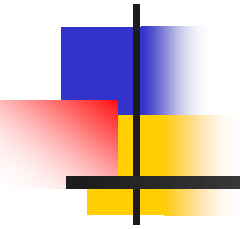


# ENERGY

Nutrition Sciences Nutr 2901

# ISSUES TO BE COVERED

- Energy processes
- Energy requirements
- Energy in the diet
- Measurement of energy expenditure
- Energy balance
  - undernutrition
  - overnutrition

# David Blane London, 2003

# IRISH HUNGER STRIKERS 1981

**Sands**
**5 May 81**
**66 days**

**Hughes**
**12 May 81**
**59 days**

**O'Hara**
**21 May 81**
**61 days**

**McCreesh**
**21 May 81**
**61 days**

**McDonnell**
**8 July 81**
**61 days**

**Hurson**
**13 July 81**
**46 days**

**Lynch**
**1 Aug 81**
**71 days**

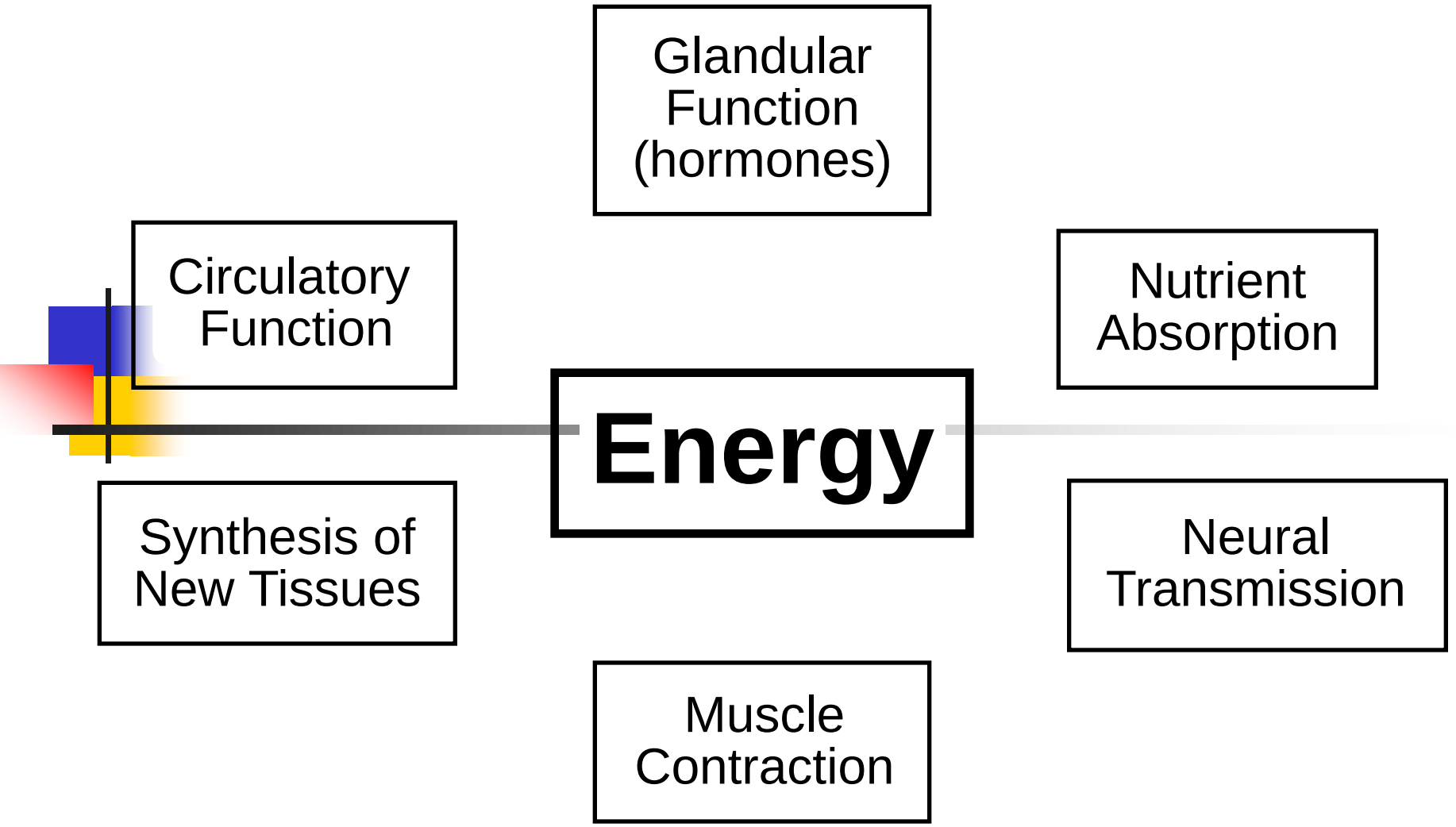
**Doherty**
**2 Aug 81**
**73 days**

**McElwee**
**8 Aug 81**
**62 days**

**Devine**
**20 Aug 81**
**60 days**

# FORMS OF ENERGY

- Solar
- Chemical
- Mechanical
- Electrical
- Thermal


Glandular Function (hormones)
Circulatory Function
Nutrient Absorption
Energy
Synthesis of New Tissues
Neural Transmission
Muscle Contraction

