

Hypertrophy (muscle growth)

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18.3.2025

Muscle growth or hypertrophy occurs, when you send a signal to the body through resistance training, declaring that the current muscles are inadequate. As a response, protein is used to improve the muscles during the following days of rest. This document gives an overview of both the practicalities and the interesting cellular biology involved in the process.

Basics

- For the first months or years of weight training the recipe for success is straight forward: Workout 2-3 times per week. Focus on composite movements like bench press/dip, pull-up/lat pulldown, squat/deadlift, which involve multiple muscles at the same time. Prioritize learning the technique. Don't go too heavy too fast. Eat a lot of protein and rest well.
- During a workout, do 4 working sets per movement, with 6-12 repetitions per set. Choose the weight so that by the end of the set you could do only 1-2 additional reps. Write down the result as "Bench 4 x 6 x 50 kg".
- Warmup by biking/running 5-10 min. Additionally, do a couple of warmup sets for each movement, accompanied with appropriate dynamic stretches.
- Supersets save time by working two different muscle groups at the same time: While having a break between bench press sets, you can do a set of lat pulldowns. Don't involve those movements in a superset, which activate same muscles.
- If it hurts, stop. If you're tired, leave out one set per movement. If you're in a hurry, just do the composite movements. Already with a couple of working sets per week you can gain >60% of the growth potential for that week! jeffnippard.com/blogs/news/how-to-train-like-a-minimalist-more-gains-in-less-time.
- If you feel energetic, add a set per movement, add movements per workout or add workouts per week - the additional gains are like compounding interest.
- Progressive overload: Try to add reps or weight to the sets when you can. For example,
 - o First week 4 x 6 x 50 kg
 - o Second week 4 x 7 x 50 kg
 - o Third week 4 x 6 x 52.5 kg

What to expect with results?

- After 3 workouts you can feel the difference in strength. The progress can be rapid over months, when the body adapts to a new kind of a stimulus. Strength increases as a result of muscle growth, but also due to improved coordination between muscles and within a muscle.
- After 20 workouts you can see the difference in the mirror.
- In a couple of years, you can drastically change how you feel and look. Building muscles require an initial investment in effort and time, after which they can be maintained and recovered with a fraction of the initial. Having muscle mass prevents injuries in everyday life, supports a long and healthy life, improves brain health and makes life more versatile and fun. It also looks nice to have your frame filled up with muscle.

Nutrition

- Food can be broken down into three macronutrients: Protein, fat and carbohydrate.
- Eat 1.5-2 grams of protein per kilogram of bodyweight per day. Protein is used for repairing and enlarging muscles. If you're a vegan, make sure to combine protein sources correctly to get a good amino acid profile.
- Healthy fats are needed for hormonal balance.
- Before a hard workout, eat carbs at lunch or at the dinner a day prior. The carbs will be stored as glycogen in the muscles and are used as fuel during the workout.
- Eating excess calories reassures your body of abundance, encouraging it to invest more freely into building muscle. Muscles are a costly investment, because they require scarce resources both to be built and to be maintained. Eat 200 kcal over maintenance for two months. This builds muscle but perhaps also accumulates a little bit of fat. Then eat 200 kcal below maintenance for one month to cut down the added fat. You can also just eat at maintenance all the time.
- Creatine monohydrate (voluntary supplement) can help you train a bit harder by extending the "fuel tank" in muscles. In practice, with creatine you might get 7 reps with the same weight that you otherwise would get 5-6 reps. Creatine stores more water in the muscles, making them look larger. This also increases body weight. These effects vanish if you stop taking creatine, but you get to keep the additional muscle mass that you got if you managed to train harder with creatine. Creatine monohydrate is cheap and safe, having been well researched through decades.

How to cause muscle growth, or hypertrophy?

1. Stimulus: Body adapts to its environment. Resistance training causes damage to the muscle fibers. This signals to the body that the current muscles are inadequate.
2. Nutrition: There must be enough protein available to be used as building blocks for the muscles.
3. Recovery: Muscles recover during the days of rest after the initial stimulus. The muscles also supercompensate to overcome the challenge. Sleep quality is also important.

