INTRODUCTION

Anatomy is a science that deals with the structures of the body and the relationship of various parts to each other. A knowledge of these structures is necessary to understand their functions.
Anatomy is derived from Greek words: ana means 'up' and tomy means 'cutting', and hence anatomy deals with study of structural components of body i.e. organs by means of surgical dissection.

SUBDIVISIONS OF ANATOMY

a) Gross Anatomy: Study of body parts visible to naked eye
b) Microscopic Anatomy: Anatomical study by means of modern microscopes including study of cells (Cytology) and tissues (Histology)
c) Developmental Anatomy: Study of human growth and development
d) Pathological Anatomy: Study of diseased body structure
e) Systemic Anatomy: Study of body by system (System is a group of organs that have common function e.g. bones in skeleton system and muscles in muscular system).

The subject matter of Anatomy includes:

1. Cytology:	study of cells
2. Histology:	study of tissues
3. Osteology:	study of bones
4. Myology:	study of muscles
5. Arthrology:	study of joints
6. Splanchnology:	study of organs
7. Neurology:	study of the nervous system

Descriptive terms used in Anatomy: The arrangement of various parts of the body may be :

i) Symmetric e.g. limbs, eyes, ears and lungs. Their arrangement on the right side and left side are similar.
ii) Assymmetric e.g. spleen and liver. The spleen lies entirely in the left side. Liver lies mostly on the right side.

The study of the human body is done in anatomical position. In this position, the body is erect, the head facing forwards, arms by the sides and palms of hand facing forward.

The following are a few important terms which are used to describe the human body :

1.	Median line (mid sagittal plane):	The central plane which divides the body into two halves i.e. right and left.
2.	Medial:	Nearer to the median line
3.	Lateral:	Away from the median line
4.	Superior:	Nearer to the head
5.	Inferior :	Nearer to the foot
6.	Anterior :	Nearer to the front surface of the body
7.	Posterior:	Nearer to the back surface of the body
8.	Proximal:	Nearer to the origin of the structure
9.	Distal:	Away from the origin of the structure
10.	Superficial:	Nearer to the skin surface
11.	Deep:	Deeper from the skin surface
12.	Plantar:	Belonging to the sole of the foot
13.	Palmer:	Belonging to the palm of the hand
14.	Transverse:	Separates superior from inferior
15.	Coronal (frontal):	Separates anterior from posterior

16. Bony sinus: A hollow cavity within a bone
17. Condoyle: A smooth rounded projection of bone that forms part of joint
18. Foramen: A hollow in structure
19. Septum: A partition separating two cavities
20. Tubercle/ trochanter: A roughened bony projection, usually for attachment of muscles or ligaments.
21. Meatus: A tube shaped cavity within a bone.
22. Styloid process: A sharp downward projection of bone that gives attachment to muscles and ligaments.
23. Fossa: A hollow or depression
24. Facet: A small, flat articulating surface
25. Fissure: A narrow slit

Movement at joints: The following are a few descriptive terms used to convey the movements which occur at various joints:

1. Flexion: A movement where similar surfaces come nearer to each other. This reduces the angle between two bones e.g. bending the forearm at the elbow.
2. Extension: Movement where similar surfaces go apart. The angle between two bones is decreased. It is the opposite of flexion e.g. straightening of the bent forearm.
3. Adduction: A movement which brings the limb towards mid line.
4. Abduction: It is the opposite of adduction where the limb is drawn away from the mid line.
5. Rotation: A movement around a central axis involving 360°.
6. Medial rotation: A rotation towards medial direction.
7. Lateral rotation: A rotation towards lateral direction.
8. Circumduction: A movement involving flexion, abduction, extension and adduction which occur in a sequence. This movement occurs in shoulder, hip etc.

The study of anatomy is divided into 2 major fields:

1. **Gross anatomy** is the study of large visible structures
2. **Microscopic anatomy** is the study of structures that are too small to see, such as cells and molecules.

Gross anatomy (study of large visible structures), also called macroscopic anatomy, is separated into 5 major divisions:

- **Surface anatomy** describes surface forms and marks.
- **Regional anatomy** describes the organization of specific areas of the body such as the head or hand. This approach is used mostly in professional schools: medical, dental, physical therapy.
- **Systemic anatomy** describes groups of organs that function together for a single purpose.
- **Developmental anatomy** describes the structural changes in an organism from fertilized egg to maturity. Embryology is the anatomical study of early development.
- **Clinical anatomy** describes various medical specialties, including medical anatomy (changes that occur during illness), and radiographic anatomy.

