# Exercise Physiology

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หน่วยเวชศาสตร์ฟื้นฟู โรงพยาบาลปิยะเวท

# แพทย์เวชศาสตร์ฟื้นฟู

- Experts at diagnosing and treating pain
- Restore maximum function lost through injury, illness or disabling conditions
- Treat the whole person, not just the problem area
- Lead a team of medical professionals
- Provide non-surgical treatments
- Explain your medical problems and treatment plan
- Work not only on treatment but also prevention

# Outline

- **Immediate energy: The ATP-PCr System**
  - Use stored ATP in muscle cells
- **Non-oxidative energy: The Lactic Acid System**
  - Glycolytic pathway, give 2 ATPs/glucose
  - No $O_2$, Lactic acid production
- **Oxidative energy : The Aerobic System**
  - Need $O_2$ in mitochondria
  - Produce 36 ATPs/glucose

## Components of Daily Energy Expenditure

**Resting Metabolic Rate (~60-75%)**

- sleeping metabolism
- basal metabolism
- arousal metabolism

**Thermic Effect of Feeding (~ 10%)**

**Thermic Effect of Physical Activity (~15-30%)**

# Immediate Energy: The ATP-PCr System

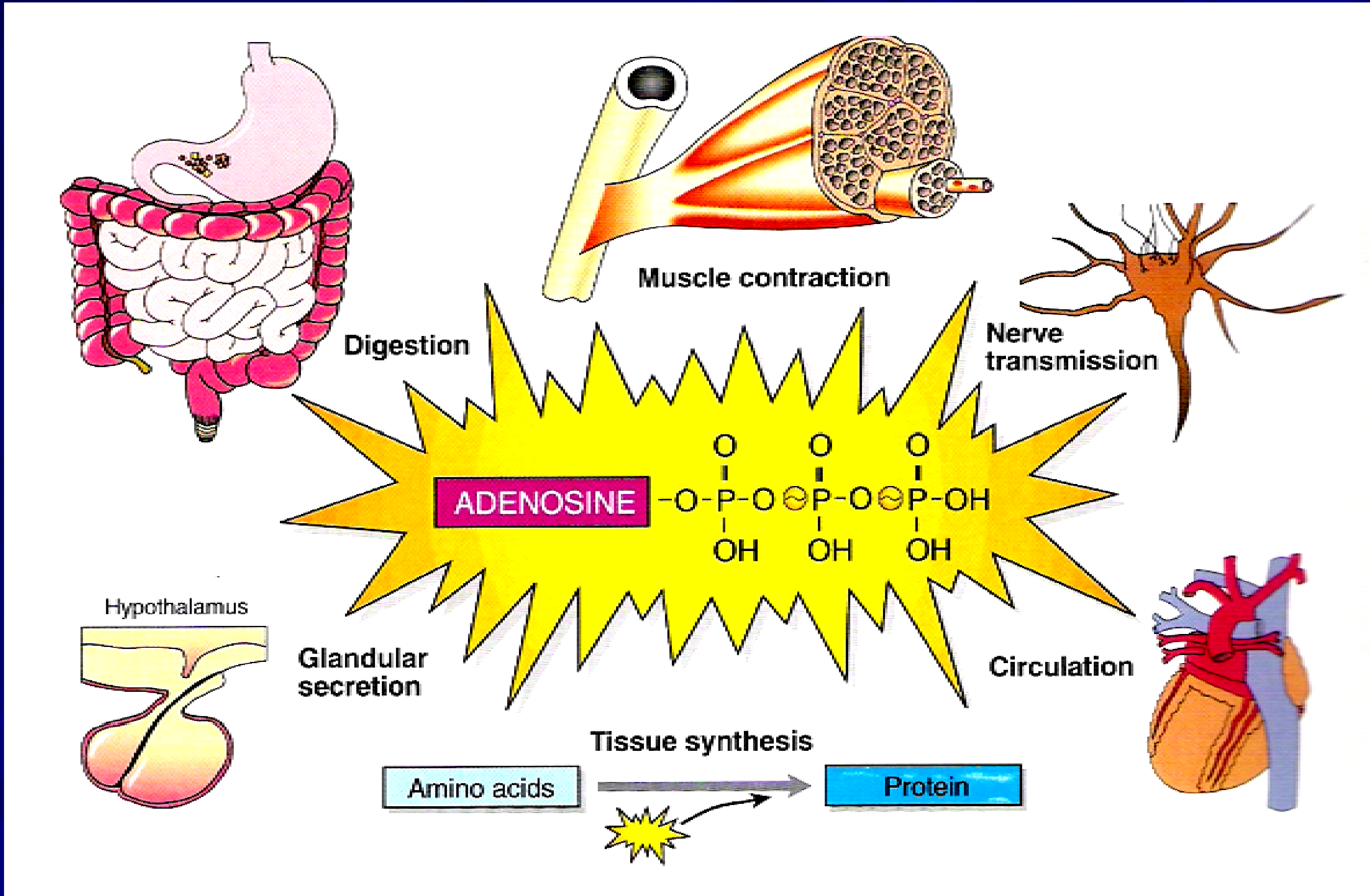
**The quantity of intramuscular phosphagens significantly influences ability to generate "all-out" energy for 6 – 8 seconds**

