Applied Ergonomics

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Lecture – 04

Welcome to this lecture. Today we are going to start very interesting topic that is Physical Ergonomics. It is having a very much important. In fact, heavy weightage we can say, because this particular physical ergonomics is related to our body itself. All of us do work. In context with that a large number of occupations require the expenditure of energy. And since it is a matter of body we must be aware of the facts and the internal mechanism that is happening inside our body when we perform a particular task.

In context with that I am going to start this physical ergonomics, I am sure that you will find interest in this particular topic that is a sub part of applied ergonomics part; applied ergonomics course.

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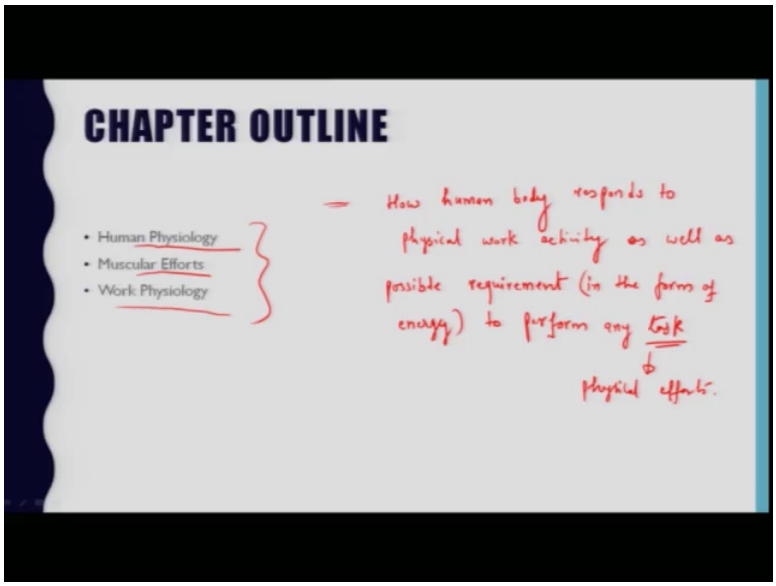

In that we will be covering human physiology. In this particular section we will be covering the human physiology part and muscular efforts as well as work physiology.

These three we will try to finish within this lecture. Before going into deep of these all these topics we must be aware of the fact that energy requirement is there in order to perform any physical task. And every job requires some sort of work activity. This manual labour is primary work activity in industries may be any construction industry agriculture mining and irrespective of any specific task oriented industry manual labour is required.

And that the significant amount of work includes lifting of any object, carrying one particular object and transporting from one place to another; and other manual handling task which involves parts, packaging materials and containers and some sort of repetitive work that we need to perform in a particular job. This particular section is dealing with the how human body responds to physical work activity as well as the possible requirement in the form of energy to perform any task and that task is in the in the form of physical efforts.

In this way you will be able to correlate with what is the requirement in terms of energy, nutrients and what a particular in order to perform a particular task. First we will start with human physiology.

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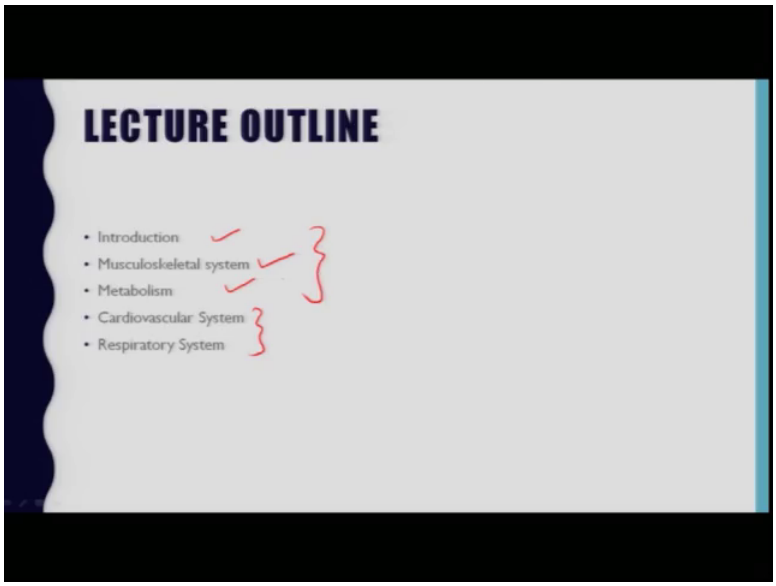

In that also we will try to cover this introduction about this physiology, some sort of musculoskeletal system it is description and the basics of metabolism and these 2 topics we will be covering in the next lecture

Today itself we will try to cover this introduction and musculoskeletal systems and metabolism. As far as introduction to the physiology is concerned it is we can define it as a branch of biology that is concerned with the vital process of living organisms and how their constituent tissues and cells function.

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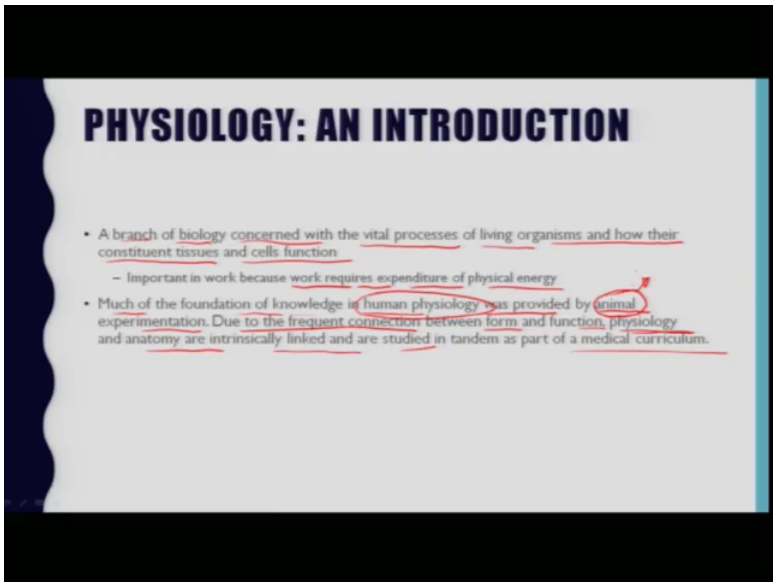

This study is important because any kind of work basically the physical work requires expenditure of a physical energy.

Much of the foundation of the knowledge in human physiology was provided by animal experimentation due to the frequent connection between form and function physiology and anatomy are intrinsically linked and are studied in tandem as a part of medical curriculum. In initial days that all sort of information are related to human physiology was obtained by testing over the animal. The animal was a one of the testing specimen through which we were able to predict the functionality of the human body also.

