

# Chronic Adaptations to Training



# Assumed knowledge

- Detailed understanding of the respiratory and circulatory systems.
- A thorough understanding of energy systems and anaerobic versus aerobic training.
- Skeletal muscle structure and function



# Chronic versus acute

- Chronic changes are actually adaptations that occur as a result of long term training. Chronic adaptations occur at both the cardio-respiratory system level and the muscle site.
- Acute changes are changes that occur as a result of one off sessions – that is each time you undertake exercise acute changes can occur at the muscle site and to the cardio-respiratory systems.

# Chronic Training Adaptations

- When we discuss chronic adaptations to training we are assuming that training has been occurring for a minimum of 6-8 weeks, training at least 3 sessions per week.
- Why is this important? What if the athlete was training less than this?
- Chronic adaptations can be seen either at rest, during submaximal work or during maximal work.

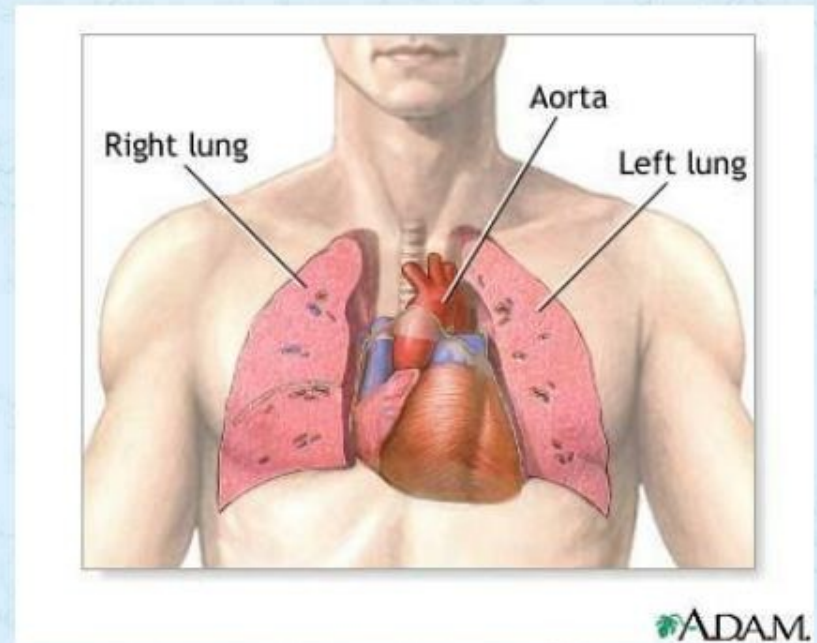
# **Chronic Adaptations vary depending on the following:**

- Type and method of training – aerobic versus anaerobic.
- Frequency, duration and intensity of training.
- Individuals capacities – hereditary factors (your genetic make up)



