Effects of exercise on the respiratory system.

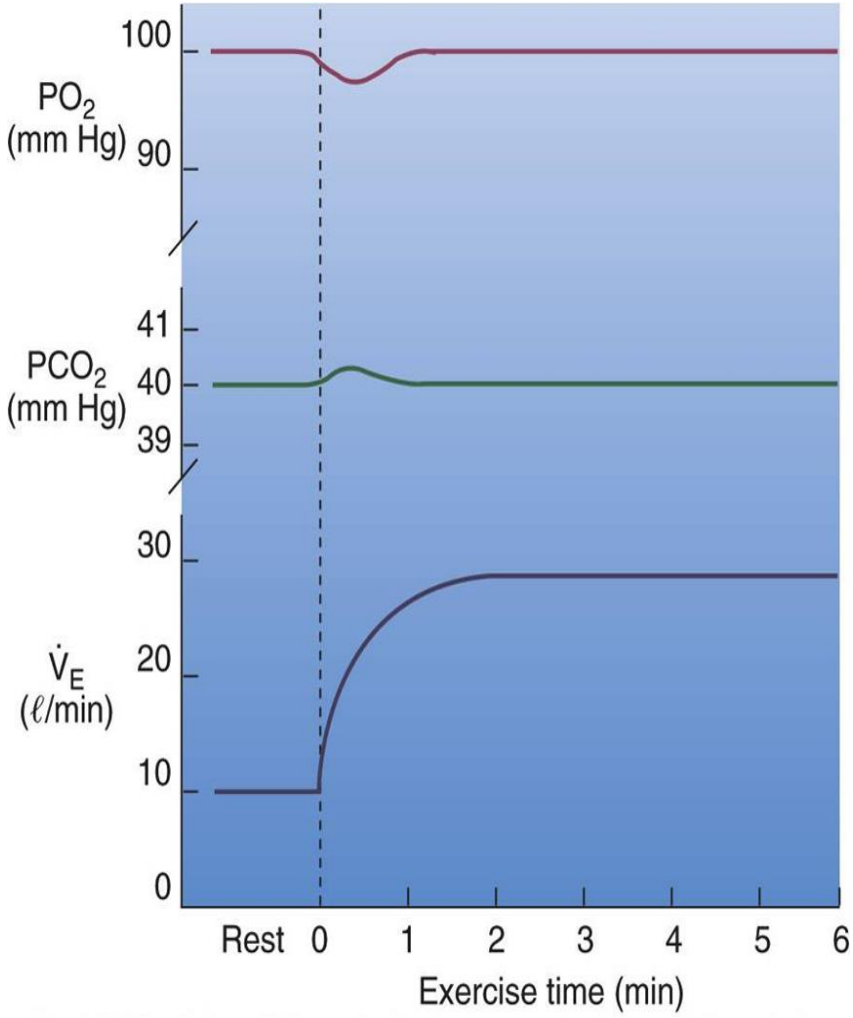
Objectives

By the end of this lecture the students should be able to: -

1. Describe the effects of moderate and severe exercise on oxygen consumption, and ventilation volumes.
2. Describe the effects of exercise on arterial PO_2, PCO_2 and H^+ ions.
3. Define the diffusing capacity of the respiratory membrane, and its typical values at rest, and explain its changes in exercise.
4. Explain causes of hyperventilation in exercise.

Effect of Exercise on the respiratory system

- The blood gases do not always have to become abnormal for respiration to be stimulated in exercise.
- Instead, respiration is stimulated mainly by neurogenic mechanisms during exercise
- Arterial tensions of PCO2 and PO2 are relatively unchanged during submaximal exercise
- BUT: arterial PO2 decreases & PCO2 increases slight in transition from rest □ steady-state exercise



Regulation of respiration during exercise.

- In strenuous (exhausting)exercise O2 consumption and CO2 formation may increase 20 folds but alveolar ventilation increases almost exactly in step with the increased levels of metabolism.
- Therefore the arterial PO2, PCO2, PH all remain almost exactly normal.