Microscopic anatomy is divided into two major divisions:

- **Cytology,** the study of cells and their structures.
- **Histology,** the study of tissues and their structures.

Levels of Organization

- Our bodies are organized at many different levels.
  - The levels of organization of living things, from smallest to largest, are:
    1. **Atoms,** the smallest functional units of matter.

2. **Molecules,** active chemicals.
3. **Organelles**, specialized structures within a cell.
4. **Cells,** the smallest living units.
5. **Tissues,** a group of similar cells that work together.
6. **Organs,** two or more tissue types working together.
7. **Organ systems,** two or more organs working together.
8. **Organism,** a single individual, including all of the above.

Physiology: It is the science of life which deals with normal functions of the body. It explains how various systems in the body function together normally as a single unit.

- Physiology derived from Greek words physis means 'nature' and logos means 'science or study', and hence physiology helps to understand how body works i.e. functioning of body.
- Physiology has many specialties. The 4 basic divisions are:

1. **Cell physiology**, including chemical and molecular processes within and between cells.
2. **Special physiology**, the study of specific organs such as the heart.
3. **Systemic physiology,** the cooperative functions of all the organs in an organ system.
4. **Pathological physiology**, the effects of diseases on organs and organ systems.

- The human body is divided into 11 interconnected organ systems. All organ systems work together, and many organs function in more than 1 organ system.

The subject matter of Physiology includes the study of various systems like:

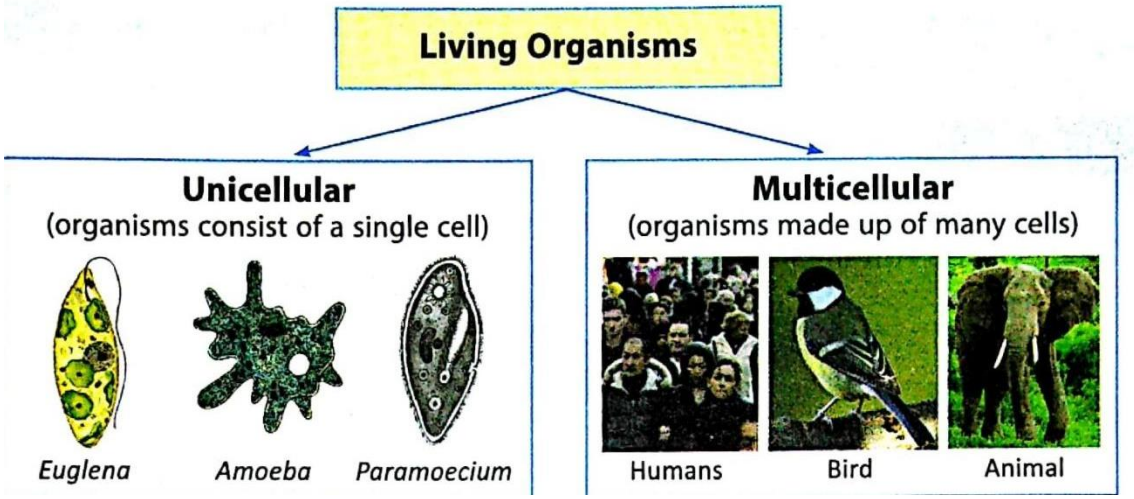
1. **The Integumentary System:** includes the skin & derived structures, it protects internal organs & helps maintain body temperature.
2. **The Skeletal System:** includes the bones & joints, it provides support & protection to internal organs.
3. **The Muscular System:** includes skeletal muscle and it provides movement.
4. **The Nervous System:** includes the brain, spinal cord, and nerves. It provides regulation of body functions & sensory perception.
5. **The Endocrine System:** includes hormone-producing cells & glands. It regulates homeostasis, growth & development.
6. **The Cardiovascular System:** includes blood, heart, & blood vessels. It is responsible for delivery of oxygen & nutrients to the tissues.
7. **The Lymphatics & Immune System:** includes lymphatic vessels & fluid. It is involved in the defense against infection.
8. **The Respiratory System:** includes lungs & airways. It is involved in the absorption of oxygen & release of carbon dioxide.
9. **The Digestive System:** includes organs of the gastrointestinal tract. It is responsible for the absorption of nutrients.
10. **The Urinary System:** includes the kidneys, ureters, and bladder. It is responsible for electrolyte balance & waste removal.
11. **The Reproductive System:** includes the reproductive organs in males and females. It controls the biological process by which new individuals are produced.

