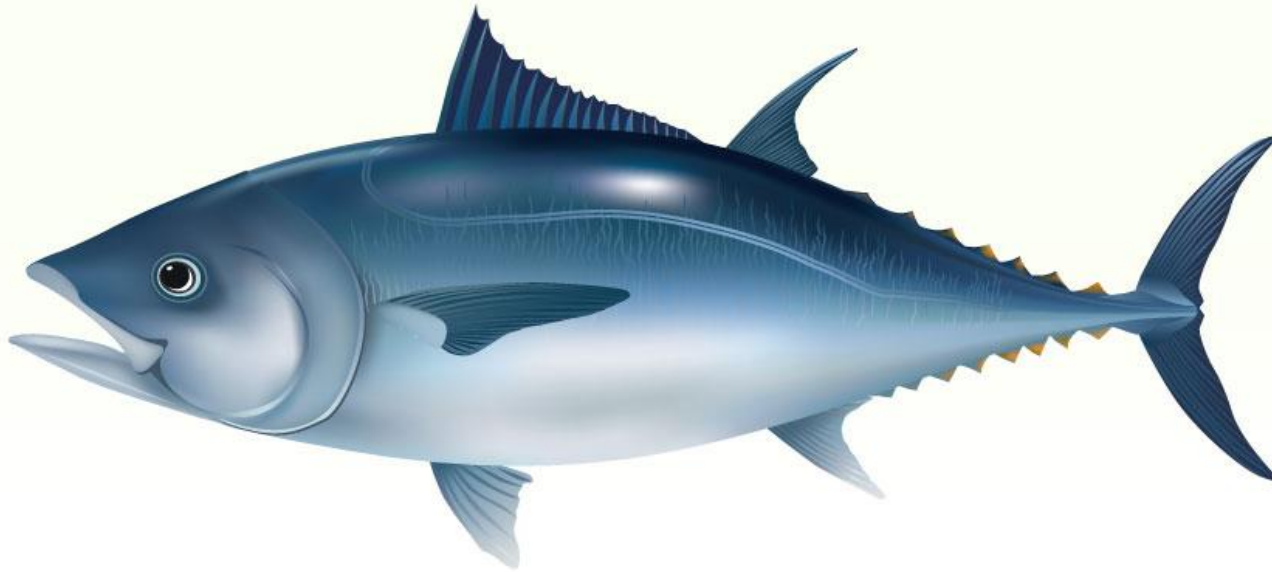




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## **Structure of fish and shellfish myosystems**

# INTRODUCTION

- The structure of fish muscle is due to the structural proteins that responsible for the filamentous organisation of the muscle.
- The main structural proteins in the fish muscle is myofibrilar proteins.
- The general structure of a muscle fiber include **myofibrils** (chains of repeating subunits) composed of two kinds of filaments: **thick filaments** (composed of **myosin**) and **thin filaments** (composed of **actin**, **tropomyosin** and **troponin**) that interact by binding to produce a sliding movement between the filaments, and that creates tension in the muscle fiber leading to muscle contraction.



# Classification of fish Muscles

## □ Presence/Absence of striations

### 1 **Striated muscle:**

- ✓ **Skeletal muscle** { make up *skeletal attached* to bone }
- ✓ **Cardiac muscle** { *heart muscle* }

### 2 **Non-striated muscle (unstriated)**

- ✓ **smooth muscles:** found in hollow or tubular organs such as the intestines, and blood vessels.

## □ Besed on Color

- **Red** - highly vascularized and rich in myoglobin; resist fatigue
- **white** - low vascularization and lower in myoglobin; quicker to fatigue



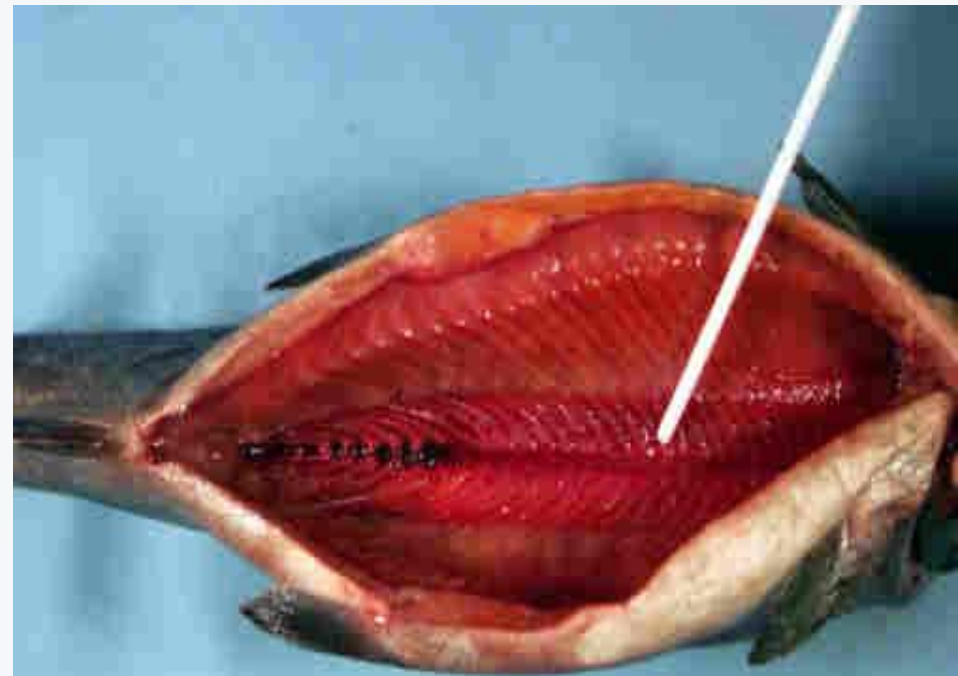
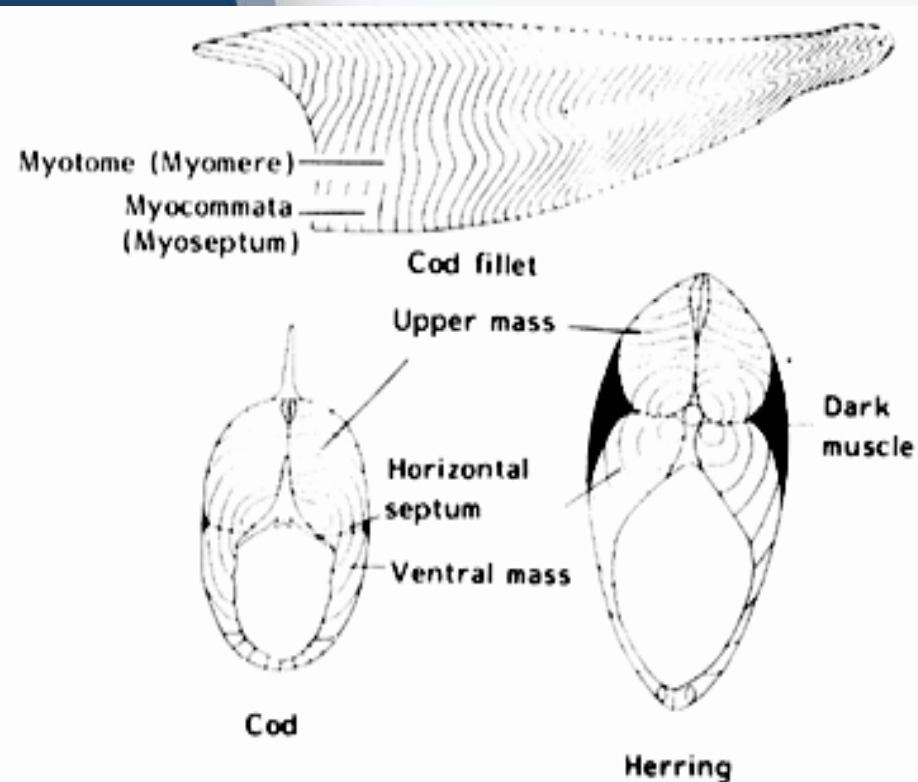
# SKELETAL MUSCLE

- Fish use their skeletal muscles to move their **bones and fins**.
- A fish's flesh consists almost entirely of skeletal muscles. They are arranged one behind the other in broad vertical bands called **myomeres**.
  - The myomeres can easily be seen in a skinned fish.
  - Each myomere is controlled by a separate nerve.
  - As a result, a fish can bend the front part of its body in one direction while bending its tail in the opposite direction.
  - Most fish make such movements with their bodies to swim.