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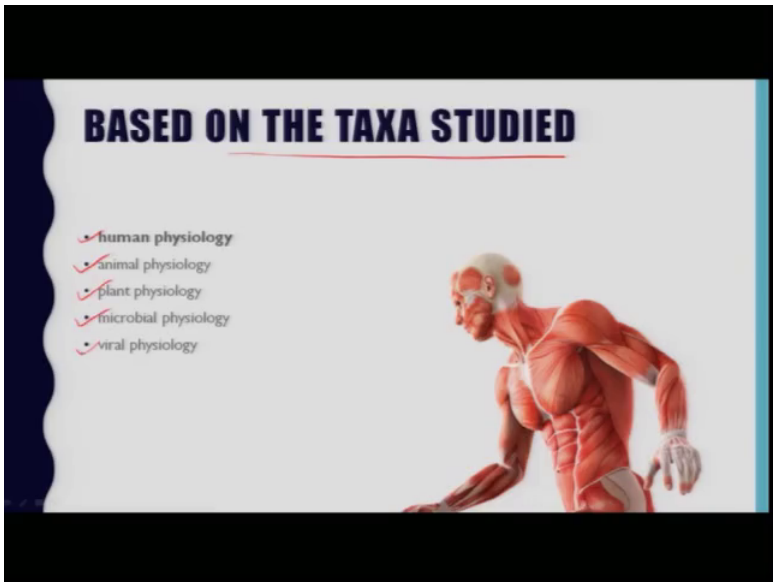

Although we are going to into detail of that, but just for the knowledge I would like to state you that based on the taxa studies the physiology can be discriminated into human physiology, animal physiology, plant physiology, microbial physiology and viral physiology.

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Based on the level of organization this physiology is also divided into a self physiology, molecular physiology, system physiology, organismal physiology, ecological physiology, and integrative physiology.

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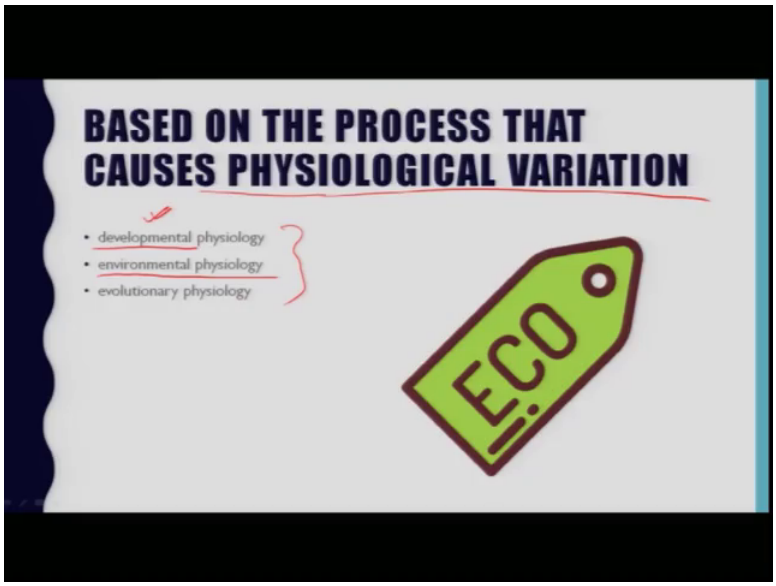

Also based on the process that causes physiological variations developmental physiology, developmental in the sense of human, evolvement and environmental physiology, evolutionary physiology that sort of 3 categories in which that physiology is divided.

And based on these topics that physiology is used to be studied also based on the ultimate goal of the research this it is discriminated into applied physiology and non applied physiology.

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In any case we are going to discuss about the physiology which is relevant to the ergonomic part.

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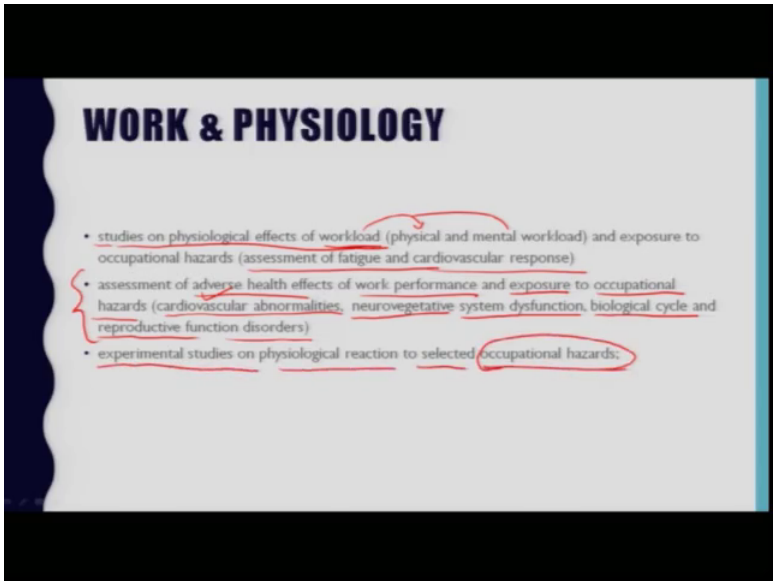

We will now discuss about the work physiology. Basically this physiology studies on the physiological effects of the workload, this work physiology and this work load is consisting of the physical workload, as well as mental work load and exposure to occupational hazards.

Assessment of fatigue and cardiovascular responses that also the matter of study and that study comes in this work physiology part, it also assess the adverse health effects of the work performance and exposure to occupational hazards which maybe cardiovascular abnormalities, neurovegetative system dysfunction, biological cycle and reproductive functional disorders. So, by continuous and by repetitive work we may be exposed to several kind of diseases in either of the cases whether we are excessively doing some particular work for a prolong period of time or if we are doing nothing and just sitting idle without performing any physical task and just involving in cognitive activities like some just you are doing some mental processing and rest of the part is doing nothing as an external effort.

So, in both cases you are going to make your life troublesome and going to face some sort of abnormalities in the form of these given disorders. Thus this work physiology also includes the experimental studies on physiological reactions to selected occupational

hazards. Basically this occupational hazards is related to the to the hazards that that you face when perform any task in an organization. So, related to the it is basically it is related to the industry and we will we will discuss in detail in an additional topic which is named as occupational ergonomics in later time of this course.

