UKRAINIAN MEDICAL DENTAL ACADEMY

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METHODICAL INSTRUCTIONS
NORMAL PHYSIOLOGY
(PART I)

FOR DENTAL AND MEDICAL DEPARTMENTS' STUDENTS
SECOND COURSE (ENGLISH-SPEAKING STUDY FORM)
PRACTICAL CLASSES

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MODULE 1. GENERAL PHYSIOLOGY

CONTENT MODULE 1,2: INTRODUCTION TO PHYSIOLOGY. EXCITABLE TISSUES PHYSIOLOGY

PRACTICAL WORK 1

PHYSIOLOGIC INVESTIGATION METHODS

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 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. **Excitation** – complex (difficult) 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. **Physico-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). **Inadequate** stimuli are such, to perception of which the given structure is not adjusted specially (e.g., for a sceletal muscle the adequate stimulus is the nervous impulse, but it can contracts at a mechanical impact too).

Materials and methods: electrofeeding source for practical works, kymograph, preparation instruments set, dielectrical plate.

Investigation object: frog.

Task 1. Aquaintance with devices for the work performing.

1) Electrofeeding source - has the function of voltage creating (till 0 to 40 V).
2) Kimograph – has the aim of graphic registration of mechanical transitions through the paper tape.
3) Universal stand – is for fixing the investigation object and registrating devices on it. It allows to rotate the subjects vertically and horizontally.
4) Myograph – is situated on universal stand. The aim of its usage is the registration of muscular contraction on kimograph drum. The main part of it are:

- Engelman's lever with the writing device at the long arm end.
- Hook for muscle fixating on the short arm.

One should fix another muscular end in a squeeze.

Myogram – the record of muscular contractions the altitude of which are increased.

Task 2. To prepare nervous-muscilar preparation.

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. 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.

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. 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 vertebraes articulation. The investigator tightens the skin from the legs posterior.

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.

One should bring the glass stick to lumbo-sacral plexus and separate pelvis bone from spinal with scissors. The plexus should be connected with spinal. 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" (fig.).

For the muscular contraction registration by means of kymograph one should use the preparation "sciatic nerve-gastrocnemius muscle". For its receiving on the

preparation " sciatic nerve-legs muscles" ine should separate gastrocnemius muscle together with the tendon from bones and other tibia muscles alongside with the preservation of femur bone residue (1 cm). Then they remove tibia below hip joint. Gastrocnemius muscle with hip joint and sciatic nerve remain as a result. The hip joint is used for the preparation fixating in myograph.

The preparation must be often damped (moisted) with Ringer's solution for drying prevention.

Task 3. To study the different stimuli influence to the nervous-muscular preparation.

Put the nervous-muscular preparation to the dielectric plate. Nerve irritation is performed on the most farther localized regions from the muscle. As the irritation disappeares we get down to the irritation of the nearest regions to the muscle.

1. To perform mechanic muscular irritation having compressed its end with the tweezers or having cutted. Monitor the muscle state.
2. To bring the heated glass stick to the nerve and observe the muscle state.
3. To put salt (natrium chloridum) to the cutted nerve end, make humid and observe the answer reaction. The effect develops in course of 2-6 minutes (this time is necessary for natrium chloridum ions diffusion).
4. To fix the preparation " sciatic nerve-gastrocnemius muscle" in myograph and to plug the myograph electrods into electrofeeding source. To close the chain. Observe the effect.

To make the conclusions.

Control questions.

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

PRACTICAL WORK 2.

IRRITATION AND IRRITABILITY. IRRITATION LAWS.

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 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 that each functional unit of tissues (for example, muscular) has its exaltation threshold. That's why 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 **optimum**. 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 can even 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"** 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 2B (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.

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 sceletal muscles - 150-200 impulses per second. There is a sceletal muscles lability rising with ageing. It is shown in augmentation of irritation freaquency, at which the gear (incomplete) tetanus turns in smooth. In newborn's muscles it occurs at a stimulus freaquency 4-20 per second, at adulthood - 50-100 impulses per second.

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

Investigation object: frog.

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 voltmetr ciphras 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. These are so-called optimum irritation conditions.

After that one should increase quickly current force and determine the contraction force diminishing. The phenomenon observed is called force pessimum. The curves received must be glued into students' copy-books.

The students must make the conclusion about dependence between irritation level and muscular contraction force. Explain the phenomena of force pessimum and optimum.

Task 3. Draw and analize the curve "force-time".

To mark "rheobase", "useful time", "chronaxy" on your graphic. Make the conclusions.

Control tasks.

1. Excitability as the special form of irritability.
2. Law "everything or nothing".
3. Muscular contraction force dependence on irritation force.
4. Stimulus threshold force dependence on its duration.
5. Excitability measures.
6. Lability as one of the excitable tissues features.
7. Excitability changes in course of exitation.

PRACTICAL WORK 3

NERVOUS AND MUSCULAR FIBRES RESTING AND ACTION POTENTIAL INVESTIGATION

Characteristic attribute of exitation is an electrical current occurrence in tissues (cells). The electrical phenomena (currents or potentials), which arise in organism cells, tissues and organs are named the **biological potentials.**

The biological potentials arise because there is a difference of potentials between the external and internal party of a cell membrane, which is in a status of rest. Potential, which is registered in a such cell status, is named a **membrane potential (resting potential).** It is caused by the difference of a potassium, calcium, sodium, chlorine and other ions concentration between intracellular and extracellular medium. So, the potassium ions concentration in a cell exceeds in many times (about 20-40 times) their contents in extracellular medium. The of sodium ions concentration, on the contrary, is lower in intracellular medium in 10-20 times. The ions of chlorine, as well as of a sodium, are mainly concentrated outside of cell membrane, where their content is in 15-20 times more than inside. Their such non-uniform distribution till that and other membrane party provide ion pumps. Ion canals, available in a membrane, can be opened and closed, that depends on a membrane status. So, in a cell which is in a resting status, the sodic canals are closed, and the potassium ones - are opened. Therefore the permeability for different ions is various. If a potassium ions permeability to accept for 1,0, for chlorine it will make - 0,45, and sodium - 0,04. It results that the potassium ions on a concentration gradient diffuse from a cell to extracellular space. The sodium ions counter flow is a very small. In a result the potentials difference between cell internal medium and its outer surface is formed which is from 50 up to 100 mV for different tissues. This potentials difference also refers to as a resting potential or a membrane potential.

At stimulus action there is a membrane status change, ion canals open in it, through which positively charged ions available in excess behind its limits can move in a cell. The "fast" sodic canals opening occured most often. Originally ion current to cell is promoted also by a transmembrane potentials difference. Such process is called depolarization, because it results in this potentials difference reducing. If the stimulus is weaker (subliminal), ion canals are opened a little, therefore the ion current is insignificant. Depolarization occurs slowly. Such changes are named the **local depolarization** or local potential.

If the of threshold stimulus acts, the depolarization reaches a **critical (threshold)** level. As a result of it all active electroexcitable ion canals are opened. Depolarization is sharply accelerated and there is even a potential reversion (potential mark change). Thus the positively charged sodium ions flow stops, the appropriate canals are closed. Excessive potassium ions from inside direct outside, resulting to the membrane potential restoration. At first it occurs rather quickly (**fast repolarization**), and then, when the potassium ions flow decreases, the membrane potential restoration occurs in a slowed-up way (**slow repolarization**). Further potassium ions exit can proceed and cause a **hyperpolarization**. Potassium-sodic

pump work adducting in initial potentials difference restoration (**to polarization**) amplifies at this time. All this process from a beginning up to the end is called as an **action potential**.

As the vital activity of all cells, tissues, organs is accompanied by their electrical activity, the registration of potentials, arising at it, allows to judge processes occurring in them. The diagnostics and control of a treatment of this or that disease is based on it. For example, in a heart such registration of its biological potentials wears the name electrocardiogram (ECG).

Historical information

Many scientists tried to explain mechanism of excitation spreading through nerves. *Newton* thought that nerve was an optic illuminator, *Lomonosov* proved that thin (gentle) nervous liquid is moving through any nerve. Real study of nervous system language has begun at the end of XVIIIth century. *Louigy Galwany* from Italy proved in his experiments indirectly that alive electricity occured in nervous-muscular preparation too. His experimets became classic. They are of great importance nowadays too. You will see them at your practical classes on this topic. Famous physicist *Alessandro Wolta* studied alive electricity too. In 1843 German physiologist *E.Duboua-Reimon* demonstrated at first the existance of electrical fields in nerves, having used special apparatuses improved by himself.

But unfortunately only at the beginning of XXth century one has managed to discover the source of "animal electricity" and to determine plasmatic membrane leading role in this phenomenon.

Materials and methods: scissors, anatomic tweezers, preparation needle, dielectric plate, bimetallic "balcony", plastic tweezers, current source.

Investigatioin object: frog.

Task 1. Galwani's first experiment.

The investigator must destroy frog's spine with preparation needle, destroying body in 2 cm in front of articulation place of spine and pelvis bones. It's necessary to remove frontal body part and abdomen wall with visceral organs, to remove skin from posterior legs. Copper hook of "balcony" is bought to lumbo-sacral plexus radixes (rootlets, radicles). For this aim the investigator must hang the preparation on it. Then one should touch the legs muscles with "balcony" zinc plate. In the touching moment all legs are contracted.

Draw the experiment scheme in your copy-book. Explain the reason of bimetallic "balcony" irritative action.

Task 2. Galwani's second experiment (contraction without metal).

To prepare the preparation "sciatic nerve-legs muscles". To catch the spine residue with plastic tweezers, not touching the nerve. On femur muscles resting after

the preparation one must make transversal cutting and throw on the nerve on it for the nerve's touching to the injured electronegative and non-injured electropositive muscle locuses. The experiment must be carried out some times while observing under the preparation muscles. It's very important to take the nerve possessing high excitability.

Draw the experiment scheme in your copy-books using the next figure.

Second Galwani's experiment scheme.

Explain the reason of preparation muscles contraction.

Task 3. K.Matteuchi's experiment.

To prepare 2 nervo-muscular preparations "sciatic nerve-legs muscles". Put them to the dry dielectric plate so that the first praparation nerve were touching to the current source electrodes and the second preparation nerve must be lied longitudinally to the first preparation muscles. After that one should act to the first preparation sciatic nerve with unconstant current in course of some seconds. The result of the current action: both legs musclular contractions. The second legs muscular contractions (the nerve of which are located on the first preparation muscle) are called secondary.

Draw the experiment's scheme in your copy-book.

They say traditionally that the second preparation nerve irritation reason is the first preparation sceletal muscle action currents.

Control questions.

1. Bioelectrical phenomena investigation methods.
2. Resting potential:
   - A. Appearence reasons and ion gradients levels. Potassium-sodium pump.
   - B. Plasmatic membrane permeability for different ions.
   - C. Membrane potential appearence mechanisms. Membrane potential level.
3. Action potential:
   - A. Action potential appearence conditions and reasons. Local answer. Depolarization critical level.
   - B. Action potential altitude and duration. Rule "everything or nothing".
   - C. Action potential appearence and development mechanism. Action potential phases.
4. Bioelectrical phenomena registration practical significance.

PRACTICAL WORK 4.

NERVOUS AND MUSCULAR FIBRES ELECTRICAL IRRITATION MECHANISMS INVESTIGATION.

ELECTROMYOGRAPHY (EMG). MASTICATORY MUSCLES ELECTROMYOGRAPHY.

Electromyography is a functional method that allows to registrate graphically electrical muscular activity while its excitation. The curve receiving at this method usage is named electromyogram. It is the result of interfering of multiply action

potential that appear asynchronically in different muscular fibres and is registrated by means of intracellular electrodes.

There are 3 main electromyogram kinds:

1) *interferential* – muscular biopotentials are taken off from large surface while applying the electrodes on skin;
2) *local* – separate motor units activity is registrated by means of needle electrodes;
3) *stimulatory* – the registration of electrical muscle answer to the stimulation of nerve innervating it.

This functional method has the most spread usage in neurology and dentistry.

Local electromyography is used in surgical stomatology at masticatory (chewing) muscles dystrophies and hypertrophies; in stomatoneurology – at traumatic and infectious injuries of nerves of maxillo-facial region; in stomatology of children – for the determining of soft palate muscles bioelectrical activity in children under norma and congenital developmental anomalies.

Stimulatory electromyography is used in stomatoneurology and surgical stomatology at face nerve injuries for the determining of its conduction and impulses spreading velocity through the nerve, for the assessment of expression muscles paresis degree.

Interferential electromyography has the biggest spreading in various dentistry branches. For example, it is used in therapeutical stomatology for the registration of masticatory muscles contraction force regulation at parodontites because there are functional-dynamic disturbances of masticatory apparatus at this disease. It is usually performed in parallel with gnatodynamometry for the assessment of mandibular (lower jaw) force during chewing. In surgical stomatology interferential EMG is used at:

- jaws fractures;
- maxillo-facial region inflammatory diseases (phlegmones, abscesses, osteomyelitis);
- during myoplastic operations at expression muscles pareses.

In orthopedic stomatology this method is applied for study of bioelectrical activity of chewing muscles under the condition of complete teeth absence in cource of adaptation to the new demountable (removable) dentures. In stomatology of childhood interferential EMG is used for zygomatic and masticatory muscles coordinating correlations reorganization control while bite anomalies treatment.

EMG is performed at different muscles states:

- at their relaxation;
- at reflectory tonus changes (during otfler muscles tension, under emotional reactions, at deep inspiration);
- during arbitrary contractions.

Muscular potentials bringing out is performed by means of electrodes:

- needle – they are involved in the muscle and bioelectric potentials of separate muscle fibres are registrated;
- surface – they registrate summary muscle activity from many muscular fibres.

At EMG analysis one should takes into account:

- altitudes level;
- potentials oscillations freaquency;
- common oscillograms structure (osclillations monotony or division into volleys, volleys form, duration and freaquency).

Under norma in a resting state (at local bringing out with needle electrodes) the bioelectrical potentials oscillations don't increase (at summary EMG one can see low-altituded weak oscillations up to 10-15 mcV). Reflectory tonus increasing is accompanied by insignificant rising up of electrical activity (up to 50-100 mcV). At arbitrary tension freaquent high oscillations (1000-2000 mcV) are occured.

EMG have different picture at movement disorders that are connected with anomalies of central and perypheral nervous system and muscular apparatus as itself. The muscular bioelectrical activity changes are delt with pathological process topics, severity and course stages. EMG helps at diagnostics of central, segmentary, neurithic and myopathic motor disturbances, it helps to determine typical disorders at early disease stage under conditions of low-expressed symptoms. It also gives the opportunity to observe process dynamics and trearment effectiveness. Sometimes in neurological practice tthey use **electroneuromyography** – complex investigation method including in it:

- registration and analysis of muscles and nerves stimulated potentials parameters (stimulated potentials parameters latent period, form, altitude and duration);
- functionning motor units determining;
- impulses transmission velocity through peripheral nerves motor and sensor fibres et al.

At interpherential EMG one should determine such parameters as:

- altitude;
- duration and
- temporary course of bioelectrical activity during functional probes;
- symmetrical muscles activity correlation;
- activity distribution in muscles of one and different groups.

Qualitative EMG analysis – EMG character describing:

- saturated;
- non-saturated;
- EMG rounding curve character – activity slow or sharp increasing and decreasing;
- activity phases number.