# SKELETAL MUSCLE

- ❖ Skeletal muscle are made up of unit cells fibers which are long, multinucleated cylinders.
- ❖ The diameter of the fibers ranges between 10-100m and their length extend 47cm.
- ❖ Fiber diameter is dependent on size, sex, and age of the animal.
- ❖ The connective tissue of fish muscle is called myocommata (Endomysium) that maintain the muscle integrity.



# Different part of Skeletal Muscle

## 1. Myofibrils(Threadlike strands within muscle fibers)

- Further divisions of myofibrils
  - Z-line
  - A-band
  - I-band

## 2. Sarcomeres

- ❖ Thick and thin filaments are arranged into **sarcomeres**

## 3. Actin (thin filament)

- Troponin
- Tropomyosin

## 4. Myosin (thick filament)



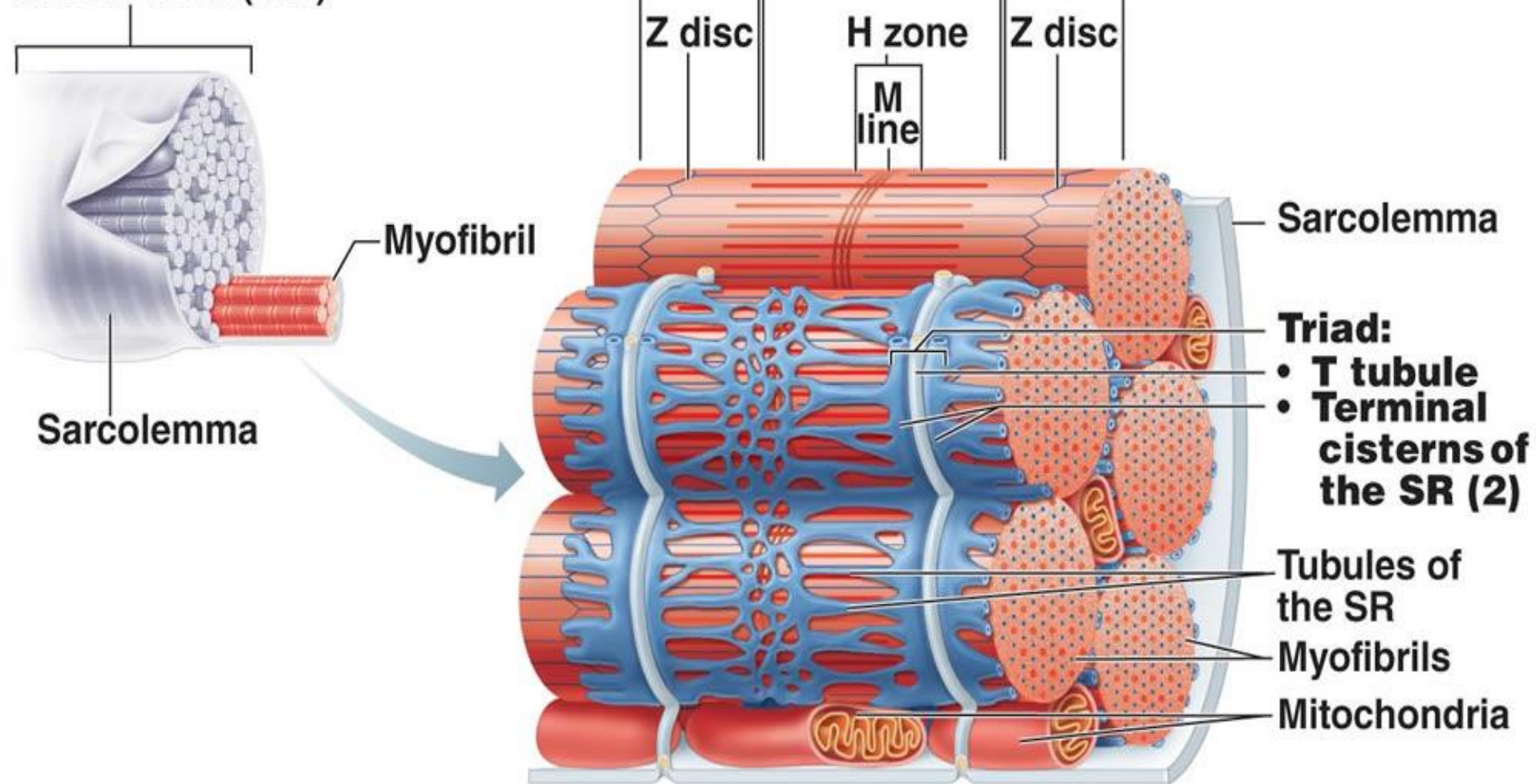
# Myofibrillar Proteins

- The protein responsible for the filamentous organisation of the fish muscle is myofibrillar proteins or structural proteins.
- The myofibrillar protein account for 65-75 percent of the total fish muscle proteins.
- They are directly involved in muscle contraction, rigor mortis, protein denaturation , and toughness of texture.
  - The general structure of a muscle fiber include **myofibrils** (chains of repeating subunits) composed of two kinds of filaments:
    - Actin (thin filament)
      - Troponin
      - Tropomyosin
    - Myosin (thick filament



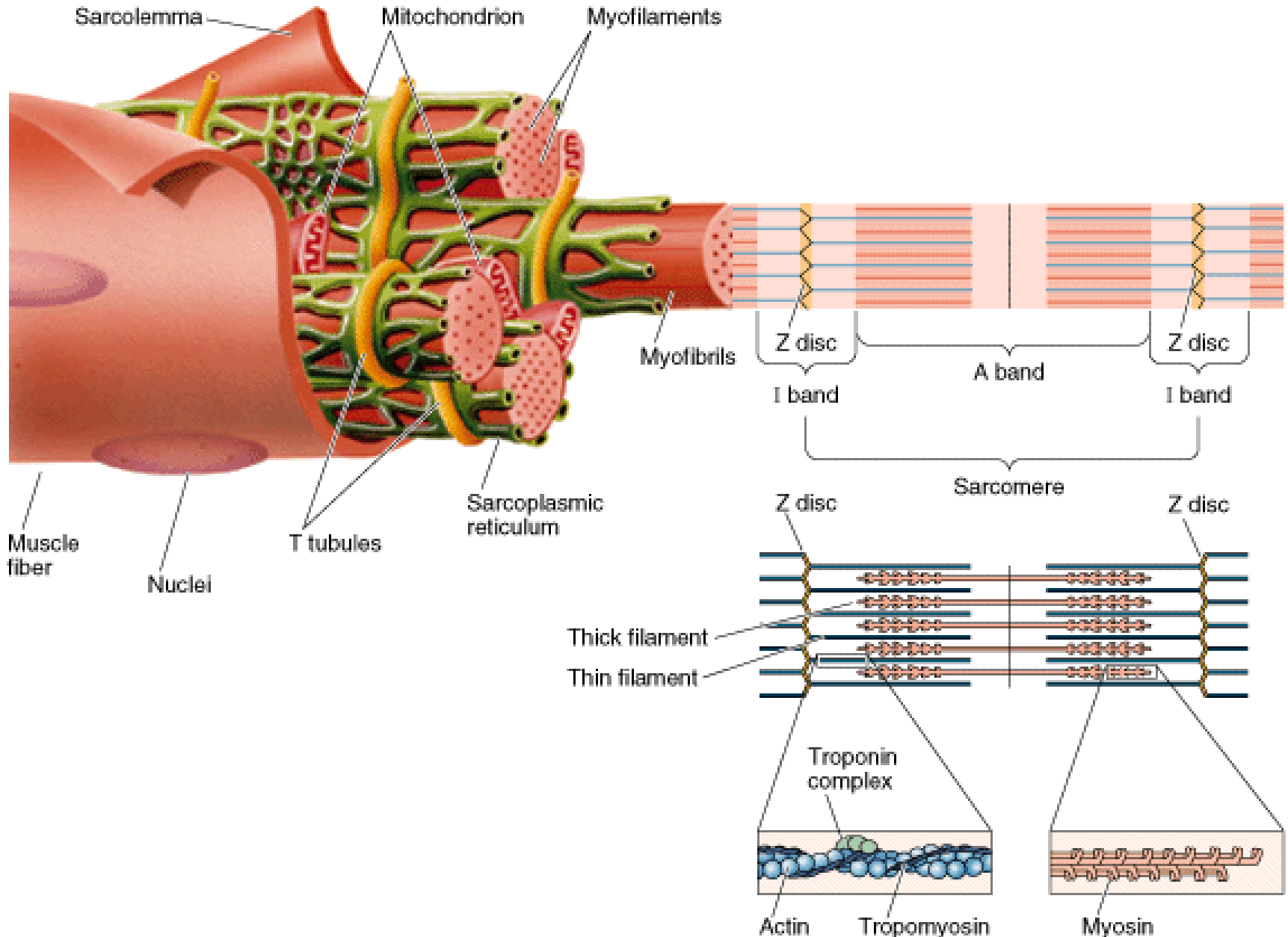
# Structure of myofibrillar protein

Part of a skeletal muscle fiber (cell)