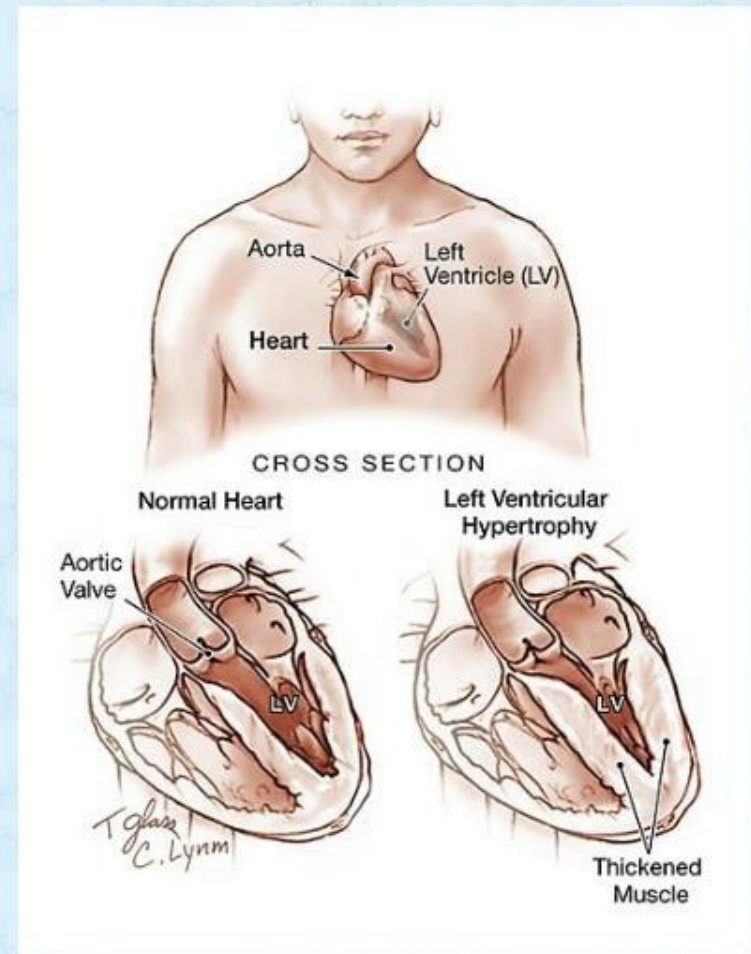
# Aerobic Training

- The minimum period for chronic adaptations to occur is 6 weeks.
- Adaptations from aerobic training can occur at the muscle site and in the cardio-respiratory systems.



# Cardio respiratory adaptations from aerobic training

- Chronic cardio (heart) and respiratory (lungs) changes are easier to remember if you understand that the changes are occurring to improve the ability to carry oxygen around the body to the working muscles
- These changes are important and decrease your chance of developing heart disease / problems.





# Chronic adaptations to Aerobic training

- Cardiac hypertrophy (increased ventricular volume)
- Increased capillarisation of the heart muscle
- Increased stroke volume
- Lower resting heart rate
- Lower heart rate during sub max workloads
- Improved heart rate recovery rates



# Chronic adaptations to Aerobic training

- Increased cardiac output at max. workloads
- Lower blood pressure
- Increased arterio-venous oxygen difference (a-VO<sub>2</sub> diff)
- Increased blood volume and haemoglobin levels
- Increased capillarisation of skeletal muscle

# Chronic adaptations to Aerobic training

- Changes to blood cholesterol, triglycerides, lipoprotein levels (L.D.L's and H.D.L's)
- Increased lung ventilation
- Increased max. oxygen uptake ( $\text{VO}_2$  max)
- Increased anaerobic threshold



# Chronic adaptations to Aerobic training

- Cardio respiratory adaptations are best developed through the following methods:
- Continuous training
- Fartlek training
- Long interval training



# CARDIOVASCULAR ADAPTATIONS

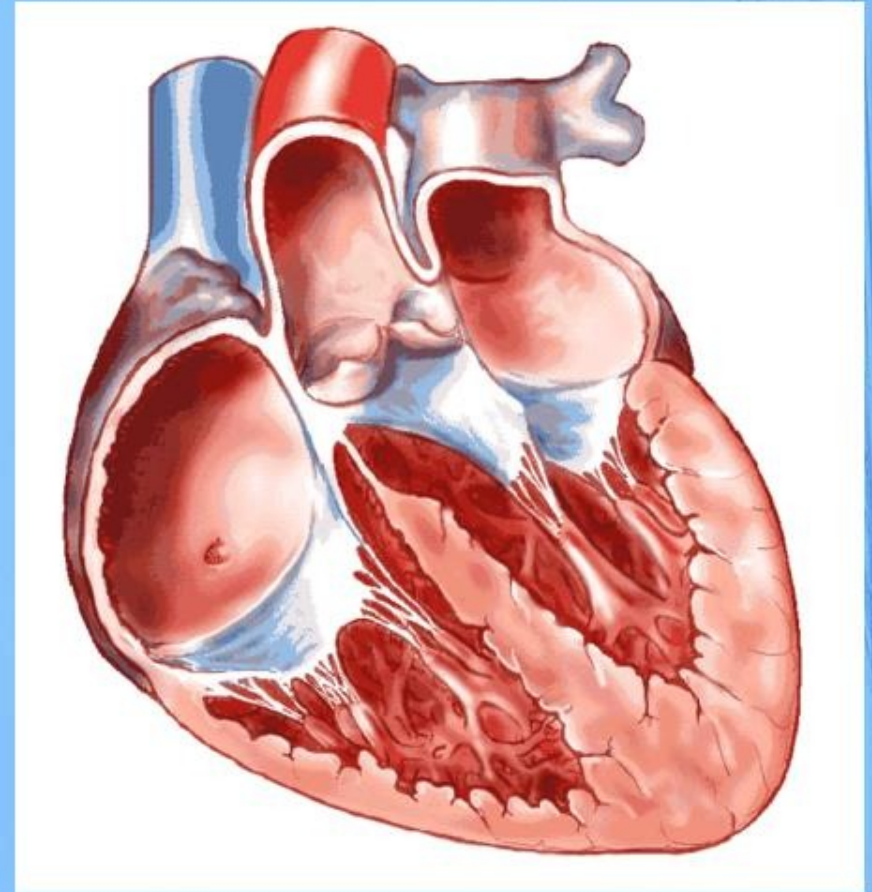
- The easiest way to remember them all is categorize the adaptations into:
  - Cardiovascular adaptations
  - Respiratory adaptations
  - Muscle adaptations
- When discussing cardiovascular changes we are talking specifically about the heart, blood vessels and blood.