Quantitative analysis :

- activity and rest phases duration;
- temporary intervals between activity beginning in different muscles;
- common electrical muscular activity level (the most important parameter) - is determined by EMG oscillations altitudes measurement and by means of special devices. Moda (the most common oscillations ciphra, number that are repeated the most often in variational row) is usually taken as the level of summary EMG oscillations altitude. It's necessary to measure all main oscillations during definite time period (for example, for 0,5 sec) and to determine the altitude meaning the

most often meat from pick to pick. Second way of summary oscillations altitude assessment is to measure 10 most expressed oscillations at definite time period with farther estimation of their middle meaning. Then the altitude of this section must be compared with proper meaning of calibrating sygnal and EMG altitude received must be expressed in mcV. Received EMG summary altitude is a conditional quantity but very important because it's a proportional to (it's correlated to) isometric muscular contraction intensivity at any assessment way.

- Oscillations freaquency – under norma is great (100 oscillations per second) and doesn't connected with muscular contraction force. Thus, EMG looks like saturated one. In such cases EMG is not analysed.

PRACTICAL WORK 5.
SCELETAL MUSCLES CONTRACTION MECHANISMS INVESTIGATION SCELETAL AND SMOOTH MUSCLES WORK COMPARATIVE CHARACTERISTICS

As it is known, muscle is the contractile unit of body. Nearly 40% of the body is skeletal muscle. There are 2 muscles types:

1. Striated muscles:
   - Skeletal muscle
   - Cardiac muscle
2. Unstriated muscle-smooth muscle of inner organs, skin and vessels.

One can differentiate 3 muscles types: skeletal, cardiac and smooth.

Skeletal muscles physiological properties. Skeletal muscles possess excitability, conduction, contractility, lability (ability to reproduce the irritation freaquency). At a muscle irritation by single stimulus the single muscular contraction arises. One can distinguish the **latent** period (from irritation beginning to answer-back reaction beginning), **shortnening** period (actually contraction) and **relaxation** period. In reply to a rhythmic irritation (namely the such one our muscles are received) the muscle is reduced lengthly (for a long time). Such contraction has received the name **tetanic** or **summarized**. If each subsequent pulse approaches to a muscle in the period, when it began to be relaxed, there is an **infused** or **incomplete** tetanus. If the interval between irritations decreases so, that each subsequent pulse comes to a muscle, at that moment, when it is in a contraction phase, there is a **smooth** tetanus.

In a certain degree the tetanus formation mechanism is explained by **superposition** phenomenon. However, it can be caused by excitability changing as well. And if to take into account, that the excitability changes are caused by membrane potential change features during exaltation, then it is easy to explain smooth tetanus occurrence and its size. Let's try to understand this phenomenon together. If to render an irritation to muscle during its contraction (smooth tetanus) or relaxation (incomplete or infused tetanus), it is necessary on that moment the excitability increasing existance. Why it's so? At this time the slow depolarization phase develops in a muscle, when the membrane potential is lower, than in rest state, but is higher, the than threshold potential. That's why even subthreshold (subliminal) stimulus will cause the depolarization acceleration (i.e. the excitability at this time in

a muscle is raised - **supernormal excitability**). Fast depolarization beginning results in the situation when the tissue loses ability to react to an irritation. This phase refers to as **absolute refracterity** (absolute inexcitability). At repolarization time the excitability is restored. This period refers to as **relative refracterity**. An excitability at this moment is below than the initial one, and only strong (epiliminal) stimuli can cause the answer-back reaction. Then when the restful (remainded) repolarization develops, the excitability grows and becomes above initial. This phase refers to as **exaltation** (hyperexcitability). During its occurrence even subliminal stimuli can cause the answer-back reaction. Precisely at this moment the threshold stimuli also cause the phenomenon of a tetanus (both infused, and smooth). That's why this reaction is more on size, than the single muscular contractrion. Further a membrane hyperpolarization comes and the excitability falls, it is a a **subnormal excitability** phase. At this moment the epiliminal stimulus is required to cause the answer-back reaction.

Under natural (physiological) activity conditions in human being organism the muscle shortness degree can be various.

One can differentiate the following types of muscular contraction according to the shortness size:

1) **isotonic** is the muscular contraction, at which its fibers are shortened at a constant external load (under real conditions such type is practically absent);
2) **isometric** is a muscular activation type, at which it develops a strain (tension) without the length change, it underlies the static work;
3) **auxotonic** is a regimen, in which the muscles develop a tension and are shortened, such reductions are the characteristic of walking, run, sailing.

The muscles have the certain force. The **myodynamia (muscle force)** is the greatest load size, which it can lift. There is a concept of an **absolute muscle force** - it is a maximal load, which the muscle lifts on 1 sm of transversal physiological section. For example, at a masseter it makes - 10,0 kg /sm^2. Besides there is a concept of a **relative muscle force**. It is the muscle ability to rise of a load on unit of a muscle anatomic section (is measured in kg / sm^2).

The muscular force grows during all period of a childhood, but especially intensively - in young age. At the second childhood period beginning the force of the majority of muscular groups in boys and girls does not differ. By 12-15 years of age, the muscles force in boys becomes approximately on 30 % more, than in girls. With age especially after 8 years, the ability to performance of long muscular work – endurance - is enlarged. It is higher in boys.

The muscular work is determined by product of mass of the lifted load on muscle shortage size. All human muscles **useful action coefficient** is equal to 15-25 %, at trained people it is higher - 35 %. There is a **law of average loads**, at which the muscle is working for a long time at average loads in an optimum (average) contraction rhythm. At long-termed exercise the **working muscular hypertrophy** develops. There occurs the whole musculation mass and each muscular fiber mass augmentation. At a hypodynaemia muscles atrophy comes. At long mode of operations of muscles **weariness** comes - subjective status, and then the **fatigue** develops. The objective attributes of ability to work hard decreasing join to the feeling of weariness: the force, endurance, rate of impellent (motor) reactions falls. One can distinguish the acute fatigue - the result of a hard work (for example, sport

competitions) and the chronic fatigue - the result of repeated regular influence of loads without regular rest.

Fatigue reasons:

1) accumulation metabolites (lactic, pyruvic and other acids, ions suppressing an action potential) in muscular tissue;
2) power (energy) musclular stocks exhaustion (glycogen, ATP);
3) infringement as a result of a muscular circulation tension;
4) nervous centers efficiency (capacity for work) change. The efficiency is quickly restored at active rest, when there is activity kind change or change of working bodies (organs).

At dynamic work:

- hypoxy in cells;
- substances decomposition products accumulation;
- energy forming decreasing.

At stathic work:

- nrevous center, innerving muscle, fatigue

In musclular work there can be two statuses:

1) **dynamic** - there is a load moving and movement of bones and joints;
2) **static** - the muscular fibers develop a strain (tension), but are not shortened almost (deduction or restraining of a load). The static work is more tiring, than the dynamic one.

In a whole, the sceletal muscles play an important role not only in body moving in space, parts of a body opposite each other, pose maintenance, but also they take part in blood and lymph movement, heat producing, an inspiration and exhalation (expiration) act, they are the depot of liquids and salts, glycogen, provide mechanical protection of cavitary bodies (organs). And, at last, the movements caused by skeletal musculation work, are the powerful antistressful factor.

It's interesting to know

Muscles of expression

Face expression is one of display of human being's rich emotional life. It depends on similar muscles set. It has been estimated that their amount on face and neck is approximately equal to 25 per cent. Face muscles are often called expression muscles although there are 2 main types of face muscles:

- muscles of expression;
- chewing (masticatory) ones.

They are fixed to bone with its one end, with another one – they are plaited into skin. Skin tension is changed and skin relief is changed at their contraction. Thus definite face display (expression) is formed. Truth is the statement: "Everything is written at his face".

- Forehead muscle is called muscle of patience or malice.
- Muscle that moves eyebrows are called muscle of pain.
- Orbicular muscle upper part is called muscle of thinking, surprise and piety.
- Jugal (zygomatic) muscle is considered to be muscle of joy.

- Orbicular muscle lower part –of submissiveness and friendly attitude to someone.
- Muscle rising upper lip – muscle of crying and bitter tears and stinginess (niggardliness, miserliness).
- Around the mouth muscles of laughter, envy (jealousy), grief, misfortune and disgust.

Sceletal muscles contraction

Brain and cerebellum
↓
nervous impulses
(motor nerves)
↓
muscular fibres excaltation
↓
muscular contraction

Muscular contraction and relaxation mechanism

(algorythm) – sliding theory by H. And A. Huxley:

Nervous impuls
↓
muscular fibres irritation
↓
electrical impuls occuring in muscle
↓
mediator (acetylcholin) releasing
↓
calcium and ATP energy releasing
↓
calcium+throponin
↓
throponin+ thropomyosin
↓
thropomyosin+actin
↓
actin and myosin interaction
↓
myofilaments sliding
↓
sarcomer contraction
↓
muscular contraction (or tension development)
↓
calcium hiding in endoplasmatic reticulum
↓
muscular relaxation

Muscles physical features

- force;
- endurance;
- tonus;
- contraction velocity;
- work.

Sceletal and smooth muscles comparative characteristics

Sceletal muscles	*Smooth muscles*
1	2
They are the structural part of fuleral-motor apparatus They have no plastic tonus They have fast short-termed depolarization and short absolute refracterity period They have no the ability for differentiation and division They are innerved by somatic nervous system They are contracted under impulses transducting through the motor nerves from spinal motoneurons (automatism absence) They have the ability to fast phasic contractions They realize arbitrary muscular movements that are accompanied by significant energy loss They have weak sensitivity to chemical substances They react to medicines in some extent	They are the structural part of inner organs and vessels membranes (tunics) They have plastic tonus They have slow depolarization and long-termed absolute refracterity period They have the feature of differentiation, division and regeneration under injury They are innerved by vegetative nervous system and have their own innervation apparatus (metasympathic nervous system They are contracted both under impulses that occur in muscles themselves (automatism existance) and impulses transducting through vegetative nerves They have the ability to long-termed tonic contractions They realize arbitrary muscular movements that are accompanied by insignificant energy loss They have high sensitivity to chemical, pharmacological, endogenous and exogenous biologically active substances They react to medicines in large extent

Materials and methods: vertical myograph, stimulator, irritating electrodes, kymograph, strand, preparation instruments set, gauze napkins, Ringer's solution.

Investigatioin object: frog.

Task 1. Sceletal muscle contractions curves registration

a) 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.

b) *Infused (incomplete) tetanus.* Right after the separate muscular contraction curve the investigator performes 10-20 fast going one after another key closing and unclosing. As a result imperfect, incomplete summation of separate muscular contractions - infused (incomplete) tetanus – occurs.

c) *Smooth (complete) tetatus.* For its receiving the muscle must be irritated with high freaquency – 50 oscillations per second. Electrods must be brought to the unconstant current electrofeeding 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.

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

Task 2. Frog's stomach smooth muscles contractions registration

To cut the ring 5 mm wide from the frog's stomach. One end should be fixed on motionless hook, another one – on hook connected with writing lever. Hooks are the electrods in parallel. As the smooth muscles excitability is low one should use strong and long-termed current for the irritation. Kymograph must have very slow working (movement).

To registrate and to analize smooth muscles contractive process. To compare with the frog's sceletal muscle contractions registration.

Control questions.

a) Call and characterize main muscles types according to structure and function peculiarities.

b) Describe the gliding (sliding) fibres theory, explaining muscular contraction.

c) Call contractive protheins (effector, regulatory) and tell about their role in course of muscular contraction.

d) Give the definition of:

- sarcomere;
- sarcoplasmic reticulum;
- A-disc (anisotropic);
- I-disc (isotropic);
- Z-line.

e) What muscles are arbitrary (voluntary) and what are involuntary ones? What do these terms mean?

f) Where and in what organs are there sceletal and smooth muscles?

g) Give the definition of isotonic and isometric contractions.

h) What is the trigger mechanism of sceletal muscles action potential?
i) Why tetanic contraction level is bigger than single contraction level?
j) Draw the curves of sceletal muscle excitability change in course of its exaltation.
k) What are the differences between smooth and sceletal muscular contraction?
l) Give the characteristics of smooth muscles excitability, conduction and automatism.

PRACTICAL WORK 6

HEART MUSCLE BIOPHYSIC FEATURES. CONDUCTIVITY, CONTRACTIVITY, AUTOMATISM, EXCITABILITY

Sceletal, smooth and heart muscle comparative characteristics

Indexes	Sceletal	Smooth	Cardiac (Heart)
Chronaxy, msec	0,08-0,4	2,0-3,0	20,0-40,0
Refracterity period, sec	0,005-0.01	0,3-0,4	tenth fractions of second
Contraction velocity	Large	Small	Rhythmic
Fatigue	They are getting tired quickly	They have ability to long-termed contraction (plastic tonus – see below)	They are indefatigable (tiredless)
Exaltation conducting velocity, msec	6,0-11,0	1,0-4,0	0,5-1,0
What are the muscles structural parts?	Muscular fibres	Unstriated myocytes	Striated myocytes
Striating (strias)	Present	Absent	Present
Contractile protheins localization	Actin and myosin fibres are alternated	Contractile protheins don't have special order	Contractile protheins actin and myosin have special order in their localization
Separate contraction longitude, sec	0,1 3 periods: 0,01 sec – latent period; 0,04 sec – shortage period; 0,05 sec – relaxation period	1,0	0,8 - one heart circle Phases: atriums systole – 0,1 sec; ventricles systole – 0,3 sec; heart pause – 0,4 sec: - atriums diastole 0,7 sec and ventricles diastole 0,5 sec (0,7+0,5-0,1-0,3=0,4)

Laws of work	☐ all muscle – force law; ☐ separate fibre – "everything or nothing"; ☐ "time-force" law.	None of them	"everything or nothing"
Main features:	☐ excitability; ☐ conductivity; ☐ contractility; ☐ elasticity (ability to develop tension at stretching); ☐ lability.	☐ Its elasticity is more expressed in comparison with the sceletal one; ☐ Plastic tonus – ability to long-termed contraction without further relaxation (f.ex., any vessel can't be dilated or constricted in the maximal extent) ☐ Answer reaction to stretch (staining) – contraction; ☐ Automatism (all myocytes)	☐ one can differentiate typical (contractive, working) and atypical (automatical) myocardium; ☐ excitability decreasing from heart base to its apex (from venous end till arterial one) – Gaskell's law or gradient, the reason of which is the following: atypical cardiac muscle excitability is more because its threshold is less (20 mV comparatively with typical myocardium- 25 mV).; ☐ conductivity possess both typical and atypical myocardium, it is different in different heart locuses: - atrium 1m/sec; - a/v node 0,02-0,05 m/sec (a/v delay the duration of which is 0,05-0,06 sec); - ventricle –

			1m/sec; - Purkin'e fibres – 4,0-5,0 m/sec Right atrium is contracted first, then (after 0,01 sec – left one), ventricles are contracted simultaneously (at the same time).
Tetanus existance	There are 2 main tetanus kinds: 1) Complete or smooth; 2) Incomplete or infused.	Smooth muscle doesn't give any tetanus	Tetanus is impossible: during systole there is the phase of absolute refracterity (heart muscle excitability is equal to zero because membrane potential=0). In course of diastole - extrasystole (unsheduled) muscular contraction occurs. There are 2 main extrasystole kinds: physiologic one (physical training, emotional reactions, sauna) and pathologic one.
Action potential peculiarities	6 phases (see above)	1) it is located at zero level for a long time; 2) exaltation period is absent.	1) In typical myocardiocytes – fast increasing action potential. It has long-termed absolute refracterity period (0,3-0, 33 sec). 2) In atypical myocardiocytes (mainly in sino-atrium node) - slow increasing action potential. It has spontaneous slow diastolic depolarization.

