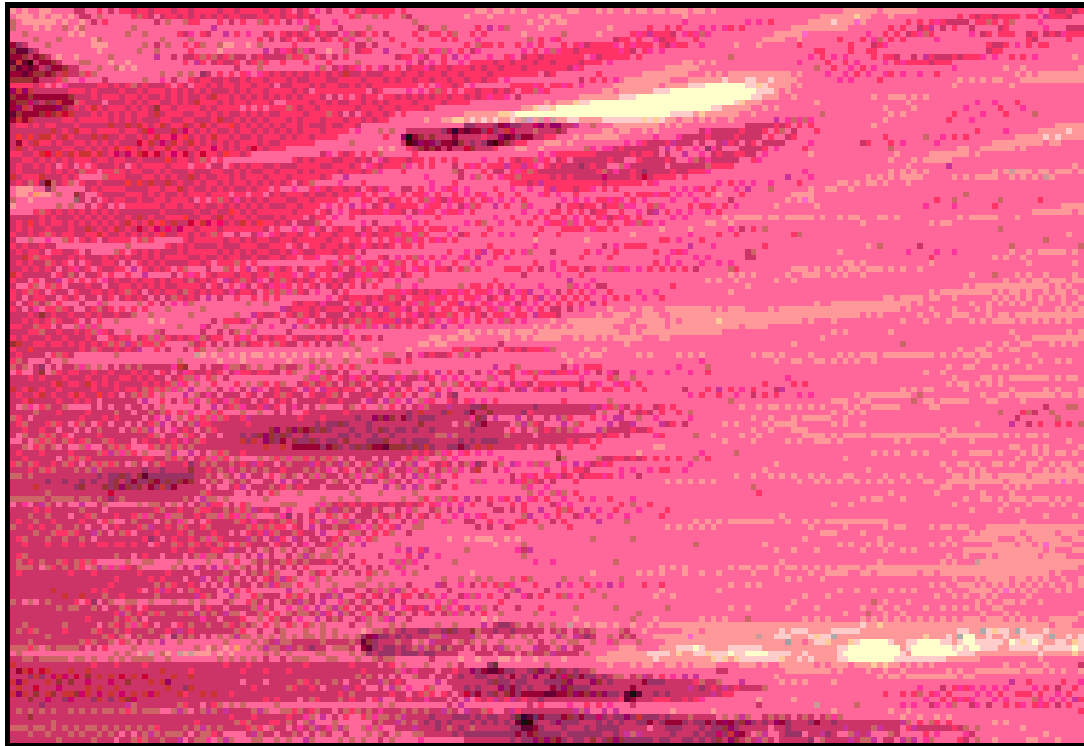


# KAS FİZYOLOJİSİ

# KASLARIN SINIFLANDIRILMASI

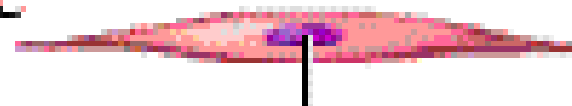
- ✗ **Düz Kas:** Belirgin çizgilere sahip olmadığı için bu ismi alır. İğ şeklindedirler ve merkezde bir çekirdeğe sahiptirler. Otonom sinirlerle kontrol edilirler. Miyofilamentlerin tamamı aktin ve miyozin kontraktıl proteinlerinden oluşmuştur. Filamentler düzenli dağılım göstermedikleri için belirgin çizgileri yoktur.

# KASLARIN SINIFLANDIRILMASI



Smooth Muscle

1200 x



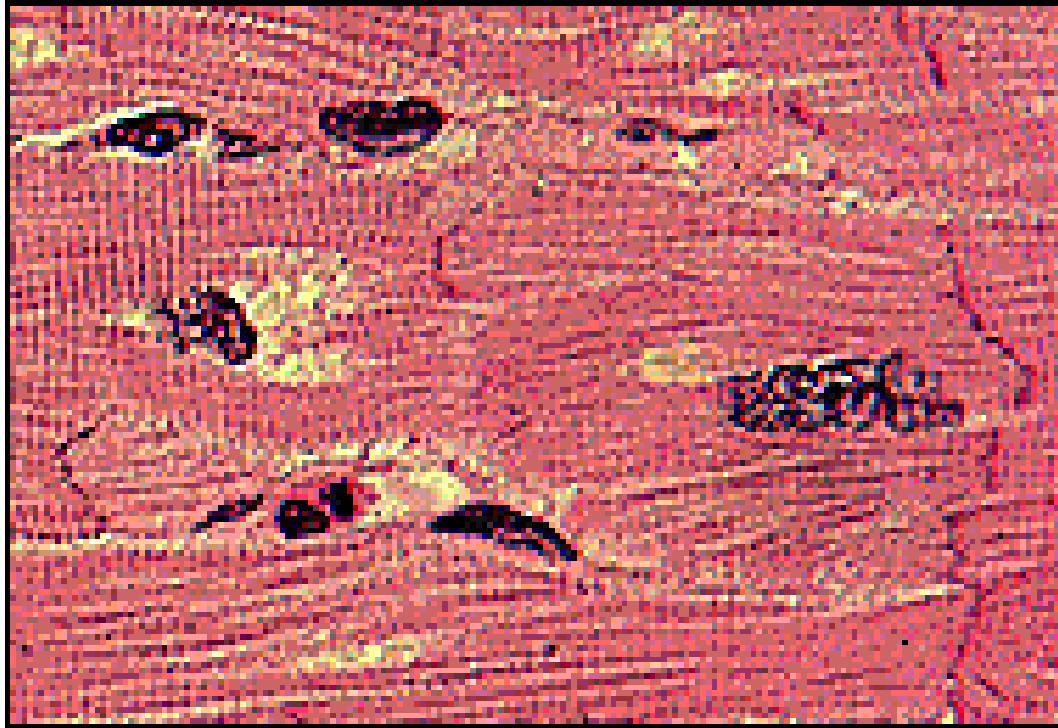
Nucleus

# KASLARIN SINIFLANDIRILMASI

- ✗ **Kalp Kası:** Sadece kalpte bulunur. Otonom sinir sistemi tarafından kontrol edilmesine karşın mikroskopik bakıda birbirini takip eden koyu ve açık renkli bantlarla karakterize çizgiler gösterir. Bir hücrenin komşu hücre ile birleşme bölgesi interkale disk adını alır.

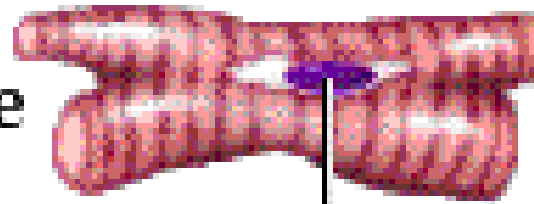


# KASLARIN SINIFLANDIRILMASI



Cardiac Muscle

400 x



Nucleus

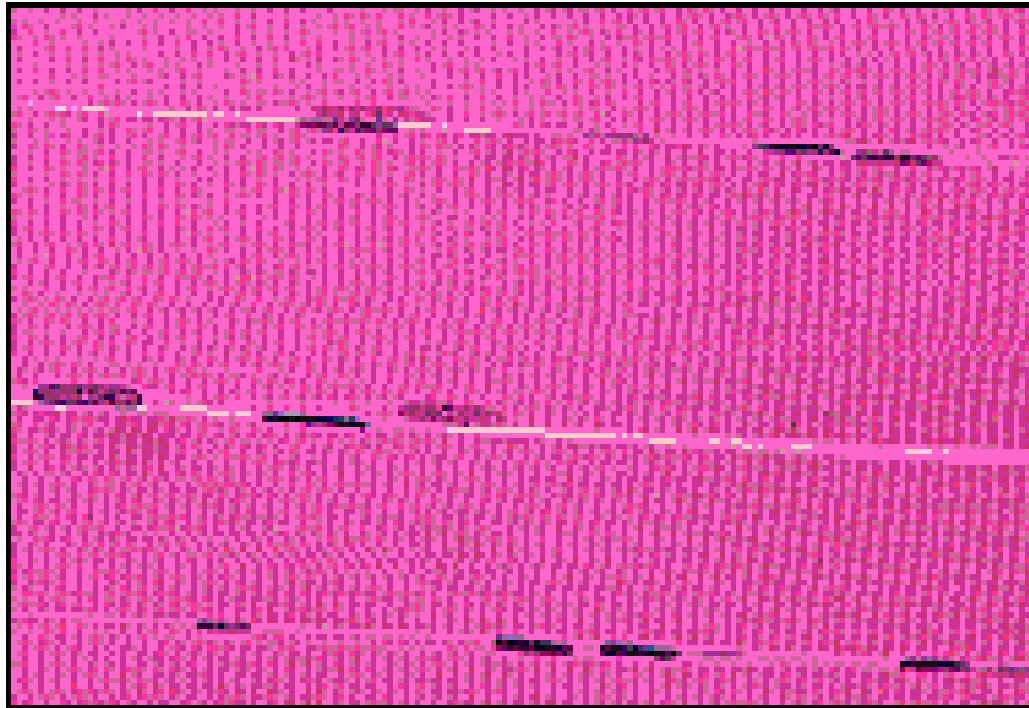
# KASLARIN SINIFLANDIRILMASI

- ✗ **İskelet Kası:** Vücutta en fazla bulunan kas türüdür. Bireysel kas lifleri bütün kas boyunca uzanabilirler. Mikroskopik bakıda çizgili görünüme sahiptir. Kalp kasından farklı olarak dallanma ve anastomoz içermediği için interkale diskler bulundurmaz. Kraniyal ve spinal sinirlerle innerve edilir ve uyarım için her kas lifine bir sinir impulsu gelmesi gerekir. Periferik olarak yerleşmiş çok sayıda çekirdek içerir.

# KASLARIN SINIFLANDIRILMASI

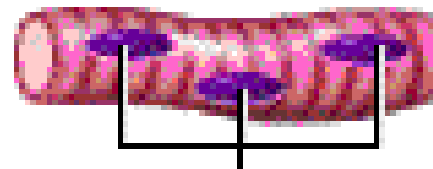
- ✗ **İskelet Kası (devam):** Genel olarak kırmızı ve beyaz tip olmak üzere ikiye ayrılır. Kırmızı kas lifleri beyaz kas liflerine oranla daha fazla miyogloblin ve mitokondriye sahiptir. Beyaz kas lifleri daha hızlı kasılır ve çabuk yorulurken, kırmızı kas lifleri daha yavaş kasılır ve geç yorulur.

# KASLARIN SINIFLANDIRILMASI



Skeletal Muscle

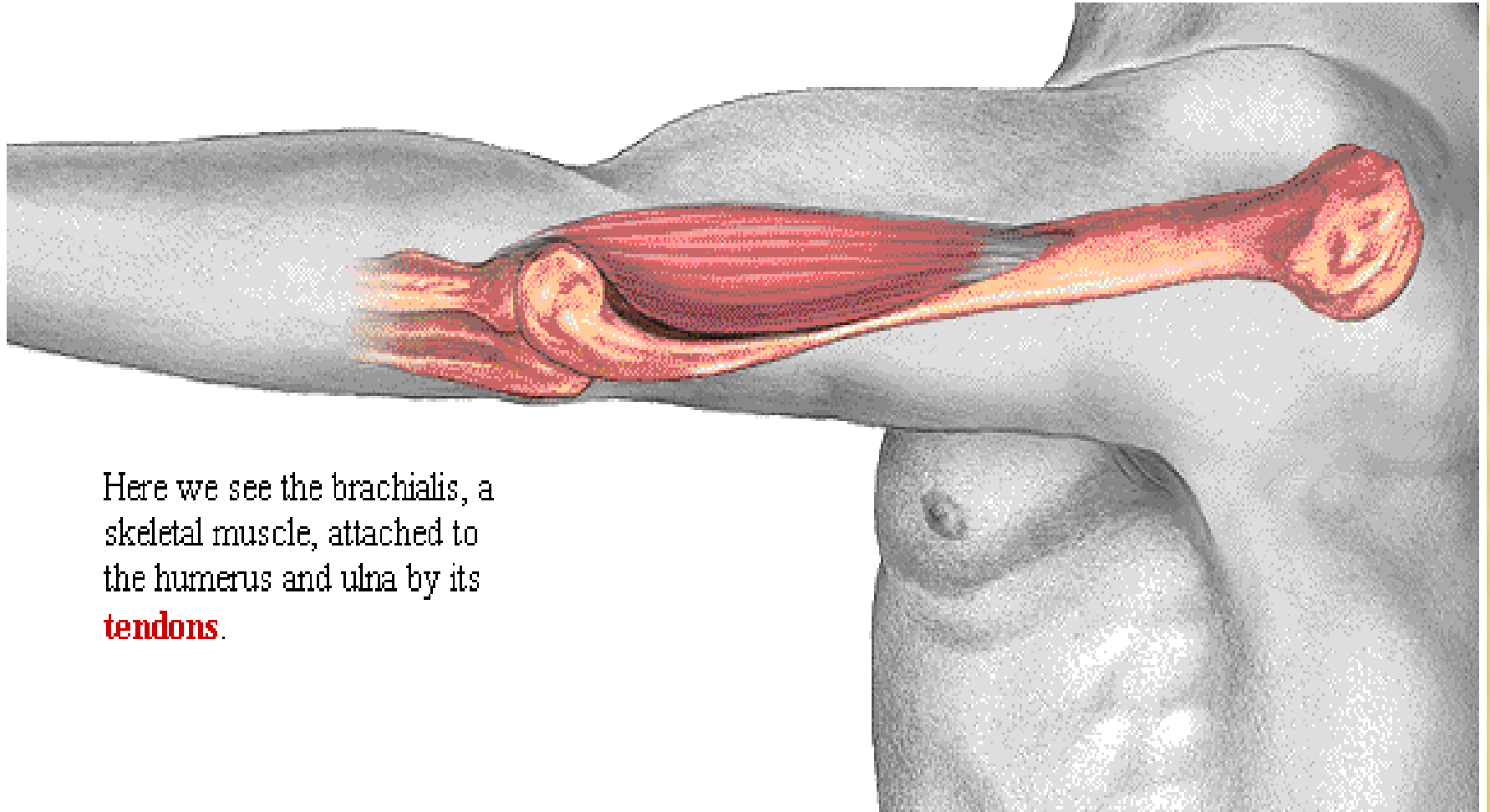
300 x



Nuclei



# İSKELET KASININ MİKRO YAPISI

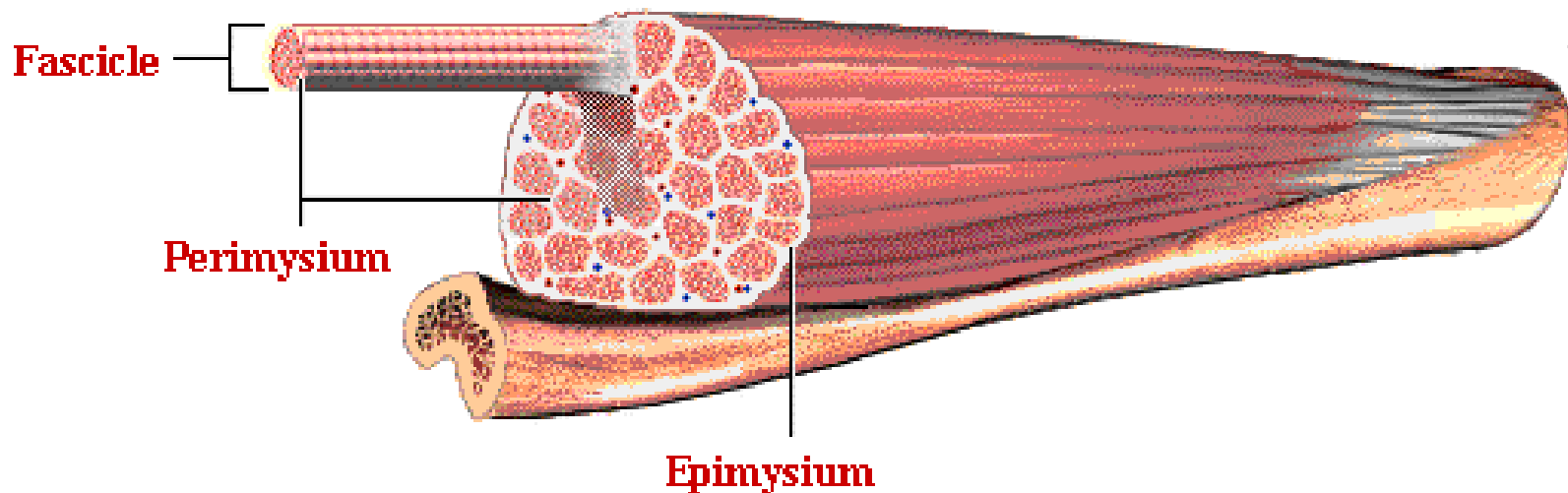


Here we see the brachialis, a skeletal muscle, attached to the humerus and ulna by its **tendons**.

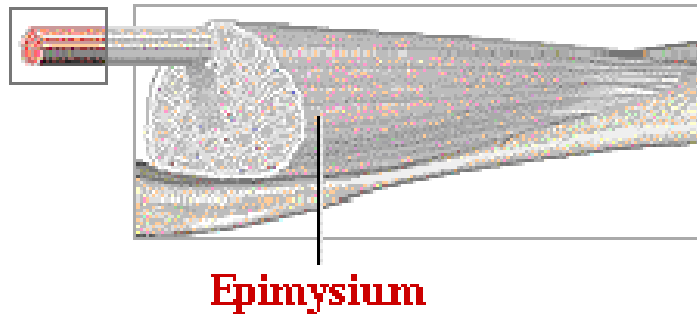
# İSKELET KASININ MİKRO YAPISI

Skeletal muscle is composed of an orderly arrangement of **connective tissue** and contractile cells:

- The entire muscle is surrounded by an external connective tissue wrapping called the epimysium.
- Skeletal muscle is made up of fascicles, which are bundles of individual muscle cells.
- Each fascicle is surrounded by a connective tissue layer called the perimysium.

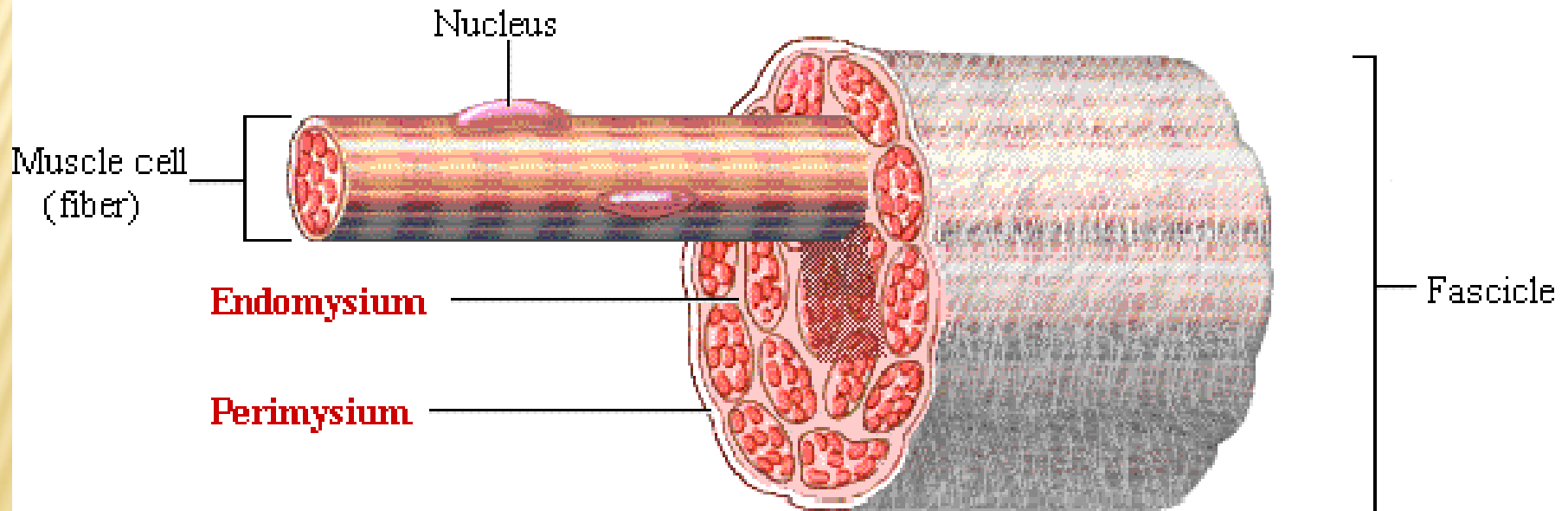


# İSKELET KASININ MİKRO YAPISI

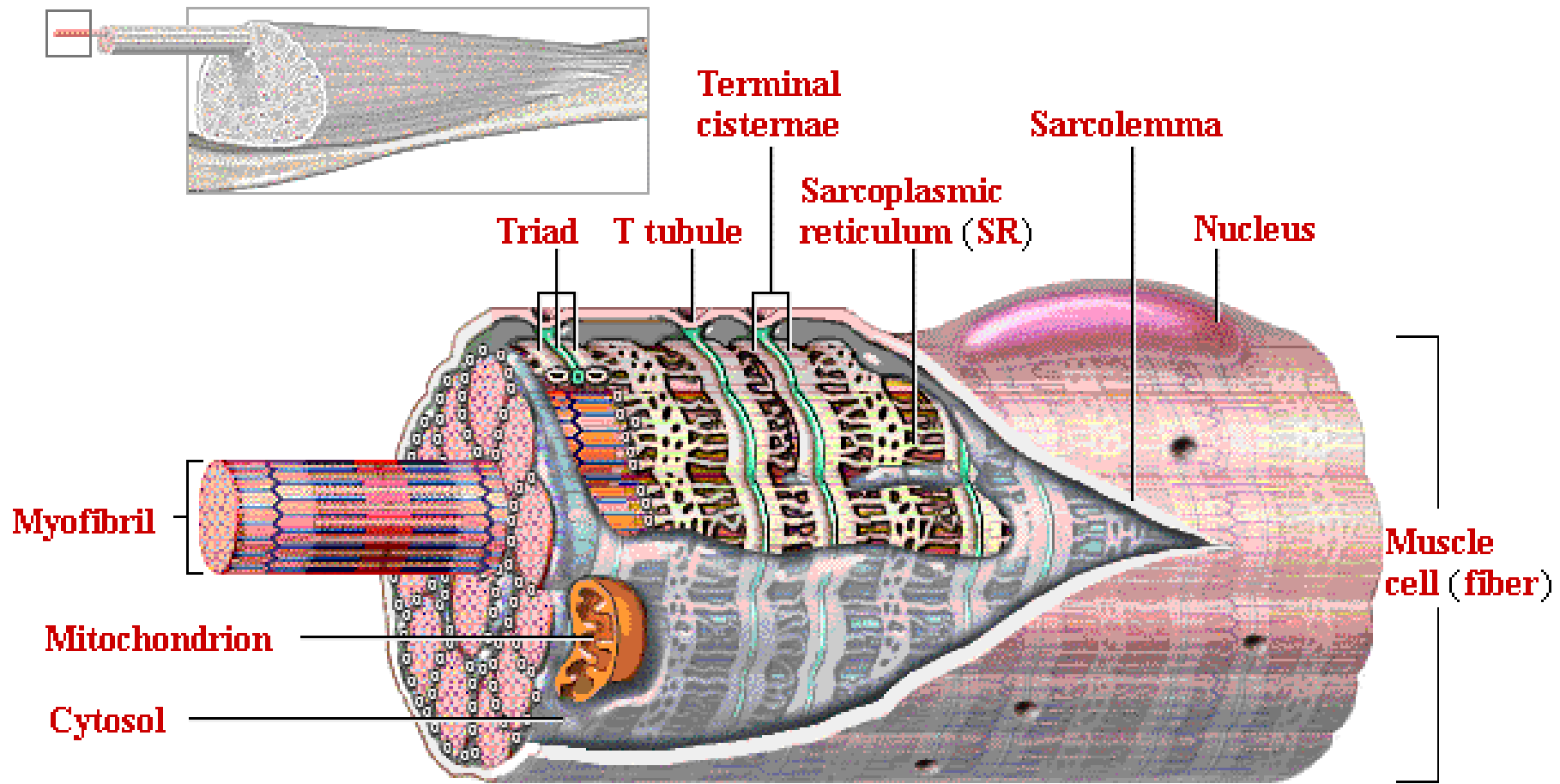


Within the **fascicle**, the third connective tissue layer, the endomysium, separates and electrically insulates the muscle cells from each other.

All three connective tissue layers bind the muscle cells together, providing strength and support to the entire muscle. They merge at the ends of the muscle and are continuous with the **tendons**.

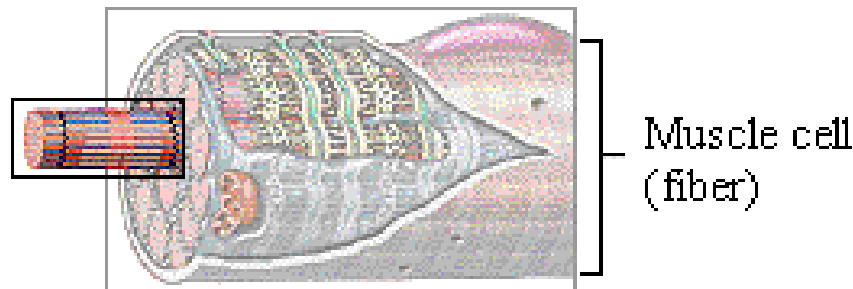


# İSKELET KASININ MİKRO YAPISI





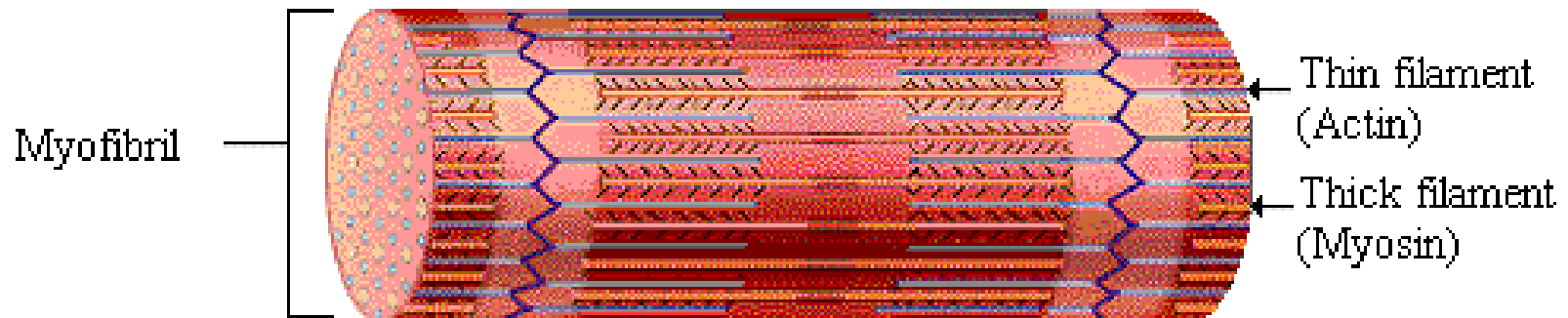
# İSKELET KASININ MİKRO YAPISI



The **myofibrils** are composed of individual contractile proteins called **myofilaments**.

There are two types of myofilaments:

- The thin filament is composed mainly of the protein actin.
- The thick filament is made up chiefly of the protein myosin.



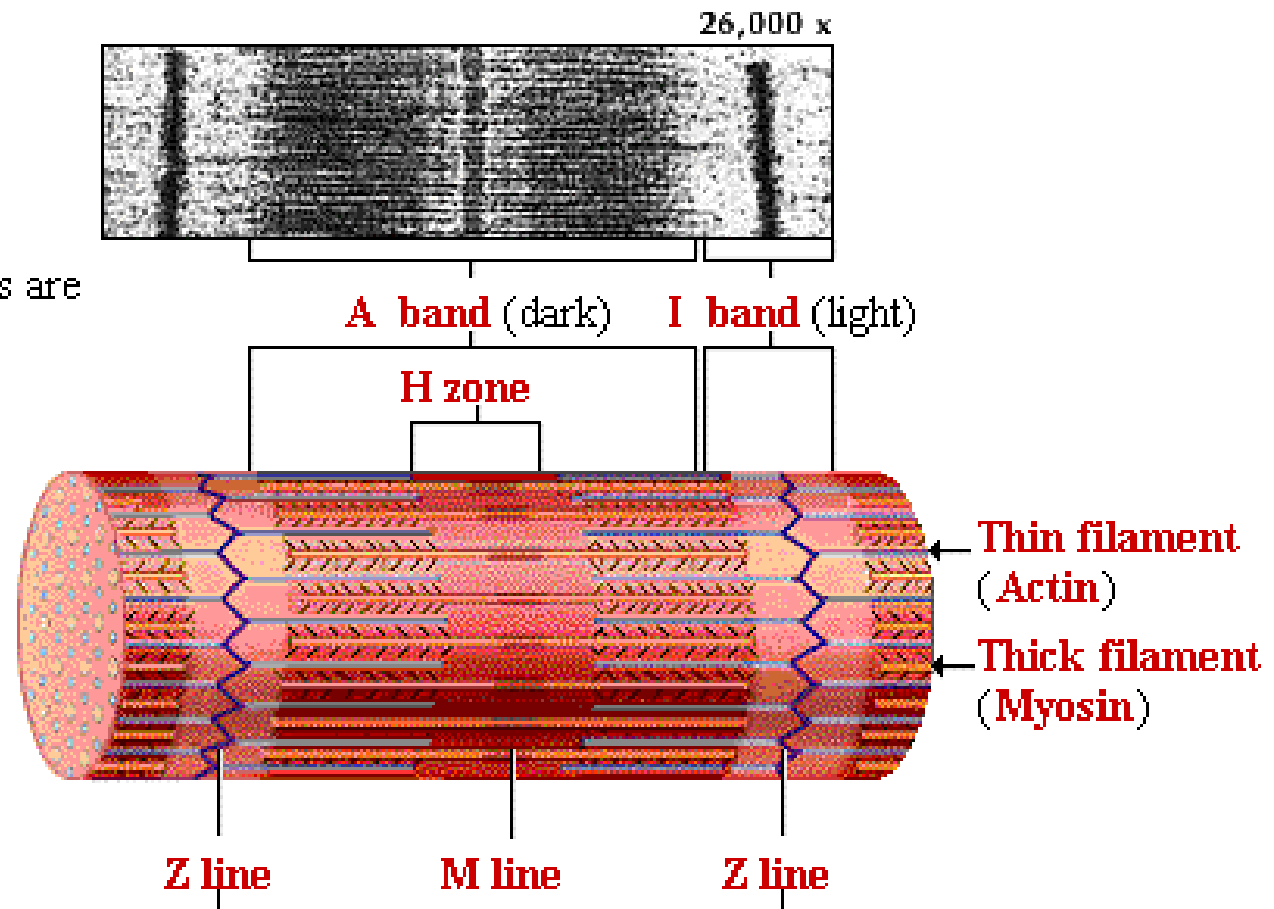
# İSKELET KASININ MİKRO YAPISI

- ✖ Bir kas lifinde lifin çapına bağlı olarak birkaç yüz ile birkaç bin miyofibril bulunabilir. Her miyofibrilde çizgi veya bantlar bulunur.

# ISKELET KASININ MİKRO YAPISI

The arrangement of thick and thin myofilaments forms light and dark alternating bands (striations) along the myofibril.

Features of these bands are identified by letters.



# MOTOR NÖRON

- ✗ Her iskelet kas lifi nöromuskuler bağlantı denen özelleşmiş bir bölge bulundurur. Bu bağlantı kas lifi ile sinir lifinin terminal kolunun yakın birlikteliğidir. Bir sinir lifi her biri farklı kas liflerine giden birçok terminal dala sahip olabilir. Bir sinir lifi ve innerve ettiği kas liflerine motor ünite adı verilir. Bir sinir lifinin innerve ettiği kas teli sayısı azaldıkça hareket duyarlılığı artar.

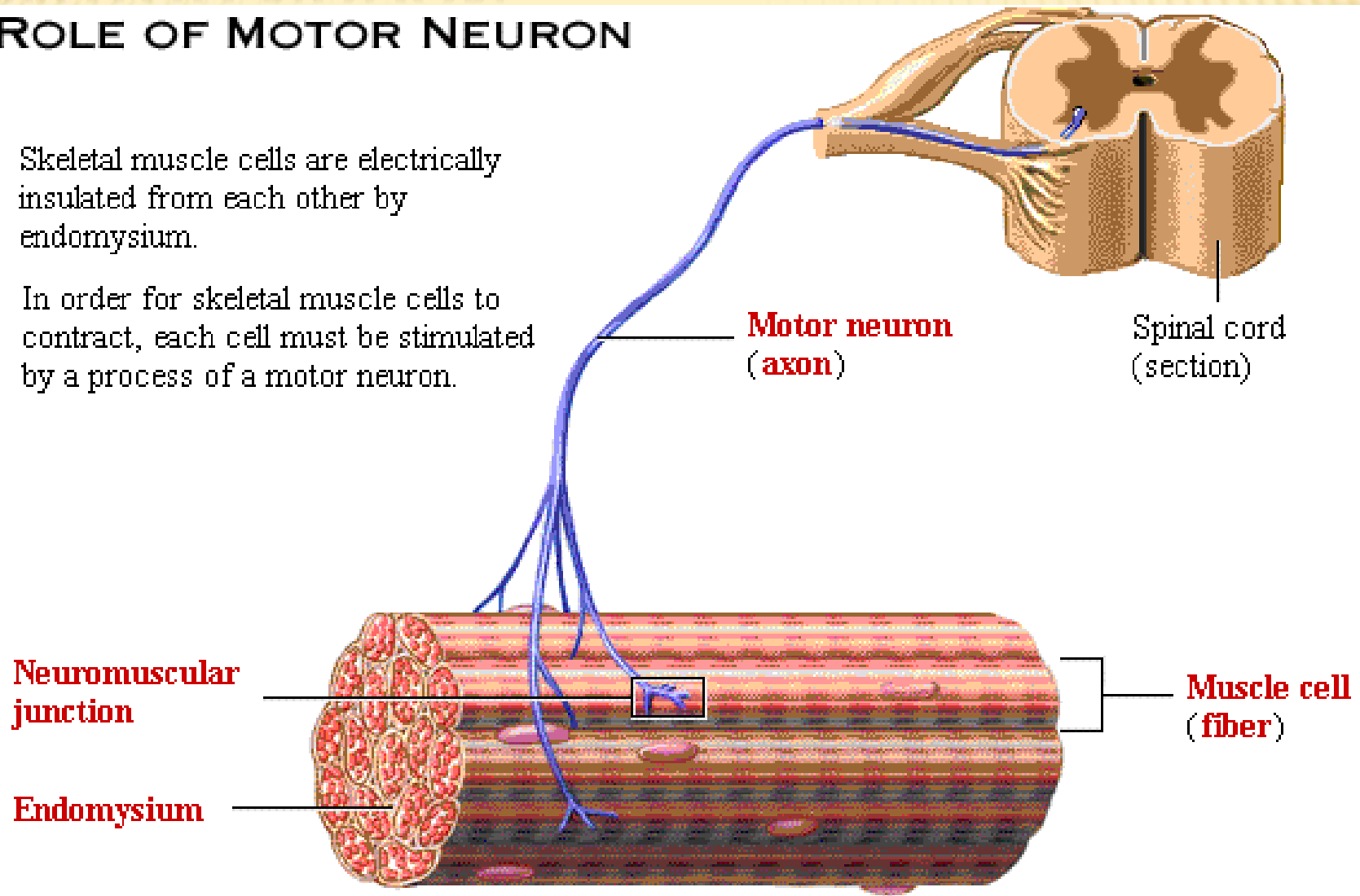


# MOTOR NÖRON

## ROLE OF MOTOR NEURON

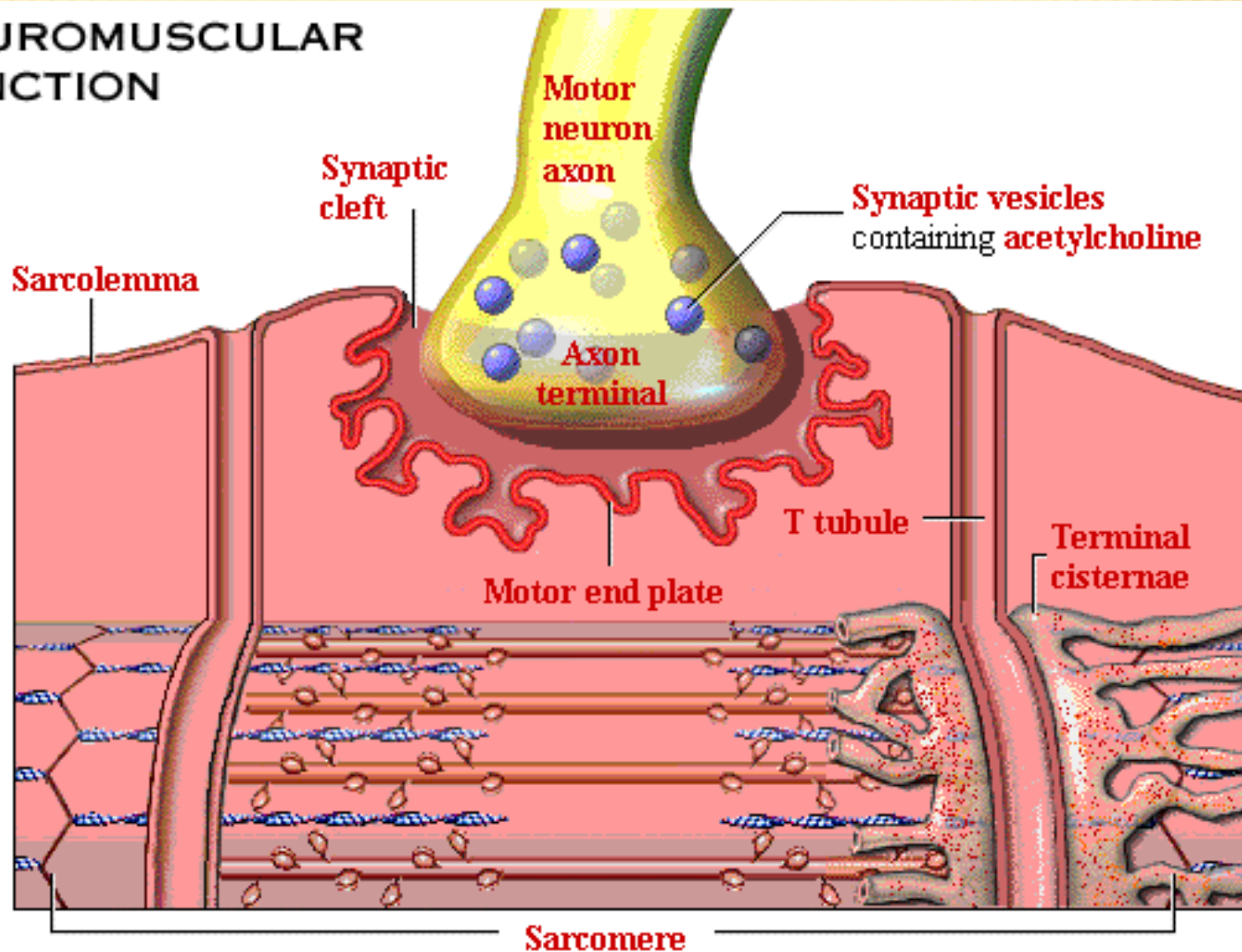
Skeletal muscle cells are electrically insulated from each other by endomysium.