# CARDIOVASCULAR ADAPTATIONS

- **CARDIAC HYPERTROPHY**

Enlargement of the heart muscle itself. The heart chambers are enlarged, therefore increased ventricular volume – most important is LV size – why?

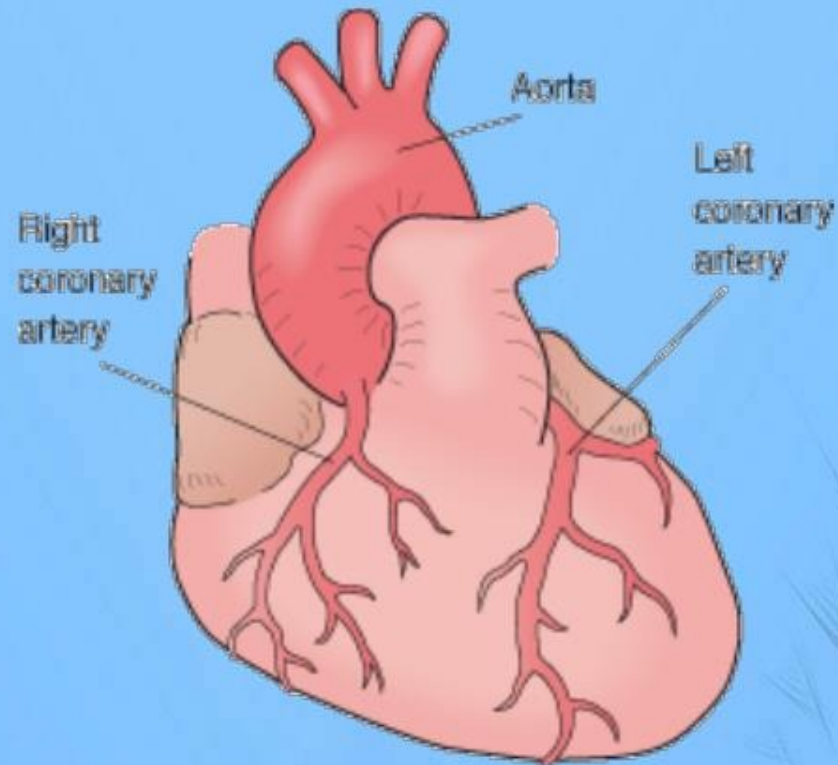


# CARDIOVASCULAR ADAPTATIONS

- **INCREASED CAPILLARISATION OF THE HEART MUSCLE**
- Cardiac hypertrophy also leads to an increase in the capillary density and blood flow to the heart muscle itself.
- The increased supply of blood and O<sub>2</sub> allows the heart to beat more strongly and efficiently during both EXERCISE and REST.
- Also decreases chance of heart attack.



# The Coronary arteries



# CARDIOVASCULAR ADAPTATIONS

- **INCREASED STROKE VOLUME**

Stroke volume is the amount of blood pumped per beat. Through aerobic training SV increases at REST, during SUB MAX. workloads and MAX. workloads.



# CARDIOVASCULAR ADAPTATIONS

- **LOWER RESTING HEART RATE**
- Resting heart rate is very useful in determining aerobic fitness. Generally the lower the resting heart rate the greater the aerobic fitness level.
- Because the athlete has greater stroke volume the heart does not need to beat as often to pump the same amount of blood around the body
- Page 252 LIU –  $Q = SV \times HR$  equations!

