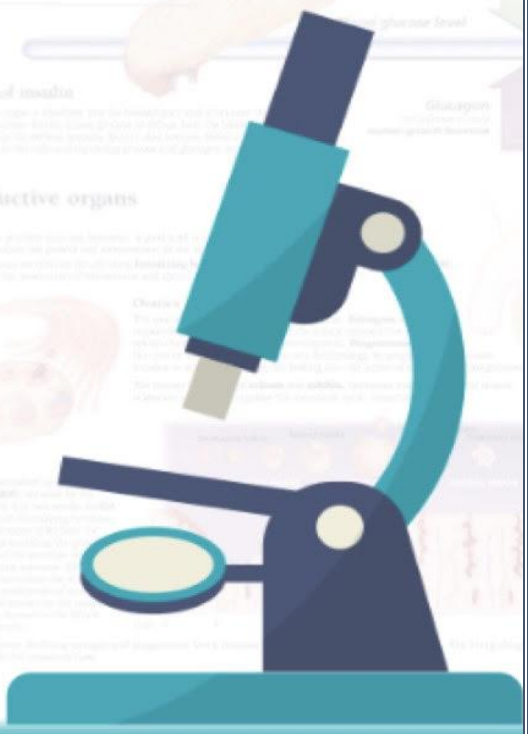
Doctor 022

Histology

Sheet no.5



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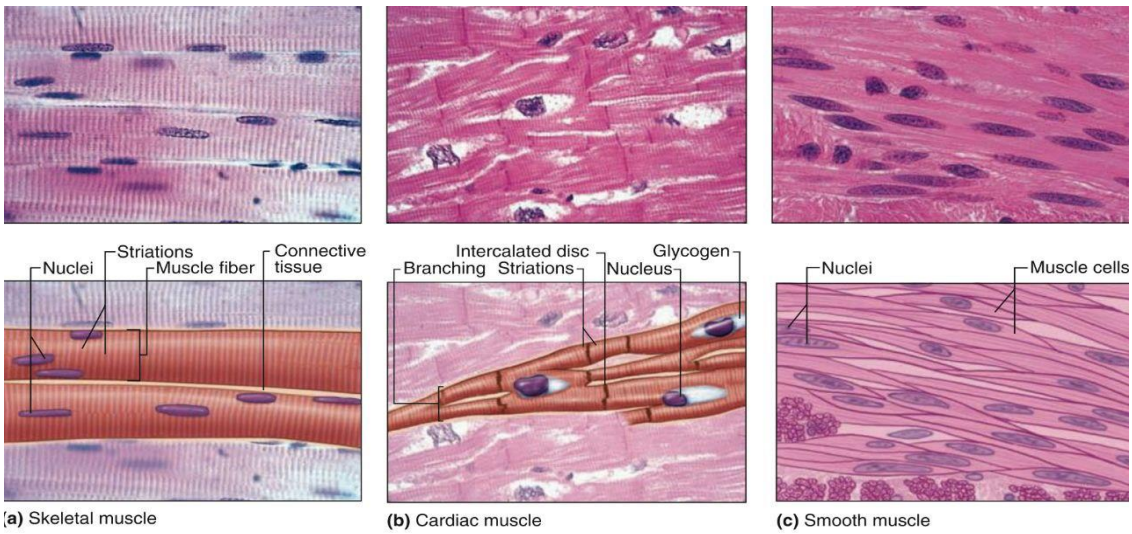
ملاحظة: كلام الدكتورة باللون الأسود و السلايدات باللون الأزق والكتاب بالأحمر

ملاحظة2: آخر صفحتين هي الموضوع الي حكت الدكتورة ادرسوه لحالكم من الكتاب (بسيط)

Muscles Tissue:

- We have 3 types of muscle tissue because each one has its own special characteristics, even the contraction varies in type.



(a) Skeletal muscle (b) Cardiac muscle (c) Smooth muscle

- If we look at skeletal muscle, we will notice that it is straited.
- If we look at cardiac muscle, we will notice that it is straited too but with branches. (that's why they look shorter)
- If we look at smooth muscle, we will notice that it is spindle shaped and elongated.

- Skeletal muscle can be associated with: Bone, skin (that's why you are able to do facial expression),other muscles and ligaments. Its more accurate to say muscle fiber not muscle cell because it composed of so many cells.

- Cardiac muscle fibers contract throw out your life and they stop when u die so you can't imagen skeletal muscle or smooth to do such a function like that.
- Smooth muscle are everywhere(doctor said a lot of examples but I think she will repeat them when we study smooth muscles, if she not I will edit this), if we look at blood vessels specifically at aorta(largest blood vessel) I will find smooth muscle but the elastic fibers are the ones that control the dilatation and narrowing of it, in capillaries we won't find smooth muscles.

Skeletal muscle	Cardiac muscle(heart only)	Smooth muscle
1- bundles of very long, multinucleated (10-100 µm) diameter (because it comes from many cells) cells with cross-striations (due to the special arrangement of the thick and thin filament within the muscle fiber). 2- Their contraction is quick, forceful, and usually under voluntary control. (the only muscle that you have control on it). innervated by somatic motor nerve.	1- cross-striated and is composed of elongated (often branched), cells bound to one another at structures called intercalated discs (unique). (dark pinkish lines between the cells) 2- Contraction is involuntary, vigorous, and rhythmic. (قوي ومنتظم وما بتحكم فيه) When I see a darker color than the one around it that's mean I have concentration of something, it is the finger like junction between the cardiac muscles fibers and we call it intercalated discs.	1-consists of collections of fusiform cells that lack striations (because the structure that connect with the thin is different from the ones in the skeletal and cardiac) and have slow, involuntary contractions. Innervated by autonomic nerves system.

Skeletal (striated) muscle:

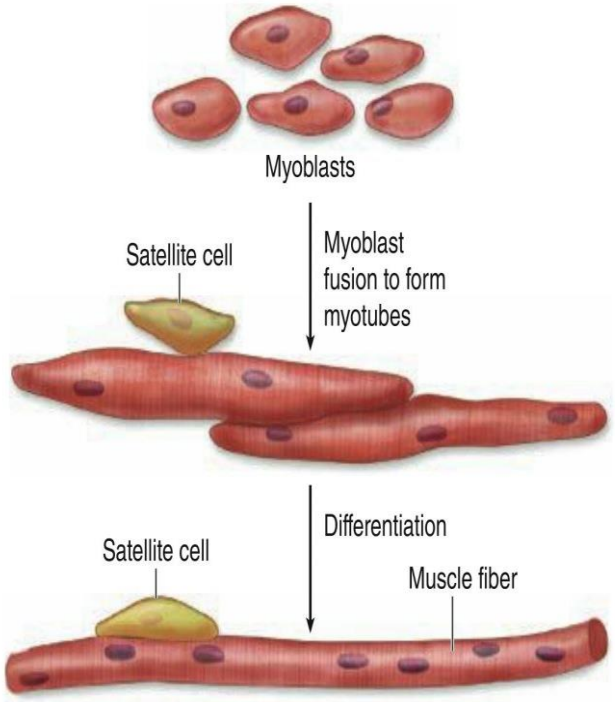
- All the muscles in general speaking are coming from mesenchyme.

