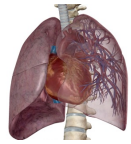
THE WRIGHT FOUNDATION
Heart Cancer Referral



The Cardiorespiratory System

by Dr Grant Ralston

1

Objectives

- Fun facts about the heart
- Describe anatomy of the heart
- Describe oxygen delivery via blood
- Understand heart rate, blood pressure responses
- Understand adaptations to training

2

Public Health England

Health Matters

Scale of the problem

Cardiovascular disease (CVD)
is the leading cause of death worldwide

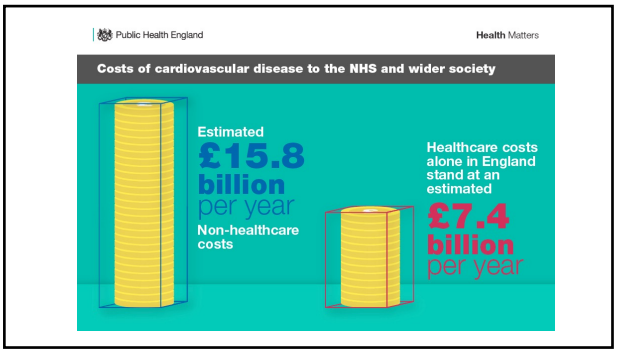
In England, CVD causes

1 in **4** deaths

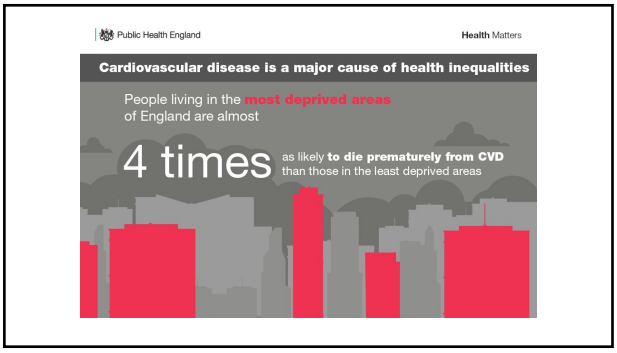
which equates to

1 death every 4 minutes

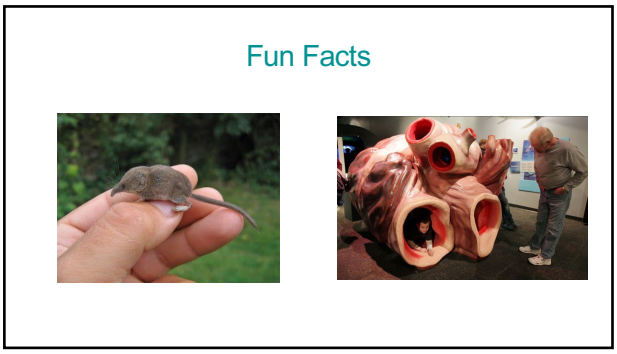
3


Public Health England
Health Matters
Costs of cardiovascular disease to the NHS and wider society
Estimated
£15.8
billion
per year
Non-healthcare costs
Healthcare costs alone in England stand at an estimated
£7.4
billion
per year

4


Public Health England
Health Matters
Cardiovascular disease is a major cause of health inequalities
People living in the most deprived areas of England are almost
4 times
as likely to die prematurely from CVD than those in the least deprived areas

5


Fun Facts

6

Impact to the CV System



7


8

Would you drive [train] the engines the same way?

John's heart

Jane's heart

Would you drive [train] the engines as fast?

9

Fun Facts

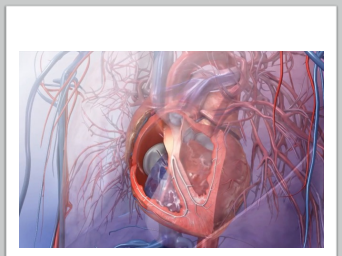
10

Fun Facts

11

Name the footballer

12



Myocardium

- Heart muscle
- Similar to striated skeletal muscle
- Fibers are multinucleated and interconnected end to end by intercalated disks

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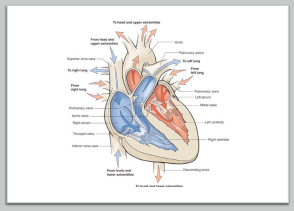
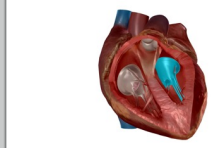
Structure

