MODEL ANSWER

M.P.Ed - I st Sem.

EXERCISE PHYSIOLOGY

AS-2589.

PAPER - THIRD

SECTION - A

1) FASCICULI - Bundles of muscle fibres are known as Fasciculus. When the bundle of fibres are more than one, it is Fasciculi.

2) PULMONARY DIFFUSION CAPACITY - The rate of diffusion of gas between the alveoli of the lungs and the blood of the lung capillaries is called Pulmonary Diffusion Capacity. During maximal exercise, the pulmonary diffusing capacity for oxygen increases by 300%.

3) MYOGLOBIN - Myoglobin is the oxygen binding component of the muscle.

4) EXERCISE PHYSIOLOGY - It is the science dealing with human body's structure and functions and how the human body functions when it is exposed to acute and chronic bouts of exercise.

SPORTS PHYSIOLOGY:- The sports Physiology further applies the concepts of exercise physiology for training the athlete and enhancing the athlete's sports performance.

5) Z-LINE - The Z-lines are short fibrous membran that interconnects the actin filaments from two adjoining sarcomere. The Z line anchors the actin filaments. The actin filament extends from the Z-line towards the centre of the sarcomere where it overlaps with the myosin filaments.
A Sarcomere is the area between two consecutive Z-lines.

H-ZONE - The H-zone is found in between the A-Band where only the myosin filament exist.

M-LINE - It is the dark centre portion found in the centre of H-zone (a region of low density known as Pseudo-H-Zone).

6) WARM UP - Warm up consists of a gradual increase in intensity in physical activity, consists of joint mobility exercise and stretching followed by the activity.

CONDITIONING - The training given to the athlete for improving sports performance so that the body gets adapted or conditioned.

7) KINESTHESIS - The sense that detects bodily position, weight, or movement of the muscles, tendons and joints. Different proprioceptors of the body helps in Kinesthetic sense.

8) Different Motor Fibres Components are :-

1. Endurance.
2. Speed.
3. Strength.
4. Flexibility
5. Co-Ordinative Ability.

9) Red Fibres are also called as Slow Twitch fibres. Slow Twitch fibres have high level of aerobic endurance. Most often Slow Twitch fibers are recruited during low-intensity endurance events Eg:- Marathon Runners, Long Distance Runners.

10) Different Proprioceptors of the Body are :-

(a) Muscle Spindle in the muscles
(b) Golgi Tendon in the Tendon
(c) Joint Receptors in Ligaments and Joints

SECTION-B

UNIT-I

SLIDING FILAMENT THEORY OF MUSCULAR CONTRACTION

27] This theory was proposed by H.E. Huxley (1969). It explains the mechanical and chemical basis of muscular contraction. Length of the actin and myosin filaments does not change during contraction, rather the actin filaments slide over the myosin filament.

This theory states that when a muscle is stimulated, through certain physiological and bio-chemical process, the actin filament slides over the myosin filament resulting in shortening of the muscle.

The mechanical, physiological and biochemical events which are involved in this theory can be dealt in 5 different phases:-

(1) Rest
(2) Excitation - Coupling
(3) Contraction
(4) Recharging
(5) Relaxation.

(1) REST:- During conditions of rest, the myosin cross-bridges extend towards the actin filament but do not form a bond with actin filament. Calcium ions are stored in the outer vesicles of Sarcoplasmic Reticulum. A molecule of ATP is present at the end of cross bridge. (1)

During rest, this complex is called "Uncharged ATP Cross-Bridge Complex". Due to the absence of Ca^{2+}, the troponin of the actin filament inhibits the binding of actin with myosin filament.

(2) EXCITATION-COUPLING - When a nerve impulse reaches the neuro-muscular junction, through the motor nerve, acetylcholine is released. This further stimulates the generation of impulse in the sarcolemma of the muscle fibre. These nerve impulses quickly spread across the fibre through the T-tubules. Troponin has got strong affinity for Ca^{2+}, thereby Ca^{2+} and Troponin both leads to opening of active sites. Therefore, Myosin Cross-Bridge gets attached to Actin filament on the active sites. On the other, the nerve impulses help in the release of Ca^{2+} from the vesicles of Sarcoplasmic Reticulum. As soon as the Calcium ions is released, it is immediately taken up by the troponin molecules on the actin filaments. This results in "turning on" of the active sites of the actin filament. This is a result of Ca^{2+} triggering changes in the structure of both troponin and tropomyosin. The troponin molecule pulls the tropomyosin towards itself, thereby exposing the active sites on the actin filament.

Simultaneously the uncharged ATP Cross-Bridges become charged ATP Cross Bridges complex. Thus it leads to the physical-chemical coupling of actin and myosin resulting in a complex called Actomyosin.

(3) CONTRACTION:- Actomyosin formation activates an enzyme myosin ATPase which is a component of the myosin filament. This enzyme breaks the ATP into ADP and Pi thereby releasing lot of energy. This released energy allows the cross-bridge to move to a new angle, in such a way that the actin filament to which it is attached slides over the myosin filament towards the centre of sarcomere.

Thus, the tension is developed in the muscle and it shortens. H-Zone disappears as the actin filament slides over myosin filament.