In order for skeletal muscle cells to contract, each cell must be stimulated by a process of a motor neuron.



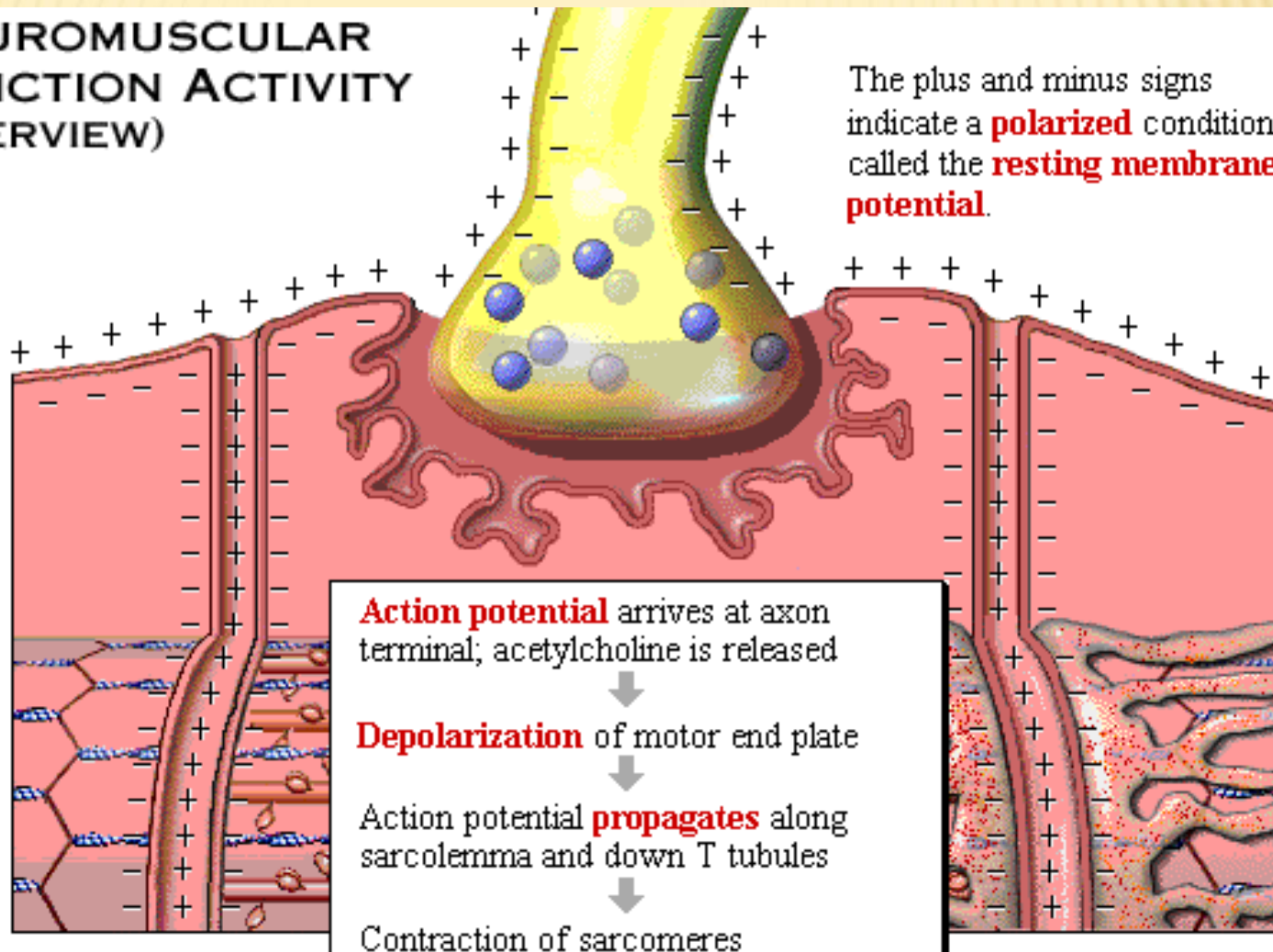
# NÖROMUSKULER KAVŞAK

## NEUROMUSCULAR JUNCTION



# NÖROMUSKULER KAVŞAK

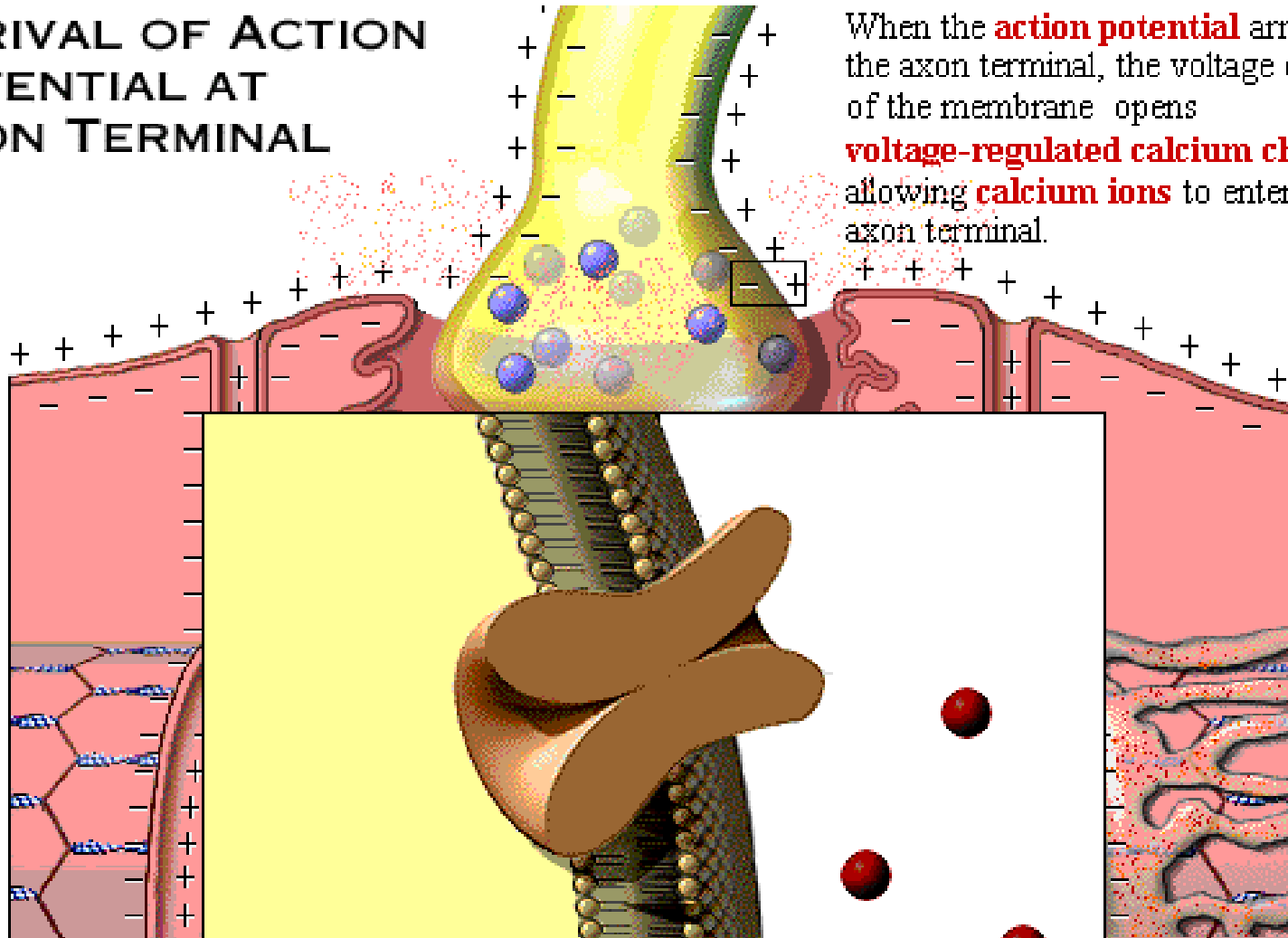
## NEUROMUSCULAR JUNCTION ACTIVITY (OVERVIEW)



# NOKOMIUSKULLER KAVSAR

## ARRIVAL OF ACTION POTENTIAL AT AXON TERMINAL

When the **action potential** arrives at the axon terminal, the voltage change of the membrane opens **voltage-regulated calcium channels** allowing **calcium ions** to enter the axon terminal.

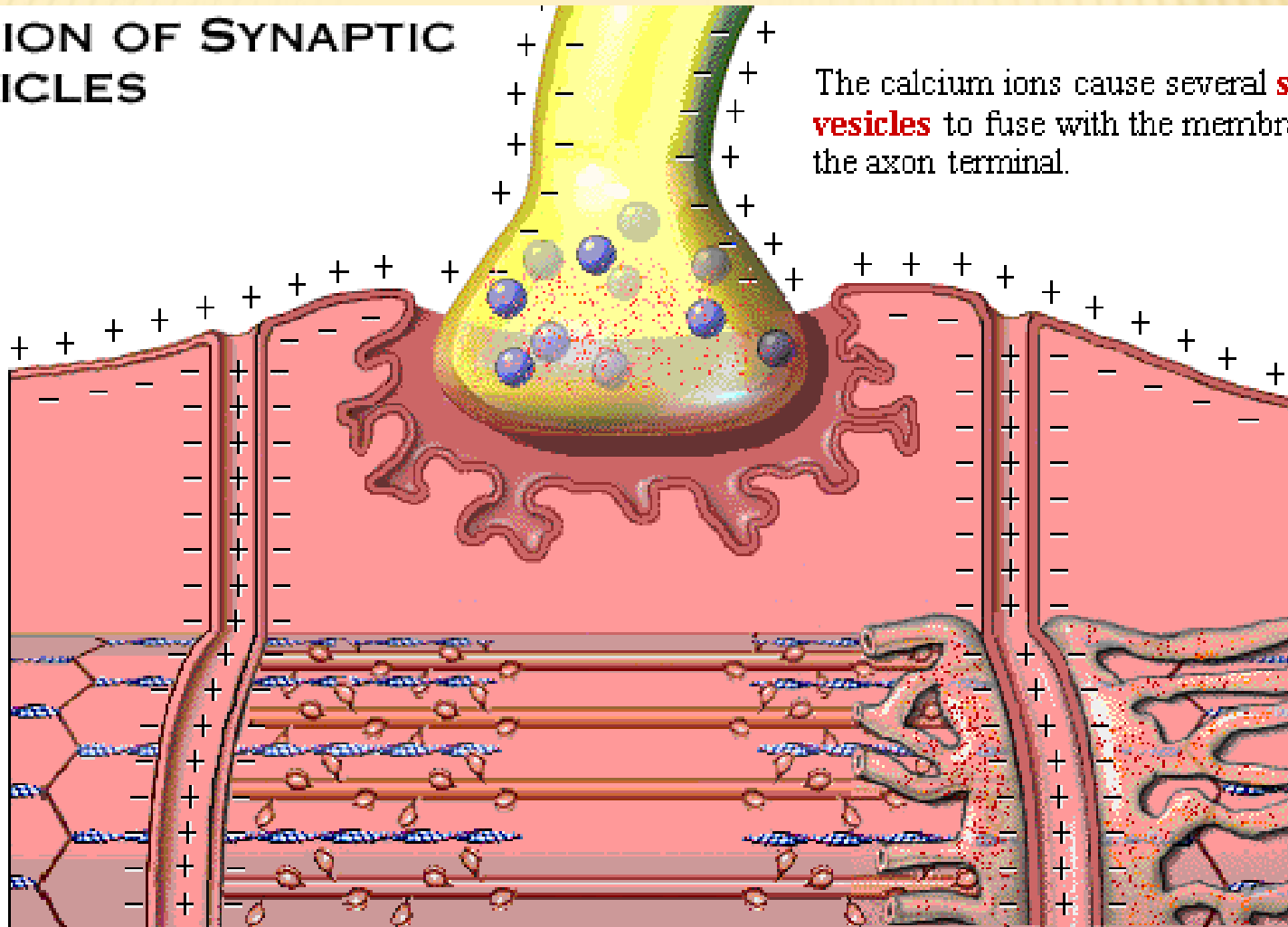




# NÖROMUSKULER KAVŞAK

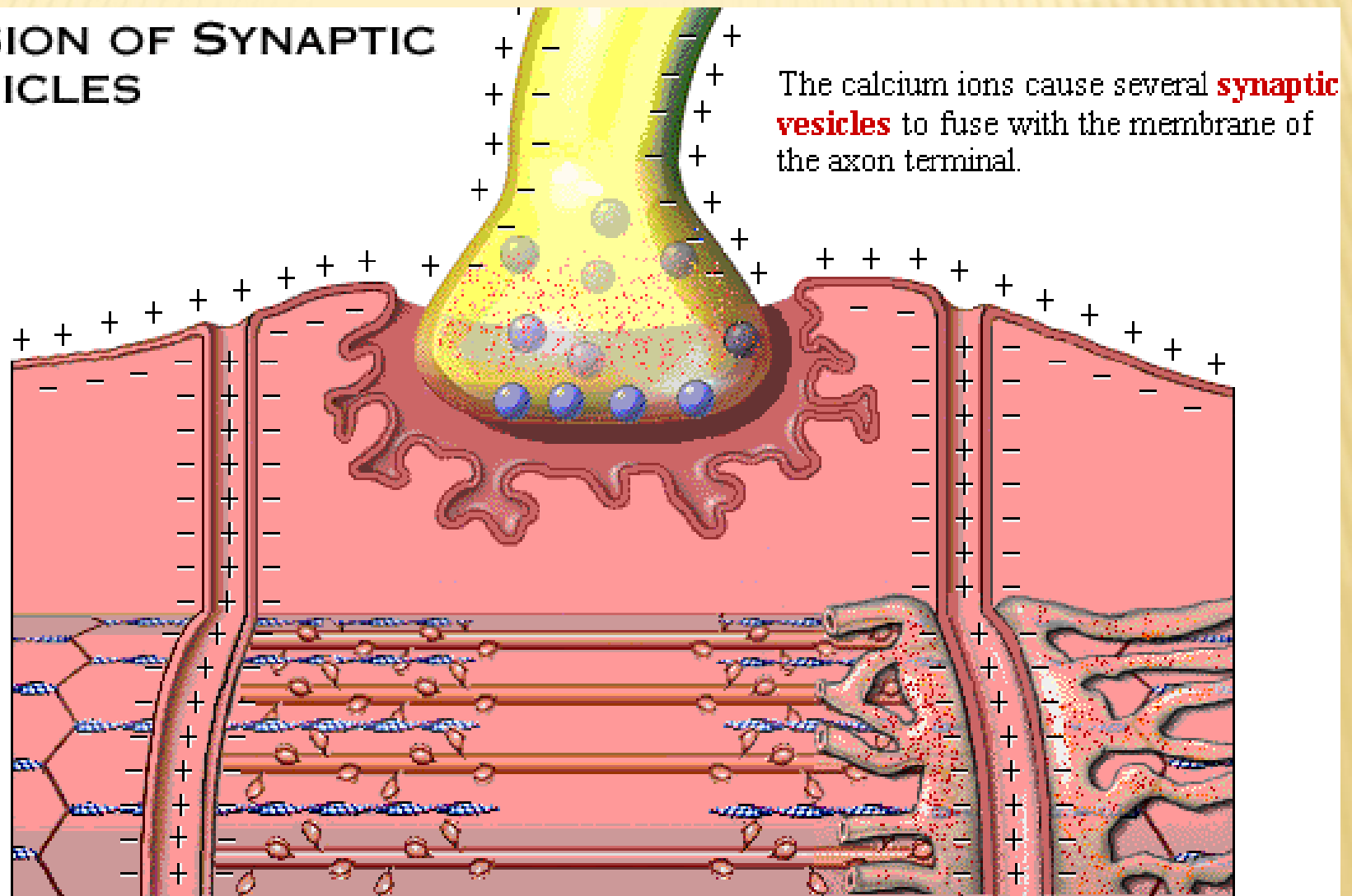
## FUSION OF SYNAPTIC VESICLES

The calcium ions cause several **synaptic vesicles** to fuse with the membrane of the axon terminal.



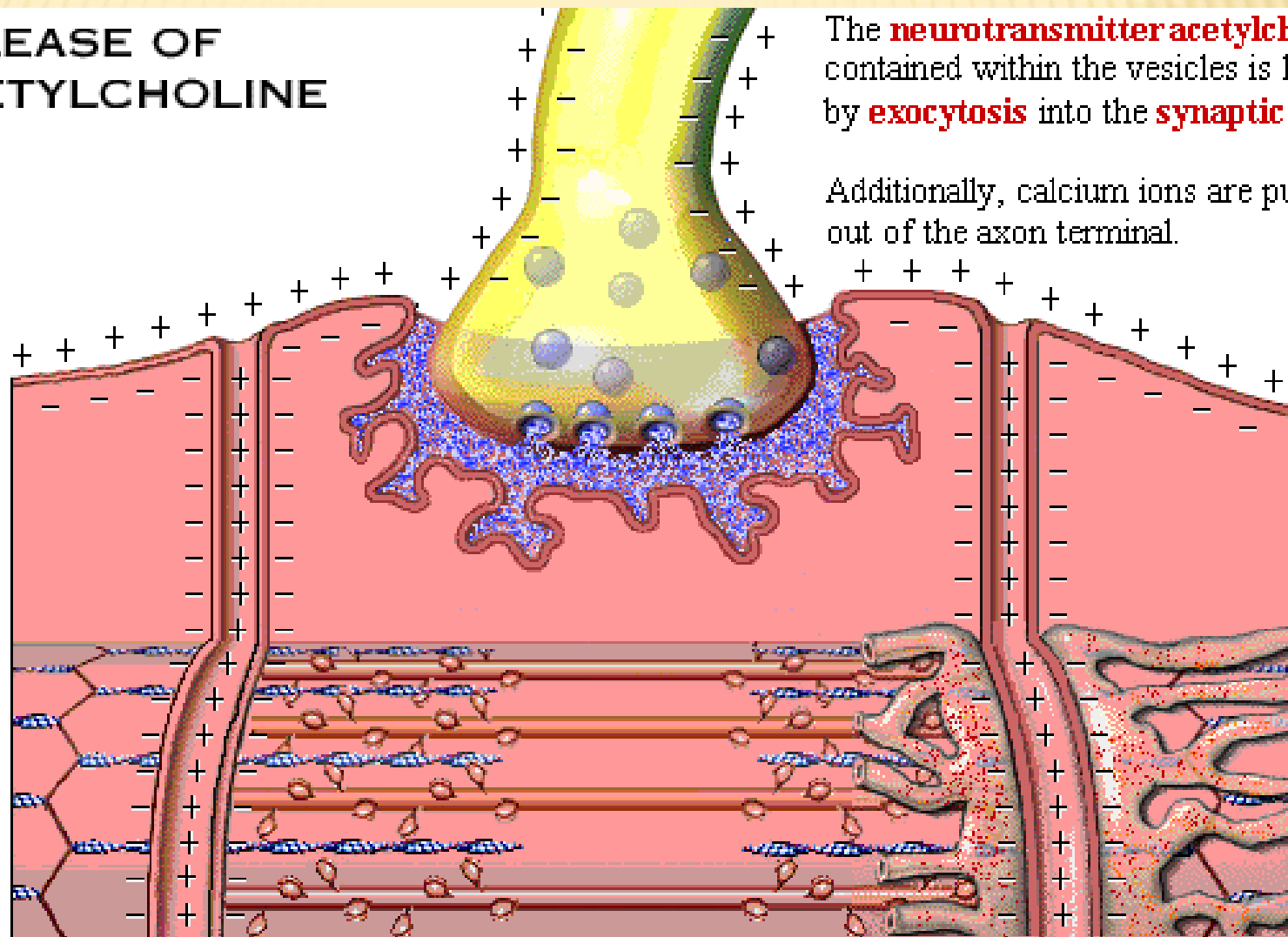
# NÖROMUSKULER KAVŞAK

## FUSION OF SYNAPTIC VESICLES



# NÖROMUSKULER KAVŞAK

## RELEASE OF ACETYLCHOLINE

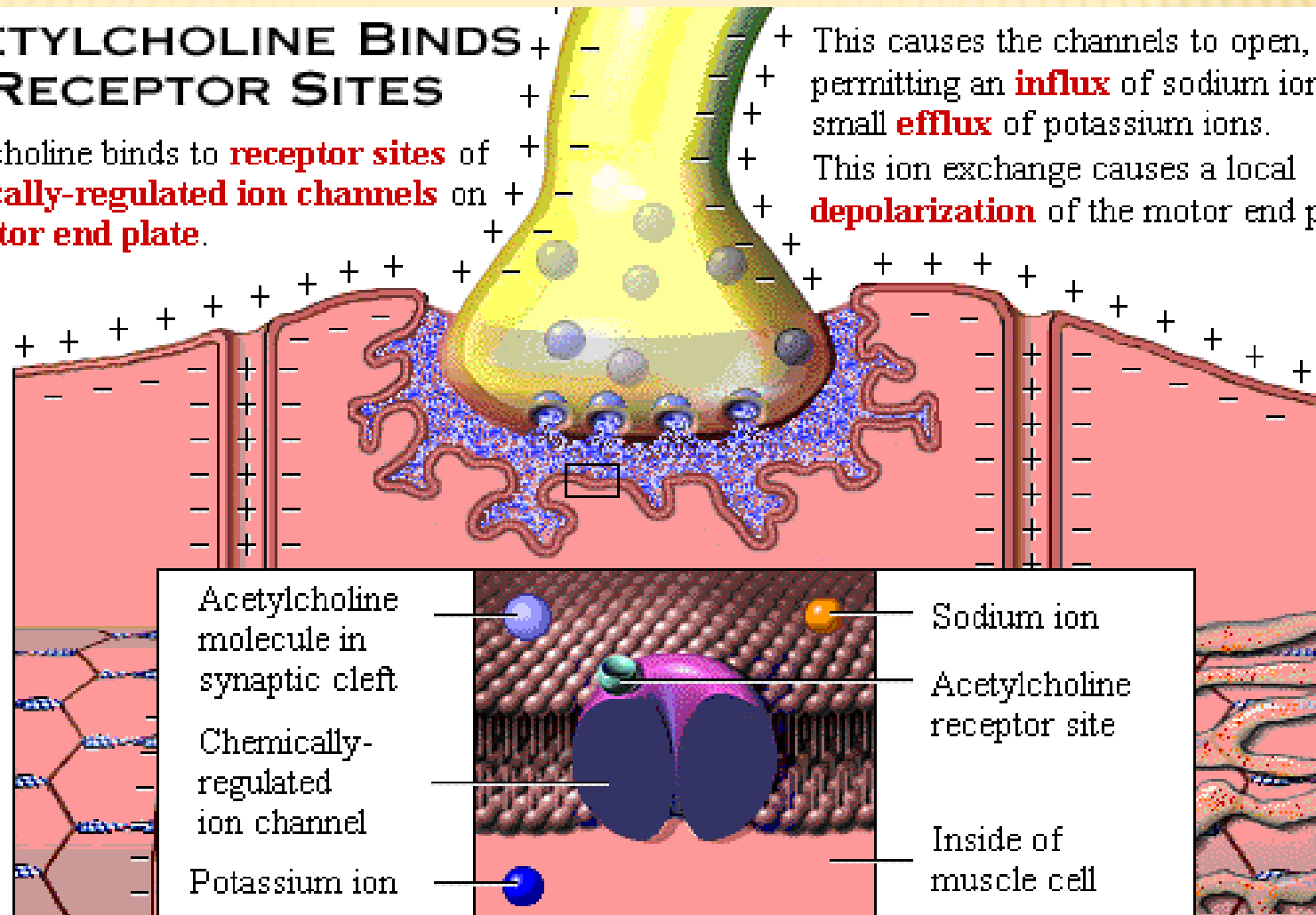


# NÖROMUSKULER KAVŞAK

## ACETYLCHOLINE BINDS TO RECEPTOR SITES

Acetylcholine binds to **receptor sites** of **chemically-regulated ion channels** on the **motor end plate**.

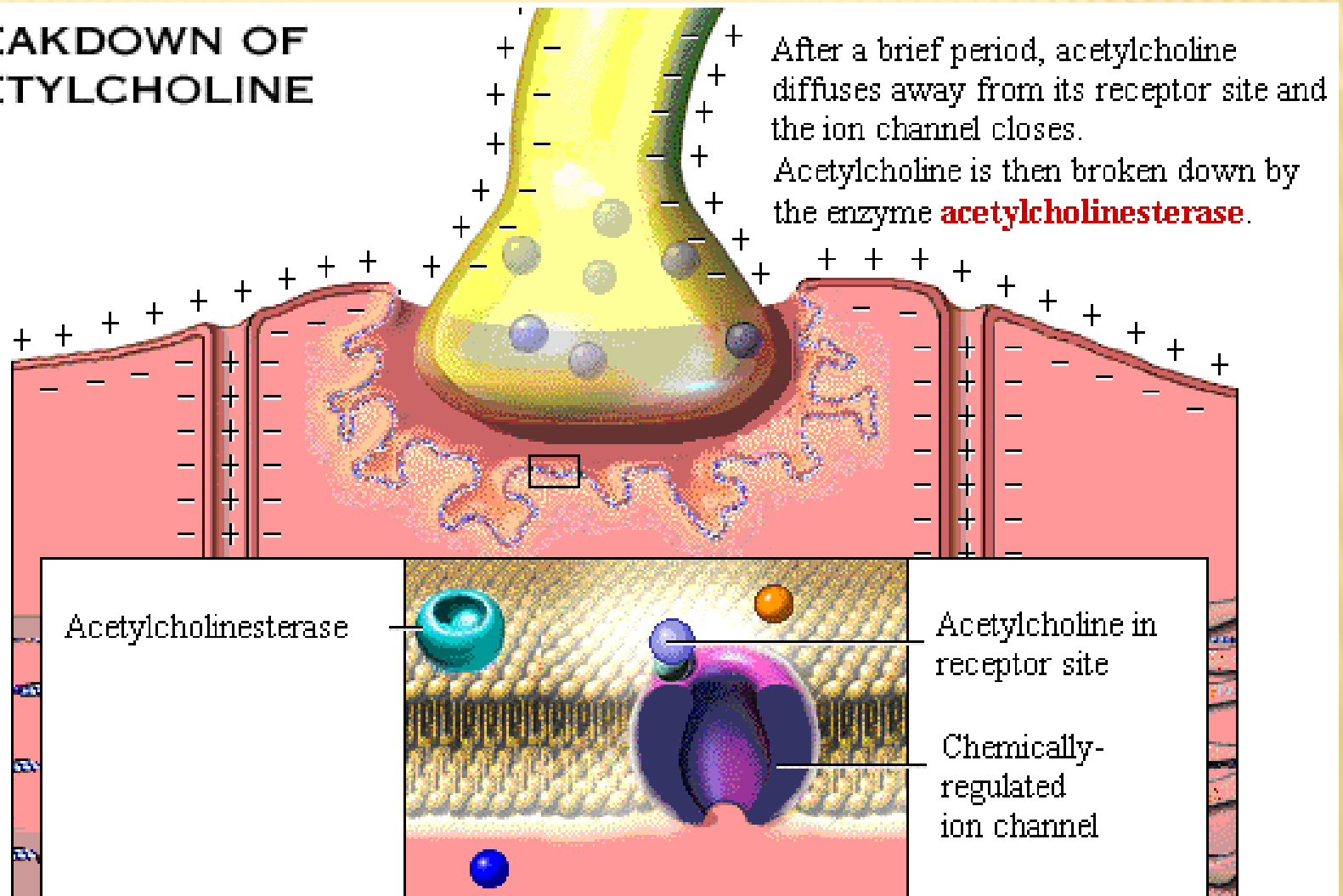
This causes the channels to open, permitting an **influx** of sodium ions and a small **efflux** of potassium ions. This ion exchange causes a local **depolarization** of the motor end plate.





