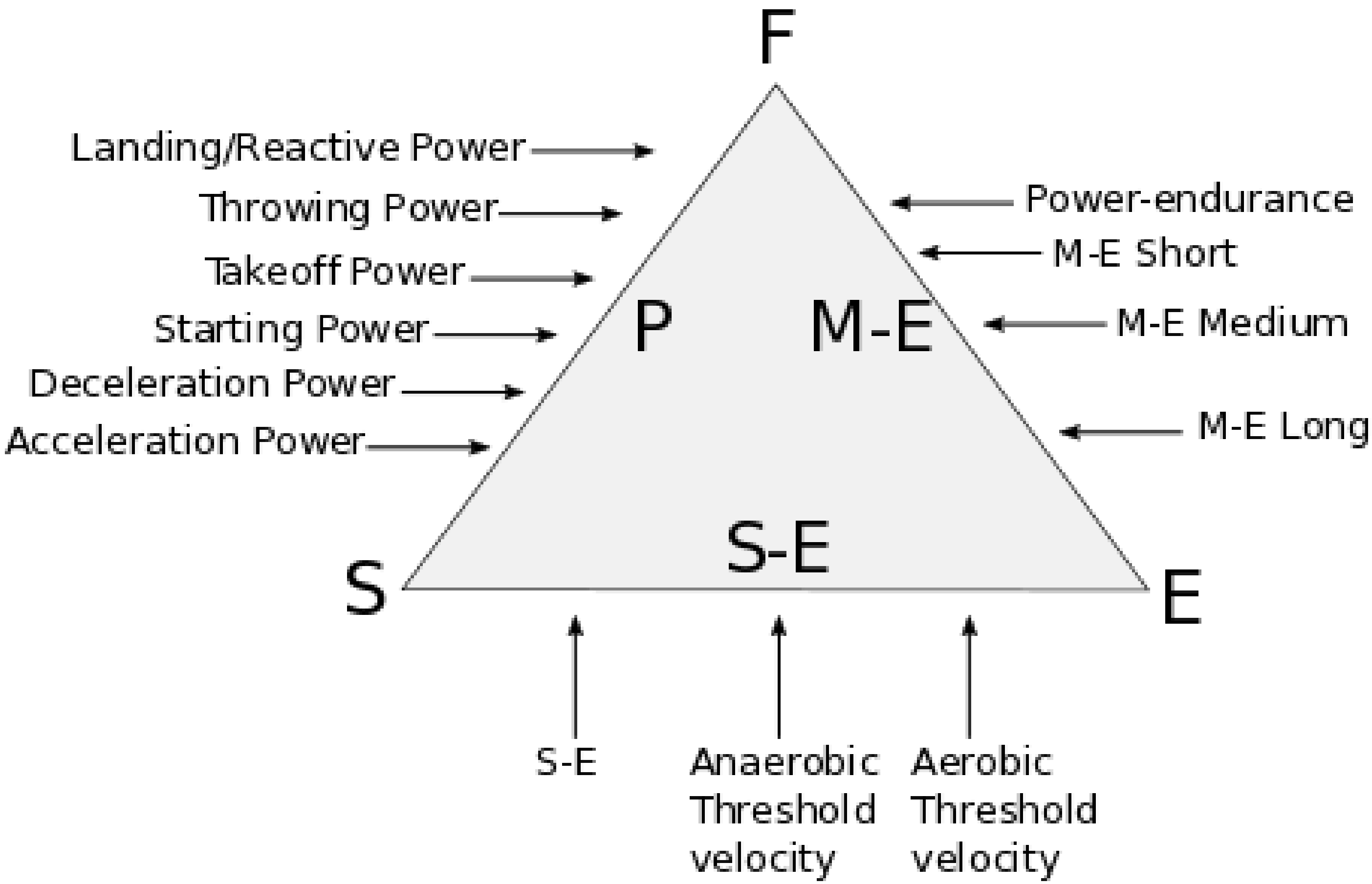
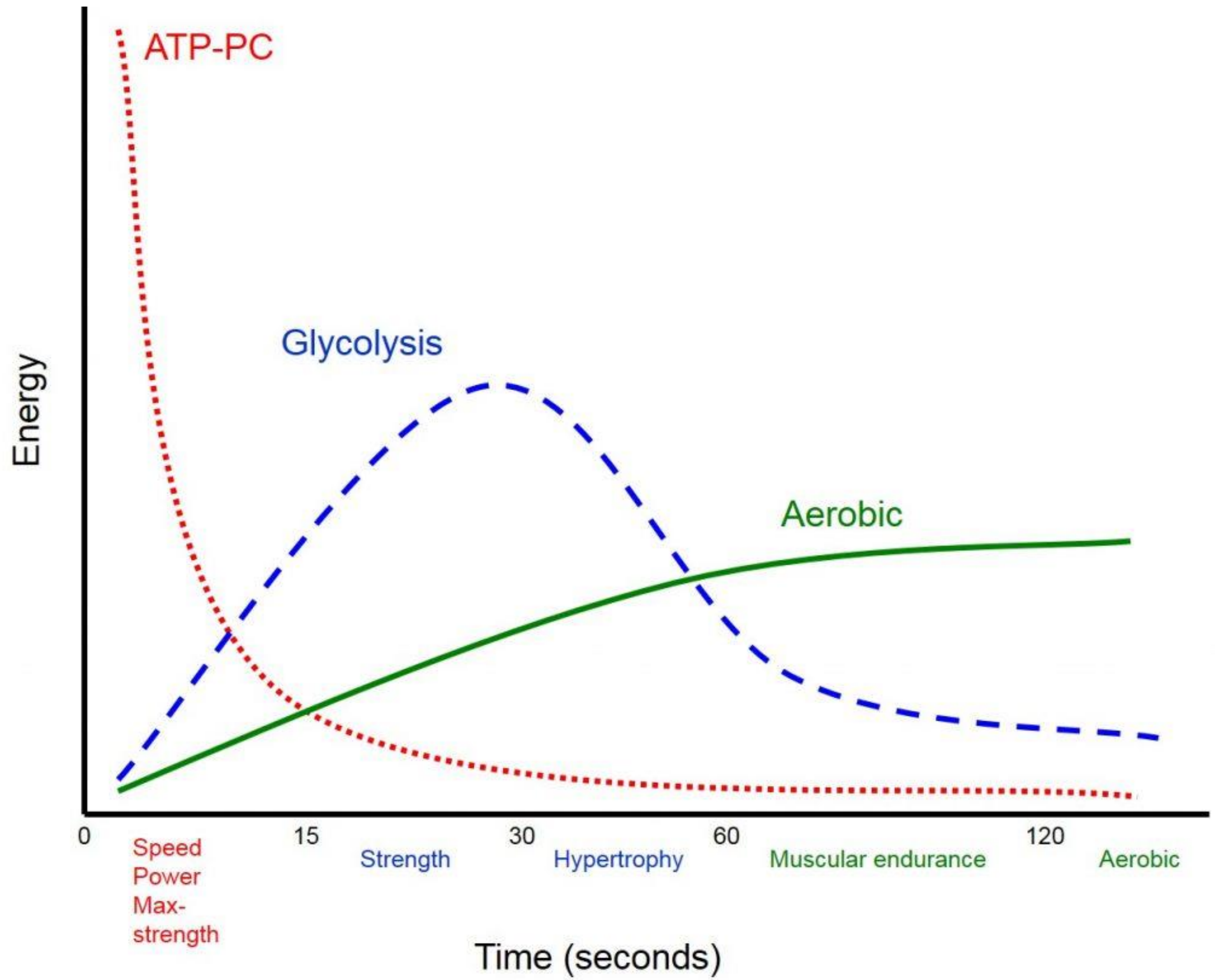
Muscle hypertrophy

