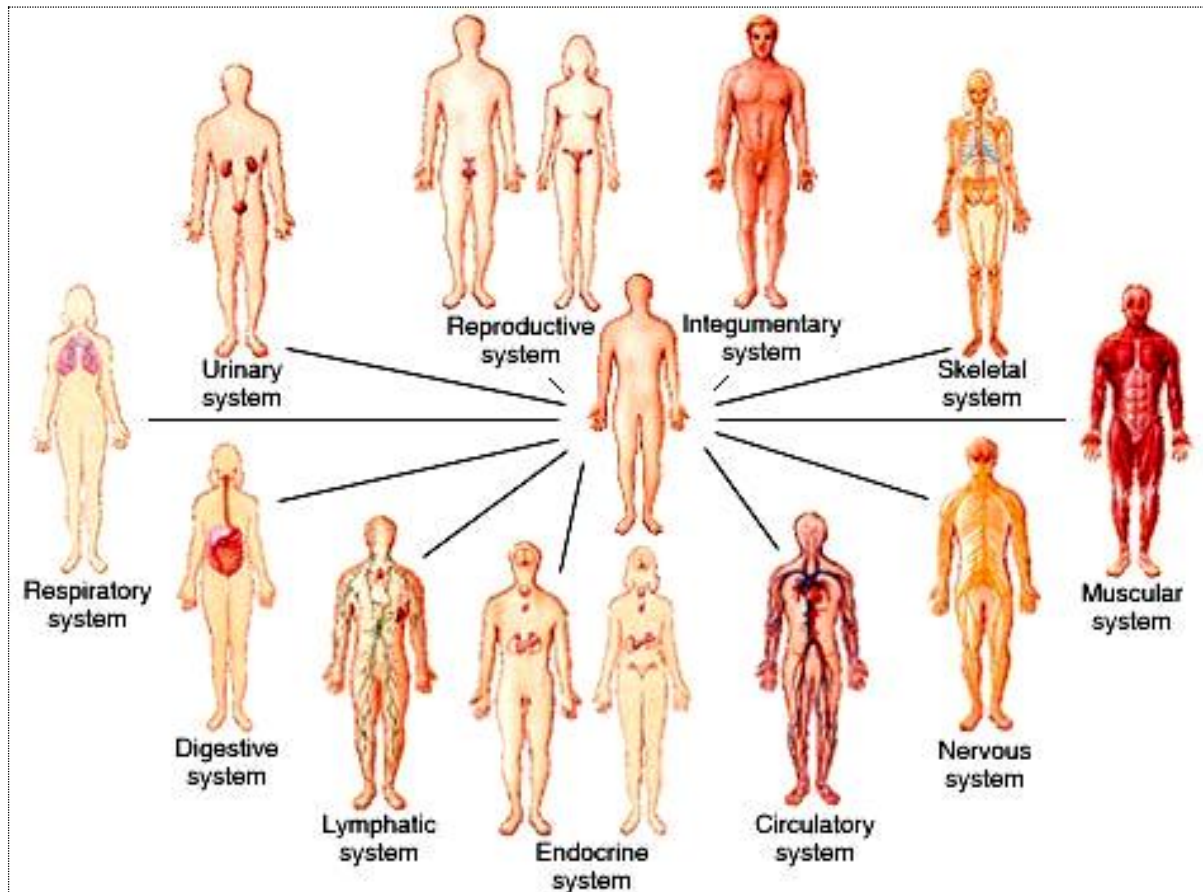


# INTRODUCTION TO SYSTEMIC ANATOMY

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## **SOURCES USED**

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- Keith L. Moore, Arthur F. Dalley, Anne M. R. Agur. Clinically Oriented Anatomy. 7th Edition, Lippincott Williams & Wilkins, Philadelphia, PA, USA, 2013. ISBN: 9781-45111-9459

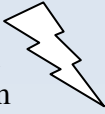
**READABILITY SCORE**

**50 %**

# SUMMARY

The organs serving for the same function are organized under 9 systems (11 systems if you count skeletal, articular and muscular systems separately, 12 systems if you consider the lymphatic system separate from the circulatory system, and 13 systems if you consider the vestibular system; which contributes to our balance and our sense of spatial orientation not under the nervous system, but separately).