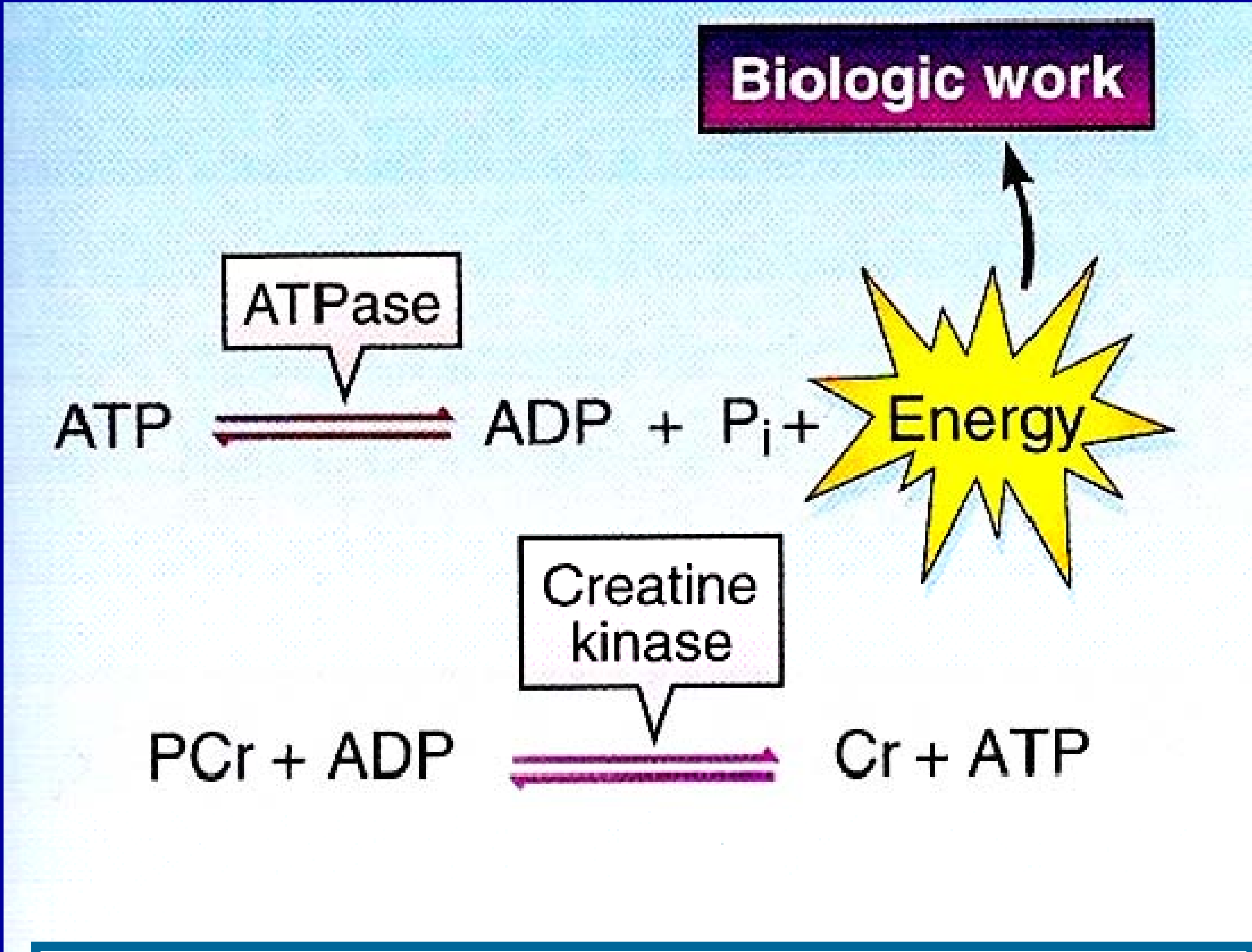
# ATP hydrolysis

$$ATP + H_2O \xrightarrow{ATPase} ADP + Pi - 7.3 \text{ kcal per mol}$$

**ATP: high energy phosphate compound**

# ATP → the cell's "energy currency"





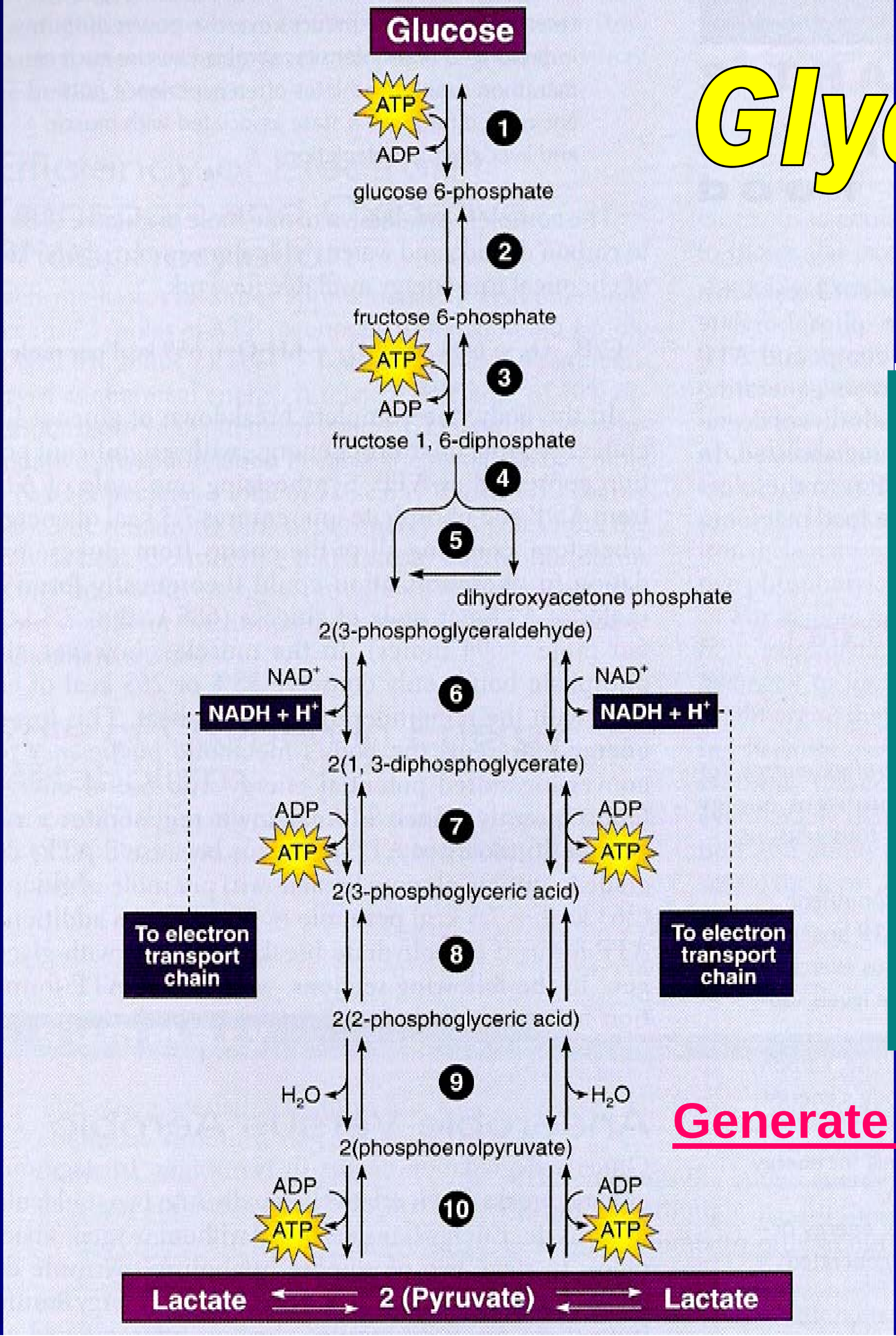