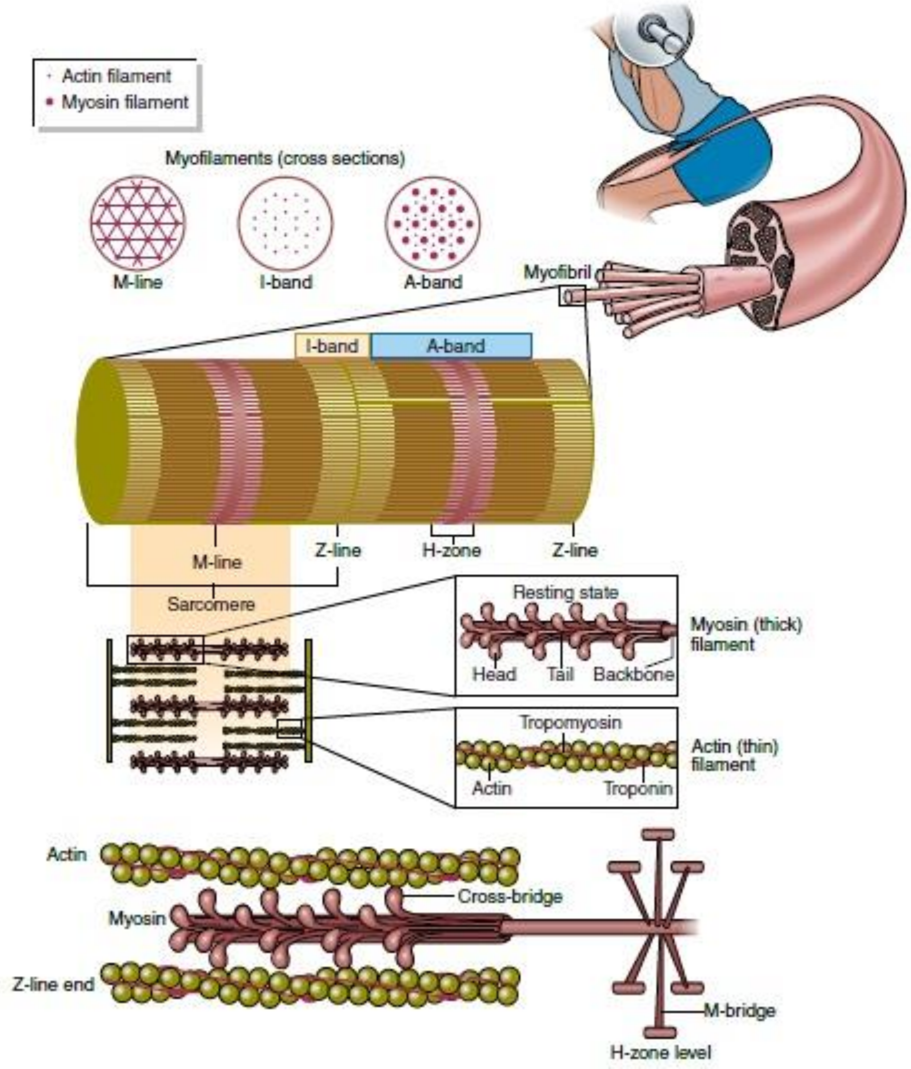
Fitness components



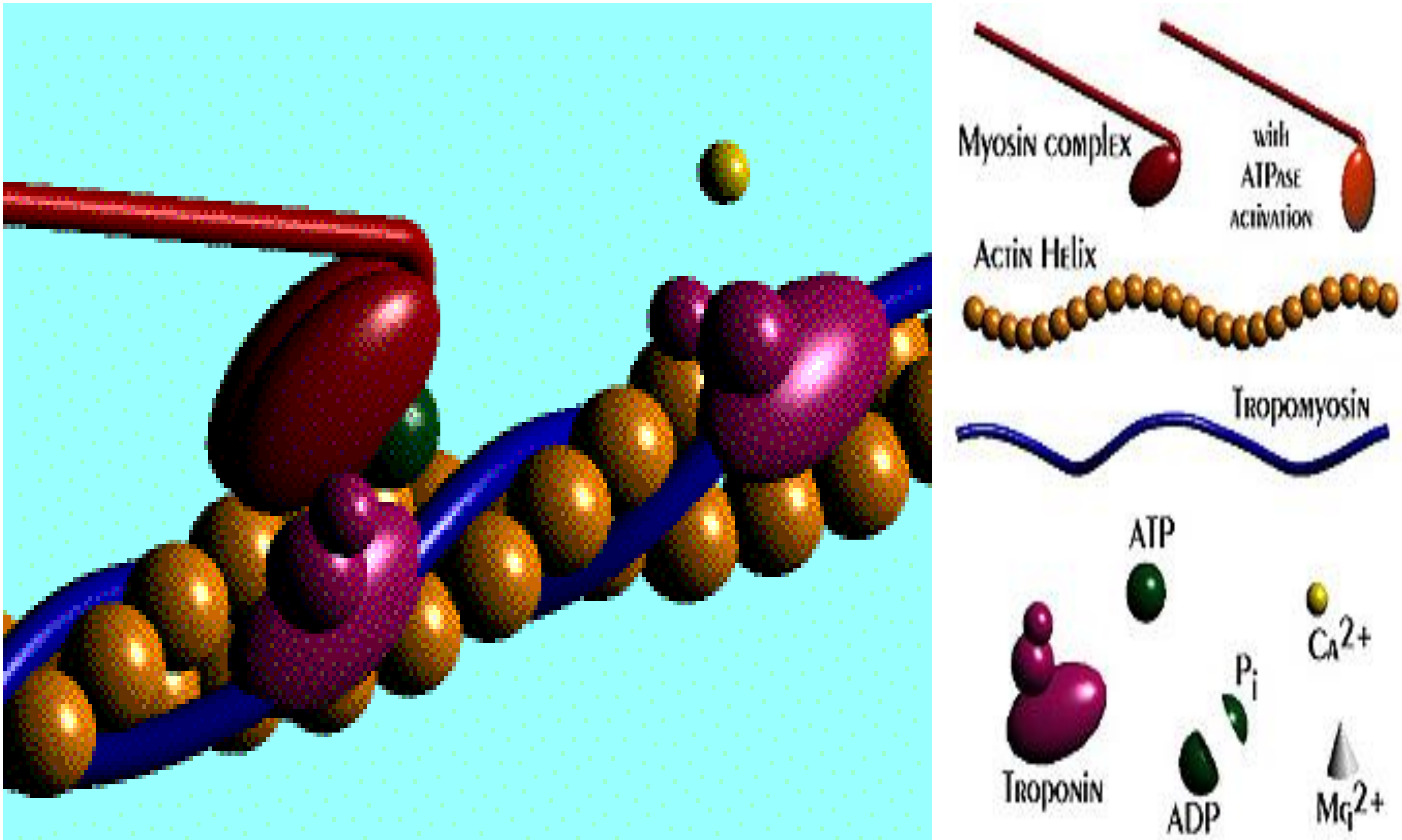
Aerobic and Anaerobic pathway



Skeletal muscle physiology



Skeletal muscle physiology

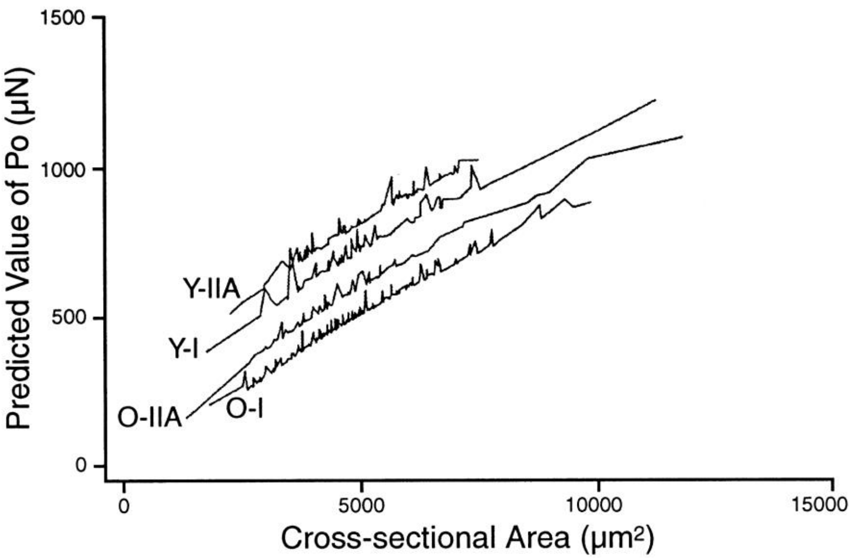


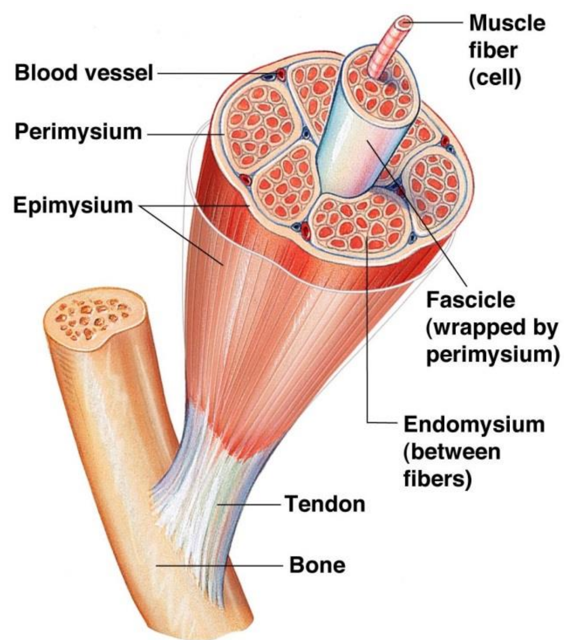
Factors affecting force

- Muscle cross sectional area
- Neural activation
- kind of motor unit activation
- The number of activated motor units
- Autogenic inhibition
- Biomechanical factors
- The length of muscle
- Velocity of lengthening and shortening of muscle
- Muscle pennation

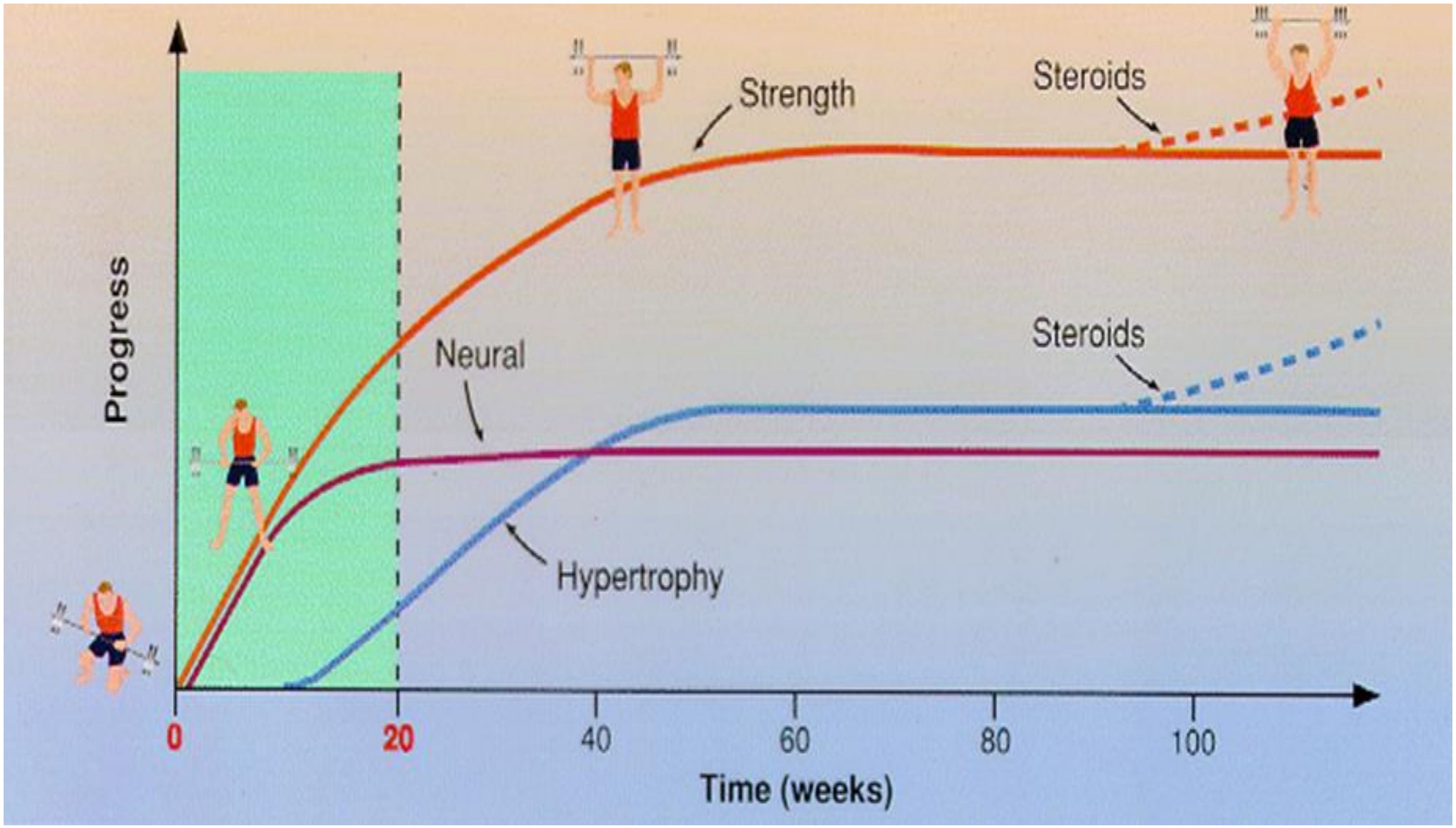
Muscle cross sectional area

- Transient hypertrophy is the pumping up of muscle during a single exercise bout due to fluid accumulation from the blood plasma into the interstitial spaces of the muscle.
- Chronic hypertrophy is the increase of muscle size after long-term resistance training due to changes in number of muscle fibers (fiber hyperplasia) or size of muscle fibers (fiber hypertrophy).



