

PHYSIOLOGY



Lec: 26

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General physiology
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Lecture 26
Skeletal Muscle Contraction I

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Types of Muscle

- **Skeletal**

- Attached to bones of skeleton *through tendons*
- Makes up 40% of body weight
- Responsible for locomotion, facial expressions, posture, respiratory movements, vocalization *الصوت*

*فصل
العضلات*

→ Joints stabilization etc.

– Voluntary in action; controlled by somatic motor neurons

– Striated

*Why?? Because it is innervated by α motor neurons [*التي تسيطر على*]*

– Heat production

– Excitable tissue

– Contract in response to nerve stimulation

Types of muscles

- **Smooth**

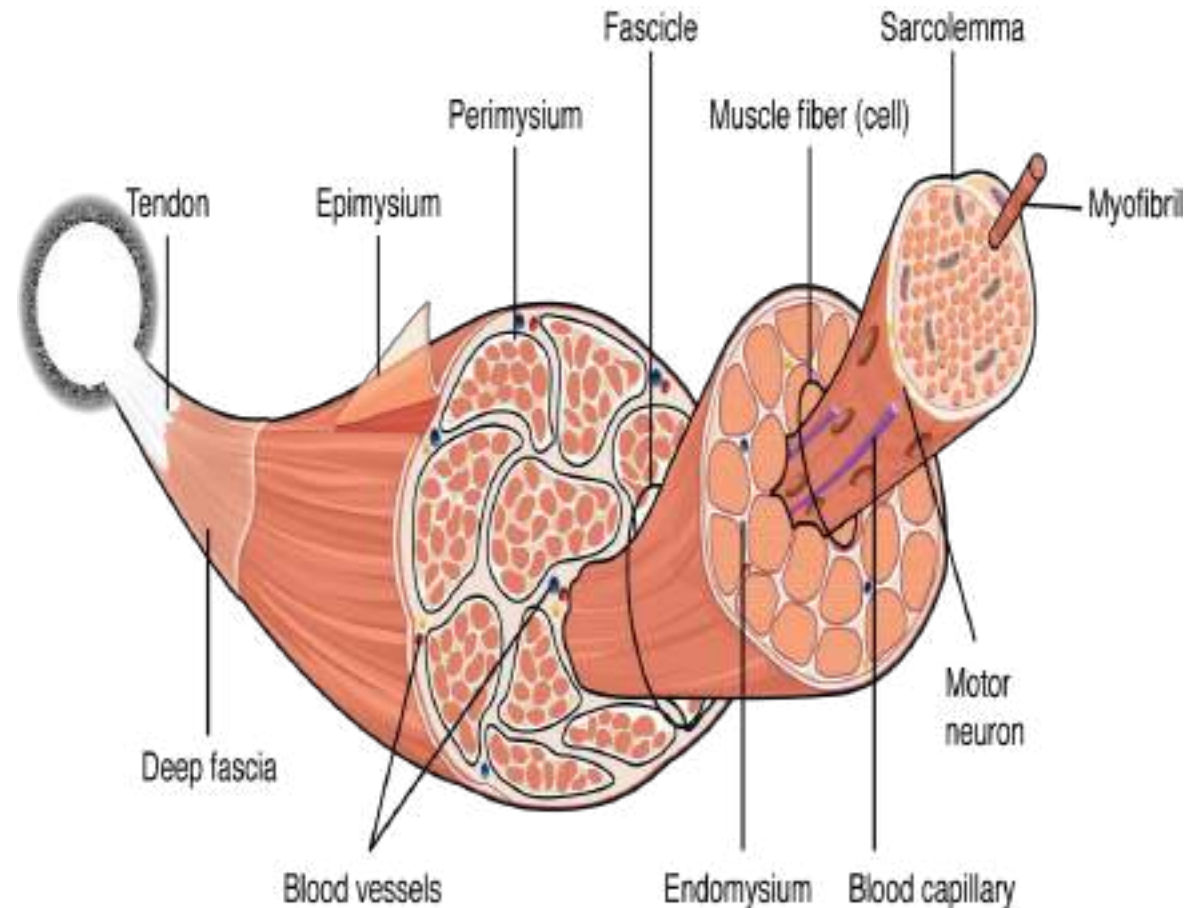
- In the walls of hollow organs, blood vessels, eye, uterus, skin
① ② ③ ④
– Some functions: propel urine, mix food in digestive tract, dilating/constricting pupils, regulating blood flow, regulate airways resistance etc *in eye*
– In some locations, **autorhythmic** → *pacemaker* → *تولید AP بدون آئیون*
– **Controlled involuntarily by endocrine and autonomic nervous systems**
– Some have spontaneous activity
– Non striated

- **Cardiac**

- Striated
- Heart: major source of pumping blood and movement of blood in circulatory system
- **Autorhythmic**
- **Controlled involuntarily by endocrine and autonomic nervous systems**

Functional Anatomy of skeletal muscles .

- Epimysium – loose connective tissue sheath surrounding each skeletal muscle
تغيب العضلة بالكامل
- Muscle Fasciculi – visible bundles that compose the muscle – these bundles are composed of multiple muscle fibers (cells)
مجموعة بينة كل bundle و bundle
- Perimysium – loose connective tissue surrounding the muscle fasciculi
مجموعة بينة كل muscle fiber
- Endomysium – loose connective tissue surrounding each muscle fiber – functions to separate and electrically isolate each cell



Ultrastructure of muscle fiber

muscle cell

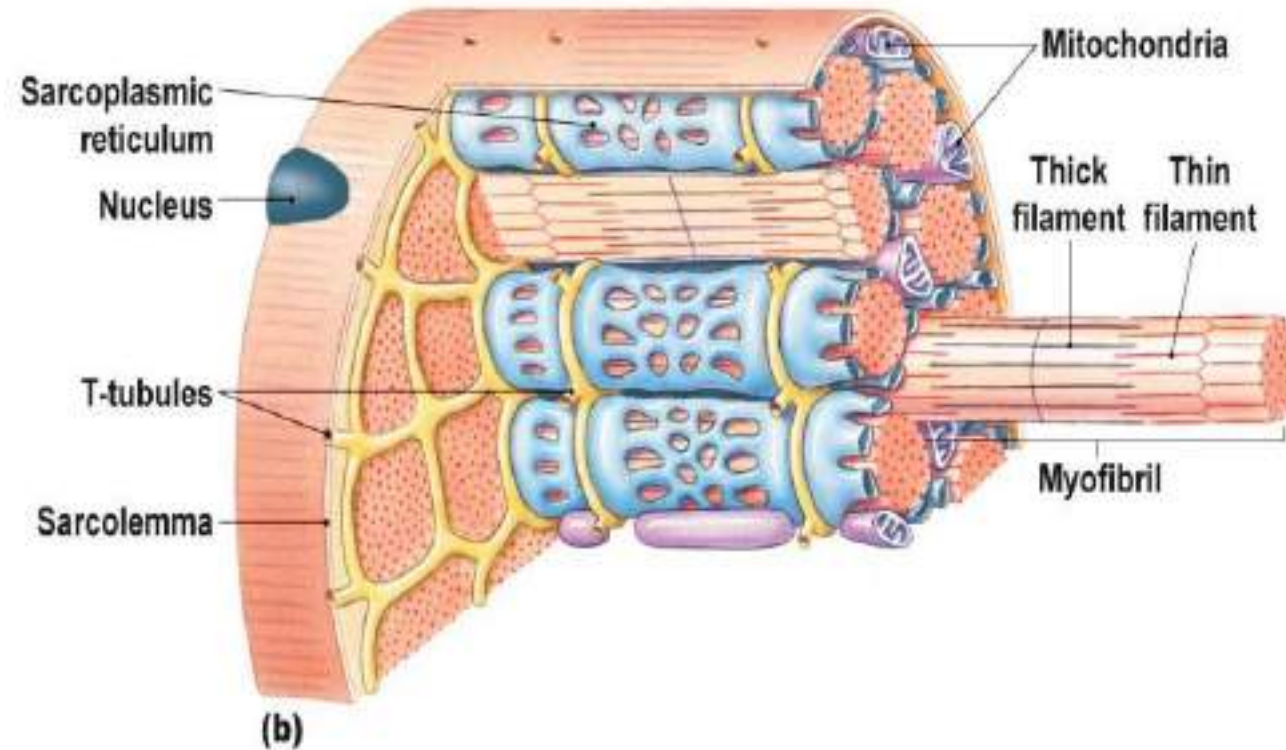
Muscle Fiber – a single cylindrical cell that contains several nuclei located at the periphery (edge) of the cell – largest are up to 30cm long, .15mm in diameter, and containing several thousand nuclei

سكون من ال Sacromere

Myofibril – thread like structure extending through the muscle fiber from one end to the other in the sarcoplasm – composed of two myofilaments (protein fibers)-actin and myosin

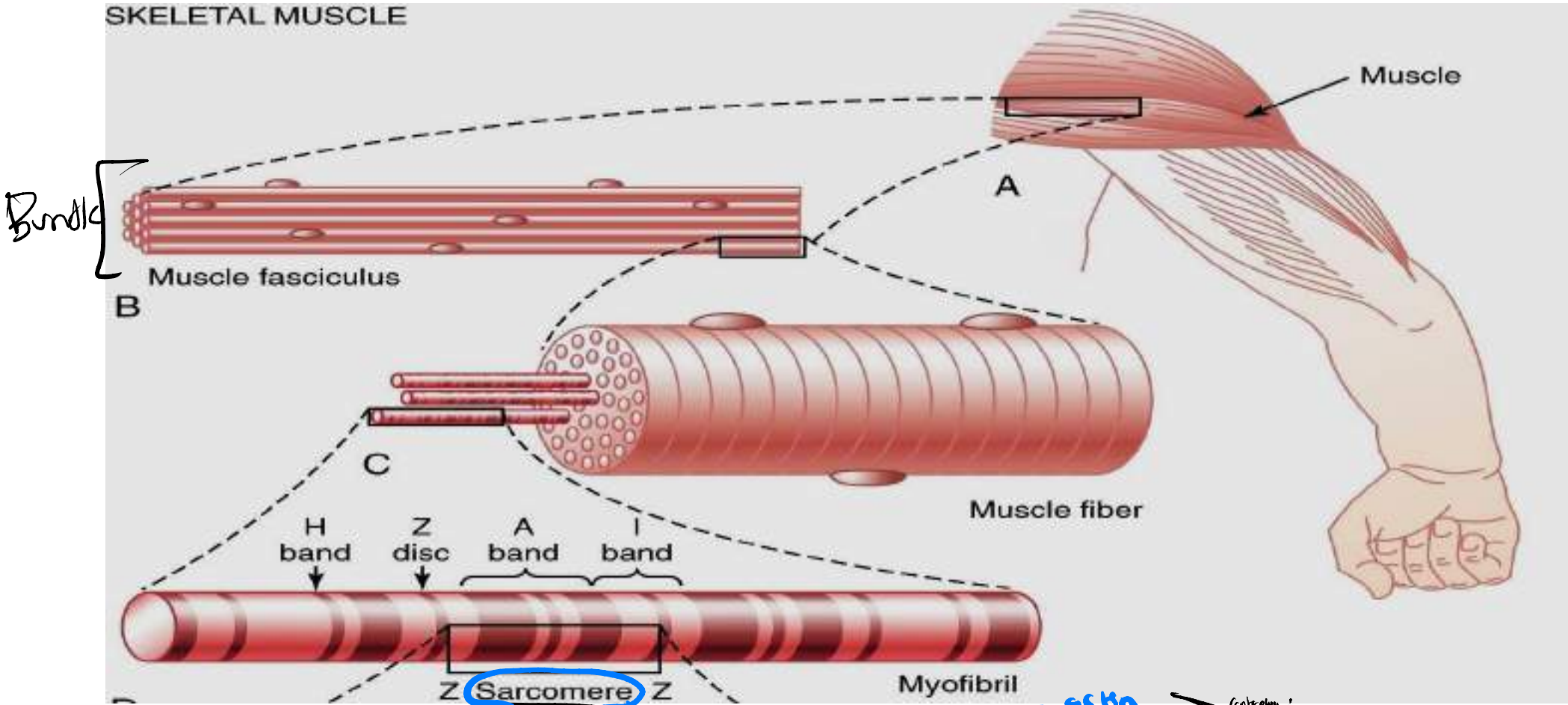
Sarcolemma – cell membrane of a muscle fiber

ULTRASTRUCTURE OF MUSCLE



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Skeletal muscle organization and Ultrastructure of muscle fiber



4/30/2024

Functional unit

2 types of proteins

actin
myosin

Controlled by nervous system

Structure of Skeletal Muscle : Functional Anatomy

- all skeletal muscles are composed of numerous fibers ranging from 10 to 80 micrometers in diameter.
- In most skeletal muscles, each fiber extends the entire length of the muscle.
- Each of these fibers is made up of successively smaller subunits known as myofibrils.
- Each muscle fiber contains several hundred to several thousand myofibrils which are thread-like structures extending through the muscle fiber from one end to the other in the sarcoplasm.

Ultrastructure of muscle fibers

- Each myofibril is composed of about 1500 adjacent myosin filaments and 3000 actin filaments, which are large polymerized protein molecules that are responsible for the muscle contraction
- The thick filaments are myosin, and the thin filaments are actin
- Actin myofilaments – thin filaments resembling two strands of pearls twisted together
- Myosin myofilaments – thick filaments resembling bundles of miniature golf clubs
- The myosin and actin myofilaments , partially **interdigitate** and thus cause the myofibrils to have alternate light and dark

Skeletal muscles

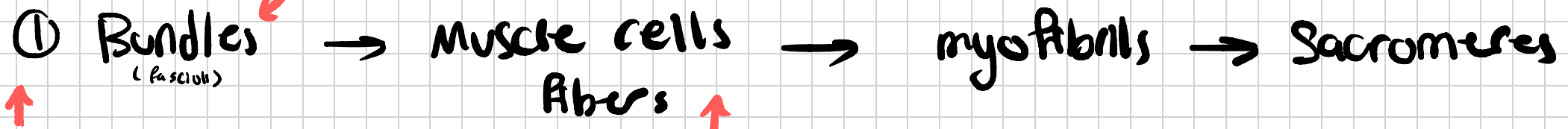
The functional unit of skeletal muscles

Sarcomere

* ألياف وحدة (ج) ال Skeletal muscle

← ال Skeletal muscle يتكون من كل bundles (fasciculi) و الحزب bundles الحزبية
ب tendon و لذا ال tendon يكون شريك ب Bone

each bundle is surrounded by perimysium



↑
epimysium (CT) covers each skeletal muscle

↑
each muscle cell is covered by Endomysium

- The light bands contain only actin filaments and are called *I bands* because they are *isotropic* to polarized light.
- The dark bands contain myosin filaments, as well as the ends of the actin filaments, where they overlap the myosin, and are called *A bands* because they are *anisotropic* to polarized light. Note also the small projections from the sides of the myosin filaments in
- . These projections are *cross-bridges*. It is the interaction between these cross-bridges and the actin filaments that causes contraction

Z disks

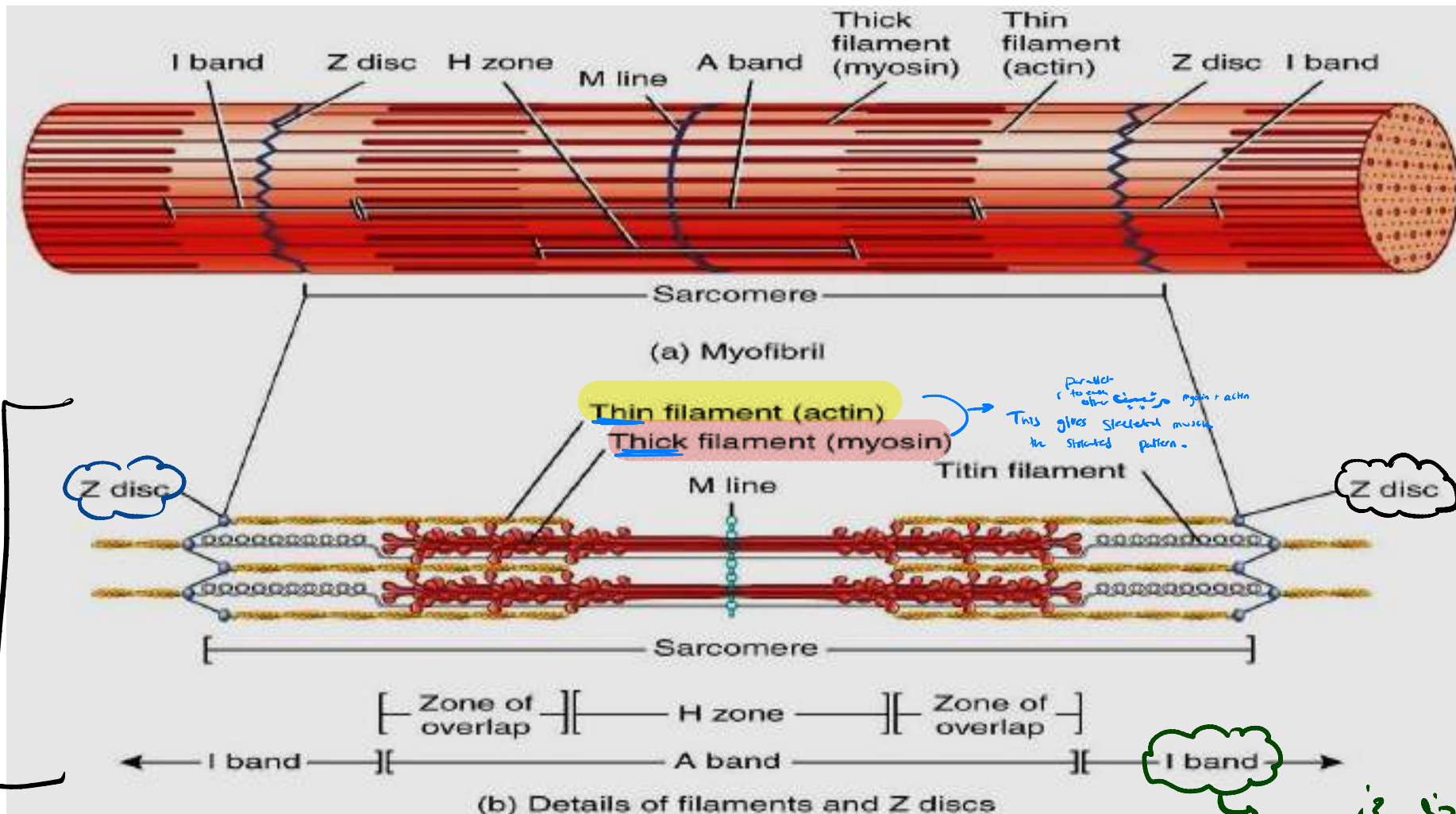
- The Z disk, which is composed of filamentous proteins, passes crosswise across the myofibril and also crosswise from myofibril to myofibril, attaching the myofibrils to one another all the way across the muscle fiber.
- Therefore, the entire muscle fiber has light and dark bands, as do the individual myofibrils. These bands give skeletal and cardiac muscle their striated appearance.
- From Z disc, actin filaments extend in both directions to interdigitate with the myosin filaments.