Shortening of I-Band takes place because the actin filament which is attached to Z-lines on either side of the sarcomere are pulled towards the centre. No change in the length of the A-Band occurs. No change in the length of Actin and Myosin filament because of sliding mechanism

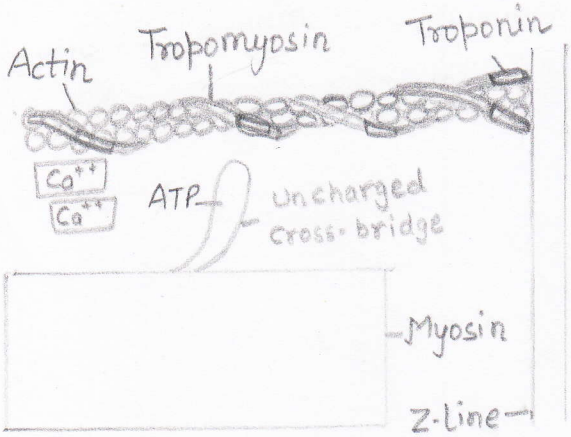
(4) RECHARGING:- In a period of a 1 second contraction the myosin cross bridges may "make and break" with active sites on the actin filaments hundreds of times. For such process to occur time and again the myosin cross bridges must be recharged.

First step involved in recharging is the breaking of the old bond between actin and myosin cross-bridges must be recharged. The first step involved in recharging is breaking of the old bond between the actin and myosin cross-bridges. This is attained by re-loading the myosin cross-bridge with a fresh molecule of ATP through resynthesis. After a new ATP molecule is reloaded, the old bond between actin and myosin is broken, the ATP cross-bridge is freed from actin. The cross-bridge as well as the new actin site is made available for recycling. In other words, there is breaking up of old bond and forming of a new site by reloading a fresh molecule of ATP. $ADP + P_i \longrightarrow ATP + E \uparrow$.

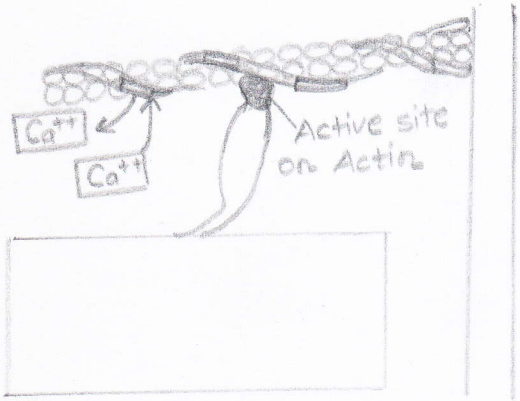
RELAXATION –

As the nerve impulse ceases, the Ca^{2+} is taken back from troponin and is pumped back to the storage (called vesicles). Removal of Ca^{2+} "turn off" the actin filament and thereby no forming of bond between the myosin cross-bridge and active sites on actin occur. The activity of the MyosinATPase is stopped and no more ATP is broken down.

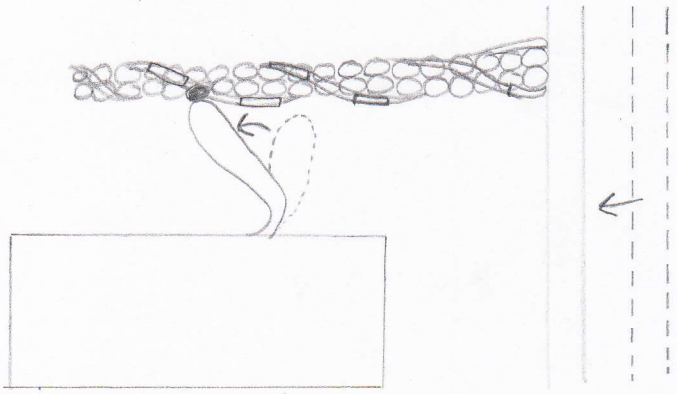
The muscle filaments return to original position and thus the muscle relaxes.



① Rest

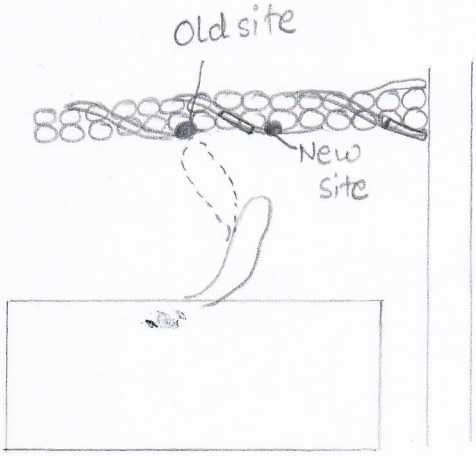


② Excitation-Coupling



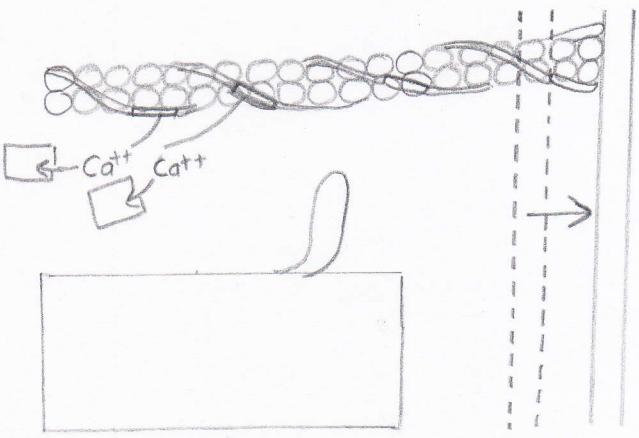
ATP → ADP + Pi

③ Contraction



ATP ← ADP + Pi

④ Recharging



⑤ Relaxation

OR

GROSS STRUCTURE OF SKELETAL MUSCLE

The structure of skeletal muscle is divided into two categories :- (a) Gross Structure
(b) Microscopic Structure.