1-the first sign of these mesenchymal cells preparation to be muscle cells is to give us Myoblasts.

2- Mesenchymal myoblasts will fuse together to make longer, multinucleated tubes called myotubes (very long and the nuclei is located periphery of the cell not in the middle of it). Myotubes continue differentiating to form functional striated muscle fiber.

3- Satellite cells: A small population of reserve progenitor cells.

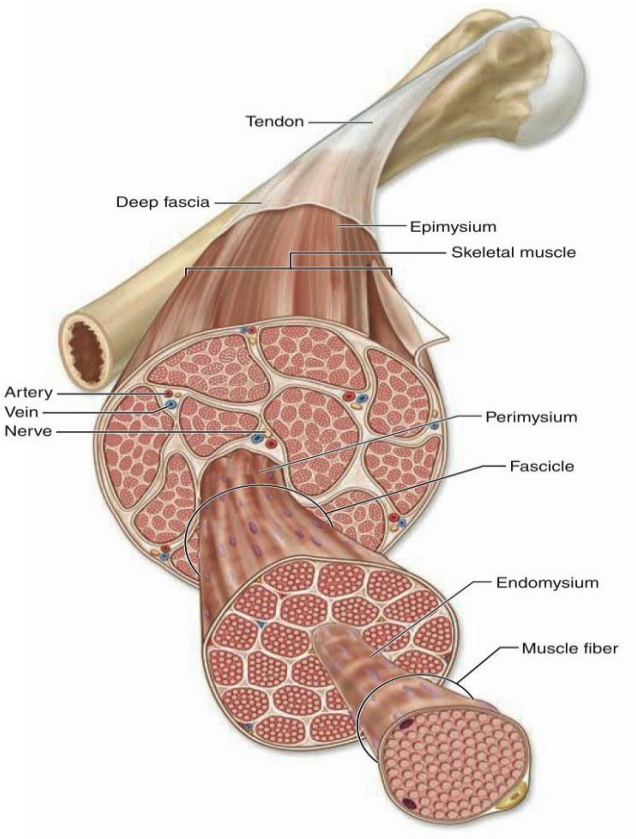
- progenitor cells: myoblast cells that not fully differentiated.
- If we need to do some regeneration or repair for the muscle some of these will go finally differentiate and gives us muscle fiber. (Fuse with pre-existing muscle fiber).



However, their percentage is small, so if the damage is massive, they will not be able to heal the muscle and the only way to heal it is scar tissue which is strong and less elastic compared to the muscle fiber so we will lost significance amount of the contraction of the muscle and big part of the muscle is replaced by scar tissue .

Organization of Skeletal muscle:

- There must be a connective tissue around the skeletal muscle to make it one isolated structure, because when contraction happen all are moving together not in different directions.
- We have 3 layer of connective tissue that cover the skeletal muscle generally and each one has a name depending on which part of the muscle you are talking about.



• All three layers, plus the deep fascia (overlies the epimysium) are continuous with the connective tissue of a tendon at myotendinous junctions (join the muscle to bone, skin, or another muscle).

1- Epimysium (around skeletal from out side): External sheath of dense irregular connective tissue (it is thick). Carries vessels, nerves, and lymphatics.

Note that arteries and nerves are coming to the muscle while veins and lymphatics are moving away from it. And all of them are moving under Epimysium.

2- Perimysium :Thin connective tissue layer that immediately surrounds each bundle of muscle fibers (fascicle). Nerves, blood vessels, and lymphatics penetrate the perimysium to supply each fascicle .(filtration happen to it to make blood supply reach the inner muscle fiber)

3- Endomysium (around muscle fiber): Very thin and delicate layer of reticular fibers/scattered fibroblasts. fibers, capillaries form a rich network around it.

The smallest around the muscle fiber.

- We can make it look like the building we are in, every hall is a Fascicle and everyone of us is a muscle fiber and Endomysium around it.

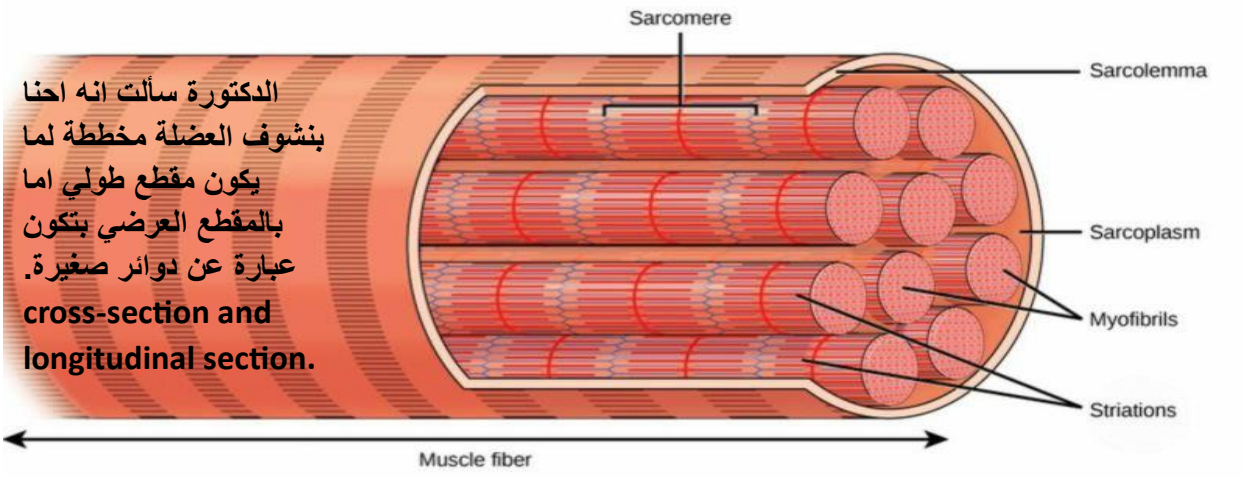
- The tiny artery further broken down into network of capillaries which will surround the muscle fiber to bring O2 to it.

