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The Art of Care

# Relationship between Tissues of the Body with Tibb

## Interpreting relationship between tissues of The body from the Tibb perspective

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January 2016

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### General Overview

The relationship between tissues of the body with Tibb describes the four main tissues of the body, namely, epithelial, muscular, connective and nervous tissues. Tibb believes that there is a connection between the interaction of the liver, heart and the brain, and its qualities of heat, dryness and moistness respectively. The structure and functioning of the tissues work harmoniously with the organs when the ideal qualitative state is in sync with the temperament of the individual.

**Epithelial Tissue** plays a significant role in the body, by either covering a surface or lining a body cavity, and offers protection, secretion, absorption, filtration, excretion, sensation and separating organs from one another.

Epithelium is described as either simple epithelia, which consists of a single cell layer, or stratified epithelia, which are composed of two or more cell layers stacked on top of each other. Epithelia is also described in terms of its shape and height, either as squamous cells, which are flat and scale-like; cuboidal cells, which are box-like, having the same height and width; and columnar cells, which are tall and shaped like a column.

**Muscular tissue** is composed of cells that have the special ability to shorten or contract in order to produce movement of the body parts. Muscle tissue can be categorised into skeletal muscle tissue, which are under voluntary control and are responsible for movement and contraction of skeletal parts of the body; smooth muscle tissue is under involuntary control and is responsible for sustained contractions in the vascular system, gastrointestinal tract, and other areas of the body; and cardiac muscle tissue which is under involuntary control and is responsible for pumping blood throughout the body.

**Connective tissue** is a broad term for supportive tissues that provide the body's framework. Connective tissue forms a platform upon which epithelial tissue rests, and within which nerve and muscle tissue are embedded. Blood vessels and nerves travel through connective tissue. It not only functions as a mechanical support for other tissues, it is also an avenue for

communication and transport among other tissues. Most significantly, connective tissue is involved in immunological defence.

**Nervous tissue** is the main component of the two parts of the nervous system, namely the brain and spinal cord of the central nervous system, and the branching peripheral nerves of the peripheral nervous system, which regulates and controls functions of the body and its activities. It is composed of neurons, or nerve cells, which receive and transmit impulses, as well as neuroglia, or glial cells, which assist the propagation of the nerve impulse, and provides nutrients to the neurons.

## **Epithelial Tissue**

Epithelial tissues are sheets of cells which covers a body surface or lines a body cavity, such as forming the outer layer of the skin; lining open cavities of the digestive and respiratory systems; and covering the walls of organs of the closed ventral body cavity. Another type of epithelial tissue is glandular epithelium, which surrounds glands within the body, and which produce and secrete specific products. Glands are classified according to their characteristics, namely: endocrine glands, which secrete their product internally; or exocrine glands, which secrete their product externally.

Epithelial cells have many functions, including: forming a protective barrier between the body and the external environment, secretion, absorption, filtration, excretion, sensation and separating organs from one another.

Epithelium is described in two ways, first one which indicates the number of cell layers, and the second one describes the shape of its cell. Based on the number of cell layers, epithelia can either be simple or stratified. Simple epithelia consist of a single cell layer (found where absorption, secretion, and filtration occur); whereas stratified epithelia are composed of two or more cell layers stacked on top of each other (typically found in high abrasion areas where protection is needed).

There are three ways to describe the shape and height of epithelial cells, namely: Squamous cells, which are flat and scale-like; cuboidal cells, which are box-like, having the same height and width; and columnar cells, which are tall and shaped like a column.<sup>6</sup>

In Tibb, the liver is considered to be linked to the endoderm, the middle embryonic layer, and it is the seat of the metabolic faculty. It regulates the endocrine/glandular systems and nutritional use and it controls the epithelial tissue. It has a dominant quality of heat.

### **Functions of Epithelium**

Epithelium is a tissue composed of sheets of cells that are joined together in one or more layers. Epithelial tissue covers the body surface, forms glands, and forms the lining for most of the internal cavities. Its functions include: Protection, secretion, absorption, filtration, excretion and sensation.

The skin, for example, protects the body from dirt, dust, bacteria and other harmful microbes. It has a hot and dry to hot and moist temperament, with a dominant quality of heat.

## **Composition of Epithelial Tissue**

Epithelial tissues are widespread throughout the body. They form the covering of all body surfaces, line body cavities and hollow organs, and are the major tissue in glands. They perform a variety of functions that include protection, secretion, absorption, excretion, filtration diffusion, and sensory reception. The cells in epithelial tissue are tightly packed together with very little intercellular matrix. Because the tissues form coverings and linings, the cells have one free surface that is not in contact with other cells.<sup>1</sup>

Epithelial tissue comprises an uninterrupted layer of cells which covers nearly all external and internal surfaces of the body. All exchange of materials and information (nutrients, gases, wastes, sensation, heat) between the body and the environment must take place across the boundary of epithelial cells, thus serving both as a protective barrier for the body, as well as an active interface with the environment. This boundary extends from the skin through various orifices and including the many invaginations into the internal organs of the respiratory, urinary, digestive, and gastrointestinal tracts.

Epithelial tissue covers and lines epithelium the outer layer of the skin (epidermis), dips into and lines the open cavities of the cardiovascular, digestive, and respiratory systems, and covers the walls of organs of the closed ventral body cavity. Glandular epithelium forms the glands of the body.

Epithelial tissue has an apical surface which is exposed to the outside, and an attached surface, the basal surface, resting on the underlying connective tissue. The base of each cell of a simple epithelium is attached to an underlying basement membrane, while the apical end faces free space. The lateral surfaces are attached to neighbouring epithelial cells.

## **Classification of Epithelium**

Epithelia are classified on the basis of cell shape and number of layers. The function of the body dictates its structure, and parts of the body share a form that is dictated by their function.

### **Shape:**

- Squamous cells are thin and flat.
- Cuboidal cells are cubical to round.
- Columnar cells are elongated, tall and cylindrical.

### **Layers:**

- Simple epithelium is composed of a single cell layers.
- A stratified epithelium is composed of two or more cell layers.