**Phosphocreatinine: The Energy Reservoir**

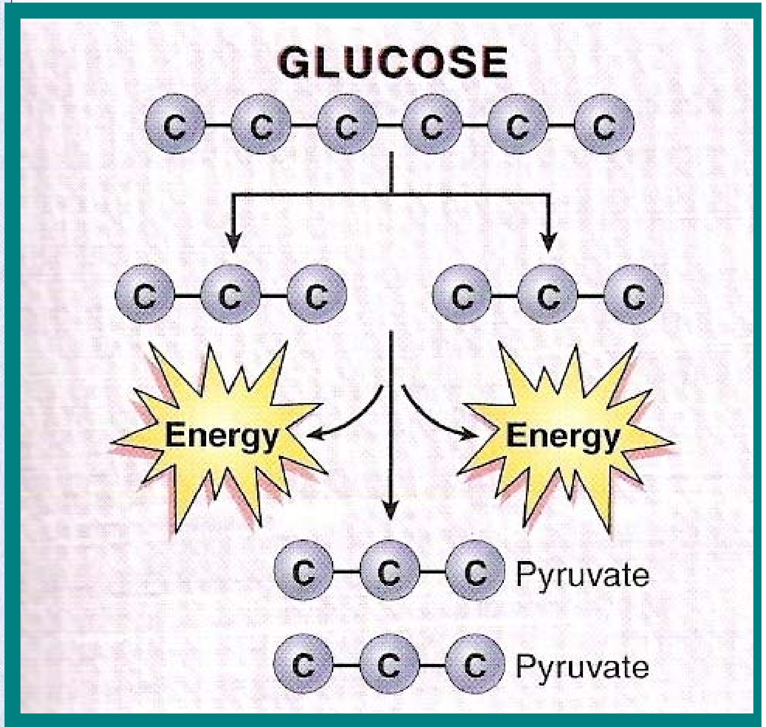
# Short-Term Energy: The Lactic Acid System

During intense exercise, intramuscular stored glycogen provided the energy source to phosphorylate ADP during anaerobic glycogenolysis, forming lactate