1. Skeletal System
  2. Articular system
  3. Muscular System
  4. Circulatory (Cardiovascular) system
  5. Respiratory System
  6. Digestive (Alimentary) System
  7. Excretory (Urinary) System
  8. Reproductive (Genital) System
  9. Endocrine System
  10. Nervous system
  11. Integumentary system
- Locomotor system (Musculoskeletal system)



None of the systems functions in isolation. The passive skeletal and articular systems and the active muscular system collectively constitute a supersystem, the locomotor system, because they must work together to produce locomotion of the body. Although the structures directly responsible for locomotion are the muscles, bones, joints, and ligaments of the limbs, other systems are indirectly involved as well.

Bones are organs, and along with the cartilages form the skeletal system.

The articular system consists of joints and their associated ligaments, connecting the bony parts of the skeletal system and providing the sites at which movements occur.

The three types of muscle can be characterized by whether they are controlled voluntarily or involuntarily, whether they appear striated (striped) or smooth, and whether they are associated with the body wall (somatic), or with organs and blood vessels (visceral).

The Circulatory (Cardiovascular) System transports fluids throughout the body. The heart and blood vessels make up the blood transportation network, the cardiovascular system. The heart pumps blood throughout the body, and the blood vessels, which are a closed network of tubes that transport the blood. There are three types of blood vessels: arteries, veins, capillaries.

The respiratory system consists of air passages & lungs. The respiratory system supplies oxygen to the blood and eliminates carbon dioxide from it. The thorax is an irregularly shaped cylinder with a narrow opening (superior thoracic aperture) superiorly and a relatively large opening (inferior thoracic aperture) inferiorly. The superior thoracic aperture is open, allowing continuity with the neck; the inferior thoracic aperture is closed by the diaphragm. The diaphragm forms a section between thorax and abdomen.

The digestion starts in the mouth. Most of the digestive organs are localized in the abdomen. The abdominal wall covers a large area. It is bounded superiorly by the xiphoid process (the third-most inferior part- of the sternum) and costal margins, posteriorly by the vertebral column, and inferiorly by the upper parts of the pelvic bones.

The urinary (excretory) system consists of the kidneys, ureters, urinary bladder, and urethra, which filter blood and subsequently produce, transport, store, and intermittently excrete urine (liquid waste). The two bean-shaped kidneys are located in the posterior abdominal region. The ureters are muscular tubes that transport urine from the kidneys to the bladder. The ureters descend down to the pelvis exiting from the kidneys on each side. They enter the pelvic cavity, and continue their journey to the bladder.

The reproductive tracts are located in the pelvic cavity. The pelvic cavity, between the pelvic inlet superiorly and the pelvic diaphragm inferiorly, contains the terminal parts of the urinary and digestive systems, the internal genital organs, the associated vascular structures, and the nerves supplying both the pelvis and lower limbs.

The endocrine system consists of specialized structures that secrete hormones, including discrete ductless endocrine glands (such as the thyroid gland), isolated and clustered cells of the gut and blood vessel walls, and specialized nerve endings.

The central nervous system (CNS) has two parts: the brain and the spinal cord. The peripheral nervous system (PNS) is the remainder of the nervous system outside of the CNS. The peripheral nervous system (PNS) consists of nerve fibers and cell bodies outside the CNS that conduct impulses to or away from the CNS. The PNS is organized into nerves that connect the CNS with peripheral structures.

**T**he atoms make molecules. The molecules make organelles of the cell. Trillions of the cells in the human body form tissues. The tissues make up the 78 organs. The organs serving for the same function are organized under 9 systems. Is it really 9?

You can say there are 11 systems if you count skeletal, articular and muscular systems separately. But if you call these three systems as “locomotor system”, then you have fewer systems.

It will be 12 systems totally if you consider the lymphatic system separate from the circulatory system.