**There are four types of simple epithelial tissue:**

1. Simple squamous.
2. Simple cuboidal.
3. Simple columnar.
4. Pseudostratified columnar.

**There are four types of stratified epithelia tissue:**

1. Stratified squamous.
2. Stratified cuboidal.
3. Stratified columnar.
4. Transitional epithelium.

**Simple squamous epithelium** is a single layer of flat cells.

Location

- Lining of blood vessels (endothelium).
- Lining of body cavities (mesothelium), and external covering around the organs.
- Lining of the heart.
- Alveoli of the lungs.
- Kidney glomeruli – Bowman’s capsule and loop of Henle of the kidney.

Functions:

- Filtration.
- Secretion - reducing friction by secreting a lubricating substance in serosae.

**Simple Cuboidal epithelium** has a single layer of cubical cells.

Location:

- Lining of kidney tubules.
- Small ducts of the exocrine glands.
- Secretory portions of small glands.
- Surface of the ovary.

Functions:

- Secretion.
- Absorption.

**Simple columnar epithelium** has a single layer of columnar cells.

Location:

It is classified in two types:

- ***Non-ciliated type***: lines most of the digestive tract (stomach to anal canal), gallbladder, and excretory ducts of some glands.
- ***Ciliated type***: lines small bronchi, fallopian tubes, and some regions of the uterus.

Functions:

- Absorption.
- Secretion (mucous, enzymes, and other substances).

### **Stratified squamous epithelium** (skin)

#### Location

- Lining of the oral cavity (mouth, throat, and epiglottis), oesophagus, cornea, cervix, vulva, vagina, glans penis, and anus.

#### Functions:

- Protection against abrasion, pathogens, and chemical attack.

### **Stratified Cuboidal epithelium**

#### Location:

- Largest ducts of sweat glands, mammary glands, and salivary glands.

#### Function:

- Protection.
- Secretion.
- Absorption.

### **Stratified columnar epithelium**

#### Location:

- Lining of large ducts, and small areas of the pharynx, epiglottis, anus, mammary glands, salivary ducts and urethra.

#### Functions:

- Protection.

### **Pseudostratified Columnar Epithelium**

Pseudostratified columnar epithelium is a simple epithelium that looks stratified because some of its cells are shorter than others and do not reach the free surface.

#### Location:

It is classified in two types:

- ***Non-ciliated type***: Ducts of large glands, vas deferens.
- ***Ciliated type***: lines most of the lining of the upper respiratory tract, including the trachea, bronchi, and nasal cavity.

#### Functions:

- Protection.
- Secretion.
- Movement.

### **Transitional epithelium** (relaxed)

#### Location:

- Lining of hollow urinary organs, such as the urinary bladder, renal pelvis (urine collects in the renal pelvis and is funnelled into the ureter), urethra and ureters.

## Functions:

- Elasticity - allows for expansion and recoil after stretching.

## **Glandular epithelium**

The function of glandular epithelial cells is directly related to their location. There are two types, namely, the endocrine and exocrine glands.

The major difference between endocrine and exocrine glands is that:

### **Endocrine glands**

Endocrine glands have no ducts, but distribute their product (hormones) via the blood. It is found in the ovary and testes.

Endocrine and nervous systems are the regulators of physiological function.

Endocrine glands have no duct system, releasing their secretions directly into the bloodstream. Endocrine glands are the source of many of the body's chemical messengers (hormones) that act at a distance from their source, such as insulin.

The secretion of hormones by endocrine glands is controlled by metabolic factors (such as blood glucose levels); secretion of other hormones (such as TSH controls secretion of thyroxine); the nervous system (such as the secretion of adrenaline by the adrenal medulla); or a mixture of all of these factors.

Solid organs of the endocrine glands include: thyroid, anterior pituitary, adrenals, and pancreas (islets of Langerhans).<sup>4</sup>

### **Features**

- It is missing ducts and stays as blocks of tissue.
- It secretes chemical substances directly to the blood stream, as it does not have a duct system.
- Responses are slower than exocrine glands, as it travels through the blood stream.
- The hormones produced by endocrine glands circulate through the blood stream and over the body and act on the target.
- It has a relatively large blood supply compared to the exocrine gland.
- It has a less complex structure compared to the exocrine gland.

### **Exocrine gland**

Exocrine glands often secrete their product through ducts to an epithelial surface, such as the skin. They are composed of highly specialised epithelial cells. The ducts may be either unbranched (simple glands), or branched (compound gland). They vary from microscopic, (such as sweat glands of the skin), to large solid organs (such as the liver). Secretory component may be tubular or acinar (roughly spherical). They secrete sweat or oil (sebum), mucus, saliva, earwax, milk, and digestive enzymes. It is found attached to hair follicles, intestines, and mammary glands.

**Solid organs** of the exocrine glands include: major salivary glands, sweat glands, liver, and pancreas (acinar tissue).<sup>4</sup>

### **Features**

- It has ducts.
- It secretes its product via a duct onto an epithelial surface. Merocrine, Holocrine, and Apocrine glands are three different ways of secreting products of exocrine glands into ducts.
- Responses are quicker than endocrine glands, as it does not have to travel through the blood stream.
- Products of exocrine gland do not circulate all over the body.
- It has a smaller blood supply compared to the endocrine gland.
- Exocrine glands have more complex structure than endocrine glands.

### **Mechanism of Secretion**

Glandular epithelial cells (glands) are specialised cells that secrete bodily products. Glands are secretory structures derived from epithelium in which goblet cells (mucous producing) are embedded.

- **Merocrine glands** do not include cell elements in their secretions. They excrete their substances by direct exocytosis of protein. Only secretions exit the gland, such as sudoriferous (sweat) glands, which are small tubular structures situated within and under the skin (in the subcutaneous tissue). They discharge sweat by tiny openings in the surface of the skin. Most common are pancreatic enzymes.
- **Apocrine glands** are pieces of cells, which uses membrane vesicles, and secretory products and some membrane is lost. Examples include mammary glands, sebaceous (sweat) glands and the prostate.
- **Holocrine glands** are whole cells which are released and which may later release the secretions inside the duct. The entire secretory cell is lost, as the plasma membrane breaks to release the product. Examples include the sebaceous glands of the skin. The entire cell is released (exfoliated), which later deteriorates to release secretions/sebum, such as the sebaceous (oil) glands.