Ultrastructure of muscle fiber

Sarcomere

- Sarcomere – the basic structural and functional unit of skeletal muscle – the smallest portion of skeletal muscle capable of contraction
- It is the portion of the myofibril (or of the whole muscle fiber) that lies between two successive Z disks. When the muscle fiber is contracted, as shown at the bottom of the length of the sarcomere is about 2 micrometers.
- At this length, the actin filaments completely overlap the myosin filaments, and the tips of the actin filaments are just beginning to overlap one another.
- At this length the muscle can generate its greatest force of contraction

The Arrangement of a Sarcomere



Titin filaments and its functions

- **Titin Filamentous Molecules Keep the Myosin and Actin Filaments in Place**
- The side-by-side relationship between the myosin and actin filaments is maintained by a large number of filamentous molecules of a protein called *titin*
- Also, because it is filamentous, it is very *springy*. These springy titin molecules act as a framework that holds the myosin and actin filaments in place so that the contractile machinery of
- One end of the titin molecule is elastic and is attached to the Z disk, acting as a spring and changing length as the sarcomere contracts and relaxes.
- The other part of the titin molecule tethers it to the myosin thick filament.
- The titin molecule may also act as a template for the initial formation of portions of the contractile filaments of the sarcomere, especially the myosin filaments.

Ultrastructure of sarcomeres Zones and bands of myofibril

- Zones – areas of measurement that make up the sarcomere to show contraction in the sliding filament model

خط القياس
Sarcomere شرفته
خط القياس لـ Myosin

- **M line** – center line of a sarcomere and attachment site for myosin filaments

ما فيه actin
بعض myosin

- **H zone** – area of the sarcomere extending out from the M line on either side - composed of myosin only (no actin)

- **A band** – area of the sarcomere extending from one end of the myosin to the other end, includes the M line, the H zone, and the area where actin and myosin overlap

الاماكن التي تتقابل فيها الـ actin
و myosin

@ the ends

- **Z disk** – the area of the sarcomere indicating the ends of the sarcomere and the attachment site for actin filaments.

only actin

- **I band** – area that includes the Z disk , made out of 2 ends of adjoining sarcomeres, and composed of actin only (no myosin)

نموذج لـ
Sarcomere
والذي يوضح الـ (contract)

- **Sliding filament model** – used to show/explain muscle contraction with one sarcomere – in this model myosin and actin filaments slide past one another shortening or narrowing the H zone and I band, the filaments themselves do not shorten