# First Law of Thermodynamics

- Fundamental biological principle—energy is not produced, consumed, or used up. It is merely transformed from one form into another
- This Law illustrates the principle of the *Conservation of Energy*

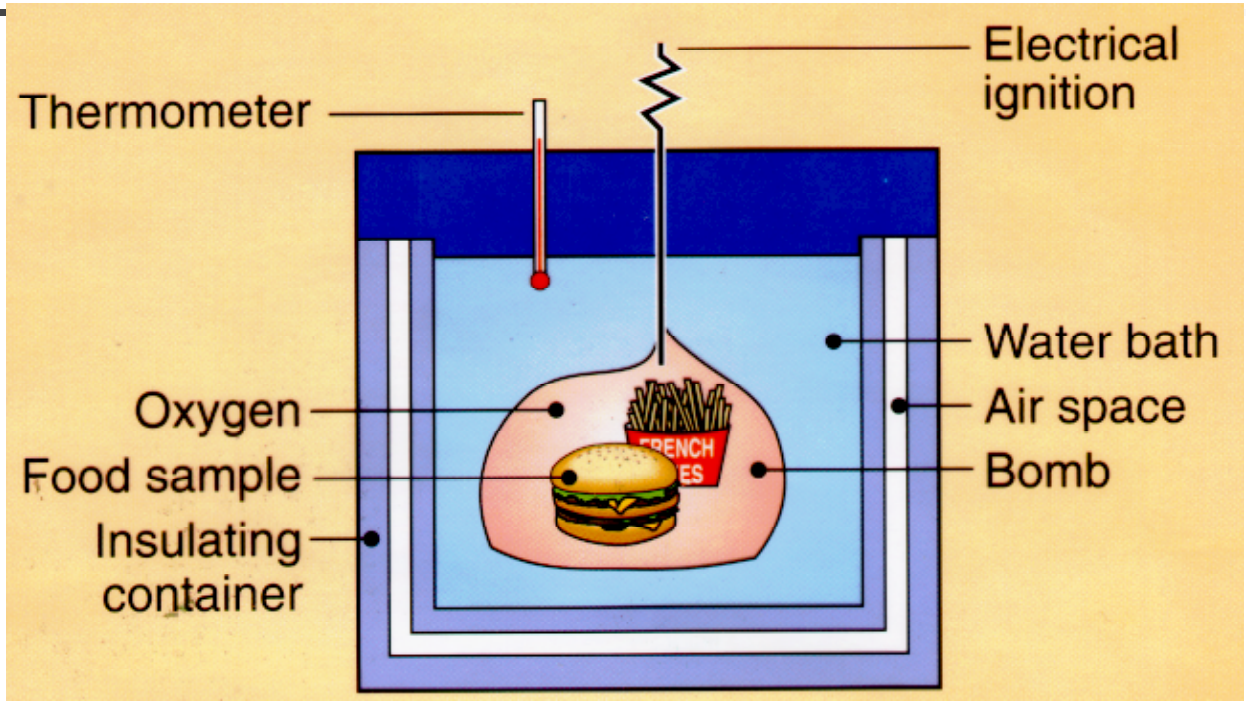
# Energy = Energy = Energy

- All forms of biological work are powered by the direct *transfer* of chemical energy
- Chemical energy ->
  mechanical work (muscle contraction)
  electrical work (ionic gradients)
  chemical work (synthesis of new molecules)
  Thermal energy (dissipation of heat)

# Food Is a Source of Chemical Energy

- Macronutrients in food can be broken down to liberate energy
- Not all energy in food available to body
  - Not all absorbed
  - Not completely metabolised (urea)
  - Inefficiencies in processing and storage

# Bomb Calorimeter



# What Is A Joule or a Calorie?

**A Joule or a Calorie Is A Measure Of Energy For Both Food And Physical Activity**

**Definitions:**

A Calorie is the Amount of Heat Required to increase 1 kg of Water by 1 Degree Centigrade (use kcal)

