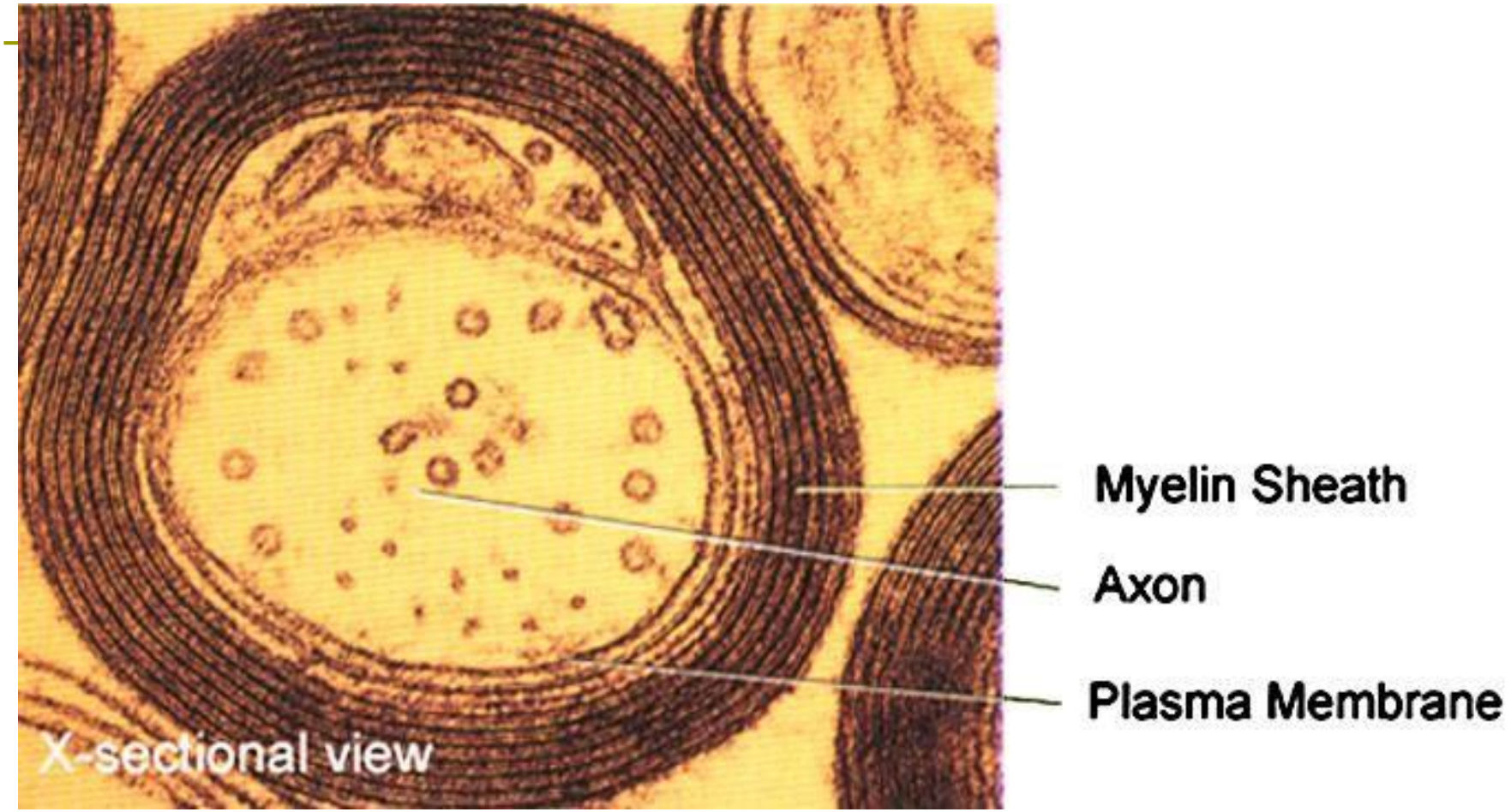
In myelinated nerve fiber, the axis cylinder is covered by a thick sheath called myelin sheath. Myelin sheath in turn is covered by neurilemma.

Myelinated nerve fiber



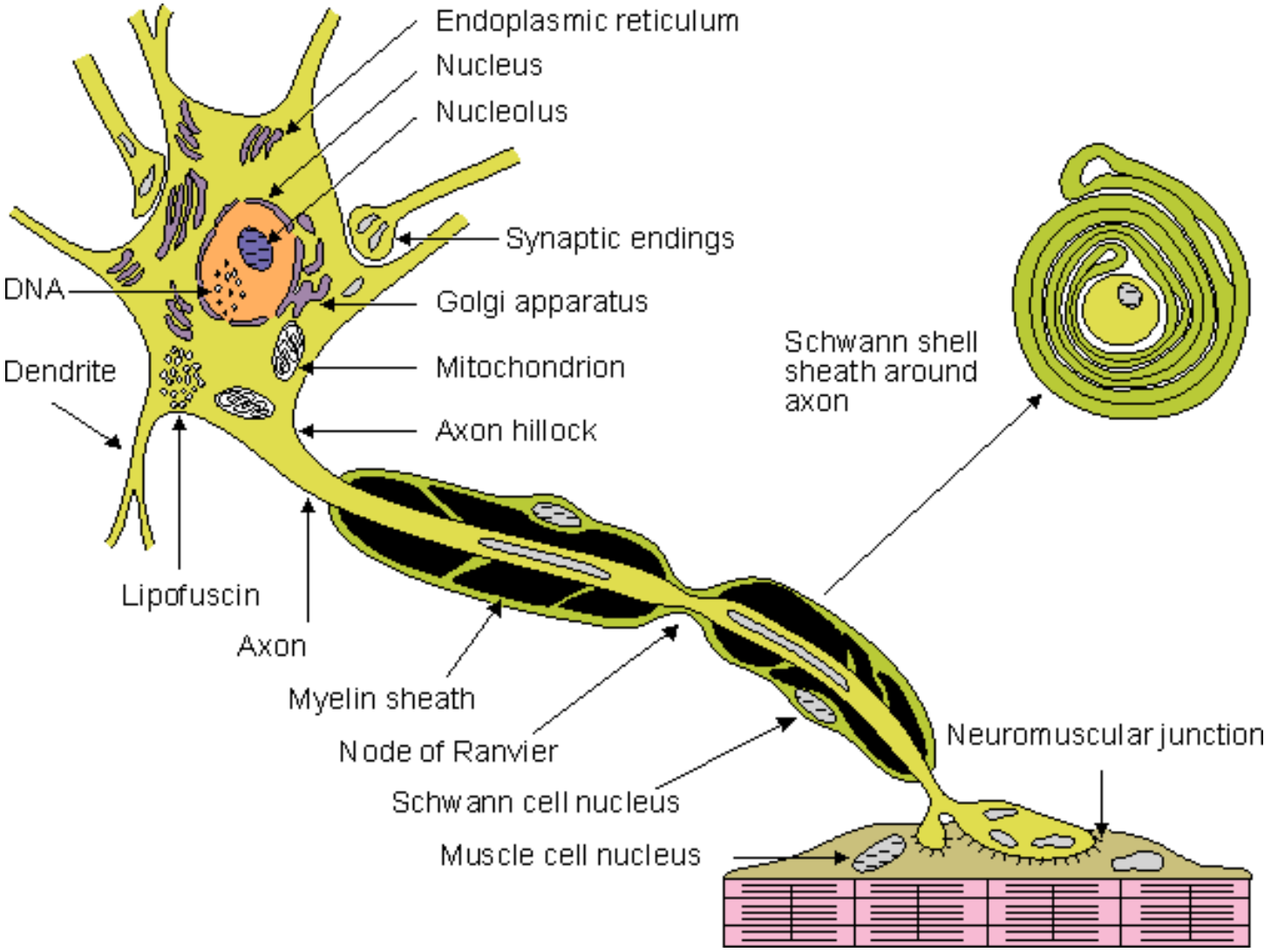
The Myelin Sheath




Myelin Sheath
Axon
Plasma Membrane
X-sectional view

NERVOUS FIBERS PHYSIOLOGY

Myelinated nerve fiber



Mechanism of Saltatory Conduction

In a myelinated nerve fiber, the axis cylinder is covered by sheath called myelin sheath. The area where it is absent is called node of Ranvier. Myelin is lipoproteid.

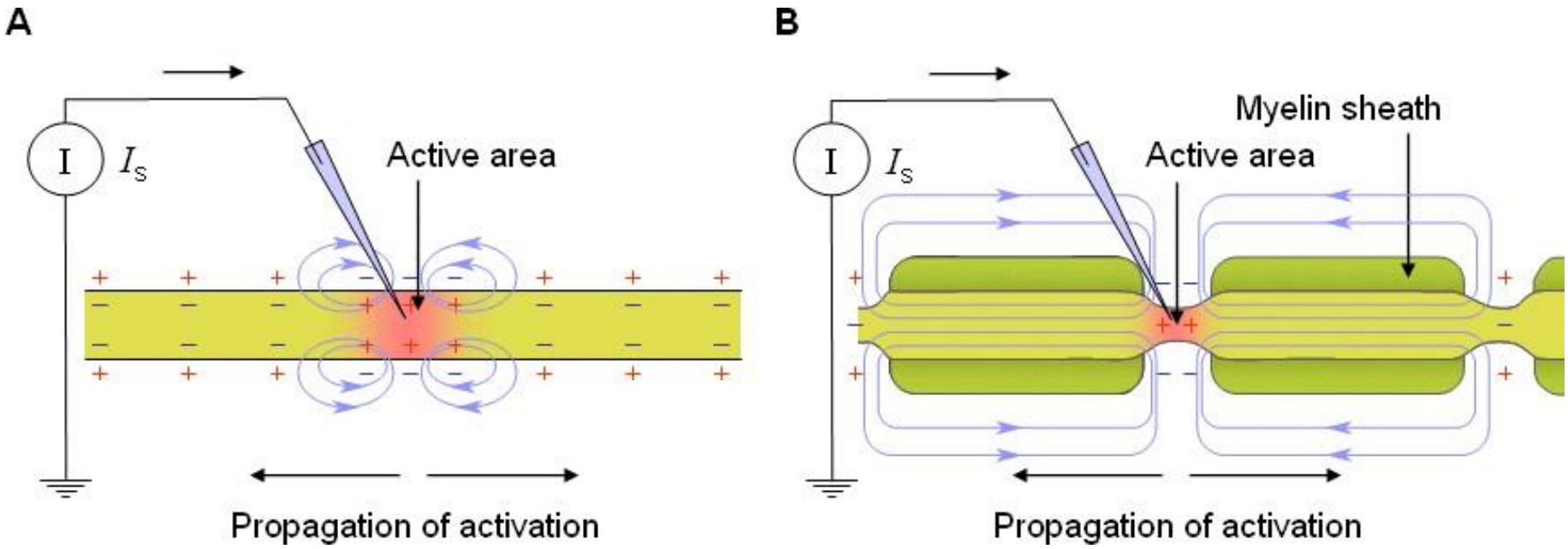
Myelin sheath is responsible for faster conduction of impulse through the nerve fibers because impulses jump from one Ranvier node to another. It is so-called saltatory or jumping conduction.

Nervous impulses conduction

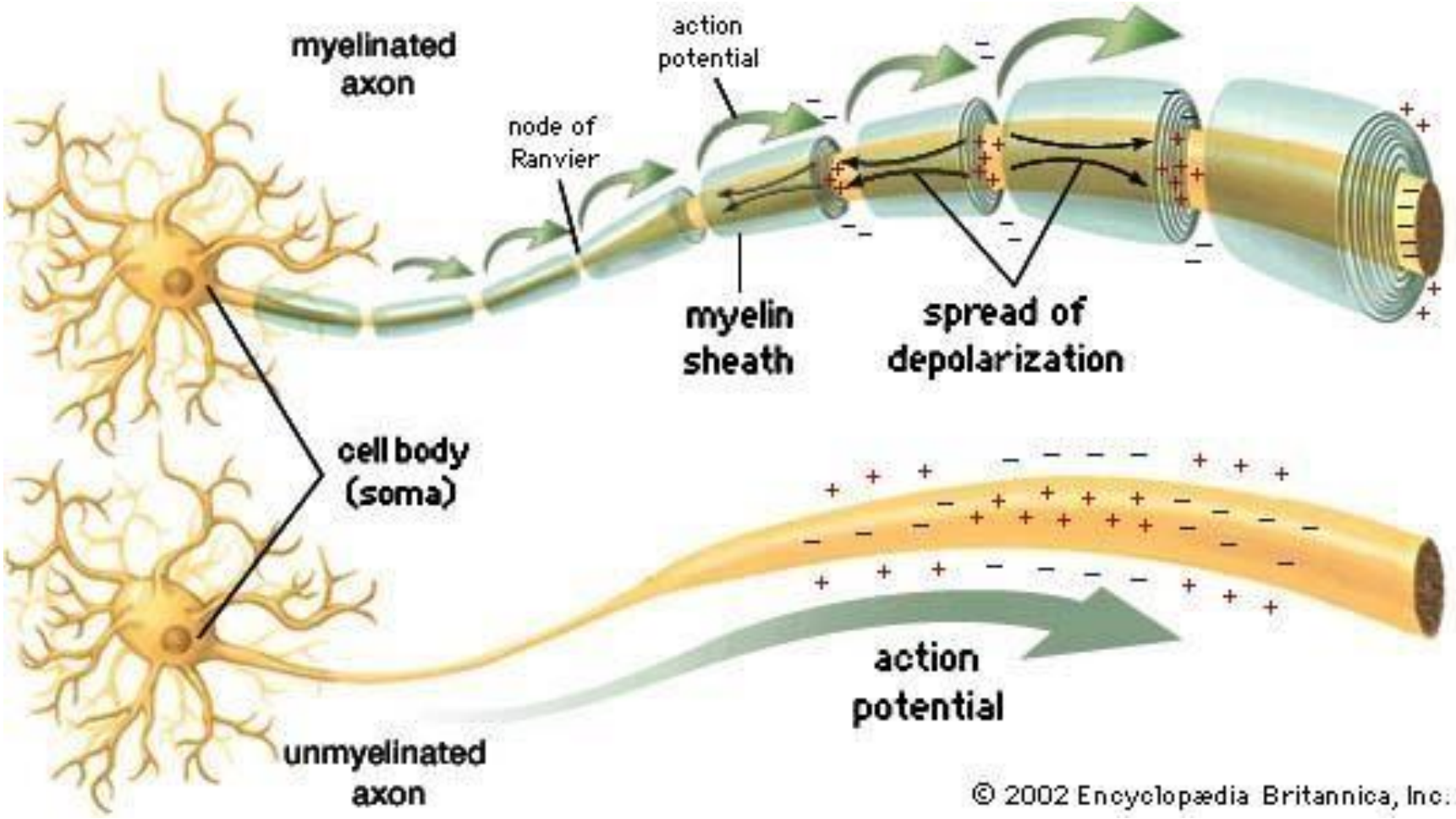
Mode of conduction through nerve fibers.

A. Non-myelinated nerve fiber — ***continuous conduction***

B. Myelinated nerve fiber — ***saltatory conduction***: impulse jumps from node to node.



Nervous impulses conduction



NERVOUS FIBERS CLASSIFICATION (peripheral nervous system)

1. **Depending on structure**:
   a) Myelinated Nerve Fibers.
   b) Non-myelinated Nerve Fibers.
2. **Depending on distribution**:
   a) Somatic Nerve Fibers.
   b) Visceral or Autonomic Nerve Fibers.
3. **Depending on function**:
   a) Motor or Efferent Nerve Fibers.
   b) Sensory Nerve or Afferent Fibers.
4. **Depending on chemical neurotransmitter**:
   a) Noradrenergic — secrete noradrenaline;
   b) Cholinergic — secrete acetylcholine.