All-out activity for 60 – 90 seconds

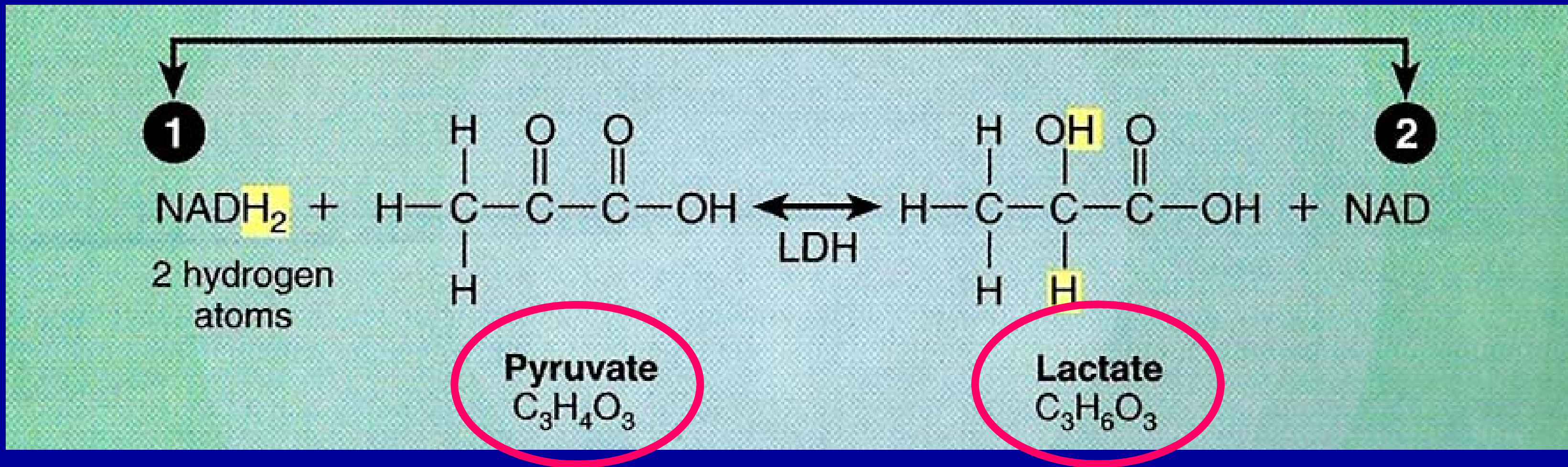
# Glycolysis



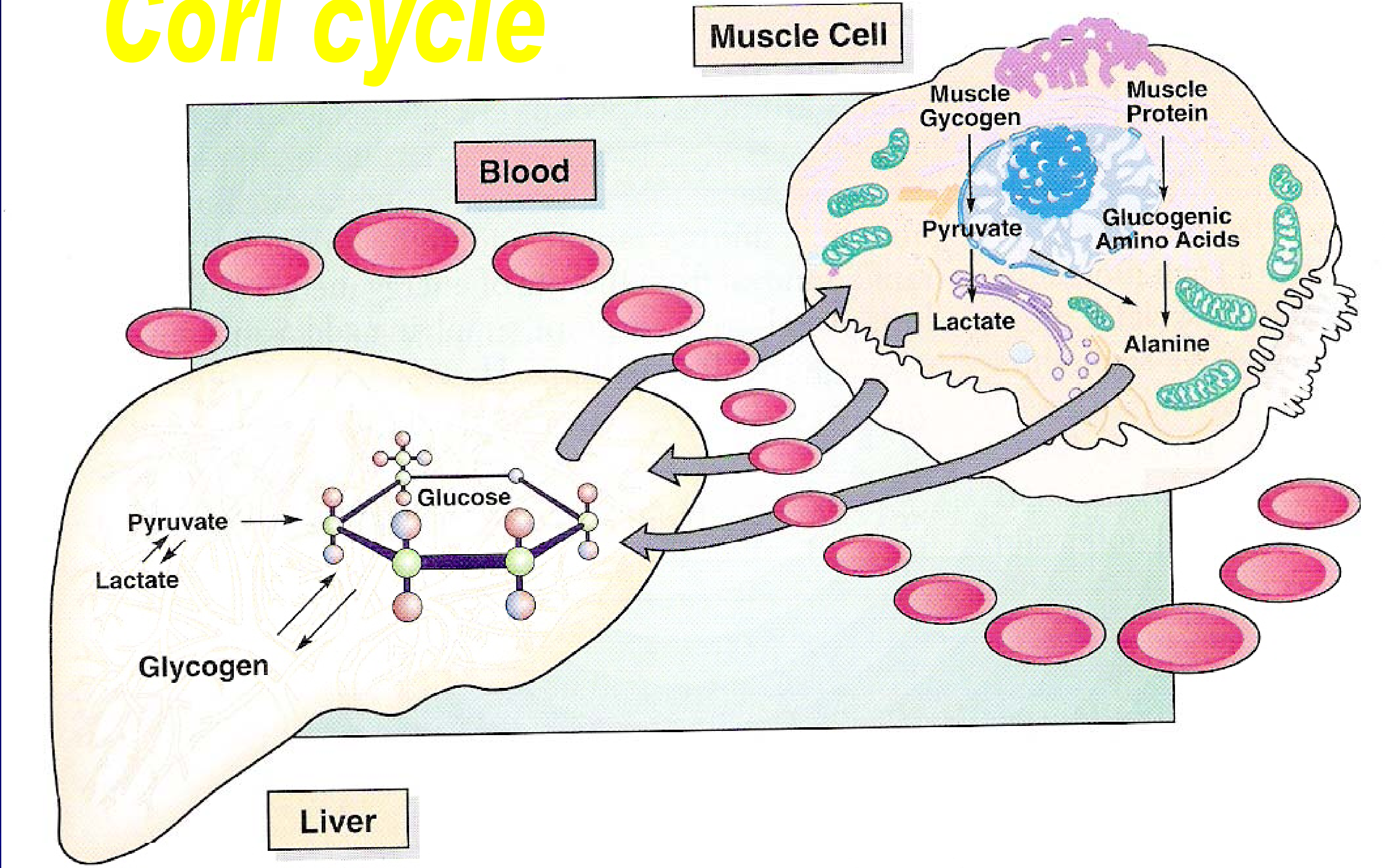

Generate net gain of 2 ATP molecules

# Pyruvate + 2H → Lactate




**Lactate forms when excess hydrogens from NADH combine temporarily with pyruvate: Storage bin**

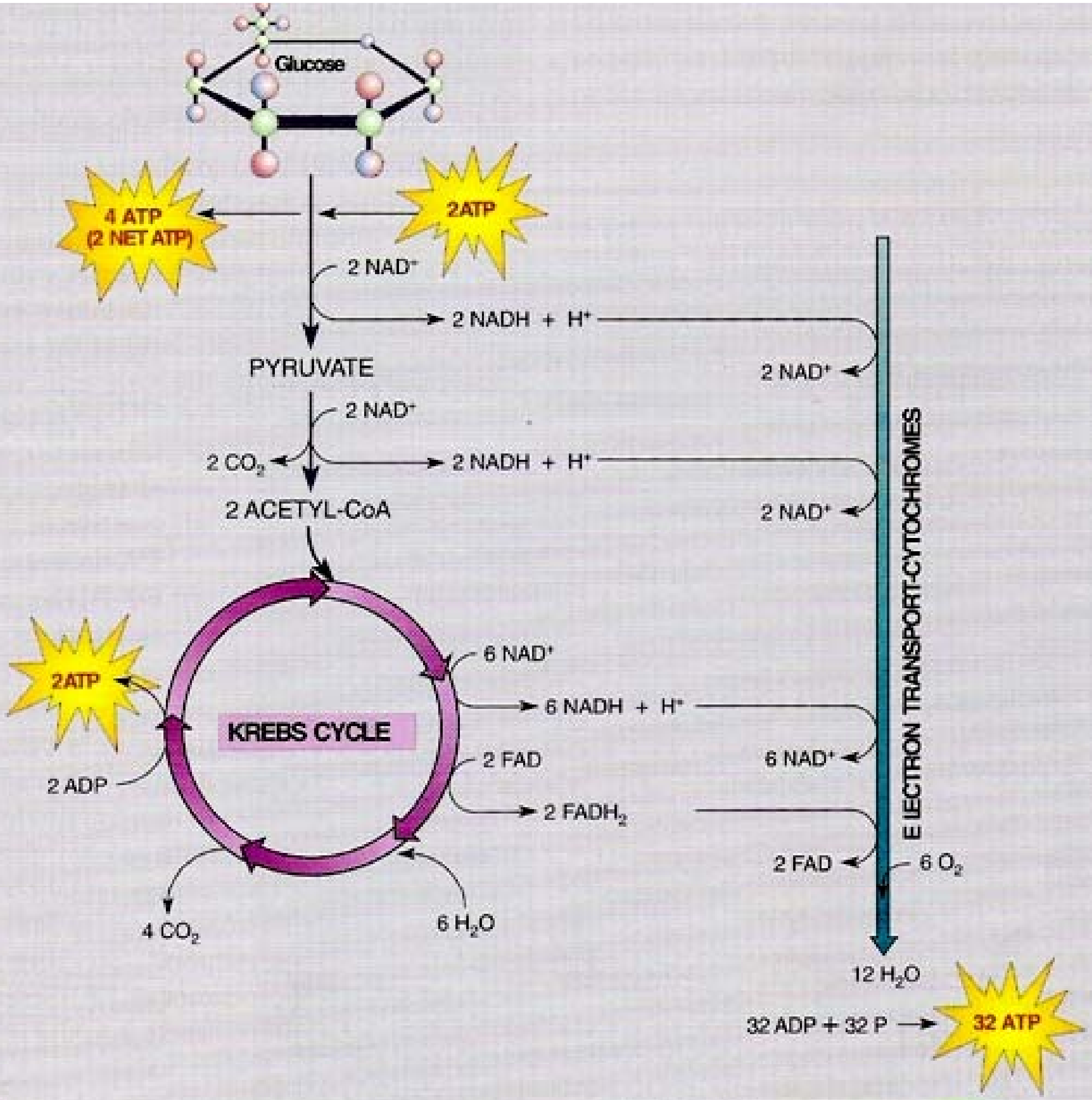
