Smooth Muscle: Morphology, Single-unit and multi-unit smooth muscle

❖ Morphology of Smooth muscle:

Smooth muscles exhibit remarkable morphological diversity among different organs in their geometrical arrangement, shape, size, amount, and packing density of muscle fibers. The smooth muscle is composed of elongated spindle-shaped cells about **20 to 500 µm** large (the largest are contained in uterus of pregnant woman). The cells are present **individually** or in **slight bundles** found e.g. in **walls of hollow organs** (intestine, uterus etc.). The cells contain **rod-shaped nuclei** located **centrally** in the widened portion of cells. Nuclei are surrounded by numerous mitochondria, free ribosomes and Golgi complexes. Sarcoplasmic reticulum is reduced, membrane **lacks T-tubules**. Cytoplasm contain actin and myosin myofilaments which do not form myofibrils. Intermediate filaments are also found containing chiefly **desmin** and **vimentin**. The **dense bodies** are analogue of Z-lines in striated muscle and are responsible for anchoring the thin actin and intermediate filaments. These **dense bodies** are connected to the sarcolemma or dispersed in cytoplasm. The smooth muscle is found in many organs of the human body – **walls of hollow organs** (GIT, respiratory system, urogenital system, **skin**, **walls of vessels** or **iris**.

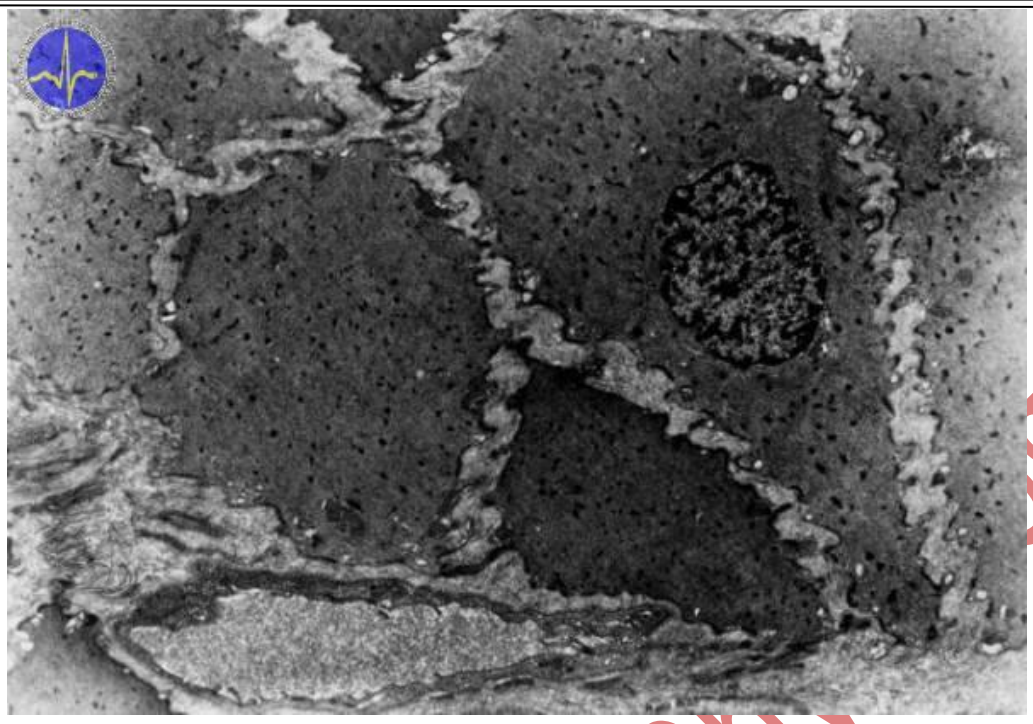

Figure: The largest smooth muscles are contained in uterus of pregnant woman.

❖ Single-unit and multi-unit smooth muscle:

The classification scheme is based on whether the smooth muscles cells in an organ function together as "one" muscle or whether each muscle cell is independent.