Diffusion capacity of the respiratory membrane

- Is the volume of gas that diffuses through the membrane each minute for a pressure difference of 1mmHg.

- **Diffusing capacity for oxygen at rest**

  21ml/min/mmHg

- **Even if the oxygen pressure difference across the respiratory membrane is 11mmHg----------11x21= 230ml oxygen diffusing through the membrane each minute.**
- **During rest tissues consume 250 ml O2 /min**

Changes in the oxygen- diffusing capacity during exercise

- **65ml/min/mmHg**
- This is due **to increased number of open pulmonary capillaries** which was dormant(inactive), thereby increasing the surface area for gas exchange.
- In addition to **increased alveolar ventilation**.

Diffusing capacity for carbon dioxide

- It diffuses 20 times greater than oxygen due to greater diffusion coefficient which is 20 times that for oxygen.
- Diffusion capacity for carbon dioxide 400ml/min/mmHg.
- During exercise 1200 to 1300ml/min/mmHg.

- During exercise the oxygen requirement increased 20 times, and cardiac output increased and so the time blood remained in the pulmonary capillaries becomes less than half normal despite the fact that additional capillaries open up
- But the blood is almost completely saturated with oxygen when it leaves the pulmonary capillaries.

Reasons for this are as follow:

1- The diffusing capacity for oxygen increases almost three fold during exercise, this results mainly from increasing numbers of capillaries participating in the diffusion, and a more even V/Q ratio all over the lung. (It is the ratio of alveolar ventilation to pulmonary blood flow per minute)

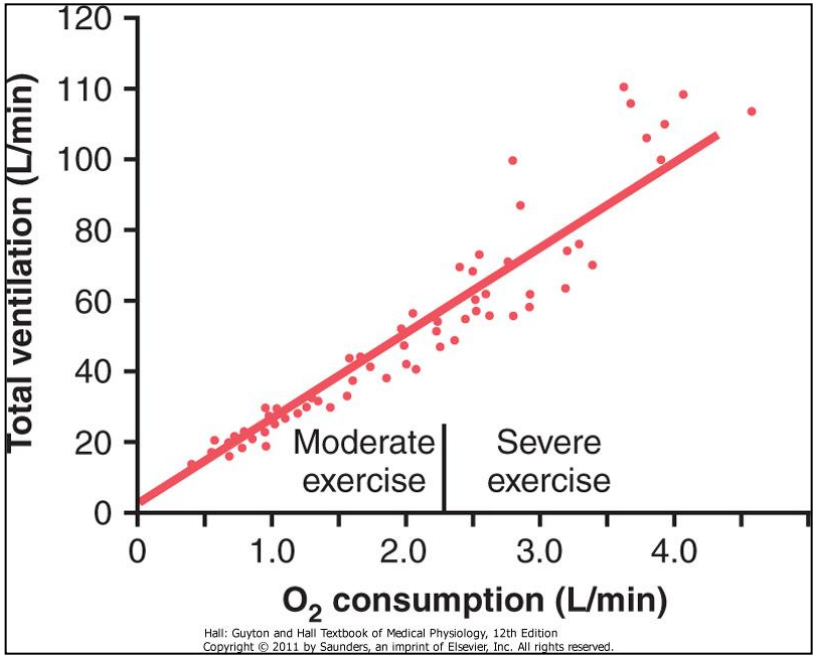
2- At rest the blood normally stays in the lung capillaries about three times as long as necessary to cause full oxygenation. Therefore, **even with shortened time of exposure in exercise, the blood is still fully oxygenated or nearly so.**

Oxygen-Diffusing Capacity of Athletes cont…

- differences between diffusing capacity at resting and the state of maximal exercise make blood flow through many of the pulmonary capillaries and providing greater surface area through which oxygen can diffuse into the pulmonary capillary of blood.

Relation between oxygen consumption and total pulmonary ventilation at different levels of exercise.

- There is a linear relation between both oxygen consumption (Vo2 Max) and total pulmonary ventilation increase about 20-fold between the resting state and maximal intensity of exercise in the well-trained athlete.



What cause intense ventilation during exercise?