مين جيف بيزوس الي برن تلفونه ؟محمد؟؟ لحد الآن حالتين طرد و7 حالات بهدلة وما زلنا مستمرين (:

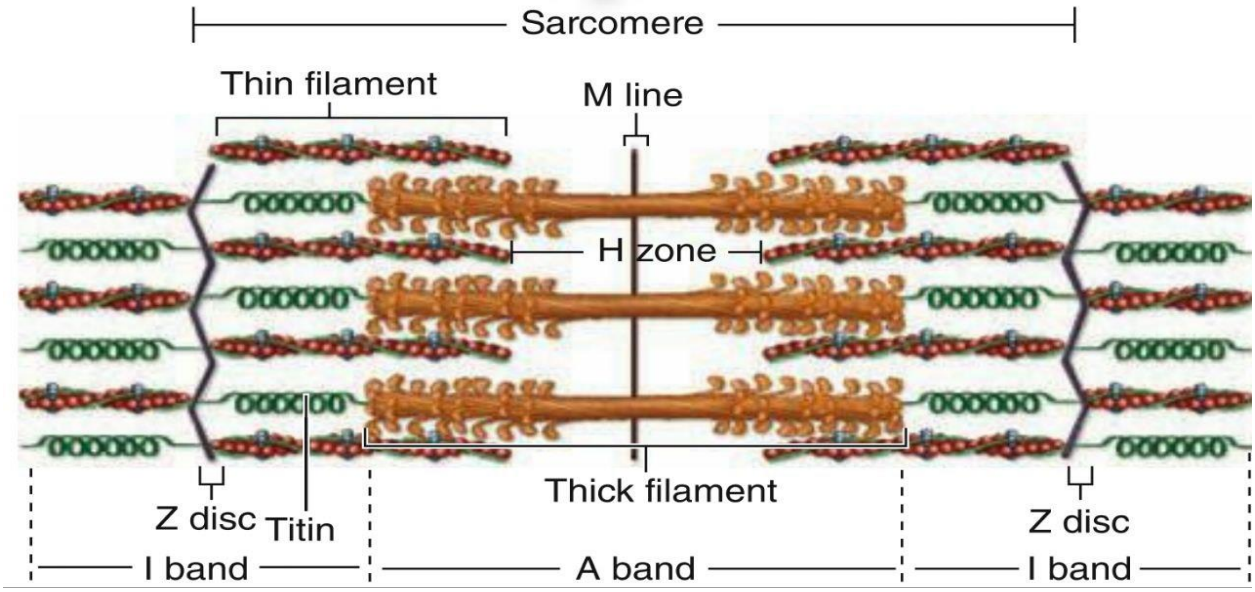
Organization within muscle fibers:

- We have cytoplasm inside the cells but in muscle fibers we call it **sarcoplasm**.
- The cell membrane is called **sarcolemma**.

The thin filaments surrounding the thick filaments from all directions.



- Longitudinally, skeletal muscle fibers show striations of alternating light and dark bands Contains cylindrical filament bundles called **myofibrils** that run parallel to the long axis of the fiber.
- The dark bands are called **A-band**, the light bands are called **I-bands**, The I-band is bisected by a dark transverse line (Z-disc).
- Sarcomere is the repetitive functional subunit of the contractile apparatus, as well as the one that shortens (contraction) and lengthens (relaxation) (extends between 2 Z-discs). **2.5 um** in resting muscle.
- Contraction and relaxation Depending on the length of the sarcomere.
- Myofibrils: consist of an end-to-end repetitive arrangement of sarcomeres. (Thick and Thin filament, and that's why the myofibrils are striation.)



تم بهدلة 9 اشخاص حتى اللحظة :)

- If we look at this picture what will we note? I think it is better to read then see the picture

1- In the center of the light (I-band) there is a Z-disc and in between the sarcomere.

Z-disc: linking and anchoring protein. (Thin filaments bound to α-actinin in the Z disc)

2-In the center of A-band (dark) is m-Line and it is in the middle of the sarcomere.

3- A-band contain thick and overlapping thin filament but there is a region contain just thick filaments in the middle of it we call it H-zone.

4- I-band contain only thin filaments.

To summarize: A-band: contain thick and thin.

H-zone: only thick.

I-band: only thin.

By the way it is not accurate to say myosin and actin.

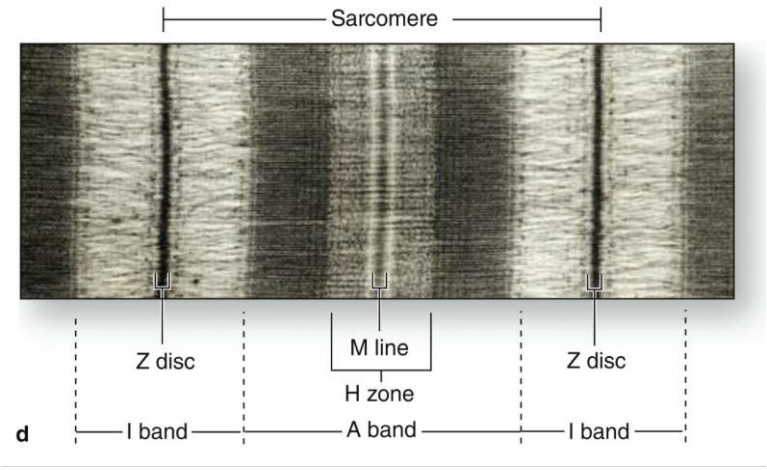
We say thick and thin then we take the thin and see the compartments and take the thick and see the compartments.

5-in the picture there is a protein called titin (very large linking protein).

So the thin filaments make direct contact but the thick make indirect contact with Z-disc(by contacting with titin and titin contacting with Z).

Now, what do u expect to be shorter? I-band, H-zone and sarcomere only!!

The thin filaments will be part of A-band in contraction because it will slide to m-line.



- Transmission Electron microscope

The lighter region in the center of A- band is H-zone and I can know if the muscle is relaxed or contract by notice if H-zone disappear or not.

اكيد جاي سؤال بالامتحان عن هاي الصورة سواء كانت العضلة مرتاحة او مقبوضة فمهم الموضوع

- In I-band one half belongs to sarcomere and the other one belongs to another sarcomere.