Smooth muscle is organized in two ways:

1. Single-unit smooth muscle:

Single-unit smooth muscle is named because all the smooth muscle cells in the organ behave as one unit. Histologically, this is accomplished by having a lot of gap junctions interconnecting the smooth muscle cells. Since gap junctions allow for electrical connections between cells, when one smooth muscle cell depolarizes, they all do. Rhythmically active smooth muscle is often also single-unit smooth muscle. This type of smooth muscle is found in the walls of all visceral organs except the heart (which has cardiac muscle in its walls), and so it is commonly called **visceral muscle**. Because the muscle

fibers are not constrained by the organization and stretchability limits of sarcomeres, visceral smooth muscle has a **stress-relaxation response**. This means that as the muscle of a hollow organ is stretched when it fills, the mechanical stress of the stretching will trigger contraction, but this is immediately followed by relaxation so that the organ does not empty its contents prematurely. This is important for hollow organs, such as the stomach or urinary bladder, which continuously expand as they fill. The smooth muscle around these organs also can maintain a muscle tone when the organ empties and shrinks, a feature that prevents "flabbiness" in the empty organ. In single-unit smooth muscle, a single smooth muscle cell in a bundle is innervated by an autonomic nerve fiber. An action potential can be propagated through neighbouring muscle cells due to the presence of many gap junctions between the cells. Due to this property, SUVSM bundles form a syncytium that contracts in a coordinated fashion (such as uterine muscles do during childbirth). Single-unit visceral smooth muscle is **myogenic**; it can contract regularly without input from a motor neuron (as opposed to multiunit smooth muscle, which is neurogenic that is, its contraction must be initiated by an autonomic nervous system neuron). A few of the cells in a given single-unit smooth muscle unit may behave as pacemaker cells, generating rhythmic action potentials due to their intrinsic electrical activity. Because of its myogenic nature, single-unit smooth muscle is usually active, even when it's not receiving any neural stimulation.

The smooth muscle of the GI tract is a good example of single-unit smooth muscle. In order to mix the gastric/intestinal secretions with the food you ingest and then single-unit smooth muscle produces slow, steady contractions that propel the mixture onto the parts of the digestive tract that will absorb the food, the smooth muscle must function as a coordinated group of muscle.

Single-unit smooth muscle found in the uterus, gastro-intestinal tract, and the bladder.

2. Multi-unit smooth muscle:

In multi-unit smooth muscle, the smooth muscle cells in an organ all behave independently - each cell contracts and relaxes on its own. Histologically, multi-unit smooth muscle has many fewer gap junctions than other types of smooth muscle. Since each smooth muscle cell is on its own, there is no great need to electrically couple the cells via a gap junction. As a result, contraction does not spread from one cell to the next, but is instead confined to the cell that was originally stimulated. Stimuli for multiunit smooth muscles come from autonomic nerves or hormones but not from stretching. Multi-unit smooth muscles are neurogenic in nature. Its contraction must be initiated by an autonomic nervous system neuron. Tonically active smooth muscle is often multiunit in nature - when you spend most of the time contracting, it does not matter whether you and your neighbors are all working "in synch" or not. Multi-unit smooth muscle is found in several places, but vascular smooth muscle is one good example of multi-unit smooth muscle. They found around large blood vessels, in the respiratory airways, and in the eyes.

❖Differentiate between Single-unit smooth muscles and multi-unit smooth muscles:

Single-unit smooth muscles	Multi-unit smooth muscles
Single-unit muscles are made of muscle fibres closely joined together by gap junctions.	Fibres remain separated from each other by a basement membrane.
Single unit smooth muscle cells are electrically coupled, so that the action potential can pass from one cell to the	Multi unit smooth cells, however, are not electrically coupled and hence the cells must be stimulated seperatley.

adjacent cells via gap junctions.	
All fibres in a muscle contract together as a single unit.	The individual fibres of these muscles thus contract as separate units.
Single-unit muscles are innervated by an autonomous nerve and they contract all together in a coordinated rhythm.	Each cell is therefore situated close to an axon terminal or variscosity where it can easily make contact with a neurotransmitter, This structure allows specific selection of cells and therefore a greater control of the contractions.
Single-unit visceral smooth muscle is myogenic. It can contract regularly without input from a motor neuron.	Multi-unit smooth muscles are neurogenic in nature. Its contraction must be initiated by an autonomic nervous system neuron.
The fibres are therefore all stimulated at the same time so force of contraction is controlled by the calcium ion concentration, the higher the concentration the more force is generated.	As the cells are not electrically coupled the force of contraction can be controlled by the number of contractile muscle fibres.
The majority of smooth muscle is of the single-unit type for simultaneous contraction within organs. Single-unit smooth muscle found in the uterus, gastro-intestinal tract, and the bladder.	Multiunit smooth cells can be found in the Iris of the eye and the Vas deferens in the male genital tract.