### **Shape and Arrangement of Glands**

Some examples of the shapes include: simple tubular, simple branched acinar, compound tubular, and compound alveolar, or a combination of these. The arrangement can either be simple, branched or compound.

These are the simple tubular, simple branched tubular, simple coiled tubular, simple acinar, and simple branched acinar glands.

### **Simple Glandular Epithelium**

Simple glandular epithelium includes: the colon, stomach, and merocrine sweat glands.

### **Simple tubular gland.**

Simple tubular gland is a single, unbranched duct, into which secretory products are discharged, such as mucous-secreting gland of the colon, or glands of the large intestine.

**Simple exocrine glands** have only a few branches.

### **Simple branched acinar gland.**

There is a saclike secretory unit with an obvious lumen. It is found on the surface of the skin (sebaceous gland).

### **Compound Glandular Epithelium**

These are the compound tubular, compound acinar, and compound tubulo-acinar glands.

Compound glandular epithelium has many branches, and include: sebaceous glands, Brunner's glands of the duodenum, small salivary glands, the breast and the prostate.

### **Compound tubular gland**

Compound tubular glands consist of a number of distinct system of ducts that pen into a main excretory duct. The secretory portions are in the form of long branching tubules which are usually coiled or convoluted. Examples include: kidneys and testes.<sup>5</sup>

**Compound Alveolar exocrine gland** is found in the mammary glands.

Compound alveolar glands have a large number of duct systems. The terminal excretory end of the duct ends in a sac-like alveoli.

Other compound glands include:

- ***Branched tubular***, as in Brunner's gland of the duodenum.
- ***Compound Acinar*** drains into a branched duct system, such as the pancreas.
- ***Compound tubule-acinar***, such as submandibular salivary glands.

## **Muscular Tissue**

Muscle refers to multiple bundles of muscle fibres which are held together by connective tissue. Muscle tissue is highly cellular, well-vascularised tissues that is responsible for most types of body movement.

Muscular tissue is specialised for contraction and it contains proteins, actin and myosin, that slide past one another, thereby enabling the body and its parts to move. It is made up of: skeletal muscle, which is a voluntary type of muscle tissue that is used in the contraction of skeletal parts; smooth muscle, which is an involuntary type and is found in the walls of internal organs and blood vessels; and cardiac muscle, which is an involuntary type and is only found in the walls of the heart.



Skeletal muscle is the most common and widely distributed muscle tissue in the body, making up around 40% of the body's total mass. It forms all of the skeletal muscles, such as the biceps brachii and gluteus maximus, and is found in the eyes, throat, diaphragm, and anus. Four characteristics define skeletal muscle tissue cells: they are voluntary, striated, not branched, and multinucleated.

Smooth muscle cells are found in the organs, blood vessels, and bronchioles to move substances throughout the body. Four characteristics define smooth muscle tissue cells: they are involuntarily controlled, not striated, not branched, and singly nucleated.

Cardiac muscle cells are found only in the heart, and are specialized to pump blood powerfully and efficiently throughout our entire lifetime. Four characteristics define cardiac muscle tissue cells: they are involuntary and intrinsically controlled, striated, branched, and single nucleated.<sup>8</sup>

### **Three Types of Muscular Tissue**

Muscular tissue is composed of cells that have the special ability to shorten or contract in order to produce movement of the body parts. The tissue is highly cellular and is well supplied with blood vessels. The cells are long and slender so they are sometimes called muscle fibres, and these are usually arranged in bundles or layers that are surrounded by connective tissue. Actin and myosin are contractile proteins in muscle tissue.<sup>10</sup>

Muscle tissue can be categorized into skeletal muscle tissue, smooth muscle tissue, and cardiac muscle tissue.

### **Skeletal Muscle**

Skeletal muscle is a form of striated muscle tissue which is under the control of the somatic nervous system. They are tissue sheets that are attached to the bones by tendons. Its main function is to facilitate movement of the skeleton by contraction of the muscles. As the muscles contract, they pull on bones or skin, causing body movements. It is a voluntary muscle, as one has direct control over them through nervous impulses from the brain, which sends messages to the muscles.

Skeletal muscle has fibres which occur in muscles that are attached to the skeleton. It is made up of individual components, known as myocytes, or muscle cells/muscle fibres. They are formed from the fusion of developmental myoblasts, in a process known as myogenesis. These long, cylindrical, multinucleated cells are also called myofibres, which are composed of myofibrils. The myofibrils are composed of actin and myosin filaments, repeated in units, called a sarcomere, which is the basic functional unit of the muscle fibre. The sarcomere is responsible for the skeletal muscle's striated appearance, and forms the basic mechanism necessary for muscle contraction. Skeletal muscles have the ability to stretch or contract, and still return to their original shape.

## **Structure of Muscular Tissue**

Each skeletal muscle fibre is a single cylindrical muscle cell. An individual skeletal muscle may be made up of hundreds, or even thousands, of muscle fibres, which are bundled together and wrapped in a connective tissue covering.

Each muscle is surrounded by a connective tissue sheath called the epimysium. Connective tissue outside the epimysium, called fascia, surrounds and separates the muscles. Portions of the epimysium project inward to divide the muscle into compartments.<sup>11</sup>

Each compartment contains a bundle of muscle fibres. Each bundle of muscle fibre is called a fasciculus, and is surrounded by a layer of connective tissue called the perimysium. Within the fasciculus, each individual muscle cell, called a muscle fibre, is surrounded by connective tissue called the endomysium.<sup>12</sup>

## **Four Characteristics of Skeletal Muscle**

- Voluntary.
- Striated.
- Not branched.
- Multinucleated.

## **Smooth Muscle**

Visceral muscles are also commonly known as smooth muscle due to their lack of striations. Smooth muscle is primarily under the control of autonomic nervous system, which is involuntary muscle, due to one's inability to control its movements.

It consists of narrow spindle-shaped cells with a single, centrally located nucleus. Smooth muscle tissue, unlike striated muscle, contracts slowly and automatically. Excitation, the electrochemical event occurring at the membrane, is followed by the mechanical event, contraction.