- Three separate areas:
  - Atrial
  - Ventricular
  - Conductive





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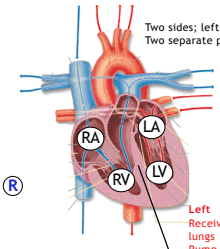
Heart Macro-anatomy



Two sides; left (L) and right (R)
Two separate pumps(L) and right (R)

Atrial chambers
- Thin walled
- Booster/primer pumps
- Pump into ventricles

Ventricular chambers
- Thick walled
- Strong pump
- Pump blood to tissues

Left
Receive oxygenated blood from lungs
Pump blood to body (systemic circulation)

Right
Receive blood returning from body
Pump blood to lungs for oxygenation

Septum

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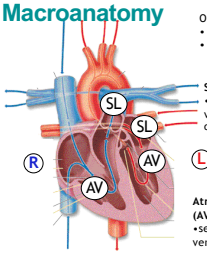
Heart Macroanatomy



One way valves;
- control blood flow
- generate pressure

Semilunar (SL)
- control blood flow from ventricles into body (out of heart)

Atrioventricular valves (AV)
- separate atrium and ventricle on each side (into heart)

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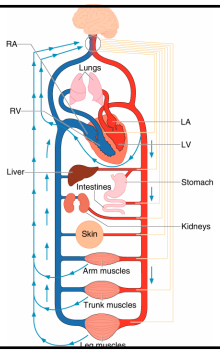
Circulatory System

- closed system

lungs → left atrium
↑ ↓
right ventricle ← left ventricle
↑ ↓
right atrium → aorta
↑ ↓
vena cava → arteries
↑ ↓
veins → arterioles
↑ ↓
venules → arterioles
↓ ↓
capillaries (exchange of nutrients)



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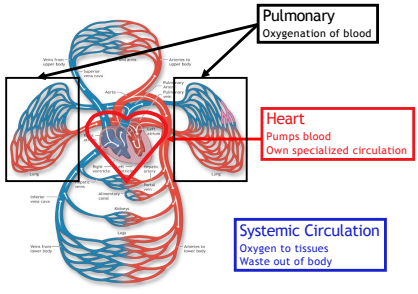

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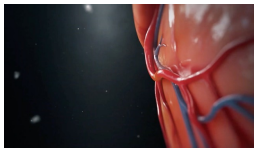
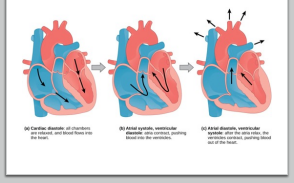
The Cardiac Cycle





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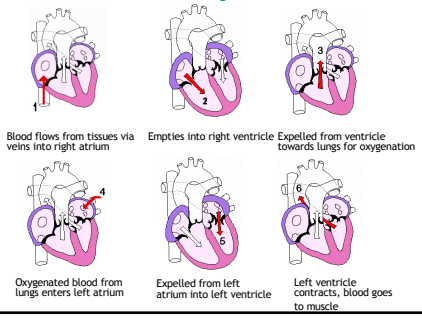
Cardiac Cycle



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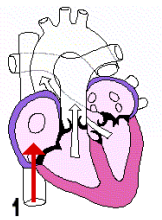
Cardiac Cycle in Action



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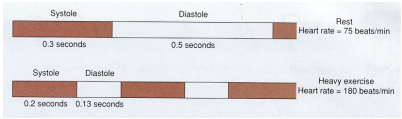
The Cardiac Cycle

Systole
- contraction phase
- blood expelled from chambers

Diastole
- relaxation phase
- chambers filled with blood



N.B. !
When heart rate increases diastole shortens
Remember for later

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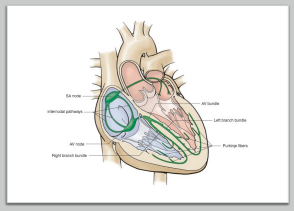
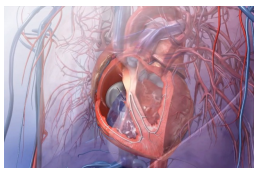
Heart Rate and Conduction