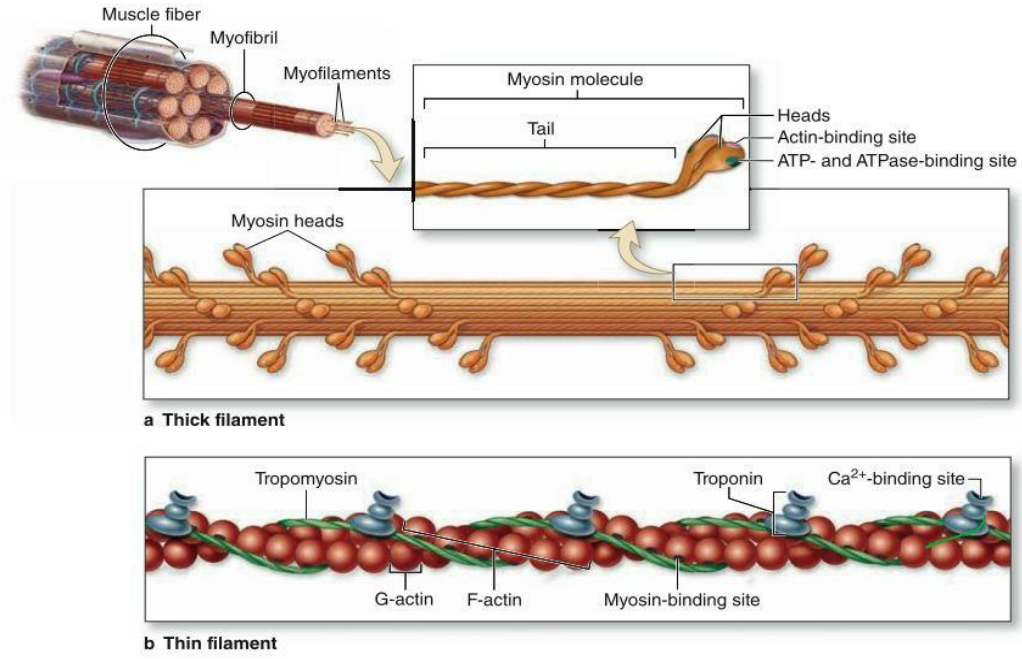
- H-zone disappear in the fully contracted muscle.

لولا المشقة ساد الناس كلهمُ الجود يفقر والإقدام قتّالُ

صدقت الدكتورة عندما قالت انها تحفظ الوجوه يا مايكل!

Structure:

- The thick filament is composed of many many many myosin molecules twisted and screwed together. (A thick myofilament contains 200-500 molecules of myosin)
- Myosin is a large complex with two identical heavy chains and two pairs of light chains. (2 heavy and 4 light)
- Globular projections containing the four myosin light chains form a head at one end of each heavy chain.
- Globular which have the heads of myosin are the ones which will sticking out because it will attach with thin filament.
- The myosin heads bind both actins (The thin filament consists of two twisted strands of actin molecules), forming transient crossbridge between the thick and thin filaments, and ATP, catalysing energy release (actomyosin ATPase activity).
- Several hundred myosin molecules are arranged within each thick filament with overlapping rodlike portions and the globular heads directed toward either end.



ملاحظة : انتبه على جميع الرسمات

ملاحظة 2: انتبه على الأرقام أيضا لأنه كان في سؤال بالفيرست

- The thin, helical actin filaments are each 1.0-µm long and 8- nm wide and run between the thick filaments.
- Many proteins make thin filaments so it's incorrect when we say actin only.
- We have G-actin protein and when they bound together we will have F-actin ,there is Tropomyosin wrapped around F-actin and Troponin attached to Tropomyosin.
- ca^{+2}will bind to Troponin.
- Each G-actin monomer contains a binding site for myosin.
- Now what will happen(we will take details in physiology), we have 2 sites on the myosin head (actin binding site and ATP-ATPase-binding site where it will bound and then it will hydrolyse then we will use its energy and then released as ADP)when ATP bind to myosin head, at the same time we will have ca^{+2} binding.

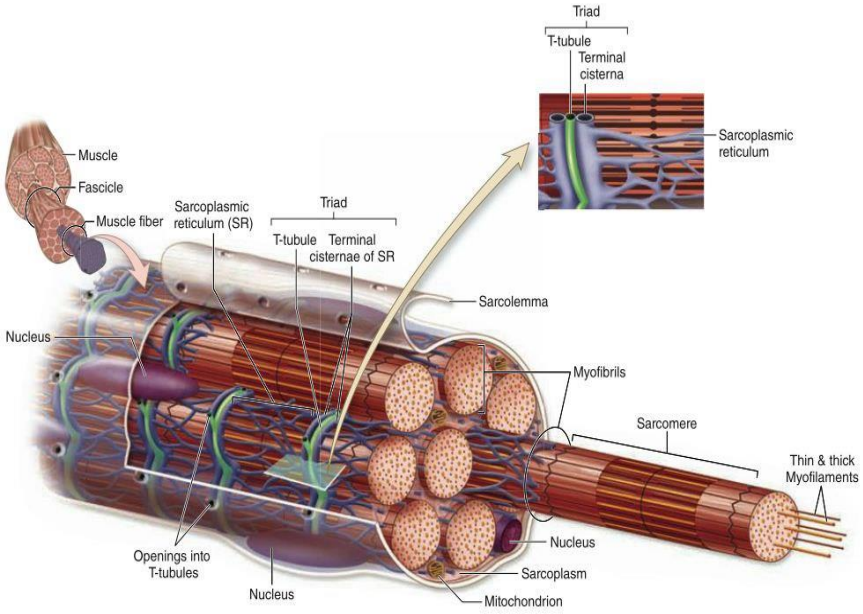
After that, the head of myosin will bind to the binding site on the actin filament and conformational change will happen.

- When they bind what they doing? They will pull the thin lines toward the m-line, then release then they will bind to much further location closer to the Z-disc and so on until they reach the contraction that we need, now there is a different between light contraction or maximum contraction where there is overlapping between the thin filaments.

SARCOPLASMIC RETICULUM & TRANSVERSE TUBULE SYSTEM:

- Endoplasmic reticulum in the muscle fiber is called SARCOPLASMIC RETICULUM.
- Sarcoplasmic reticulum contains pumps and other proteins for ca2+ sequestration and surrounds the myofibrils.

