KHE 206

Human Anatomy, Physiology and Sports 2

BY

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Course Code: KHE 206

Course Title: HUMAN ANATOMY, PHYSIOLOGY AND SPORTS 2 (2 C)

Course Description: Anatomy, physiology and Sports 2 exposes students to the possession of an in-depth knowledge of structural and functional organisation of the human body for movement, and the principles and laws related to human movement as they relate to sports performance and coaching.

Course Guide

Introduction

This is an overview of human anatomy and physiology in relation to human movements such as found in sports and the place of the nervous system in the control of locomotion. It is an in-depth study of the body's neuro-muscular and skeletal systems' structure and function in the production of sports movement techniques and skills.

Course Aim

The course is aimed at studying the mechanics of muscular contraction leading to physical activity. The metabolic processes of sourcing energy for muscular contractions, nervous stimulation of muscular contraction and attachments of muscles across joints of the skeletal system that makes movement possible in addition to responses to physical activities shall be discussed specifically.

Course Objectives

By the end of this course you will be able to:

1. Understand the concepts of movement, physical activity, exercise, and training in specific movements as found in sports skills.
2. Identify the bones that used to form the different types of joints that allows for human movement.
3. Explain how the skeletal muscles are organised and innervated to bring about movement.
4. Show how the nervous system is organised and suited for instigating all forms of human movement and sensing of internal and external environments.
5. Describe the metabolic processes of sourcing energy for human movement
6. Explain how the human body systems respond to physical activity in various atmospheric conditions.

Working through this Course

You need a minimum of 90 hours of study to successfully complete this course. This time include the hours of studying the course guide and study units. Spend a minimum of 6 hours of study per study unit in a week.

In each unit, read the unit Intended Learning Outcome(s). When you are done studying the unit, check to see the extent to which you have been able to achieve the unit Intended Learning Outcome(s). If you are not, go through the study unit once more and ensure you are able to achieve the stated Intended Learning Outcome(s) in the study unit before you move on to the next unit. Do all the self-assessment exercises in each unit. The self-assessment exercises will help you check your progress.

Take notes when reading and listening to the video clips. You may use your note pad and pen, or Microsoft Word document in your computer or use Google drive. This will help you create and organise your portfolio. Should you encounter any technical challenge while studying, contact the technical support in the direction or links provided.

You are to take the four Tutor Marked Assignments (TMAs) in this course. They will be graded and returned to you.

Study Units

There are 15 study units in this course divided into five modules. The modules and units are presented as follows:

Module 1 Introduction to Human Movement (Physical Activity) and Sports Performance
Unit 1: Conceptual Clarifications in Human Movements and Sports

Module 2 Organisation of the Skeletal and Muscular Systems for Physical Activity

Unit 1: Organisation of the Skeletal System for Physical Activity
Unit 2: Types of Bones and their Arrangement in the Human Skeleton for Physical Activity
Unit 3: Organisation of the Muscular System for Physical Activity
Unit 4: Skeletal Muscles' Structure and Arrangements for Physical Activity

Module 3 Organisation of the Nervous System and the Senses for Physical Activity

Unit 1: Structural Organization of Nervous System for Physical Activity

Unit 2: Functional Organisation of the Nervous System

Unit 3: The Senses I; Sensations and the Sensory Pathways

Unit 4: The Senses II; Structural Organisation of the Different Types of Senses

Module 4 Overview of Digestive, Circulatory and Respiratory Processes in Physical Activity

Unit 1: Digestive System's Processes in Physical Activity

Unit 2: Circulatory System's Processes Physical Activity

Unit 3: Respiratory System's Processes in Physical Activity

Module 5 Neuromuscular Actions and Metabolic Processes in the Sourcing of Energy for Physical Activity

Unit 1: Neuromuscular Actions I

Unit 2: Neuromuscular Actions II

Unit 3: Metabolic Processes in the Sourcing of Energy for Physical Activity

References and Further Reading

The following reference links are provided for further readings.

Robergs, R. A. & Kateyian, S. J. (2003). *Fundamentals of exercise physiology for fitness, performance and health. (2nd ed.).* New York. McGraw Hill.

Amusa, L. O. & Abass, A. O. (2002) *Physiology Applied to Physical Conditioning.* Centre for External Studies, University of Ibadan.

Fox, E. L. & Matthew, D. K. (1981). *The Physiological Basis of Physical Education and Athletics.* Philadelphia: Saunders College Publishing.

McGlynn, G. (1999). *Dynamics of Fitness: A Practical Approach. (5^{th} ed.).* The McGraw – Hill Company Inc.

Presentation Schedule

The presentation schedule sent to you gives you the important dates for the completion of your TMAs and participation at facilitation. Remember, you are required to submit all your assignments at the appropriate time. You should guard against delays and plagiarism in your work. Plagiarism is criminal and is highly penalised.

Assessment

There are two aspects of the assessments in this course. The first is your TMAs and the second is a written examination at the end of the course; which you will take through the use of the computer. In tackling the assignments, you are expected to apply information, knowledge and techniques gathered during the course. The assignments must be submitted through the links provided in the course page in accordance with the timelines for formal assessment and feedback. The TMAs shall form 30% of the course total marks. Your portfolio may form part of your TMA assessment.

At the end of the course you will have to sit for a final written examination for two hours. The examination shall be taken through the use of the computer or pen-on-paper. The system will be programmed to open at the start of the examination and automatically closes at the scheduled time to end examination. The examination takes70 percent of your course marks.

Tutor-Marked Assignment (TMA)

There are four Tutor-Marked Assignments in this course. You need to submit the four assignments for grading. Three best scores shall be selected from the four TMAs for use as your continuous assessment score. The maximum score for the three TMAs shall be 30%.

Should you have any challenge starting the assignments or submitting at the due dates, you may request for extension from your facilitator.

Final Examination and Grading

The final examination for KHE 206 will be for two hours and it takes 70 percent of the total course grade. The examination will consist of questions that reflect the types of self-assessment and Tutor-Marked exercises you have previously encountered. All areas of the course will be assessed. Deploy the time between finishing the last unit and sitting for the examination to revise the entire course. You may find it useful to review your self-assessment exercises and comments by your tutorial facilitators before the examination. The final examination covers information from all parts of the course.

How to Get the Most from the Course

In distance learning programme, the study unit replaces the university lecturer. This is one of the greatest advantages of distance learning programme. In this course you have the opportunity of working and studying through a well-designed study material at your own pace and at a time and place that suits you best. Read the material as against listening to a lecturer in the conventional school system. The content is complemented with audios teachings as well as watching related videos. In the same way that a lecturer might recommend some reading materials, the study units tell you when to read recommended books or other materials and when to undertake practical activities. Just as a lecturer might give you class exercises/activities, your study units provide exercises for you to do at the appropriate time. Each of the study units follows a common format. The first item is an introduction to the subject matter of the unit and how a particular unit is integrated with the other ones and the course as a whole. Next is a set of learning Intended Learning Outcome(s) which state what you will be able to do by the time you have completed the unit. These Intended Learning Outcome(s) are set to guide your study. When you have finished a unit, you must go back and check whether you have achieved the Intended Learning Outcome(s). If you cultivate the habit of doing this, you will make tremendous improvement in your chances of passing the course.

The main body of the unit guides you through the required reading from other courses. This will usually be either from your recommended books or from a reading section. Self-assessment exercises are interspersed throughout the unit. You are expected to work on them as well. Working through these exercises will help you to achieve the Intended Learning Outcome(s) of the unit and prepare you for the assignments and the examination. You should attempt the self-assessment exercise as you come across it in the study unit. There will also be several examples given in the study units; work through these when you come across them too.

Study Guide

Module	Unit	Week	Activity	Time
	Study Guide	1	Read the Study Guide	6 hrs
Module 1	1		**Conceptual Clarifications in Human Movements and Sports**	
Module 2	1	2	**Organisation of the Skeletal System for Physical Activity**	6 hrs
	2	3	**Types of Bones and their Arrangement in the Human Skeleton for Physical Activity**	6 hrs
	3	4	**Organisation of the Muscular System for Physical Activity**	
	4	5	**Skeletal Muscles' Structure and Arrangements for Physical Activity**	
			TMA 1	
Module 3	1	6	**Structural Organization of Nervous System for Physical Activity**	6 hrs
	2	7	**Functional Organisation of the Nervous System**	6 hrs
	3	8	**The Senses I; Sensations and the Sensory Pathways**	6 hrs
	4	9	**The Senses II; Structural Organisation of the Different Types of Senses**	
			TMA 2	
Module 4	1	10	**Digestive System's Processes in Physical Activity**	6 hrs
	2	11	**Circulatory System's Processes Physical Activity**	6 hrs
	3	12	**Respiratory System's Processes in Physical Activity**	6 hrs
			TMA 3	
Module 5	1	13	**Neuromuscular Actions I**	6 hrs
	2	14	**Neuromuscular Actions II**	6 hrs
	3	15	**Metabolic Processes in the Sourcing of Energy for Physical Activity**	6 hrs
			TMA 4	

Module	Unit	Week	Activity	Time
		16	Revision	6 hrs
			Exam	2 hrs
Required Total Hours of Study				**90 hrs**

Facilitation

You will receive online facilitation. The mode of facilitation shall be asynchronous. Your facilitator will summarise each unit of study and send to your mail weekly. The facilitator will also direct and coordinate your activities on the learning platform.

Do not hesitate to contact your tutor by telephone and e-mail. Contact your facilitator if you:

- do not understand any part of the study units or the assignment;
- have difficulty with the self-assessment exercises; or
- have a question or problem with an assignment or with your tutor's comments on an assignment;

Read all the comments and notes of your facilitator especially on your assignments and participate in the forums and discussions. This is the only chance you have to socialise with others in the programme. You can raise any problem encountered in the course of your study. To gain the maximum benefit from course tutorials, prepare a list of questions before the discussion session. You will learn a lot from participating actively in the discussions.

Course Code: KHE 206

Module 1 Introduction to Human Movement (Physical Activity) and Sports Performance

An in-depth study of the mechanics of human movement that is aimed at gaining knowledge of the body's neuro-muscular and skeletal systems' structure and function in the production of sports movement techniques and skills should rightly start with clarification of related concepts. In this module, you will be introduced to concepts of movement as a characteristic of all living thing things generally and the types of movements used in sports specifically.

Unit 1: Conceptual Clarifications in Human Movements and Sports

1.0 Introduction

This unit will introduce you to the concept of physical activity as the movement resulting from skeletal muscle contraction that is used in exercise and training for improving human performance abilities in sports techniques and skills.

2.0 Intended Learning Outcome(s)

By the end of this unit, you would be able to

- Understand movement as a major process of human life that is expressed in sports performance.
- Describe techniques and skills as the basic movements of every sport
- Describe the different classes of sport movement skills
- Show how physical activity is related to exercise and training for improvement of physical fitness and performance of skills as found in sports and dance.

3.0 Main Content

Movement; the Major Process of Human Life

When you wake up from sleep in the morning, you stretch on the bed, push yourself up with your arms and sit up on the bed. You get off the bed and perform your morning chores, including self care activities such as brushing your teeth, taking your bath, preparing and taking breakfast and so on the day continues. Throughout the day, you move different parts of your body for different purposes. You might even decide to play one sport or another. All of these activities are described as movement. Movement is described as the act of changing place, position and/or posture in relation to a given environment. Movement is not only the whole body movements described above. Circulation of molecules or blood cells around the body, the rise and fall of our chests as we breathe in and out are also described as movement.

All the processes of a living being are seen in a moving person. We know that a person is alive when he performs all the movement activities of keeping the house and himself/herself in order before leaving for school, work, market, places of worship and recreation or the field for sports training. All the movement activities outside the home, in those places he left home for are signs that the person is alive. When he/she finally returns home, he performs other movement activities before going to sleep and we know the person is living by the movement activities of breathing and heartbeat. Indeed it is movement that enables us to know the difference between a living person and one who is not. Movement, therefore, is a process of human life what identifies a living person.

The body can perform and instigate (or cause to take place) several types of movements. Crawling, climbing, walking, running, hopping, skipping, leaping, galloping, rotating, bending, stretching, jumping and turning in any direction are movements that the body can make. Throwing, pulling, pushing, kicking, spiking, slapping and punching are movement actions humans use to make other objects, animals or humans to move. These types of movement actions, of moving themselves and making others to move, are used by humans to perform several sports and dance skills.

Techniques and Skills in Sports

Techniques are the basic movements of any sport or event. For example, the block start in a 100m race is a technique, a kick in Karate and the breaking-of-balance pull or pushes for a throw in Judo are techniques. Skill is sports specific and so skill learning is more of learning specific sports techniques. There are a large range of sports movement actions. Each of these movement actions requires its own specific set of techniques and skills. Skills have many characteristics that can change in relation to the situation and circumstances that abounds. For this reason, it is difficult to classify sports skills. It is thus better and more understandable when skills are placed on a continuum since they cannot be neatly labelled.

Playing sports in a continuously changing environment requires that movement need to be adapted on a continuous basis if such sports movements are to be successfully executed. These kinds of sports are said to involve open skills. For example, judo is said to involve both open skills and closed skills. In competitive judo a player could seize the opportunity of a false move by the opponent and follows with a throw or ground work attack which is a predominantly perceptual and an externally paced move. The player could also go into a throwing technique that is so strong that the contest ends with an ippon (a full point winning score) thereby being the demonstration of a skill that is self-paced and so could be regarded as a closed skill.

Swimming, running and cycling are examples of sports that involve the use of continuous skills. Individual skills as used in high jump, are those performed in isolation, coactive skills as found in running and swimming are those performed at the same time as others but without direct confrontation while interactive skills as used in rugby, football, basketball, netball, judo, taekwondo and karate are those performed where other performers are directly involved.

The element of timing in the successful return of a tennis serve makes tennis a self-paced skills sport as well as an externally paced skills sport in that a tennis player usually instigate his opponent to move by the type of serve he delivers while it is the type and direction of the opponent's service movement that determines the type and direction of the return.

Physical Activity, Exercise and Training in Sports Techniques and Skills.

It is the working together of the body's skeletal, muscular, nervous and energy systems that makes movement to occur. All of these body systems must interact and adapt to a constantly changing environment for the body to successfully move itself or others. It is contracting muscles that pull the bones they are attached to together about a joint. These bones act as levers to bring about the movement of the body part these bones are supporting. Muscles cannot contract unless they are stimulated to do so by the nervous system. Muscles can only contract when there is energy supply for the contraction to take. Therefore, any kind of movement of the human body and/or its part(s) brought about by contracting skeletal muscles which is due to nervous stimulation and is accompanied by energy consumption is described as physical activity. All the things we do at home that involve muscular contractions, such as sweeping the house and compound, bathing ourselves, gardening, cooking, are physical activities. Every movement we make as we move out of our home for work, worship, school or play are physical activities. Also, all the sports techniques that can be skilfully executed are physical activities.

Exercise, on the other hand, is any physical activity that is performed for the purpose of improving, maintaining, or expressing a particular type(s) of physical fitness. For example, physical activities, such as running or sets of weight lifting can be arranged as exercises for the purpose of specifically preparing athletes for races and weight lifting events of the National Sports Festival. Also, walking can be arranged as an exercise to help patients who are recovering from stroke to recover walking functions.

The repeated use of exercise for the purpose of improving any of the components of physical fitness is described as training. For this reason, we have sports training, fitness training and dance training. Taking out sprinters to the field to practice any new running technique for successfully executing 100m sprint is sport training. Going out early in the morning for jogging for the purpose of maintaining our health or weight reduction is fitness training. Going for ballet dance classes to learn a particular dance move is dance training.

Physical fitness refers to how well the human being's body is capable of performing every physical activity at work, leisure and in exercise for recreation and competition, and participation. Physical fitness is divided into two major sets of components used for describing how physically healthy people are and those indicating how well people can perform different skills as found in sports and dance. These two sets of physical fitness components are health-related components and skill-related components of physical fitness. Health-related components of physical fitness are cardio-respiratory endurance, body composition, muscular strength, muscular endurance and flexibility.

Cardio-respiratory endurance indicates how well a person's circulatory and respiratory systems are functioning. Body composition shows the level of healthy fatness of a person. Muscular strength and muscular endurance indicates the extent to which a person's muscles are able to generate force for doing maximum work and repeated small amounts of work respectively. Flexibility is the amount of movement allowed by a given joint.

Skill-related components of physical fitness are power, agility, speed, balance, coordination and kinaesthetic perception (or accuracy). Power shows fast an individual's muscle can generate force. For instance, a long jumper with higher amount of leg power can jump a longer distance than the one whose leg power is less. Agility is the ability to change direction while in motion. A football player whose agility values are high would do very well in fast dribbling skills. Speed indicates how fast an athlete can move the whole of his body or part of it. Balance indicates how well one can stand on one leg while using the other leg for other activities as dribbling in football. Coordination shows how well an athlete can do more than one movement at nearly the same time such as found when a basketball player is dribbling to avoid an opponent and bouncing the ball at the same time. Kinaesthetic perception describes how well an athlete can accurately locate a partner in team events, and arrange his/her forces to execute specific movements. For example, knowing and applying the exact amount of force to throw a handball across the handball court to an advancing and strategically placed partner during a handball contest is a measures of his/her kinaesthetic perception.

4.0 Conclusion

In this in-depth study of the mechanics of human movement, you have been made to become aware that movement is the very essence of life. You have also been introduced to the different types of movement used in sports and dance and other physical activities of daily living. You also learnt that physical activity is the term used for describing any movement that is due to skeletal muscle contraction during performance of daily living chores, exercise and training for improving human performance abilities in sports and other skills.

5.0 Summary

Now that you have learned that all activities of daily living, movement of the human body as a whole and/or its part(s), brought about by contracting skeletal muscles which is due to nervous stimulation when energy is available are collectively known as physical activity, you are now prepared to go further in the in-depth study of the mechanism of muscular contraction by studying the organisation of the skeletal, muscular and nervous systems in the instigation of human movement.

Self Assessment Exercise

1. In what ways can movement be used to differentiate between a living human being and the one who is not?
2. Show how techniques and skills are used to distinguish the different classes of sport movement skills.
3. Write short notes on the following:
    a. physical activity;
    b. exercise
    c. training
    d. physical fitness

6.0 References/Further Readings

Ajiduah, A. O. (1998). *Basic theory of sports training.* Lagos: University of Lagos press

McGlynn, G. (1999). *Dynamics of Fitness: A Practical Approach. (5th ed.).* The McGraw – Hill Company Inc.

Robergs, R. A. and Kateyian, S. J. (2003). *Fundamentals of exercise physiology for fitness, performance and health. (2nd ed)* New York. McGraw Hill.

Module 2 Organisation of the Skeletal and Muscular Systems for Physical Activity

The in-depth study of the mechanics of physical activity in sports and other skills such as danced skills will be continued in this module. You learnt, in the previous module, that physical activity is any kind of movement of the human body and/or its part(s) brought about by contracting skeletal muscles that are stimulated by the nervous stimulation when there is energy. In this module, you will learn how the skeletal and muscular systems are arranged so as to make the body participate in the movements used in sports and dance.

Unit 1: Organisation of the Skeletal System for Physical Activity

1.0 Introduction

This unit will introduce you to how the bones of the human skeleton are organised into the axial and appendicular skeletons that allows humans make the different types of movement in exercise and training for improving human performance capacities of skills as found in sports and dance.

2.0 Intended Learning Outcome(s)

After studying this unit, you would be expected to:

- Name the different bones of the human skeleton
- Show how bones are arranged in the formation of the axial skeleton
- Describe the arrangement of bones in the appendicular skeleton

3.0 Main Content

Organisation of Bones in the Human Skeleton

Humans are vertebrates or animals having a vertebral column or backbone. They rely on a sturdy internal frame that is centred on a prominent spine. The skeletal system is made up of bones, cartilage, ligaments and tendons which jointly constitute about 20% of the human being's body. Every one of the bones in the skeleton has unique features that are specific to it. These features can be used to identify the bones of the skeleton. Surface markings such as holes, depressions, smooth facets, lines, projections and other markings which got formed so to provide space for blood vessels and nerves, or areas of the bone where it joins to other bones or areas where ligaments and tendons were attached.

There are 206 bones that can be identified in an adult human being's skeleton. These bones are arranged in two groups known as the axial skeleton and appendicular skeleton. The axial consists of a total of 80 bones while the appendicular skeleton is made up of 126 bones. The body is held upright by the bones of the axial skeleton while the appendages, hands and legs with their attachments, are made up of bones of the appendicular skeleton. The bones that form the framework of the head, the vertebral column, ribs and sternum or the breastbone are the bones of the axial skeleton. The 80 bones of the axial skeleton consist of 28 bones of the skull, 26 bones of the vertebral column and 25 bones of the thoracic cage. The skull bones are 8 cranial bones, 14 facial bones and 7 auditory bones. Bones of the vertebral column are 7 cervical vertebrae, 12 thoracic vertebrae, 5 lumbar vertebrae, one (1) Sacrum and one (1) Coccyx. The bones of the axial skeleton are arranged as shown in the illustrations shown on Figures 2.1.1 – 2.1.5 below.

Axial Skeleton

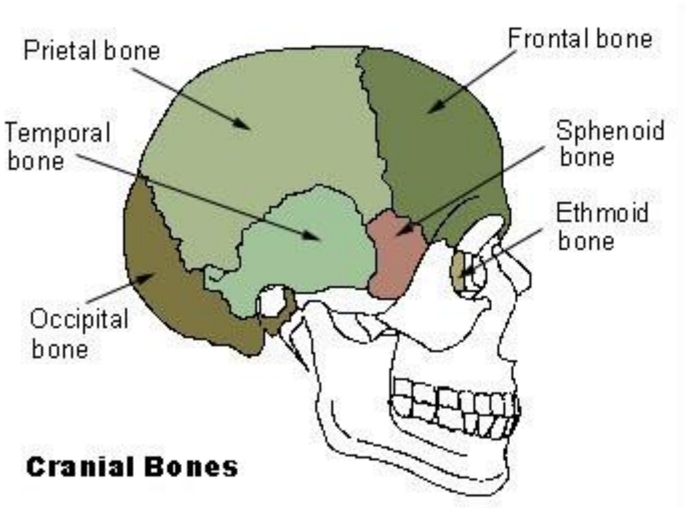

Figure 2.1.1: Bones in the Cranium. Source: ICD-0-3 (2007)

As can be seen from the illustration above, the number and names of the cranial bones are Parietal (2), Temporal (2), Frontal (1) , Occipital (1), Ethmoid (1), Sphenoid (1).

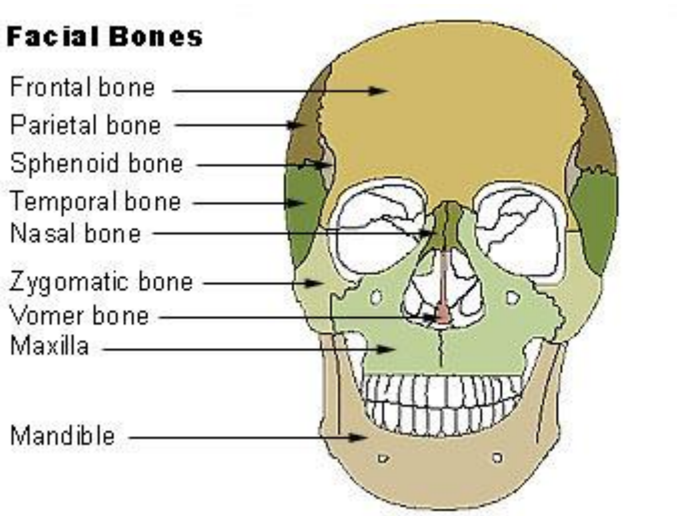

Figure 2.1.2: Facial Bones. Source: ICD-0-3 (2007)

The number and names of the facial bones are Maxilla (2), Zygomatic (2), Mandible (1), Nasal (2), Platine (2), Inferior nasal concha (2), Lacrimal (2) and Vomer (1).

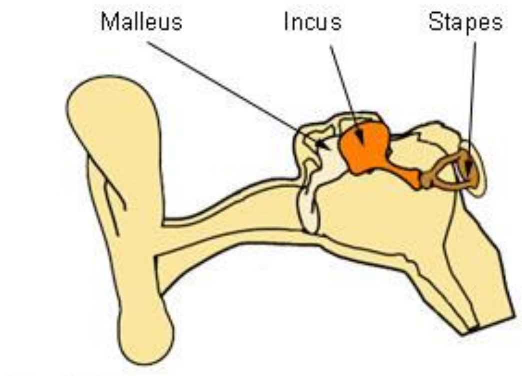

Figure 2.1.3: Ear Bones. Source: ICD-0-3 (2007)

The number and names of ear the bones are Malleus (2), Incus (2), Stapes (2) Hyoid (1).

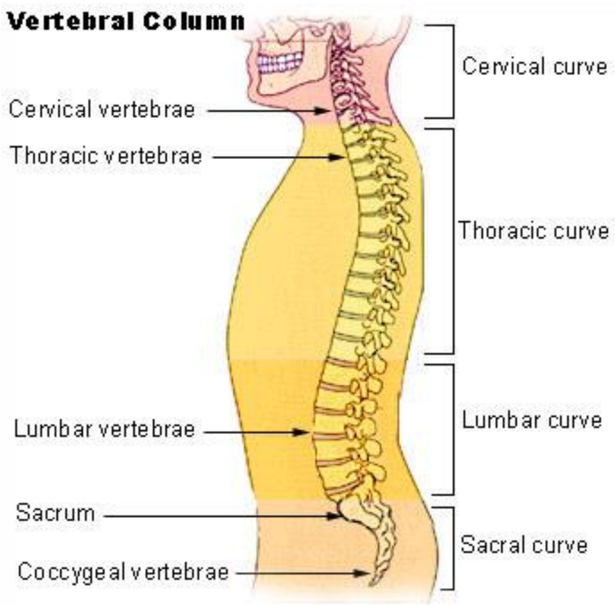

Figure 2.1.4: Bones in the Vertebral Column. Source: ICD-0-3 (2007)

The number and names of the bones in the vertebral column are Cervical vertebrae (7), Thoracic vertebrae (12), Lumbar vertebrae (5), Sacrum (1) and Coccyx (1)

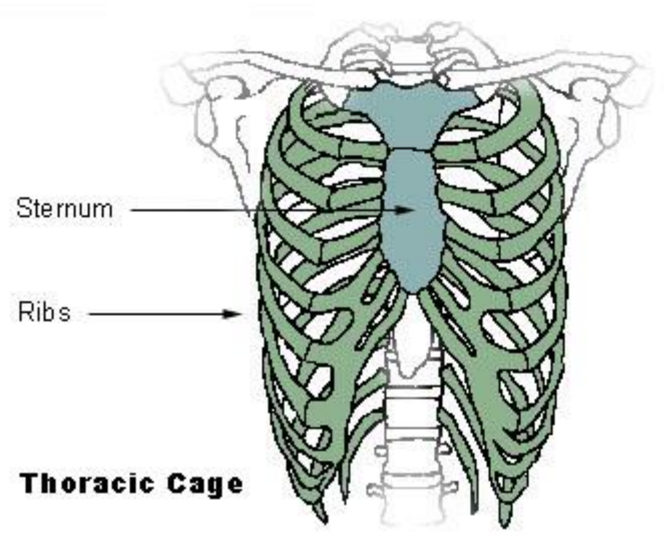

Figure 2.1.5: Bones in the Thoracic Cage. Source: ICD-0-3 (2007)

The Thoracic cage has just two kinds of bones, namely Sternum (1) and Ribs (24)

Appendicular Skeleton

The 126 bones of the appendicular skeleton consist of 4 bones of the pectoral girdles, 60 bones of the upper extremities, 2 bones of the pelvic girdle and 60 bones of the lower extremities. Bones of the pectoral girdle are 2 clavicles and 2 scapulas. Bones of the upper extremities are 2 humerus, 2 radius, 2 ulna, 16 carpals, 10 metacarpals and 28 phalanges (28). The bones of the appendicular skeleton are arranged as shown in the illustrations shown on Figures 2.1.6 to 2.1.9 below.