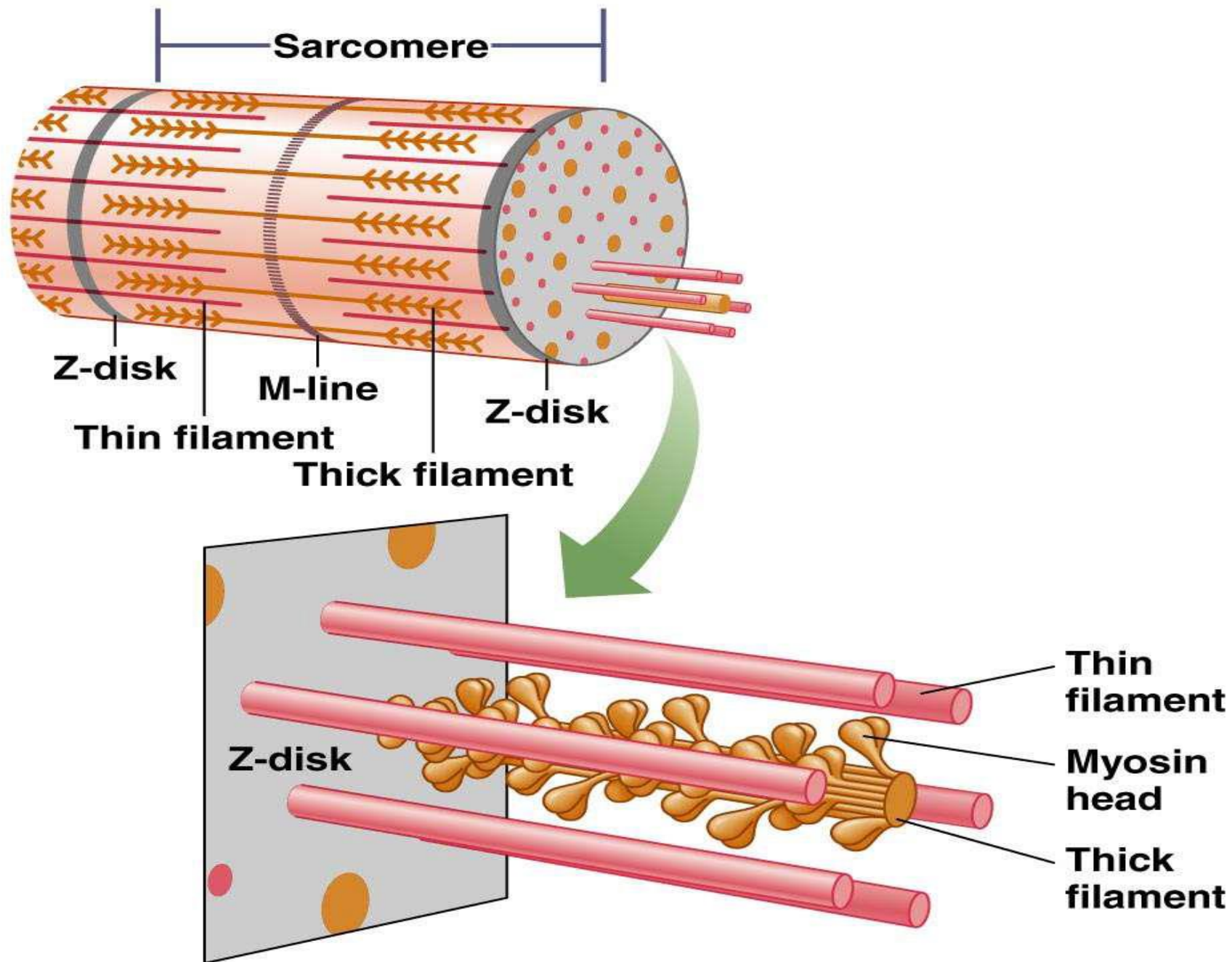
# ► Organization of a Muscle Fiber



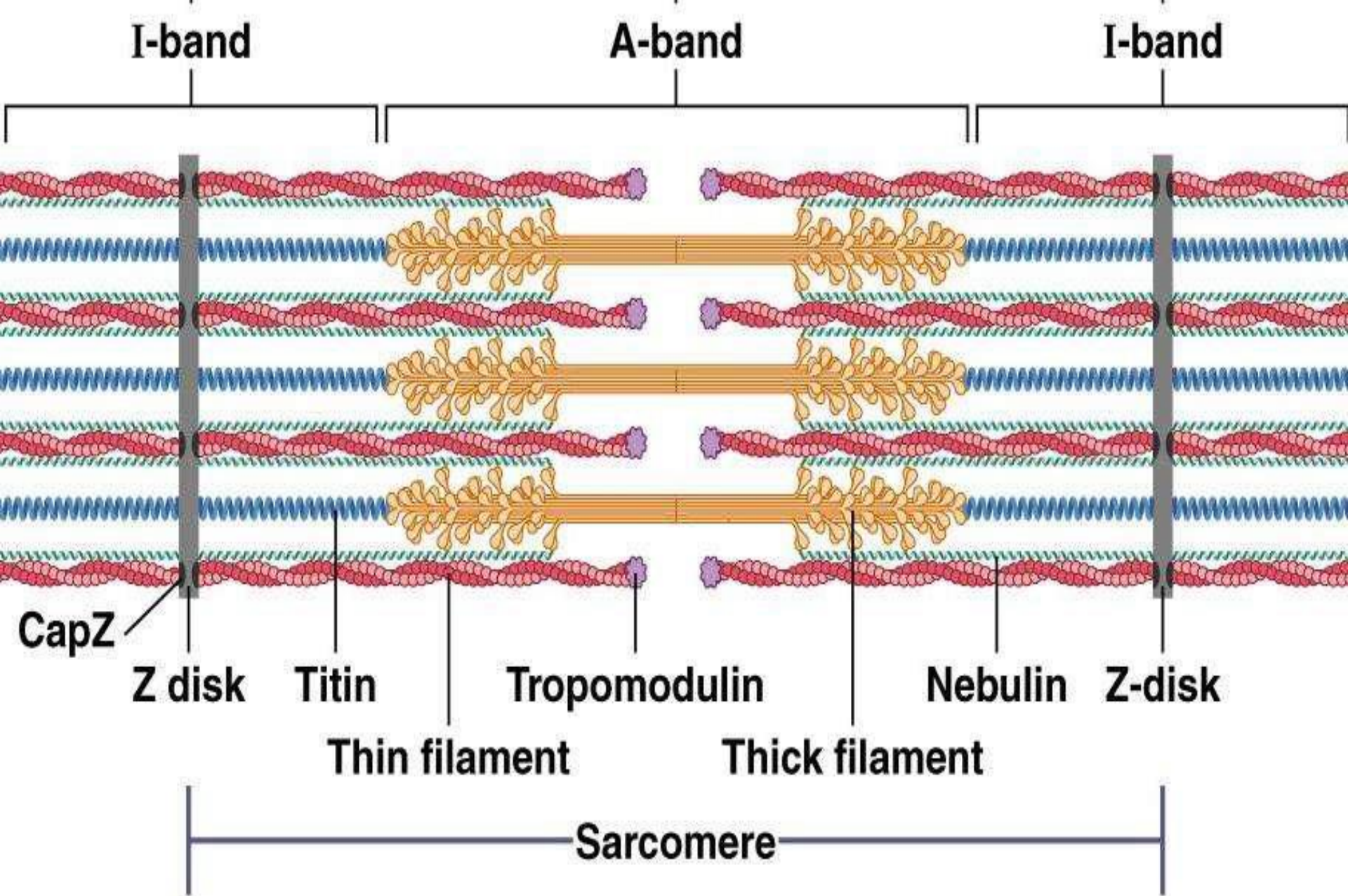
# Structure of Sarcomeres

- ❖ Thick and thin filaments are arranged into sarcomeres.
- ❖ Each thick filament is surrounded by an *array of thin filaments*.
  - This is repeated in parallel throughout the muscle cell.
  - **Z-disk:** forms the end of each sarcomere
    - Thin filaments extend from
  - **A-band:** thick filament occurs
    - dark region
  - **I-band:** spans portions of thin filaments without overlap of thick filaments.
    - Light region
    - spans a z-disk
  - **M-line:** central region of sarcomere
    - Between 2 minus ends of thin filament