The Gross structure of Skeletal Muscle encompasses different parts. The outermost connective tissue covering is the Epimysium. The Epimysium surrounds the entire muscle, holding it together. Once the Epimysium is cut, or next to the first layer lies the small bundles of fibres wrapped in a connective tissue sheath. These bundles are called Fasciculi. The connective tissue sheath surround each fasciculus is the Perimysium. The Fasciculus consists of numerous individual muscle fibres which are individual muscle cells. Each muscle fibre is also covered by a sheath of connective tissue called Endomysium. A single muscle cell is known as Muscle fibre. Muscle fibre consists of :-

1. Sarcolemma.
2. Sarcoplasm.
3. Sarcoplasmic Reticulum.
4. Myofibril.
5. Sarcomere.

① SARCOLEMMA - Individual muscle fibre is surrounded by plasma membrane known as Sarcolemma. Sarcolemma fuses with tendon, which inserts into the bone. Tendons are made of fibrous cords of connective tissue that transmit the force generated by muscle fibers to the bones. Therefore each muscle fibre is attached to the bone.

② SARCOPLASM - Entire muscle is filled with muscle fibres. A gelatin-like substance fills the space between the myofibrils called Sarcoplasm. similar to

Its the fluid part of the muscle fibre (cytoplasm of cell): It contains mainly dissolved proteins, minerals, glycogen, fats, and necessary organelles. It contains large quantity of stored glycogen as well as Oxygen binding component Myoglobin.

③ SARCOPLASMIC RETICULUM -

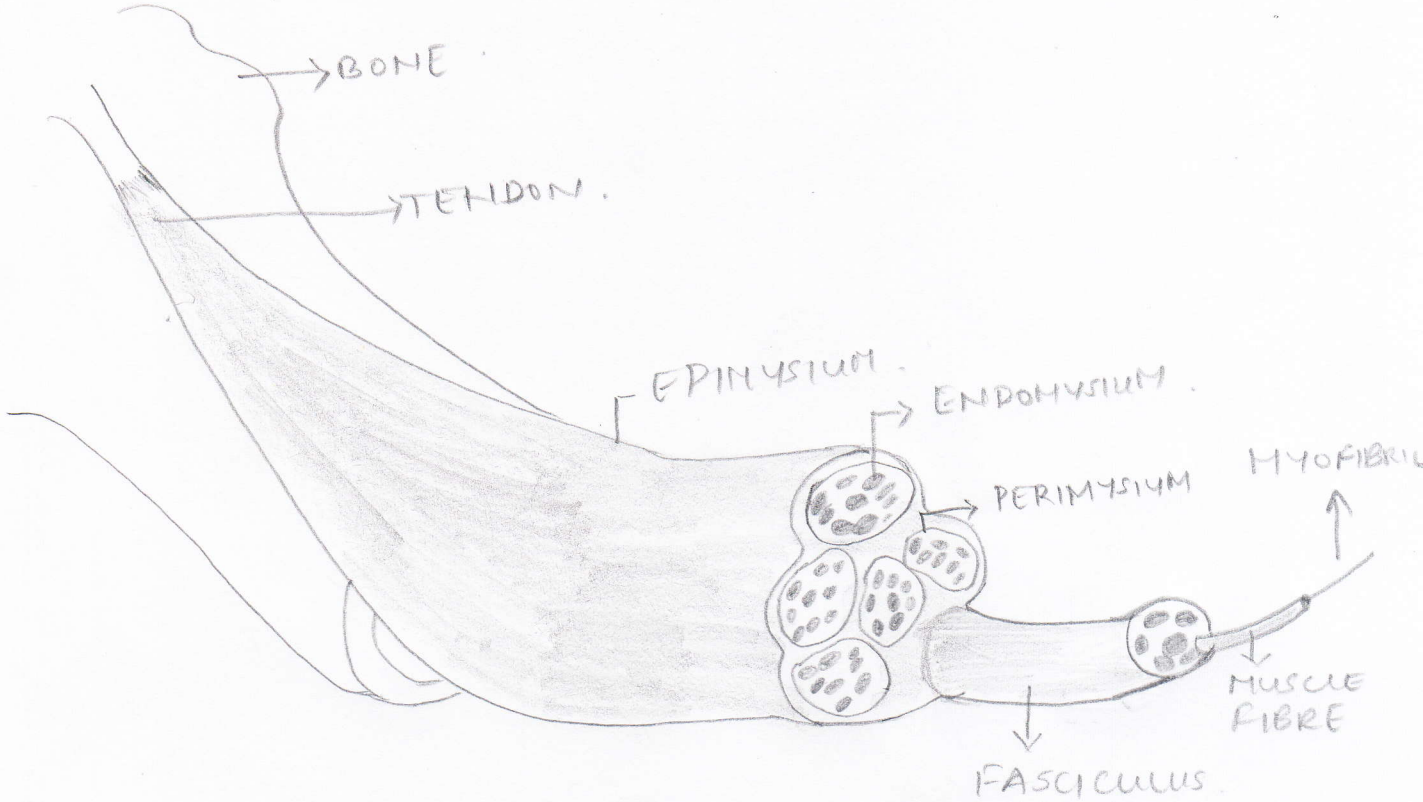
It is an Endoplasmic Reticulum which is made of network of tubules and vesicles. Tubules as they run parallel to myofibrils are called Longitudinal tubules. On either end these tubules terminate to form vesicles/cisterns which are called Outer Vesicles/Cisterns.

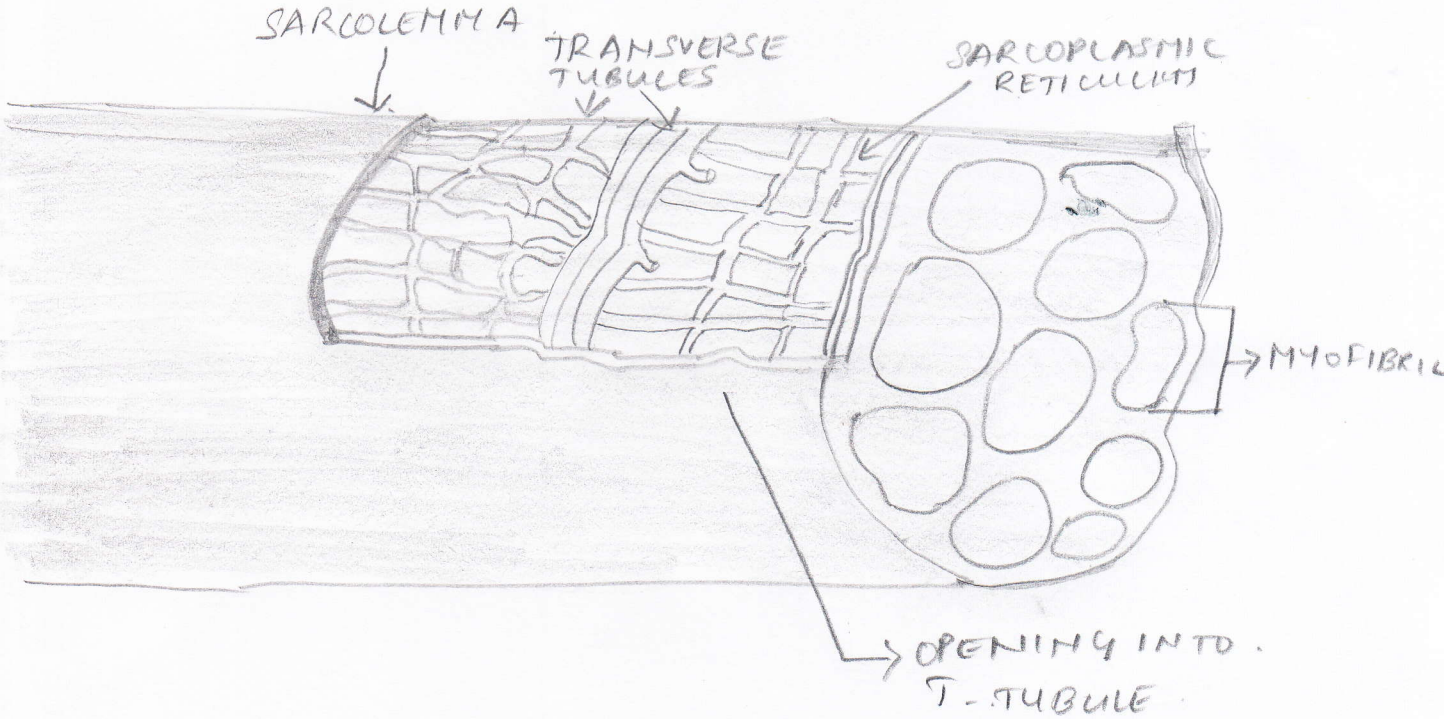
- Outer Vessicles of 1 reticular pattern is seperated from the consecutive outer vessicle by a Transverse tubules (T-tubules). Two outer vessicles and T-tubules seperating them form a TRIAD. Calcium ions are stored in outer vesicle when neuron impulses are transmitted over T-tubules, Ca^{2+} is

released between outer vesicle.

MYOFIBRIL - Myofibril are "protien" thread like strands which are embedded in the sarcoplasm. Each myofibril is about 1 to 2 mm in diameter and is continous through the entire length of muscle fibre. They constitute about 80% of the fibre volume. Myofibril constitutes two protien filaments, thin filament is called Actin and thick filament Myosin.

Actin & Myosin filament lie parallel and play an important role in muscle contraction. Myofibrils are further designed into a series of repeating light and dark patterns called Sarcomere. Sarcomere is called the functional unit of myofibrils.


BONE
TENDON
EPIMYSIUM
ENDOMYSIUM
PERIMYSIUM
MYOFIBRIL
MUSCLE FIBRE
FASCICULUS


SARCOLEMMA
TRANSVERSE TUBULES
SARCOPLASMIC RETICULUM
MYOFIBRIL
OPENING INTO T-TUBULE

UNIT – II

3) ANAEROBIC GLYCOLYSIS OR LACTIC ACID SYSTEM

Anaerobic glycolysis is another method of ATP production which involves the liberation of energy through the breakdown of glucose. This system is called Glycolytic System because it involves glycolysis, with the help of glycolytic enzymes.

Glucose accounts for about 90% of all sugars circulating in the blood. Blood glucose comes from the digestion of carbohydrate and the breakdown of liver glycogen. In the human body the carbohydrates are converted into glucose which may be used immediately stored in form of glucose in muscle and liver.

This System is also refered to as Lactic Acid System. It involves the breakdown of glucose or glycogen resulting in the formation of Lactic Acid. This system is also called Embden – Meyerhoff cycle.

During activity, glycogen in the liver of the muscle is broken down into Glucose – 1 – Phosphate through a process called Glycogenolysis.

In order to liberate energy glucose / glycogen must be first converted into Glucose-6-Phosphate. When a molecule of glucose is converted, it needs 1 molecule of ATP.