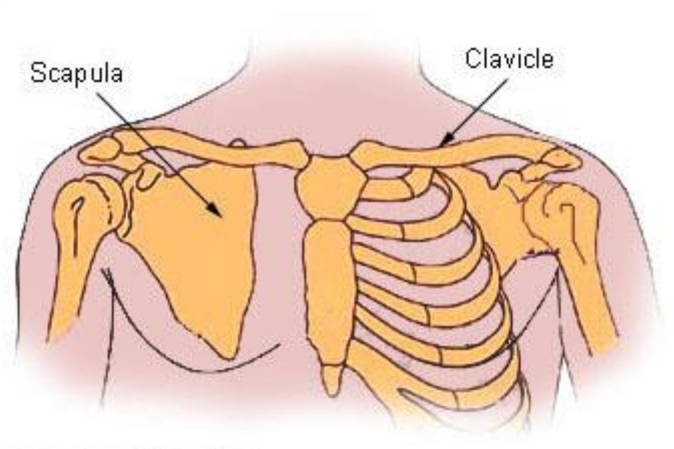

Figure 2.1.6: Bones in the Pectoral Girdles. Source: ICD-0-3 (2007)

There are two types of bones in the pectoral girdles; Clavicle (2) and Scapula (2)

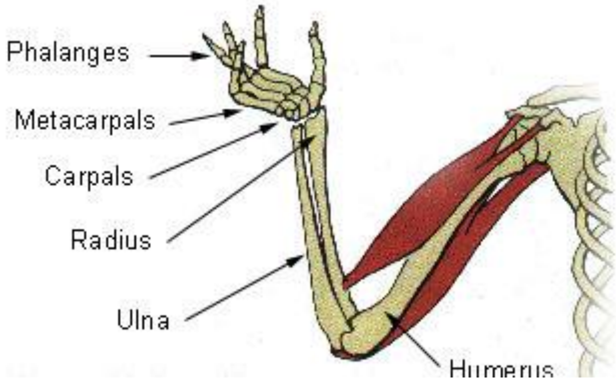

Figure 2.1.7: Bones in the Upper Extremities. Source: ICD-0-3 (2007)

The bones in the upper extremities are; Humerus (2), Radius (2), Ulna (2), Carpals (16), Metacarpals (10) and Phalanges (28).

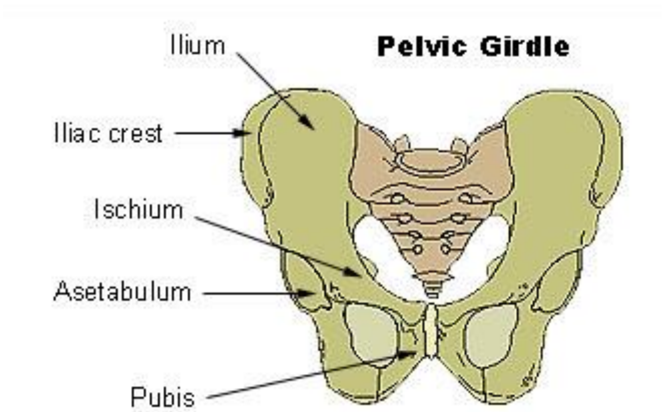

Figure 2.1.8: Hip Bones. Source: ICD-0-3 (2007)

The bones in the pelvic girdle are Coxal and innominate or hip bones (2)

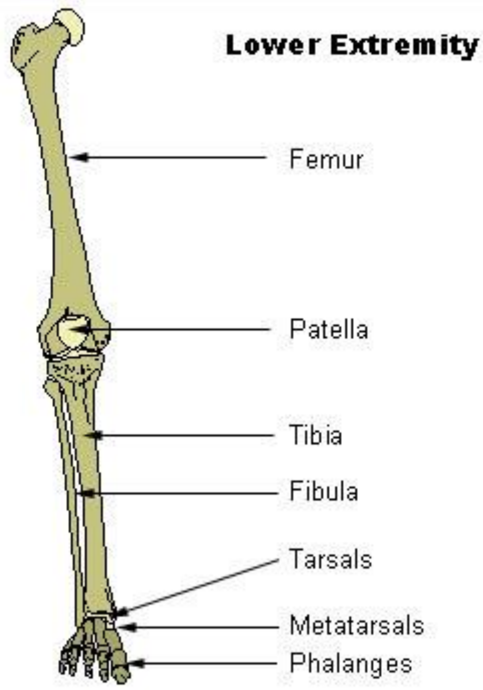

Figure 2.1.9: Bones in the Lower Extremities. Source: ICD-0-3 (2007)

The bones of the lower extremities are Femur (2), Tibia (2), Fibula (2), Patella (2), Tarsals (14), Metatarsals (10) and Phalanges (28).

4.0 Conclusion

In this unit you were introduced to how the bones of the human skeleton are organised into the axial and appendicular skeletons that allows for the different types of movements the body can perform.

5.0 Summary

You have learned that the bones of the skeleton are arranged in such a manner that makes act as simple mechanical lever systems to which muscles are attached for the purpose of moving the body, its parts and/or other objects. You are now prepared to go further in this in-depth study of the mechanism of human movement by studying the arrangement of the bones in the human skeleton in accordance with the features on them in the next unit.

Self Assessment Exercise

1. Identify the different bones in the axial and appendicular skeletons.
2. How many bones are there in the axial and appendicular skeletons respectively?
3. Show how the bones of the thoracic cage are different from the facial bones.

6.0 Reference/Further Reading

Ajiduah, A. O. (1998). *Basic theory of sports training.* Lagos: University of Lagos press

ICD-0-3 (2007). Body Structure and Function. Retrieved on May 10, 2007 from *http://training.seer.gov/module_anatomy/unit1_body_structure.html*

McGlynn, G. (1999). *Dynamics of Fitness: A Practical Approach. (5th ed.).* The McGraw – Hill Company Inc.

Robergs, R. A. and Kateyian, S. J. (2003). *Fundamentals of exercise physiology for fitness, performance and health. (2nd ed)* New York. McGraw Hill.

Unit 2: Types of Bones and their Arrangement in the Human Skeleton for Physical Activity

1.0 Introduction

This unit will introduce you to how the different bones of the human skeleton are arranged in accordance with the particular features found on them. The general functions of the skeletal system will also be studied in this unit.

2.0 Intended Learning Outcome(s)

After studying this unit, you would be expected to:

- Name the different types of bones that forms the human skeleton
- List the different types of joints in the body and describe them
- Describe the general functions of the human skeleton.

3.0 Main Content

Classification of Bones in the Human Skeleton

The human skeleton is made up of bones that are of various shapes and sizes. There are four major types of bones which can readily be identified in the skeleton. These bones are long, short, flat and irregular bones.

Long Bones

Long bones are identified by the fact that they are longer than they are wide. Characteristically, most long bones have compact bone tissue and a long shaft with two bulky extremities or ends that are mainly made of spongy bone tissue. Bones of the thigh and the arms are examples of long bones.

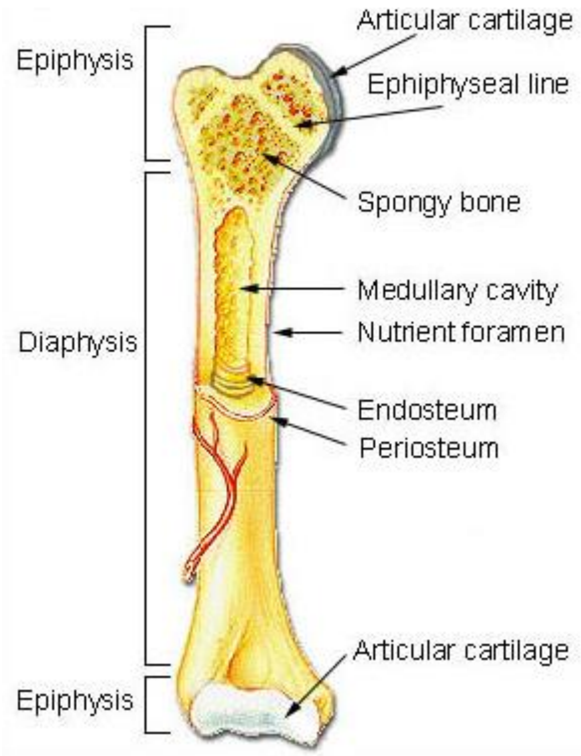

Figure 2.1.1: Long Bone. Source: ICD-0-3 (2007)

Short Bones

Bones that are as long as they are short are classified as short bones. Characteristically, short bones have a shape that look like a cube whose vertical sides are nearly equal in length with its horizontal sides. Short bones are generally made up of spongy bone tissue that is covered by a thin layer of compact bone. Short bones are mostly found in the wrists and the ankles.

Flat Bones

Thin, flattened and mostly bones of the skeleton are generally classified as flat bones. Most of the cranial bones are flat bones.

Irregular Bones

Bones that cannot be classified as long, short or flat bones are classified as irregular bones. Most irregular bones characteristically comprises of spongy bone tissue upon which is a thin layer of compact bone tissue. Bones of the vertebrae generally and some bones of the skull are classified as irregular bones.

Articulation or Joints

All 206 bones of the adult human being are arranged in such a way that two or more bones are connected to each in a point of articulation or joint. Points of articulation or joints in the body are classified into tree major groups depending on the amount of movement the given joint allows. These groups of joints in the body are synarthroses or joints that are fixed in such a manner that they do not any kind of movement, amphiarthroses or joints that allows only slight movements and diarthroses or freely movable.

Synarthroses (singular: synarthrosis) are points of articulation or joints where participating bones are placed so close to one another that they are only separated by a thin layer of fibrous connective tissue. Examples of synarthroses are the thin sutures that hold the flat and slightly concave-shaped bones the skull together.

Amphiarthroses (singular: amphiarthrosis) are joints where hyaline cartilage or fibrocartilage joins the participating bones to one another at the point of articulation. The points of articulation that connect the ribs to the sternum are made up of hyaline cartilage called costal cartilages. The two bones of the symphysis pubis are held together by a joint that is made up of a fibrocartilage pad. The vertebrae are connected to the inter-vertebral disks by amphiarthroses.

In diarthroses (singular: diarthrosis), the bones are plugged into a capsule-like structure made up of dense fibrous tissue. Hyaline cartilage, called articular cartilage, covers the ends of participating bones in a diarthrosis. Participating bones in a diarthrosis do not touch one another; they are separated by a space called the joint cavity. The capsule-like structure in a diarthrosis is called a joint capsule. There are ligaments on the outer layer of the joint capsule that hold the bones together. The joint capsule is covered on insides by a layer of synovial membrane. The synovial membrane secretes a fluid known as synovial fluid into the joint cavity. It is the synovial fluid inside the joint capsules of diarthroses that enables them allows movements to occur freely without friction. It is for this reason that diarthroses are also called synovial joints.

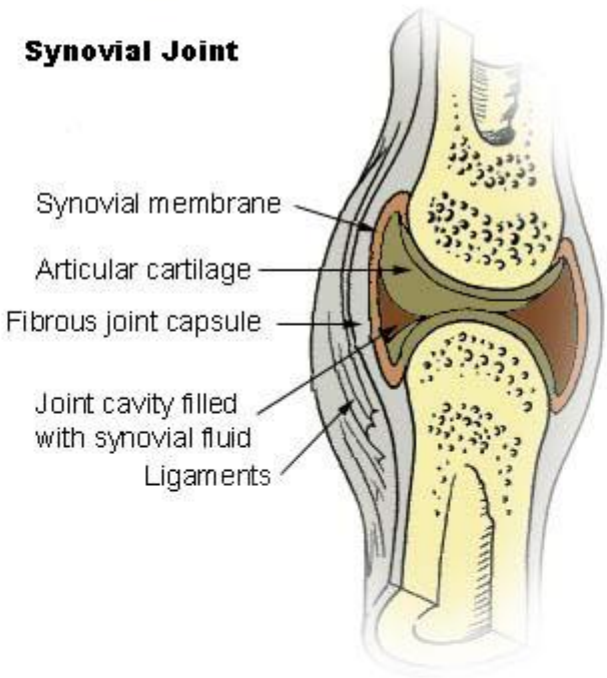

Figure 2.1.2: Diarthrosic or Synovial Joint. Source: ICD-0-3 (2007)

Functions of the Skeletal System

The skeleton performs several important functions for the body. Specifically, the skeleton performs supportive, protective, movement, homeostatic and haematopoietic functions as described below.

Supportive Functions
The skeleton is made up, primarily, of bones which consist of very hard dense irregular connective tissues. The characteristic of bones in the skeleton enables it act as a rigid frame work that every other organ of the body. Gravitational pull does not collapse the body because of its rigid framework provided by the skeleton. The arrangement of long bones of the lower extremities provides support for the trunk of person that is standing upright.

Protective Functions
The body's soft organs are protected by the special arrangement of the bones in the skeleton. So as to protect the brain, the bones of the cranium are fused in such a manner that the brain is surrounded by a hard skull that is less vulnerable to injury. Bones of the vertebral column are arranged in such a manner that the spinal cord is surrounded and protected. The arrangement of the bones known as ribs in the rib cage ensures that the heart and lungs are protected.

Movement Functions
The bones in the skeleton provide a framework of joints across which skeletal muscles are attached and so act as simple mechanical lever systems that make it possible for the body move itself. The force produced by contracting skeletal muscles acts on the mechanical lever system formed by the bones of the skeleton to bring about movement.

Homeostatic Functions
Large amounts of calcium salts, including calcium phosphate, are stored within the intercellular matrix of bones. Anytime the levels of calcium in the blood lower than the amount required for normal metabolic needs of the body, the bones releases calcium to correct the shortage. Also, anytime levels of calcium increases above the amounts needed for metabolic functions, the bones takes up and stores the excess calcium in the matrix of the bone. It is this dynamic function of the skeleton that releases and stores calcium

that goes on nearly on a continuous basis that described as the homeostatic functions of the bones of the human skeleton.

Haematopoietic Functions

Haematopoiesis is the process of forming new blood cells. This process (haematopoiesis) takes place, essentially, in the red marrow of the bones of the skeleton. Red marrow of bones functions in the formation of red blood cells, white blood cells and blood platelets. While nearly every bone cavity contains red marrow in infancy, in adulthood red marrow is restricted to the spongy bone in the skull, ribs, sternum, clavicles, vertebrae and pelvis. It is because as one gets older, most of the red marrow gets re replaced by yellow marrow that is utilized for fat storage.

4.0 Conclusion

In this unit you were introduced to how the different types of bones are arranged in the human skeleton for the different types of movements the body performs. Specifically, the different types of bones and how they were joined to allow the body move itself, its parts or other objects were learned.

5.0 Summary

You have learned that the arrangement of the bones of the human skeleton makes them act as simple mechanical lever systems to which muscles are attached for the purpose of moving the body, its parts and/or other objects. You are now prepared to go further in this in-depth study of the mechanism of human movement by studying the organisation of the muscular in the instigation of human movement in the next unit.

Self Assessment Exercise

1. With specific named examples, show how long bones are different from short and irregular bones.
2. Describe the three major types of joints in the body and the amount of movement they allow.
3. Briefly describe five (5) five (5) specific functions of the human skeleton.

6.0 Reference/Further Reading

Ajiduah, A. O. (1998). *Basic theory of sports training.* Lagos: University of Lagos press

ICD-0-3 (2007). Body Structure and Function. Retrieved on May 10, 2007 from *http://training.seer.gov/module_anatomy/unit1_body_structure.html*

McGlynn, G. (1999). *Dynamics of Fitness: A Practical Approach. (5th ed.).* The McGraw – Hill Company Inc.

Robergs, R. A. and Kateyian, S. J. (2003). *Fundamentals of exercise physiology for fitness, performance and health. (2nd ed)* New York. McGraw Hill.

Unit 3: Organisation of the Muscular System for Physical Activity

1.0 Introduction

This unit will introduce you to the muscles which are attached to the human skeleton and their arrangements that make it possible for a person to make the different types of movement in exercise and training for improving human performance capacities of skills as found in sports and dance.

2.0 Intended Learning Outcome(s)

By the end of this unit, you would be able to

- Describe the structural organisation of the muscular system
- Identify the different muscles found in the body and explain how they function

3.0 Main Content

Organisation of Muscles in the Muscular Systems

Humans are equipped with three different types of muscles so that they can accomplish their bodily needs. Muscles are attached to bones, internal organs and blood vessels so that they can contract to produce the different kinds of movements the body is capable of performing. With the exception of the movement caused by flagella of sperm cells and amoeboid movement of some white blood cells, every other movement in the body is due to muscular contraction. In the heart, cardiac muscles pumps blood throughout the body. The walls of the internal organs and blood vessels contain smooth muscles. Cardiac and smooth muscles are not controlled voluntarily and so they are called involuntary muscles. Skeletal muscles, the third type of muscles, contract whenever we decide to execute a movement. In other words, skeletal muscles are under voluntary or conscious control. The most abundant organ in the body is skeletal muscle.

There are over 600 skeletal muscles that are identifiable in the body. Each of these muscles has its specific name. One or more feature of a skeletal muscle is used to name the muscle. The strategy here is to give a better understanding of the muscles by associating the muscle's characteristics with its name. Consequently muscles are named according to their sizes as follows: the name of huge muscle will include the term “vastus”, a large muscle, “maximus”, long muscle, “longus”, a small muscle, “minimus” and short muscle “brevis”. The shapes of certain muscles have also been used to name them. The deltoid muscle is so named because it is triangular in shape, the rhomboid muscle has equal and parallel sides like a rhombus, the latissimus muscle has a wide, the teres muscle has a round shape while there are four sides in a trapezius muscle with two parallel sides like a trapezoid.

The direction of the fibres making up a muscle is also used to name some muscles. For example, muscles whose fibres are straight have “rectus” as part of its name, while muscles whose fibres are arranged in a cross, diagonal or circular manner, respectively have transverse, oblique and orbicularis as part of their names. Where a muscle is located have also been used to name it. Thus we have pectoralis (chest); gluteus (buttock or rump); brachii (arm); supra- (above); infra- (below); sub- (under or beneath) and lateralis (lateral).

Muscles are also named in accordance to how they are attached to bones at the point of origin or insertion. The terms origin and insertion of a muscle are used to describe the bones to which the muscle is attached at both of its ends. The bone to which a muscle is attached called the origin do not move when the muscle contracts. The bone described as the insertion of muscle is the bone that moves when the muscle contracts. Consequently all muscles have points of origin and insertion. How and where, the origin and insertion of a muscle are, have utilized in the naming of some muscles. A muscle having two points of attachments at its origin is called the biceps while triceps and quadriceps are so named because their respective origins have three and four points of insertion. Some muscles have their names arising from a combination of a description of their origin and insertion. The first part of the name of such muscles indicates the origin while the second part indicates the insertion. For example, sternocleidomastoid is the name given to the muscle that has its origin on the breast bone and clavicle (collar bone) and that inserts on a breast shaped process of the skull, while brachioradialis is the name given to the muscle whose origin is on the brachium or arm and insertion is on the radius.

The action of muscles is also utilized in the naming of muscles. Thus we have abductor is the name of a muscle that abducts a structure, adductor is the name of a muscle that adducts a structure, flexor is muscle that flexes a structure, extensor extends a structure, levator lifts or elevates a structure, while the masseter is the muscle used for chewing.

4.0 Conclusion

Skeletal muscles are arranged in the muscular system so that their contraction can bring about the different types of movements the body performs. Specifically, the different types of skeletal muscles and how they are attached to the bones of the skeleton and contract to bring about movement were learned.

5.0 Summary

You have learned that the muscles of the muscular system are arranged in such a manner that makes it possible for them to produce body movement when they contract. You are now prepared to go further in this in-depth study of the mechanism of human movement by studying the organisation of the nervous system in the instigation of human movement in the next unit.

Self Assessment Exercise

1. Why is a whole skeletal muscle considered to be an organ?
2. With specific examples, name and describe five (5) features used in identifying and naming the muscles of muscular system.
3. What do you understand by the terms ‘point of attachment’ and ‘point of insertion’ of a skeletal muscle.

6.0 Reference/Further Reading

Ajiduah, A. O. (1998). *Basic theory of sports training.* Lagos: University of Lagos press

ICD-0-3 (2007). Body Structure and Function. Retrieved on May 10, 2007 from *http://training.seer.gov/module_anatomy/unit1_body_structure.html*

McArdle, D. Katch, F. I., Katch, V. L. (1999): *Exercise Physiology: Energy, Nutrition and Human Performance. (4th ed.)* U.S.A. Lippricot Williams and Wilkins.

McGlynn, G. (1999). *Dynamics of Fitness: A Practical Approach. (5th ed.).* The McGraw – Hill Company Inc.

Robergs, R. A. and Kateyian, S. J. (2003). *Fundamentals of exercise physiology for fitness, performance and health. (2nd ed)* New York. McGraw Hill.

Unit 4: Skeletal Muscles’ Structure and Arrangements for Physical Activity

1.0 Introduction

This unit will show how some specific muscles are arranged in their attachments to the human skeleton that make it possible for a person to make the different types of movement in exercise and training for improving human performance capacities of skills as found in sports and dance.

2.0 Intended Learning Outcome(s)

By the end of this unit, you would be able to

- Describe the arrangements of the muscles that are attached to the human skeleton.
- Name the different types of muscles that are attached to the human skeleton and explain how they function.

3.0 Main Content

Arrangements of Some Specific Skeletal Muscles and their Function

Muscles of the Head and Neck

The bones that form the human face have attached to them muscles that are generally known as facial muscles. There are several facial expressions that are due to the contraction of these well-developed facial muscles. The contractions of these facial muscles are used in nonverbal communication to show surprise, disgust, anger, fear, and other emotions. Facial muscles include frontalis, orbicularis oris, laris oculi, buccinator, and zygomaticus. These muscles are shown on Figure 2.2.2 below.

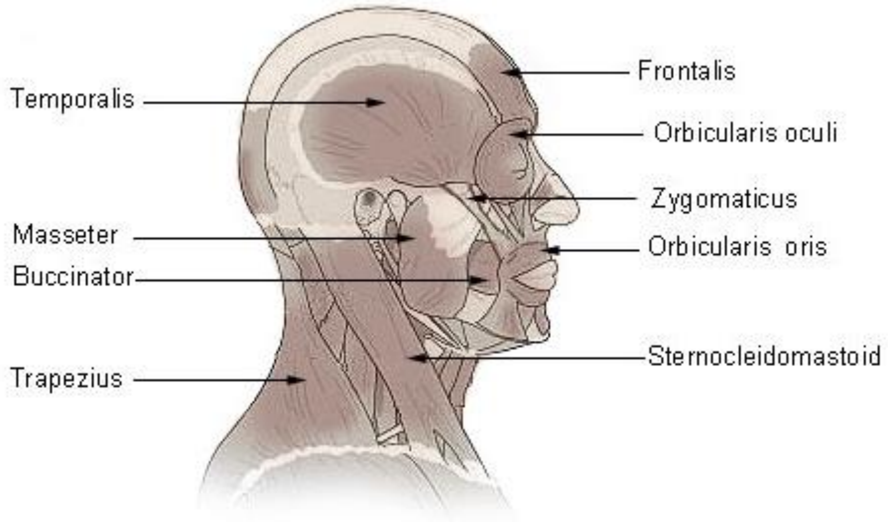

Figure 2.2.1: Skeletal Muscles found in the Head and the Neck. Source: ICD-0-3 (2007)

Four pairs of muscles are used for chewing or mastication. These muscles are among the strongest muscles in the body and are connected to the mandible. Two of these pairs of muscles, temporalis and masseter are shown on Figure 2.2.1. The sternocleidomastoid and trapezius muscles are among the numerous muscles of the throat, the hyoid bone and the vertebral column. These muscles are used for nodding and looking sideways among the numerous movements allowed by the neck.

Muscles of the Trunk

The muscles that are used to move the vertebral column are among the muscles referred to as muscles of the trunk. Muscles of the abdominal walls and those that cover the thoracic cavity and the pelvic outlet of the trunk are also classified as muscles of the trunk.