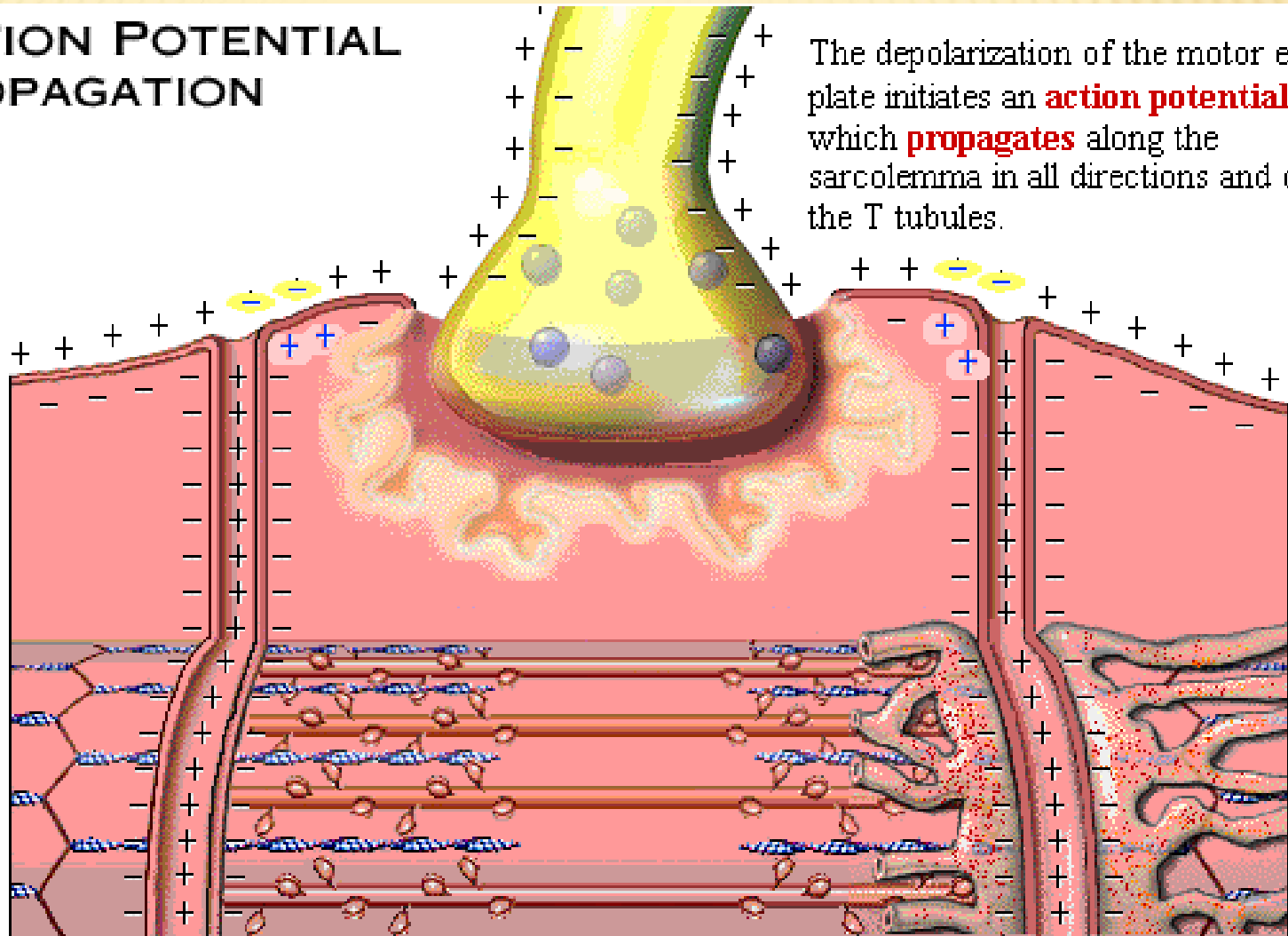
# NÖROMUSKULER KAVŞAK

## BREAKDOWN OF ACETYLCHOLINE



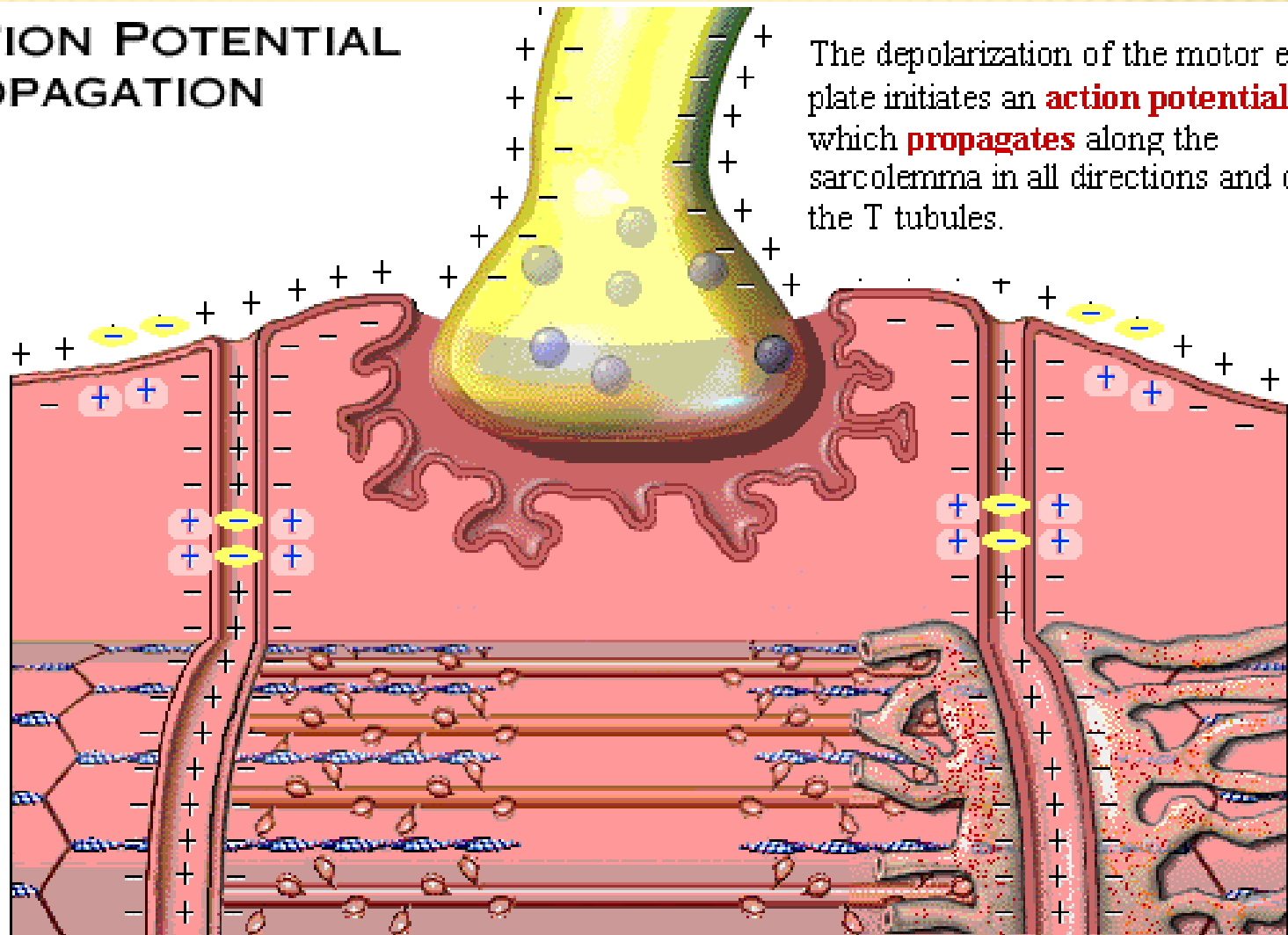
# NÖROMUSKULER KAVŞAK

## ACTION POTENTIAL PROPAGATION



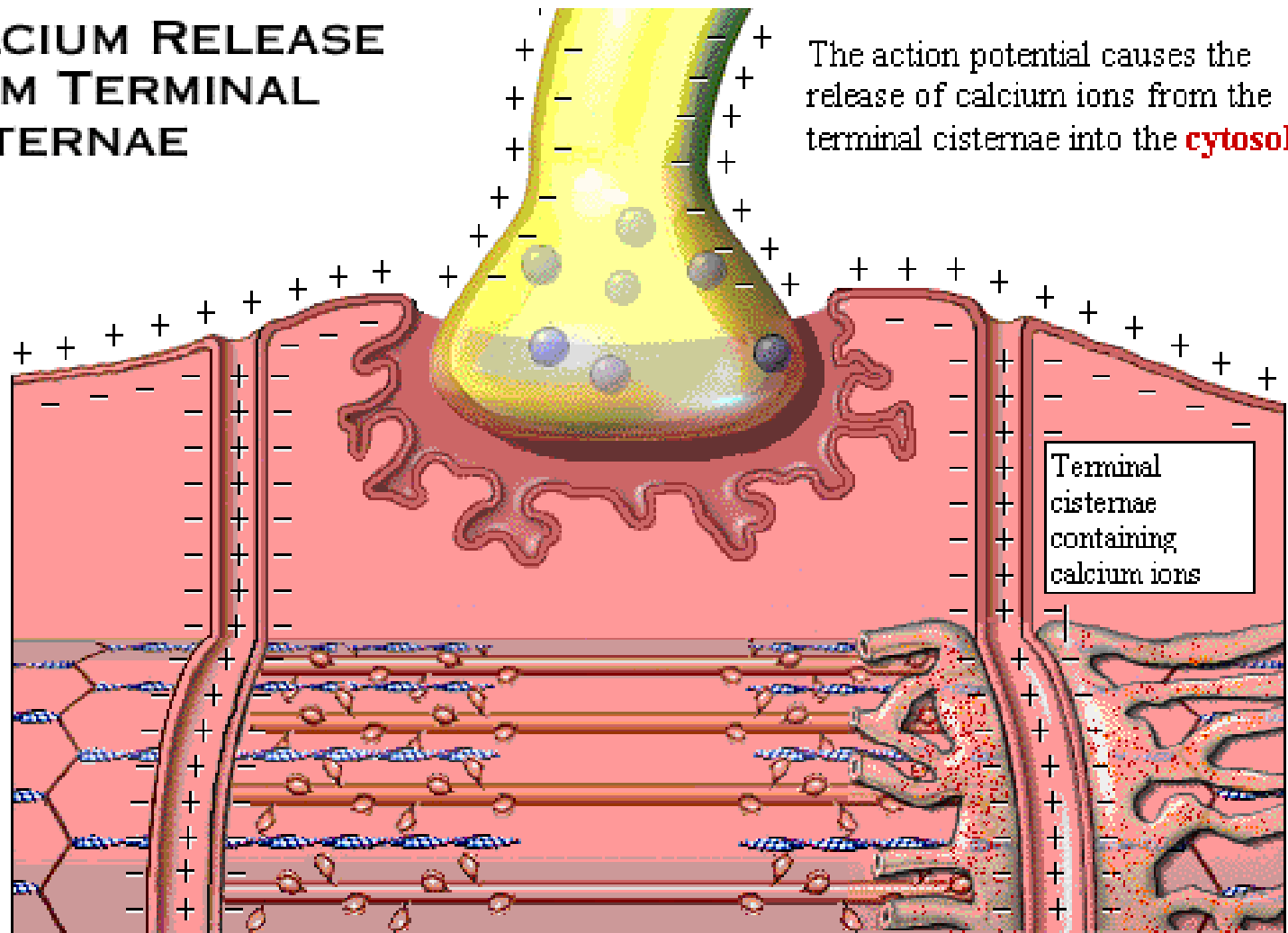
# NÖROMUSKULER KAVŞAK

## ACTION POTENTIAL PROPAGATION



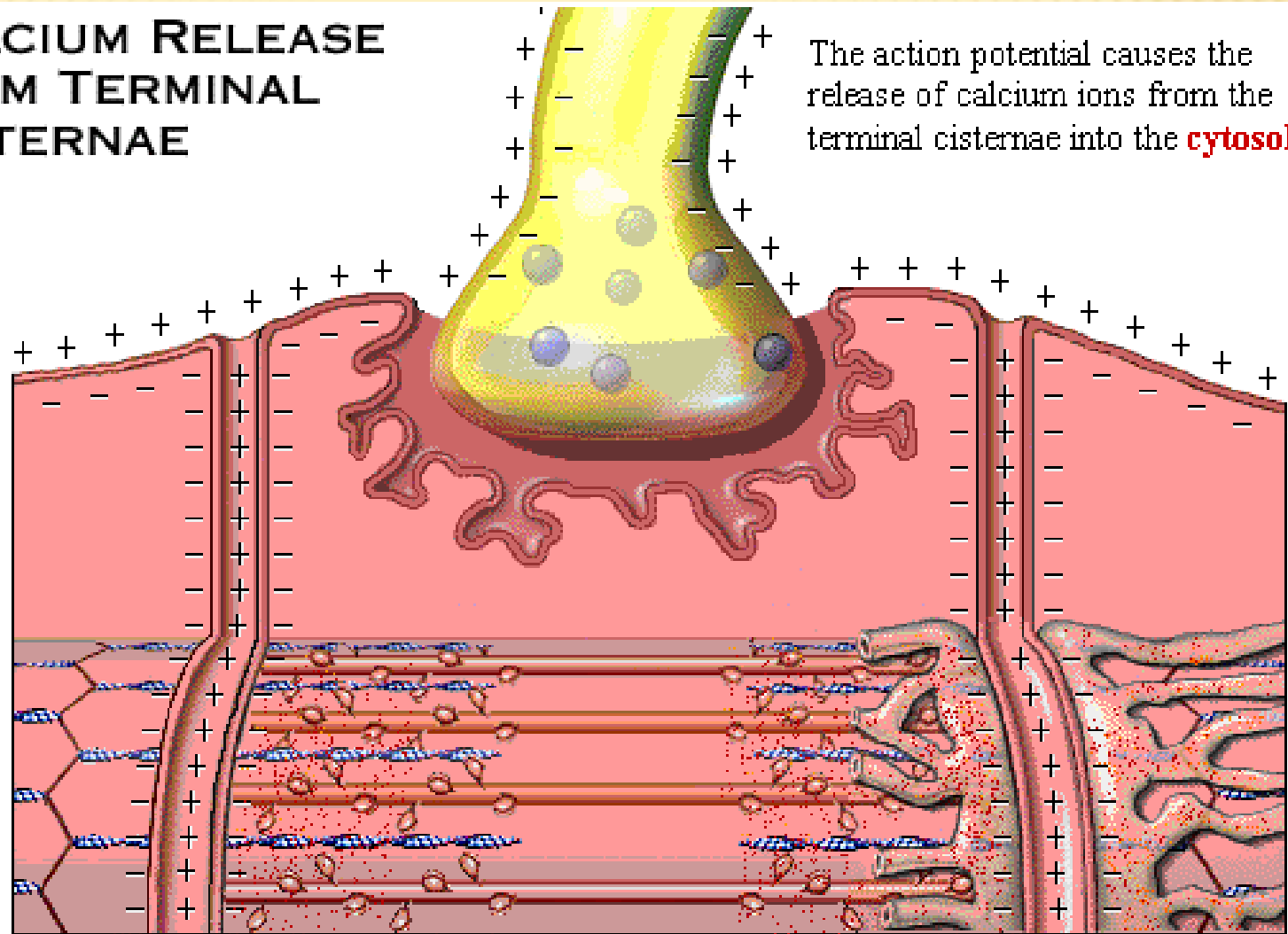
# NÖROMUSKULER KAVŞAK

## CALCIUM RELEASE FROM TERMINAL CISTERNAE



# NÖROMUSKULER KAVŞAK

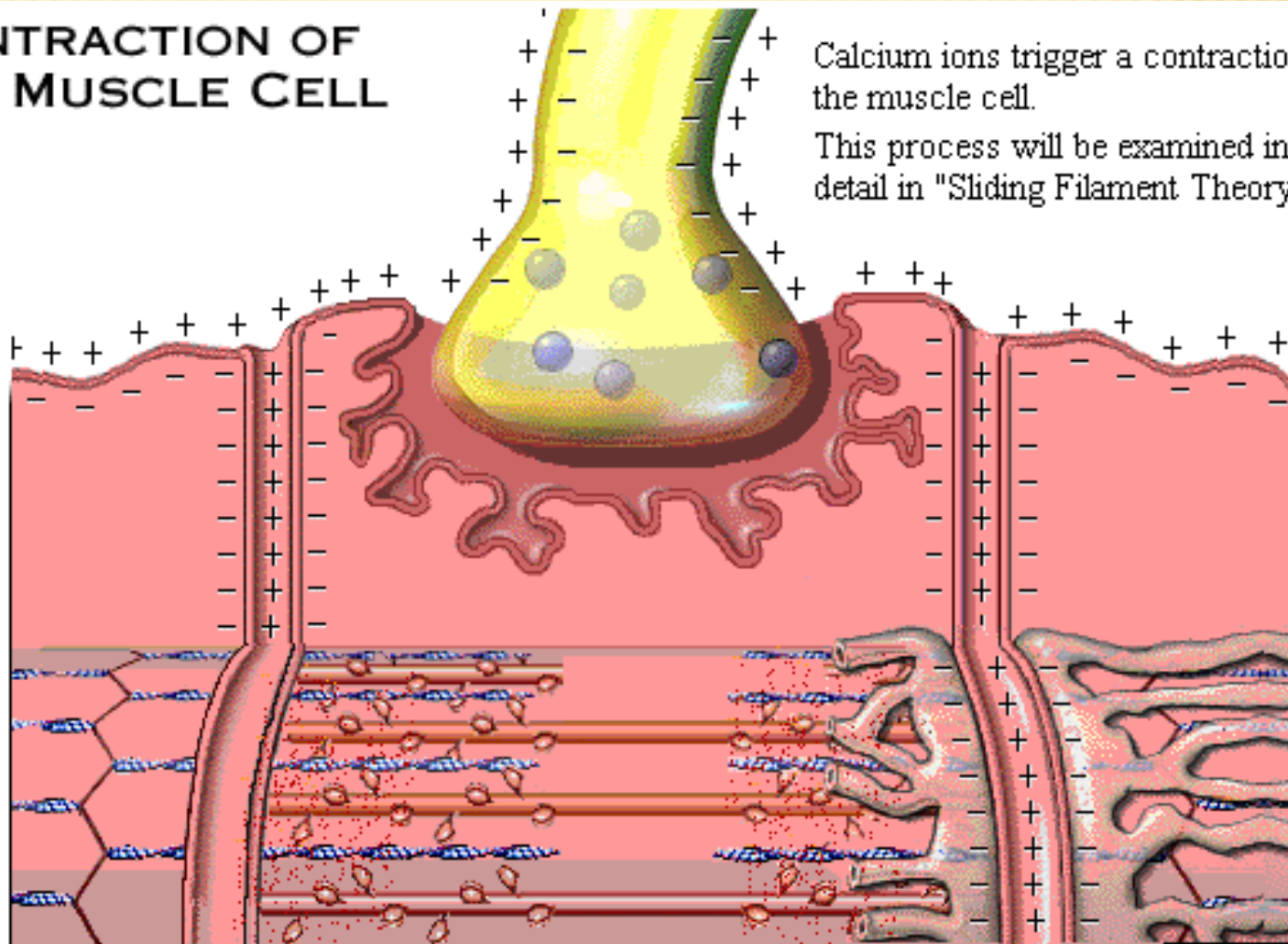
## CALCIUM RELEASE FROM TERMINAL CISTERNAE





# NÖROMUSKULER KAVŞAK

## CONTRACTION OF THE MUSCLE CELL

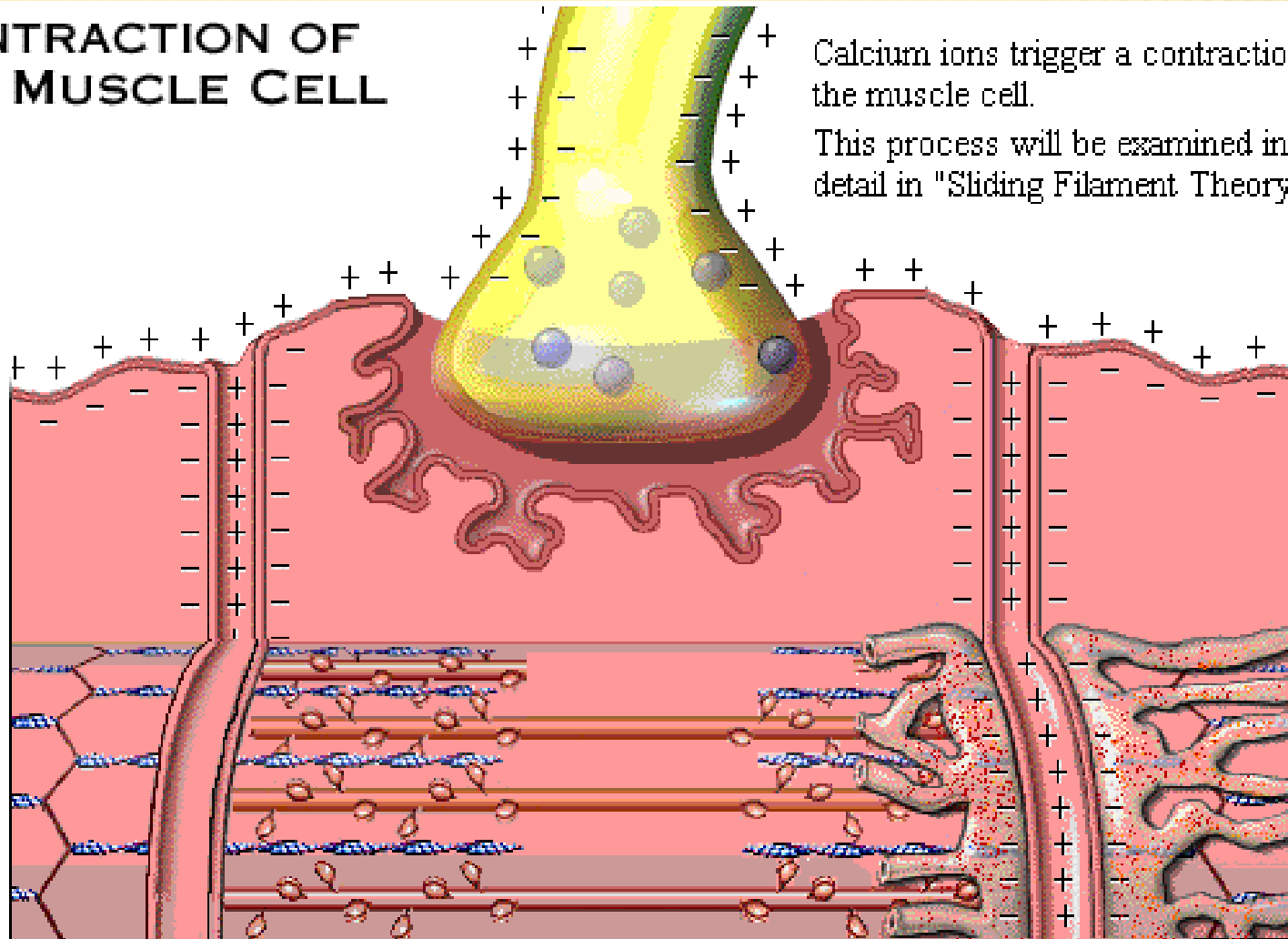


# NÖROMUSKULER KAVŞAK

## CONTRACTION OF THE MUSCLE CELL

Calcium ions trigger a contraction of the muscle cell.

This process will be examined in more detail in "Sliding Filament Theory."



# İSKELET KASININ KASILMASI

# GEREKLİ MOLEKÜLER YAPILAR

## MOLECULAR PARTICIPANTS

The **sliding filament theory** of how a skeletal muscle contracts involves the activities of five different molecules plus calcium ions:

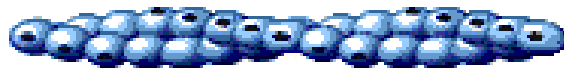
1. **Myosin**



4. **Troponin**



2. **Actin**



5. **ATP**



3. **Tropomyosin**

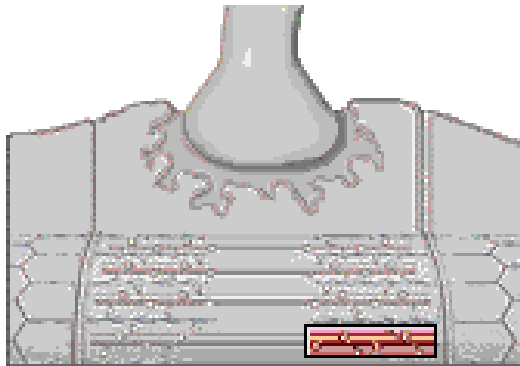


6. **Calcium ions**



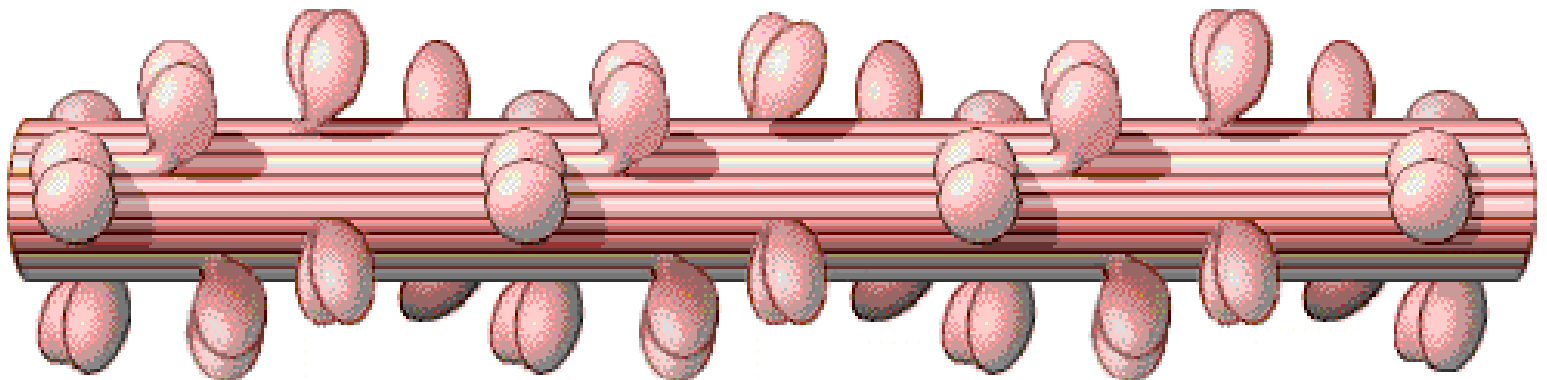
# GEREKLİ MOLEKÜLER YAPILAR

## MYOSIN



In skeletal muscle cells the **myosin** molecules are bundled together to form the thick filaments.







Portion of thick filament



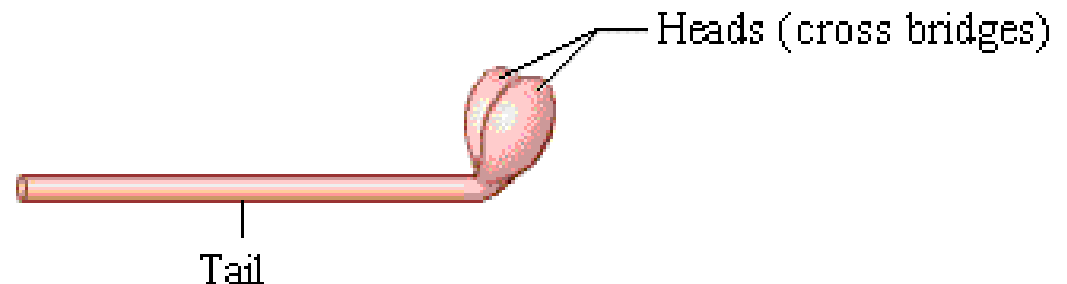


# GEREKLİ MOLEKÜLER YAPILAR






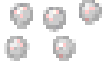
## MYOSIN MOLECULE WITH HINGED HEAD

 MYOSIN	 TROPONIN
 ACTIN	 ATP
 TROPOMYOSIN	 CALCIUM IONS

- The shape of an individual myosin molecule is similar to a golf club with two heads.
- The head (**cross bridge**) has the ability to move back and forth.
- The flexing movement of the head provides the "**power stroke**" for muscle contraction.



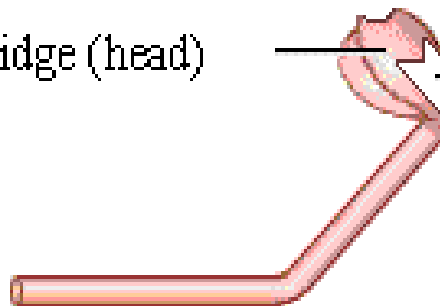
# GEREKLİ MOLEKÜLER YAPILAR

 MYOSIN	 TROPONIN
 ACTIN	 ATP
 TROPOMYOSIN	 CALCIUM IONS

The cross bridge has two important **binding sites**. One site specifically binds **ATP** (adenosine triphosphate), a high-energy molecule. Notice the position of the cross bridge. This is called the low-energy **conformation**.









Myosin cross bridge (head)



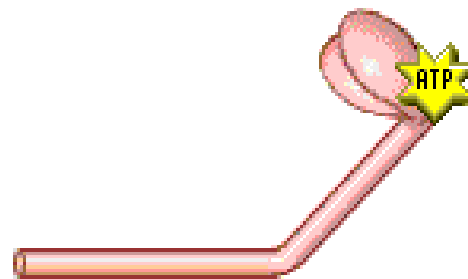
ATP binding site

# GEREKLİ MOLEKÜLER YAPILAR

## ENERGIZED CROSS BRIDGE







 MYOSIN	 TROPONIN
 ACTIN	 ATP
 TROPOMYOSIN	 CALCIUM IONS

The binding of ATP transfers energy to the myosin cross bridge as ATP is **hydrolyzed** into **ADP** and  $P_i$  (**inorganic phosphate**).

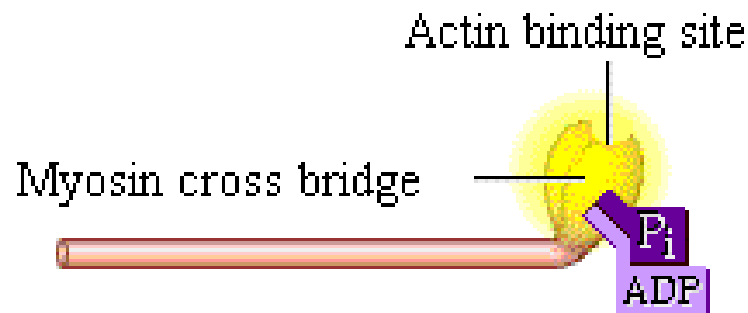


# GEREKLİ MOLEKÜLER YAPILAR

## ACTIN BINDING SITE ON MYOSIN







 MYOSIN	 TROPONIN
 ACTIN	 ATP
 TROPOMYOSIN	 CALCIUM IONS

The second binding site on the myosin cross bridge has a strong attraction for binding to **actin**.

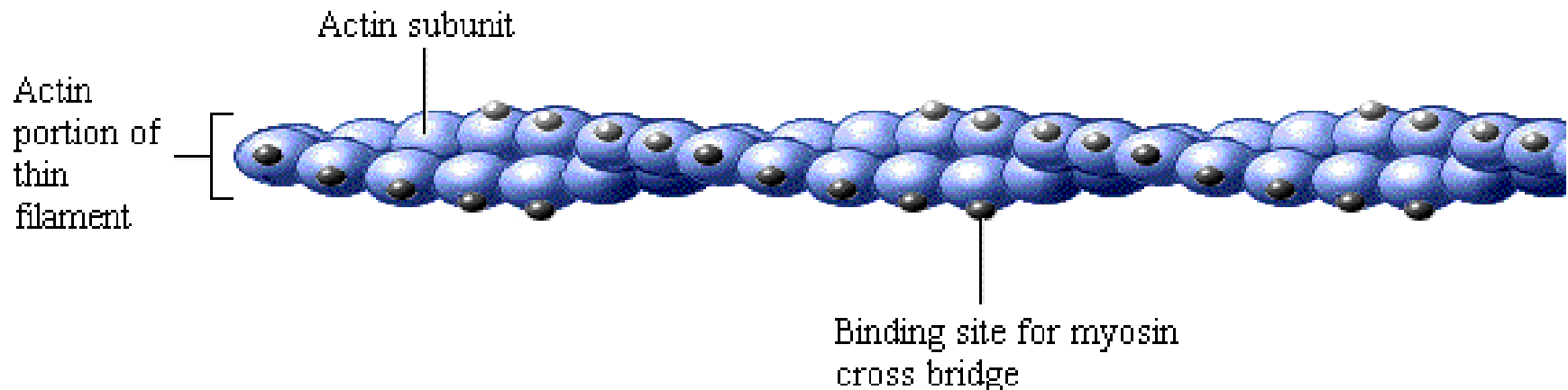


# GEREKLİ MOLEKÜLER YAPILAR

## ACTIN

 MYOSIN	 TROPONIN
 ACTIN	 ATP
 TROPOMYOSIN	 CALCIUM IONS







- **Actin** is the major component of the thin filament.
- The actin portion of the thin filament is composed of actin subunits twisted into a **double helical chain**.
- Each actin subunit has a specific binding site to which the myosin cross bridge binds.



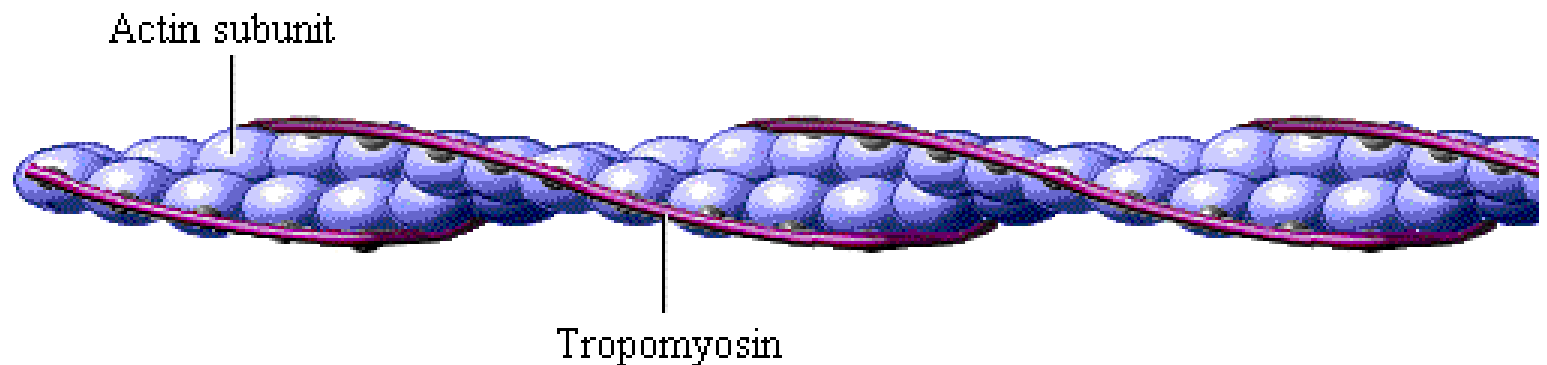


# GEREKLİ MOLEKÜLER YAPILAR

## TROPOMYOSIN







 MYOSIN	 TROPONIN
 ACTIN	 ATP
 TROPOMYOSIN	 CALCIUM IONS

- The regulatory protein **tropomyosin** is also part of the thin filament.
- Tropomyosin entwines around the actin.
- In the unstimulated muscle, the position of the tropomyosin covers the binding sites on the actin subunits and prevents myosin cross bridge binding.

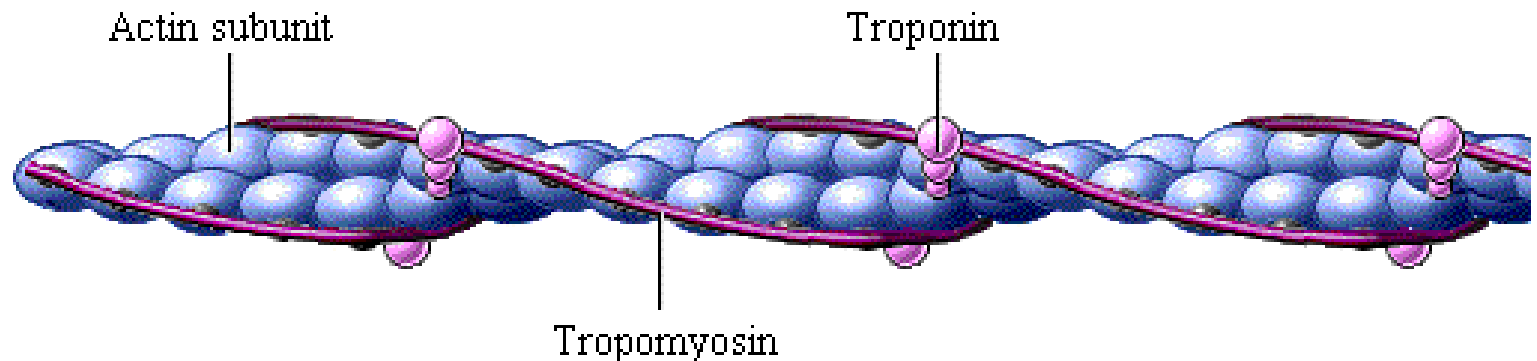


# GEREKLİ MOLEKÜLER YAPILAR

## TROPONIN







 MYOSIN	 TROPONIN
 ACTIN	 ATP
 TROPOMYOSIN	 CALCIUM IONS

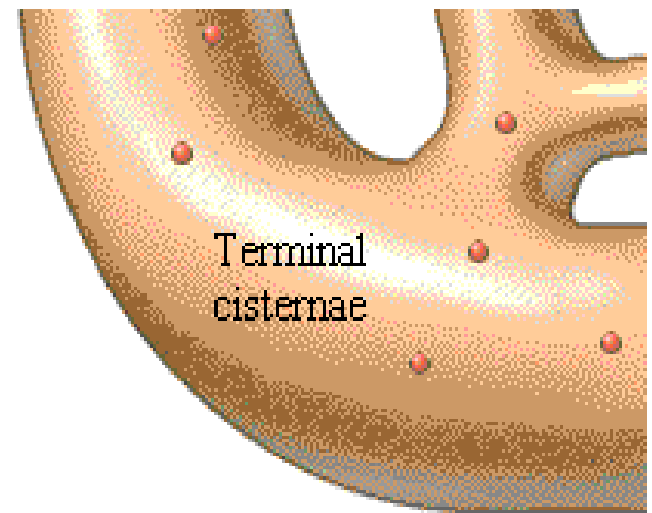
- To expose the binding sites for binding with myosin, the tropomyosin molecule must be moved aside.
- This is facilitated by the presence of a third molecular complex called **troponin**.
- Troponin is attached and spaced periodically along the tropomyosin strand.



# GEREKLİ MOLEKÜLER YAPILAR

## CALCIUM IONS

 MYOSIN	 TROPONIN
 ACTIN	 ATP
 TROPOMYOSIN	 CALCIUM IONS



After an **action potential**, **calcium ions** are released from the terminal cisternae and bind to troponin. This causes a conformational change in the tropomyosin-troponin complex, "dragging" the tropomyosin strands off the binding sites.

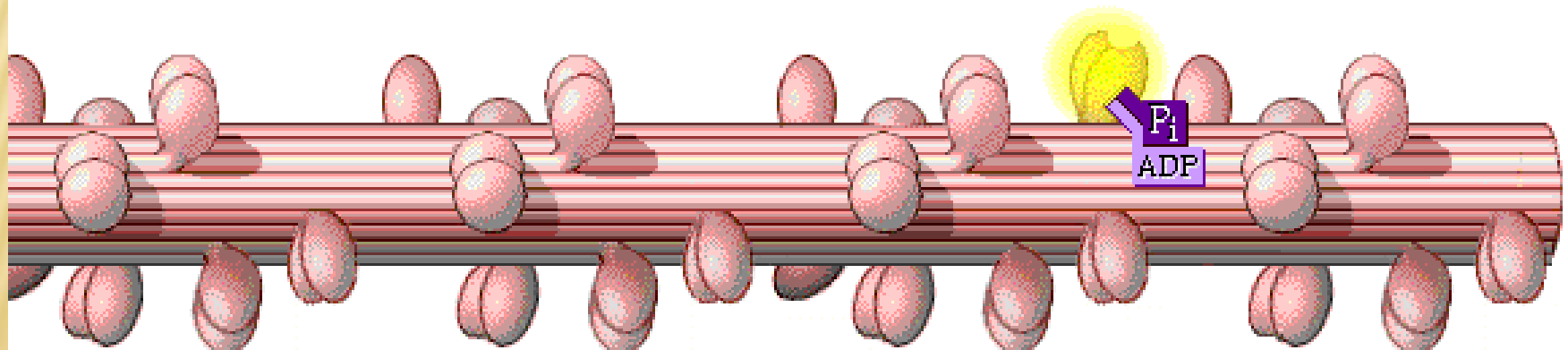
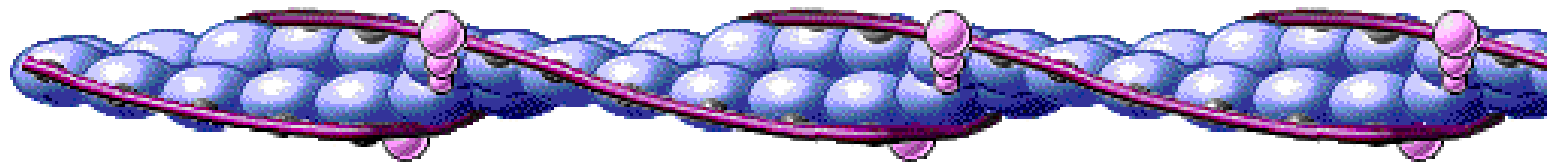
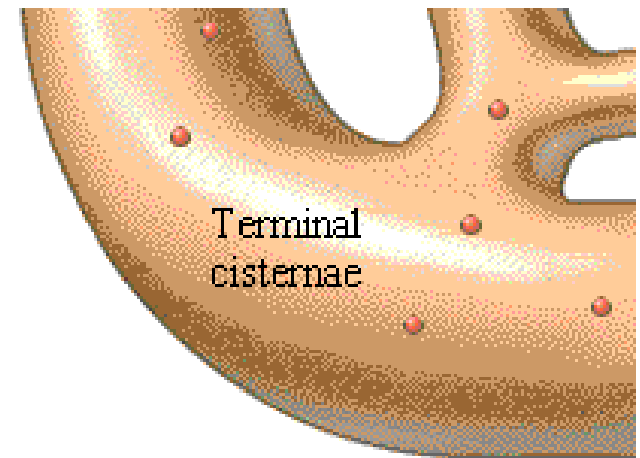


# SLIDING FILAMENT TEORİSİ

## SINGLE CROSS BRIDGE CYCLE

We will first show an animation of a single cross bridge cycle and then describe this process step-by-step on the following pages.

