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Faculty of General Medicine
Department of Physiology and General Pathology

NORMAL PHYSIOLOGY

Training manual for students

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М 89

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The training manual outlines modern ideas about physiology with a description of the practical application of knowledge within the competence of a future specialist. The training manual for practical lessons teaches the skills in researching of various functions of systems and organs. Teaches to analyze the results, systematize them and make conclusions. This book is for Medical students studying "Normal Physiology", and it can also be used by students of biological specialties while studying the course "Human and Animal Physiology".

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Chapter 1. EXCITABLE TISSUES PHYSIOLOGY

PRACTICAL LESSON 1. To prepare nervous-muscular preparation.

Materials and methods: preparating instruments set, pipette, gauze napkin, Ringer's solution.
Object of study: frog.
Main questions:
1. Physiology as a scientific basis of medicine. Application of knowledge on normal physiology.
2. Stages of Physiology evaluation (short story). The contribution of native scientists in the development of physiology.
3. The concept of physiological research methods. Safety rules when performing physiological studies.

Procedure:

1. Frog is taken in a left hand. Her abdomen must be orientated to the investigator's palm. He must incline frog's head forward with his thumb. One should find small deepening behind occipital bone and take in the preparation needle in suboccipital opening on depth of 1-2 mm.

2. Having performed several transverse movements with the needle end it's necessary to separate brain from spinal cord. After that one must turn the needle toward the trunk. They take the needle in spinal canal while destroying spinal cord.

3. After that taking the animal by his posterior legs one cut spine (vertebral column) by the distance of 2 cm in front of spine articulation with pelvis bones (Fig.1).

4. One should remove all anterior body surface cutting the skin and visceral organs. Legs posterior with pelvis and spine residue are raised up and urostyle is cutted. Urostyle is the bone formed by tail vertebras articulation. The investigator tightens the skin from posterior legs. Then one seperates legs one from another cutting carefully in the middle line the vertebral column residue and the pelvis in mons articulation. One of the legs is preparated, the another one is put in Ringer's solution.

5. One should bring the glass stick to lumbo-sacral plexus and separate pelvis bone from spinal with scissors. The plexus should be connected with spine. One should preparate lumbo-sacral plexus to the hip joint. One should move apart biceps brachii and musculus

semimembranosus at femur dorsal surface. Then the investigator must find sciatic nerve and preparate it through all the distance carefully cutting its branches. The investigator must remove all the tissues above the hip joint. They receive the preparation " sciatic nerve-legs muscles". The preparation must be often damped (moisted) with Ringer's solution for drying prevention.

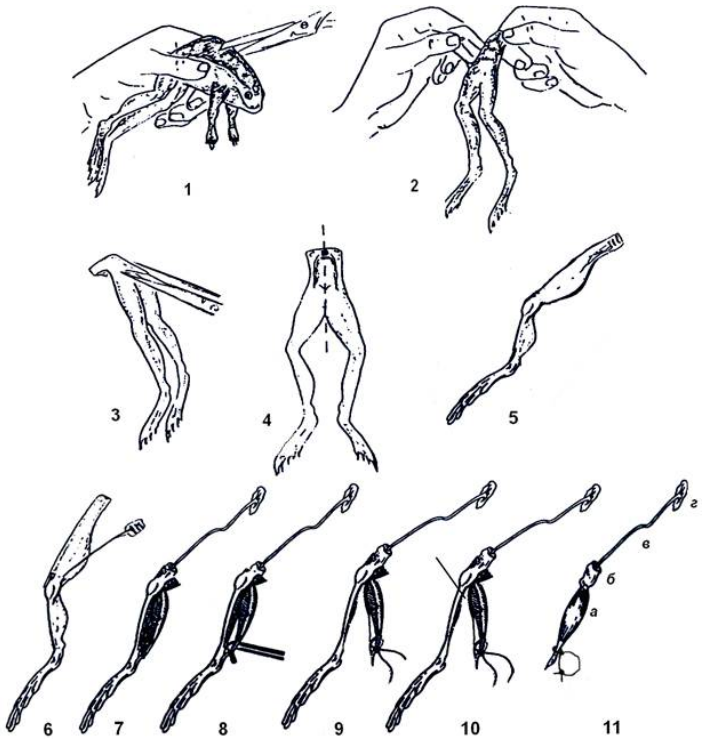


Fig. 1. Sequential steps prepare of the neuromuscular preparation.

Work design: Draw a neuromuscular preparation, consisting of part of the spine, sciatic nerve, gastrocnemius muscle and femur. Make notation.

PRACTICAL LESSON 2.The effect of various stimuli on the neuro-muscular preparation

Materials and methods: preparating instruments set, pipette, gauze napkin, Ringer's solution, Petri dishes, galvanic tweezers, spirit lamp, dissecting needle, matches, salt.

Object of study: frog.

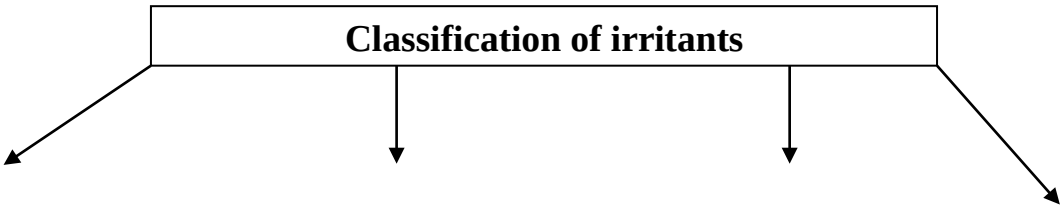
Main questions:

1. Irritability and irritation as they are.
2. Stimuli, definition and classification.
3. Excitability.
4. Call excitable tissues.

5. Law “everything or nothing”.
6. Muscular contraction force dependence on irritation force.
7. Stimulus threshold force dependence on its duration.
8. Excitability measures.
9. Chronaxia, rheobase, useful time. Accommodation.
10. Lability as one of the excitable tissues features

Independent work

1. Fill in the proposed scheme yourself.



Human and animals’ organism has the highest ability to adapt to the constantly varying conditions of external and internal medium. In the basis of adaptive organism reactions lies the universal property of alive tissue - irritability - the ability to respond to the irritating factors action by metabolism change. The irritability is evolutionally the ancient form of tissues reaction. During evolution gradual differentiation of tissues participating in adaptive organism activity has taken place. The irritability in these tissues has reached the best expression and has received the name an excitability. The excitability is an ability of a tissue to respond to an irritation specializedly, singlemindedly and with the maximal velocity. Excitement – is a complex (complicated) biological process expressing by response reaction to an irritation.

A nervous, muscular, epithelial secretory tissue (excitable tissues) have an excitability. The specialized form of response reaction is an excitation process physiological display. A contraction will be a response reaction in any muscular tissue. At a nervous tissue it will be an impulse conduction. At a secretory tissue it will be a synthesis and allocation of biologically active substance.

The excitability of tissues is various. A measure of an excitability is the threshold of stimulation – minimal stimulus force, capable to cause excitation. The stimuli with a size that is less than a threshold one, are called subliminal ones. The stimuli, on force exceeding a threshold of stimulation are called epiliminal ones.

All stimuli can be divided into three groups: physical, chemical and physico- chemical. Physical stimuli - mechanical, temperature, light,

sound and electrical ones. Chemical stimuli - acid, alkalis, medicines. Physical-chemical stimuli – osmotic pressure, pH, ion structure changing. Besides, they distinguish biological stimuli - hormones, vitamins and others, biologically active substances. They allocate also a group of social stimuli - a word.

All stimuli divide on adequate and inadequate on biological value. Adequate stimuli are such stimuli, acting to the given biological structure under natural conditions and to perception of which it is adjusted specially (e.g., for eye retina photoceptors the seen part of light is an adequate stimulus). Non-adequate stimuli are such, to perception of which the given structure is not adjusted specially (e.g., for a skeletal muscle the adequate stimulus is the nervous impulse, but it can contracts at a mechanical impact too).

Between the irritation character and the answer-back reaction of an alive tissue there are close mutual relations, which find expression in the irritation laws.

Irritation force law: the more force of an irritation, the more strong is answer- back reaction (up to known limits). The further stimulus force augmentation any more does not lead to the answer-back reaction increasing, and even can cause return reaction, down to its disappearance. It is explained by the fact that each functional unit of tissues (for example, muscular) has its exaltation threshold. That'swhy while working the threshold stimulus, those fibers, for which this stimulus is of a such size are only involved in the answer. Others do not react.

At stimulus force augmentation the new fibers are involved, for which the given stimulus is a threshold etc. Further, when the stimulus force will exceed the opportunities of all fibers of the given tissue, its answer-back reaction to the force augmentation will not change (the resources are settled!). Such stimuli, which cause the maximal answer-back reaction, are named in physiology maximal or optimal. At the even greater stimulus force augmentation the answer-back reaction even will decrease, as at such a stimulus force the separate functional fibers of excitable tissues even can be injured. In a result, the answer-back reaction decreases and this phenomenon in physiology is named pessimum, and the stimuli causing it - pessimal.

The law "nothing" or "everything" (“all” or “nothing”) is shown, first of all, at the cardiac muscle work analysis. According to this law, subliminal stimuli, acting to a cardiac muscle, do not cause an answer in

it (it is "nothing"), and threshold and epiliminal stimuli cause answer-back reaction of the same size (it is named "everything"). Under the same law the functional unit of any excitable tissue works. Let's take, for example, a muscular fiber and we shall imagine, that threshold stimulus at it is 2V (electrical current strain or voltage). If we act the stimulus of 1V to it, we naturally shall not receive any reaction ("nothing"), and if we take the stimulus of 4V, the muscle will give the same answer-back reaction, as well as on 2V ("all"). Naturally, "nothing" and "everything" are relative concepts, as at the subliminal stimulus action there is a local answer (local potential), therefore it already cannot be treated as "anything".

The law of force-time – with the augmentation of a stimulus force it is required less time of its influence to tissue for answer-back reaction reception. The relation between the duration and force can be expressed by hyperbolic curve, the both branches of which go at any stage in parallel to axes of coordinates. This last circumstance forms the basis that the stimuli of a very small size (less than the threshold) can not cause the answer-back reaction.

The excitability curve demonstrates the exact relationship between the strength and the duration of a stimulus. So, it is also called the strength—duration curve (Fig. 2).

Characteristic Features of the Curve

The shape of the curve is similar in almost all excitable tissues. Following are some of the important points to be studied in the excitability curve:

Rheobase: This is the least possible, i.e. minimum, strength (voltage) of stimulus which can excite the tissue. The voltage below this cannot excite the tissue, whatever may be the duration of stimulus.

Utilization time: It is the minimum time required for a rheobasic strength (threshold strength) to excite the tissue.

Chronaxie: It is the minimum time, at which a stimulus with double the rheobasic strength (voltage) can excite the tissue.

Importance of Chronaxie

The value of chronaxie is used to compare the excitability in different tissues. The measurement of chronaxie determines the excitability of tissue. Longer the chronaxie, lesser is the excitability. Chronaxie in human skeletal muscles varies from 0.08 milliseconds to 0.32 milliseconds. In frog's skeletal muscle, it is about 3 milliseconds.

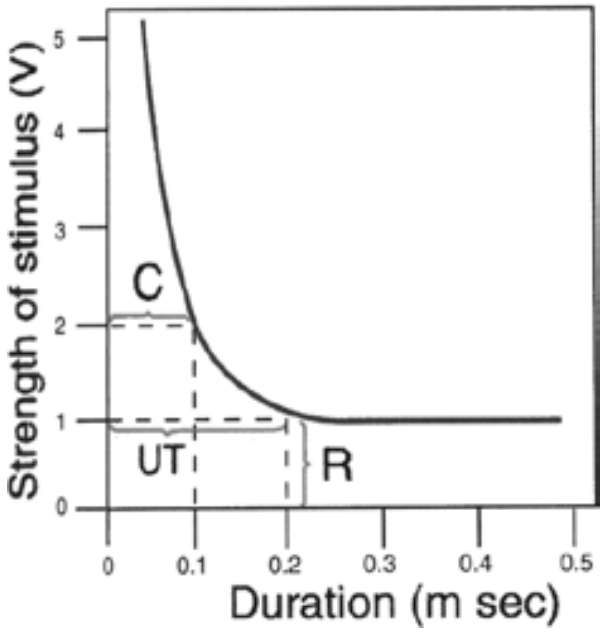


Fig.2. Strength—duration curve.

Chronaxie is 10 times more in skeletal muscles of infants than in the skeletal muscles of adults.

Chronaxie is shortened by increased temperature and prolonged in cold temperature. It is shorter in homoiothermic animals than in poikilothermic animals. Chronaxie is shorter in red muscles than in white muscles.

In physiology they determine one more property of excitable tissues, which has received the name a lability. It is a functional mobility of tissues, its parameter is the potentials action maximal number, which the excitable tissue is capable to generate per 1 second according to a rhythm of a submitted boring (irritation). The normal size of a lability, e.g., for a nervous tissue makes 500-1000 impulses per second, and for skeletal muscles - 150-200 impulses per second. There is a skeletal muscles lability rising with ageing. It is shown in augmentation of irritation frequency, at which the gear (incomplete) tetanus turns in smooth. In newborn's muscles it occurs at a stimulus frequency 4-20 per second, at adulthood - 50-100 impulses per second.

Procedure:

1. Prepare nerve-muscle preparation of a frog.
2. Put irritation with galvanic tweezers.
3. Put mechanical irritation: near a vertebra to hit on a nerve with an edge of scissors or to pinch tweezers. To observe reduction of a muscle.
4. Put thermal irritation: to touch a nerve with the heated microscopic needle. To observe reduction of a muscle.

5. Observe reduction of a muscle when drawing chemical irritation: imposing of a kristallik of table salt. To wash away salt Ringera solution. Reduction of a muscle stops.

Work registration: To write down the data obtained in experience, to draw a conclusion on conditions of preservation of nerve-muscle preparation and on advantages of these or those irritants. To describe degree of manifestation and force of response. What factors can have an impact on response.

PRACTICAL LESSON 3. A study of the bioelectric phenomena in living tissues

Materials and equipments: set of preparing tools (anatomic pincers, small scissors, large scissors, scalpel, probe), physiological solution, preparing small planks, serviettes, cotton wool, tray, electrostimulator, with electrodes, bimetal pincers with copper and zinc ends, a research

Object: frog.

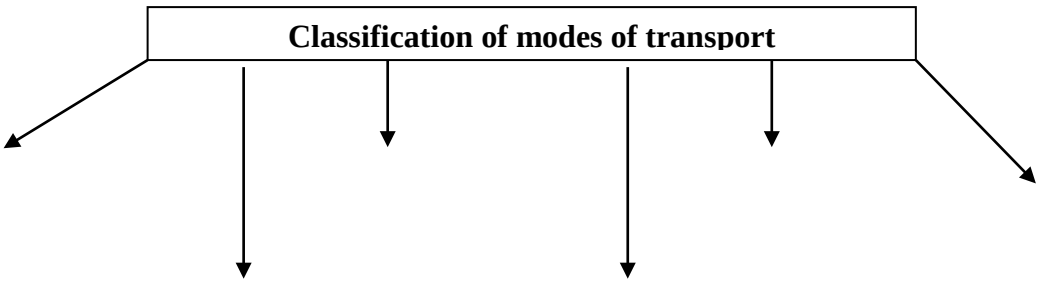
Main questions:

1. Differences of chemical composition of extracellular liquid and intracellular environment.
2. The passive transport of components, its types and mechanisms (diffusion, osmosis).
3. The active transport of components, its types and mechanisms. Co-transport, counte- transport.
4. A concept of the membrane potential and resting potential. Methods of registration of resting potential, and its physical characteristics.
5. The ionic mechanisms of origin of the normal resting membrane potential (diffusion potential, Nernst potential).
6. Resting membrane potential of nerves and skeletal muscles fibers. Main and complimentary factors which influence on a value of the resting membrane potential.
7. Action potential: the structure, physical and physiological characteristics.
8. Structure and basic properties of ionic protein channels, which take part in development of active potential. Voltage-gated sodium and potassium channels.
9. Ionic mechanisms of development of basic phases of action potential.
10. Initiation of the action potential: a positive-feedback mechanism, threshold for initiation of the AP.

11. Excitability, its changes during development of active potential, refractory period.

Independent work

1. Fill in the proposed scheme yourself.



One can use potentials leads from body surface in clinical practice. The records received are called correspondingly to the potentials origin: electrocardiogram (ECG), electroencephalogram (EEG), electromyogram (MG) and so on.

Tooth solid tissues electrical features determining is performed in dental practice for acute and chronic pulpitis diagnostics. This methodics is rather complicated. It requires measurements taking into account individual peculiarities of teeth morphological shape and geometric sizes as well as obligatory following the mot possible stimulus parameters.

Nowadays one uses also possibility of oral mucosa biopotentials measurement for its functional state assessment. There was detected summary biopotentials age dynamics as well as their level change at parodontosis, oral mucosa diseases which is of important diagnostic value.

Dentist can touch with potentials occurrence between similar metals (for instance, amalgame) of different content or between crowns made from the same metal if there is metal filling under them. Appearing microcurrents can be the reason of such a phenomenon named as galvanism. Sometimes pathological process is developed in years after denturing. It depends on the patient individual reactivity. Galvanism clinical symptoms are rather different. They can be divided into two big groups: subjective complaints which occur directly right after metallic fillings and crowns fixation in oral cavity. “Metallic taste” and some others belong to them. They are usually stopped in several days. Complaints which are appeared in prolonged time (sometimes in several years) belong to other group: metallic taste, pain. Oral mucosa inflammation can be developed: reddish color, tongue papillas swelling, erosions and ulcers appearance.

Electrical changes during muscular contraction

When the muscle is stimulated, electrical changes occur before onset of mechanical changes. Usually the electrical events in a muscle (or any living tissue) are measured by using a Cathode Ray Oscilloscope. Nowadays, sophisti cated electronic equipments like computerized polygraph are available to record and analyze the electrical activities of any tissue.

RESTING MEMBRANE POTENTIAL

The potential difference between inside and outside of the cell under resting condition is known as resting membrane potential.

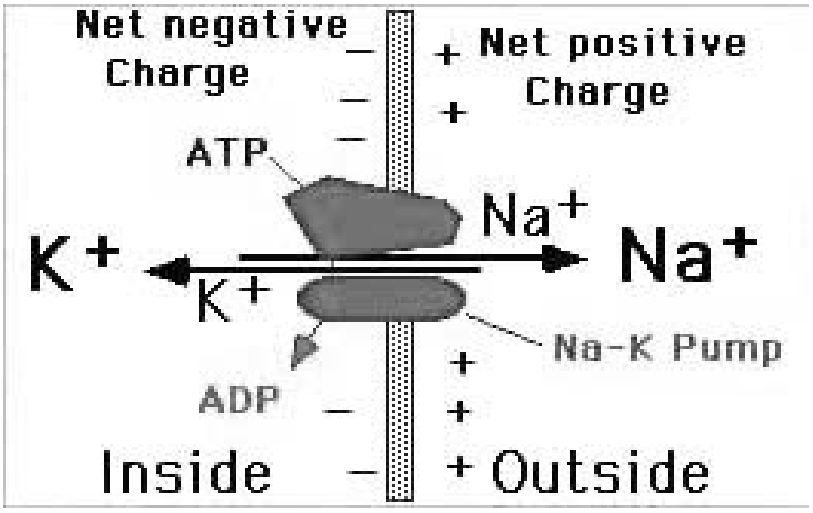


Fig.3. Resting membrane potential.

When two electrodes are connected to a cathode ray oscilloscope through a suitable amplifier and placed over the surface of the muscle fiber, there is no potential difference. There is zero potential difference. But, if one of the electrodes is inserted into the interior of the muscle fiber, potential difference is observed across the sarcolemma (cell membrane). There is negativity inside the muscle fiber in relation to the outside. This potential difference is constant and is called resting membrane potential. The condition of the muscle during resting membrane potential is called polarized state. In human skeletal muscle, the resting membrane potential is -90 mV.

ACTION POTENTIAL

When the muscle is stimulated, a series of changes occur in the membrane potential, which is called action potential. The action potential occurs in two phases.Depolarization and Repolarization.

Depolarization

When the impulse reaches the muscle, the polarized condition (-90 mV) is altered, i.e. the resting membrane potential is abolished. The interior of the muscle becomes positive and outside becomes negative. This condition is called depolarization. With other words, depolarisation is membrane potentials difference decreasing.

Repolarization

Within a short time, the muscle obtains the resting membrane potential once again. Interior of the muscle becomes negative and outside becomes positive. So, the polarized state of the muscle is re-established. This process is called repolarization. So, it is potentials difference restoration.

ACTION POTENTIAL CURVE

Resting Membrane Potential

The resting membrane potential is recorded as a straight baseline at -90 mV .

Stimulus Artifact (local potential)

When a stimulus is applied, there is a slight irregular deflection of baseline for a very short period. This is called stimulus artifact.

Latent Period

The stimulus artifact is followed by a short period without any change. This period is called latent period, which is about 0.5 to 1 millisecond.

Firing Level or Critical Depolarization Level

Depolarization starts after the latent period. Initially, it is very slow. After the initial slow depolarization up to -15 mV, the rate of depolarization increases suddenly. The point at which, the rate of depolarization increases is called firing level.

Overshoot

From firing level, the curve reaches the isoelectric potential (zero potential) rapidly and then overshoots the zero line up to +55 mV.

After Depolarization or Negative after Potential

The rapid fall in spike potential is followed by a slow repolarization process. This is called after-depolarization, trace depolarisation or negative after potential. The duration of this is 2 to 4 milliseconds.

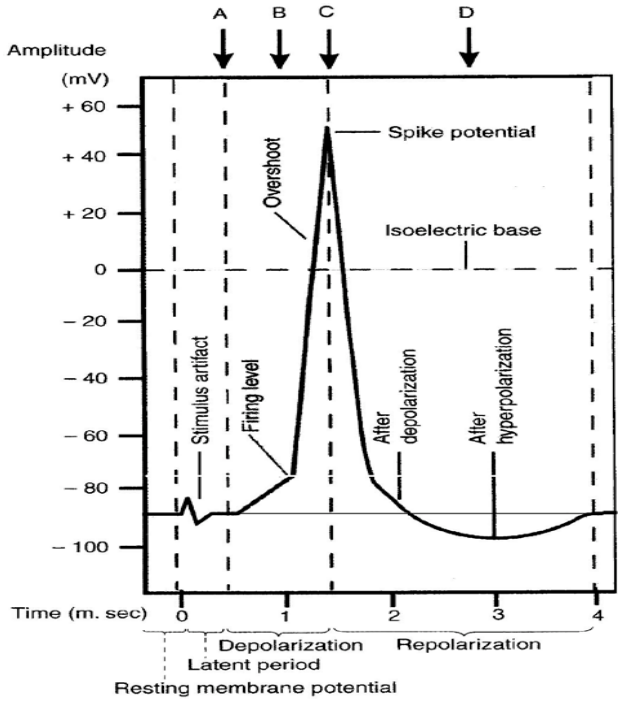


Fig. 4 Action potential in a skeletal muscle.

After Hyperpolarization or Positive after Potential

After reaching the resting level (-90 mV) it becomes little more negative than resting level. This is called after hyperpolarization, trace hyperpolarization or positive after potential. This lasts for more than 50 milliseconds. After this, the normal resting membrane potential is restored.

IONIC BASIS OF ELECTRICAL EVENTS

Resting Membrane Potential

The development and maintenance of resting membrane potential in a muscle fiber or a neuron are carried out by some mechanisms, which produce ionic imbalance across the cell membrane. This results in the development of more positivity outside and more negativity inside the cell. The ionic imbalance is produced mainly by two transport mechanisms in the cell membrane.

1. Sodium-potassium pump and 2. Selective permeability of cell membrane

Sodium-potassium Pump

Sodium and potassium ions are actively transported in opposite directions across the cell membrane by means of an electrogenic pump called sodium-potassium pump This moves three sodium ions out of the cell and two potassium ions inside the cell by using energy from ATP. Since more positive ions are pumped outside than inside, a net deficit of positive ions occurs inside the cell. This leads to negativity inside and

positivity outside the cell.

Selective Permeability of Cell Membrane

The permeability of cell membrane depends largely on the transport channels. The transport channels are selective for the movement of some specific ions. Their permeability to these ions also varies. Most of the channels are gated channels and the specific ions can move across the membrane only when these gated channels are opened.

Channels for major anions like proteins: However, the channels for some of the negatively charged large substances such as proteins and negatively charged organic phosphate compounds and sulfate compounds are absent or closed. Such substances remain inside the cell and play a major role in the development of resting membrane potential.

Leak channels: In addition, the channels for three important ions — sodium, chloride and potassium — also play an important role in maintaining the resting membrane potential.

Since, the Cl- channels are mostly closed in resting conditions, these ions are retained outside the cell. Thus, only the positive ions, Na^+ and K^+ can move across the cell membrane. The Na ions are actively transported (against the concentration gradient) out of the cell and K^+ is actively transported (against the concentration gradient) inside the cell. However, because of concentration gradient Na^+ diffuses back into the cell through Na^+ leak channels. And, K^+ diffuses out of the cell through K^+ leak channels.

In resting conditions, almost all the K^+ leak channels are opened but most of the Na^+ leak channels are closed. Because of this, K^+ ions transported actively into the cell and can diffuse back out of the cell in an attempt to maintain the concentration equilibrium. But only very little amount of Na^+ ions transported actively out of the cell can diffuse back into the cell. That means in resting conditions, the passive K^+ efflux is much greater than the passive Na^+ influx. This results in resting membrane potential with negativity inside compared to outside.

After establishment of the resting membrane potential (i.e. inside negativity and outside positivity), the efflux of K^+ ions stops in spite of concentration gradient. This is because of two reasons.

1. The positivity outside the cell repels the positive K^+ ions and prevents the further efflux of these ions.
2. The negativity inside the cell attracts the positive K^+ ions and prevents further leakage of these ions outside.

Importance of intracellular potassium ions:

The concentration of K^+ ions inside the cell is about 140 mmol/l, which is almost equal to that of Na^+ ions outside. The high concentration of K^+ inside the cell is essential to check the negativity. Normally, the negativity (resting membrane potential) inside the muscle fiber is -90 mV and in a nerve fiber, it is -70 mV. Suppose if the K^+ ions are not present or decreased, the negativity increases beyond -120 mV, which is called hyperpolarization. At this stage, the development of action potential is not possible.

Action Potential

The voltage gated Na^+ channels and the voltage gated K^+ channels play important role in the development of action potential.

During the onset of depolarization, there is slow influx of Na+ ions. When depolarization reaches 7 to 10 mV, the voltage gated Na+ channels start opening at a faster rate. This is called Na+ channel activation. When the firing level is reached, the influx of Na+ ions is very great and the overshoot occurs.

But the Na+ transport is short-lived. This is because of rapid inactivation of Na+ channels. Thus, the Na+ channels open and close quickly. The Na+ channels remain in this inactivated state for some time before returning to resting condition. At the same time, the K+ channels start opening. This leads to efflux of K+ ions out of the cell, causing repolarization thereby.

Unlike the Na+ channels, the K+ channels remain open for longer duration. These channels remain opened for few more milliseconds after completion of repolarization. This causes efflux of more number of K+ ions producing more negativity inside. This is the cause for hyperpolarization.

REFRACTORY PERIOD

Refractory period is the period at which the muscle does not show any response to a stimulus.

Types of Refractory Period.