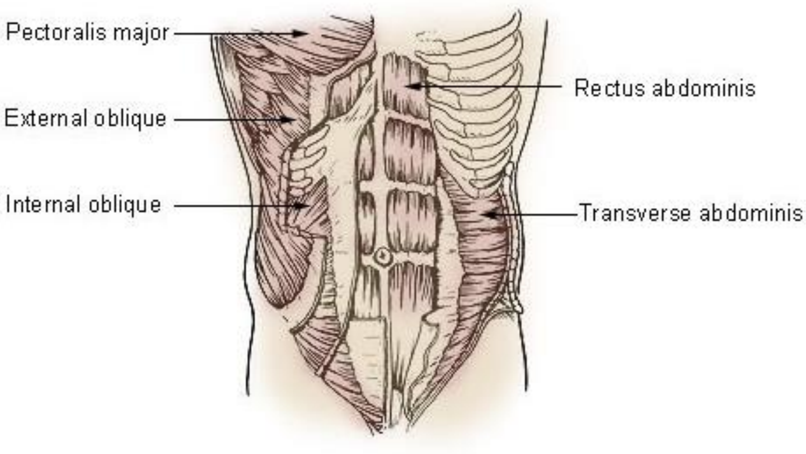

Figure 3: Muscles of the Trunk. Source: ICD-0-3 (2007)

There is a large mass of muscle that extends from the sacrum to the skull. This muscle mass is called erector spinae group of muscles. The erector spinae are used mainly for extending the vertebral column to a posture that is erect. Breathing is controlled by the thoracic wall muscles. Intercostals muscles (internal and external) raises the ribs up while breathing in. The diaphragm is a dome-shaped muscle that forms a partition between the thorax and the abdomen. It has three openings in it for structures that have to pass from the thorax to the abdomen. The abdominal wall muscles are identified in 2.2.2. The pelvic outlet is formed by two muscular sheets and their associated fascia.

Muscles of the Upper Extremities

These are muscles that attach the bones of the arms to the chest. The illustration below shows some of the muscles of the upper extremity.

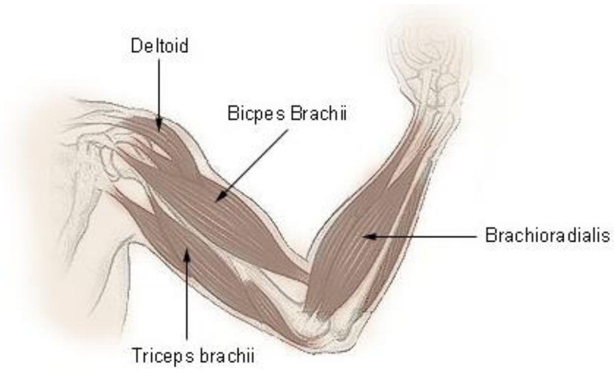

Figure 4: Muscles of the Upper Extremities. ICD-0-3 (2007)

Muscles that move the shoulder and arm include the trapezius and serratus anterior. The pectoralis major, latissimus dorsi, deltoid, and rotator cuff muscles connect to the humerus and move the arm.

Muscles of the Lower Extremities

The muscles that move the thigh have their origins on some part of the pelvic girdle and their insertions on the femur.

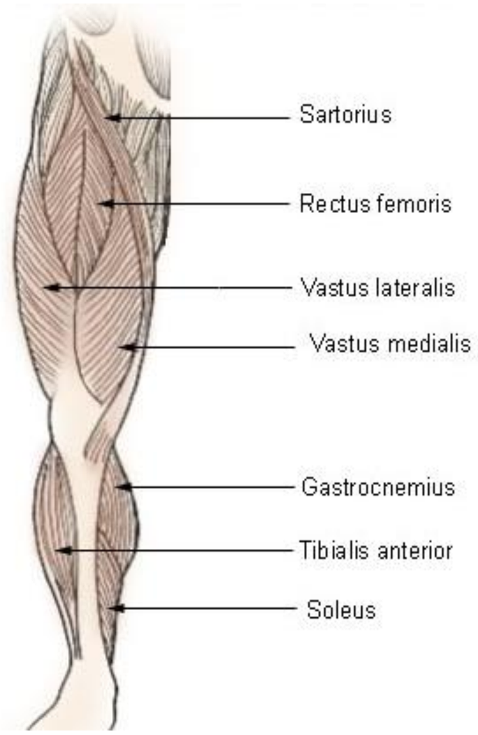

Figure 5: Muscles of the Lower Extremities. Source: ICD-0-3 (2007)

Other Functions of the Muscular System

Apart from movement, there are other functions of muscular contraction are equally important. For example, maintenance of posture, holding joints in stable conditions and production of heat for maintaining core body temperature are important functions of the muscular system. It is continuous small amounts of skeletal muscle contraction that keeps the body in an upright or bending standing or sitting posture. The tendons that attach muscles to the skeleton usually extend over joints thereby contributing to joint stability. For instance, it is muscle tendon holds the knee and shoulder joints in a stable state. Humans must maintain a constant internal body temperature.

4.0 Conclusion

Skeletal muscles are arranged in the muscular system so that their contraction can bring about the different types of movements the body performs. Specifically, the different types of skeletal muscles and how they are attached to the bones of the skeleton and contract to bring about movement were learned.

5.0 Summary

You have learned that the muscles of the muscular system are arranged in such a manner that makes it possible for them to produce body movement when they contract. You are now prepared to go further in this in-depth study of the mechanism of human movement by studying the organisation of the nervous system in the instigation of human movement in the next unit.

Self Assessment Exercise

1. Describe the movement and other functions of the skeletal system.
2. With the aid of a well labelled diagram, describe:
    a. the skeletal muscles attached to the bones of the head and the neck;
    b. the human trunk muscles;
    c. muscles attached to bones of the upper extremities; and
    d. muscles used by the lower extremities of the human body.

6.0 Reference/Further Reading

Ajiduah, A. O. (1998). *Basic theory of sports training.* Lagos: University of Lagos press

ICD-0-3 (2007). Body Structure and Function. Retrieved on May 10, 2007 from *http://training.seer.gov/module_anatomy/unit1_body_structure.html*

McArdle, D. Katch, F. I., Katch, V. L. (1999): *Exercise Physiology: Energy, Nutrition and Human Performance. (4th ed.)* U.S.A. Lippricot Williams and Wilkins.

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Module 3 Organisation of Nervous the System and the Senses for Physical Activity

You learnt, at the beginning of this course, that it is skeletal muscles that are stimulated to contract by the nervous system that bring about all the movements described as physical activity. You are going to continue the in-depth study of the mechanics of physical activity in sports and other skills such as danced skills, in this module, by learning how organs of the nervous system are arranged so as to make the body participate in the movements used in sports and dance in addition to sensing of our internal and external environments.

Unit 1: Structural Organization of Nervous System for Physical Activity

1.0 Introduction

The nervous system is made up the organs, brain, spinal cord, nerves and ganglia which are in turn composed of nervous tissue, blood and other connective tissues. You will learn in this unit, how the nervous system is organised and suited to the performance of sensory, integrative and motor functions for the body.

2.0 Intended Learning Outcome(s)

By the end of this unit, you would be able to

- Describe the structural organisation of the nervous system
- Discuss the functions of the nervous system

3.0 Main Content

Structural Organization of the Nervous System

The nervous system as a whole is divided into two subdivisions: the central nervous system (CNS) and the peripheral nervous system (PNS).

The Central Nervous System

The brain and spinal constitutes cord central nervous system. The foramen magnum is point where the brain is connected to the spinal cord. The central nervous system, as a whole, is covered by bone in the dorsal body cavity of the body. The brain is covered by the bones of the skull in the cranial cavity while the spinal cord is covered by the bones of the vertebral column in the vertebral canal. Additionally, the brain and spinal cord are also covered by the connective tissue membranes called the meninges and by cerebrospinal fluid.

Meninges

The meninges surround the brain and spinal cord in three layers. The outer layer of the meninges is made up a tough white fibrous connective tissue known as the dura mater. The arachnoid layer is the middle layer of meninges. The arachnoid layer looks like a cobweb made of a thin layer of several threadlike strands that attaches itself to the innermost layer of the meninges. The space within the arachnoid layer is called the subarachnoid space. The arachnoid space contains blood vessels and is filled with cerebrospinal fluid. The innermost layer of meninges is called pia mater. The pia mater is a thin and delicate membrane that is tightly bound to the surface of the brain and spinal cord.

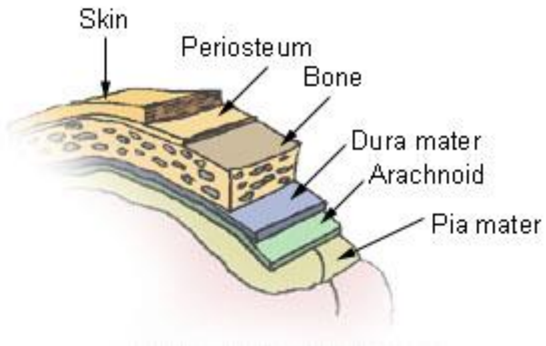

Figure 3.1.1: The Meninges. ICD-0-3 (2007)

Brain

The brain has four major portions; the cerebrum, diencephalons, brain stem and cerebellum.

Cerebrum

The cerebrum is the largest and most obvious portion of the brain. There is a deep longitudinal fissure that divides the cerebrum into parts known as cerebral hemispheres. The corpus callosum is a band of white fibres that connects two hemispheres and enables them to communicate with each other. There are five lobes in each of the cerebral hemispheres. Four of these lobes are named after the cranial bone covering them such that we have the frontal lobe, the parietal lobe, the occipital lobe, and the temporal lobe. The fifth lobe lies deep within the lateral sulcus and is called the insula or Island of Reil.

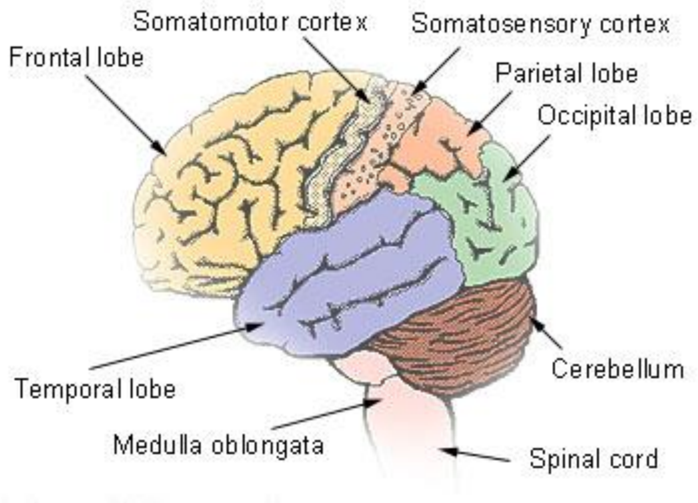

Figure 3.1.2: Lobes of the Cerebrum. ICD-0-3 (2007)

Diencephalon

There are three structures that are located towards the centre of the brain known as the diencephalons. The diencephalons, called the thalamus, hypothalamus, and epithalamus, are almost covered by the two cerebral hemispheres. The thalamus constitutes about 80 percent of the diencephalons. The thalamus has two oval masses of gray matter that serve as relay stations for sensory impulses; the only exception is the sense of smell that goes to the cerebral cortex.

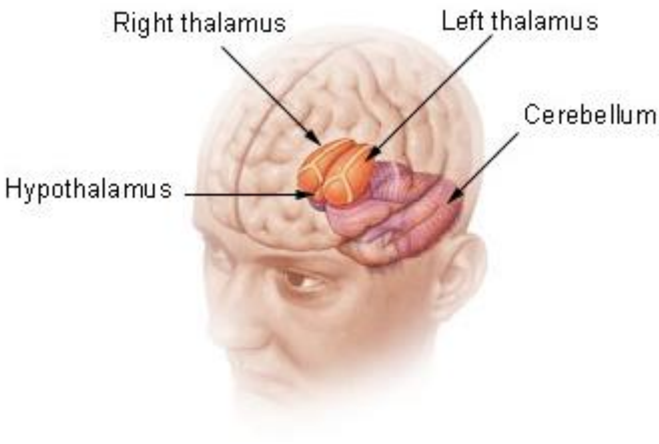

Figure 3.1.3: Diencephalon. ICD-0-3 (2007)

The small region below the thalamus is called the hypothalamus. The hypothalamus regulates many visceral activities thereby playing a significant role in maintaining homeostasis. The most dorsal portion of the diencephalons is the epithalamus. The epithalamus is a small gland that acts like a biological clock in the onset of puberty and rhythmic cycles in the body.

Brain Stem

The section of the brain that is between the diencephalons and the spinal cord is known as the brain stem. The brain stem has three areas. These areas are the midbrain, the pons, and the medulla oblongata. Located at the topmost portion of the brain stem is the midbrain. The brain stem has a middle section that bulges out from its remaining parts. This bulging middle section of the brain stem is called the pons. The pons has nerve fibres that conduct impulses between the higher brain centres and the spinal cord. The bottommost portion of the brain stem is called the medulla oblongata (or simply medulla). The medulla runs from bottom of the pons to the spinal cord at a point known as the foramen magnum. Every nerve fibre that sends impulses from the brain to the spinal cord (also known as the descending motor nerve fibres) and those that sends impulses to the brain from the spinal cord (also known as the ascending sensory nerve fibres) pass through the medulla.

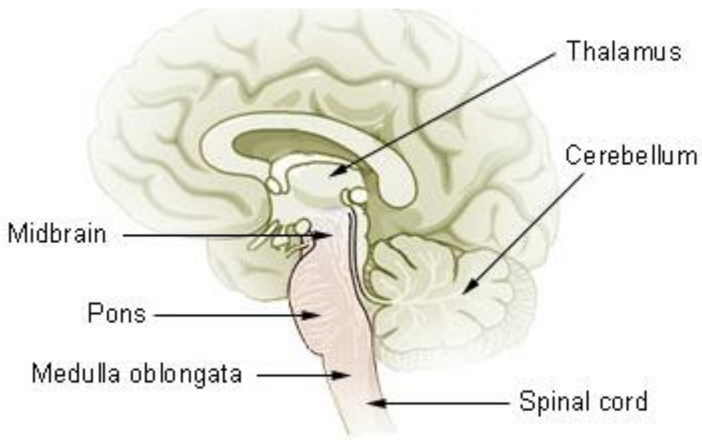

Figure 3.1.4: Brain Stem, ICD-0-3 (2007)

Cerebellum

The cerebellum is a very large section of the brain. The cerebrum is the only portion of the brain that is larger than the cerebellum. The cerebellum is located at rear bottom of the occipital lobes of the cerebrum. There are three groups of nerve fibres covered with myelin sheath, known as cerebellar peduncles, that conducts impulses between the cerebellum and other areas of the central nervous system.

Ventricles and Cerebrospinal Fluid
These are series of interconnected, fluid-filled cavities are found within the brain. These cavities are the ventricles of the brain, and the fluid is cerebrospinal fluid (CSF).

Spinal Cord
The spinal cord extends from the foramen magnum at the base of the skull to the level of the first lumbar vertebra. There are 31 segments in the spinal cord. Each of these 31 segments gives rise to a pair of spinal nerves. The far end of the spinal cord looks like a horse's tail named the cauda equine. The cauda equine has many spinal nerves that go beyond the section of the medulla called the conus medullaris.

The spinal cord performs two major functions. First, it serves as a pathway through which impulses go to and from the brain. Secondly, the spinal cord serves as a reflex centre that mediates responses to stimuli that do not require conscious thought in the brain. For example, the reflex action of dropping a hot piece of steel that looks ordinary before you become aware that it is causing pain is a reflex action mediated in the spinal cord that does not involve the higher centres of the brain.

The Peripheral Nervous System

The organs of the peripheral nervous system are the nerves and ganglia. The ganglia (singular: ganglion) are structures that containing cell bodies outside of the CNS. Cell body is the name given to the power house of a nerve cell. The nerves constitute a network for transfer of impulses between CNS and other parts of the body. There are three types of nerves; sensory nerves, motor nerves and mixed nerves. The nerve cells (sensory neurons) in a sensory nerve are called afferent nerve fibres, and have long dendrites used for sending impulses from peripheral organs to the CNS. The nerve cells (motor neurons) in a motor nerve are called efferent nerve fibres, and have long axons used for sending impulses from the CNS to peripheral organs. There are both afferent and efferent nerve cells and fibres in a mixed nerve. Nerves are bundles of nerve cells called neurones or nerve fibres, much like muscles are bundles of muscle fibres. The axons or dendrites of the nerve fibres in a nerve are enclosed in connective tissue.

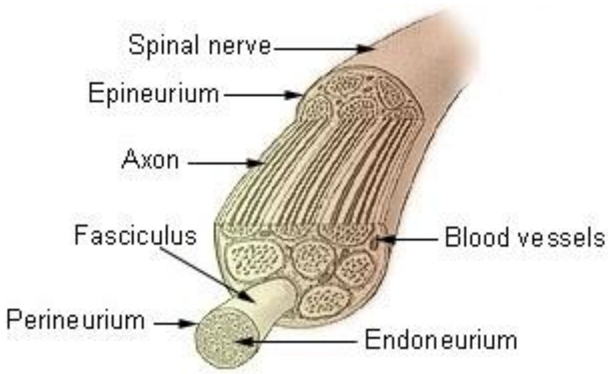

Figure 3.1.5: Nerve Structure. ICD-0-3 (2007)

Every axon dendrite of neurons outside the CNS is covered by myelin neurilemma. The covered axons and/or dendrites of several neurons are packaged inside the lumen of a tube-like connective tissue sheath called endoneurium to make up the bundle of nerve fibres known as the fasciculus. There is a connective tissue sheath known as the perineurium that covers a fasciculus. Every fasciculus is wrapped up, along with others, inside a layer of connective tissue known as the epineurium. Blood vessels are sometimes packaged inside of the epineurium that covers every nerve.

There are two major types of nerves in the peripheral nervous system. These are the cranial nerves and spinal nerves. Cranial nerves originate at the brain section of the CNS and extend to other organs of the body. Spinal nerves also originate at the CNS (the spinal cord section) and extend to other peripheral organs.

Cranial Nerves

There are twelve pairs of cranial nerves in the peripheral nervous system. All the cranial leave the brain at its bottommost portion. With the exception of the vagus nerve, it is the foramina of the skull that gives way for every other cranial nerve to leave the skull and innervate areas of the head, neck, and face. The order in which the cranial nerves appear on the bottommost surface of the brain is used in identifying and naming them. Majority of the cranial nerves are mixed nerves in that they perform both sensory and motor functions. To be precise, four of the cranial nerves are essentially mixed nerves having both sensory and motor fibres. Although five of the cranial nerves are mainly associated with motor function, some sensory fibres used for proprioception have also been identified with them. Only three of the cranial nerves are made up, wholly, of sensory fibres used in the sensing of smell, sight, hearing, and equilibrium.

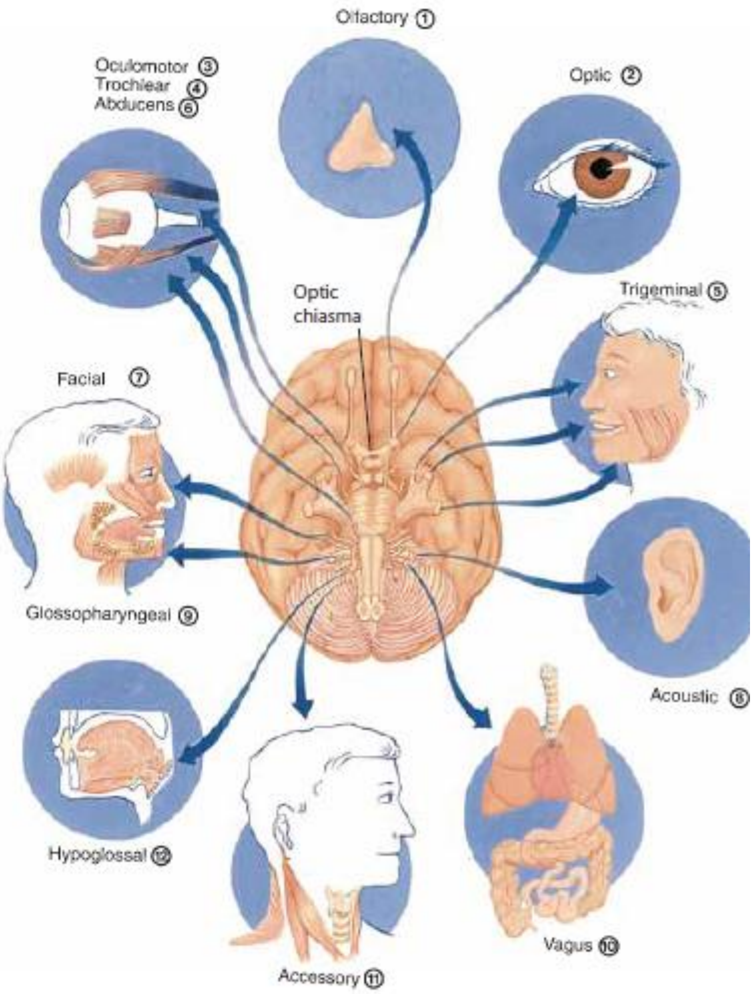

Figure 6: Distribution of Cranial Nerves. Source: Scanlon and Sanders (2007, p 188).

Spinal Nerves

There are thirty-one pairs of spinal nerves in the peripheral nervous system. Spinal nerves are mixed nerves in that they are composed of both sensory and motor nerve fibres. These nerves are attached to both sides of the spinal cord by a dorsal root and a ventral root. The sensory neurons have their cell bodies embedded in the dorsal root ganglion while the cell bodies of the motor neurons are embedded in the gray matter of the spinal cord. Both dorsal and ventral roots combine to form a spinal nerve that leaves the side of vertebral column. The pair of spinal nerves are identified and named according to the section of the spinal cord to which they are attached and the point where the nerve leaves the vertebral column. Therefore, the spinal nerves in the peripheral nervous system are eight (8) cervical nerves, twelve (12) thoracic nerves, five (5) lumbar nerves, five (5) sacral nerves and one (1) coccygeal nerve.

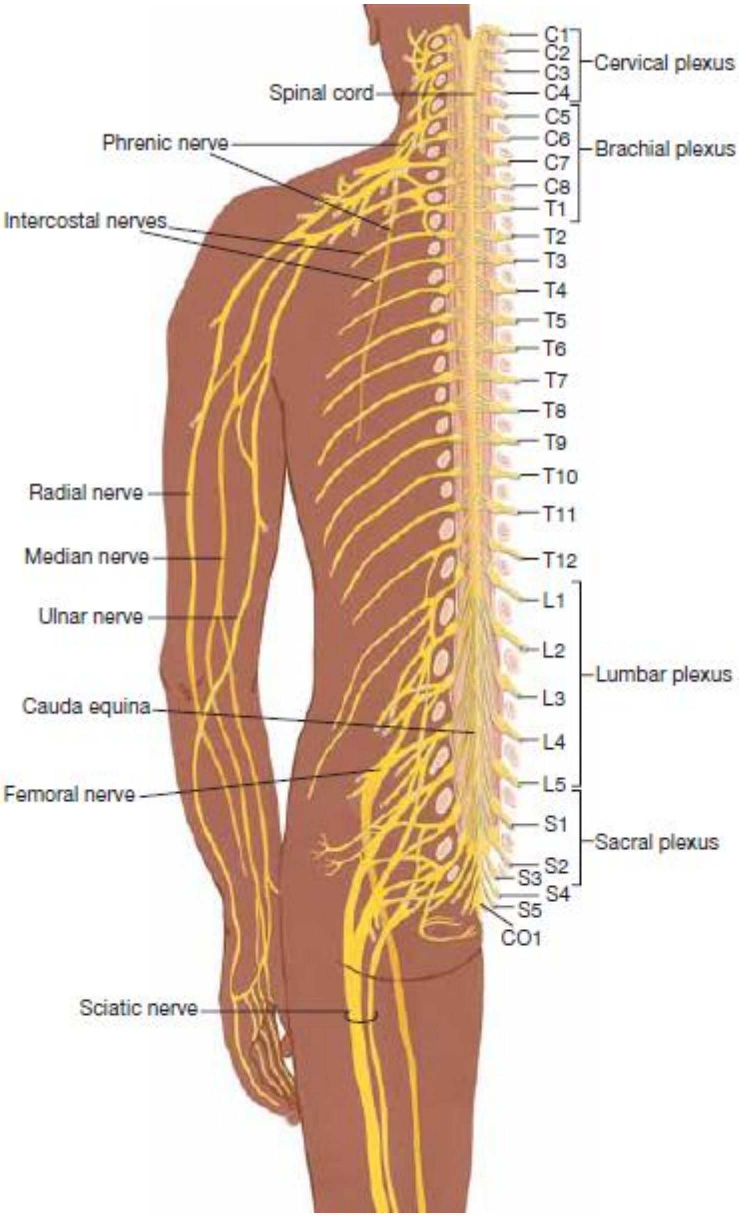

Figure 7: The Spinal Cord and Distribution of Spinal Nerves. Source: Scanlon and Sanders (2007, p 173). Spinal nerves' distribution is shown on the left side while nerve plexuses are shown on the right side.

The types of activities the efferent peripheral nerves mediate are used to also classify the peripheral nervous system into the autonomic nervous system and the somatic nervous system.

4.0 Conclusion

The nervous is structured in such a way that it is in contact with every organ and its tissue in the body. The organs of the central and peripheral nervous system are arranged in such a manner that makes them suited to performing sensory, integrating and motor functions of the body. You specifically studied organisation of the nervous system in the instigation of human movement in this unit

5.0 Summary

You have learned that the nerves of the nervous system are arranged in such a manner that makes it possible for them to perform sensory, integrating and motor functions for the body. You are now prepared to go further in this in-depth study of the mechanism of human movement by studying the functional organisation of the nervous system in bringing about the different types of movements that the body is capable of performing.

Self Assessment Exercise

1. Describe the organs of the central nervous system and their functions.
2. Name and describe the organs of the peripheral nervous system.
3. What is a nerve? Show how cranial nerves are different from spinal nerves.
4. List and explain the functions of the three different types of nerves.

6.0 Reference/Further Reading

Ajiduah, A. O. (1998). *Basic theory of sports training.* Lagos: University of Lagos press

ICD-0-3 (2007). Body Structure and Function. Retrieved on May 10, 2007 from *http://training.seer.gov/module_anatomy/unit1_body_structure.html*

McArdle, D. Katch, F. I., Katch, V. L. (1999): *Exercise Physiology: Energy, Nutrition and Human Performance. (4th ed.)* U.S.A. Lippricot Williams and Wilkins.

McGlynn, G. (1999). *Dynamics of Fitness: A Practical Approach. (5th ed.).* The McGraw – Hill Company Inc.

Robergs, R. A. and Kateyian, S. J. (2003). *Fundamentals of exercise physiology for fitness, performance and health. (2nd ed)* New York. McGraw Hill.

Unit 2: Functional Organisation of the Nervous System

1.0 Introduction

You will study, in this unit, the functional organisation of nervous system for instigating automatic and voluntary movements of the body.