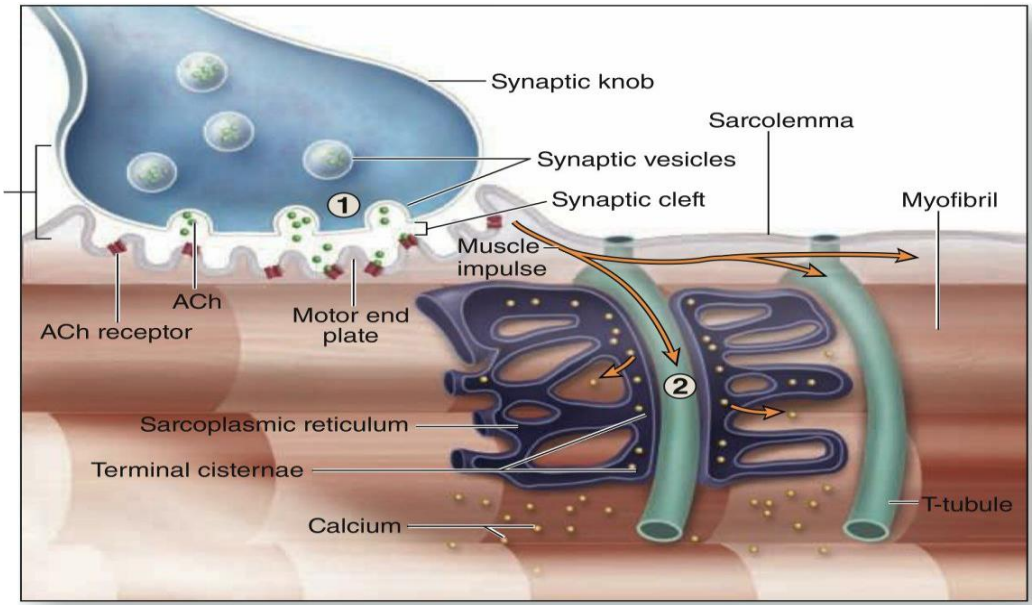
  - sarcolemma has tubular infoldings called transverse or t-tubules (finger like). Penetrate deeply into the sarcoplasm and encircle each myofibril near the aligned A- and I-band boundaries of sarcomeres.
  - Adjacent to each t-tubule are expanded terminal cisternae of sarcoplasmic reticulum.
  - Complex of a t-tubule with two terminal cisternae is called a triad.



- It will be spread out along the muscle fiber because all of it will contract at the same time.
- This arrangement of 1 T-tubules in the center and 2 cisternae side by side is called Triad.

In this slide we see axon, and this is axon terminal which contain vesicles that contain neurotransmitters.

This is somatic motor neuron as it going to a muscle fiber (somatic motor going to muscle to contract or to gland to secrete and in this pic, we have just muscle fiber.



- The neurotransmitters for muscles is acetylcholine (ACh), so this Ach neurotransmitters will bind to the receptors on the motor end plates(MEP) and this will translated into electricity (which is the action potential).(depolarization)

Information from the slides that the doctor mention some of them and some not

And I will write them in black to make it easier to read:

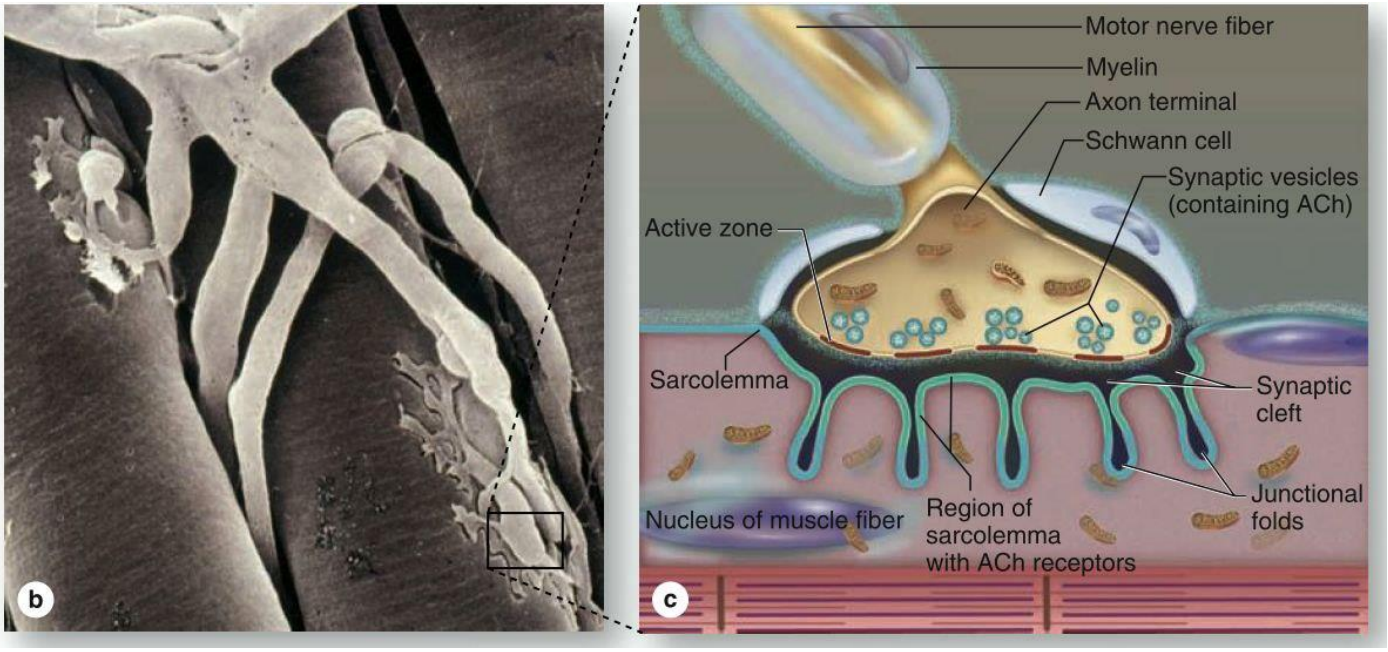
- Myelinated motor nerves branch out within the perimysium, where each nerve gives rise to several unmyelinated terminal twigs that pass-through endomysium and form synapses with individual muscle fibers.

- Schwann cells enclose the small axon branches.
- Each axonal branch forms a dilated termination called neuromuscular junctions, or motor end plates (MEP).

- The axon terminal contains mitochondria and numerous synaptic vesicles which contain neurotransmitter acetylcholine.
- Between the axon and the muscle is the synaptic cleft.

- Adjacent to the synaptic cleft is the sarcolemma which have deep junctional folds which will make greater postsynaptic surface area and more acetylcholine receptors.
- Acetylcholine + receptor-----depolarizing the sarcolemma---muscle action potential.

- muscle action potential moves along the sarcolemma and along T-tubules.
- At triads the depolarization signal triggers the release of Ca2+ from terminal cisterns of the sarcoplasmic reticulum--- contraction cycle.
- An axon can form MEPs with one or many muscle fibers.