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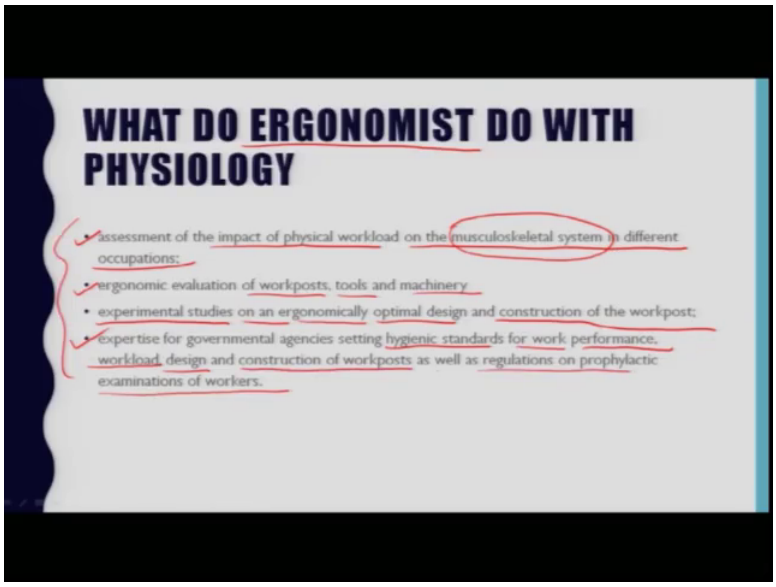

Now the question arises that since we are discussing about the physiology. What do ergonomist do with this physiology? What is the task of ergonomist in these physiological activities? So, what it does, it does the assessment of impact of physical workload on the musculoskeletal system in different occupations I will tell you the what this particular musculoskeletal system is all about and the second is ergonomic evaluation of work post tools and machinery, it also does the experimental studies on an ergonomically optimal design and construction of work post and it also gives expertise for governmental agencies setting hygienic standards for work performance workload design and construction of work post, as well as regulation on prophylactic examinations of workers.

In a nutshell those all 4 task that used to be performed by an ergonomist before going to explain the basic part of this physiology and physical ergonomics as well.

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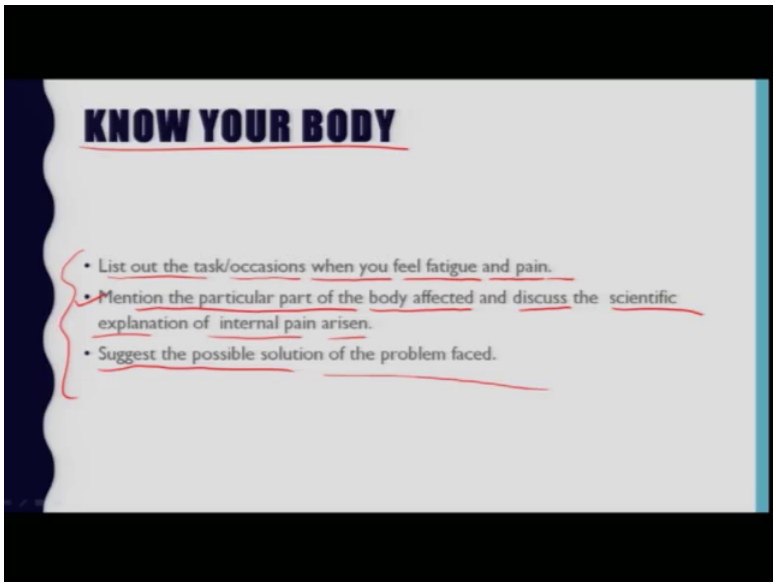

One assignment for you is just to know your body and you have to list out the task and occasions, when and whenever you have felt some sort of fatigue and pain the second task that you have to perform is you have to accumulate, the list of the particular part of the body affected and discuss the scientific explanation of internal pain arisen and you have to also search about the possible solutions of the problem faced.

In this way you will come to know that how your body reacts to a particular situation, as well as if you perform any physical task.

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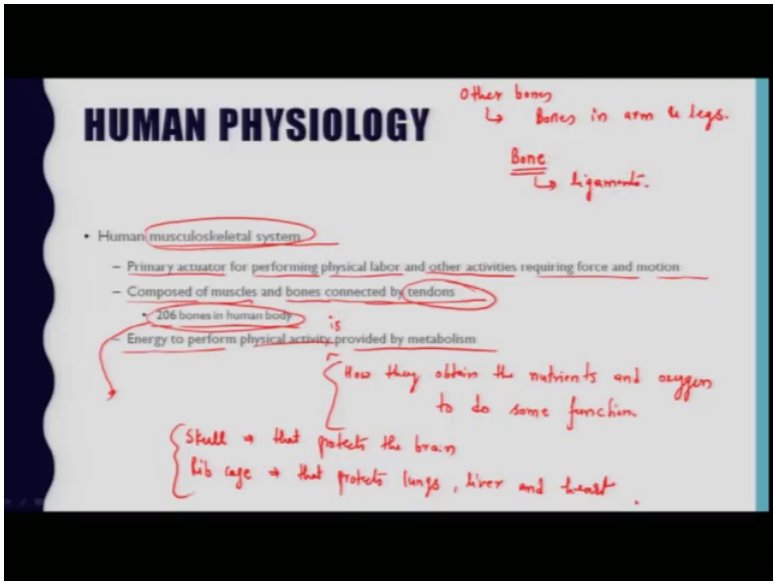

Now, about the human physiology, as far as this human physiology is concerned first of all we have to understand what this musculoskeletal system is. It basically this human musculoskeletal system, is basically the primary actuator for performing physical labor and other activities requiring force and motion. It is basically composed of muscles bones connected by tendons.

In fact, muscles and bones in the body and tissues connected by them these tissues are known as tendons. Energy to perform the physical activities is basically is provided by phenomena known as metabolism. In this lecture we will also try to understand about the metabolic process of human muscles and as well as, how they obtain, how do they obtain the nutrients and oxygen to do some functions. Firstly, we will briefly describe about the skeletal component of the musculoskeletal system.

As we know that normal human body contains 206 bones in the human body. The bone and their joints provide the structure of the musculoskeletal system. There are various bones and which have different functions also. Function of some bones is to provide protection of vital organs. The principle examples are the skull, that protects the brain and the rib cage that is one of the most important part in our body, that protects our lungs liver and heart and most of the other bones provide a framework for the physical activities other bones includes, like bones in arm and leg.

The bones in the body are connected to each other at their joints by means of ligaments bones and, In fact, bones of the body are connected to each other with the ligaments by means of ligaments. Now, our main purpose is to understand the basic mechanism. We need to know about the various joints which are present in our body.

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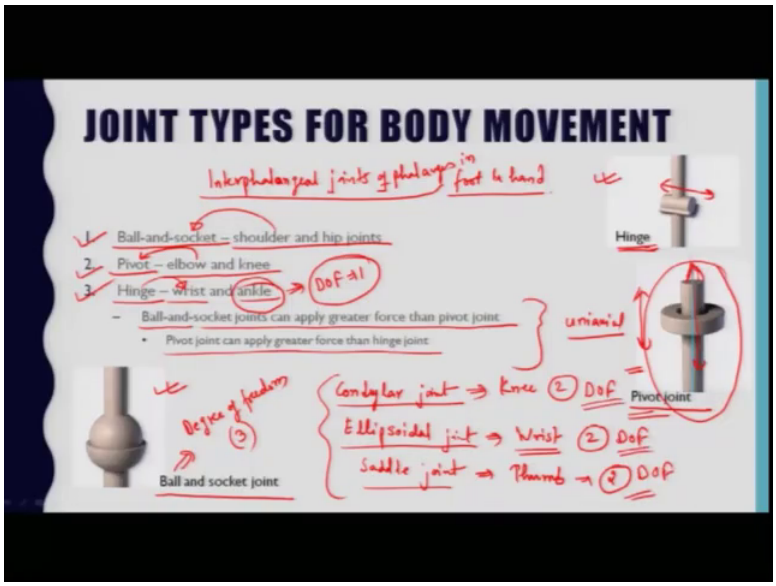

Now we will discuss about the various joint types for our body movement, because as an engineer, we must be aware of the various joints which are responsible for our body movements.

In that series there are there are basically 3 principle types of joints first kind of joint is ball and socket joint, which you can visualize with the help of this figure. This is ball and socket joint second kind of joint is pivot joint. So, example of this pivot is this one you can easily visualize with the help of this figure and third kind of joint is hinge joint, so exactly in the human body where these particular joints are playing their roles. So, shoulder and hip joints are examples of ball and socket joint elbow and knee, acting as a pivot joint and wrist and ankle joints are hinge joint.

As a knowledge as a knowledge you can see that ball and socket joint can apply greater force than pivot joint and pivot joint can apply greater force than hinge joint. So, of these are all the ball and socket pivot and hinge joint and as far as the other description of these joints are concerned, this hinge joint as you can see from this figure that it this particular hinge joint along only one movement in one plane. And is termed as a uniaxial also this as far as this pivot joint is concerned this pivot joint also allows movement in one plane only.

This particular part can move to and fro sorry, in the top in the top bottom and vice versa. This particular joint is also uniaxial. Basically these pivot joints are located at the

superior and inferior radioulnar joint and Atlanta atlantoaxial articulation this particular hinge joint is located like this particular hinge joint in the body are the interphalangeal joints of the phalanges in the foot and hand, there are other joints also like condylar joint, ellipsoidal joint, saddle joint so, but. In fact, these are located in various parts of the body. So, the each and every joint is having some sort of degree of freedom.

So, this ball and socket joint is having a degree of freedom as 3 as far as shoulder joint is concerned and as far as knee joint is concerned. This knee is having a 2 degree of freedom and this particular, in fact, if we could say the example of these particular joint. So, saddle joint is located in your thumb which is having 2 degree of freedom as far as ellipsoidal joint is concerned. So, rest is the kind of example that you can take and it is also having degree of freedom 2 condylar joint is located in the knee.

So, that is also degree of freedom has a 2 and as far as hinge joint is concerned this ankle is the live example, this is only having a degree of freedom as one. So, in this way these are the brief description of the major joints of the body type of joints and some sort of degree of freedom, that is being provided by the mother nature it iself to the human body.

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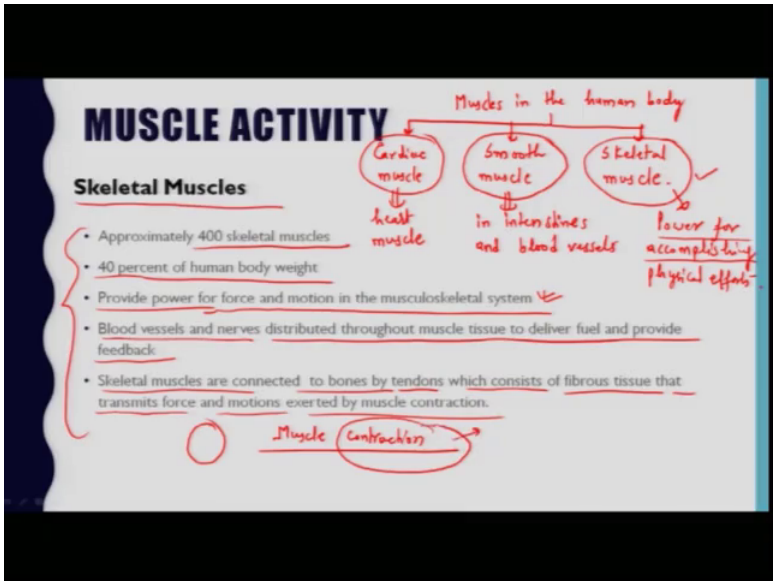

Now, we will move to the next topic that is muscle activity. As you are aware that every heavy function or any physical effort is involving these muscles activity, we will also have to be aware of the various facts and functioning of these skeletal muscles.

In that muscle activities basically before going into detail let us have some knowledge about these muscles in the human body In fact, these muscles in the human body are of 3 types, cardiac muscle, second is smooth muscle and third kind of muscle is skeletal muscle. This cardiac muscle is the heart muscle that performs the pumping function for the cardiovascular system.

So, cardiac muscle is a heart muscle, this smooth muscle is normally found in our intestine and blood vessels as well. So, we can in a in a summarized manner we can write it as a smooth muscles in intestine as well as and blood vessels and as far as this skeletal muscle is concerned this is our main interest of a study that provides power. In fact, we can say power for accomplishing, the physical efforts. In this way this is brief discrimination of muscles in human body.

These are 3 types first is cardiac muscle, second is a smooth muscle, third is skeletal muscle. So, our main interest is lying in the understanding of a skeletal muscle which is providing which is providing power for a force and motion in the musculoskeletal system. There are few points that I have added. So, there are approximately 400 skeletal muscles in our body. This comprises of 40 percent of the human body and weight and it also provides power, for force and motion in the musculoskeletal system blood vessels and nerves distributed throughout the muscle tissue to deliver fuel and provide feedback.

Skeletal muscles are connected to the bones by tendons, which consist of fibrous tissues that transmit force and motion exerted by the muscle contraction. A skeletal muscle functions by contracting between the bones to which it is attached and contraction occurs when the muscle is activated in response to impulses from the body from the bodies central nerves system. In fact, when we talk about this muscle contraction it does not mean that when we talk about a muscle contraction it does not mean that muscle has become shorter it actually this particular contraction refers to a some sort of physiological condition of the muscle when it is activated. So, again since it is of our interest, muscle contraction we can also divided into some parts.

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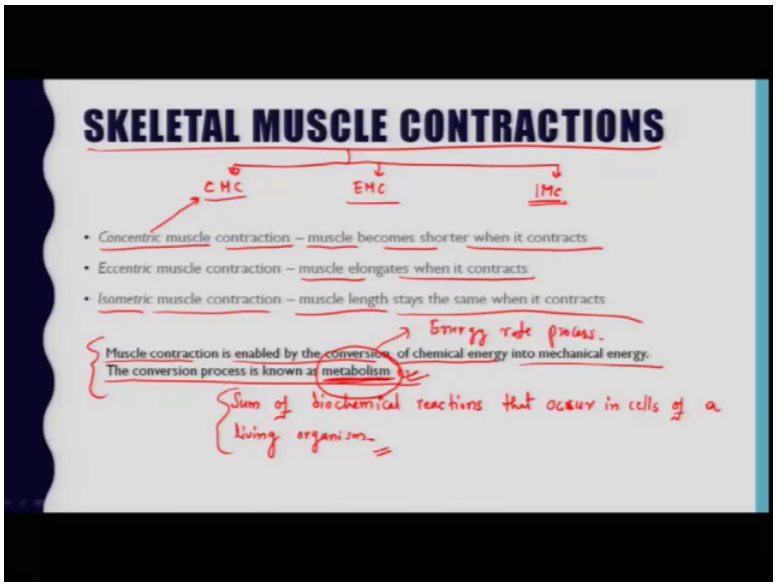

This skeletal muscle contraction again it is of 3 types, since it is directly related to performance and performing physical efforts. We need to have some basics of muscle contraction. In context with that we are extending our knowledge towards this particular topic. Muscle contraction is of 3 types he first type is concentric muscle which is this, concentric muscle contraction, in which the muscle becomes shorter when it contracts, second is eccentric muscle contraction, in which muscle elongates when it contracts and third kind of this muscle contraction is isometric muscle contraction, in which muscle length stays the same when it contracts. And now, the main point towards which we are going is that that can be cleared by this the coming sentence that muscle contraction is enabled by the conversion of chemical energy into mechanical energy this conversion process is known as a phenomena named as metabolism.

Basically, this particular metabolism is nothing, but the sum of biochemical reactions that basically occur in cells of living organisms the main purpose of this metabolism is to provide energy for vital process and assimilate new organic material into the body. This particular metabolism process can be can be can be analyzed or can be viewed as a energy rate process. Here the story of metabolism goes like it can be defined as a sum of the biochemical reactions that occur in the civil cells of living organisms.

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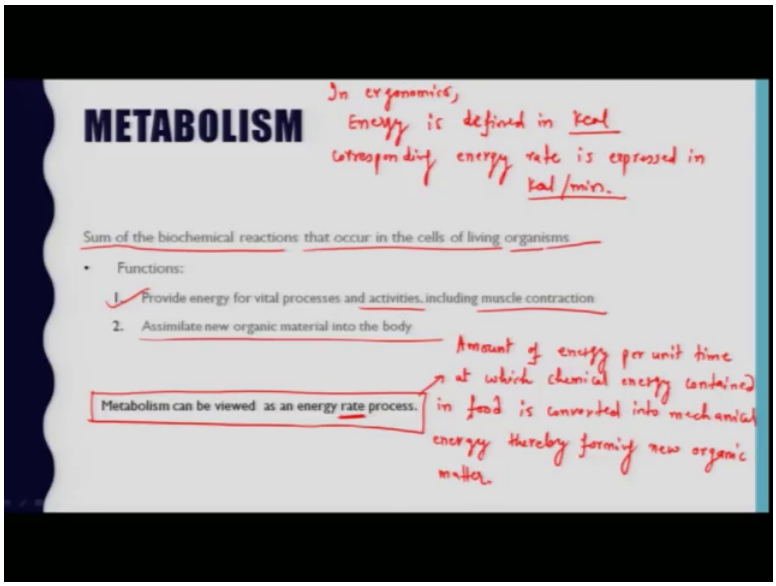

Its function is to provide energy for vital process and activities including muscle contraction and second is assimilate new organic material into the body. This metabolism can be viewed as an energy rate process, that is it is defined as the since it is in the rate defined as a rate. Amount of energy we can define it as a amount of energy, since it is rate. So, we can define it as a per unit time, at which chemical energy contained in food is converted into mechanical energy thereby forming new organic matter.

In ergonomics this particular energy is defined in kilo calorie and corresponding energy rate corresponding energy is expressed in kilo calorie per minute. This kilo calorie and kilo calorie per minute can be converted to other measures of energy and energy rate by means by equivalence, but in the ergonomics and in the in this series of lectures where were we will be using this energy and energy rate calculation we will be using this unit as an kilo calorie for energy and for energy rate calculation kilo calorie per minute.

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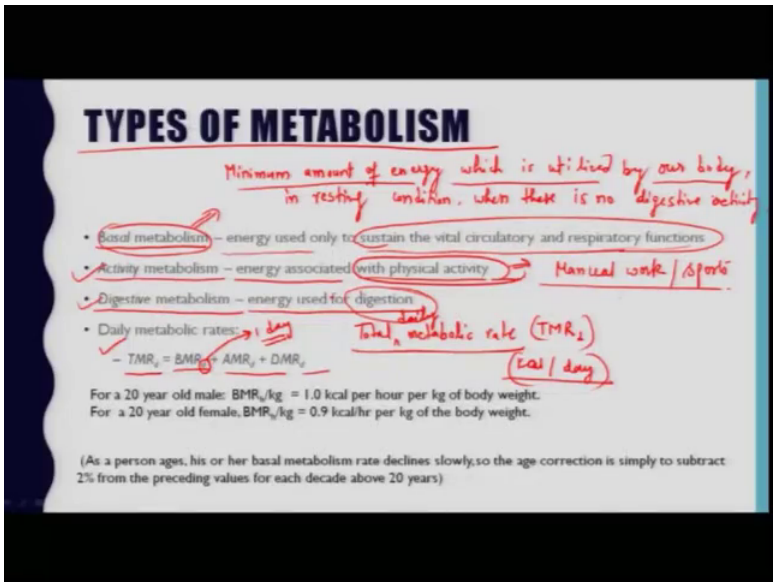

Now the most important point here we are going to discuss that is what are the possible types of metabolism because this possible conversion of energy will decide your course of action and how much you can perform as a task and for that particular task how much energy is required. That calculation is coming in this metabolism process and we will now try to understand various metabolism rate and activities related to that. The types of metabolism here we are going to discuss and. This particular metabolism can be discriminated as basal mechanism, activity metabolism and digestive metabolism. So, what is this basal metabolism?