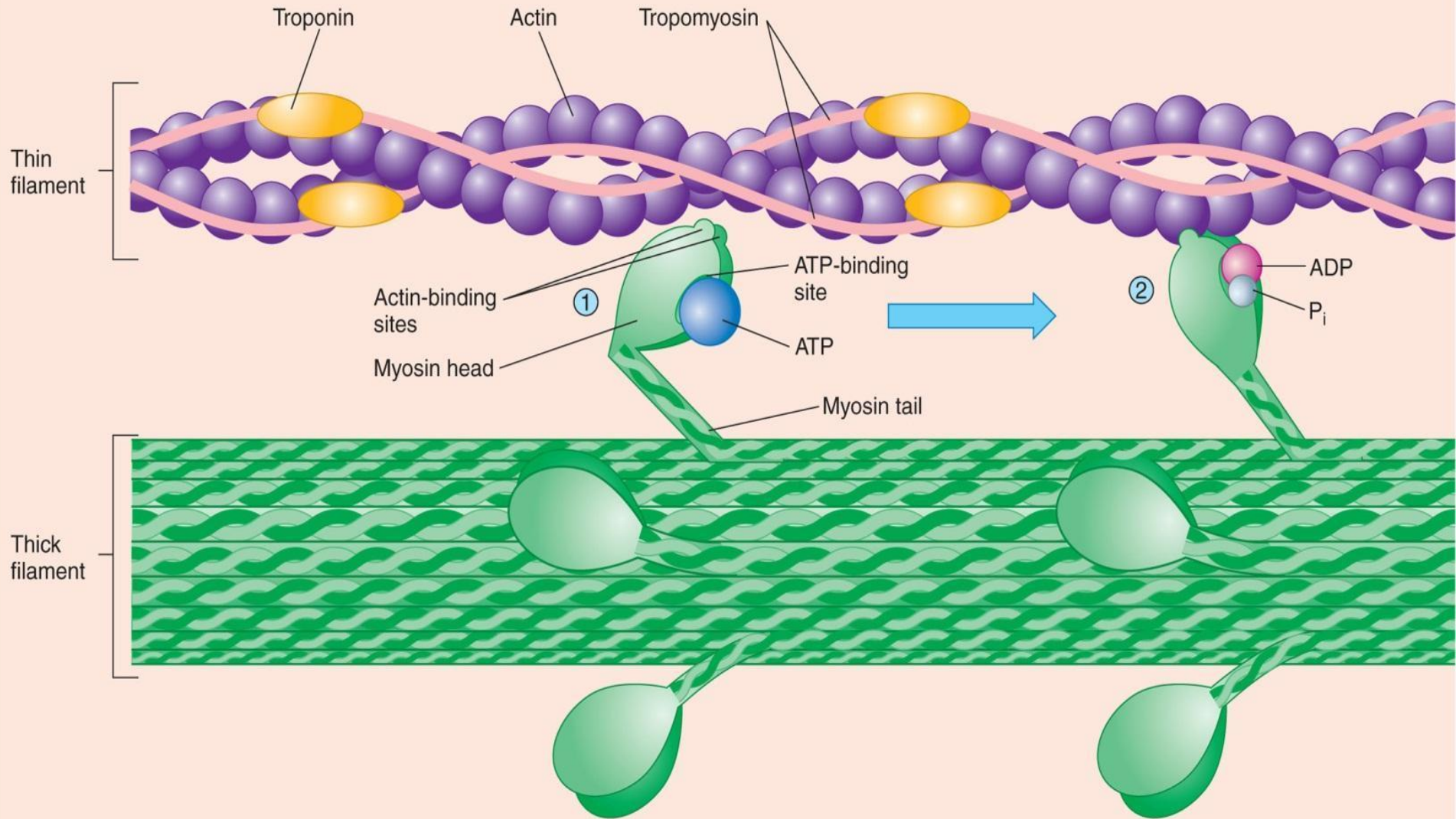
# Actin

- ❖ It is the major protein of thin filaments
- ❖ It constitutes 15-30 percent of the myofibrillar proteins of the muscle.
- ❖ Actin is bound to the structure of the muscle more firmly than the myosin.
- ❖ It exists in the muscle as a double helical structure of the fibrous actin or F actin, and globular actin or G actin.
- ❑ **Actomyosin:** When actin is mixed with myosin in vitro a complex compound called actomyosin is formed.
- ❖ The interaction of actin and myosin in the absence of ATP and ADP and the plasticising effect of these nucleotides when they are present are important factors deciding the quality of the fish meat.



# Actin Structure

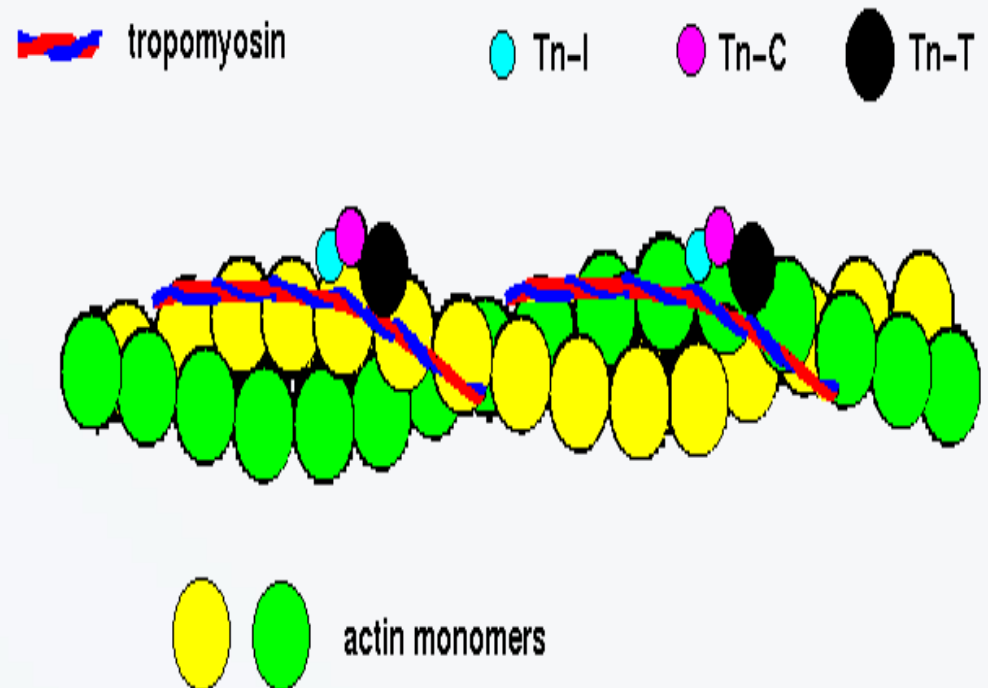
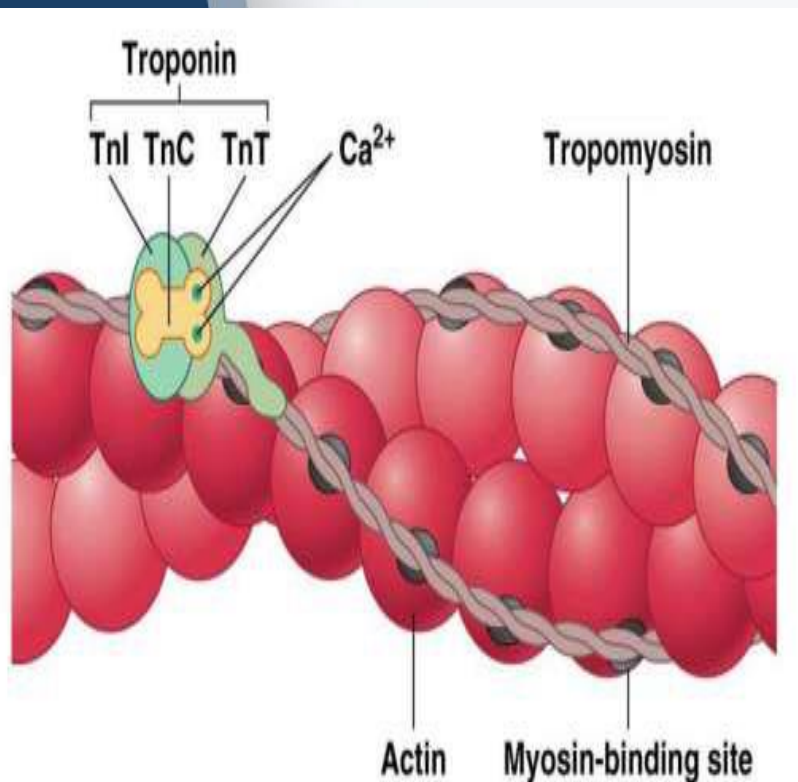
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# Troponin and tropomyosin complex