- Neural signals from the motor areas of the brain to the respiratory center.
- The joint proprioceptors
- Body temperature (hypothalamus).
- Possibility that the neurogenic factor for control of ventilation during exercise is a learned response.

What cause intense ventilation during exercise? Cont…

- During maximal effort:
- Pulmonary ventilation at maximal exercise 100-110L/min
- Maximal breathing capacity 150-170L/min
- maximal breathing capacity is about 50 % greater than the actual pulmonary ventilation during maximal exercise. to giving athletes extra ventilation E.g

(1) exercise at high altitudes,

(2) exercise under very hot conditions, and

(3) abnormalities in the respiratory system.

Effects of exercise on arterial PO_2, PCO_2 and H+ ions.

- Many studies have since reported that the lactat threshold (LT) is strongly correlated with ventilatory anaerobic threshold (VAT)The term VAT actually refers to the onset of exercise induced hyperventilation during effort. This increase in is a homeostatic response to deal with the consequences of the excess lactate production which can dissociate to release H+ ions from lactic acid into the blood stream. The H+ ions are buffered by bicarbonate and release CO2 .This buffering of lactic acid results in extra CO2 production over that produced by aerobic metabolism and increases the arterial CO2 partial pressure (PaCO2). The increase in PaCO2 stimulates excess ventilation that follows on from the lactate threshold.

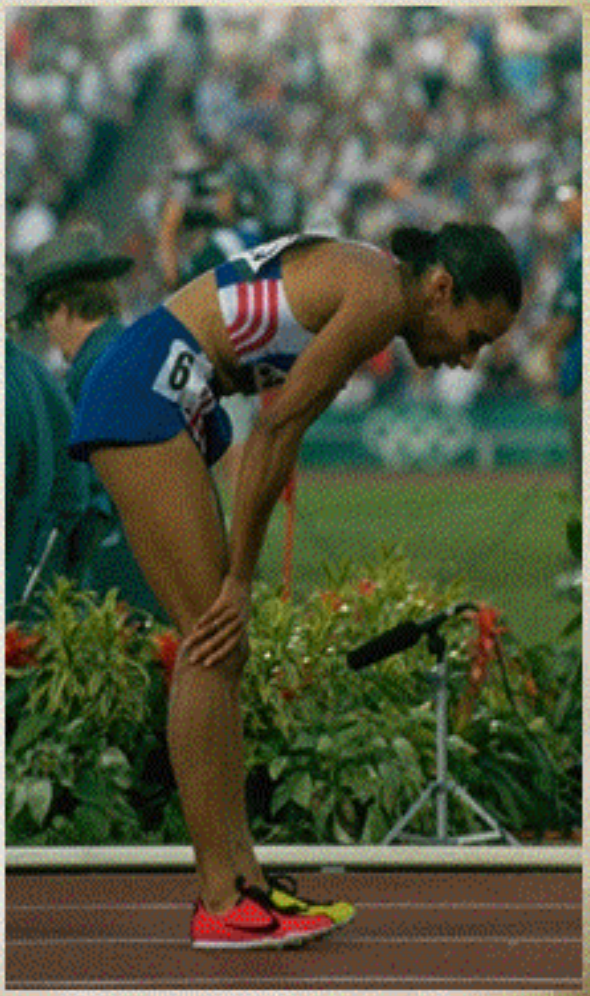
The respiratory system and exercise

When we exercise more oxygen is needed by the working muscles and more carbon dioxide must be removed from the muscles.