# CARDIOVASCULAR ADAPTATION

- **LOWER HEART RATE DURING SUB MAX WORKLOADS**
- Compared to untrained individuals, athletes have lower heart rates during sub max. workloads. Mainly due to increased SV.
- The heart works more efficiently





# CARDIOVASCULAR ADAPTATIONS

- **IMPROVED HEART RATE RECOVERY**
- The heart rate of an athlete will return to normal (pre exercise levels) quicker than an untrained person.



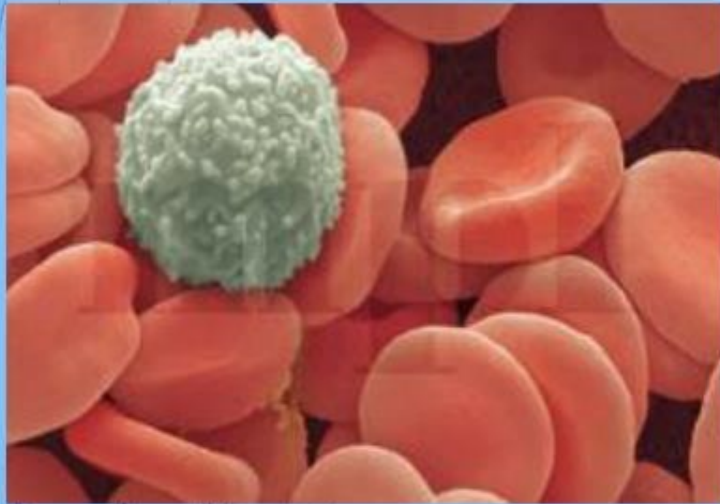
# CARDIOVASCULAR ADAPTATIONS

- **INCREASED CARDIAC OUTPUT (Q) AT MAXIMUM WORKLOADS**

- Cardiac Output (Q) is the amount of blood pumped by the heart per minute
- Q remains unchanged at rest and even during sub max. work regardless of how hard you train.
- During max. exercise Q may increase up to 30 litres per minute for highly trained athletes



# CARDIOVASCULAR ADAPTATIONS

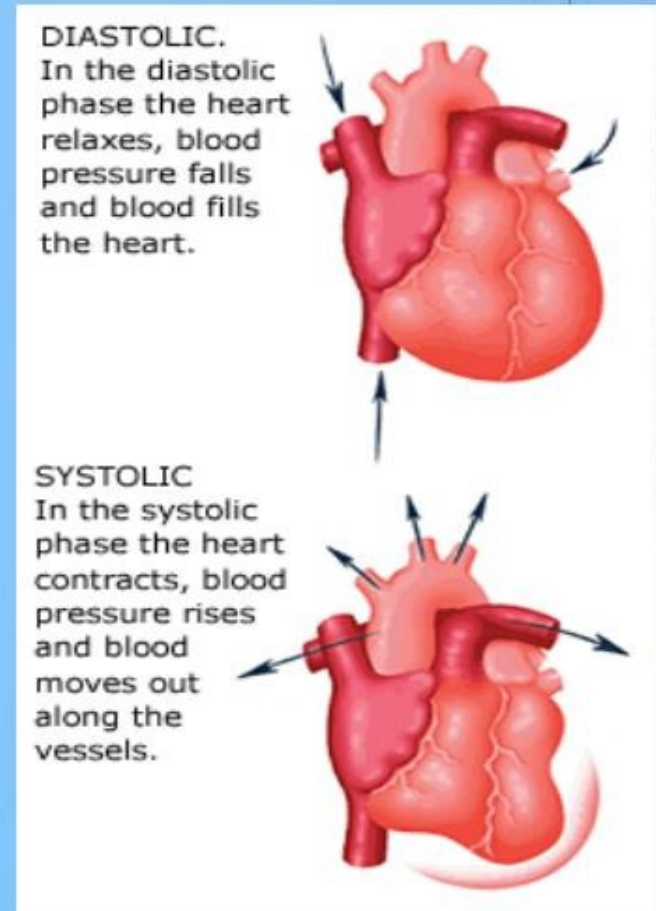


$$Q = SV \\ \times HR$$

Look at Page 252 LIU  
again for equations!

# CARDIOVASCULAR ADAPTATIONS

- **LOWER BLOOD PRESSURE**
- Both systolic and diastolic blood pressure levels may decrease during REST and EXERCISE.
- This helps by reducing resistance to blood flow and reduces strain on the heart.





