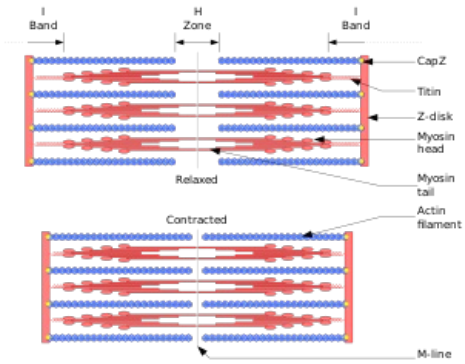
Connection of excitation and contraction

The combination of excitation and contraction is the basis of muscle activity. Muscles provide all the movements that enable human work, communication through facial expressions, the spoken word, writing, and of course also blood circulation, transport of GIT digestion, sphincter activity, etc. **Excitation** is associated with the creation ands propagating action potential, which is a consequence of the movement of ions. Excitation is followed by *contraction*, which is a direct conversion of chemical energy into mechanical energy and is manifested by active muscle force or muscle shortening.

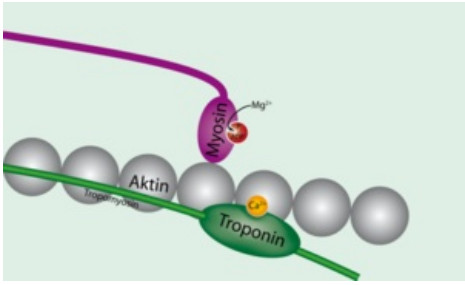
The structure of skeletal muscle

Skeletal muscle makes up about 40% of body weight. Individual muscles are made up of muscle bundles, which are composed of muscle fibers. Muscle fibers contain a large number of myofibrils, which are made up of contractile proteins - actin and myosin. Myofibrils are divided into regular sections - so-called **sarcomeres**, which are basic structural and functional units. A sarcomere is the distance between two Z-lines. Thin actin filaments are embedded in the Z-lines, between them are thick myosin filaments. Actin and myosin filaments partially overlap, resulting in a typical microscopic picture of transverse striations, in which anisotropic (A) and isotropic (I) parts alternate. The A-strip corresponds to the length of the thick filament, the I-strip is the part where there are only thin filaments. H-band, the middle part of the A-band contains only thick filaments.



Thin filament - Actin

A thin actin filament is a double helix of filamentous F-actin, formed by globular units of G-actin. On both sides, tropomyosin and troponin molecules are attached.Tropomyosin under resting conditions covers the active sites. Troponin is a protein located at certain distances on actin and has 3 subunits: Tn-C, which connects troponin to tropomyosin, and Tn-I, which changes the position of tropomyosin and thereby exposes binding sites for myosin.



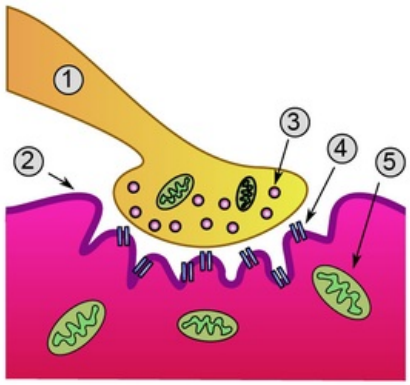
Thick filament - Myosin

Each filament consists of two myosin molecules that wrap around each other (tail) and expand at the end (head). The part between the head and the tail has the ability to bend (the neck). The head has ATPase activity and binds to actin active sites. The thick filament is made up of many myosin molecules. The tails form the axis of the filament, the heads reach into space.

Excitation and contraction

Excitation and contraction have several consecutive phases:

1. **Neuromuscular transmission:**
   - Presynaptic action potential (AP).
   - Opening of the Ca^{2+} channels.
   - Increase in intracellular Ca^{2+} and nerve axon.
   - Release of ACh (higher concentration induces movement of vesicles with ACh to the synaptic cleft).
   - Diffusion of ACh.
   - Binding of ACh to cholinergic receptors on the postsynaptic membrane.
   - Opening of channels for Na^{+} and K^{+}.
   - Plate potential (depolarization of the excitable postsynaptic membrane).
   - AP muscle fiber.
   - Breakdown of ACh by acetylcholinesterase.