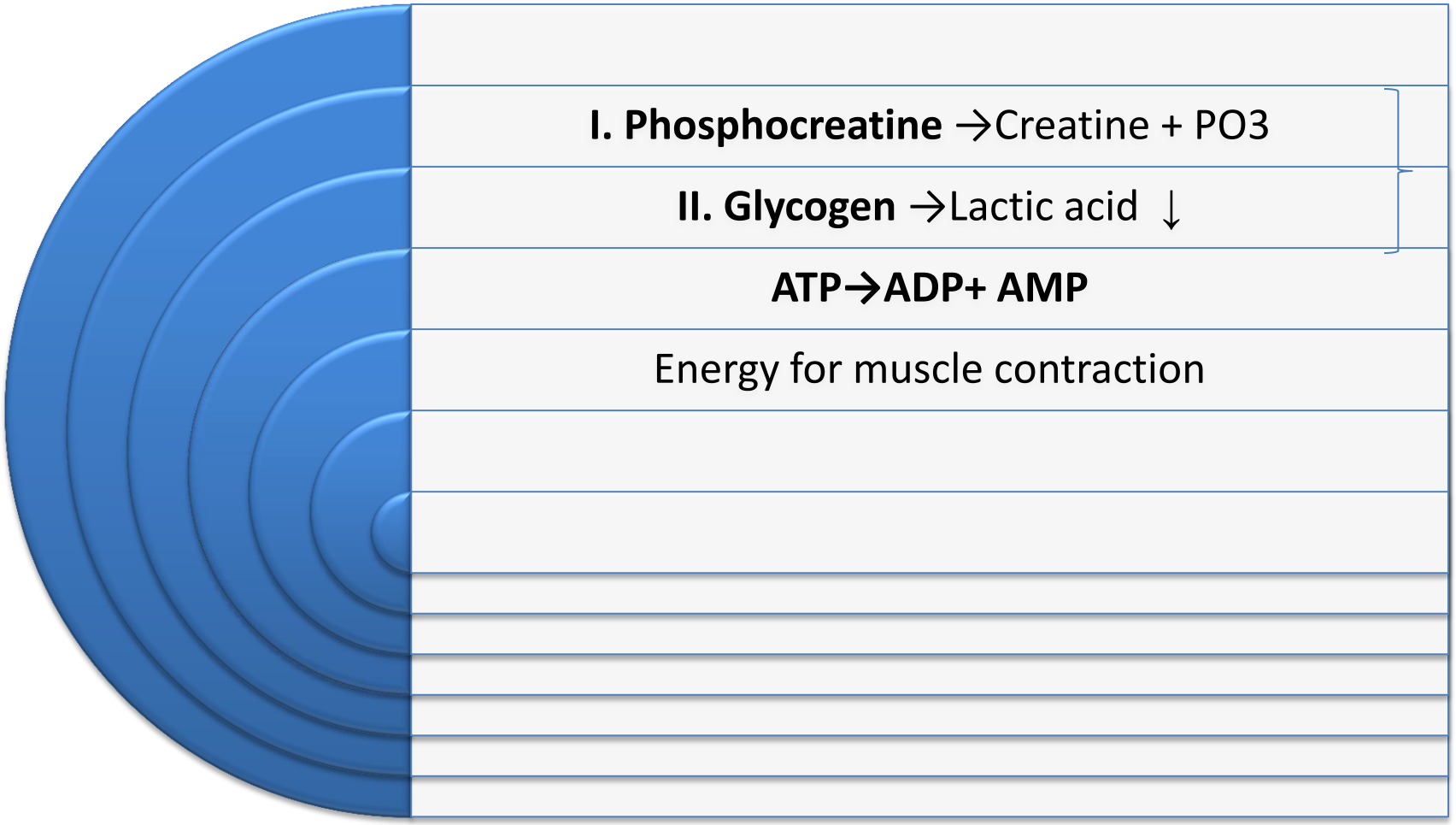
As a result:

- our rate of breathing increases;
- we increase the depth of our breathing, up to our vital capacity;
- we increase the blood flow through the lungs;
- we increase the oxygen taken up and used by the body.