NERVOUS FIBERS CLASSIFICATION (continuation)

5. **Depending on diameter and conduction velocity.**

Fibres type	Fibres diameter (mcm)	Transduction velocity (m/sec)	Main function
A_{α} (Type I)	13-22	70-120	skeletal muscles efferent fibres; receptors (muscular spindles) afferent fibres
A_{β} (Type II)	8-13	40-70	afferents from pressure and touching receptors
A_{γ}	4-8	15-40	receptors (muscular spindles) efferent fibres; part of afferents from pressure and touching receptors

NERVOUS FIBERS CLASSIFICATION (continuation)

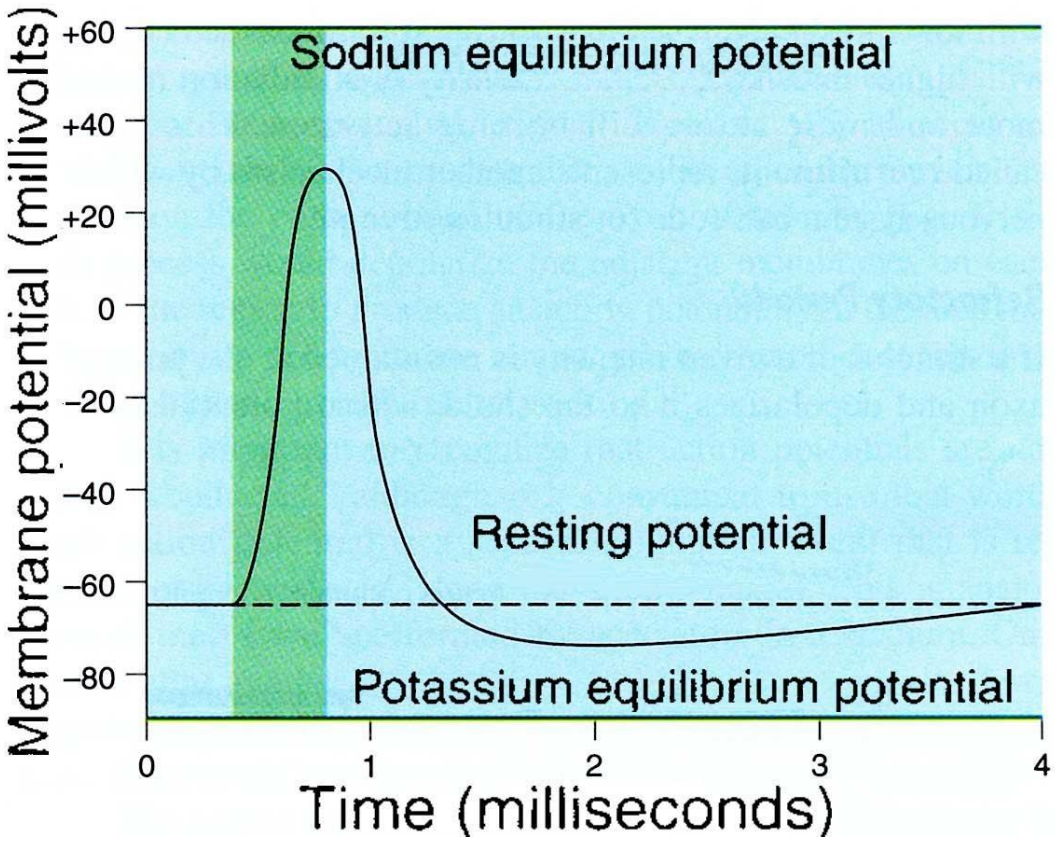
5. **Depending on diameter and conduction velocity (continuation).**

Fibres type	Fibres diameter (mcm)	Transduction velocity (m/sec)	Main function
A_δ (Type III)	1-4	5-15	afferents from skin temperature and pain receptors, partially pressure
B	1-3	3-14	autonomic nervous system preganglionar efferents
C (Type IV)	0,5-1,5	0,5-2	autonomic nervous system postganglionar efferents; pain and warmth skin receptors afferents

NERVOUS FIBERS PROPERTIES

Velocity of impulse through a nerve fiber is directly proportional to thickness of fibers. Except C type of fibers, all nerve fibers are myelinated, B type is partially myelinated.

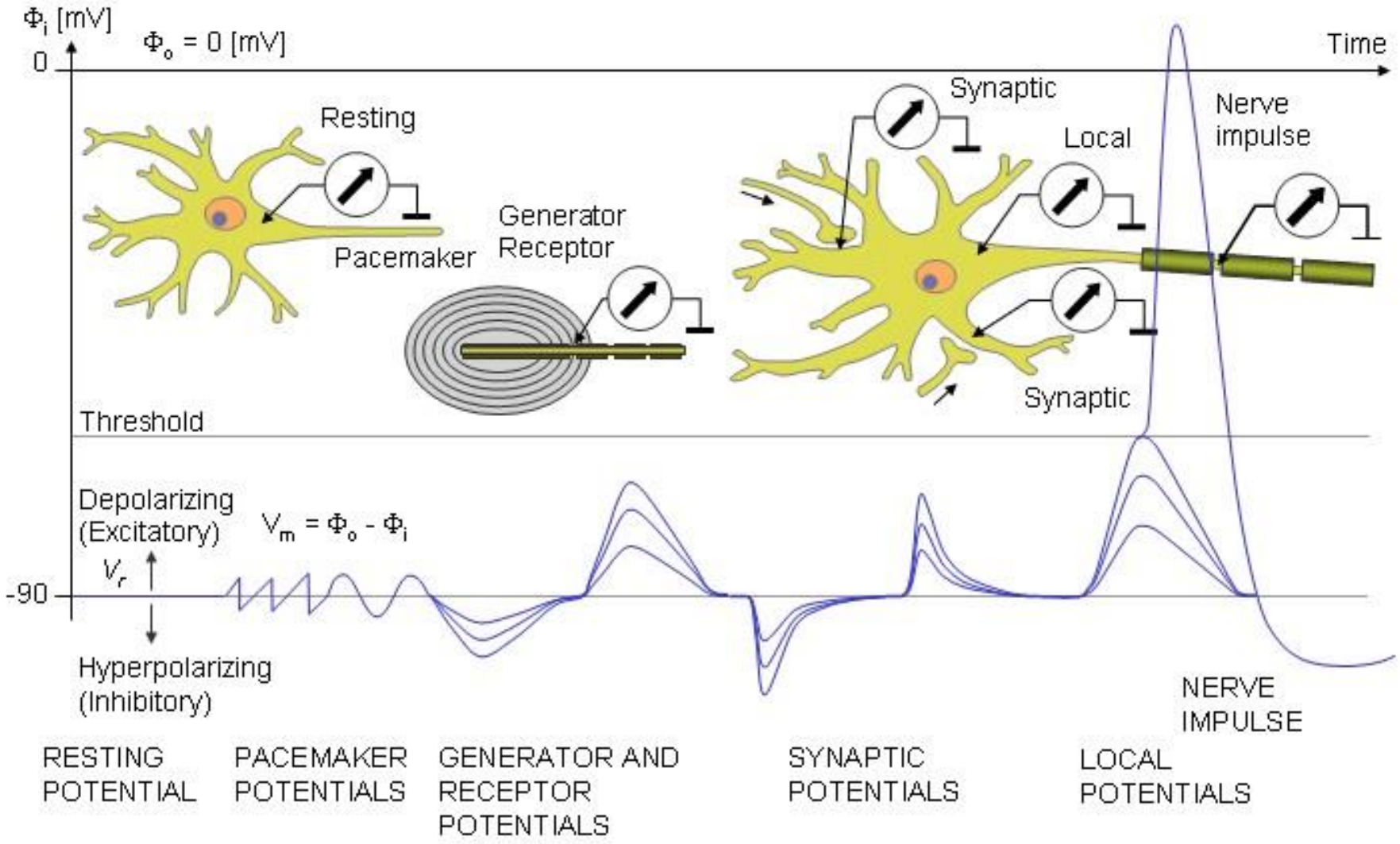
1.Excitability. The resting membrane potential in the nerve fiber is -70 mV. Depolarization ends at +35 mV.



NEROUS FIBERS PROPERTIES

2. Action potentials occur in axonal hillus. It exists prolonged trace hyperpolarization (due to potassium conductivity increasing).
3. **Conductivity:**
   a) Law of physiological integrity.
   b) Law of two-sided conduction: in experimental conditions and pathological conditions (tumor, anaesthesia, inflammation).
   c) Law of excitement isolated conduction.
4. **Non-fatigability.** A nerve fiber cannot be fatigued (Russian physiologist Vvedensky).
5. **Law "Everything or nothing".**
6. **Lability** – is the biggest among all tissues in the body (about 1000 impulses per 1 sec for associative neurons and 40-50 impulses for motoneurons).

NEROUS FIBERS PROPERTIES



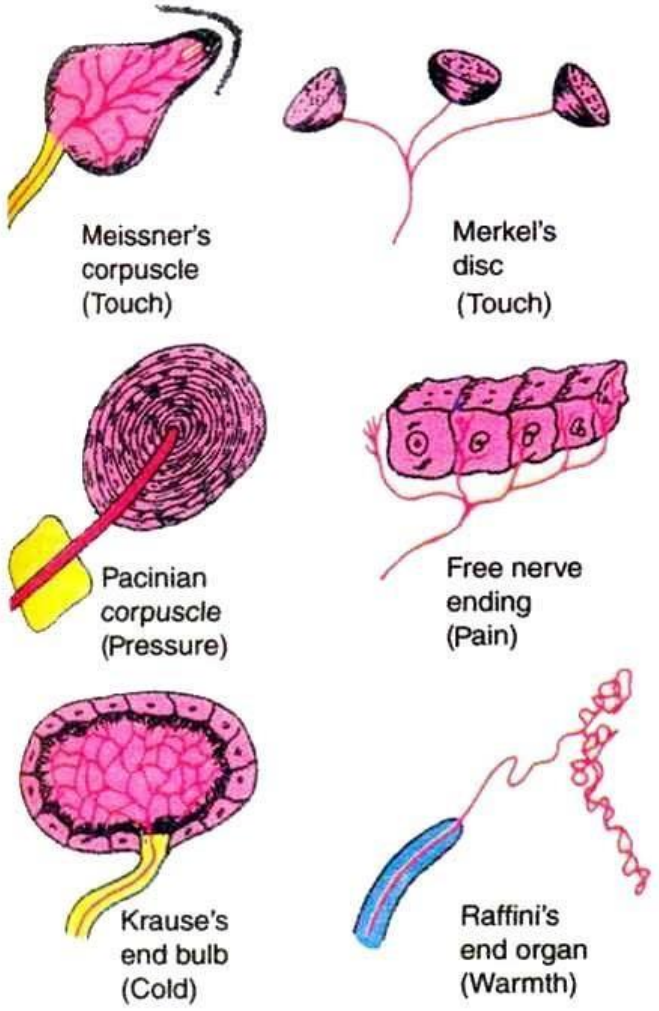
RECEPTORS PHYSIOLOGY

Receptors are excitive cells which transform bioelectrical potential into nerve impulse. The receptors give response to the stimuli.

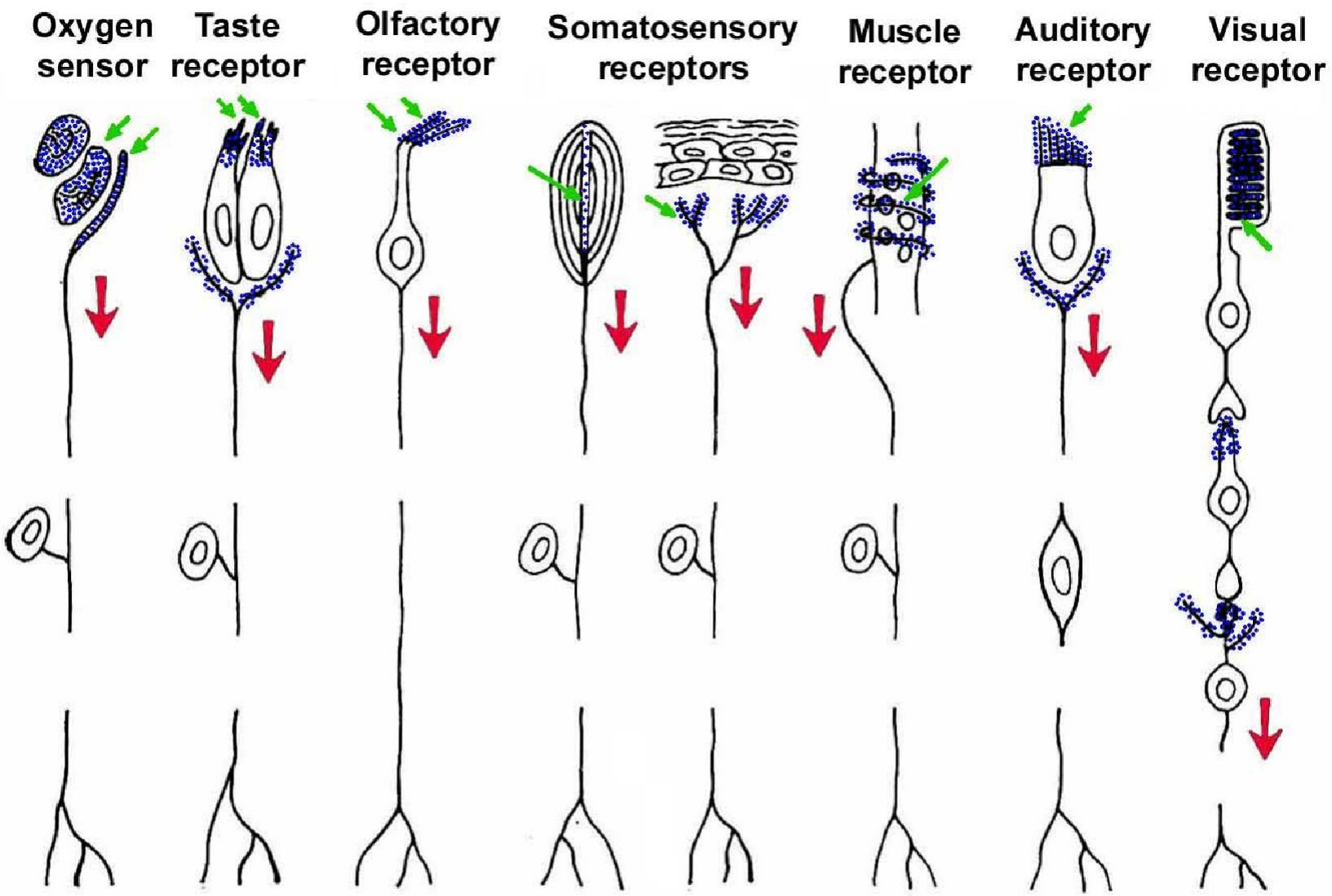
Receptors for heat, cold and pain are simply the naked endings of sensory neurons (uncaplulated receptors).

Receptors for touch are the naked dendritic endings surrounding hair follicles and expanded dendritic endings.