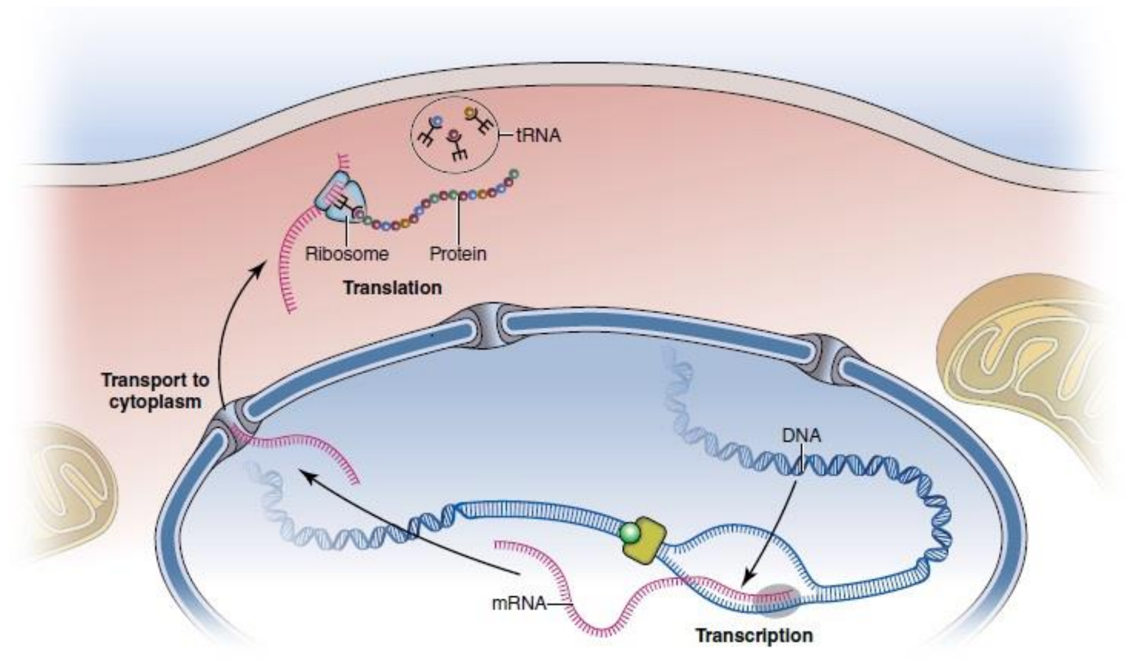


Neural activation

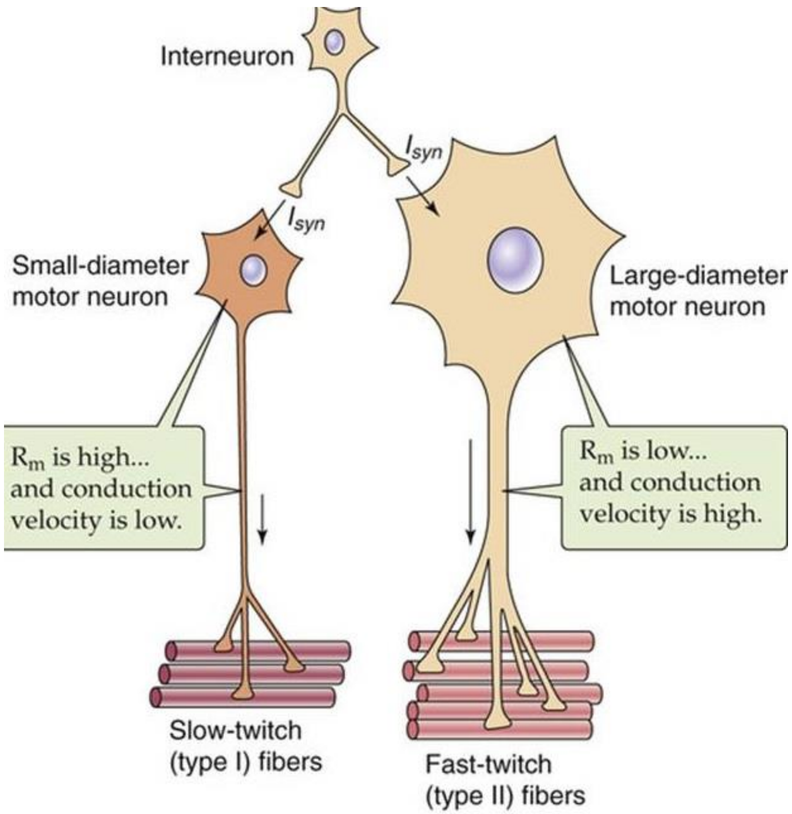


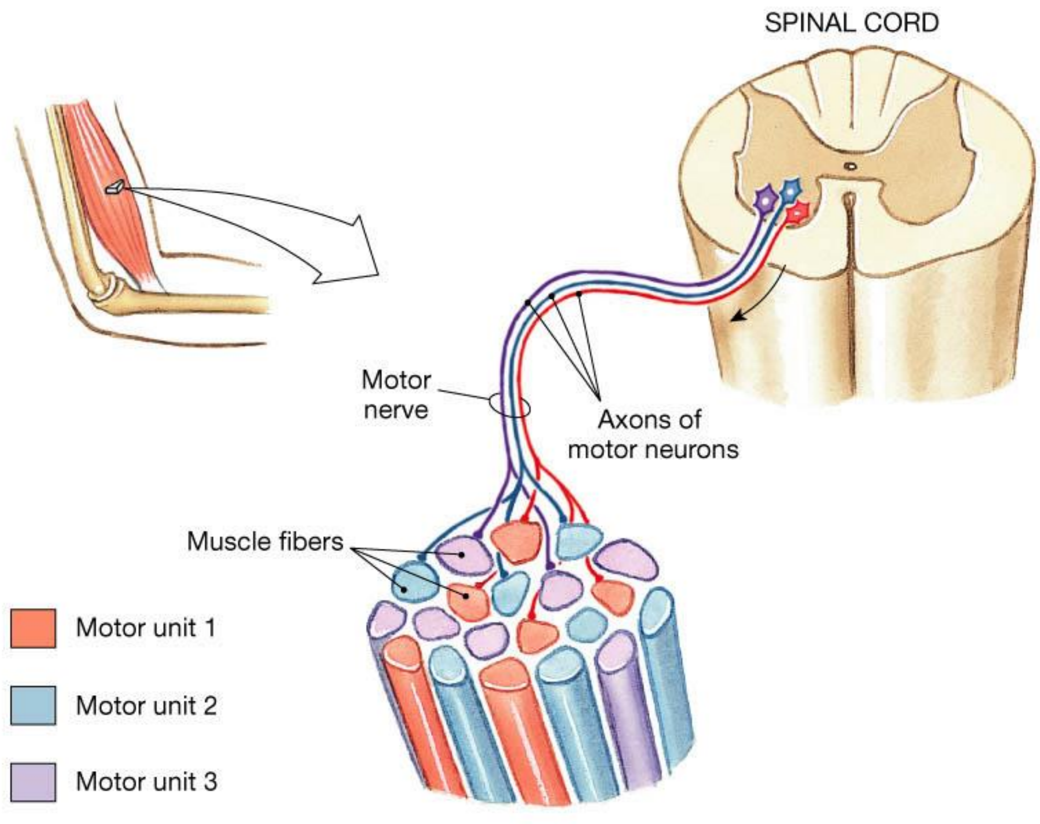
Neural activation

- Neural drive:
  - ✓ Muscle activation
  - ✓ Firing rate
  - ✓ Motor unit synchronization
  - ✓ Antagonist coactivation
- Protein balance:



kind of motor unit activation





kind of motor unit activation

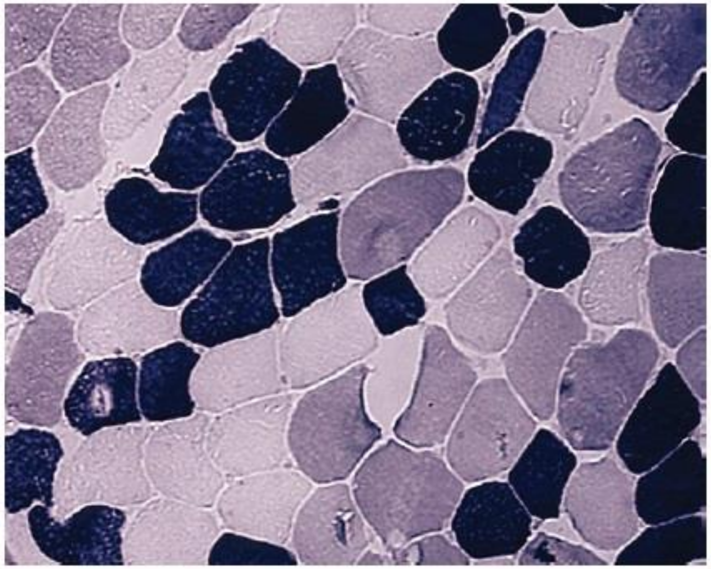
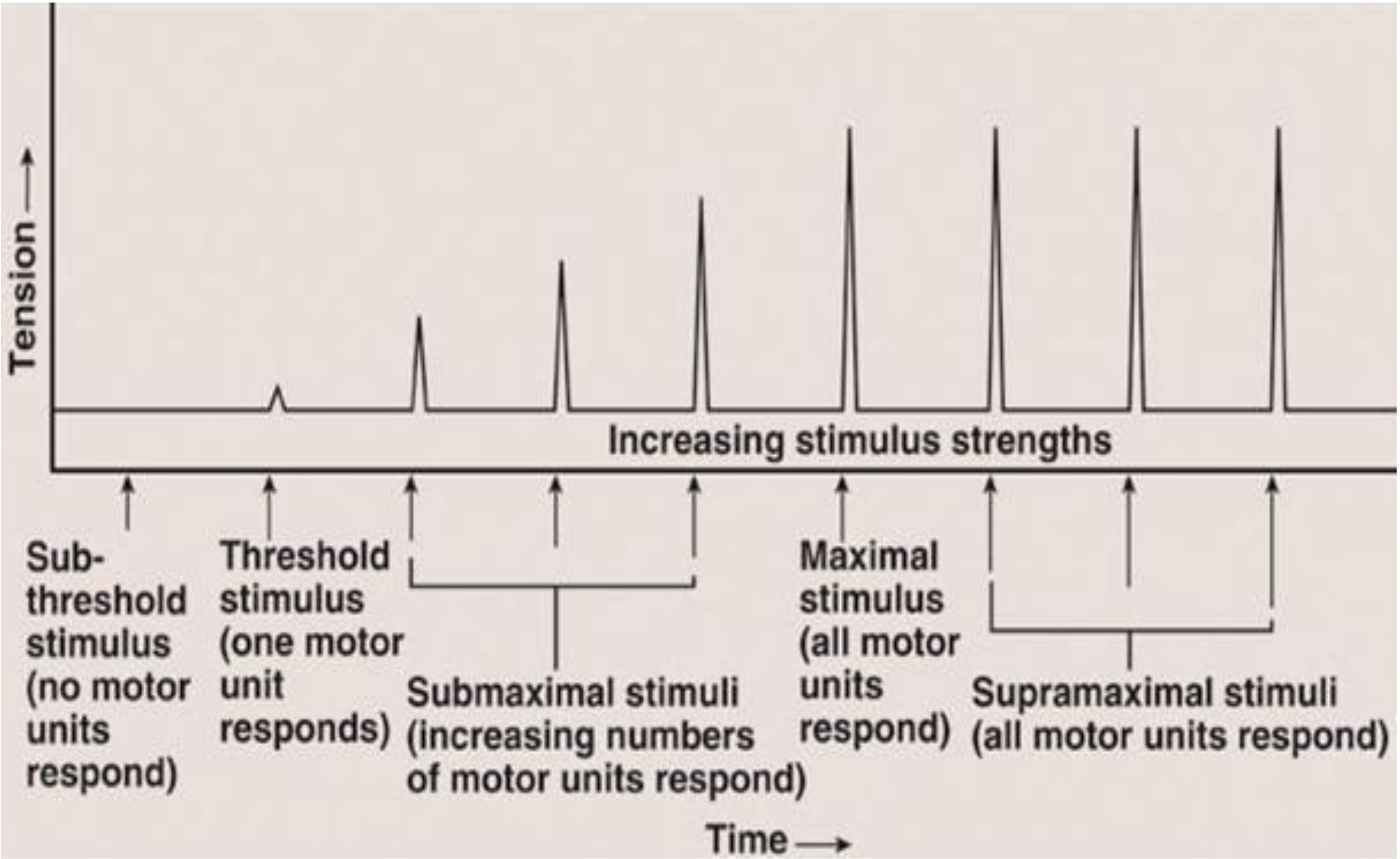