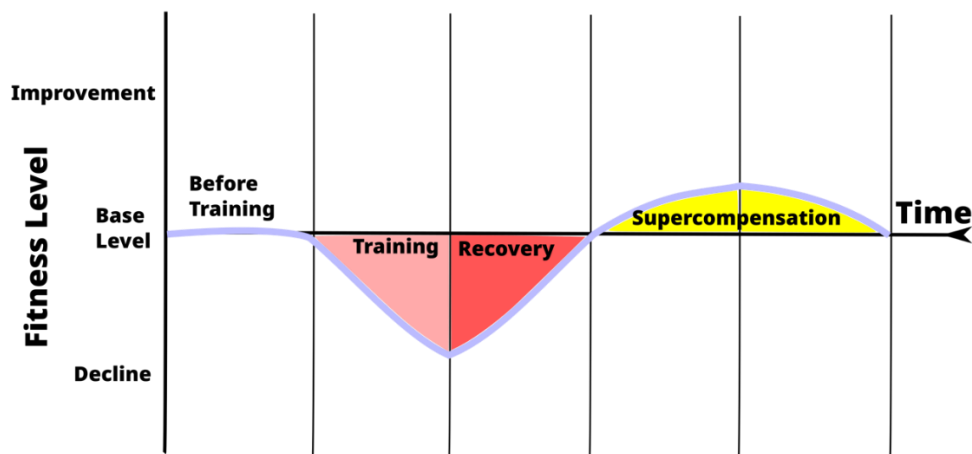
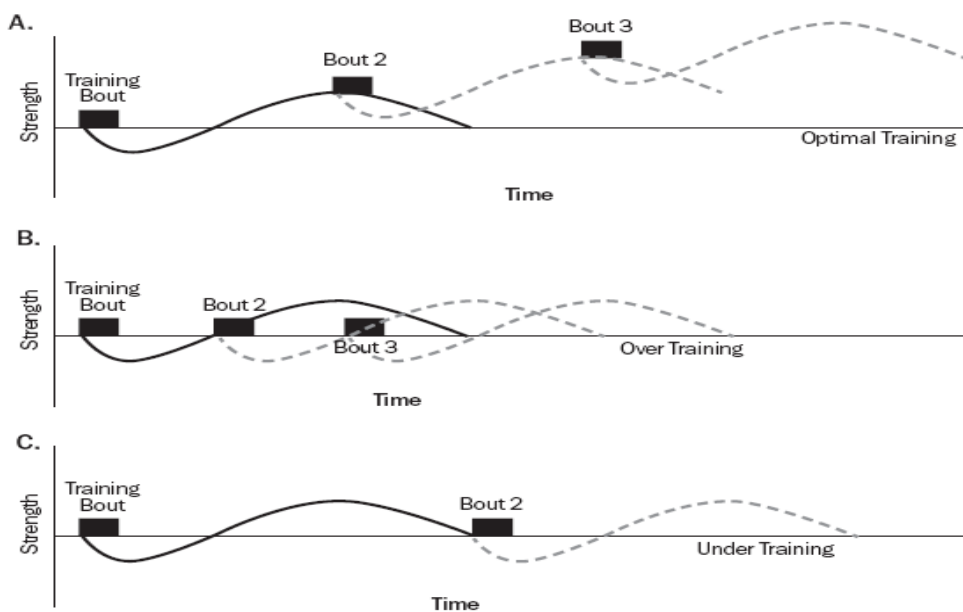


Figure: [wikipedia.org/wiki/Supercompensation](https://en.wikipedia.org/wiki/Supercompensation)

To progress over time, the next workout for the same muscle should take place during the supercompensation period. For more advanced lifters it becomes harder to achieve supercompensation on top of the recovery/upkeep.



Hypertrophy on cellular level

Muscle cell is a long fiber. In the cell there are myofibril tubes, composed of stacked sarcomere cylinders. According to the Sliding Filament Theory, the binding and releasing of actin and myosin (protein) filaments in a sarcomere performs the muscle contraction. In other words, the myofibril tubes in muscle cells form the contracting filament-structure, which moves the skeleton.