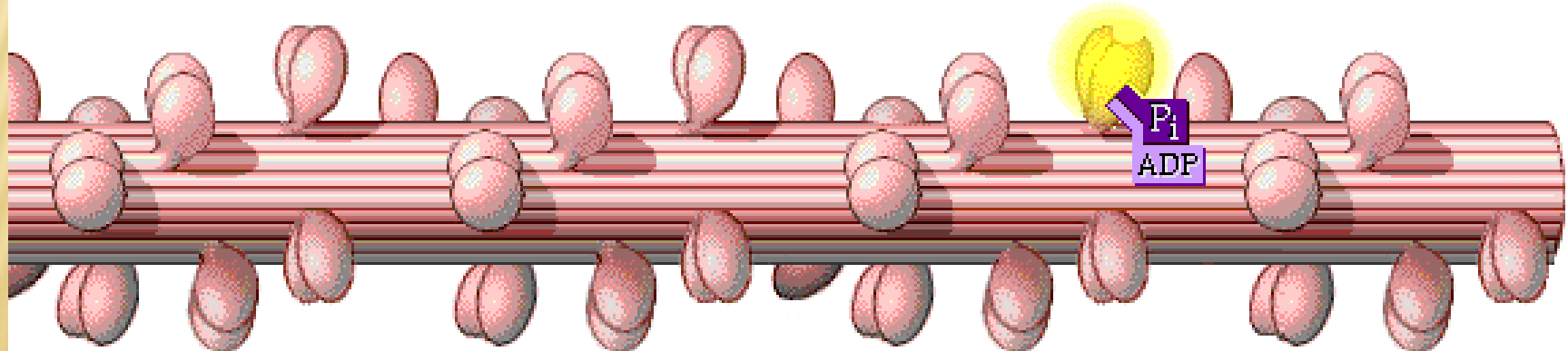
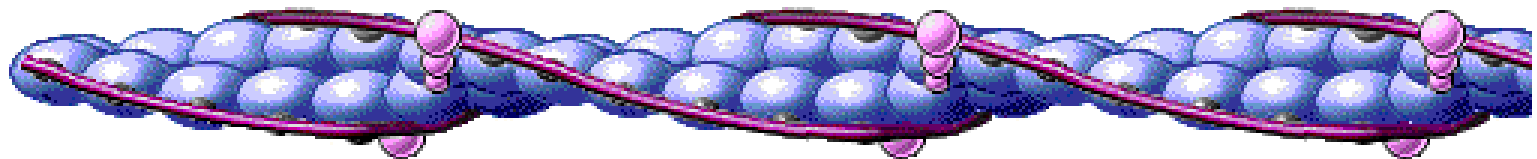
To see the entire process of a single cross bridge cycle, click the terminal cisternae.



# SLIDING FILAMENT TEORİSİ

## STEP 1: EXPOSURE OF BINDING SITES ON ACTIN

- An **action potential** brings about the release of calcium ions from the terminal cisternae of the sarcoplasmic reticulum.
- Calcium ions flood into the **cytosol** and bind to the troponin, causing a change in conformation of the troponin-tropomyosin complex.
- This conformational change exposes the binding sites on actin.

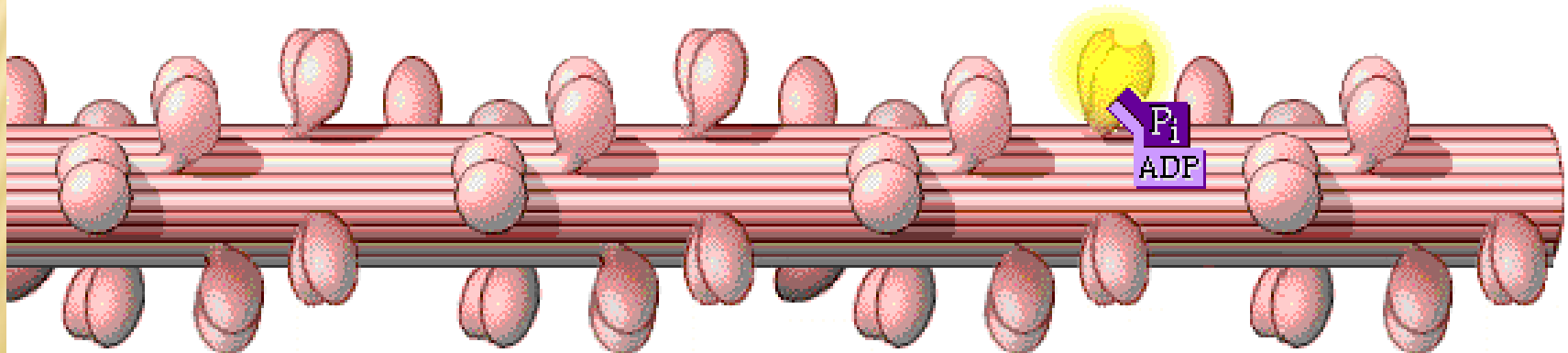
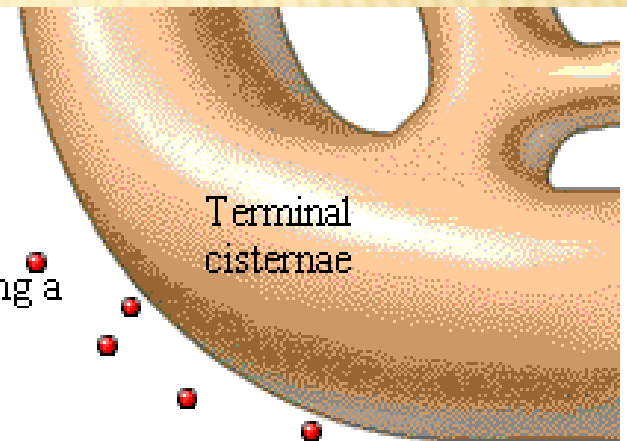




# SLIDING FILAMENT TEORISI

## STEP 1: EXPOSURE OF BINDING SITES ON ACTIN

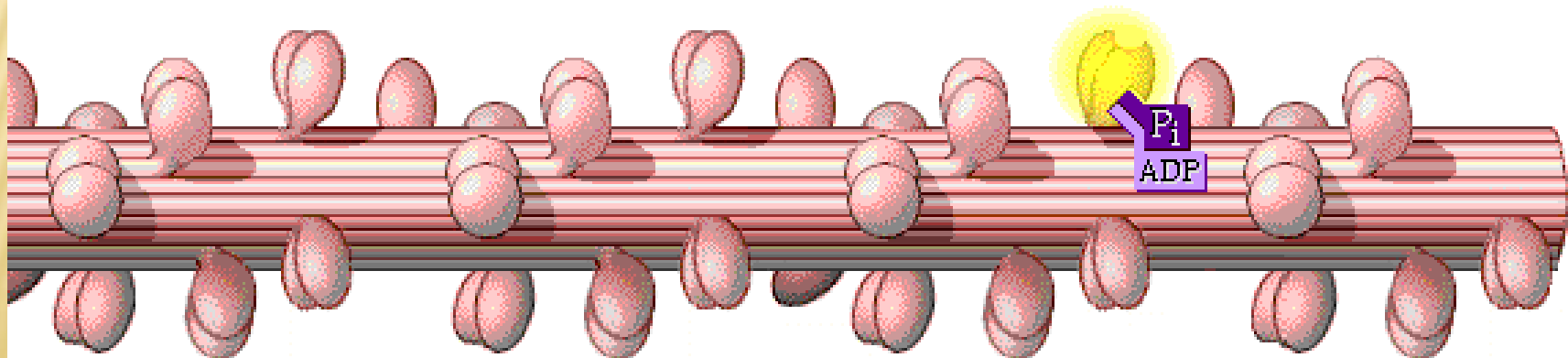
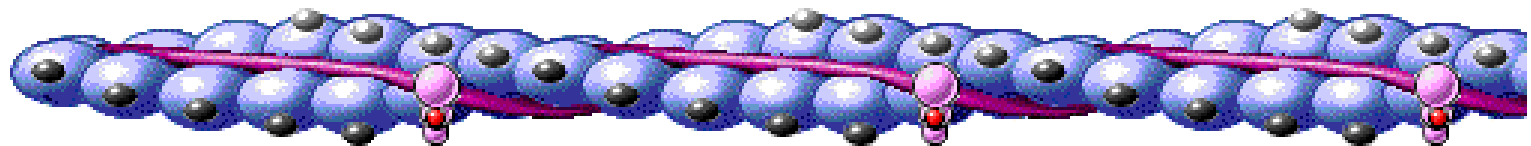
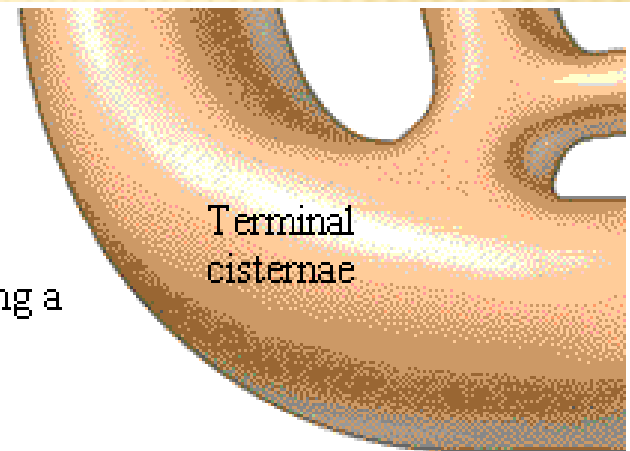
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- Calcium ions flood into the **cytosol** and bind to the troponin, causing a change in conformation of the troponin-tropomyosin complex.
- This conformational change exposes the binding sites on actin.



# SLIDING FILAMENT TEORISI

## STEP 1: EXPOSURE OF BINDING SITES ON ACTIN

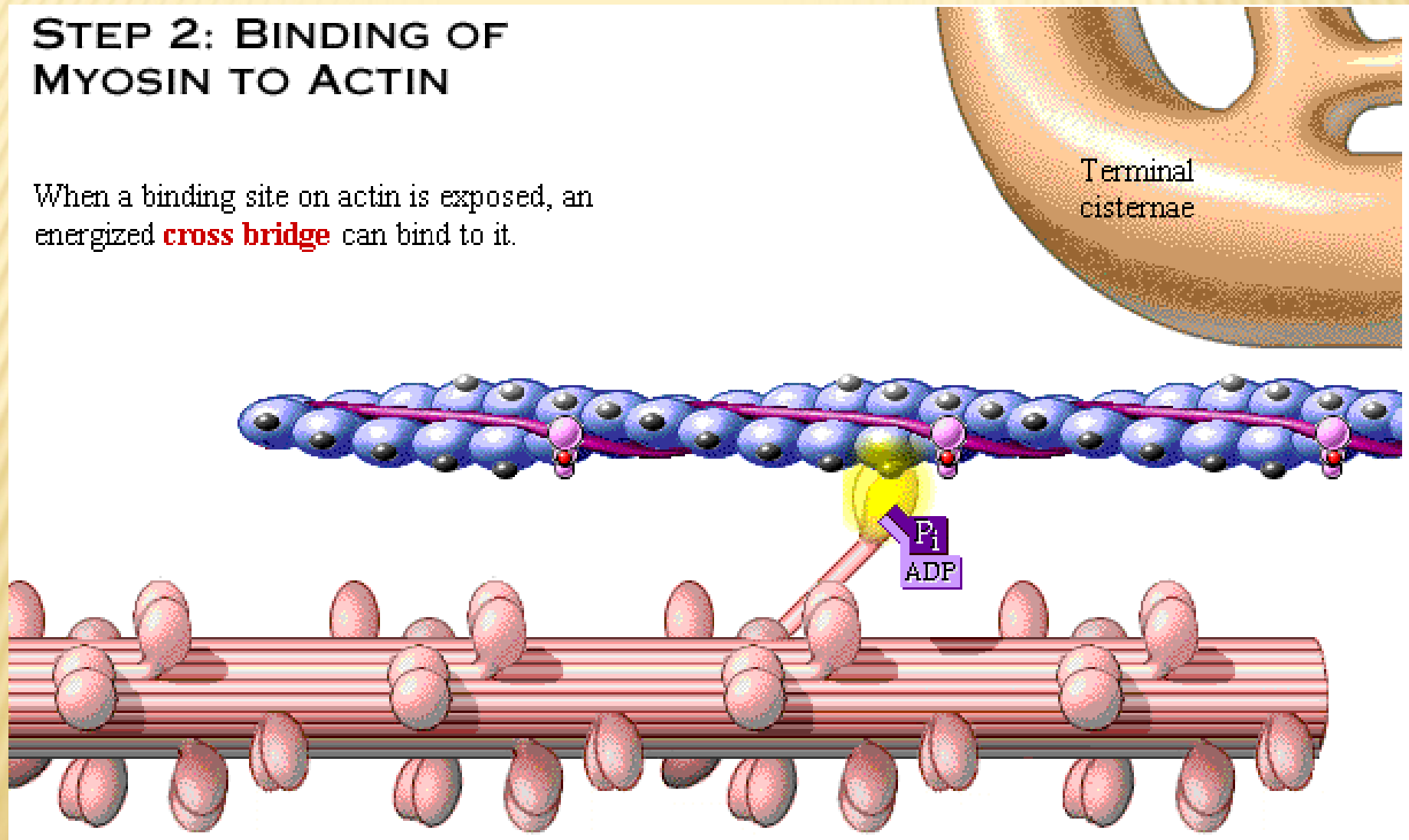
- An **action potential** brings about the release of calcium ions from the terminal cisternae of the sarcoplasmic reticulum.
- Calcium ions flood into the **cytosol** and bind to the troponin, causing a change in conformation of the troponin-tropomyosin complex.
- This conformational change exposes the binding sites on actin.



# SLIDING FILAMENT TEORİSİ

## STEP 2: BINDING OF MYOSIN TO ACTIN

When a binding site on actin is exposed, an energized **cross bridge** can bind to it.



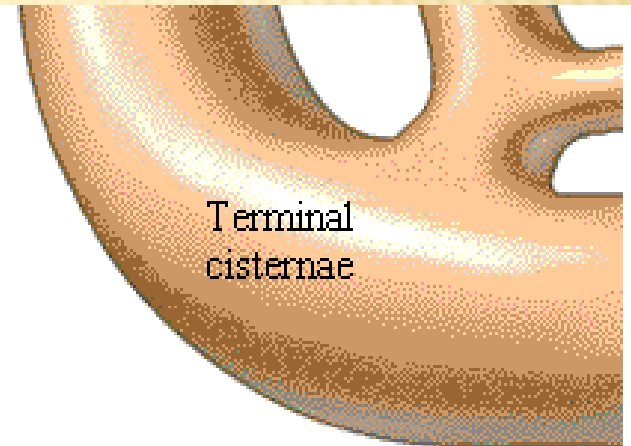
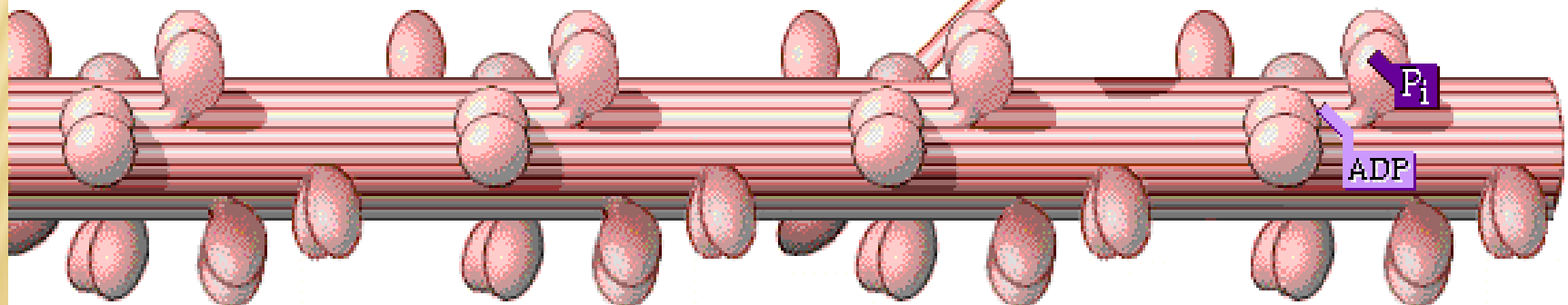
# SLIDING FILAMENT TEORISI

## STEP 3: POWER STROKE OF THE CROSS BRIDGE

- The binding of myosin to actin brings about a change in the conformation of the cross bridge, resulting in the release of **ADP** and **inorganic phosphate**.
- At the same time, the cross bridge flexes, pulling the thin filament inward toward the center of the **sarcomere**. This movement is called the power stroke.



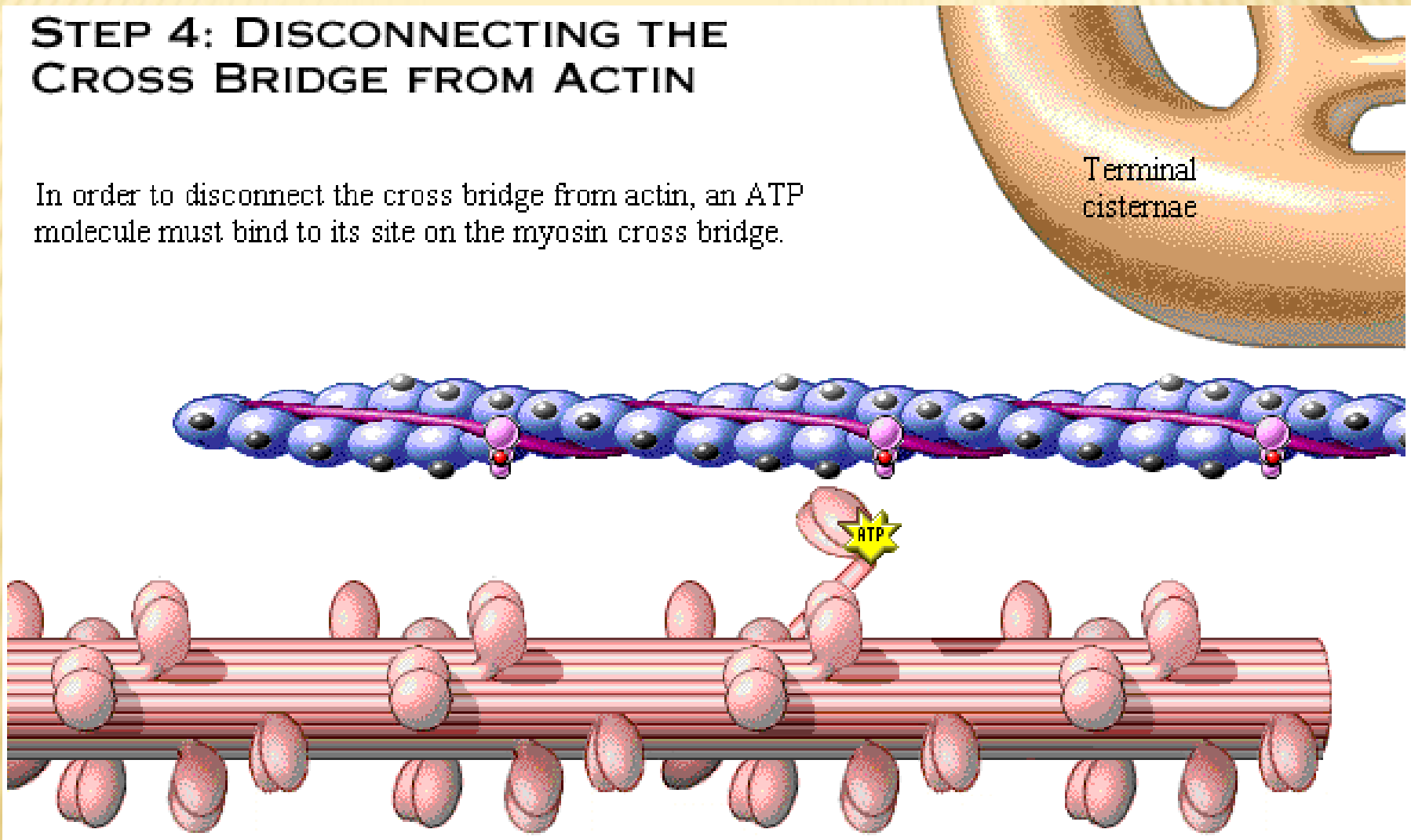
- The **chemical energy** of ATP has been transformed into the **mechanical energy** of a contraction.



# SLIDING FILAMENT TEORISI

## STEP 4: DISCONNECTING THE CROSS BRIDGE FROM ACTIN

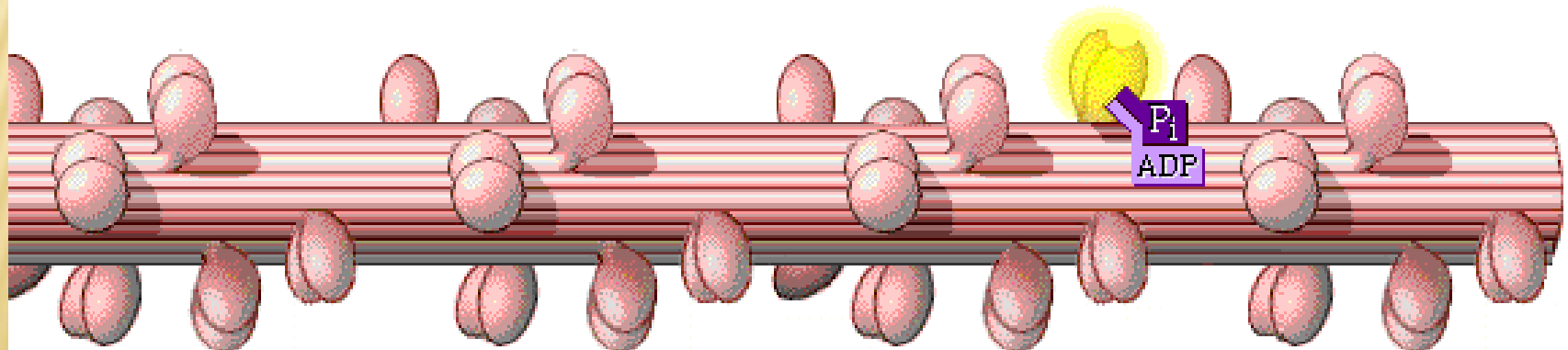
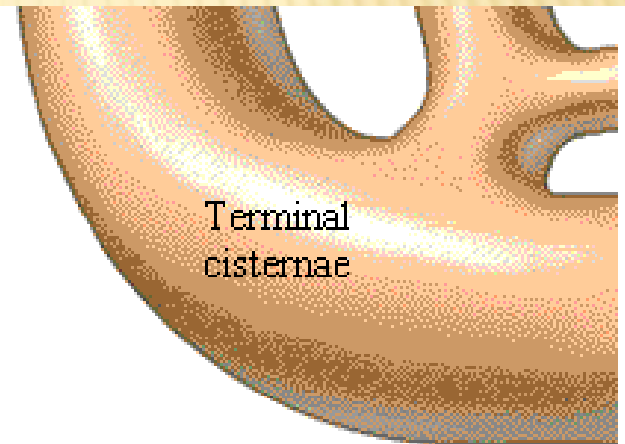
In order to disconnect the cross bridge from actin, an ATP molecule must bind to its site on the myosin cross bridge.



# SLIDING FILAMENT TEORISI

## STEP 5: RE-ENERGIZING AND REPOSITIONING THE CROSS BRIDGE

- The release of the myosin cross bridge from actin triggers the **hydrolysis** of the ATP molecule into ADP and  $P_i$ .
- Energy is transferred from ATP to the myosin cross bridge, which returns to its high-energy conformation.

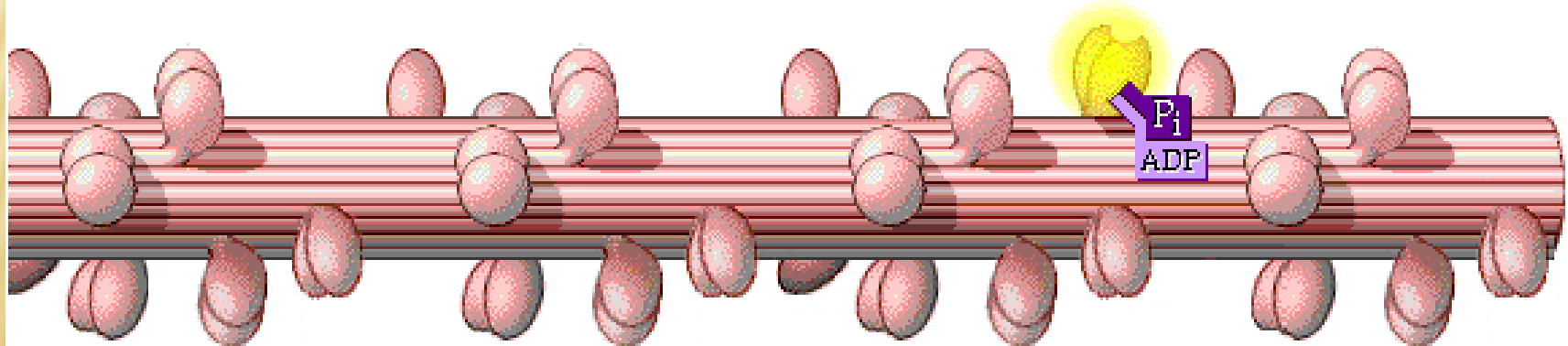
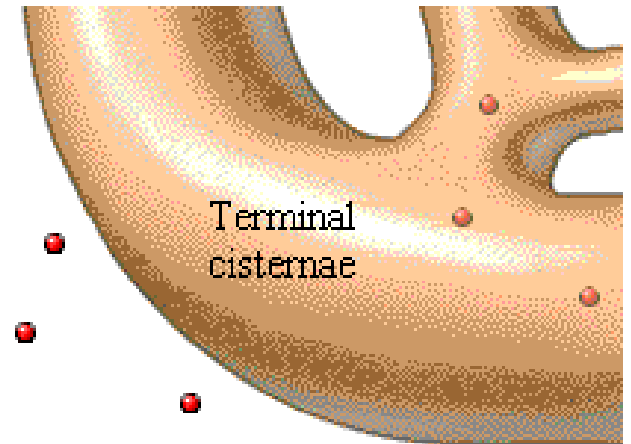




# SLIDING FILAMENT TEORISI

## STEP 6: REMOVAL OF CALCIUM IONS

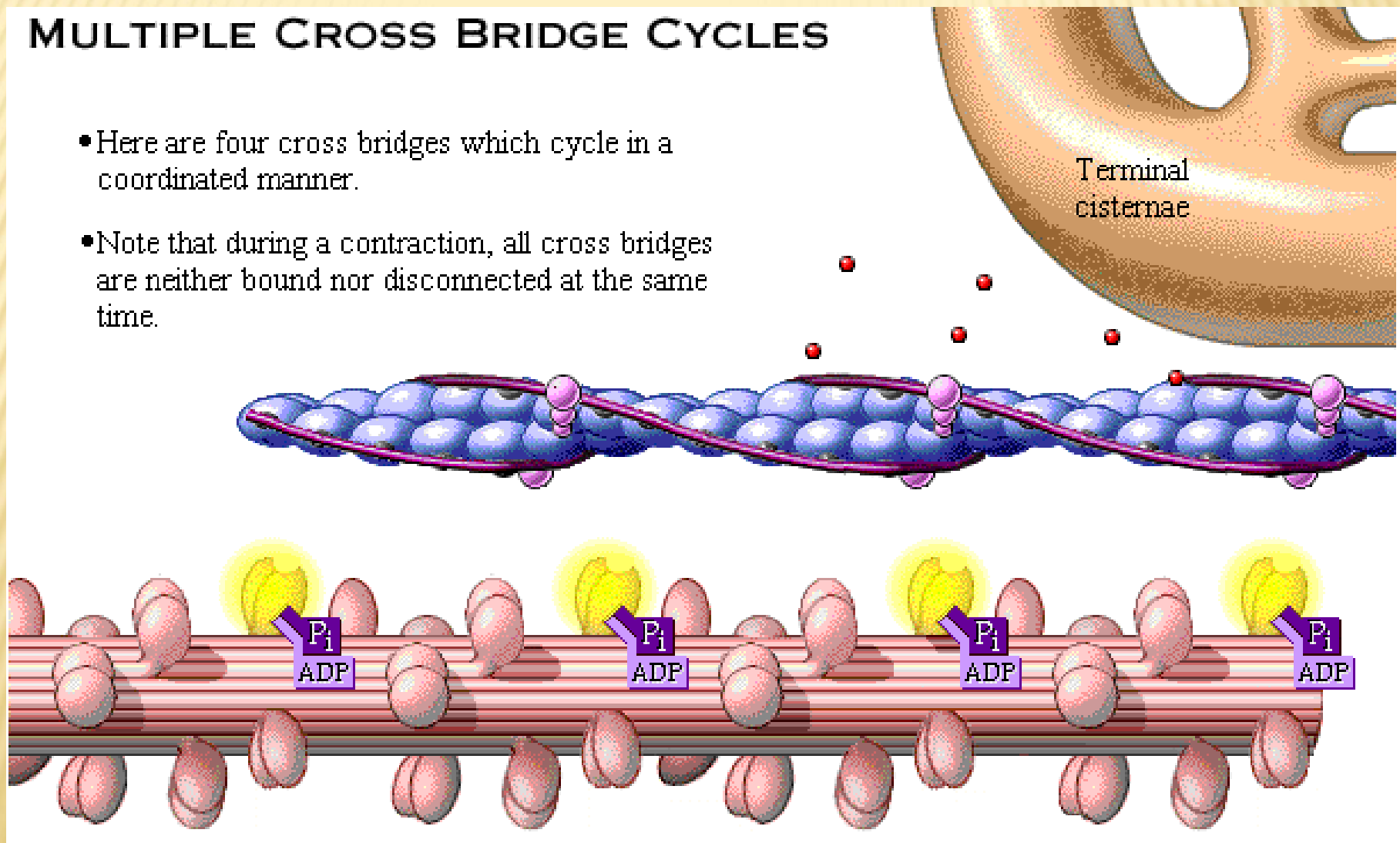
- Calcium is actively transported from the cytosol into the **sarcoplasmic reticulum** by **ion pumps**.
- As the calcium is removed, the troponin-tropomyosin complex again covers the binding sites on actin.



# SLIDING FILAMENT TEORISI

## MULTIPLE CROSS BRIDGE CYCLES

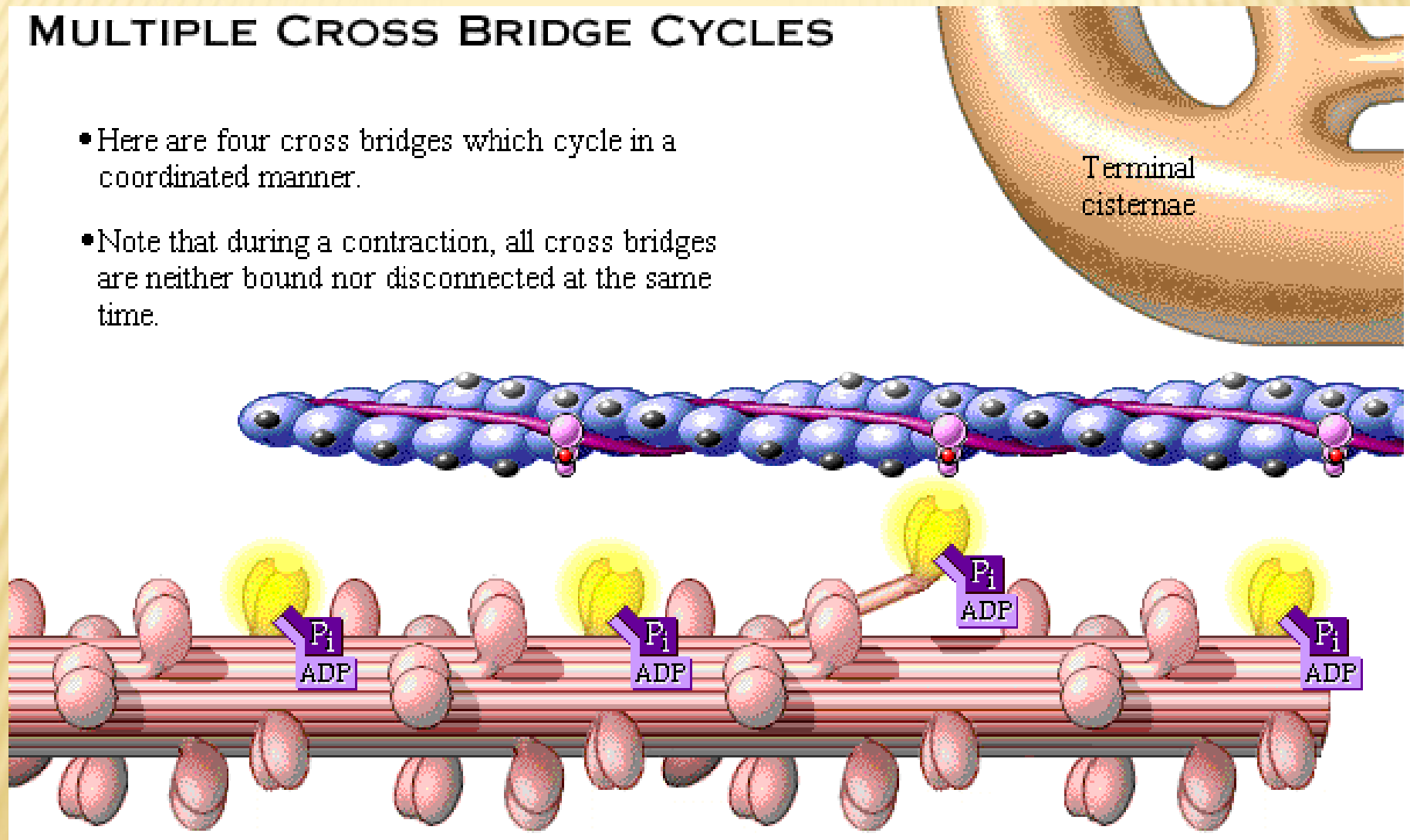
- Here are four cross bridges which cycle in a coordinated manner.
- Note that during a contraction, all cross bridges are neither bound nor disconnected at the same time.