# CARDIOVASCULAR ADAPTATIONS

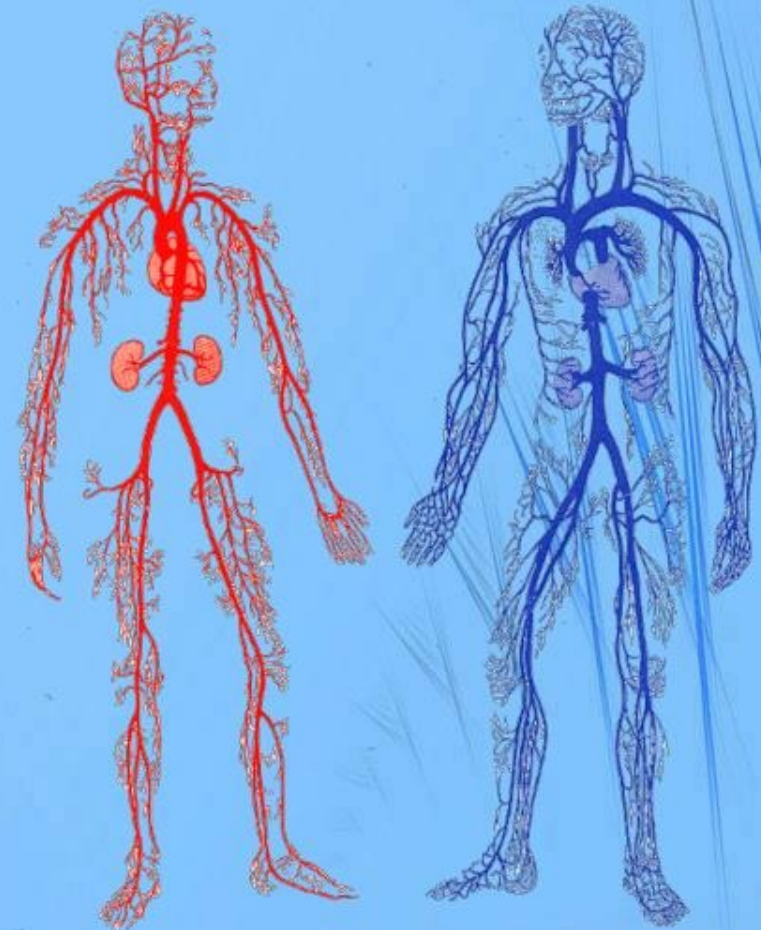
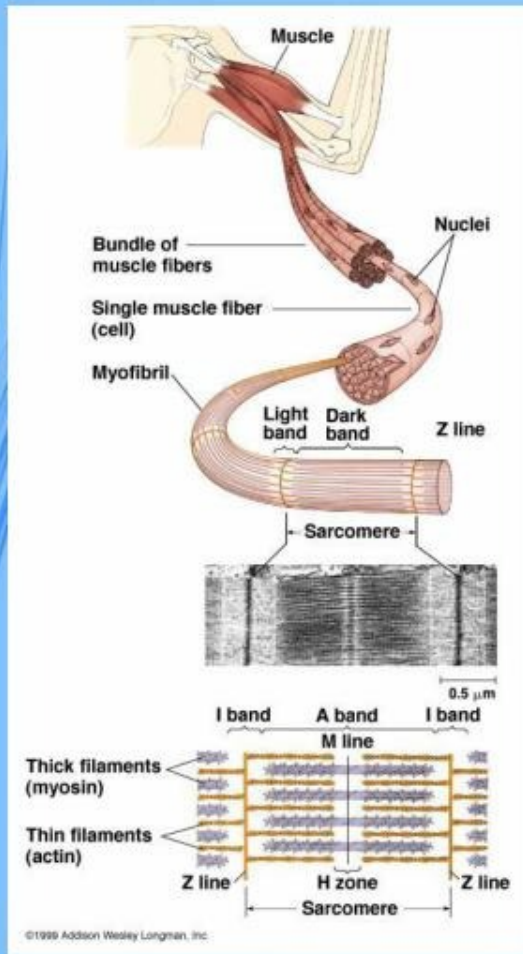
- **INCREASED ARTERIO-VENOUS OXYGEN DIFFERENCE ( $a\text{-VO}_2$  diff)**
- Due to increased myoglobin stores and an increase in size and number of mitochondria trained individuals are able to absorb more  $O_2$  from their blood.
- $a\text{-VO}_2$  diff is increased during SUB MAX and MAX exercise. A bigger  $a\text{-VO}_2$  diff indicates greater uptake of  $O_2$  by the muscle