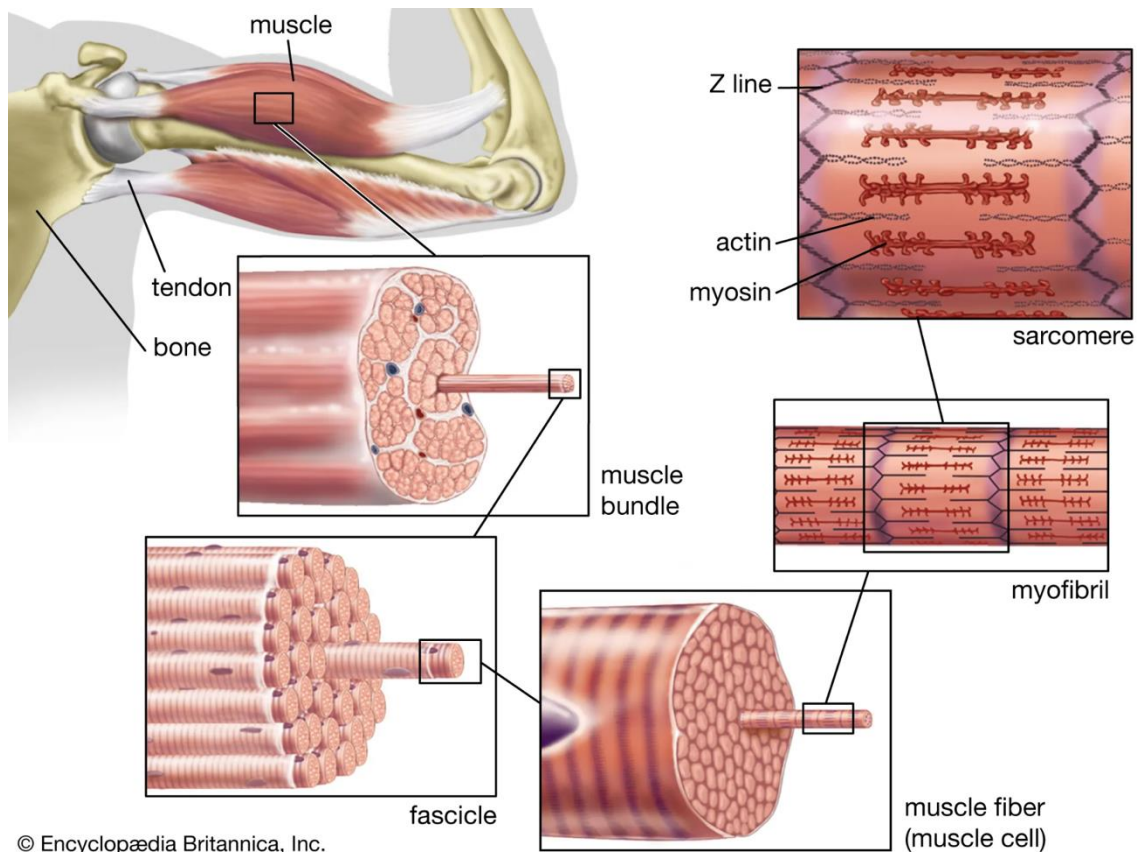


Figure: britannica.com/science/skeletal-muscle

A muscle cell has multiple mitochondria, which produce energy (ATP) from fat and carbs, to fuel the contraction. Muscle cells can also have multiple nuclei, unlike other cells in the body. The nuclei conduct protein synthesis. This protein is used for repairing and enhancing the myofibril tubes, which are damaged during resistance training. As the contracting filament-structure enlarges, the muscle cell becomes bigger and stronger, i.e. goes through myofibrillar hypertrophy.

Muscle memory

Stimulus from a workout can incentivize a satellite cell (stem cell) to fuse with a damaged muscle cell. The muscle cell receives the nucleus from the satellite cell. These additional nuclei make it possible for the muscle cell to build and upkeep an even larger contracting filament structure. If you stop training, the contracting filaments will wither and thereby the muscles deteriorate, but it seems that you get to keep the additional nuclei for much longer. Myonuclear Domain Theory suggests an explanation to the evident muscle memory: The added nuclei help you quickly build back a physique and strength you once had, when you continue training.

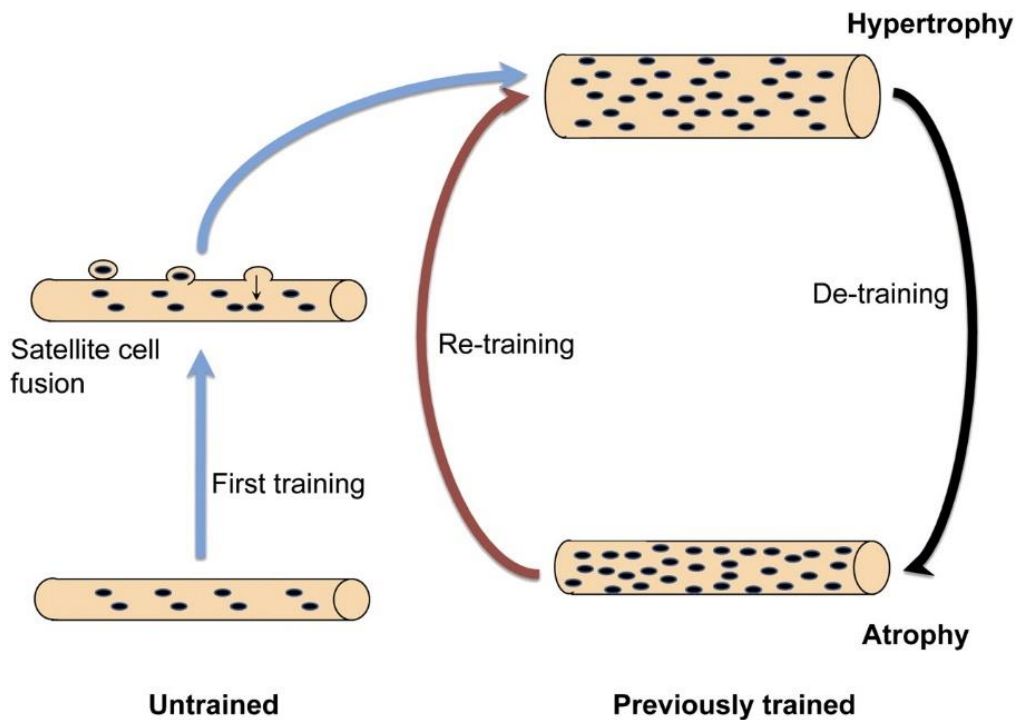


Figure: strongerbyscience.com/grow-like-a-new-lifter-again