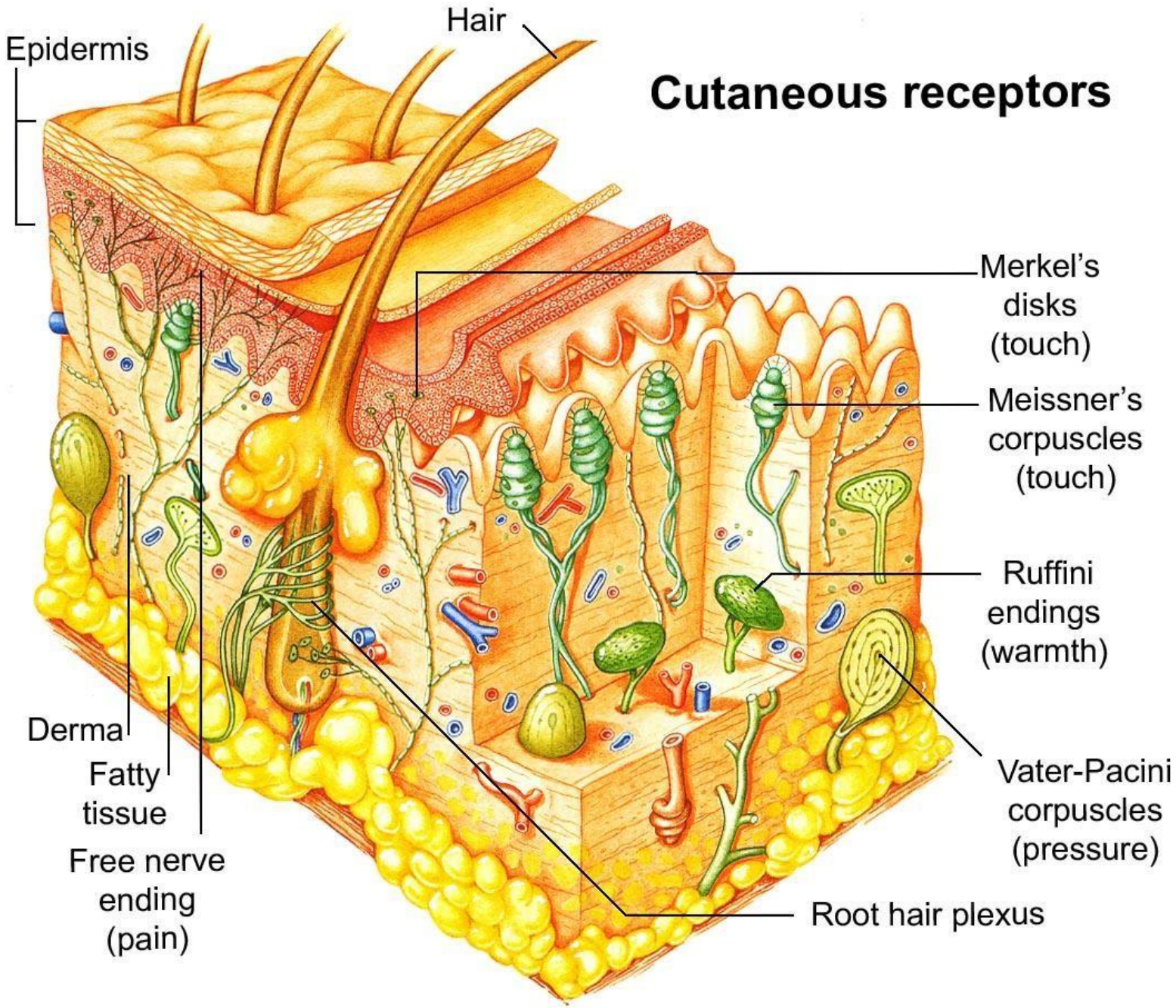
Receptors for touch and pressure are the endings of sensory neurons encaplulated within various structures.



Cutaneous receptors



Diffeternt types of receptor cells in vertebrates.
Green arrows shows places where it be effects by sensory stimuluses.
Blue dotted lines marks places of sensory stimulus transformation
and synaptic transmission. In both zones gradually transmission of signal are occur.
Red arrows is places of impulse beginnings.
(Bodian, 1962, with modification).


Cutaneous receptors
Hair
Epidermis
Merkel's disks (touch)
Meissner's corpuscles (touch)
Ruffini endings (warmth)
Vater-Pacini corpuscles (pressure)
Root hair plexus
Derma
Fatty tissue
Free nerve ending (pain)

CLASSIFICATION OF RECEPTORS

I. EXTERORECEPTORS (superficial)

1. **Cutaneous receptors**:

Touch receptors:	Meissner's corpuscle and Merkel's discs
Pressure receptors:	Pacinian corpuscles
For cold:	Krause's end organ
For warmth:	Ruffini's end organ
Pain receptors or nociceptors:	Free (naked) nerve ending

2. **Chemoreceptors** — give response to chemical stimuli:

Taste:	Taste buds
Smell:	Olfactory receptors

3. **Telereceptors** or distant: of hearing (phono-), vision (photo-), olfaction.

CLASSIFICATION OF RECEPTORS

II. INTERORECEPTORS

Interoreceptors are of two types:

1. **Visceroreceptors** — situated in the viscera (in heart, blood vessels, lungs, gastrointestinal tract, urinary tract and brain):

a) stretch receptors;

b) baroreceptors,

c) chemoreceptors;

d) osmoreceptors.

2. **Proprioreceptors** — give response to change in the position of different parts of the body:

a) receptors in labyrinthine apparatus;

b) muscular-articular receptors.

CLASSIFICATION OF RECEPTORS

One can tell in clinics about:

- ***superficial sensitivity*** (nociceptive, tactile, temperature);
- ***deep sensitivity*** (muscular-articular, pressure and vibration).

By morphology receptors are divided into:

1) simple – they are free nervous fiber;
2) complex – they are receptor cell + free nervous fiber.

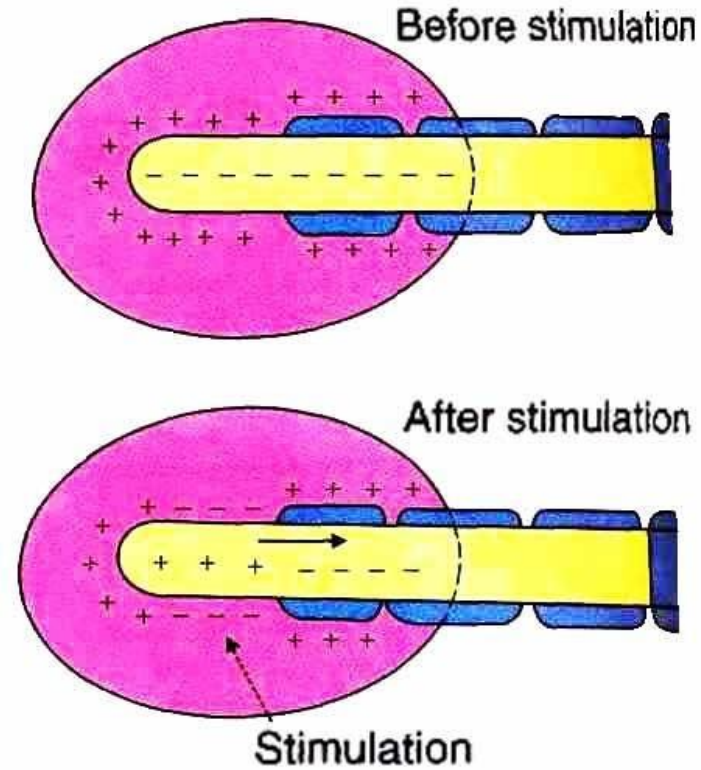
PROPERTIES OF RECEPTORS

1. **Specificity of response** — each type of receptor gives response to its own specific sensation.
2. **Adaptation or desensitization** — sensitivity decreasing after receptor prolonged stimulation. By this receptors are divided into two types:
   a) phasic (rapidly adapted) — touch and pressure receptors;
   b)tonic (slowly adapted) – muscle spindle, pain receptors and cold receptors.
3. **Weber-Fechner law** : change in response of a receptor is directly proportional to the logarithmic increase in the intensity of stimulus.
4. **Electrical property** — ability to generate receptor and generator potentials.

Receptor potential (generator potential) is receptor cells membrane potential change at stimuli action.

Significance of Receptor Potential

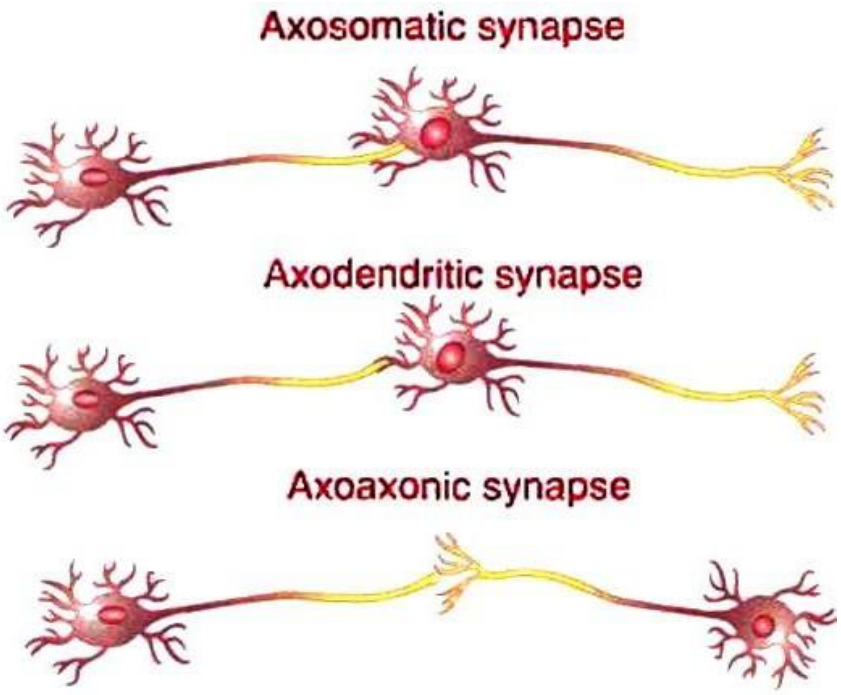
When the receptor potential is sufficiently strong (when the magnitude is about 10mV), it causes development of action potential in the sensory nerve.



Development of receptor potential in pacinian corpuscle.
When this current reaches the first node of Ranvier within the corpuscle, it cause development of action potential in the nerve fiber.

SYNAPSES PHYSIOLOGY

Contact between neurons is performed by **synapses**.



Different types of anatomical synapses.

CLASSIFICATION OF SYNAPSES

I. ANATOMICAL CLASSIFICATION:

1)Axo-somatic synapse: axon of one neuron ends on soma (cell body) of other neuron.

2)Axo-dendritic synapse: axon of one neuron terminates on dendrite of other neuron.

3)Axo-axonic synapse: axon of one neuron terminates on axon of other neuron.

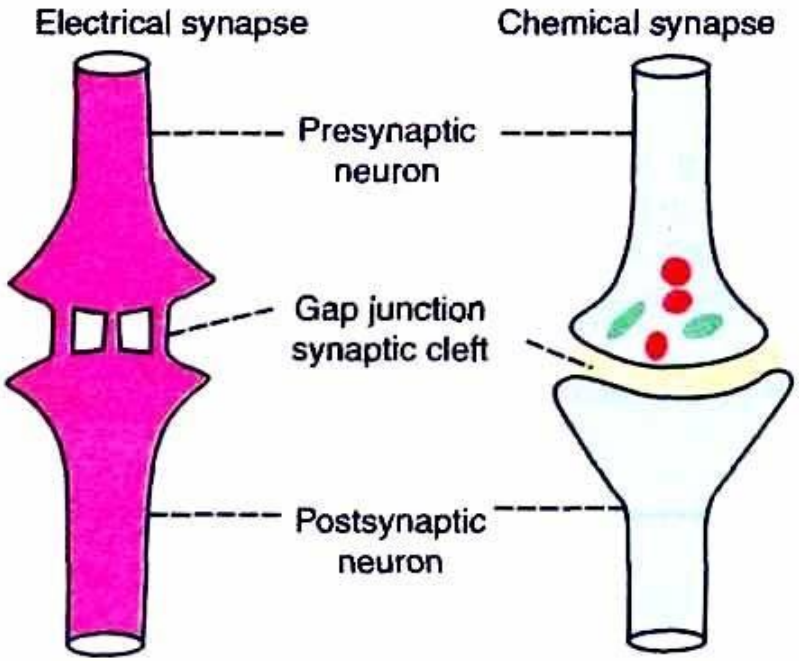
II. FUNCTIONAL CLASSIFICATION

1) electrical synapse;

2) chemical synapse.

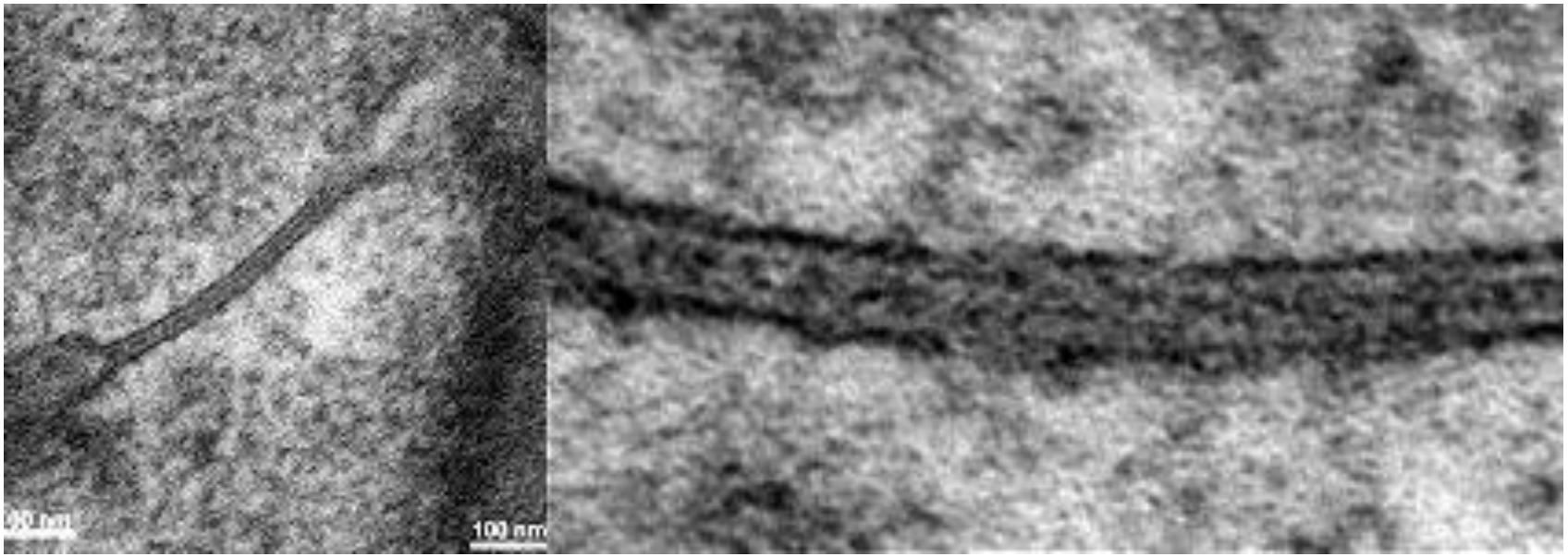
Electrical Synapse

Electrical Synapse — there is proteinic bridges between presynaptic and postsynaptic neurons. Synaptic cleft is narrow and equal to 2-4 nm. They are only exciting. They conduct impulses in both directions. Synaptic delay is absent. Exciting post-synaptic potential (EPSP) is generated on post-synaptic membrane.