# SLIDING FILAMENT TEORISI

## MULTIPLE CROSS BRIDGE CYCLES

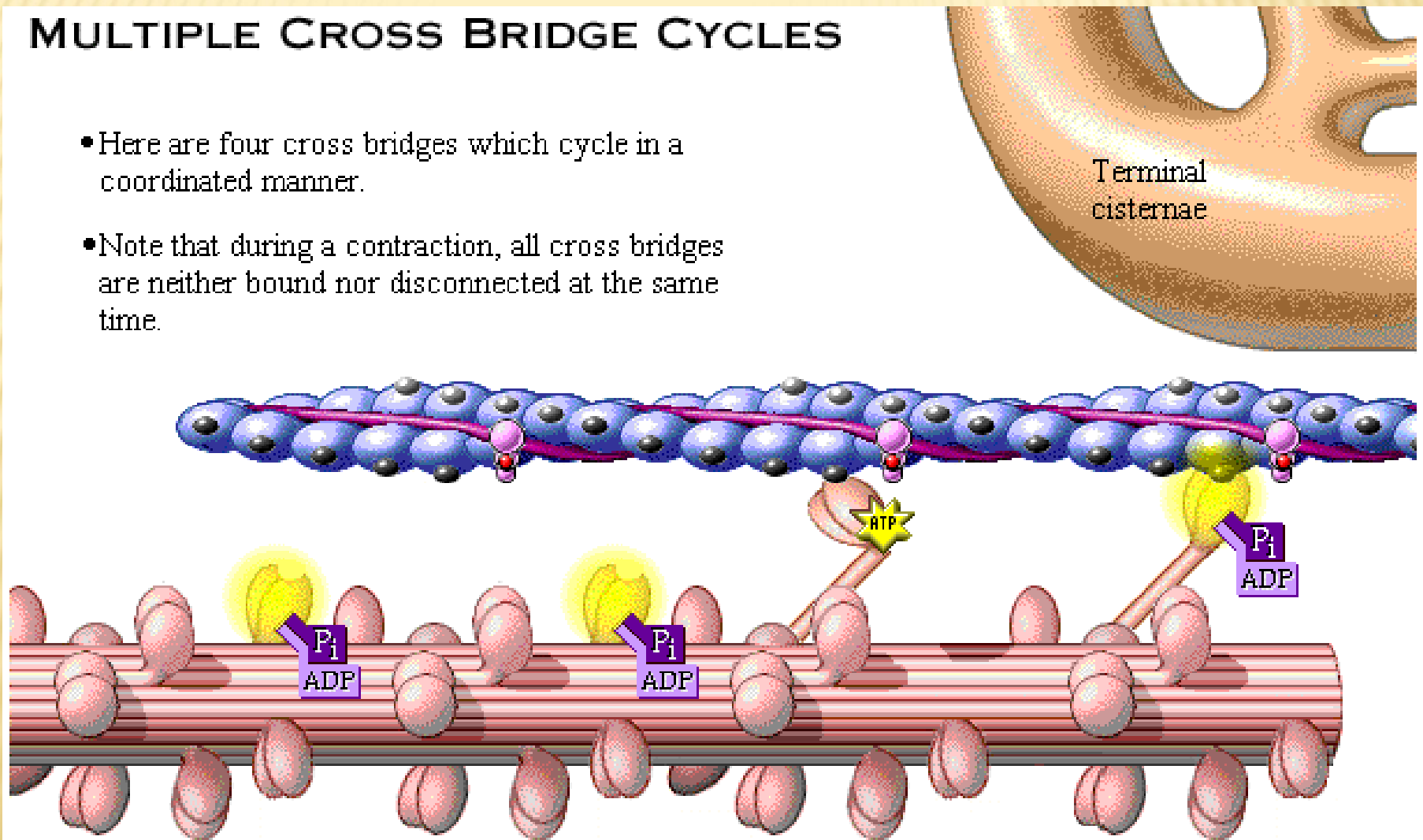
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# SLIDING FILAMENT TEORISI

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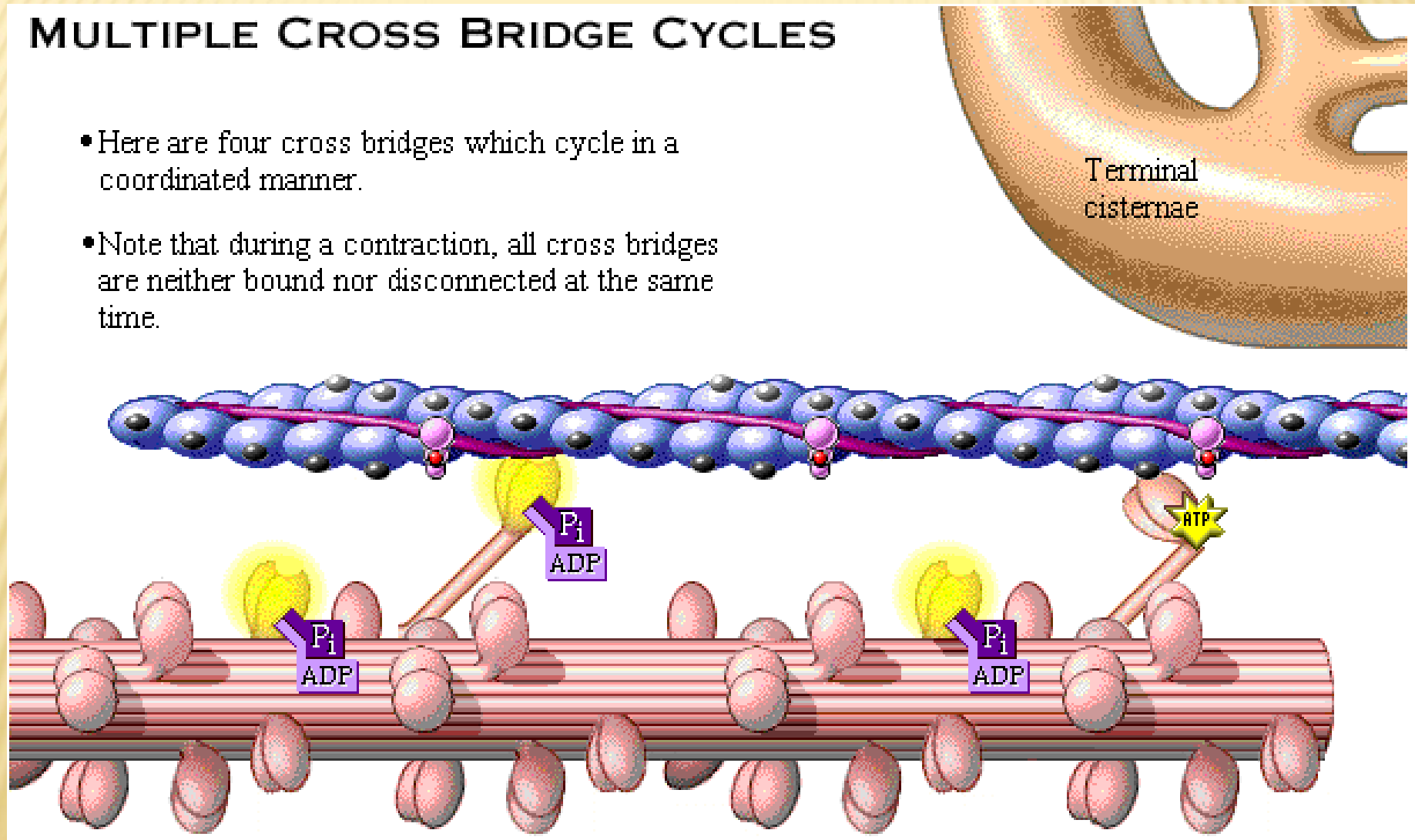
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# SLIDING FILAMENT TEORISI

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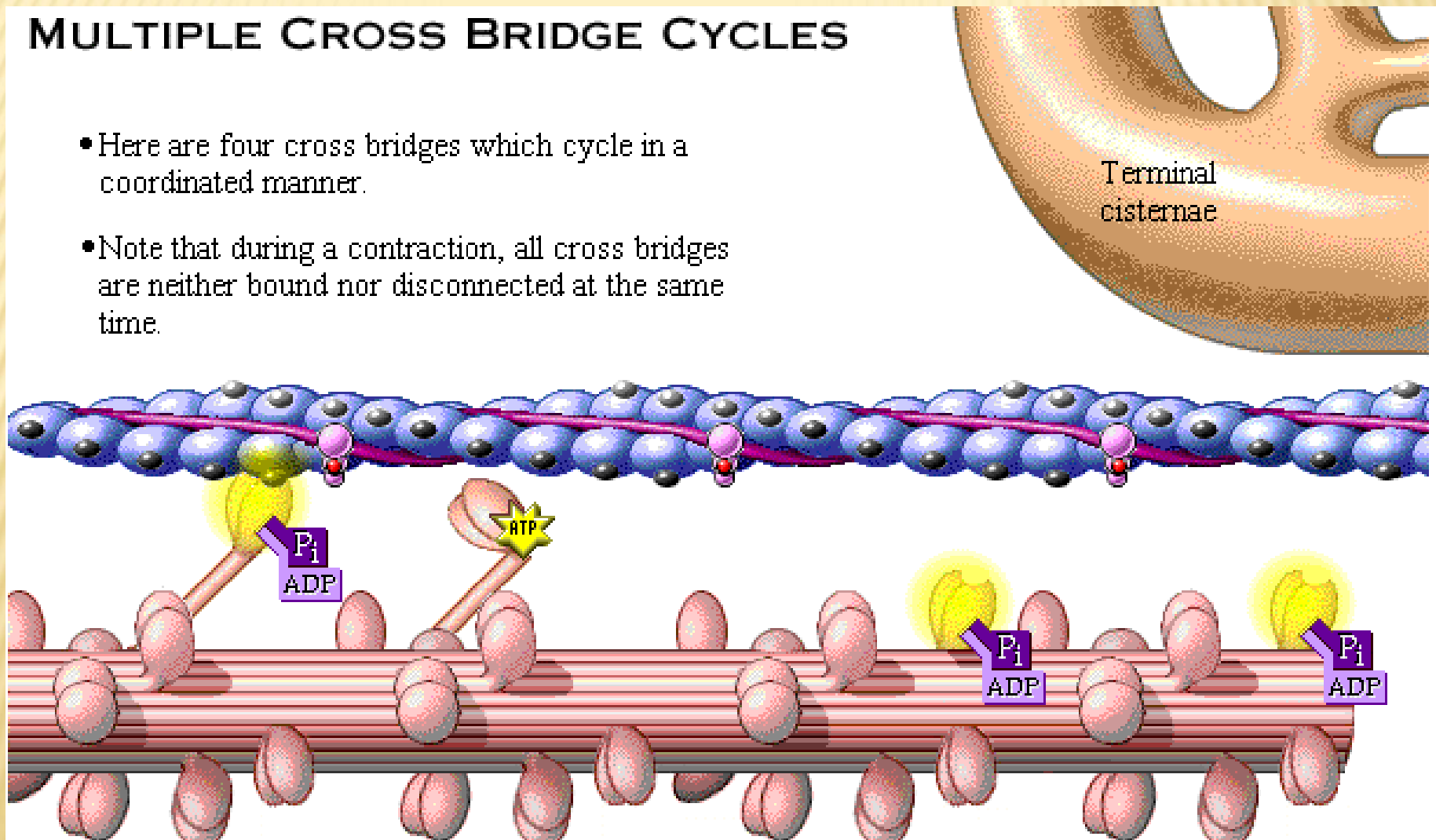
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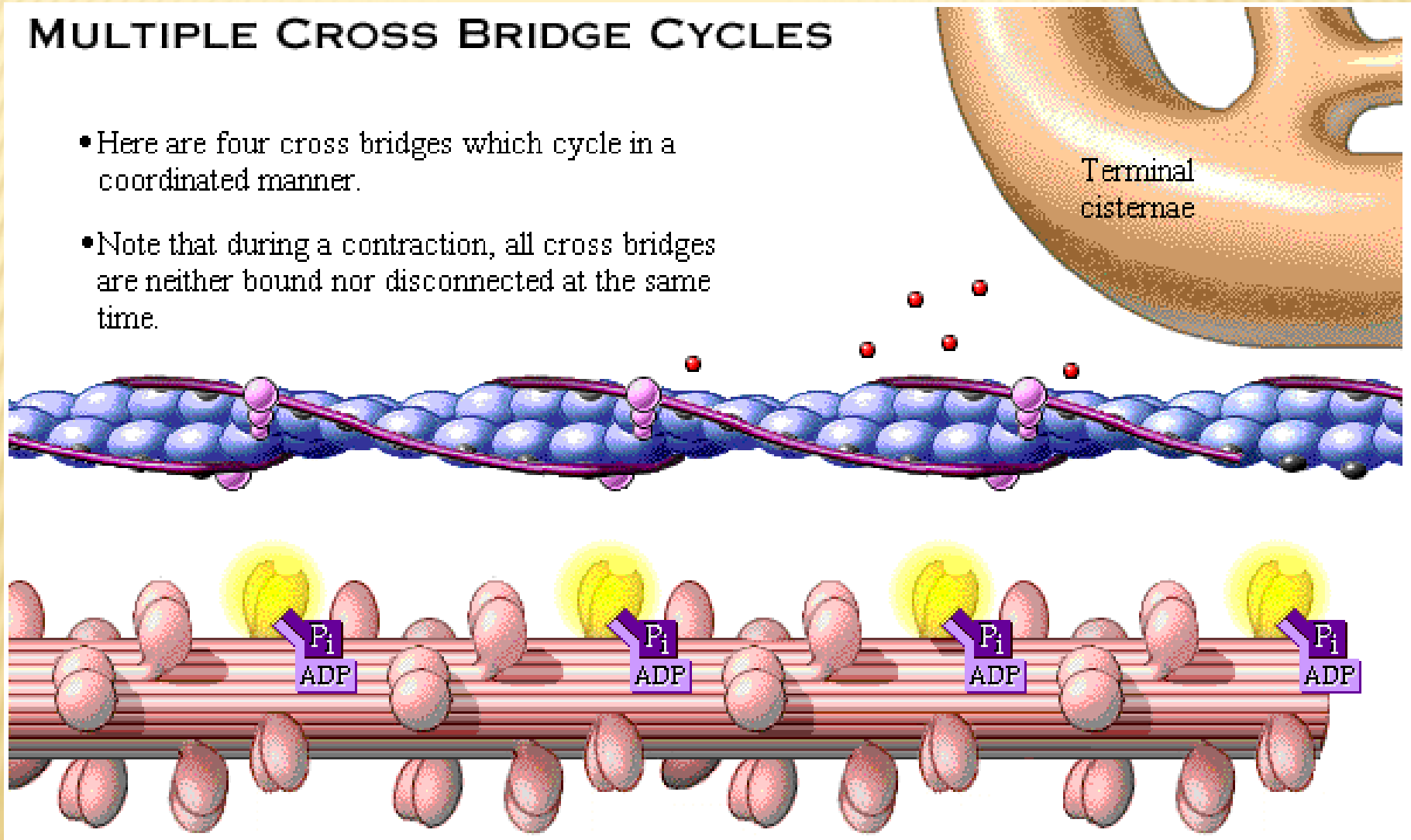




# SLIDING FILAMENT TEORISI

## MULTIPLE CROSS BRIDGE CYCLES

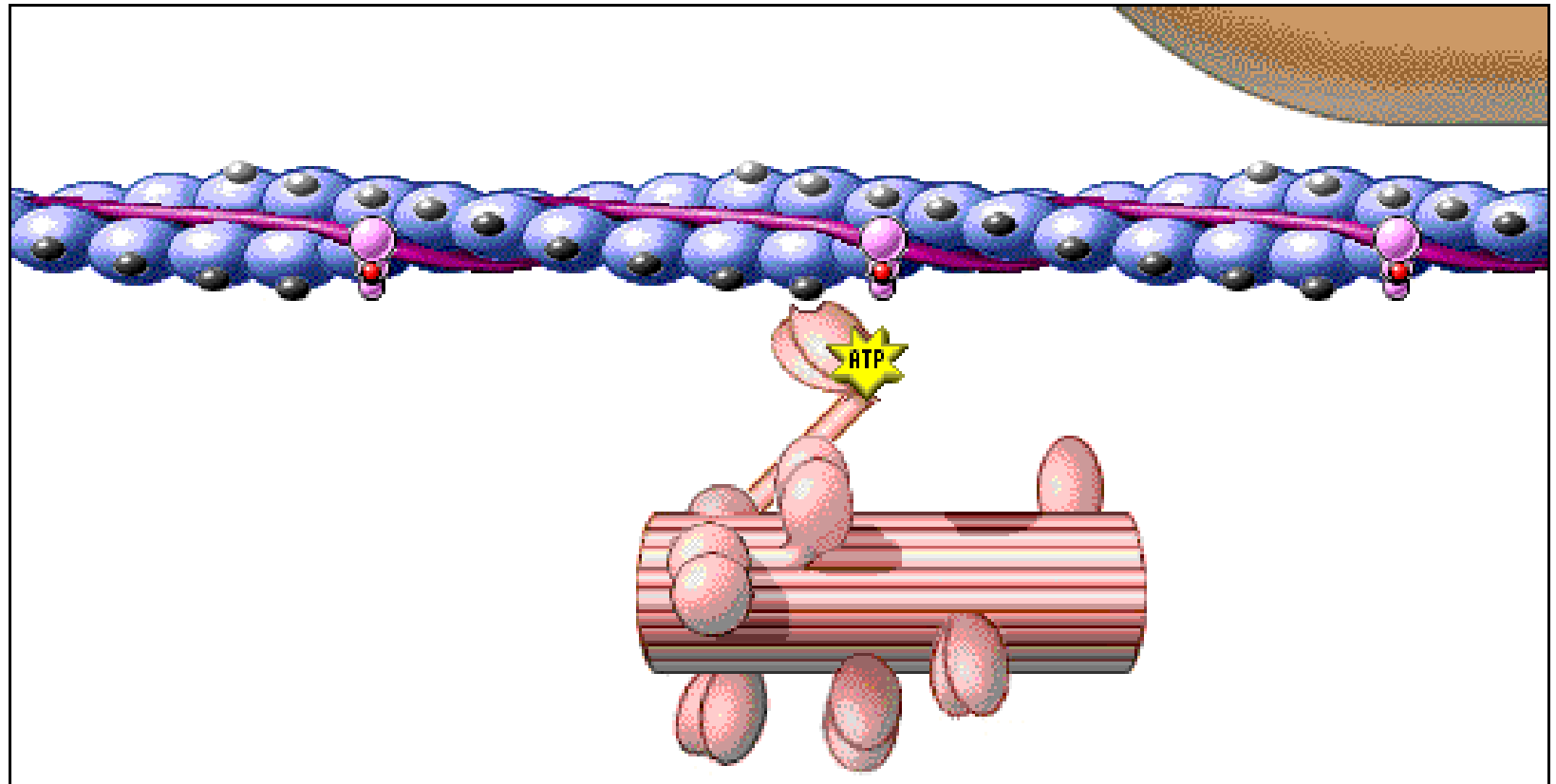
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# KASIN ENERJİ METABOLİZMASI

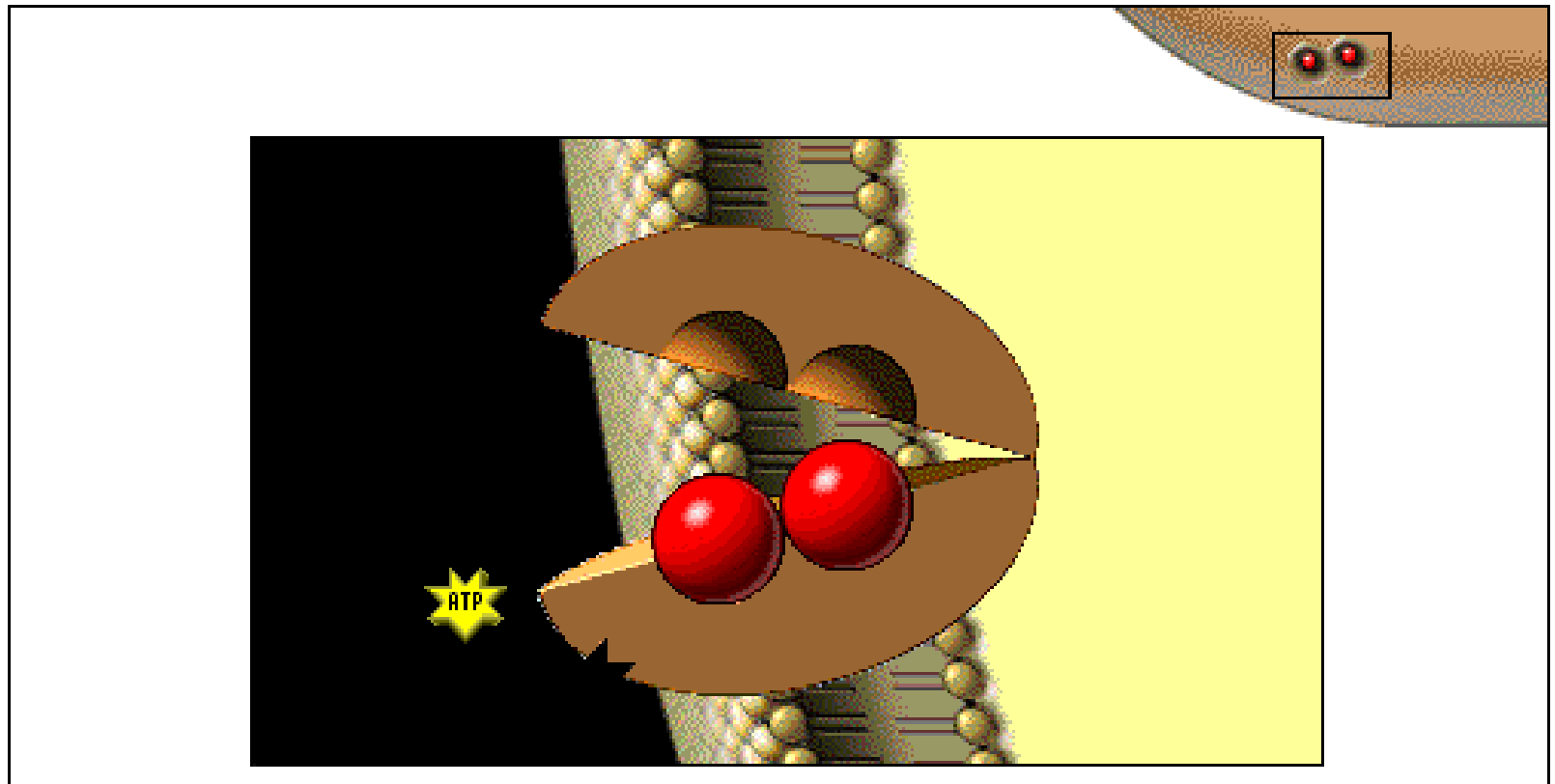
# ATP'NİN ROLÜ

## ROLE OF ATP



# ATP'NİN ROLÜ

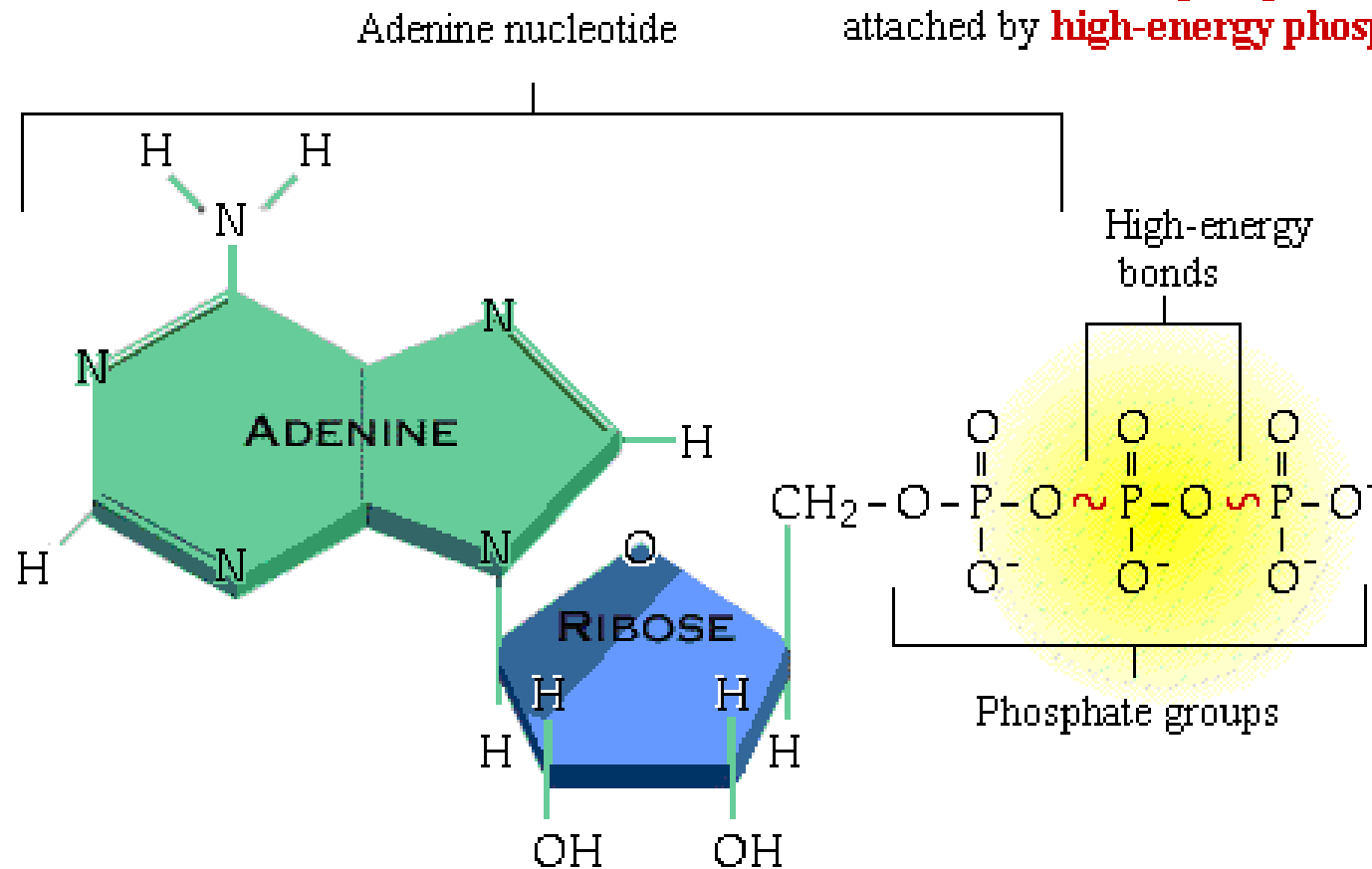
## ROLE OF ATP



# ATP'NİN YAPISI

## STRUCTURE OF ADENOSINE TRIPHOSPHATE (ATP)

**ATP** is composed of the **adenine nucleotide** with two additional **phosphate groups** attached by **high-energy phosphate bonds**.

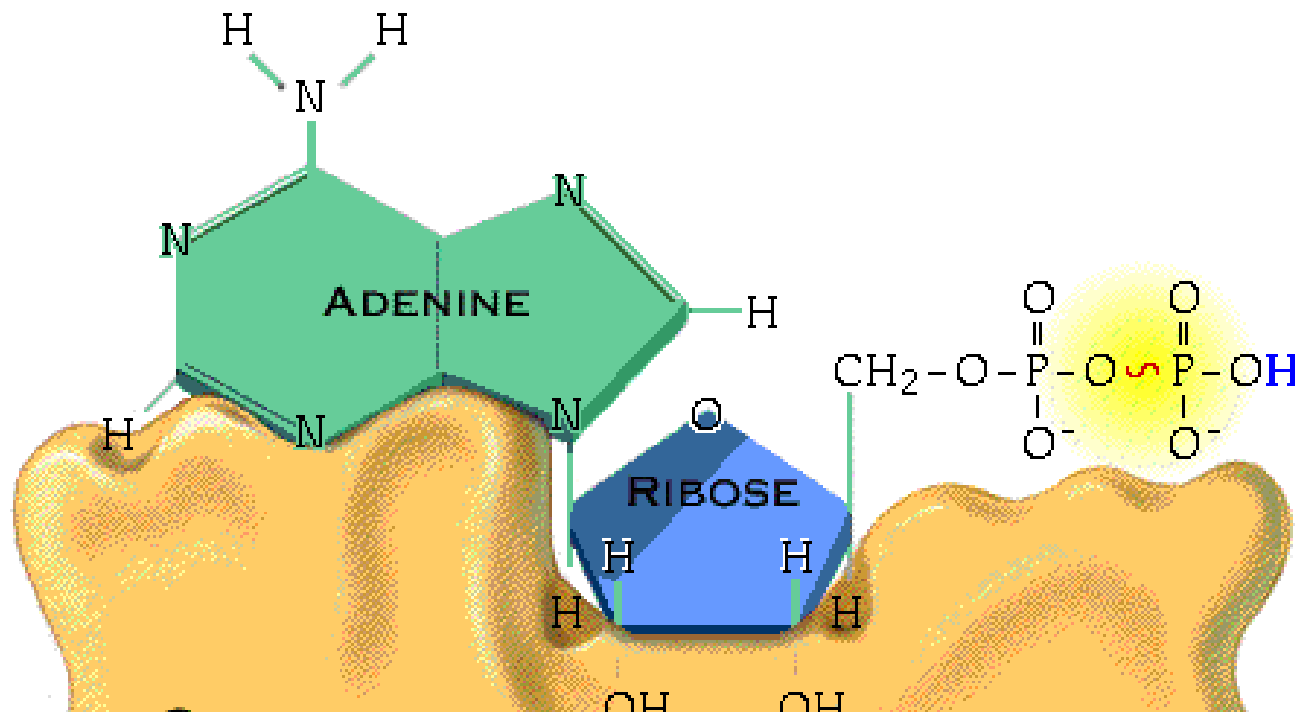


# ADP

## DEHYDRATION SYNTHESIS OF ATP

The end products of ATP hydrolysis are not discarded as waste but can be recombined to form a new ATP molecule.

Rebuilding ADP into ATP requires a **synthetic enzyme** to carry out **dehydration synthesis** and a new source of energy to "rebuild" the high-energy bond.



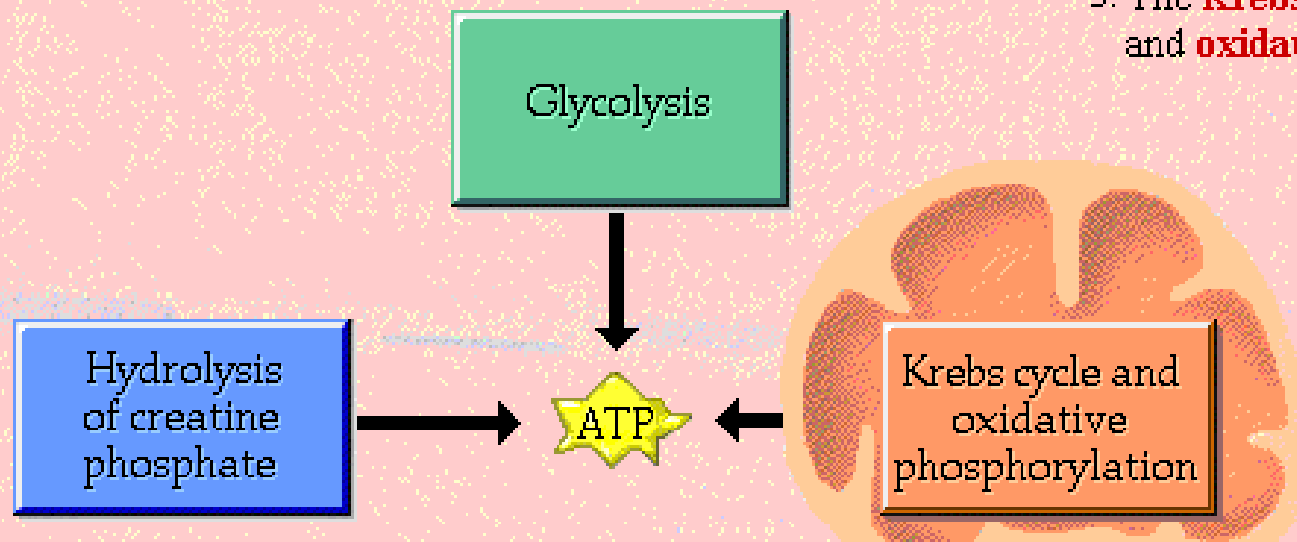


# ATP SENTEZİ

## OVERVIEW: ATP SYNTHESIS

When ATP supplies are low, muscle cells use three processes to synthesize additional ATP:

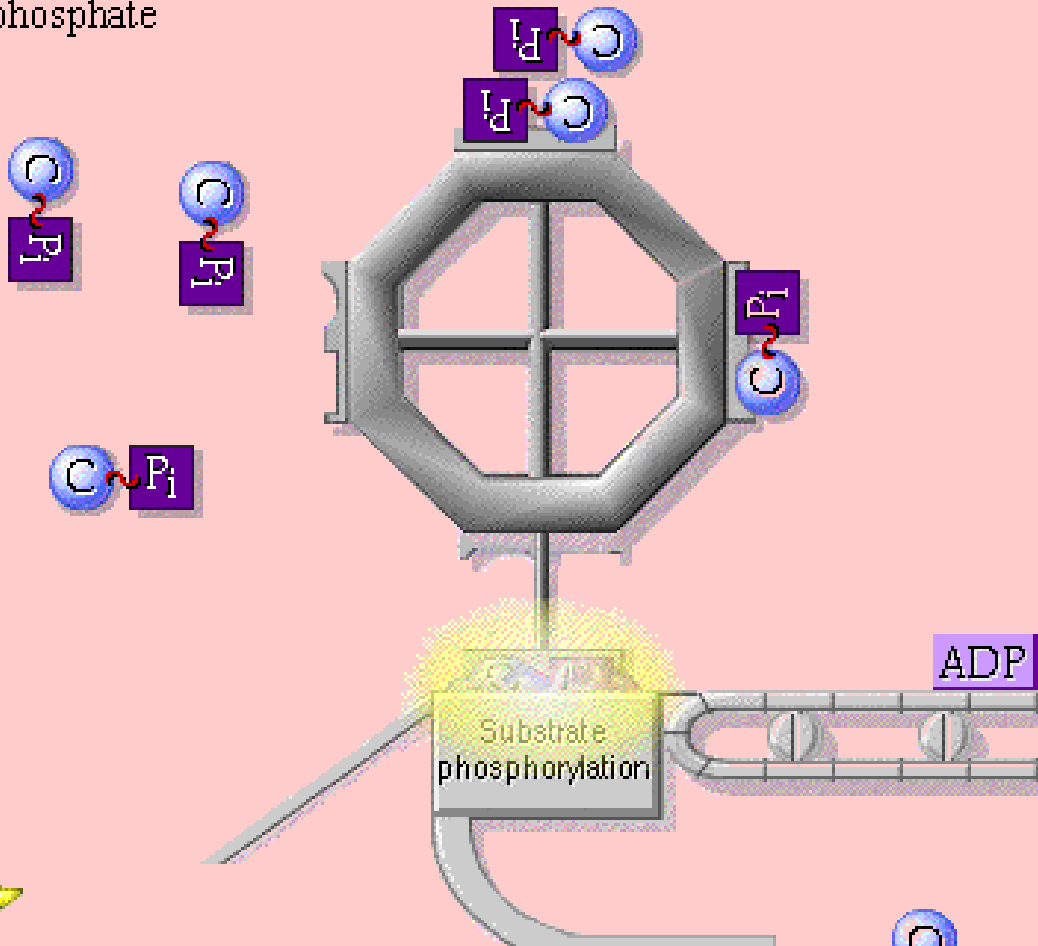
1. **Hydrolysis of creatine phosphate**
2. **Glycolysis**
3. The **Krebs cycle (citric acid cycle)** and **oxidative phosphorylation**



# KREATIN FOSFAT

## CREATINE PHOSPHATE “FACTORY”

Creatine phosphate



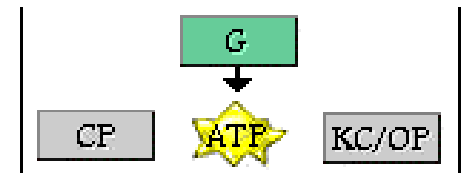
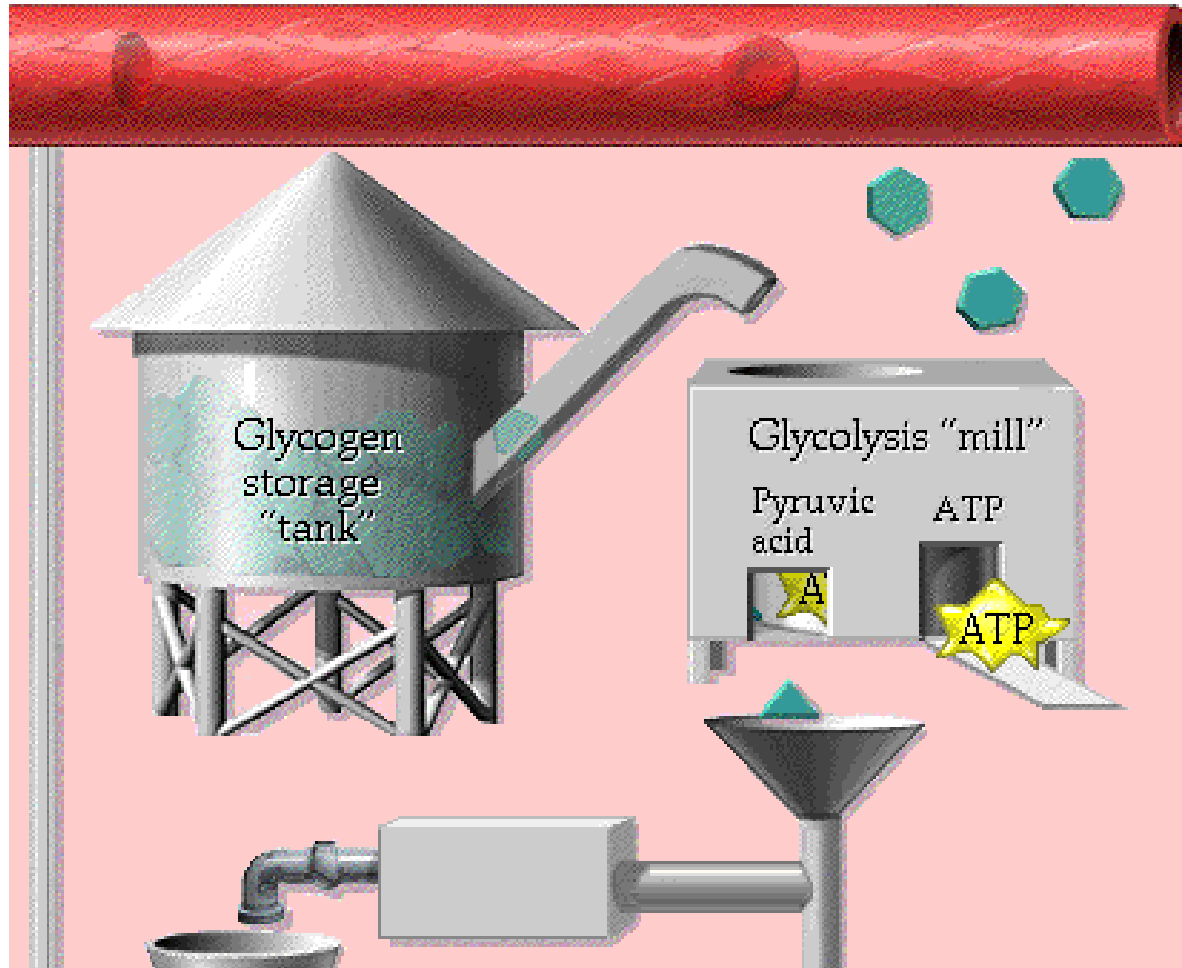
**Creatine phosphate** uses a process called **substrate phosphorylation** to transfer energy and a phosphate group to ADP, forming ATP.