THE CELL

- Cells are the basic 'structural unit' of all living beings.
- Cell is defined as the fundamental, structural and functional unit of all living organisms.
- Robert Hooke (1665) – an English scientist who observed honeycomb like dead cells in thin slices of cork and coined the term CELL (in Latin, *'cell'* means 'a little room')..
- Anton Von Leeuwenhoek first described a living cell (1667).
- Robert Brown discovered nucleus (1833).
- The cells have the same basic structure, but they are different, with respect to their number,shape and size, in different living organisms.

- **Cell Number**

An *Amoeba* and an earthworm are of different sizes. This difference, in the size of the organism, is due to the number of cells present in them. While *Amoeba* is a living organism consisting of a single cell, an earthworm has millions of cells. Hence, on the basis of their 'number of cells, living organisms can be classified into two categories: unicellular and multicellular.

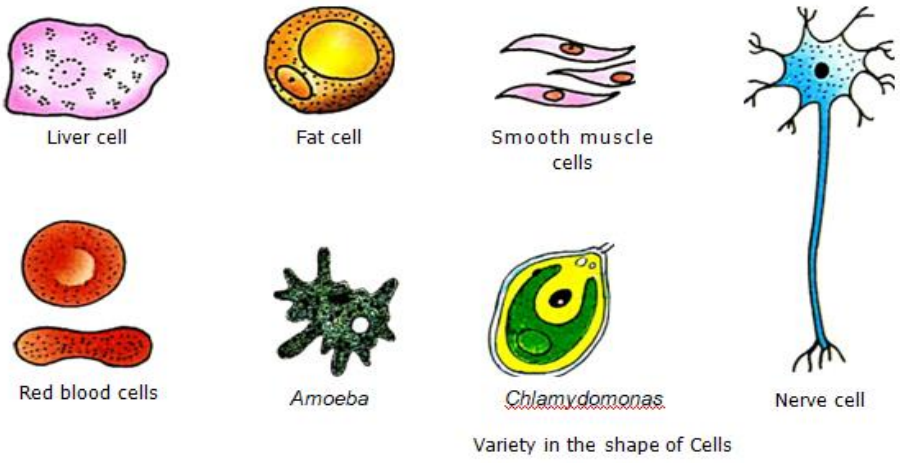


- **Cell Shape**

The shapes of cells differ not only in different organisms but also in different organs of the same organism. They may be oval, spherical, cuboidal, fibre-like or polygonal. These differences in shapes are due to their location and function in the tissue. For eg, a nerve cell has to transmit nerve impulses to organs located in different parts of the body. Hence, they possess a long fibre-like structure.

- **Cell Size**

Cells vary considerably in their size. The smallest cell PPLO (Pleuro pneumonia-like organism), also called mycoplasma, is about 0.1 micron The ostrich egg, considered to be the largest cell, is (nearly) 170 mm in diameter. The hen's egg also represents a single cell; it is big enough to be seen with the unaided eye.



Variety in the shape of Cells

CELL THEORY

Mathias J Schleiden (1838) ; a German botanist and Theodore Schwann (1839) ; a British Zoologist proposed cell theory. The theory states:

- All living organisms are composed of cells and product of cells.
- All cells arise from pre existing cells through the process of cell division.
- The body of living organisms is made up of one or more cells.

PARTS OF A CELL

A cell consists of living protoplasm surrounded by a cell membrane. The protoplasm consists of the cytoplasm and the nucleus.

Cytoplasm contains a number of structures, which are called cell organelles. Organelles are, therefore, structures present within a cell that help it to perform its relevant functions.

- **Cell Membrane**

  All living cells are bound by a membrane called the plasma membrane, or the cell membrane. It surrounds its inner gel-like material called protoplasm. The plasma membrane controls the entry and exit of substances as per the requirements of the cell.

  The cells of plants, fungi and bacteria have an additional outer covering called the cell wall.

  The cell wall is an important covering in plant cells; it provides rigidity and protection to the cell against variations in the environment. It also gives a definite shape, size and support to the cell.