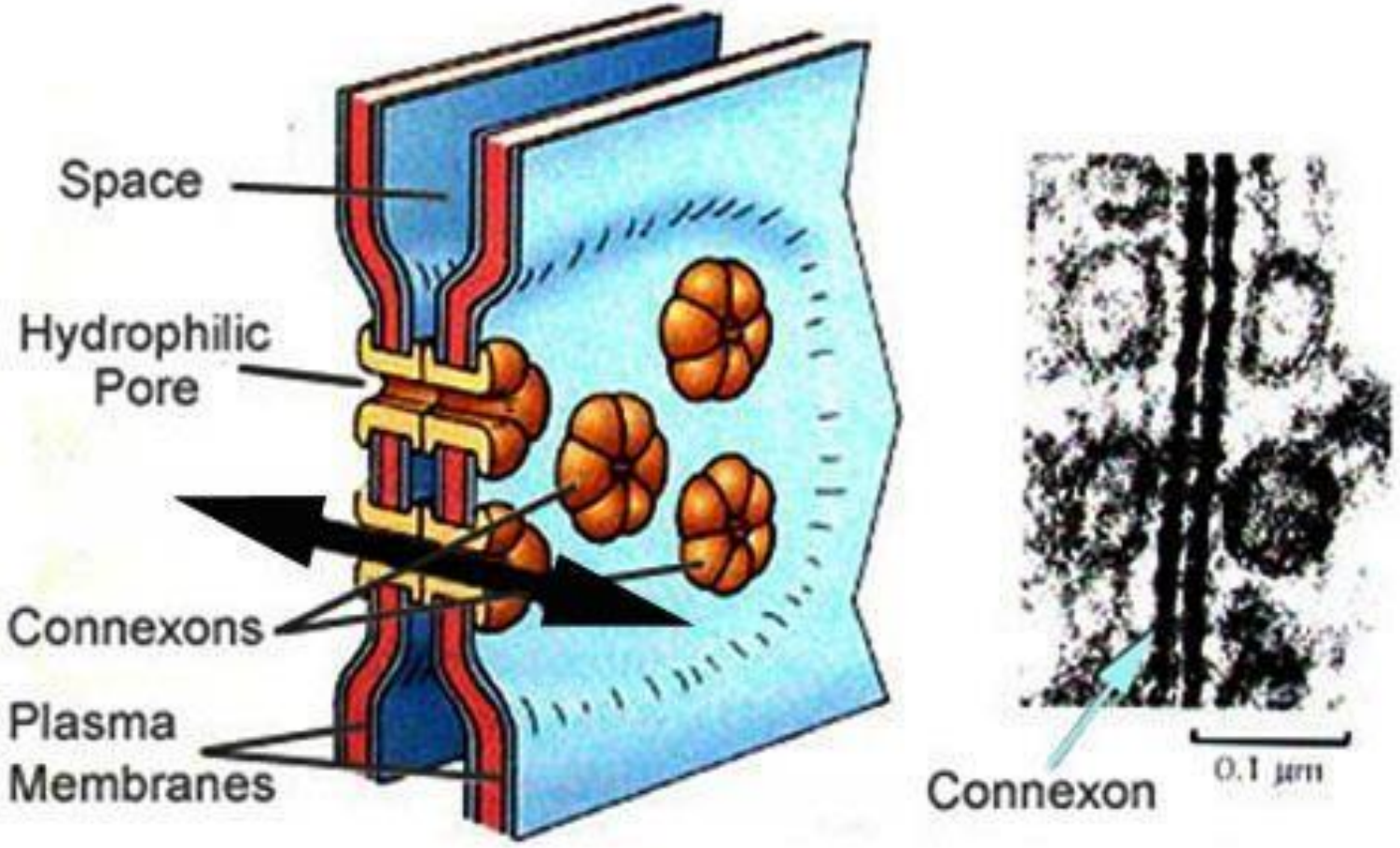


Electrical and chemical synapse (see figure). The electrical synapse is found not only in nervous system but also between some non-nervous cells like the cardiac muscle fibers, smooth muscle fibers of intestine and the epithelial cells of lens in eye.

Electrical Synapse
Nexus



Electrical Synapse

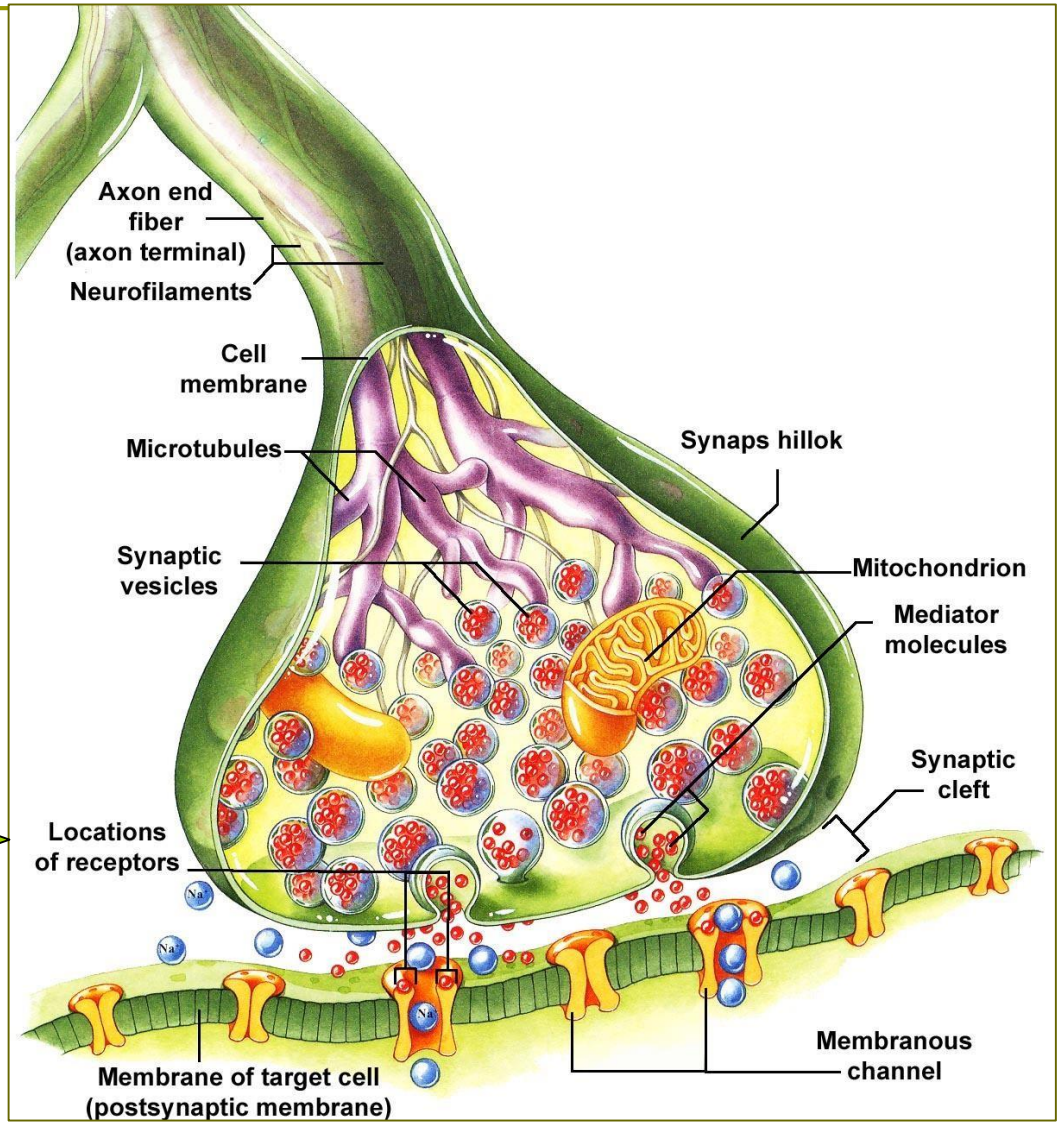


Chemical Synapse

Chemical Synapse has cleft about 50 nm. Synaptic delay is 0,2-0,5 msec. One-sided conductance of excitement and inhibiting. Synaptic vesicles release neuro-transmitters portionally.

STRUCTURE OF SYNAPSE

The structure of an axo-somatic synapse is shown in Figure



FUNCTIONS OF CHEMICAL SYNAPSE

The main function of the synapse is to transmit the impulses, i.e. action potential from one neuron to another. However, some of the synapses inhibit these impulses and so, the impulses are not transmitted to the postsynaptic neuron. Thus, the synapses are of two types. There are:

- Excitatory synapses, which transmit the impulses — excitatory function;
- Inhibitory synapses, which inhibit the transmission of impulses — inhibitory function.

Sequence of events during synaptic transmission

Presynaptic neuron	Arrive of action potential in axon terminal
	Opening of calcium channels in presynaptic membrane
	Influx of calcium ions from ECF into the axon terminal
	Opening of vesicles and release of Ach
Passage of Ach through synaptic cleft	
Postsynaptic neuron	Formation of Ach-receptop complex
	Development of EPSP
	Opening of sodium channels and influx of sodium ions from ECF
	Opening of sodium channels in initial segment of axon
	Influx of sodium ions from ECF and development of action potential
	Spread of action potential through axon of postsynaptic neuron

Ach = Acetylcholine. ECF = Extracellular fluid.
EPSP = Excitatory postsynaptic potential

EXCITATORY SYNAPSES

When the action potential reaches the presynaptic axon terminal, the voltage gated calcium channels at the presynaptic membrane are opened. Now the calcium ions enter the axon terminal from extracellular fluid (Fig. above).

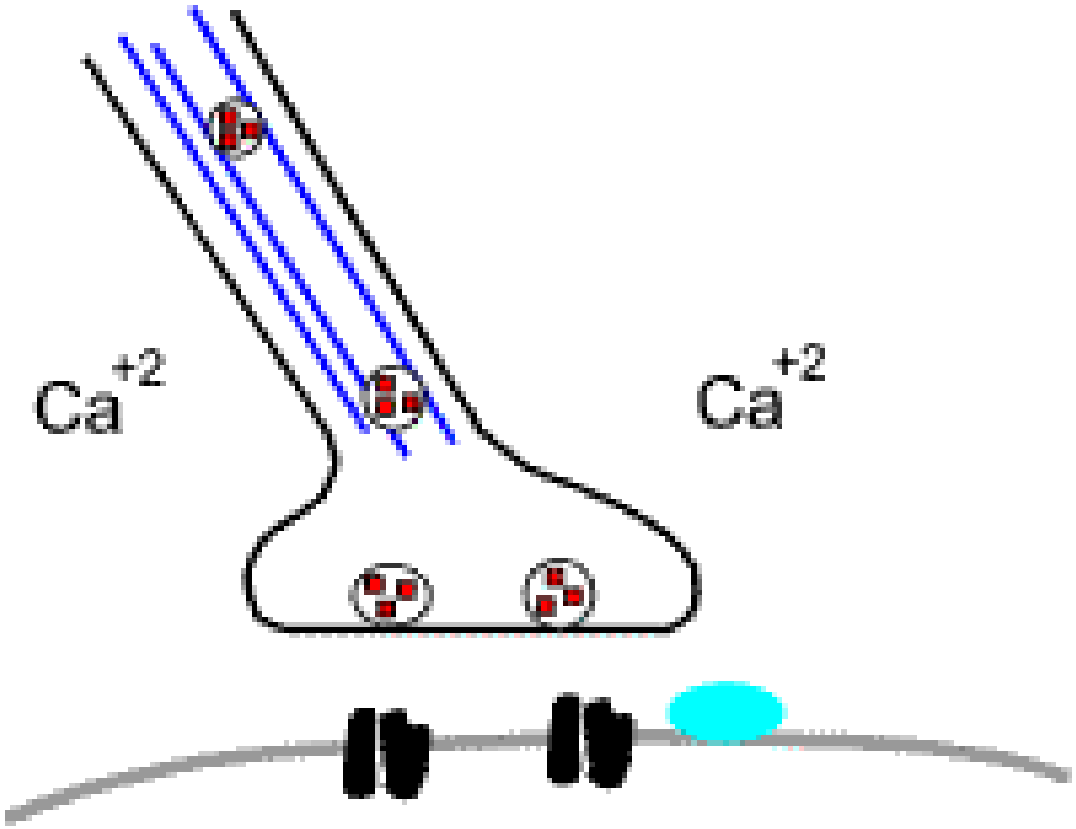
The calcium ions cause the fusion of synaptic vesicles with cell membrane and release of neurotransmitter substance from the vesicles by means of exocytosis

Excitive mediators are:

L-glutamate;

acetylcholine, adrenaline, dophamine, noradrenaline, serotonine – either excitive or inhibitory.