Materials and methods: kymograph, universal strand, Engelman's cardiograph with light two-armed lever, fuze plate, instruments set, cotton wool, Ringer's physiological solution, thread.

Investigatioin object: frog.

Task 1. Frog's heart activity observation and registration

Frog must be motionless without decapitating. To dissect carefully thoracoabdominal cavity, pericardium, to denude heart and to observe his work. To pay the attention to the order of different heart parts contractions.

You can see venous sinus contractions better if heart is raised by its apex and its dorsal surface is observed. Venous sinus is separated from atriums by white stripes.

To count heart beating freaquency for 1 min, then to registrate electrocardiogram. To gain this it's necessary to catch heart apex by serfin.

Using received heart beating frequency for 1 min they count the frog's heart cycle duration.

Task 2. To draw in increased habitus the scheme of 2-3 cardiac contractions and mark on it:

1. Atriums systole.
2. Atriums diastole.
3. Ventricles systole.
4. Ventricles diastole.
5. Common heart pause.

Task 3. Stannius experiment (frog's heart different regions automatism degree study)

Having catched heart apex by serfin, to registrate cardiac contractions. To count their amount for 1 min.

To put the first (isolating) ligature between venous sinus and atrium. To registrate heart work having counted cardiac contractions number for 1 min. To stretch the thread under aortas and to put the second ligature (irritating) on the border between atriums and ventricle. To registrate heart work having counted cardiac contractions number for 1 min. To put third ligature to lower ventricle third and to mark heart apex state. Then it's necessary to cut heart apex and to put it on the subject table with Ringer's solution drop. To irritate heart apex with needle puncture and to note it's reaction.

To draw the experiment scheme in copy-books, making the conclusion about pacemakers.

Task 4. To draw human conducting heart system scheme
and to indicate excaltation conducting velocity through atriums and ventricles typical and atypical fibers.

Task 5. Refracterity and ventricle extrasystole receiving

Frog must be motionless without decapitating. To dissect carefully thoracoabdominal cavity, pericardium, to denude heart and to observe his work. To fix heart apex with serfin and to registrate electrocardiogram. One of irritating electrodes is attaching to the sefrin. The second electrode must be located on heart base. They have to select such a voltage that the frog's heart reacts but the animal doesn't shudder. Short-temed irritation must be realized during ventricles systole. To repeat it some time.

Then to irritate the ventricles in course of dyastole. After 3-4 normal contractions one should repeat the irritation. Mark the extrasystole and compensatory pause. Draw the scheme in your copy-book.

Task 6. To compare myocardium answer to the irritation force increasing

To put the first ligature by Stannius (see above). The registration must be done on stopped drum (it's necessary to turn it by hand). The heart contraction is registrated as vertical line. To mark irritation threshold. To registrate cardiac muscle answer to the increasing stimulus force (one should use constant current). The investigator must use 4-6 stimuli including threshold level.

To analyse the character of cardiac muscle answer according to the irritation force. It's very important to use equal time spaces between irritations (approximately 30 sec).

Task 6. To draw the curve of cardiac muscle excitability change in course of single excaltation cycle

One should indicate on the figure:
1) myocardium length change;
2) membrane potential change;
3) cardiac muscle excaltation change.

Control questions.

1. What fibers in myocardium do you know?
2. What subcellular structures do cardiac muscular fibers consist of?
3. Tell about cardiomyocytes contraction mechanism.
4. What are differences between sceletal, smooth and cardiac muscles?
5. What is heart cycle? Call its duration and main phases.
6. What do you know about membrane resting and action potential ion bases in myocardium?
7. What's the nature of repolarization phase?
8. Myocardiocytes acting potential phases.

9. Cardiac automatism, its biological role.
10. Diastolic depolarization and threshold potential significance in heart automatism supporting.
11. Cardiac conduction system main elements.
12. What peculiarities of excaltation transmitting in atriums and ventricles do you know?
13. What are the main peculiarities of excaltation transmitting through atrio-ventricular node?
14. Relative and absolute heart refractiveness.
15. What is the refracterity period significance for heart activity?
16. Extrasystole and compensatory pause as they are.
17. Cardiac muscle contraction laws.
18. Law "everything or nothing" limitation for cardiac muscle.
19. Primary myocardium fibres length influence on contraction force.
20. Physical-chemical processes in myocardium in course of its contraction and relaxing.

PRACTICAL WORK 7

INVESTIGATION OF EXCITATION CONDUCTANCE THROUGH NERVOUS FIBRES AND NERVOUS-MUSCULAR SYNAPSES

A **synapse** is a functional point of contact between 2 neurons that transmits impulse from first to the second neuron.

TYPES:

1. **According to communicational basis**:
   - Axo-somatic.
   - Axo-dendritic.
   - Axo-axonic.
   - Dendro-somatic.
2. **According to nature:**
   - Electric synapses (ephapses).
   - Chemical synapse.
3. **According to mediators –** only chemical synapses.
4. **According to ending effect:**
   - Stimulating – both electrical and chemical ones.
   - Inhibiting- only chemical ones.

SYNAPSE STRUCTURE:

1. Presynaptic terminal.
2. Synaptic cleft.
3. Receptor site on post-synaptic neuron.

SYNAPSE OR SYNAPTIC TRANSMISSION PROPERTIES:

1. Fatigue – they may get tired maximally of all nervous system elements.
2. Synaptic delay.
3. Forward conduction.

4. Spatial summation.
5. Temporal summation.
6. Synaptic block.
7. Divergence.
8. Inhibition.

EXCALTATION CONDUCTING LAWS THROUGH NERVOUS FIBRE:

1. Of isolated impulse conducting.
2. Of two-sided conducting.
3. Of physiological integrity.

MAIN PHYSIOLOGICAL PROPERTIES (CHARACTERISTICS) OF NERVOUS FIBRES OF DIFFERENT DIAMETER

Fibres type	Fibres diameter (mcm)	Transduction velocity (m/sec)	Main function
A_α	13-22	70-120	☐ sceletal muscles efferent fibres; ☐ receptors (muscular spindles) afferent fibres
A_β	8-13	40-70	afferents from pressure and touching receptors
A_γ	4-8	15-40	☐ receptors (muscular spindles) efferent fibres; ☐ part of afferents from pressure and touching receptors
A_δ	1-4	5-15	afferents from skin temperature and pain receptors, partially pressure
B	1-3	3-14	autonomic nervous system pregangliar efferents
C	0,5-1,5	0,5-2	☐ autonomic nervous system postgangliar efferents; ☐ pain and warmth skin receptors afferents

Materials and methods: current source, electrodes, preparating plank, glass plate, ligatures, kymograph, myograph, current source, Ringer's solution.

Investigatioin object: frog.

Task 1. Isolated impulse conducting law (through nervous fibres).

The students must prepare the preparation of frog's lower extremities with skin taking off and with 3 lower vertebras saving. You should ligatured each of nervous

fibres at the place of sciatic nerve exit from the spine and to separate from the spine. Students must irritate every fibre of sciatic nerve one after another with weak electrical current, while observing different irritation phenomena at it.

Task 2. Two-sized conducting law.

Students must make frog's extremity and preparated sciatic nerve so that not to hurt branchlets passing to the musculus quadriceps femoris and gastrocnemius muscle. One should irritate the nerve by electrical current near gastrocnemius muscle and observe the contraction both musculus quadriceps femoris and gastrocnemius muscle.

Task 3. Physiological inrtegrity law.

Put the preparation on glass plate. To irritate the preparation nerve by electrical current. Frog's leg is bended. To put the ligature on sciatic nerve. To irritate the nerve by electrical current again. The muscle doesn't contract. If you attach the electrodes so that the ligature is between 2 electrodes the leg will be contracted. To repeat the examination but to use cotton wool tampon washed in novocain solution despite ligature.

Task 4. To study fatigue (tiredness) ability in synapse.

To prepare nervous-muscular preparation and to fix it into myograph. To irritate this preparation nerve with optimal freaquency and force (voltage 1-5 V, freaquency 50-100 Herz), to registrate myogram till tiredness becoming; to move electrodes to the muscle having increased the irritation force till optimum for tired muscle (10-20 V) and to continue to registrate myogram. The contraction altitude must get increased at it.

In conclusion: students must underline main synapses tiredness reasons and to mark that synaps is the most highly-tired structure in a whole central nervous system.

Control questions.

1. Nervous fibre structure.
2. Nervous fibres 2 kinds and their peculiarities.
3. Nervous fibre action potential.
4. Exaltation conducting laws through nervous fibre.
5. Excaltation conducting ways (mechanisms) through nervous fibres of different types.
6. Synapses structure peculiarities and classification.
7. Chemical synapses and electrical synapses functional features.
8. Ion mechanisms of exciting post-synaptic potential (EPSP).
9. Exciting mediators.
10. Nervous-muscular and central synapses distinguishing features.
11. Synaptic lack and its physiological role.

CONTENT MODULE 3: "ORGANISM FUNCTIONS NERVOUS REGULATION"

PRACTICAL WORK 8

REFLEX ARC INVESTIGATION. RECEPTORS PHYSIOLOGY

The idea about the fact that organism having nervous system has the possibility to react to the external stimuli action by type "buttom-answer" was pronounced by French phylosophist *Renej Decart* (XVIIth century).

The term "reflex" was introduced by *Irgi Prochazka* at the end of XVIIIth 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) the response 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): 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:
   - Voluntary muscle.
   - Smooth muscle.
   - Glands.

Reflex arc types:

1) - Simple – without associative link.
   - Complex – with associative link.
2) – Monosynaptic (little amount).
   - Polysynaptic: tendinous, from skin flexors et al.
3) - 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) Subliminal fringe.
14) Central inhibiton.
15) Rebound phenomenon.

Reflexes classification:

I. According to reflectory arc formation:

Uncondioned	*Conditioned*
Inborn and transmitted by hereditary to all individuals; they are present at birth. Examples: swallowing, breathing, salivation (sialorrhea).	They are aquired 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 inconditioned reflexes.
They are realized at the 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:

1. Monosynaptic.
2. Polysynaptic.

III. According to main arc neurons localization:

1. Spinal.
2. Stem:
   - bulbar;
   - of pons cerebri.
3. Cerebellar.
4. Mesencephalic.
5. Subcortical.
6. Cortical.

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

1. Interoceptive.
2. Proprioceptive.
3. Exteroceptive or:
4. Nociceptive.
5. Visual.
6. Gustatory.
7. Auditory et al.

V. ***According to receptors localization:***

1. Superficial:

A. Skin:
- cremasteric,
- planter,
- abdominal et al.

B. From mucous membranes:
- corneal;
- conjunctival et al.

2. Deep:

A. Muscular.

B. Tendinous:
- biceps jerk;
- triceps jerk;
- knee jerk;
- ankle jerk et al.

C. Periosteal:
- carporadialis et al.

VI. ***According to biological significance:***

1. Sexual.
2. Defensive.
3. Alimentary et al.

VII. ***According to principle - what part takes part in reflex realizing:***

1. Somatic.
2. Vegetative.

VIII. ***According to ending result:***

1. Alimentary.
2. Respiratory.
3. Cardiac.
4. Vessel.
5. Salivatory et al.

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

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

Receptors classification

I. ***According to the localization: 1. Exteroreceptors:***

A. Skin

B. Visual mucosas (particularly of oral cavity)

2. Viscereroreceptors:

A. *Interoreceptors* – in inner organs

B. *Proprioreceptors* – in motor apparatus.

II. ***According to the activity character:***

1. Exteroreceptors:

A. Contact:

a) tactile (cutaneous):

- tactile corpuscles for touch;
- Pacinian corpuscles for pressure;
- Rouffinian bodies for vibration

b) temperature:

-free nervous terminals for heat;
-end bulb of Krause for cold;
-receptors of burniing sensation

c) nociceptors (pain receptors):

-of skin;
-of mucosas (visual

d) of taste (4):

-for bitter;
-for sugar;
-for salty;
-for sour.

B. Distant:

a) photoreceptors (to light);

b) phonoreceptors (to sound);

c) olfactory;

d) temperature (if the irritation source is very powerful)

2. Interoreceptors:

A. Presso (baroreceptors):

-in vessels;
-in sex organs.

B. Chemo-receptors.

C. Nociceptors.

D. Temperature.

3. Proprioreceptors:

A. Muscular (muscle spindle)

B. Tendinous (Golgi tendon organ)

C. Of ligamentum

D. Of joints

E. Of vestibular apparatus.

III. ***By the nature:***

1. Mechanoreceptors.
2. Thermoreceptors.
3. Nociceptors.
4. Electromagnetic receptors (which detect light on the retina of an eye)
5. Chemoreceptors – they detect:

- taste in the mouth;

- smell in the nose;
- oxygen level in the artery blood;
- osmolality of the body fluids;
- carbon dioxide.

IV. ***According to structure:***

1. ***Simple (primary-sensing)*** – nerve ending:
- olfactory;
- cutaneous.

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

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 peripheral structures:</u>
- gustatory;
- temperature;
- tactile;
- nociceptive;
- proprioceptive.

2. <u>On functionning specificity:</u>

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 "<u>oral analizator</u>".

Receptor parts of mandibular-facial region sensor systems are powerful reflexogenic zone from which different organism system reflectory reactions are origined. The most complete investigations were dedicated to alimentary function changes occuring in course of oral cavity receptors irritation. There are salivatory reflexes, gastric and pancreatic juice releasing. Motor activity of alimentary tract different parts for example mastication and swallowing, stomach movements are realized reflectory at facial-mandibular region irritation too. One knows influencings from facial-mandibular region to heart-vascular system; at oral cavity washing with sweet solutions extremities vessel are dilated; with sour and bitter – are constricted.

Under impulses from oral cavity receptors metabolism, muscular tone, haematopoiesis are changed.

Tactile receptors in different parts of facial-mandibular region are located unequally: maximally densely – at tongue end, oral mucosa and red lip limb. Probably, it is determined by the fact that these structures are first instation for analizing of mechanical features of substances coming into oral cavity. Superior lip (mucosa and red limb) is more sensitive to mechanical irritations than the inferior one. High level of tactile sensitivity has hard palate mucosa. It is of special importance at food aprobation (orienting mastication phase on electrogastrography – see below) as well as alimentary piece forming in the very beginning of swallowing. Minimal tactile sensitivity possesses gims vestibular surface mucosa. Moreover, the sensitivity from the right is larger, than from the left. Such asymmetry is determined by innervation peculiarities: nervous receptor structures amount is maximal from right face side.

Temperature sensitivity. Warm sensitivity is increased from anterior oral cavity part to posterior part. Cold sensitivity is decreased from anterior oral cavity part to posterior part. Cheeks mucosa has small sensitivity to warmth, smaller - to coldness. Warmth perception is absolutely absent in hard palate center. Central part of posterior tongue surface percept neither cold nor warm stimuli. High sensitivity to thermostimuli possess tongue end and red lip limb. In course of food taking these regions are irritated first.