We need to understand this particular topic. For that since basal metabolism is minimum amount of energy oh which is utilized by our body, this is the minimum energy minimum amount of energy which is utilized by our body in resting condition or when body is in rest in rest condition and especially when there is no digestive activity, that particular energy is known as basal metabolism. In other words since this is the minimum amount of energy which is required in order to just sustain the body it is not involving in any kind of digestive activity or in any physical activity.

This kind of activity is known as basal metabolism. This is just to sustain our body and for in order to sustain our body. So, only the circulatory and respiratory functions need to be conducted within the body. The energy used only to sustain the vital circulatory and respiratory functions that particular energy is known as basal metabolism. Now the

second kind of metabolism is activity metabolism. So, that particular activity metabolism is energy associated with physical activity.

Here energy associated with physical activity is known as activity metabolism and this particular as a physical activity you can take any example, let us say if you are playing any sport or involving any physical activity, the example you can take as any kind of manual work or sports and other activities where exactly you perform a physical actions the third kind of metabolism is the digestive metabolism. So, here the energy used for digestion whenever you intake food, body starts functioning and it provides you energy to digest that particular food.

Here if you combined these 3 metabolic rates. In fact, those were the metabolism and the energy affiliated with that. So, that is known as let us say this basal metabolic rate activity metabolic rate and digestive metabolic rate. Here if you combine these 3 metabolism as a combination of that we can define as a total metabolic rate and that we will express as a T M R D and since if we are talking if we are talking the total metabolic rate in the course of whole day the one day what kind of activity that has been performed and if you want to calculate the energy rate corresponding to that.

So, you will have to put small d over this T M R. So, the T M R D is known as total. In fact, total daily metabolic rate. This is expressed as the T M R and since this particular small d is put for one day one day activity. So, the T M R as a combination of all the activities is B M R plus A M R D plus D M R D. So, T M R is the total daily metabolic rate which is expressed in kilo calorie per day and this B M R is the daily basal metabolic rate, which is also expressed in kilo calorie per day A M R D is daily activity metabolic rate and D M R D is a daily digestive metabolic rate that is also expressed in kilo calorie per day

Now if you want to calculate our metabolic rate. So, the basic metabolic rate of an individual depends on the person’s weight.

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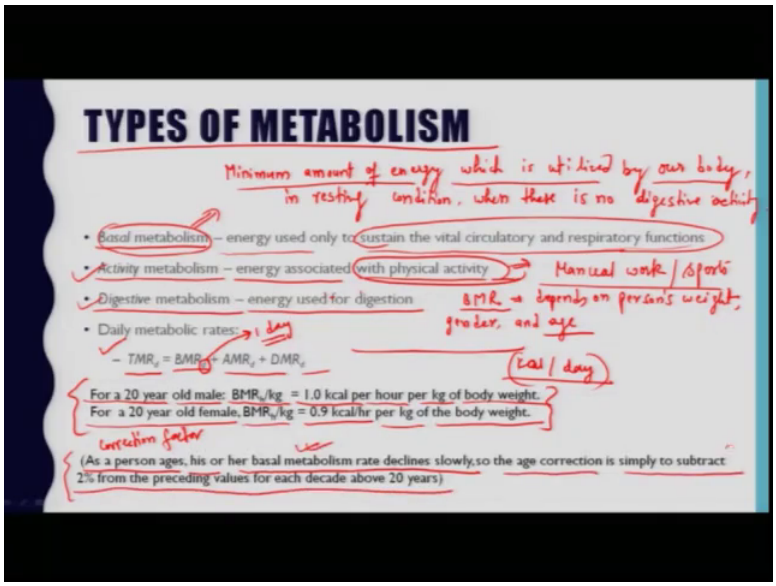

This particular in fact, B M R is depending on the person's weight gender and age also it this particular B M R is depending on other factors like heredity and percentage of the body fat. So, for our purpose we will use the particular these values for weight and gender and then apply age correction depending on the situation and depending on the person to person clarification.

So, here as an as a reference we are taking 2 things first for male. Let us say for a 20 year old male. So, B M R per kilogram will be one kilo calorie per hour per kilogram of a body weight and for 20 years old female. So, B M R per kilogram we will be taking as 0.9 kilo calorie per hour per kilogram of the body weight. And as well as, one the correction factor we have to include as far as in order to calculate any basal metabolic rate.

So, correction factor we have to also take care in mind like, as a person ages his or her basal metabolism rate declines slowly. As the person age advances, his or her basal metabolism rate declines slowly. The age correction is simply to subtract 2 persons from the preceding values for each decade above 20 years. This particular sentence we are going to implement in one numerical which we are going to solve in the next slide, that the understanding of this whole concept could be developed.

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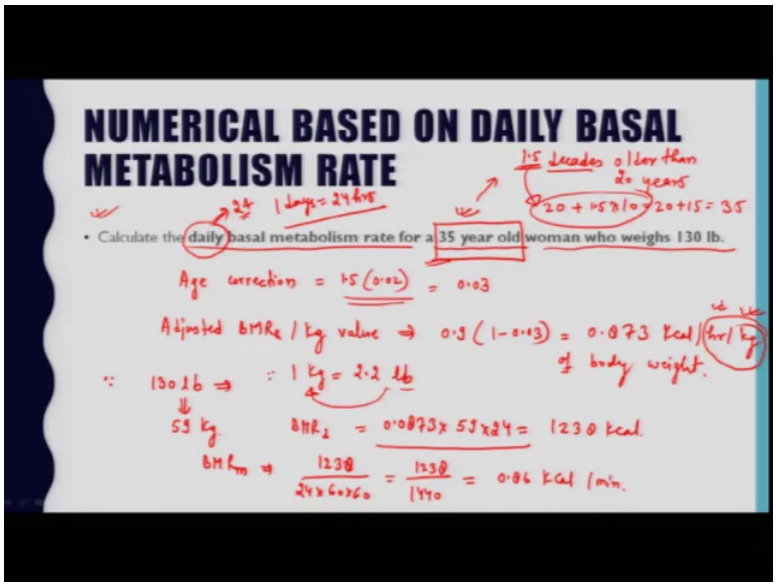

Now, based on the previous fundamentals and concepts that we have discussed- now we are going to solve a particular numerical that is completely dependent on the theory that, we have covered. Now, suppose you have been told to calculate the daily basal metabolism rate for a let us say 35 year old woman who weighs 130pound. So, what will be your approach in order to solve this particular equation this particular question. So, now, this since this particular woman is 35 year old woman.