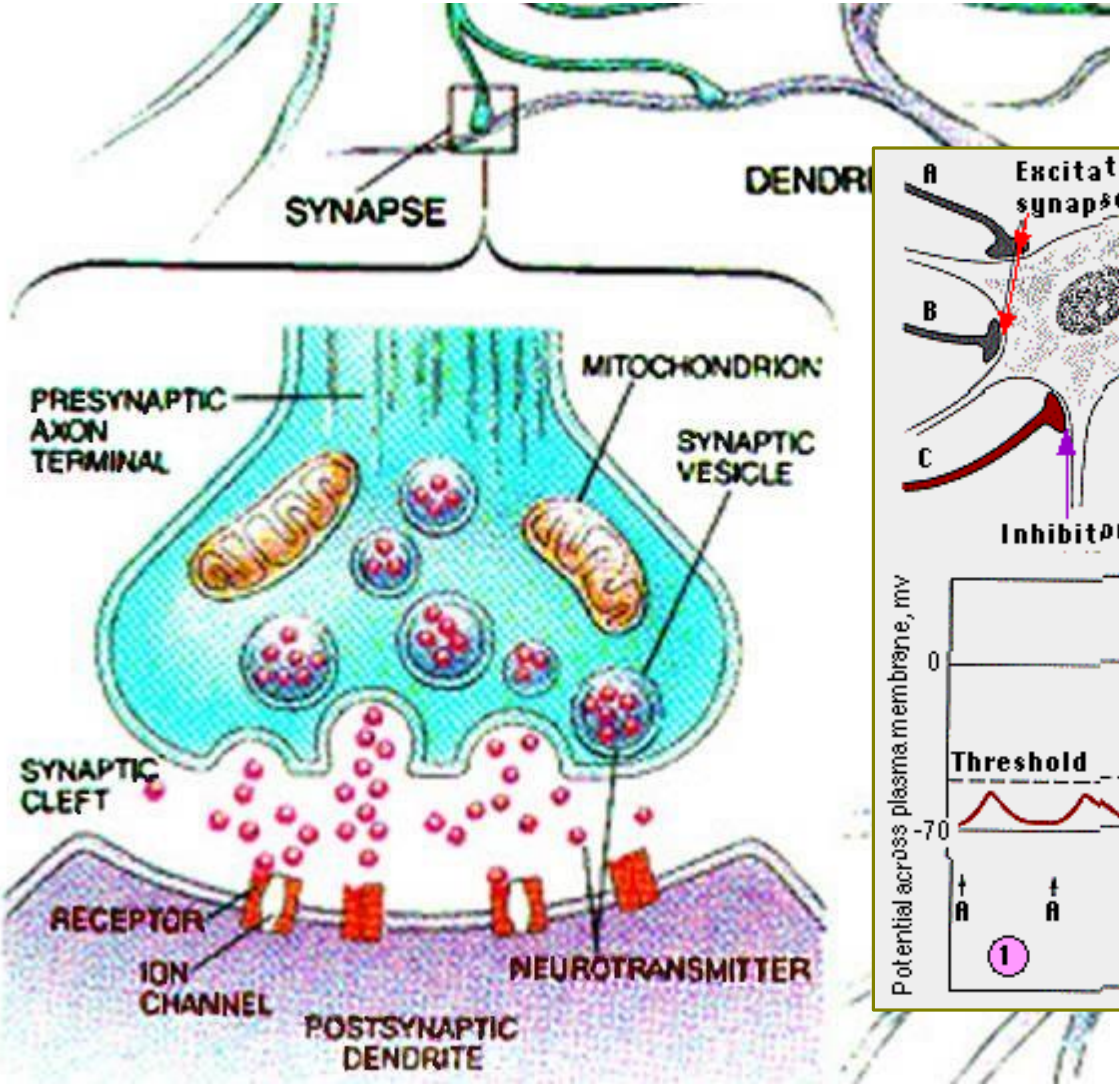
EXCITATORY SYNAPSES

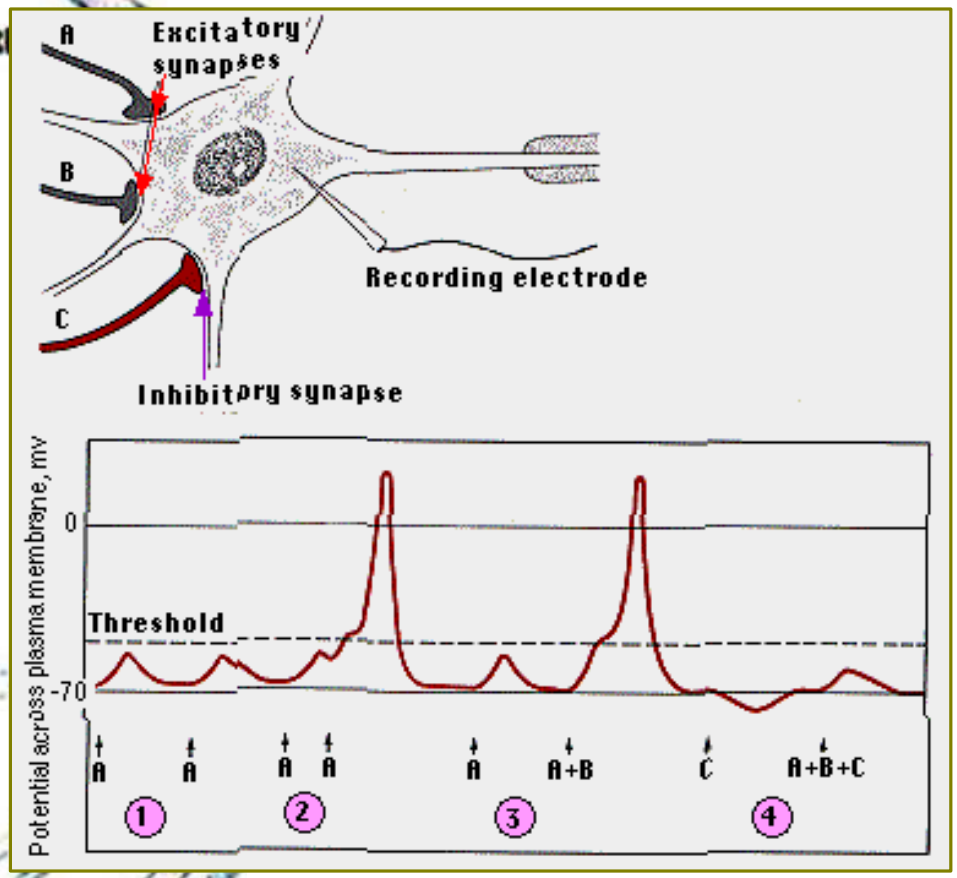


EXCITATORY SYNAPSES

The neurotransmitter, which is excitatory in function (excitatory neurotransmitter) passes through presynaptic membrane and synaptic cleft and reaches the postsynaptic membrane. Now, the neurotransmitter binds with the receptor protein present in the postsynaptic membrane to form the neurotransmitter receptor complex. The neurotransmitter receptor complex causes production of nonpropagative electrical potential called excitatory postsynaptic potential (EPSP). The most common excitatory neurotransmitter in a synapse is acetylcholine.

EXCITATORY SYNAPSES





EXCITATORY SYNAPSES

Mechanism of Development of EPSP

The neurotransmitter receptor complex causes opening of ligand gated sodium channels. Now, the sodium ions from extracellular fluid enter the synapse, i.e. soma. As the sodium ions are positively charged, the resting membrane potential inside the soma is altered and mild depolarization develops. This mild depolarization is called EPSP. It is a local response in the synapse.

EXCITATORY SYNAPSES

Properties of EPSP

EPSP is confined only to the synapse. It differs from the action potential and is similar to receptor potential and endplate potential. EPSP has such properties.

1) It is non-propagated;

2) It is monophasic and

3) It does not work according to law “everything or nothing”.

EXCITATORY SYNAPSES

Significance of EPSP

The EPSP is not transmitted into the axon of postsynaptic neuron. It causes development of action potential in the axon. Because of the opening of voltage gated sodium channels in the initial segment of axon. Now, due to the entrance of sodium ions, the depolarization occurs in the initial segment of axon and thus, the action potential develops. From here, the action potential spreads to other segment of the axon.

INHIBITORY SYNAPSES

Inhibition of synaptic transmission is classified into three types:

1) Postsynaptic inhibition;
2) Presynaptic inhibition;
3) Renshaw cell inhibition.

INHIBITORY SYNAPSES

1. Postsynaptic Inhibition

This is also called direct inhibition. This occurs due to the release of an inhibitory neurotransmitter from presynaptic terminal instead of excitatory neurotransmitter substance. The most important inhibitory neurotransmitter is gamma-amino butyric acid (GABA). The other inhibitory neurotransmitter substance is glycine.

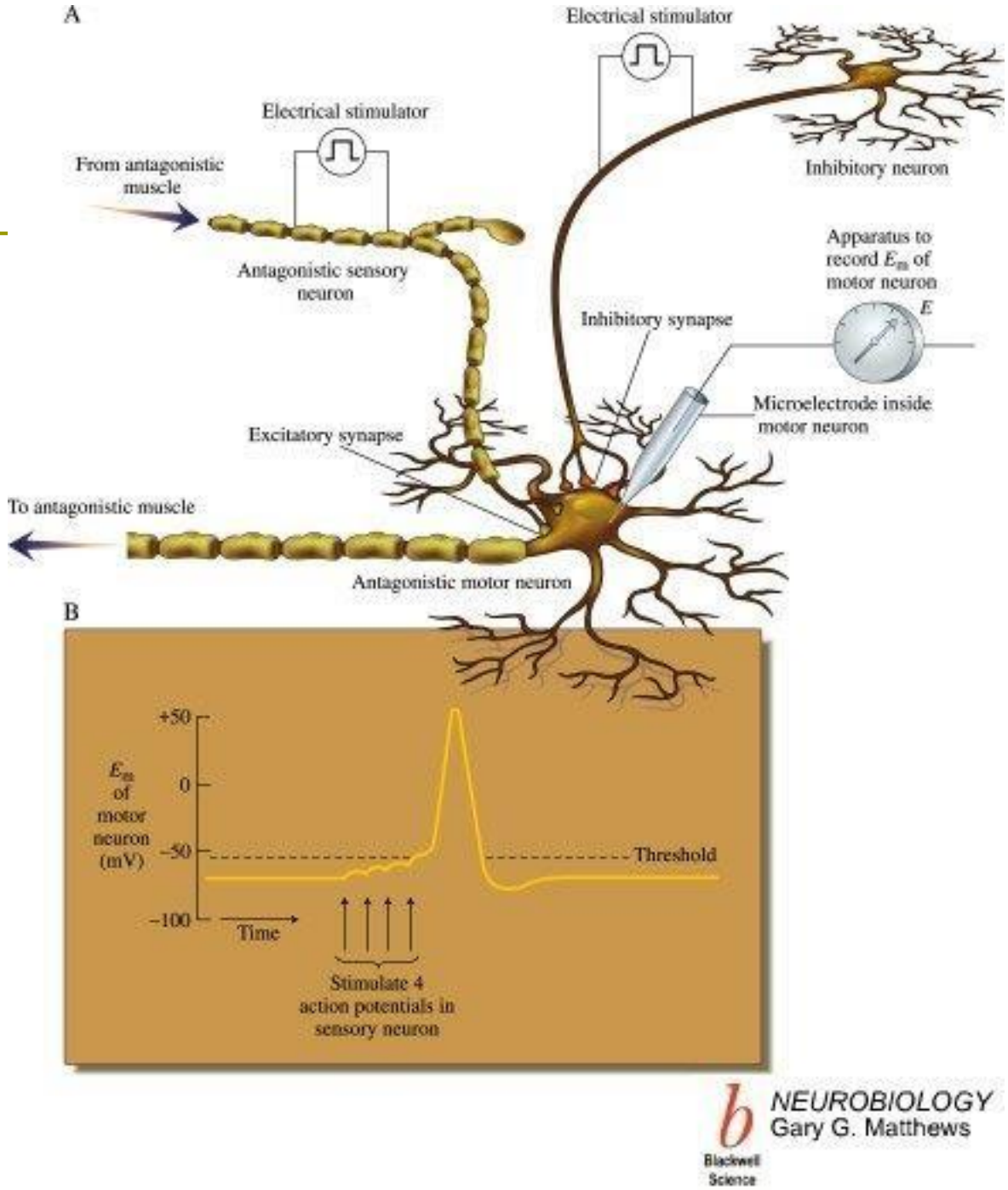
INHIBITORY SYNAPSES

1. Postsynaptic Inhibition

Action of GABA—IPSP

The inhibitory neurotransmitter substance acts on postsynaptic membrane by binding with receptor. The transmitter receptor complex opens the ligand gated potassium channels instead of opening the sodium channels. Now, the potassium ions pass out of the synapse postsynaptic cell into extracellular fluid. Chloride channels also open followed by influx of chloride ions inside. The exit of potassium ions and influx of chloride ions cause more negativity inside, leading to hyperpolarization. This is called inhibitory postsynaptic potential (IPSP).

INHIBITORY SYNAPSES



NEUROBIOLOGY
Gary G. Matthews
Blackwell Science

INHIBITORY SYNAPSES

2. Presynaptic Inhibition

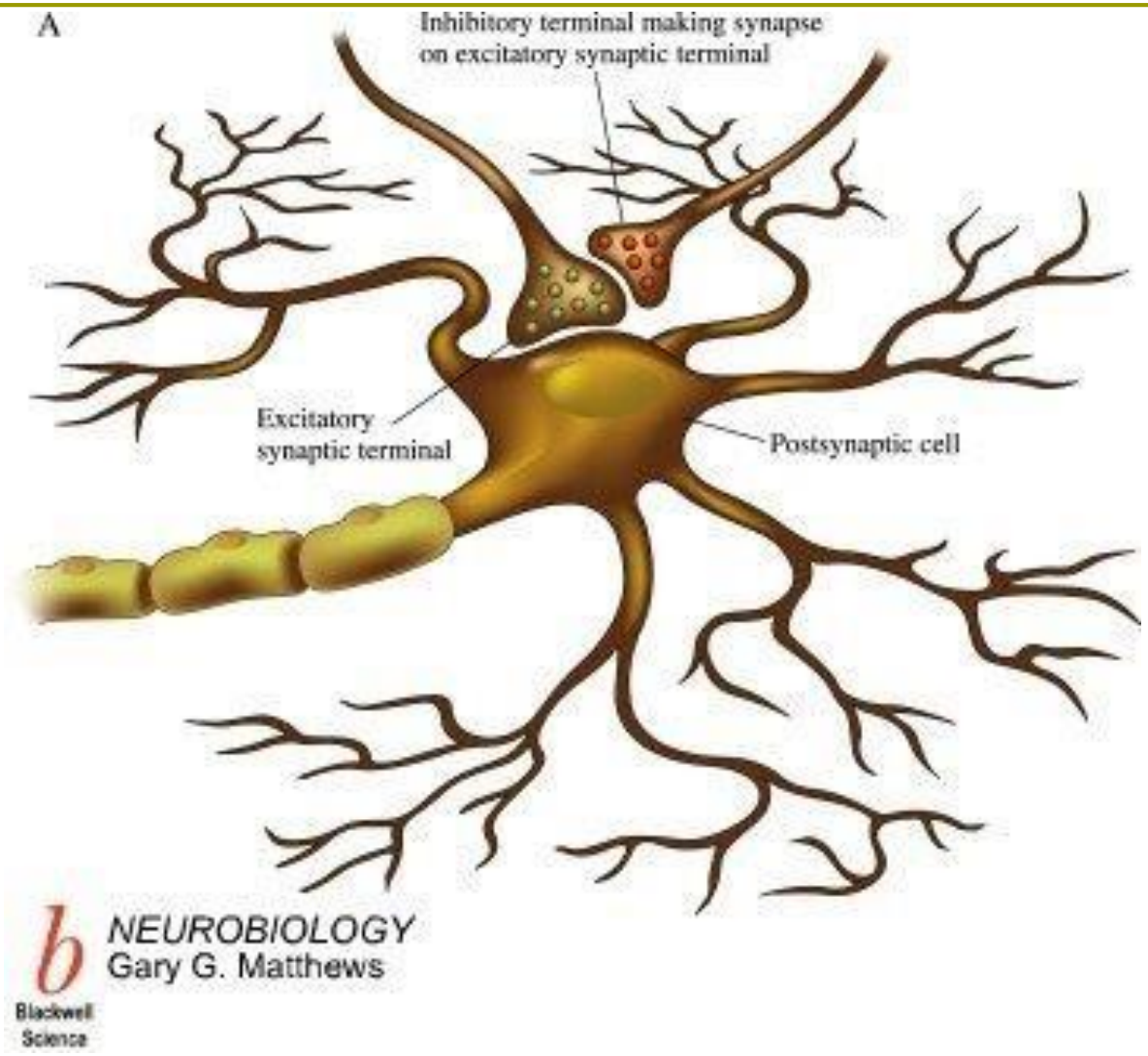
This is also called direct inhibition. This occurs due to the release This is also known as indirect inhibition and it occurs because of the failure of presynaptic axon terminal to release the excitatory neurotransmitter substance.

3. Renshaw Cell Inhibition

This occurs in spinal cord. The anterior nerve root consists of nerve fibers leaving the spinal cord. These nerve fibers arise from the alpha motor neurons in anterior gray horn of the spinal cord and reach the effector organ, muscles. Some of the fibers called collaterals end in Renshaw cells instead of leaving the spinal cord. Renshaw cells are situated in between motor neurons.

When motor neurons send motor impulses, some of the impulses reach the Renshaw cell by passing via collaterals. Now, the Renshaw cell is stimulated. In turn, it sends inhibitory impulses to alpha motor neurons so that, the discharge from motor neurons is reduced.