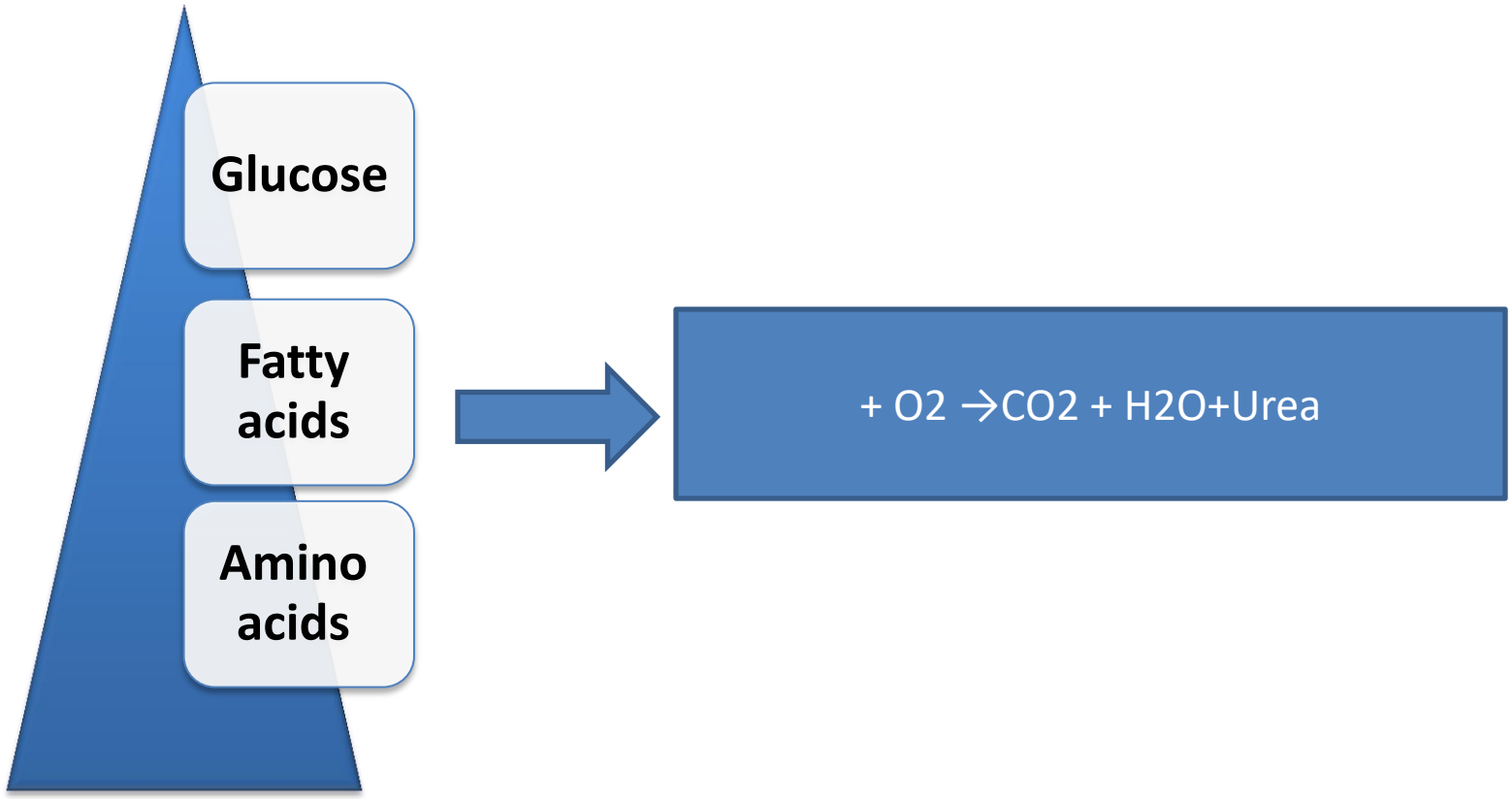
Oxygen used during exercise can be up to twenty times a person's normal oxygen uptake.