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Cardiac Output

- Product of heart rate and stroke volume: the amount of blood pumped by the heart in 1 minute
- Average adult male (regardless of training status): total volume of blood pumped out of the left ventricle per minute at rest is approximately 5 litres
- Endurance athlete: heart rate is usually much lower at rest due to greater vagal tone and reduced sympathetic drive

Cardiac Output = SV × HR

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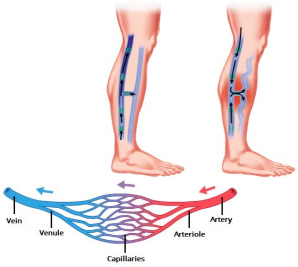
What About Blood Flow



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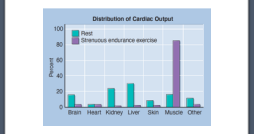
Systemic Circulation

Left ventricle
- Aorta
- Arteries
- Arterioles (small arterial branches)
- Metarterioles (smaller branches)
- Capillaries



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Systemic Circulation (cont.)

- Capillaries
- Venous circulation
  - Venules (small veins)
  - Superior vena cava (venous blood returning from areas above the heart) and the
  - Inferior vena cava (venous blood returning from areas below the heart)
  - Right atrium

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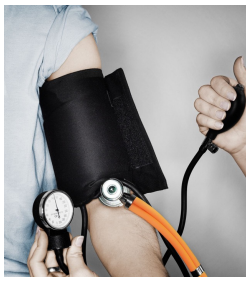
Blood Pressure

Systolic Blood

- Approximately 120 mm Hg at rest
- Represents the strain against the arterial walls during ventricular contraction (systole)

Diastolic Blood

- 80 mm Hg at rest
- An indication of the peripheral resistance, or ease at which blood flows into the capillaries
- As blood flows through the systemic circulation pressure will continue to fall and reach approximately 0 mm Hg as it reaches the right atrium



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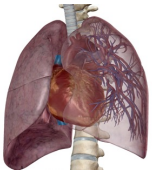
Respiratory and Circulatory System



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Alveoli and Gaseous Exchange

- Oxygen in the air is exchanged for waste carbon dioxide from the bloodstream.
- This process of external respiration takes place in hundreds of millions of alveoli [air sacs].
- Inhaled oxygen diffuses from the alveoli into the pulmonary capillaries into the bloodstream.
- Carbon dioxide from oxygen depleted blood diffuses from the capillaries into the alveoli

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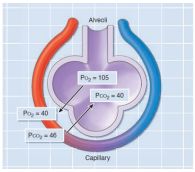
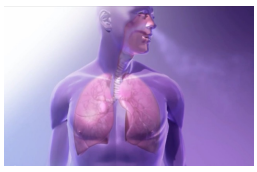
Dalton's Law [Law of Partial Pressure]

- Gas exchange occurs in the lungs as oxygen diffuses from the alveoli into the blood stream and carbon dioxide diffuse into the alveoli.
- Oxygen diffuse from the alveolus into the pulmonary capillary. Carbon dioxide diffuses out of the capillary and into the alveoli





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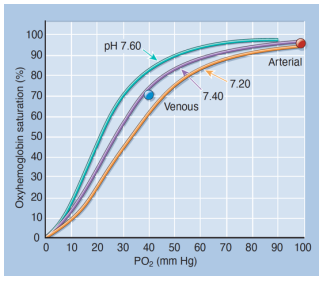
Transporting O_2 and CO_2

- Oxygen: transported in the blood with hemoglobin or plasma
- Carbon dioxide: transport occurs in the form of bicarbonate ion or plasma
- Bohr effect: as the pH of the blood decreases, the affinity of hemoglobin to oxygen decreases and oxygen is released



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Blood

- Made up of cells and plasma
- More than 99% of blood → red blood cells
- Remainder of cells → white blood cells
- Plasma: part of the body's extracellular fluid
- Hematocrit: percent of the blood that is cells
- Hematocrit in males: 42; in females: 38

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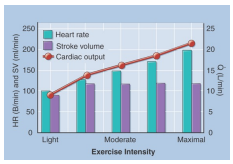
Cardiovascular Response to Exercise