- **Cytoplasm**

  The portion of the protoplasm, lying inner to the cell membrane but outside the nuclear membrane, is called cytoplasm *[kytos* (hollow), *plasma* (liquid)]. It acts as a 'ground substance' for all cell activities. It is made up of carbohydrates, proteins, fats, minerals and vitamins, along with a large proportion of water. All these components work together to provide a unique living nature to the protoplasm.

- **Nucleus**

It is the most important part of the cell. It generally lies in the centre of the cell, however, in some cases, it may also occupy peripheral positions. It controls all the activities of the cell.

The nucleus is a dense structure bound by a nuclear membrane. The protoplasm of the nucleus is called nucleoplasm. It has a thread-like network called chromatin. Cell is ready to divide, this chromatin condenses to form thicker, thread-like structures, called chromosomes. These chromosomes are the structures responsible for the characters (genes) inherited by one generation from the earlier generations. The number of chromosomes in a cell differs.

Many small living structures are present in the cell. These are equivalent to the organs of the body. Hence, they are named as 'cell organelles'. The main cell organelles are:

- **Plastids :**

  These are large cell organelles, characteristic of plant cells. These may contain pigments that provide colour to the cell. The green-coloured plastids are called chloroplasts. They manufacture food for green plants by the process of photosynthesis. The plastids, associated with the different coloured parts of the plants (like fruits, vegetables and flowers) are called chromoplasts. They are responsible for imparting colour (other than green) to the different parts of the plant. Plants also contain some colourless plastids called leucoplasts; these provide space to store starch, proteins, oils, etc.

- **Mitochondria:**

  These are rod-shaped or spherical structures. They are present in large numbers in cells engaged in different physiological activities. They are responsible for cellular respiration and for generation of energy for different activities of life. Hence, they are also called the powerhouse of the cell.

- **Endoplasmic Reticulum (ER):**

  It is a network of membranes. It provides channels for transport of materials in a cell. ER is of two types:

  Rough ER : This type of ER has a rough appearance as it is studded with ribosomes. It plays a vital role in synthesis of proteins.

  Smooth ER: This type of ER does not have ribosomes attached to it; it, therefore, has a smooth appearance. It helps in the synthesis of fats.

- **Golgi Complex** : They are sac-like structures stacked one above the other. They are involved in the processing and packaging of materials produced by the cell.
- **Vacuole:** It appears as an empty space in the cytoplasm. It is generally large in plant cells. It stores excess of water and waste products. In *Amoeba,* food materials are held in its food vacuoles for digestion.
- **Ribosomes:** These are tiny granules present in the cytoplasm and on the rough ER. They help in protein synthesis.
- **Cilia and flagella**: Some cells have these small extensions on their cell membrane. They help in locomotion and collection of food. Unicellular organisms, like *Paramecium,* have numerous cilia while *Euglena* has a single flagellum.

All these cell organelles work together to perform different functions of the cell.

CONNECTIVE TISSUE

Connective tissues serve to connect or bind together different organs or different parts of an organ.
They contain an intercellular substance called matrix.
It helps in binding and supporting the cells. Connective tissues are classified as:

1. Areolar tissue (loose connective tissue):

- It is the most widely distributed tissue in the body.
- It is a loose irregular connective tissue.
- It connects the skin to the underlying structures.
- Also it fills un-occupied spaces between organs.
- It is found between muscles, blood vessels and nerves.

2. Dense fibrous tissue:

- This tissue has compactly arranged fibres with greatly reduced interspace.
- The cells are less in number than areolar tissue.
- This type of tissue is present in dermis of skin.

3. Elastic tissue:

- This tissue is yellow in colour and contains more number of elastic fibres.
- It is present in tissues where strength is required with elasticity e.g. trachea and bronchi.

4. Adipose tissue (Fatty tissue):

- It contains large, rounded cells and cytoplasm is loaded with fat.
- The nucleus of the cells is pushed towards the periphery e.g. subcutaneous tissue of skin.

5. Cartilage:

- It has a tough, gelatinous and elastic matrix formed of chondrin.
- The cells are more or less round and lie in groups of four embedded in the matrix.

Cartilage is of three types:
a) Hyaline cartilage: Here, the matrix is free from fibres and is transparent. Also, the cells are arranged in small groups. e.g. trachea and tip of nose
b) Fibro cartilage: Here, the ground substance contains thick bundles of collagen fibres. It is found in the intervertebral discs.
c) Elastic cartilage : It is almost similar to hyaline cartilage. But it contains a network of branching and rejoining collagenous fibres (which give a yellow colour to the matrix) e.g. epiglottis and laryngeal cartilage.