The number is 13, if you consider the vestibular system as a single system. In this case it will not be a part of the nervous system. The vestibular system is about our balance and our sense of spatial orientation.

## **1. SYSTEMS IN THE BODY**

For the ease of understanding, you see the list of the 9 systems of the human body. You will see that we will examine the skeletal system, articular system, and the muscular system separately during our FHS 122 class. So, the number of systems for us will be **11**. Just like a football team, eh?

*Locomotor system (Musculoskeletal system)*

- **Skeletal System**

- **Articular system**

- **Muscular System**

*Circulatory (Cardiovascular) system*

*Respiratory System*

*Digestive (Alimentary) System*

*Excretory (Urinary) System*

*Reproductive (Genital) System*

*Endocrine System*

*Nervous system*

*Integumentary system*

### **1.1. LOCOMOTOR SYSTEM**

MOVEMENT

None of the systems functions in isolation. The passive skeletal and articular systems and the active muscular system collectively make a supersystem. This supersystem is named as the “locomotor system”. The three systems must work together to produce movement of the body. The structures directly responsible for locomotion are the muscles, bones, joints, and ligaments of the limbs. Other systems are indirectly involved as well. The brain and nerves of the nervous system stimulate them to act. The arteries and veins of the circulatory system supply oxygen and nutrients. They also remove waste from these structures. The sensory organs (especially vision and equilibrium) play important roles in movement.

#### **1.1.1. SKELETAL SYSTEM**

Bones are organs of the skeletal system. Along with the cartilages they form the skeletal system. A *framework* is needed to keep the parts of the human body in place. The skeletal system makes this framework with its strong composure. The skeletal system provides our basic shape. It supports the soft tissues. It is vital for the movement. It serves as a point of attachment for ligaments, tendons, fascia, and muscle. To understand the human body better, let’s talk a little bit on an important function of the bones; **protection**.

The cranium (skull) is the skeleton of the head. It protects the brain which resides within itself. [The vertebral column in an adult typically consists of 33 vertebrae arranged in five regions. The number of vertebrae in each region are as follows: 7 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 4 coccygeal.](#) The vertebral column protects the spinal cord. The brain and the spinal cord together form the central nervous system.

The thorax is the part of the body between the neck and abdomen. Its skeletal framework is formed by the sternum in the middle. The 12 ribs are on each side. The 12 thoracic vertebrae lie posteriorly. The thoracic skeleton forms a framework to protect the two vital organs. These organs are the heart and the lungs.

The bones of the pelvis are: right and left pelvic (hip) bones, sacrum, and coccyx. The three hip bones are ilium, ischium and pubis. When you come to this world you have the three hip bones separate. Around the age of 14 to 16 the three bones fuse and become one bone: the hip bone. The sacrum articulates superiorly with the fifth lumbar vertebra. The pelvic bones articulate posteriorly with the sacrum. The pubic bones articulate with each other anteriorly.

The pelvic skeleton protects the lower part of the digestive system and urinary system. It also protects the organs of the reproductive system.

There is one bone in the arm. It is called humerus. There is one in the thigh. It is called femur. There are two bones in the forearm. One is radius. It is on the lateral side. The one on the medial side is ulna. There are also two bones in the leg. The fibula is on the lateral side. The tibia is on the anteromedial side. The clavicle (collar bone) is the only bony attachment between the trunk and the upper limb. The scapula is the shoulder blade. It connects humerus with the clavicle.

### **1.1.2. ARTICULAR SYSTEM**

The joints and their ligaments make the articular system. The ligaments connect the bony parts of the skeletal system. They provide the sites at which movements occur.

### **1.1.3. MUSCULAR SYSTEM**

You can group the muscles by three ways. One way is about a muscle's being controlled voluntarily or involuntarily. Another one relies on the appearance of the muscle: striated (striped) or smooth. The third one is about a muscle being associated with the body wall (somatic), or with organs and blood vessels (visceral).