Anaerobic energy sources



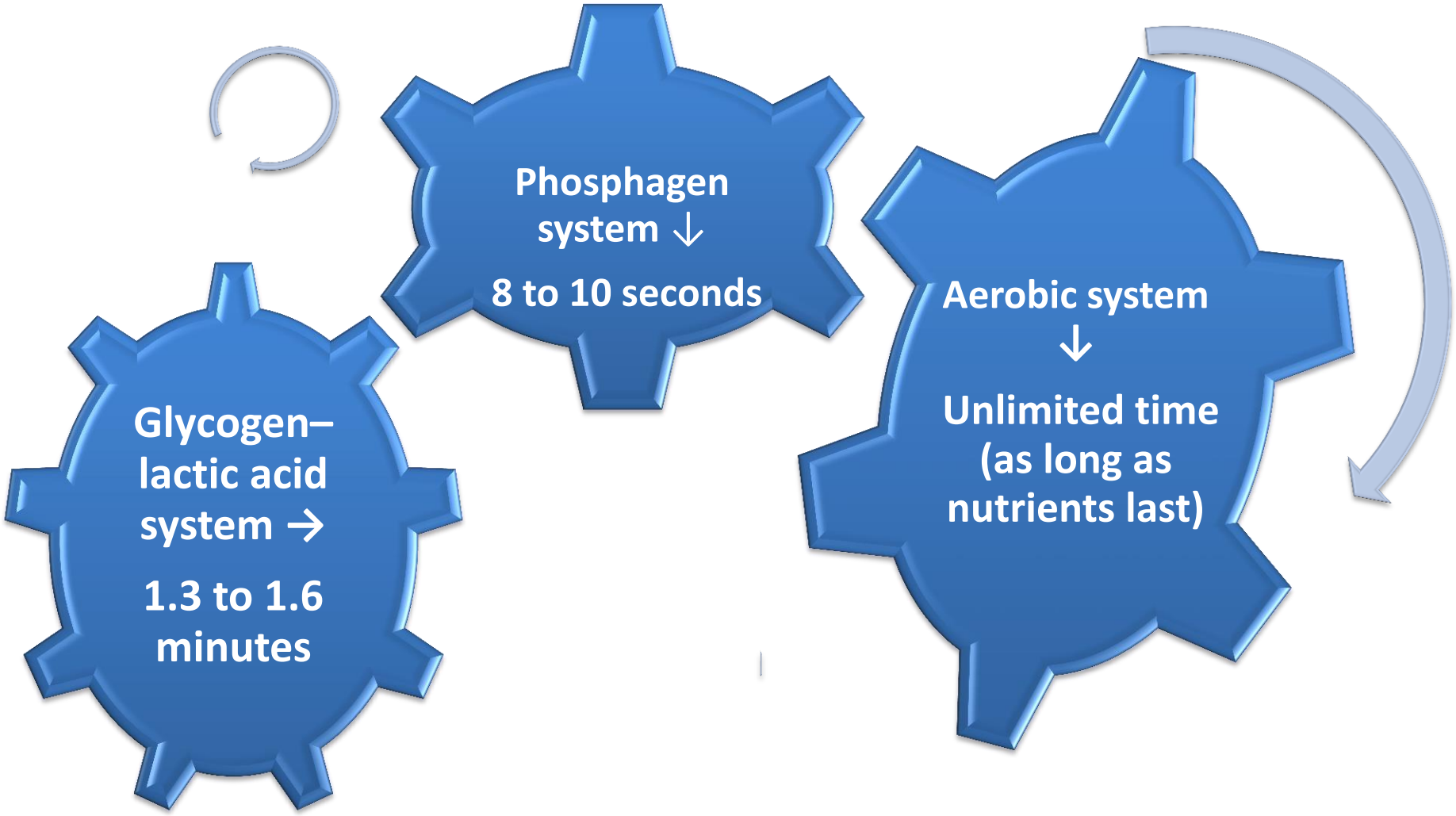
Aerobic system



The phosphagen energy system.

- The combined amounts of cell ATP and cell phosphocreatine are called the **phosphagen energy system**.
- These together can provide maximal muscle power for 8 to 10 seconds, almost ***enough for the 100-meter run.***
- *Thus, the energy from the phosphagen system is used for maximal short bursts of muscle power*.

Relation between exercise duration& energy source



Oxygen Consumption and Pulmonary Ventilation in Exercise.