INHIBITORY SYNAPSES

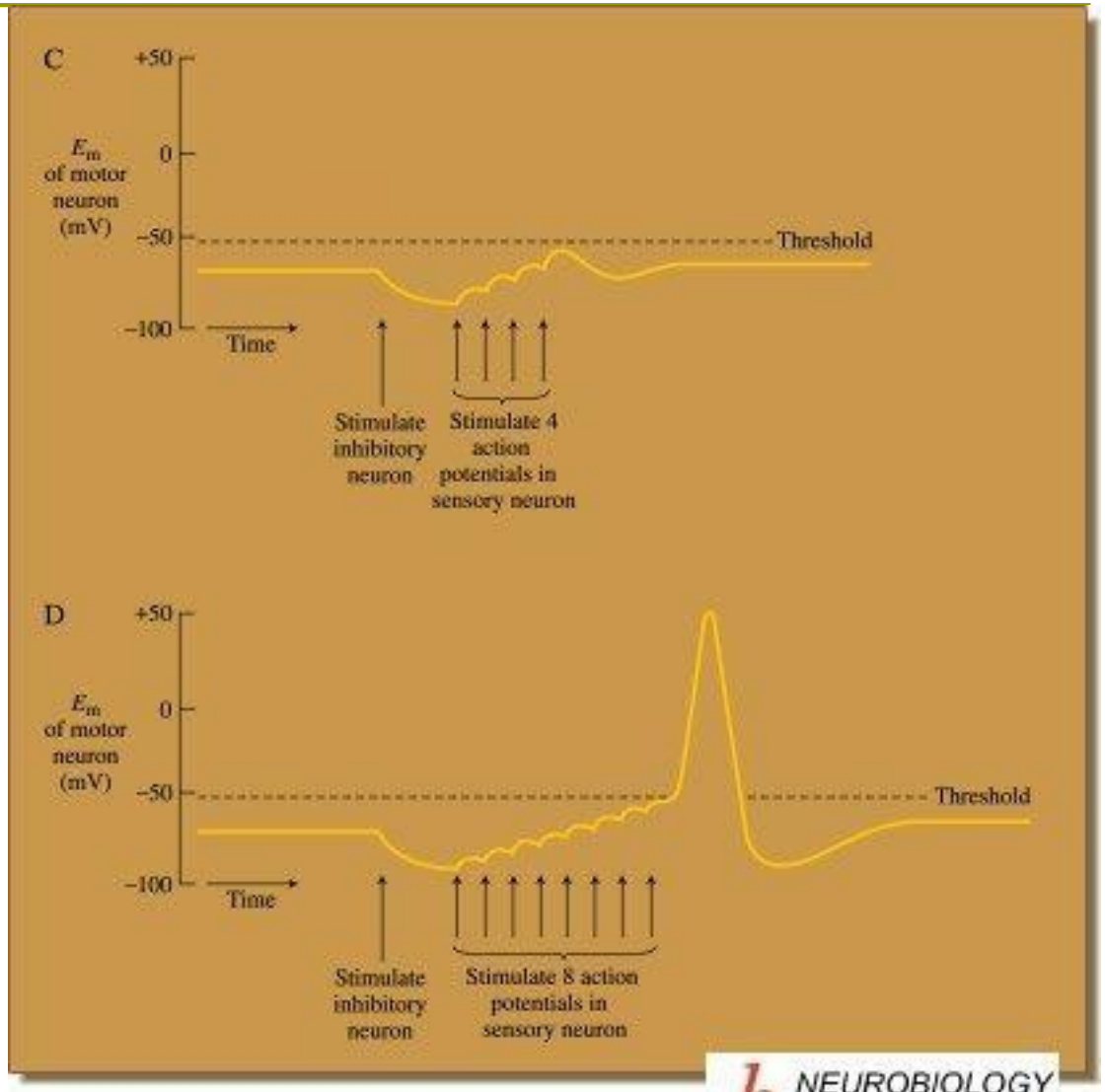


Presynaptic Inhibition

INHIBITORY SYNAPSES

Significance of Synaptic Inhibition

It helps to select exact number of impulses and to block the excess ones.



PROPERTIES OF SYNAPSE

1. ONE WAY CONDUCTION (BELL-MAGENDIE LAW)
   The impulses are transmitted only in one direction in synapse, i.e. from presynaptic neuron to postsynaptic neuron.
2. SYNAPTIC DELAY
   During the transmission of impulses via the synapse, there is a little delay in the transmission. This is called the synaptic delay. This is due to the time taken for:

a) Release of neurotransmitter;

b) Movement of neurotransmitter from axon terminal to postsynaptic membrane;

c) Action of the neurotransmitter to open the ionic channels in postsynaptic membrane.

The synaptic delay is one of the causes for the latent period of the reflex activity.

PROPERTIES OF SYNAPSE

3. FATIGUE

The fatigue at the synapse is due to neurotansmitter substance, acetylcholine, level decreasing. After producing the action, this neurotransmitter is destroyed by acetylcholinesterase.

The electrical properties of the synapse are the EPSP and IPSP.

4. SUMMATION

When many presynaptic excitatory terminals are stimulated simultaneously or when single presynaptic terminal is stimulated repeatedly, there is summation in postsynaptic neuron. This is called summation. Summation is of two types.

1) Spatial Summation:

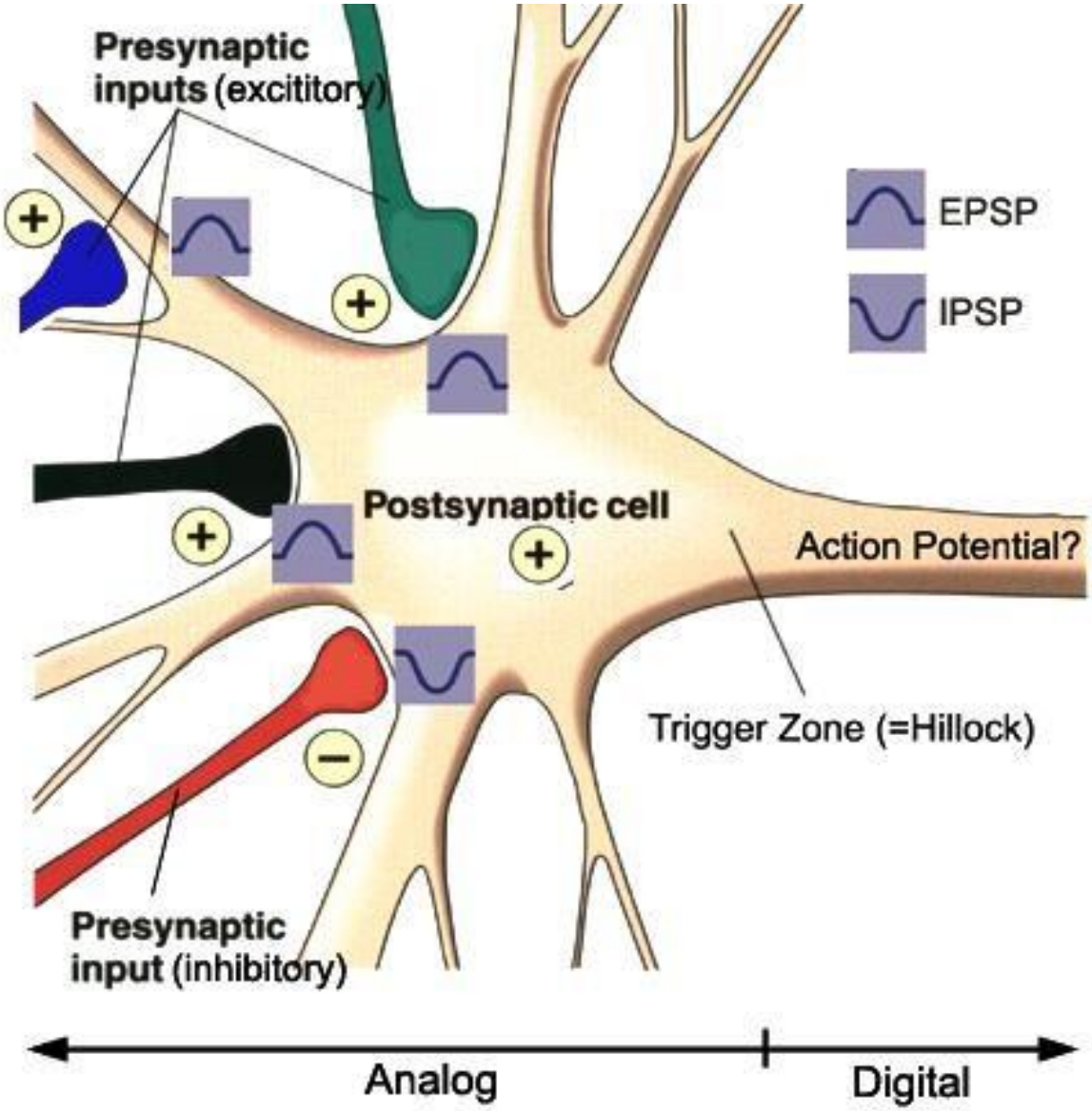
This occurs when many presynaptic terminals are stimulated simultaneously.

2) Temporal Summation:

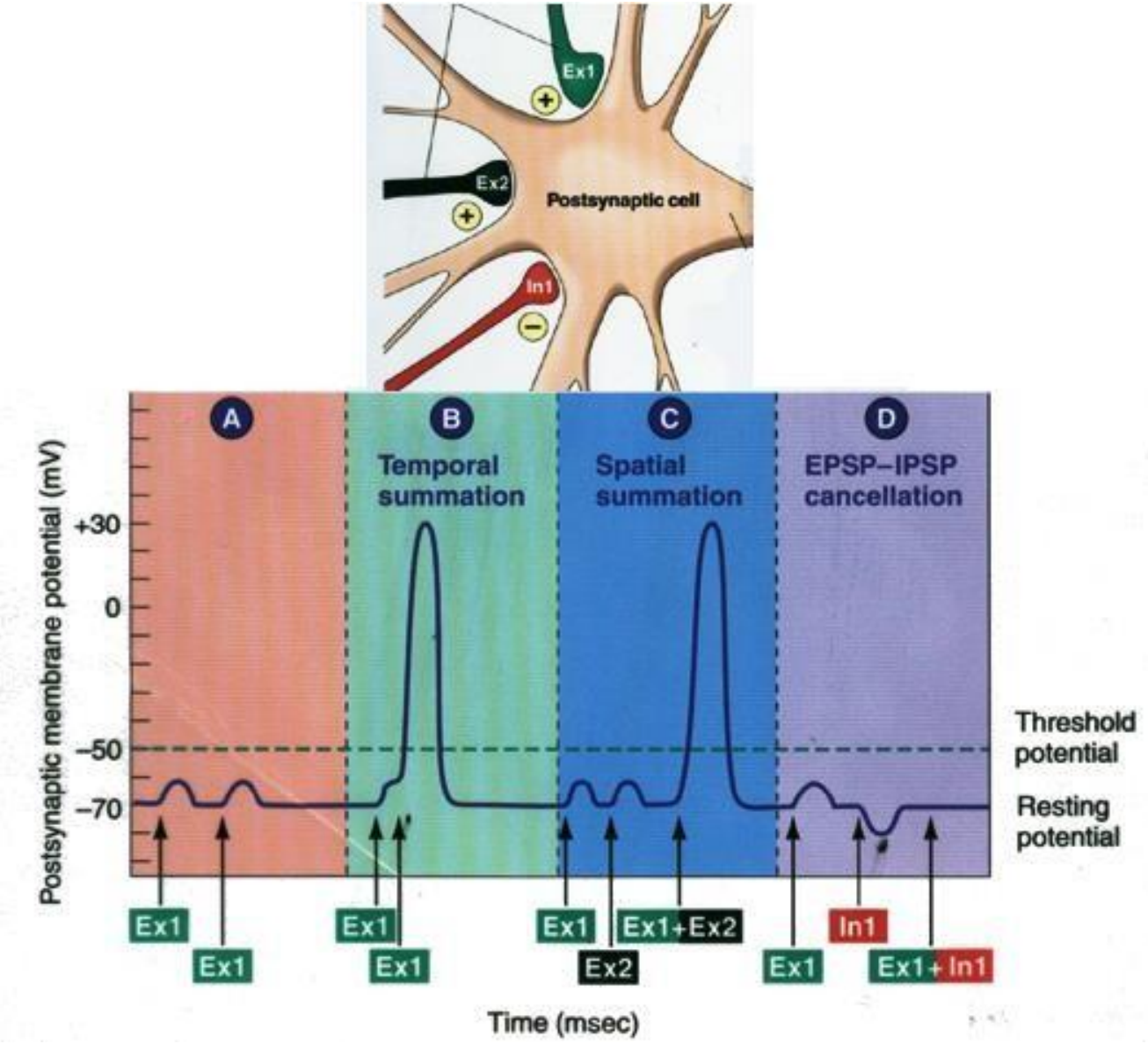
It occurs when one presynaptic terminal is stimulated repeatedly.

Thus, both spatial summation and temporal summation play an important role in the facilitation of response.

SUMMATION


Presynaptic inputs (excititory)
EPSP
IPSP
Postsynaptic cell
Action Potential?
Trigger Zone (=Hillock)
Presynaptic input (inhibitory)
Analog
Digital

SUMMATION


Ex1
Ex2
In1
Postsynaptic cell
A
B
C
D
Temporal summation
Spatial summation
EPSP–IPSP cancellation
Postsynaptic membrane potential (mV)
+30
0
–50
–70
Threshold potential
Resting potential
Ex1
Ex1
Ex1
Ex1
Ex1
Ex2
Ex1+Ex2
Ex1
In1
Ex1+In1
Time (msec)

PROPERTIES OF SYNAPSE

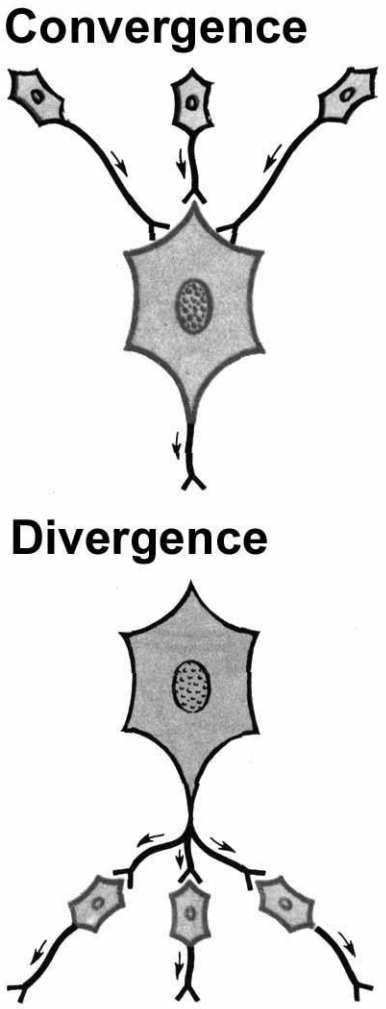
5. ELECTRICAL PROPERTY
   The electrical properties of the synapse are the EPSP and IPSP.
6. CONVERGENCE AND DIVERGENCE