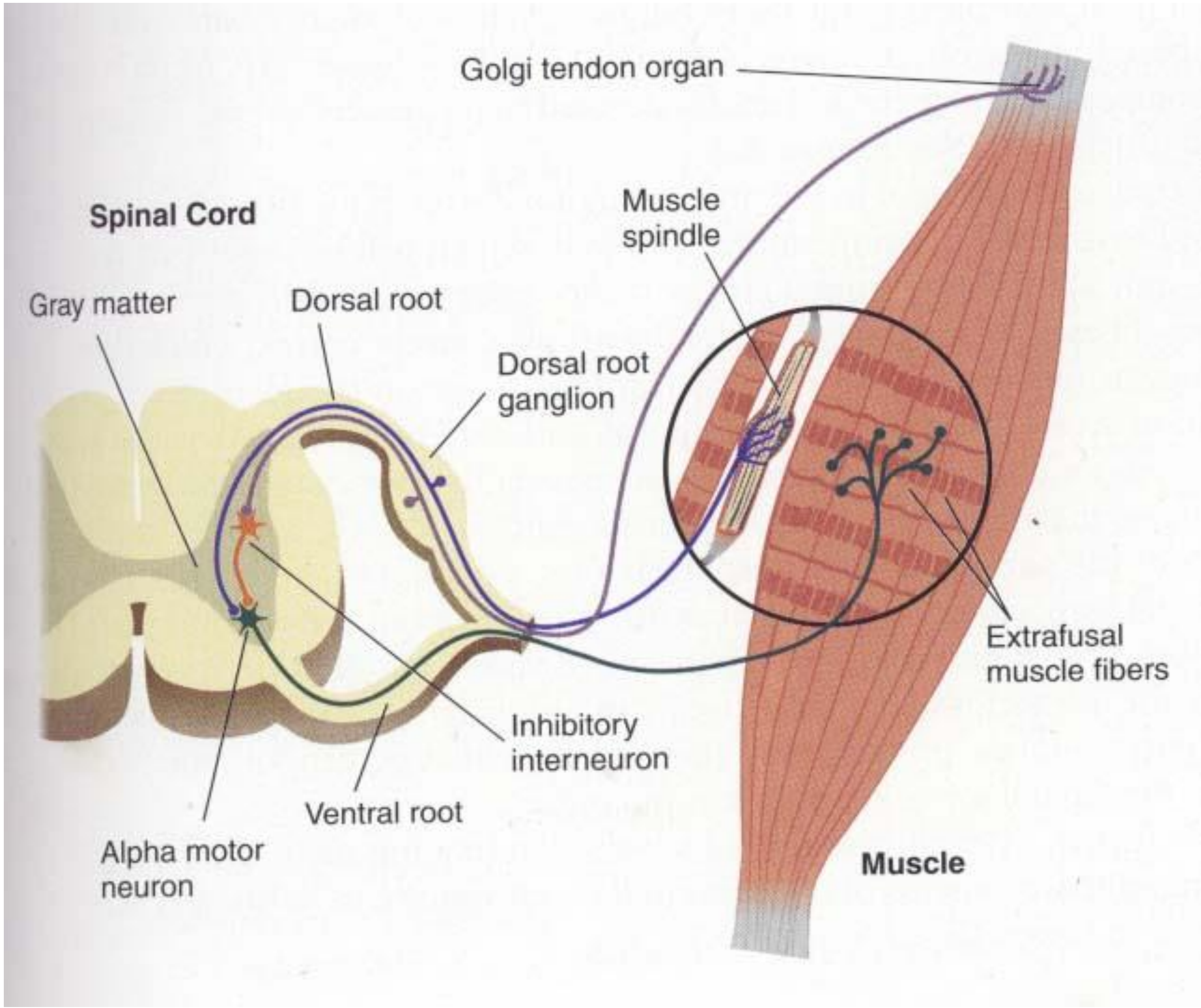
FIGURE 1.4 A photomicrograph showing Type I (black), Type IIa (white), and Type IIx (gray) muscle fibers.

	Type I	Type IIa	Type IIx
Size of motor neuron	Small	Medium	Large
Contraction time	Slow	Moderately fast	Fast
Force production	Low	Moderate	High
Resistance to fatigue	High	Moderate	Low
Mitochondrial density	High	Moderate	Low
Oxidative capacity	High	High	Low
Glycolytic capacity	Low	High	High
Capillary density	High	Moderate	Low
Myoglobin content	High	Moderate	Low
Glycogen stores	Low	High	High
Triglyceride stores	High	Moderate	Low