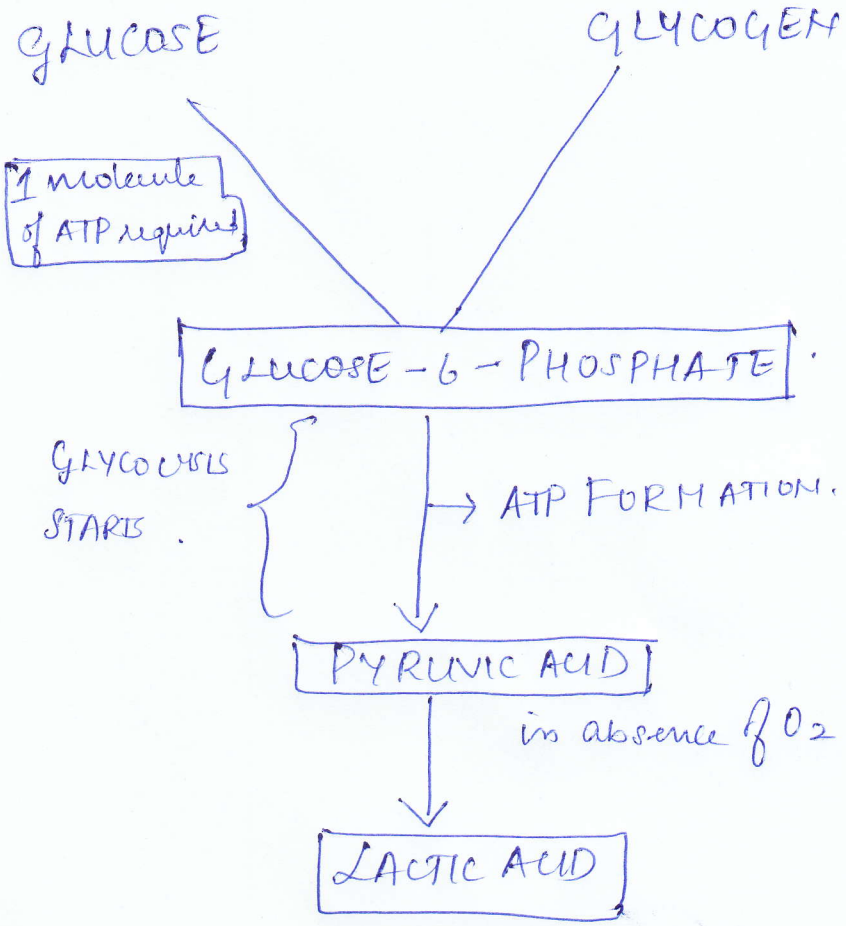
When Glycogen is converted, glucose-1-Phosphate helps in the formation of Glucose-6-Phosphate without energy expenditure.

Once the compound Glucose-6-Phosphate is formed, glycolysis starts. Glycolysis results in the formation of Pyruvic Acid. This process does not require the presence of O_2, but the fate of Pyruvic Acid is determined by the presence of O_2.

At this stage, it is in the absence of O_2, the Pyruvic acid is converted into Lactic Acid.

There are a series of 12 chemical reactions acted upon by different enzymes occuring in glycolysis.

For each mole of glycogen broken, 3 moles of ATP is formed. When glucose is used, then only 2 mole of ATP is formed because 1 mole of ATP already used for converting glucose to Glucose-6-Phosphate. Both Phosphagen and Lactic Acid System enhances the force generating capacity of muscles even when the oxygen supply is limited.



COUPLED REACTIONS:-

$(C_6H_{12}O_6)_n \longrightarrow 2C_3H_6O_3 + E$.

(Glycogen) (Lactic Acid)

$E + 3ADP + 3Pi \longrightarrow 3ATP$.

OR.

AEROBIC METABOLISM-

Aerobic metabolism is also refered to as Oxidative System. System deals with aerobic source of ATP. During long duration activities, muscles need a steady supply of energy. There is a great demand of Energy supply or to deliver Oxygen to working muscles.

The series of reaction involved in Aerobic metabolism can be classified as:-

1. Aerobic Glycolysis
2. Krebs Cycle.
3. Electron Transport Chain

(1) AEROBIC GLYCOLYSIS - The Process involved in the Glycolysis in the aerobic and anaerobic system is similar. The only difference that exists between the two is that in the presence of O_2, lactic acid accumulation does not occur. But, resynthesis of ATP is not inhibited. The fate of the end product of glycolysis ie. Pyruvic Acid depends upon the presence of O_2. In the presence of O_2, the Pyruvic Acid is converted into a chemical Compound called Acetyl - Co-Enzyme A (AcetylCoA)

(2) KREBS CYCLE - Krebs Cycle is also referred to as Tricarboxylic Acid (TCA) Cycle, as well as Citric Acid Cycle. The series of reactions occurring during the cycle was discovered by Sir Hans Krebs. Acetyl Co-Enzyme once formed during aerobic glycolysis enters Krebs Cycle. The Acetyl Co-A is completely oxidised.

Removal of electrons in the form of H_2 atoms takes place and only the compounds of Carbon and O_2 remains thereby resulting in the production of CO_2.

The Pyruvic Acid formed in Glycolysis contains, C, H & O_2. When H_2 is removed, only CO_2 remains. This CO_2 diffuses into the blood and goes to the lungs from where it is eliminated. The Energy yield of this cycle is only 2 moles of ATP, for each mole of glycogen, which is metabolised.

(3) ELECTRON TRANSPORT CHAIN (ETC)

During the aerobic glycolysis, H_2 is released. When glucose is converted into Pyruvic Acid. Even during the Krebs cycle, H^+ ions are removed. All these H^+ ions should not remain in the cell, which may make the cell more acidic

The H^+ ions released combine with two Co-Enzymes i NAD (Nicotinamide Dinucleotide) and FAD (Flavin Adenine Dinucleotide).

These enzymes carry the H^+ ions and electrons through election transport chain. The NADH and $FADH_2$ are reduced form of NAD^+ and FAD^+. It is because when a compound receives a H^+ ion. It is considered to be reduced.

H^+ ions removed during the previous cycle is accepted by these two co-Enzymes. At the end H^+ ions combining with O_2 to form H_2O, further inhibiting acidification.

$$4H^+ + 4e^\ominus + O_2 \longrightarrow 2H_2O$$

$4H^+$ ions combine with $4e^\ominus$ with 1 mole O_2 yielding 2 moles of H_2O. As and when the electrons are passed downward from a high energy level to a lower energy level, Energy is released and ATP resynthesis occurs. For 1 pair of electron carried down the chain, enough energy is released to resynthesis an average of 3 moles of ATP. When 12 pairs of electrons are removed from 1 mole of glycogen, which are transported as NADH or $FADH_2$, thereby yielding 36 moles of ATP.

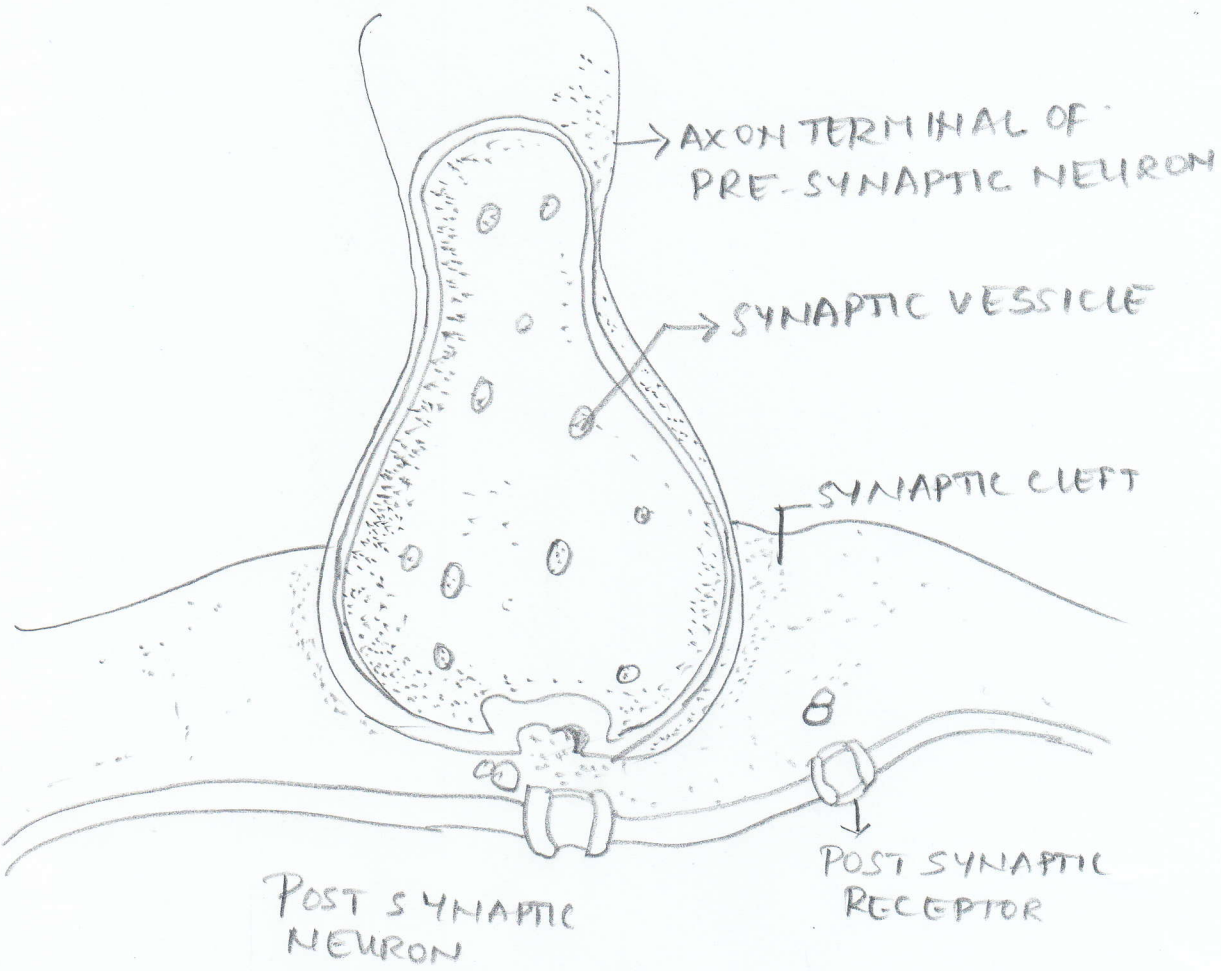
39 molecules of ATP can be generated from 1 molecule of Glycogen, But if the process starts with the glucose, then the energy yield is of 38 molecules of ATP. (as 1 molecule is used for ~~community~~ converting glucose into glucose-6-phosphate) during glycolysis.

UNIT-III

47 SYNAPSE- Neurons communicate with each other across synapse. A synapse is the site of impulse transmission from one neuron to another.

A Synapse includes - ① Axon terminals of neuron carrying the impulse.
② Receptors of 2nd neuron.
③ Space between these structures.