2.0 Intended Learning Outcome(s)

By the end of this unit, you would be able to

- Explain how the nervous system generally functions.
- Describe the sympathetic and parasympathetic pathways of the autonomic nervous system.
- Discuss the physiologic responses to these autonomic nervous system pathways.
- Give a brief explanation of the somatic nervous system.

3.0 Main Content

The Autonomic Nervous System

The unconscious activities of the heart, stomach, intestines and other visceral organs are mediated by efferent nerves that are categorised as autonomic nervous system. The autonomic nervous system supplies motor impulses to cardiac muscle, to smooth muscle, and to glandular epithelium. The autonomic nervous system sends motor impulses to the smooth muscles of visceral organs and glands and the cardiac muscles of the heart. It is these impulses that instigate the automatic and continuous functioning of these organs. Autonomic efferent nerves are also said be nerves of the involuntary nervous system because they mediate the automatic and continuous activities of the visceral organs. The autonomic nervous system controls the rate at which the heart beats, rate of breathing, blood pressure, internal temperature of the body, and every of the other visceral activities that function harmoniously to maintain homeostasis.

The autonomic nervous system operates through two pathways; the sympathetic and the parasympathetic pathway. The sympathetic pathway comes into operation when one is faced with stressful situations. Stressful situations as found during exercise, sports training, sports competitions, anxiety, anger and fear brings the sympathetic autonomic nervous system into action. The parasympathetic pathway increases the heart rate so as to supply more blood and nutrients to the muscles that gets engaged in fighting and/or running away from the danger as demanded by the stressful situation. This pathway also elicits increases in dilatation of bronchioles and in vasodilatation within skeletal muscles so that there would be more oxygen for producing the increased energy demands of the stressful situation in addition to making the liver to change glycogen to glucose for more energy supply. The actions of the sympathetic pathway of the autonomic nervous system also slows down peristalsis, decreases digestive secretions and reduces blood supply to the skin and the visceral organs that are not needed in responding to stressful situations. In other words, the sympathetic pathway shunts blood supply to more vital organs such as the brain, heart and muscles that are required for meeting up with the demands of stressful situations.

The parasympathetic pathway operates in situations that are not stressful, those situations that need normal functioning of visceral organs. The parasympathetic pathway restores normal blood supply for effective digestion, increases gastric secretions and peristalsis resulting in normal defecation and urination. The parasympathetic pathway of the autonomic nervous system makes the heart to beat at a normal resting rate. The point to note is that most of organs in the body receive both sympathetic and parasympathetic impulses that are opposed to each other. During stressful situations, the sympathetic pathway of the autonomic nervous system operates at optimum level so that resources for meeting up with the demands of the situation are supplied. The parasympathetic pathway operates in normal situation and restores the body and its systems to normalcy when the stress is removed. However, there are a few organs in the body such as the sweat glands that do not receive parasympathetic impulses. Decrease in the reception of impulses from the sympathetic pathway of the autonomic nervous systems therefore restores normalcy to such organs.
Table 3.2.1 summarizes the functions of the sympathetic and parasympathetic pathways of the autonomic nervous system.

Table 3.2.1: Physiologic Responses to Sympathetic Instigation and Parasympathetic Instigation. Source: Scanlon and Sanders (2007, p 191)

Organ	Sympathetic Response	Parasympathetic Response
Heart (cardiac muscle)	Increase rate	Decrease rate (to normal)
Bronchioles (smooth muscle)	Dilate	Constrict (to normal)
Iris (smooth muscle)	Dilates pupil	Constricts pupil to normal
Salivary glands	Decrease secretion	Increase secretion (to normal)
Stomach and intestines (smooth muscle)	Decrease peristalsis	Increase peristalsis for normal digestion
Stomach and intestines (glands)	Decrease secretion	Increase secretion for normal digestion
Internal anal sphincter	Contracts to prevent defecation	Relaxes to permit defecation
Urinary bladder (smooth muscle)	Relaxes to prevent urination	Contracts for normal urination
Internal urethral sphincter	Contracts to prevent urination	Relaxes to permit urination
Liver	Changes glycogen to glucose	None
Pancreas	Secretes glucagon	Secretes insulin and digestive enzymes
Sweat glands	Increase secretion	None
Blood vessels in skin and viscera (smooth muscle)	Constrict	None
Blood vessels in skeletal muscle (smooth muscle)	Dilate	None
Adrenal glands	Increase secretion of adrenaline and noradrenalin	None

Somatic Nervous System

Those nerves that mediate conscious activities of skeletal muscles and the skin are categorised as the components of the somatic nervous system. The somatic nervous system is also called the somatomotor or somatic efferent nervous system. The somatomotor send motor impulses to skeletal muscles that are used for voluntary activities. Somatomotor efferent nerves are also said be nerves of voluntary nervous system because they allow one to consciously control his/her skeletal muscles.

Functions of the Nervous System Summarised

The nervous system performs the complex functions of being the centre of all mental activity including thought, learning and memory. The complex functions which the nervous system performs can be classified into the three broad groups of sensory functions, integrative functions and motor functions. The human body can only survive within a limited range of environmental factors such as temperature, pressure, humidity, sound, etc. There is therefore the need to detect any change in these environmental factors so as to allow the body to react to such change without adversely affecting it. Man's internal environment can also vary in form of blood pressure, pH, carbon dioxide concentration, and the levels of various electrolytes. The body needs to be informed about these changes which are called stimuli (singular: stimulus). There are millions of sensory receptors within the nervous system that monitors these external and internal environmental factors for any change. Immediately such changes in either the external, internal or both external and internal environments occur, the body is said to have received sensory input. The sensory receptors convert any of such sensory input into electrical signals called impulses which are transmitted to the brain. In this manner, the nervous system performs its sensory functions.

The integrative functions of the nervous system take place in the brain. In the brain, signals from the sensory nerves are brought together to create sensations, to produce thoughts, or to add to memory. From these sensations, thoughts and memory, decisions are made and actions take place. Integration therefore, is what occurs in the brain from when impulses get to the brain to when the brain sends out impulses. The signal(s) the brain sends out causes an effect(s) on the receiving organ(s). Usually the organs that receive impulses from the brain are the muscles and the glands. The muscles and glands which respond to stimuli from the brain by contracting and producing secretions respectively are called effector organs. Within the nervous system there are millions of motor nerves that transmit signals from the brain to the effector organs that perform motor functions.

4.0 Conclusion

The functional organisation of the nervous system allows it to regulate all the visible and invisible actions of the human body.

5.0 Summary

The functional organisation of the nervous system is such that regulate the functioning of the tissues, organs, and systems of the body. It is the functioning of the nervous system that makes it possible for people to perceive and respond to the world around them and the changes that occur inside them. In the next unit, you will study how the sense organs function in detecting such changes.

Self Assessment Exercise

1. Briefly show how the autonomic nervous system is different from the somatic nervous system.
2. How is the sympathetic pathway related to the parasympathetic pathway and how are they different?
3. How does the autonomic nervous system and somatic nervous contribute to the general functioning of the nervous systems

6.0 Reference/Further Reading

ICD-0-3 (2007). Body Structure and Function. Retrieved on May 10, 2007 from *http://training.seer.gov/module_anatomy/unit1_body_structure.html*

Robergs, R. A. and Kateyian, S. J. (2003). *Fundamentals of exercise physiology for fitness, performance and health. (2nd ed)* New York. McGraw Hill.

Scanlon, V. C. and Sanders, T. (2007): *Essentials of Anatomy and Physiology*. Philadelphia: F. A. Davis Company

Unit 3: The Senses I; Sensations and the Sensory Pathways

1.0 Introduction

The senses of sight, hearing, touching, tasting and smelling makes it possible for us to know about what is happening in the environment in which we live. The senses also supply us information about what is happening inside of us. It is the senses that enable our bodies to give a proper response to our internal and external environments that are continuously changing.

2.0 Intended Learning Outcome(s)

By the end of this unit, you would be able to

- Describe the structural organisation of the sensory pathways
- Discuss the different types of sensation and their functions

3.0 Main Content

The Sensory Pathways

The generation, transmission and interpretation of nerve impulses and the instigation of appropriate responses to such impulses follows precise specific pathways known as the sensory pathways. The sensory pathways are composed of specific components of the nervous system. The nervous system has receptors in every organ of the body that generate impulses based on any change they detect on the organ. Every receptor can only detect one specific change or stimulus (stimuli - plural). For this reason, light rays can only be detected by receptors in the retina of the eye. Every receptor is linked to the nervous system by sensory neurons. It is the sensory neurons that transmit the impulses generated by the receptors to the central nervous system. Sensory neurons are found in both spinal nerves and cranial nerves. Since each receptor is specific in the stimulus it responds to, each sensory neuron can only carry impulses from one type of receptor. Sensory tracts are located in the white matter of the spinal cord and brain. Sensory tracts transmit impulses received from sensory neurons to the sensory areas of the brain. It is the sensory areas of the brain receive impulses from sensory tracts and interpret them. The cerebral cortex of the brain is usually the sensory area of the brain.

Types and functions of Sensations

The way we feel sensations is a reflection of the how the sensory areas of the brain handles the information it gets from the receptors. Five (5) of such ways are described below.

1. The brain projects the sensation to appear as if it is coming from the area where the receptors are located. Although it is the cerebral cortex of the brain that is receiving and interpreting the sensation that the cloth you are wearing has a velvety touch, you feel it in your hand. For this reason an amputated leg itches after the amputation. After the loss of a leg the person can some of the time feel that the leg is still there and requires scratching due to its itching. The reason for this is that although the receptors in the hand are no longer present, the nerve endings of the cut leg continue to generate impulses. These impulses get to the sensory area of the brain for the hand, and the brain projects the feeling that the hand is still there. This sensation is very useful when an amputee is learning how to use an artificial leg for instance.

2. Intensity of a sensation depends on the number of receptors that are stimulated. The more the receptors that are stimulated, the more are the impulses that will arrive at the sensory area of the brain. The brain "counts" the impulses and projects a more or less intense sensation depending on this counted number of impulses. It is why some sensations are felt more clearly and to a higher extent than are others. For example, a small number of receptors are affected by a weak stimulus that generated by a cup of room temperature cold water. On the other hand, another cup with near freezing water will stimulate more receptors and so it has a stronger stimulus.

3. The brain compares sensations on a constant basis. For this reason, the effect a given sensation may be exaggerated or diminished due to a previous sensation. For example, if, on a very hot day, if you dip your hand into the water of a swimming pool, the water will feel quite cold at first; but the water will seem to be much colder when you jump into the pool. The brain compares the new sensation to the previous one, and since there is a significant difference between the two, the water will seem colder than it actually is.

4. The brain adapts or gets used to every stimulus that is continuous. For this reason, an unclean poultry house will smell very strongly at first. The sense of the smelling poultry house will however reduce gradually until it becomes nonexistent if we stayed in the poultry house for a longer time.

5. A stimulus that stimulates a receptor very strongly will remain in the consciousness for sometime after removal of the stimulus in the form that is referred to as 'After-image'. A typical example is the bright after-image seen after watching a flashbulb go-off. The bright light from the flashbulb had a very strong stimulus effect on the receptors of the retina that generated many impulses in response and are perceived as an intense sensation that remains longer than the actual stimulus when the light is switched off.

4.0 Conclusion

It is the nervous system that makes it possible for us to sense the environment in which we live and the environment that is inside of us. Also, it is the senses that enable us to give proper response to our internal and external environments that are continuously changing.

5.0 Summary

You have come to know the different types of senses and the sensory pathways that use in their functions of helping us to detect happenings within our bodies and within the environment in which we live. You are now ready to go further in your study by specifically learning how the senses of sight, hearing, touching, tasting and smelling among others operate in helping us to monitor our external and internal environments.

Self Assessment Exercise

1. Explain briefly the term, sensory pathways.
2. List and describe the specific components of the sensory pathways.
3. Describe five (5) ways used by the brain to handle information that enable us feel sensations of our internal and external environments.

6.0 Reference/Further Reading

OpenStax College, *Anatomy & Physiology*. OpenStax College. 25 April 2013. *http://cnx.org/content/col11496/latest/*

Scanlon, V. C. and Sanders, T. (2007): *Essentials of Anatomy and Physiology*. Philadelphia: F. A. Davis Company

Robergs, R. A. and Kateyian, S. J. (2003). *Fundamentals of exercise physiology for fitness, performance and health. (2nd ed)* New York. McGraw Hill.

Unit 4: Structural Organisation of the Different Types of Senses

1.0 Introduction

The focus of Unit 4 is the specific structures utilised by the body for the senses of sight, hearing, touching, tasting and smelling among others. Specifically, you will study the mechanism used by the senses of sight, hearing, touching, tasting and smelling among others to enable our bodies to give a proper response to our internal and external environments that are continuously changing.

4.0 Intended Learning Outcome(s)

By the end of this unit, you would be able to

- List and describe the different types of senses
- Explain the structural organisation of the different types of senses.
- Discuss the mechanism used for operating the different types of sensations.

5.0 Main Content

Types of Senses

Cutaneous Senses

There are receptors in the dermis of the skin and the subcutaneous tissue that respond to the sensations of touch, pressure, heat, cold, and pain. These receptors for pain, heat, and cold are in free nerve endings that are not covered while those that respond to the sensation described as touch or pressure are encapsulated by cellular structures. The parietal lobes are the sensory areas of the brain to which sensations from the skin are sent and interpreted. The more the number of receptors present in any part of the skin, the more sensitive is it is. In the same vein, the more the number of receptors in an area of the skin, the larger is the size of the sensory area in the cerebral cortex. For this reason, the largest parts of the sensory cortex, where parietal lobes are located, are used for receiving information from the hands and face, the parts of the skin that has the largest number of receptors.

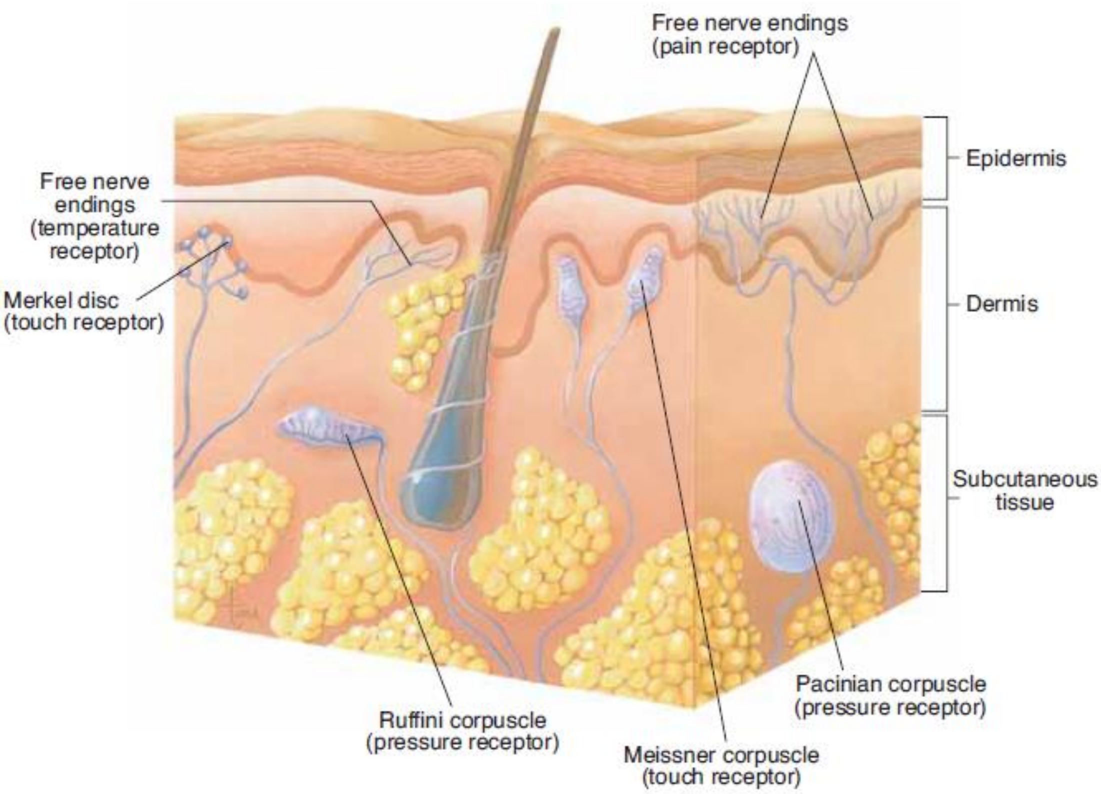

Figure 3.3.1: Cutaneous receptors in a section of the skin.

Referred Pain

Free nerve endings are also found on internal organs such as the smooth muscles of the small intestine whose free nerve endings can be stimulated by too much stretching or contraction and interpreted as visceral pain. A pain of this nature is not usually sensed in the organ but in a cutaneous area close to the organ. Since such a pain or sensation is being felt in an area different from where its source, it is called referred pain. Examples of referred pains are the pains of heart attack (myocardial infarction) that could be felt in the left arm and shoulder and pains of gallstones that are felt in the right shoulder. Physiologically there are sensory tracts in the spinal cord that receive impulses from receptors in both cutaneous and visceral organs. Since cutaneous impulses occur much more frequently than visceral impulses, there is a tendency for the brain to project all such pains as sensation in the skin.

Muscle Sense

Proprioceptors or muscle spindles are receptors on muscles that senses the stretch of a muscle. These receptors send messages to brain and so make it possible for us to sense our muscle positioning and exactly how they are being stretched. It is the parietal lobes of the brain that receives and coordinates muscle sense in skeletal muscles that are voluntarily controlled while it is the cerebellum that coordinates muscle sense in smooth muscles that are controlled unconsciously. Muscle sense enables our muscles to perform their normal functions without our conscious knowledge and/or guidance and also help us to distinguish the shape one object from that of others.

Sense of Taste

Majority of papillae on the tongue contain taste buds in which there are special types of receptors known as chemoreceptors that are used in the sensation of taste. There are about five general types of chemopreceptors used as taste receptors. Each of these receptors detects sweet, sour, salty, bitter and savoury tastes respectively. These different receptors for taste makes it possible to have many more different types of tastes than these five because foods are complex chemicals that have the capability to stimulate different combinations of receptors. It is facial and glossopharyngeal nerves that transmit impulses from receptors in the taste buds to the taste areas of the parietal-temporal cortex of the brain. It is the sense of taste makes eating an enjoyable experience.

Sense of Smell

The upper portions of the nasal cavities have chemoreceptors that are capable of detecting vaporized chemicals in the form of smell (also known as ‘olfaction’). There are several hundreds of different and specific receptors for different scents in the nasal cavities of humans. Each or a combination of these receptors can be stimulated by vapour molecules to generate impulses that get carried by the olfactory nerves of the brain. For this reason the human brain is thought to be capable of distinguishing among 10,000 different types of scents.

Hunger and Thirst

The receptors for the senses of hunger and thirst are located in specialized cells of the hypothalamus in the brain. The hypothalamus collects chemical signals from hormones released into the blood stream by the stomach and small intestines indicating a lack of food to be digested in the gastrointestinal tract. These sensations in the hypothalamus are projected to the stomach, which contracts in hunger pangs. The sensation of hunger, if not assuaged by eating, would, however, gradually reduce up to a point when hunger is no longer felt; a point when adaptation to hunger can be said to have taken place. It is because when blood nutrients level is reducing as hunger progresses, it gets to a point when the body's fatty tissue is mobilised and used for producing energy required for metabolic functions. As the body's energy is now being met by fat in adipose tissues, the digestive system becomes stable in its hormones' production and the hypothalamus' stimulation is reduced leading to a reduction of the hunger pangs in the stomach. Adipose tissues also release hormones when they are mobilised to produce energy for metabolic functions when there is a shortage of energy supply from the digestive system. Although these hormones released by the adipose tissues also stimulate the hypothalamus, the number of receptors in the hypothalamus reduces significantly and hunger becomes much less intense.

There are also receptors in the hypothalamus that detect changes in body water content in the form of the proportion or quantity of salt dissolved in a given volume of the water. This stimulus is interpreted as thirst and projected to the mouth and pharynx where there is reduced production of saliva. Unlike the sensation of hunger that diminishes as adipose tissues takes over energy production, the sensation of thirst cannot be reduced except by drinking of water alone. The body cannot adapt water lose because as the amount of body water keeps decreasing with progressive thirst. Prolonged thirst continuously stimulates receptors in the hypothalamus up a point where it may become painful.

Sense of Sight

The eye is the organ used for the sensation of sight called vision. The eye is shaped like a hollow sphere surrounded by three separate tissue layers called the fibrous tunic, the vascular tunic and the neural tunic or retina. The fibrous tunic is the outermost layer, and it is composed of the white sclera and clear cornea. The sclera is white in colour accounts for over 80% of the surface of the eye. The clear cornea is transparent and allows light to enter the eye through the front tip which it covers.

The vascular tunic is the middle layer of the eye. The vascular tunic has a connective tissue layer, called the 'choroid', with a lot of blood vessels through which blood flows. The ciliary body, located in front of the choroid within the vascular tunic, is a muscular structure to which the lens is attached by zonule fibers. It is the contraction of the ciliary muscles that makes the eye lens to be and concentrate light rays on the rear of eye. There is a structure that spreads over the ciliary body that is visible in front of the eye as the coloured portion of the eye. This structure is called the iris. The iris is a smooth muscle that opens or closes the pupil, the tiny hole at the centre of the eye, which makes it possible for light to enter inside the eye. Bright light makes the iris contract and reduces the width of the pupil while dim light makes the iris to dilate the pupil.

The neural tunic is the part of the eye that is farthest from the surface of the body. The neural tunic has that can respond to light. The retina, with three layers of cells and two synaptic layers in between, is located within the neural tunic. There is a small indentation called the fovea located at the centre of the retina. The several layers of cells in the retina contain specialized cells, called photoreceptors, which are used to start processing the stimuli for the sensation of sight.

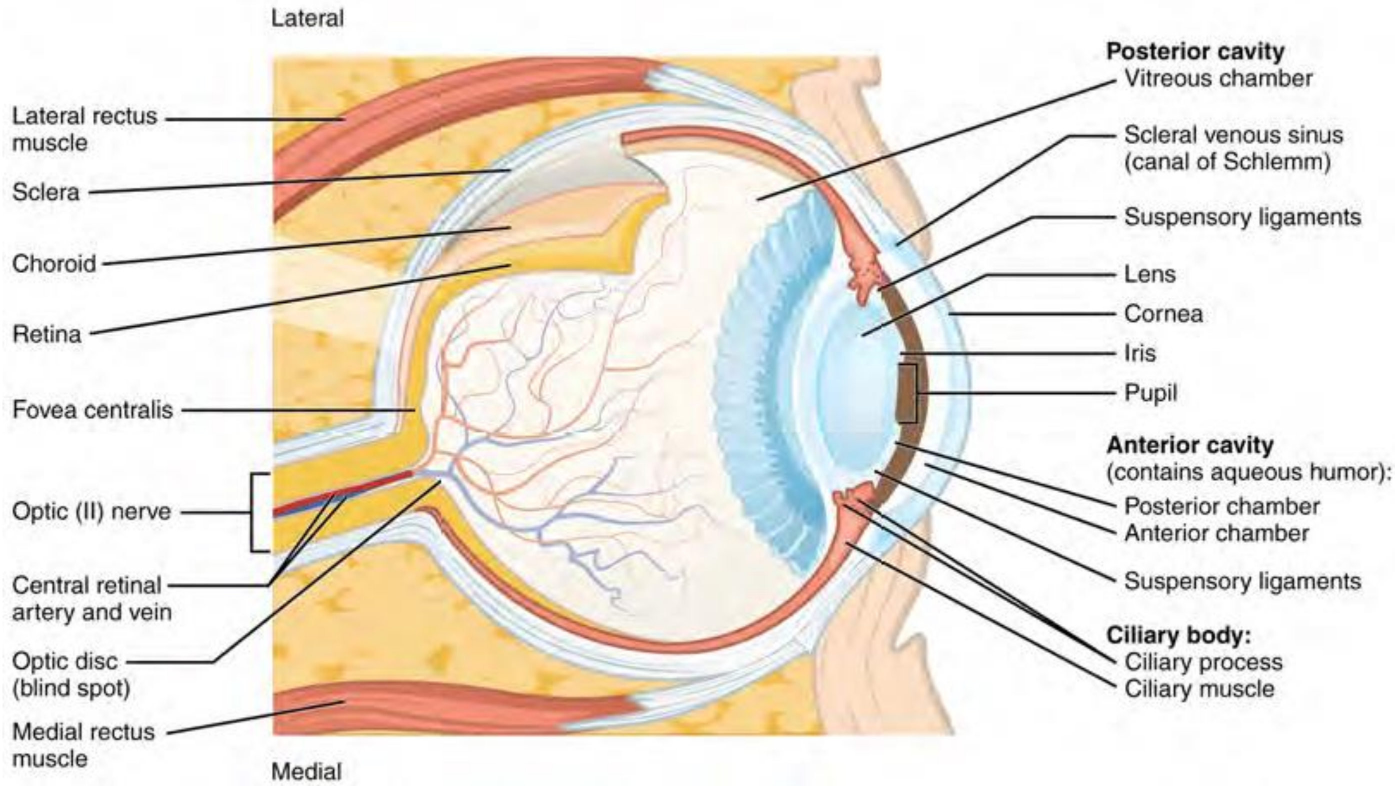

Figure 3.3.2: Structure of the Eye. Source: OpenStax College (2013, *Page 581).*

As can be seen from Figure 3.3.2, there are two cavities in the eye; the cavity is located towards the front of the eye, called the anterior cavity, and the cavity that is located towards the back of eye, called the posterior cavity.

There is need for light rays to be focused on the retina, which will generate nerve impulses that is transmitted to the visual areas of the cerebral cortex of the brain for us to feel the sensation of sight or for vision to take place. Focusing light on the retina means bending, deflection or refraction of light rays that enters the eye to the retina. The structural organisation of the eye for refraction of light rays includes the arrangement of the cornea, aqueous humour, lens, and vitreous humour in the specific order shown on Figure 3.3.2. The ciliary muscle relaxes and allows the lens to be elongated and thin so that we can see clearly see objects that are far from us. The ciliary muscle will, however, contracts to make the lens thick and bulge at its middle so that we can see objects that are closer to us.