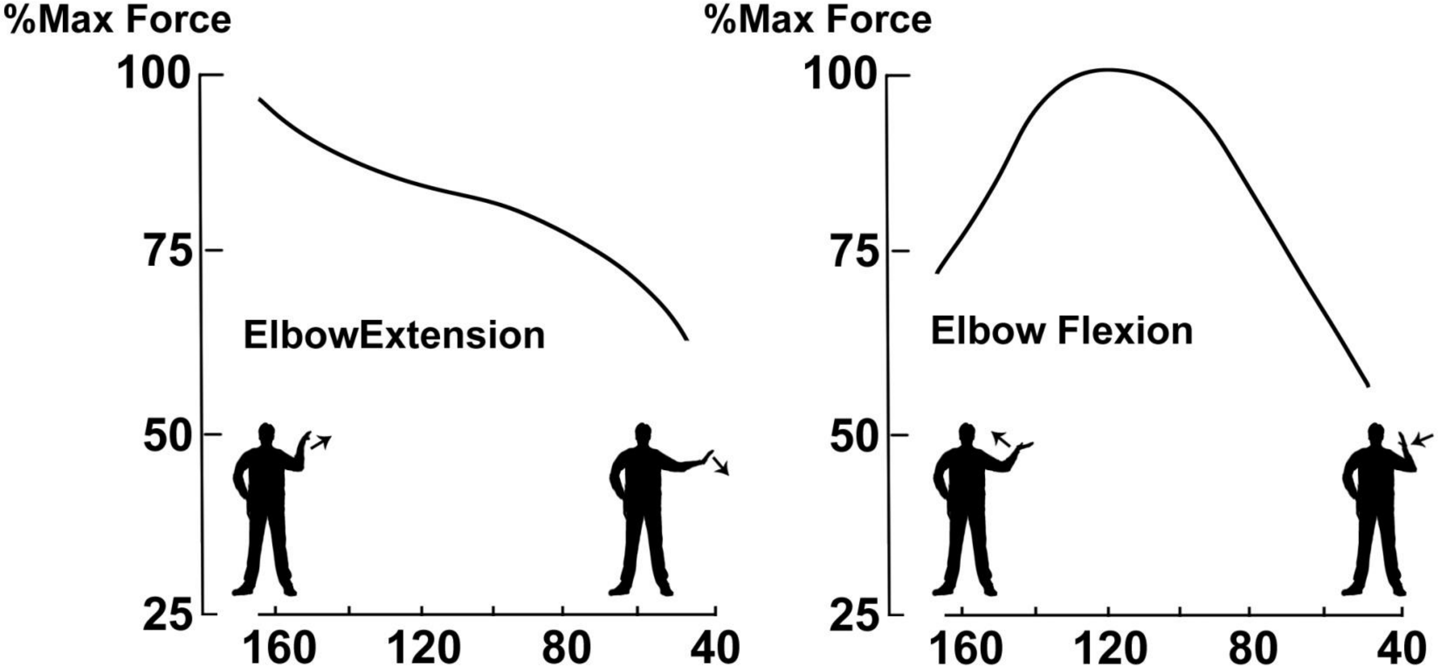
The number of activated motor units



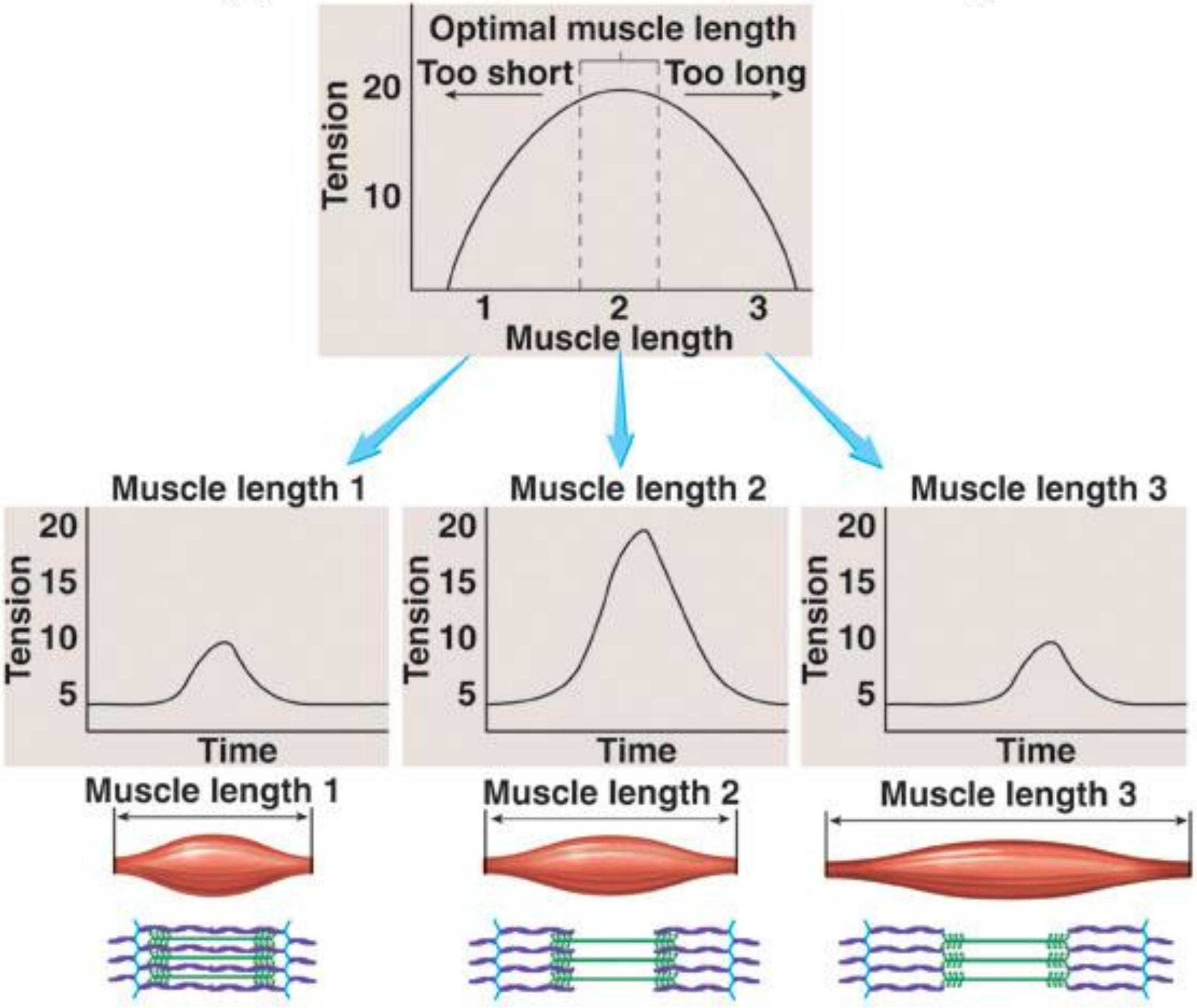
Autogenic inhibition



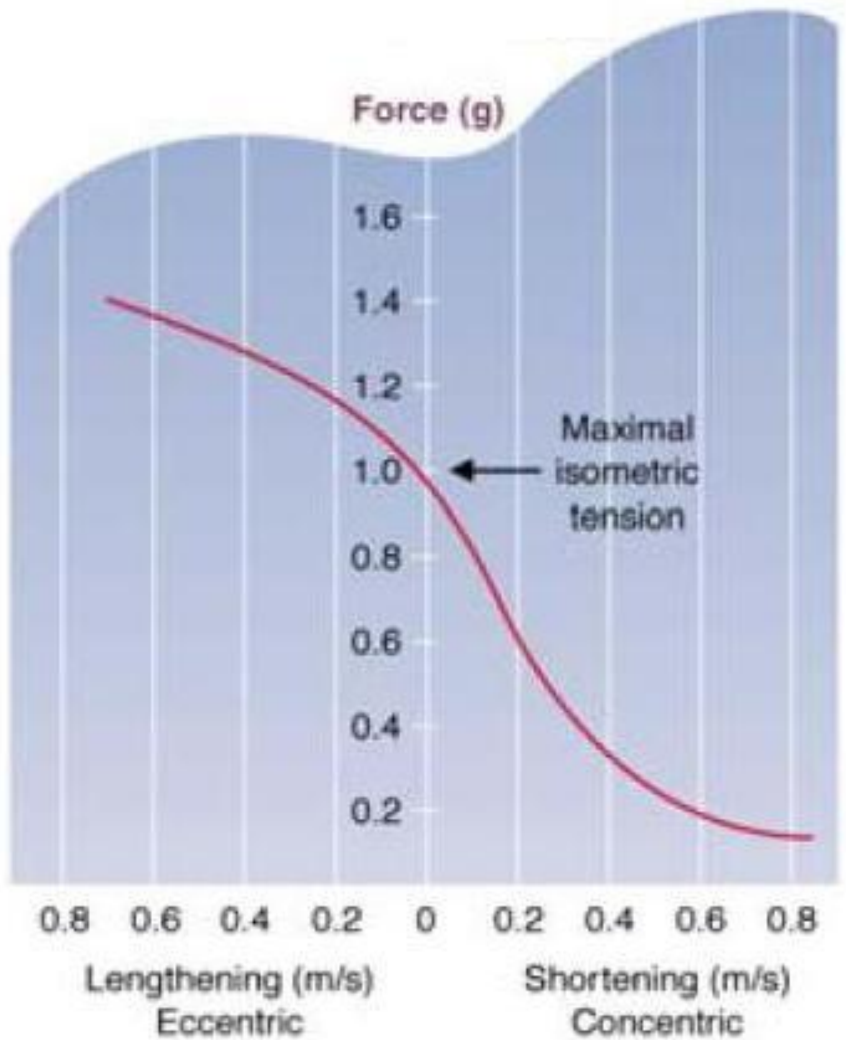
Biomechanical factors



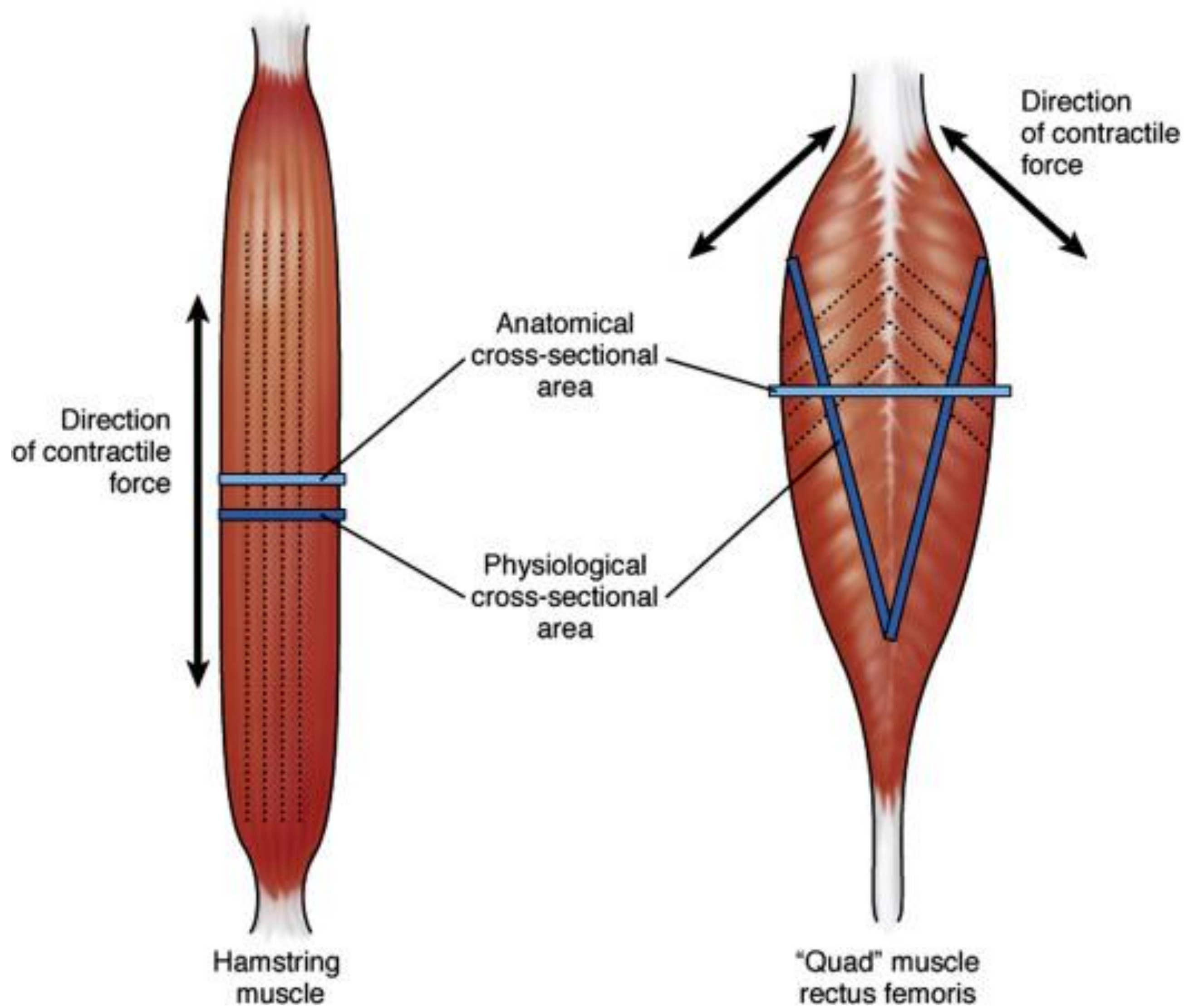
The length of muscle



Velocity of lengthening and shortening of muscle

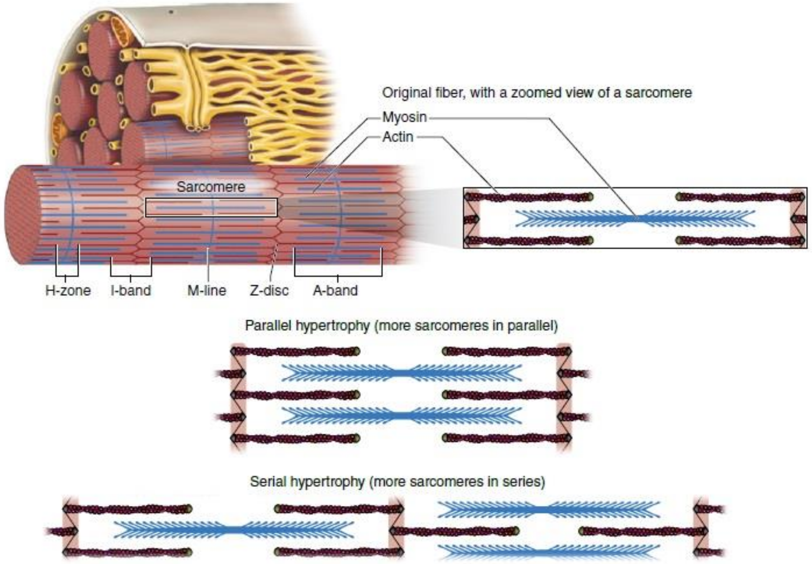


Muscle pennation



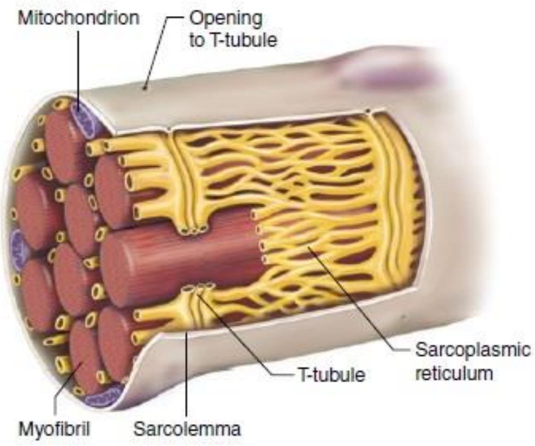
Hypertrophy related responses and adaptation to exercise