Troponin & Tropomyosin are thin filament proteins that together make up a **troponin-tropomyosin complex**

When  $[Ca^{2+}]$  is low, the troponin tropomyosin complex blocks actin binding sites for myosin. Prevents cross-bridge formation



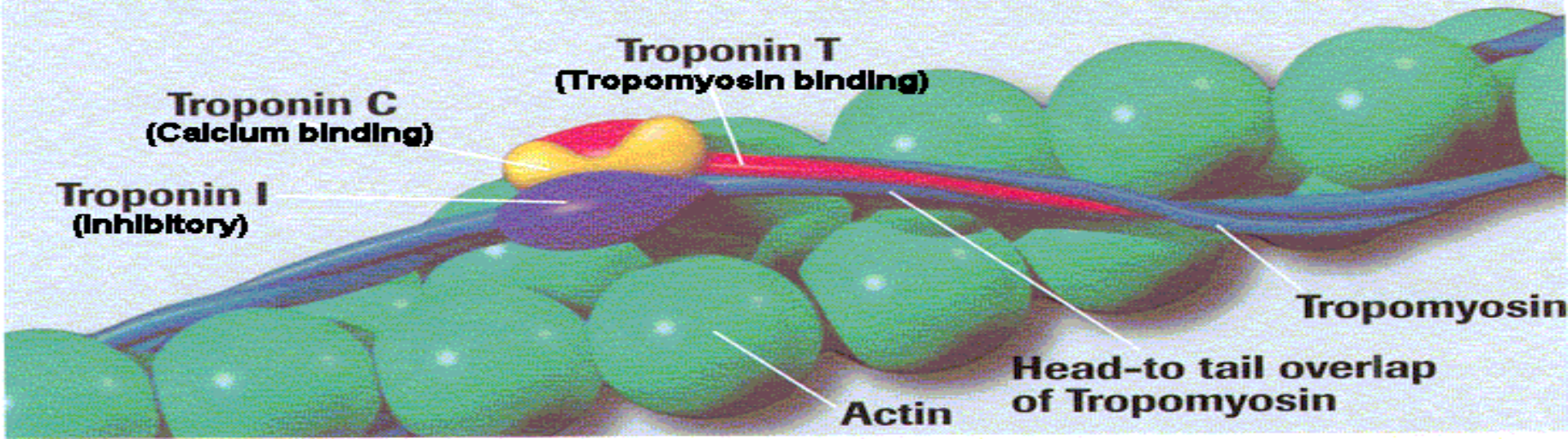


# Troponin Tropomyosin Complex

- $[Ca^{2+}]$  and troponin-tropomyosin complex rolls out of the way, allowing myosin to bind to actin.
- Initiating cross-bridge cycle
  - 3 components of troponin:
    - TnC
    - TnI
    - TnT
  - Tropomyosin:
    - Double stranded protein
    - Blocks myosin binding sites

## TROPONIN T

A regulatory protein released when cardiac cell necrosis occurs.