Scanning electron microscope

Now let's talk about something else:

- If we look at the muscle on top, it is a big muscle, if the ratio between every muscle and axon is 1:1 this axon must be as big as the muscle, is this actually happen? No, what happen is motor axons branch profusely and innervated 100 or more muscle fibers (motor unit). That's explain why the muscle is big but the nerve that coming to it is not big.
- On the other hand, we have muscles that the every axon is going to one muscle fiber, we find that in muscles have high precision like the muscles in the outside of the eye ball (eye movement) and we call them (extraocular muscles).
- In this muscles the ratio between the muscle fiber and axon is 1:1 almost.
- Motor unit: one axon that provides many muscle fibers which means higher ratio of axon muscle fiber.(1:100 or more)
- So we can say: "The more the precise is higher in the muscle the lower the ratio between axons muscle fibers"
- "The bigger the muscle, the less specific of its function the higher the ratio between axons muscle fibers"

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تَعصي الإِلَهَ وَأَنتَ تُظهِرُ حُبَّهُ هَذا مَحالٌ في القِياسِ بَديعُ

لَو كانَ حُبُّكَ صادِقاً لَأَطَعتَهُ إِنَّ المُحِبَّ لِمَن يُحِبُّ مُطيعُ

في كُلِّ يَومٍ يَبتَديكَ بِنِعمَةٍ مِنهُ وَأَنتَ لِشُكرِ ذاكَ مُضيعُ

الامام الشافعي رحمه الله

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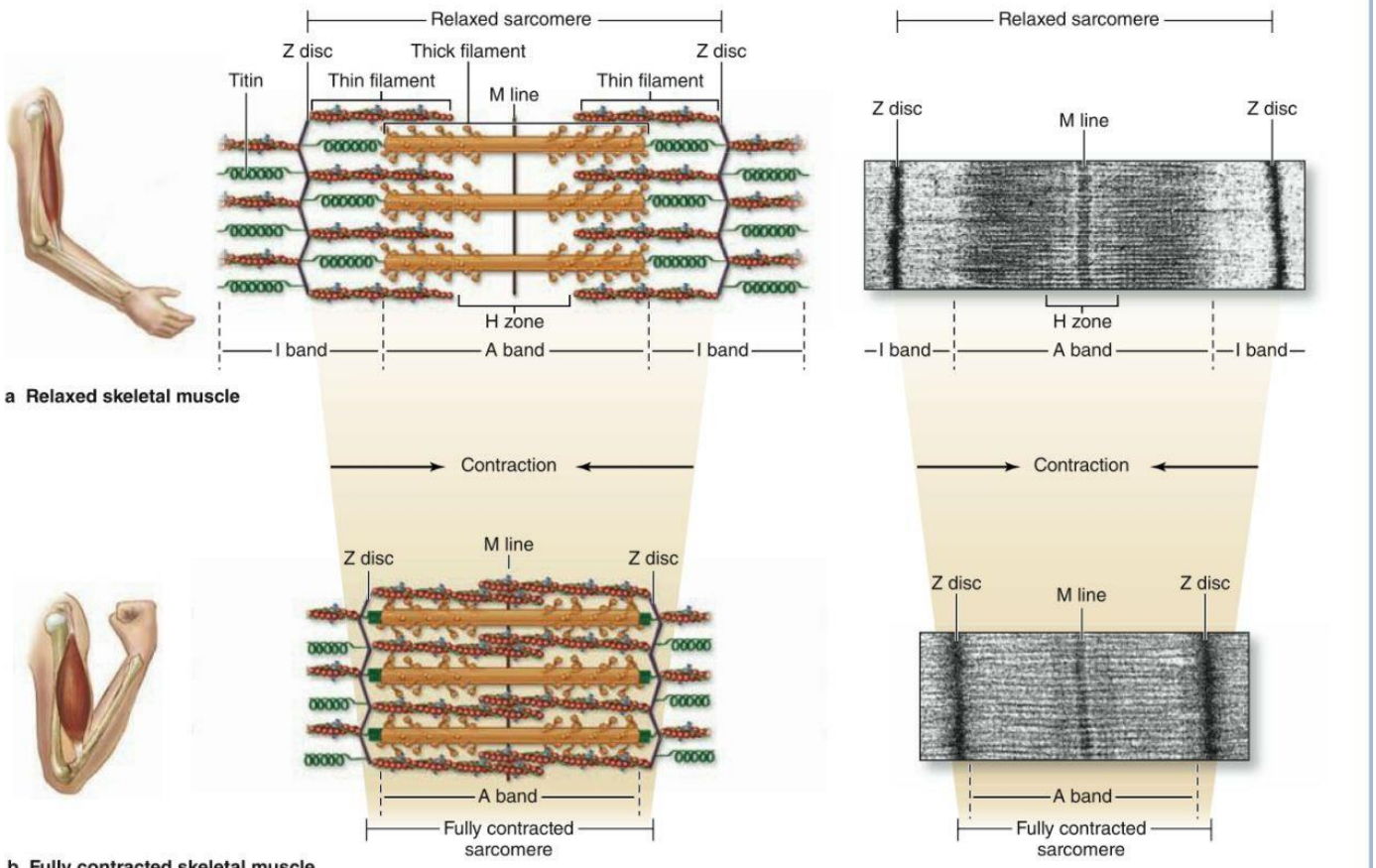
FIGURE **10–12** **Sliding filaments and sarcomere shortening in contraction.**



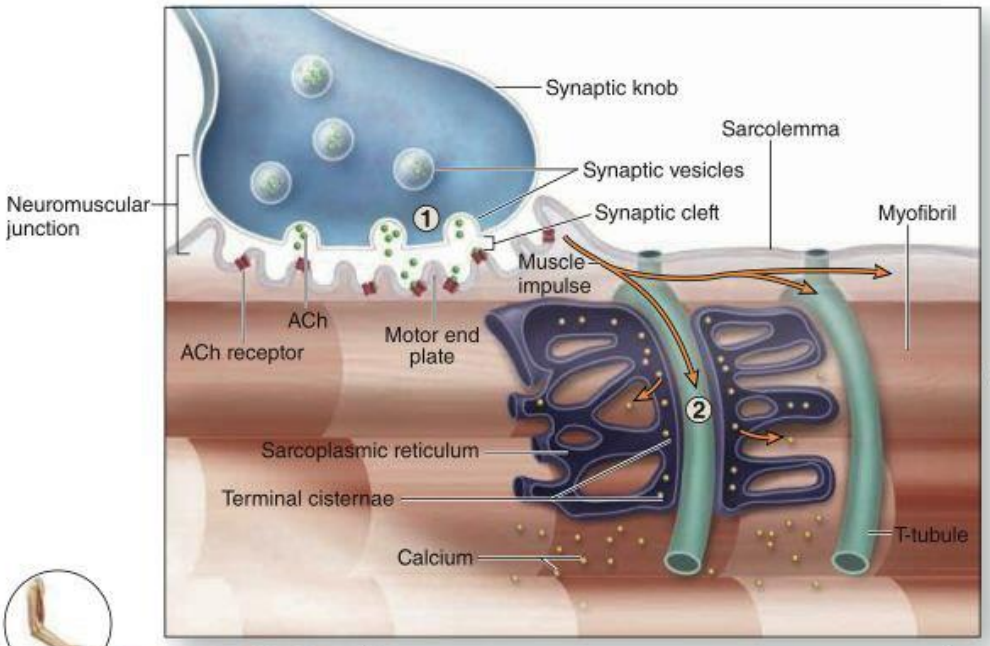
- Striated muscle fibers do not show graded contraction = all or none(كلهم بنقبضوا أو لا)
- There is something that might happen we call it **partial contraction**, not all the fibers contract at the same time but if contraction happen in muscle fiber all the sarcomere must contract.
- Look at the thick filament in the contraction muscle, almost touching the Z-disc
  If the titin was not Exist, the thick filaments would touch it.
- The thin filaments are over lapping.
- Look at Z-disk in contraction muscle it look loke there is something around it because the approach of the thick filament toward the Z-disc.
- In the fully contracted muscle almost all of its sarcomere become A-band and I-band is extremely shorten.
- When you don't see striation you are looking at contraction muscle.