- Growth occurs by adding sarcomeres, increasing noncontractile elements and sarcoplasmic fluid, and bolstering satellite cell. :
  - ✓ Parallel and in-series hypertrophy
  - ✓ Sarcoplasmic hypertrophy
  - ✓ Satellite cells
- Parallel and in-series hypertrophy:

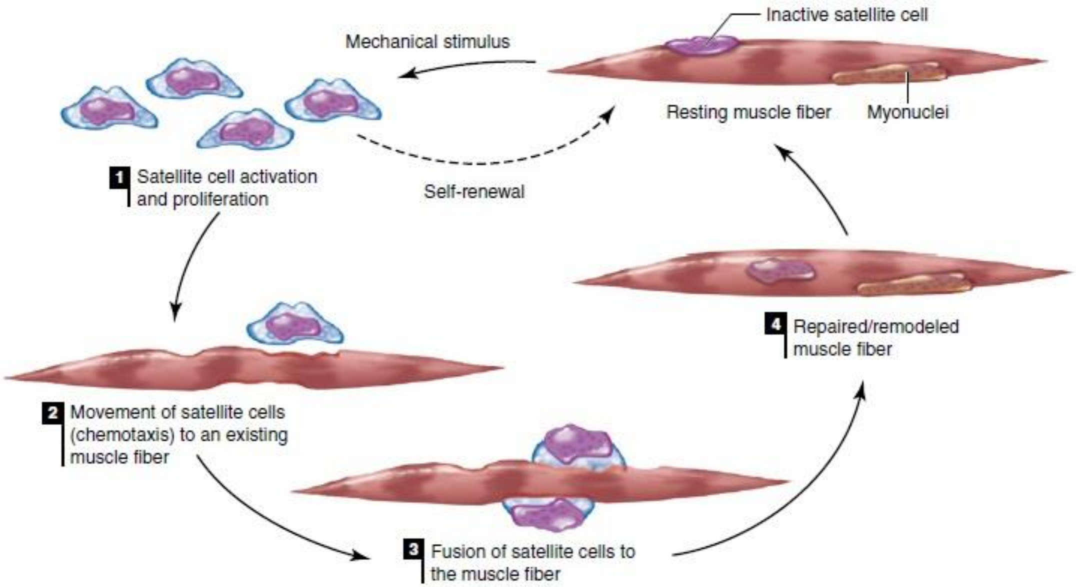


Hypertrophy related responses and adaptation to exercise

- Sarcoplasmic hypertrophy



- Satellite cells:

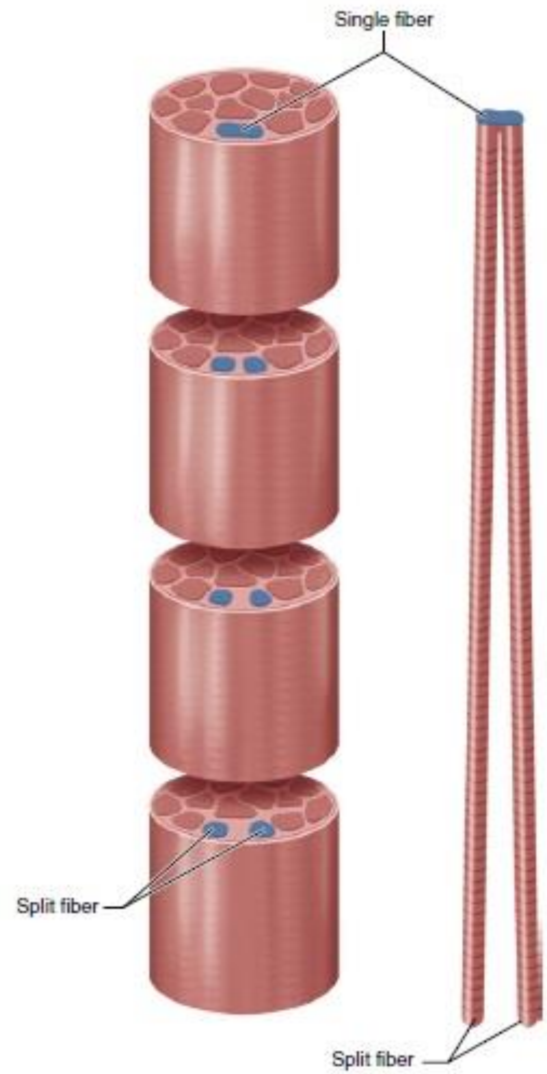


Hypertrophy related responses and adaptation to exercise

- Hyperplasia

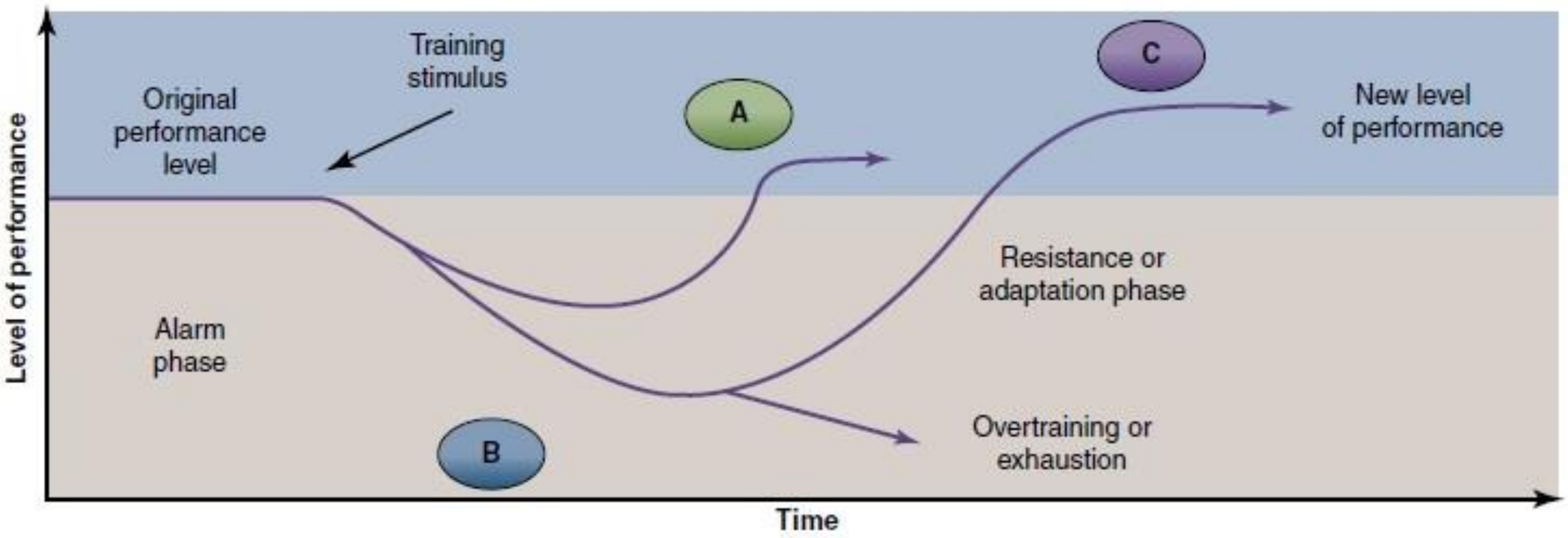
Evidence supporting the ability of muscles to undergo hyperplasia is primarily derived from animal research.

humans cannot naturally increase muscle size to reach the critical threshold that warrants fiber splitting.



GAS and hypertrophy

- General Adaptation Syndrome (GAS)



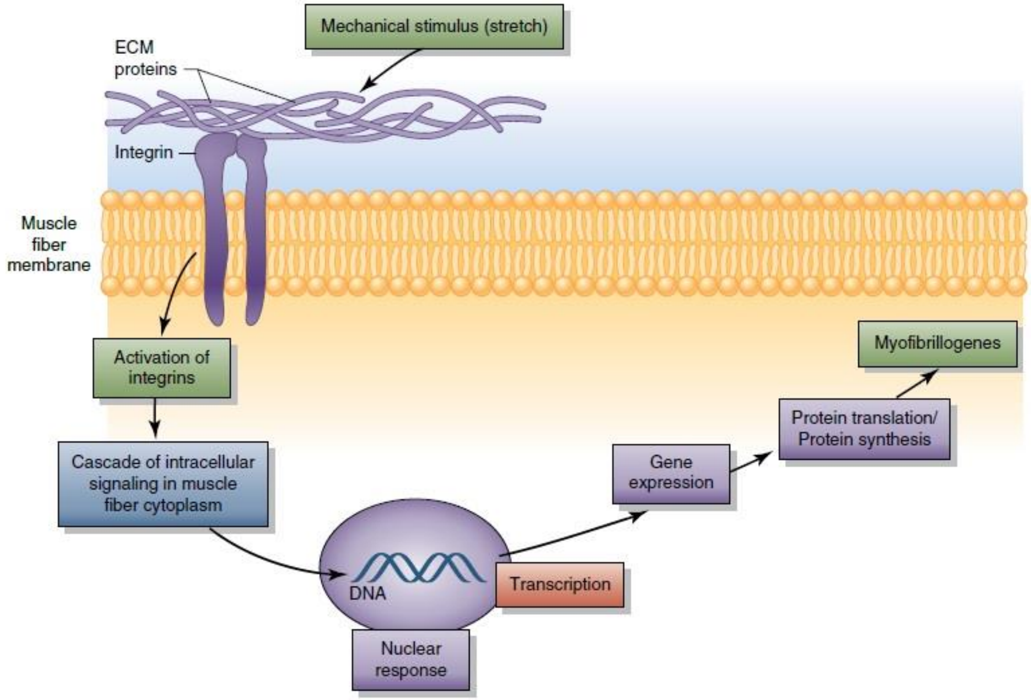
GAS and hypertrophy

Hormone	Actions
Insulin-like growth factor-1 (IGF-1)	Primary hypertrophic effects of the systemic isoform appear to be in stimulating differentiation and fusion following myotrauma and thereby facilitating the donation of myonuclei to muscle fibers. Although IGF-1 does directly influence anabolic intracellular signaling, it is not clear whether these effects are synergistic for exercise-induced muscle growth.
Growth hormone (GH)	Anabolic effects of GH on muscle tissue are carried out primarily via its potentiating effect on IGF-1. Although some evidence supports that GH promotes anabolism independent of IGF-1, it remains questionable whether these effects have an appreciable impact on postnatal muscle development.
Testosterone	Directly increases myofibrillar protein synthesis and decreases proteolysis. Potentiates the release of GH and IGF-1 while inhibiting activity of IGFBP-4. Increases the number of myogenically committed satellite cells.
Insulin	Primary effect on exercise-induced hypertrophic adaptations is believed to be a reduction in protein breakdown as opposed to increases in MPS.