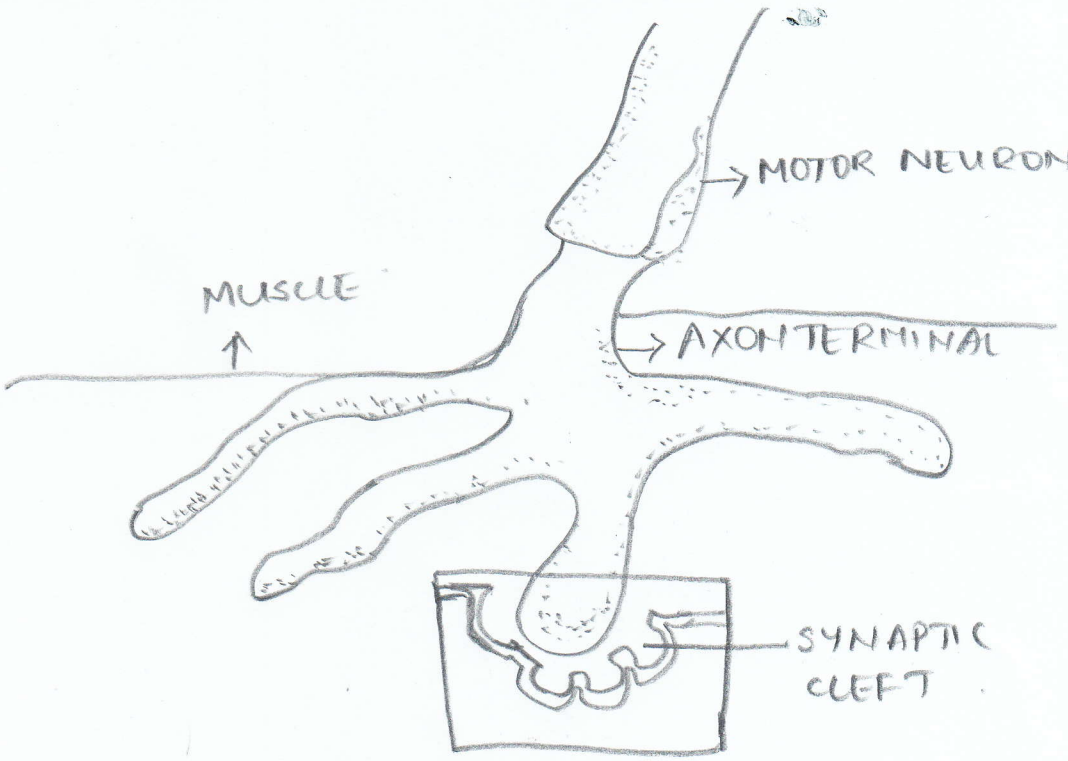
Neurons which carry the nerve impulses towards the Synapse are called Pre Synaptic Neurons
Neurons which carry these impulses away are called Post Synaptic Neuron. Post Synaptic Neurons are located on the other side of the Synapse.
Pre-Synaptic and Post-Synaptic are not structurally attached to each other. A narrow gap seperates these two, which is called Synaptic Cleft. Pre-Synaptic terminals of axon contain large number of sac like structures Synaptic Vessicles
These Synaptic Vessicles contain Neurotransmitters.
When impulse reaches PreSynaptic terminal, Synaptic vessicles respond by dumping their chemicals into Synaptic cleft. These Neurotransmitters diffuse across Synaptic cleft to Post Synaptic Neuron receptors.
Post Synaptic Receptor binds neutidransmitters, once it diffuses across the Synaptic cleft
When Binding occurs, impulse has been transmitted successfully to next neuron and is transmitted onward.



OR (UNIT-III)

4) NEUROMUSCULAR JUNCTION - When neurons communicate with each other (neuron at its synapse, a motor neuron communicates with muscle fibre at the site is called as Neuromuscular Function. The functioning is same as Synapse. The proximal part of motor neuron releases neurotransmitters into the space between two cells. Axon terminals are expanded into flat disks called Motor End Plates. In Neuromuscular junction, impulse is received by muscle fibre. When axon terminals approach muscle fibre,

invaginated to form cavities known as Synaptic Gutter. The gap between the two are known as Synaptic cleft. Neurotransmitters released from motor axon terminal diffuse across synaptic cleft and bind to receptors on muscle fibre (sarcolemma). The neurotransmitter released is Acetyl choline. 1 muscle fibre receives only 1 nerve fibre. Large fibres of Effrent (motor nerve) neuron divide into numerous smaller fibres serving as many as 200 muscle fibres. The individual nerve fibre and all muscle fibres it innervates is called as MOTOR UNIT.



NEUROMUSCULAR JUNCTION

UNIT - IV

5) EFFECT OF EXERCISE ON RESPIRATORY SYSTEM

The Exercise and training induces a great change in the functioning of Respiratory System. They are :-

(1) The Strength and Endurance of the Respiratory muscles is significantly increased following a training program. It includes the larger lung volumes of the trained athlete.

(2) The Oxygen cost of ventilation increases greatly with increased ventilation.

(3) There is greater lung volume in trained than in untrained subjects with exception of Tidal Volume

(4) A larger Diffusion Capacity is observed in athletes than in non-athlete.

(5) There is a increase in recruitment of Inspiratory intercoastal muscles and the expiratory muscles of ribcage and abdomen.

(6) There is 10 to 20 fold increase in the inspiratory and expiratory flow rate.

(7).

