# Myofibril

**Myofibrils** are fibrillar protein complexes that represent the functional essence of muscle fiber. A set of myofibrils make up the contractile apparatus of a muscle fiber.

## Building Stones

1. **Myosin** - fibrous protein, the basis of *thick filaments*
2. **F-actin** - fibrous protein, the basis of *thin filaments*
3. **Tropomyosin and Troponins** - proteins, components of *thin filaments*
4. **Accessory proteins** - ensuring the correct arrangement of the components of the contractile apparatus; alpha-actinin, filamin, amorphin, Z-protein, myomesin, desmin

## Thick filaments

Base: *Myosin type II*

1. Fibrous segment – 2 heavy chains spirally wound, at one end of the chain a header
2. Globular segment - string headers + 2 pairs of light strings associated with headers; binds actin

300–400 myosin molecules = thick filament – myosin molecules arranged symmetrically, heads pointing towards the nearer end of the filament

→ smooth central zone without globular segments + peripheral zone with laterally protruding globs. segments

## Thin filament

**The basis is *F-actin***

G-actin polymer = globular G-actin monomer, polarized → precise ordering during polymerization. Formation of 2 helically wound chains from G-actin units.

***Tropomyosin***

A molecule formed by two spirally wound chains. The molecules are arranged one behind the other, inserted into the groove of the F-actin filament. 1 molecule exceeds 7 actin monomer units. Stabilization and strengthening of thin fiber.

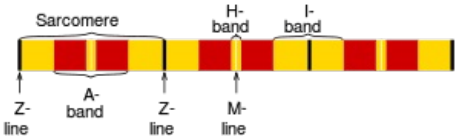
***Troponin***

A complex of 3 globular units – T, C, I, bound to the tropomyosin molecule.

- Troponin T – binding to tropomyosin
- Troponin C – binds calcium ions
- Troponin I – inhibits the binding site for myosin on actin

## Sarcomere

The sarcomere is the basic functional and structural unit of the *myofibril*. Each myofibril consists of overlapping actin and myosin myofilaments. Their longitudinal arrangement creates characteristic transverse striations. The structural proteins of myofibrils also include titin and nebulin, and the regulatory proteins tropomyosin and troponin.



Schematic representation of myofibril structure (lighter part is yellow, darker part is red)

**Arrangement of myofilaments:**

- **I-strip** - isotropic actin filaments (7 nm);
- **A-stripe** - anisotropic myosin filaments (15 nm).

The actin filaments reach their free end into the A-strip and create the **H-zone*. Two adjacent sarcomeres are connected in a Z-line'*** (telophragm). Here, two sets of thin filaments of two adjacent sarcomeres are anchored in the so-called Z-plate. Anchoring is accomplished by alpha-actin (a major component of the disc), filamin, amorphin, and Z-protein.

In cross-section, the arrangement of both types of filaments is hexagonal. In the overlap region, the myosin filament is surrounded by six actin filaments. In the middle of the H-strip, myosin filaments are anchored in the so-called **M-line'** (using myomesin), from which they diverge to both sides. The M-band also contains the enzyme creatine kinase, which catalyzes the transfer of phosphate groups from phosphocreatine to ADP.

## Mechanism of contraction

The mechanism of contraction is an active process that involves '*shortening of the sarcomere*. The I-stripe narrows, the A-stripe remains the same width, and the H-stripe gradually disappears.

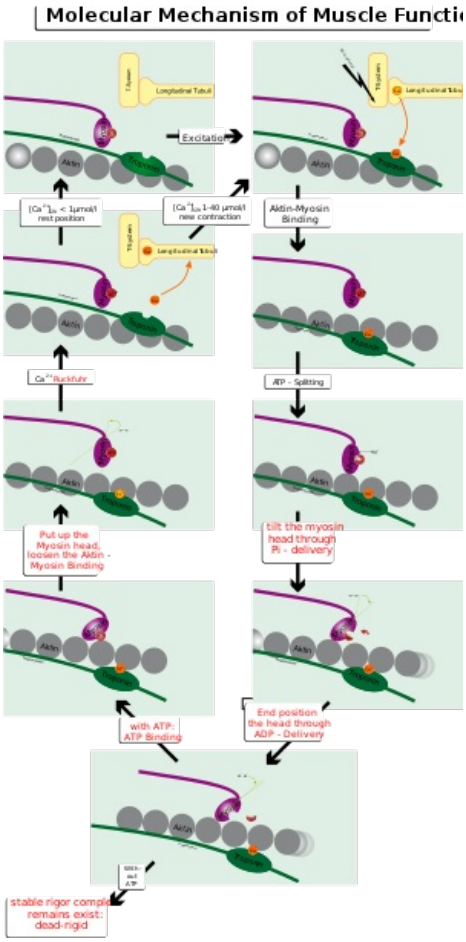
The globular segment of the thick filament has a binding site for ATP supplied to the mitochondria surrounding the myofibrils. In the resting state, tropomyosin blocks the association of myosin with actin.

1. When the level of calcium ions in the cytoplasm changes above the threshold value, $Ca^{2+}$ binds to Troponin C.
2. Subsequently, the configuration of the troponin complex changes and tropomyosin is pulled into the groove of the actin filament; this process exposes the myosin binding site and an **actin-myosin complex** is formed.
3. ATP hydrolysis occurs and the globular segment of myosin bends by 45°. Thin and thick filaments move against each other; the thin filament is drawn towards the A-stripe.

Actin-myosin "uncoupling" occurs only in the presence of ATP. Because of the previous shift, the next shift is directed against another binding site of the thin filament. If the level of $Ca^{2+}$ is sufficient, the events are repeated.

When the $Ca^{2+}$ level falls below the threshold value, tropomyosin moves to its original position and the myosin binding site is blocked. Depletion of ATP reserves makes it impossible to untie the actin-myosin bond and the muscle is unable to relax - rigor mortis.

🔎 *For more information see Coupling excitation and contraction.*



Muscle Contraction

# Links

## Related Articles

- Muscle
- Coupling of excitation and contraction
- Neuromuscular plate
- Actin
- Myosin
- Skeletal Muscle Structure

## References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