# Cori cycle



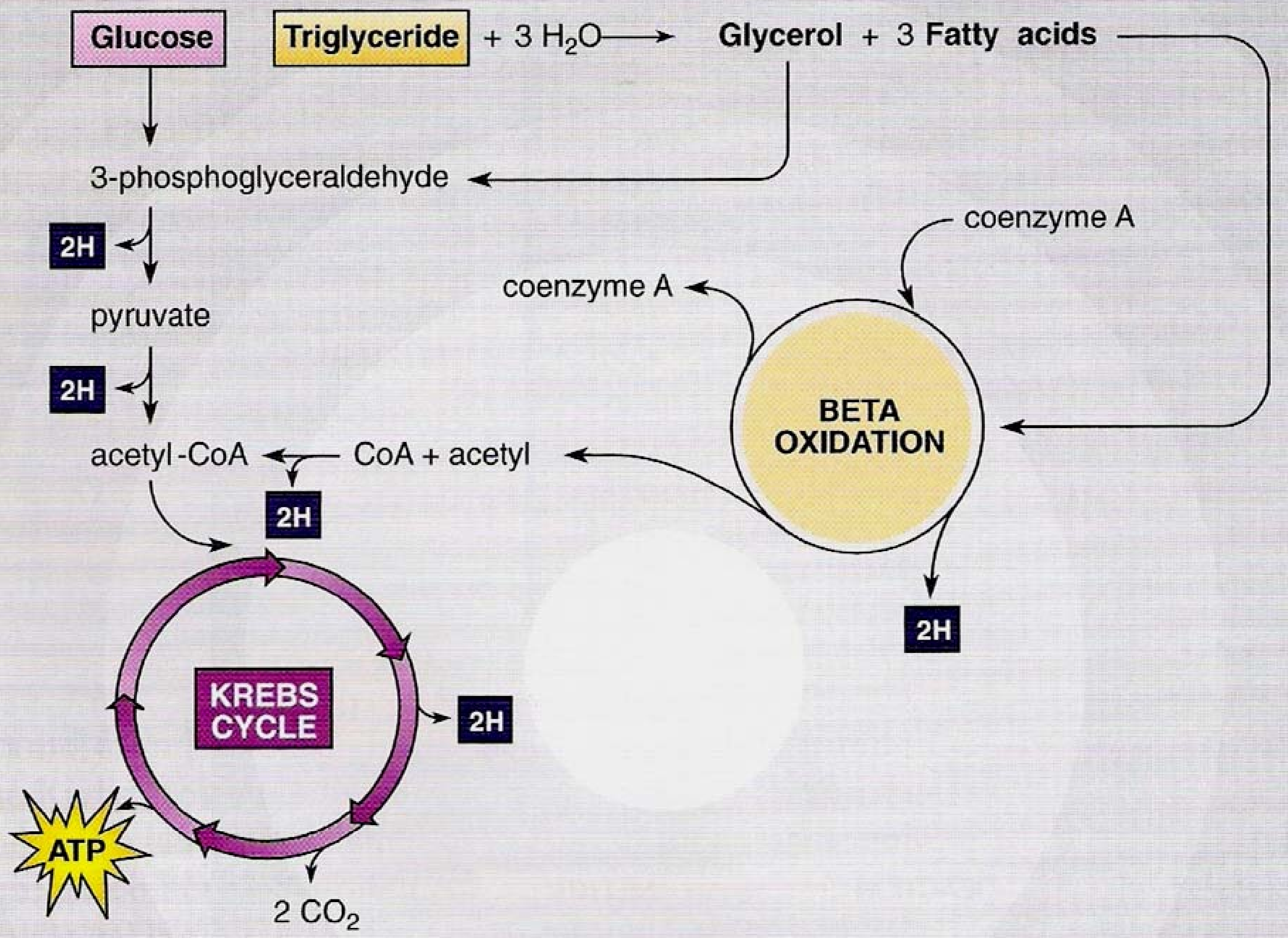

**Muscle glycogen → Glucose → Pyruvate → Lactate (which travels to the liver) → Glucose (which returns to muscle) → Muscle glycogen**

# Long-Term Energy: The Aerobic System

provide for the greatest portion of energy transfer, particularly when exercise duration extendes longer than 2 to 3 minutes