Smooth muscle is stimulated by involuntary neurogenic impulses, and has slow, rhythmical contractions used in controlling internal organs, for example, moving food along the oesophagus or constricting blood vessels during vasoconstriction.

It is responsible for the contracting hollow organs, such as blood vessels, the gastrointestinal tract, the bladder, or the uterus. The most striking feature of smooth muscle is the lack of visible cross striations (hence the name smooth).

## **Four Characteristics of Smooth Muscle**

- Involuntary.
- Not striated.
- Not branched.
- Singly nucleated.

## **Cardiac Muscle**

Cardiac muscle is involuntary striated muscle, which is found solely in the walls of the heart, and which makes up the bulk of the heart's mass, propelling blood into the circulation. It has

similarities with skeletal muscles in that it is striated, and with smooth muscles, in that its contractions are not under conscious control, being under the control of the autonomic nervous system. As cardiac muscle makes up the bulk of the heart's mass, its qualities of dryness from the protein structure, gives the heart its dominant qualities of dryness, as well as heat from constant movement and well vascularised blood supply.

Cardiac muscle is highly resistant to fatigue, due to the presence of a large number of mitochondria, myoglobin and a good blood supply, allowing continuous aerobic metabolism.<sup>14</sup>

Cardiac muscle tissue is made up of many interlocking cardiac muscle cells, or fibres, that give the tissue its properties. Each cardiac muscle fibre contains a single nucleus, and it is striated, or striped, because it appears to have light and dark bands when seen through a microscope. The dark bands represent areas of thick protein filaments made of myosin proteins that block light passing through the cell, and appear dark. Between the dark bands are thin filaments, made of actin protein that allow light to pass through, and appear light.

Cardiac muscle cells have a branched shape so that each cell is in contact with three or four other cardiac muscle cells. These form a very big interconnected network, with overlapping intercalated discs, which ensure that electrochemical signals can be passed quickly from cells to cell. Cardiac muscle tissue is able to set its own contraction rhythm, due to the presence of pacemaker cells that stimulate the other cardiac muscle cells to either increase or decrease the heart rate.<sup>15</sup>

#### **Four Characteristics of Cardiac Muscle**

- Involuntary and intrinsically controlled to initiate and distribute electrical impulses throughout the heart automatically.
- Striated.
- Branched.
- Single nucleated.

#### **Physiology of Muscle Contractions**

Different types of fibres contract at different speeds, and which are suited to different types of activity. They vary in colour depending on their myoglobin (an oxygen carrying protein) content. Contractions can vary to produce powerful, fast movements, or small precision actions. There are four types of muscle contractions, namely, concentric, eccentric, isometric contractions, and passive stretch:

**Concentric Contractions** - muscle actively shortening:

When a muscle is activated, and required to lift a load which is less than the maximum tetanic tension (maximally stimulated by its motor neuron) it can generate, the muscle begins to shorten. Example: ***Raising of a weight*** during a bicep curl.

**Eccentric Contractions** - muscle actively lengthening:

During normal activity, muscles are often active while they are lengthening. Example: ***Walking***, when the quadriceps (knee extensors) are active just after heel strike while the

knee flexes. ***Setting an object down gently*** (the arm flexors must be active to control the fall of the object).

### **Isometric Contraction - muscle actively held at a fixed length:**

The muscle is activated, but instead of being allowed to lengthen or shorten, it is held at a constant length. Example: ***Carrying an object in front of one***. The weight of the object would be pulling downward, but the hands and arms would be opposing the motion with equal force going upwards. Since the arms are neither raising nor lowering, the biceps will be isometrically contracting.

### **Passive Stretch - muscle passively lengthening:**

The muscle is being lengthened while in a passive state (i.e. not being stimulated to contract). Example: ***Feeling the pull in the hamstrings while touching the toes***.<sup>16</sup>

## **Connective Tissue**

Connective tissue is a broad term for supportive tissues that provide the body's framework. The word 'connective' means 'serving as a link or binding.'<sup>17</sup> It supports and binds other tissues in the body. Unlike epithelial tissue which has cells that are closely packed together, connective tissue typically has cells scattered throughout an extracellular matrix of fibrous proteins and glycoproteins attached to a basement membrane.

Connective tissue forms a platform upon which epithelial tissue rests, and within which nerve and muscle tissue are embedded. Blood vessels and nerves travel through connective tissue. It not only functions as a mechanical support for other tissues, it is also an avenue for communication and transport among other tissues. Most significantly, connective tissue is involved in immunological defence.<sup>18</sup>

Granular white blood cells are produced in the bone marrow, while agranular white blood cells are produced in lymph tissue, such as in the lymph nodes. Lymph nodes are supported within a meshwork of connective tissue, called reticulin fibres, and are populated by aggregates of lymphocytes and macrophages.<sup>19</sup>

The largest concentration of connective tissue is found within the bones, which forms the foundation of the framework of the body. It has a cold and dry qualities, and as such, the structures are not as affected by changes in the qualities as are the other tissues. Bone marrow plays an important role in the production of the immune cells and storage of minerals.

Mesoderm is composed of stellate, or fusiform cells embedded in an extensive, jelly-like ground substance. Mesenchyme is the stem tissue of all the connective tissues of the body. It is the most abundant and widely distributed tissue type, which is found everywhere in the body.

The qualities of connective tissue are determined according to the types of tissue they represent: Blood (hot and moist) is also connective tissue, and which is also found in bone marrow. The flexibility of cartilage is enabled by the qualities of moisture, which allows it to move. Adipose tissue contains large numbers of fat-storing adipocytes cells, which provides the necessary moisture. Fat has an overall quality of heat. Heat melts fat, but coldness makes it hard, as in atherosclerosis.

### **Determining the Properties of Connective Tissue**

Connective tissue is divided into many types of tissue, namely: loose connective tissue (areolar, adipose and reticular); dense connective tissue (dense regular, irregular and elastic connective tissue); cartilage (hyaline, elastic and fibrocartilage); bone (spongy and compact bone), and blood and blood forming tissue (red marrow).

Connective tissue supports, binds, connects, or separates different types of tissues and organs in the body, as well as providing protection, insulation and a means of transportation of substances within the body.