CONVERGENCE

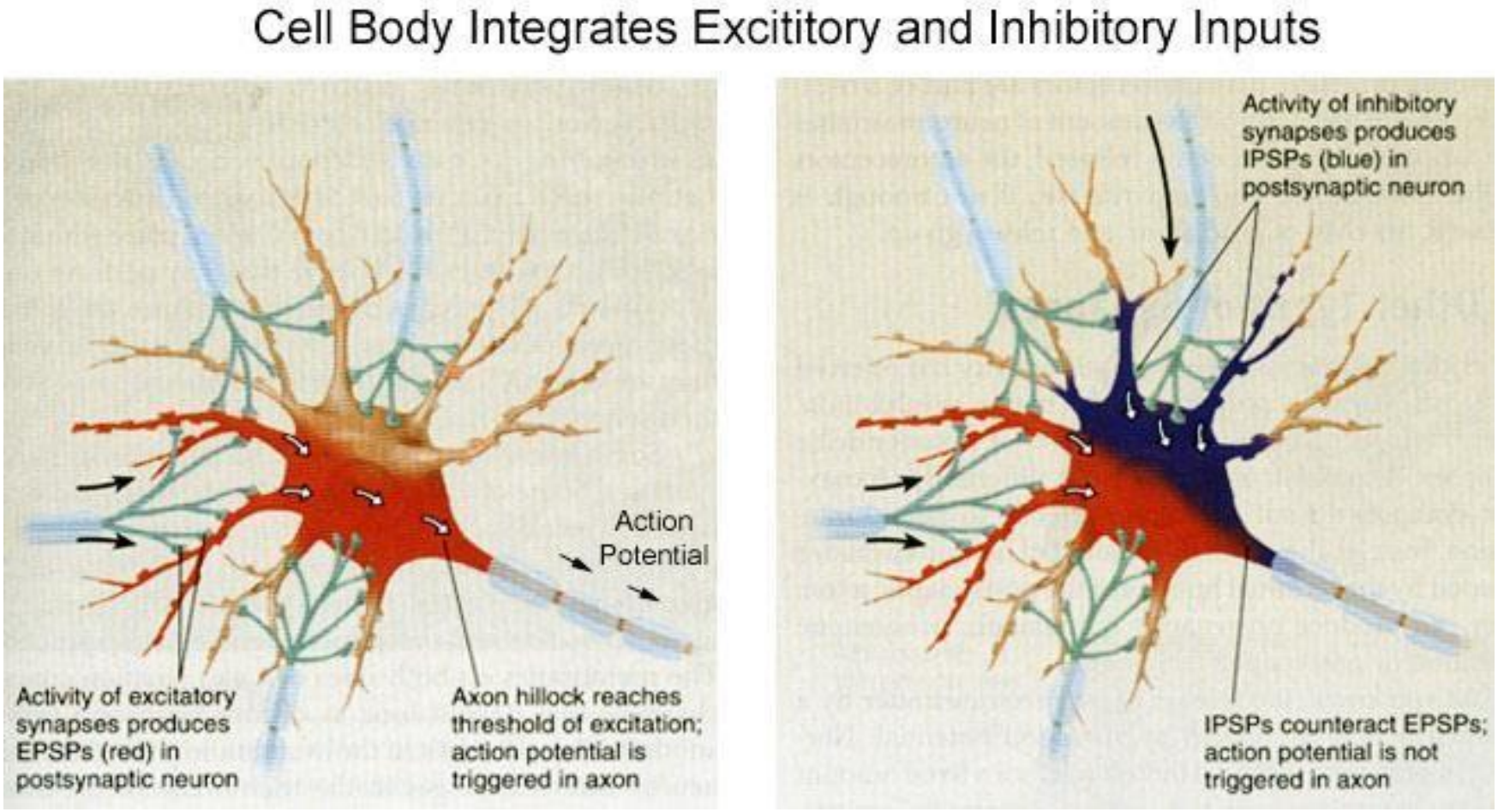
When many presynaptic neurons terminate on a single postsynaptic neuron.

DIVERGENCE

When one presynaptic neuron terminates on many postsynaptic neurons.



CONVERGENCE



Examples of Chemicals That Are Either Proven or Suspected Neurotransmitters

Category	Chemicals
Amines	Acetylcholine, Histamine, Serotonin
Catecholamines	Dopamine (Epinephrine — a hormone) Norepinephrine
Aminoacids	Aspartic acid, GABA (gamma-aminobutyric acid)
	Glutamic acid, Glycine
Polypeptides	Glucagon, Insulin, Somatostatin, Substance P, ACTH, (adrenocorticotrophic hormone), Angiotensin II, Endogenous opioids (enkephalins and endorphins), LHRH (luteinizing hormone-releasing hormone), TRH (thyrotrophin-releasing hormone), Vasopressin (antidiuretic hormone), CCK (cholecystokinin)
Gases	Nitric oxide, Carbon monoxide

REFLEX ACTIVITY

DEFINITION AND SIGNIFICANCE OF REFLEXES

Response to a peripheral nervous stimulation that occurs without our consciousness is known as reflex activity. It is a type of protective mechanism and it protects the body from irreparable damages.

For example, when the hand is placed on a hot object, it is withdrawn immediately. When a very bright light is thrown into the eyes, eyelids are closed and pupil is constricted to prevent the damage of retina by the entrance of excessive light into the eyes.

REFLEX ACTIVITY

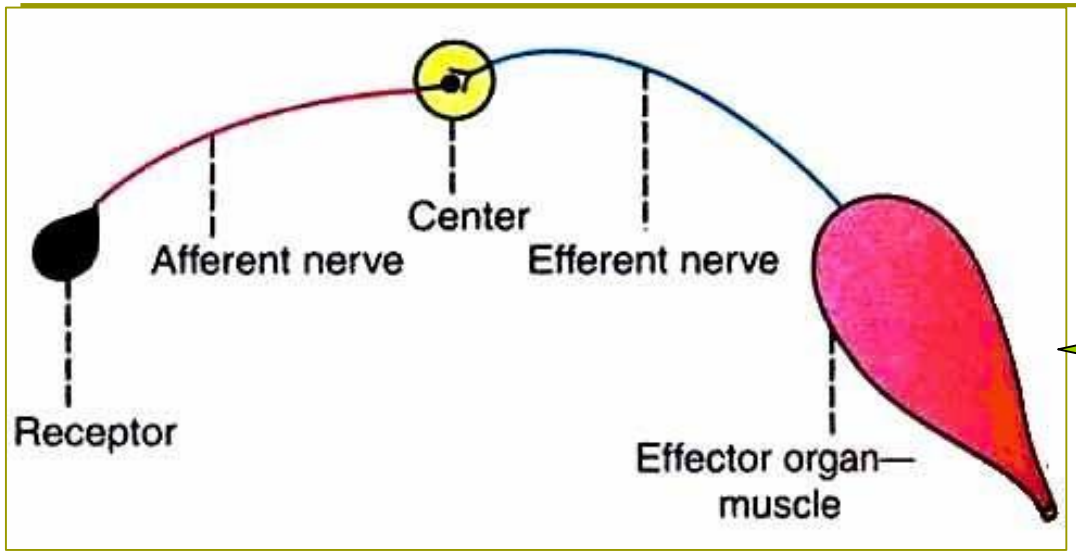


Fig. Scheme of simple (monosynaptic) reflex arc.

REFLEX ARC

The anatomical nervous pathway for a reflex action is called reflex arc. A simple reflex arc includes five components

1. Receptor.
2. Afferent Nerve.
3. Center.
4. Efferent Nerve.
5. Effector Organ.

REFLEX ACTIVITY

REFLEX ARC

1. Receptor.

It is the end organ, which receives the stimulus. When the receptor is stimulated, impulses are generated in afferent nerve.

2. Afferent Nerve.

Afferent or sensory nerve transmits sensory impulses from the receptor to the center.

3. Center.

The center receives the sensory impulses via afferent nerve fibers and in turn, it generates appropriate motor impulses. The center is located in the brain or spinal cord.

4. Efferent Nerve.

Efferent or motor nerve transmits motor impulses from center to the effector organ.

5. Effector Organ.

Like the muscle or the gland shows 'e response to the stimulus.

Afferent and efferent nerve fibers may be connected to the center. In some places, one or more cells are interposed between these nerve fibers and the center. Such nerve cells are called connector neurons or internuncial neurons or interneurons.

CLASSIFICATION OF REFLEXES

1) DEPENDING UPON WHETHER INBORN OR ACQUIRED

a) Unconditioned reflexes, or inborn reflexes: The unconditioned reflexes are present at the time of birth. Such reflexes do not require previous learning, training, or conditioning. The best example is the secretion of saliva when any object is kept in the mouth.

b) Conditioned reflexes or acquired reflexes: The conditioned reflexes are acquired after birth. Such reflexes need previous learning, training, or conditioning. The example is the secretion of saliva by the sight, smell, thought or hearing of a known edible substance.

CLASSIFICATION OF REFLEXES (continuation)

2) DEPENDING UPON THE SITUATION OF THE CENTER

a) Cerebellar reflexes: The center for this type of reflexes is in the cerebellum.

b) Cortical reflexes: Cortical reflexes have the center in cerebral cortex.

c) Midbrain reflexes: For these reflexes, the center is in the midbrain.

d) Bulbar or medullary reflexes: Bulbar reflexes have the center in the medulla oblongata.

e) Spinal reflexes: These reflexes have their center in the spinal cord. Depending upon the segments involved, the spinal reflexes are divided into three groups.

- Segmental spinal reflexes;
- Intrasegmental spinal reflexes;
- Suprasegmental spinal reflexes.

CLASSIFICATION OF REFLEXES (continuation)

3) DEPENDING UPON THE PURPOSE-FUNCTIONAL SIGNIFICANCE

a) Protective reflexes or flexor reflexes: The protective reflexes are also called withdrawal reflexes. These reflexes protect the body from harmful stimuli, which are called nociceptive stimuli. The protective reflexes are flexor reflexes because, during these reflexes, the flexion at different joints occurs.

b) Antigravity reflexes or extensor reflexes: The antigravity reflexes protect the body against the gravitational force. These reflexes are called the extensor reflexes because, during these reflexes, the extensor muscles contract resulting in extension at joints.

CLASSIFICATION OF REFLEXES (continuation)

4) DEPENDING UPON THE NUMBER OF SYNAPSE

a) Monosynaptic reflexes: have only one synapse in the reflex arc. Stretch reflex
is the best example for monosynaptic reflex and it is elicited due to the stimulation of muscle spindle.

b) Polysynaptic reflexes:The polysynaptic reflexes have more than one synapse in the reflex arc. Withdrawal reflexes are the polysynaptic reflexes.

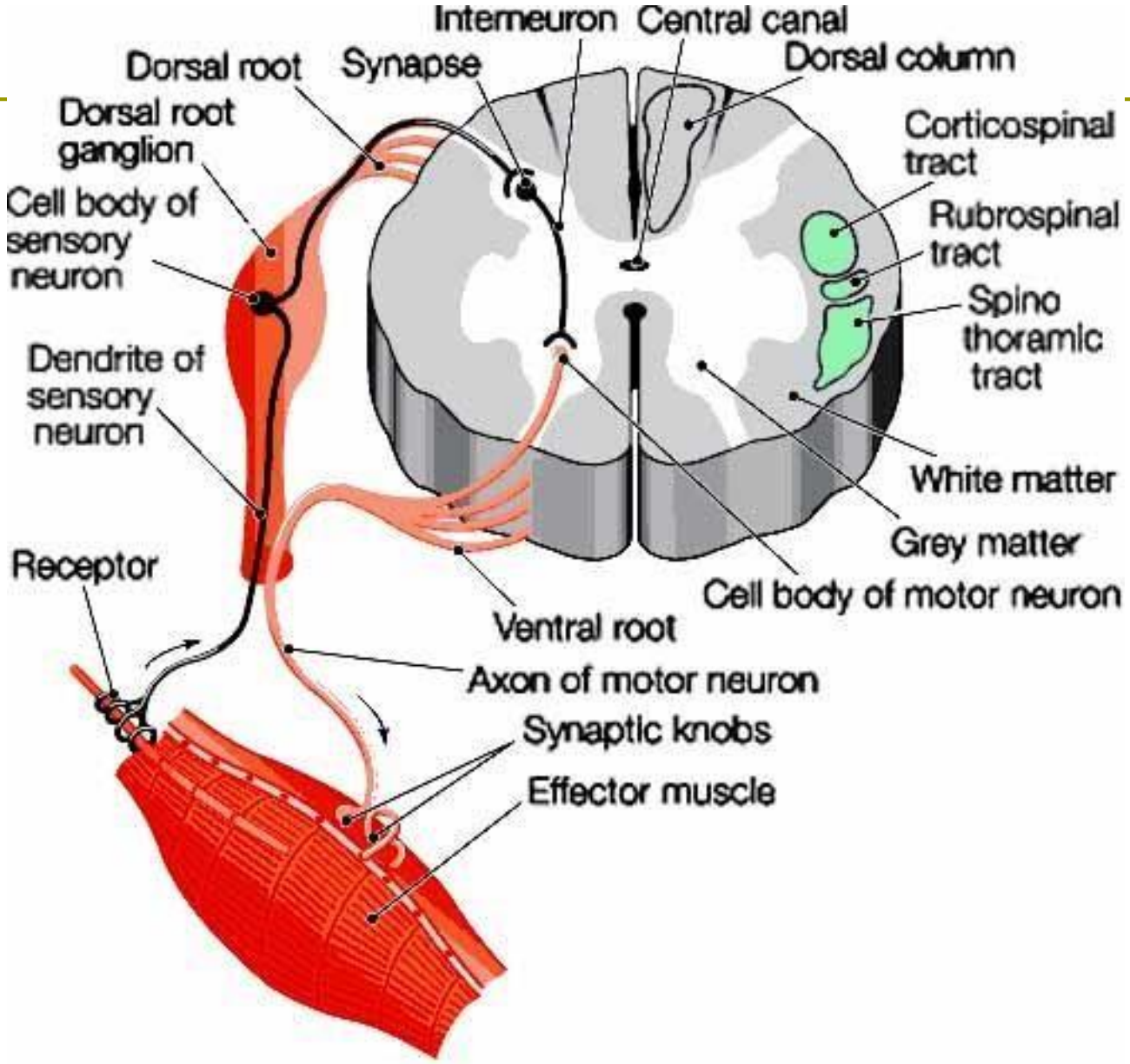
CLASSIFICATION OF REFLEXES (continuation)

5) DEPENDING UPON CLINICAL BASIS

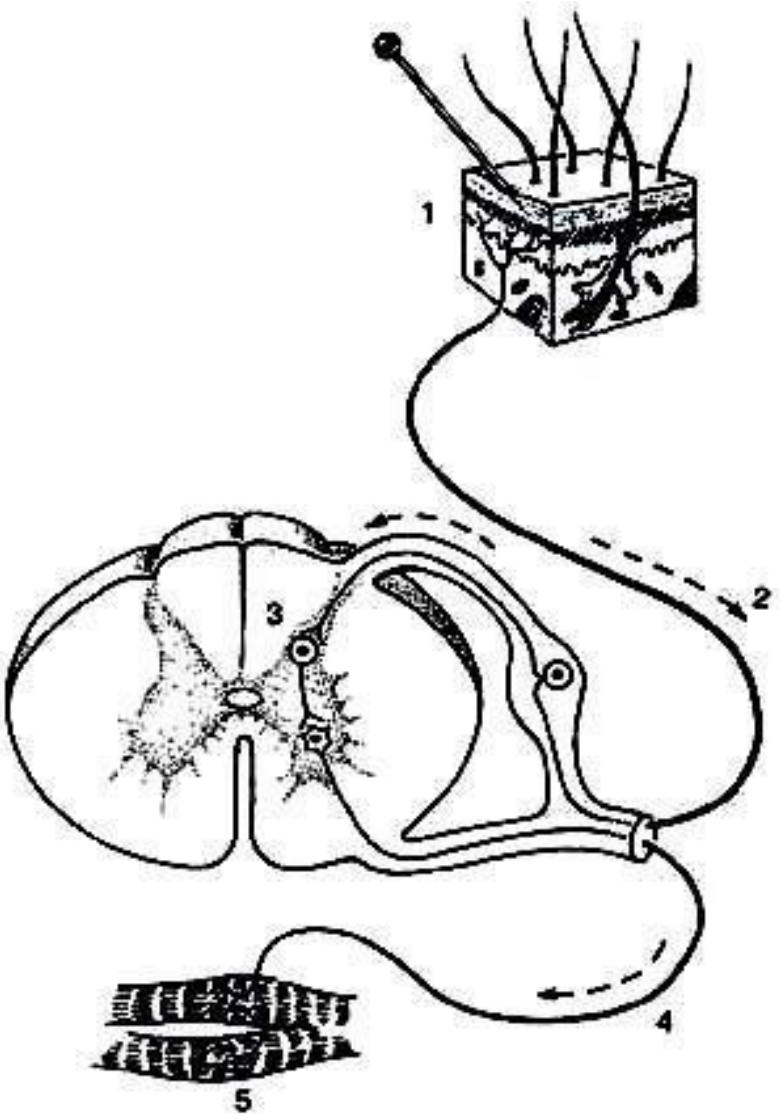
In clinical practice, the reflexes are classified into four types.