Nociceptive sensitivity. Nociceptors of facial skin and oral cavity mucosas are represented by free non-incapsulated nervous fibres, having different shape (hairiness, spirals, plates). Minimal nociceptive sensitivity is on gims oral surface (on the right is bigger than on the left). It is connected with more significant innervation of right face half. On cheek internal surface there is a locus that doesn't have any painful sensitivity. Expressed painful sensitivity has mucosa part on a mandibule vestibular part in lateral incisives region. Maximal nocecoceptive sensitivity is a characteristics of frontal gingival papillas. It is decreased near masticatory teeth gingival papillas. Painful irritation thresholds are less on mandibule. In periodontal tissue one can find out both free nervous endings and receptors (Meisner's bodies). Free nervous endings are ended either in form of separate fibres or their collaterals in a shape of bushes and baskets and are primarily located in alveolar dental part and apical root's one third. Perpendicularly oriented connective tissular periodontal fibres are penetrated into nervous endings plexes. Such anatomic organization helps to activate periodontal receptors easily while pressure to the tooth or touching to it. At excessive pressure this system serves painful sensations origin.

Maximal nocecoceptors number are located in tooth tissue. For example, in 1 cm^2 of dentine 15000-30000 nocecoceptors are located, on the boarder between enamel and dentine their amount reaches 75000 (for comparison: in 1 cm^2 of skin their amount is up to 200 receptors of pain). Dental pain is considered to be one of the strongest pains occurs at teeth injuring by pathologic process. Tooth treatment stops it and liquidates it. But the treatment itself is a very painful procedure. Besides, at denturing one should often denture a healthy tooth that also causes sense of pain.

Dentine, not covered by enamel has high sensitivity to polymodal stimuli – temperature (coldness, warmth), chemical (high- and low-concentrated solutions independently from their content), mechanical (pressure fluctuations). Dentine receptors irritation cause pain sensation. They connect high dentine sensitivity with free nervous endings existance in dentine channels (tubules). Besides, there exists also dentine sensitivity "hydrodynamic" theory. According to this theory, external pressure or temperature increasing leads to fluid pressure or temperature rising up in dentine channels as well as to odontoblasts processes transition. Such odontoblasts have tight connection with pulp nervous endings. One of dentine receptors functions is, probably, dentine channels identification. These channels are opened externally for harmful factors penetrating (toxins, enzymes, microorganisms) in the result of injury.

Pulpal receptors irritation, even easy touching causes very strong painful sensation. In pulp crown's part nervous fibres and free nervous endings form expressed odontoblastic net. Part of thin nervous fibres penetrates through dentine channels in dentine up to enamel – dentine boarder. In pulp there are also fibres with dilations and perivascular nervous endings among thin myeline-free endings. Afferent pulpal fibres belong to A-beta, A-delta and C. A-beta fibres are activated by mechanical actions to dental dense tissues; A-delta fibres conduct (transmit) excitation in course of mechanical and thermal stimuli; C-fibres are activated at a very strong thermal irritation.

Materials and methods: istruments preparation set, metronom, stand, acids set (sulfuric acid 0,1%, 0,3%, 0,5%, 1,0% solutions), Ringer's solution; glass, threads, novocain solution.

Investigation object: frog.

Task 1. **Receptive field definition.**

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 disappearing. 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 flexible 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 response 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 to wash the animal from acid residues.

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

Task 2. Reflex arc analysis.

To prepare spinal frog and to hang it with inferior jaw on a stand. To put one of her legs in 0,5% of sulfuric acid.

Convince in reflex existance. To do round skin incision below knee jerk and to release the leg from its skin. To irritate this leg tibia again. To observe the reaction.

To cut other posterior (inferior) leg femur skin of the same frog and to prepare sciatic nerve over the distance of 1,5-2,0 cm. To bring the thread under the nerve but not to tie it. To call flexion reflex by means taking this leg fingers ends into acid. Then to tighten the nerve carefully by the thread and put the cotton wool washing into novocain solution under it for excaltation transduction blocking into sciatic nerve fibres. To check the reflex existance.

To check the reflexes existance on superior legs.

To destroy the spine and to observe all reflexes disappearing.

On the base of investigations performed make the conclusion about reflex arc structure. Designate their links.

Task 3. Gustatory receptors functional mobility determining (before and after eating)

To be convinced of eating leading to demobilization i.e. actively functionning gustatory receptors number decreasing.

The work must be performed on an empty stomach or at least after 3-4 hours after eating. The experienced person tongue must be dried with filter paper. Gustatory stimulus (sugar solution: 8 gramms of sugar for 20 ml of dist water) must be taken on separate tongue fungiform papillas with pipette. 4 papillas becomes differentiated at this that give sweet taste sensation. It is one probe. Students must perform 5 probes with intervals 1-2 minutes between them. One must rinse mouth out after every probe. You should investigate the same papillas. The gustatory sensation appearing is marked in protocol with sign "+", the disappearing- "-". You should count positive answers common number and express mobilization level in per cents. The investigations must be repeated after eating (sweet tea glass with white bread). The investigations results must be in the table.

Papillas number	Functionning gustatory papillas amount									
	Probes					probes				
	1	2	3	4	5	1	2	3	4	5
	Before eating					After eating				
1										
2										
3										
4										
5										
Conclu-sion	Mobilization level, %					Mobilization level, %				

Control questions.

1. The term "reflex".
2. Reflex receptor zone.
3. Reflex reflectory arc and its structure.
4. Reflex time.
5. Reflexes classification.
6. Reflectory arcs types.
7. Receptors distingushing features.
8. Receptor and generating potential.

PRACTICAL WORK 9

EXCITATION PROCESSES INVESTIGATION IN CNS. REFLECTORY PROCESSES COORDINATION PRINCIPLES.

Organism reflectory activity is defined by general features of nervous centres in more extent. In narrow context, **nervous centre** is synapse as itself and in wider aspect it is neurons complex located at different floors of CNS (this term is not anatomical, but physiological one). Main function of any nervous center is definite reflectory acts performing or managing one of organism functions.

Principle of dynamic functions localization - functional nervous centre may be localized into different anatomical (morphological) structures.

Nervous centres hierarchy – separate sides of one organism function are managed by nervous centres localized at different levels of nervous system.

Nervous centres common features are the following:

1. One-sided impulse (excaltation) conduction.
2. Excaltation transduction lack.
3. Summation:
   - temporary (consequent);
   - spatial.
4. Excaltation rhythm transformation:
   - reducing;
   - increasing.
5. Automatism.
6. Chemothropy.
7. Reflectory afteraction.
8. Tiredness.
9. Rhythmical activity.

Main co-ordination principles:

1. Dominanta.
2. Of common ending way.
3. Convergency.
4. Induction.
5. Divergency.

6. Irradiation:
   - ☐ elective;
   - ☐ diffuse.
7. Occlusion.

Materials and methods: current source, electrodes, preparating plank, glass plate, kymograph, current source, metronom, cotton wool, napkin, natrium chloridum, 0,5% solution of sulfuric acid.

Investigatioin object: frog.

Task 1. Temporary excitation 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 shoud 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 freaquency of 1 Herz, 20 Herz.

Task 2. Excitation summation.

Thalamic frog must be hang 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.

Task 3. Excaltation irradiation in central nervous system.

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.

Control questions.

1. Nerve center definition, its main parts.
2. Excaltation transduction way in nervous centers.
3. Exciting post-synaptic potential.
4. Nervous centres distinguishing features.
5. Main coordination principles in CNS.

PRACTICAL WORK 10

INHIBITING PROCESSES IN CNS

Inhibiting is a special active process expressing in diminishing or complete disappearing of answer reaction. It is the form of resistant, non-fluctuating excaltation that occurs as a result of strong or long-termed action of any irritation.

There are 2 main kinds of inhibiting:

1) *Primary* – it occurs at participance of inhibiting neurons (for examples, Renshow's cells).
2) *Secondary* – it occurs without inhibiting neurons, as the result of strong excaltation neuron.

Task 1. Sechenov's (central) inhibiting.

To nuddle frog's brain and to separate big hemispheres at visual tubercles. To determine reflex time after drying while using 0,5% acid solution. To make 5 measuring and to receive the refelex time average number.

After this to dry incision locus and to put the salt crystal to the visual tubercles. After 1-2 minutes to determine reflex time again. To make 5 measuring like at the first case.

After exact inhibiting of moving reflex to liquidate salt crystal, to wash the experimental place by Ringer's solution and after 5 min to repeat the determining of reflex time. To make sure that it became the first one (like before the inhibiting).

I.M.Sechenov determined centers in brain that inhibit spinal reflexes. He showed the role of these centers in reflectory co-ordination of moving acts. The experiment you have performed lately is the classical one and it hasn't been changed since its discovering by Sechenov.

Main conclusion from this experiment is follows as: inhibiting is an active process occuring as excaltation while irritation of any loci of central nervous system. The role of Sechenov's discovery: he established simultaneous existance of excaltation and inhibiting process in CNS.

Control questions

1. Inhibiting definition.
2. Inhibiting types.
3. Inhibiting significance for organism.
4. I.M.Sechenov's role in inhibiting study.

CONTENT MODULE 4: "CNS ROLE IN MOTOR FUNCTIONS REGULATION"

The nervous system is responsible for sensory and motor activities, for behaviour (instinctinctive and learned) and for regulating activities of the internal organs and systems.

The nervous system as a whole may be divided into 2 systems: the central nervous system (CNS) and the peripheral nervous system (PNS). The CNS, consisting of the brain and spinal cord, processes sensory information and integrates it with past experience to produce appropriate motor commands. The PNS consisits of the sensory receptors (organs), which are specialized to detect changes in the external environment or in the body interior and to communicate these sygnals to the CNS via the afferent sensory nerves. Another part of PNS is the motor effectors. These consist of the voluntary skeletal muscles, responsible for body and limb movements, and the smooth muscles and glands, which effect sygnals in visceral organ motility and secretions. Efferent motor nerves extending from the CNS to these organs are also the part of PNS. Based on these different targets, the peripheral motor system has been divided into a somatic division, which deals with the voluntary skeletal muscles, and an autonomic division, which deals with the visceral effectors. Although the autonomic and somatic systems are distinct in terms of their motor output nerves and targets, they may share both peripheral sensors and a certain central nervous centers.

Different parts of brain possess different functions.

For example, **diencephalon** has such functions as:

1. Conducts excitation from all receptors to cortex.
2. Homeostasis regulation.
3. Vegetative functions regulation:
   - hunger (lateral hypothalamus) and saturation (medial hypothalamus);
   - thirst (lateral hypothalamus) and its satisfaction (medial hypothalamus);
   - thermoproduction (posterior hypothalamus) and thermoreleasing (anterior hypothalamus) et al.
4. Participation in endocrine glands functionning control.
5. Dream process and biorythms (hypophysis and hypothalamus).
6. Memory.
7. Complex motor reflexes realizing - walking, running, swimming and so on.
8. Instinctive behaviour and so on.

Brain hemispheres has such functions as:

1. Complex behaviour providing.
2. All organism organs and systems activity co-ordination.
3. Centers of all receptor systems:
   - occipital lobe – optic center;
   - temporal lobe – acoustic center, speech control, spatial analysis, memory center;
   - parietal lobe – spatial orientation, speech control, somatic sensitivity center;
   - frontal lobe – arbitrary movements, logic thinking center;
   - postcentralis gyrus – skin and muscular-articular sensitivity zone;
   - precentralis gyrus – motor zone;
   - near lateral gyrus – gustatory zone;
   - near hemispheres basis – olfactory zone.
4. Brain hemispheres cortex is functionning as a whole and is the material basis of human psychical activity.

PRACTICAL WORK 11

SPINE PHYSIOLOGY. SPINE ROLE INVESTIGATION IN MOTOR ORGANISM FUNCTIONS REGULATION

The **spinal cord** (SC) is one of the 2 main parts of the CNS. The SC is about 40-45 cm (16-18 inches) long, extending within the inner cavities of the vertebral column from the neck to the loin. Practically all the voluntary skeletal muscles in the neck, trunk, and limbs receive their supply of motor nerves from the SC. All the sympathetic and some of the parasympathetic motor outputs to the skin and visceral organs also emerge from the SC. All sensory sygnals from the peripheral receptors of the skin, muscles, and joints in the trunk and limbs are sent to the SC.

The spinal cord performs **2 basic functions.**

1. Conductive.
2. Reflectory.

It's necessary for work: neurologic hammer, human being.

Task 1. To investigate muscular tonus in human being

Muscular tonus must be determined by palpation and by passive movements in joints performing. You should determine by palpation the degree of muscular tension. Light tension is observed at normal muscular tonus. The students assess the degree of resistancy to passive movements by performing the passive movements.

At significant hypotony the movements volume is increased and they are performed without any resistance.

At hypertony passive movements at the first moments of flexion meet with strong (significant) resistance.

Task 2. To investigate surface (skin) reflexes on stretch

1. *Abdominal reflexes:*
   a) superior – it's caused by puncture irritation of abdomen skin in parallel of rib arc; the reflexes arc is closed at D_6-D_8 segments of spinal cord (from D – dorsalis);
   b) intermediate – by similar irritation but at horizontal dimension at navel level; the reflexes arc is closed at D_9-D_{10};
   c) inferior- in parallel to groin plica; the reflexes arc is closed at D_{11}-D_{12}.
2. *Plantar reflex-* is a plantar flexion of foot toes as a response of puncture irritation of external planta limb; the reflexes arc is closed at L_5-S_2 and is in sciatic nerve.

At injury of corresponding motor nerve and corresponding link of reflectory arc the response reaction is decreased or disappeared (areflexy), muscular atony, atrophy is observed.

Task 3. Deep (prophound) spinal reflexes investigation

1. *Biceps-reflex* – is caused by irritation of muscle tendon above cubital joint by neurologic hammer. Answer reaction – hand flexion in cubital joint. The

reflexes arc is closed at C_5-C_6. Afferent and efferent fibres are in muscular-cutaneous nerve structure.

2. *Triceps-reflex*- is caused by hammer shock on triceps-muscle tendon, on 1-1,5 cm upper of posterior processus of ulna. Answer reaction- muscular contraction and antebrachium (fore-arm) extension. The reflexes arc is closed at C_6-C_8. The fibres are in medianus, radialis and muscular-cutaneous nerves.
3. *Carpo-radialis reflex* –is investigated by hummer shock onto awl-like processus of radius. Answer reaction – flexure in cubital joint and antebrachium pronation. Origin location: investigated person hand must be bended at obtuse angle in cubital joint; person's examinated hand is supported by doctor's hand at the locus between pronation and supination. The reflexes arc is closed at C_5-C_8. The fibres are in medianus, radialis and muscular-cutaneous nerves.
4. *Knee jerk or patellar tendon reflex* - is caused by light shock of hummer on musculus quadriceps femoris tendon. Answer reaction – tibia extension. The reflexes arc is closed at L_2-L_4. Sensor and motor fibres are in femoral nerve. Every doctor must know how to elicit knee jerk. Knee jerk can be elicited by tapping the patellar tendon after the knee is semiflexed by placing one knee over the other while sitting on a chair or edge of a table. Immediately after the tendon tap the quadriceps femoris muscle contracts and there is jerking forward of the leg. There can be some alterations in knee jerk. Knee jerk is decreased or lost in:

- Lesions in afferent neuron e.g. tabes dorsalis (Neurosyphilis).
- Lesions in center, e.g. poliomyelitis.
- Lesions in efferent neuron, e.g. lower neuron i.e. nerve pathway from anterior horn cell to muscle.
- During sleep and anaesthesia.