The amount of creatine phosphate is limited and is rapidly depleted during warm-up activities.



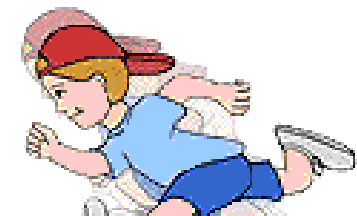
# GLIKOLİZ

## GLYCOLYSIS "FACTORY"



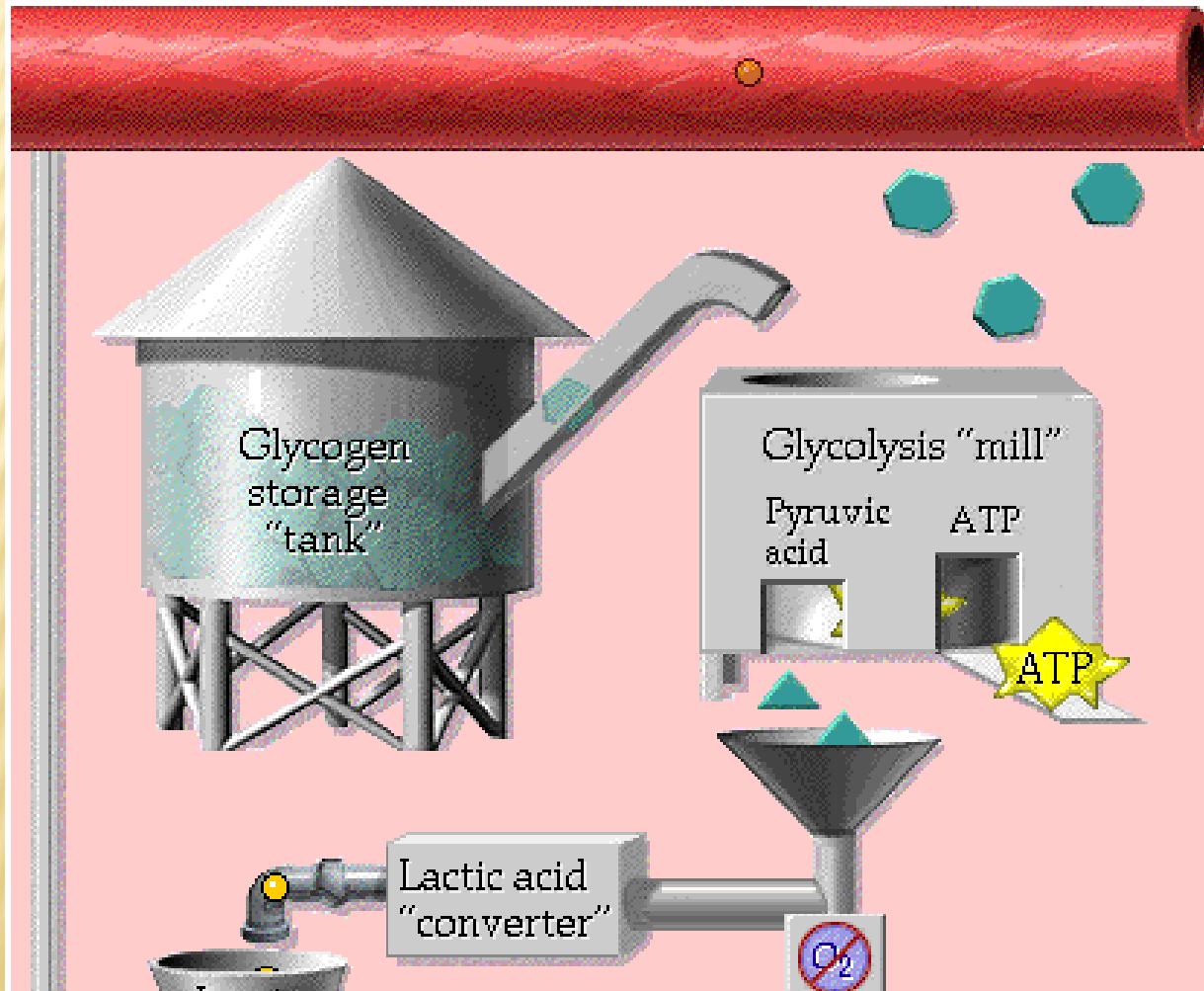
For each **glucose** molecule processed, the net end products of **glycolysis** include:

- 2 ATP molecules
- 2 **pyruvic acid** molecules

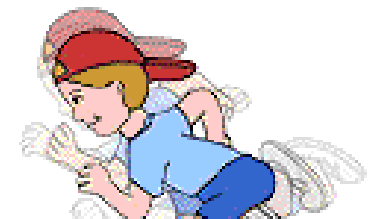


# GLIKOLİZ

## ANAEROBIC PATHWAY “FACTORY”

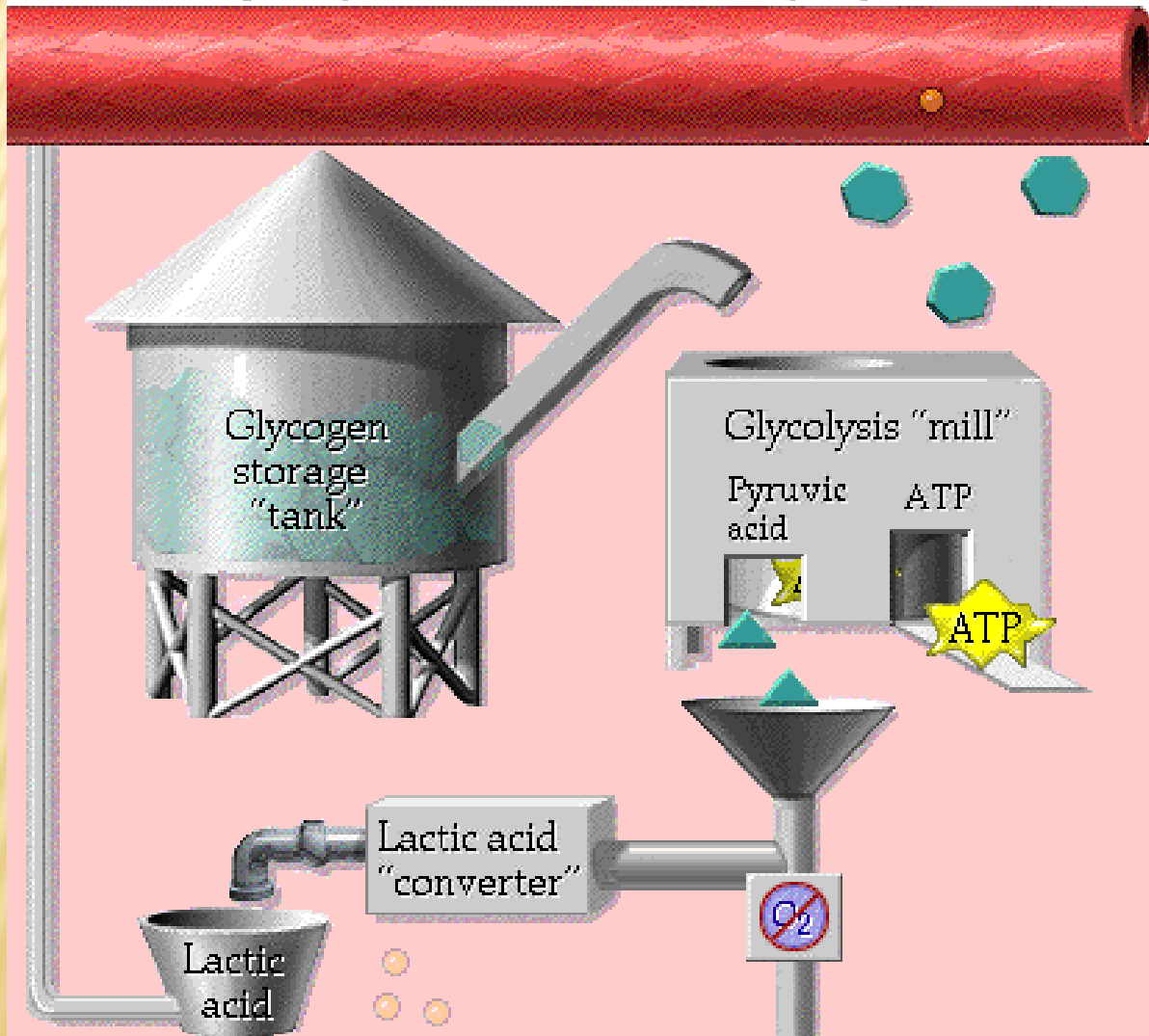


During anaerobic conditions the muscle cell has an inadequate oxygen supply, causing pyruvic acid to be converted into **lactic acid**. Excess lactic acid quickly brings about muscle fatigue.

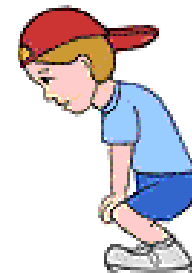


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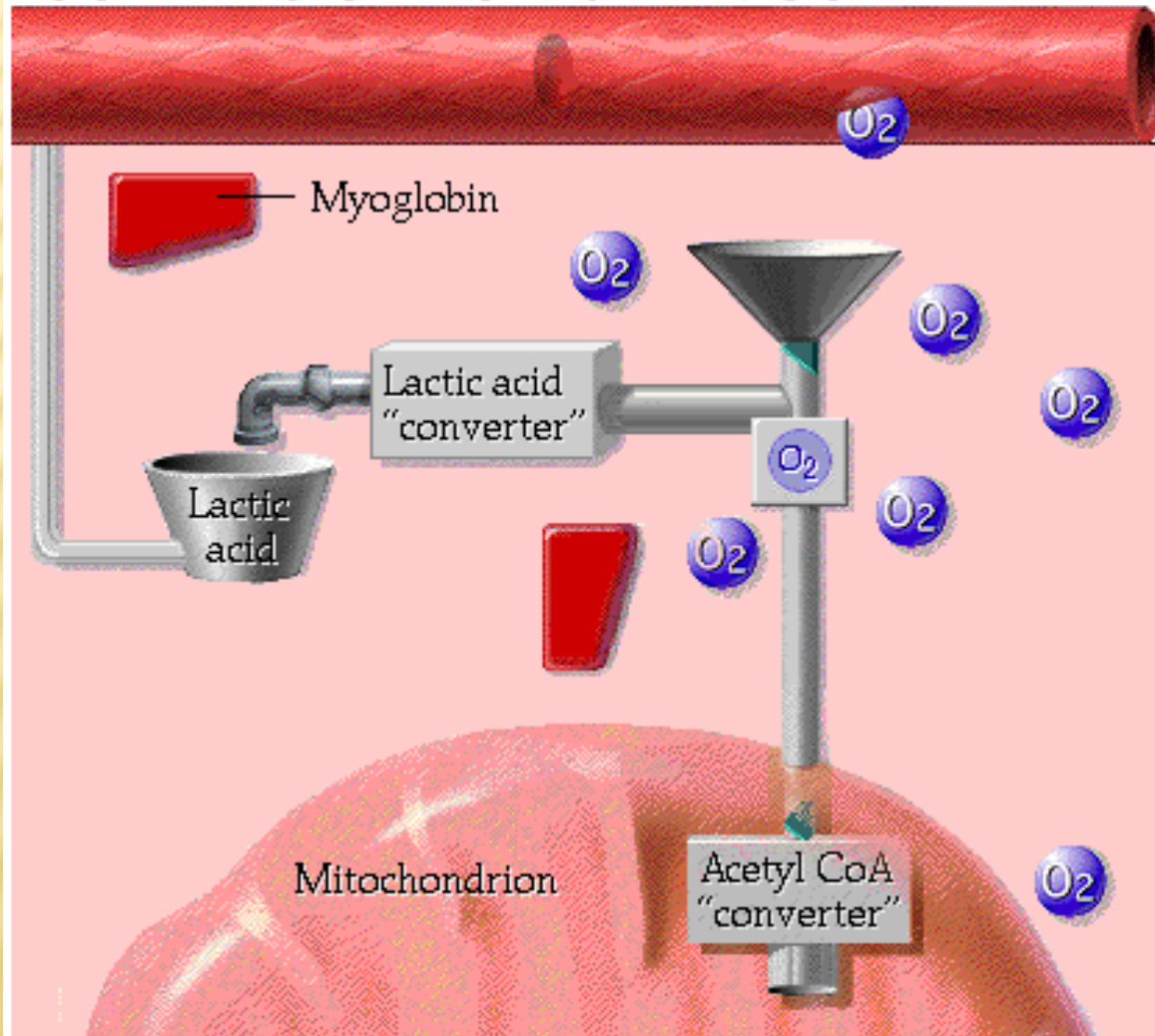


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# OKSIDATİF FOSFORİLASYON

## CONVERSION TO ACETYL CoA



If oxygen is available, the cells can carry out **aerobic** respiration.

Instead of conversion to lactic acid, pyruvic acid enters the **mitochondria**, where it is converted to **acetyl CoA**.

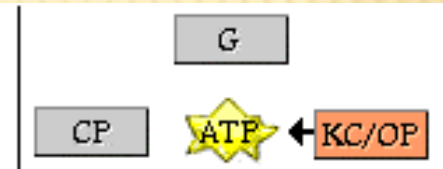
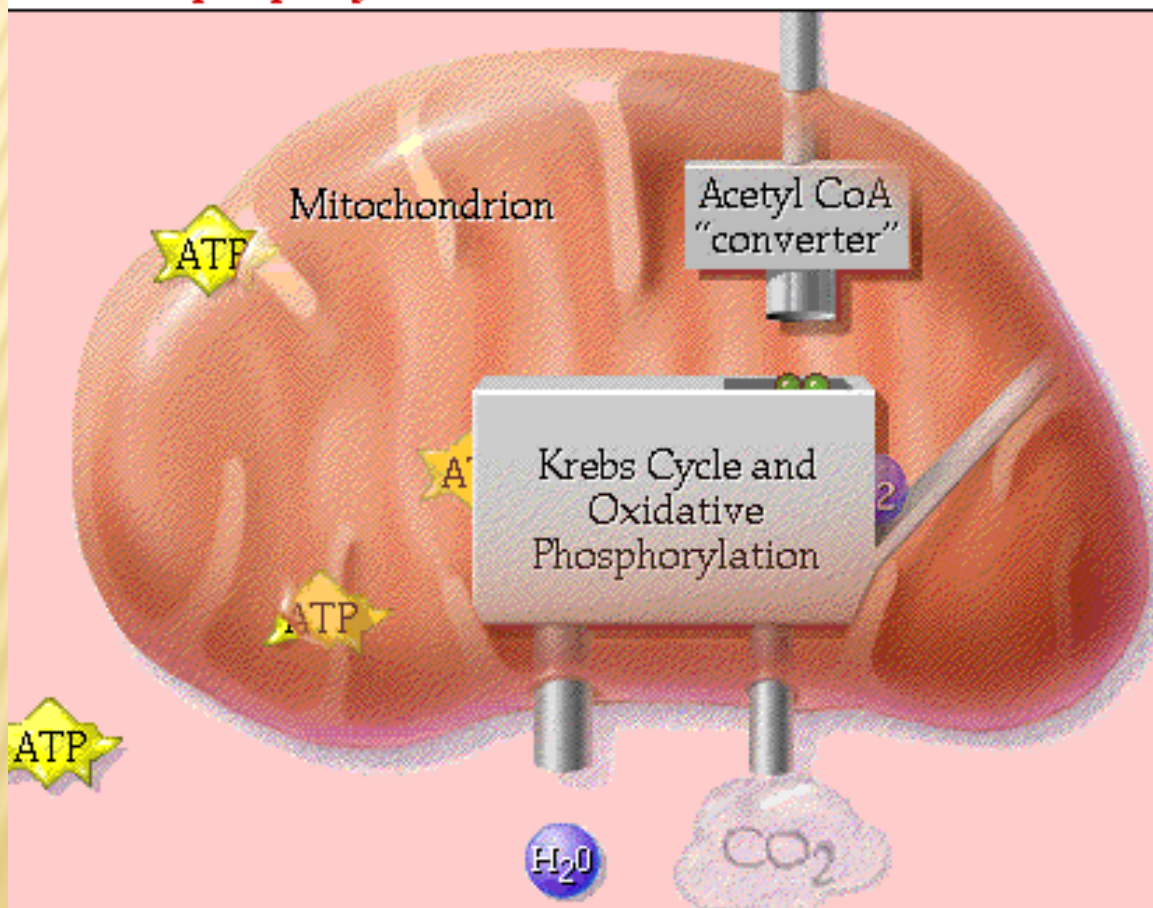




# OKSİDATİF FOSFORİLASYON

## AEROBIC RESPIRATION "FACTORY"

Within the mitochondria, enzymatic breakdown of acetyl CoA occurs in the **Krebs cycle** and energy is transferred to ATP in **oxidative phosphorylation**.



The end products of aerobic respiration are:

- Carbon dioxide (CO<sub>2</sub>)
- Water (H<sub>2</sub>O)
- 36 ATP molecules

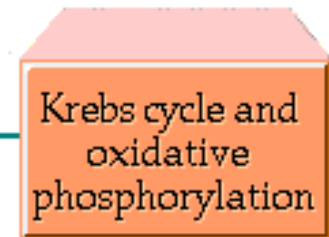
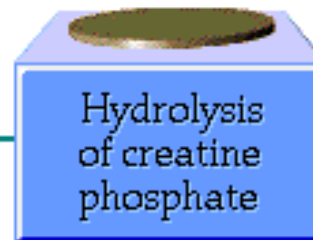


# ATP KAZANCI

## COMPARISON OF ATP PRODUCTION

We have now examined the three processes for synthesizing ATP: hydrolysis of creatine phosphate, glycolysis, and the Krebs cycle and oxidative phosphorylation.

1 ATP per creatine phosphate molecule



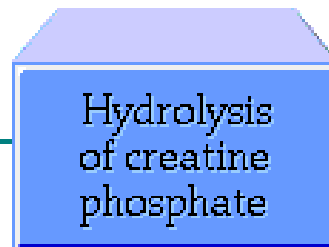
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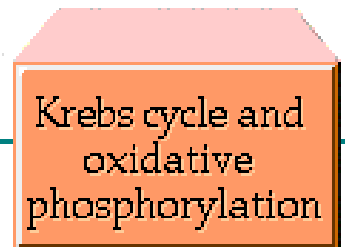
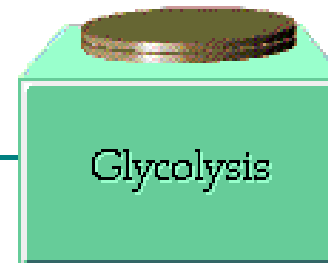
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1 ATP per creatine  
phosphate molecule



2 ATP per glucose  
molecule



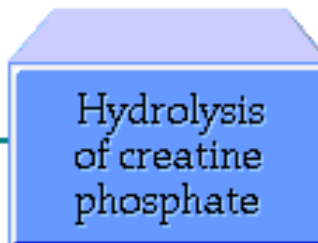
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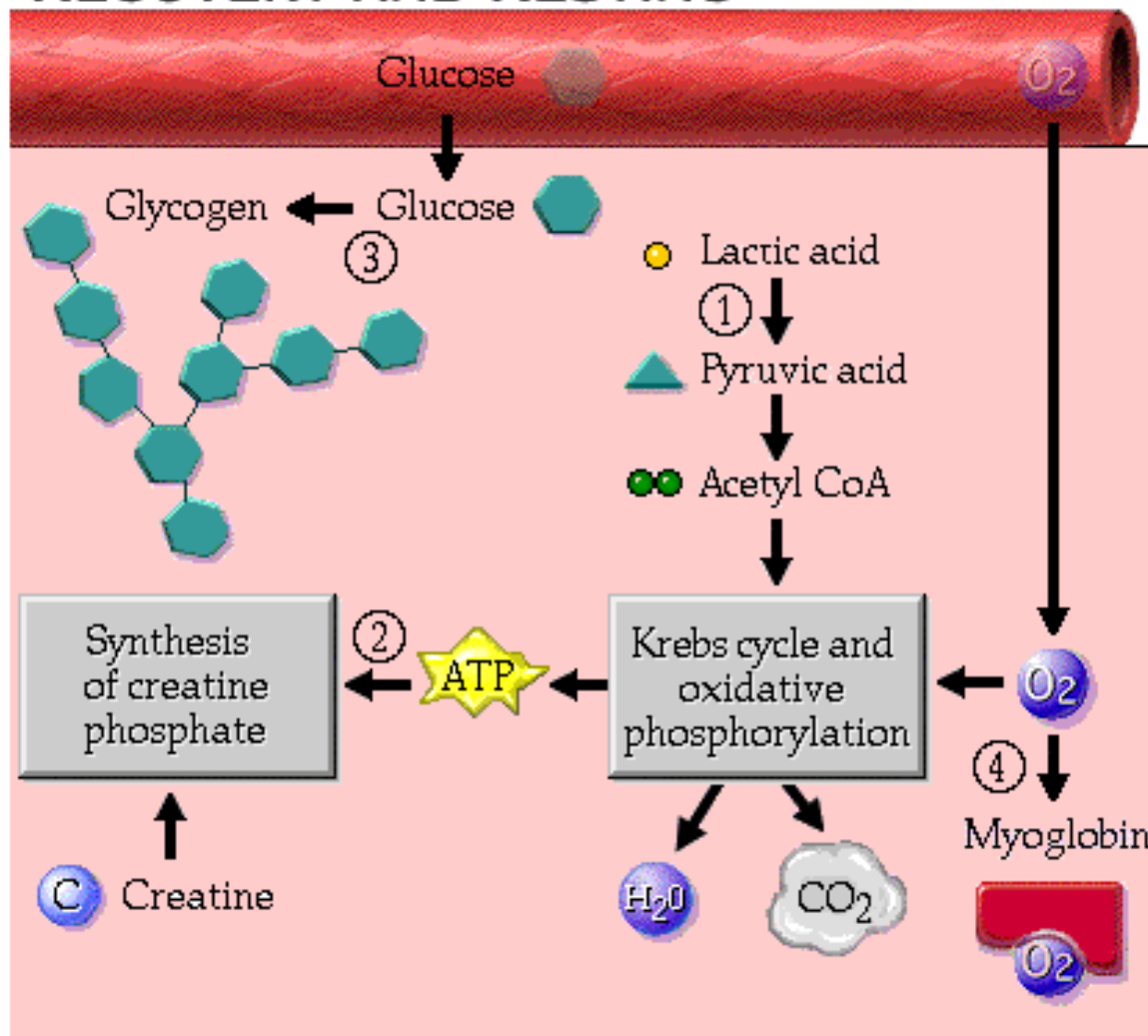
36 ATP per glucose molecule





# DINLENME

## RECOVERY AND RESTING



After the exercise period is concluded, the muscle restores the depleted energy reserves used earlier in the exercise. These processes are usually referred to as repaying the "**oxygen debt**".

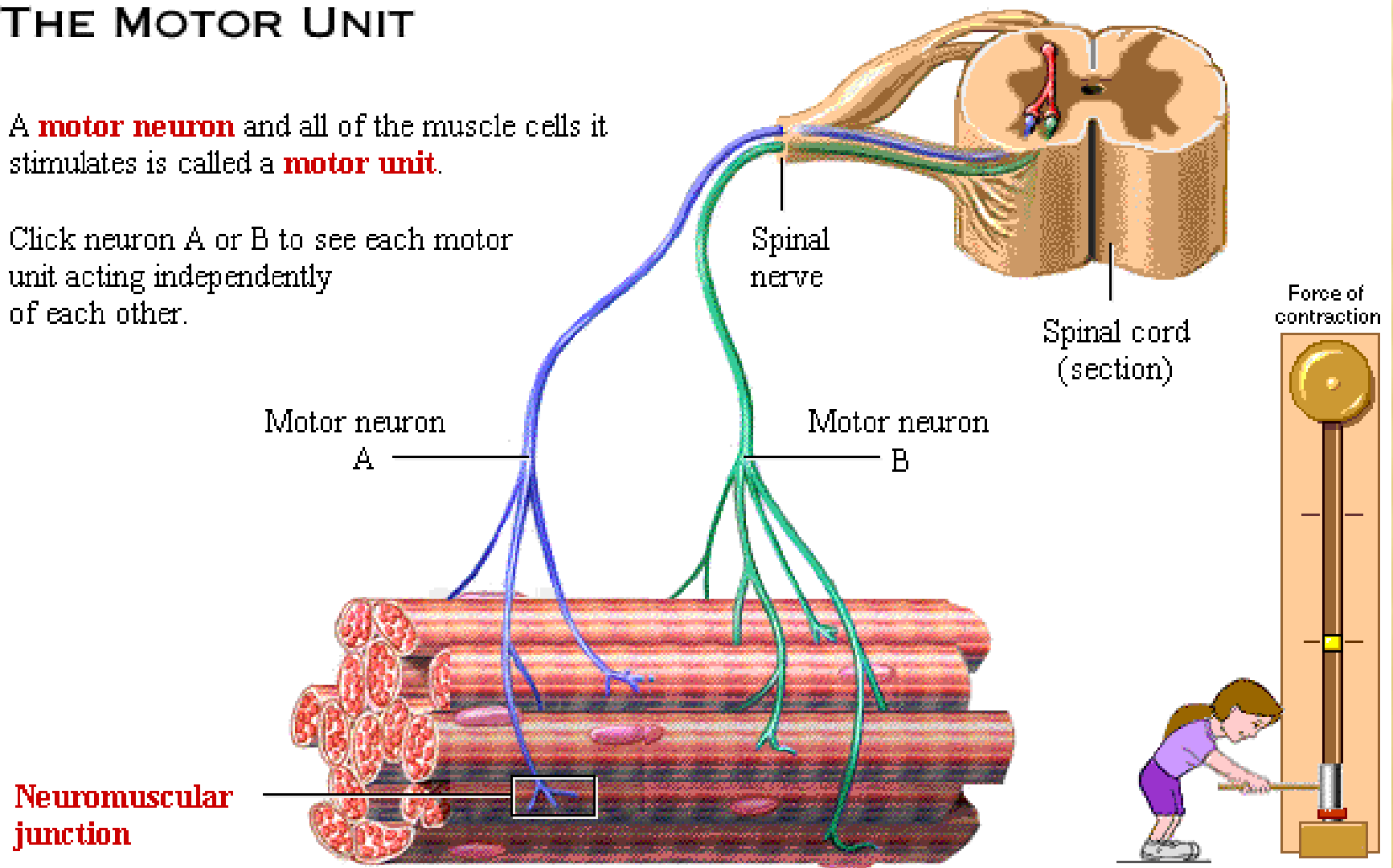
1. **Lactic acid** present in the cytosol is converted back into pyruvic acid, which enters the Krebs cycle, producing ATP.
2. The ATP is used to rephosphorylate creatine into **creatine phosphate**.
3. **Glycogen** is synthesized from glucose molecules.
4. Additional oxygen re-binds to **myoglobin**.

# MOTOR NÖRON

## THE MOTOR UNIT

A **motor neuron** and all of the muscle cells it stimulates is called a **motor unit**.

Click neuron A or B to see each motor unit acting independently of each other.

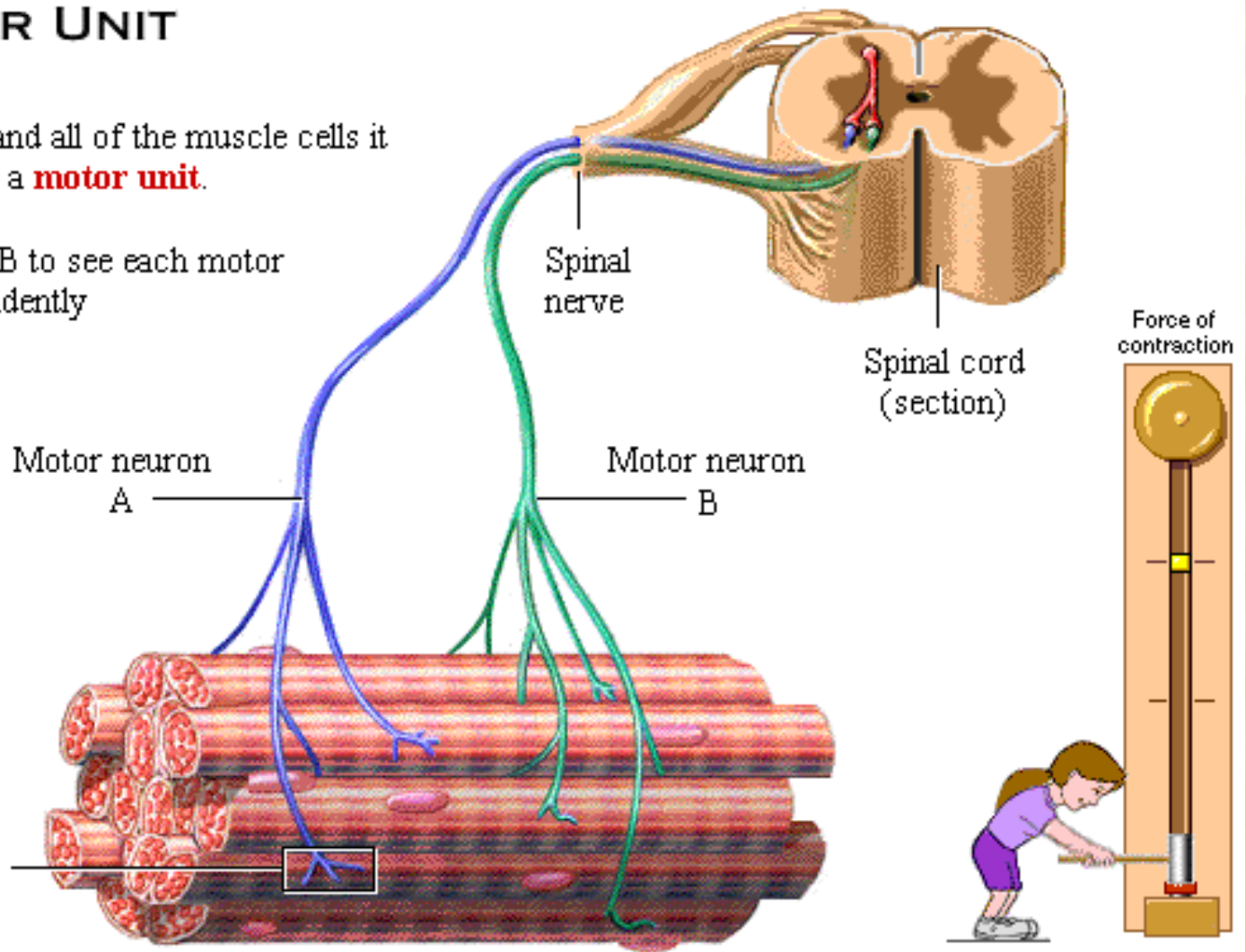


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# MOTOR NÖRON

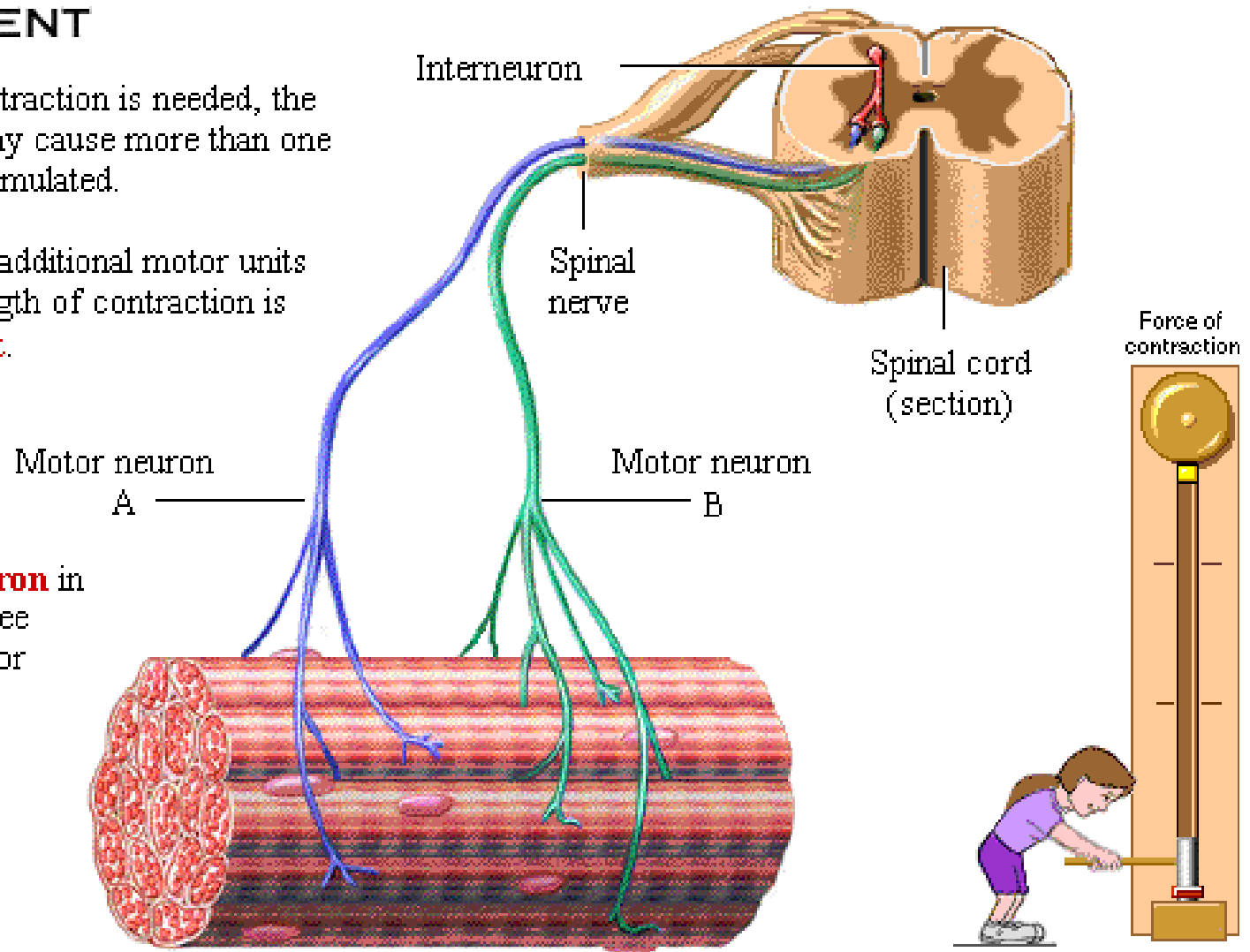
## RECRUITMENT

When a strong contraction is needed, the nervous system may cause more than one motor unit to be stimulated.