1-المفروض بس يصير انقباض يصير اللون أغمق ولكن في الصورة الثانية مبين أفتح لأنه الصورة من موقع آخر غير موقع العضلة وهي مرتاحة

2-في سؤال عن الصورة هاي 100% الدكتورة حكت فركزوا عليها

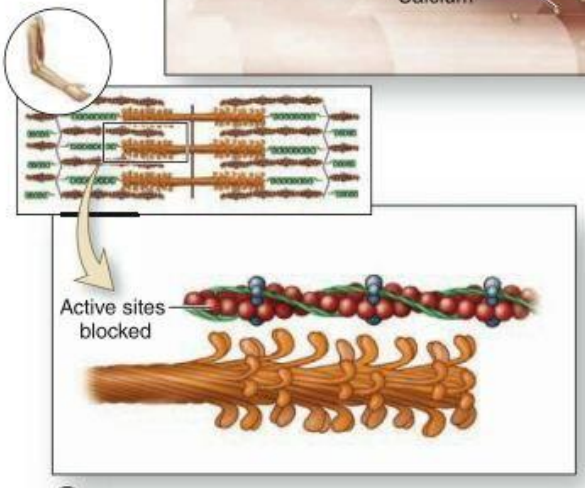
3-لا تنسونا من صالح دعائكم وأي نقص أو خطأ يرجى التنبيه وجُزيتم خيرًا

You can read this if you want (take my advice and read it) (a lot of information we have mention earlier).

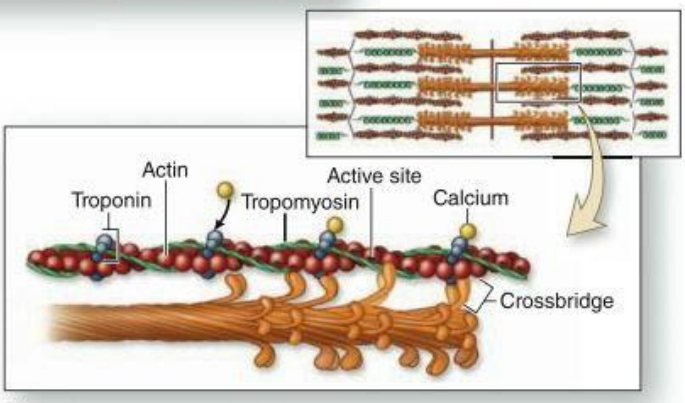


① A nerve impulse triggers release of ACh from the synaptic knob into the synaptic cleft. ACh binds to ACh receptors in the motor end plate of the neuromuscular junction, initiating a muscle impulse in the sarcolemma of the muscle fiber.

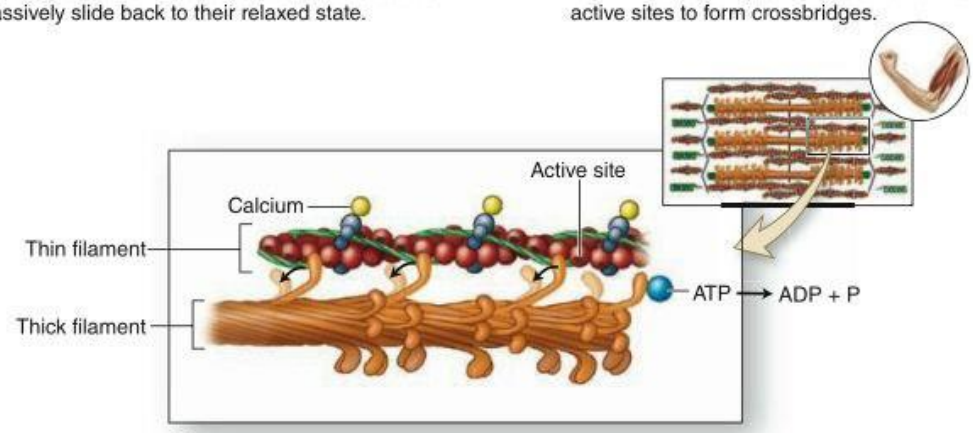
② As the muscle impulse spreads quickly from the sarcolemma along T tubules, calcium ions are released from terminal cisternae into the sarcoplasm.



⑤ When the impulse stops, calcium ions are actively transported into the sarcoplasmic reticulum, tropomyosin re-covers active sites, and filaments passively slide back to their relaxed state.

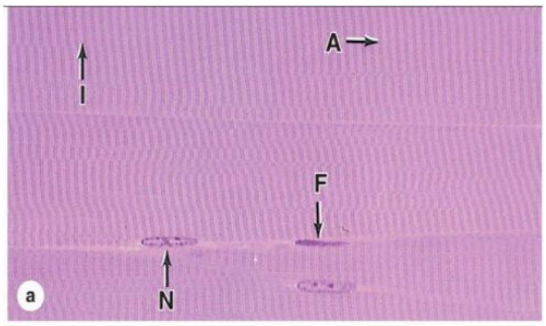


③ Calcium ions bind to troponin. Troponin changes shape, moving tropomyosin on the actin to expose active sites on actin molecules of thin filaments. Myosin heads of thick filaments attach to exposed active sites to form crossbridges.