The characteristics of connective tissue and the types of cells it contains vary, depending on where it is found in the body. Variations in the composition of the extracellular matrix (ratio of different tissues), determines the properties of the connective tissue, as well as the amount of blood that supplies the organ, and how much movement the tissue or organ undergoes. For example:

**Bones:** If the matrix is calcified, it can form bone or teeth. Bones are stiff because they are *cold and dry*, which enables them to support the weight of the body.

**Adipose:** (fat) is a connective tissue, which is composed of cells, called adipocytes. Adipocytes have small nuclei at the cell edge and store fat for energy usage. Fat has qualities of moistness with heat. The heat enables fat to store energy, and to keep the body warm.

**Blood:** is considered as a connective tissue because it has a fluid matrix, called plasma, and has no fibres. The essence of blood is exchange and contact, as it is the basic nutritional and metabolic currency of the organism. It has hot and moist qualities, as blood is the very essence of vitality and health, nutrition and growth. Haemopoiesis is the process of blood cell formation, which also falls into the category of connective tissue.

Specialised forms of extracellular matrix also makes up tendons, cartilage, and the cornea of the eye. General connective tissue is either loose, or dense, depending on the arrangement of the fibres.<sup>20</sup>

### **The Matrix of Connective Tissue**

Connective tissue fills the spaces between organs and tissues, and provides structural and metabolic support for other tissues and organs. It is made up of cells and extracellular matrix. The extracellular matrix is made up of fibres in a protein and polysaccharide matrix, secreted and organised by cells in the extracellular matrix.

The matrix of connective tissue typically consists of fibres and a featureless ground substance. The most abundant fibre in connective tissues is a tough protein called collagen. In Tibb protein is considered to have an overall quality of dryness, but with some degree of

heat or coldness, and the least amount of moistness. Collagen also strengthens bone and cartilage. Elastic and reticular fibres are less abundant connective tissue proteins, with a more limited distribution.

The ground substance may be liquid, as in blood; gelatinous, as in areolar tissue; rubbery, as in cartilage; or calcified and stony, as in bone. It consists mainly of water and small dissolved ions and organic molecules, but the gelatinous to rubbery consistency of some tissues results from enormous protein-carbohydrate complexes in the ground substance. The hard consistency of bone results mainly from calcium phosphate salts in the ground substance. The bones are stiff and hard because they're cold and dry.<sup>21</sup>

### **Composition of Connective Tissue Cells**

- **Mesenchymal cells** are capable of differentiation and proliferation during regeneration.
- **Fibroblasts** are large, flat, branching cells which appear spindle-shaped in a side view.
- **Macrophages** are the next in abundance to the fibroblasts in loose connective tissue. During inflammation, they become very actively amoeboid and phagocytic. They readily engulf blood cells, bacteria, dead cells and debris, digesting this material with powerful enzymes. These cells are an important component of the reticulo-endothelial system (RES), located in the spleen, liver, lymph nodes and other organs.
- **Adipose cells** are commonly seen in loose connective tissue (areolar). They are often found arranged around small blood vessels.
- **Leukocytes** are white blood cells which wander into the connective tissues surrounding blood vessels. Eosinophils are very common throughout the respiratory and digestive tracts, as well as in active mammary tissue. Neutrophils are found at sites of inflammation. Plasma cells, derived from B-lymphocytes, are common in areas of chronic inflammation.
- **Mast cells** are large cells which are filled with deeply basophilic granules which often obscure the nucleus. They probably arise from mesenchyme cells in the body tissues, and are usually adjacent to blood vessels. Like the blood basophils, which they closely resemble, these cells contain mediators of immediate hypersensitivity, such as histamine, heparin and serotonin.
- **Melanocytes** are pigment cells which are found in the connective tissues of the skin and choroid coat of the eye. The melanin produced by these cells is known to absorb ultra violet light.<sup>23</sup>

Connective tissue fibres include Collagen fibres, reticular fibres, and elastic fibres.

### **Collagen Fibres**

**Collagen** is the most abundant protein, forming extracellular fibre in virtually every tissue of the body. The amount of collagen in a particular connective tissue depends on the density of the tissue. In loose connective tissue collagen is sparse, and in dense connective tissue collagen is abundant. It is important for resisting tensile forces, and its arrangement of collagen fibres will vary with the function of that tissue in different regions of the body.

The fibroblast is the most common cell that creates collagen. Collagen, in the form of elongated fibrils, is mostly found in fibrous tissues, such as tendons, ligaments, muscles, cartilage, bones, and skin. It is also abundant in the cornea, blood vessels, the gut, intervertebral discs and the dentin in teeth. In muscle tissue, it serves as a major component of the endomysium. Collagen constitutes one to two percent of muscle tissue, and accounts for 6% of the weight of strong, tendinous muscles.

### **Reticular Fibres**

Reticular fibres are very fine collagen fibrils, which are made of type 2 collagen. They are found around the liver, kidneys, spleen and lymph nodes, as well as in bone marrow. The cells that make the reticular fibres are fibroblasts, called reticular cells.

Reticular tissue forms a labyrinth-like stroma (mattress), or internal framework/scaffolding that can support many blood cells (large lymphocytes), lymph nodes, the spleen, and red bone marrow.

### **Elastic Fibres**

Elastic connective tissue is both strong and highly flexible, allowing for recoil of tissue following stretching; maintaining pulsatile flow of blood through arteries; and aiding passive recoil of lungs following inspiration.

Elastic connective tissue is found in the ligaments of the vertebral column; the lungs, and walls of air passages; the walls of blood vessels; and the suspensory ligament of the penis.<sup>24</sup>

## **Types of Connective Tissue**

There are four types of connective tissue, namely:

### 1. **Loose connective tissue**

- Areolar.
- Adipose.
- Reticular.

### 2. **Dense Connective Tissue**

- Dense regular.
- Dense irregular.

### 3. **Supportive connective tissue (cartilage and bone).**

- Hyaline cartilage.
- Elastic cartilage.
- Fibrocartilage.
- Spongy bone (cancellous or trabecular).
- Compact bone(cortical).

#### 4. **Blood and blood forming tissue (red marrow).**

- Red blood cells.
- Platelets.
- White blood cells.
- Plasma.