The stimulation of additional motor units for increased strength of contraction is called **recruitment**.

Click the **interneuron** in the spinal cord to see recruitment of motor units A and B.

Click neuron A or B to see individual motor units being stimulated.



# KAS TONUSU

## MUSCLE TONE

Even in a muscle's relaxed state, random, **asynchronous** motor unit contractions provide a nearly constant state of low-level **tension** and resistance to stretch called **muscle tone**.

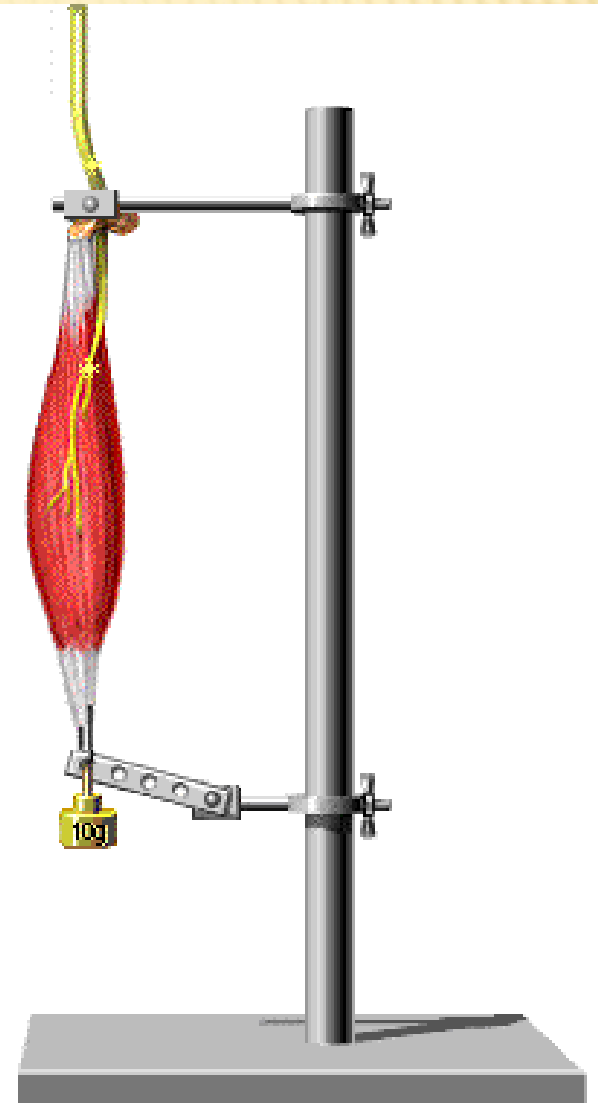
These minute contractions are maintained by activities of the spinal cord and result in a firmness of the muscle.

What do you think will happen to the muscle if the motor nerve is cut or damaged? Choose the correct answer.

Will contract strongly

No change

Will become flaccid



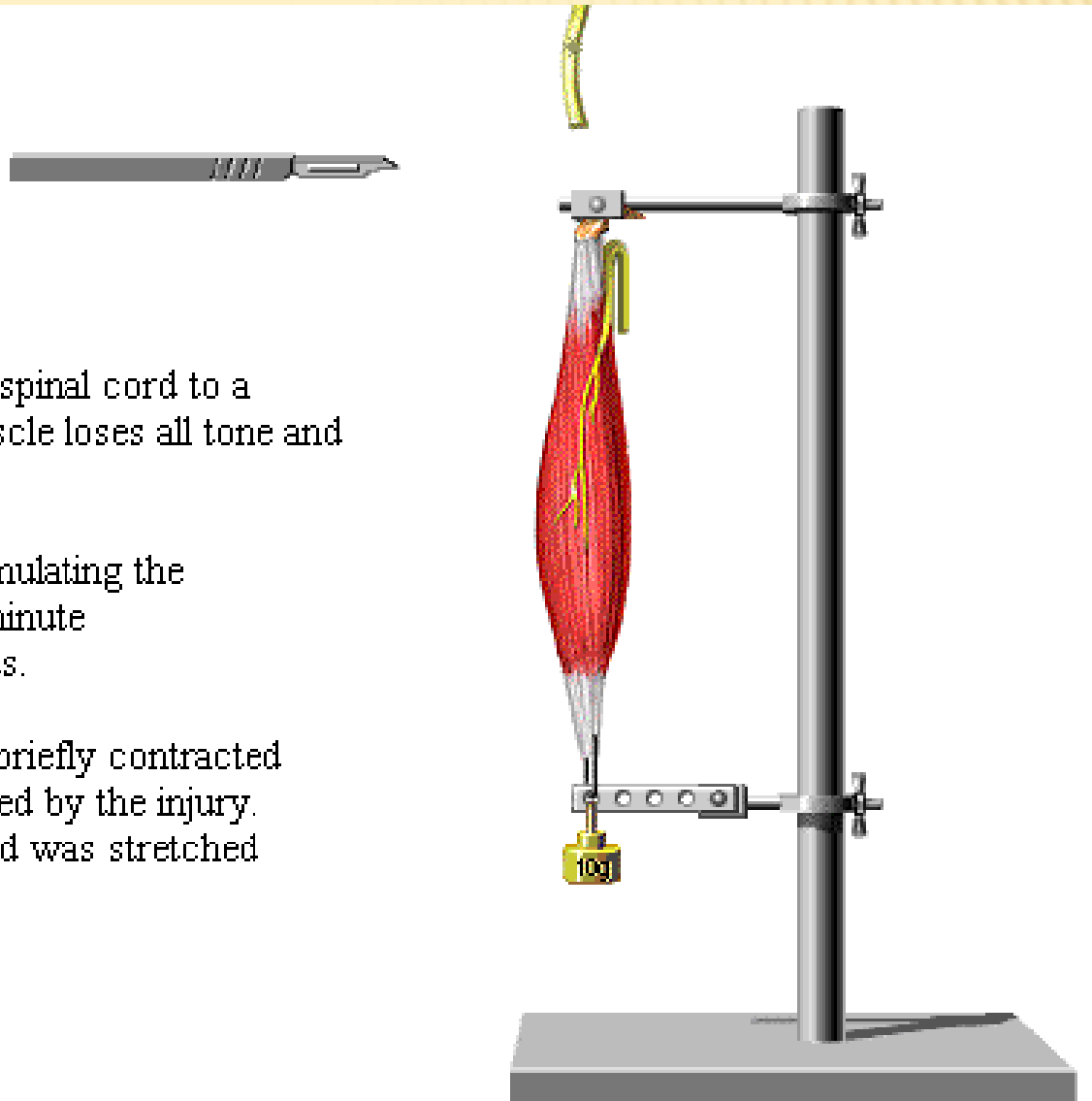
# KAS TONUSU

## MUSCLE TONE DEMO

If the motor nerve connecting the spinal cord to a muscle is cut or damaged, the muscle loses all tone and becomes **flaccid**.

Until the nerve was cut, it was stimulating the muscle at a low level, producing minute contractions of random motor units.

As the nerve was cut, the muscle briefly contracted because of nerve impulses generated by the injury. The muscle then lost all tension and was stretched by the weight.



# KAS KASILMASINI ETKİLEYEN FAKTÖRLER

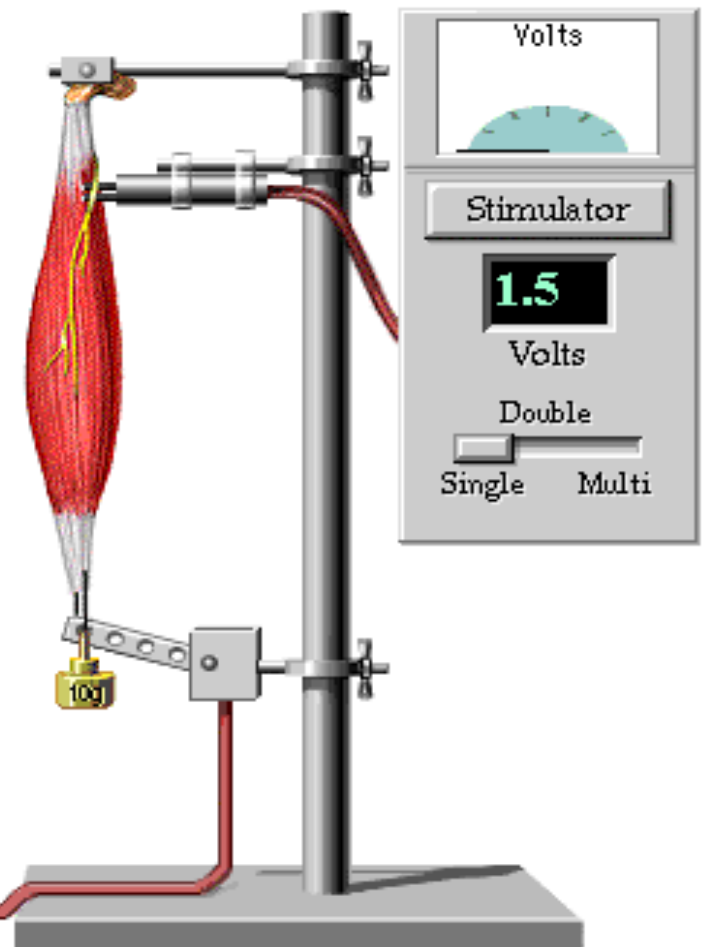
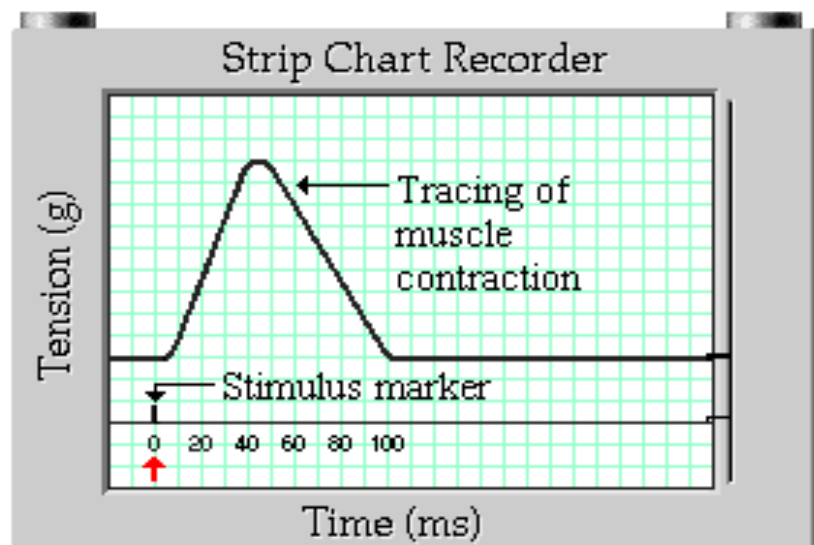
- ✘ Kasa gelen uyarımın frekansı
- ✘ Kasa uyarım gönderen motor nöron sayısı (motor ünite)
- ✘ Kasın kasılmaya başlamadan önceki boyu

# UYARIM FREKANSI

## MUSCLE TWITCH

We will begin our study of whole muscle contraction by looking at how a muscle responds to a single **stimulus**.

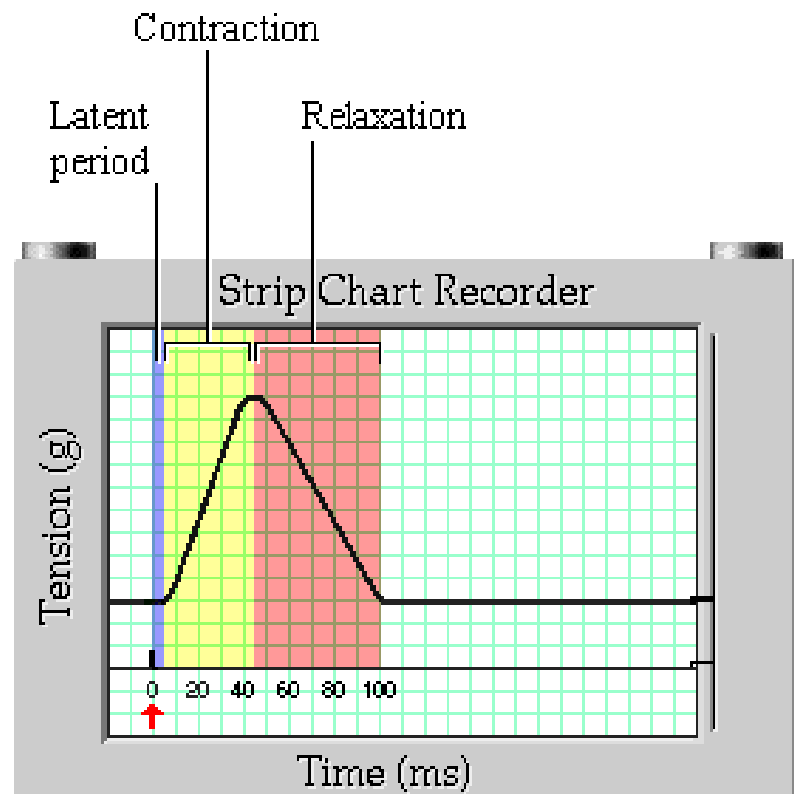
A muscle contraction in response to a single stimulus of adequate strength is called a **muscle twitch**.



# UYARIM FREKANSI

## THE THREE PHASES OF A MUSCLE TWITCH

A complete muscle twitch is divided into three phases: latent period, contraction period, and relaxation period. Click each region of the graph for more information.

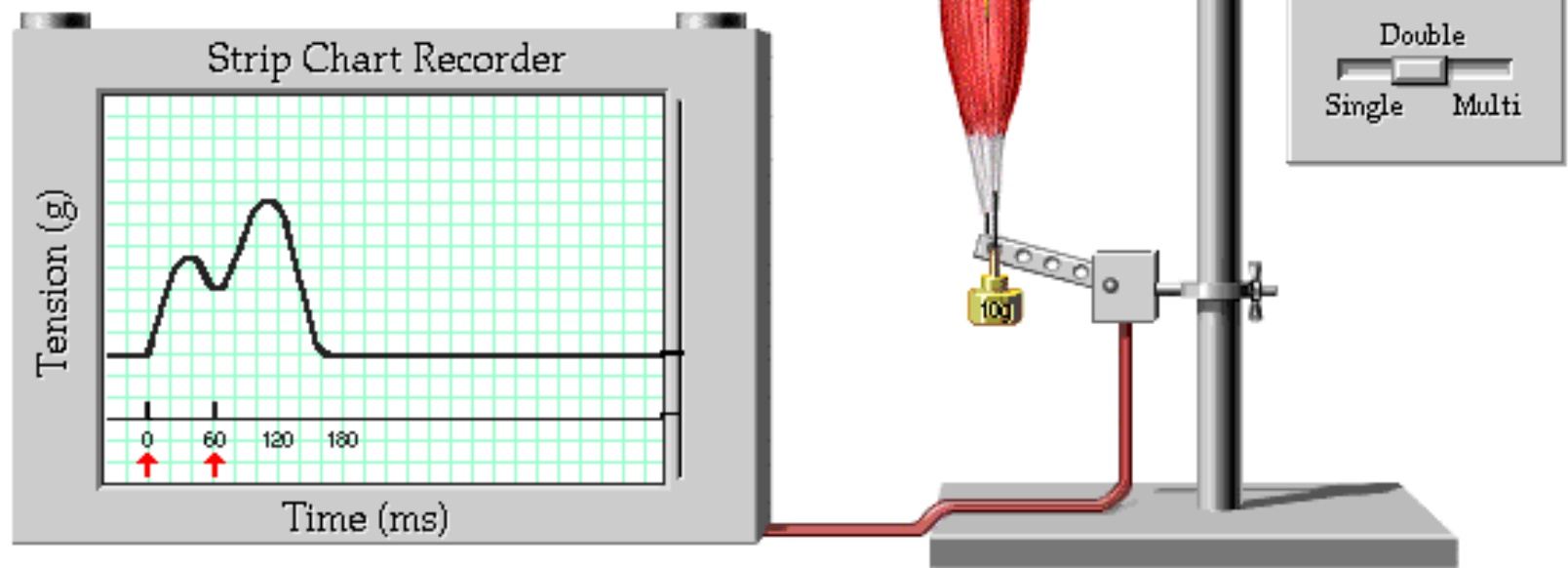


# UYARIM FREKANSI

## TEMPORAL SUMMATION OF TWO STIMULI

- Second stimulus of same intensity is applied
- Applied before completion of relaxation
- Second contraction added to first contraction
- **Temporal (wave) summation** increases muscle tension

Click once on the Stimulator button to see the response to a double stimulation.

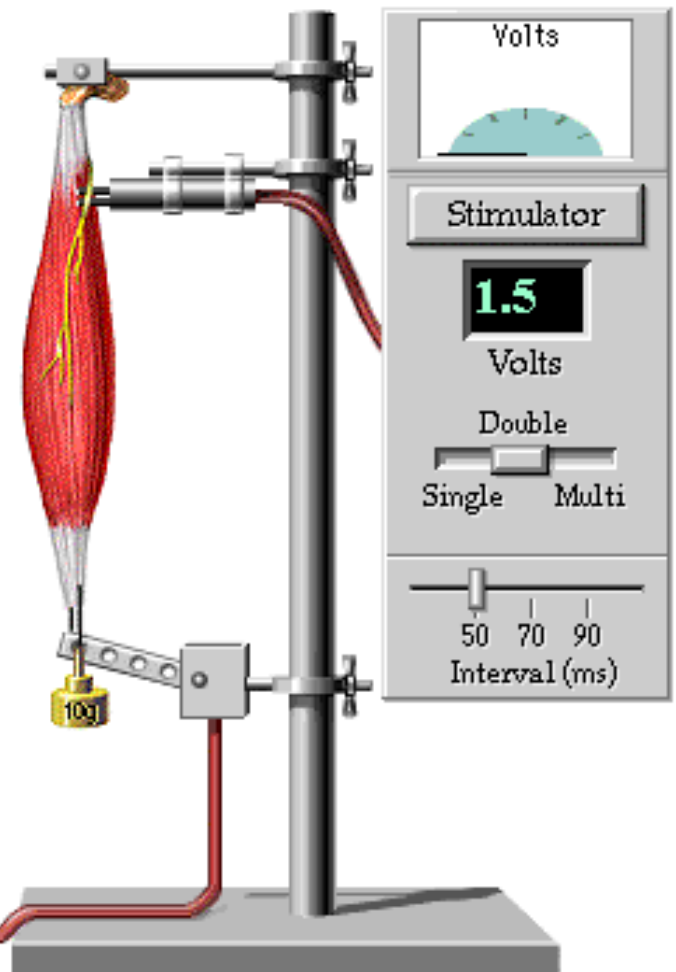
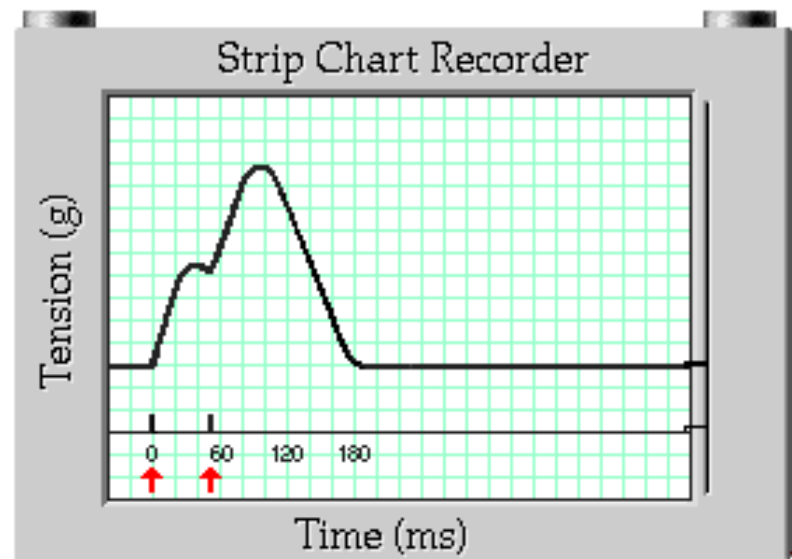




# UYARIM FREKANSI

## EFFECT OF TIME INTERVAL ON SECOND CONTRACTION

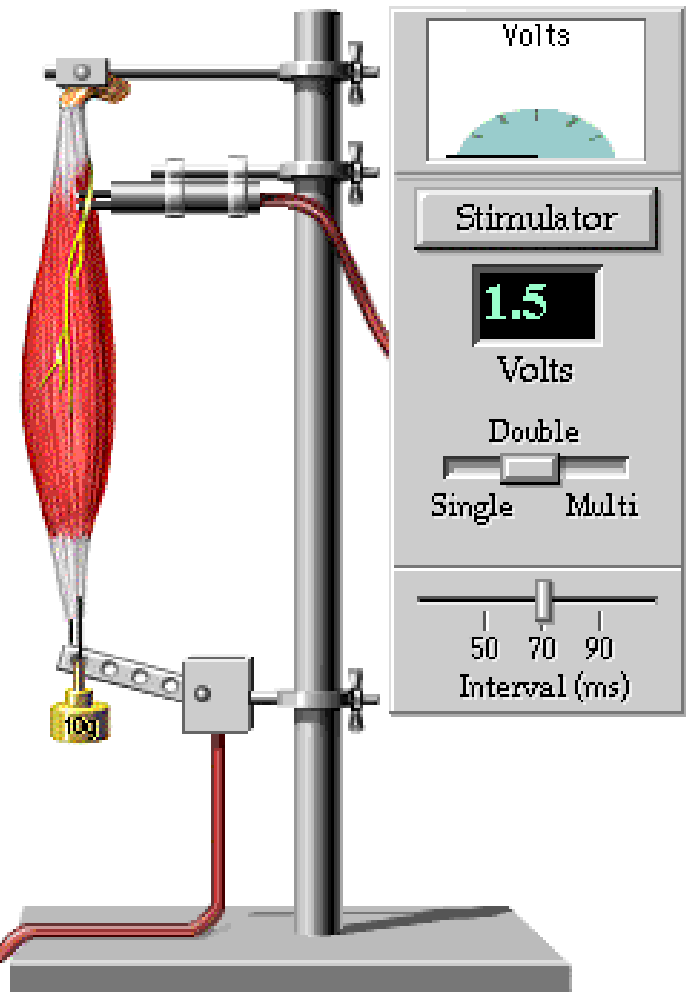
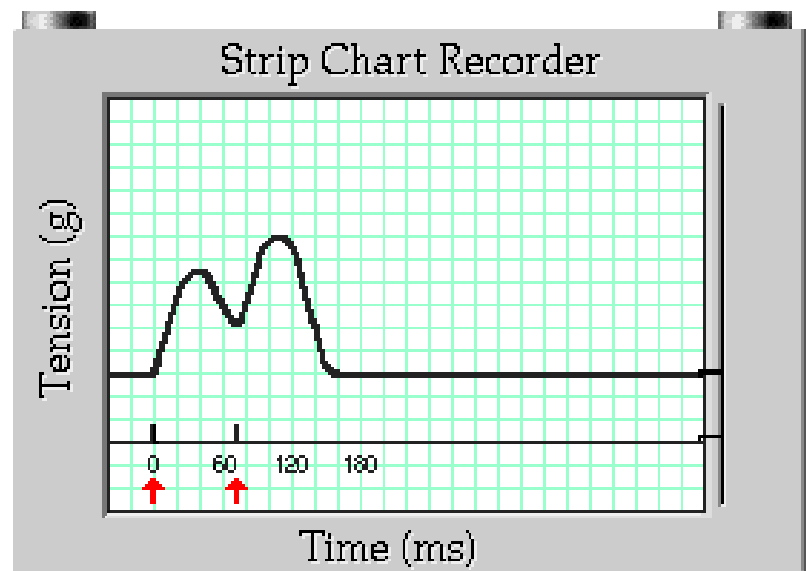
Now predict how the time interval between stimuli will affect the height of the second contraction. Click and drag the slider bar to each time interval, make your prediction, and then click the Stimulator button to see the effect.



# UYARIM FREKANSI

## EFFECT OF TIME INTERVAL ON SECOND CONTRACTION

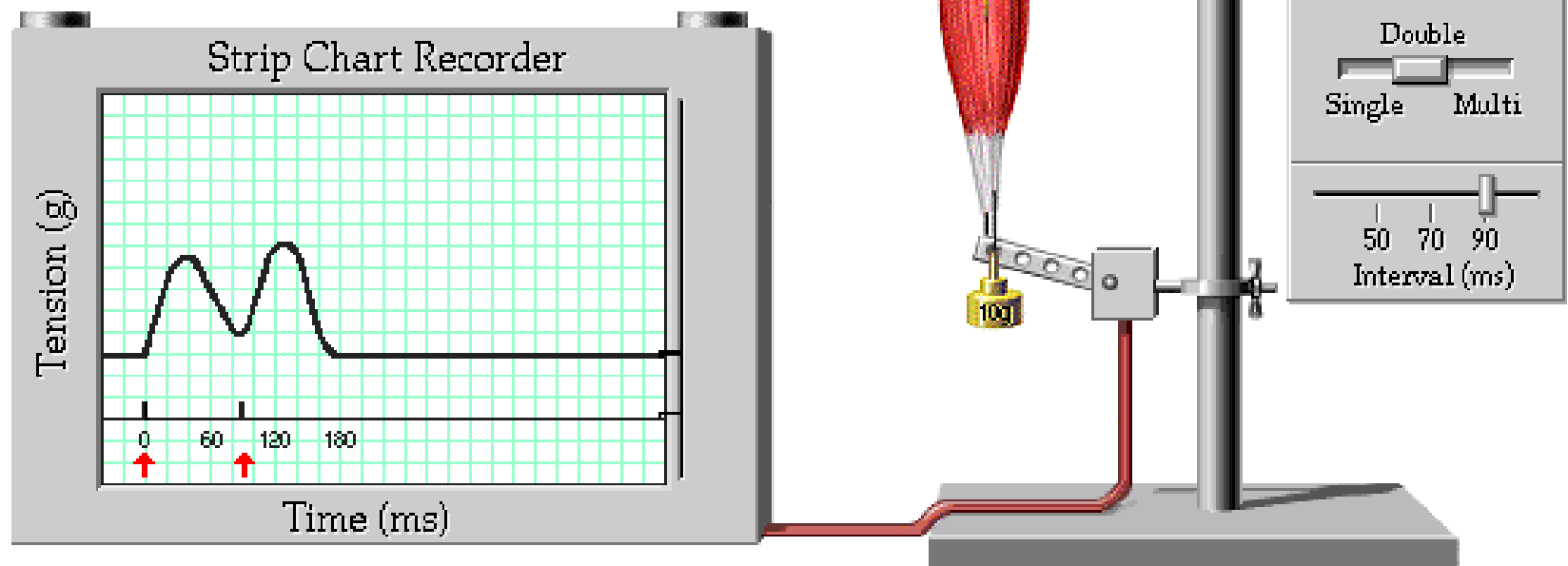
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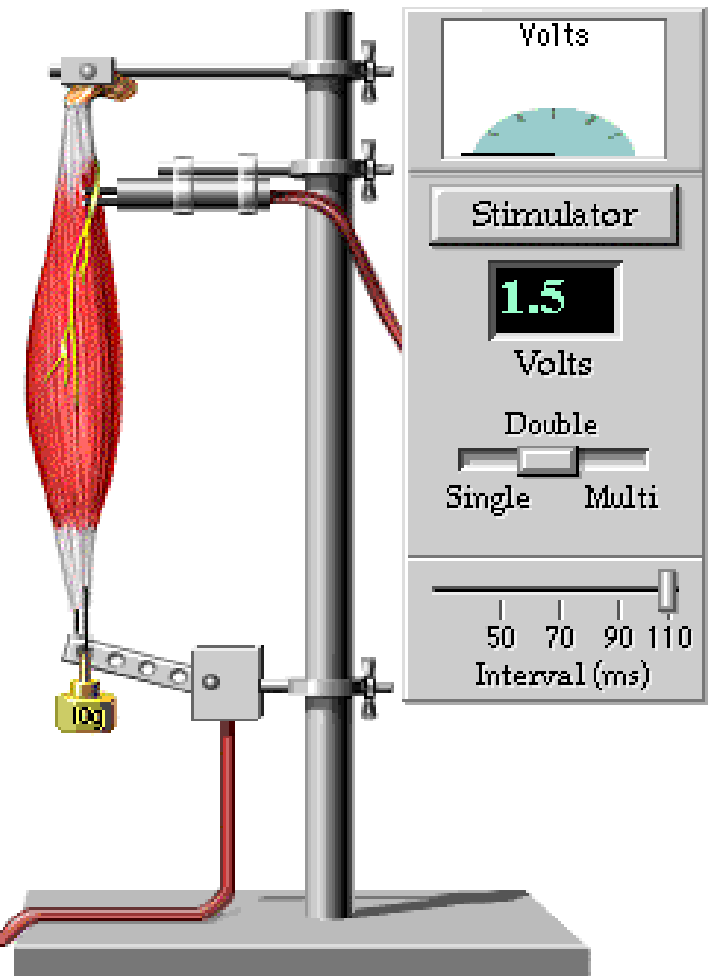
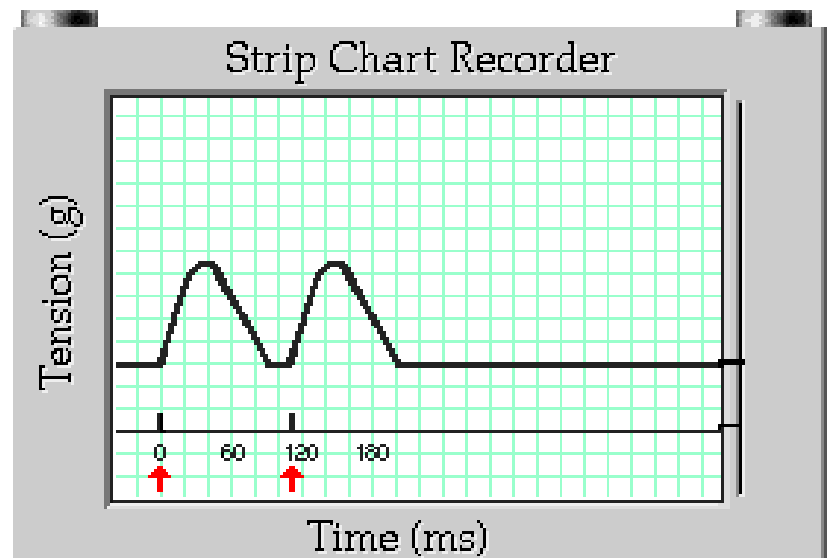


# UYARIM FREKANSI

## QUESTIONS ON EFFECT OF TIME INTERVAL

Why is the height of the curve equal to the first contraction?

- ✓ Cross bridge cycling has stopped; there is no activity to be summed.
- ✓ The calcium ions from the first contraction have already been actively transported back into the terminal cisternae.
- ✓ Both of the above.



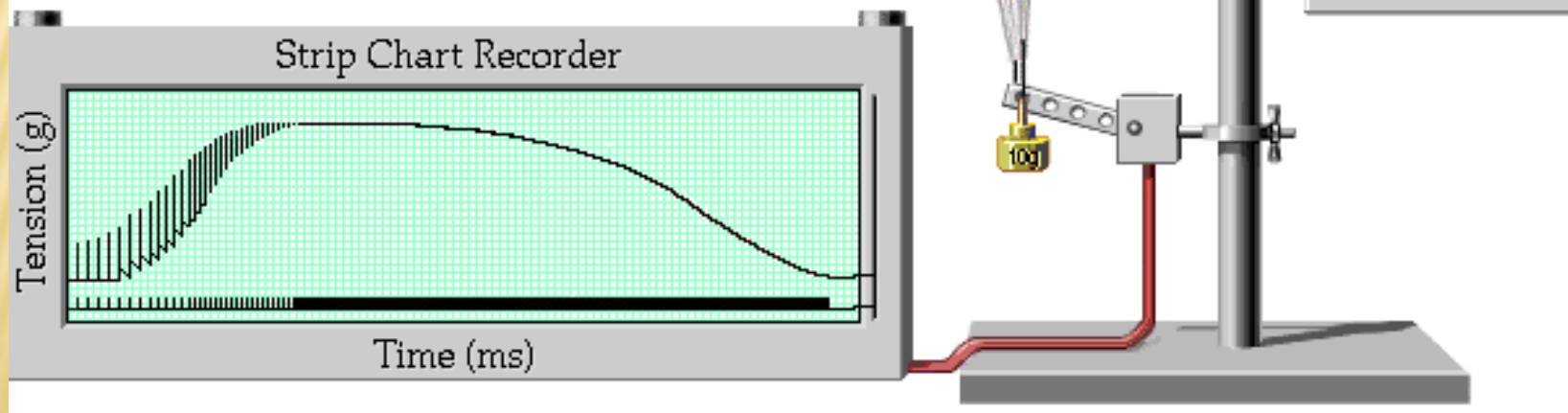
# UYARIM FREKANSI

## SUMMATION OF MULTIPLE STIMULI

Now observe the following situation:

- A muscle is repeatedly stimulated.
- The interval between stimuli is gradually decreased.
- All stimuli are of equal intensity (voltage).

The Stimulator has been set to send a series of stimuli to the muscle. Click the Stimulator to see how the muscle responds.

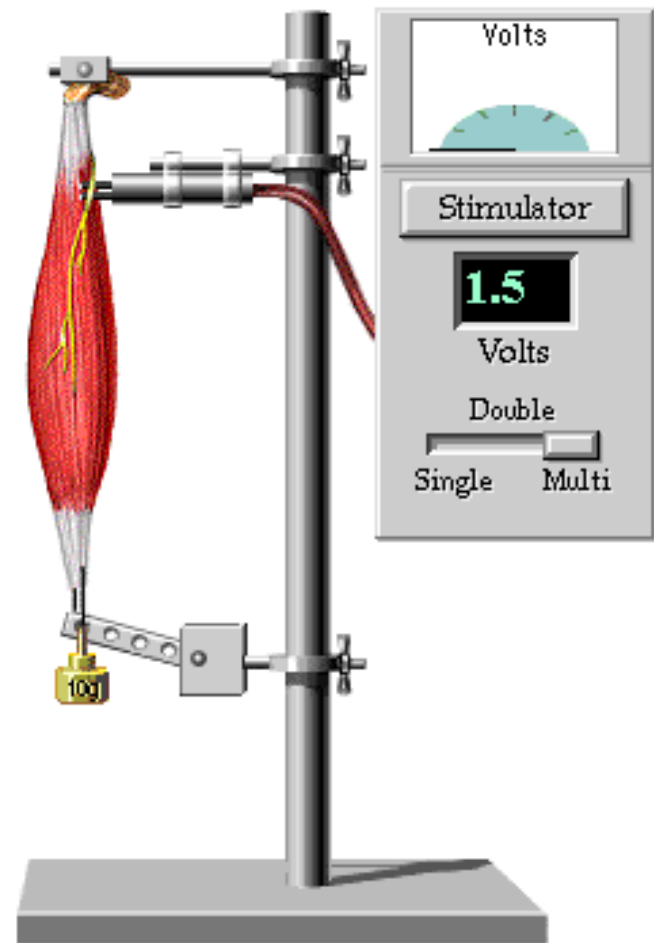
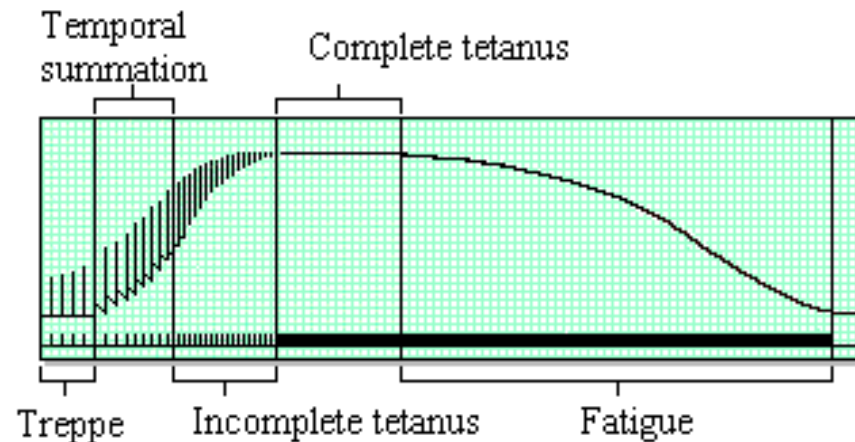


# UYARIM FREKANSI

## GRAPH OF MULTIPLE STIMULI

The resulting graph shows several aspects of the mechanical activity of muscles when the **frequency** of stimulation is altered.