1. *Absolute refractory period*: Absolute refractory period is the period during which the muscle does not show any response at all, whatever maybe the strength of stimulus.

2. *Relative refractory period*. This is the period, during which the muscle shows some response if the strength of stimulus is increased to maximum.

Refractory Period in Skeletal Muscle

In skeletal muscle, the absolute refractory period falls during first half of latent period (0,005 sec). And, relative refractory period extends during second half of latent period (0,005 sec). Totally, it is 0,01 sec.

Local excitement and distributed excitement comparative characteristics

Local excitement (local potential)	Distributed excitement (action potential)
Stimulus force is subliminal	Stimulus force is threshold
Depolarization looks like S-curve	Special form (see figure)
Depolarization is increased with stimulus force increasing (law "everything" or "nothing" does not work, law "force correlation")	Law "everything' or "nothing": action potential occurs only when depolarization will reach its critical or firing level
It occurs right after irritation	It occurs not right after irritator action because depolarization needs several time for its critical level reaching
It does not have any threshold	It has its threshold
It is realized at the point of stimulus action and practically can not be distributed because of decreasing big velocity	It is easily distributed from occurrence place with a big velocity (up to 140 m/sec)
Ionic reason: Na coming to the cell	Ionic reason: further Na coming to the cell
Excitability is increased	See figure
Subthreshold stimuli can be summarized	Summation is absent
After irritation stoppage depolarization is increased and then disappears slowly	It can be even after stimulus action stoppage (trace potentials)

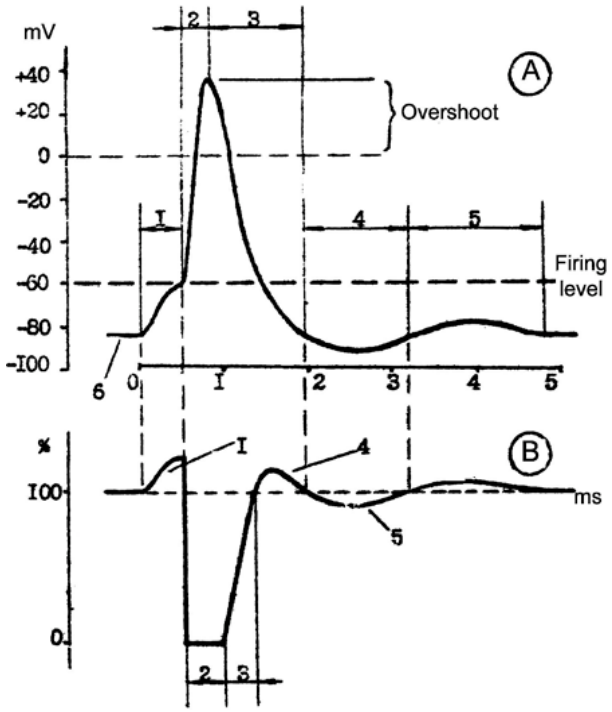


Fig.5. Action potential and changes of cell membrane excitability.

A. Phases of action potential: 1 – slow depolarization, 2 – quick depolarization, 3 – repolarization, 4 – hyperpolarization, 5 – negative afterpotential, 6 – rest potential.

B. Changes of excitability: 1, 4 – supernormal period, 2 – absolute refractory period, 3 – relative refractory period, 5 – subnormal period.

Excitability changings
(figure of action potentials phases and excitability changings correlation)

Action potential phase	Excitability changing	Reasons and mechanisms
Partial depolarization	Supernormal period	The less threshold is, the more excitability is
Complete depolarization	Absolute refractiveness (non-excitability)	During overshoot cellular excitability is equal to zero due to Na-channels inactivation and K-channels activaton. Membranes can not react even to epiliminal stimuli. Potentials difference is equal to 0.
Rapid repolarization	Relative refractiveness	K-ions come from cell and negative charge is accumulated on internal membrane surface. Excitability is restored. Membrane can react to superliminal stimuli. Substances prolonging relative refractory period (antiarhythmical) decrease cardiac contraction rate and repair heart rhythm.
Slow repolarization	Supernormal period (exaltation)	Membrane is partially depolarized and is excited very easy. Answer reaction can occur even at subliminal stimuli action.
Hyperpolarization	Subnormal excitability	Membrane potential increasing, threshold increasing define excitability decreasing. Besides, hypoexcitability is delt with Na-channels inactivation and K-ions activation. Only epiliminal stimuli can cause answer reaction.

Procedure:

I. The first experiment of Galvani (contraction coused by a metal)

1. To make a preparation of hind legs of a frog;

2. Using galvanic pincers simultaneously touch the nervous fibres and muscles of a femur on the same side;

3. Observe the contraction of muscles of the whole preparation.

The results of the work and their registration.

II. The Second experiment of Galvani (contraction without a metal)

This experiment of Galvani consisted of the reduction of muscles of frogs foot was reproduced without participation of a metal, by throwing of preparation of sciatic nerve on the damaged area of thigh. Difference of potentials between an external surface of a muscle and the inside surface, which exists at rest, expressly shows up when a muscle is damaged. Potential which arises up between unharmed and damaged areas is called «potential of damage». When a nerve gets on the damaged electronegative area of muscle, there is shorting of chain, in which positive pole (the unharmed surface of muscle) and the area of nerve which compresses with it take part. Thus in the second experiment

of Galvani reason of excitation of nerve is an irritating action of current which arises directly in tissues.

Between an external surface of a muscle and the inside surface in a state of rest, is a difference potential, which brightly shows up at a damage (fig. 6. Potential which arises between the damaged and unharmed areas of a muscle, «potential of damage» can be reason of excitation a nerve.

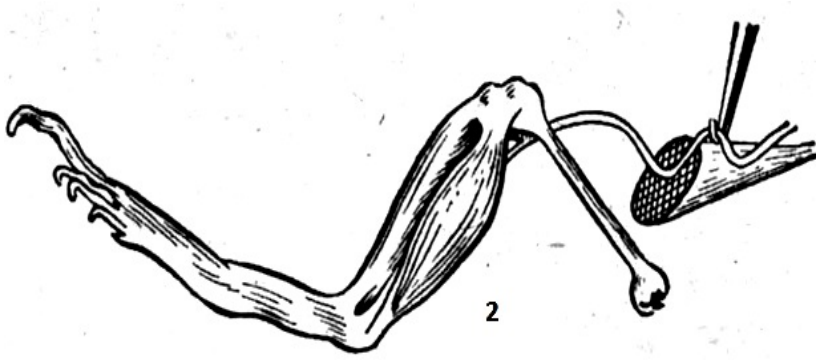


Fig. 6 The Second experiment of Galvani

1. On one of the rheoscopic legs make an incision of a muscle for ming leg on the dameged area.

2. Quickly out the nerve of the second rheoscopic leg on the dameged area so that could touch both the damaged, and the intact surface at the same time.

3. Observe the contraction of the leg.

The results of the work and their registration.

III. **An exposure of electric current in experiment with the second reduction (Experiment of Matteuchi)**

Matteuchi showed that it is possible to cause reduction of muscles of nerve-muscular preparation, by putting a nerve to the muscles of the second preparation, which grow short. This experiment demonstrates that in a muscle which grows short there are considerable currents, which can be utilized in the quality of an irritant for the nerve of the second preparation. These currents are called «currents of action».

1. To prepare a rheoscopic paw from the second half of frog.
2. Place the buttock's nerve of the 1st part on the electrodes.
3. Place the buttock's nerve of the 2nd part along the shin muscle of the 1st part.
4. Give the electric current of 2V for 0,5 ms (fig. 7. Observe the twitching of the two legs.

During the experiment it is necessary to moisten nerve-muscular preparation by physiological solution.

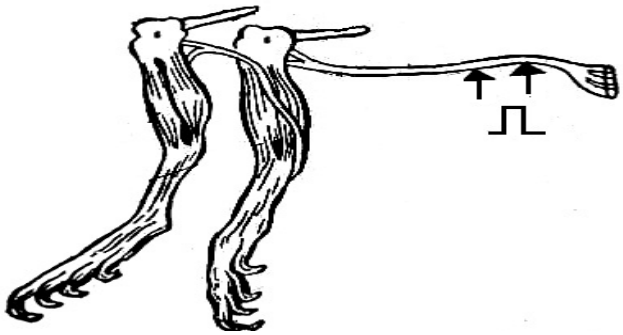


Fig. 7. Nero-muscular preparation - the experience of K. Matteucci

IV. Kellicker's Experience

The dedicated heart of a frog be dried with filter paper and along the long axis to throw the nerve of the drug. Muscle contractions occur in the rhythm of his heart contractions. Draw diagrams of all experiments. Explain the causes of muscle contraction drugs in all experiments.

Conclusion:

1. How was the proved existence of the bioelectric phenomena proved in excitable structures?
2. What is the reason of irritation of a muscle?
3. What are the differences between I-st and II-nd experiment of Galvani?

PRACTICAL LESSON 4. Nervous and muscular excitability determining.

Materials and methods: vertical myograph, stimulator, irritating electrods, kymograph, universal stand, preparating instruments set, pipette, gauze napkin, Ringer's solution.

Object of study: frog.

Main questions:

1. Structural organization of the skeletal muscle.
2. The theory ―sliding myofilaments of the muscle contraction.
3. The structure of actin and myosin filaments.
4. Stages of muscle contraction.
5. The concept of the motor unit. Classification of motor units. Fast fibers, slow fibers.
6. Physiological characteristics of muscle contraction: length of the sarcomer, isometric – isotonic, multiple fiber, summation – frequency

summation (tetanization), muscle hypertrophy - muscle atrophy, muscle tone – muscle fatigue.

7. Types of the smooth muscle. Physical basis for smooth muscle contraction.
8. Tetanus and its types.
9. The mechanism of the appearance of titanic contractions.
10. Dependence of the tetanus amplitude on the frequency of stimulation.
11. Muscle tone and its difference from tetanus.

Independent work

1. Place the symbols in figure 8. Describe (briefly) step by step the mechanism of muscle contraction, note the role of Ca2+ and ATP ions in this process.

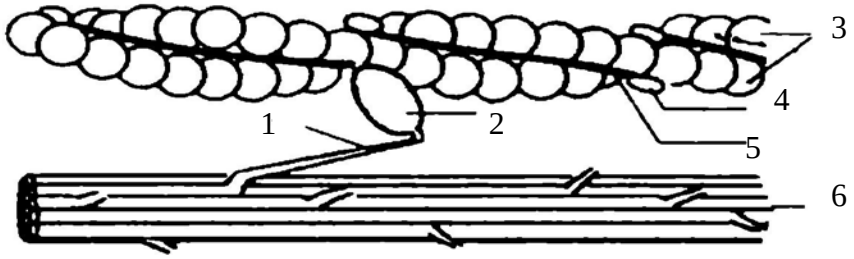


Fig. 8. Schematic structure of myofibrils.

Skeletal Muscle

Skeletal muscles are in association with bones forming the skeletal system. These muscles form from 40 to 50% of body mass. In human beings, about 600 muscles are identified. Skeletal muscles are voluntary and striated. These muscles are supplied by somatic nerves.

Striations, control and nerve supply of muscles

Muscle	Striations	Control	Nerve supply
Skeletal muscle	Present	Voluntary	Somatic nerves
Cardiac muscle	Present	Involuntary	Autonomic nerves
Smooth muscle	Absent	Involuntary	Autonomic nerves

Myofibrils or myofibrillae are fine parallel filaments present in sarcoplasm of the muscle cell. Myofibrils run through the entire length of the muscle fiber.

In cross section of a muscle fiber, the myofibrils are separated from one another by sarcoplasm. In some muscle fibers, some of the

myofibrils are arranged in groups. These groups of myofibrils are called Cohnheim's areas or fields. The diameter of the myofibril is 0,2 to 2,0 microns. And, the length of a myofibril varies between 1,0 to 4,0 cm depending on length of the muscle fiber.

Microscopic structure of myofibril

Light microscopic studies show that, each myofibril consists of a number of alternating light and dark bands. These bands are otherwise called the sections, segments or discs.

Dark band is called “A” band. “A” band is anisotropic. If polarized light is passed through the muscle fiber at this area, the light rays are refracted at different directions (An = not; iso = it; trops = turning). Light band is isotropic. Rays of polarized light, passed through the muscle fiber at this area, are refracted at the sail angle. So, this band is called “I” band.

The light band is otherwise called J band and the dark bands called Q disc (Querscheibe = cross disc).

In an intact muscle fiber, “I” band and “A” band of adjacent myofibrils are placed side by side. This gives the appearance of characteristic cross striations in muscular fiber.

A narrow lighter area called “H” zone (H = hell = light-in German, “H” = Henson - discoverer) is seen at the middle of “A” band. “I” band is divided into two by a narrow line called “Z” line (in German Zwischenscheibe = between discs). The portion of myofibril in between two “Z” lines is called sarcomere.

Sarcomere

Sarcomere is structural and functional unit of the skeletal muscle. Each sarcomere extends between two “Z” lines of myofibril. Thus, each myofibril contains many sarcomeres arranged in series throughout the length of myofibril. Each myofibril consists of alternated dark “A” band and light “I” band (Fig. 9). In the middle of “A” band, there is a light area called “H” zone. In the middle of “H” zone middle part of myosin filament lies. It is called “M” line. Similarly, “'I” band is divided into two equal portions by means of a narrow line called “Z” line. Part of myofibril between two “Z” lines is sarcomere. When muscle is in relaxed state, the average length of each sarcomere is 2 to 3 microns.

Composition of muscle

Skeletal muscle is formed by 75% of water, 20% of proteins and 5% of organic substances other than proteins and some inorganic substances.

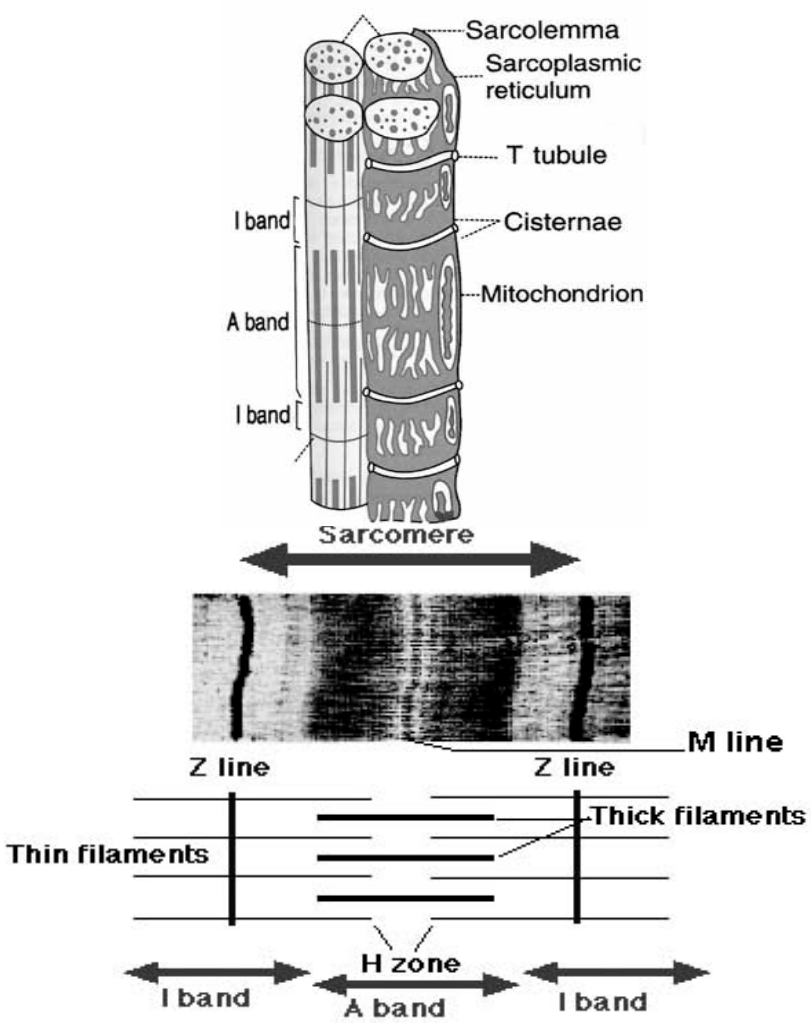


Fig.9. Structure of skeletal muscle.

MUSCLE PROTEINS

Following are the proteins present in the muscle:

1.Myosin
2.Actin
3.Tropomyosin
4.Troponin
5.Actinin
6.Titin
7.Desmin
8.Myogen
9.Myoglobulin.

Myogen is the protein present in sarcoplasm of the muscle cell. Myoglobulin is also present in sarcoplasm. This is also called myohemoglobin. Its function is similar to that of hemoglobin, that is to carry oxygen. This is a conjugated protein with molecular weight of 17,000.

Actinin attaches actin filament to “Z” line.

Titin is a large protein and it connects “M” line and “Z” line. Each titin molecule forms a scaffolding for sarcomere and provides elasticity to the muscle. When the muscle is stretched the titin unfolds itself. However, if stretching more it is offers resistance and protects sarcomere from overstretching. Desmin binds “Z” line with sarcolemma.

Simple muscle contraction or twitch

The contractile property of muscle is studied by using the frog's gastrocnemius- sciatic preparation. This is also called muscle-nerve preparation.

When the stimulus with threshold strength is applied, the muscle contracts and then relaxes. These activities can be recorded graphically by using suitable instruments. The contraction is recorded as upward deflection from the base line. And relaxation is recorded as downward deflection back to the base line (Fig. 10).

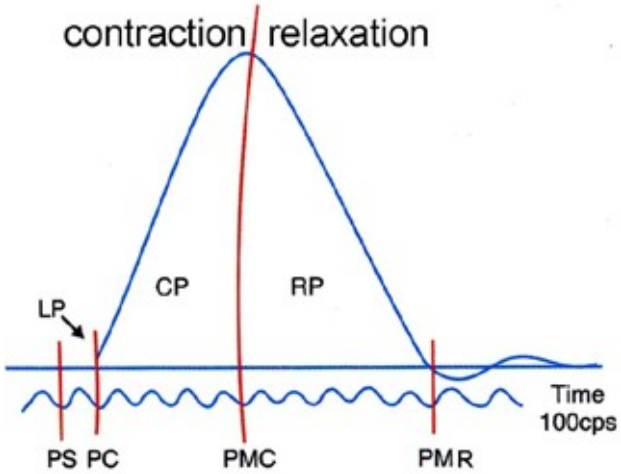


Fig. 10. Isotonic simple muscle curve. PS = Point of stimulus. PC = Point of contraction. PMC = Point of maximum contraction. PMR = Point of maximum relaxation. LP = Latent period (0.01 sec). CP = Contraction period (0.04 sec). RP = Relaxation period (0.05 sec).

Simple contraction is called simple muscle twitch and graphical recording of this is called simple muscle curve. Four points are to be noted in this curve.

1. Point of stimulus (-PS): This denotes the time when the stimulus is applied.
2. Point of contraction (PC): This indicates the time when muscle begins to contract.
3. Point of maximum contraction (PMC): The muscle is contracting up to this point. This point also indicates the beginning of relaxation of the muscle.

4. Point of maximum relaxation (PMR): This point indicates complete relaxation of the muscle.

All these four points divide entire simple muscle curve into 3 periods.

1. Latent period (LP) is time interval between point of stimulus and point of contraction. There is no mechanical activity in the muscle during this period.
2. Contraction period (CP) is interval between point of contraction and point of maximum contraction. The muscle contracts during this period.
3. Relaxation period (RP) is the interval between point of maximum contraction and point of maximum relaxation. Relaxation of the muscle occurs during this period.

Duration of different periods in a typical simple muscle curve is as follows:

- Latent period: 0,01 second
- Contraction period: 0,04 second
- Relaxation period: 0,05 second

Total twitch (contraction) period: 0,10 second

Contraction period is always shorter than relaxation period. This is because the contraction is active process and relaxation is passive process.

Contraction time

Contraction time or total twich period in simple muscle varies from species to species. It is less in warm-blooded (homoiothermic) animals than in cold-blooded (poikilothermal) animals. In the same animal, it varies in different groups of muscles.

Based on contraction time, skeletal muscles are classified into two types, the red muscles and white muscles. Similarly, depending upon contraction time and myosin ATPase activity the muscle fibers are also divided into two types, type I and type II fibers. Type I fibers (slow fibers or slow twitch fibers) have small diameter. Type II fibers (fast fibers or fast twitch fibers) have large diameter. Most of skeletal muscles in human beings contain both types of fibers.

Red Muscles

Muscles containing large number of type I fibers are called red muscles, slow muscles or slow twitch muscles. These muscles have longer contraction time. Back muscles and gastrocnemius muscles are red muscles.

White Muscles

Muscles containing large number of type II fibers are called white muscles, pale muscles, fast muscles or fast twitch muscles. These muscles have shorter contraction time. Hand muscles and ocular muscles are white muscles.

The characteristic features of red and white muscles are given in table below.

Factors affecting contraction force

Skeletal muscle contraction force is affected by following factors:

1. Stimulus strength
2. Stimuli number
3. Temperature and
4. Load

Effect of Strength of Stimulus

If a series of electrical stimuli are applied by increasing the strength (voltage of current) each time, force of contraction is increased. Thus, the curves of different amplitude are obtained. The strength of stimuli is of five types.

Subminimal or subliminal stimulus: the muscle does not show any response.

Minimal stimulus: this is also called threshold or liminal stimulus - minimal contraction occurs.

Submaximal stimulus: muscle contraction force is increased.

Maximal stimulus: force of contraction reaches the maximum.

Supramaximal stimulus: beyond maximal strength, there is no further increase in contraction force.

Features of red and white muscles

Red (slow) muscle	Pale (fast) muscle
1. Myoglobin content is more.	Myoglobin content is less
2. Sarcoplasmic reticulum is less extensive	Sarcoplasmic reticulum is more
3. Blood vessels are more extensive	Blood vessels are less extensive
4. Mitochondria are more in number	Mitochondria are less in number
5. Response is slow with long latent period	Response is rapid with short latent period
6. Contraction is less powerful	Contraction is more powerful
7. This muscle is involved in prolonged and continued activity	This muscle is not involved in prolonged and continued activity
8. Fatigue occurs slowly	Fatigue occurs quickly
9. Depends on cellular respiration for ATP production	Depends on glycolysis for ATP production

Tetanic or summarized contraction

In reply to a rhythmic irritation (namely the such one our muscles are received) the muscle is reduced lengthly (for a long time). Such a contraction has received the name tetanic or summarized. If each subsequent stimulus approaches to a muscle in the period, when it began to be relaxed, there is an infused, dentate or incomplete tetanus. Impulsations rate is 30 in 1 min. It can be expressed under experimental conditions. Fits also are dentate tetanus example. So, it is not physiological. It requires much energy.

If the interval between irritations decreases so, that each subsequent stimulus comes to a muscle at that moment when it is in a contraction phase, there is a smooth or complete tetanus. Impulsations frequency is 60 in 1 min. Smooth tetanus is more physiologic. It requires less energy for its performance. Neck movements to the both sides can be example of such tetanus.

Muscle tone definition

Muscle fibers always maintain a state of slight contraction with certain degree of vigor and tension. This property of muscle is called tone or tonus.

All skeletal muscles show little tonus. But antigravity muscles like extensors of lower limb, trunk muscles and neck muscles show tonus to a greater extent.

Maintenance of muscle tone

In Skeletal Muscle

Maintenance of tone in skeletal muscle is neurogenic. It is due to continuous discharge of impulses from gamma motor neurons in anterior grey horn of spinal cord. Gamma motor neurons in spinal cord are controlled by higher centers in brain.

Abnormalities of muscle tone

The abnormalities of muscle tone are:

1. Hypertonic State

When tone is increased, the muscle becomes spastic (rigid or stiff). This condition of the muscle is called spasticity. Upper motor neuron lesion causes spastic paralysis of muscles, because during upper motor neuron lesion, inhibition of lower motor neuron is lost. So, there is exaggeration of activity of lower motor neuron causing increased muscle tone.

2. Hypotonic State

If muscle tone is decreased or lost, the muscle becomes flaccid and the condition is called flaccidity. Lower motor neuron lesion causes flaccid paralysis of muscles. The muscles undergo wasting.

3. Myotonia

This is an inherited disease characterized by continuous contraction of muscle even after the cessation of voluntary act. The power of relaxation is decreased. Myotonia is due to some abnormal gene that affects the ionic channels in sarcolemma.

Tongue, lips muscles and masticatory muscles contractive types and regimens at conversation.

During mastication mandible displacement takes place due to masticatory muscles contractions occurring in tetanic regimen (mainly incomplete). Contraction type – auxotonic (accompanied by muscle length and tension changings). Lips participate in sounds formation; one can see isometric, isotonic and auxotonic (or auxometric) contractions. Regimen – tetanus.Contractive types and regimens at mastication.
Masticatory muscles contractive type is auxotonic, regimen is tetanic. Tongue: types – isotonic and auxotonic, regimen – tetanic.

Masticatory muscles physiological properties. Masticatory musculature force and work.

As it is well-known, maxillary-facial region muscles are divided into 2 main groups: masticatory and mimic. They belong to skeletal muscles and possess the same features. Masticatory muscles contract mainly in auxotonic regimen i.e. with parallel tension and length changing. Masticatory muscles contracture can be developed due to masticatory muscles fatigue. Contracture means muscles retarded relaxation.

Masticatory musculature belongs to force muscles. It means that they develop mainly force comparatively to other skeletal muscles which develop velocity. In course of masticatory musculature contraction force is developed. Such force is necessary for mechanical action to the food piece, its crush, wearing down and grinding. Skeletal muscle with square in 1 cm^2 can develop muscular force in 10 kg. Transversal section sum for masticatory muscles ascending mandible on 1 side of face is equal to 19,5 cm^2, from the both sides – 39,0 cm^2. Thus, masticatory muscles absolute force is equal to 390 kg. At the same time, separate teeth parodont durability is weak. That is why, pain occurs in parodont during jaws enforced closure and pressure further increasing reflectory stoppage is observed though muscular force has not exhausted yet.

Dental row masticatory center is dental-mandibular system region where food mechanical processing is performed maximally. In healthy

people such center are small and large molars of another side from the one on which mastication takes place. During mastication left and right masticatory centers act in turns. At both masticatory centers functions loosing crushing function is transferred to the first teeth which are adapted badly for this function performance under physiological conditions. That is why food crushing becomes bad and its processing by saliva becomes non-complete.

Masticatory pressure – is a force which is developed by masticatory muscles on mechanical food processing side. This pressure is caused by masticatory muscles contraction and tension in parodontal tissues: the more it is the closer to the attaching place of masticatory muscles and mandible the tooth is.

Masticatory musculature work takes place when muscles are contracted; thus, it is dynamic one.

Muscular work effectiveness – or coefficient of useful action – is up to 30 per cent for masticatory musculature. The work which is in fact is performed during mastication is known as mastication effectiveness. It depends on:

- mastication intensivity;
- masticatory pressure force;
- saliva qualities;
- bite character;
- tongue movement during food piece formation.

Dentists should remember about such physiological methods widely used in practice. Gnatodynamometry is used for determining the tooth supporting tissues resistance to pressure. It is performed by means of gnatodynamometers. They have special plates for teeth. Teeth transmit definite pressure to the spring during mouth closure. This pressure is recorded on the scale. It is established that frontal teeth durability is equal to 60 kg while the one for masticatory one is 180 kg.

Parodont durability depends on masticatory musculature and parodont individual development, their age- and sex-dependent functional state.