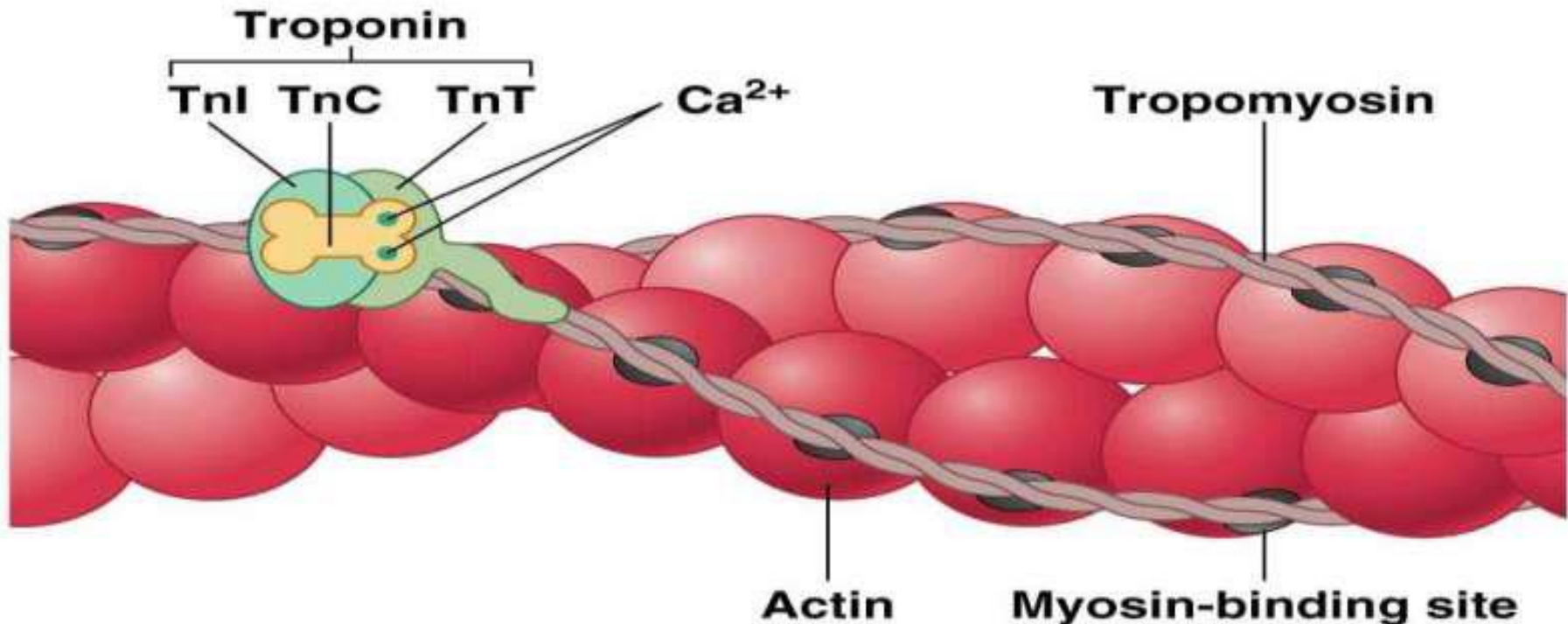


# Troponin Tropomyosin Complex

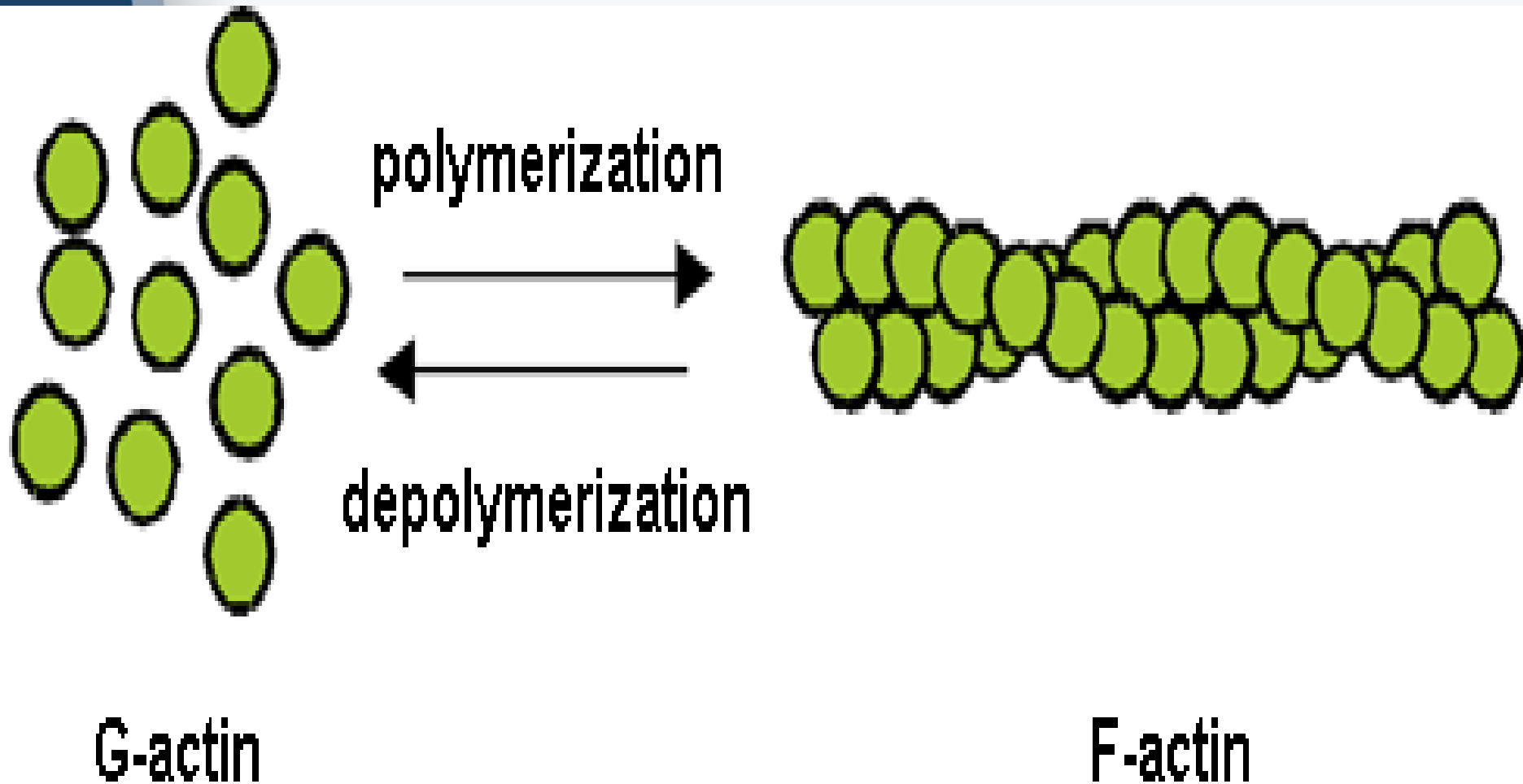
## Troponin Tropomyosin Complex

- TnC has 4  $\text{Ca}^{2+}$  binding sites:
  - 2 C-terminal sites
  - 2 N-terminal sites

Troponin tropomyosin complex acts as a single unit, shifting in response to  $\text{Ca}^{2+}$



# Structure of F-actin and G - actin

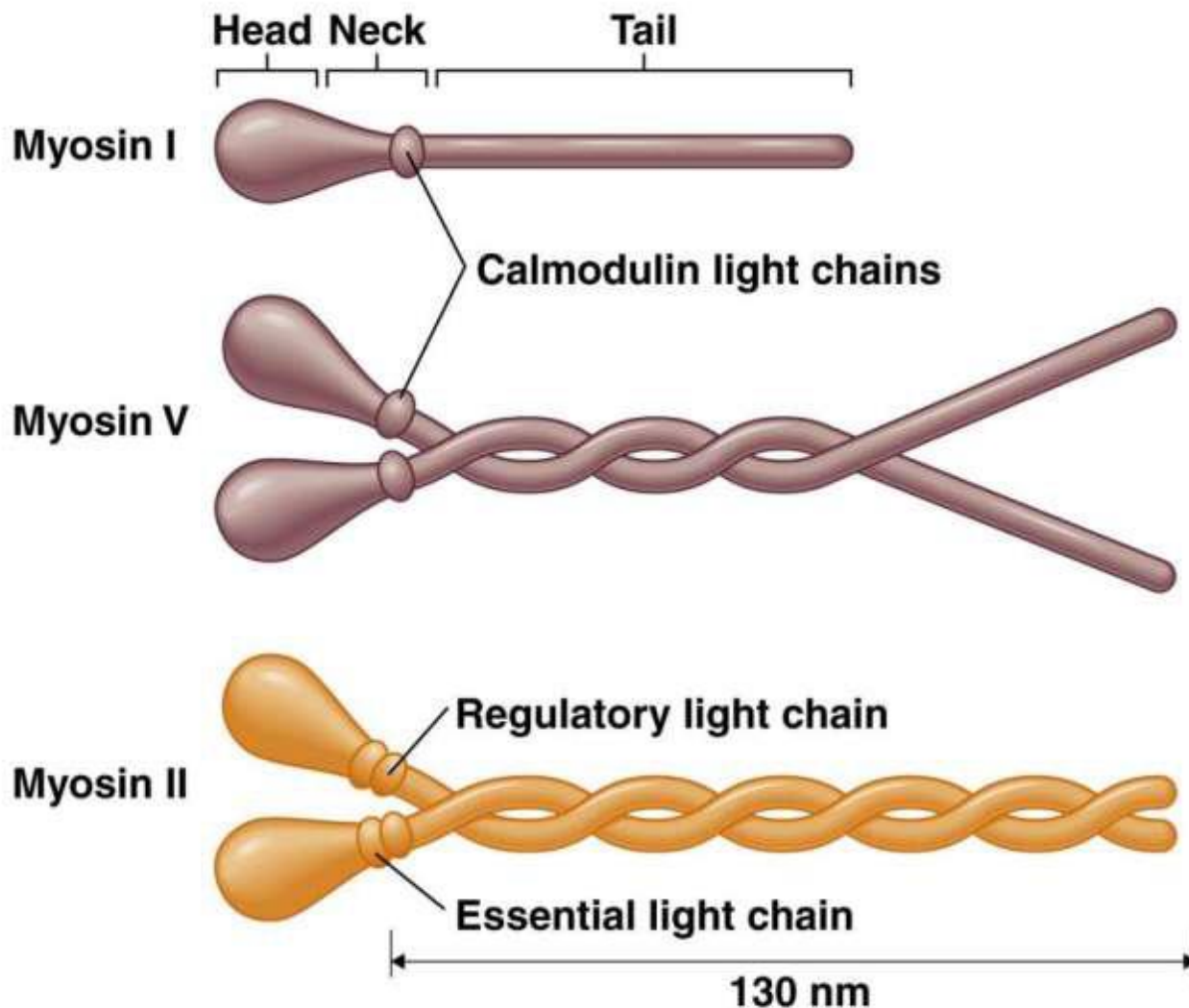


# Myosin

- Myosin is the protein of the thick filaments.
- It constitute approximately 50-60 percent of the myofibrillar contractile proteins of the fish muscle.
- Myosin is a motor molecule that works to move the cell. This will result in a contraction and expansion movement.
- It works closely with a globular protein called actin that polymerizes to create actin filaments.
- Myosin is a special protein that converts adenosine triphosphate (ATP), a molecule that cells use in order to live and work, into mechanical energy (energy of work). This will then generate force and movement.



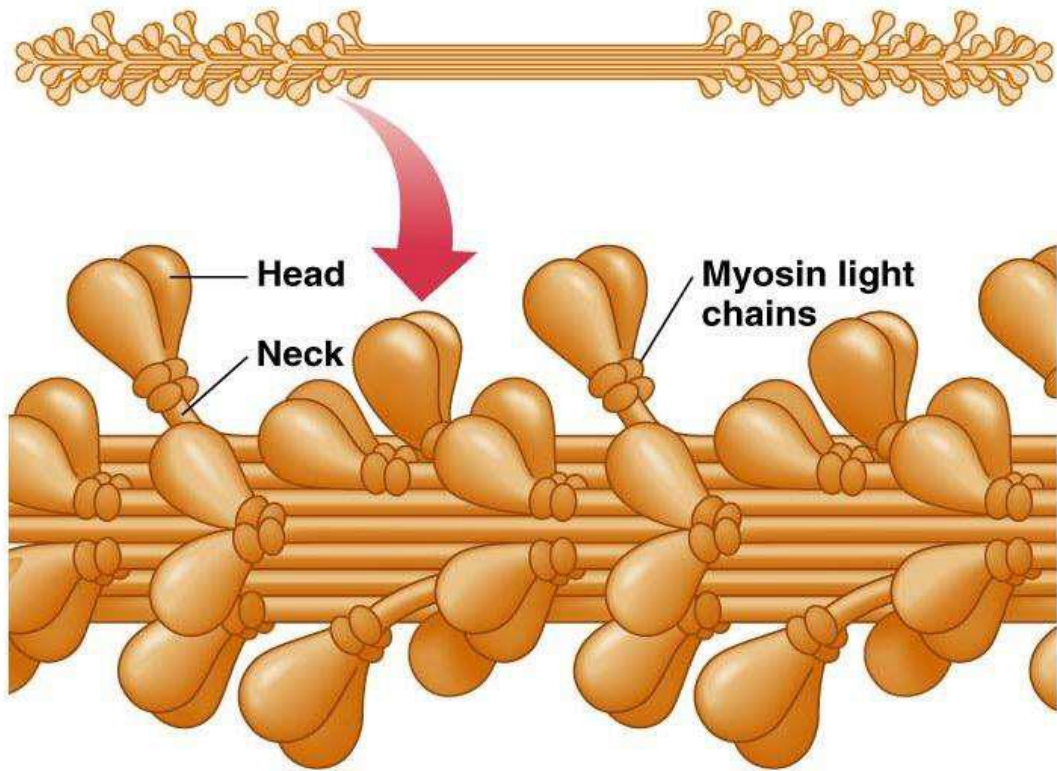
# Myosin structure



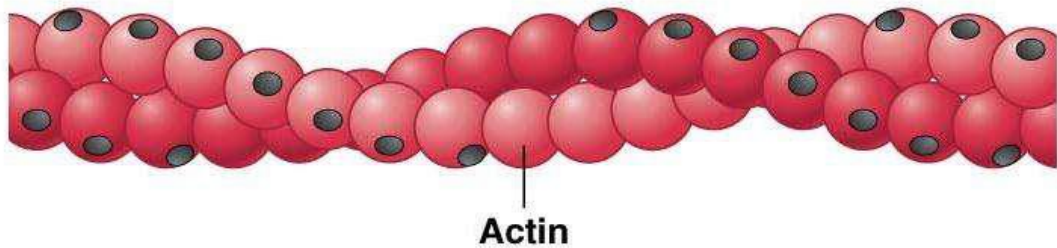
**Head:** Provides energy for movement.