- Normal oxygen consumption for a young man at rest is about 250 ml/min.
- However, under maximal conditions,

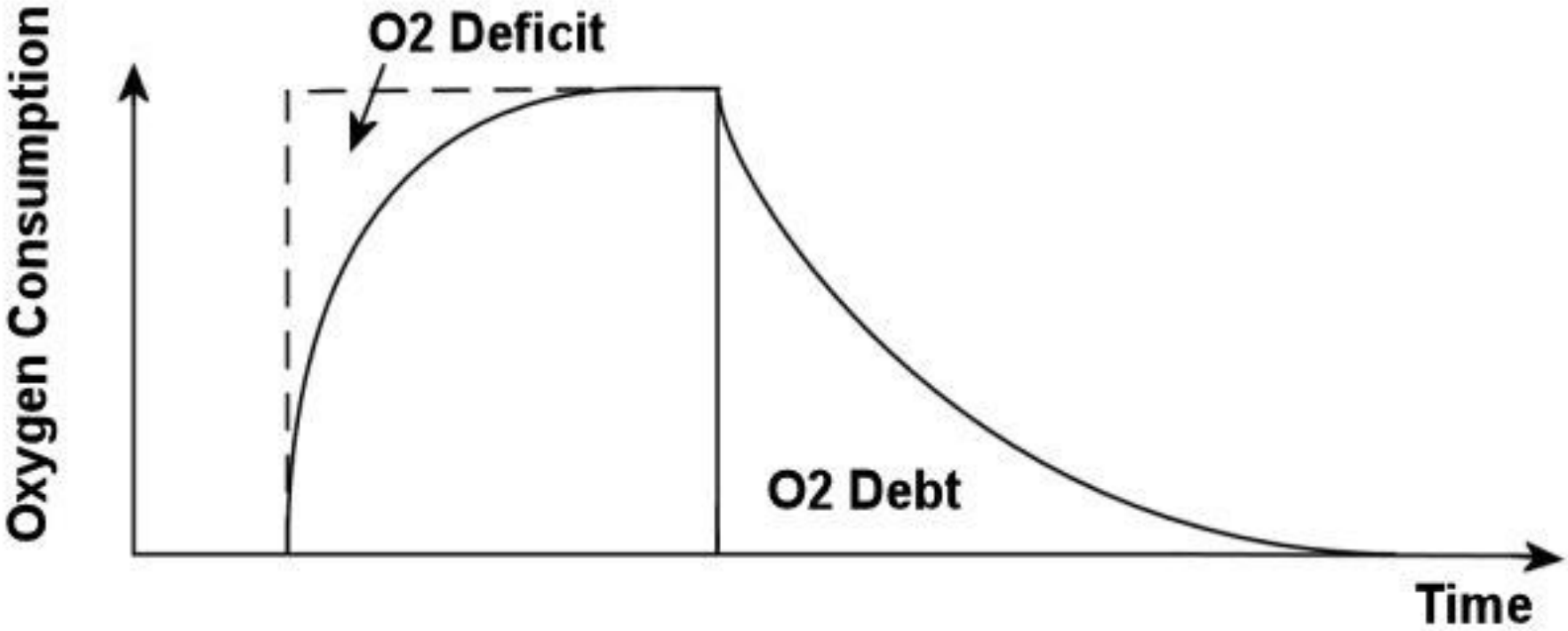
- this can be increased to approximately the following average levels:
- ml/min
- Untrained average male ----------3600
- Athletically trained average male ---4000
- Male marathon runner---------- 5100

OXYGEN DEBT-

Oxygen Debt Is the Extra Consumption of Oxygen After Completion of Strenuous Exercise (about 11.5 liters)

You will develop oxygen debt after about 5 minutes or more of constant exercise. This is the point when the exercise becomes ANAEROBIC (without the use of oxygen) and which has to be paid back. If the exercise is just AEROBIC (with oxygen) there will be no oxygen debt.

E.G When you have a short intense burst of exercise such as sprinting you generate energy for this anaerobically or without oxygen. When you stop exercising you are still breathing heavily. This is your body taking in extra oxygen to 'repay' the oxygen debt.


Oxygen Consumption
O2 Deficit
O2 Debt
Time