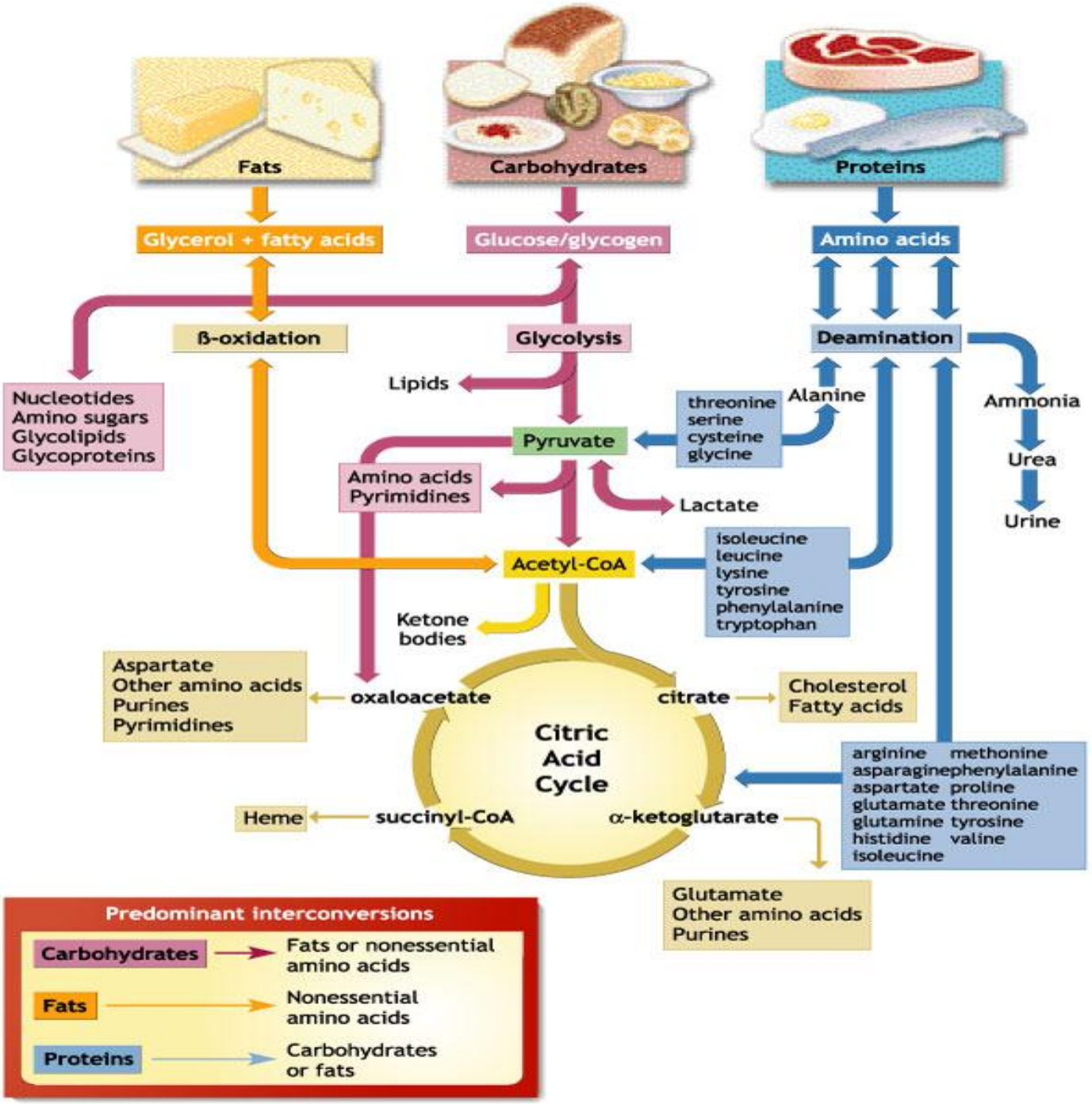
A joule is the energy used when 1kg is moved 1m by a force of 1 newton (use kj)