   Neuromuscular transfer – McGraw Hill (animation, english (http

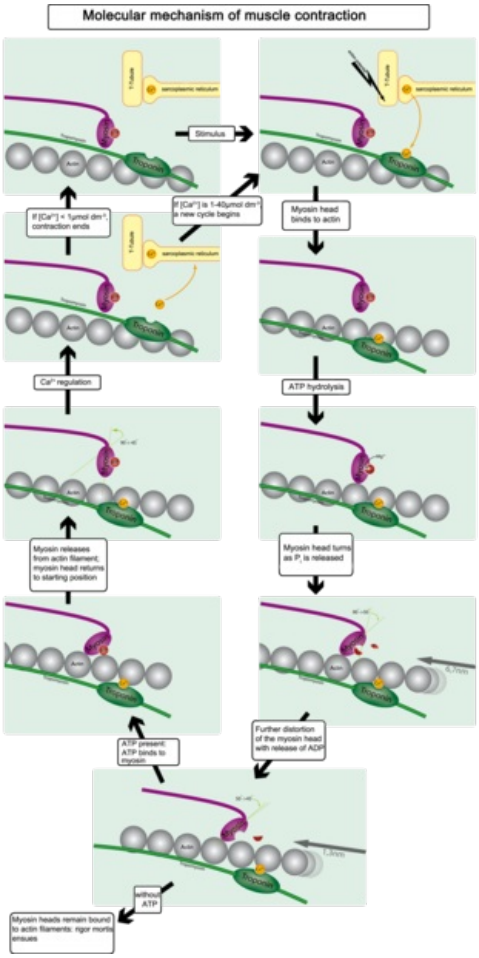
   ://highered.mheducation.com/sites/0072495855/student_view0/chapter10/animation__function_of_the_neuromuscular_junction__quiz_3_.html)

2. **Link between excitation and contraction:**

- Neuromzscular transfer.
- AP muscle fiber.
- Propagation of AP along the muscle fiber.
- Release of calcium from SR.
- Calcium binding to troponin C.
- Activation of the contractile apparatus.
- Muscle fiber contraction

3. **Contraction:**
   - Binding of ATP to the myosin head.
   - Splitting of ATP into ADP and phosphate.
   - Formation of a cross-bridge between actin and myosin.
   - Release of phosphate.
   - Movement of myosin head, release of ADP.
   - Binding of a new ATP molecule to myosin.
   - Detachment of the myosin head from actin.
   - Splitting of ATP into ADP and phosphate.
   - Straightening of the myosin head.
   - Repeating the cycle.

   Kontrakce – McGraw Hill (animace, anglicky) (http://highered.mheducation.com/sites/0072495855/student_view0/chapter10/animation__breakdown_of_atp_and_cross-bridge_movement_during_muscle_contraction.html)



4. **Relaxation:**
   - Ca^{2+} efflux into the SR (SERCA).
   - Ca^{2+} release from troponin C
   - Cloning of active sites by tropomyosin

   SERIAL ELASTICITY – is provided by the protein titin, which returns the sarcomere to its original length.

5. **Pharmacy:**
   - ACh effect – methacholine, succinylcholine (their slow degradability causes permanent depolarization).
   - ACHE blockers (blocking the degradation of ACH).
   1. Short-term – physostigmine, neostigmine (drug for ACH deficiency).
   2. Long-term – organophosphates, neurotoxins (World War II).
   - Transmission blockers – curare, bungarotoxin (block N-receptors).
   - ACh release blockers – botulinum toxin, Mg^{2+}, Ca^{2+} removal (experimentáal).
   - Choline uptake blockers - hemicholinium (experimental).

Links

Related articles

- Muscle
- Contraction of the heart muscle
- Myorelaxation
- ATP
- Creatine Phosphate • Creatine • Creatinine

Sources

- TROJAN, Stanislav, et al. *Lékařská fyziologie*. 4. dopl. vyd. Praha : Grada Publishing, 2003. 772 s. ISBN 80-247-0512-5.

- GANONG, William F. *Přehled lékařské fyziologie*. 20. vyd. Praha : Galén, 2005. 890 s. ISBN 80-7262-311-7.