#### **Loose Areolar connective tissue**

Loose areolar connective tissue is a loose array of random fibres, with a wide variety of cell types. Areolar means 'spaces', therefore loose connective tissue therefore possesses randomly arranged protein fibres with abundant intercellular spaces.

It is distributed under all the epithelia of body. It is found in the outer coverings of blood vessels, nerves, glands, oesophagus and other organs; within the dermis and subcutaneous layers of the skin; fascia between muscles; pleural and pericardial sacs.

#### **Functions:**

- Cushions epithelia.
- Provides flexibility, elasticity, and support, and binds other organs and tissues.
- Fills spaces.
- Holds tissue fluid.
- Allows passage for nerves and blood vessels through other tissues.
- Defending against infection (white blood cells & macrophages).
- Nourishes epithelia - stores nutrients as fat (in fat cells).

#### **Adipose connective tissue**

Adipose tissue contains large numbers of fat-storing adipocytes cells. Fat has an overall quality of heat. Heat melts fat, but coldness makes it hard, as in atherosclerosis.

Adipose tissue forms within areolar tissues as adipocytes proliferate under conditions of high energy availability. As the delivery and mobilisation of energy molecules to and from adipose storage sites requires blood flow, adipose tissue is highly vascularised with well-developed capillary beds.<sup>25</sup>

It is found in the subcutaneous layer of the skin; surrounding eyeballs, kidneys, heart, and blood vessels; the padding in joint cavities, and cavities within bones.

#### **Functions:**

- Providing a reserve food fuel as energy by storing fat.
- Insulating against heat loss to maintain body temperature.
- Supporting, cushioning and protecting organs.
- Fills spaces and shapes the body.



## **Reticular Connective Tissue**

Reticular connective tissue is supportive tissue making up the framework of glands, organs, and lymph nodes. In glands and organs, secretory epithelial cells are attached and anchored to this network of fibres.

Reticular connective tissue is a type of tissue found in the body that is supported with a branching framework of collagen fibres known as reticular fibres. It is found in the liver, spleen, lymph nodes, bone marrow, surrounding blood vessels and muscle fibres. The fibres form a soft internal skeleton (stroma) which supports other types of cells, including white blood cells, mast cells, and macrophages.<sup>26</sup>

### **Functions:**

- Reticular cells secrete a fine network of thin, highly branched reticular fibres, which forms a three-dimensional supportive framework.
- Binds muscles together.

## **Dense Regular Connective Tissue**

Dense regular connective tissue is densely spaced, parallel collagen fibres and fibroblasts. It is also called white fibrous tissue because of its white appearance. The fibres are all aligned to resist stress and pressure in one direction.

It is found in tendons, most ligaments, and aponeuroses.<sup>27</sup>

### **Functions:**

- Attaching muscles to bones or to muscles.
- Attaching and binds bones together.
- Transfers force from muscle to bone - withstands great tensile stress when pulling.

## **Dense Irregular connective tissue**

Dense Irregular connective tissue is densely spaced, randomly arranged (not parallel) fibres and fibroblasts. The densely packed collagen fibres are irregularly positioned into three-dimensional networks to provide strength and resistance to stress in all directions.

Dense Irregular connective tissue is located in areas of the body where tissues are attached or anchored, such as the skin on the palms of the hands and the soles of the feet, which are firmly attached to underlying muscle. This muscle is then anchored to underlying bone. In addition, these bones also connect via capsules to form synovial joints for movement.

It found in the dermis of the skin; the walls of the digestive organs; capsules around organs; the pericardium, heart valves, periosteum, perichondrium, and joint capsules.<sup>28</sup>

Strong interconnectivity and support between tissues in the walls of organs, such as those of the digestive system, is essential. This prevents separations of the epithelial linings and underlying muscle layers, as they fulfil their functions when these organs fill and mix with enzymes. Another example why strong and resilient tissues are needed, are across the heart valves, because of the constant opening and closing that these valves have to withstand 60 – 80 times per minute.<sup>29</sup>

### **Functions:**

- Tough – withstands tension exerted in many directions.
- Providing structural strength.
- Protects organs from injury. It provides a protective capsule around many organs.

### **Supportive Connective Tissue**

Supportive connective tissue comprises cartilage and bone.

### **Cartilage**

Cartilage is divided into three types, namely, hyaline cartilage, elastic cartilage and fibrocartilage. The flexibility of cartilage is enabled by the qualities of moisture, which allows it to move.

It is composed of cells and a firm matrix, which can resist distortion in response to mechanical stresses, which is flexible but strong supportive connective tissue. Unlike bone and all other connective tissue types, cartilage is avascular, lacking blood vessels, therefore cartilage does not possess the regenerative capacity of bone or the other connective tissue types. Most cartilage is surrounded by a layer of dense irregular connective tissue, called the perichondrium, which supplies cartilage with its blood and nerve supply.<sup>30</sup>

Cartilage is widely spaced cells in small cavities (lacunae), which have a rubbery matrix.

There are three types of cartilage, namely, hyaline, elastic and fibrocartilage.

### **Hyaline Cartilage**

The most abundant type of cartilage in the body is hyaline cartilage. As articular cartilage, hyaline is found covering the articular surfaces of bones in synovial joints, where hyaline cartilage reduces friction and acts as shock-absorbing tissue.

Hyaline cartilage also forms the costal cartilages where ribs attach to the sternum, and the foetal skeleton. It is also found as supportive tissues in the nasal septum, ears, trachea, larynx, and smaller respiratory tubes.<sup>31</sup>

In hyaline cartilage, protein fibres are large and predominantly collagen. It forms most of embryonic skeleton, covers the ends of long bones in joint cavities, and forms costal cartilages of the ribs, cartilages of the nose, trachea, and larynx.

### **Functions:**

- Flexibility and support.
- Reduces friction and absorbs shock at the joints.
- Provides a smooth surface for movement of joints.

## **Elastic Cartilage**

Elastic cartilage is similar in structure and function to hyaline cartilage, except that in addition to collagen, the matrix also contains many elastic fibres.

Elastic cartilage is found in areas of the body which require support and elasticity, such as in the pharyngo-tympanic (eustachian) and auditory tubes, epiglottis, ear auricles, and portions of the external ear canal.