Knee jerk is increased or exaggerated in:

- Upper motor neuron lesion.
- Tetany, where there is increased neuromuscular excitability.
- Neurotic subjects due to hyperexcitability of CNS.

Pendular knee jerk occurs in lesion of neocerebellum which is characterized by hypotonia. In this type of knee jerk:

- Contraction of quadriceps is weaker than in normal knee jerk.
- Relaxation of quadriceps is quicker than normal knee jerk leading to quick fall of the leg like a dead weight. This is followed by vibrations or swinging of the leg like a pendulum. Hence the name pendular knee jerk. Hypotonia is the cause of the pendular knee jerk.

5. *Achilles' reflex* – the investigated person kneels on a chair for free feet hanging. To shock with hummer on achilles' (calcaneus) tendon. Answer reaction – musculus gastrocnemius contraction and plantar foot flexion. The reflexory arc is closed at S_1-S_2. Sensor and motor fibres are in tibial nerve.

If prophound myotatic reflexes are decreased or lost it testifies to reflectory arc links disturbances. If answer reaction to the irritation is increased with

significant excitation irradiation and involving other muscular groups into the answer reaction, reflectory field spreading - it testifies to suprasegmentory central nervous system disorder existance.

Control questions

1. Innervation segmentary character and its significance.
2. Spinal centers.
3. Spinal conductive tracts.
4. Spinal reflexes.
5. Spinal shock.

PRACTICAL WORK 11

SOMATO-SENSOR SYSTEM (SKIN, PROPRIOCEPTIVE, NOCYCEPTIVE SENSITIVITY) INVESTIGATION

The **sense of pain** is a complex because it involves not only a sensation but feelings and emotions as well. For this reason, the neurophysiology of pain involves structures not normally considered as part of the sensory nervous system. Furthermore, classically, the ascending sensory (excitatory) aspects of pain sygnals have been emphasized. The intrinsic capacity of CNS structures to supress pain sygnals have recently become the focus of much attention for research.

The sense of pain is served by free nerve endings located in the skin and certain visceral tissues. Pain can be caused by stimuli of different natures. For example, strong mechanical stimuli (intensive pressure), very hot and very cold thermal stimuli, and certain chemical stimuli such as acidic substances all can cause pain. It's important to note that the pain receptors generally have a high threshold of stimulation, so, they are usually activated when stimulus strength is very high. Because such strong stimuli are usually noxious, pain sensation is also called nociception, and the pain receptors activated by nociceptive stimuli are called nociceptors. One view holds that all nociceptive stimuli cause tissue damage, the extent of which may vary from the slight effects of a simple pinch to the severe consequences of burns. Tissue damage results in the local release of certain internal nociceptive substances such as serotonin, substance P, histamine, and kinin peptides (bradykinin, etc.) in the injured tissue. These substances then act on the free nerve endings, activating pain signals.

There appear to be 2 systems of pain transmission to the CNS, which are associated with 2 distinct types of pain experience. When one steps on a thumbtack, one feels a sharp sensation, followed a while later by a more dull pain sensation. In addition to arriving earlier, the sharp and pricking sensation is short lasting, and its source can be accurately localized. The dull sensation is long lasting and diffuse; it hurts and aches, but the ache source cannot be pinpointed and generally is described to a larger body part.

It's now believed that the sharp pain is conveyed by thin but myelinated, relatively fast, nerve fibers (type A-delta), and the dull, aching, and hurting pain by unmyelinated slow conducting type C fibers. Conduction velocity in the A-delta fibers is about 10 times faster than in the C-fibers. Both types of fibers terminate in the dorsal horn and ascend by the spinothalamic pathway. Whereas the slow /aching pain signals make a major input into the brain stem reticular formation and essentially terminate in the thalamus, the sharp /fast pain signals ascend more directly to the

thalamus and up to the sensory cortex. The cortical component gives the fine localization capacity to the sharp/fast brain system, whereas the heavy subcortical projection of the dull /slow pain system to the reticular formation and the structures of the limbic system is associated with the aching/hurting component. Patients with damage to the sensory cortex can still feel pain and are hurted by it, but they are unable to accurately localize the source.

It has recently been shown that electrical stimulation of certain neuronal groups in the brain stem reticular formation makes the conscious animal completely oblivious to pain stimuli. Further research has indicated that, from the reticular formation, descending control fibers project to the dorsal horn of the spinal cord, where they suppress the relay of pain signals to the brain. The system is believed to help animals and humans cope with the debilitating hurtful consequences of pain arising during physical stress and fighting. It is presumably the active training of this descending inhibition that gives the Yogis of India thjeir great tolerance of pain and athletes and soldiers their ability to continue strugging in the face of bodily hurts and trauma.

One mechanism by which higher reticular centers inhibit pain is beginning to be understood. Descending fibers activate certain inhibitory interneurons in the dorsal horn, which release a peptide neurotransmitter called enkephalin (one of the endorphins). Enkephalin suprresses the transmission of pain signals by binding with particular receptor molecules (opiate receptors) present in the synapses of cells in the dorsal horn. The binding either decreases the amount of the neurotransmitter substance P released from the type C pain afferents or induces postsynaptic inhibition of the relay cells. Morphine and other opiate analgesics (pain killers) act in the same way as endorphins to relieve pain.

The interneurons of the dorsal horn may also be involved in a different type of pain inhibition. It has been known that skin rubbing relieves the dull /hurtful pain sensation originating from that or a nearby area. Rubbing activates the large, fast-conducting tactile fibers (type A-alpha) while pain is conveyed by C fibers. In the dorsal horn, branches of touch fibers activate inhibitory interneurons, which in turn, inhibit the synaptic transmission of pain signals. This is called a gate theory of afferent inhibition. Presumably, the more powerful tactile sygnals limit the transmission gates in the dorsal horn to their own, suppressing and excluding access for the weaker pain sygnal. The gate theory of afferent inhibition as well as central inhibition of pain by way of endorphins may have implications for the phenomenon of acupuncture analgesia.

The afferent pain fibers originating from the same area show extensive convergence onto the dorsal horn relay cells. In certain cases, the convergence may take place by fibers from different areas, causing the relay cell to be activated by pain originating in different body parts. Usually, one part is a visceral area or organ. This mechanism may underlie the phenomenon of referred pain. For example, pain originating in the heart is often left as coming from the inner aspects of the left arm. Physicians make extensive use of referred pain, for which maps have been constructed, as means of diagnosing problems in the visceral organs (e.g. heart conditions).

There exists some abnormalities of pain:

- Hyperalgesia - a pain pathway sometimes becomes excessively excitable; this gives rise to hyperalgesia, which means hypersensitivity of pain.
- The thalamic syndrom- is a collection of symptoms resulting from damage of posteroventral portion of thalamus due to thrombosis. It has 3 main features: loss of almost all sensation from the opposite body side; ataxia; after a few weeks some sensory perception in the opposite side of body returns, but poorly.
- Herpes Zoster (Shingles). It is the infection of dorsal root ganglion. This causes severe pain in the dermatormal segment normally subserved by the ganglion, thus eliciting a segmental type of pain that circles halfway around the body. The disease is called herpes zoster, or "shingles" because of the eruption. The cause of the pain is presumably excitation of the neuronal cells of the dorsal root ganglion by the virus infection.
- Tic douloureux- lancinating pains occurs in some people over one side of the face in part of the sensory distribution area of the fifth or nineth nerve; this phenomenon is called tic douloureux (or trigeminal neuralgia or glossopharyngeal neuralgia).

Pain proective zones at different teeth diseases

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

Dental pain conductive tracts and central mechanisms

Irritation from nociceptors of facial skin, oral cavity, tongue mucosa, periodontal and pulpal receptors is directed through nervous fibres (maxillar and mandibular nerves) to sensory neurons in trigeminal nerve ganglion. Their central processes go to medulla oblongata where they finish ipsylaterally on trigeminal nerve spinal tract nucleus neurons. The nociceptive afferentes largest part is ended into its caudal and intrapolar part; nociceptive fibres small part – on spinal tract nucleus collateral structures. Afferentes some part reaches reticular formation gygantocellular, paragygantocellular and lateral nuclei and suture nuclei. Mainly innociceptive information from mechanoreceptors comes into trigeminal nerve

anterior and main sensor nuclei. Collaterals large amount provides functional connection between trigeminal nerve different nuclei (nuclei trigeminal complex) that is essential for interrelations of nociceptive and innociceptive excitations. The biggest part of these tracts fibres are ended into thalamic posterior ventromedial nucleus neurons. These proections are organized according to somatotopic principle. One part of the cells of this nucleus is a specific nociceptive that are responsible for only 1 type of nociceptive stimulation, others – neurons of a wide dynamic row answering on mechano-, thermo- and chemonociceptive stimulation.

Trigeminal complex nuclei neurons give the beginning to some ascendant tracts. Thygemino-thalamic proections form 4 tracts. 2 of them – contralateral trygeminal lemnisc ("trygeminal lemnisc") and ipsylateral trygeminal tract – transmit excitation caused by innociceptive stimulation of tactile receptors of facial-mandibular region different structures. Ventral central and dorsal trygeminothalamic tracts are formed from axones of neurons of I, III-IV layers of caudal and intrapolar parts of trigeminal nerve spinal tract nucleus caudal and interpolar parts.

Essential role in propozalgias forming plays trygemino-reticulo-thalamic way transducting excitations from dental pulp and nociceptors of facial-mandibular region other structures – through reticular formation nuclei to non-specific thalamic nuclei (parafascicular, central lateral nuclei, median center, interlaminar group). This nuclear group contains mainly polymodal neurons that are responsible for various sensor stimulation. Besides, there are several neurons in it reacting only nociceptive actions. Reticular formation, specific and non-specific thalamic nuclei switching on in course of nociceptive information transmission from facial-mandibular region organs determines its coming in cortical sensor zones, to its orbito-frontal region as well as wide generalization of nociceptive excitations in lymbico-hypothalamic region structures.

In cortical sensor zones there are topical organization of representation of maxillo-facial region structures particularly of different teeth. Cortical cells responsible for dental pulp irritation are divided into 2 groups:

1) Neurons of the first group – F (from "fast" – quick) are responsible for the first and second teeth pulp stimulation with a short latent period. Information to them comes through thrigemino-thalamic tracts ending on posterior ventro-medial nucleus neurons forming direct proections in "oral" sensor cortical zone.
2) Neurons of the second group – S (from "slow") answers to the fourth-eighth teeth stimulation with large latent period. These neurons are activated through trigemino-reticulo-thalamic ways ending in non-specific thalamic nuclei that give wide thalamo-cortical proections.

They consider that *sensor zone I* forms sensor-discriminative system that defines dental pain quantity, space organization, intensivity as well as regulates motor acts appearance at nociceptive action, forms the sensation of primary epicrytic pain.

Sensor zone II takes the information not only from thalamus specific nuclei but from its non-specific nuclei too. This zone is responsible for pain perception as sensor modality excitation, potentially harmful stimuli assessment and adequate protective reactions forming, switching antinociceptive mechanisms on.

Cortical orbital-frontal region participates in a formation of complicated emotionally-affective pain expressions and psychiatric emotional reactions connected with it, especially expressed at facial-mandibular region structures injury. Nociceptive excitations generalization through intraplatelet thalamic nuclei provides limbic structures involving in the process of coming nociceptive information processing and formation of vegetative "portrait", nociceptive reaction motivational and emotional components as well as subjective emotional and adaptive reactions prolongation. The result of excitation coming into central brain parts is a nociceptive sensations forming with more or less expressed behavioral, emotionally-affective and vegetative reactions directed onto saving of facial-maxillar tissues integrity.

Convergence of nociceptive sygnals from different teeth pulpal afferents and surrounding tissues on cortical neurons is a characteristics of dental pain especially the intensive one. It provides wide excitation irradiation impeding pain localization. Sometimes dental pains can be proected not only into the region of pathologic processes development (for example, to injected tooth or parodont locus) but also to far located regions of face, head and neck (reflected pains). In the basis of proectional zones appearence lies tight interrelation of nociceptive and innociceptive neurons of different trigeminal complex nuclei as the result of rich connections between them as well as with reticular formation nuclei. Essential role is also played by thin-organized facial skin representation in brain hemispheres occupying significant region of sensor zone. It creates the possibility to nociceptive and innociceptive excitations convergency on cortical neurons providing skin sensitivity of definite face, head and neck zones with pain proection namely to these regions.

Sometimes after teeth removal (extraction) operation *phanthome pains* can be developed. They are pain sensation in removed tooth or at the region of its fixation. Phantome pains are considered to be deafferentative. Tooth retraction leads to excitability increasing with the parallel deficiency of inhibitory processes in cells of different CNS levels, providing the sensitivity for this tooth. Previous as for the preparation more or less durable nociceptive afferentation from injured tooth region provides definite base for nervous structures to excitations durable circulation. Additional afferentation at tooth extraction "sweatches on" circulation while creating the generator of pathologically increased excitations percepted by cortical neurons as durable, orten constant, pains. Involving in process the circulation of pathologically enforced excitations of several brain structures leads to the pathological algic system forming. At phanthome pains treaty measures of a local character don't lead to pains disappearing of reducing because their origin lies inside brain structures on which one should act increasing inhibitory mechanisms work.

Thermal sensation. The human being can perceive different gradations of cold and heat, progressing from freezing cold-to cool-to indifferent-to warm-to hot-to burning-hot.

Thermal gradations are discriminated by at least 3 types of sensory receptors:

- The cold receptors.
- The warmth receptors.
- The pain receptors.

The pain receptors are stimulated only by extreme degrees of heat or cold and therefore are responsible, along with the cold and warmth receptors for "freezing cold" and "burning hot" sensations.

The cold and warmth receptors are located immediately under the skin at discrete but separated points each having a stimulatory diameter of about 1 mm.

It's necessary for work: neadle, cotton wool, subject glass, weight set, human being.

Task 1. To investigate hands and face skin pain sensitivity

There may be painful sensation in face and head region at oral cavity organs diseases. For example, at the diseases of teeth of superior jaw sensation locus is localized for incisivi teeth in a region of plica fronto-nasal (it's maximal in superciliary arc at 1,5 cm from its middle); for canine teeth (fang) and premolars – in naso-labial region of corresponding side; at injury of the 1^{st} and 2^{nd} molars – in cheek region; the 2^{nd} and 3^{rd} molars – mandibular region. At pathology of teeth of mandibular: for teeth incisivi, canine teeth and 1^{st} premolar - chin region; for the 2^{nd} molar – in sublingual region maximal downwards and backwards from the mandibular angle or at region of meatus acousticus externus; at the diseases of the 3^{rd} molar maximal pain is localized in front of muscle sternocleidomastoid.

One can irritate the skin of face or hand by neadle. The irritation mustn't be too strong or freaquent. One should first determine whether the investigated person differentiates prick or touching. For this aim it's necessary in turn but without regular order to touch to skin with blunt and acute subject. While this procedure the investigated person is proposed to find out the character of influencing (blunt or acute one). The injections must be short-termed, they mustn't cause acute pain. For clerifying of the boundaries of changed sensitivity the investigation must be performed out off healthy locus and on the contrary.