## **1.2. CIRCULATORY (CARDIOVASCULAR) SYSTEM**

### **BLOOD**

The **Circulatory (Cardiovascular) System** transports fluids throughout the body. The heart and blood vessels make up the blood transportation network. This network is called the cardiovascular system. The heart pumps blood throughout the body. The blood vessels are a closed network of tubes. They transport the blood. There are three types of blood vessels.

- ♥ Arteries transport blood away from the heart.
- ♥ Veins transport blood toward the heart.
- ♥ Capillaries connect the arteries and veins. They are the smallest of the blood vessels. They are found where oxygen, nutrients, and wastes are exchanged within the tissues.

The main artery in the body is the aorta. All the arteries in the body leave from the branches of the aorta. Arteries have also branches themselves. Some large arteries are divided into different parts by distinct muscles. The direction of the blood flow in arteries is from the heart to the body. The direction of the blood flow in veins is from the body to the heart. Veins drain into other veins. Vein A draining into vein B is called the tributary of the vein B.

**Lymphatic system** is a network of lymphatic vessels. They withdraw excess tissue fluid (lymph) from the body's interstitial (intercellular) fluid compartment. They filter it through lymph nodes. Then the lymph returns it to the bloodstream. Lymph nodes are small masses of lymphatic tissue. They are located along the course of lymphatic vessels. Lymph is filtered through these vessels on its way to the venous system. This system can also be considered separate from the circulatory system.

## **1.3. RESPIRATORY SYSTEM**

### **BREATHE**

The respiratory system consists of air passages & lungs. The respiratory system supplies oxygen to the blood and eliminates carbon dioxide from it. The respiratory tract has two parts. These are upper and lower respiratory tracts. The lower respiratory tract fills most of the thorax. Lungs are important parts of the lower respiratory tract.

The thorax is an irregularly shaped cylinder with a narrow opening (superior thoracic aperture) superiorly and a relatively large opening (inferior thoracic aperture) inferiorly. The superior thoracic aperture is open. It allows continuity with the neck. The inferior thoracic aperture is closed by the diaphragm. The diaphragm is the important muscle for respiration. It forms a section between thorax and abdomen.

## **1.4. DIGESTIVE (ALIMENTARY) SYSTEM**

### FOOD

The digestive system consists of the digestive tract from the mouth to the anus. There are also other associated organs and glands. This system functions in ingestion, chewing and swallowing. As the name says, it also has the function of digestion. The food is absorbed and solid waste is eliminated as feces. This is done after absorbing the nutrients. The digestion starts in the mouth. Most of the digestive organs are in the **abdomen**. The abdominal wall has a large area. It is bounded superiorly by the xiphoid process (the third-most inferior part- of the sternum) and costal margins. It is bounded posteriorly by the vertebral column. It goes all the way down till the pelvic inlet.

Visualization of the position of abdominal viscera is fundamental to a physical examination. Some of these viscera or their parts can be felt by palpating through the abdominal wall. Surface features can be used to establish the positions of deep structures.

## **1.5. EXCRETORY (URINARY) SYSTEM**

### DRINK

The urinary (excretory) system is made by the kidneys, ureters, urinary bladder, and urethra. These organs filter blood. As a result they produce, transport, store, and excrete urine (liquid waste).

The kidneys are located in the posterior abdominal region. The ureters are muscular tubes. They transport urine from the kidneys to the bladder. The ureters descend down to the pelvis exiting from the kidneys on each side. They enter the pelvic cavity. They then reach the bladder.

In common usage, the **pelvis** (L. basin) is the part of the trunk inferoposterior to the abdomen. Pelvis is the area of transition between the trunk and the lower limbs.

The pelvis has two parts: greater pelvis (pelvis major) superiorly and lesser pelvis (pelvis minor) located inferiorly. The greater pelvis is actually part of the abdominal cavity. The pelvic inlet is the circular opening between the abdominal cavity and the pelvic cavity. Structures pass between the abdomen and pelvic cavity through the **pelvic inlet**. The boundary between the greater and lesser pelvis; pelvic inlet; is bordered posteriorly by sacrum, and laterally by the medial edges of ilium and pubic bones. This border is called [pelvic brim](#). The **pelvic outlet**; the inferior opening is between the pubic bones united anteriorly and coccyx posteriorly. The [pelvic cavity](#) is the inferiormost part of the abdominopelvic cavity. The abdominopelvic cavity extends superiorly into the thoracic cage and inferiorly into the pelvis.