# CARDIOVASCULAR ADAPTATIONS

- **INCREASED BLOOD VOLUME AND HAEMOGLOBIN LEVELS**
- Aerobic training may lead to total blood volume increasing up to 25%, as a result RBC's may increase in number and therefore haemoglobin content increases thus O<sub>2</sub> carrying capacity increases also.
- **INCREASED CAPILLARISATION OF SKELETAL MUSCLE**
- Long term aerobic training leads to increased capillarisation of the muscle, therefore more blood supply therefore more O<sub>2</sub> can be delivered to the muscle

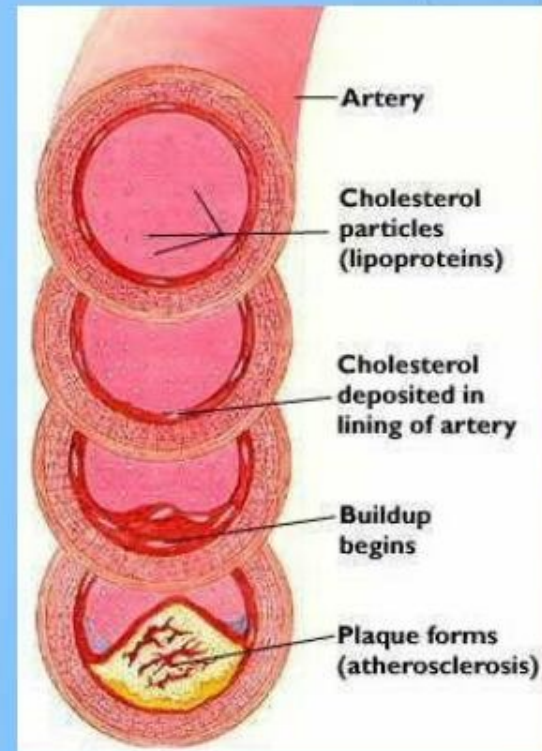


# CARDIOVASCULAR ADAPTATIONS



# CARDIOVASCULAR ADAPTATIONS

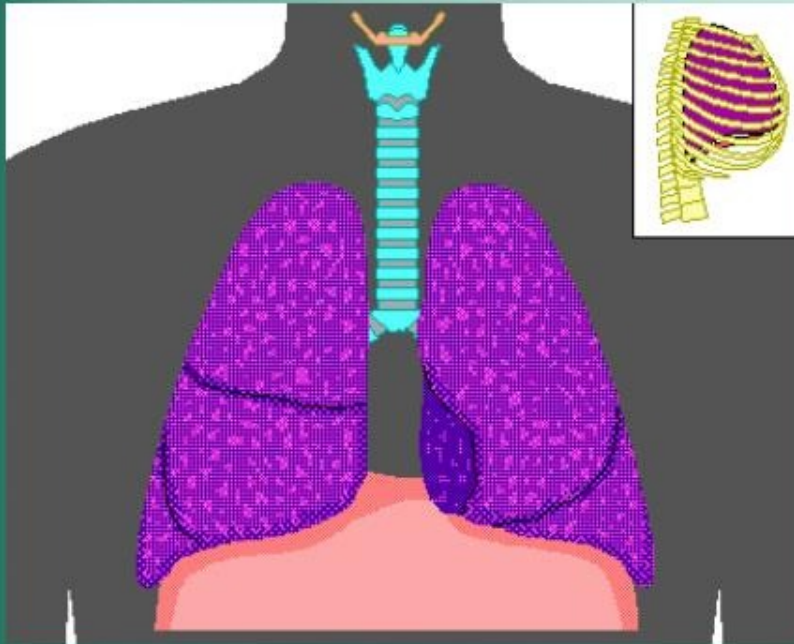
- **CHANGES TO BLOOD CHOLESTEROL, TRIGLYCERIDES, LOW AND HIGH DENSITY LIPOPROTEIN LEVELS**
- Regular aerobic training may result in a decrease in blood cholesterol levels, triglycerides and LDL's. These substances are important in fighting heart disease.
- Also HDL's are thought to increase – these are the good lipoproteins and protect us against heart disease.