Now recall the just made sentence that as a person ages his basal metabolism rate declines slowly. So, the age correction is simply to subtract 2 percent from the preceding values for each decade about 20 years. Now, what we need to do is since, she is we can say that 1.5 decades older than 20 years. So, here for since it is she is a female. For 20 years old female, B M R is 0.9 kilo calorie per hour per kilo gram of the body weight.

This particular value we will take as well as the age correction that we will also take into consideration. Now, we have to adjust it is according to the her age. So, she is 1.5 decades older than 20 years. So, age correction will be 1.5 times like it is a 2 percent. So, 0.02 which is equal to 0.03 since she is 1.5 decades older than 20 years it is simply like 20 plus 1.5 decade mean 10 into 10 times.

So, 20 plus 15 equals to 35. So, the sentence is just made by this particular thing. So, that this particular 1.5 we have applied as a 1.5 times 0.02 is 0.03, now adjusted B M R will be adjusted B M R per kilogram value will be since she is a woman. So, 0.9 is the actual

for 20 years old female B M R value and since we have to subtract it with this value. So, the value is coming something if you will calculate to something will come out.

So, this is like kilo calorie per hour per kilogram of body weight. Now, since her weight is 130 pound, we need to convert it into kilogram. So, since 1 k g equals to 2.2 pounds. So, her weight will be if you convert it from 1 pound from this pound to kilogram. So, you will be getting equivalency of 59 k g and now if you are talking about the daily base daily basal metabolism rate. So, we have to multiply it by 24 because one day carries this 24 hours.

Now B M R for on the daily basis will be something like 0.873 into her weight that is 59 since we have to remove these things. We have to accordingly multiply those options like in a kilogram and since daily activity we have to consider. So, 24 we have to multiply with these particular digits. So, the lump sum amount we are getting as a 1 2 3 8 kilo calorie. In fact, this can be converted into the equivalent numeral value per minute also.

So, you just have to divide by number of minutes in 24 hours period. If you gone to calculate it in minutes. So, that correction you can take as 1 2 3 8 upon something 24 into 60 into 60. So, that you will get as 1 4 4 0 and that the value will be you will be getting as something 0.86 kilo calorie per minute. So, in adjurate associated with activity metabolism is essential to calculate in order to have your proper body functioning.

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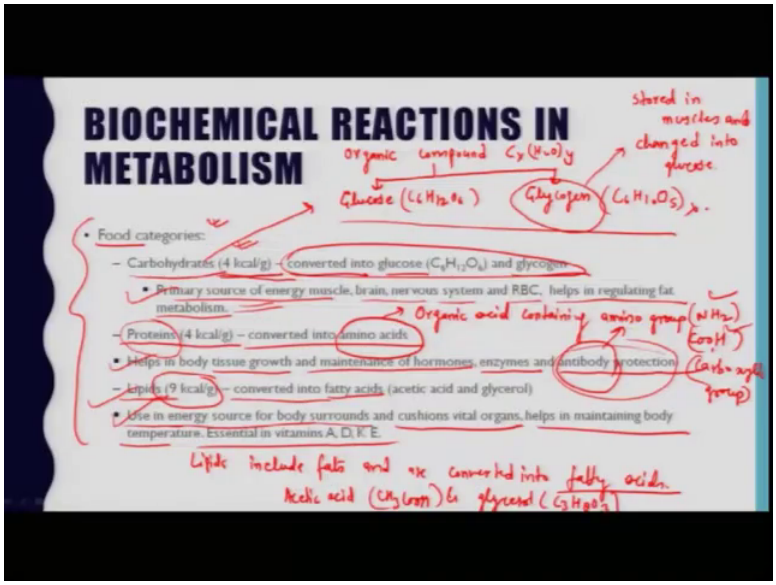

Now the gain the next topic which you are going to cover is biochemical reactions and in metabolism. Before going into detail about the various nutrient contents and various functions in the body and common food sources as well as the energy related to particular source particular source. Let us consider process by which, the human body converts the food into muscle activity. The source of chemical energy for metabolism is the food that is ingested and digested by the body.

It requires primary food nutrients. Those food nutrients are carbohydrates, proteins and lipids. There is a energy associated with these food categories and those are this particular carbohydrate is having 4 kilo calorie per gram as an energy this protein is having energy as a 4 kilo calorie per gram the proteins in fact this lipids having the highest as a 9 kilo calorie per gram. So, these are basically 3 basic nutrients in food with this calories content and generally what does this carbohydrate does, it converts it basically this carbohydrate is converted into glucose and glycogen.

The primary source of energy muscle brain, nerves system and RBC and it also this particular carbohydrate helps in regulating fat metabolism. So, the common food sources for these particular carbohydrates are fruits, juice, milk, rice, potato. That can be obtained from some other sources also and the protein as we are aware that this particular protein is helping is helpful in body for a tissue growth and maintenance of hormones enzymes and antibody protection.

So, antibody is required in order to tackle, in order to fight for external matters that is antigen. So, the antibodies created in the body itself and again this protection of the antibody is also essential which is performed with the help of proteins and another kind of category is lipids. So, it uses the use in energy source for the body surrounds and cushions vital organs helps in maintaining body temperature and it is essential in essential in vitamin A D K E.

This is the some of the basic nutrients in the food with some sort of calorie content and functions in the body. These are the functions which we have just listed down and basically this carbohydrate if you are talking about this conversion of glucose and glycogen. Let us have a some brief overview about this functioning of this carbohydrate. So, this carbohydrate is basically an organic compound as you are aware of the fact that this is a organic compound having general chemical formula of Cx H2Oy and it is simply

transformed into 2 simpler sugars it is glucose the chemical formula is C6 H 12 O 6 and the second kind of sugar is glycogen whose chemical formula is C 6 H 10 O 5 sixso this particular glycogen is stored in the muscles this is stored in muscles and changed into glucose wherever it is required whenever it is required changed into glucose. So, this is in brief this about the carbohydrate functioning now this protein basically this protein is broken down into amino acids. So, amino acids are again these are the organic acids organic we mean that it consist of carbon, hydrogen, nitrogen and oxygen. So, this organic acid which contains which contains amino group that is NH 2 and carboxylic group that is COH

These 2 groups carboxylic group and as well as this lipid is concerned, it is converted into fatty acids and glycerol. So, lipid includes this lipid. In fact, these lipids include fats and are converted into fatty acids. So, these fatty acids' meaning thereby these acetic acids that is CH 3 COH and glycerol this is C 3 H 8 O 3.