**Tail:** Allows the binding of cargo (vesicles, organelles, plasma membranes)

**Neck:** Regulates the activity of the head



**(a) Thick filament**



**(b) Thin filament**

# Cardiac muscle

- ❖ These are found solely in the musculature of the heart wall.
- ❖ In cardiac muscle the branching of the cells increase its overall connectivity and the cells are firmly united with each other through the **intercalated disks**
- ❖ Cardiac muscle does not fatigue readily, which is a desirable trait in the muscles that maintain circulation of blood
- ❖ Action of the cardiac muscle fibers shows mixed control, such that the Myogenic rhythm of the heart is maintained by neurogenic control and the entire unit of the cardiac muscle acts as a **syncytium**, or single functional unit.



# Smooth Muscle

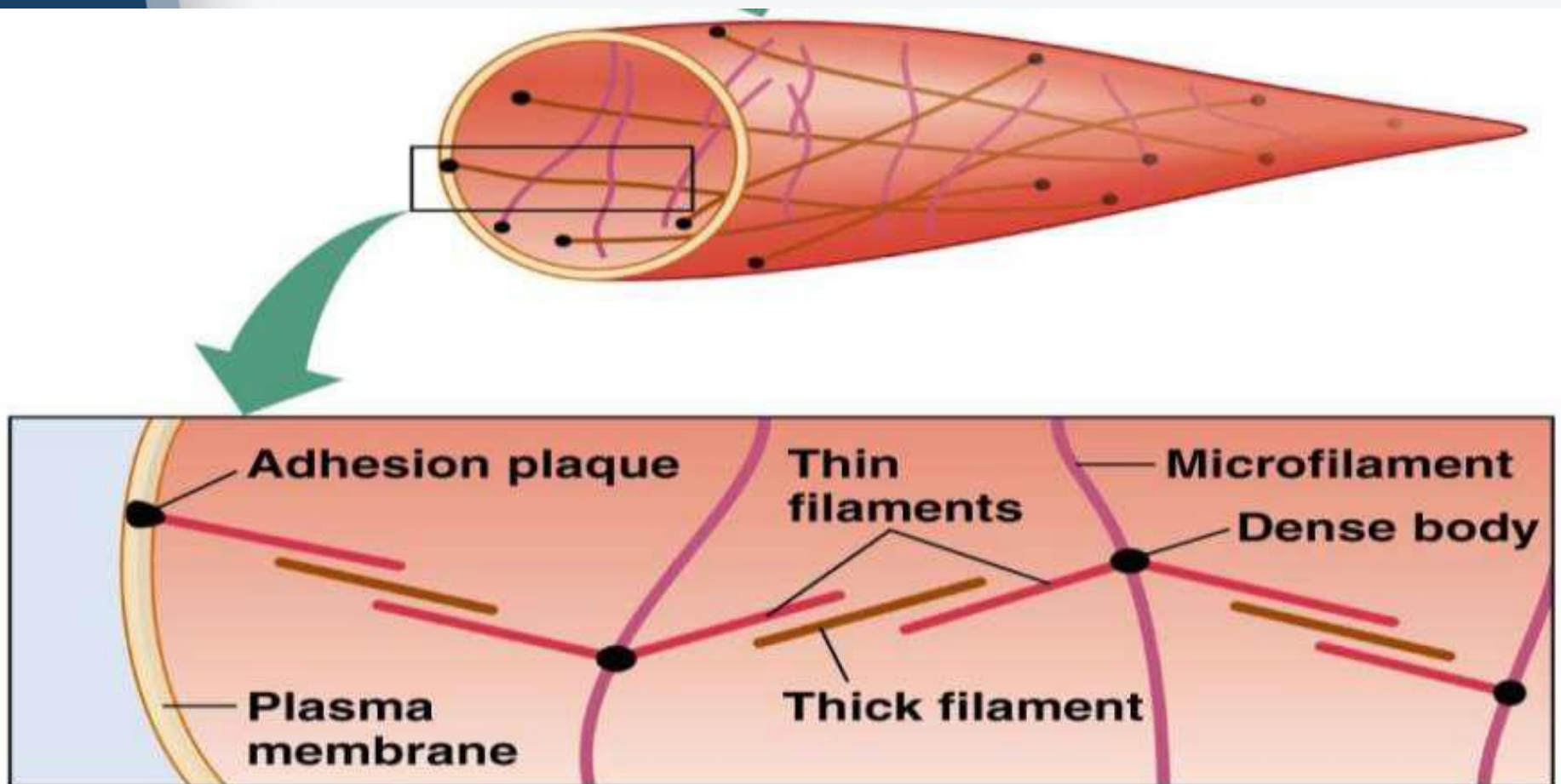
- Fish Smooth Muscle is Non-striated muscle (unstriated)
- It works automatically.
- The smooth muscles are responsible for operating such internal organs as the stomach and intestines.
- Layers of smooth muscle induce slow
- regular contractions:
  - ◦ Blood vessels
  - ◦ Airways
  - ◦ Digestion (intestines, bowel, etc)
- Lack sarcomeres!