6. Bone :

It is the hardest connective tissue. Bones contain a high concentration of salts like calcium phosphate and calcium carbonate. A bone generally consists of:

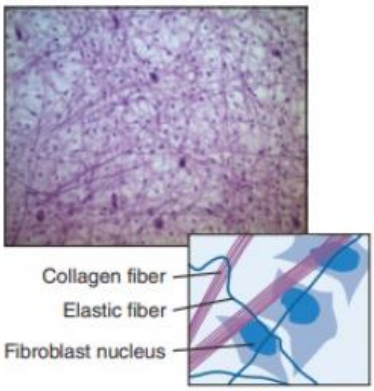
- Periosteum: It is a membrane of fibrous tissue covering the surface of a bone.
- Compact bone : It is a hard dense substance found below the periosteum
- Cancellous or spongy bone: It is a spongy, porous tissue. It forms the interior of mature bone.
- Bone marrow : It is a soft material which fills the hollow interior of a mature bone.
  It is of two types: a) Yellow bone marrow which is a fatty tissue.
  b) Red bone marrow from which the cells of blood are developed.

Microscopic structure of bone:

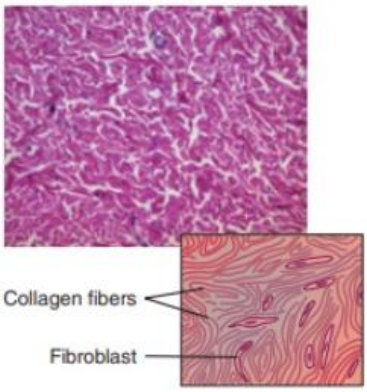
Cross section of a bone under the microscope shows the following structures:
1. A central Haversian canal which contains nerves, blood vessels and lymphatics.
2. Lamellae which are layers of bone deposited in concentric circles around the Haversian canal.
3. Lacunae which are the spaces between the lamellae.
4. Canaliculi which are the minute canals. They join the lamellae and also communicate with the central Haversian canal.

All these structures together form a unit. This unit is called as the Haversian system.