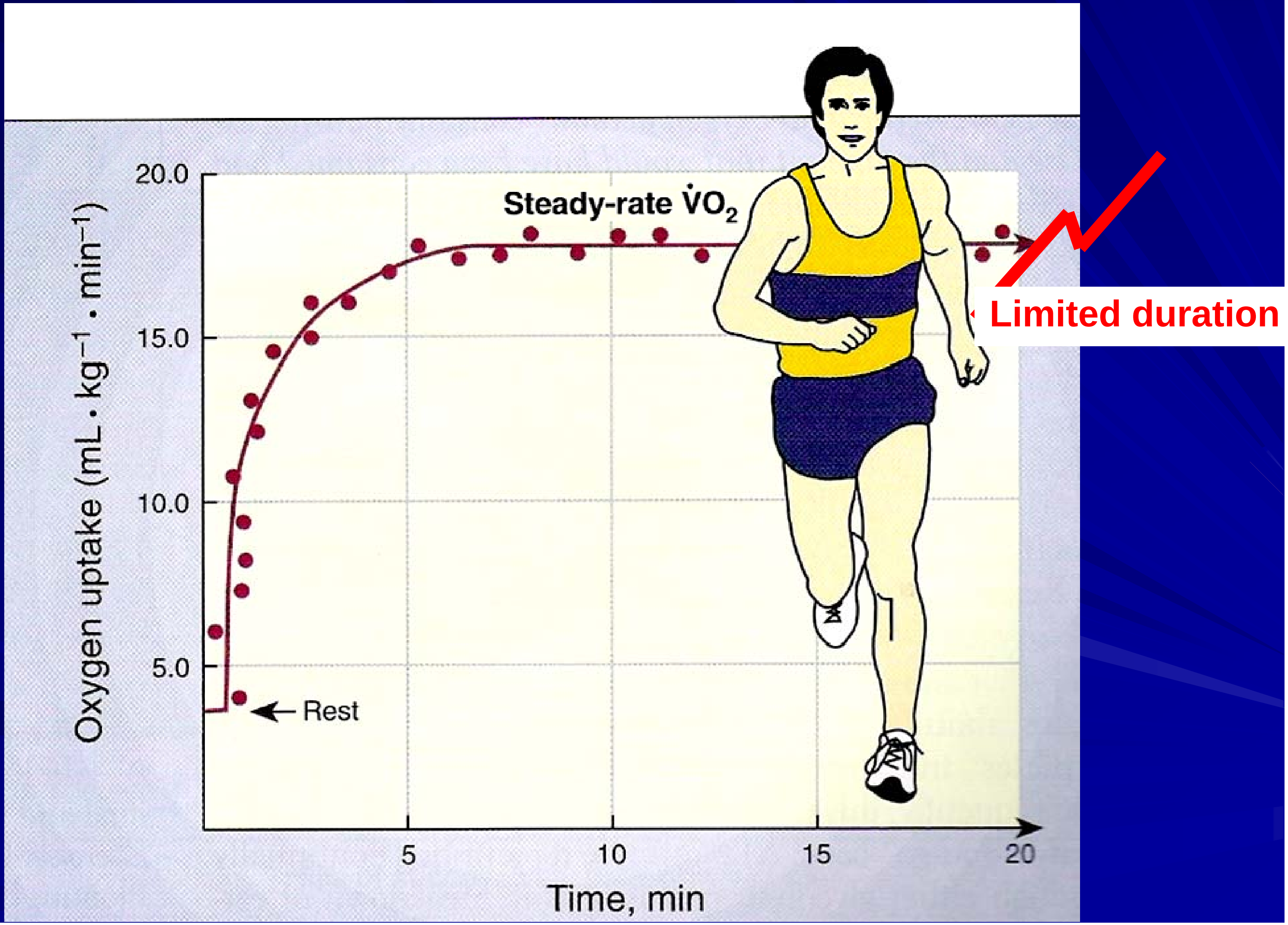



| SOURCE | REACTION | NET ATP |
|---|---|---|
| Substrate phosphorylation | Glycolysis | 2 |
| 2 $H_2$ (4 H) | Glycolysis | 4 |
| 2 $H_2$ (4 H) | Pyruvate → Acetyl-CoA | 6 |
| Substrate phosphorylation | Krebs cycle | 2 |
| 8 $H_2$ (16 H) | Krebs cycle | 22 |
| | | TOTAL : 36 ATP |




| Source | Pathway | ATP yield per molecule neutral fat |
|---|---|---|
| 1 molecule glycerol | Glycolysis + Krebs cycle | 19 |
| 3 molecules of 18-carbon fatty acid | Beta oxidation + Krebs cycle | 441 |
| | | TOTAL: 460 ATP |

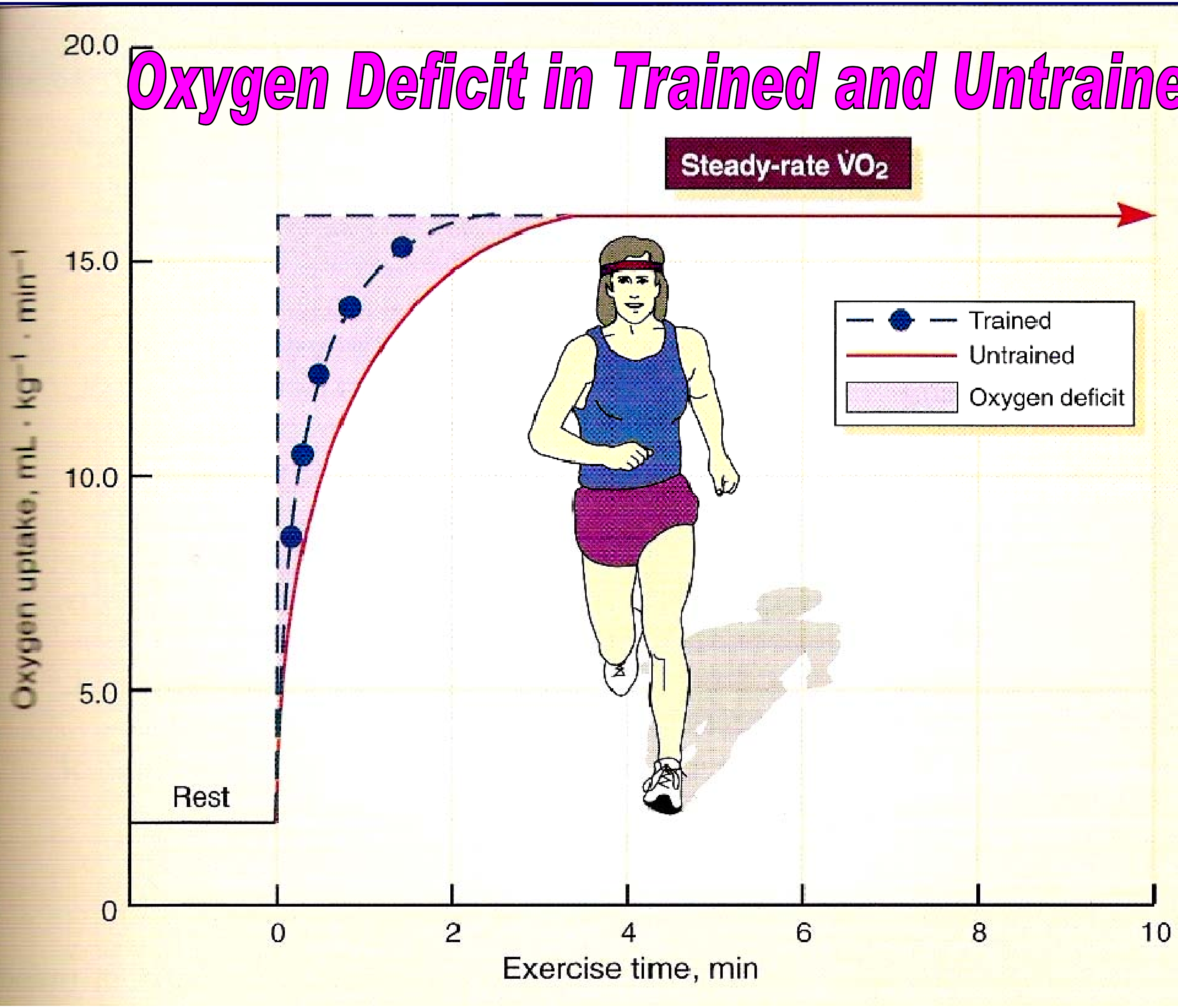
# Oxygen Uptake During Exercise

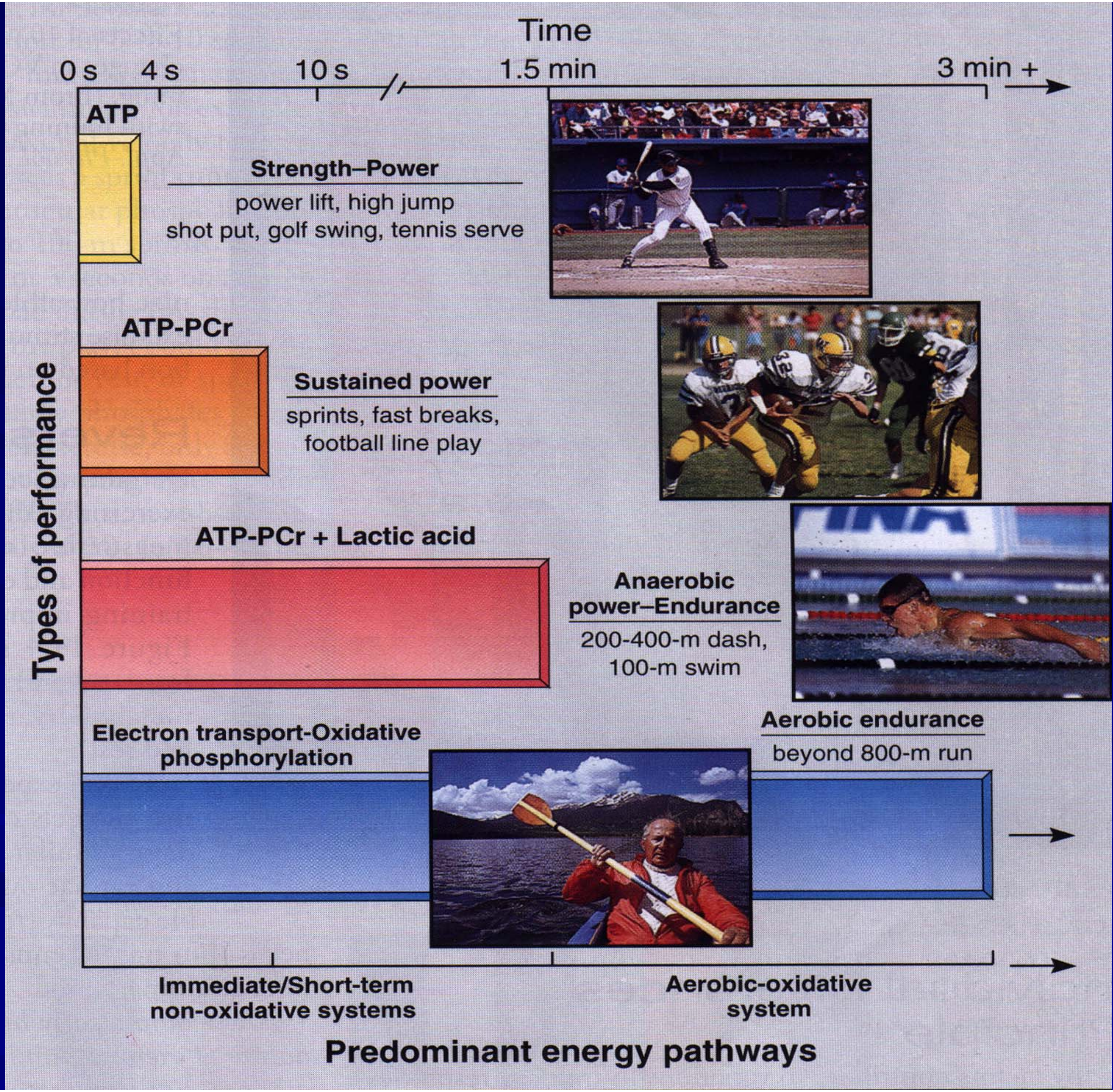


# Oxygen Deficit

The difference between total oxygen actually consumed during exercise and the amount that would have been consumed had a steady -rate, aerobic metabolism occurred immediately when exercise began

# Oxygen Deficit in Trained and Untrained





Time
0 s
4 s
10 s
1.5 min
3 min +
ATP
Strength–Power
power lift, high jump
shot put, golf swing, tennis serve
ATP-PCr
Sustained power
sprints, fast breaks,
football line play
ATP-PCr + Lactic acid
Anaerobic
power–Endurance
200-400-m dash,
100-m swim
Electron transport-Oxidative
phosphorylation
Aerobic endurance
beyond 800-m run
Types of performance
Immediate/Short-term
non-oxidative systems
Aerobic-oxidative
system
Predominant energy pathways