Masticatory muscles injury due to their inflammation or trigeminal nerve disease can be mandible contracture reason. Reason is delt with changes occurring in temporal-mandibular joint. That is why myoartrography is of clinical importance. This method allows to registrate simultaneously masticatory muscles contractions and articulatory heads movements.

Procedure:

Task 1. Nerve and muscle excitability measurement.

The investigation is performed on the preparation “sciatic nerve-legs muscles”. The investigator put the preparation on the plate. The scientist puts sciatic nerve to the electrods. Then he slowly increases the voltage till the level at which the muscle will have minimal answer. The founded minimal irritation force is called the irritation threshold.

Then one should determine the muscle irritation threshold at its direct irritation by electrical current. For this gaim the investigator brings up the electrods to one of tibia muscles. Then he finds minimal irritation force causing muscular contraction.

Compare irritation and excitability threshold at direct muscular irritation and nerve irritation (indirect irritation). Make the final conclusion.

Task 2. Muscles contractions dependence on single irritations force.

The observations are performed on nerve-muscular preparation (gastrocnemius muscle and femur bone residue). The preparation are fixed in myograph and the electrods are brought up to the muscle. Find the threshold level. To perform this muscular contraction registration on kymograph. The investigator must write voltmeter numerals under the myogram. To continue the voltage increasing and myogram registration on kymograph. Then one must find the irritation level at which further altidude rising up is absent, i.e. the muscular contraction becomes maximal (fig.11).

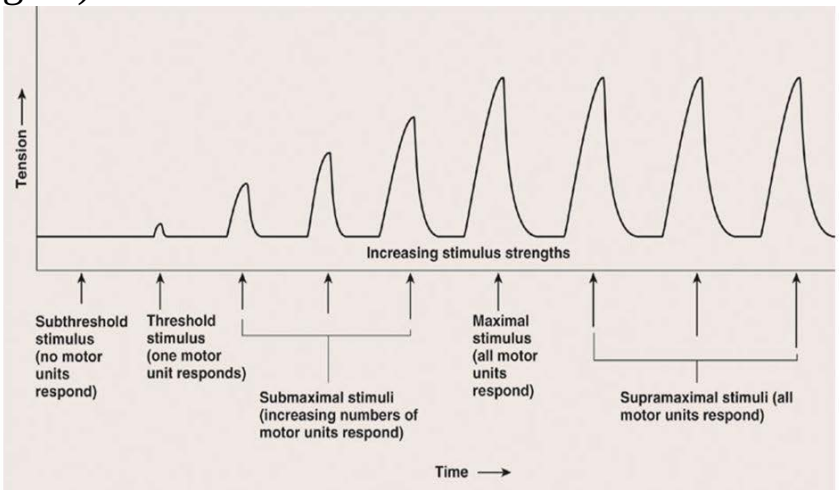


Fig. 11. Contraction of the whole muscle

Task 3. Skeletal muscle contractions curves registration

To prepare nervous-muscular preparation, to fix it in myograph and to bring the electrodes from constant current electrofeeding source. To irritate the muscle with separate key blow and to registrate (write)

separate muscular contraction curve. The velocity of kymograph drum must be maximal. Mark the separate muscular contraction phases and their duration.

Infused (incomplete) tetanus. Right after the separate muscular contraction curve the investigator performes 10-20 fast going one after another key closing and unclosing (fig.12). As a result imperfect, incomplete summation of separate muscular contractions - infused (incomplete) tetanus – occurs.Smooth (complete) tetatus. For its receiving the muscle must be irritated with high frequency – 50 oscillations per second. Electrods must be brought to the unconstant current electrical feeding and the key must be closed in course of 2-5 seconds. To measure the altitude of single muscular contraction, infused and smooth tetanus curves received at equal stimulus force.

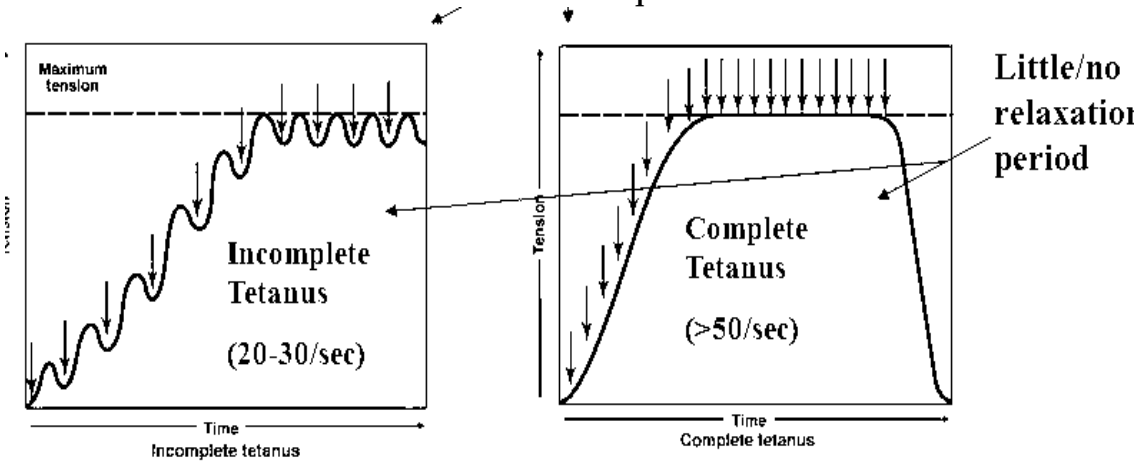


Fig. 12. The dependence of muscle contraction on the frequency of irritation

To glue the curves received into copy-books. To make the conclusions.

PRACTICAL LESSON 5. The determination of the absolute muscular strength of a hand.

Materials and methods: dynamometers.

Main questions:

1. A concept about the general and absolute force of a muscle.
2. Absolute force of some muscles of the person. Dynamometry.

Distribution

Smooth muscles are non-striated (plain) and involuntary muscles. These muscles form the major contractile tissues of various organs.

Muscles, which are in association with viscera, are called smooth muscles or visceral muscles. These muscles are supplied by sympathetic and parasympathetic division of autonomic nervous system. Smooth muscles form the main contractile units of wall of the various visceral organs and are present in the following structures:

- Wall of organs like esophagus, stomach and intestine in gastrointestinal tract
- Ducts of digestive glands
- Trachea, bronchial tube and alveolar ducts of respiratory tract
- Ureter, urinary bladder and urethra in excretory system
- Wall of blood vessels in circulatory system
- Errector pilorum of skin
- Mammary glands, uterus, genital ducts, prostate gland and scrotum in reproductive system
- Iris and ciliary body of the eye.

Structure

Smooth muscle fibers are fusiformed or elongated cells of different length. Smooth muscle fibers are generally very small, measuring 2 to 5 microns in diameter and 50 to 200 microns in length. Each muscle fiber contains myofibrils. The myofibrils are made up of muscle proteins. But, there are no dark and light alternated bands. This is the cause for nonstriated appearance of the smooth muscle.

Smooth muscle fiber contains actin, myosin and tropomyosin components. But troponin or troponin like substance is not present. For the initiation of contraction in skeletal muscle, the calcium ions released from cisternae of sarcoplasmic reticulum, combine with troponin. But in smooth muscle, in addition to the absence of troponin, the sarcoplasmic reticulum is also poorly developed. So, when smooth muscle fiber is excited, the calcium ions enter the sarcoplasm from extracellular fluid through the voltage-gated calcium channels. The calcium ions combine with another protein called calmodulin leading to initiation of contraction.

Electron microscopic studies reveal that some dense bodies are attached to the cell membrane and scattered all over the body of the fibers. Actin filaments are attached to these dense bodies. In between actin filaments, the thick myosin filaments are situated. There are cross bridges between actin and myosin filaments. The cross bridges help in the sliding mechanism of muscle contraction.

Contractile process in smooth muscle

In smooth muscle, latent period is long and contraction process is slow. The relaxation is also slow. Thus, the total twitch period is about 1 to 3 seconds.

Nerve supply to smooth muscle

Smooth muscles are supplied by both sympathetic and parasympathetic nerves, which antagonize each other in control the activities of smooth muscles. However, nerves are not responsible for the initiation of any activity in smooth muscle. Tonus of smooth muscles is independent of nervous control.

Skeletal muscles	Smooth muscles
They are the structural part of musculo-skeletal apparatus.	They are the structural part of inner organs and vessels membranes.
They have no plastic tonus.	They have plastic tonus.
They have fast short-termed depolarization and short absolute refractory period.	They have slow depolarization and long- termed absolute refractory period.
They have no the ability for differentiation and division.	They have the feature of differentiation, division and regeneration under injury.
They are innerved by somatic nervous system.	They are innerved by vegetative nervous system and have their own innervation apparatus (metasympathic nervous system.
They are contracted under impulses transduction through the motor nerves from spinal motoneurons (automatism absence).	They are contracted both under impulses that occur in muscles themselves (automatism existance) and impulses transduction through vegetative nerves.
They have the ability to fast phasic contractions.	They have the ability to long-termed tonic contractions.
They realize arbitrary muscular movements that are accompanied by significant energy loss.	They realize arbitrary muscular movements that are accompanied by insignificant energy loss.
They have weak sensitivity to chemical substances.	They have high sensitivity to chemical, pharmacological, endogenous and exogenous biologically active substances.
They react to medicines in some extent.	They react to medicines in large extent.

Molecular basis of smooth muscle contraction

The process of excitation and contraction is very slow in smooth muscles. This is because of poorly developed L tubules (sarcoplasmic reticulum) in smooth muscle fibers. So, the calcium ions, which are responsible for excitation contraction coupling, must be obtained from the extracellular fluid. This makes the process of excitation contraction coupling slow.

Stimulation of ATPase activity of myosin in smooth muscle is different from that in the skeletal muscle. In smooth muscle, the myosin has to be phosphorylated for the activation of myosin ATPase. The phosphorylation of myosin occurs in the following manner. Calcium entering the sarcoplasm from the extracellular fluid combines with calmodulin forming calcium-calmodulin complex. This activates an enzyme called calmodulin-dependent myosin light chain kinase. This

enzyme in turn causes phosphorylation of myosin followed by activation of myosin ATPase. Now, the sliding of actin filaments starts.

Phosphorylated myosin gets attached to the actin molecule for longer period. It is called latch bridge mechanism and it is responsible for sustained contraction of the muscle with expenditure of little energy. Relaxation of muscle may occur due to the dissociation of calcium-calmodulin complex.

Hormones influence on smooth muscle

Some hormones of the body cause the contraction of smooth muscle and some hormones inhibit the contraction. Action of the hormone depends upon receptors present in the cell membrane. Receptors are of two types namely excitatory receptors and inhibitory receptors. Hormones binding with excitatory receptors cause contraction of muscle by producing depolarization. Hormones binding with inhibitory receptors inhibit contraction by increasing the negativity of membrane potential, which is called hyperpolarization.

Neuro-muscular junction of smooth muscle

There is no well defined neuro-muscular junction in smooth muscle. The nerve fibers diffuse on to muscle fibers The chemical neurotransmitters are directly released in the interstitial fluid.

Skeletal and smooth muscles comparative characteristics.

Further events (common for skeletal and smooth muscles) – ATP-dependent contraction part

Myosin head binds ATP molecule.

Myosin head decomposes ATP till ADP and phosphate, ADP and phosphate are remained binded with myosin head; myosin head containing ADP and phosphate is turned and is binded to actin.

ADP and phosphate are disconnected from myosin head binding to actin; at the moment myosin head makes rowing movement and myosin molecule passes alongside actin molecule (with other words, myosin molecule stretches actin out to itself).

Myosin head binds new ATP molecule and right after this it is disconnected from actin and acquires its initial location. So, muscle can neither contract nor relax without ATP. Myosin head possesses ATP-ase activity only under contraction condition.

Procedure:

1. To demonstrate the method of determination of absolute force of muscles of hand;

2. To demonstrate the method of determination of level of capacity of muscles of hand;
3. To demonstrate the method of determination of index of decline of capacity of muscles of hand.

A tester in the standing position takes his hand with a dynamometer aside on the right angle of 90° in relationship to the body. Another hand is let down and relaxed. On a signal the tester makes the maximum efforts on the dynamometer 5 times. One should hold the dynamometer by fingers without jerks but with all his strength. Every result should be fixed down. The muscular strength is estimated on the best result.

Results:

Right	**Left**
f1=	f1=
f2=	f2=
f3=	f3=
f4=	f4=
f5=	f5=

Conclusion: The absolute muscular strength of the hand is H/cm^2

II. The determination of the level of the ability to work of a hand.

Materials and methods: dynamometers.

Procedure:

A tester measures an absolute muscular strength of the hand 10 times with an interval in 5 seconds.

The results should be fixed down.

The levels of the muscular ability to work are set with the help of the formula: P = (f1 + f2 + f3 + f4 + f5 + f6 + f7 + f8 + f9 + f10):10

P- is the ability to work level, f – the dynamometer index.

Results: f1 =

f2 = f3 = f4 = f5 =

f6 = f7 = f8 = f9 = f10 =

P = (+ + + + + + + + +) : 10 =

Conclusion: The levels of the muscular ability to work is H/cm^2

III. The determination of the reduction of the muscular ability to work level of the hand.

Materials and methods: dynamometers.

Procedure:

Using the results that had been received in the experiment 2, one should calculate the reduction of the ability to work index with the help of the formula:

S = ((f1 - fmin) : fmax) x 100%

S – is the reduction of the ability to work index;

f1 - the rate of the primary dynamometry

fmax - the maximum rate of efforts

min - the minimum rate of efforts

Results: 1. S = ((- _) :) x 100% S = %

2. Draw the graph that will make clear the character of ability to work reduction:

On the abscissa axis you should put down the numbers of efforts, on the coordinate axis you should put down of the dynamometer on every effort.

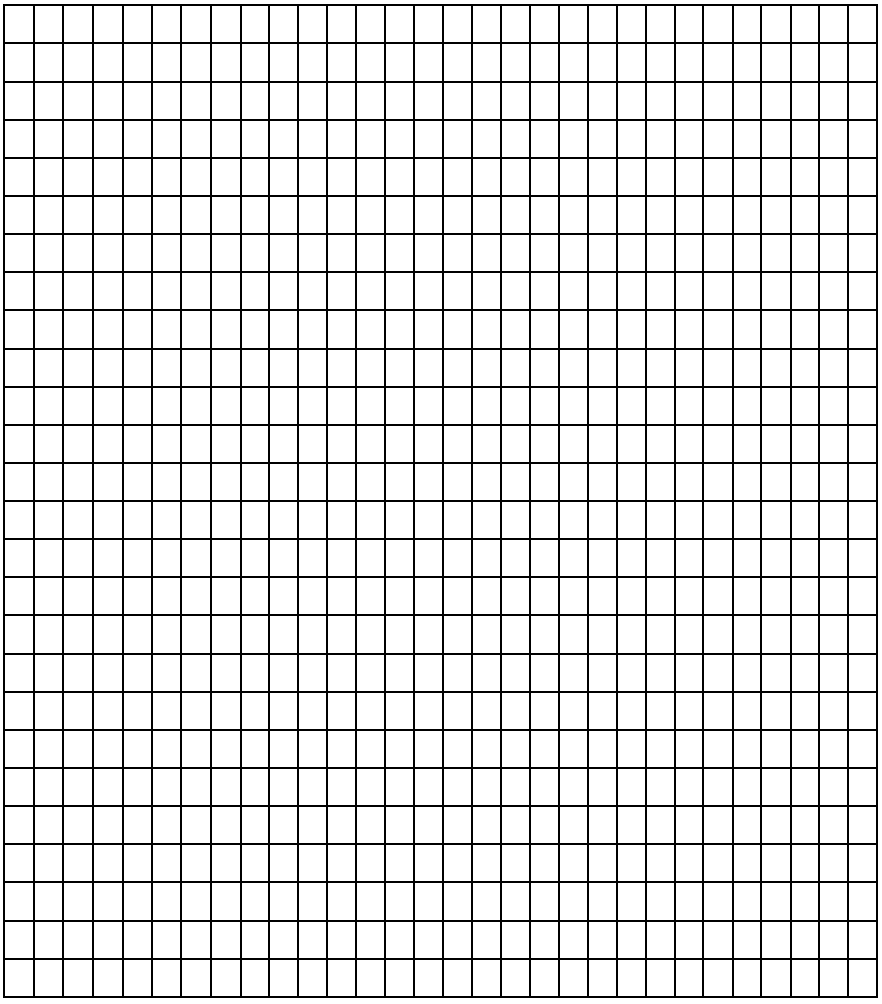


Fig. 13. Layout for plotting

Conclusion: the reduction of the ability to work index is____%

THEME: "MODULE ON THE PHYSIOLOGY OF EXCITABLE STRUCTURES".

1. The structure features of cellular membrane, functions of it, basic components.
2. Differences of chemical composition of extracellular liquid and intracellular environment.
3. The passive transport of components, its types and mechanisms (diffusion, osmosis).
4. Protein channels: selective permeability, gating.
5. The active transport of components, its types and mechanisms. Pinocytosis, phagocytosis.
6. Intercommunication of organism with an environment. A concept is about irritants, irritations, biological reaction, excitation, excitability, excitative structures.
7. A concept of the membrane potential and resting potential. Methods of registration of resting potential, and its physical characteristics.
8. Action potential: the structure, physical and physiological characteristics.
9. Structure and basic properties of ionic protein channels, which take part in development of active potential. Voltage-gated sodium and potassium channels.
10. Ionic mechanisms of development of basic phases of active potential.
11. Excitability, its changes during development of active potential, refractory period.
12. Threshold for excitation and ―acute local potentials‖.
13. Irritants, their classification. The concept of irritation.
14. Laws of irritation. The role of the steepness factor of the increase in the strength of the stimulus. The phenomenon of accommodation.
15. Force-Duration Graphics. Chronaxia, reobase, useful time.
16. Structural organization of the skeletal muscle.
17. The theory ―sliding myofilaments‖ of the muscle contraction.
18. The structure of actin and myosin filaments.
19. Stages of muscle contraction.
20. The concept of the motor unit. Classification of motor units. Fast fibers, slow fibers.
21. Physiological characteristics of muscle contraction: length of the sarcomer, isometric – isotonic, multiple fiber, summation –

frequency summation (tetanization), muscle hypertrophy - muscle atrophy, muscle tone – muscle fatigue.

22. Types of the smooth muscle. Physical basis for smooth muscle contraction.
23. Tetanus and its types.
24. The mechanism of the appearance of titanic contractions.
25. Dependence of the tetanus amplitude on the frequency of stimulation.
26. Muscle tone and its difference from tetanus.
27. A concept about the general and absolute force of a muscle.
28. Absolute force of some muscles of the person. Dynamometry.

Chapter 2. CENTRAL NERVOUS SYSTEM

PRACTICAL LESSON 1. Analysis of the reflex arc.

Materials and methods: set of preparing tools (anatomic pincers, small scissors, large scissors, scalpel, probe), physiological solution, preparing small planks, serviettes, cotton wool, tray, stand, solution 0,5%, 1% H_2SO_4, glass with water, stop watch.

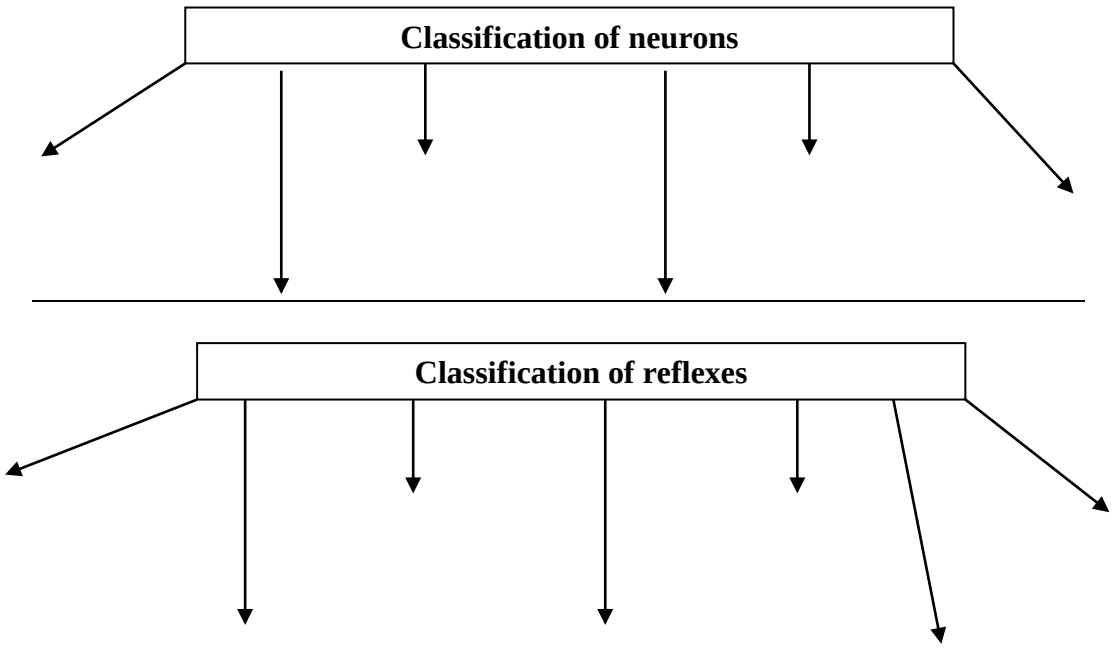
Object of study: frog.

Main questions:

1. Structure and functions a neuron. Classification of Neurons**.** Functions of neuroglia.
2. Physiologic Anatomy of the Synapse. Types of Synapses—Chemical and Electrical
3. Chemical Substances That Function as Synaptic Transmitters Basic lines of the nervous adjusting of functions.
4. Neurochemical mechanisms of the integrative function of the CNS.
5. Classification of mediators, their general characteristics.
6. Reflex arc. Structural and functional component of the reflex arc.
7. P.K. Anokhin's doctrine about functional systems.

Independent work

1. Fill in the suggested schemes yourself.



2. Based on the scheme of the classical "Functional system" according to P. K. Anokhin, draw an example of any FS acting in your body.

3. Make notations to the proposed drawing. Describe step by step the mechanism of synaptic transmission in the chemical and electrical synapses. What is the difference? Note the role of Ca2 + ions in the signal transmission process.

Central nervous system

It includes brain and spine. It is formed by neurons and supporting cells called neuroglia. The structures of brain and spinal cord are arranged in two layers namely grey matter and white matter. Grey matter is formed by nerve cell bodies and proximal parts of axons and dendrites. White matter contains nerve fibers.

Peripheral nervous system

It is formed by neurons and their processes present in all regions of body. This consists of cranial nerves arising from brain and spinal nerves arising from spinal cord. This is again divided into two subgroups:

a) Somatic nervous system and
b) Autonomic nervous system.

1. Somatic Nervous System

It includes nerves supplying skeletal muscles. Somatic nervous system controls movements of 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.

The idea about the fact that organism having nervous system has possibility to react to external stimuli action by type “buttom-answer” was pronounced by French phylosophist Reneh Decart (XVII-th century).

The term “reflex” was introduced by Irgi Prochazka at the end of XVIII-th century. The theory of reflectory activity was developed by:

- I.M.Sechenov (inhibiting phenomenon discovery; to his point of view, all conscious and unconscious reactions are the reflectory ones).
- I.P.Pavlov (science about conditioned reflexes).

Reflex action – 1) is a protective phenomenon which occurs

in response to a change inside or outside of the body;

2) responce resulting from passage of a nerve impulse through a reflex arc.

Reflex arc:

It is composed of 5 components i.e.:

1. Afferent neuron: from receptor to CNS.
2. Inter Neuron (interneuron) or associative neuron: which lies inside CNS.
3. Synapse: which is the contact between 2 neurons.
4. Efferent Neuron: which comes from CNS upto the effector organ.
5. Efferent Organ: which may be:
   1. skeletal muscle.
   2. smooth muscle.
   3. glands.

Reflex arc types:

4. Simple – without associative link. Complex – with associative link.
5. Monosynaptic (little amount).
6. Polysynaptic: tendinous, from skin flexors et al.
7. Somatic (animalous). Vegetative (autonomic).

Reflex action properties:

1. The law of forward conduction.
2. Localization.
3. Summation:

- Temporal summation.
- Spatial summation.

4. Facilitation phenomenon.
5. Central fatigue phenomenon.
6. Central block phenomenon.
7. Central delay.
8. Fractionation phenomenon.
9. Irradiation phenomenon.
10. Recruitment and after discharge.
11. Reciprocal innervation.
12. Occlusion.
13. Central inhibiton.
14. Rebound phenomenon (feed-back reaction).

Reflexes classification:

I.According to reflectory arc formation:

Uncondioned or non-conditioned	Conditioned
Inborn and transmitted by hereditary to all individuals; they are present at birth. Examples: swallowing, breathing, salivation (sialorrhea or ptyalorhea).	They are acquired by organism throughout his life. They are absent at birth.
They are species characteristics.	Individual ones.
They have constant reflectory arcs and are closed at spine and brain stem level.	Reflectory arcs are temporary, they are closed at brain hemispheres level.
They are practically constant, non-changed.	Changeable, may appear and disappear.
They are realized in response to specific (adequate) irritation without any conditions.	They are realized in response to any irritation percepted by organism. They are formed on the base of unconditioned reflexes.
They are realized at level of spine, stem and subcortex nuclei.	They are formed by subcortex but are realized by cortex.
Biological role: they provide organism's existance at first moments after birth and then they are the base of conditioned reflexes development.	Biological role: they encourage to organism adaptation to environmental conditions.

II.According to reflectory arc components:

III.According to main arc neurons localization:

IV.According to receptors character, the irritation of which causes given reflex:

V. According to receptors localization:

1. Superficial;
2. From mucous membranes;
3. Tendinous;
4. Periosteal;
5. According to biological significance;
6. According to principle - what part takes part in reflex realizing;
7. According to ending result.

Receptor is a specialized structure at the terminoma (end) of afferent neurons. It responds to minor changes around it, inside or outside the body.

Receptors tasks:

- giving information about stimulus nature;
- giving information about stimulus force;
- giving information about stimulus action time;
- analysis can not be realized without them.

There are several approaches to the receptors classification (and, thus, several receptors types).

Receptors classification

1. According to the localization:

Visceroreceptors:

Interoreceptors – in inner organs

Proprioreceptors – in motor apparatus and vestibular apparatus.

2. By the nature:

- Mechanoreceptors.
- Thermoreceptors.
- Nociceptors.
- Electromagnetic receptors (which detect light on the retina of an eye)
- Chemoreceptors.

3. According to structure:

- Simple (primary-sensing) – nerve ending:

olfactory;

cutaneous.

- Complex (secondary-sensing) – they have a special receptor cell in front of nerve ending: photo, phono.

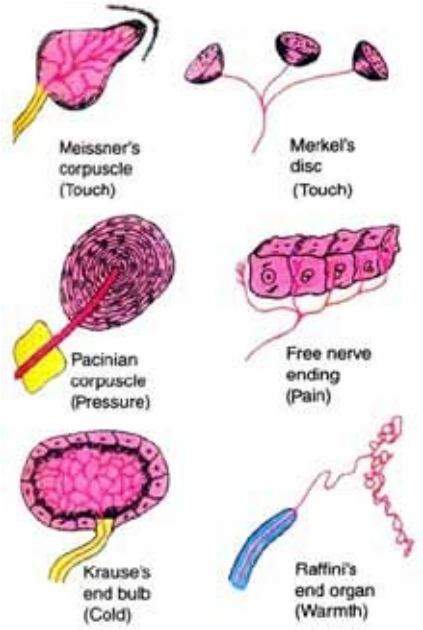


Fig.14. Cutaneous receptors.

Facial-mandibular region receptors

Nowadays term “analizator” has been changed in the term “sensor system”. Sensor system is an integrity of peripheral (receptive) and central structures of different levels the management of which is realized by means of direct and indirect connections.

Classification:

1. <u>According to information character coming into CNS from</u>

peripheral structures:

- gustatory;
- temperature;
- tactile;
- nociceptive;
- proprioceptive.

2. On functioning specificity:

A. Somato-sensor:

- tactile;
- temperature;
- nociceptive.

B. Chemoreceptors:

- gustatory.

C. Proprioreceptors.

Lingual receptors investigations demonstrated that tactile receptors gives answer reactions first, temperature – second. The latest ones are chemoreceptors.

I.P.Pavlov called all receptors of oral cavity "oral analizator".

Properties of receptors

1. Specificity of response - each type of receptor gives response to its own specific sensation. Stimulation of pain receptors produces pain sensation. Similarly, stimulation of touch receptors produces touch sensation. Synonym: adequacy or monomodality. Receptors order (from maximum to minimum):

- distant exteroreceptors;
- contact exteroreceptors;
- proprioreceptors;
- interoreceptors do not possess because these receptors must not react to specific stimuli but must act to any stimuli coming inside organism.

2. Polymodality is opposite to specificity. It means possibility to act to all stimuli. Receptors order (from maximum to minimum):

- interoreceptors;
- proprioreceptors;
- contact exteroreceptors;
- distant exteroreceptors (they do not have).

3. Adaptation or desensitization - when a receptor is continuously stimulated with the same strength of stimulus, after sometime the receptor stops sending impulses through the afferent

nerve. Depending upon this property, the receptors are divided into two types:

a) phasic receptors, which get adapted rapidly - touch and pressure receptors;

b) tonic receptors, which are adapted slowly – muscle spindle, pain receptors and cold receptors.

Maximal adaptation have exteroreceptors (more expressed – contact ones: first touching or kiss, clothes; then – distant – phono- and photoreceptors).

4. Response to increase in the strength of stimulus - during stimulation of a receptor, if response given by receptor is to be doubled, strength of stimulus must be increased 100 times. This phenomenon is called Weber-Fechner law, which states that the change in response of a receptor is directly proportional to logarithmic increase in the intensity of stimulus.

5. Electrical property - ability to generate receptor potential and generator potential.

When a receptor is stimulated, a nonpropagated transmembrane potential difference is developed. This is called receptor potential. Receptor potential is not action potential. It is similar to excitatory postsynaptic potential (EPSP) in synapse, endplate potential in neuro-muscular junction and electro-tonic potential in the nerve fiber.

Receptor potential has such important properties.

a) It is non-propagated (local).

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

Receptor potential is receptor cell membrane depolarization (in complex receptor) or free nervous fiber (in simple receptor) at irritator action to the receptor. Receptor potential is local one. It coincides generator potential in simple receptor. But it differs from it in complex receptor. Generator potential is depolarization of free nervous fiber membrane at mediator portion action. Mediator releasing is caused by receptor formation generation. Generator potential is an action potential. It is equal to action potential and works according to law “everything or nothing” (receptor potential undergoes law of force correlation).

Significance of Receptor Potential

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

Mechanism of Development of Receptor Potential and Generation of Action Potential in the Nerve Fiber

The deformation of the nerve fiber causes opening of sodium channels. So, positively charged sodium ions enter interior of nerve fiber and a mild depolarization, i.e. the receptor potential occurs (Fig.14). This receptor potential spreads along the non-myelinated part of the nerve fiber.

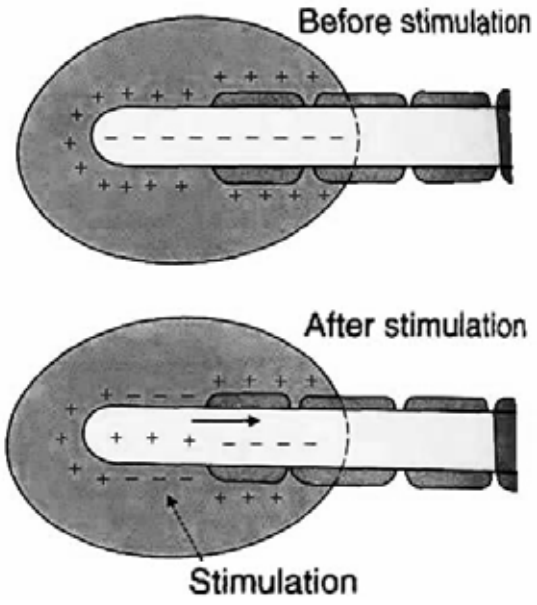


Fig.14. Development of receptor potential in Pacinian corpuscle.

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

1. Sensory transduction – the process, which helps the receptor to give response to a stimulus is called sensory transduction (transduction = conversion of one form of energy into another). Sensory transduction depends on type of receptor. For example, chemoreceptor converts chemical energy into action potential in sensory nerve fiber. Touch receptor converts mechanical energy into action potential in sensory nerve fiber.
2. After-action - receptor action continuation after stimulus action stoppage; it is connected with rhythmical activity.
3. Rhythmical activity – receptor is working despite mediator down-releasing and stimulus absence.
4. Ability to transform force in frequency – receptor is increasing transformer because the more is stimulus action the bigger is generator potential duration (synapse is decreasing transformer because 3-5 EPSP give only 1 action potential).
5. Higher excitability comparatively to neurons and nervous fibers.

6. Excitabilily fluctuation in one and the same receptor – it is fluctuated from high level to low excitability and finally its absence because of receptor rest.
7. Simular-grouped receptors have non-equal excitability because of different threshold. It allows to rest to one receptors.

Nervous fibers physiology

Structure of Myelinated Nerve Fiber

Axis cylinder of nerve fiber is covered by a membrane called neurilemma.

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

Myelin sheath

In a myelinated nerve fiber, axis cylinder is covered by a thick tubular sheath called myelin sheath. Myelin sheath does not form a continuous sheath and is absent at regular intervals. The area where the myelin sheath is absent is called node of Ranvier. The segment of nerve fiber between two nodes is called internode. Myelin sheath is responsible for white colour of nerve fibers. Myelin is lipoproteid.

Functions of Myelin Sheath

Myelin sheath is responsible for faster conduction of impulse through nerve fibers. In these nerve fibers, impulses jump from one node to another. Transmission of impulses from one node to another is by means of saltatory conduction.

Myelin sheath also has a high insulating capacity. Because of this, myelin sheath restricts nerve impulse within single nerve fiber, and prevents stimulation of neighboring nerve fibers.

Neurilemma

Surrounding myelin sheath, there is a thin membrane called neurilemmal sheath. This is also called neurilemma or sheath of Schwann. It contains Schwann cells. Cytoplasm is thin and modified to form the thin sheath of neurilemma enclosing the myelin sheath. At node of Ranvier (where myelin sheath is absent), the neurilemma invaginates and runs up to axolemma in form of a finger-like process. Neurilemma is necessary for formation of myelin sheath (myelinogenesis). Neurilemma is absent in central nervous system.

In non-myelinated nerve fiber, the neurilemma continuously surrounds axolemma.

Nervous impulses conduction

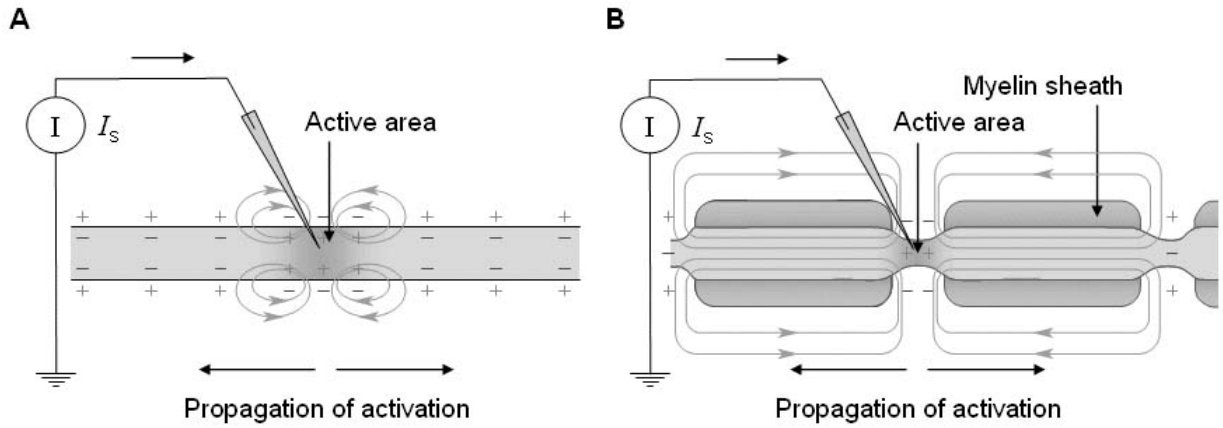


Fig.15. Mode of conduction through nerve fibers.
a. Non-myelinated nerve fiber — Continuous conduction.
b. Myelinated nerve fiber — Saltatory conduction: impulse jumps from node to node. AP = action potential.

Conduction through myelinated nerve fiber—saltatory conduction

Conduction of impulse through a myelinated nerve fiber is about 150 times faster than through a non-myelinated fiber. This is because, myelin sheath forms an effective insulator and flow of current through this sheath is negligible. But action potential jumps from one node to another node of Ranvier. So, velocity of conduction is faster. This type of jumping of action potential from one node to another is called saltatory conduction.

Mechanism of Saltatory Conduction

The myelin sheath is not permeable to ions. So, entry of sodium from extracellular fluid into nerve fiber occurs only in the node of Ranvier, where myelin sheath is absent. This causes depolarization in the node, and not in the internode. Thus, depolarization occurs at successive nodes. So, action potential jumps from one node to another. Hence, this is called saltatory conduction (saltare = jumping).

Nervous fibers classification

1. Depending on structure:
   - Myelinated Nerve Fibers
   - Myelinated nerve fibers are covered by myelin sheath.
   - Non-myelinated Nerve Fibers
   - Nerve fibers of this type do not have myelin sheath.

2. Depending upon distribution:

a) Somatic Nerve Fibers - supply the skeletal muscles of the body.

b) Visceral or Autonomic Nerve Fibers - supply the various internal organs of the body.

3. Depending on source of origin:

- Cranial Nerves - arising from the brain.
- Spinal Nerves - arising from the spinal cord.

4. Depending on function:

a) Motor or Efferent Nerve Fibers - carry motor impulses from central nervous system to different parts of the body.

b) Sensory Nerve or Afferent Fibers - carry sensory impulses from different parts of the body to the central nervous system.

5. Depending on chemical neurotransmitter:

a) noradrenergic - secrete noradrenaline;

b) cholinergic - secrete acetylcholine.

6. Depending on diameter and conduction

Fibers type	Fibers diameter (mcm)	nsduction velocity (m/sec)	Main function
A_α (Type I)	13-22	70-120	skeletal muscles efferent fibers; receptors (muscular spindles) afferent fibers
A_β (Type II)	8-13	40-70	afferents from pressure and touching receptors
A_γ	4-8	15-40	receptors (muscular spindles) efferent fibers; part of afferents from pressure and touching receptors
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

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.

Nervous fibers properties

Excitability - nerve fibers have lower threshold for excitation than other cells. Resting membrane potential in nerve fiber is-70 mV. Firing level (critical depolarization level) is at-55 mV. Depolarization ends at +35 mV.

Conductivity - normally in body action potential is transmitted through nerve fiber in only one direction. However, in experimental conditions when the nerve is stimulated or damaged (tumor, anaesthesia, inflammation) action potential travels through the nerve fiber in both direction.

Refractory period

Summation. When one subliminal stimulus is applied, it does not produce any response in the nerve fiber. However, if two or more

subliminal stimuli are applied within a short interval of about 0.5 m sec, the response is produced. This is because the subliminal stimuli are summed up together. This is known as summation.

Adaptation. While stimulating a nerve fiber continuously, excitability of nerve fiber is maximum at the beginning. Later - response decreases slowly and finally nerve fiber does not show any response at all. This phenomenon is known as adaptation or accommodation.

Infatigability. A nerve fiber cannot be fatigued, even if it is stimulated continuously for a long time. The reason for this is that nerve fiber can conduct only one action potential at a time. At that time, it is completely refractory and does not conduct another action potential.

Procedure:

1. Prepare spinal frog.
2. Lock the spinal frog in the lower jaw to the tripod hook.
3. Play Turk reflex for the right limbs.
4. Preparation washout.
5. At the bottom ending in a hip area to make a circular incision of the skin and remove it from the leg.
6. Repeat Turk reflex. Watch as the preparation.
7. Play Turk reflex for the left limb.
8. At the bottom left thigh ending cut the skin, find sciatic nerve and cut it.
9. Repeat Turk reflex. Watch as the preparation.
10. Prepare second spinal frog.
11. Lock the spinal frog in the lower jaw to the tripod hook.
12. Play Turk reflex.
13. Destroyed spinal cord.
14. Repeat Turk reflex. Watch as the preparation.

Results:

- Reflex arc diagram drawn, noting that the functional components were destroyed.
- What are the laws of the excitation of reflex arc?
-

Conclusion:

1. What are the material substrate reflexes?
2. What are the functional components of reflex arc?
3. What are the conditions necessary for the occurrence of reflex response?

PRACTICAL LESSON 2. Research of reflex time (by Turk)

Materials and methods: set of preparing tools (anatomic pincers, small scissors, large scissors, scalpel, probe), physiological solution, preparing small planks, serviettes, cotton wool, tray, stand, acids set (sulfuric acid 0,1%, 0,3%, 0,5%, 1,0% solutions), glass with water, stop watch.

Object of study: frog.

Main questions:

1. Reflexes Classification.
2. Classification of receptors. General mechanisms actions of receptors.
3. Reflex time.

Procedure:

Every reflex has its own reflex field, i.e. body locus at irritation of which this reflex occurs. Response answer character at reflex field irritation depends not only on its localization on body surface but also on irritation force and duration.

Frog's brain must be removed. After that you receive spinal frog's preparation it's necessary to wait 2-3 minutes for spinal shock phenomena disappearance. Then the investigators must hang the frog by his inferior jaw on the hook fixated in a stand. They wash filter paper piece in 0,1% sulfuric acid solution and put it on inferior leg tibia external skin surface. To observe flexory reaction of corresponding leg. To wash the leg from acid by means of leg's plunging into water. To realize the irritation of the same leg with 0,3%, then with 0,5% of acid solutions.

To choose those concentration at which one can see maximal flexory reflex. Paper with sulfuric acid of this concentration put on lateral abdomen surface. After some minutes you can observe defensive reflex: frog takes the paper off with the nearest leg. To put the paper to the external surface of anterior leg, on the abdomen near to the thoracic part, between superior and inferior legs. You must registrate answer reaction every time.

The intervals between irritations must be at least 2-3 min. After each irritation you should put the frog to the glass with water and wash the animal from acid residues.

In second experiment you should put your attention to the correlation of reflex time to stimulus force (students must perform the experiments with all solutions (time must be fixed with metronom or watch with second pointer).

Results:

1. Calculate the average time for each Turk's reflex force stimuli.
2. Graphically depict the time dependence of strength reflex stimulus (low of fourse of time).
3. Drawn circuit experiment.
4. Drawn diagram reflex arc of Turk reflex.

Concentration of sulfuric acid (в %)	**Reflex time (three tests) (in sec.)**			**Average time of reflex (in sec.)**
	1	2	3	
0,1				
0,3				
0,5				

Conclusion:

1. What is time of reflex, what are periods consist of?
2. What does the number of stimuli to time reflexes?
3. What is the value of reflex time?

PRACTICAL LESSON 3. Spinal Shock. Receptive field of reflex.

Materials and methods: set of preparing tools (anatomic pincers, small scissors, large scissors, scalpel, probe), physiological solution, preparing small planks, serviettes, cotton wool, tray, stand, stop watch.

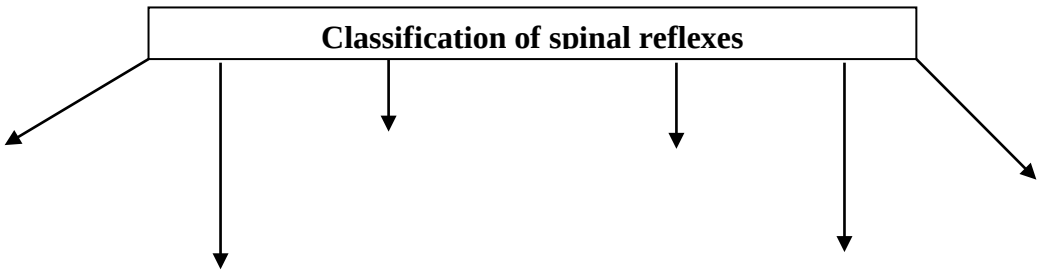
Object of study: frog.

Main questions:

1. Organization of the Spinal Cord. Alpha Motor Neurons. Gamma Motor Neurons. Neurochemical integrative mechanisms of CNS function.
2. Functions of the Spinal Cord. Ascending tracts and Functions. Descending Tracts.
3. Autonomic Reflexes in the Spinal Cord. Law Bella-Mazhandi.
4. Muscle Stretch Reflex. Flexor Reflex and the Withdrawal Reflexes. Reflexes of Posture and Locomotion.
5. Clinical Applications of the Stretch Reflex.
6. Spinal Cord Transection and Spinal Shock. The Brown-Sequard Syndrome.

Independent work

1. Fill out the proposed scheme yourself.



Spine represents main canal for afferent (cutaneous, temperature, proprioceptive and noceoceptive or pain) signalization from peripheral receptors to CNS highest parts. At afferent impulses conductance disorders through spine (at syphilitic spine injury i.e. tabes dorsalis) human being can not perform movements at closed eyes (ataxy). For example, mother can not take his baby on her arms. Spine is main canal of opposite afferentation about motor acts results. Also spine is a leading tract of excitement passage from CNS to motoneurons and associative neurons of lateral corns which form motor and vegetative reactions. One can tell that spine provides relatively primitive, simple, stereotypic activity. Spinal neurons excitability is low: exciting influence from brain is essential for their activity. Spine is responsible for most reflexes realization. Spinal reflexes are specifically changed or even disappeared at spine injury.

Spinal shock is observed after spine cutting. All spine functions disappear rapidly at this. Spinal reflector reactions are restored quickly in lower animals (in frogs – in 10-15 min), moreover, the lower alive organism is, the restoration time less is because they have developed subcortex comparatively to cortex. Cutted spine is practically not restored in human being. There are some theories of spinal shock. F.Goltz considered spinal shock as an irritation result. But Ch. Sherrington, G.Trendelenburgh also studied spinal shock at spine cooling blockade. Repeated cutting of spine lower than first cutting also does not cause spinal shock. All this indicates to the fact that spinal shock occurs due to spine separation from brain parts located above.

Microelectrode investigations demonstrated that motoneurons do not suffer at spinal shock. Associative neurons are injured due to which reactions to afferent stimuli are absent. Paralyses belong to one of the most widely-spread motor disorders. Main distinguishing features of central and peripheral paralyses are given in a table.

Paralysis type	Central or spastic	Peripheral, sluggish or atrophic
Injuries location	Cortex motor projectional area or pyramidal fascicles	Spine anterior corn, peripheral nerves anterior fascicles and anterior fibers
Paralysis distribution	More often diffused	More often limited
Muscles tone	Hypertony, spasticity	Hypotony, atrophy
Reflexes	Deep reflexes are increased, abdominal and plantar are decreased or lost	Deep and skin reflexes are decreased or lost
Pathological reflexes	Some of them are present	Absent
Paralysis type	Central or spastic	Peripheral, sluggish or atrophic
Conjugating movement	Present	Absent
Degeneration reaction	Absent	Present

Motor ways different floors injuries are accompanied by varies symptoms complexes:

1. Peripheral nerve injury causes peripheral paralysis in the area of muscles innervated by given nerve. Also sensitivity disorders are observed because biggest amount of nerves are mixed (with motor and sensor fibers).
2. Plexuses injuries lead to peripheral paralyses, pain and sensitivity disorders.
3. Spine anterior corns and anterior radixes (also cranial nerves motor nuclei) pathology causes only peripheral paralyses without pain and sensitivity disorders.
4. Spine lateral corn (with lateral cortico-spinal tract passing in it) injury causes diffused (central paralysis below from the injury locus); leg paralysis if thoracical part is injured; arm and leg central paralysis is observed if pyramidal fascicle is injured upper than cervical plexus. Also lateral corn injury is accompanied by noceoceptive and temperature sensitivity loosing on opposite side.
5. Spine transversal cutting gives lower extremities central paraplegia (pyramidal fascicles two-sided injury) – at location in thoracical part, or tetraplegia (all 4 extremities injury) – at upper (superior cervical injuries).
6. Brown-Sequard' syndrome (spine half injury) – spastic paralysis and deep sensitivity disorders on the injury side and superficial sensitivity loosing on an opposite side.
7. Pyramidal fascicle injury in brain stem (pons cerebri, medulla oblongata, peduculi cerebri) gives central hemiplegia on opposite side because pyramidal ways are crossed below, on the boarder with spine.

Usually cranial nerves are involved on the focus side. It creates the picture of so-called alternating (crossing) paralysis: cranial nerves injury on injury focus side, central hemiplegia – on opposite side.

8. Pyramidal fibers injury in internal capsule causes central hemiplegia (leg and arm on one side), facial musculature inferior part central paralysis on opposite side because cortico-nuclearis tract is also injured at the same time.
9. Motor projectional zone irritation causes epileptic fits (local or generalized).

Spinal cord lies loosely in the vertebral canal. It extends from foramen magnum where it is continuous with medulla oblongata, above and up to the lower border of first lumbar vertebra below. The coverings of the spinal cord are membranous in nature and are called the meninges. The meninges are dura mater, pia mater and arachnoid mater. These meninges are responsible for protection and nourishment of the nervous tissues. The length of the spinal cord is about 45 cm in males and about 43 cm in females.

Spinal cord is cylindrical in shape with two spindle shaped swellings—the cervical and lumbar enlargements. These two portions of spinal cord innervate upper and lower extremities respectively. Below the lumbar enlargement, the spinal cord rapidly narrows to a cone shaped termination called conus medullaris. A slender non-nervous filament called filum terminale extends from conus medullaris downward to the fundus of the dural sac at the level of second sacral vertebra. Spinal cord is made up of 31 segments.

Cervical segments	=	8
Thoracic segments	=	12
Lumbar segments	=	5
Sacral segments	=	5
Coccygeal segment	=	1

In fact, the spinal cord is a continuous structure. The appearance of the segment is given by the 31 pairs of nerves arising from the spinal cord. Thus, the segments of spinal cord correspond to the 31 pairs of spinal nerves in a symmetrical manner.

Cervical nerves=	8
Thoracic nerves=	12
Lumbar nerves=	5
Sacral nerves=	5
Coccygeal nerve=	1

Each spinal nerve is formed by an anterior (ventral) root and a posterior (dorsal) root. Both the roots on either side leave the spinal cord

and pass through the corresponding intervertebral foramina. The first cervical spinal nerves pass through the foramen between occipital bone and the first vertebra called atlas. The cervical and thoracic roots are shorter whereas, the lumbar and sacral roots are longer. The long nerves descend in dural sac to reach their respective intervertebral foramina. This bundle of descending roots surrounding the filum terminale resembles the tail of horse. Hence, it is called cauda equina.

On the anterior surface of spinal cord, there is a deep furrow known as anterior median fissure. The depth of this is about 3 mm. Lateral to the anterior median fissure on either side, there is a slight depression called the anterolateral sulcus. This denotes the exit of anterior nerve root. On the posterior aspect, there is a depression called posterior median sulcus. The posterior median sulcus is continuous with a thin glial partition called the posterior median septum. It extends inside the spinal cord for about 5 mm and reaches the gray matter. On either side, lateral to the posterior median sulcus, there is posterior intermediate sulcus. It is continuous with posterior intermediate septum, which extends for about 3 mm into the spinal cord. Lateral to the posterior intermediate sulcus, is the posterolateral sulcus. This denotes the entry of posterior nerve root.

Internal structures of spinal cord

Substance of spinal cord is divided into inner gray matter and outer white matter. Gray matter is the collection of nerve cell bodies, dendrites and parts of axons. It is placed centrally in the form of wings of the butterfly and it resembles the letter H. Exactly in the center of gray matter, there is a canal called the spinal canal. White matter is the collection of myelinated and non-myelinated nerve fibers (Fig. 16).

Gray matter of spinal cord

Ventral and the dorsal portions of each lateral half of gray matter are called ventral (anterior) and dorsal (posterior) gray horns respectively. Lateral horns of gray matter are present in the thoracic segments and first two lumbar segments only. The part of the gray matter anterior to central canal is called the anterior gray commissure and the part of gray matter posterior to the central canal is called the posterior gray commissure.

Nerve cells present in the gray matter are multipolar type. Golgi I type cells with long axons are usually found in anterior horns and Golgi II type cells with short axons are found mostly in posterior horns. Axons of Golgi I type cells form the tracts of spinal cord and short axons from type II cells pass towards the anterior horn of same side or opposite side.

Neurons in Gray Matter of Spinal Cord

In the gray matter of spinal cord, the neurons are arranged in different groups.

Following are the important neurons in the gray matter (Fig.17).

Neurons in Anterior Gray Horn

The neurons of the anterior gray horn are involved in motor function and send motor nerve fibers to muscles and other effector organs.

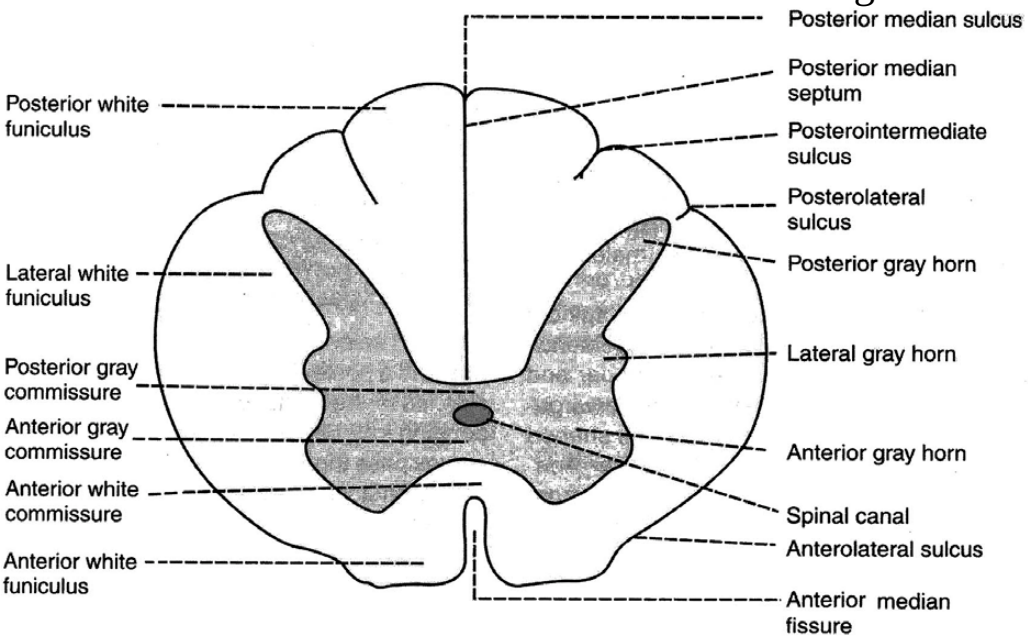


Fig.16.Section of spinal cord — thoracic segment.