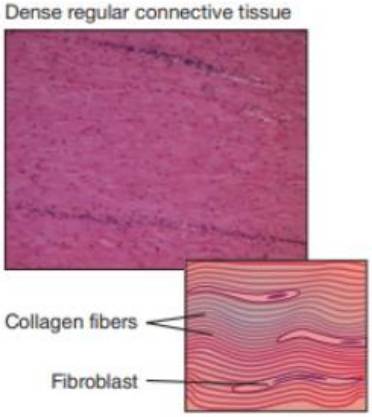
Loose connective tissue



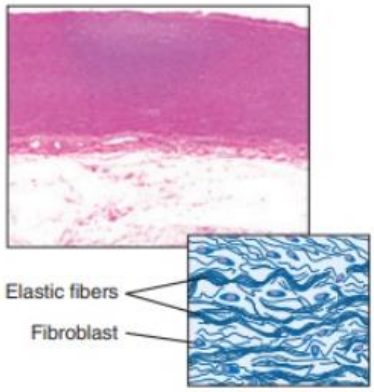
Dense irregular connective tissue



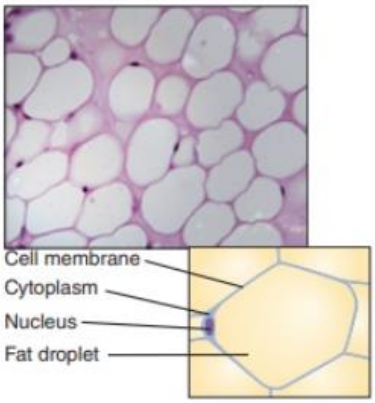
Dense regular connective tissue



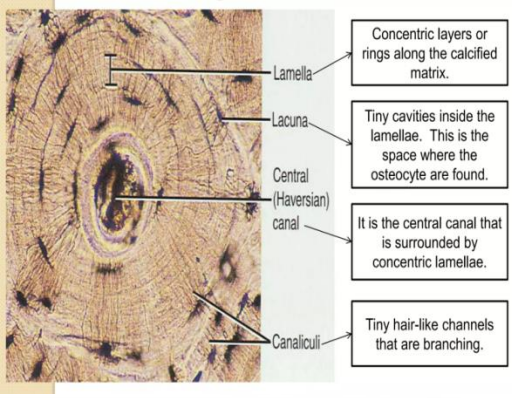
Elastic connective tissue



Adipose tissue



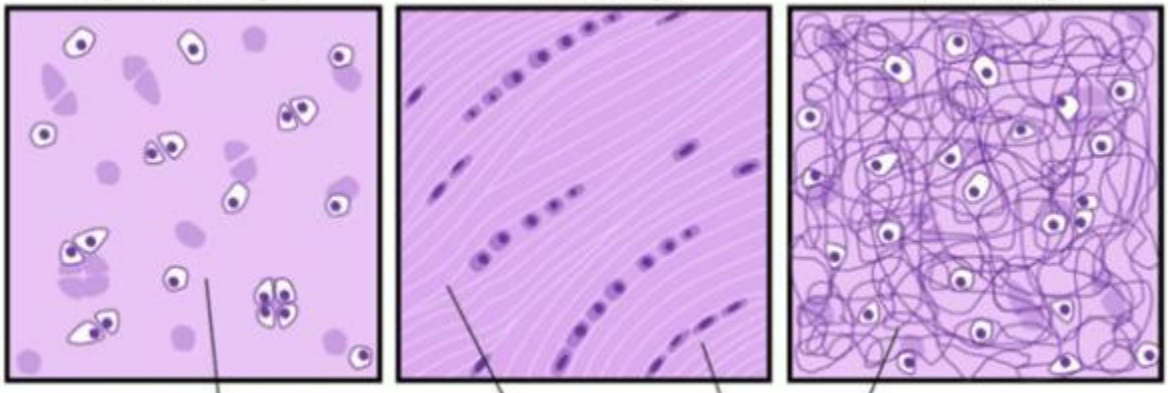
Compact Bone



Hyaline cartilage

Fibrocartilage

Elastic cartilage



MUSCULAR TISSUE

Muscle is a tissue which has the power of contraction. Contraction of muscles produces movements. All muscles contain bundles of fibres which run in the same direction.

Muscles are classified into three types. They are

1) Voluntary muscle 2) Involuntary muscle 3) Cardiac Muscle

1) Voluntary muscle (Striated or skeletal muscle):-

- It is under the control of will.
- It forms the flesh of limbs and trunk.
- It contains unbranched fibres called myofibrils.
- These fibres are cylindrical in shape containing: a) distinct striations b) a number of nuclei.
- Each fibre is surrounded by a thin membrane called sarcolemma.

2. Involuntary muscle (non-striated, plain or smooth muscle):

- It is not controlled by will.
- It is present in internal organs like stomach, intestine and uterus.
- It contains long, spindle shaped fibres with central nucleus.
- The fibres are not striated and are not covered by any membrane.
- But they are joined together by a loose connective tissue.
- These muscles are controlled by autonomic nervous system.

3. Cardiac muscle:

- It is found only in the heart.
- It consists of short, cylindrical and branched fibres.
- The nucleus is centrally placed.
- The striations are vague.
- The cardiac muscle is not controlled by will.
- But it contracts automatically in a rhythmic manner.

NERVOUS TISSUE

Nervous tissue is composed of three kinds of matter.

1. Gray matter which forms the nerve cells.
2. White matter which forms the nerve fibres.
3. Neuroglia which is a supporting tissue. It holds together and supports nerve cells and fibres.

Neurone: It is the unit with which the nervous system is composed of. It consists of 1. nerve cell. 2. axon 3. dendrite.

1. Nerve cell: Each nerve cell has a nucleus and a highly specialised protoplasm. The body of the nerve cell gives rise to nerve fibres.

2. Axon : It is the main fibre which arises from the body of each nerve cell. Impulses pass through the axon in one direction only.

3. Dendrites: These are short fibres arising from the body of the nerve cell. They conduct impulses towards the cell body. Synapse is the junction between axon of one neurone and dendrite of another.

Myelin sheath: It is the sheath which covers and protects the axon of some nerves. Nerves which contain this sheath are called as medullated nerves. Nerves which not contain this sheath are called as non medullated nerves.

The medullated nerves contain nuclei. The nucleus lies in between the myelin sheath and outer covering called neurilemma. Node of Ranveir is the interruption found in the myelin sheath at regular intervals.