### **Functions:**

Elastic cartilage maintains the shape of a structure, while allowing for great support, flexibility and movement; moves vocal cords.

## **Fibrocartilage**

Fibrocartilage is the strongest and most resilient of all the different types of cartilage. It possesses a more open or spongy appearance than hyaline cartilage, with gaps between the lacunae and collagen fibre bundles. This open spongy structure makes fibrocartilage a good shock-absorbing cartilage, which is always associated with dense connective tissue, but it lacks a perichondrium.

It is found in intervertebral discs between vertebral bones; the pubic symphysis, and menisci disks of knee joint, as well as the dense connective tissue of some tendons.

### **Functions:**

- Resists compression and shearing forces.
- Provides shock absorption.
- Provides support.

## **Bones**

There are two types of bones, namely, spongy bone and compact bone. Spongy bone contains many spaces within the matrix, and which is less dense than compact bone. Compact bone is very dense and much more organised.

### **Spongy (cancellous or trabecular) Bone**

Compared to compact bone, spongy bone has a higher surface area to mass ratio, because it is less dense. This makes it softer, weaker, and more flexible. The greater surface area in comparison with cortical bone makes cancellous bone suitable for metabolic activity, such as the exchange of calcium ions.

Spongy bone is typically found at the ends of long bones (epiphysis), proximal to joints and within the interior of vertebrae. It is highly vascular and frequently contains red bone marrow where haematopoiesis, the production of blood cells, occurs. Spongy bone comprises 20% of bone tissue in the skeleton. The structural unit of spongy bone is called trabeculae, which is an irregular lattice providing space for red bone marrow.

## **Compact (cortical) Bone**

Compact bone forms the cortex, or outer shell, of most bones, and which is much denser than spongy bone, being harder, stronger and stiffer. Compact bones found in the shaft (diaphysis) of long bone and the surface of flat bone. It is found throughout the skeletal system, and comprises 80% of bone tissue in the skeleton.

### **Functions:**

- Physically supports the body, as well as the soft tissue.
- Encloses and protects internal organs.
- Provides movement.
- Acts as levers during muscle contraction.
- Storage and release of calcium and phosphorus.
- Resists stresses produced by weight and movement.

## **Blood**

**Red Blood Cells:** Erythrocytes (red blood cells) transports oxygen to tissue cells of the entire body. Haemoglobin is the protein inside red blood cells that carries the oxygen. Red blood cells also remove carbon dioxide from the body, transporting it to the lungs to exhale. Red blood cells are made inside the bones, in the bone marrow. They typically live for about 120 days, and then they die.

**White Blood cells:** Leucocytes (white blood cells) are the cells of the immune system that protect the body against foreign invaders and infectious diseases.

**Platelets:** Platelets (thrombocytes) are a component of blood whose function (along with coagulation factors) is to stop bleeding by clumping and clogging blood vessel injuries. Platelets have no cell nucleus, but are fragments of cytoplasm which are derived from bone marrow, and then enter the circulation.

Platelets contain dense granules, lambda granules and alpha granules. Activated platelets secrete the contents of these granules through their canalicular systems to the exterior. Bound and activated platelets degranulate to release platelet chemotactic agents to attract more platelets to the site of endothelial injury.

**Plasma:** The matrix of the blood is a yellow liquid, called plasma. It is mostly water but also contains dissolved substances, including proteins, sugars, ions and gases. It holds the blood cells in whole blood in suspension, which makes up about 55% of the total blood volume of the body. Plasma is used for blood transfusions, typically as fresh frozen plasma.

Plasma also serves as the protein reserve of the human body. It plays a vital role in the intravascular osmotic effect that keeps electrolytes in balance, and protects the body from infection and other blood disorders.

# Nervous Tissue

Nervous tissue is the main component of the two parts of the nervous system, namely the brain and spinal cord of the central nervous system, and the branching peripheral nerves of the peripheral nervous system, which regulates and controls functions of the body and its activities.

Nervous tissue is composed of neurons, or nerve cells, which receive and transmit impulses, as well as neuroglia, or glial cells, which assist the propagation of the nerve impulse, and provides nutrients to the neurons.

## Composition of Nervous Tissue

The main components of the nervous system are the brain, spinal cord and nerves. Nervous tissue is responsible for sensing stimuli and transmitting signals to and from different parts of an organism.

Nervous tissue is specialised for the conduction of electrical impulses, which allow communication among other tissue types. The major structural and functional unit of nervous tissue is the nerve cell called neuron.

Nervous Tissue is composed of two major cell types, namely, neurons and supporting or accessory cells.

1. **Neurons** have amplified electrical excitability, and have axons which can initiate and transmit nerve impulses (action potentials).
2. **Supporting or accessory cells** are smaller cells which are associated with neurons. Their functions include:
  - Forms the framework which holds neurons in position, and protects neurons from some types of damage.
  - Pass nutrients and other materials from blood or cerebrospinal fluid to neurons.
  - Surrounds all axons in the peripheral nervous system (PNS), and form the myelin sheaths around myelinated axons in both the central and peripheral nervous systems.<sup>33</sup>

## Composition of the Neuron

Neurons, or nerve cells, carry out the functions of the nervous system by conducting nerve impulses. Neurons are the basic structural unit of the nervous system. Neurons are electrically excitable and sensitive to various types of stimuli, such as heat and cold, light and dark, and pressure. They are specialised cells that **generate and conduct nerve impulses** around the body. There are many types of neurons, including motor neurons, sensory neurons and relay neurons. Each cell consists of the following parts:

- The cell body contains the nucleus and one or more long cytoplasmic extensions known as fibres, as well as other cellular organelles.
- The dendrites are highly branched fibres, which are cell body extensions, without the ability to generate action potentials. They are typically short, slender extensions of the cell body that receive stimuli, bringing impulses towards the cell body.

- The axon is a cell body extension which can generate an action potential. It is typically a long, slender extension of the cell body that sends stimuli. The axon carries the electrical impulses and information away from the cell body. The axon branches are, typically, smaller extensions of the axon. The axon, together with its covering sheath forms the nerve fibre.<sup>17</sup> It is protected by a fatty sheath, which increases the speed at which the nerve impulse is transmitted. The nerve ending is branched to make good contact with other neurons or the effector organ.
- Synapses allow signals to quickly pass from one cell to an adjacent cell. All synapses in humans are chemical synapses, in which a signal is transmitted in the form of a secreted chemical transmitter.
- Neuroglia, or glial cells, provide support functions for the neurons, such as insulation or anchoring neurons to blood vessels.

### Neuronal Signals

Neurons generate electrical signals that travel along their axons. When a pulse of electricity reaches a junction called a synapse, it causes a neurotransmitter chemical to be released, which binds to receptors on other cells and thereby alters their electrical activity.

Two neurons do not make direct contact. Where they meet, there is a very small gap called a synapse. The signal needs to cross this synapse to the central nervous system. This is done by means of chemicals which **diffuse** across the gap between the two neurons.

### Saltatory Conduction

The dendrites and axons of sensory neurons and motor neurons that lie outside of the central nervous system in the peripheral nervous system may be myelinated. Myelin sheaths (neuron wraps) are formed by Schwann Cells. Schwann cells, which form multiple layers of membrane around the neuron and insulate it.

In between the areas of myelin sheath, Nodes of Ranvier, or bare patches, exist. The nerve impulse or action potential will jump from node to node, greatly increasing the speed of nerve transmission. This node to node transmission, called saltatory conduction, can produce transmission speeds of up to two hundred meters per second and explains the speed at which one can react to potentially harmful stimuli.<sup>34</sup>

### Reflex Actions

Reflex actions are carried out by a path called a reflex arc. Reflex arcs involve five main parts. These parts are the sensory receptors, the sensory neurons, the interneurons, the motor neurons, and effectors.

The sensory receptors receive a stimulus and generate a nerve impulse. The sensory neurons then carry this impulse to the interneurons of the spinal cord. The interneurons then carry the impulse directly to the motor neurons bypassing the brain. The motor neurons then carry the impulse to an effector. The effector, which is normally a muscle or a gland, responds by contracting or releasing a biologically active compound. The action of the muscle or gland often is beneficial to the individual. Examples of common reflex arcs are the

knee jerk (patellar tendon reflex), the eye blink, the gag reflex, and pupil constriction in bright light.<sup>35</sup>

### **Types of Neurons**

Nervous tissue is made up of neurons and neuroglia:

- **Neurons** generate and conduct nerve impulses, thereby moving information to the body.
- **Neuroglia** (glial cells) supports, insulates and protects neurons.

There are three types of neurons, namely:

- **Sensory afferent** neurons.
- **Motor efferent** neurons.
- **Interneuron**.

Each spinal nerve has motor and sensory nerve roots. The sensory nerve roots enter the back of the spinal cord to join fibres that lead to the brain. Nerve fibres carrying signals from the brain join motor nerve roots leaving the front of the cord.

### **Sensory Neuron**

Sensory neurons convey signals from peripherally located sensory structures to CNS neurons.

**Afferent** neurons are also called sensory neurons, which receive stimuli from the outside environment (sensory receptors), and transmit impulses towards the brain. These neurons carry nerve impulses from receptors or sense organs toward the central nervous system, which produces a response.

### **Motor Neuron**

Motor neurons convey signals from the CNS to peripherally located effector organs (muscles or glands).

**Efferent** neurons are also called motor neurons, which receives information from other neurons, and then carries the impulses in the opposite direction, away from the brain (central nervous system) and other nerve centres, to muscles or glands, which produces a response.

### **Interneuron**

Interneurons **connect** two or more neurons *within the CNS*.

**Interneuron** is found in the brain and spinal cord, which conducts impulses from afferent to efferent neurons.

## Classification of Nervous Tissue

1. **Central Nervous System tissues** are *internal to the meninges* of the brain and spinal cord.
  - **Grey matter** contains neuron cell bodies, dendrites, and axons, protoplasmic astrocytes, satellite oligodendrocytes, and microglia. The outer layer of the brain, the cerebral cortex, is made of grey matter. Beneath are white matter and islands of grey matter.
    - Grey matter processes nerve impulses, from which nerve impulses originate.
    - Basal ganglia are islands of grey matter, which help to coordinate movement.
  - **White matter** contains no neuron cell bodies but contains numerous axons along with fibrous astrocytes, myelinating oligodendrocytes, and microglia.
    - White matter transmits nerve impulses.
2. **Peripheral Nervous System tissues** are external to the meninges of the brain and spinal cord.
  - **Ganglion tissue** contains neuron cell bodies, axons, dendrites, and satellite cells.
  - **Peripheral nerve tissue** contains no neuron cell bodies but contains numerous axons (myelinated and/or unmyelinated) plus myelinating Schwann cells.<sup>33</sup>

## Conclusion

The embryonic origin of all living cells gives rise to specific tissues, organs, and the formation of all parts of the body. Ectodermic tissues build nerves, and their centre is the brain. Mesoderm tissues build muscles, and their centre is the heart. Endodermic tissues build epithelial cells, and their centre is the liver. A human cell determines the type, the nature and function of the tissues. A group of different types of cells form tissues, and one or more types of tissues form organs. The organs work together in unison the body, which make up the organ systems.

According to the Simple Organ Theory, there must be complete integration between the brain, heart and liver, in terms of both information and energy transfer. Any imbalances of the humours can lead to physical, emotional, social and spiritual imbalances.

The four kinds of tissues that make up the human body are based on differences in their anatomy and functions, namely: nervous, muscular, epithelial and connective tissues, which work synergistically with the brain, heart, the liver and the skeleton, respectively. Every cell, tissue, organ and the total human being (body, mind and soul), has its own specific qualities of heat, moistness, coldness and dryness in relation to its ideal qualitative state.

The group of cells that make up a tissue have physiological functions that work together in a coordinated way to support special functions, and which are influenced by the kind of material that surrounds the tissue, and by communication among the cells of the tissue. Different kinds of tissue have different physical properties. Tissues may be hard, such as bone, soft, such as muscle, or even liquid, such as blood.



The properties, structure and functions of the body rely on the intricate balance of the humours and qualities in the body. As each tissue and organ is endowed with its own ideal qualitative state, any change in the qualities of heat, moisture, coldness and dryness, will affect its functioning.

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