The pelvic cavity is bounded posteriorly by the coccyx and sacrum. The superior part of the sacrum forms a roof over the posterior half of the cavity. The anterior wall is formed by the pubic bones.

The **pelvis major** (false pelvis) includes the abdominal organs like ileum. The lesser pelvis (**pelvis minor**) is the true pelvis. It includes the organs of the excretory system and reproductive system, as well as the terminal parts of the digestive system. The pelvic cavity contains the terminal parts of the ureters, the urinary bladder, rectum, pelvic genital organs, blood vessels, lymphatics, and nerves. In addition, it also contains an overflow of abdominal organs.

## **1.6. REPRODUCTIVE (GENITAL) SYSTEM**

### BIRTH

The major parts of the reproductive system are gonads. The genital gonads are ovaries and testes. They produce oocytes (eggs) and sperms. The ducts transport them. They are also parts of the system. Another part would be the "genitalia" that enable their union. There are also accessory glands in the system.

The reproductive tracts are located in the pelvic cavity. The pelvic cavity is between the pelvic inlet superiorly. The pelvic diaphragm lies inferiorly.



The pelvic cavity has the terminal parts of the urinary and digestive systems. It has the internal genital organs inside. It also contains the associated vascular structures, and the nerves supplying both the pelvis and lower limbs.

## **1.7. ENDOCRINE SYSTEM**

### HORMONES

The endocrine system consists of specialized structures that secrete hormones. These include discrete ductless endocrine glands. The thyroid gland is an example. Hormones are organic molecules. They are carried by the circulatory system to distant effector cells in all parts of the body. Hormones influence metabolism and other processes. Examples are the menstrual cycle, pregnancy, and parturition (giving birth).

## **1.8. NERVOUS SYSTEM**

### THE BOSS

When it comes to the body, it does not change; the boss sits upstairs. The boss of the body is the brain. We do react to external and internal stimuli every second of our daily lives. We get hungry. We drink water. We think. We sleep. We get excited. As a result our heart beat increases. We sweat when we are under threat.

All these organs above work by the innervation organized by the nervous system. All these functions are organized by one system: the nervous system. How does this happen? The nervous system is divided into two parts. These are the central nervous system [CNS] peripheral nervous system [PNS]. The central nervous system (CNS) has two parts: the brain and the spinal cord. The peripheral nervous system (PNS) is the remainder of the nervous system outside of the CNS. The PNS consists of nerve fibers and cell bodies outside the CNS. They conduct impulses to or away from the CNS. The PNS is organized into nerves that connect the CNS with peripheral structures. The PNS consists of the spinal and cranial nerves, visceral nerves and plexuses, and the enteric system.

The nerve cell is called **neuron**. The **neuroglia** are other cells of the system. They support the neurons. Neurons are the structural and functional units of the nervous system. They are specialized for rapid communication. The neurons arranged together to do the same function(s) in the CNS are called nuclei (singular, **nucleus**). Outside the CNS in the peripheral nervous system we call them as “ganglia” (singular **ganglion**). These groups of cells are the relay stations throughout the journey of the neuronal “signal”. The signal is carried away by “**axon**” of each neuron. Axons come together and make the nerve fibers. Nerve fibers make the tracts.

How does a signal go from one neuron to another? The axon (or dendirite) of a neuron connects with another neuron by a place called **synapse**. The axons before reaching this synapse are called **presynaptic fibers**. After the synapse they are called **postsynaptic**. This can occur at a ganglion. The axons reaching the ganglion from a neuron are preganglionic fibers. After leaving the ganglion they are called postganglionic. You can also use the terms pre-and post-synaptic instead. The postganglionic fibers exit from the ganglion in the periphery to reach the target of destination. This destination can be a smooth muscle of a vessel. It can be a gland. The destination can be a skeletal muscle tissue, etc. A nerve fiber either goes down from the brain or leaves out from the spinal cord. It carries information to accomplish a behavior/action. These fibers are called **efferent fibers**. It can also carry information from the periphery or from the spinal cord to the brain. The fibers bringing information to the CNS are called **afferent fibers**.