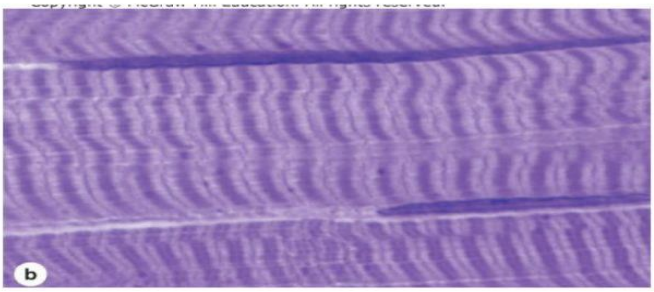


④ Myosin heads pivot, moving thin filaments toward the sarcomere center. ATP binds myosin heads and is broken down into ADP and P. Myosin heads detach from thin filaments and return to their prepivot position. The repeating cycle of *attach-pivot-detach-return* slides thick and thin filaments past one another. The sarcomere shortens and the muscle contracts. The cycle continues as long as calcium ions remain bound to troponin to keep active sites exposed.

- Structure and striation



A: A Band
I: I Band
N: Nucleus of muscle f
F: Nucleus of fibroblas
Z: Z disc
H: H zone
M: Mitochondria.



الدكتورة ما حكت اشي عنهم ولكن اظن
انه راح تحكي عنهم باللاب

MUSCLE SPINDLES & TENDON ORGANS: Self Study!!!

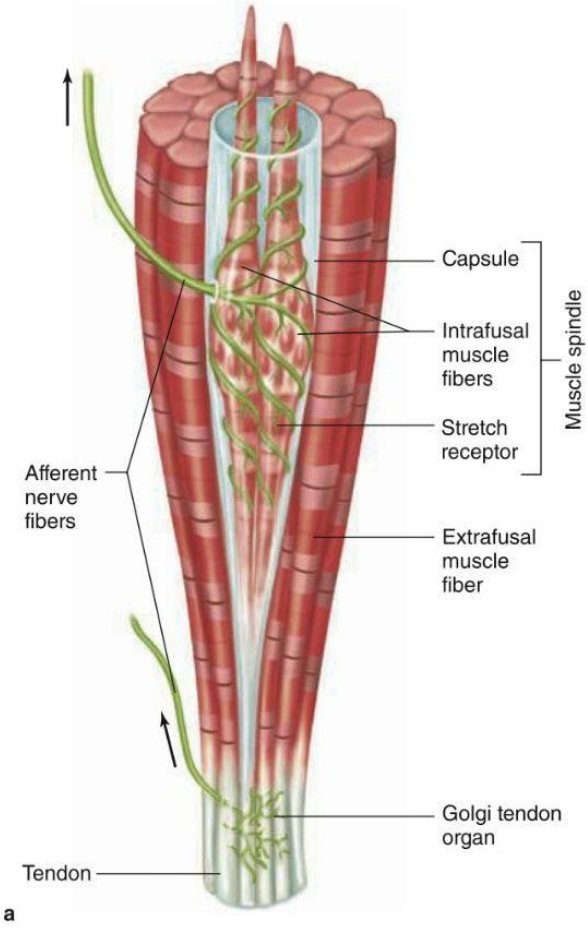
Muscle Spindles & Tendon Organs

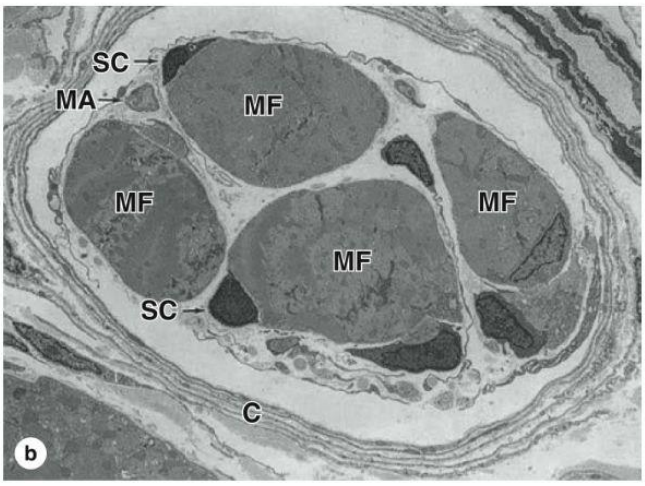
Striated muscles and myotendinous junctions contain sensory receptors acting as proprioceptors (L. *proprius*, one's own + *capio*, to take), providing the central nervous system (CNS) with data from the musculoskeletal system. Among the muscle fascicles are stretch detectors known as **muscle spindles**, approximately 2-mm long and 0.1-mm wide (Figure 10–14a). A muscle spindle is encapsulated by modified perimysium, with concentric layers of flattened cells, containing interstitial fluid and a few thin muscle fibers filled with nuclei and called **intrafusal fibers** (Figure 10–14). Several sensory nerve axons penetrate each muscle spindle and wrap around individual intrafusal fibers. Changes in length (distension) of the surrounding (extrafusal) muscle fibers caused by body movements are detected by the muscle spindles and the sensory nerves relay this information to the spinal cord. Different types of sensory and intrafusal fibers mediate reflexes of varying complexity to help maintain posture and to regulate the activity of opposing muscle groups involved in motor activities such as walking.

A similar role is played by **Golgi tendon organs**, much smaller encapsulated structures that enclose sensory axons penetrating among the collagen bundles at the myotendinous junction (Figure 10–14a). Tendon organs detect changes in tension within tendons produced by muscle contraction and act to inhibit motor nerve activity if tension becomes excessive. Because both of these proprioceptors detect increases in tension, they help regulate the amount of effort required to perform movements that call for variable amounts of muscular force.

عليه سؤال بالامتحان أكيد

FIGURE **10–14** **Sensory receptors associated with skeletal muscle.**





(a) The diagram shows both a **muscle spindle** and a **tendon organ**. Muscle spindles have **afferent sensory** and efferent motor nerve fibers associated with the **intrafusal fibers**, which are modified muscle fibers. The size of the spindle is exaggerated relative to the extrafusal fibers to show better the nuclei packed in the intrafusal fibers. Both types of sensory receptors provide the CNS with information concerning degrees of stretch and tension within the musculoskeletal system.

(b) A TEM cross section near the end of a muscle spindle shows the capsule (**C**), lightly myelinated axons (**MA**) of a sensory nerve, and the intrafusal muscle fibers (**MF**). These thin fibers differ from the ordinary skeletal muscle fibers in having very few myofibrils. Their many nuclei can either be closely aligned (nuclear chain fibers) or piled in a central dilation (nuclear bag fibers). Muscle satellite cells (**SC**) are also present within the external lamina of the intrafusal fibers. (X3600)

The End

تم بحمد الله تعالى

محصلة المحاضرة: كرت احمر 2

كرت اصفر 10

حكيت للدكتورة إني ما فهمت شغلة ورجعت شرحتلي إياها (: