Effects of exercise on the respiratory system.

Dr. Aida Korish
Assoc. Prof Physiology
KSU

Objectives

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

Describe the effects of moderate and severe exercise on oxygen consumption, and ventilation volumes.

Describe the effects of exercise on arterial PO_2, PCO_2 and H^+ ions.

Define the diffusing capacity of the respiratory membrane, and its typical values at rest, and explain its changes in exercise.

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,

Regulation of respiration during exercise.

- In strenuous 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, thereby increasing the surface area for gas exchange.
- In addition to **increased alveolar ventilation**.

Diffusing capacity for carbon dioxide

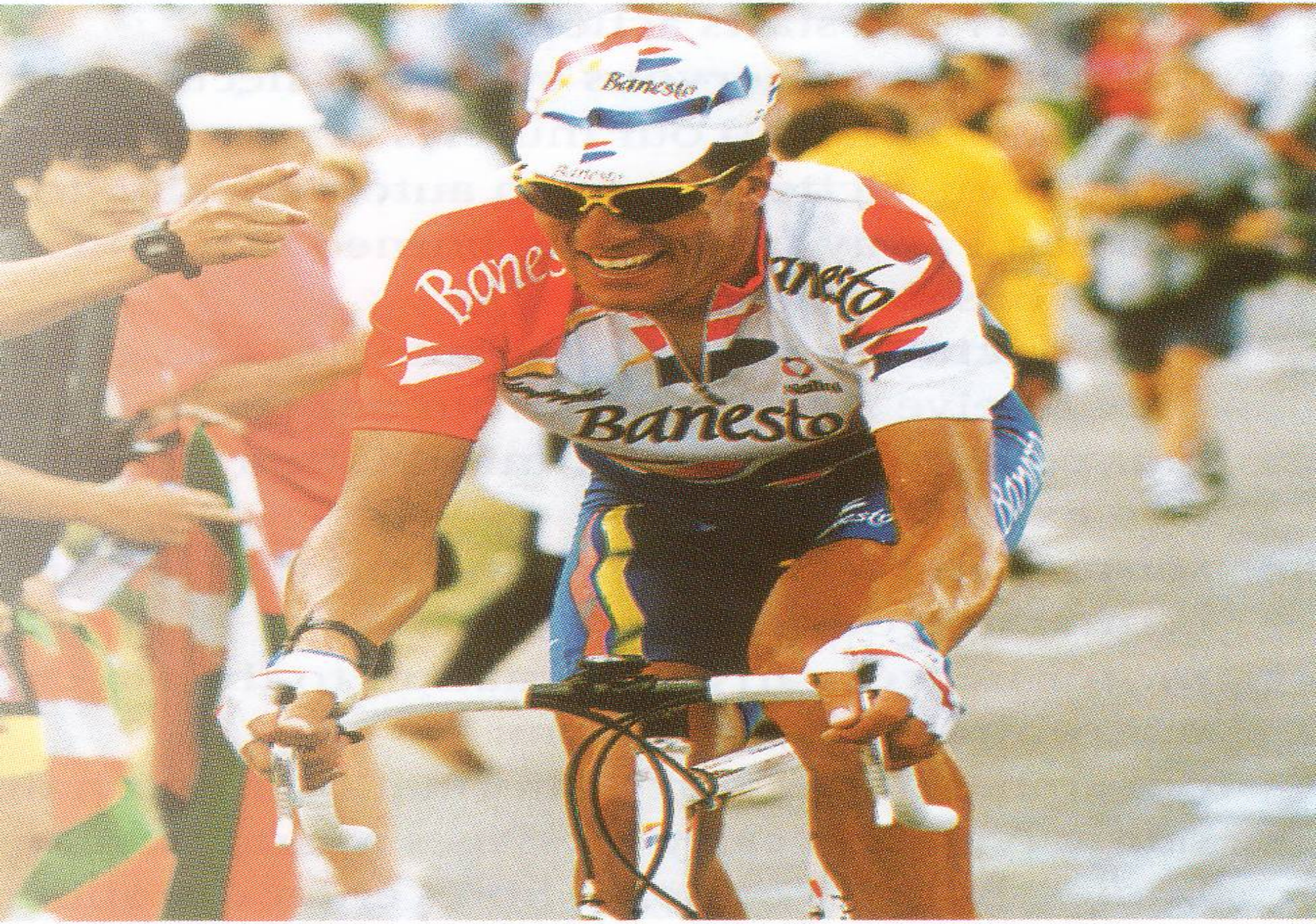
- It diffuses 20 times greater than oxygen due to greater diffusion coefficient which is 20 times that for oxygen.
- Diffusion capacity for carbon dioxide 400ml/ min/mmHg.
- During exercise 1200 to 1300ml/min/mmHg.

- 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.

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.**



When we exercise, we need more oxygen

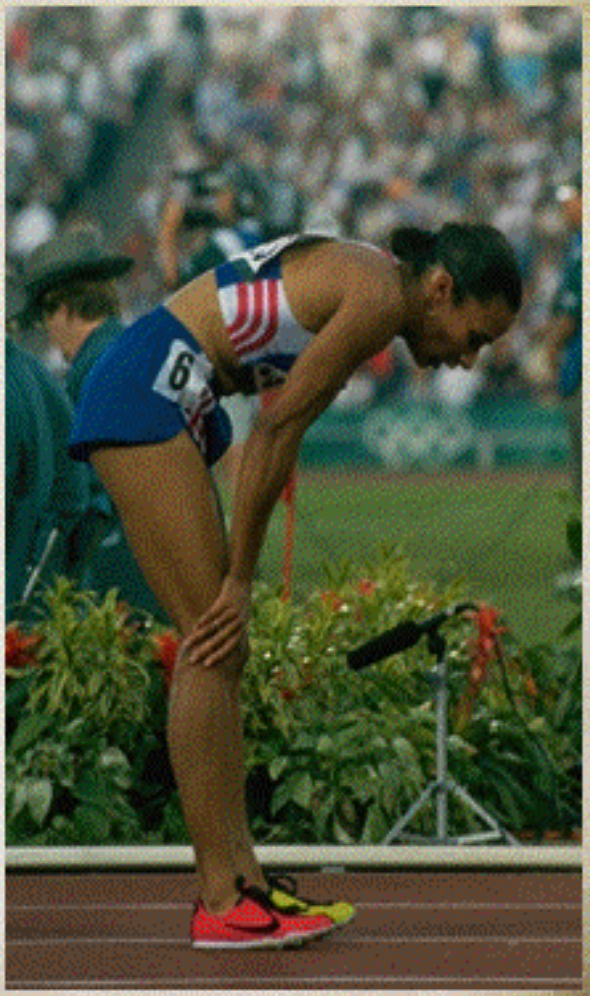
The respiratory system and exercise

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.



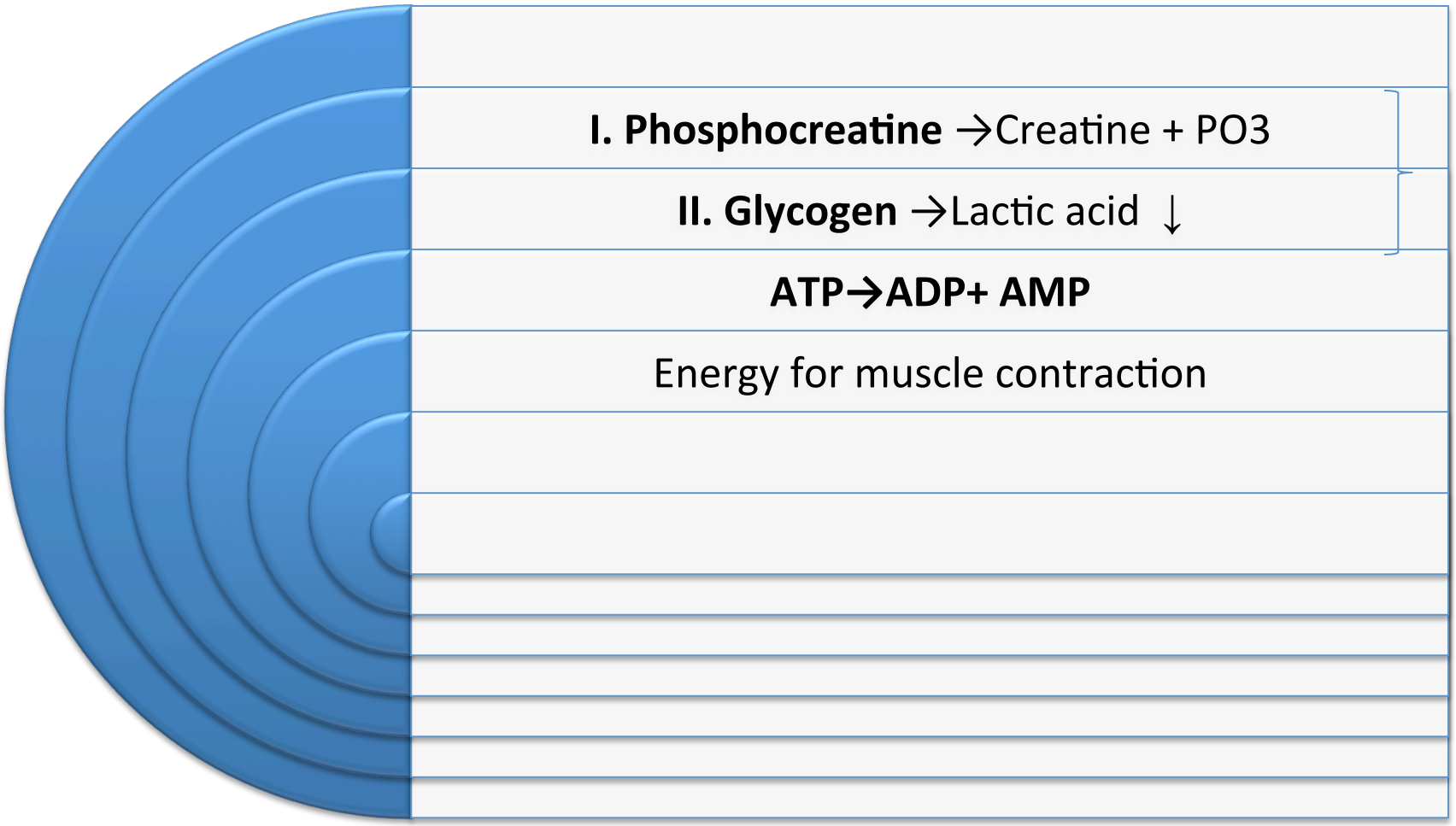
Gasping for air after a hard race, to repay the oxygen debt

Runners at the end of a race are often left gasping for air

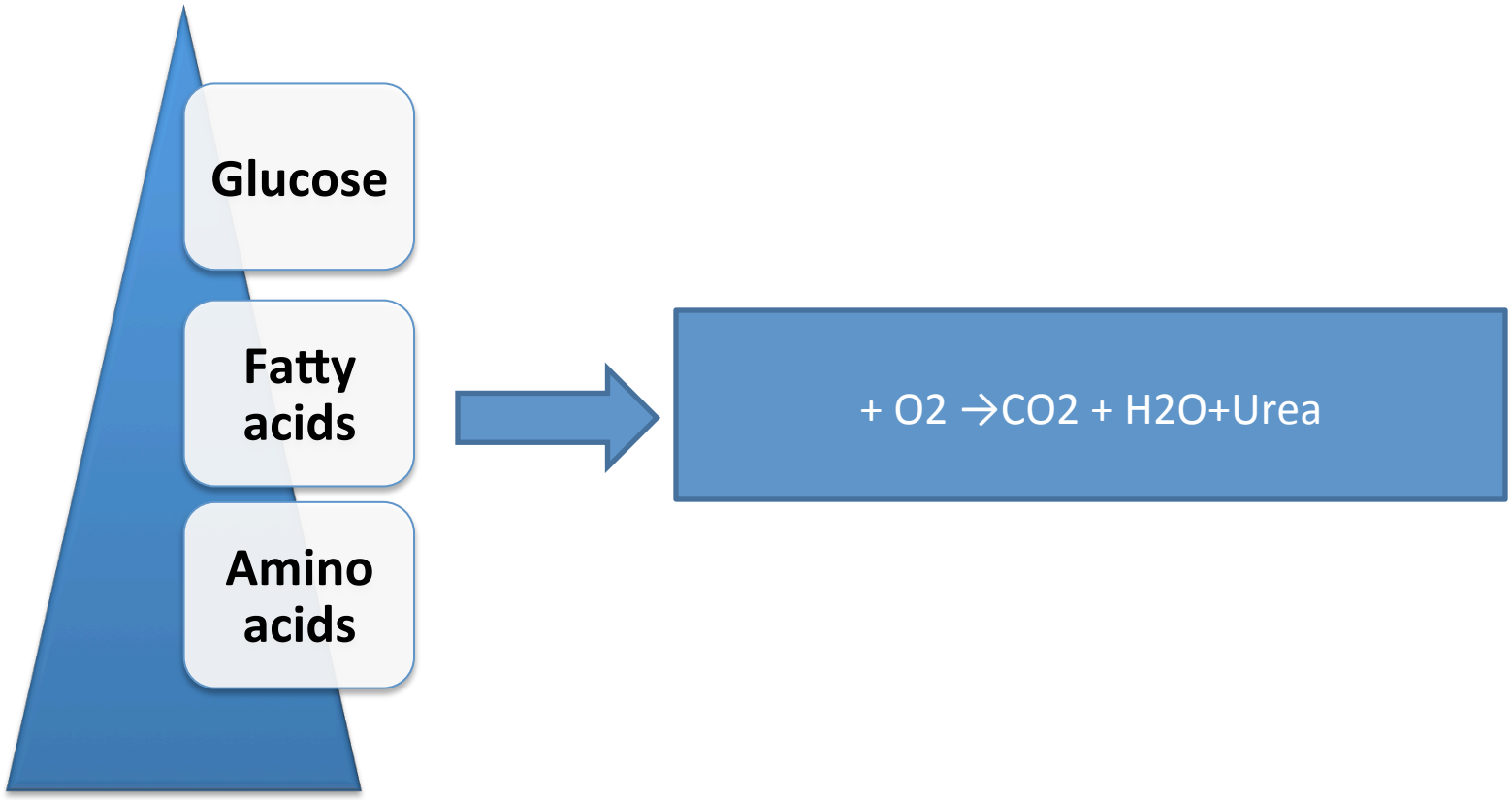
What cause intense ventilation during exercise?