Myokine	Actions
Mechano growth factor (MGF)	Believed to kick-start the growth process following resistance training. Upregulates anabolic processes and downregulates catabolic processes. Involved in early-stage satellite cell responses to mechanical stimuli.
Interleukins (ILs)	Numerous ILs are released to control and coordinate the post-exercise immune response. IL-6, the most studied of the ILs, appears to carry out hypertrophic actions by inducing satellite cell proliferation and influencing satellite cell–mediated myonuclear accretion. Emerging research indicates that IL-15 may be important to exercise-induced anabolism, although evidence remains somewhat preliminary. Other ILs also have been postulated to play a role in hypertrophy, including IL-4, IL-7, IL-8, and IL-10, although evidence on their exercise-induced effects remains equivocal.
Myostatin	Serves as a negative regulator of muscle growth. Acts to reduce myofibrillar protein synthesis and may also suppress satellite cell activation.
Hepatocyte growth factor (HGF)	Activated by nitric oxide synthase and possibly calcium–calmodulin as well. HGF is believed to be critical to the activation of quiescent satellite cells.
Leukemia inhibitory factor (LIF)	Upregulated by the calcium flux associated with resistance exercise. Believed to act in a paracrine fashion on adjacent satellite cells to induce their proliferation.

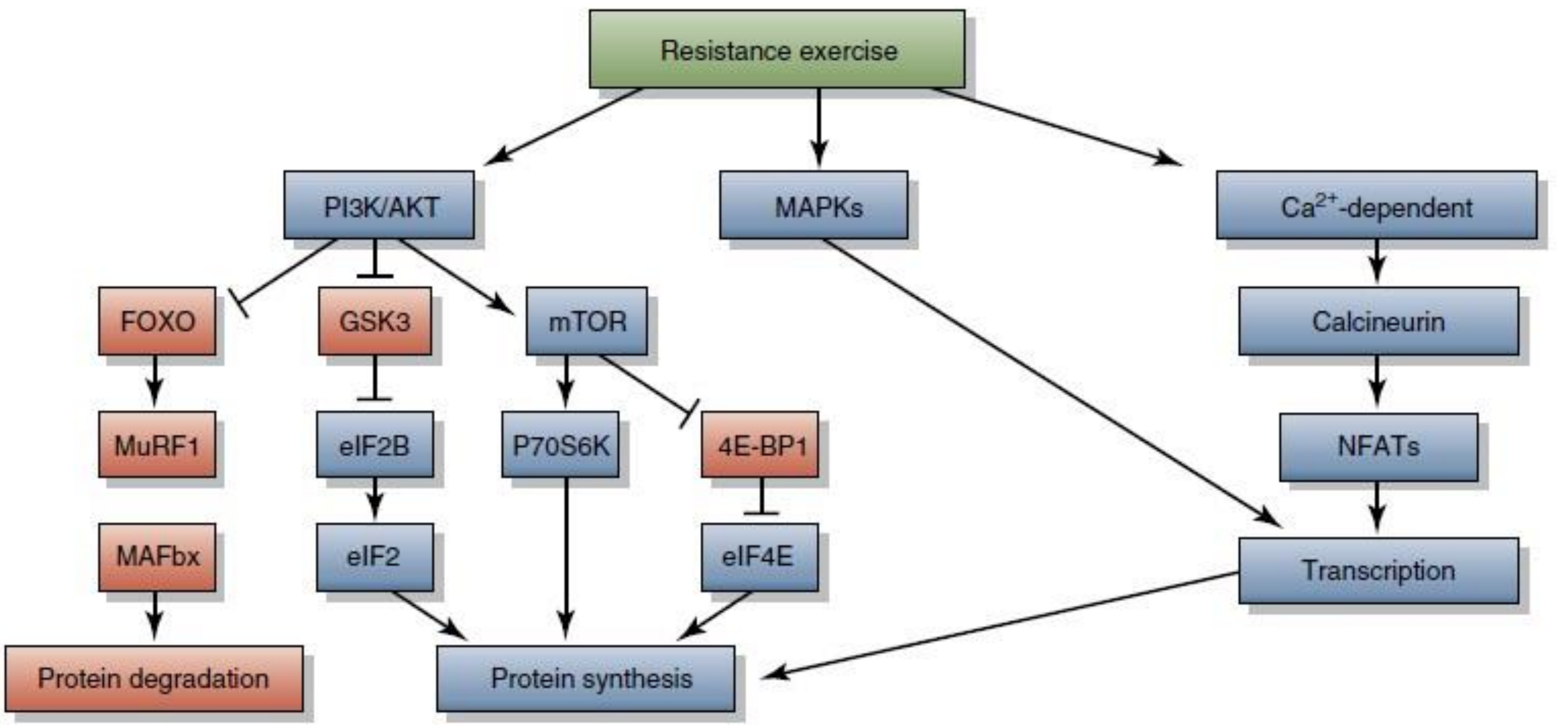
Mechanisms of hypertrophy

- Increased muscle protein accretion following resistance exercise has been attributed to three primary mechanisms:
    - ✓ Mechanical tension
    - ✓ Metabolic stress
    - ✓ Muscle damage
- Mechanical tension



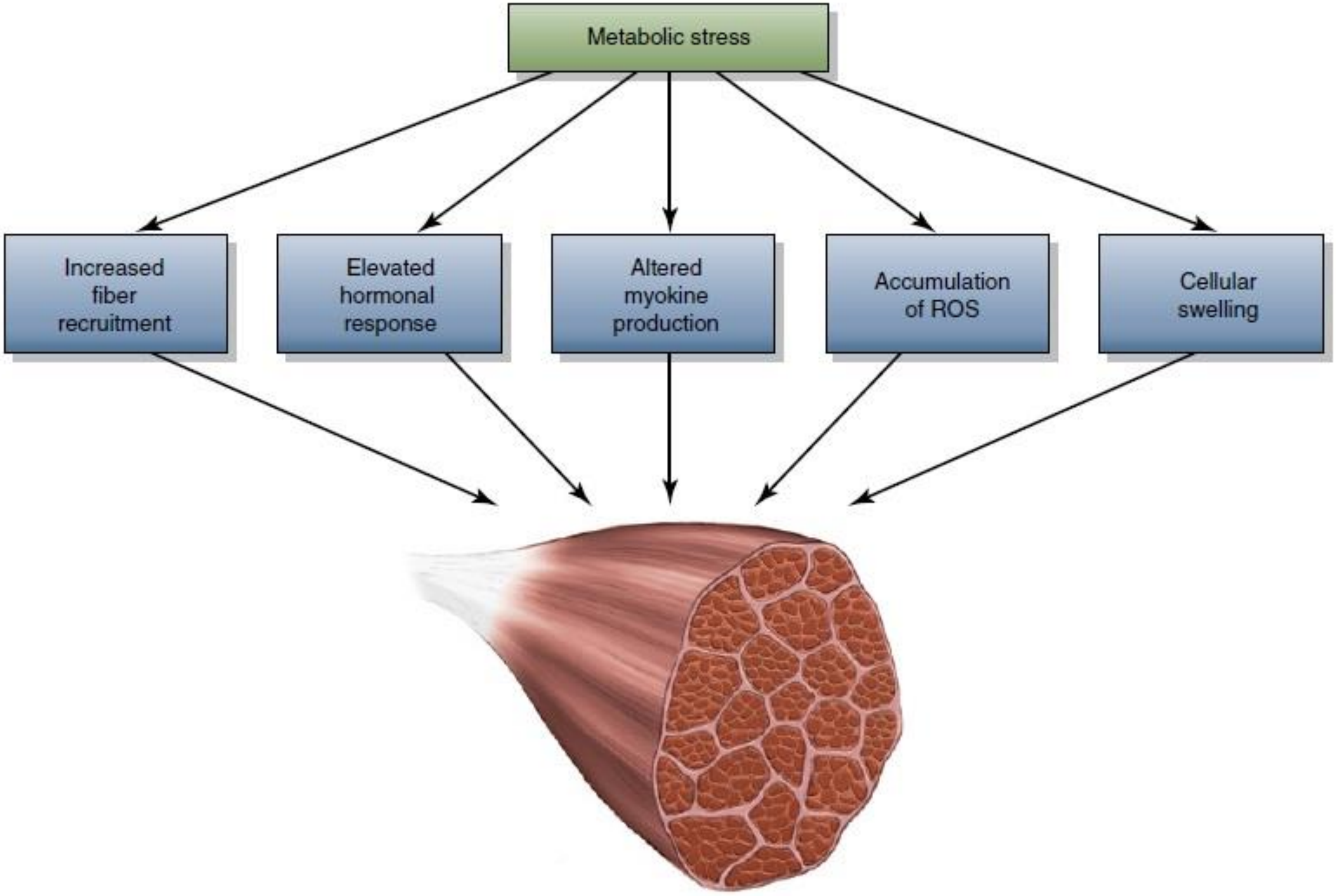
Mechanisms of hypertrophy

- Mechanical tension (cont.)