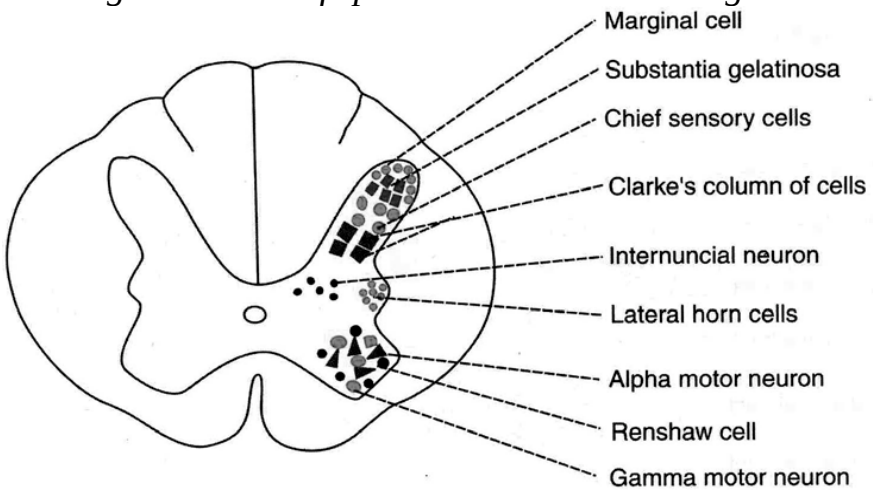


Fig.17.Neurons in gray horn of spinal cord — thoracic segment.

Three types of motorneurons are located in anterior gray horn.

Alpha motorneurons: Alpha motor neurons are large and multipolar cells. Axons of these neurons leave the spinal cord through the anterior root and end in groups of skeletal muscle fibers, i.e. extrafusal fibers.

Gamma motor neurons: Gamma motor neurons are smaller cells scattered among alpha motor neurons. These neurons send axons to the intrafusal fibers of the muscle spindle.

Renshaw cells: These cells are also smaller cells. Renshaw cells are the inhibitory neurons playing an important role in synaptic inhibition at the spinal cord.

Neurons in Lateral Gray Horn

In thoracic and upper two lumbar segments, the gray matter forms a small projection in between the anterior and posterior horns. This is called the lateral gray horn. This has cluster of nerve cells called intermediolateral horn cells. These cells give rise to sympathetic preganglionic fibers, which leave the spinal cord through the anterior nerve root.

Neurons in Posterior Gray Horn

The posterior gray horn contains the sensory neurons, which receive impulses from various receptors of the body through posterior nerve root fibers. Four groups of neurons are present in the posterior gray horn.

Substantia gelatinosa of Rolando: This is a cap like gelatinous material at the apex of posterior horn. This is formed by smaller nerve cells.

Marginal cells: Marginal cells cover the substantia gelatinosa at the very tip of the posterior gray horn. Sometimes the marginal cells are also called the border cells.

Chief sensory cells: The chief sensory neurons are situated in the remaining parts of posterior column.

Clarke's column of cells: The Clarke's column of cells is the collection of well- defined cells and occupies the inner part of posterior horn.

White matter of spinal cord

White matter of spinal cord surrounds the gray matter. It is formed by the bundles of both myelinated and non-myelinated fibers, but predominantly the myelinated fibers. The anterior median fissure and the posterior median septum divide the entire mass of white matter into two lateral halves. The band of white matter lying in front of anterior gray commissure is called the anterior white commissure.

Each half of the white matter is divided by the fibers of anterior and posterior nerve roots into three white columns or funiculi.

Anterior or Ventral White Funiculus

This lies between the anterior median fissure on one side and anterior nerve root and anterior gray horn on the other side.

Lateral White Funiculus

This is present between the anterior nerve root and anterior gray horn on one side and posterior nerve root and posterior gray horn on the other side.

Posterior or Dorsal White Funiculus

It is situated between the posterior nerve root and posterior gray horn on one side and posterior median septum on the other side.

Spinal proper functions:

- Spinal reflexes.
- Organism motor activity co-ordination particularly spinal motoneurons functions.
- Vegetative reactions.
- Uroreleasing and defecation.

Spinal animals – are animals with cutted spine on the boarder with medulla oblongata.

Spinal animals features:

Respiration absence.

- Low blood pressure, decreased vascular tone.
- Loosing the ability to support homoiothermism (constant body temperature).
- Disapperance of all forms of singleminded activity (alimentary, sexual, protective).
- Anal and uroreleasing ceneters paralysis at spine cutting lower than lumbal parts.

Spine vegetative functions:

- Defecation.
- Uroreleasing.
- Vascular tone regulation.
- Erection and ejaculation.
- Sweat releasing.

Spine afferent ways

- Goll's and Burdah's ways.
- Spinal-thalamic tracts.
- Spinal-cerebellar tracts.

Significance of afferent information coming into spine:

- It carries the information about environment changings.
- It participates in CNS co-ordinative activity by guiding the skeletal musculature: at switching-off the afferent impulsation from working

organ its guiding becomes non-perfect.

- It encourages CNS tone supporting; summary tonic CNS impulsation is decreased at afferent impulsation switching off.
- It participates in inner (visceral) organs regulation processes.

Efferent ways:

- Pyramidal tract.
- Extrapyramidal ways:
- reticulo-spinal tract;
- rubro-spinal tract;
- tecto-spinal tract;
- vestibule-spinal tract.

Pyramidal tracts

Pyramidal tracts of spinal cord are descending tracts concerned with voluntary motor activities of the body. These tracts are otherwise known as corticospinal tracts. There are two corticospinal tracts, the anterior corticospinal tract and lateral corticospinal tract. While running from cerebral cortex towards spinal cord, the fibers of these two tracts give the appearance of a pyramid on the upper part of anterior surface of medulla oblongata. Hence, these two tracts are called pyramidal tracts.

The pyramidal tracts are concerned with voluntary motor activities and were the first tracts to be found in man (Fig. 18).

Nerve fibers of pyramidal tracts: All the fibers of the pyramidal tracts are present since birth. However, the myelination of these fibers is completed in about two years after birth. The pyramidal tracts on each side have more than a million fibers. About 70% of the fibers are myelinated and large having a diameter of 4 to 22 microns.

Larger fibers of pyramidal tracts have the tendency to disappear at old age. Since these tracts are concerned with control of voluntary movements, the disappearance of the fibers of pyramidal tracts causes automatic shivering movements in old age.

The fibers of pyramidal tracts are the axons of upper motor neurons.

Origin

Fibers of pyramidal tracts arise from the following nerve cells in the cerebral cortex.

- Giant cells or Betz cells or pyramidal cells in precentral gyrus of the motor cortex. The giant cells are situated in area 4 (primary motor area) of frontal lobe of the cerebral cortex.

- Other areas of motor cortex namely, premotor area (area 6) and supplementary motor areas.
- Other parts of frontal lobe.
- Parietal lobe of cerebral cortex particularly from somatosensory areas (areas 3,1,2). It is believed that 30% of pyramidal fibers arise from primary motor area (area 4) and supplementary motor areas, another 30% from premotor area (area 6) and the remaining 40% of fibers arise from the parietal lobe particularly from somatosensory areas (areas 3,1,2). All the above fibers form the fibers of upper motor neurons of motor pathway.

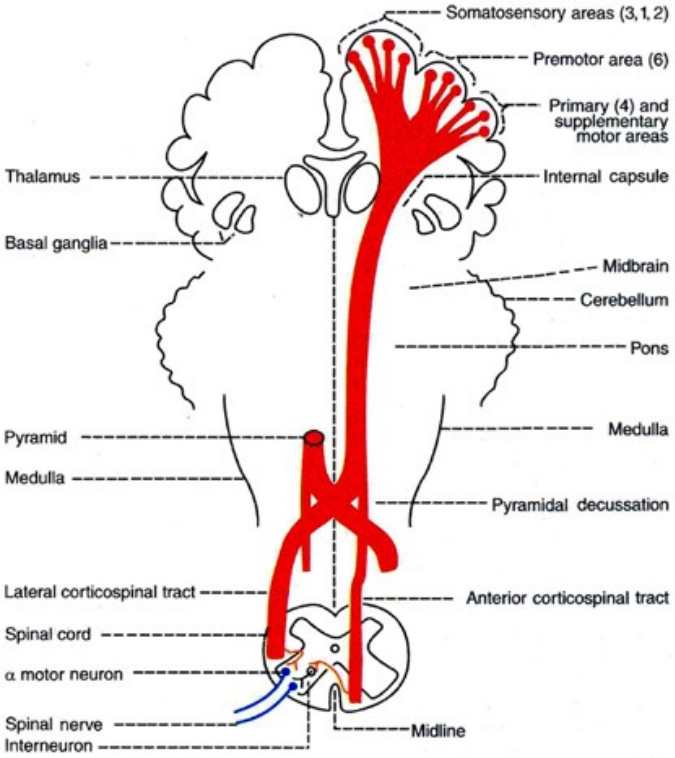


Fig. 18. Corticospinal tract.

Course

After taking origin, the nerve fibers run downwards in a diffused manner through white matter of cerebral hemisphere and converge in the form of a fan like structure along with ascending fibers which project from thalamus to cerebral cortex. The fan like structure is called corona radiata. Then, the fibers descend down through internal capsule, midbrain and pons. While descending through pons, the fibers are divided into different bundles by the nuclei of pons. At the lower border of pons, the fibers are grouped once again into a compact bundle and then descend down into medulla oblongata.

This compact bundle of corticospinal fibers gives the appearance of a pyramid in the anterior surface of upper part of medulla. Because of this, the corticospinal tracts are called the pyramidal tracts.

At the lower border of medulla, the pyramidal tract on each side is divided into two bundles of unequal sizes. About 80% of fibers from each side cross to the opposite side. Thus, the fibers of both sides while crossing the midline form pyramidal decussation. After crossing and forming pyramidal decussation, the fibers descend through the posterior part of lateral white funiculus of the spinal cord. This bundle of crossed fibers is called the crossed pyramidal tract or lateral corticospinal tract or indirect corticospinal tract.

The remaining 20% of fibers do not cross to the opposite side but descend down through the anterior white funiculus of the spinal cord. This bundle of uncrossed fibers is called the uncrossed pyramidal tract or anterior corticospinal tract or direct corticospinal tract. This tract is well-marked in cervical region. Since, the fibers of this tract terminate in different segments of spinal cord, this tract usually gets thinner while descending through the successive segments of spinal cord. The fibers of this tract are absent mostly below the midle thoracic level. Before termination, majority of the fibers cross to the opposite side at different levels of spinal cord.

Termination

All the fibers of pyramidal tracts, either crossed or uncrossed, terminate in the motor neurons situated in anterior gray horn either directly or through internuncial neurons. The axons of the anterior motor neurons supply the skeletal muscles directly by passing through the anterior nerve root. The neurons giving origin to the fibers of pyramidal tract and their axons are together called the upper motor neurons. The anterior motor neurons in the spinal cord and their axons are called the lower motor neurons.

Function

The pyramidal tracts are concerned with voluntary movements of the body. Fibers of the pyramidal tracts transmit motor impulses from motor area of cerebral cortex to the anterior motor neurons of the spinal cord. These two tracts are responsible for fine, skilled movements.

Effects of Lesion

The lesion in the neurons of motor cortex and the fibers of pyramidal tracts is called the upper motor neuron lesion. The following are the symptoms:

Voluntary movements: Voluntary movements of the body are very much affected. Initially, there is loss of voluntary movements in the extremities. Later, it involves the other parts of the body like hip and shoulder.

Muscle tone. The muscle tone is increased leading to spasticity of muscles. The muscles are paralyzed. This type of paralysis of muscles is called the spastic paralysis. The spasticity is due to the failure of inhibitory impulses from cerebral cortex to reach the spinal cord.

Reflexes: All the superficial reflexes are lost. And the deep reflexes are exaggerated. Some pathological reflexes are positive.

Ascending tracts of spinal cord

Situation	Tract	Origin	Course	Termination	Function
Anterior white funiculus	1.Anterior spinothalamic tract	Chief sensory cells	Crossing in spinal cord, forms spinal lemniscus	Ventral posterolateral nucleus of thalamus	Crude touch sensation
Lateral white funiculus	2. Lateral spinothalamic tract	Substantia gelatinosa	Crossing in spinal cord, forms spinal lemniscus	Ventral posterolateral nucleus of thalamus	Pain and temperature sensations
	3. Ventral spino-cerebellar tract	Marginal cells	Crossing in spinal cord	Anterior lobe of cerebellum	Subconscious kinesthetic sensations
	4. Dorsal spino-cerebellar tract	Clarke's column cells	Uncrossed fibers	Anterior lobe of cerebellum	Subconscious kinesthetic sensations
	Spinotectal tract	Chief sensory cells	Crossing in spinal cord	Superior colliculus	Concerned with spinovisual reflex
	6.Fasciculus dorsolateralis	Posterior nerve root ganglion	Component of lateral spinothalamic tract	Substantia gelatinosa	Pain and temperature sensations
	7.Spinoreticular tract	Intermedio-lateral cells	Crossed and uncrossed fibers	Reticular formation of brainstem	Consciousness and awareness
	8.Spino-olivary tract	Not specific	Uncrossed fibers	Olivary nucleus	Proprioception
	9.Spino-vesti-bular tract	Not specific	Crossed and uncrossed fibers	Lateral vestibular nucleus	Proprioception
Posterior white funiculus	10.Fasciculus gracilis	Posterior nerve root ganglia	Uncrossed fibers. No synapse in spinal cord	Nucleus gracilis in medulla	Tactile sensation. Tactile localization. Tactile discrimination. Vibratory sensation. Conscious kinesthetic sensation. Stereognosis.
	11.Fasciculus cuneatus	Posterior nerve root ganglia	Uncrossed fibers. No synapse in spinal cord	Nucleus cuneatus in medulla	

Descending tracts of spinal cord

Tract		Situation	Origin	Course	Function
Pyramidal tracts	1. Anterior corticospinal tract	Anterior white funiculus	Betz cells and other cells of motor area	Uncrossed fibers	Control of voluntary movements. Upper motor Neurons functions
	2. Lateral corticospinal tract	Lateral white funiculus	Betz cells and other cells of motor area	Crossed fibers	
Extra-pyramidal tracts	1. Medial longitudinal fasciculus	Anterior white fasciculus	Vestibular nucleus. Reticular formation. Superior colliculus and cells of Cajal	Uncrossed fibers. Extend up to upper cervical segments	Coordination of reflex ocular move- ments. Integration of movements of eyes and neck.
	2. Anterior vestibulo-spinal tract	Anterior white funiculus	Medial vestibular nucleus	Uncrossed fibers. Extend up to upper thoracic segments	Maintenance of muscle tone and posture. Maintenance of position of head and body during acceleration
	3. Lateral vestibule-spinal tract	Lateral white funiculus	Lateral vestibular nucleus	Mostly un-crossed. Extend to all segments	
	4. Reticulo-spinal tract	Lateral white fasciculus	Reticular formation of pons and medulla	Mostly un-crossed. Extend upto thoracic segments	Coordination of voluntary and reflex movements. Control of muscle tone. Control of respi- ration and blood vessels
	5. Tectospi-nal tract	Anterior white funiculus	Superior colliculus	Crossed fibers. Extend up to lower cervical segments.	Control of movement of head in response to visual and auditory impulses
	6. Rubro-spinal tract	Lateral white funiculus	Red nucleus	Crossed fibers. Extend up to thoracic seg-ments.	Facilitatory influence on flexor muscle tone
	7. Olivo-spinal tract	Lateral white funiculus	Inferior olivary nucleus	Mostly crossed. Extent—not clear.	Control of movements due to proprioception
Termination — Fibers of all the tracts terminate in motor neurons situated in the anterior gray horn of spinal cord					

Sensory pathways

Sensation	Receptor	First order neuron in	Second order neuron in	Third order neuron in	Center
Fine touch Tactile localization, tactile discrimination, vibratory sensation, stereognosis.	Meissner's corpuscles and Merkel's disc	Posterior nerve root ganglion Ganglion – Fibers form fasciculus gracilis and fasciculus cuneatus	Nucleus gracilis and Nucleus cuneatus- Internal arcuate fibers	Ventral postero-lateral nucleus of thalamus	Sensory cortex
Pressure, crude touch	Pacinian corpuscle	Posterior nerve root ganglion	Chief sensory cells- Fibers form anterior spinothalamic tract	Ventral postero-lateral nucleus of thalamus	Sensory cortex
Temperature	Warmth- Raffini's end bulb, cold- Krause's end bulb	Posterior nerve root ganglion	Substantia gelatinosa- Fibers form lateral spinothalamic tract	Ventral postero-lateral nucleus of thalamus	Sensory cortex
Conscious kinesthetic sensation	Proprioceptors— muscle spindle, Golgi tendon apparatus, etc.	Posterior nerve root ganglion--Fibers form fasciculus gracilis and fasciculus cuneatus.	Nucleus gracilis and nucleus cuneatus— Internal arcuate fibers	Ventral postero-lateral nucleus of thalamus	Sensory cortex
Subcon- scious kine- sthetic sensation	Proprioceptors— muscle spindle, Golgi tendon apparatus, etc.	Posterior nerve root ganglion	Clarke's column of cells and marginal cells— Fibers form dorsal and ventral spinocerebellar tracts		Cerebel- lum
Pain	Free nerve endings	Posterior nerve root – Ganglion – Fast pain – A 5 fibers Slow pain – C fibers	Fast pain— marginal cells in spinal cord. Slow pain- substantia gelatinosa	Ventral postero-lateral nucleus of thalamus. Reticular forma- tion and midbrain	Sensory cortex

Pain projective zones at different teeth diseases

Disease localization	Projection zone	Maximal painful sense point
Maxilla: incisives, canines first premolars second premolars, first molars, second and third molars	 fronto-nasal naso-labial maxillar and temporal mandibular	 superciliary arch temporal region near external ear auricule
Mandible: incisives, canines, first premolar second premolar first and second molars third molar	 omental (chin) it is not established sublingual larynx, parietal head region	 mandible inferior limb at mouth angle level mandible angle

Procedure:

I. Spinal Shock

1. Prepare a spinal frog, suspend her for the lower jaw on a support hook.
2. At once start determination of reflex excitability of the centers of a spinal cord. For this purpose tweezers carry out mechanical irritation, squeezing fingers of a back pad of a frog right after a dekapitation and then in each 30 sec. before emergence of a flexion reflex.
3. The received results enter in table, analyze, determine duration of spinal shock and draw a conclusion.

The studied indicator	Moment of influence of irritation						
	Right after a dekapitation	after a dekapitation through					
		30"	60"	90"	120"	150"	180"
Emergence of a reflex of bending							

II. Receptive field of reflex

Materials and methods: set of preparing tools (anatomic pincers, small scissors, large scissors, scalpel, probe), physiological solution, preparing small planks, serviettes, cotton wool, tray, stand, solution 0,5%, H_2SO_4, glass with water, stop watch.

Object of study: frog.

Procedure:

Spinal reflexes and their receptive fields

1. To prepare a spinal frog and to suspend her on a support. To wait until there passes shock (postoperative oppression of a spinal cord).
2. “Kvakatelny” reflex. It is accurate to squeeze fingers the side surface of a body of a male of a frog on both sides and to note reaction.

3. “Obkhvatyvatelny” reflex. To irritate to observe chest area of a male behind a reflex, for possible strengthening of reaction accurately tweezers to squeeze the lower pad.
4. To investigate reflexes of a spinal cord of a frog:
a) At irritation of a back surface of foot or a shin (squeezing by tweezers or imposing of a piece of the filter paper moistened with sulfuric acid). To observe a reflex of bending of a back extremity.
b) At irritation of an internal surface of a hip or shin a piece of the filter paper moistened with sulfuric acid to observe a reflex of extension of a back extremity.
c) At irritation a piece of the filter paper moistened with sulfuric acid of the external surface of a hip, lateral face of a trunk, skin of a belly surface between front pads to observe a “potiratelny” reflex.

PRACTICAL LESSON 4. Mutual inhibition of spinal reflexes. Excitement irradiation in central nervous system. Research of the phenomenon of summation.

I. Mutual inhibition of spinal reflexes

Materials and methods: set of preparing tools (anatomic pincers, small scissors, large scissors, scalpel, probe), physiological solution, preparing small planks, serviettes, cotton wool, tray, stand, solution 0,5%, H_2SO_4, glass with water, stop watch.

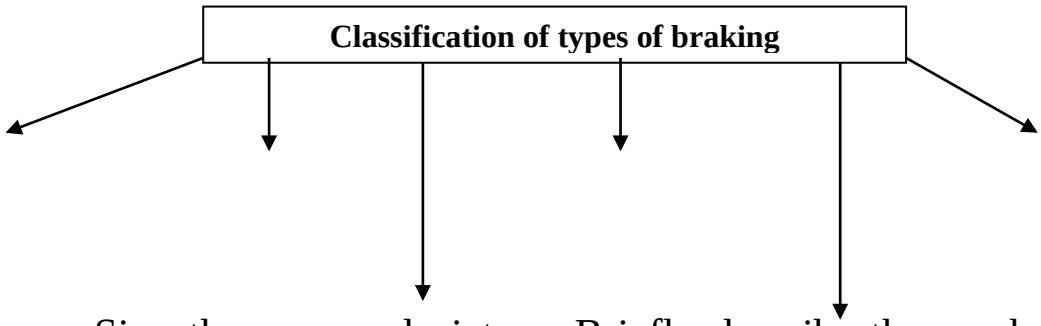
Object of study: frog.

Main questions:

1. Inhibitory neurons and their functions. Inhibitory mediators.
2. Central inhibition main types. Inhibitory synapses.
3. Presynaptic inhibiting developmental mechanisms.
4. Postsynaptic inhibiting developmental mechanisms.
5. Inhibitory postsynaptic potential (IPSP).
6. Interaction between excitement and inhibiting processes as a base of reflexes co-ordination.
7. Irradiation (elective, diffused) and divergence.
8. General ending way principle. Convergence and concentration. Dominanta. Dominant locus features.
9. Feed-back binding or reverse afferentation principle.
10. Synergic and antagonistic reflexes.
11. Temporal (consequent) excitement summation.
12. Spatial summation (realized at the same time).

Independent work

1. Fill out the proposed scheme yourself.



2. . Sign the proposed picture. Briefly describe the mechanism of pre- and postsynaptic inhibition.

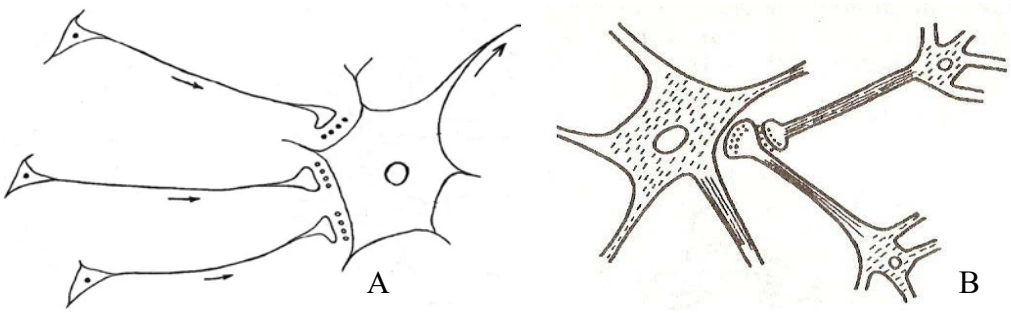


Fig.19. Types of braking

Inhibiting in CNS

Russian physiologist Ivan Sechenov discovered central inhibiting – chemical irritation of thalamus inhibits simple spine non-conditioned reactions. He was the first who underlined that inhibiting is active process. Inhibiting has been considered only as passive process coming after overexcitement before Sechenov.

Inhibiting (inhibition) is a special nervous process expressed externally in answer reaction weakening or complete disappearance. It is characterized by definite intensiveness and duration. Inhibition is an innate process which is improved in course of human onthogenesis.

Primary – it is not connected with excitement process and occurs with inhibitory cells (Ranshow cells) participation.

Secondary – appears without inhibitory neurons. It is nervous system overexcitement result.

Postsynaptic – EPSP formation. It is urgent but particular one.

Presynaptic or protective - it is developed the mostly often in axo-axonal synapses in brain stem and spine. Essence: presynaptic membrane hyperpolarization. Mediator – glycine. It protects from pathological, excessive, unnecessary information. It is non-urgent but more complete comparatively to the previous one.

Pessimal - It is central inhibition type. It appears at irritation high frequency. High rate of answer excitement occurs at first moment. Then stimulated central neuron comes in inhibiting state while working in such a regimen.

Recurrent – it is primary inhibition example. Essence: neuron activity inhibiting caused by recurrent axon collateral of this neuron.

Reciprocal –It belongs to postsynaptic inhibiting. This inhibiting can be belonged to nervous center co-ordination principles (see materials of next lesson). Expiration and inspiration centers are inhibited reciprocally in medulla oblongata, pressor and depressor cardiac-vascular centers. It is rather distinct at spine level at highly co-ordinated acts performance (walking, running, scretching et al.). At spinal segments the excitement of motoneurons causing muscles-flexors contraction is accompanied by reciprocal inhibiting of other motoneurons group leading to extensors relaxation. So, shortly, flexors excitement and parallel extensors inhibiting (and on the contrary) occurs. There are two explanation of spinal reciprocal inhibiting:

– impulses multiplication mechanism is switched on on the way from afferent fiber to muscle extensor motoneurons at muscle flexor motoneurons excitement; as a result – extensors motoneurons are receiving highly-rated impulsation leading to their pessimum state – so, inhibiting;

– inhibitory associative neurons synthesizing inhibitory mediator are switched on on the way to extensors motoneurons.

Lateral – activity neurons or receptors located near to excited neurons or receptors are interrupted. Lateral inhibiting mechanism provides sensory systems discriminative ability. So, it provides sounds rate determining in auditory sensory system; in visual one – increases significantly contrast of percepted image; in tactile one – encourages differentiating 2 points of touching. Lateral inhibiting is connected significantly with recurrent inhibiting mechanisms. It is also postsynaptic inhibiting.

These principles make one’s reflectory activity urgent, well-singleminded, accompanied by less energy consumption and so more comfortable for performance by organism. Main of them are:

Convergency (convergence) - is many afferent ways gathering to one neuron (associative or efferent one); with other words – it is so when many presynaptic neurons terminate on singular postsynaptic neuron.

Divergency (divergence) – is an ability to form polysynaptic bonds (it lies on the base of irradiation); with other words – it is so when one presynaptic neuron terminates on many postsynaptic neurons; this principle is opposite to convergence.

Total ending way principle (discovered by Charles Sherrington in 1906). Essence: impulses from many receptors of different body parts come to one motoneuron (convergence is on its base). Information through afferents come to associative neurons, efferents and finally to axon of 1 motoneuron. This axon represents total ending way. Such a principle realizing is possible because afferents number is bigger than efferents in 5 times. This principle second name is watering-can principle. Role: only several, the mostly important and essential at the moment impulses (of all coming through all different ways) will give answer reaction.

Irradiation – (from Latin word "irradiare" – "shine, beam") – excitement distribution through CNS. 2 main types:

a) *elective* – it is physiological one – impulses are distributed through definite ways involving just essential organs and muscles in the reaction; if one needs to wake up more rapidly and to have better mental abilities he can make following procedure in the morning right after standing up: washing face with cold water (at the biggest degree – "drinking through nose") will activate trigeminal nerve, reticular formation and finally cortex. It is so-called activation reaction lying on the base of human consciousness. Use this during exam – and you will see that your mental abilities will be great;

b) *diffused (generalized)* – other muscles get involved into the reaction, disturbing the movement and making it constrained (bound). Examples: "start fever" in sportsmen, epilepsy. This type of irradiation is physiological one for lower animals such as amphibias (their subcortex is developed more than cortex).

Concentration – phenomenon opposite to irradiation. It is information coming from different presynaptic neurons to one postsynaptic one on the base of convergence. So, convergence is primary, information concentration – secondary process (like divergence is primary, irradiation is secondary process).

Occlusion is nervous centers interference. Final result of such an interference is less, quicker. This principle is known from dentistry (occlusion of jaws mean denturing).

Dominanta (Alexei Uhtomsky, 1904) – temporally prevailing

excitement focus determining answer reactions character to all external and internal stimuli. External expression of dominanta is a definite activity or organism working posture (pose) supported by different stimuli and excluding other activities and poses for a given moment. Reasons: leading motivation, impulsation increasing to the excitement locus from effector, biologically-active substances (hormones and others) level increasing in blood. Examples: sexual (hormones increasing), dominanta of urinary vesicle or stomach (increased impulsation from urinary vesicle and from stomach).

Dominant focus 5 main characteristics:

- increased excitability;
- excitement stability;
- increased ability to excitement summation;
- inertia – ability to preserve excitement for long after stimulus action stoppage;
- ability to cause conjugated inhibition in neighboring nervous centers.

Feed-back reaction or ***opposite afferentation principle*** – afferentation from effector about action final result.

Induction of excitement and inhibiting. Excitement and inhibiting interact. Big hemispheres cortex definite locuses excitement causes inhibiting in other cortex parts and, on the contrary, inhibiting in one cortical points causes excitement in others. This phenomenon is performed by law of mutual excitement and inhibiting. One differentiates 2 induction types.

a) Positive – inhibiting in separate cortical point causes excitement in other locuses. Organism activity is realized by direction of this excitement, attention to the current activity is enforced.

b) Negative – excitement in one cortical focus causes inhibiting in its those parts which have been active before. Negative induction acts at inclination from main (dominant) activity and it is concentrated on occasional stimuli, which inhibit excitement from main stimulus. Result: coming out of the activity performed.

Procedure:

1. Experience is performed on a spinal frog is hanged from the bottom jaw on a hook of the tripod;
2. Immerse the frog's foot in a 0.5% sulfuric acid solution, determine the flexion reflex time. The experience is repeated 2-3 times with an interval of 15-20C;
3. Then simultaneously with the immersion of the foot in acid tweezers to squeeze another foot. Thus the flexion-reflex to the irritation of acid or missing, or that it dramatically lengthened. If you stop the

strong mechanical stimulation of the opposite foot, restored the reflex to acid.

II. Excitement irradiation in central nervous system.

Materials and methods: set of preparing tools (anatomic pincers, small scissors, large scissors, scalpel, probe), physiological solution, preparing small planks, serviettes, cotton wool, tray, stand, solution 0,5%, H_2SO_4, glass with water, stop watch.

Object of study: frog.

Procedure:

The experiment should be performed in spinal frog. Chemical or mechanical stimulus is performed for irritation. The students must irritate spinal frog's leg by nipping with tweezers or sulfuric acid solution. The animal must jerk only one of his leg back (the stimulus must be weak). Then it's necessary to increase the irritation force.

To compare the answer reactions. To make the conclusion.

III. Research of the phenomenon of summation

Materials and methods: set of preparing tools (anatomic pincers, small scissors, large scissors, scalpel, probe), physiological solution, preparing small planks, serviettes, cotton wool, tray, stand, solution 0,5%, H_2SO_4, glass with water, stop watch.

Object of study: frog.

Procedure:

Investigation of successive summation.

The experiment must be performed on thalamic frog. For this aim it's necessary to cut frog's head behind her eyes. Then students should put the animal to the operation table. You should fix the electrodes on one of posterior legs. The electrodes must be connected with the stimulator. The electrodes must be put
above and below knee joint over the distance at least 0,5 cm between each other. One should find threshold irritation force. Then one must observe the reaction at irritation with the frequency of 1 Herz, 20 Herz.

Investigation of simultaneous summation.

Thalamic frog must be hanged by her inferior jaw on hook. You must put cork at the end of the hook till the end of the animal's movements. Spatial summation can be observed while flexing reflex. You must wash frog's posterior leg fingers ends in threshold concentration acid and determine reflex time having counted seconds number from the beginning of fingers sinking till the leg's jerking back moment. Then after leg's washing in the glass of water you must determine reflex time at foot sinking in acid.

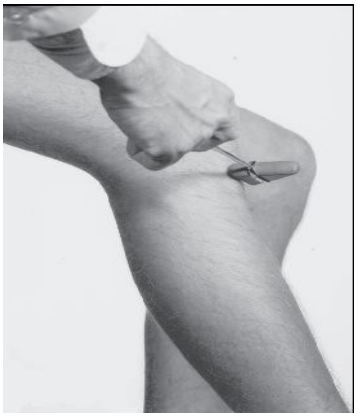
PRACTICAL LESSON 5. Research of clinically important reflexes."

Materials and methods: neurological hammers.
Object of study: human.

Procedure:

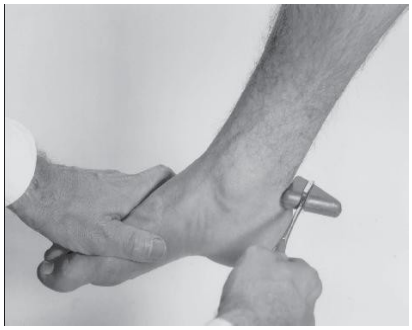
In this exercise, a number of reflex arcs will be tested that are initiated by distinctive stretch receptors within muscles. These receptors, called muscle spindles, are embedded within the connective tissue of the muscle and consist of specialized thin muscle fibers (intrafusal fibers) that are innervated by sensory neurons. The intrafusal fibers are arranged in parallel with the normal muscle cells (extrafusal fibers), so that stretch of the muscle also places tension on the intrafusal fibers. Located within the spindles, the intrafusal fibers respond to the tension by causing the stimulation (depolarization) of the sensory neuron. The sensory neuron arising from the intrafusal fiber synapses with the motor neuron in the spinal cord that, in turn, innervates the extrafusal fibers. The resultant contraction of the extrafusal fibers of the muscle releases tension on the intrafusal fibers and decreases stimulation of the stretch receptors. In a typical clinical examination, this reflex is elicited by striking the muscle tendon with a rubber mallet, creating a momentary stretch. When the extrafusal muscle fibers contract during the stretch reflex, they produce a short, rapid movement of the limb (the jerk). This is very obvious for the kneejerk reflex, but can be quite subtle for the biceps- and triceps-jerk reflexes. Use of the flexicomp allows the limb movement to be seen as a tracing on the computer screen.

1. Procedure for knee-jerk reflex – tests femoral nerve



- Allow the subject to sit comfortably with his or her legs free.
- Strike the ligament portion of the patellar tendon just below the patella (kneecap), and observe the resulting contraction of the quadriceps muscles and extension of the lower leg.

2. Procedure for ankle-jerk reflex – tests medial popliteal nerve



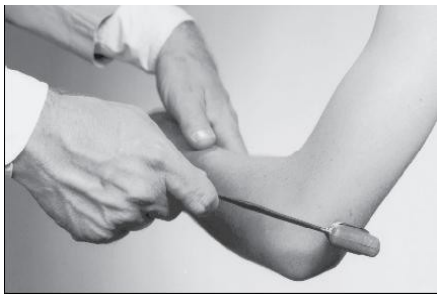
- Have the subject kneel on a chair with his or her back to you, and with feet (shoes and socks off) projecting over the edge.
- Strike the Achilles (calcaneal) tendon at the level of the ankle and observe the resulting plantar extension of the foot.

3. Procedure for biceps-jerk reflex – tests musculocutaneous nerve

- With the subject's arm relaxed but fully extended ondesk, gently press his or her biceps tendon in the antecubital fossa with your thumb or forefinger and this finger with the mallet.

- If this procedure is performed correctly, the biceps muscle will twitch but usually will not contract strongly enough to produce arm movement.

4. Procedure for triceps-jerk reflex – tests radial nerve

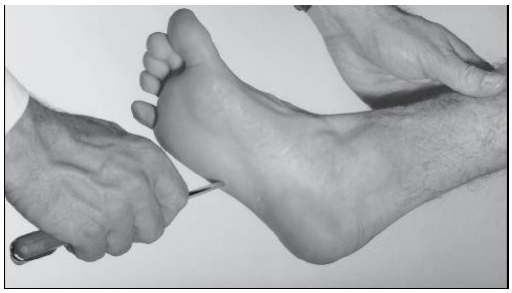


- Have the subject lie on his or her back with the elbow bent, so that the arm lies loosely across the abdomen.
- Strike the triceps tendon about 2 inches above the elbow. If there is no response, repeat this procedure, striking to either side of the original point.
- If this procedure is correctly performed, the triceps muscle will twitch but usually will not contract strongly enough to produce arm movement.

A cutaneous reflex: the plantar reflex and Babinski's sign

The plantar reflex is elicited by cutaneous (skin) receptors of the foot and is one of the most important neurological tests. In normal individuals, proper stimulation of these receptors located in the sole of the foot results in the flexion (downward movement) of the great toe, while the other toes flex and come together. The normal plantar reflex requires the uninterrupted conduction of nerve impulses along the pyramidal motor tracts, which descend directly from the cerebral cortex

to motor neurons lower in the spinal cord. Damage anywhere along the pyramidal motor tracts produces a Babinski reflex, or Babinski's sign, to this stimulation, in which the great toe extends (moves upward) and the other toes fan laterally. Infants exhibit Babinski's sign normally because neural control is not yet fully developed. **Abdominal reflex** is a superficial neurologic reflex obtained by firmly stroking the skin of the abdomen around the umbilicus. It normally results in a briskcontraction of abdominal muscles in which the umbilicus moves toward the site of the stimulus. This reflex is often lost in diseases of thepyramidal tract and can also be lost with age or abdominal surgery.



- Have the subject lie on his or her back with knees slightly bent, and with the thigh rotated so that the lateral (outer) side of the foot is resting on the floor
- Applying firm (but not painful) pressure, draw the blunt probe along the lateral border of the sole, the heel and ending at the base of the big toe. Observe the response of the toes to this procedure.

PRACTICAL LESSON 6. Reproduction on the person of reflexes of a medulla, midbrain, cerebellum, intermediate brain. Bark of big hemispheres.

Object of study: Human.
Main questions:
1. What is the significance of the autonomic and somatic nerve centers in the reflex work of the body?
2. The structure and functions of the medulla oblongata, for which reflexes the medulla oblongata is responsible.
3. What is the structure and function of the cerebellum, the types of neurons in the gray matter of the cerebellum?
4. What departments the diencephalon consists of, and what are the functions of these departments.
5. The hypotolamic-pituitary system as the highest subcortical regulator.
6. The structure of the cerebral cortex.
7. Primary, secondary, tertiary zones of the cortex.
8. Cortical nuclei of analyzers.

Cerebellum physiology

Cerebellum consists of a narrow, worm like central body called vermis and two lateral lobes, the right and left cerebellar hemispheres. Cerebellar hemispheres are the extended portions on either side of the vermis.

Divisions of cerebellum

I Anatomical:

On the basis of structure, the whole cerebellum is divided into three portions.

Anterior Lobe

This lobe includes lingula, central lobe and culmen. It is separated from posterior lobe by the primary fissure.

Posterior Lobe

This consists of lobulus simplex, declive, tuber, pyramid, uvula, paraflocculi and the two portions of hemispheres-ansiform lobe and paramedian lobe.

Flocculonodular Lobe

This includes nodulus and the lateral extension on either side called flocculus. It is separated from rest of the cerebellum by posterolateral fissure.

II. Phylogenetic:

Depending upon phylogeny, the cerebellum is divided into two divisions.

Paleocerebellum

This is the phylogenetically oldest part of cerebellum. It includes two divisions, archicerebellum and paleocerebellum proper.

a). Archicerebellum—Flocculonodular lobe

b) Paleocerebellum proper—It includes lingula, central lobe, culmen, lobulus simplex, pyramid, uvula and paraflocculi

Neocerebellum

This is the phylogenetically newer portion of cerebellum. It includes declive, tuber and lateral portions of hemispheres, lobulus ansiformis and lobulus paramedianus.

III. Functional:

Based on the functions, the cerebellum is divided into three divisions.

Vestibulocerebellum

This includes flocculonodular lobe that forms the archi-cerebellum.

Spinocerebellum

This includes lingula, central lobe, culmen, lobulus simplex,

declive, tuber, pyramid, uvula and paraflocculi and medial portions of cerebellar hemispheres.

Corticocerebellum

This includes the lateral portions of hemispheres.

Structure

Cerebellum is made up of outergray matter or cerebellar cortex and an inner white matter. The white matter is formed by afferent and efferent nerve fibers of cerebellum. The gray masses called cerebellar nuclei are located within white mater.

Gray matter

Gray matter or cerebellar cortex is made up of structures arranged in three layers. Each layer of gray matter is uniform in thickness and appearance throughout cerebellum. The three layers of gray matter are:

- Outer molecular or plexiform layer
- Intermediate Purkinje layer and
- Inner granular layer

1. Molecular or Plexiform Layer

It is the outer most layer of cortex having the cells arranged in two strata. The superficial stratum contains few star shaped cells known as stellate cells. The deep stratum contains basket cells. In addition to stellate and basket cells, the molecular layer has the following structures:

a) Parallel fibers, which are the axons of granule cells, present in granular layer

b) The terminal portions of climbing fibers.

c) Dendrites of Purkinje cells and Golgi cells.

Molecular layer also contains the following cellular junctions:

a) The dendrites of stellate cells and basket cells synapse with parallel fibers, which are the axons of granule cells

b) The axons of stellate cells end on the dendrites of Purkinje cells. However, the axon of basket cell descends down into the Purkinje layer and forms the transverse fiber that ends on the soma of Purkinje cells

c) The dendrites of Purkinje cells synapse with climbing fibers and parallel fibers

d) The dendrites of Golgi cells situated in granular layer enter the molecular layer and end on parallel fibers.

2. Purkinje Layer

It is situated in between outer molecular layer and inner granular layer. It is the thinnest layer having a single layer of flask shaped

Purkinje cells. The Purkinje cells are the largest neurons in the body. The dendrites of these cells ascend through the entire thickness of molecular layer. These dendrites terminate either on climbing fibers or the parallel fibers. The axons of the basket cells form the transverse fibers and end on the soma of Purkinje cells. The axons of Purkinje cells descend into the white matter and terminate on the cerebellar nuclei and vestibular nuclei via cerebellovestibular tract. The Purkinje cells are termed as "Final common path" of cerebellar cortex because the impulses from different parts of cerebellar cortex are transmitted to other parts of brain only through Purkinje cells.

3. Granular Layer

This layer is placed in between Purkinje layer and the white matter. It is formed by interneurons namely granule cells and Golgi cells. The total number of interneurons in this layer is about half the number of all neurons in the whole nervous system.

The axon of the granule cell ascends into molecular layer and forms the parallel fiber, which synapses with dendrites of Purkinje cells, stellate cells, basket cells and Golgi cells. The dendrites of granule cells and the axon and few dendrites of a Golgi cell synapse with mossy fiber. The synaptic area of these cells is called the glomerulus and it is encapsulated by the processes of glial cells.

Afferent Fibers to Cerebellar Cortex

The cerebellar cortex receives afferent signals from other parts of brain through two types of nerve fibers.

- Climbing fibers
- Mossy fibers

Climbing fibers: they arise from the neurons of inferior olivary nucleus situated in medulla and reach the cerebellum via olivocerebellar tract. The inferior olivary nucleus relays the output signals from motor areas of cerebral cortex and the proprioceptive signals from different parts of the body to the cerebellar cortex via climbing fibers. The proprioceptive impulses from different parts of the body reach the inferior olivary nucleus through spinal cord and vestibular system.

After reaching the cerebellum, the climbing fibers ascend into the molecular layer and terminate on the dendrites of Purkinje cells. While passing through cerebellum, the olivocerebellar tract sends collaterals to cerebellar nuclei. Because of this, the impulses from cerebral cortex and proprioceptors of the body are conveyed to not only the cerebellar cortex but also the cerebellar nuclei by the climbing fibers. Each climbing fiber innervates one single Purkinje cell.

Mossy fibers: Unlike climbing fibers, the mossy fibers have many

sources of origin namely motor areas of cerebral cortex, pons, medulla and spinal cord. Fibers arising from all these areas send collaterals to the cerebellar nuclei before reaching the cerebellar cortex. So, like climbing fibers, the mossy fibers also convey afferent impulses to both cerebellar nuclei and cerebellar cortex. Some of the mossy fibers arise from cerebellar nuclei. After reaching the granular layer of cerebellar cortex, the mossy fiber divides into many terminals. Each terminal enters the glomerulus and ends in a large expanded structure that forms the central portion of the glomerulus. The dendrites of granule cells and the axon and dendrites of Golgi cells synapse on the mossy fiber giving a thick bushy appearance. The word "mossy" refers to the appearance of a plant called moss, which grows into dense clumps, and hence, the name mossy fibers is given to these fibers.

Neuronal Activity in Cerebellar Cortex and Nuclei

The functions of cerebellum are executed mainly by the impulses discharged from the cerebellar nuclei. However, the cerebellar cortex controls the discharge from the nucleus constantly via the fibers of Purkinje cells. This is done in accordance with the signals received by the cerebellar cortex from different parts of brain and body via climbing and mossy fibers. The entire process involves a series of neuronal activity as mentioned in Table .

Interneuronal activity in cerebellum

Neuron	*Action on*	*Action*	*Neurotransmitter*
Climbing fibers	Purkinje cells and Cerebellar nuclei	Excitation	Aspartate
Mossy fibers	Granule cells Golgi cells and Cerebellar nuclei	Excitation	Glutamate
Granule cells	Purkinje cells Stellate cells Basket cells	Excitation	Glutamate/ Aspartate
Stellate cells	Purkinje cells	Inhibition	GABA
Basket cells	Purkinje cells	Inhibition	GABA
Golgi cells	Granule cells	Inhibition	GABA
Purkinje cells	Cerebellar nuclei Vestibular nuclei	Inhibition	GABA
GABA—Gamma aminobutyric acid			

The climbing fibers excite the Purkinje cells directly and the cerebellar nuclei via the collaterals by releasing aspartate. Each climbing fiber ends on a single Purkinje cell. Because of this, the excitatory effect of climbing fiber on Purkinje cell is very strong. Mossy fibers excite the Purkinje cells indirectly. In the glomeruli, the mossy fibers release glutamate and excite the granule cells and Golgi cells. The collaterals of mossy fibers activate the cerebellar nuclei also by glutamate. The granule cells, which are activated by mossy fibers in turn, excite the Purkinje cells, stellate cells and the basket cells through the parallel

fibers. The neurotransmitter utilized by granule cells is glutamate or aspartate. The granule cells are the only excitatory cells in cerebellar cortex while all the other cells are inhibitory. Each mossy fiber innervates many Purkinje cells indirectly via granule cells. So, the excitatory effect of mossy fibers on Purkinje cells is weak. The stellate cells and basket cells, which are activated by the granule cells, inhibit the Purkinje cells by releasing gamma aminobutyric acid (GABA).

The Golgi cell that is activated by mossy fibers in turn provides feedback inhibition to granule cells by releasing GABA, i.e. it inhibits the transmission of impulse from mossy fiber to granule cell.

The cerebellar nuclei are excited by collaterals from climbing and mossy fibers. In turn, the nuclei send excitatory impulses to thalamus and different nuclei n brainstem. However, the signals discharged from Purkinje cells inhibit the cerebellar nuclei via GABA. The Purkinje cells inhibit the activities of vestibular nuclei also. Thus, it is clear that the cerebellar cortex plays an important role in modulating the excitatory signals of following pathways:

1. From cerebellar nuclei to cerebral cortex via thalamus.
2. From final common motor pathway via brainstem and spinal cord.

Because of this, the movements of body become well organized and coordinated.

Cerebellar nuclei

Cerebellar nuclei are the masses of gray matter scattered in the white matter of cerebellum. There are four nuclei on either side.

1. Fastigial Nucleus

This is also known as nucleus fastigi. Phylogenetically, this is the oldest cerebellar nucleus. It is placed near the midline on the roof of IV ventricle.

2. Globosal Nucleus

This is situated lateral to nucleus fastigi. This is also known as nucleus globosus.

3. Emboliform Nucleus

It is also called nucleus emboliformis. This nucleus is slow the nucleus fastigi and nucleus globosus.

4. Dentate Nucleus

Is is also called nucleus dentatus. This is the largest cerebellar nucleus. As it is crenated, it is called dentate nucleus. It is situated lateral to all the other nuclei.

White matter

Pile matter of cerebellum is formed by afferent and perent nerve fibers. These nerve fibers are classified into three groups.

Projection fibers: Projection fibers leave or enter the paleocerebellum and connect cerebellum with other parts of central nervous system.
Association fibers: Association fibers connect different tons of same cerebellar hemisphere.
Commissural fibers: The commissural fibers connect fhe areas of both halves of cerebellar cortex.

Peduncles

- Inferior cerebellar peduncles between cerebellum and medulla oblongata.
- Middle cerebellar peduncles between cerebellum and pons.
- Superior cerebellar peduncles between cerebellum and midbrain.
- Inferior Peduncles
- The inferior cerebellar peduncles are otherwise called restiform bodies and contain predominantly afferent fibers. These nerve fibers transmit the impulses from tactile receptors, proprioceptors and receptors in vestibular apparatus to cerebellum.
- Middle Peduncles
- The middle cerebellar peduncles are otherwise called brachia pontis. These penduncles contain predominantly the afferent fibers. Most of the fibers of the middle cerebellar peduncles are commissural fibers, which connect the areas of both the halves of cerebellar cortex.
- Superior Peduncles

The superior cerebellar peduncles are otherwise called brachia conjunctivae and contain predominantly efferent fibers.

Components and connections of functional divisions of cerebellum

Division	*Components*	*Afferent connections*	*Efferent connections*
Vestibulo-cerebellum	Flocculonodular lobe (Nodulus and Flocculi)	Vestibulocerebellar tract	1. Cerebello-vestibular tract 2. Fastigiobulbar tract
Spinocerebellum	Lingula, central lobe, culmen, lobulus simplex, declive, tuber, pyramid, uvula, paraflocculi and medial portions of cerebral hemispheres	1. Dorsal spinocerebellar tract 2. Ventral spinocerebellar tract Cuneocerebellar tract Olivocerebellar tract Pontocerebellar tract Tectocerebellar tract Trigeminocerebellar tract	1. Fastigiobulbar tract 2. Cerebelloreticular tract 3. Cerebello-olivary tract
Division	*Components*	*Afferent connections*	*Efferent connections*
Corticocerebellum	Lateral portions of cerebral hemispheres	Pontocerebellar tract Olivocerebellar tract	1. Dentatothalamic tract Dentatorubral tract

1. Cerebellovestibular Tract

Fibers of this tract arise from the flocculonodular lobe, pass through the inferior cerebellar peduncle of the same side and terminate on the vestibular nuclei in brainstem. The fibers from vestibular nuclei form medial and vestibulospinal tracts, which terminate on the medial group of alpha motor neuron in the spinal cord. This pathway forms the medial system of motor pathway (extrapyramidal system).

2. Dorsal Spinocerebellar Tract

This tract arises from Clarke's column of cells in the dorsal gray horn of spinal cord. It is uncrossed tract, and reaches the spinocerebellum through the inferior peduncle of same side. This tract conveys the proprioceptive information from the limbs of same side regarding the position and movements.

3. Ventral Spinocerebellar Tract

The fibers of this tract arise from the marginal cells in the dorsal gray horn of spinal cord. After taking the origin, the fibers cross the midline, ascend in the opposite side and reach the spinocerebellum through superior cerebellar peduncle. This tract conveys he information about the position and movements of opposite limbs to spinocerebellum.

4. Olivocerebellar Tract

This tract is formed by the climbing fibers arising from the inferior olivary nucleus in medulla. After taking origin, these fibers cross the midline and reach the spinocerebellum through the inferior cerebellar peduncle of the opposite side. This tract also gives collaterals to the cerebellar nuclei particularly, the globosus nucleus and emboliform nucleus. The inferior olivary nucleus receives afferent fibers from three sources.

- The brainstem nuclei of the same side
- The spinal cord through spino-olivary tract of same side
- Cerebral cortex of opposite side

The olivocerebellar tract conveys proprioceptive impulses from the body and output signals from cerebral cortex to spinocerebellum.

1. Pontocerebellar Tract

This tract arises from pontine nuclei, crosses the midline and reaches the spinocerebellum through the middle cerebellar peduncle of opposite side. The pontine nuclei receive afferents from cerebral cortex. The pontocerebellar tract conveys the information to spinocerebellum about the motor signals discharged from cerebral cortex.

2. Tectocerebellar Tract

The tectocerebellar tract arises from the superior and inferior colliculi of tectum in midbrain. It reaches the spinocerebellum through the superior cerebellar peduncle of the same side. This tract carries visual impulses from superior colliculus and auditory impulses from inferior colliculus to spinocerebellum.

Functions of spinocerebellum

Spinocerebellum regulates tone, posture and equilibrium by receiving impulses form proprioceptors in muscles, tendons and joints, tactile receptors, visual receptors and auditory receptors.

Spinocerebellum is the receiving area for the tactile, proprioceptive, auditory and visual impulses. It also receives the cortical impulses via pontine nuclei. The tactile and proprioceptive impulses are localized in the spinocerebellum. Localization of tactile and proprioceptive impulses in spinocerebellum is determined by stimulating the tactile receptors in skin and the proprioceptors and by recording the electrical responses in different parts of spinocerebellum. Different parts of the body are represented in the cerebral cortex in an inverted manner. Whereas in the cerebellum the different parts are represented in upright manner.

Spinocerebellum regulates the postural reflexes by modifying muscle tone. It facilitates the gamma motor neurons in the spinal cord via cerebellovestibulospinal and cerebelloreticulospinal fibers. The gamma motor neurons reflexly modify the activity of alpha motor neurons and thus regulate the muscle tone. The lesion, destruction or abolishing the function of this part by cooling, causes stoppage of discharge from the gamma motor neurons resulting in hypotonia and disturbances in posture.

Spinocerebellum also receives impulses from optic and auditory pathway and helps in adjustment of posture and equilibrium in response to visual and auditory impulses.

Corticocerebellum (neocerebellum)

Corticocerebellum is largest part of cerebellum. Because of its connection with cerebral cortex, it is called corticocerebellum or cerebrocerebellum. It is phylogenetically newer part of cerebellum. So, it is also called neocerebellum. It is concerned with planning, programming and coordination of skilled movements.

Functions of corticocerebellum

Corticocerebellum is concerned with the integration and regulation of well coordinated muscular activities. The lesion in corticocerebellum leads to disturbances in movements.

Corticocerebellum takes part in the integration and regulation of coordinated activities because of its afferent-efferent connection with cerebral cortex called the cerebro-cerebello-cerebral circuit. Apart from its connections with cerebral cortex, cerebellum also receives nerve fibers from proprioceptors in muscle. Thus, cerebellum receives feedback signals from the muscles during muscular activity.