1) Superficial reflexes: Superficial reflexes are elicited from the surface of the body. These reflexes are again divided into two types (a) mucus membrane reflexes which are elicited from mucus membrane and, (b) cutaneous reflexes which are arising from skin.
2) Deep reflexes: Deep reflexes arise from structures under the skin.
3) Visceral reflexes: The visceral reflexes are elicited from deep lying structures of the organs in viscera.
4) Pathological reflexes: The pathological reflexes are abnormal reflexes and can be elicited only in diseased conditions.

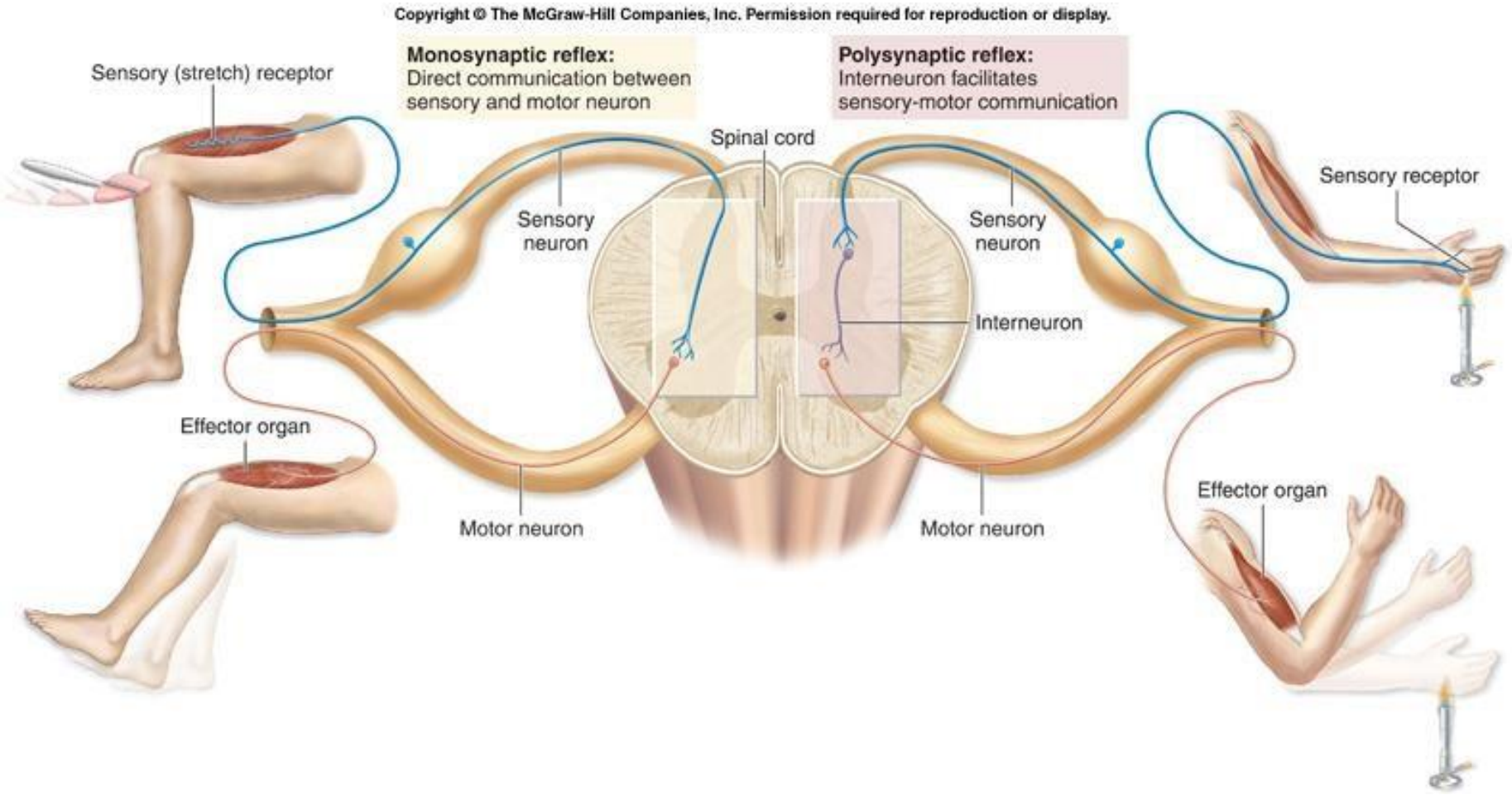
POLYSYNAPTIC REFLEX ARC



POLYSYNAPTIC REFLEX ARC



MONOSYNAPTIC AND POLYSYNAPTIC REFLEX ARCS



PROPERTIES OF REFLEXES

1. REACTION TIME

   The time interval between application of stimulus and the onset of reflex is called reaction time.

2. SUMMATION

   The summation is of two types.

a. Spatial summation: When two afferent nerve fibers supplying a muscle are stimulated separately with subliminal stimulus, there is no response. But, if both the nerve fibers are stimulated together with stimulus of same strength, the muscle contracts. This is called spatial summation.

b. Temporal summation: When one nerve fiber is stimulated repeatedly with subliminal stimuli, these stimuli are summed up to give response in the muscle. This is called temporal summation.

Thus, both spatial summation and temporal summation play an important role in the facilitation of responses during the reflex activity.

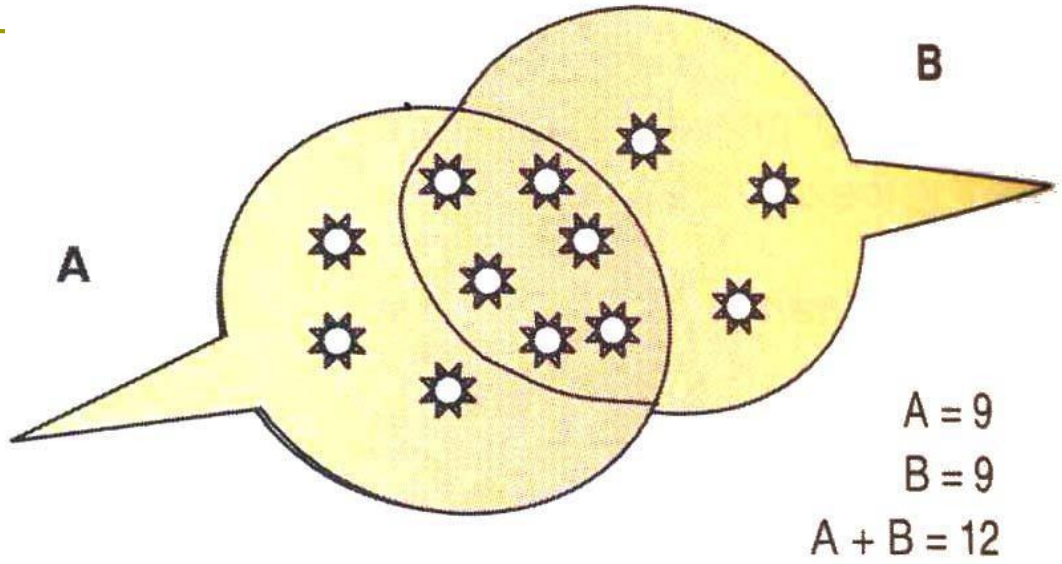
PROPERTIES OF REFLEXES (continuation)

3. OCCLUSION

This is demonstrated in a flexor reflex involving a muscle, which is innervated by two motor nerves. The nerves can be called as A and B. When both the nerves, A and B are stimulated simultaneously, the tension developed by the muscle is less than the sum of the tension developed when each nerve is stimulated separately.

PROPERTIES OF REFLEXES (continuation)

Fig. Occlusion



For example, if nerve A is stimulated alone, the arbitrary unit of tension developed is 9. If the nerve B is stimulated the 9 units of tension developed. So, the sum of tension developed when the nerves A and B are separately stimulated = 9 + 9 = 18 units (see Figure below). But, when both A and B are stimulated together, the tension produced is (A+B) = 12 units. Thus, the tension here is less than sum of tension produced when A and B were stimulated separately. This phenomenon is called occlusion. The occlusion is due to the overlapping of the nerve fibers during the distribution.

PROPERTIES OF REFLEXES (continuation)

6. RECRUITMENT

When an excitatory nerve is stimulated with a stimulus of constant strength for a long time, there is a progressive increase in the response of reflex activities. This is due to the progressive increase in the number of motor neurons activated. This phenomenon is called recruitment. It is similar to the effect of temporal summation.

7. FATIGUE

This type of failure to give response to the stimulus is called fatigue. The center or the synapse of the reflex arc is the first seat of fatigue.

PROPERTIES OF REFLEXES (continuation)

8. RECIPROCAL INHIBITION AND RECIPROCAL INNERVATION

a) RECIPROCAL INHIBITION

Reciprocal innervation is one of the important features of both flexor and extensor reflexes. Usually, the excitation of one group of muscles is associated with inhibition of another, i.e. antagonistic group of muscles on the same side. For example, when a flexor reflex is elicited, the flexor muscles are excited (contracted) and the extensor muscles are inhibited (relaxed) on that side. This phenomenon is called the reciprocal inhibition.

PROPERTIES OF REFLEXES (continuation)

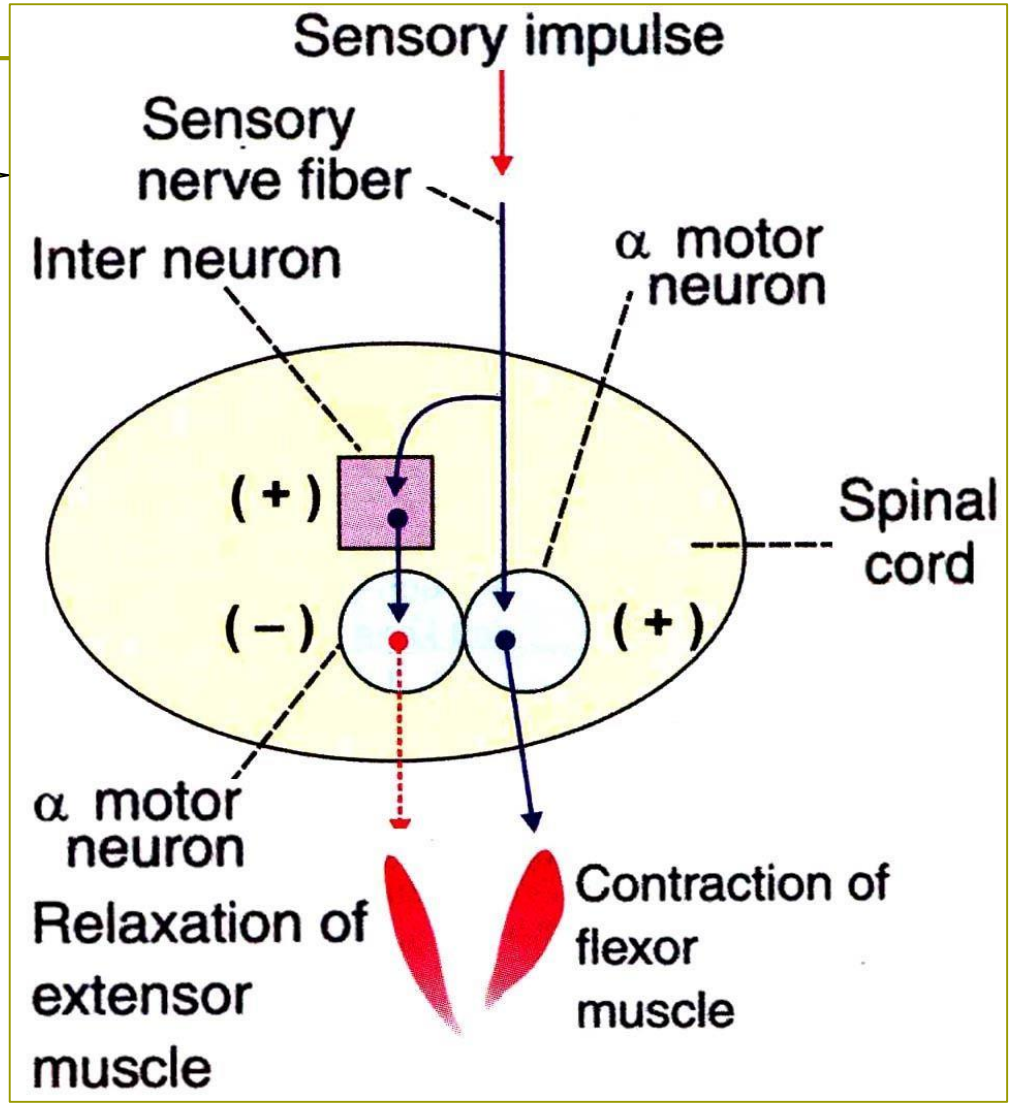
8. RECIPROCAL INHIBITION AND RECIPROCAL INNERVATION (continuation)

b) SHERRINGTON'S LAW OF RECIPROCAL INNERVATION

The neural mechanism involved in reciprocal inhibition was postulated by Sherrington. Hence it is called Sherrington's law of reciprocal innervation. According to this law, the reciprocal inhibition is due to segmental arrangement of afferent and efferent connections in the spinal cord. The afferent nerve fibers, which evoke flexor reflex in a limb have connections with motor neurons supplying flexors and the motor neurons supplying the extensors of same side. The afferent nerve fibers excite the motor neurons supplying flexors. It also inhibits the motor neurons supplying extensors through an interneuron. Accordingly, the flexor muscles contract and extensor muscles relax resulting in flexion of the limb (see Figure below).

PROPERTIES OF REFLEXES (continuation)

Fig. Reciprocal inhibition.
(+) = excitation.
(-) = inhibition.



SIGNIFICANCE OF RECIPROCAL INHIBITION

Reciprocal innervation is very important in spinal reflexes, which are involved in locomotion. It helps in the forward movement of one limb while causing the backward movement of the opposite limb.

NERVOUS CENTERS PHYSIOLOGY

Nervous centre is neurons complex located at different floors of CNS. Main function of any nervous center is definite reflectory acts performance.

Nervous centres properties:

1. **One-sided impulse (excitement) conduction**.
2. **Excitement transduction lack**.
3. **Summation** of subliminal stimuli. There are two main summation types:
   a) temporary (consequent) — when one nerve fiber is stimulated repeatedly with subliminal stimuli frequently. Example: sneezing reflex.
   b) spatial — when two afferent nerve fibers supplying a muscle are stimulated separately with subliminal stimulus.
4. **Excitement rhythm transformation**. Nervous centers are able to transform frequency and rhythm of coming impulses.
5. **Automatism (**of vital nervous centers).
6. **Reflectory afteraction** : answer reflectory reaction is present during some time after stimulus action stoppage.
7. **Fatigue** — they belong to the structures with the biggest fatigue among all nervous system parts. It is determined by nervous center low lability.