Click each region on the graph for more information.

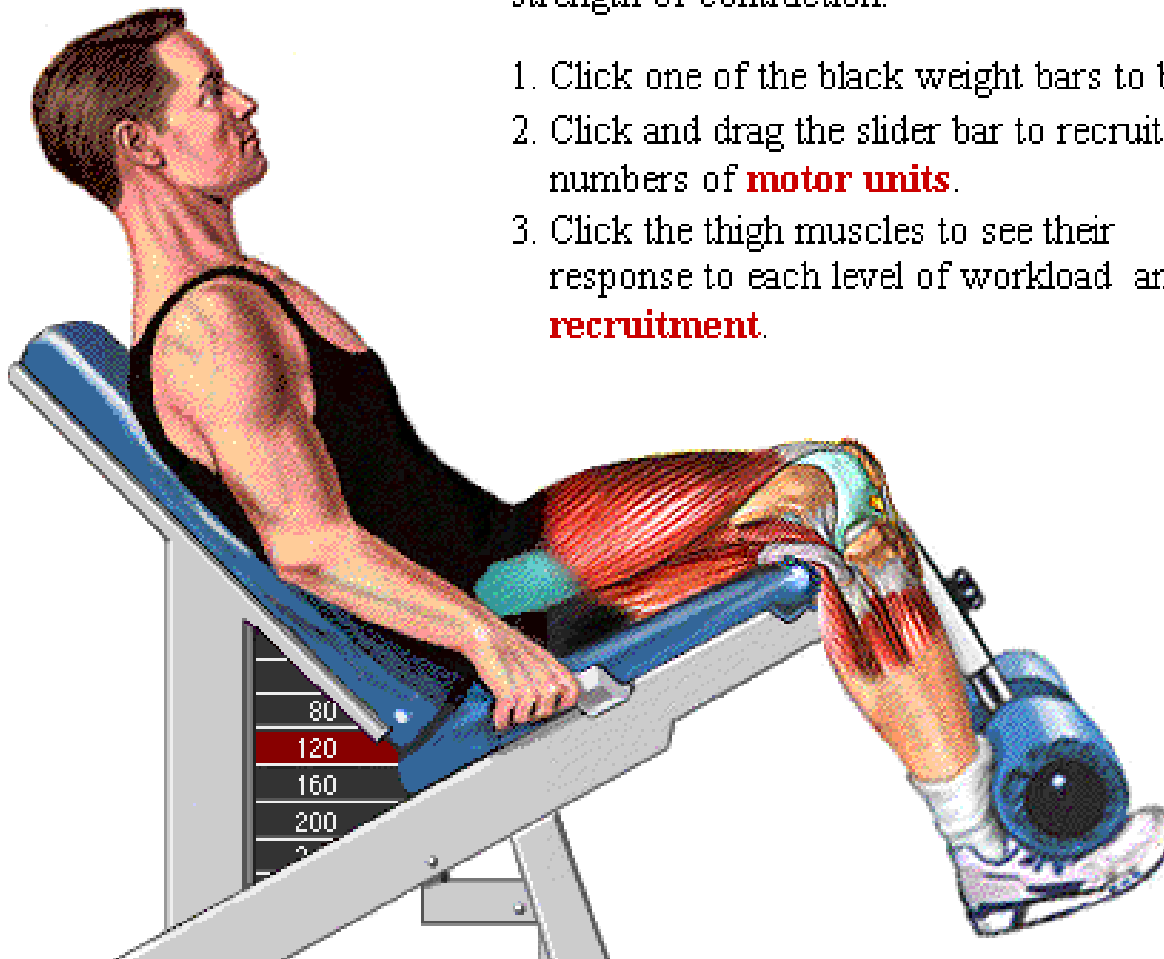
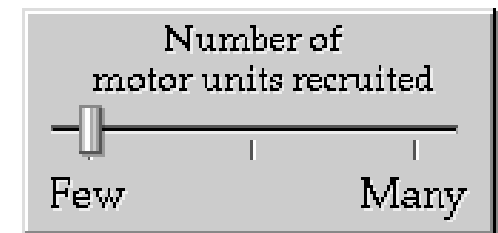


# MOTOR NÖRON SAYISI

## MULTIPLE MOTOR UNIT SUMMATION IN THE BODY

To see the relationship between number of motor units recruited and strength of contraction:

1. Click one of the black weight bars to be lifted.
2. Click and drag the slider bar to recruit different numbers of **motor units**.
3. Click the thigh muscles to see their response to each level of workload and **recruitment**.



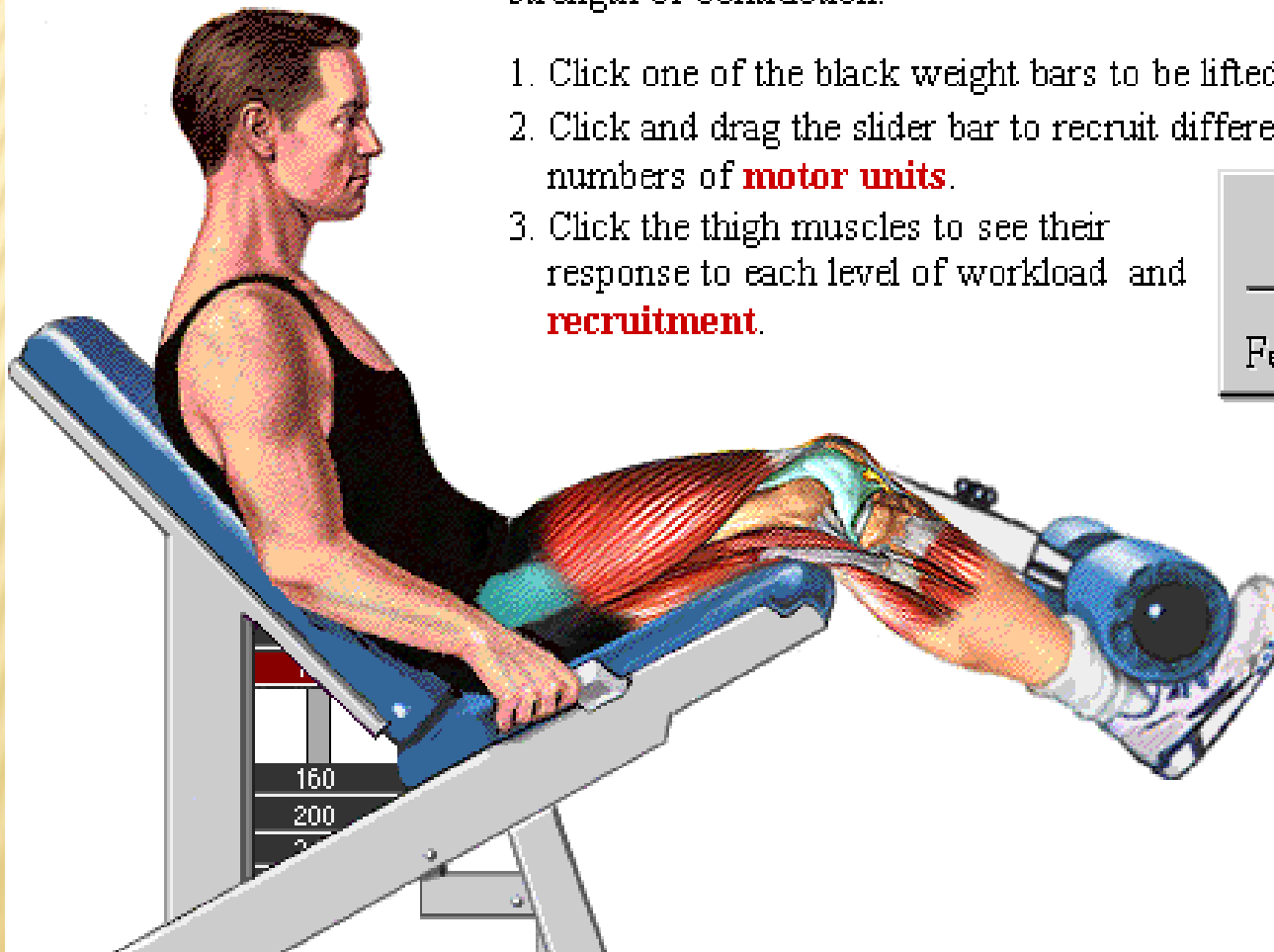
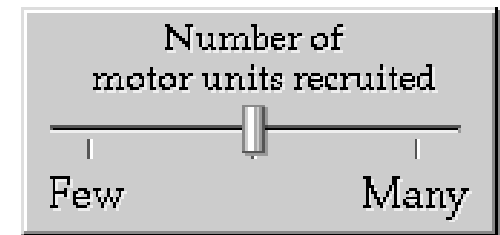


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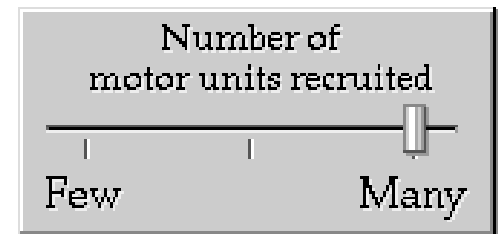
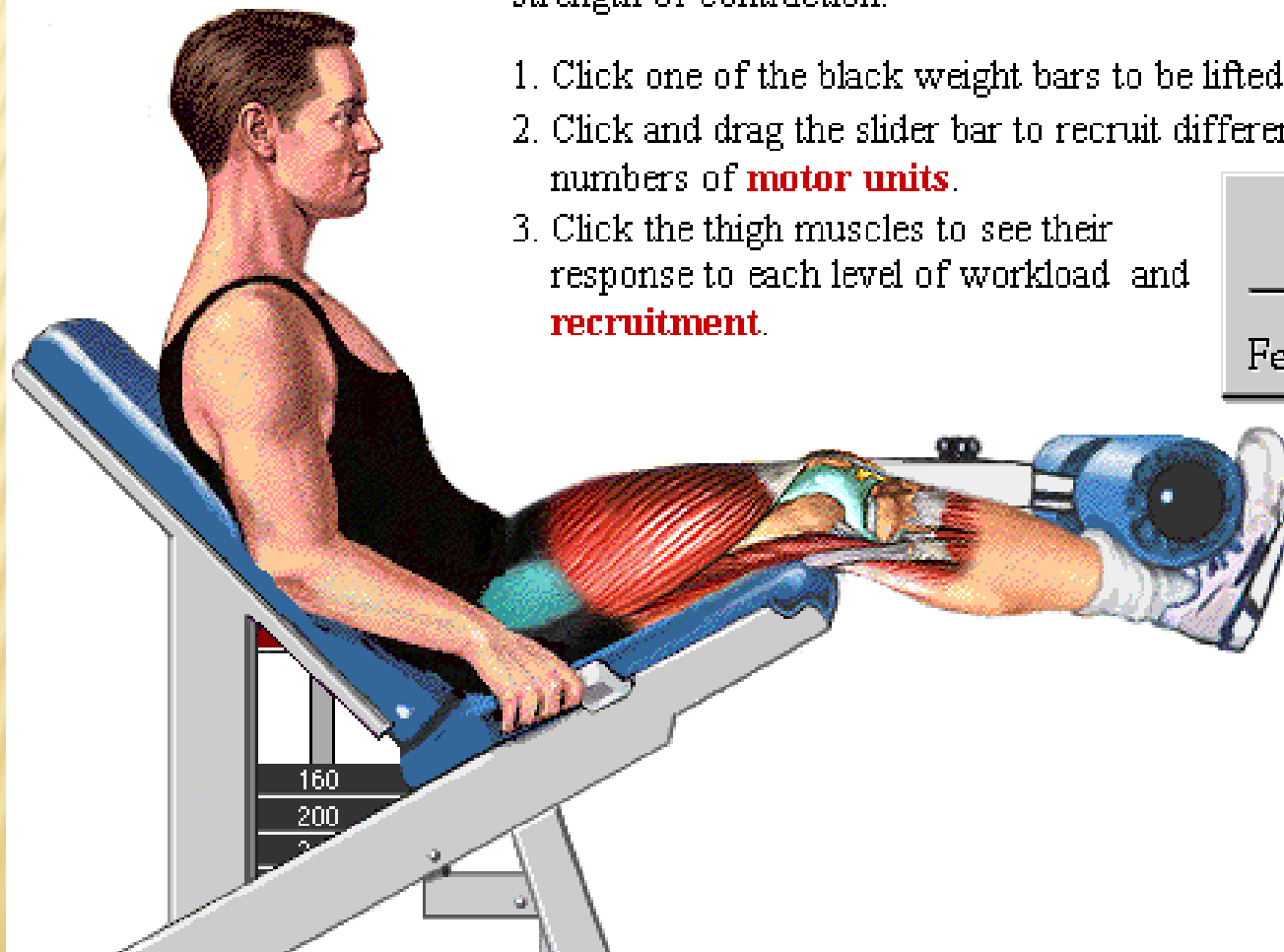


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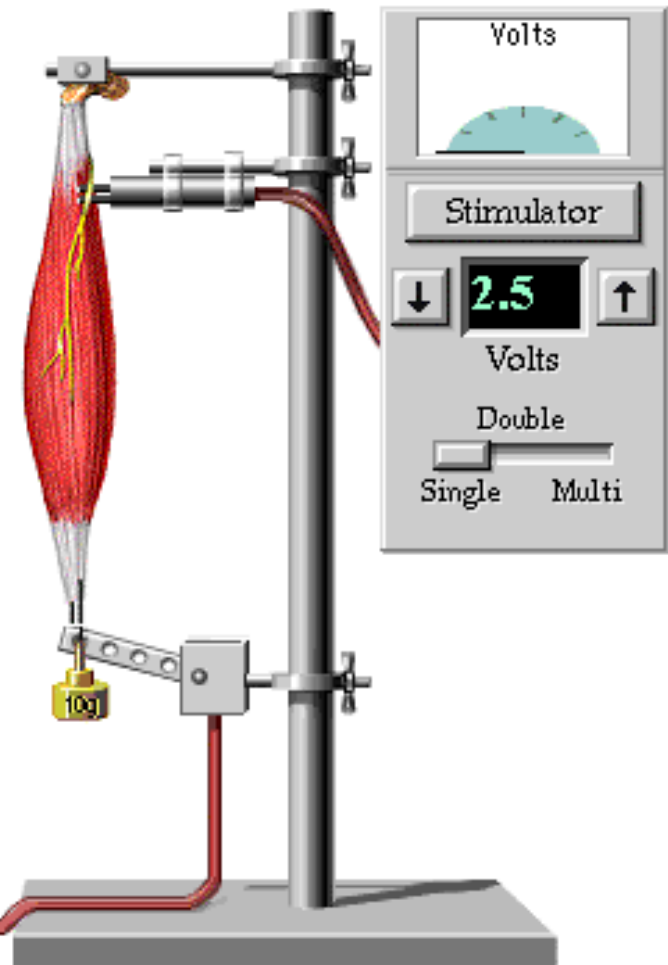
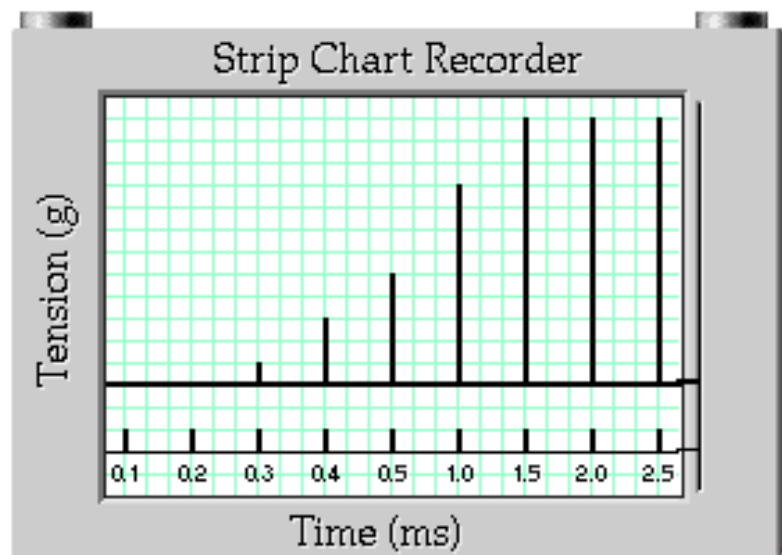


# MOTOR NÖRON SAYISI

## LAB SIMULATION: MULTIPLE MOTOR UNIT SUMMATION

Similar responses at 1.5, 2.0, and 2.5 volts confirm the assumption that maximal stimulus was reached at 1.5 volts.

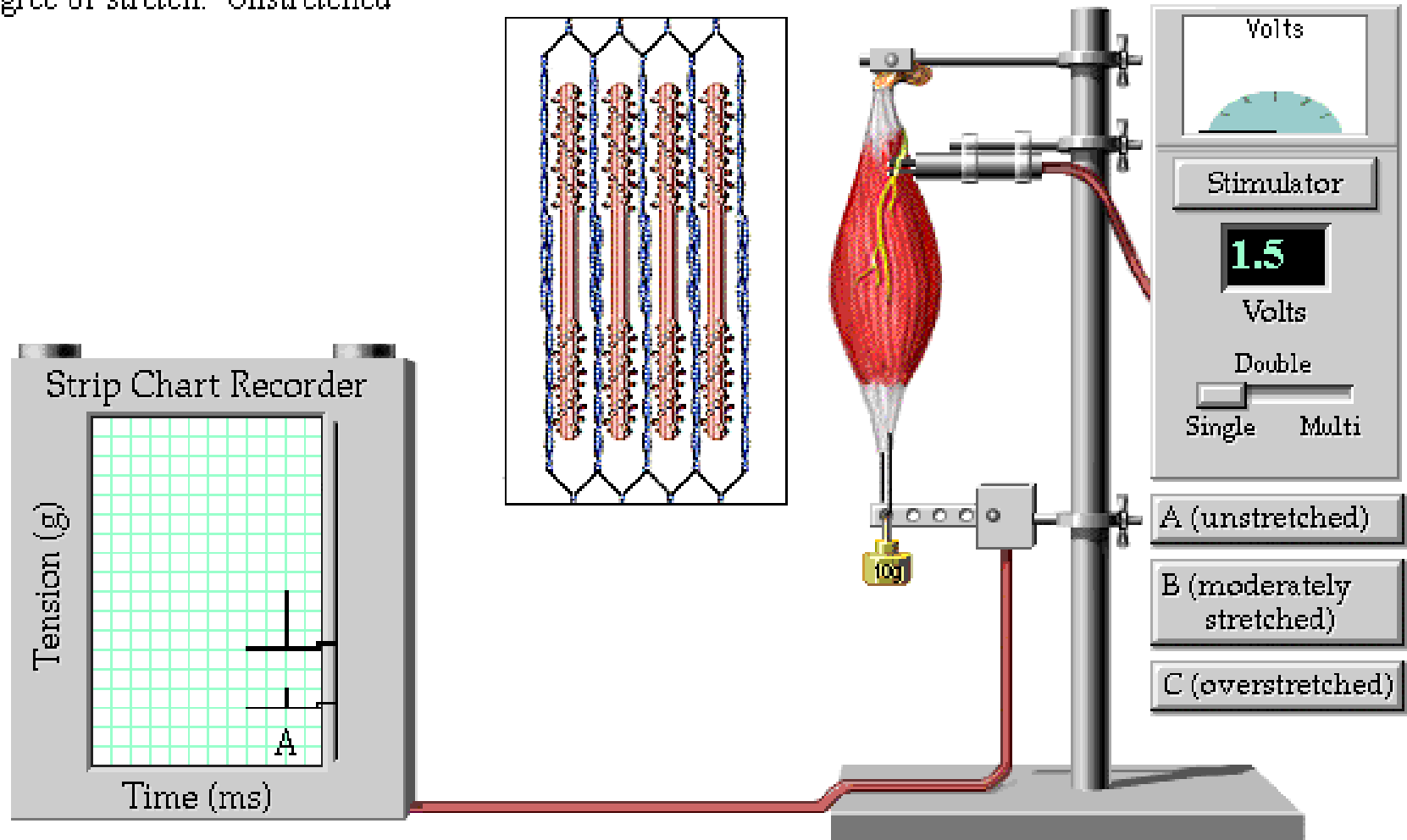
For this particular muscle, a stimulus of 1.5 volts or higher is clearly maximal and will evoke the contraction of all motor units.



# KASIN BOYU

## LENGTH-TENSION RELATIONSHIP

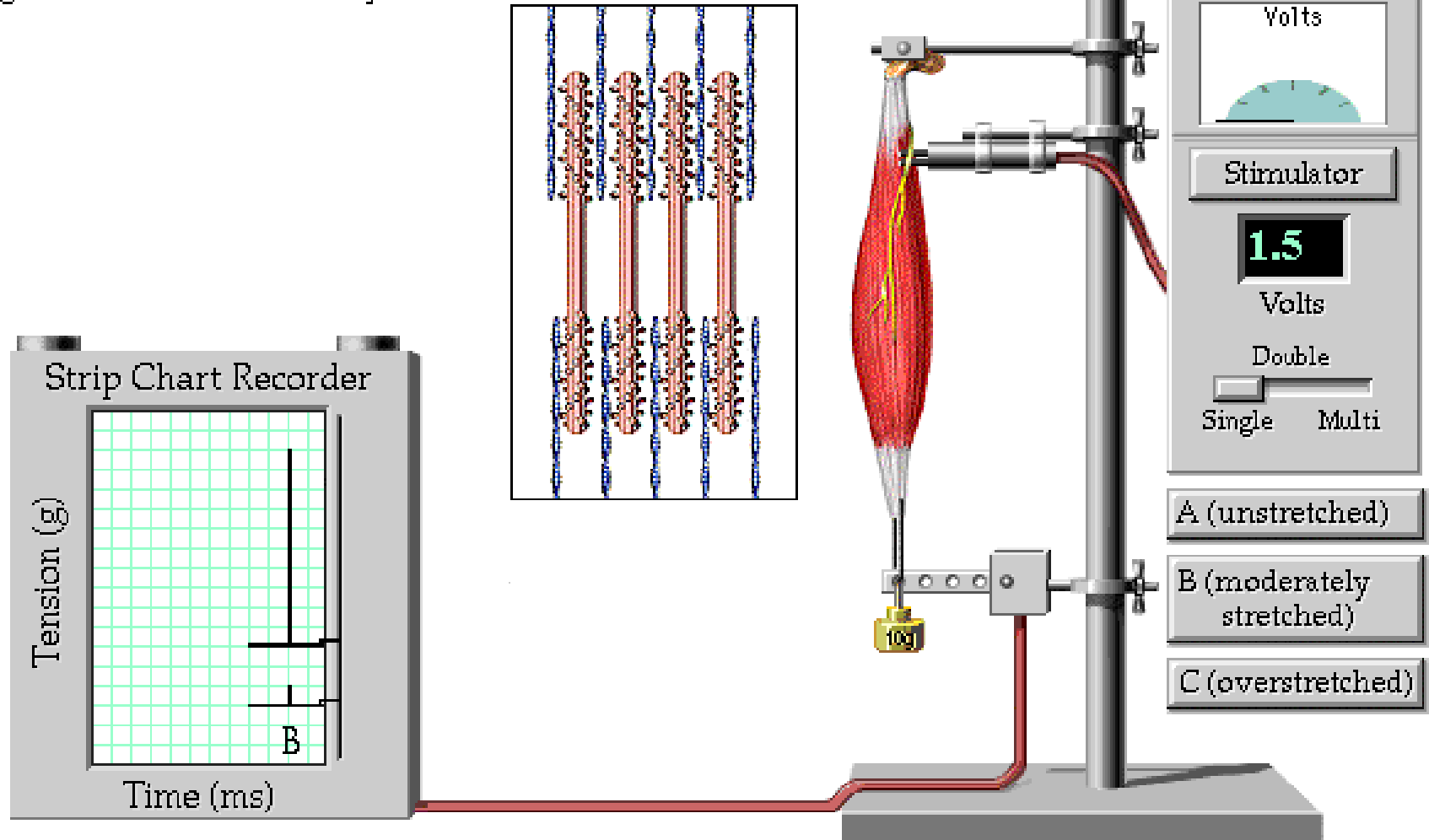
Degree of stretch: Unstretched



# KASIN BOYU

## LENGTH-TENSION RELATIONSHIP

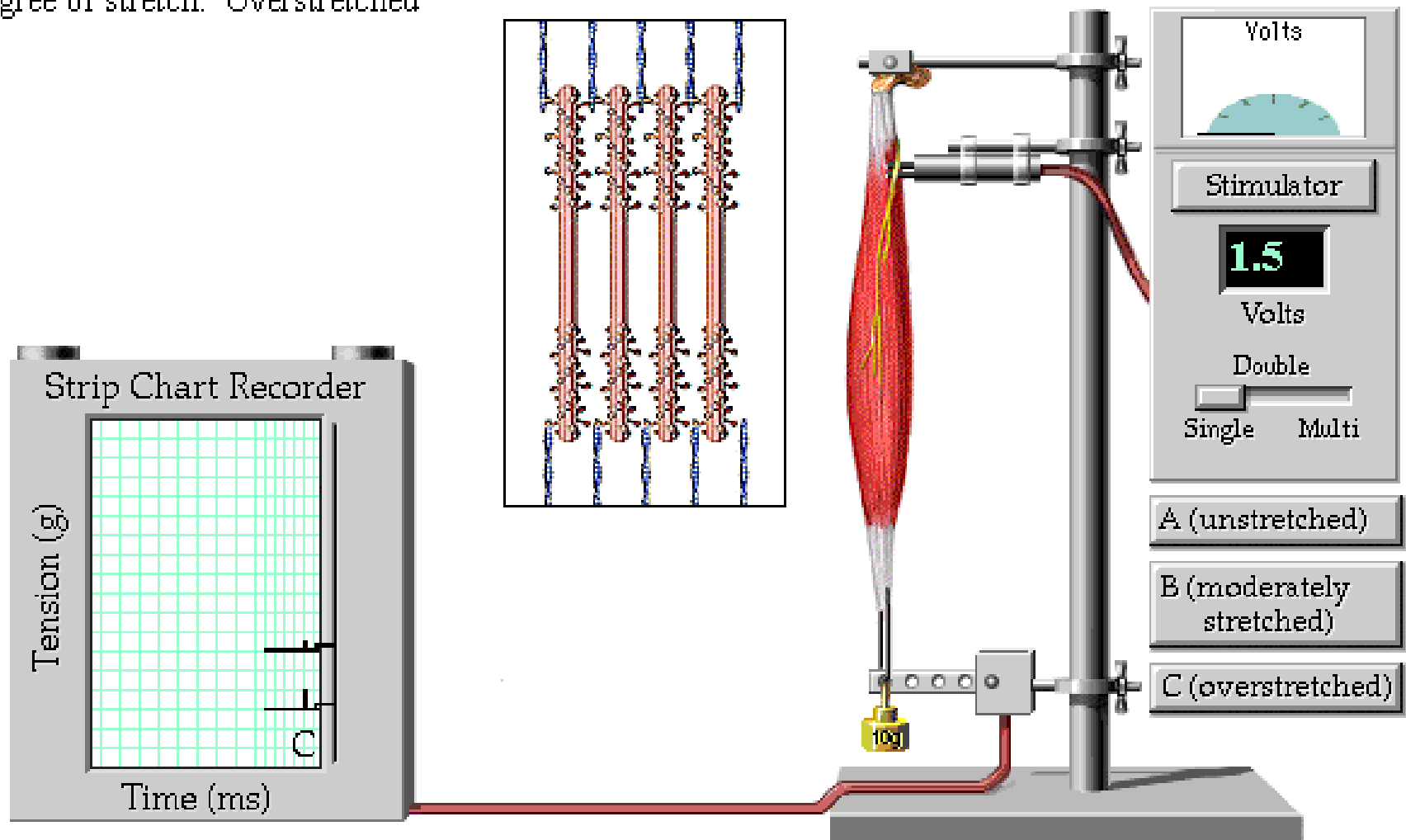
Degree of stretch: Moderately stretched



# KASIN BOYU

## LENGTH-TENSION RELATIONSHIP

Degree of stretch: Overstretched



# DÜZ KASLARDA KASILMA



# GENEL ÖZELLİKLERİ

- ✗ Düz kas kasılmasının genel özellikleri iskelet kası ile aynıdır
- ✗ Kas lifinin boyu iskelet kası lifine göre çok daha küçüktür
- ✗ Düz kasta da kasılabilir proteinler aktin ve miyozindir
- ✗ Hücre içi fiziksel düzenlenmeleri ise çok farklıdır

# DÜZ KASIN DAĞILIMI VE ÖNEMİ

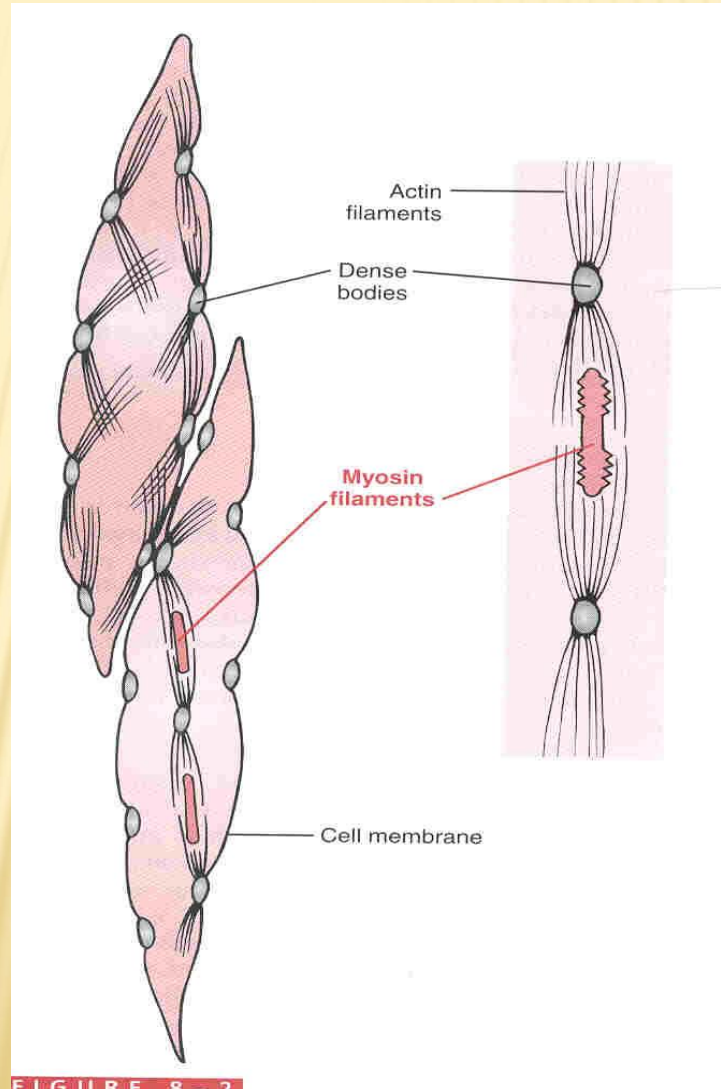
- ✗ Mide-barsak sistemi-pasajın hareketleri
- ✗ İdrar kesesi-idrarın boşaltılması
- ✗ Bronşlar-solunum işlemi
- ✗ Uterus-menturasyon, doğum
- ✗ Gözler-miyozis, midriyazis, akomodasyon
- ✗ Damarlar-kan basıncının düzenlenmesi

# KASILMANIN FİZİKSEL TEMELLERİ

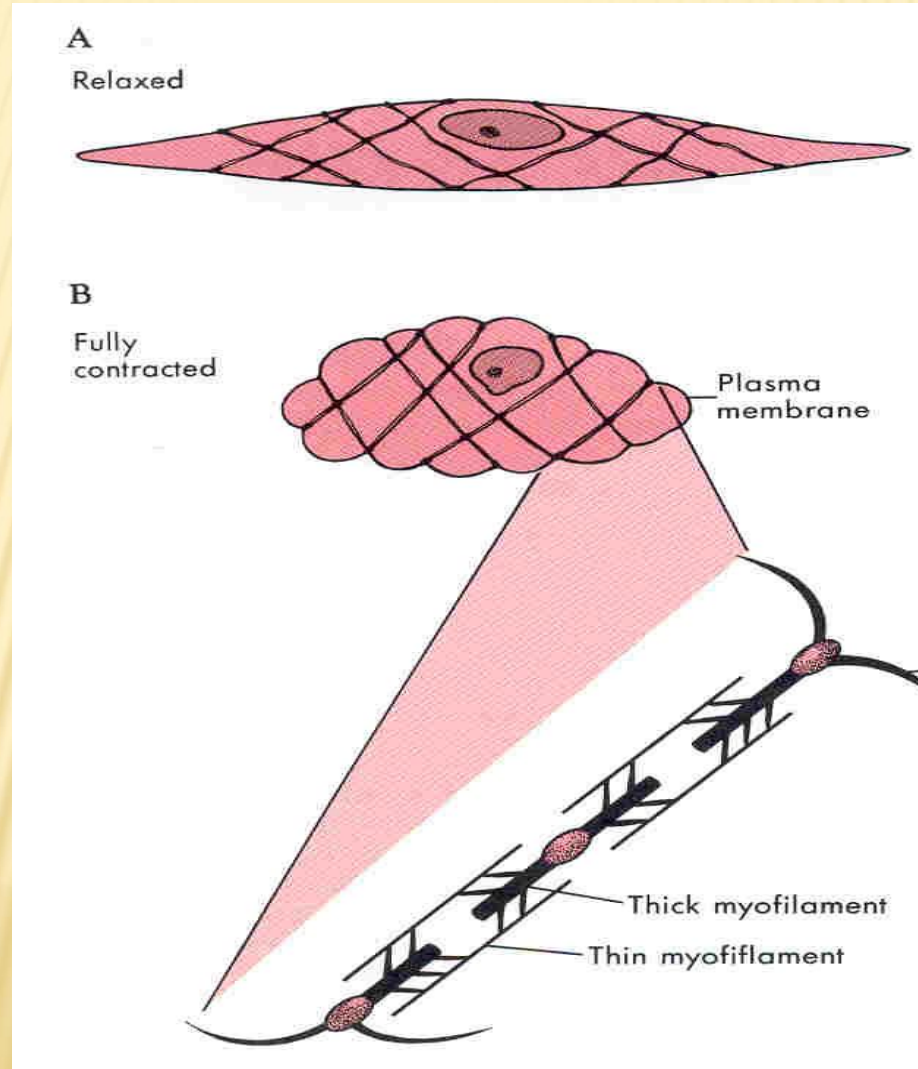
- ✗ Aktin filamentleri yoğun cisimlere tutunmuştur
- ✗ Komşu hücrelerin membranlarındaki yoğun cisimler de protein köprüleri ile birbirlerine tutunmuşlardır
- ✗ Kasılma gücü başlıca bu bağlarla bir hücreden diğerine geçmektedir



# DÜZ KASIN ORGANİZASYONU



# KASILMA



# KASILMA

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- ✗ İskelet kasının Z çizgileri görevini yoğun cisimler görür
- ✗ Miyozin filamentlerinin çoğu ‘yan kutup’ denen çapraz köprülere sahiptir
- ✗ Düz kasın boyunu kısaltma oranı %80’e kadar çıkabilir



# KASILMA

- ✘ İskelet kasının Z çizgileri görevini yoğun cisimler görür
- ✘ Miyozin filamentlerinin çoğu 'yan kutup' denen çapraz köprülere sahiptir
- ✘ Düz kasın boyunu kısaltma oranı %80'e kadar çıkabilir
- ✘ Düz kasta aynı kasılma gerimini devam ettirmek için gerekli enerji  $1/10$ - $1/300$  kadar daha azdır
- ✘ Bu sayede barsak, mesane, safra kesesi gibi iç organların devamlı olan tonik kasılmaları az bir enerji harcanarak gerçekleştirilebilir



# MANDAL MEKANİZMASI

- ✗ Düz kas tam kasıldıktan sonra;
  - + Kasın aktivasyon derecesi başlangıç seviyesinin altına düşebilir
  - + kas buna rağmen tam kasılma gücünü sürdürebilir
  - + ve çok az enerjiye ihtiyaç duyar
- ✗ Bu sayede bir düz kas;
  - + tonik kasılmasını saatlerce az enerji harcayarak sürdürebilir

# KASLARLA İLGİLİ TERİMLER

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- ✗ Hipertrofi, hiperplazi, atrofi
- ✗ İzotonik kasılma, izometrik kasılma
- ✗ Plastisite