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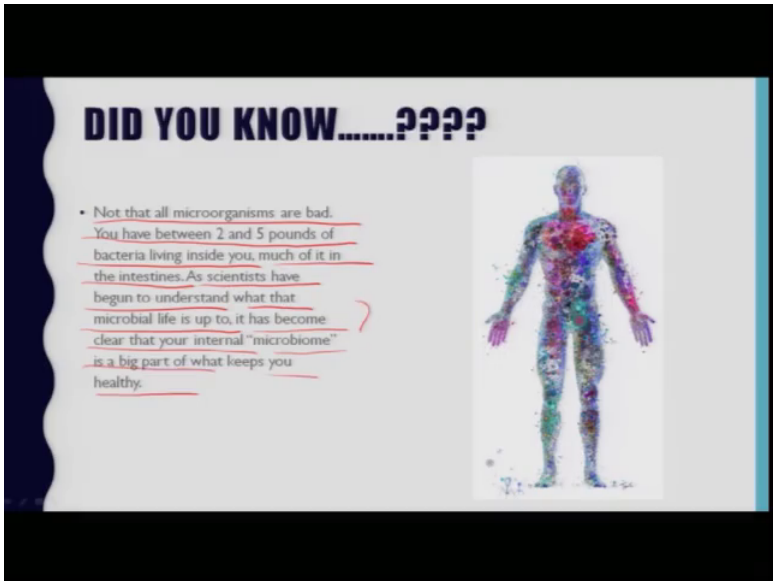

I hope this has clarified about the metabolism biochemical reactions and various food categories and their energy content and now with this I am going to close this lecture and I hope some sort of things apart from engineering you have been gone through and I hope you have found somewhat interest in that because it is related to your human body and it is our duty to know the various facts which are happening inside our body and. So, that we could live our life disease free of disease and with greater with certain longevity

and. So, I am going to close this lecture before that just have a fact for refreshing you for your refreshing purpose that not that all microorganisms are bad.

You have between 2 and 5 pounds of bacteria living inside you much of it in the intestines as scientist have began to understand what that microbial life is up to it has become clear that your internal micro biome is a big part of what keeps you healthy. So, another thing that if you were a navy commander.

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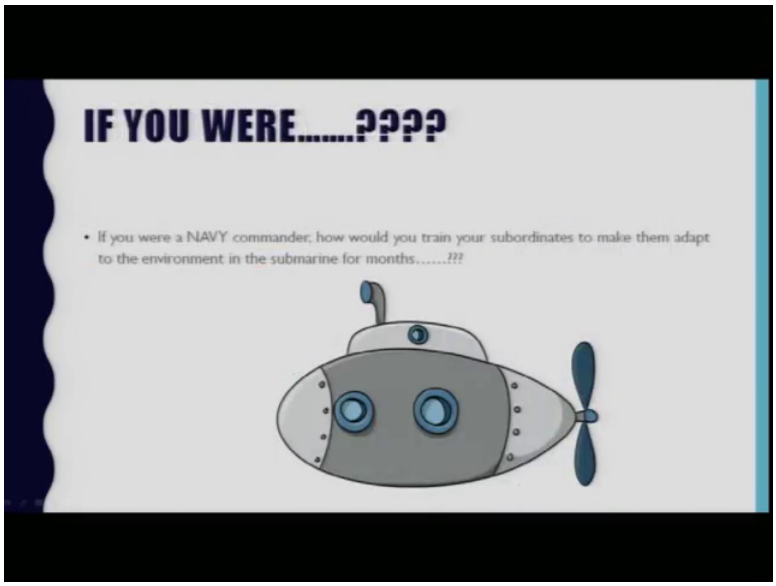

How would you train your subordinates to make them adapt to the environment in the submarine for months just have a brief history of human physiology.

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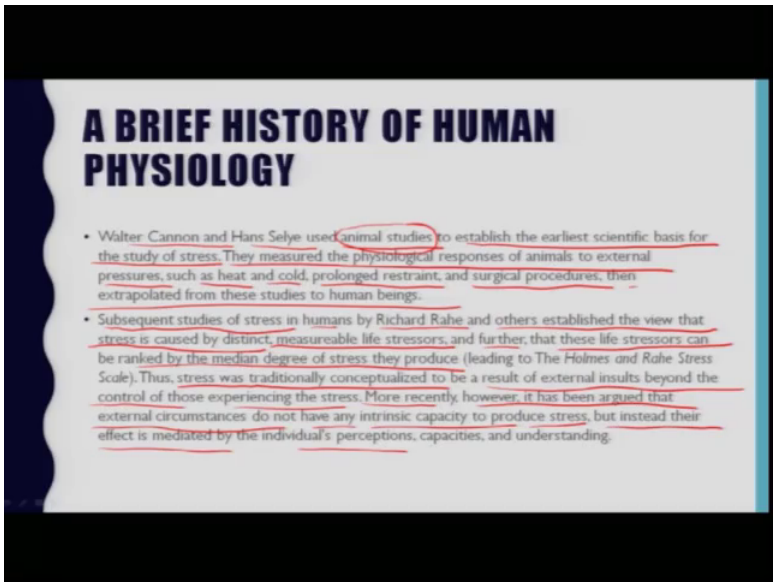

Since we have started with physiology let us have a some facts in things like water cannon and Hans Selye used animal studies to establish the earliest scientific basis for the study of a stress. So, that animal we used to take help of animals in order to have a some theory and which we can relate with the human physiology.

They measure the physiological responses of animals to external pressures such as heat and cold prolonged restraint and surgical procedures then extrapolated from these studies to human beings subsequent studies if stress in humans by Richard Rahe and other established the view that stress is caused by distinct measurable life stressors and further that these life stressors can be ranked by the median degree of stress they produced and thus stress was traditionally conceptualized to be a result of external insults beyond the control of those experiencing the stress.

So, more recently; however, it has been argued that external circumstances do not have any intrinsic capacity to produce a stress, but instead their effect is mediated by the individuals perception capacity understanding.

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This is brief overview just for the sake of your knowledge and the final graffiti is the exercise is great way to reduce a stress. So, that is all for now.

Thank you.