OR (UNIT-IV)

57.(a) CARDIAC OUTPUT—

Cardiac Output is the amount of blood pumped by the heart in one minute. It is the product of Stroke Volume and Heart Rate.

Cardiac Output (C.O) = Heart Rate × Stroke Volume

Cardiac Output is expressed in ml blood/min or Litres/min.

During rest, the resting Cardiac Output is approximately between 4 to 6 L/min in the supine position. C.O increases directly with increasing exercise intensity. The increase is about 4 to 5 folds.

Difference in trained and untrained athlete—

① During Rest :—

Untrained Athlete — C.O = S.V × HR
= 70 × 77.0 ml
= 5390 ml
= 5.3 L.

Trained Athlete — C.O = HR × SV
= 45 × 111.1 ml
= 4999.5 ml
= 5 L.

During Exercise :—

Untrained Athlete :— 200 × 100 ml
= 20000 ml or 20 L.

Trained Athlete = 200 × 20 = 40000 ml = 40 L

C.O increases directly with exercise intensity. Maximal C.O for an unlicained male may ranges between 20 to 25 L/min and in an untrained female it may be around 15 L/min.

(b) BRADYCARDIA –

A case of decreased Heart Rate especially evident in a liianced endurance athlete.

Decreased Resting Heart Rate is also called the Resting Bradycardia. This is very common seen in the case of trained individuals.

Resting Bradycardia takes place as a result of long term strenous training. The factors which indue the training Bradycardia are:-

(a) an increased parasympathetic influence.
(b) a decreased sympathetic influence.
(c) a combination of parasympathetic and sympathetic influence.

When the parasympathetic nerves are stimulated, it decreases the Heart Rate, whereas the Sympathetic nerves when stimulated increases the Heart Rate. Therefore Resting Bradycardia due to training can be induced if the parasympathetic nerves (which decreases the Hea

are stimulated and the sympathetic nerves (which increases the HR) may be inhibited which may be dominated then, by the parasympathetic influence. A combination of these two finally could produce training Bradycardia at Rest.

UNIT V

6)(a) PHYSICAL FITNESS - Physical Fitness is a general concept defined in many ways by differing scientists. Physical Fitness has been defined as set of attributes or characteristics that people have or achieve that relates to the ability to perform physical activity. In other words, it is considered a measure of the body's ability to function efficiently and effectively in work and leisure activities, to be healthy, to resist hypokinetic diseases and to meet emergency situations. The main Motor Fitness Components which analyses Physical Fitness are:- Endurance, Strength, Speed, Flexibility, Co-ordinative Ability.

(b) PHYSICAL TRAINING:-

Physical Training is the systematic use of exercises to promote bodily fitness and strength. Physical Training is the basic form of preparation of sportsmen. It is a pedagogical process, based on scientific principles aiming at preparing sportsmen for higher performances in sports competition. The physical fitness or condition is the sum total of five motor abilities namely strength, speed, endurance, flexibility and co-ordinative abilities. The improvement and maintenance of physical fitness or condition is the most important aim of physical training. Physical Training aims at improving the performance of sports persons. The sports performance depends on several factors. It primarily depends on motor components. The constitution or physique is almost completely genetically determined and hence cannot be improved by training. But the other four factors, which are physical fitness, technical skill, tactical efficiency and education are trainable to a greater extent. The above mentioned four factors, are generally considered the aim of sports training.

(c) WARM-UP - Warm up consists of a gradual increase in intensity in physical activity, consists of joint mobility exercise and stretching followed by the activity. Warm up brings the body to a condition at which it safely responds to nerve signals for quick and efficient action. Before running or playing an intense sport, the athlete might slowly jog to warm their muscles and increase their heart-rate. There are two kinds of warm up - general warm ups and Specific Warmup. Specific warm up is essential and differs from game to game. Warm up prepares the athlete physically and mentally. The most essential aspect of warm up is it prevents athlete from injury.

OR.. (UNIT-V)

PHYSIOLOGICAL ASPECTS OF DEVELOPMENT OF STRENGTH & ENDURANCE

Other than the physical training, there are physiological aspects also which affect the motor fitness components of the athlete. Physiological factors has a great link with the specific event.

STRENGTH — Athletes involved in Strength events such as Throwers, Jumpers, Power Lifters develop following changes due to training:-

(a) Muscle Fibre Spectrum - These Athletes have greater amount of White Muscle Fibres and recruitment of White Fibres increases due to training.

(b) Muscle Cross-Section - The cross-Section area of Muscle increases due to anaerobic training.

(c) Energy Supply - There is a increase in ATP-PC stores, and anaerobic activity enzymes such as Phosphofructokinase & Lactatedehydrogenase.

(d) Body Weight - Body Weight decreases.

(e) Cardiac Hypertrophy - Increase in Cardiac muscle wall thickness due to Strength training.

ENDURANCE-

(a) Increase in Heart Size - Increase in Ventricular Cavity due to longer duration of activity and continuous supply of blood.

(b) Increase in Cardiac Output - There is a increase in Cardiac Output of Endurance Runners. Due to training, C.O increases

from as high as 40 litres per minute as compared to 25 litres per minute in untrained persons.

(c) Increase in Stroke Volume - Due to training, S.V increases from 70ml to 120ml from trained to untrained athletes.

(d) Increase in Capillaries :- Due to training the capillarisation increases.

(e) Increase in Red Fibres :- Increase in number of Red Fibres. Also there is increase in amount of Haemoglobin in Red Fibres due to aerobic training.

(f) Decrease in Heart Rate - The Resting Heart Rate of the athlete decreases due to aerobic training.

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