The functional process of seeing involve light rays from objects striking the retina. Upon reaching the retina, the light rays stimulate chemical reactions in the photoreceptors that are shaped like rods and cones. The chemical, rhodopsin, in the rods breaks down into a derivative of vitamin A called retinal and another chemical called scotopsin. This chemical breakdown of rhodopsin generates an electrical impulse that is transmitted to the ganglion neuron. Rhodopsin, after the transmission of the electrical impulse, is slowly re-synthesized from its components of retinal and scotopsin. Most of the rhodopsins are broken down in a well lit area while only a few are broken down so as to see in a darker environment. For this reason, adaptation to sudden darkness or bright light takes a while to accomplish. Therefore, one does not see very well upon entering a dark environment from a well lit one because all the rhodopsins are still being slowly re-synthesized. After, a while one gets used to the darkness and begins to see a little better. Upon entering a brightly lit environment from a poorly lit one results in a lot of the rhodopsins being broken down at once. The increase breakdown of rhodopsins brings about a barrage of impulse generation that is very intense, a sensation which the brain may interpret as pain. A few minutes later the bright light seems fine because the rods are recycling their rhodopsin slowly, and it is not breaking down all at once.

The cone-shaped photoreceptors also possess retinal that reacts to different wavelengths of light. There are three types of cones; red-absorbing, blue-absorbing, and green-absorbing cones. Each of these types of cones can absorb wavelengths of light that cover about one-third of the visible light spectrum. For this reason, red cones can absorb red, orange and yellow light wavelengths. These chemical reactions in cones also generate electrical impulses that are also transmitted to ganglion neurons that converge at the optic disc to constitute the optic nerve that passes through the back wall of the eyeball. The optic nerves from both eyes come together at the optic chiasma (or chiasm), just in front of the pituitary gland. At this point, the medial fibres of each optic nerve cross to the other side and so permit each visual area to receive impulses from both eyes, in the process known as binocular vision.

The visual areas also right the image, because the image on the retina is upside down. The image on film in a camera is also upside down, but we don't even realize that because we look at the pictures right side up. The brain just as automatically ensures that we see our world right side up.

There are two bony orbits in the skull in which the two eyes are located. The eyeballs are protected and anchored to the soft tissues of the eye by the bony orbits that surround the eyes. Each eye is equipped with eyelids to which are attached eye lashes at their loose edges. The outer surface of the eyelid helps to protect the eye by blocking out particles that may fall on or contact the surface of the eye and possibly cause it abrasions. There is a thin layer of membrane called the palpebral conjunctiva that covers the inner surface of each lid. The conjunctiva spreads over the sclera, the white portion of the eye, to connect the eyelids with the eyeball. There are lacrimal glands located at the upper, outer corner of the eyeball, within the eye orbit just under the outer edges of the nose. The lacrimal glands produces tears that flow through the lacrimal duct to the central corner of the eye, from where the tears flow over the conjunctiva and wash off foreign particles that may have fallen on the eyes.

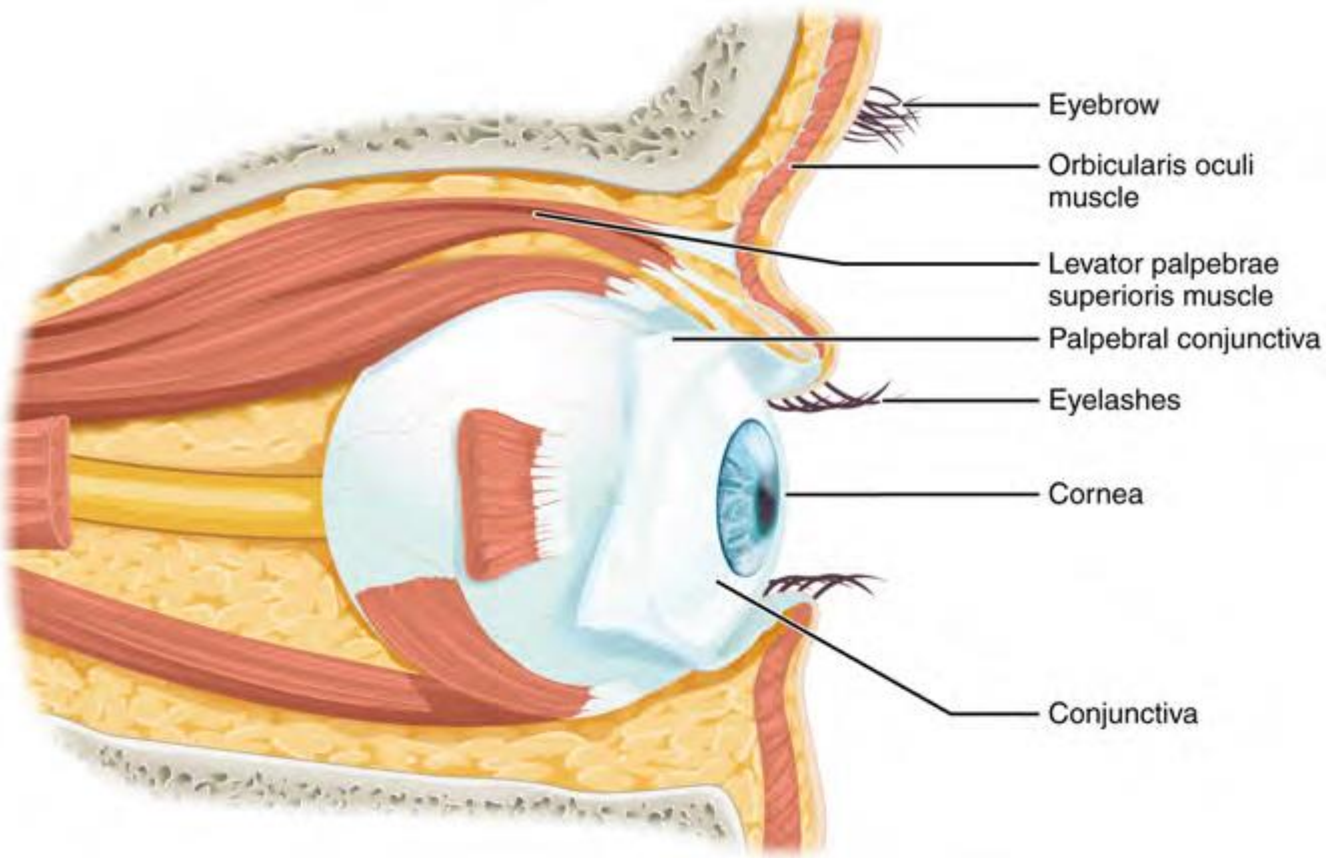

Figure 3.3.3: The Eye in the Skull's Bony Orbit. Source: OpenStax College 2013 *Page 580).*
There are six skeletal muscles, collectively called the extraocular muscles, which attach each eye to the bones of the eye orbit. These muscles can combine singly or in combination with one or more others to rotate the eyes upwards, to the sides, downwards and in circular fashion. There is another skeletal muscle, called levator palpebrae superioris, located within the orbit that is used for raising and bringing down the

upper eyelid. The extraocular muscles and the levator palpebrae superioris are innervated by three cranial nerves, namely the abducens nerve, the trochlear nerve and the oculomotor nerve.

Sense of Hearing and Balance

Audition (Hearing)

The sensation of hearing is known as audition. The ear is structurally organised in such a way that translates sound waves into a neural signals (see Figure 3.3.4).

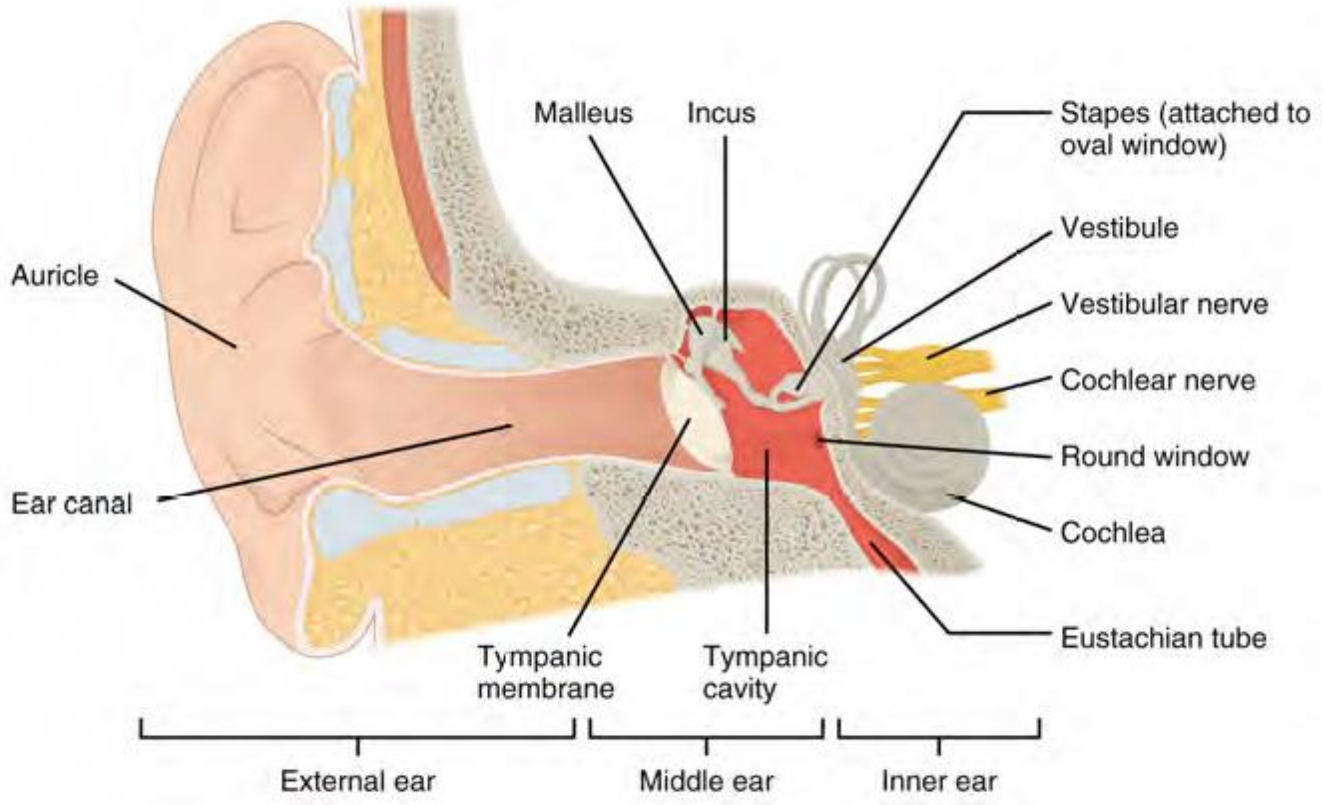

Figure 3.3.4: Structural Organisation of the Ear. Source: OpenStax College (2013. *Page 572).*

The outermost portion of the ear, called the external ear, contains the auricle, ear canal, and tympanic membrane. The middle portion of the ear, called the middle ear, contains the ossicles and is connected to the pharynx by the Eustachian tube. The inner ear is the innermost portion of the ear. It contains the cochlea that is used for hearing, and the vestibule, which is responsible for the sensation of balance. The curved shape of the auricle allows it to direct sound waves inwards into the auditory canal that passes through the external auditory meatus of the temporal bone and enters the skull. The tympanic membrane, also known as the ear drum, is located at the end of the auditory canal, which vibrates anytime sound waves get to it.

The middle ear is an air filled space within the skull. Within the middle ear are three tiny bones known as the ear ossicles. One of the ossicles is shaped like a hammer and so it is called 'malleus'. The second tiny bone of the middle ear is an anvil shaped bone known as the incus (Latin name for anvil), while stapes (Latin name for stirrup) is the name of the third tiny bone. The malleus is connected to the tympanic membrane at one end and joined to the incus at its inner end. The incus, on its own, is joined with the stapes, which is then attached to the inner ear, where sound waves get converted to neural signals. The Eustachian tube connects the middle ear to the pharynx, helps equilibrate air pressure across the tympanic membrane. The tube is normally closed but will pop open when the muscles of the pharynx contract during swallowing or yawning.

The inner ear is usually described as a bony labyrinth where a series of canals are embedded within the temporal bone. The labyrinth of the inner ear has two separate regions; the cochlea that is used for hearing and the vestibule that is responsible balance or stability. The shape of the cochlea is like that of the shell of a snail shell that has two-and a-half structural turns. The cochlea is divided, on the inside, into three canals. Each of the cochlear canals is filled with fluid. There is a duct at the centre of the central canal. The floor of this duct (cochlear duct) is composed of the basilar membrane that supports the receptors for hearing in the organ of Corti (spiral organ). These hearing receptors, called hair cells, contain endings of the cochlear branch of the 8th cranial nerve over which hangs the tectorial membrane.
When sound waves enter the ear canal, they trigger vibrations in the ear drum, which are transmitted to the three of the middle ear and the fluids within the cochlear. These vibrations create waves in the fluids of the cochlear. These waves make the basilar membrane to ripple and push the hair cells towards the tectorial membrane. The hair cells then send messages to the areas of the brain where sounds are heard and interpreted. It is the auditory areas that also make it possible for us to know the direction from which a sound is coming. The auditory areas are able to do this because they count and compare the number of impulses coming from each of the inner ears. A sound will be projected as coming from the left if there are more impulses that arrived from the left cochlea than from the right one and vice versa. A sound that is directly above your head would appear to come from all directions, because each auditory area is receiving approximately the same number of impulses and cannot project the sensation to one side or the other.

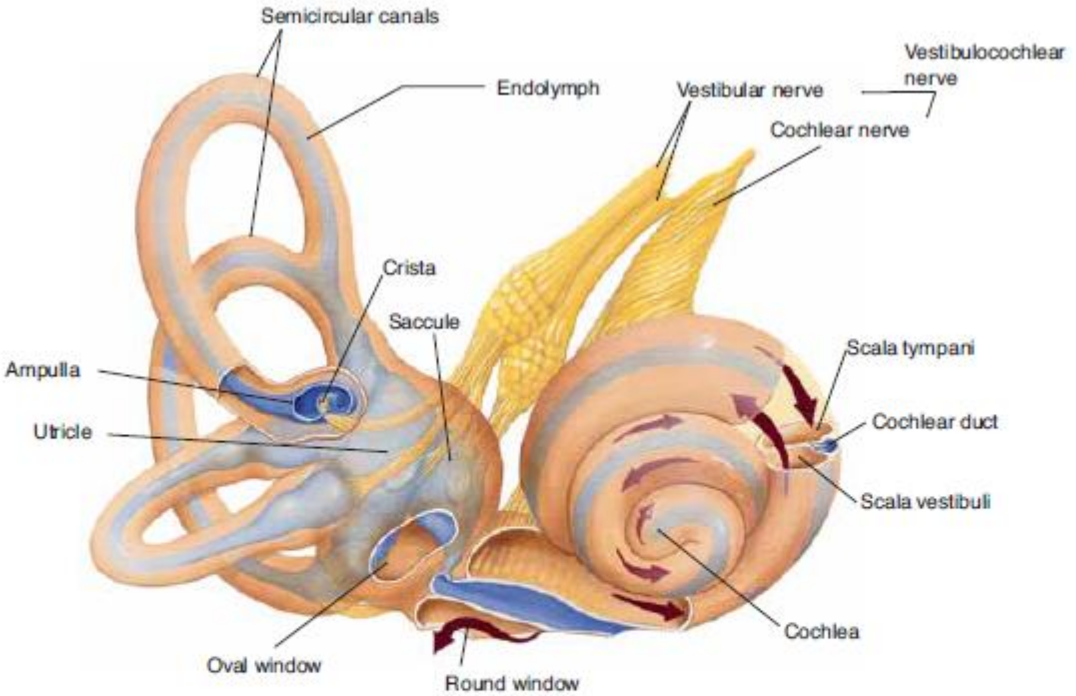

Figure 3.3.5: Artistic Impression of the Inner Ear Structures. The arrows show the transmission of vibrations during hearing.

The other ear structure involved in hearing is the membrane-covered round window that is located just below the oval window. The round window bulges out in response to the push of the stapes in the fluid at the oval window rather than the pressure to go and damage the hearing hair cells.

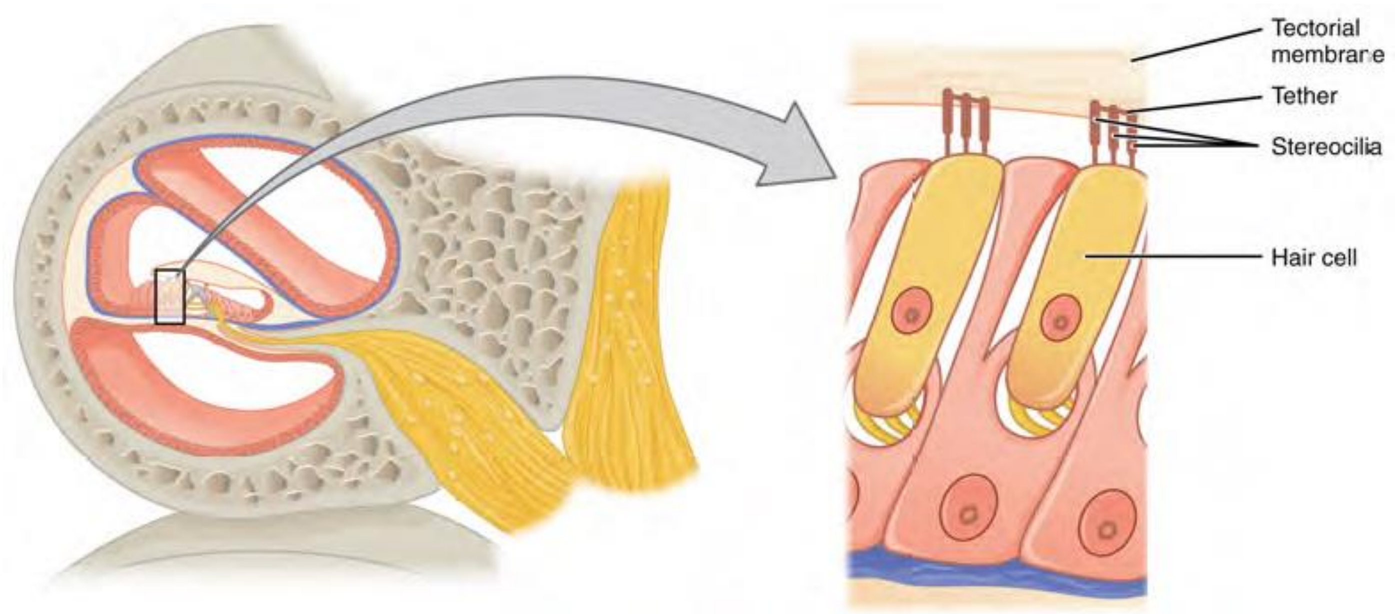

Figure 3.3.6: Structural Organisation of the Hair Cell used for Hearing and Balance.
Source: OpenStax College (2013). The hair cell is depicted here as the mechanoreceptor that has arrays of stereocilia which emerge from its surface.

Equilibrium (Balance)
The utricle, saccule and semicircular canals of the inner ear are the organs utilised in the sensation of balance. The mechanoreceptors, hair cells with stereocilia found within the vestibule of the inner ear, are used by the brain to sense the position of the head when the body is stationary or in motion. The utricle and saccule senses the position of the head position while head movement is sensed by the semicircular canals. The utricle and saccule are mainly made up a bunch of hair cells that are surrounded by support cells collectively known as macula tissue (plural = maculae). The stereocilia of the hair cells extend into a viscous gel called the otolithic membrane (See Figure 3.3.7). There is a layer of calcium carbonate crystals, called otoliths on top of the otolithic membrane. The top of the otolithic membrane is made heavy by the otoliths. Anytime there is movement of the head, the otolithic membrane corresponding movement is different from that of the macula. For this reason, the otolithic membrane slides over the macula, in the direction of gravity, anytime the head is tilted. These patterns of hair-cell depolarization in response to the position of the head are used to interpret the head position by the brain.

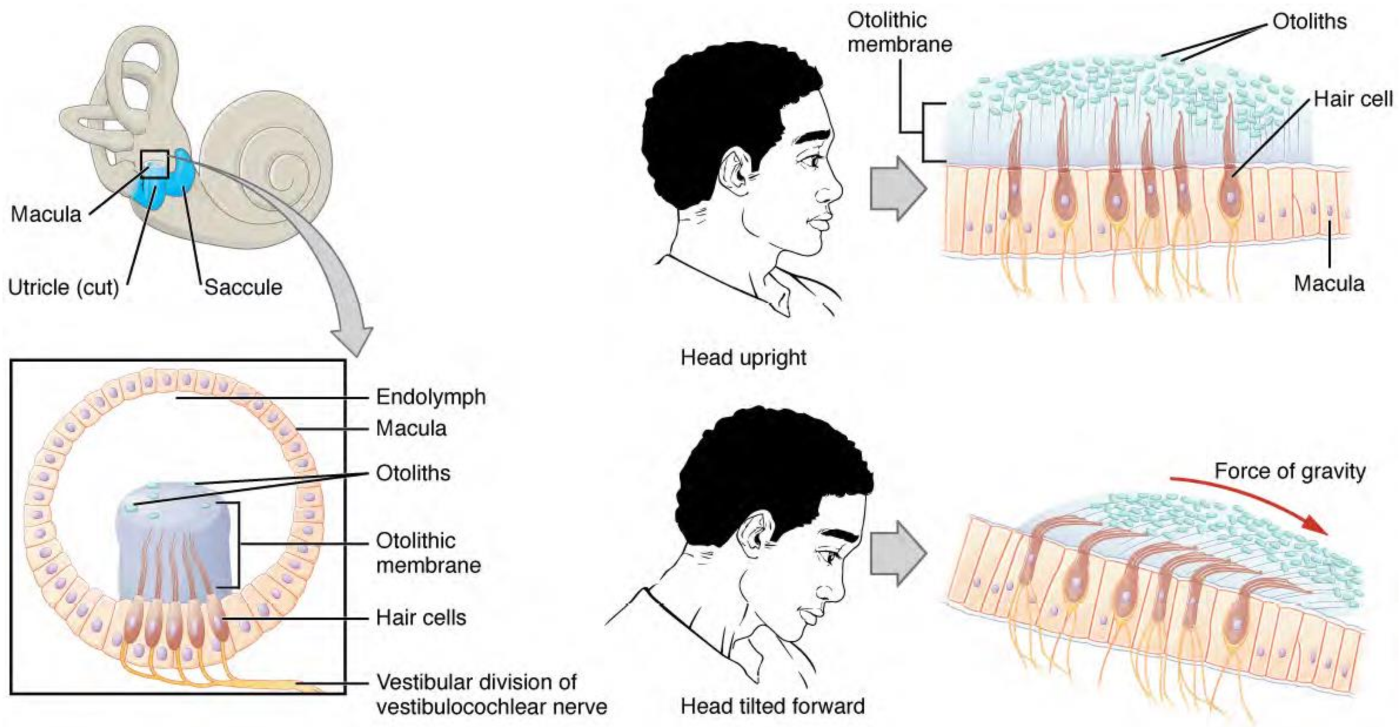

Figure 3.3.7: Depiction of Linear Acceleration Coding by Maculae Source: OpenStax College (2013).
The vestibule of the inner ear extends into three ring-like structures called the semicircular canals. The semicircular canals emerge from an enlarged region of the vestibule, which is known as the ampulla. One of the rings of the semicircular canal extends horizontally from the ampulla, while the other two extends vertically from it at an angle of about 45 degrees towards the front and rear, each, based on the sagittal plane (See Figures 3.3.5 and 3.3.7). There are hair cells in the ampulla that are sensitive to rotational movement, such as those used to indicate 'NO' by turning the head to the left and right sides along the horizontal axis. There is a membrane, called the cupula, which is attached to the top of the ampulla, into which the stereocilia of these hair cells extend.

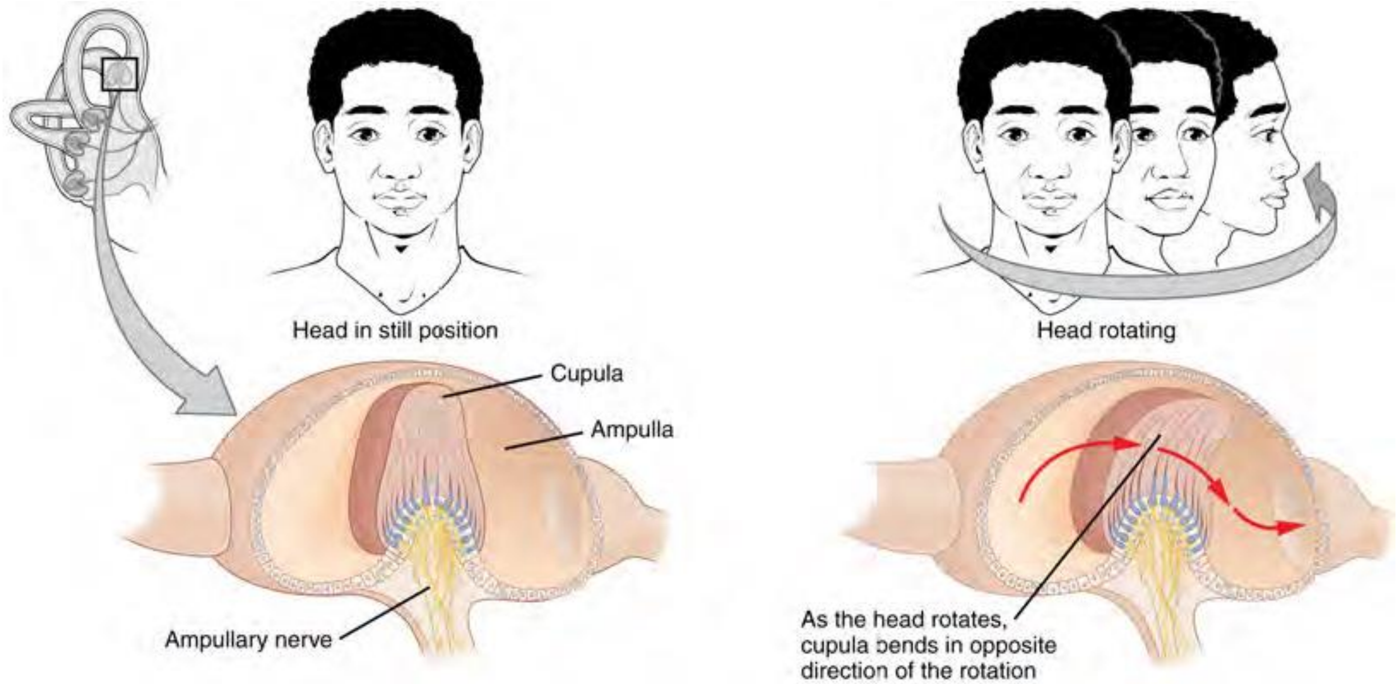

Figure 3.3.8: Rotational Coding by Semicircular Canals. Source: OpenStax College (2013. *Page 578).*
It is the hair cells in the semicircular canals that detect rotation of the head.