Mechanism of action of corticocerebellum

Damping Action

All the voluntary muscular activities are initiated by motor areas of cerebral cortex. Simultaneously, corticocerebellum receives impulses from motor cortex as well as feedback signals from the muscles as soon as the muscular activity starts.

Corticocerebellum in turn sends impulses to cerebral cortex to discharge appropriate signals to the muscles so that, any extra or exaggeration of muscular activity is prevented and the movements become smooth and accurate. This action of corticocerebellum is called damping action.

Control of Ballistic Movements

The rapid alternate movements, which take place in different parts of the body while doing any skilled or trained work like typing, cycling, dancing, etc. are called ballistic movements. Corticocerebellum plays an important role in preplanning these movements during learning process.

Timing and Programming the Movements

While using a typewriter or while doing any other fast skilled work, a chain of movements occur rapidly in a sequential manner. During the learning processes of these skilled works, corticocerebellum plays an important role. The corticocerebellum plans the various sequential movements. It also plans the time duration of each movement and the time interval between movements. All the information from corticocerebellum are communicated to sensory motor area of cerebral cortex and stored in the form of memory. So, after the learning process is over, these activities are executed easily and smoothly in sequential manner.

Servomechanism

Once the skilled works are learnt, the sequential movements are executed without any interruption. Cerebellum lets the cerebral cortex to discharge the signals, which are already programmed and

stored at sensory motor cortex, and, does not interfere much. However, if there is any disturbance or interference, the corticocerebellum immediately influences the cortex and corrects the movements. This action of corticocerebellum is known as servomechanism.

Comparator Function

The integration and coordination of the various muscular activities are regulated by the comparator function of the corticocerebellum. As already mentioned, it receives the representation of cortical impulses which are sent to the muscles and the feedback proprioceptive impulses coming from the muscles. By receiving the messages from both ends, corticocerebellum compares the actual cortical commands for muscular activity and the movements taking place in the muscles. Now, it sends impulses to the motor cortex to correct or modify the cortical signals to muscles, so that the movements become accurate and precise. This function of corticocerebellum is known as comparator function. Simultaneously, it also receives impulses from tactile receptors, eye and ear. Such additional information facilitates the comparator function of corticocerebellum.

Functions of cerebellum

Functions		Division of cerebellum involved
1. Regulation of tone, posture and equilibrium	By receiving impulses from vestibular apparatus	Vestibulocerebellum
	By receiving impulses from proprioceptors in muscles, tendons and joints, tactile receptors, visual receptors and auditory receptors	Spinocerebellum
2. Regulation of coordinated movements	Damping action Control of ballistic movements Timingand programming the movements Servomechanism Comparator function	Corticocerebellum (Neocerebellum)

Basal ganglia physiology

Basal ganglia are the scattered masses of gray matter submerged in subcortical substance of cerebral hemisphere. Basal ganglia form the part of extrapyramidal system, which is concerned with integration, and the regulation of motor activities.

COMPONENTS

1. Corpus striatum

2. Substantia nigra and
3. Subthalamic nucleus of Luys.

Corpus striatum

It is a mass of gray matter situated at the base of cerebral hemispheres in close relation to the thalamus. The internal capsule incompletely divides the corpus striatum into two parts.

- Caudate nucleus
- Lenticular nucleus.

1. Caudate Nucleus

This is an elongated arched gray mass, lying medial to internal capsule. Throughout its length, the caudate nucleus is related to lateral ventricle. Caudate nucleus has a head portion and a tail portion. The head is bulged into lateral ventricle and situated rostral to thalamus. The tail is long and arched. It extends along the dorsolateral surface of thalamus and ends in amygdaloid nucleus.

2. Lenticular Nucleus

It is a wedge shaped gray mass, situated lateral to internal capsule. A vertical plate of white matter called the external medullary lamina, divides lenticular nucleus into two portions.

- The outer putamen and
- The inner globus pallidus

Putamen and caudate nucleus are the phylogenetically newer parts of corpus striatum and these two parts are together called neostriatum or striatum. The globus pallidus is phylogenetically older part of corpus striatum. And, it is called pallidum or paleostriatum. The globus pallidus has two parts, an outer part and an inner part.

Substantia nigra. This is situated below red nucleus. It is made up of small unpigmented and large pigmented cells. The pigments have high of quantity of iron.**Subthalamic nucleus of luys.** This is situated lateral to red nucleus and dorsal to substantia nigra.

Basal ganglia connections

The afferent and efferent connections of corpus striatum (Figs 29 and 30), substantia nigra and subthalamic nucleus of Luys are given in Table below In addition to afferent and efferent connections, the different components of corpus striatum of the same side are interconnected by intrinsic fibers.

- Putamen to globus pallidus
- Caudate nucleus to globus pallidus
- Caudate nucleus to putamen

The different components of corpus striatum in each side are connected to those of the opposite side by commissural fibers.

Connections of basal ganglia

Component	Afferent connections from	Efferent connections to
Corpus striatum	Thalamic nuclei to caudate nucleus and putamen Cerebral cortex to caudate nucleus and putamen Substantia nigra to putamen Subthalamic nucleus to globus pallidus	Thalamic nuclei Subthalamic nucleus Red nucleus Substantia nigra Hypothalamus Reticular formation (most of the fibers leave from globus pallidus)
Substantia nigra	Putamen Frontal lobe of cerebral cortex Superior colliculus Mamillary body of hypothalamus Medial and lateral lemnisci Red nucleus	1. Putamen
Subthalamic nucleus of Luys	1.Globus pallidus	Globus pallidus Red nucleus

Control of voluntary motor activity

The movements during voluntary motor activity are initiated by cerebral cortex. However, these movements are controlled by basal ganglia, which are in close association with cerebral cortex. During lesions of basal ganglia, this controlling mechanism is lost and so movements become inaccurate and awkward. Basal ganglia control the motor activities because of the nervous (neuronal) circuits between basal ganglia and other parts of the brain involved in motor activity. The neuronal circuits arise from three areas of the cerebral cortex.

- Premotor area,
- Primary motor area and
- Supplementary motor area

All these nerve fibers from cerebral cortex reach the caudate nucleus. From here, the fibers go to putamen. Some of fibers from cerebral cortex go directly to putamen also. Putamen sends fibers to globus pallidus. The fibers from here run towards the thalamus, subthalamic nucleus of Luys and substantia nigra. The subthalamic nucleus and substantia nigra are in turn, projected into thalamus. Now, the fibers from thalamus are projected back into the primary motor area and the other two motor areas, i.e. premotor area and supplementary motor area.

Fibers between cerebral cortex and caudate nucleus are concerned with regulation of conscious movements known as the cognitive control

of activity. The cortical fibers reaching putamen are directly concerned with control of subconscious execution of some movements during performance of trained motor activities, i.e. skilled activities.

Control of muscle tone

Gamma motor neurons of spinal cord are responsible for maintaining the tone of muscles, which is important for posture. The tone of the muscle also depends on actions of muscle spindle. Gamma motor neurons, muscle spindle and muscle tone are all controlled by basal ganglia especially substantia nigra. In the lesion of basal ganglia, tone increases leading to rigidity.

Control of reflex muscular activity

Some of the reflex muscular activities, particularly visual and labyrinthine reflexes are important in the maintenance of posture. Coordination and integration of impulses for these activities depend upon basal ganglia.

During lesion of basal ganglia, postural movements, especially visual and labyrinthine reflexes become abnormal. These abnormal movements are associated with rigidity. Rigidity is because of the loss of inhibitory influence from the cerebral cortex on spinal cord via basal ganglia

Control of automatic associated movements

Automatic associated movements are the movements in body, which take place along with some motor activities. Examples are the swing of the arms while walking, appropriate facial expressions while talking or doing any work. Basal ganglia are responsible for these movements. The lesion in basal ganglia causes absence of these automatic associated movements, resulting in poverty of movements. Face without appropriate expressions while doing any work is called mask like face. Body without associated movements is called statue like body.

Role in arousal (excitive) mechanism

Globus pallidus and red nucleus are involved in arousal mechanism because of their connections with reticular formation. Extensive lesion in globus pallidus causes drowsiness, leading to sleep.

Role of neurotransmitters in the functions of basal ganglia

The functions of basal ganglia on motor activities are executed by some neurotransmitters released by nerve endings within basal ganglia. Following neurotransmitters are released in basal ganglia.

Dopamine: It is released by dopaminergic fibers from substantia

nigra to corpus striatum (putamen and caudate nucleus - nigra strial fibers). The deficiency of dopamine leads to Parkinsonism.

Gamma aminobutyric acid (GABA): It is secreted by intrinsic fibers of corpus striatum and substantia nigra.

Acetylcholine: It is released by fibers from cerebral cortex to caudate nucleus and putamen.

Substance P and enkephalins: These are released by fibers from globus pallidus reaching substantia nigra.

Noradrenaline: This is secreted by the fibers between basal ganglia and reticular formation.

Among all these neurotransmitters, dopamine and GABA are inhibitory neurotransmitters. So, the dopaminergic fibers and the fibers releasing GABA are inhibitory fibers. All other transmitters possess excitatory function.

Task 1. To investigate movement co-ordination

Romberg's pose- the investigated person is proposed to move his feet together, to rise his head, to put his hands alongside his trunk. To determine whether his pose is stable. Complicated Romberg's pose: the doctor proposes to the investigated person to stretch his hands forward horizontally. Initially his eyes must be opened, than closed. Cerebellum functions disorders are accompanied by unstable pose (falling forward is observed at vermis anterior parts injuries; ahead - at vermis caudal parts disorders).

Walking- the investigated person must go on right line with his opened eyes, then with closed ones. At good performing these tests the investigated person is proposed to go on right line such that sock of one foot was touched to the heel of the other one.

Phalanx walking- step movements towards; the investigator put his attention to the step clearance and to the possibility of fast stoppage at sudden order (at injury one can see ataxic walking: legs are significantly extensed and putted forward).

Task 2. Asynergy investigation

Babynsky probe- the investigated person lies on solid bed, he is asked to cross his hands on his thorax and to stand up (legs are rised without legs in people with cerebellum injury).

Ozhehovsky probe - the investigated person while his standing is strongly leant on doctor's palm. At sudden taking doctor's hands away the investigated person must be on his place, must be unmoved or turned ahead (in sick person this probe leads to the turning his trunk forward).

Stuart-Holms's probe - upper extremities proximal parts asynergy is checking. The hand putted till horizontal state investigated person must strongly bend in crural joint (antebrachium and hand in pronation state, hand is in fist). Doctor tries to straighten the investigated person antebrachium out and at sudden resistance stoppage the investigated person hand mustn't beat himself in his thorax. For the control the investigator's second hand must be putted to the place of allowed beat. In a healthy person muscles-antagonists are involved quickly and the beat is prevented.

Task 3. Dynamic ataxy investigation

Finger-nose probe- investigated person while his standing with closed eyes must touch nose ending by his index finger. To pay the attention to finger movement trajectory (locomotory ataxy existance) and putting to mentioned place (dysmetry existance), finger's tremor.

Heel-knee probe- the investigated person while sitting at the chair must touch by heel of one foot the knee of another one and to draw by it through tibia down. To mention locomotor ataxy absence or presence and dysmetry from lower extremities.

Probe to adiadochokinesis- investigated person while his sitting must at the same time (simultaneously) by two hands stretched forward to perform pronation and supination. At disturbance of movement sinchronism and equality one can determine adiadochokinesis on the side where the extremity is retarded.

Probe to the movement proportionality - the investigated person must stretch his hands forward by his palms up, the fingers are diverged. At order to turn hands by their palms down. At cerebellum injury side one can determine excessive rotation - dysmetry.

Task 4. Trigeminal nerve (V-th pair investigation)

a) *Corneal reflex* – the investigated person looks up and towards. The investigator touches with thin paper strip to the inferior-exterior eyeside without touching the eyelashes. The reflex arc - orbital nerve (Vth pair ramus), pons, facial nerve. Decreasing or lost of corneal reflex is found out at trigeminal nerve, facial nerve, pons injuries, at shock, in course of narcosis.
b) *Conjunctival reflex* – is caused by touching to conjunctive. Answer reaction- eyelid close. Reflectory arc – see like at corneal reflex.
c) *Superciliar reflex* - is caused by hummer shock at superciliar arc limb. Answer reaction - eyelid closure. Reflex arc – orbital nerve, pons, facial nerve.

d) *Mandibular reflex* - the investigated person slightly opens his mouth. Masticatory muscles contraction is caused by hammer shock down on chip from one than from another side. Answer reaction – mandible lifting. This reflex can be absent under normal conditions.

Task 5. Facial nerve (VII-th pair) investigation

For this gaim it's necessary to perform face examination: difficulties at mastication, muscular volume diminishing, frontal and nasolabial plicas asymmetry, whether the face become distorted (mouth angle). They ask to perform masticatory movements putting their fingers to the facial muscles. The investigator asks the investigated person to wrinkle, to frown (knit) the eyebrows, to close eyes, to billow cheeks, to show teeth, to stretch lips.

a) Orbicular muscle force determining - the investigated person is asked to close his eyes strongly. The investigator tries to raise eyelid superior determining resistance force at this.

Task 6. Glossopharyngeal nerve (IX-th pair) investigation

The investigation must be begun from the determining of the investigated person voice timbre and sounding. At disorder of innervation of velum palatinum (if it doesn't close nasopharynx cavity completely) the voice is nasal. At vocal chords injury one can aphony and wheezing. Then the investigator must examine soft palate. The investigated person is asked to tell "A" (at one-sided injury at given side soft palate doesn't tighten).

Palatine and pharyngeal reflexes – with the paper rolling up into long strip to touch the soft palate and pharynx posterior wall mucosa. Answer reaction is swallowing and vomiting. Reflexes are realized by means of glossopharyngeal and vagus nerves. The decreasing or lost of these reflexes can be both at healthy people and at injury of IX-th and X-th pairs of cranial nerves or their nuclei in medulla oblongata (so-called bulbar syndrom).

Task 7. Accessory nerve (XI-th pair) investigation

Accessory nerve is a motor one, it innerves sternocleidomastoid and trapezius muscles (head turn in an opposite side and shrugging one's shoulders). The investigated person turns his head towards and up and restrains in such location. The investigator tries to oppose to this. For sternocleidomastoid muscle force you can tell according to resistance degree. Trapezius muscle is investigated by raising and fixating in such a situation. Shoulder girdle is lowered at paralysis.

Task 5. Hypoglossal nerve (XII-th pair) investigation

This nerve innerves the tongue. One should perform the tongue investigation. It's necessary to put it forward behind the teeth line. At one-sided nerve injury – atrophy of the same tongue half, thinness, foldedness of mucosa, fibrillations. The tongue is sticked out in a sick side. At injury of two nerves – the tongue is almost immovable, the speech is disturbed as well as pushing of chilus in mouth.

The injury of V, IX, X, XIIth pairs leads to the disorders of swallowing (dysphagy), sounding voice loss (aphony), speech nasal shade (nasolaly), anomaly of correct order of articulate sounds prononciation (dysarthry).

Task 8. Complicated sensitivity types investigation.

Stereognostic sense - is the ability to recognize by palpation familiar subject with closed eyes (coin, key, pin, neadle etc). Healthy person usually solves this task easy and successfully, he characterizes subject's features (dense, soft) correctly.

Discriminative sense – separate sensation of 2 irritations putted on the skin simultaneously. It is investigated with Weber's compasses. Compasses legs are making together up to double touchings will be percepted like one. Norma: 1,0-1,5 cm between legs should be percepted like 2 separate points.

Irritation location sensation – the investigated person must answer where the irritation is made by the investigator.

PRACTICAL LESSON 7. Electroencephalographic analysis of brain activity.

Equipment: the encephalograph – Neyrospektr 4/VPM, alcohol, gel-paste (physiological solution).

Research object: human.

Main questions:

1. Methods of a research of functions of brain. History of development of these methods.
2. Electroencephalogram. EEG forms and their diagnostic value. Characteristic of the rhythms.

Independent work

1.On the proposed fragment (Fig.20) note which rhythm dominates, in which area, and why?

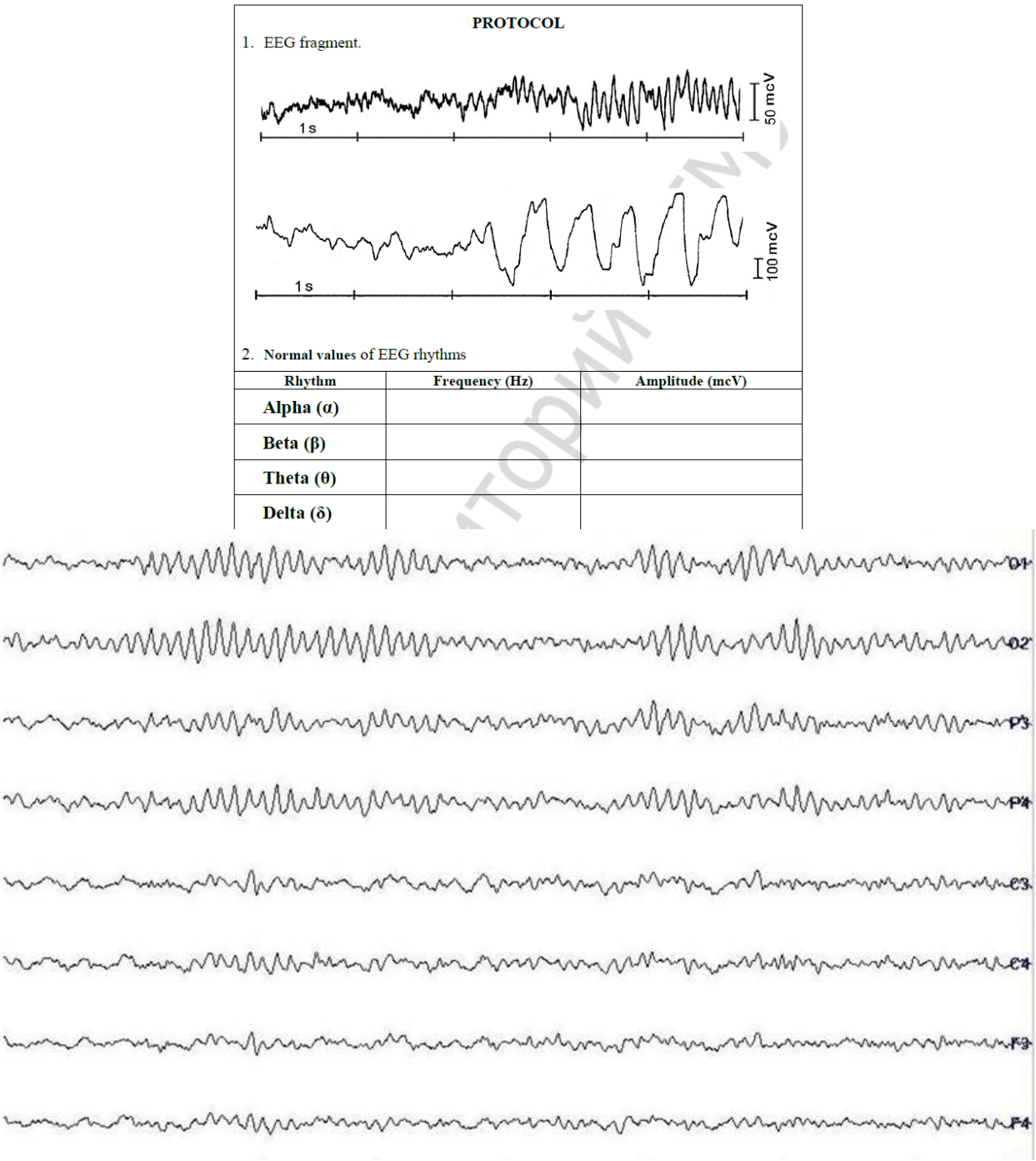


Fig. 20. EEG Example

Modern brain research methods

First of all, we would like to tell few words about new investigative methods used in neurology and neurophysiology for nervous system functions assessment.

Method of surgical extirpations. It includes different brain structures removal, their mechanical destruction or coagulation with constant current anode. Brain structures functional switching off is achieved by their cooling or anodic polarization. This method disadvantage is expressed in haemorrhagias in the injury zone and

further irritation with forming scared tissue. This method separate type is brain tissue local extirpation through injected canules.

Method of different brain structures electrical and chemical irritation. It includes naked brain structures irritation. German investigators G.Frich and E.Gitzig were the first who have performed brain cortex direct irritation. This method is also non-exact and rough. It is accompanied by cerebral sheathes section, intracerebral pressure disorders and others.

Stereotaxic method of irritating electrodes introducing got wide distribution. It is performed in brain definite points through trepanative foramens in skull.

Animal head under narcosis is fixated in stereotaxic device with fixators injected in auricular meatuses, for orbitae inferior limbs or maxillae. Stereotaxic atlases for definite animals are used for electrodes orientation in brain. Brain serial cuttings in frontal, horizontal and sagittal planes are represented in them. The counting is performed from zero planes. In cats, for example, frontal zero plane passes through external acoustic meatuses. Horizontal zero plane – 10 mm higher than external acoustic meatuses. Zero sagittal plane coincides to sagittal suture. Frontal plane is chosen for electrodes putting because necessary structure is the most distinctly visual here (for example, numerals for hypothalamus are equal to: F=12 mm, L=2 mm, H=12 mm).

Introduced electrode is fixated in electrode holder. First of all, holder should be located so that electrode end was located above frontal plane. Than electrode holder must be putted 12 mm forward and 2 mm laterally. Foramen must be drilled in the point in skull bone. Electrode is putted in 12 mm in depth. X-ray-scopy controls additionally electrodes ends location in brain.

Stereotaxises for human being with special atlases are performed for clinical aims.

Brain structures irritation can be made (except ends) with isolated bipolar electrodes (distance between their ends are 0,5 mm and less) or unipolarly when indifferent electrode is located above nasal sinus or in muscle.

Canules-chemotrodes are used for brain structures chemical stimulation. Brain irritation can be performed by contact or by telestimulation.

Method of functional degeneration. One can see degeneration of synapses and neurons of brain parts located below at axons cutting for example of brain cortex pyramidal neurons.

Method of horseradish peroxidase. Horseradish peroxidase injection in brain definite parts causes reaction in neighboring brain locuses.

Strichnin neuronography. Strichnin application to definite brain locuses leads to spike activity not only in application point but also in brain structures connected with them.

Chemicals application, microionophoresis. Synaptic transmission blockators or activator application can be performed directly to brain cortex or by way of their giving through electrodes (chemotrodes) to different deep brain structures. Substances can be applicated to the separate brain neurons through microcanules by charges electrical pushing away – microionophoresis.

Microdialysis. It is performed by liquids microdoses taking from brain definite structures at experimental animals definite states with special micropumps.

Method of caused potentials. Caused potentials are registrated in different subcortical structures at singular irritations applying to the peripheral receptors or afferent nervous fibers in cortex projectional zones.

Caused potentials in cortex projectional zones have following phases:

1) primary positive potential – it occurs due to axo-somatic synapses excitement on neurons of the 3^{rd}-4^{th} cortex layer;
2) primary negative potential - it occurs due to axo-somatic synapses excitement on neurons of the 3^{rd}-4^{th} cortex layer inhibiting;
3) secondary potentials – are determined by axo-dendrite synapses excitement.

Different distribution maps are observed at different narcosis types for instance of somato-sensor caused potentials through brain cortex which indicates to different drugs selective action to brain synaptic structures.

Microelectrode investigations. Metallic or glass electrodes filled with sodium chloride are used for separate neurons electrical activity investigation. Microelectrodes ends diameter is fluctuated from 1 to 0,5 mcm. Methods of extracellular and intracellular biopotentials leading are applied in microelectrode investigations.

Magneto-resonance tomography. Brain liquids (for example, water molecules) dipoles acquire the direction of irradiating field at brain irradiation with electrical- magnetic field. Dipoles are returned to their initial position at external magnetic field switching off. Magnetic signal are appeared at this which is percepted by special devices and are registrated as graphic in computer. As external magnetic field can be

made plane, than brain can be “cutted” layer by layer. This method allows tumors and brain circulation zones detection in brain.

Positrone-emission tomography. This investigation is based on positrons- irradiating short-lived isotopes injection to brain circulation. Data about radioactivity distribution in brain are calculated for definite time periods in computer and then are reconstructed in three-dimensioned image. This method gives an opportunity to see excitement focuses in different brain parts at investigated people mental activity.

Brain functions modeling with computer. It became widely-spread during the latest years. Nervous nets models were built performing separate brain functions. “Intellect detector” has been made giving an opportunity to determine individual features of human psychical activity systemic organization different stages.

Brain electrical activity registration. Biopotentials registration from head surface or skull is known as electroencephalogram. It reflects spontaneous activity of such brain structures as: neurons, synapses, glia and intercellular substance.

Human electroencephalography

One of the important functions of the nervous system is to organize the regulation of the different physiological functions on the level of the organs, organs systems as well as on the level of the whole organism. Besides the regulation, another equally important function is the analysis of the stimuli arriving both from the outside world and the body. Associative processes regarding time and space context of the stimuli lead to memory formation and learning, both are very important function of the central nervous system as well as generation of emotions and motivations. These higher order functions are associated with the activity of the cortex. With the method of the electroencephalography, it is possible to measure bioelectrical potential changes accompanying brain functions. The tool for this examination is the electroencephalograph which records wave series called as electroencephalogram (EEG). In the first time, Richard Caton recorded EEG in rabbits in 1875 followed by Hans Berger who recorded first time electrical activity from human scalp. In 1929, Berger defined the major frequency bands by which the pattern of brain activity is conventionally characterized. Gamma activity or gamma oscillation was described later. It contains characteristic sine waves and closely associated with cognitive functions. This rhythm usually can not be recorded from the scalp; it requires the usage of electrodes placed directly to the cortical

tissue. It can be peformed in animal models or in specific cases in humans.

Field potential recordings provide an important tool for qualitative and quantitative analysis of neural population activity. Transmembrane currents of neurons with synchronized activity flow through the extracellular space and these currents can be recorded as field potentials by appropriate electrodes. One of the most extensively studied field potentials is the EEG which examination serves also diagnostic purposes and it had own evolution from the "30s parallelly with the development of electrical engineering.

Waves representing potential changes have different frequencies. These waves can be recorded with electrodes placed to the scalp or attached directly to the cortical surface. The amplitude of these macropotential waves, when recorded from the scalp, is in the 10 V magnitudes. During synaptic activity, positive (inward) current flows through the dendritic membranes into the cell generating an active „sink". Current flows into the opposite (outward) direction through the membrane of the soma (so called passive „source"). When depolarization 100 spreads to the soma, position of the sink and source is swapped. The sink and source form a dipole, and the circuit will be closed through the extracellular space. The main sources of the EEG signal are these dipoles generated by slow synaptic potentials (EPSPs and IPSPs), but non-synaptic currents such as burst-evoked afterhyperpolarizations also contribute. Action potentials usually do not play a role in generation of the EEG as they have a short duration (<2 ms) and only a small membrane surface is involved in their generation. It is important to note that the extracellular space of the neural tissue is not conductive to high-frequency electrical waves which hamper the spatial summation of the high-frequency signals. Neuronal geometry also plays a role in the EEG generation. Neurons with concentrically situated dendrites can not produce macropotential changes as dipoles with different directions will quench each other. Field potentials can be easily recorded from structures containing elongated cells. The cortex and the hippocampus are ideal structures where large pyramidal cells meet the above mentioned morphological criteria. Potentials of individual cells have very small amplitude. If slow membrane potential fluctuations in neighboring cells are ordered in time, high-amplitude and low-frequency waves appear. This phenomenon is called synchronization. If electrical activation of the neurons is not

coordinated, signals from individual neurons quench each other resulting in low-amplitude and high-frequency waves, i.e. desynchronization. Appropriate amplification is also an important factor for recording EEG signals.