Task 2. Temperature sensitivity investigation on hand

For stimuli you must use 2 test tubes (with hot – of 40-50° C and cold 25° C or lower water). One should determine first whether the investigated person differentiates warm from cold (healthy people feel the temperature difference in 2° C). Then you must compare the temperature stimuli perception intensivity on different skin locuses of hands, face and to determine the boundaries of increased or lost temperature sensitivity.

Task 3. Muscular-articular sensitivity investigation

At muscular-articular sensitivity investigation one should check up the sense of passive movements, localization sense, skin kynaesthesia, pressure and weight sense. The investigator asks the investigated person close his eyes, the first one moves the fingers of investigated person. The last (investigated person) must find out the localization of extremity. The investigated person must reproduce the localization of other extremity with his closed eyes. If he doesn't differentiates light movements

their altitude must be increased. The investigator muct touch to the investigated person's very easy without extra (spare) influencing onto the skin receptors.

Skin kynaesthesia must be checked up by shift of plica, the investigated person must determine the direction of shift.

Task 4. Pressure and weight sense investigation (Weber-Fechner's law)

The investigated person is sitting with closed eyes and puts his hand on the table. The investigator puts subject glass to the ends of investigated person's straighten fingers. The investigator puts the weight of certain mass onto the glass and the pressure sense is estimated. Then while slow increasing the weight mass the investigated person is asked when he will feel the addition in weight. The experiment must be performed several times while checking up the sensation threshold at different loading (10, 20, 50, 100 and 200 g) and the constant quantity must be estimated (K= addition size /origin weight mass).

In conclusion it's necessary to compare constants received in 5 experiments. Under norma the investigated person must tell about difference in 10% of weight mass.

Task 5. Stereognostic sense 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 characterises subject's features (dense, soft) correctly.

Control questions

1. Nociceptors structure.
2. Temperature receptors structure.
3. Spinal cord and stem nociception conductive ways.
4. Spinal cord and stem thermosensitivity conductive ways.
5. Proprioreceptors.
6. Proprioceptive sensitivity conductive ways.
7. Prophound sensitivity conductive ways in spinal cord and stem.

PRACTICAL WORK 12

POSTERIOR BRAIN PHYSIOLOGY. POSTERIOR BRAIN ROLE INVESTIGATION IN MOTOR AND SENSOR FUNCTIONS (PARTICULARLY OF MANDIBULO-FACIAL REGIONS STRUCTURES)

Posterior brain consists of pons and medulla oblongata.

Medulla oblongata functions:

I. *Reflectory:*

1. Defencive:
   - cough;
   - blinking;
   - tears releasing;
   - vomiting.
2. Alimentary:
   - sucking;
   - swallowing;
   - releasing of digestive juices.
3. Cardio-vascular (heart and vessels activity regulation).
4. Respiratory.
5. Control of volume of information conducting by spinal column.
6. Sound freaquency, intensivity and origin recognizing.

II. *Conductive.*

Task 1. Trigeminal nerve (Vth 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 close. Reflex arc – orbital nerve, pons, facial nerve.

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

Task 2. Facial nerve (VIIth 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 eyelip superior determining resistance force at this. To make the conclusion.

Task 3. 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 – 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).

A) Palatine and pharyngeal reflexes – with the paper rolling up into long strip to touch the soft palate and pharynx posterior wall mucosa. Answer reaction – 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 symdrom).

Task 4. 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 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 motionless, 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).

Control questions.

1. Medulla oblongata centres.
2. Medulla oblongata reflectory activity.
3. Brain posterior vegetative reflexes.
4. Brain posterior conductive function.
5. Reflexes the most often determined in dentistry.

PRACTICAL WORK 13

MIDBRAIN PHYSIOLOGY.

MIDBRAIN ROLE INVESTIGATION IN MOTOR AND SENSOR FUNCTIONS REGULATION (PARTICULARLY OF MANDIBULO-FACIAL REGIONS STRUCTURES)

Midbrain functions:

I. *Reflectory:*

1. Sceletal muscle tone regulation (red nucleus).
2. Preserving of body equillibrium and orienting reflexes on light and sound (corpora quadrigemina).
3. Start-reflexes performing (corpora quadrigemina).
4. Participating in mastication, swallowing, writing and other rhythmic movements (black substation).

II. *Conductive.*

It's necesstary for work: scale, rotating arm-chair, stall, guinea pigs.

Task 1. To investigate nerves: oculo-motorius (III), trochlear (IV) and abducens (VI).

While examination of eyeballs the investigator should pay the attention to the:

- pupils' width;
- orbital fissures width,
- pupil shape,
- eyeballs localization in orbit (falling back, protrusion),
- strabismus (cross-eyedness or squint-eyedness).

Pupillar reactions – the investigated person eye should be closed by scale or hand. After this it's necessary to determine change of another pupil size. To ask to perform eyes movement on the right and on the left.

At III-rd or IV-th pairs (cranial-cerebral nerves) injury orbital fissure can be narrowed or closed – ptosis. At III-rd pair injury one can see pupil deformation, disturbance convergent eyes movement disturbance.

Task 2. Stato-kinetic human reflexes.

The investigated person must sit in rotatory arm-chair, turn his head forward and close his eyes. In such position horizontal semicurcular channnels are investigated. Then it's necessary to carry out arm-chair rotation on the right or on the left with the velocity of 5 times in 10 sec (1 turn in 2 sec). Then to stop arm-chair quickly, to ask investigated person to open his eyes and to observe eyelids movements, how long do they continue. It's also possible to carry out rotation with head turned on 90° on right or left shoulder or tossed (throwed) back on 60° behind

(vertical channels are investigated). To describe investigated reactions, to call receptive fields of investigated reflexes and to indicate closure level of them in CNS.

To take another investigated person, to sit into arm-chair. To propose to turn his head on 30° forward, to perform rotation as in previous investigation, to stop arm-chair and to propose to investigated person to go after rotation directly on straight line forward. To observe movements character.

Task 3. Investigate static and stato-kinetic reflexes in guinea pig.

To put guinea pig to the table, to pay the attention to animal's pose, head location, moving reactions. To turn over the animal on his back and to lie with his abdomen up. To pay attention to movement character, their order and definite animal pose.

To put guinea pig on board, to raise and to rock the animal, in turn raising board anterior or posterior end. Pay attention to fore-limbs (anterior extremities) status and movement, head status. To put down or to raise the board very fast, while observing anterior extremities status at the beginning and at the end of the movement, animal head status.

To put giunea pig on rotating chair, to perform rotations in horizontal plane to the right or to the left, to pay the attention to animal pose shift in course of movement, to head movement in course of rotation. To indicate, what happens at the rotation beginning and at rotation stoppage.

Control questions.

1. Midbrain main functions.
2. Cranio-cerebral nerves responsible for midbrain functions.

PRACTICAL WORK N.14

CEREBELLUM PHYSIOLOGY. ITS ROLE IN MOTOR ORGANISM FUNCTIONS REGULATION.

Cerebellum.

The cerebellum, located in the back of the brain stem and attached to the midbrain, is a major motor structure involved in moltor co-ordination. Somatic motor centers (nuclei) in the midbrain are involved in regulation of walking and posture and of reflexes for head and eye movements.

The cerebellum hemispheres have two-way communication channels with both the motor cortex in the brain and the voluntary muscles in the periphery to coordinate motor perfomance. Remember that whenever a voluntary movement is desired (e.g., picking up a glass), the premotor cortex generates the movement patterns, sending them to the primary motor cortex, which then activates the muscles via the descending upper and lower motor neurons. Each time the premotor cortex sends these sygnals, it also sends a copy to the cerebellum via the cerebellar relay pathways in the pons. The cerebellum matches these commands with muscle perfomance and

signals the motor cortex via relay centers in the thalamus, informing it of any wrong commands or needs for adjustments.

At the same time, cerebellum acting through the red nucleus and its descending connections with the gamma motoneurons modifies muscle tension and the stretch reflex to being the muscles in line with motor cortex commands. Thus, the cerebellum oversees the ongoing communication between the cortex and the muscles, controlling motor perfomance.

The input from the motor cortex snd the muscles arrives via brain stem relay centers to the cerebellum cortex, where the cerebellum circuits analyze it. The outcome is relayed by the prominent Purkin'e cells in the cerebellum cortex to the deep cerebellum nuclei. Interestingly, the Purkin'e cells are inhibitory neurons, releasing GABA as the neurotransmitter. However, the neurons of cerebellum nuclei, being the real cerebellum output neurons (they innervate cerebellum targets in the midbrain): red nucleus and thalamus) are excitatory.

Thus, cerebellum has two main functions:

1. Movements co-ordination.
2. Muscular tone regulation.

It's necessary for work: investigasted person, bed.

Task 1. To investigate movement co-ordination

a) *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).

b) *Walking*- the investigated person must go on right line with his opened eyes, then with closed ones. At good performing of 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.

c) *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

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

b) *Ozhechovsky 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).

c) *Stuart-Cholms'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

a) *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 traectory (locomotory ataxy existance) and putting to mentioned place (dysmetry existance), finger's tremor.

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

c) *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.

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

Task 4. To put the attention to:

a) At cerebellum injury speech is slowed, speech fluency, explosed, scanding-accents are not on necessary syllable.
b) The writing in sick people is large, uneven, the person hasn't draw the circle.
c) There is rhythmic eyeballs fluctuation at sight towards and up - nistagm.

Control questions

1. Cerebellum connections with other CNS parts.
2. Cerebellum irritation and extirpation effects.
3. Cerebellum influence on vegetative functions.
4. Cerebellum influence on motor acts.

CONTENT MODULE 5,6: "VISCERAL ORGANISM FUNCTIONS NERVOUS AND HUMORAL REGULATION"

PRACTICAL WORK 15

VEGETATIVE FUNCTIONS INVESTIGATION - VISCERAL ORGANISM FUNCTIONS NERVOUS REGULATION INVESTIGATION

Autonomic nervous system (ANS)

ANS together with the endocrine (hormone), controls the body's internal organs. It:

- innervates smooth muscle;
- cardiac muscle;
- glands;
- controlling blood circulation;
- gastro-intestinal tract activity;
- body temperature etc.

Most of this control is not conscious.

The ANS is divided into 3 main parts:

- the sympathetic nervous system (SNS);
- the parasympathetic nervous system (PNS);
- the metasympathetic nervous system (MNS).

AUTONOMIC EFFECTS OF SELECTED ORGANS

Organ	Effect of sympathetic stimulation	Effect of parasympathetic stimulation
Eye - pupil; - ciliary muscle	Dilated Slight relaxation (far vision)	Constricted Constricted (near vision)
Heart: - muscle - coronaries	Increased rate Increased force of contraction Dilated (β), constricted (α)	Slowed rate Decreased force of contraction (especially of atrium) Dilated
Systemic arterioles: - abdominal; - muscle; - skin	Constricted Constricted (adrenergic α) Dilated (adrenergic β) Constricted	None None None
Lungs: - bronchi; - blood vessels	Dilated Mildly constricted	Constricted ? Dilated
Arteries medullary secretion	Increased	None

Liver	Glucose releasing	Slight glycogen synthesis
Sweat glands	Copious sweating	None
Glands: nasal, lacrimal, salivary, gastric	Vasoconstriction and slight secretion	Stimulation of copious secretion (exept pancreas)
Gut: - lumen; - sphincter	Decreased peristalsis and tone Increased tone	Increased peristalsis and tone Relaxed (most times)
Gallbladder and bile ducts	Relaxed	Contracted
Kidney	Decreased output and renin secretion	None
Bladder: - detrusor; - trigone	Relaxed (slight) Excited	Excited Relaxed
Penis	Ejaculation	Erection
Basal metabolism	Increased	None

It's necessary for work: bed, scale, investigated person.

Task 1. To perform pupils investtigation

Pupils investigation better to carry out at day dispersed light of middle force. The investigated person sits on a chair with the face turnes to the window, turns his head behind to the chair back and looks into ceiling (pupils are seen distinguishly). To mark pupils size and equality. To close one investigated person eye with hand (or scale) and to pay the attention to convergent size change and equality of other eye pupil, then to open it. To mark pupil reaction, to assess this reaction: alive, middle or weak.

Under norma at bright lighting the pupil is narrowed. In dark room, on the contrary, pupils are dilated. Dilated pupil's state is called midriasis. The constant narrowing state – miosis.

Task 2. Reflex to eyes convergence

To determine investigated person pulse while his sitting for 15 seconds. Then the investigated person converges eyeballs axes for 15 seconds. After this it's necessary to determine pulse again. To make the conclusion.

Task 3. Vasomotor skin functions investigation

The investigated person rises one hand up (maximally) with divergent extensed fingers, other puts down for 30 sec. To determine skin colour difference. Then the investigated person stretches both hands before himself for 30 seconds.

Under normal conditions hands colour must become equal in course of this time. At vegetative disfunction the skin colour leveling are retarded or becomes zyanotic for long, hand putted down or raised up becomes pale for 1 or more minutes.

Task 4. Dermographism

There exists 2 main dermographism kinds: white and red.

White dermographism is caused by light stroke skin irritation with acute subject. Under norma after 5-20 sec one can see white stripe (width - several millimeters), that disappears after 1-10 min.

If stroke irritation is performed stronger and slower, red stripe appears, that continues longer (for 1-1,5 min), sometimes even for 1-2 hours - *red dermographism.* To pay the attention to oedema existance or absence (jugum, elevation).

At dermographism investigation you should mark:

- its character (white, red, mixed),
- stripe width,
- reaction duration.

When analyse you should take into account that red dermographism is maximally expressed on skin in upper body part, white one – on lower extremities.

On one's face they can use another way- *white spot (stain) probe*- finger pressure to skin in course of 3 sec leads to white spot appearing for 2-3 sec. Doctor should remember that at hypersympathicotony white spot disappears slower.

Task 5. Erben's reflex

To count investigated person's pulse for 1 min while his staying. Then the investigated person must be turned forward or to squat down and to turn his head till chin touching with knees. To count pulse again for 1 min.

In healthy people pulse is retarded on 4-12 beats per minute. At hyperparasympathicotony pulse is very seldom; at hypersympathicotony- very quick.

Task 6. Abrams' reflex

The investigated person lying on his back is trying to take his chin to his breastbone, but doctor impedes.

Under norma pulse is retarded more than on 12 per minute. It indicates on hyperparasympathicotony and is thought to be positive probe.

Control questions.

1. Vegetative nerves structural features:
   - autonomic nervous system centres;
   - ganglions;
   - synapses cholino- andrenoreceptive structures.
2. Autonomic nervous system functional features:
   - vegetative innervation comparative characteristics;
   - vegetative reflexes;
   - autonomic nervous system influence on salivation.
3. Autonomic nervous system and behaviour reactions.

PRACTICAL WORK 16

ORGANISM VISCERAL FUNCTIONS HUMORAL REGULATION MECHANISMS INVESTIGATION

It's necessary for work: preparation instruments set, glass cups with Ringer's solution, adrenaline in concentration 1:10000, microscope, pituitryne, syringe, insuline, glucose 20% solution, pregnant woman urine, eye pipette, subject glass, white mice, frogs.