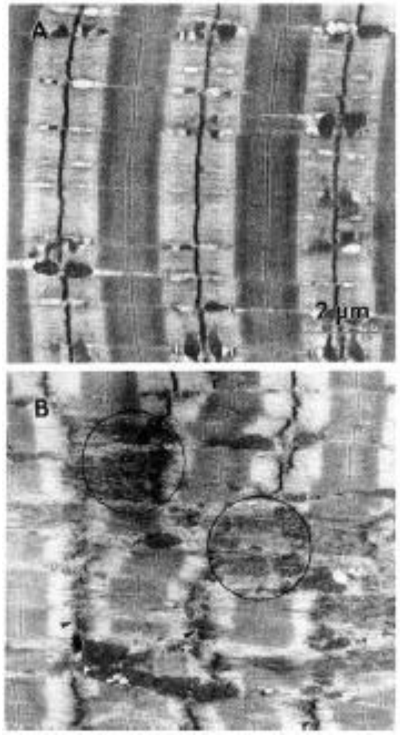
Mechanisms of hypertrophy

- Metabolic stress



Mechanisms of hypertrophy

- Muscle damage: This phenomenon, commonly known as *exercise-induced muscle damage* (EIMD), can be specific to just a few macromolecules of tissue or manifest as large tears in the sarcolemma, basal lamina, and supportive connective tissue, as well as injury to contractile elements and the cytoskeleton.

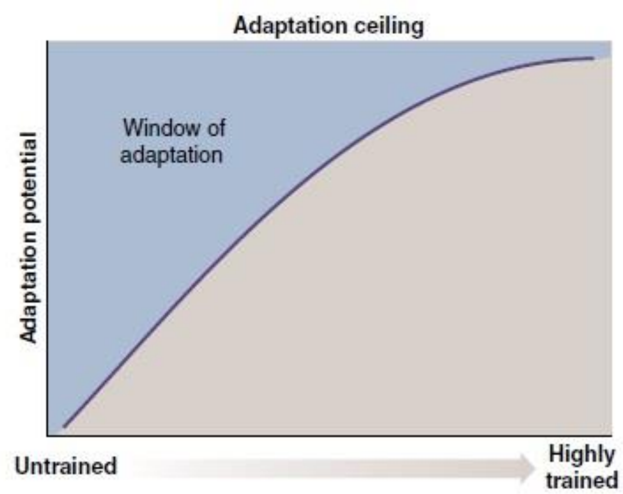


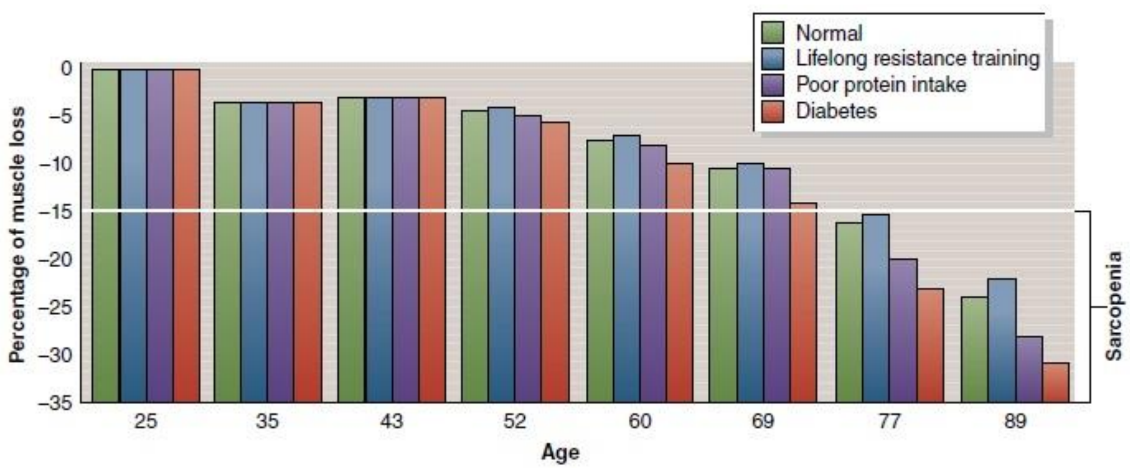
  - ✓ Inflammatory processes
  - ✓ Satellite cell activity
  - ✓ IGF-1 production
  - ✓ Cell swelling

Factors in maximal hypertrophic development

- Several population-specific factors affect skeletal muscle mass and the hypertrophic response to resistance exercise. Of particular note are:

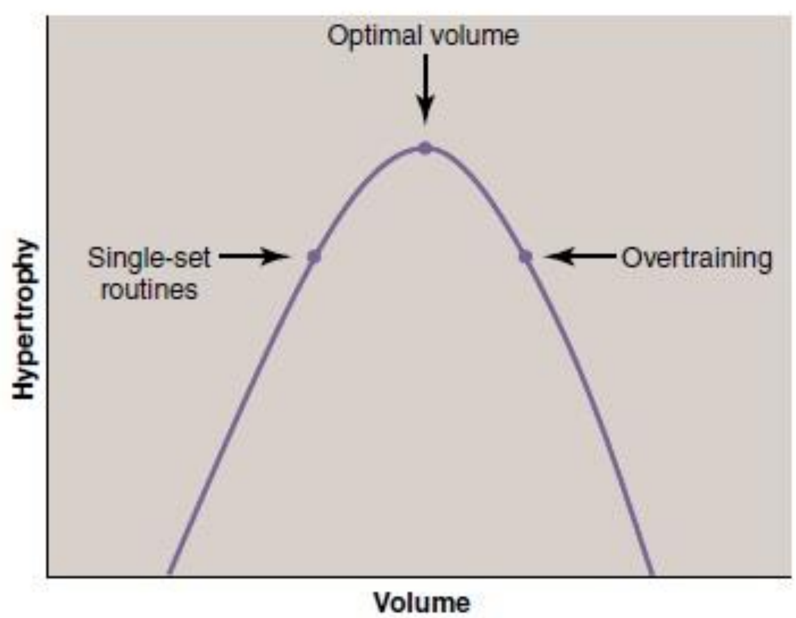
  - ✓ Genetics
  - ✓ Age
  - ✓ Sex
  - ✓ Training experience





Resistance training variables in hypertrophy

- Volume: Multiset protocols favoring high volumes of resistance training optimize the hypertrophic response. To avoid overtraining, people should increase volume progressively over the course of a training cycle and integrate periods of reduced training volume regularly to facilitate the recovery process.



Resistance training variables in hypertrophy

- Frequency: Split routines allow for a greater volume of work per muscle group per session, potentially enhancing muscular adaptations via the dose–response relationship between volume and hypertrophy.

- Load: Training across a wide spectrum of repetition ranges (1 to 20+) is recommended to maximize all possible avenues for the complete development of the whole muscle. However, there is some merit in focusing on a medium-repetition range (6RM to 12RM), which may provide an optimal combination of mechanical tension and metabolic stress.

Resistance training variables in hypertrophy

- Exercise selection: Once trainees have learned the movement patterns of basic resistance training exercises, they should use a <u>variety of exercises</u> to maximize whole-body muscle hypertrophy. This should include free-form as well as machine-based exercises. Similarly, both multi- and single-joint exercises should be included in hypertrophy-specific routines to maximize muscular growth.

- Type of muscle action: <u>Concentric and eccentric muscle actions</u> appear to recruit muscle fibers in different orders, result in different signaling responses, and produce distinct morphological adaptations in muscle fibers and fascicles. Therefore, both concentric and eccentric actions should be incorporated during training to maximize the hypertrophic response.

Resistance training variables in hypertrophy

- Rest interval length: Although rest periods of 60 to 90 seconds induce a seemingly favorable metabolic environment for achieving hypertrophy, research indicates that resting at least 2 minutes between sets provides a hypertrophic advantage compared to shorter rest periods because of the ability to maintain greater volume load.

- Repetition duration: Current evidence suggests that little difference exists in muscle hypertrophy when training at isotonic repetition durations from 0.5 to 6 seconds.

Resistance training variables in hypertrophy

- Exercise order: Despite widespread belief that exercise order should proceed from large- to small-muscle groups, the hypertrophic benefit has not been demonstrated in controlled research studies.

- Range of motion: Muscles are activated differentially throughout the range of motion. Full ROM movements should therefore form the basis of a hypertrophy training program, although including some partial-ROM training may provide additional benefit.

- Intensity of effort: Evidence that training to failure maximizes motor unit recruitment is lacking, although other benefits of training to failure have been shown.

Resistance training variables in hypertrophy

Training variable	
Training load	70-80% 1RM
No. of repetition	6 to 12
Rest period between sets	1-3 min
The velocity of movement	Very slow

Resistance training variables in maximum strength

Training variable	isotonic	isometric	eccentric
Training load	85-100% 1RM	80-100% 1RM	110-160% 1RM
No. of repetition	3 to 5	6-12 sec	1 to 4
Rest period between sets	1-3 min	60-90 sec	1-3 min
The velocity of movement	Very slow	-	Very slow

Suggested sets per workout

Muscle group		No. sets
chest		8
back		10
legs	quadriceps	6
	hamstring	4-6
	calves	6-8
arms	biceps	6
	triceps	6
shoulders		10-12
abdominal		6

Suggested methods of hypertrophy training

- Supersets, Tri-sets and Giant Sets
- Basic agonist / antagonist Super-set
- Boring But Big Method
- Pyramid, double pyramid, reverse pyramid
- Drop Sets
- Rest-Pause Sets
- Pre-exhaustion Super-set Method
- Post-exhaustion Super-set Method
- etc.

The split routines

Classic six- day split	
Day	Body part
1	Quadriceps, hamstring, calves and shoulder
2	Chest and biceps
3	Back and triceps
4	Quadriceps, hamstring, calves and shoulder
5	Chest and biceps
6	Back and triceps
7	Rest

The split routines

Moderate- adaptive six- day split	
Day	Body part
1	Quadriceps, hamstring and calves
2	Chest, biceps and back
3	Shoulder, triceps and abdominal
4	Quadriceps, hamstring and calves
5	Chest, biceps and back
6	Shoulder, triceps and abdominal
7	Rest

The split routines

high- adaptive six- day split	
Day	Body part
1	Chest, back, biceps and triceps
2	Quadriceps, hamstring, calves, shoulders and abdominals
3	Chest, back, biceps and triceps
4	Quadriceps, hamstring, calves, shoulders and abdominals
5	Chest, back, biceps and triceps
6	Quadriceps, hamstring, calves, shoulders and abdominals
7	Rest

The split routines

High-adaptive six-day double split

Day		Body part
1	a.m	Quadriceps, hamstring and calves
	p.m	Chest and biceps
2	a.m	Shoulder and triceps
	p.m	Back and abdominals
3	a.m	Quadriceps, hamstring and calves
	p.m	Chest and biceps
4	a.m	Shoulder and triceps
	p.m	Back and abdominals
5	a.m	Quadriceps, hamstring and calves
	p.m	Chest and biceps
6	a.m	Shoulder and triceps
	p.m	Back and abdominals
7		rest

Thank you