Actual EEG patterns depend on the actual sleep-wake stage (Figure 21). Several so-called ascending activating systems were identified by extensive research.

These systems (serotonergic, noradrenergic, histaminergic, GABAergic and cholinergic from the basal forebrain etc.) originate from subcortical regions and influence the electrical activity of the cortical neurons by modifying their membrane properties. Thus, activation level and activity pattern of the cortex changes periodically during the cyclic alternations of the sleep-wake stages, which can be followed by EEG recordings.

During wakefulness, beta- and gamma waves can be seen. However, alpha activity can also be developed if external stimuli are minimised (eyes closed, quiet environment). During slow wave sleep, low frequency waves are charateristic and synchronization processes can be studied. In the case of sensory stimulation or awakening, beta activity develops, i.e. desyncronization occurres. Desynchronized patterns are also characteristic in paradoxical (REM) sleep. However, specific waves appear during this stage (so-called sawtooth waves). These waves are missing during wakefulness.

EEG can be routinely measured by macroelectrodes which have large surface and low electrical impedance. In the course of the practical lesson, human EEG during wakefulness will be recorded and analyzed.

EEG method has high diagnostic importance in clinical practice, especially in neurology. EEG measures have several advantages as they provide immediate information about the actual condition of the cortex by a non-invasive way. In routine examinations, brain activity can be checked by using only 6-8 electrodes. However, in more sophisticated and accurate measures, usage of 32 or even 64 electrodes is a requirement. Silver macroelectrodes are used routinely.

Placement of the electrodes on the scalp is the first step in human EEG recordings. Before the fixation of the electrode, unfolding the hair on the place of the recordings and removal the grease from the skin surface with alcohol is needed. Depending on the electrode type, conductive gel or paste is applied to ensure good electrical contacts. Electrodes can be fixed by a rubber cap or even with a piece of gauze

which is glued to the skull by a special glue (Mastisol). In the practical lessons, usage of an elastic gauze bandage is a very useful alternative. It is placed on the subjects head to fasten the electrodes and their leads. Good electrical contact can be achieved in this way.

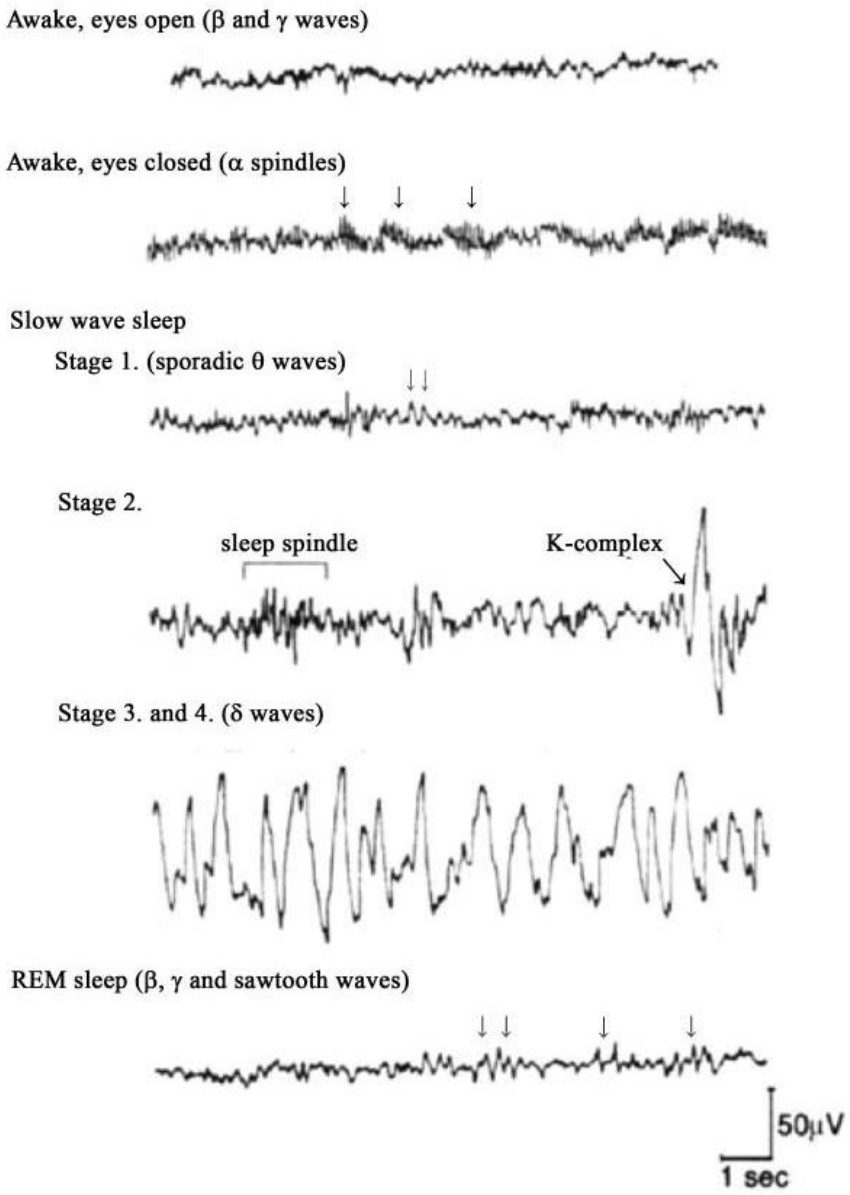


Fig. 20. Characteristics of the main rhythms EEG

In the clinical use, EEG is recorded from conventionally defined locations (Figure 22). This is the so-called *international 10-20 system*, which defines four anatomical reference points on the skull. These are the nasion (depressed area just above the bridge of the nose), the inion (the lowest point of the skull from the back of the head, indicated by a prominent bump at the level of the *foramen ovale*) and the two praeauricular point (place of the mandibular joint on the right- and on the left side, respectively). Distances are measured between the above

mentioned reference points and electrodes are placed on the 10 and 20 % dividing points of these distances. In the 10-20 system, locations are marked with capitals (F – frontal, P- parietal, C – central, T – temporal, O – occipital). Numbers followed by the capitals mark the hemisphere (even numbers - right hemisphere; odd numbers - left hemisphere), while lowercase “z” marks central position. Reference/ground electrode is provided by a clip fixed on the earlobe.

Taken into consideration the conditions present on the practical lessons, only EEG patterns characteristic to wakefulness can be recorded. Thus, only alpha- and beta activity can be demonstrated. It is possible to manipulate alpha activity by some simple ways and artefacts can be also demonstrated.

If the subject closes her/his eyes and lie in complete mental (“think about nothing”) and physical rest, alpha activity appears in the EEG characterized by a frequency of 7-13 Hz and an amplitude of about 50 V. Alpha rhythm can be preferentially recorded from occipital and posterior parietal areas. Audience should be quiet during the recording.

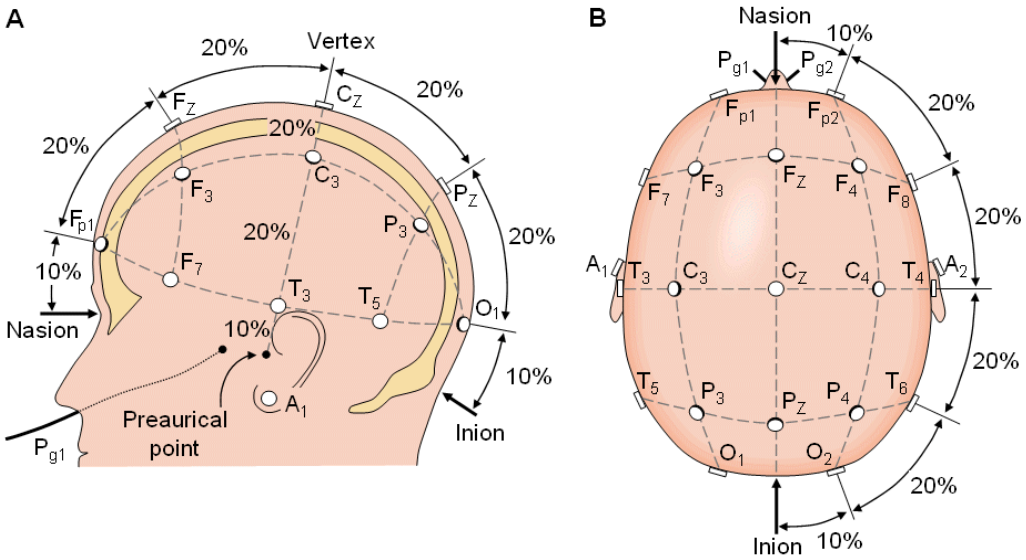


Fig. 22. The international 10-20 system seen from the left side (A) and from above the head (B). A - ear lobe, C - central, Pg - nasopharyngeal, P - parietal, F - frontal, Fp - frontopolar, O - occipital electrodes.

When a continuous alpha activity is present in the EEG, and the subject is asked to *open her/his eyes*, alpha activity disappears and beta rhythm appears with a frequency higher than 13 Hz and with amplitude lower than 50 V. Thus, desynchronization occurs. Desynchronization of the continuous alpha activity can be evoked by several ways: by sound stimuli (for example: clap), by tactile stimulation of the skin (for example: touching the hand of the subject) or by forced mental activity

(for example, to ask the subject to solve a simple arithmetic task without saying the result aloud).

Voluntary hyperventilation has a strong influence on alpha activity. To test this phenomena, the subject should hyperventilate for half a minute (breathe with maximal frequency and amplitude). Hyperventilation can provoke seizure in epileptic subjects. Thus, it is important to skip this test if the subject has previous record of seizures!

During EEG measurements, it is very important to minimize the amount of artefacts or at least to exactly identify the appearing ones. Artefacts can be very similar to normal EEG waves. For example, eye movements can result waves mimicking delta waves or K-complexes characteristic to slow wave sleep, even if the subject is awake.

The most frequent artefacts originate from eye movements appearing on the EEG electrodes close to the eyeballs. To examine this artefact, subject is asked to move her/his eyeballs slowly to the left then to the right with closed eyelids. Function of skeletal muscles can also cause characteristic artefacts. It can be demonstrated by asking the subject to tense her/his mandibular muscles. Effect of vocalization can be introduced by asking the subject to pronounce her/his name.

Result: Find sites with prevalence an alpha - and a beta rhythm, note activation reaction.

THEME:"MODULE ON THE PHYSIOLOGY OF THE NERVOUS REGULATION OF BODY FUNCTIONS."

1. General plan of the structure and value of the nervous system for the body. Structural and functional features of the somatic and autonomic nervous system.
2. General ideas about the autonomic nervous system and its departments, differences. Influence of the sympathetic and parasympathetic nervous system on innervated organs.
3. Principles, methods, mechanisms, means and forms of management.
4. Neuron, its physiological properties, classification. Association of neurons (reflex arcs, neural networks, neural ensembles, nerve centers).
5. Synapses in the Central nervous system. Structure, classification, and functional properties. Transmission of excitation in synapses.
6. Reflex arc, its components. Classification of reflexes. The concept of a "reflex ring".
7. Development of reflex theory in the works Of R. Descartes, I.

prokhazka, I. M. Sechenov, and I. P. Pavlov.

8. The doctrine of P. K. Anokhin's functional systems. Useful adaptive result as the main system-forming factor. The role of reverse afferentation.
9. The receptive field of the reflex, the time of the reflex, its dependence on the strength of the stimulus.
10. Spinal cord: morphological and functional characteristics of the law bell-Magendie. Spinal shock, brown-Secar syndrome, mechanisms of occurrence.
11. Classification of spinal cord neurons. The main pathways of the spinal cord. The most important spinal reflexes (somatic and vegetative). Static and statokinetic reflexes.
12. The concept of the nerve center, its functions and properties.
13. General principles of CNS coordination: feedback, facilitation, occlusion, common end path, dominant (types, properties), reciprocity, switching.
14. Principles of propagation of excitation in the Central nervous system: convergence, divergence, irradiation, summation, unilateral conduction, reverberation, induction, Central delay.
15. Inhibition in the Central nervous system, its role. Classification of types of Central braking. Primary braking, types and mechanisms. Secondary braking, types and mechanisms.
16. The relationship between the processes of excitation and inhibition.
17. Structure and functions of the medulla oblongata (reflex, conductor). Vital centers of the medulla oblongata, their features. Deuters core, its role in maintaining muscle tone.
18. Midbrain-structure and function. Motor centers of the midbrain: red core, black substance, four-hill mounds. Tectospinal tract and its role in the regulation of motor activity. Decerebration rigidity and the mechanism of its occurrence.
19. Functions of the cerebellum (maintenance of muscle tone, coordination and programming of purposeful movements, vegetative regulation). Cerebellar dysfunction (atony, ataxia, asynergia, diazoketones, astasia).
20. General plan of the structure and functional characteristics of the intermediate brain.
21. Thalamus. The role of specific and non-specific thalamus nuclei.
22. Hypothalamus. General functional characteristics, role in the regulation of behavioral reactions (sexual, food, aggressive and

defensive), body temperature, water and salt metabolism, and vegetative functions. Neural secrets of the hypothalamus (own hormones), their nature and functions. Hypothalamic-pituitary connection, its types and functions.

23. Architectonics of the neocortex. Functional relationships of different layers.
24. The importance of the different regions of the cortex. Functional division into sensitive (visual, auditory, somatosensory, etc.), motor and associative areas of the cortex. Primary and secondary zones, their location and differences. Brock, Wernicke, motor, visual, and auditory speech centers.
25. Interhemispheric asymmetry. Localization of speech and writing centers in left-and right-handed people.
26. Electroencephalogram. Forms of the EEG and their diagnostic value.

TESTS FOR SELF-CONTROL:

1. It is necessary to estimate the excitability level of the excitability of tissue in an experiment. What parameter is it necessary to define for this purpose?
   a. Threshold of depolarization. *
   a. Resting potential.
   b. Duration of action potential.
   c. Amplitude (altitude) of action potential.
   d. Critical level of depolarization.

2. It is necessary to estimate the level of the nerve excitability of a patient. What parameter is it necessary to define for this purpose?
Resting potential.
   a. Threshold force of the irritant. *
   b. Critical level of depolarization.
   c. Amplitude of action potential.
   d. Duration of action potential.

3. Constant current is applied with the diagnostic aim for teeth (sensitive nerves and pulp) excitability determining. Healthy teeth (independently on group) have equal excitability and react to the constant current force equal to 2-6 mcA. Such a reaction occurs in a patient at current threshold irritation at current force equal to 1 mcA. It testifies to:
   a. Hypoexcitability and parodontosis
   b. Hypoexcitability and pulpitis
   c. Hyperexcitability and parodontosis*
   d. Hyperexcitability and pulpitis
   e. Pulp decomposition.

4. Why at threshold irritation applying in absolute refracterity phase answer reaction is absent:
   a. Decreased excitability
   b. Insufficient irritation force
   c. Excitability is absent*
   d. High excitability
   e. Decreased lability.

5. The irritation of what force is it necessary to inflict on a nervous fibre to entail excitation in the phase of relative refractority?
   a. Under-threshold.
   b. Above-threshold. *
   c. Threshold.

d. Under-threshold prolonged.
e. Threshold prolonged.

6. As a result of blockade of the ionic channels of the cell membrane its resting potential diminished from –90 to -70 mV. What channels were blocked?

a. Sodium.
b. Potassium*.
c. Calcium.
d. Magnesium.
e. Chloric.

7. During the research of an isolated excitable cell it was stated that the threshold of the stimulation force of the cell diminished substantially. What was the reason for it?

a. Blockade of energy production in the cell.
b. Inactivation of membrane sodium channels.
c. Inactivation of membrane calcium channels. D.Activation of membrane potassium channels.
d. Activation of membrane sodium channels. *

8. As a result of the action of electric current on an excitable cell there was depolarization of its membrane. The movement of what ions through the membrane plays a basic part in the development of depolarization?

a. K+
b. HCO3.
c. Ca2+
d. Cl.
e. Na+.*

9. As a result of activating the ionic channels of external membrane of an excitable cell its resting potential was considerably increased. What channels were activated?

a. Fast calcium.
b. Sodium.
c. Potassium. *
d. Slow calcium.
e. Sodium and calcium.

10. What will the reduction of the muscles of the upper extremity be at an attempt to lift a load beyond one's strength?

a. Isometric. *
b. Isotonic.

c. Auxotonic.
d. Phasic.
e. Single.

11. Skeletal muscle is irritated with a series of electroimpulses in an experiment. Every next impulse is in the period of the shortening of a single muscular contraction. What type of muscular contraction will arise?

a. Smooth or complete tetanus. *
b. Toothed or non-complete tetanus.
c. Asynchronous tetanus.
d. A series of single contractions.
e. Muscle contracture.

12. An isolated muscle of a frog is rhythmically irritated by electric impulses in an experiment. Every next impulse is in the period of relaxation of the previous contraction. What contraction will arise?

a. Asynchronous.
b. Single.
c. Toothed (non-complete) tetanus. *
d. Smooth (complete) tetanus.
e. Tonic.

13. Muscles volume can become increased in sportsmen due to trainings. Call, please, muscular contraction energy direct source:

a. Kreatinephosphate.
b. AdenosinetriphosphateAdenosinediphosphate*
c. Lactic acid
d. Neutral fatty acids

14. Person is performing physical exercises. At what stage muscles activity intensiveness will be maximal?

a. Tiredness
b. Prepairing
c. Pre-start state
d. Stationary state*
e. Restoration

15. Calcium pump work is weakened in experiment under chemical substance action to the frog’s smooth muscle. What phenomena one can observe in course of this?

a. Relaxation duration increasing*
b. Action potential increasing
c. Resting potential decreasing

d. Action potential distribution velocity decreasing
e. Sodium-potassium pump activation.

16. Under experimental conditions one hangs load to muscle from urether. Muscle is stretched and is rested in such situation even after load taking down. What muscular tissue feature is demonstrated by this experiment?

a. Plasticity*
b. Automatism
c. Elasticity
d. Contractility (contractiveness)
e. Ability to stretching.

17. At skeletal and smooth muscle irritation with the same frequency smooth muscle responds (answers) with tetanic contraction and skeletal one – with separate contractions. What smooth muscle peculiarities can serve as explaining of this?

a. Smooth muscle lability is more
b. Smooth muscle refracterity is more*
c. Smooth muscle chronaxy is less
d. Smooth muscle contraction duration is less
e. Sarcoplasmic reticulum is developed more in smooth muscle.

18. Stomach or urinary vesicle slow filling in the limits of physiological norm doesn't cause pressure increasing in these organs. What smooth muscles peculiarity is on the basis of this phenomenon?

a. Plasticity*
b. Automatism
c. Excitability
d. Contractiveness.
e. Refractiveness.

19. Serotonin is applied for stomach and intestine smooth-muscular insufficiency. This substance increases alimentary organs smooth muscles contractions frequency. Which of alimentary organs smooth muscles feature will be expressed in the biggest extent?

a. Contractiveness
b. Excitability
c. Conductiveness
d. Automatism*
e. Plasticity.

20. During the examination of a sportsman after an intensive physical activity the incoordination of movements was detected. At the same time

the force of muscle contraction was the same. The reason for it can be the diminution of conduction of excitement speed. What structures does it take place in first of all?

a. Conduction tracts.
b. Nervous-muscle synapses.
c. Efferent nerves.
d. Afferent nerves.
e. Central synapses. *

21. Complete demyelinization of fibers of conductive ascending tracts of a patient is revealed. Formation of what sensations will worsen the least?

a. Acoustic.
b. Proprioceptive.
c. Aftervision.
d. Tactile
e. Temperature. *

22. A frog reacts by generalized convultions to the least irritation after the introduction of strychnine. The blockade of what structure of the CNS is the reason for such reaction?

a. Inhibitory synapses. *
b. Excitatory synapses.
c. Renshow cells.
d. Adrenoreceptors.
e. Cholinergic receptors.

23. After a long training a sportsman tired, working capacity decreased. In what link of the reflex arch did fatigue occur first of all?

a. In an efferent.
b. In an afferent.
c. In receptors.
d. In nerve centres. *
e. In muscles.

24. The toxin produced by Clostridium botulinum blocks the entrance of calcium ions into the nerve endings of axons of motoneurons. Poisoning with it is dangerous to life by:

a. Vomiting development.
b. Cardiac arrest.
c. Disorder of vascular tone.
d. Respiratory standstill. *
e. Development of diarrhea.

25. The working capacity of a man reduced as a result of physical activity. The changes in what structures are the reason for the fatigue first of all?

a. Muscles.
b. Nerve centres. *
c. Afferent nerves.
d. Efferent nerves.
e. Nervous-muscle synapses.

26. It is ascertained in an experiment that during the excitation of the motoneurons of flexor muscles the motoneurons of extensor muscles are inhibited. What kind of inhibition underlies this phenomenon?

a. Reciprocal. *
b. Inhibition after excitation.
c. Pessimal.
d. Feedback (Renshow).
e. Lateral.

27. In unfresh products (meat, fish, tinned goods) microbic toxine botulin can be present. Its action to the myo-neural synapses is similar to calcium removal from them. Why this intoxication can lead to the lethal result?

a. Because of heart stoppage
b. Due to respiratory muscles contraction in tetanic regimen because of mediator releasing increasing
c. Because of respiratory center excitability decreasing and its activity inhibiting
d. Due to excitement conductance speed decreasing in myelinized fibers
e. Due to respiration stoppage because of respiratory muscles relaxation*

28. 45-yeared patient addressed the neurologist with the complaints on skin sensitivity decreasing to touching, pressure, tickling. The doctor came to the conclusion during careful examination that the patient has decreased sensitivity of receptors located in skin. Which of mechanoreceptors mentioned below don’t belong to mechanoreceptors:

a. Auditory
b. Olfactory and gustatory receptors*
c. Vestibulary
d. Tactile
e. Receptors of sustentacular-motor apparatus

29. Nausea, vomiting, sweat releasing enforcement appeared in 25-yeared woman during the rolling merry-go-round. What receptors activation, the most probable, led to these symptoms?

a. Skin mechanoreceptors
b. Skeletal muscles proprioreceptors
c. Corti organ receptors
d. Noceoceptive receptors
e. Vestibulary receptors

30. Major mediator role in exciting synapses is in:

a. Postsynaptic membrane permeability diminishing to Na and Ca ions
b. Postsynaptic membrane depolarization*
c. Postsynaptic membrane permeability increasing to potassium and chlorum ions
d. Postsynaptic membrane permeability increasing to calcium and hydrogen ions
e. No one answer is correct

31. Frog answers with flexory reflex of the leg at this leg irritation with tweezers. But the animal answers with generalized motor reaction to stronger irritation. What is of the base of observed reaction?

a. Excitement physiological irradiation*
b. Excitement pathological irradiation
c. Inhibition process enforcement
d. Inhibition process weakening
e. Excitement process enforcement

32. It is known that excitement through nervous centers is directed in one direction. It is determined by:

a. Nerves features
b. Synapses features*
c. Dendrites structure
d. Axons features
e. Mediators features

33. It is ascertained in an experiment that during the excitation of the motoneurons of flexor muscles the motoneurons of extensor muscles are inhibited. What kind of inhibition underlies this phenomenon?

a. Reciprocal. *
b. Inhibition after excitation.
c. Pessimal.
d. Feedback (Ranshow).

e. Lateral.

34. An experiment is conducted on a spinal frog. The time of defense flexor reflex decreased from 10 sec. to 6 sec. after increasing the area of the skin surface, which is acted on with acid solution. What mechanism underlies the diminishing of the time of defense flexor reflex?

a. Irradiation of excitation on divergent nervous chains.
b. Spatial summation of excitation. *
c. Temporal summation of excitation.
d. Principle of dominant.
e. Recirculation of excitation.

35. During the pathologoanatomic research of the spinal cord of a 70-year- old man the destruction and diminishing of the quantity of anterior horns nuclei cells in cervical and thoracic spines were found. What functions were damaged during the man's life?

a. Moving functions of the lower extremities.
b. Moving functions of the upper extremities. *
c. Sensitiveness and moving functions of the upper extremities.
d. Sensitiveness of the lower extremities.
e. Sensitiveness of the upper extremities.

36. After a traffic accident a patient of 36 years got paralysis of muscles of extremities on the right, the loss of pain and temperature sensitivity on the left, partial reduction of tactile sensation on both sides. These changes are most characteristic of the defect of some part of brain. What part is it?

a. Motor cortex on the left.
b. Right half of spinal cord. C Left half of spinal cord. *
c. Anterior division of the anterolateral pathway of spinal cord.
d. Dorsal columns of spinal cord.

37. The toxin produced by Clostridium botulinum blocks the entrance of calcium ions into the nerve endings of the axons of motoneurons. Poisoning with it is dangerous to life by:

a. Vomiting development.
b. Cardiac arrest.
c. Disorder of vascular tone.
d. Respiratory standstill. *
e. Development of diarrhea.

38. Complete demyelinization of fibers of conductive ascending tracks of a patient is revealed. Formation of what sensations will worsen the least?

a. Acoustic.
b. Proprioceptive.
c. Aftervision.
d. Tactile
e. Temperature. *

39. A hemorrhage into the brainstem of a patient of 70 is diagnosed. The exa-mination found out the increase of the tone of flexor muscles and the decline of the tone of extensor muscles. The irritations of what structures of brain can explain the changes in the tone of muscles?

a. Substantia nigra.
b. Vestibular nuclei.
c. Quadrigeminal plate.
d. Red nuclei. *
e. Reticular formation.

40. For better examination of the fundus of eye a doctor began to drip the solution of atropine on the conjunctiva of the patient's eye. It resulted in pupil expansion. The blockade of what membranous cytoreceptors stipulated such effect?

a. H2-receptors.
b. N-cholinoreceptors.
c. α-adrenoreceptors.
d. β-adrenoreceptors.
e. M-cholinoreceptors. *

40. A careless student met the dean by chance. The concentration of what hormone will be increased in the student's blood first of all?

a. Cortisol.
b. Thyreoliberin.
c. Corticotropin.
d. Adrenaline. *
e. Somatotropin.

41. After a cranial trauma a patient's respiration became infrequent and deep. What structure of cerebrum is damaged?

a. Medulla oblongata.
b. Hypothalamus.
c. Metencephalon. *
d. Cortex of large hemispheres.
e. Cerebellum.

42. After the introduction of microelectrodes into the structures of diencephalon the animal's eyesight failed completely. What subcortex structure was possibly damaged?

a. Suprachiasmatic nucleus of hypothalamus.
b. Medial geniculate body.
c. Associative nuclei of thalamus. D.Supraoptical nuclei of hypothalamus.
d. Lateral geniculate body. *

43. During an operation on cerebrum it was noted that the irritation of a certain area of the cortex of cerebrum caused tactile and temperature sensation of a patient. Which area of cerebral cortex was irritated?

a. Cingulate gyrus.
b. Precentral gyrus.
c. Upper lateral gyrus.
d. Postcentral gyrus. *
e. Parahippocampal gyrus.

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List of electronic resources:

1. Video materials on the course Normal physiology. Access Mode: http: // meduniver.com/Medical/Video/38.html
2. Video materials on the course Normal physiology. Access Mode: http: // www.vdsma.com/index/video/0-172
3. Virtual Rat (Strathclyde University) (http://spider.science.strath.ac.uk/sipbs/showPage.php?page=software_sims_rat)
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