Task 1. To investigate adrenaline influence on pupil width

To destroy frog's spine and brain with zond (probe). They cut carefully both eyes and put them into 2 glass cups with Ringer's solution. They put the cups under direct bright light –as a result pupils are constricted. Then physiological solution in one cup is changed on physiological solution to which adrenaline in concentration 1:10000 is added. After 20-30 minutes midrias is begun reaching its maximum after 1,0-1,5 hours. Second eye in Ringer's solution is used at control.

Task 2. To observe pituitrine action to melanoforme cells

2 frogs are putted in glass can (jan) situated on bright disseminated light (it's better to put white paper under can and to cover can's posterior and lateral walls with it). Frogs become lighter on this shade. Before pituitryne injection one observe in posterior leg transparent membrane melanoforme cells (under microscope). The cells are constricted and look like large black cells. Then one frog is injected intraperitoneally by 0,2 ml of "pituitrine P" solution (1 ml of it contains 1,5-3,0 international units). The frog after pituitryne injection is getting dark right in 20 min after injection. Having putted swimming membrane under microscope one can see that melanoforme cells form processes. In 40-50 min after injection melanoforme processes are increased significantly. By this time one can see common frog darkening distinctly.

Task 3. To observe insuline action on white mice

2 white mice are putted under bell-glass. Mice didn't eat before experiment. One of them is injected by insuline intraperitoneally (0,5 units on 10 kg of body weight). To fixate time. The second mice is injected by 0,5 ml of physiological solution. One observe at mice state. At hypoglycaemic shoke phenomena development (tachypnoe, fits) mice to whom the investigator injectes insuline must be injected by glucose for death prevention.

Task 4. Spermatozoid reaction of Gally-Maininy

In males-frogs out of their reproductive period one can find out no spermatozoids in cloaka content (never). Mature sperm cells releasing from testes and their coming to cell occurs under gonadothropine hormones influence. This process is realized in course of several tens of minutes after pregnant woman urine introduction.

Investigated urine (4 ml) one introduces simultaneously in frog's lymphatic sac. In 30-60 min after urine injection the investigator carefully introduces in frog's cloaka eye pipette end, to fetch cloaka content little content, transmits on subject glass and, covering by covering glass see under microscope large increasing in a darkened vision field. If sperm cells are found in cloaka content, reaction result is considered to be positive. On different species frog's males in various seasons Gally-Mainini reaction gives 85-95% of positive results.

Control questions

1. Explain the term "humoral regulation".
2. Secretion types.
3. Hormones common characteristics.
4. Hormones physiological role.
5. Hormones action ways.
6. Hypophysal hormones.
7. Hypothalamo-hypophysal system.
8. Suprarenal glands hormones.
9. Hypophysal and suprarenal hormones significance for dentistry.
10. Pancreatic hormones.
11. Pancreas functional connections with other inner organs.
12. Pancreas disorders expressions in dentistry.
13. Thyroid gland influence on metabolism and other organs functionning.
14. Thyroid gland hormones.
15. Parathyroid glands disorders expressions in dental practice.
16. Female sexual hormones.
17. Sexual hormones role in secondary sexual signs development.
18. Male sexual hormones.
19. Sexual hormones influence on metabolism.
20. Sexual glands function disorders expression in dentistry.
21. Salivary glands biologically active substances.

CONTENT MODULE 7: "DIGESTIVE SYSTEM"
PRACTICAL WORK N.17
DIGESTION IN ORAL CAVITY.
GUSTATORY AND OLFACTORY SENSOR SYSTEMS ROLE.

Task 1. Gustatory lingual zone investigation

For sensitivity investigation in different lingual zones to sweet, sour, bitter and salty the investigated person must wash oral cavity by water and show his tongue and the investigator wash glass stick end in sweet, sour, bitter and salty solution touches simultaneously tongue end, then its middle and lateral parts. The investigated person tells about his sensations. After each touching by stick it's necessary to wash mouth by distillated water. The intervals between experiments must be at least 2 minutes.

As gustatory receptors have very expressed functional specificity and can percept only "primary" taste – salty, sour, sweet and bitter these receptors are located by separated groups. On tongue root – receptors for bitter, at end – sweet; on lateral surfaces - sour and salty.

Task 2. To perform linguodiagnostics

Linguodiagnostics – is a pathological process assessment in corresponding organ according to tongue appearence, covering on it, relief. Taking into account tongue appearence (its consistention, movement, colour), tongue coating assessment (on colour, thickness, shape, character: humid, dry), surface relief (smooth, tubercular, coated by small papillar infoldings) one can receive the information, it characterizes inner organs functional state.

Under norma tongue is:

- flexible;
- soft;
- red;
- covered by thin white tunic (coating or bloom).

Pale, white tongue is often met at:

- anaemias of different aethiology;
- chronic enterocolitis.

Bright red tongue is a characteristics of:

- inflammatory processes;
- B_{12}-deficient anaemia;
- chronic gastritis;
- pellagra (vitamin PP deficiency).

Tongue with tubercular surface relief (filiaformis papillas are in hypertrophia state, foliaformis ones are relief), so-called hypertrophic gastritis is met at:

- hyperacidic gastritis;
- normacidic gastritis.

Smooth tongue with elements of desquamation, epithelium atrophy is particularly connected with hypoacidic gastritis.

Swelling (oedematic) tongue or with cracks, plicas can testifies to water-salty exchange dysorders, that one can often see at:

- chronic pancreatitis;
- enteropathies.

Very often tongue covered (furred) by white coating is observed at:

- gastritis acuting;
- cholecistitis acuting;
- colitis acuting.

Yellow covering of different intensivity is a characteristics of liver infectious or viruse pathology.

Grey or black covering is observed at:

- hypovitaminoses;
- chronic gastroenteropathies.

At linguodiagnostics one should use the rule:

- tongue examination at daily light;
- tongue investigation in relaxation state;
- preliminary taking into account the character of received food (tea, milk, coffee, medicines usage).

The investigated person to whom the linguodiagnostics is performed washes his mouth by water and shows his tongue. The investigator assesses tongue appearence and colour, its covering and relief.

Task 3. To investigate saliva importance for food aprobation

To clean tongue, on its dry surface to put sugar or salt powder.

To repeat this experiment without tongue cleaning.

To put the attention to the fact, in what case of these the investigated person feels the taste of substanse putted on his tongue. Make the conclusion.

Task 4. To study several factors influencing on released saliva quantity

To collect saliva in test-tube in course of 3 min at breathing through nose.

In the second test-tube to collect saliva in course of 3 min at breathing through mouth.

In the third test-tube to collect saliva in course of 3 min at gum mastication.

To compare saliva amount in every case. To make the conclusion.

Task 5. To get aquating to masticacyogram

Masticatory movements repeating in a definite order as a result of which there occur food bite, reducing to fragments, wearing out and food piece forming are in a composition of so-called *masticatory cycle*. Under resting state mandibule usually is lowered and dental rows are diverged so that between first superior and inferior incisivi was a space in 1-6 mm. Masticatory muscles are relaxed and stretched at this.

Muscular stretching is accompanied by constantly acting proprioreceptors irritation that reflectorily causes different muscular groups tonic contraction. As a result of this mandibule can save for long definite orientation as for the maxilla. Such localization of jaws one as for another is an initial and it can seen as protective reflex. Food bite and mastication is performed at mandibular and maxillar teeth occlusion. Mandibule in course of mastication does rhythmical movements in 3 main directions oriented vertically (up till occlusion and down over the distance of 40-50 mm from superior dental row), sagitally (forward on 5-15 mm and at usual mastication 2-3 mm ahead), transversally - on the right and on the left. All mandibule movements in all directions are accompanied by simultaneous sliding and rotation of articulational heads.

Masticacyography – is mandibule masticatory movements assessment method.

Method *principle* is in air fluctuation registrating in a closed system in course of mandibule movements.

For masticacyogram one use:

- gum cuff;

- three-way adaptor;
- squeezing;
- Marey's capsule;
- kymograph;
- nut.

Gum cuff is putted under mandibule while its fixating on a head. They open squeezing through gum tube, flow the cuff, connecting it with Marey's capsule and write masticacyogram on kymograph while food mastication. The registration is begun at the moment of food introduction in mouth and finish in a swallowing moment.

Masticacyogram consists of masticatory waves curves or oscillations.

Feeding act phases:

- I-st phase – of rest.
- 2-nd phase – of feeding.
- 3-rd phase – oriented mastication.
- 4-th phase – main mastication phase.
- 5-th phase – feeding piece forming and swallowing.

Masticacyogram significance

Due to it one can determine:

- masticatory cycle time before swallowing;
- separate phases duration;
- masticatory movements number;
- mouth opening altitude.

For example, mastication time under norma is 14 seconds. This ciphra one can see on masticacyogram. But reason that caused mastication cycle and its separate phases disorder and their change by means of this method is impossible to determine.

Task 6. To get aquanted to mastication effectiveness determining methods

Masticatory effectiveness – is a degree of food reducing to fragments by teeth or mechanical food processing degree in oral cavity.

Stathic methods - are based on coefficient determining for each tooth. This coefficient determines the destiny of its participation in mastication processes. If to take dental row masticatory effectiveness of a healthy person as 100% and for the unit of masticatory ability – small incisive tooth, then every tooth will have its coefficient. Dental roe half on every jaw performs 25% of work under mastication conditions. At masticatory effectiveness determining one should exclude not only absent teeth but their antagonists too. Masticatory coefficient is expressed in per cents on formula:

5 6 4 4 3 1 2 1 2 1 3 4 4 6 5 -a
7 6 5 4 3 2 1 1 1 2 3 4 5 6 7 -b
5 6 4 4 3 1 2 1 2 1 3 4 6 5 -a

where a – masticatory coefficients, b – order teeth number

At mastication decreasing on 40% - it is a limit after which there are digestion process disorders. It serves as absolute evidence for denturing.

Functional methods in comparison to the stathic ones are based on anatomo-functional indexes assessment.

Mastication act physiology investigation under norma and at teeth loss gives the possibility to follow mastication function variation under different irritative agents action and at dental rowsa different defects. Jaws structural features and dental archs form are directly depend on their function. Mastication effectiveness determining method is used in clinical orthopedic practice for diagnosis making, denture construction choosing, treatment quality analysis as well for scientific investigations. Such method was first proposed by S.I.Gelman's, then it was modificated by I.S.Rubinov's which demonstrated reflectory acts significant role in food processing in oral cavity.

One should use for work: nut, Petry cup, glass, watering can, gauze, sieve with foramens diameters in 2, 4 mm, scales, second watches, sand bath.

To scale one nut. The investigated person takes it in his mouth and with the sygnal "to start" begins to masticate. In 30 sec with the sygnal "to stop" the mastication is stopped. Masticated mass is spitted, mouth is washed by water, which is spitted in the same cup. Cup content is strained through gauze, dry into sand bath, then sow through sieve. Non-sowed residues are scaled.

Formula: X=(Px100)/H, where

H- initial nut weight;

P - residue weight;

X –mastication disorder per cent

Mastication effectiveness (ME) is determined by means of subtraction of masticatory function disorder per cent from 100.

ME=100-X

Task 7. Masticatory pressure and parodont resiliency determining

Masticatory pressure determining has a practical interest.

Masticatory pressure – is a force developed by masticatory muscles on food mechanical processing. This masticatory force is caused by masticatory muscles contraction and tension in parodontal tissues, participating in food processing. Masticatory muscles contraction and tension in parodontal tissues degree directly depends on reduced food physical features. But masticatory pressure at the same force of muscles elevating mandibule is different on molars and anterior teeth. The nearer to masticatory muscles fixation to mandibule is the tooth situated, the more pressure it develops and on the contrary. It is explained by the fact that mandibule (from physical point of view) is a scale of the second genus with the forces fixaton on one support point - with rotation center of temporo-mandibular joint.

At masticatory muscles contraction is developed the force necessary for mechanical influence on alimentary piece and its processing under digestion. Sceletal muscle with the square of transversal section in 1 cm can develop force in 10 kg.

Temporary muscle (it plays important role in mastication) physiological section is 8 cm^2, masseter muscle – 7,5 cm^2, pterygoideal medial – 4 cm^2. According

to this temporal muscle can dvelops the force in 80 kg, masseter – 75 kg, pterygoid – 40 kg. In total, on 1 side – 195 kg, on 2 – 390 kg. Maximal tension (force) that is developed by whole masticatory musculature, is called *masticatory muscles absolute force*. It is expressed only in extremal situations, at strong emotional excitations etc.

For *parodont resiliency* determining to pressure and *masticatory muscles force determining* one can use *gnatodynamometry* method that is performed by special apparatuses– gnatodynamometers. They have plates for teeth through which pressure is transmitted to spring while mouth closing. This pressure is registered on the scale. It was established that frontal teeth resiliency is approximately equal to 60 kg, masticatory ones – 180 kg. Parodont resiliency depends on masticatory muscles and parodont individual development, their functional state according to sex, age et al.

The most widely-spread ciphras for parodont resiliency is follows as:

For men

Dental formula	1 2 3 4 5 6 7 8	
Maxilla	12 7 17 21 22 37 34 21	in total 342 kg
Mandibule	7 7 17 21 22 37 34 21	in total 332 kg

For women

Maxilla	8 5 12 15 16 27 24 16	in total 244 kg
Mandibule	5 5 12 15 16 27 24 15	in total 238 kg

Both in men and in women parodont resiliency of symmetrically located teeth is equal with exception superior premolars (left – 27, right – 25 kg).

Saliva features

☐ quantity, ml/day	1400-1500
☐ 1/3 – parotid saliva	
☐ secretion velocity	0,03-2,4 ml/min
☐ secretion velocity at mastication	3,3-5,0 ml/min
☐ in the night	reduced
☐ at food taking	increased up to 3-7 ml/min
☐ relational weight	1,002-1,020 or 1,001-0,017
☐ viscosity, puasa	1,10-1,32
☐ pH	6,75 (5,6-7,6)
☐ of parotid glands	5,81
☐ of submandicular glands	6,39
☐ pH is increased at velocity secretion increasing up to 7,8	
☐ common protein, g/l	3,86 (1,56-6,30)
☐ amylase	from 1500 ml of saliva one can receive 150 mg of crystallic amylase
☐ lysozyme	1,7±0,2

Control questions

1. Oral cavity specific and non-specific functions.

2. Oral cavity secretory function: salivation, mechanism, regulation.
3. Saliva: chemical content, functions.
4. Tongue role in digestion. Linguodiagnostics.
5. Oral cavity motor function. Mastication, swallowing: mechanism, regulation, significance.
6. Masticacyography, method essence, mastication phases, clinical importance.
7. Mastication and swallowing acts connections with respiration act.

PRACTICAL WORK N.18

DIGESTION IN STOMACH INVESTIGATION

Task 1. Stomach juice reaction (acidity) determining

It is performed by means of indicator paper.

Doctor should remember that hyperacidity is risk factor for stomach and duodenum ulcer disease; hypoacidity and especially anacidity – for stomach cancer (it plays dominant plays among cancers in men).

Normal ciphras:

On an empty stomach

- ph 1,2 and lower – hyperacidity
- ph 1,6-2,0 – normacidity
- ph 2,1 and higher – hypoacidity
- ph 6,0 and higher – anacidity

After stimulation

- ph 1,2 and lower – hyperacidity
- ph 1,2-1,3 – normacidity
- ph 3,0 – hypoacidity
- ph 6,0 and higher – anacidity

In clinics doctors use *stomach secretion stimulators (probe breakfasts)*

1. Histamine – 8 mkg/kg.
2. Pentagastrine – 6 mkg/kg.
3. 7% cabbage broth or 6% solution of dry cabbage juice – 300 ml.
4. Meat stock on Zymnitsky – 200 ml.
5. Erman's alcohol breakfast- 300 ml 5% of alcohol solution.
6. Coffein breakfast – coffein 0,2 g in 300 ml of water.