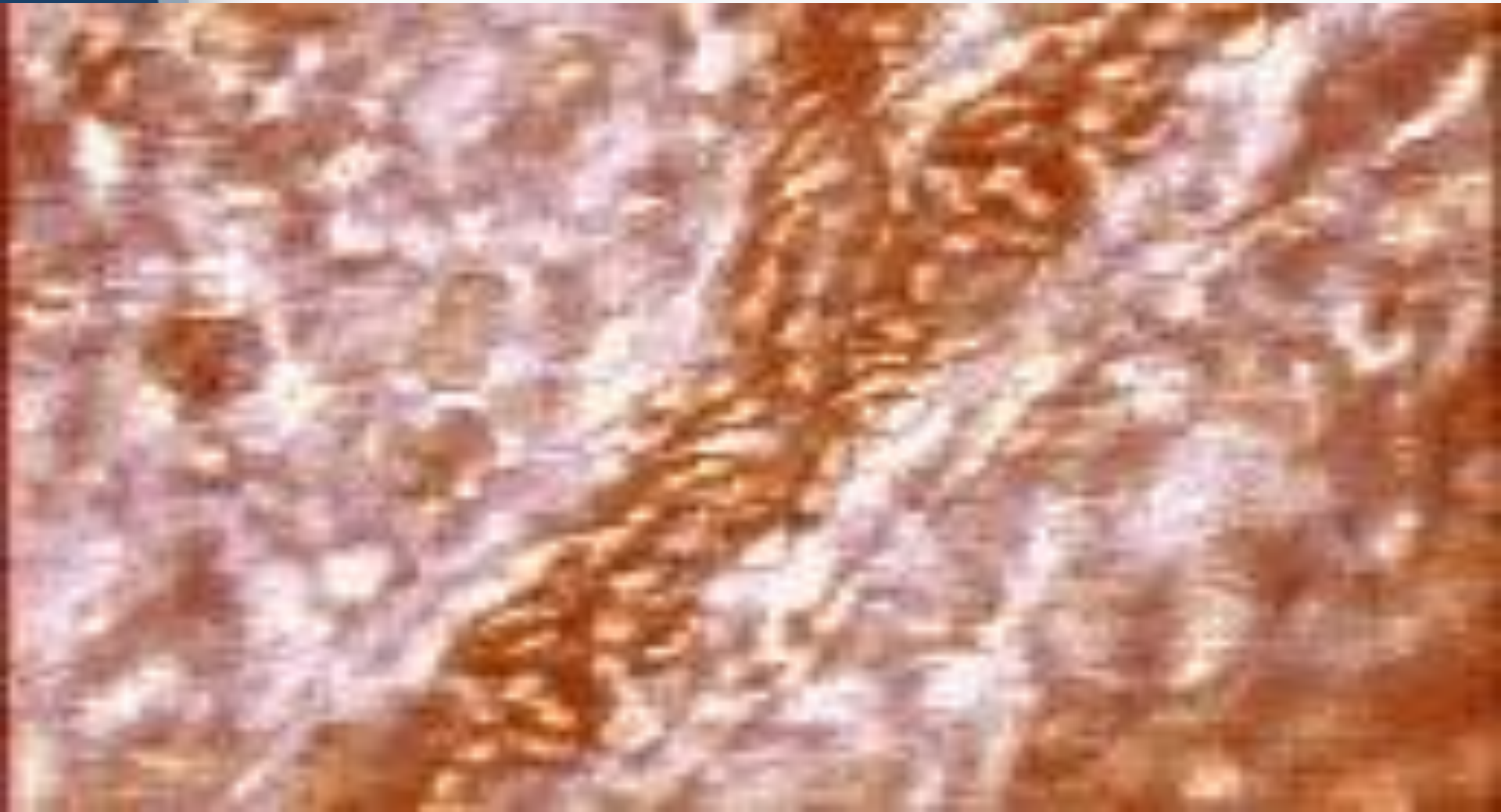


# Smooth Muscle

3D arrangement allows smooth muscle to contract in all dimensions

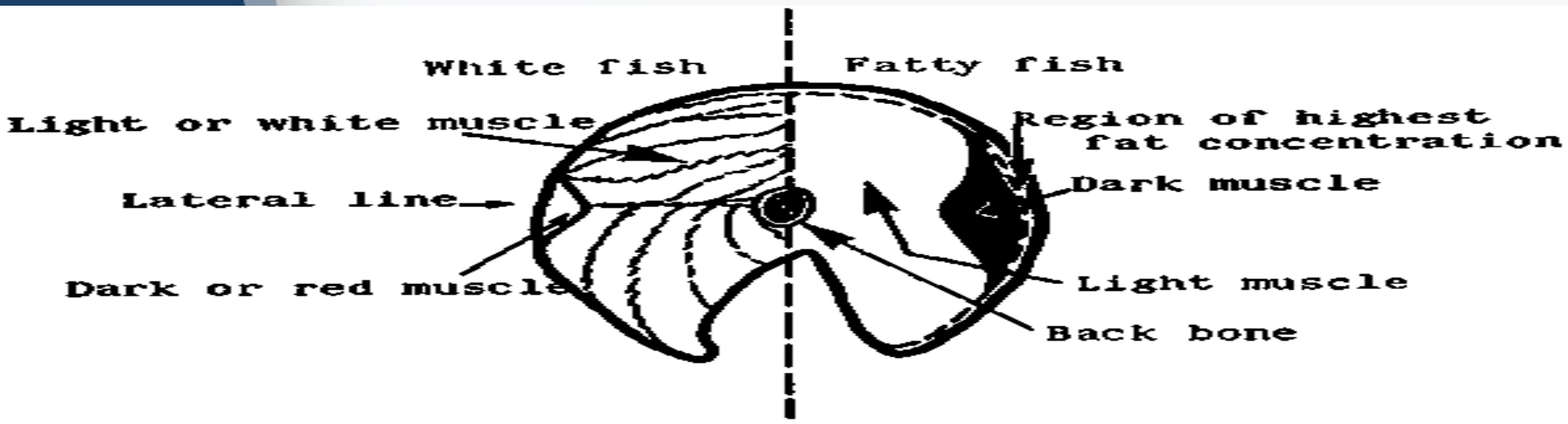


# **Smooth & Cardiac Muscles: Circulation and the Heart**



# Classification of fish muscle based on colour

- Fish muscle is of two kinds:
- light muscle and dark muscle.
- In white fish such as cod and haddock there is a small strip of dark, or red, muscle just under the skin on both sides of the body, running beneath the lateral line.
- In fatty fish such as herring and mackerel the strips of dark muscle are much larger in proportion and contain higher concentrations of fat and certain vitamins. Since it is not usually practicable to separate the dark, fatty muscle from the light muscle when preparing fish for cooking.



## Essentially three types of fish muscle: red, white, pink.

□ **Red muscle (oxidative):** Highly vascularized, myoglobin containing tissue used during sustained swimming. Small diameter and high blood volume = rich O<sub>2</sub> supply! Presence leads to strong flavor in some fishes (tuna).

• **Example; Red yellowfin tuna.**

□ **White muscle (glycolytic):** Little vascularization. Used during “burst” swimming. Large diameter fibers.

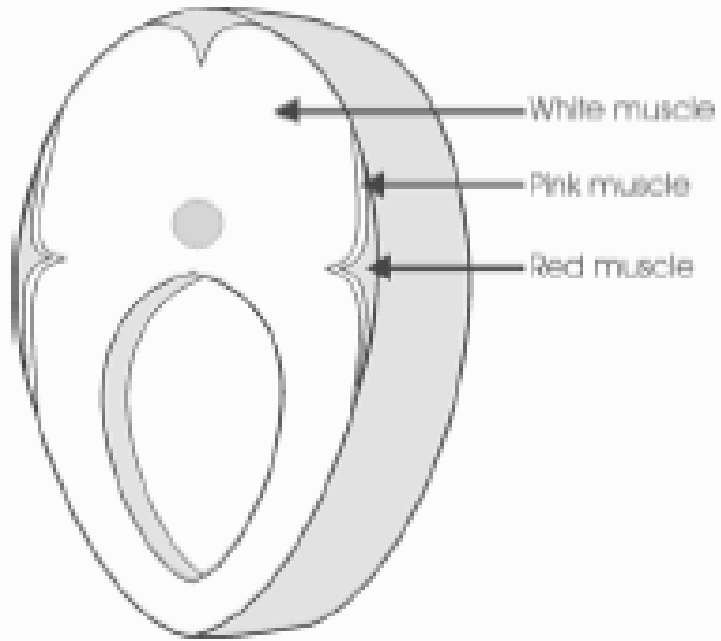
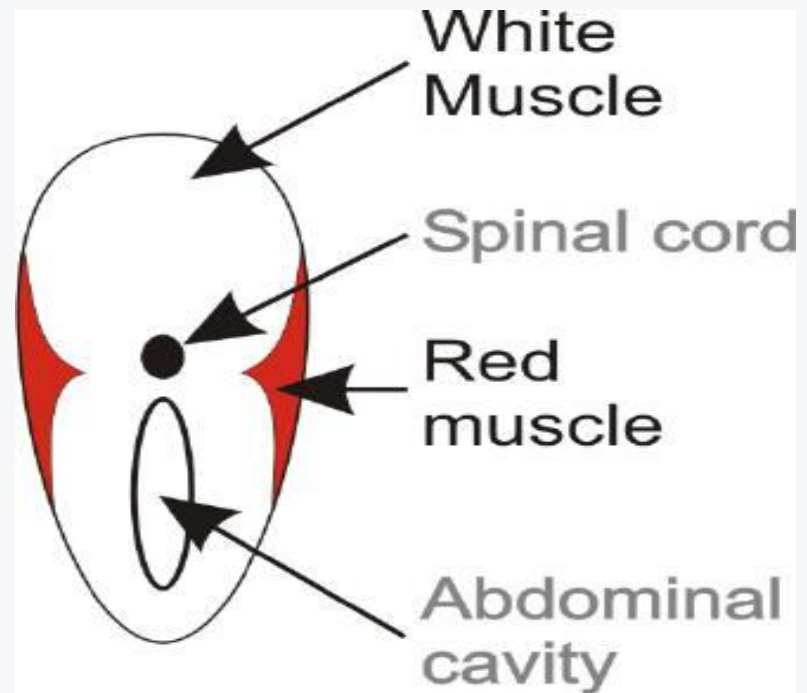
• **Example: Off-white Pacific halibut**

□ **Pink muscle:** This one is sort of in between red and white. Serves in sustained swimming, but not to the extent that red muscle is used.

• **In most salmon species these are pink due to a pigment salmon get from their diet.**

• **Example: Orange Chinook salmon:**

□ **Blue colour:** Blue Lingcod — a member of the greenling family — isn't the only West Coast species to turn up with blue-green meat.



A cross-section of a fish muscle showing the location of red (high aerobic, slow twitch), pink (high aerobic, high glycolytic and fast twitch) white (anaerobic, high glycolytic and fast twitch) muscle fibres



**Off-white Pacific halibut**



**Red yellowfin tuna**



**Orange Chinook salmon**



**Blue Lingcod**

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THANK

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