Arterial Receptors

There are receptors, located within the aorta and the carotid arteries, which detect alterations in certain properties of the blood. Among these receptors, are pressoreceptors, which detects whenever blood pressure changes as blood circulates within the heart and moves onto the brain. Similarly, the chemoreceptors are located in the carotid bodies and the aortic body detect changes in the oxygen and carbon dioxide content and the pH of blood as the blood circulates with the heart and moves onto the brain. The pressoreceptors and chemoreceptors generate impulses that give rise to sensations used to make any necessary changes in respiration or circulation rather than those that we can feel. It is the glossopharyngeal (9th cranial) and vagus (10^{th} cranial) nerves that carries sensory impulses from the pressoreceptors and chemoreceptors to the medulla of the brain. There are centres in the medulla that have the capability of increasing respiratory rate and heart rate for obtaining and circulating more oxygen when necessary. In this manner, the arterial receptors are important in the maintenance of homeostasis maintaining normal blood levels of oxygen, carbon dioxide and pH, and normal blood pressure.

4.0 Conclusion

The nervous system uses the different types of senses to sense the environment in which we live and the environment that is inside of us. The actions of the receptors in the nervous system enable us to give proper response to our internal and external environments that are continuously changing.

- List and describe the different types of senses
- Explain the structural organisation of the different types of senses.

Discuss the mechanism used for operating the different types of sensations.

5.0 Summary

You have come to know that there are specific receptors within specific organs that are sensitive to the senses of sight, hearing, touching, tasting and smelling among others. These are chemorecptors, mechanoreceptors, arterorecepotrs and muscle sense organs that help to monitor our external and internal environments.

Self Assessment Exercise

1. List and discuss the different types of sensations and their functions.
2. Describe the structure and functions of the organs used for the different types of senses.

6.0 Reference/Further Reading

OpenStax College, *Anatomy & Physiology*. OpenStax College. 25 April 2013. *http://cnx.org/content/col11496/latest/*

Scanlon, V. C. and Sanders, T. (2007): *Essentials of Anatomy and Physiology*. Philadelphia: F. A. Davis Company

Robergs, R. A. and Kateyian, S. J. (2003). *Fundamentals of exercise physiology for fitness, performance and health. (2nd ed)* New York. McGraw Hill.

Module 4 Overview of Digestive, Circulatory and Respiratory Processes in Physical Activity

You learned, in KHE 205 (Anatomy, Physiology and Sports 1), that it is tissues that combine to form organs, which perform complex functions for the body. The processes of human movement can only be properly carried out when the organs are arranged in a system that facilitates the desired purpose. You will study, in this module, an overview of the functioning of the digestive, circulatory and respiratory systems in the delivery of nutrients for fuelling physical activity and other life processes.

Unit 1: Digestive System's Processes in Physical Activity

1.0 Introduction

Energy is needed by the body so that it can perform the various physical activities found in sports and dance skills. You studied, in KHE 205 (Anatomy, Physiology and Sports 1), how the four basic tissues are organized into the organs of the digestive system and how these organs are suited for breaking down the foods you eat, release their nutrients, and absorb those nutrients into the body. You will further your study in this unit by learning the processes used by the digestive system to supply the energy for physical activities from food.

2.0 Intended Learning Outcome(s)

By the end of this unit, you would be able to

- List and describe the processes of digestion
- Explain the neural and hormonal controls of digestion

3.0 Main Content

Processes of Digestion

There are six activities in the processes of digestion. These activities are ingestion, propulsion, mechanical or physical digestion, chemical digestion, absorption, and defecation.

Ingestion

The first of these processes, ingestion, refers to the entry of food into the alimentary canal through the mouth. There, the food is chewed and mixed with saliva, which contains enzymes that begin breaking down the carbohydrates in the food plus some lipid digestion via lingual lipase. Chewing increases the surface area of the food and allows an appropriately sized bolus to be produced.

Propulsion

Food leaves the mouth when the tongue and pharyngeal muscles propel it into the oesophagus. This act of swallowing, the last voluntary act until defecation, is an example of propulsion, which refers to the movement of food through the digestive tract. It includes both the voluntary process of swallowing and the involuntary process of peristalsis. Peristalsis consists of sequential, alternating waves of contraction and relaxation of alimentary wall smooth muscles, which act to propel food along. These waves also play a role in mixing food with digestive juices. Peristalsis is so powerful that foods and liquids you swallow enter your stomach even if you are standing on your head.

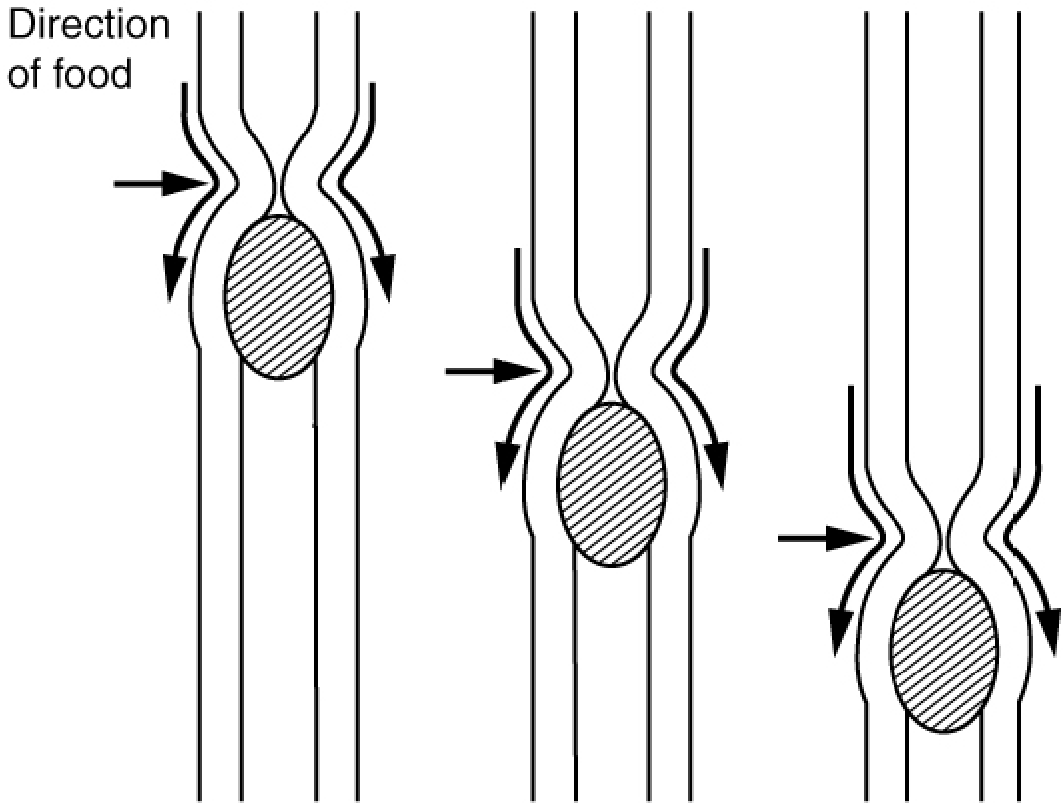

Figure 4.1.1: Peristalsis. Source: OpenStax College (2013. *Page 1039).*

Mechanical Digestion

The process known as mechanical digestion takes place in the mouth, stomach and the small intestine. The yam, plantain, rice, meat and so on that we eat on daily basis are passed through mechanical digestion so that the nutrients and energy contained in the foodstuffs can be released for our body's use. During mechanical digestion, the teeth are used to grind the foodstuffs through the process we call chewing or mastication. The tongue is used to move the foodstuffs into position for proper grinding and mixing with saliva.

Mechanical digestion continues in the stomach through the process called churning, the process whereby the food passed down from the mouth is squeezed continuously to further break them into smaller particles and mixing with gastric juices. At the small intestine, mechanical digestion continues with process known as segmentation. During segmentation, small sections of the small intestine are isolated by the contractions of its smooth muscles. These smaller sections subdivide the liquid foodstuffs, passed down from the stomach, into smaller quantities. These smaller quantities in a smaller section of the small intestines are moved back and forth on a continuous basis before passing on to the next smaller section. In this manner, segmentation further breaks up food particles, mixes them with digestive enzymes in the intestine and allows enough time for absorption to take place.

Mechanical digestion is a physical process that performs five main functions, which include:

i. break down foodstuffs into smaller particles through mastication in the mouth, churning in the stomach and the back and forth movement in the small intestine during segmentation;
ii. mix the broken down food particles with saliva in the mouth, with gastric juices in the stomach and digestive enzymes in the small intestines;
iii. increases the surface area of the food particles in readiness for chemical digestion with saliva in the mouth, gastric juices in the stomach and digestive enzymes in the small intestine;

iv. makes it easy for the ground foodstuff to move down the digestive tract; and
v. facilitation of absorption at the mouth, stomach and intestines.

Chemical Digestion

The chemical nature of foodstuffs is altered during chemical digestion. It is during chemical digestion that foods release their basic molecules/nutrients, such as amino acids from proteins. It is the action of digestive secretions, such as saliva in the mouth, gastric juices in the stomach and intestinal digestive enzymes in the intestines, that acts on the foods to release these basic molecules.

Absorption

This is the transfer of food nutrients from gastrointestinal tract into blood stream at the completion of digestion. Although some absorption occur in nearly every part of digestive tract, it occurs mainly within the small intestine.

Defecation

In defecation, the final step of digestion, undigested materials are removed from the body as faeces.

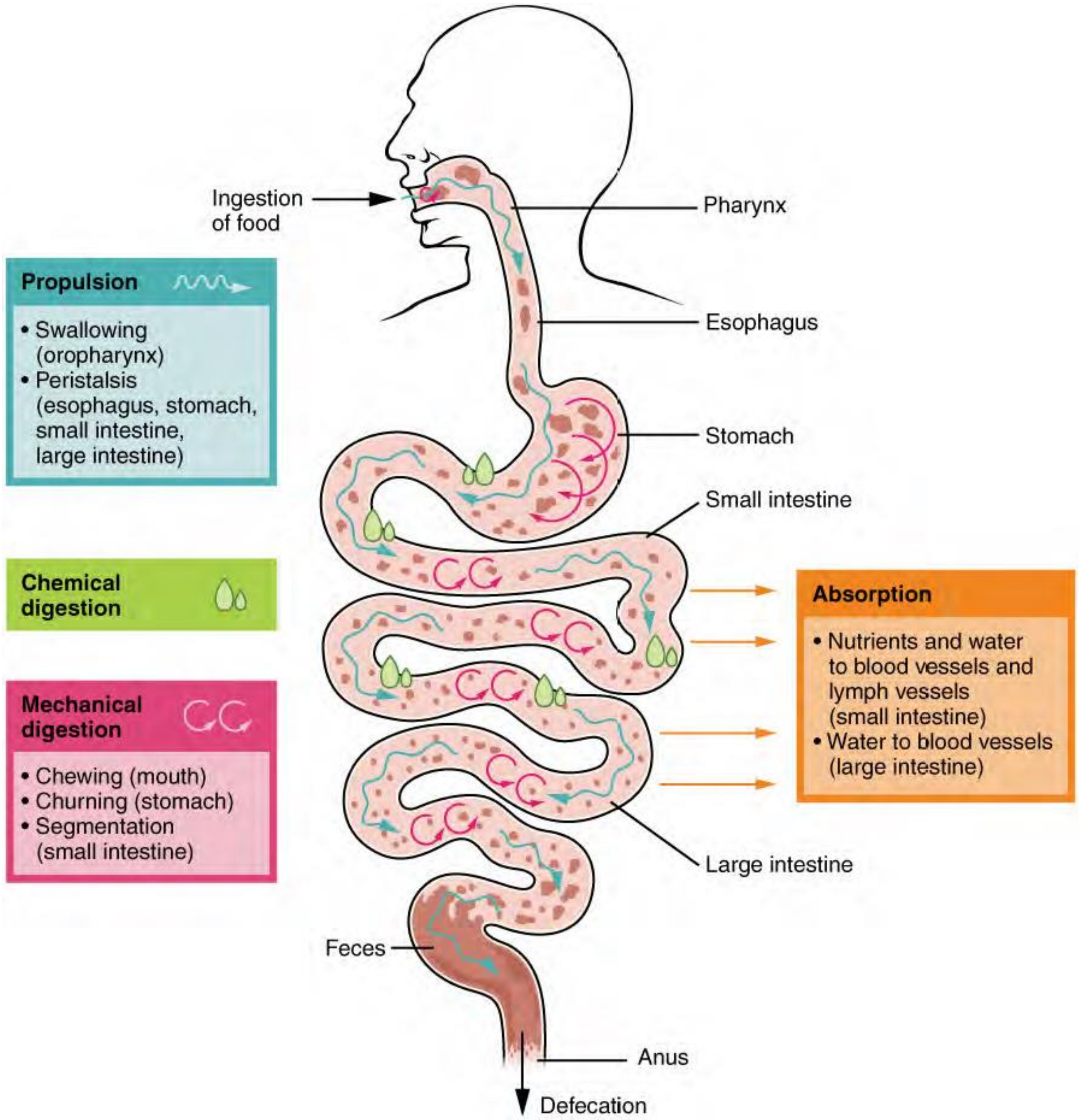

Figure 4.1.2: Digestive Processes Source: OpenStax College (2013. *Page 1040).*

Regulatory Mechanisms in the Control of Digestion

The nervous and endocrine systems work in synergy in the control of the digestive processes.

Neural Controls

There are several sensors in the walls of the digestive tract that senses and informs the need to regulate digestive functions. Among these sensors are mechanoreceptors that inform mechanical stimulation, chemoreceptors that informs chemical stimulation, and osmoreceptors that detects osmotic pressure.

Hormonal Controls

There are several hormones involved in the control of the digestion. The most important of these hormones are gastrin, secretin and cholecystokinin (CCK) that are released into the blood, which carries them to their target organs. The presence of food stimulates the production of gastrin, which makes the gastric juices to be secreted by the inner walls of the stomach. Secretin makes the duodenum to secrete bicarbonates by the pancreas. CCK makes the liver to release bile and pancreatic enzymes, and the gall bladder to secrete bile and gastric inhibitory peptides that slows down the movement of the stomach.

4.0 Conclusion

The digestive processes of ingestion, propulsion, mechanical or physical digestion, chemical digestion, absorption, and defecation delivers the nutrients that is used to supply the energy for physical activities from food. This process is controlled by the actions of nervous and endocrine systems.

5.0 Summary

You have come to know the mechanical and chemical processes of digestion, and these processes are controlled by the nervous and endocrine systems. You are now ready to go further in your study by studying how the nutrients, supplied by the digestive processes, are carried to working muscles by the circulatory processes in physical activity.

Self Assessment Exercise

1. Compare and contrast the mechanical and chemical processes of digestion
2. List and describe the receptors that informs the digestive processes
3. Show how the nervous and endocrine systems function in the controls of the digestive processes.

6.0 Reference/Further Reading

OpenStax College, *Anatomy & Physiology*. OpenStax College. 25 April 2013. http://cnx.org/content/col11496/latest/

Robergs, R. A. and Kateyian, S. J. (2003). *Fundamentals of exercise physiology for fitness, performance and health. (2nd ed)* New York. McGraw Hill.

Scanlon, V. C. and Sanders, T. (2007): *Essentials of Anatomy and Physiology*. Philadelphia: F. A. Davis Company

Unit 2: Circulatory System's Processes for Physical Activity

1.0 Introduction

Absorbed nutrients and oxygen can only get to working muscles via a well arranged and functional circulatory system. You will further your study in this unit by learning the processes used by the digestive system to supply the energy for physical activities from food.

2.0 Intended Learning Outcome(s)

By the end of this unit, you would be able to

- List and describe the processes of digestion
- Explain the neural and hormonal controls of digestion

3.0 Main Content

Circulatory Pathways

The blood vessels of the body are functionally divided into two distinctive circuits: pulmonary circuit and systemic circuit. The pump for the pulmonary circuit, which circulates blood through the lungs, is the right ventricle. The left ventricle is the pump for the systemic circuit, which provides the blood supply for the tissue cells of the body.

Pulmonary Circuit

Pulmonary circulation transports oxygen-poor blood from the right ventricle to the lungs where blood picks up a new blood supply. Then it returns the oxygen-rich blood to the left atrium.

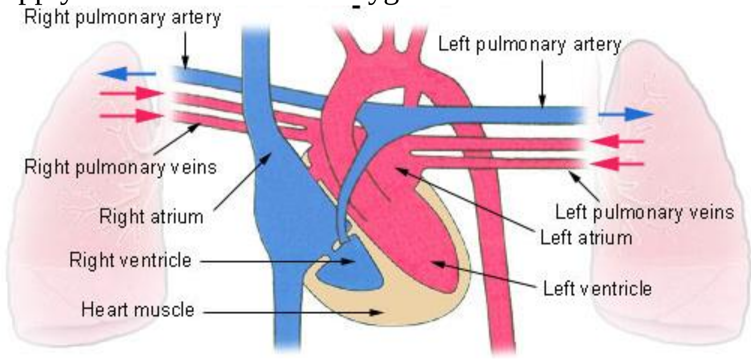

Figure 4.2.2: Pulmonary Circuit. Source: ICD-0-3 (2007)

Systemic Circuit

The systemic circulation provides the functional blood supply to all body tissue. It carries oxygen and nutrients to the cells and picks up carbon dioxide and waste products. Systemic circulation carries oxygenated blood from the left ventricle, through the arteries, to the capillaries in the tissues of the body. From the tissue capillaries, the deoxygenated blood returns through a system of veins to the right atrium of the heart.

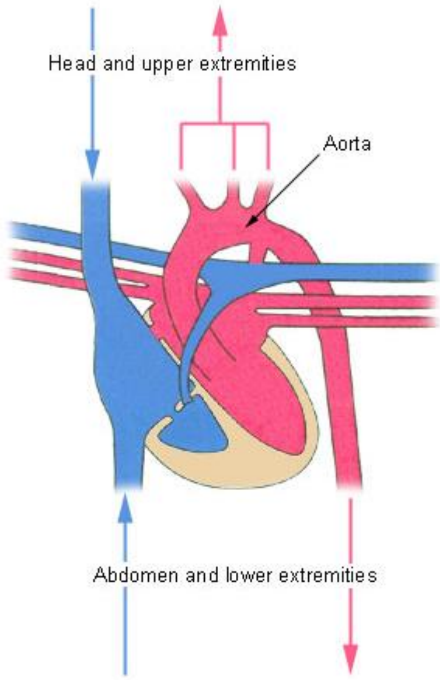

Figure 4.2.3: Systemic Circuit. Source: ICD-0-3 (2007)

The coronary arteries are the only vessels that branch from the ascending aorta. The brachiocephalic, left common carotid, and left subclavian arteries branch from the aortic arch. Blood supply for the brain is provided by the internal carotid and vertebral arteries. The subclavian arteries provide the blood supply for the upper extremity. The celiac, superior mesenteric, suprarenal, renal, gonadal, and inferior mesenteric arteries branch from the abdominal aorta to supply the abdominal viscera. Lumbar arteries provide blood for the muscles and spinal cord. Branches of the external iliac artery provide the blood supply for the lower extremity. The internal iliac artery supplies the pelvic viscera.

Major Systemic Arteries

All systemic arteries are branches, either directly or indirectly, from the aorta. The aorta ascends from the left ventricle, curves posteriorly and to the left, then descends through the thorax and abdomen. This geography divides the aorta into three portions: ascending aorta, aortic arch, and descending aorta. The descending aorta is further subdivided into the thoracic aorta and abdominal aorta.

Major Systemic Veins

After blood delivers oxygen to the tissues and picks up carbon dioxide, it returns to the heart through a system of veins. The capillaries, where the gaseous exchange occurs, merge into venules and these converge to form larger and larger veins until the blood reaches either the superior vena cava or inferior vena cava, which drain into the right atrium.

Capillary Microcirculation

In addition to forming the connection between the arteries and veins, capillaries have a vital role in the exchange of gases, nutrients, and metabolic waste products between the blood and the tissue cells. Substances pass through the capillaries wall by diffusion, filtration, and osmosis. Oxygen and carbon dioxide move across the capillary wall by diffusion. Fluid movement across a capillary wall is determined by a combination of hydrostatic and osmotic pressure. The net result of the capillary microcirculation created by hydrostatic and osmotic pressure is that substances leave the blood at one end of the capillary and return at the other end.

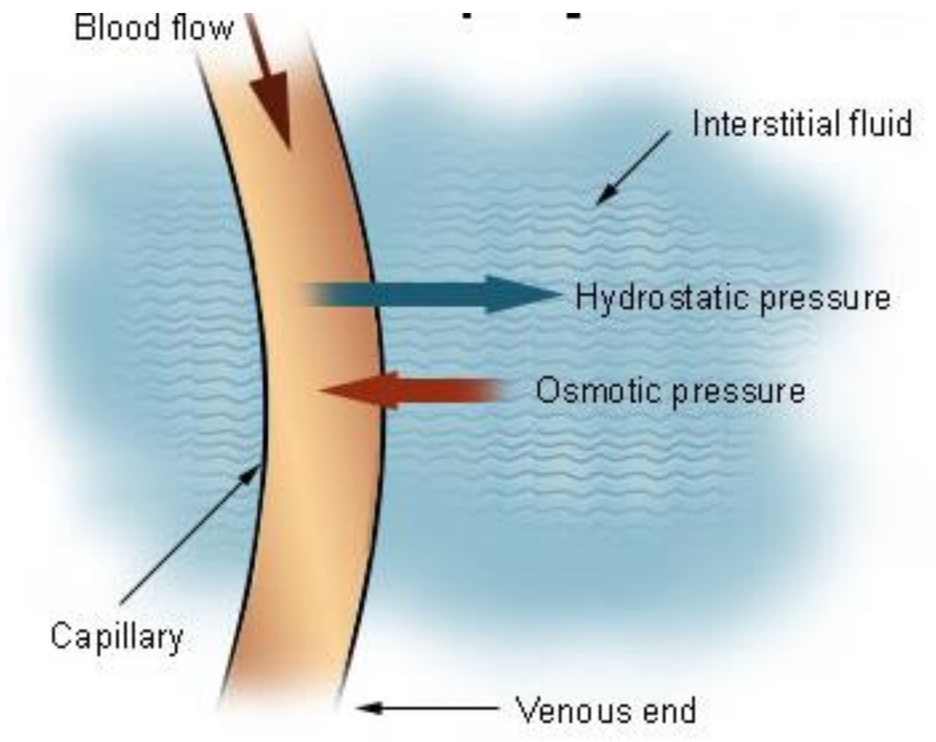

Figure 4.2.1: Capillary Microcirculation. Source: ICD-0-3 (2007)

Blood Flow

Blood flow refers to the movement of blood through the vessels from arteries to the capillaries and then into the veins. Pressure is a measure of the force that the blood exerts against the vessel walls as it moves the blood through the vessels. Like all fluids, blood flows from a high pressure area to a region with lower pressure. Blood flows in the same direction as the decreasing pressure gradient: arteries to capillaries to veins.

The rate, or velocity, of blood flow varies inversely with the total cross-sectional area of the blood vessels. As the total cross-sectional area of the vessels increases, the velocity of flow decreases. Blood flow is slowest in the capillaries, which allows time for exchange of gases and nutrients.

Resistance is a force that opposes the flow of a fluid. In blood vessels, most of the resistance is due to vessel diameter. As vessel diameter decreases, the resistance increases and blood flow decreases.

Very little pressure remains by the time blood leaves the capillaries and enters the venules. Blood flow through the veins is not the direct result of ventricular contraction. Instead, venous return depends on skeletal muscle action, respiratory movements, and constriction of smooth muscle in venous walls.

Pulse and Blood Pressure

Pulse refers to the rhythmic expansion of an artery that is caused by ejection of blood from the ventricle. It can be felt where an artery is close to the surface and rests on something firm.

In common usage, the term blood pressure refers to arterial blood pressure, the pressure in the aorta and its branches. Systolic pressure is due to ventricular contraction. Diastolic pressure occurs during cardiac relaxation. Pulse pressure is the difference between systolic pressure and diastolic pressure. Blood pressure is measured with a sphygmomanometer and is recorded as the systolic pressure over the diastolic pressure. Four major factors interact to affect blood pressure: cardiac output, blood volume, peripheral resistance, and viscosity. When these factors increase, blood pressure also increases.

Arterial blood pressure is maintained within normal ranges by changes in cardiac output and peripheral resistance. Pressure receptors (barareceptors), located in the walls of the large arteries in the thorax and neck, and are important for short-term blood pressure regulation.

4.0 Conclusion

The circulatory process carries absorbed food nutrients, air and other chemicals to working muscles where they would be made release energy for physical activities. The circulatory system accomplishes this function via the actions of the pulmonary and systemic circulation of the circulatory pathways.

4.0 Summary

You have learned how the pulmonary and systemic circulation of the circulatory pathways delivers absorbed food nutrients to working muscles, where energy for physical activity is obtained. You are now ready to go further in your study by studying how the respiratory processes releases energy from the nutrients, supplied by the digestive processes, are carried to working muscles by the circulatory processes in physical activity.

Self Assessment Exercise

1. Distinguish between the pulmonary circulation and the systemic circulation of the circulatory pathway.
2. Explain how food nutrients are delivered to working muscles during capillary microcirculation.
3. List and describe the factors that dictate the pace of blood flow.

5.0 Reference/Further Reading

Ajiduah, A. O. (1998). *Basic theory of sports training.* Lagos: University of Lagos press

ICD-0-3 (2007). Body Structure and Function. Retrieved on May 10, 2007 from *http://training.seer.gov/module_anatomy/unit1_body_structure.html*

McArdle, D. Katch, F. I., Katch, V. L. (1999): *Exercise Physiology: Energy, Nutrition and Human Performance. (4th ed.)* U.S.A. Lippricot Williams and Wilkins.

McGlynn, G. (1999). *Dynamics of Fitness: A Practical Approach. (5th ed.).* The McGraw – Hill Company Inc.

Robergs, R. A. and Kateyian, S. J. (2003). *Fundamentals of exercise physiology for fitness, performance and health. (2nd ed)* New York. McGraw Hill.