Stomach secretion stimulators and inhibitors

Stimulators	*Inhibitors*
Gastrine	ph in antrum lower than 2,5
Acetylcholine	Secretine
Hystamine	Prostaglandines
Hypercalciemia	Glucagon
Potassium increasing in blood	Hypermagniemia
Proserine	Adrenaline
Glucocorticoids	Serotonine

Pancreozimine	Heparine
Kinines	
Methylxantines	
Insuline	

Task 2. Stomach juice protheolytic activity investigation (hydrochloric acid role determining)

To number 4 test-tubes. In tubes N.1, 2, 3 to pour 2,0 ml of stomach juice. In test tube N.4 to pour 2 ml of hydrochloric acid. In test N.2 to put soda till stomach juice neutralization (to check up by lacmus paper). To drive test tube N.3 to boiling and to give it the possibility to become cold. One should put in all test-tubes equal pieces of fibrin and all test-tubes put in water bath at 38°C for 30 min.

The results received are evaluated only after fibrin disappearing.

Task 3. To make the analysis of stomach glands secretion curves depending on feeding character

To draw stomach glands secretion curves to the different alimentary stimuli. To make the analysis of stomach juice releasing mechanism depending on feeding character.

Task 4. To get aquanted to electrogastrogram method (EGG)

EGG method at biopotentials taking off body surface gives the possibility to study alimentary stomach motor activity without probe introduction in alimentary tract cavity without disorders of alimentary processes normal physiological course.

EGG analysis is performed taking into account time net and waves altitude. One can differentiate:

1. Maximal biopotential – it characterizes maximal (the strongest) stomach peristaltic wave.
2. Minimal biopotential – it characterizes minimal (the weakest) stomach wave.
3. Biopotentials oscillations rhythm – it is equal to 3 fluctuations (oscillations) per minute and expresses stomach oscillations freaquency.
4. Potentials difference (it is determined by difference between maximal and minimal potential) characterizes stomach contractive function.

Task 5. To get aquanted to stomach zonding (probing) method

It is performed by special tube. Stomach probe (zond) is a gum tube, diameter of which is 10-12 mm, length – 60-75 cm. It is introduced through mouth and reaches stomach cavity by its end; it is used for:

1) stomach juice taking for investigation (through thin tube);
2) stomach cavity washing (through thick tube) with diagnostic and treaty aims at:
   - intoxications;
   - acute gastritis;
   - pylorostenosis;
3) medicines introduction;

4) nutrients introduction at:

- unconscious states;
- burns;
- some psychiatrycal diseases.

It's warned to use this method for diagnostic aim at:

- heart-vascular diseases;
- highly expressed atherosclerosis;
- aorta aneurysma;
- respiration system serious diseases;
- nasopharynx and oesophagus diseases with swallowing disorders;
- severe cachexy;
- pregnancy;
- acute inflammation process in abdominal cavity;
- myocardium infarct (heart attack);
- acute stroke (brain circulation disorder).

Diagnostic probing is performed on empty stomach or after probe breakfast. From the evening before the investigation day the patient must not to drink, not to eat, not to smoke. Removable denture must be removed before the manipulation. The investigated patient must sit with the head turned forward; only in a case of serious unconscious patient's state he must lay. Very seldom at highly expressed vomiting reflex – it's necessary to premedicate fauces and pharynx mucosa by novocain, dicain.

Staying from the right of the patient nurse or doctor introduces warm humid thick probe (zond) by her (his) right hand on posterior fauces wall. At zond staying near epiglottis patient must swallow it. The result – zond comes in oesophagus superior part. With soft rhythmic movements zond is putted down to the stomach: patient must breathe deeply with nose. At zond transition to 40-45 cm from teeth level it usually reaches stomach. For zond introduction necessary depth determining one can use ziphra received from the formula: patient height minus 100-105 cm. All stomach content can be released at the same time or portially.

Thin stomach zond is introduced on an empty stomach and all content is released. Then it's necessary to use irritation stimuli (probe breakfast, hystamine, insuline and gastrine injection). After 10 min they take 10 ml of stomach juice off and then after 15 min – rest of the content. Then in course of 60 min doctor takes 4 portions with the interval of 15 min. It's better to take the stomach content every 5 minutes, changing portion glasses every 25 min. More exact results are achieved at stomach juice constant taking off. Sometimes it's necessary use zond introduction through nose.

For stomach washing one use thick probe with glass watering can on the end. As a liquid one use boiled water, natrium chloridum isotonic solution, soda et al. First portion of received liquid must be investigated in laboratory.

Stomach washing is also performed with diagnostic aims for further cytologic, bacteriologic and toxicologic investigation of received liquid.

For introduction in stomach nutritive mixtures and prothein preparations one use thin (2-3 mm in diameter) polychlorvynyl nasal probes. In some sick people they may be in stomach for 1-4 months.

Stomach probing main indexes

quantity, l/days	2-3
quantity in one portion, ml	5-40
specific weight	1,006 (1,004-1,010)
pH	1,49-1,80
water, %	99,4
lipase, un./ml	7,0-8,4
lysozyme, mg/l	7,57 (2,6-19,2)
pepsin, haemoglobine units/h	4119 (0-8335)
chimase (milk clotting) pepsine activity, chimase units	40-60
secretion velocity, ml/min	1,0 (0,7-9,5)
secretion on an empty stomach, ml/hour	0-70
after alimentary stimulation	50-110
after hystamine stimulation	180-220
general acidity, mmol/l	not more than 20-30 (all acid components)
free hydrochloric acid, mmol/l	less than 15
general quantity of content, gathered in 4 portions in course of 60 min on an empty stomach, ml (basal secretion)	50-110
general acidity, mmol/l	40-60
free hydrochloric acid, mmol/l	25-40
connected HCl (with prothein)	10-15
general HCl debit-time, mmol/h	1,5-5,5
free HCl debit-time, mmol/h	1,0-4,0
starch grains	single
muscular fibres	absent
fat	absent
plant cells	absent
flat epithelium	insignificant amount
erythrocytes	absent
leucocytes	small amount, changed
yeast fungi	single
sarcines	absent
lactobacilles	absent

P.S. HCl debit-time – HCl production for definite time period (for example – 1 hour) – in mg, mmol, mecv (1 mecv=35,6 g of HCl). Debit can be for general acidity, free hydrochloric acid, connected HCl, basal and stimulated secretion.

Submaximal hystamine secretion main indexes

juice general volume, ml	100-140
general acidity, mmol/l	80-100
free hydrochloric acid, mmol/l	65-85
connected HCl	10-15
general HCl debit-time, mmol/h	8-14
free HCl debit-time, mmol/h	6,5-12

Control questions

1. Stomach juice content and features.
2. Stomach juice enzymes.
3. Hydrochloric acid role in organism.
4. Stomach juice releasing regulation.
5. Complicated reflectory phase of stomach juice releasing regulation.
6. Humoral phase of stomach juice releasing regulation.

PRACTICAL WORK N.19

DIGESTION IN DUODENUM, SMALL AND LARGE INTESTINE

Task 1. Bile influence on fats assessment

a) To study bile influence on fats filtration – filtres inserted in funnel, to wash carefully; one – by water, other – by bile. To insert funnels in test-tubes and to pour a little fat in them. To compare fat filtration velocity.
b) To study bile influence on fat emulgation – in test-tube to 0,5 ml of bile to add 0,5 ml of fluid fat and 1,0 ml of water. Shake up the misture. You receive strong emulsion.

Task 2. Pancreatic juice amylolytic digestive action study

To number 4 test-tubes and to pour 1,0 ml of 1,0% starch into them. In test-tube N.1 to add 1,0 ml of distillate water; into N.2 – 1,0 ml of pancreatic juice in dilutions 1:100; in N.3 and N.4 – 1 ml of pancreatic juice in dilutions 1:400 and 1:800. To put the test-tubes into water bath at 37-38° C for 15-30 min. Then to add 1 drop of iod in each test-tube. Blue colour absence testifies to starch digestion.

Task 3. Pancreatic juice protheolytic digestive action study

To number 4 test-tubes. In test-tube N.1 to pour 1,0 ml of distillate water; N.2, 3 and 4 – see task N.2. In each test-tube to add similar fibrin piece. All the tubes put on wash bath at 37-38° C for 15-30 min. To assess the results received.

Task 4. Duodenal probing method

The aim of method: taking of:

- duodenal content;
- bile;

pancreatic juice.

It is used: 1) with diagnostic aim at:

- stomach diseases;
- duodenum diseases;
- biliary tract diseases;
- pancreas disorders;

2) for duodenum content removal at:

- hypomotor dyskynesias;
- chronic cholecistitis;
- cholestatic hepatitis;

3) for duodenum cavity washing for drugs introduction at transduodenal feeding in course of duodenal ulcer disease, pancreatitis treatment.

It is *forbidden to use*: at following pathological states:

- upper respiratory ways severe disorders;
- heart-vessel insufficiency;
- respiratory insufficiency of different aethiology;
- hepatic cirrhoses with portal hypertension;
- acute cholecistitis;
- acute pancreatitis;
- chronic cholecistitis expressed sharpening;
- chronic pancreatitis expressed sharpening;
- ulcer disease sharpening.

Duodenal probing is performed by means of usual duodenal zond – elastic gum tube (d 4,5-5,0 mm, wall thickness 1 mm, length 1400-1500 mm). There are 3 marks on zond:

1) on 40-45 cm (distance from incisives till stomach cardia);
2) on 70 cm (distance till pylorus);
3) on 80 cm (distance till large or Phaterov's duodenal papilla).

There is metallic olive fith fissures at the end of zond.

Zonds types:

- with 1 channel;
- with 2 channels (for simultaneous stomach and duodenum investigation);
- with 3 channels;
- duodenal Ph-zonds;
- endoradiozonds.

Patient must sit and swallow duodenal probe. At its reaching the stomach (mark – 45 cm) the patient must be layed on his left side and his stomach content must be taken off in course of several minutes. Then the sick turned on his right side and in course of 15 min zond is transmitted approximately to 75 cm.

Zond introduction depth:

- new-borned – 25 cm;
- 6 months – 30 cm;
- 1 year – 35 cm;

- 2-6 years – 40-50 cm;
- 6-14 years – 45-55 cm.

When transparent yellow liquid begins to flow from the zond - it means that zond reached duodenum vertical department inferior part. Sometimes rhoentgenological (X-ray) checking up is necessary for this. Or some doctors use probe with air – one can hear sound like regurgitation after zond introduction to stomach (zond introduction into duodenum is inaudible (without any sound). Introducted air from stomach is taken off very easily, from duodenum – very difficult. Sometimes zond doesn't reach duodenum long because of pylorospasm (it is liquidated by soda injection through zond, if no result – atropine).

Fractional duodenal probing

Phase 1 – portion "A" – of **choledoch** common biliary tract)	Releasing time – 10-20 min Quantity – 20 ml
Phase 2 – of closed Oddy sphincter	Releasing time – 2-6 min Bile is absent
Phase 3 – bile of portion "A" from choledoch distal part	Releasing time – 3-5 min Quantity – 3-5 ml
Phase 4 (vesicular) – portion "B"	Releasing time – 20-30 min Quantity – 30-50 ml
Phase 5 (hepatic) – portion "C"	Releasing time – 20-30 min Quantity is bigger than portion "B"

Duodenal content investigation

Index	Characteristics
Bile	
Daily quantity,ml	50-1000
Duodenal bile investigation	
Portion "A"	
Quantity, ml	20-35
Colour	gold-yellow
Transparence	transparent
Relative weight	1,007-1,015
Reaction	weakly-alkaline
Epithelium	small amount
Leucocytes	1-2 into vision field
Mucus	small amount
Cholesterine and calcium bilirubinate crystals	absent
Microorganisms	absent
Vesicular bile investigation	

Portion "B"	
Quantity, ml	30-60
Colour	dark-brown (olive)
Transparence	transparent
Relative weight	1,016-1,032
Reaction	alkaline
Epithelium	small amount
Leucocytes	2-3 in vision field
Mucus	small amount
Cholesterine and calcium bilirubinate crystals	single
Microorganisms	absent
Hepatic ducti bile investigation	
Portion "C"	
Quantity, ml	30 ml
Colour	gold-yellow
Transparence	transparent
Relative weight	1,007-1,010
Reaction	alkaline
Epithelium	small amount
Leucocytes	2-3 in vision field
Mucus	small amount
Cholesterine and calcium bilirubinate crystals	absent

Doctor should remember!

1) Accelerated or, on the contrary, retarded portion "B" transition is a sign of gall bladder dyskynesia.
2) Dark bile large amounts releasing testifies to stagnation phenomenons in gall bladder. The diagnosis is more reliable at similar results received repeatedly several times.
3) Vesicular or ductic bile absence may be observed at occlusion of choledoch and gall bladder cervix:
   - stone;
   - rumen;
   - inflammation;
   - gall bladder concentrational function disorder.
4) Under norma bile approximately doesn't contain any cellular elements. Cholesterol and calcium bilirubinate crystals large amounts in bile may be the direct sign of cholelethiasis (stones presence in bile ducts and gall bladder).
5) Diagnostic value has determining parasites in duodenal content – lamblias, cat flukes, ankylostomes, liver fluke et al.
6) Leucocytes, epitheliocytes, erythrocytes in bile are the characteristics of inflammatory process.
7) Sometimes one can find out the malignant tumors cells in bile.

Physiological constants

Pancreatic juice

Quantity, ml/day	600-700
Relative weight	1,005-1,014
Ph	8,6-9,0
Water, %	98,7
Common prothein, g/l	1,9-3,4
Lipase, units in 100 ml of juice	300,0-2788 (on Agar's)
Trypsin, units/l	71-428
Chemotrypsin, mg/l	1740
Amylase on Volhemute's	160-250

Small intestine juice

Daily quantity, ml	approximately 1000,0
Secretion velocity, ml/min	0,43 (0,17-070)
Relative weight	1,007-1,010
pH	6,51 (5,07-7,07)
Water, %	98,7

Large intestine juice

Daily quantity in a middle part, ml	840,0 (270,0-1550,0)
Daily quantity in an inferior part, ml	555,0 (420,0-705,0)
Secretion velocity in a middle part, ml/min	0,56 (0,18-1,05)
Secretion velocity in an inferior part, ml/min	0,37 (0,28-0,47)
pH in a superior part	6,1
pH in a middle part	7,05 (6,77-7,21)
pH in an inferior part	7,23 (7,16-7,31)
Water, %	90,5 (86,4-93,9)

Control questions

1. Duodenum digestion role.
2. Food transition from stomach to duodenum: mechanisms, regulations.
3. Bile: chemical content, functions.
4. Pancreatic juice: chemical content, functions.
5. Pancreatic phases phases.
6. Duodenal juice: chemical content, functions.
7. Duodenum digestion regulation.
8. Digestion in small intestine.
9. Digestion in large intestine.
10. Substances adsorbtive mechanisms in digestive tract.
11. Substance absorbtion in alimentary tract different parts.
12. Absorbtion in oral cavity.