### **How are they carried to the target places?**

### **Spinal cord & spinal nerves**

A spinal nerve leaves the spinal cord between the two vertebrae. It carries motor and sensitive information. We have 33 vertebrae. But we have 31 pairs of spinal nerves. The first spinal nerve is between the skull and the first cervical vertebrae. There are three coccygeal vertebrae. There is only one coccygeal

nerve. The spinal nerves are named according to their position with respect to associated vertebrae: Spinal nerves arise from the spinal cord as rootlets. The rootlets come together to form the two nerve roots. These roots are the anterior (ventral) and posterior (dorsal) roots. [The anterior root starts from the neurons in the anterior horn of the spinal cord. Their fibers are motor/efferent fibers.](#)

The posterior roots have **sensory/afferent** fibers. They start from the posterior horn of the spinal cord gray matter. They extend peripherally to sensory endings. Posterior and anterior nerve roots unite. [They form a mixed \(both motor and sensory\) spinal nerve.](#) A spinal nerve might carry motor signals (to the muscles basically). It can also carry sensory information. This information comes from the body to the brain. A spinal nerve also might carry autonomic signals. These signals are either from the sympathetic or parasympathetic system. As branches of the mixed spinal nerve, the posterior and anterior rami carry both motor and sensory fibers, as do all their subsequent branches. The terms motor nerve and sensory nerve are almost always relative terms, referring to the majority of fiber types conveyed.

The unilateral area of skin innervated by the sensory fibers of a single spinal nerve is called a **dermatome**. From clinical studies of lesions of the posterior roots or spinal nerves, dermatome maps have been devised to indicate the typical pattern of innervation of the skin by specific spinal nerves. Generally, at least two adjacent spinal nerves (or posterior roots) must be interrupted to produce a discernible area of numbness.

### **CRANIAL NERVES**

Like spinal nerves, cranial nerves are bundles of sensory or motor fibers that innervate muscles or glands, carry impulses from sensory receptors, or have a combination of motor and sensory fibers. They are called cranial nerves because they emerge through foramina or fissures in the cranium. The 12 pairs of cranial nerves are part of the peripheral nervous system (PNS) and pass through foramina or fissures in the cranial cavity. All nerves except one, the accessory nerve [XI], originate from the brain.

There are 12 pairs of cranial nerves, which are numbered I-XII, from rostral to caudal. Their names reflect their general distribution or function. Cranial nerves carry one or more of the following five main functional components.

#### **Motor (efferent) fibers**

**1. Motor fibers to voluntary (striated) muscle (1)** include the somatic motor (general somatic efferent) axons.

**2. Motor fibers involved in innervating involuntary (smooth) muscles or glands** include visceral motor (general visceral efferent) axons. They form the cranial outflow of the parasympathetic division of the autonomic nervous system (ANS). The presynaptic (preganglionic) fibers emerge from the brain synapse outside the central nervous system (CNS) in a parasympathetic ganglion. The postsynaptic (postganglionic) fibers continue to innervate smooth muscles and glands (e.g., the sphincter pupillae and [lacrimal gland](#)).

#### **Sensory (afferent) fibers**

**3. Fibers transmitting general sensation** (e.g., touch, pressure, heat, cold, etc.) from the skin and mucous membranes. These include somatic sensory (general somatic afferent) fibers.

**4. Fibers conveying sensation from the viscera** include visceral sensory (general visceral afferent) fibers conveying information from the carotid body and sinus, pharynx, larynx, trachea, bronchi, lungs, heart, and gastrointestinal tract.

**5. Fibers transmitting unique sensations** include special sensory fibers conveying taste and smell (special visceral afferent fibers). They serve the special senses of vision, hearing, and balance (special somatic afferent fibers).

### **Somatic Nervous System**

The somatic nervous system is made by the somatic parts of the CNS and PNS. It provides sensory and motor innervation to all parts of the body. In Latin "soma" means body. The somatic nervous system is not involved with the viscera in the body cavities, smooth muscle, and glands. The autonomic nervous system does the innervation of organs, smooth muscles and gland.

The somatic sensory system transmits sensations of touch, pain, temperature, and position from sensory receptors. Most of these sensations reach conscious levels. We are aware of them. The somatic

motor system innervates only skeletal muscles. It stimulates voluntary and reflexive movement. It causes the muscle to contract, as occurs in response to touching a hot iron. [Central and peripheral nervous systems](#)

## **VISCERAL PART OF THE NERVOUS SYSTEM**

The visceral part of the nervous system, as in the somatic part, consists of motor and sensory components:

- Sensory nerves monitor changes in the viscera.
- Motor nerves mainly innervate smooth muscle, cardiac muscle, and glands.

The sensory neurons and their processes are referred to as general visceral afferent fibers (GVAs). They are associated primarily with chemoreception, mechanoreception, and stretch reception.

*The cell bodies of the visceral motor neurons outside the CNS often associate with each other in a discrete mass called a **ganglion**. The visceral motor neurons located in the spinal cord are referred to as **preganglionic motor neurons**. Their axons are called **preganglionic fibers**. The visceral motor neurons located outside the CNS are referred to as **postganglionic motor neurons**. Their axons are called **postganglionic fibers**.*

Visceral sensory and motor fibers enter and leave the CNS with their somatic equivalents. Visceral sensory fibers enter the spinal cord together with somatic sensory fibers through *posterior roots of spinal nerves*. Preganglionic fibers of visceral motor neurons exit the spinal cord in the anterior roots of spinal nerves, along with fibers from somatic motor neurons.

Visceral motor and sensory fibers that travel to and from viscera form named visceral branches that are separate from the somatic branches. These nerves generally form plexuses from which arise branches to the viscera. In the cranial region, visceral components are associated with four of the twelve cranial nerves (CN III, VII, IX, and X). Cranial nerve number III= Oculomotor nerve. Cranial nerve number VII= Facial nerve. Cranial nerve number IX= Glossopharyngeal nerve. Cranial nerve number X= Vagus nerve.

## **AUTONOMIC NERVOUS SYSTEM**

The [parasympathetic system](#) in the spinal cord is located in the **S2-S4** spinal segments. The sympathetic division's cells are located in the spinal segments Th1-L1(2). Those visceral motor components in cranial and sacral regions, on either side of the sympathetic region, are termed parasympathetic:

- The sympathetic system innervates structures in peripheral regions of the body and viscera.
- The parasympathetic system is more restricted to innervation of the viscera only.

The visceral motor component is commonly referred to as the autonomic division of the PNS and is subdivided into sympathetic and parasympathetic parts.

The autonomic nervous system is classically described as the visceral nervous system or visceral motor system. It consists of motor fibers. These fibers stimulate smooth (involuntary) muscle, modified cardiac muscle, and glandular (secretory) cells. The efferent nerve fibers and ganglia of this system are organized into two systems or divisions. They are the sympathetic division and the parasympathetic division. The sympathetic nervous system actually functions to spend the energy. The parasympathetic nervous system is for reserving the energy. By the sympathetic system, the heart rate is increased. The blood vessels constrict. The sweat glands are activated. The sympathetic system inhibits digestive tract movements. It dilates (makes it larger) the bronchioles and the pupils. [The parasympathetic nervous system works on the contrary](#). It decreases the heart rate. The parasympathetic system dilates the blood vessels. It stimulates the digestive tract movements. It constricts the bronchioles and pupils. *An abbreviation for the functions would be SLUDD. It means salivation, lacrimation, urination, digestion, and defecation.* The sympathetic division is important in the fight or flight stress response. Both systems are active for the homeostasis of the body.

## **1.9. INTEGUMENTARY SYSTEM**

### SKIN

Skin is the largest organ of the body. It consists of the [epidermis and the dermis](#).