Chronic adaptations to Aerobic training

# RESPIRATORY ADAPTATIONS



- When talking about the respiratory system we are talking about the lungs, air passages and our breathing (ventilation).

Chronic adaptations to Aerobic training

# RESPIRATORY ADAPTATIONS

- Just as there are cardiovascular adaptations to AEROBIC training there are also respiratory adaptations. These include:
  - Increased lung ventilation
  - Increased oxygen uptake
  - Increased anaerobic or lactate threshold



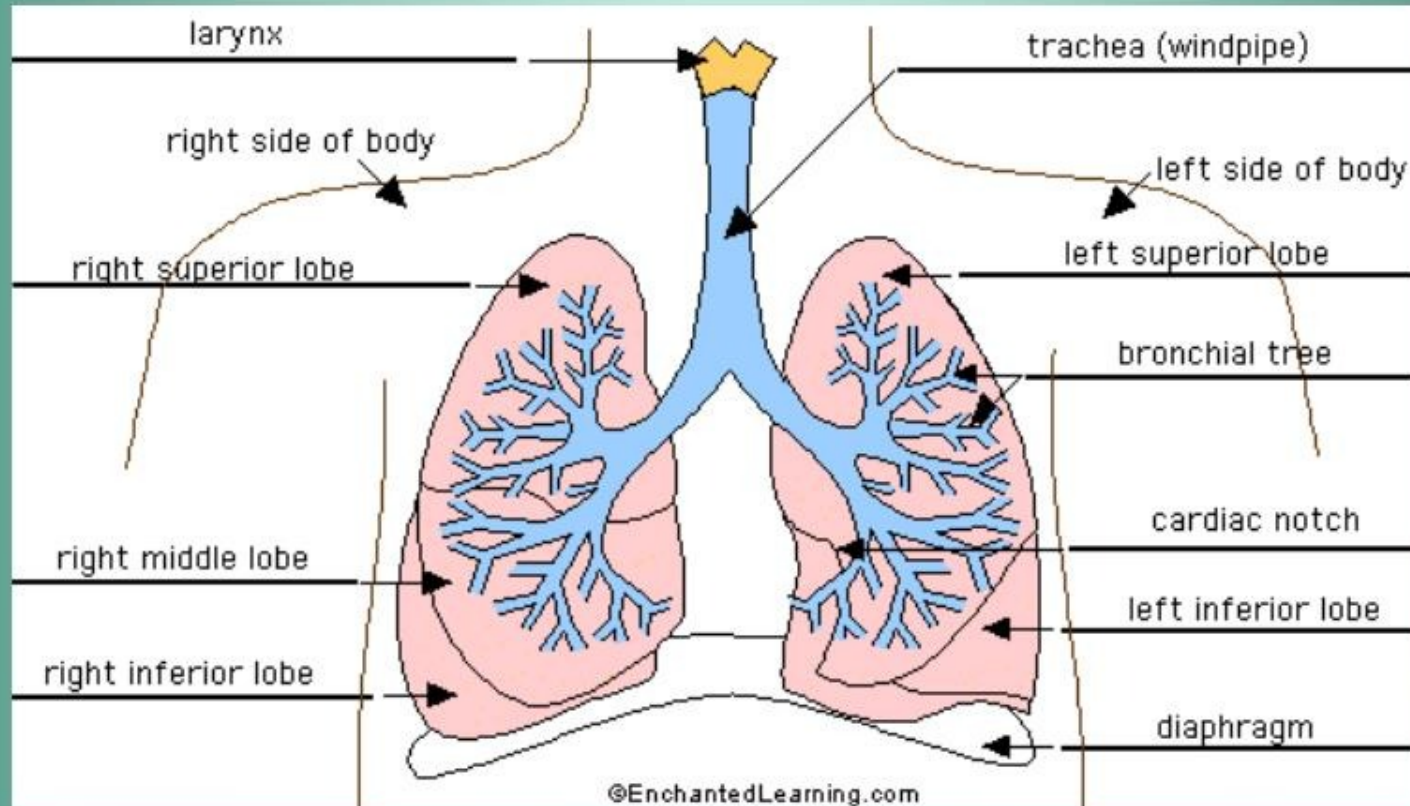
Chronic adaptations to Aerobic training

# RESPIRATORY ADAPTATIONS

- **INCREASED LUNG VENTILATION**
- Aerobic training results in a more efficient and improved lung ventilation.
- At REST and during SUB MAX. work ventilation may be decreased due to improved oxygen extraction (pulmonary diffusion), however during MAX. work ventilation is increased because of increased tidal volume and respiratory frequency.