- 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.

Anaerobic energy sources



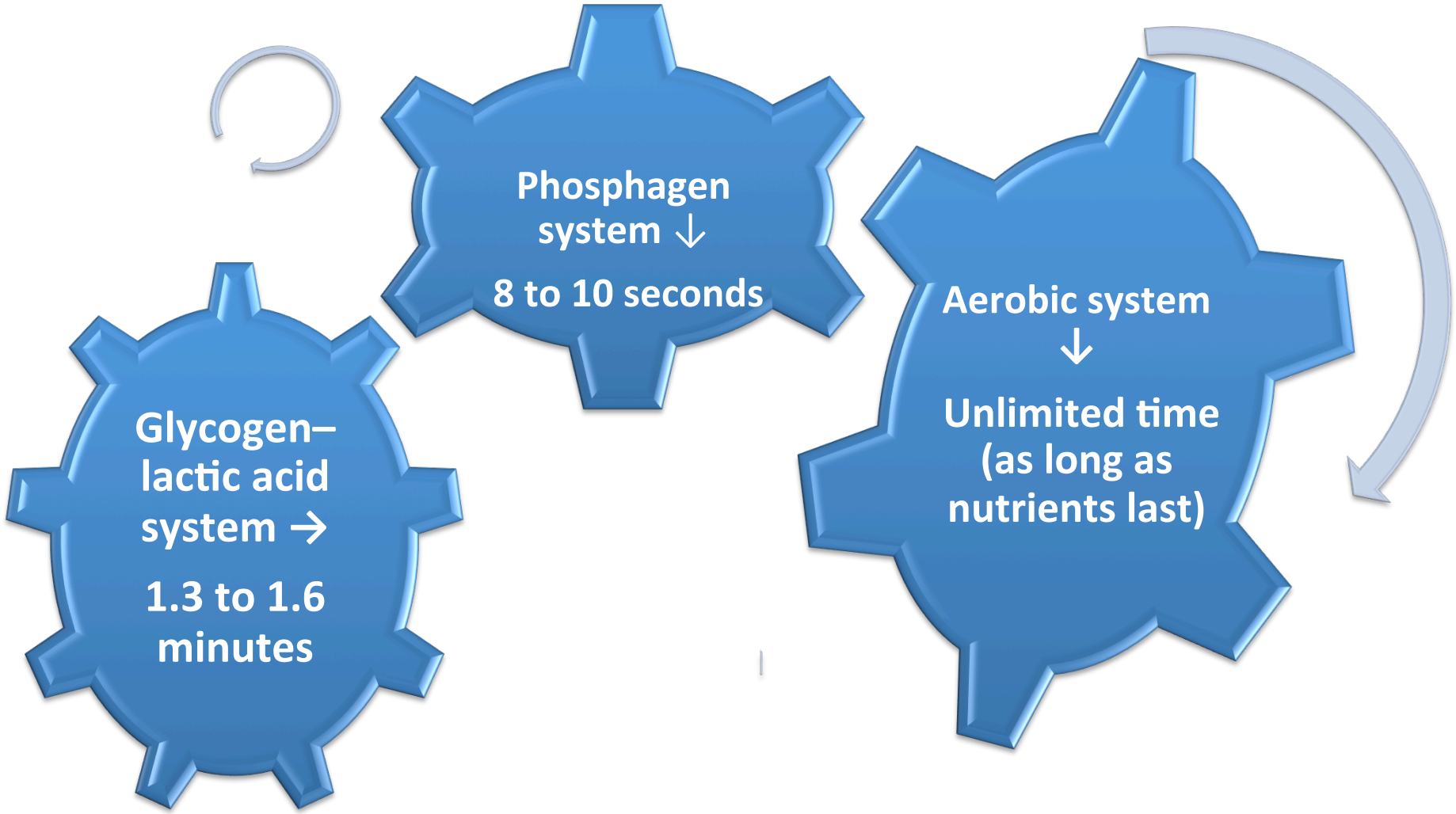
Aerobic system



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.