Unit 3: Respiratory System's Processes in Physical Activity

1.0 Introduction

Organs of the respiratory system ensure that chemical energy in digested and absorbed food nutrients are converted to energy for the different muscular contractions of the various physical activities. You will continue your in-depth study of the mechanism of human movement, in this unit, by studying the respiratory processes in the release of energy of for physical activity.

2.0 Intended Learning Outcome(s)

By the end of this unit, you would be able to

- List and describe the processes of external and internal respiration.
- Explain the factors that inhibit or enhances gaseous exchanges during external and internal respiration.

3.0 Main Content

Respiration is the process that allows the exchange of oxygen and carbon dioxide between the atmosphere and the body cells. By this process air is moved through the conducting passages every 3 to 5 seconds upon nervous stimulation. There are two types of respiration. The respiration that brings in air into the body is called external respiration while the internal respiration makes possible for the cells of the body to utilize oxygen for metabolic processes.

External Respiration

External respiration has two parts known as inspiration and expiration. During inspiration (inhalation), air is drawn into the lungs as the diaphragm contracts and the thoracic cavity increases in volume thereby reducing the pressure within the lungs. When the pressure within the lungs known as intra-alveolar pressure is reduced below the atmospheric pressure, air flows into the lungs following the natural pressure gradient thus created. Within the lungs, an exchange of gases between the lungs and the blood takes place. Oxygen in the incoming air gets absorbed into the alveolar capillaries blood while carbon dioxide in the alveolar capillaries blood gets liberated into alveolar. Following inspiration is the other part of respiration called expiration. During expiration (exhalation) the diaphragm relaxes thereby decreasing the thoracic volume and increasing the intra-alveolar pressure beyond atmospheric pressure. This pushes out the air in the lungs into the atmosphere. Expiration pushes air out of the lungs. It must be noted that the air that goes into the lungs during inspiration is oxygen rich while the air that comes out of the lungs during expiration is carbon dioxide rich. All the processes involved in inspiration and expiration are what we refer to as external respiration.

Ventilation, or breathing, is the movement of air through the conducting passages between the atmosphere and the lungs. The air moves through the passages because of pressure gradients that are produced by contraction of the diaphragm and thoracic muscles.

Pulmonary ventilation

Pulmonary ventilation is commonly referred to as breathing. It is the process of air flowing into the lungs during inspiration (inhalation) and out of the lungs during expiration (exhalation). Air flows because of pressure differences between the atmosphere and the gases inside the lungs.

Air, like other gases, flows from a region with higher pressure to a region with lower pressure. Muscular breathing movements and recoil of elastic tissues create the changes in pressure that result in ventilation. Pulmonary ventilation involves three different pressures:

- Atmospheric pressure
- Intra-alveolar (intrapulmonary) pressure
- Intra-pleural pressure

Atmospheric pressure is the pressure of the air outside the body. Intra-alveolar pressure is the pressure inside the alveoli of the lungs. Intra-pleural pressure is the pressure within the pleural cavity. These three pressures are responsible for pulmonary ventilation.

Inspiration

Inspiration (inhalation) is the process of taking air into the lungs. It is the active phase of ventilation because it is the result of muscle contraction. During inspiration, the diaphragm contracts and the thoracic cavity increases in volume. This decreases the intra-alveolar pressure so that air flows into the lungs. Inspiration draws air into the lungs.

Expiration

Expiration (exhalation) is the process of letting air out of the lungs during the breathing cycle. During expiration, the relaxation of the diaphragm and elastic recoil of tissue decreases the thoracic volume and increases the intra-alveolar pressure. Expiration pushes air out of the lungs.

Internal Respiration

This is the exchange and transport of gases exchange that takes place at the tissue level. Oxygen has a low partial pressure in tissues because it is continuously used for cell metabolism. On the other hand, oxygen has a high partial pressure in the blood. For this reason, blood that is returning to the heart from the tissues loses much of its brightness because its haemoglobins have little oxygen bound to them. Conversely, the partial pressure of carbon dioxide is lower in the blood than it is in the tissue because the tissues are always producing carbon dioxide as a waste product of their metabolic activities. When the blood is pumped back into the lungs its pressure gradient is again reversed as the blood gets oxygenated once again during external respiration.

Respiratory Volumes and Capacities

Under normal conditions, the average adult takes 12 to 15 breaths a minute. A breath is one complete respiratory cycle that consists of one inspiration and one expiration.

An instrument called a spirometer is used to measure the volume of air that moves into and out of the lungs in the sport sciences, and the process of taking the measurements is called spirometry. Respiratory (pulmonary) volumes are an important aspect of pulmonary function testing because they can provide information about the physical condition of the lungs.

Respiratory capacity (pulmonary capacity) is the sum of two or more volumes.

Factors such as age, sex, body build, and physical conditioning have an influence on lung volumes and capacities. Lungs usually reach their maximumin capacity in early adulthood and decline with age after that.

4.0 Conclusion

The external and internal mechanisms in the respiratory process releases energy for physical activities.

5.0 Summary

You have learned how the respiratory processes releases energy to working muscles for physical activity is obtained. You are now ready to go further in your study by studying the neuromuscular actions and metabolic processes in the sourcing of this energy for physical activity.

Self Assessment Exercise

1. List and describe the processes of ventilation.
2. Discuss the three pressures that are responsible for pulmonary ventilation.
3. Explain the mechanism of internal respiration.

6.0 Reference/Further Reading

Ajiduah, A. O. (1998). *Basic theory of sports training.* Lagos: University of Lagos press

ICD-0-3 (2007). Body Structure and Function. Retrieved on May 10, 2007 from *http://training.seer.gov/module_anatomy/unit1_body_structure.html*

McArdle, D. Katch, F. I., Katch, V. L. (1999): *Exercise Physiology: Energy, Nutrition and Human Performance. (4th ed.)* U.S.A. Lippricot Williams and Wilkins.

McGlynn, G. (1999). *Dynamics of Fitness: A Practical Approach. (5th ed.).* The McGraw – Hill Company Inc.

Robergs, R. A. and Kateyian, S. J. (2003). *Fundamentals of exercise physiology for fitness, performance and health. (2nd ed)* New York. McGraw Hill.

Module 5 Neuro-Muscular Actions and Metabolic Processes in the Sourcing of Energy for Physical Activity

You will continue your study of the mechanism of human movement, in this module, by studying the mechanism used by the nervous and muscular systems in bringing about physical activities of sports and other skills such as danced skills. You will specifically learn how muscular contractions occur, the nervous systems actions in stimulating these contractions and the sources and sourcing of energy for the contractions to take place.

Unit 1: Neuro- Muscular Actions I

1.0 Introduction

The organs in the muscular system are muscles, which account for over half of the human body's weight. These organs, muscles, are made up of muscle cells, which have the capacity to contract when stimulated by nerves and when there is adequate supply of chemical energy. You will learn, in this unit, the mechanism of the different types of muscular contractions used in physical activities.

2.0 Intended Learning Outcome(s)

By the end of this unit, you would be able to

1. Describe the structural and functional units of contracting muscles.
2. Explain the mechanism of muscular contraction.
3. List and describe the different types of muscular contraction.

3.0 Main Content

Structural and Functional Units of Skeletal Muscles

Skeletal muscles are organs that are composed of various tissues that are integrated in their specific functions. The tissues in skeletal muscles include skeletal muscle fibres, blood vessels, nerve fibres, and connective tissue. Every skeletal muscle is a collection of bundles of muscle fibres (skeletal muscle cells muscle cells) that are join into a tendon at each end, and are called fascicles. The bundles of muscle fibres, fascicles, are wrapped inside a layer of fascia that binds the muscle into one functional unit. Three layers of connective tissues are used in wrapping the fascilces in a skeletal muscle. These are the endomysium (plural = endomysia), the perimysium (plural = perimysia) and the epimysium (plural = epimysia). Inside the endomysium are packed several thousands of muscle fibres. Several bundles of the endomysia are then packaged into the periysium. The epimysium also separates muscle from other tissues and organs in the area, allowing the muscle to move independently.

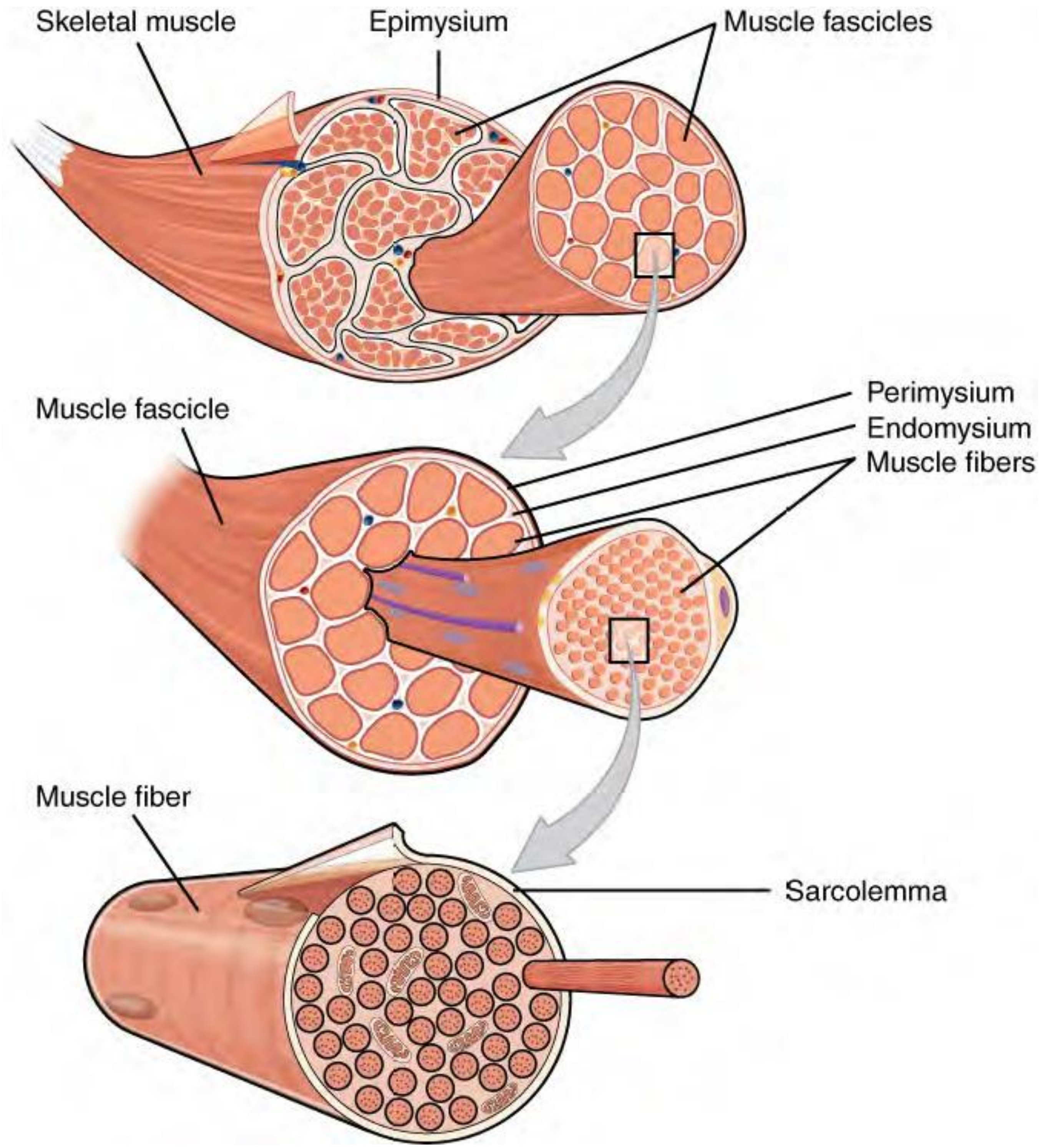

Figure 5.1.8: Bundles of Muscle Fibres (Fascicles) Wrapped in Three Layers of Connective Tissue. Source: OpenStax College (2013. *Page 384).*

Structural Organisation of the Muscle Fibre (Muscle Cell)
Skeletal muscle cells, also known as muscle fibres are long and cylindrical in shape. Muscle fibres are about the biggest cells in human body. For example, the Sartorius of the upper leg has a diameter that is up to 100 μm and it is as long as 30 cm. Every muscle fibre is composed of a cell membrane called the sarcolemma. Inside the sarcolemma is the fluid part of the cell called sarcoplasm, which contains myoglobin, fat, glycogen, ATP, PC, myofibrils and various organelles found in other cells.

The myofibril

The myofibril is the contractile element of the muscle cell. Alternate light and dark bands called I- and A-bands characterize the myofibrils. The A- band contains two proteins called actin and myosin; the I- band contains only actin filaments. The region in the middle of the A- band where actin and myosin do not overlap is called the H- zone. In the middle of each I- band is a line called the Z- line. These z- lines lend support and stability to the muscle fibre as well as play the role of transmitting nervous impulse from the sarcolemma to the myofibrils.

The distance from one Z- line to the next is called a sarcomere. The sarcomere represents the smallest functional part of the muscle cell. A portion of the sarcoplasm is called the sarcoplasmic reticulum. It consists of tubules and channels extending in the spaces between the myofibrils. Calcium ions are stored in the channels. The myosin filaments have at their tips small processes known as cross bridges. The stored ATP in the muscles are found on the cross bridges.

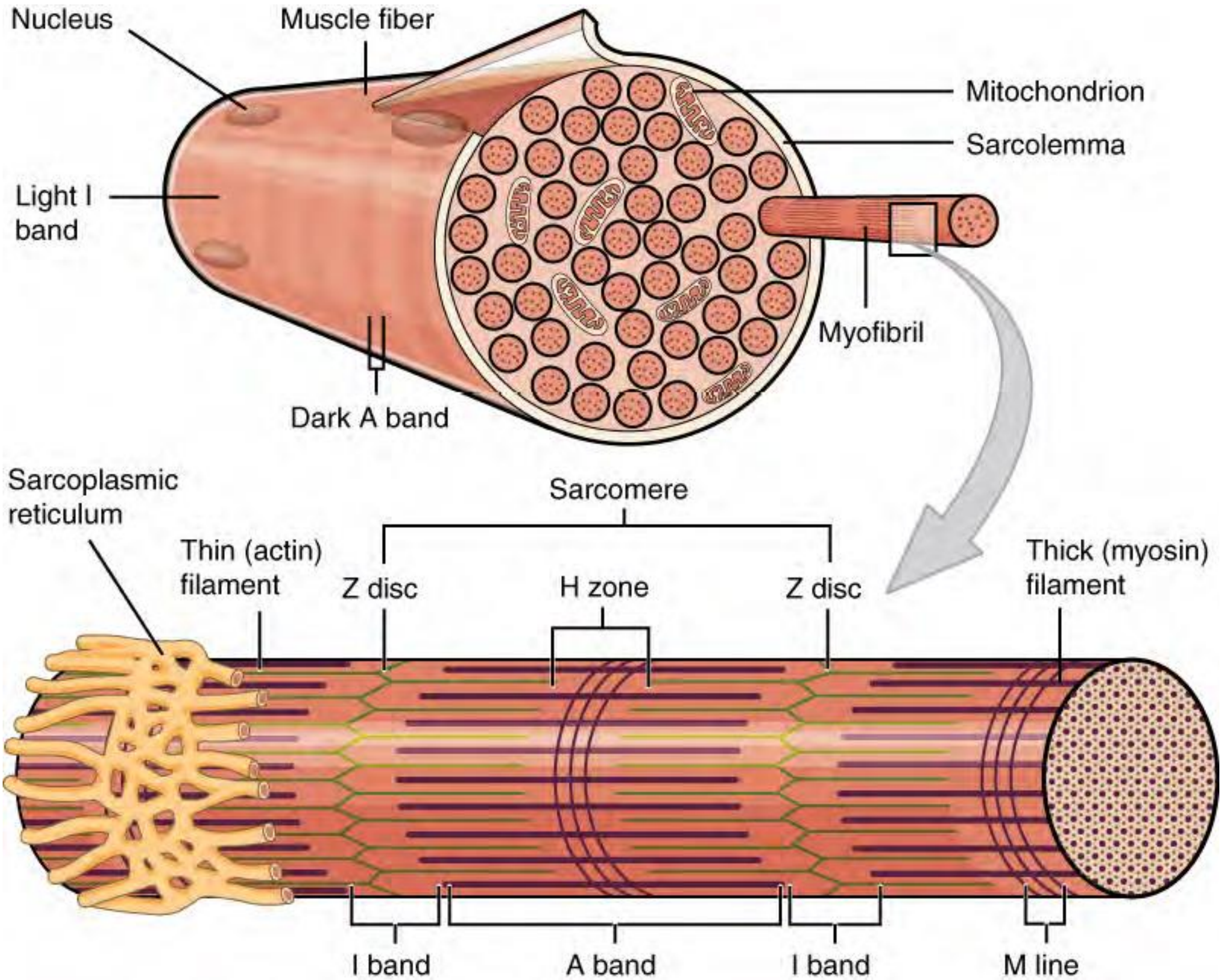

Figure 5.1.9: Structural Organisation of the Muscle Fibre Source: OpenStax College (2013. *Page 385).*
It could be seen that the muscle fibre consists of many myofibrils, which give the cell its striated appearance.

Chemical composition of muscles

The most abundant constituent of the muscle is water. Water accounts for 75 percents. Protein accounts for about 20 percent and inorganic salts, carbohydrates, and fats makeup the remaining 5 percent. The proteins are of different types are actin, myosin, tropomysin, myoglobin. Carbohydrates are in the form of glycogen and fats in triglycerides form.

Muscle contraction

Muscular contraction is controlled by the nervous system. Muscular contraction requires energy. It is the energy released by the breaking of the chemical bonds in ATP to produce ADP + Pi that is use for muscle contraction. ATP is stored in the myosin. At rest when the space for ATP in myosin is filled up, the remaining ATP combines with creatine to form a compound called creatine phosphate. Impulses reach the muscle through a motor neuron. The point of contract between a motor neuron and a muscle is called motor end plate or neuromuscular junction. Impulses reaching the motor end plate cause the release of a chemical called acetylcholine, which is transmitted to the muscle fibres, causing them to contract. In the body, skeletal muscles contract in response to nerve impulses from motor nerve fibres. The site where the nerve fibre and muscle fibre meet is known as the neuromuscular junction, or motor end plate (see Figure 5.2.1).

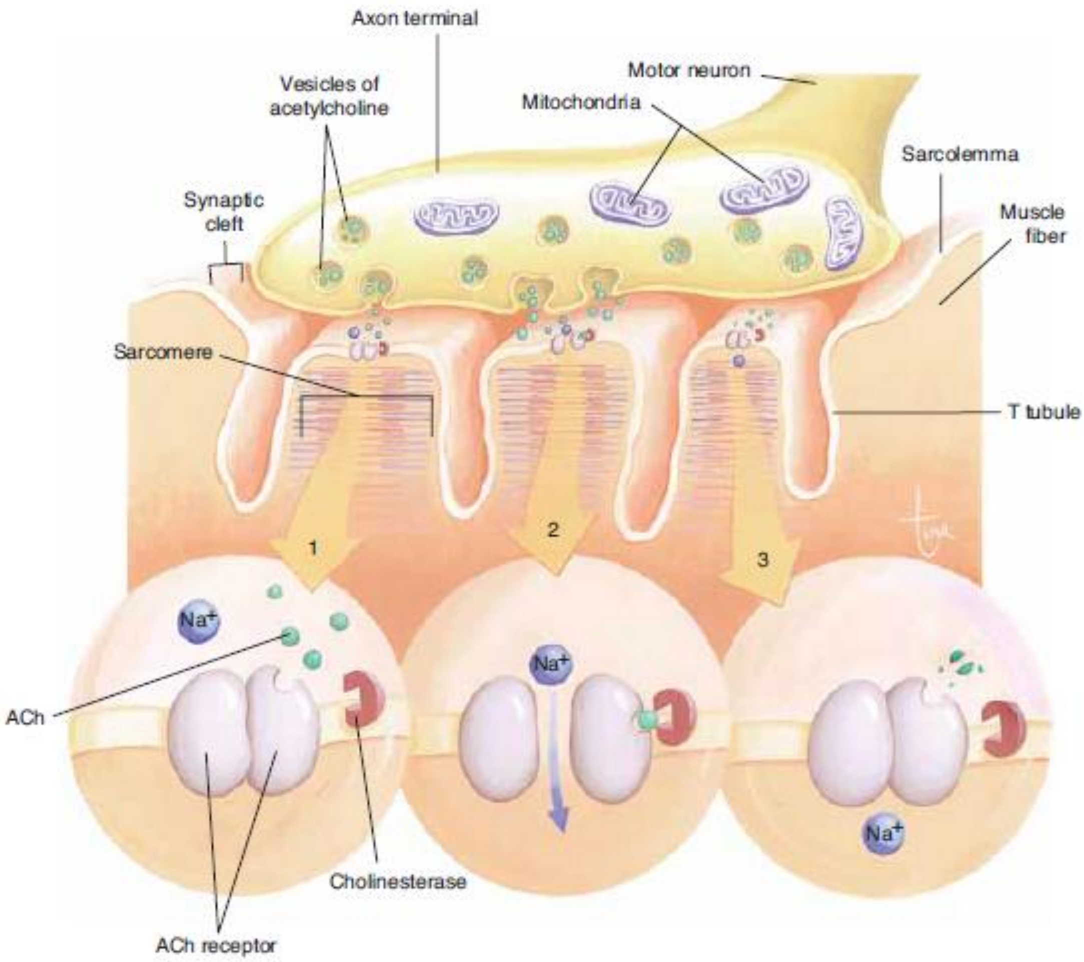

Figure 5.1.3: Scanlon and Sanders' (2007, p 143) Depiction of the Structural Organisation of the Neuromuscular Junction for Nervous Control of Movement. It shows the arrangement of an axon terminal adjacent to the sarcolemma of a muscle fibre in a neuromuscular junction. The three steps action in the nervous control of muscular contraction is also shown and labeled as 1, 2 and 3. **1**: Acetylcholine moving to bond with Acetylcholine receptor in the sarcolemma of muscle fibre. **2**: Sodium channel opens to allow Na^+ ions enter inside the muscle cell. **3**: Cholinesterase inactivates acetylcholine.

The Sarcomere and the Theory of muscular contraction

The skeletal muscle fibre is striated in appearance because the sequence of actin and myosin protein filaments in each myofibril in an order that runs from one end of the muscle fibre to the other. Each packet of these microfilaments and their regulatory proteins, troponin and tropomyosin (along with other proteins) is called a sarcomere. The sarcomere is the functional contractile unit of the muscle Fibre. It is the sarcomere, bundled within the myofibril that runs the entire length of the muscle Fibre and attaches to the sarcolemma at its end that contract. As the sarcomere of myofibrils contract, the entire muscle cell contracts. Myofibrils are very slim with a diameter that is just about 1.2 μm. Therefore every muscle fibre is equipped with hundreds to thousands myofibrils (each containing thousands of sarcomeres). Figure 3.12.3 shows a diagrammatic presentation of the sarcomere in muscular contraction.

The actin and its troponin-tropomyosin complex (projecting from the Z-discs toward the centre of the sarcomere) are called the thin filament of the sarcomere. This is because the resultin strand are thin in comparison to the mysosin. Also, the myosin strands have more mass and are thicker. For this reason, one of the widely accepted theories of muscular contraction is the sliding filament theory. This theory states that calcium ions in the myofibrils combine with myosin which functions to release energy from ATP. Once this happens contraction takes place with actin filaments sliding over myosin filaments as the muscle shortens.

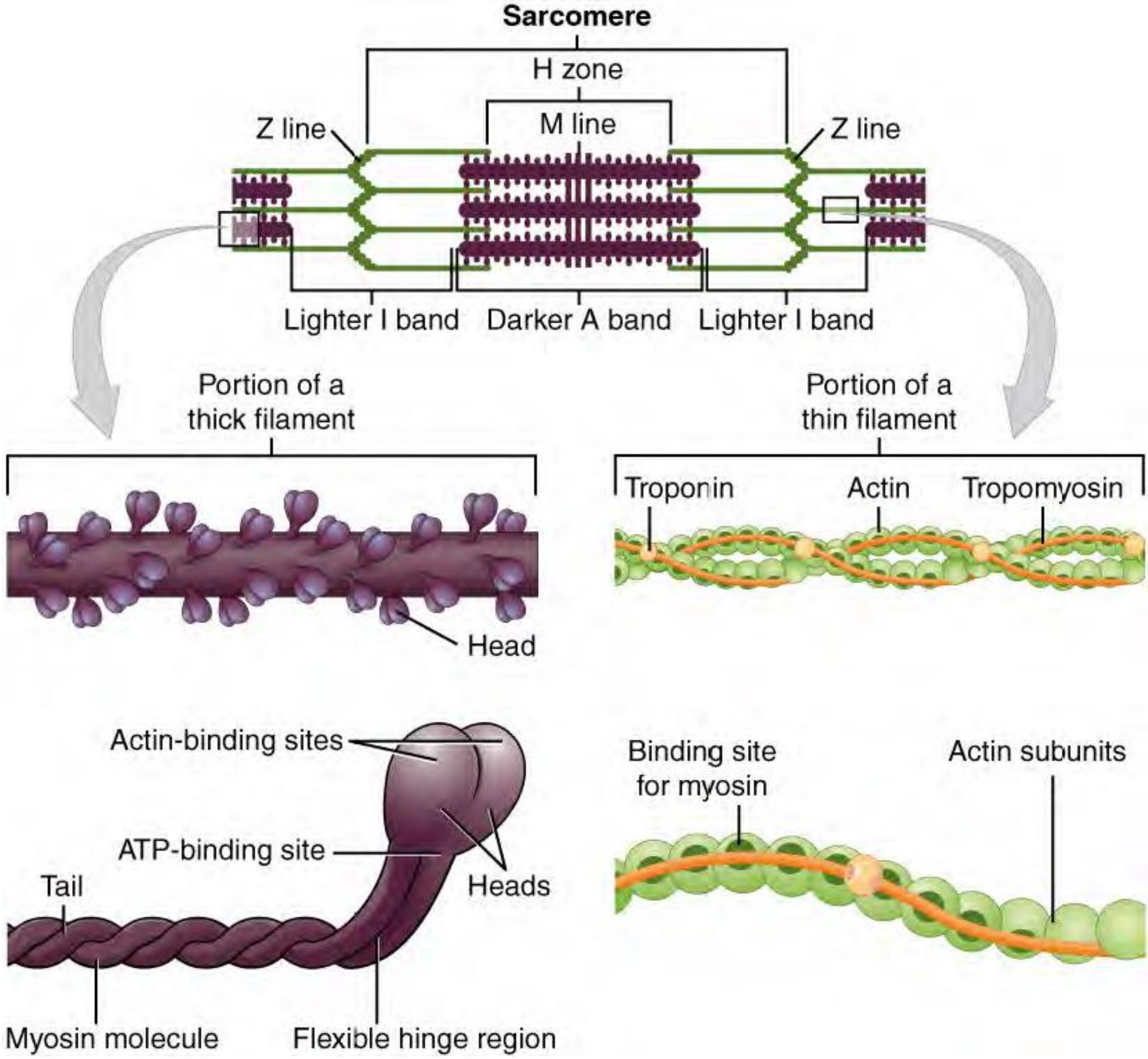

Figure 5.1.4: Structural Organisation of the Sarcomere Source: OpenStax College (2013. *Page 386)* The region between two Z-lines is known as the sarcomere of the myofibril; it is the contractile functional unit of a skeletal muscle fibre.