Chronic adaptations to Aerobic training

# RESPIRATORY ADAPTATIONS





# RESPIRATORY ADAPTATIONS

- **INCREASED MAXIMUM OXYGEN UPTAKE (VO<sub>2</sub> MAX)**
- VO<sub>2</sub> max is improved as a result of aerobic training – it can be improved between 5 to 30 %. (LIU page 255)
- Improvements are a result of:
  - Increases in cardiac output
  - red blood cell numbers
  - a-VO<sub>2</sub> diff
  - muscle capillarisation
  - greater oxygen extraction by muscles

Chronic adaptations to Aerobic training

# RESPIRATORY ADAPTATIONS

## VO<sub>2</sub> MAX





Chronic adaptations to Aerobic training

# RESPIRATORY ADAPTATIONS

- **INCREASED ANAEROBIC OR LACTATE THRESHOLD**
- As a result of improved O<sub>2</sub> delivery & utilisation a higher lactate threshold (the point where O<sub>2</sub> supply cannot keep up with O<sub>2</sub> demand) is developed.
- Much higher exercise intensities can therefore be reached and LA and H<sup>+</sup> ion accumulation is delayed.
- The athlete can work harder for longer

Chronic adaptations to Aerobic training

# RESPIRATORY ADAPTATIONS

- WORDS to KNOW
- Arterio-venous oxygen difference
- Pulmonary diffusion
- Lung ventilation
- Tidal volume
- Respiratory frequency
- $\text{VO}_2$  max
- Lactate threshold

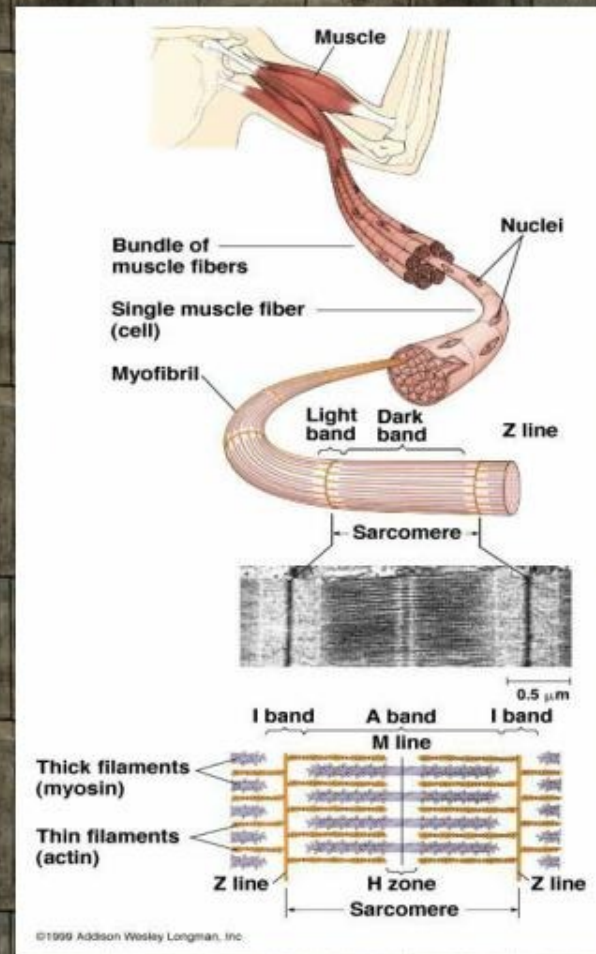




Chronic adaptations to Aerobic training

# WITHIN THE MUSCLE TISSUE

- Chronic AEROBIC training adaptations within muscle tissue are best produced through:
- Continuous training
- High repetition resistance training





Chronic adaptations to Aerobic training

# WITHIN THE MUSCLE TISSUE

- The following tissue changes occur:
- Increased O<sub>2</sub> utilisation
  - increased size and number of mitochondria
  - Increased myoglobin stores
- Increased muscular fuel stores
- Increased oxidation of glucose and fats
- Decreased utilisation of the anaerobic glycolysis (LA) system
- Muscle fibre type adaptations