1calorie (kcal)= 4.184 kj

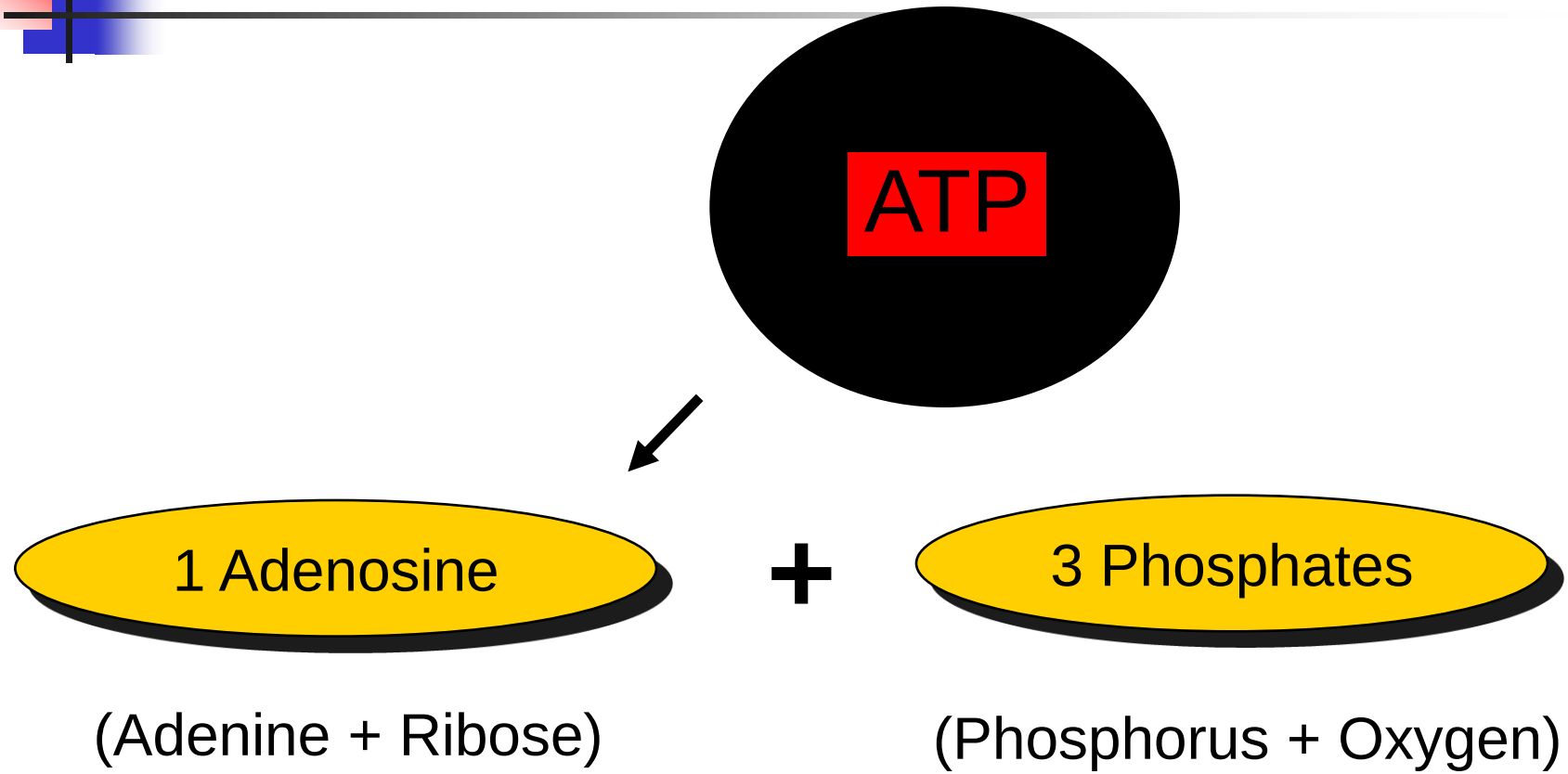
# Energy In Food

| | Bomb Calorimeter | | Net Value to Body |
|---|---|---|---|
| **CHO**: | 17.5 | → | 17.3 kj/g |
| **FAT** | 39.1 | → | 37.1 kj/g |
| **PROTEIN** | 22.9 | → | 15.9kj/g |
| | (UREA) | | |
| **Alcohol** | 29.8 | → | 29.8 kj/g |
| **Fibre** | ? | → | * 4 KJ/g |

# The Metabolic Mill



# The "Energy Currency"



# ATP Hydrolysis

$$ATP + H_2O \text{ --------> } ADP + Pi + \text{-7.3 kCal/mole}$$

~P -P

# Cellular energy stores

- ATP
- Creatine phosphate
- Glycogen
- Triglycerides

# Measurement of energy expenditure

**Direct Calorimetry**

Measure heat production in an airtight Chamber/suit

## Indirect Calorimetry

Measure oxygen uptake, carbon dioxide production

1. Open-circuit: inhale ambient air. Spirometers, meteorological balloons, computer interfaced,
2. Closed-circuit: inhale and exhale from tank