# Cardiovascular System & Exercise

- Stroke volume (SV)
- Cardiac output (Q) = SV x HR
- Systole & Diastole
- Coronary artery from Aorta
- Heart blood supply is at diastole

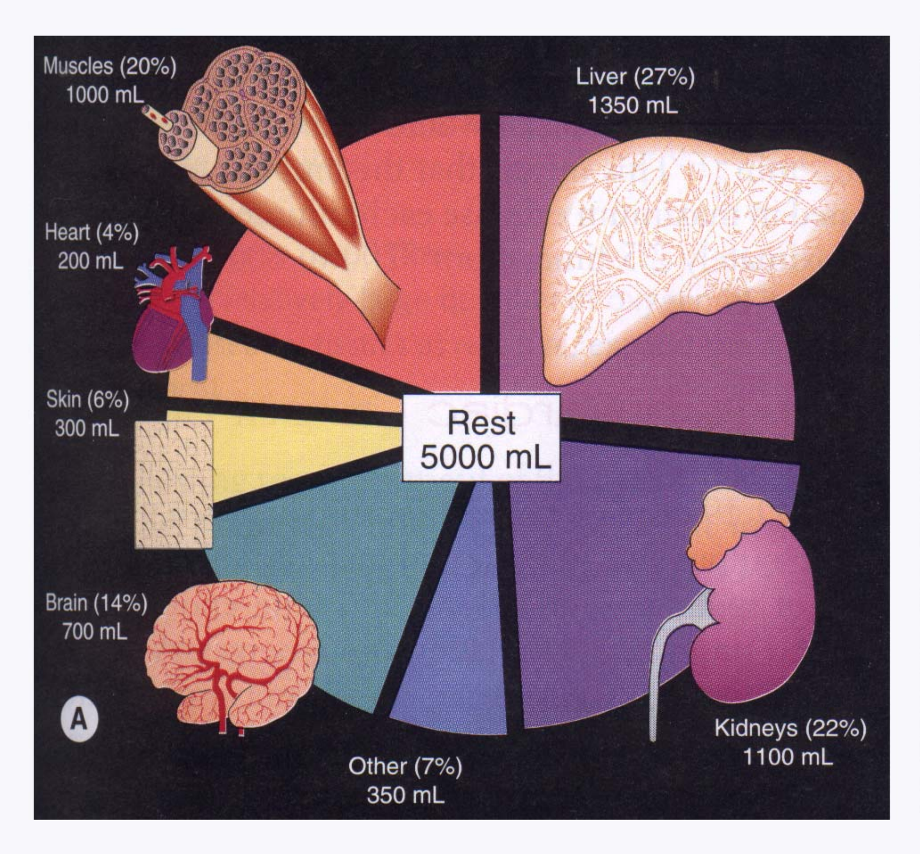
# Stroke Volume

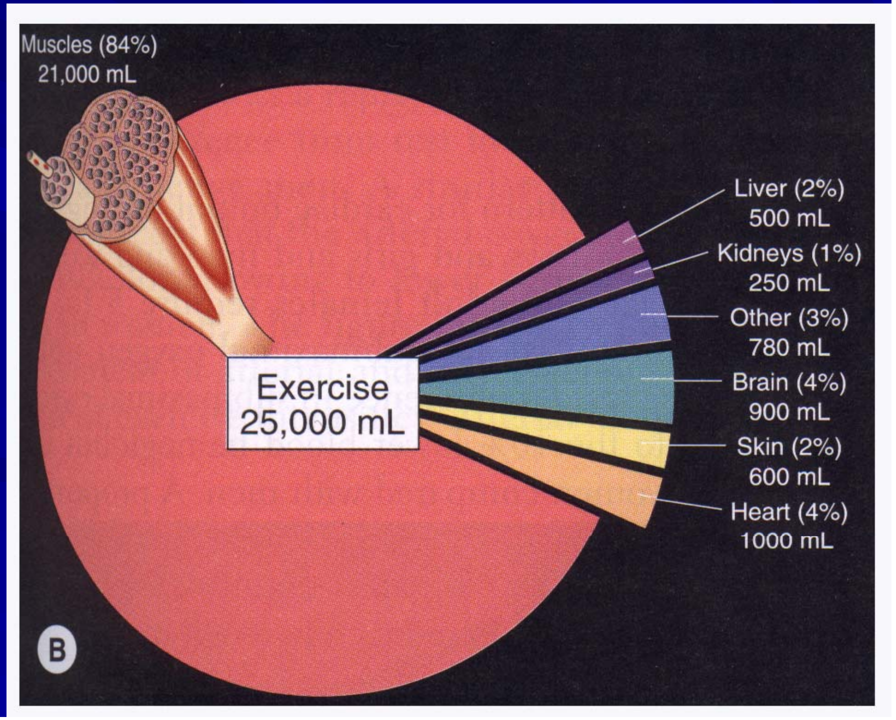
- More than twice increase with Ex.
- Increase up to 40-60%$VO_2$max then plateau until exhaustion.
- Supine > Upright position
  - Most at rest
  - Least at peak intensity

# Cardiac Output & Bl. Distribution

- Cardiac Output
  - –Initially increasing both HR & SV
  - –> 40-60%Max, inc. HR
- Blood distribution
  - –15-20% to muscles at resting
  - –80-85% to muscles when exercise

# Blood Pooling in Exercise



# Blood Pressure

- Inc. systolic BP due to more CO
- Little change to diastolic BP, >15 change is abnormal
- UE exercise> BP > LE exercise
- Prolong EX, systolic BP may slightly dec.
- Hypotensive recovery response

# Estimate of Myocardial Work

- Myocardial Oxygen utilization
  - Extract $O_2$ near maximum at rest (70-80%)
  - Coronary blood flow inc. 4-6 times in vigorous exercise
- Rate-pressure product / Double product
  - RPP = SBP x HR
  - Tension dev. within the myocardium
  - Myocardial contractility
  - Heart rate

# Blood & Circulation

- Less blood volume due to leakage to tissue
- Lost fluid volume with sweat
- Increase blood viscosity
- Less blood volume impair performance
- Hematocrit > 60%
- Blood pH is more acid

# THE END