- Increases in cardiac output during exercise result from changes in stroke volume and heart rate
- Heart rate elevation during exercise is primarily controlled by parasympathetic stimulation
- As intensity of exercise increases, heart rate continues to increase until it reaches a plateau. This is the point in which the individual has reached his/her maximal level



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Stroke Volume during Exercise

- Increases in stroke volume are accomplished early during exercise primarily through an increase in left ventricular end-diastolic volume
- Frank-Starling mechanism: with a greater volume of blood returning to the heart, the ventricles stretch more than normal and respond with a more forceful contraction

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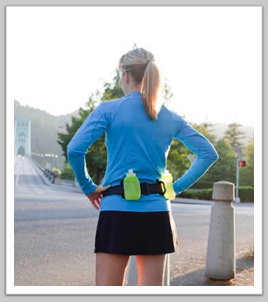
Cardiac Drift

- As exercise is prolonged or when exercise is performed in a hot environment, a gradual increase in heart rate and a decrease in stroke volume may occur even when exercise intensity is maintained



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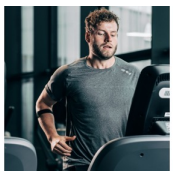
A-Vo_2 Difference

- Oxygen extraction from the arterial blood during exercise is increased
- The body's ability to extract oxygen from the blood and total blood volume available to the muscles is critical in determining the individual's aerobic capacity



VO_{2max} = maximal CO x maximal a –VO_2 difference

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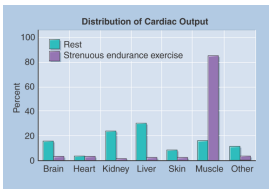
Distribution of Cardiac Output

- During exercise, most of the circulating blood is shunted to the active muscles.
- The extent of this shunting depends on environmental conditions and other factors, such as type of exercise and fatigue.
- The shunting of blood is generally accomplished by diverting blood flow from organs or areas of the body that can take a reduction in blood flow (not the heart or brain).



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Blood Pressure during Exercise

- During exercise, systolic blood pressure increases linearly with changes in exercise intensity until max HR is reached
- Diastolic blood pressure remains about the same
- During upper body exercise only, both systolic and diastolic blood pressure are higher than when exercise is performed with only the legs

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Cardiac Adaptations to Training

- Increases in Vo_{2max}
- Increases in cardiac output resulting from increased stroke volume
- Decrease in resting heart rate and a decrease in heart rate any given submaximal Vo_2
- No change in resting blood pressure for normotensive individuals

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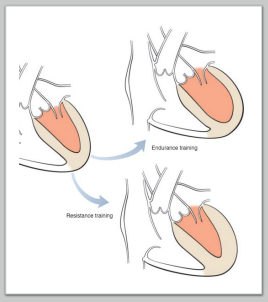

Cardiac Morphology

- An athlete's heart is quite large in comparison to that of a recreationally trained or sedentary individual
- During prolonged training, the heart adapts to match the workload placed on the left ventricle to maintain a constant relationship between systolic cavity pressure and the ratios of wall thickness to ventricular radius

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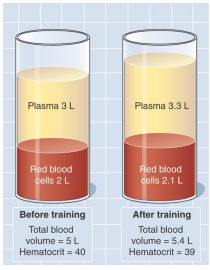
Blood Volume Adaptations to Training

- Endurance training appears to be a stimulus for causing hypervolemia (increase in blood volume)
- Increases in blood volume are due to both plasma volume expansion and an increase in the number of red blood cells
- This causes a reduction in hematocrit



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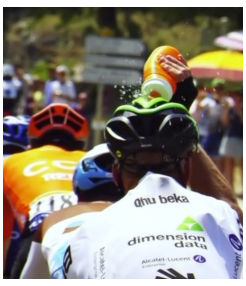
Cardiorespiratory Function and the Environment

- Effects of heat: cardiovascular function can be compromised during exercise in heat by reduction in stroke volume
- Effects of altitude: changes in partial pressure of oxygen as the result of ascending altitude will impair gas exchange in the lungs and tissues; hyperventilation can occur



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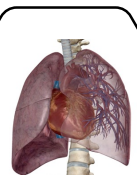
The Cardiorespiratory System

by Dr Grant Ralston



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