Types of contraction

A muscle may contract fully or partially and may contract with maximum or less force. It may contract (dynamically) (statically).

Isotonic contraction: in this contraction the muscle changes length as it develops tension. The tension developed is greater than the external resistance and thus produces movement.

Isometric contraction: in this contraction the muscle develops tension as it contracts but there is no visible change in muscle because tension developed is less than the external resistance.

Isotonic contraction: in this type of muscular contraction, the muscle develops tension as it contracts with visible change in muscle length and width as tension developed. Isotonic muscular contractions are either concentric or eccentric contraction.

Concentric contraction: in this contraction the muscle develops tension high enough to overcome a resistance. The muscle shortens cause movement e.g. lifting a weight.

Eccentric contraction: in this contraction the muscle becomes longer as it contracts. It is controlled lengthening of a muscle e.g. lowering a weight.

Isokinetic contraction: in this contraction, the muscle develops tension as it contracts and changes length. The tension developed is constant throughout the entire range of motion. Isokinetic contraction is similar to isotonic contraction the only difference is that in isokinetic contraction the tension developed is constant throughout the entire range of motion.

4.0 Conclusion

You have studied structural and functional organisation of skeletal muscles in bringing about human movement. You are now ready to continue your in-depth study of human movement by learning how organs of the nervous system function in bringing about human movement and how strength and endurance, and flexibility muscle can be developed.

5.0 Summary

Muscle groups are collection of muscle bundles that join into a tendon at each end. Each bundle is made up of thousands of fibres. Each fibre constitutes a muscle cell. The functional unit of the muscle cell is the myofibril, which contains actin and myosin the contractile elements. When the muscle contracts, the actin filaments slide over the myosin filaments; this causes the shortening and production of movement.

A muscle can contract isometrically, isotonically or isokinetically. The main function of muscles is to produce movement. The basic functional unit is the motor unit. There are two types of motor units; the fast twitch and the slow twitch motor units. The distribution of motor units varies from muscle to muscle. They possess unique characteristics. If a muscle is stimulated to contract continuously it will after a time cease to react to further stimulation. This condition is referred to as fatigue.

Self Assessment Exercise

4. With the aid of a well labelled diagram show how bundles of skeletal muscle fibres are structurally organised for move independent functioning.
5. Use the sliding filament theory to discuss the role played by the sarcomere of a skeletal muscle fibre as its structural and functional contracting unit.
6. List and describe the different types of muscular contraction.

6.0 Reference/Further Reading

OpenStax College, *Anatomy & Physiology*. OpenStax College. 25 April 2013. *http://cnx.org/content/col11496/latest/*

Scanlon, V. C. and Sanders, T. (2007): *Essentials of Anatomy and Physiology*. Philadelphia: F. A. Davis Company

Robergs, R. A. and Kateyian, S. J. (2003). *Fundamentals of exercise physiology for fitness, performance and health. (2nd ed)* New York. McGraw Hill.

Amusa, L. O. and Abass, A. O. (2002). *Physiology Applied to Physical Conditioning.* Centre for External Studies, University of Ibadan.

Unit 2: Neuro- Muscular Actions II

1.0 Introduction

Movement and every human activity must be coordinated and controlled so that the human organism can work as a unit and respond to changes in ways that help maintain a stable internal environment. The general function of controlling and coordinating body's physical activities is handled by the nervous and endocrines systems. The nervous system provides the more rapid and precise mode of action. In this unit, you will learn how the nervous system controls muscular contractions in physical activity.

2.0 Intended Learning Outcome(s)

By the end of this unit, you would be able to

a. Describe propagation of nerve impulse in physical activity
b. Explain the control of muscular contraction
c. Discuss the strength of muscular and the causation of fatigue
d. List and describe the receptors in muscles for physical activity

3.0 Main Content

Propagation of Nerve Impulse in Physical Activity

Propagation of nerve follows a sequence of five steps; namely, polarisation, depolarisation, repolarisation, action potential and propagation of action potential.

Polarisation

The normal resting state of a neurone is seen when it is in a polarized state. This state is also described as a resting potential because electrical charges inside the neurone are difference from the charges outside. In the polarized state, outside of the neurone is relatively positively charged while the inside is relatively negatively charged. The insides of the nerve cell membrane is lined by negatively charged ions that attracts to them positively charged Na^+ that lines the outside of the membrane and by K^+ ions on the inside within the cytoplasm. For this reason, outside of the nerve cell is more relatively positive while it is more relatively negative on the inside. There is a tendency for the Na^+ ions outside to diffuse into the cell, but are kept out by sodium pumps. Similarly, K^+ ions inside tend to diffuse outside, but potassium pumps keep them inside. These pumps, sodium and potassium pumps, utilises energy in the form of ATP to keep a high concentration of Na^+ ions outside the neurone and a high concentration of K^+ inside. Therefore, it is these pumps that maintain a nerve cell in the unexcited state called polarization until a nerve impulse arrive to stimulate a change called depolarisation.

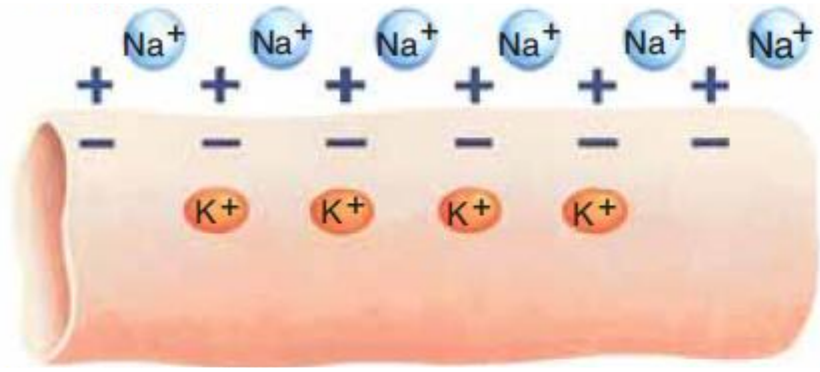

Figure 5.2.1: Nerve Cell in a Polarised State. Source: Scanlon and Sanders (2007, p 145)

Depolarisation

Any stimulus, such as a neurotransmitter, makes the membrane of the nerve cell to become very permeable to Na^+ ions, which will rush into the cell. This action, whereby Na^+ rushes inside the cytoplasm of the nerve cell brings about a reversal of charges on the membrane. This action is called **depolarization** because the outside of the cell membrane is now is now more negatively charged, while the inside is more positively charged.

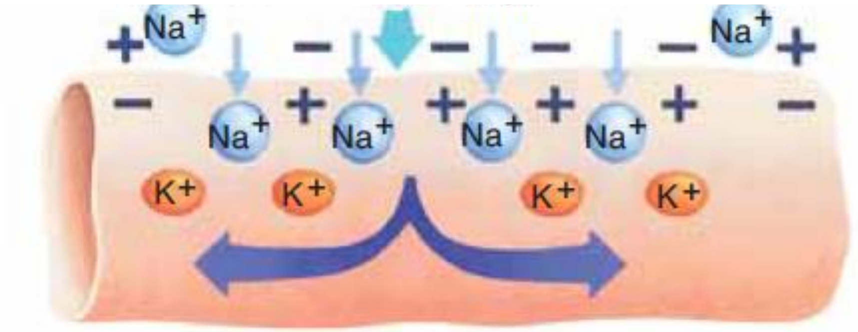

Figure 5.2.2: Nerve Cell in a Depolarised State. Source: Scanlon and Sanders (2007, p 145)

Repolarisation

Depolarization makes the nerve cell membrane to become very permeable to K^+ ions, which rush out of the cell. Outside of the cell is again more positively charged with K^+ ions while the insides are relatively more negatively charged. This action kind of restores the positive charge outside of the nerve cell and the negative charge inside, and is called repolarisation.

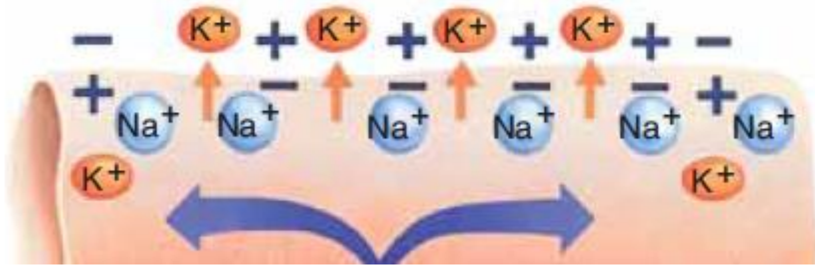

Figure 5.2.3: Nerve Cell in a Repolarised State. Source: Scanlon and Sanders (2007, p 145).

Action Potential

Action potential is the term used to describe the action of restoring polarisation in a nerve cell. During action potential, sodium pumps return Na^+ ions to the outside while potassium pumps return K^+ ions inside, and the neuron is ready to respond to another stimulus and transmit another impulse.

Propagation of Action Potential

This term is used to describe continued depolarisation along the membrane of a neurone to the end of its axon. The sequence of occurrence of depolarization and repolarisation of a portion of the nerve cell membrane makes adjacent parts of the membrane to become permeable to Na^+ ions, followed by subsequent depolarization and repolarisation, which similarly affects the next part of the membrane, and it continues till the end of the axon terminal, where a neurotransmitter is released into the synaptic cleft. Propagation of action potential can therefore be said to be the transmission of nerve impulse along a nerve cell. The propagation of an action potential in response to a stimulus takes place very rapidly and is measured in milliseconds. For this reason, an individual neurone is capable of transmitting hundreds of action potentials (impulses) each second. At synapses, nerve impulse transmission changes from electrical to chemical and depends on the release of neurotransmitters. Although diffusion across synapses is slow, the synapses are so small that this does not significantly affect the velocity of impulses in a living person.

Motor Unit

The motor neuron supplies from about five muscles (as found in the eye) to up to several thousand muscle fibres (as found in the limbs) depending on the type of movement fine or gross. The motor neuron and all the muscle fibres it supplies are collectively called a motor unit. If the stimulus is strong enough to trigger an action potential in the motor neuron, all the muscle fibres in the motor unit will contract. If the stimulus is not strong enough there will be no contraction. The number of muscle fibre depends upon the quality of movement expected of the contracting muscle. Muscles such as the soleus muscle in the leg have several hundred muscle fibres in a motor unit, while fast contact muscles such as those controlling the eye, may have as few as fifteen fibres in each unit. All the muscle fibres in a motor unit are stimulated at the same time and contract as a unit. This is referred to as the "all or none law".

Types of motor units:

Two types of fibres have been identified in man. Slow twitch (ST) motor units also known as type I, red or slow-oxidative (S) fast twitch (FT) motor units also known as type II, white or fast glycolytic (FG). The distribution of these two fibre types varies from muscle to muscle. All muscle groups contain them in certain proportion. The table below lists their characteristics.

Table 5.2.1: Characteristics of Slow Twitch and Fast Twitch Motor Units

Slow Twitch	Fast Twitch
1. Red in colour	Whitish in colour
2. Rich blood supply	Poor blood supply
3. Contains large amount of mitochondria	Contains small amount of mitochondria
4. Has high myoglobin content	Has low myoglobin content
5. Does not fatigue easily	Fatigues easily
6. Slow contracting	Fast contracting
7. Suited for endurance activity	Suited for power activities
8. Contains more fat	Contains little fat

From the table it can be seen that slow twitch motor unit more used for endurance events, while the fast twitch motor unit is built for power events. There are however, some sports that require a blend of the two motor units at different times during the game.

The Strength of Muscular Contraction

The strength of muscular contraction depends on the number of motor units contracting. To develop maximal tension all the motor units in the muscle must be activated. The greater the number of units activated the stronger the contraction. This is referred to as multiple motor unit summation.

The strength of contraction can also be graded by varying frequency of contraction. This is called summation of contraction. When an impulse reaches a motor unit, it contracts. If a second stimulus arrives before the unit relaxes he effect is stronger if the stimuli are repeated at a high frequency, they fuse up to cause a strong contraction.

Muscular Fatigue

The term used to describe the situation where a muscle or muscle groups that are stimulated to contract continuously cease to react to further stimulation, after a time, is muscular fatigue. This condition is referred to as fatigue. Fatigue is believed to be caused by;

1. Hyper activity, which results in accumulation of metabolite, which are toxic.
2. Respiratory disturbances that interfere with oxygen supply
3. Circulatory disturbances, which affects the delivery of substrates and oxygen to the working muscles
4. Depletion of glycogen and ATP

Control of Voluntary and Involuntary Physical Activity

Voluntary control

The cerebral cortex is the centre for voluntary movement. The regions of the cerebral cortex that are responsible for voluntary movement are the sensory cortex, the motor cortex, and the pre-motor cortex. The sensory cortex receives stimulus from sensory receptors, integrates the incoming stimuli and then directs appropriate responses. The motor cortex is concerned with small discrete movements initiating contraction of specific and individual muscles such as those of the thumb, forefinger, toes etc. the pre-motor area coordinates and controls complicated movement pattern involving groups of muscles. The cerebellum is the part of the brain below the cerebral cortex. It plays a role in voluntary movement. Its main function is to coordinate muscle movement. It also helps to maintain muscular tone.

Involuntary Control

The brain receives information regarding the degree of contraction or relaxation of skeletal muscles through impulses from sensory receptors located in muscles, tendons and joints. Those sensory receptors are called proprioceptors; muscle spindles, golgi tendon organ and joint receptors.

Muscle spindles

These receptors are embedded in muscles. They are sensitive to stretch and they send information to the CNS concerning the degree of stretch of the muscles. This provides information as to the exact number of motor units that would be necessary to contract in order to overcome a given resistance. The greater the stretch, the greater the number of motor units required.

Tendon organs

These receptors are found in tendons and are also sensitive to stretch. They are responsible for detecting differences in muscle tension. They can respond to both passive stretching and active contraction. When stimulated by excessive stretch or tension they conduct impulses to bring about a reflex inhibition of the muscle they supply. They thus function to protect the muscle and tendon from damage caused by excessive tension and stretch.

Joint receptors

These are found in joints tendons and muscles and consequently are pressed when muscles contract. They are thus activated by deformation or deep pressure. They are concerned with detection of passive movement and position of a body segment in space.

4.0 Conclusion

You learned, in this unit, the mechanism utilised by the nervous system in coordinating various types of physical activities via nerve impulse transmission. You are now ready to continue your in-depth study of human movement by learning how energy is sourced for bringing about human movement.

4.0 Summary

The nervous systems functions to integrate incoming stimuli and direct appropriate actions. The nervous system accomplishes these tasks by utilising the information transmitted and relayed by nerves is in the form of electrical energy and referred to as nerve impulse. A motor neuron supplies from about five to up to several thousand muscle fibres depending on the type of movement required. If the impulse transmitted is strong enough to trigger an action potential, all fibres will contract and if not, there will be no movement.

Self Assessment Exercise

1. List and describe the sequence of five steps in the propagation of nerve impulse in physical activity.
2. Describe the mechanism used by the nervous system in the control of muscular contraction for voluntary and involuntary movement.
3. How is the strength of muscular contraction related to fatigue in a skeletal muscle?

6.0 Reference/Further Reading

Amusa, L. O. and Abass, A. O. (2002). *Physiology Applied to Physical Conditioning.* Centre for External Studies, University of Ibadan.

OpenStax College, *Anatomy & Physiology*. OpenStax College. 25 April 2013. *http://cnx.org/content/col11496/latest/*
Robergs, R. A. and Kateyian, S. J. (2003). *Fundamentals of exercise physiology for fitness, performance and health. (2nd ed)* New York. McGraw Hill.
Scanlon, V. C. and Sanders, T. (2007): *Essentials of Anatomy and Physiology*. Philadelphia: F. A. Davis Company

Unit 3 Metabolic Processes in the Sourcing of Energy for Physical Activity

1.0 Introduction

Muscular contraction that leads to the production of physical activity must necessarily involve the supply of energy for powering the process. The metabolic processes of sourcing energy for powering muscular contractions that makes it possible for movement brought about by skeletal muscles (physical activities) is the focus of this unit.

2.0 Intended Learning Outcome(s)

By the end of this unit, you would be able to

a. Explain the biological energy systems and biological energy transformation.
b. Discuss carbohydrates, proteins and fats/oils as the fuels for powering muscular contraction
c. Discuss ATP as the energy currency for muscular contraction.
d. List and describe the various ways sourcing energy for muscular contractions in physical activity

3.0 Main Content

Biological Energy Systems and Biological Energy Transformation

Energy is defined as the capacity to do work. There are six forms of energy, namely; chemical, mechanical, heat, light, electrical and nuclear energies. Each of these sources can be transformed from one to another. Of these forms of energy, we are particularly interested in two namely: mechanical and chemical. In physical activities, chemical energy is transformed into mechanical energy for the purpose of accomplishing mechanical work such as physical exercise. All energy originates from the sun. This reaches the earth as sunlight or light energy. Green plants utilize this light energy in the process known as photosynthesis to build food. Man eats this food (chemical energy) for the purpose of doing mechanical work by a process known as respiration.

Bioenergetics is the term used for describing study of the transformation of energy in living organisms. The purpose of bioenergetics in anatomy, physiology and sports is to describe how the human organism acquire and transform energy for the purpose of doing muscular work in physical activity. It is therefore essential to study the metabolic pathways in bioenergetics. Metabolic pathways in bioenergetics involves the breaking and making of chemical bonds as processes that leads to exchange and transformation of energy. Energy is released for work (such as physical activities in sports and dance) when weak bonds are broken and stronger bonds are made. It is during cellular respiration that chemical bonds in energy foods are broken to release energy for physical activities.

Fuels for human physical activity: Carbohydrates, Fats and Proteins

Carbohydrates, fats, and proteins are the major fuels that are metabolized through cellular respiration for the release of energy for physical activities. These are large molecules with weak chemical bonds gets broken down into smaller molecules with relatively stronger chemical bonds, as found in sugars, fatty acids, and amino acids. These smaller molecules are fed into the cellular respiration process, where chemical energy is generated. This chemical energy released during cellular respiration is not used directly for cellular operations.

Adenosine Triphosphate (ATP) – the Energy Currency for Muscular Contraction

The energy liberated during the breakdown of food is not directly used to perform work. Instead, it is used to synthesize and re-synthesize the high energy phosphate called adenosine triphosphate (ATP). It is only the breakdown of ATP that releases energy that is usable in cellular operations such as that used for muscular contractions during physical activities. Adenosine triphosphate or simply ATP, therefore, is the only immediate useable form of chemical energy for muscular contraction. ATP is made up of one complex compound called adenosine and three other parts called phosphate groups. The phosphate groups have high energy bonds between them. When these bonds are broken energy is released, thus enabling work to be performed. The bonds are broken one at a time. It is estimated that about 7 to 12 kilocalories of energy are released with the breaking of the terminal phosphate blond.

$$ATP \longrightarrow ADP + Pi + energy$$

The Energy Systems for Sourcing of ATP

Energy sources for muscular work can be classified into broad headings: anaerobic (without utilizing oxygen) and aerobic (utilizing oxygen). The anaerobic sources include (a) the ATP-PC system and (b) the lactic acid system. The aerobic source is also known as oxidative phosphorylation.

Anaerobic Sourcing of ATP

The anaerobic sourcing of ATP involves the ATP-PC system and the lactic acid system. As stated earlier ATP is the immediate useable form of energy. The ATP stores in the body are limited and soon run out. For work to continue ATP must be re-synthesized.

ATP-PC (phosphagen) System

In this system the energy needed to re-synthesize ATP comes from the breakdown of phosphocreatine (PC). PC is an energy compound, which like ATP is stored in the body. Its breakdown yields a large amount of energy: PC + Pi + energy. The PC in the body is also limited. The storage of ATP and PC is about 570 and 690mM. This would probably be exhausted in ten seconds.

The phosphagen system is very important: (a) particularly for events of short duration (sprints, jumps, throws, spikes in volleyball, fast breaks in ball games). (b) it requires a short series of reaction. (c) it is anaerobic in nature (i.e. it does not require the use of oxygen). (d) the system is fast because the phosphagens are stored in the contractile apparatus.

Lactic Acid System

This is referred to often as anaerobic glycolysis. This involves the incomplete breakdown of carbohydrate (glucose and glycogen) to lactic acid. The accumulation of lactic acids leads to muscular fatigue.

Glucose of glycogen ⟶ to pyruvic acid ⟶ lactic + energy acid

The breakdown of glucose or glycogen requires about 12 separate but sequential chemical reactions to complete.

During anaerobic glycolysis only a few moles of ATP is manufactured 3 and 2 respectively from glycogen and glucose. ATP production through anaerobic glycolysis cannot be sustained for a long time due to accumulation of lactic acid, which causes fatigue. If exercise is to be continued therefore, the severity of the exercise must either be reduced or a more dependable source of ATP production via the aerobic pathway be found. Nevertheless, anaerobic glycolysis provides ATP fast and does not require oxygen.

Aerobic Sourcing of ATP

In this system carbohydrate, protein and fat can be used to manufacture ATP in the presence of oxygen. 1 mole of glycogen can be completely broken down when oxygen is available to carbon dioxide and water releasing 38 to 39 moles of ATP. This system involves three different series of chemical reactions (a) aerobic glycolysis (b) Kreb's cycle (c) electron transport.

In aerobic glycolysis when oxygen is supplied in sufficient quantity pyruvic acid is not converted to lactic acid. Instead it passes from the sarcoplasm into the mitochondria where a series of chemical reactions in the Krebs cycle removes hydrogen ions and electrons from the pyruvic acid and forms carbon dioxide.

In the electron transport involving another series of chemical reactions, the electrons removed are transported to oxygen and water is formed. During these reactions moles of ATP are manufactured. In aerobic metabolism, lactic acid is not accumulated to any degree. This system therefore, is useful for exercise of long duration and moderate intensity.

Aerobic ATP Production from Fat

Body fat is an excellent source of energy production at rest and during exercise. In long distance events, fats tend to be used since the exercise is of moderate intensity while carbohydrate is spared. The process whereby energy is stored in fat is gradually released for muscular work is known as beta-oxidation. Most of the ATP productions from fat metabolism are derived from stored triglycerides. These are transported by the blood to the muscles where they are broken down for energy. More moles of ATP are produced when fat is metabolised. However, less oxygen is used to breakdown carbohydrate. In this respect, it is more efficient to use carbohydrate than fat for ATP production.

Aerobic ATP production from protein

Protein is not used to any great extent to manufacture ATP during exercise except during starvation. Under normal circumstances, protein is used for building new tissues and for repair and will therefore not be considered as an energy nutrient.

Aerobic and anaerobic systems during rest and exercise

At rest about two thirds of fuel for energy is supplied by fat while the remaining one third is supplied by carbohydrates. This is done aerobically since there is a very low level of lactic acid in the system at rest.

During exercise both anaerobic and aerobic systems contribute to ATP production. Which system predominates depend on the type and intensity of the exercise. In exercise of high intensity and short duration the major energy fuel is carbohydrate. Fat play a very minor role. The energy is supplied anaerobically via the ATP-PC and the lactic acid system. The aerobic pathway is not fully mobilized. It takes 2-3 minutes for the aerobic system to be fully mobilized.

During exercises of long duration and moderate intensity carbohydrates and fats provide the energy for ATP production aerobically. At the beginning of such exercise, the major food source of ATP production is carbohydrate. Once the oxygen system is fully mobilized fat assumes a dominant role.

Interaction of energy sources during exercise

Contribution of energy for exercise is usually based on the mode or type of exercise and the intensity of the particular exercise. If the activity is of very short duration 0-30 seconds and of high intensity the predominant energy system is the ATP-PC system. As this exercise continues in duration 30-90 seconds the energy shifts to the lactic acid system and as it continues beyond 2 minutes, the intensity becomes moderate and the aerobic system takes over. All energy systems participate in production of ATP during exercise, the predominant system at any point in time is determined by the intensity and duration of the exercise.

4.0 Conclusion

It is the breakdown of the energy rich compound, ATP, which makes energy availablr for the contraction of muscles. ATP, figuratively described as the currency for purchasing contraction of muscles, can be sourced from aerobic, anaerobic and mixed sources during different types of physical activities.

5.0 Summary Energy is the ability to do work. There are six forms of energy each of which can be transformed from one to another. All energies originate from the sun and reach the earth as light energy. Green plants utilize light energy to build food. Man eats this food and utilizes its energy (chemical energy) to do mechanical work. Energy for muscular work can be aerobic or anaerobic. Anaerobic sources include ATP-PC and the lactic acid systems, and aerobic source is the oxidative phosphorylation.

Self Assessment Exercise

1. Why is ATP regarded as the energy currency for muscular contraction
2. How is ATP made available during exercise?
3. Use bioenergetics to explain how energy is released for physical activities in the energy cycle

6.0 Reference/Further Reading

OpenStax College, *Anatomy & Physiology*. OpenStax College. 25 April 2013. *http://cnx.org/content/col11496/latest/*

Scanlon, V. C. and Sanders, T. (2007): *Essentials of Anatomy and Physiology*. Philadelphia: F. A. Davis Company

Robergs, R. A. and Kateyian, S. J. (2003). *Fundamentals of exercise physiology for fitness, performance and health. (2nd ed)* New York. McGraw Hill.

Amusa, L. O. and Abass, A. O. (2002). *Physiology Applied to Physical Conditioning.* Centre for External Studies, University of Ibadan.