# Principles of indirect calorimetry

- Food $+O_2$ ->heat + $CO_2$ + $H_2O$
- EE(kj)=$16.318VO_2$+$4.628VCO_2$- 9.079N (g)
- Respiratory Quotient can be assessed
- ** Sealed chamber – all food entering and waste leaving is measured
- **Urinary N measured

**- whole body chambers

# Respiratory Quotient (RQ)

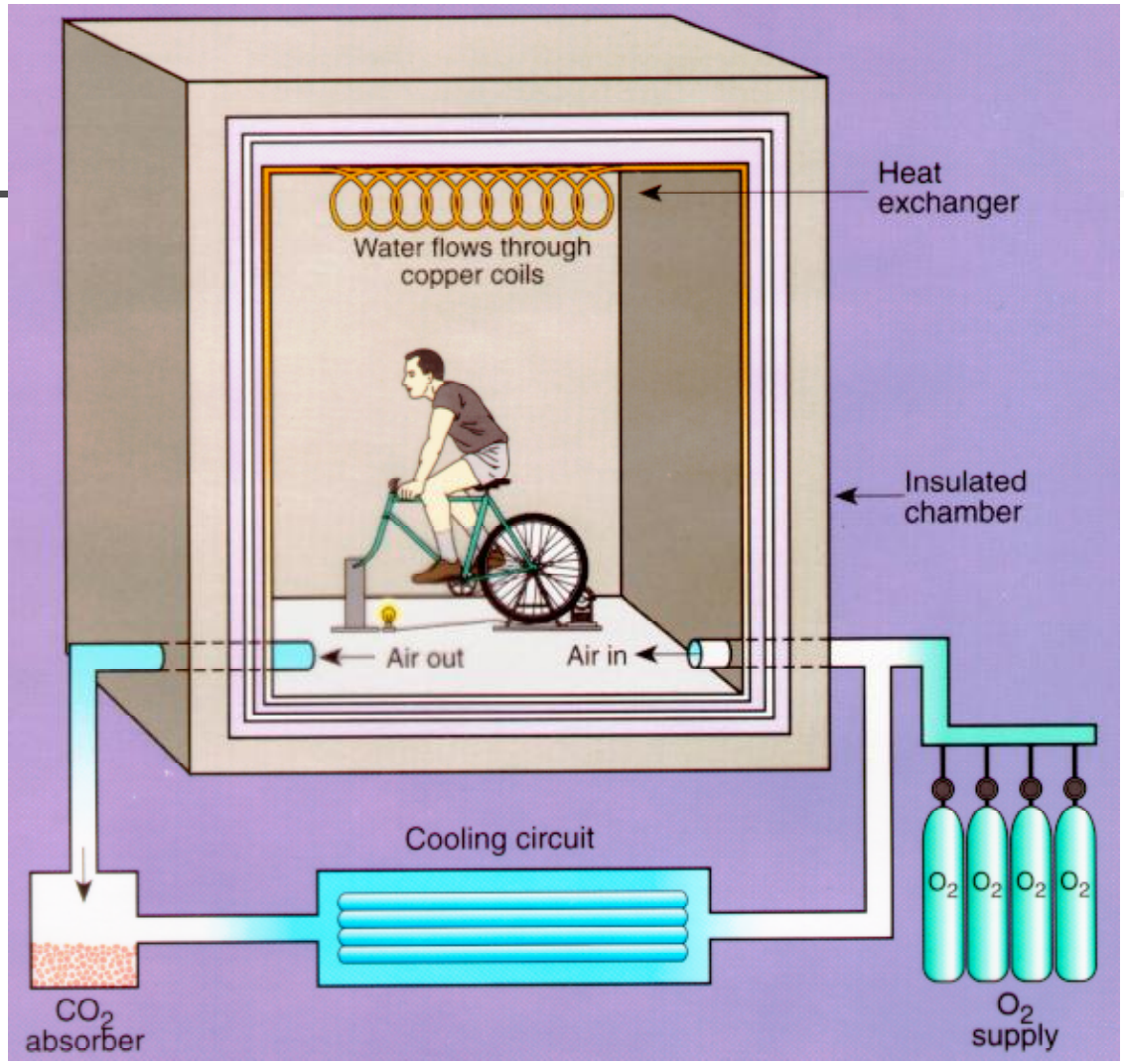
- Ratio of $VCO_2/VO_2$
- Guide to the mixture of nutrients being oxidised
- RQ Fat – 0.7, Protein- 0.81, CHO – 1.0 alcohol – 0.66
- Avoid alcohol and calculate protein metabolism from urinary N allow estimation of diet composition

# Equipment for indirect calorimetry

- Douglas bag
- Respirometer
- Ventilated hood
- Whole body chamber

# Oxygen Uptake Measurements

# Human Calorimeter



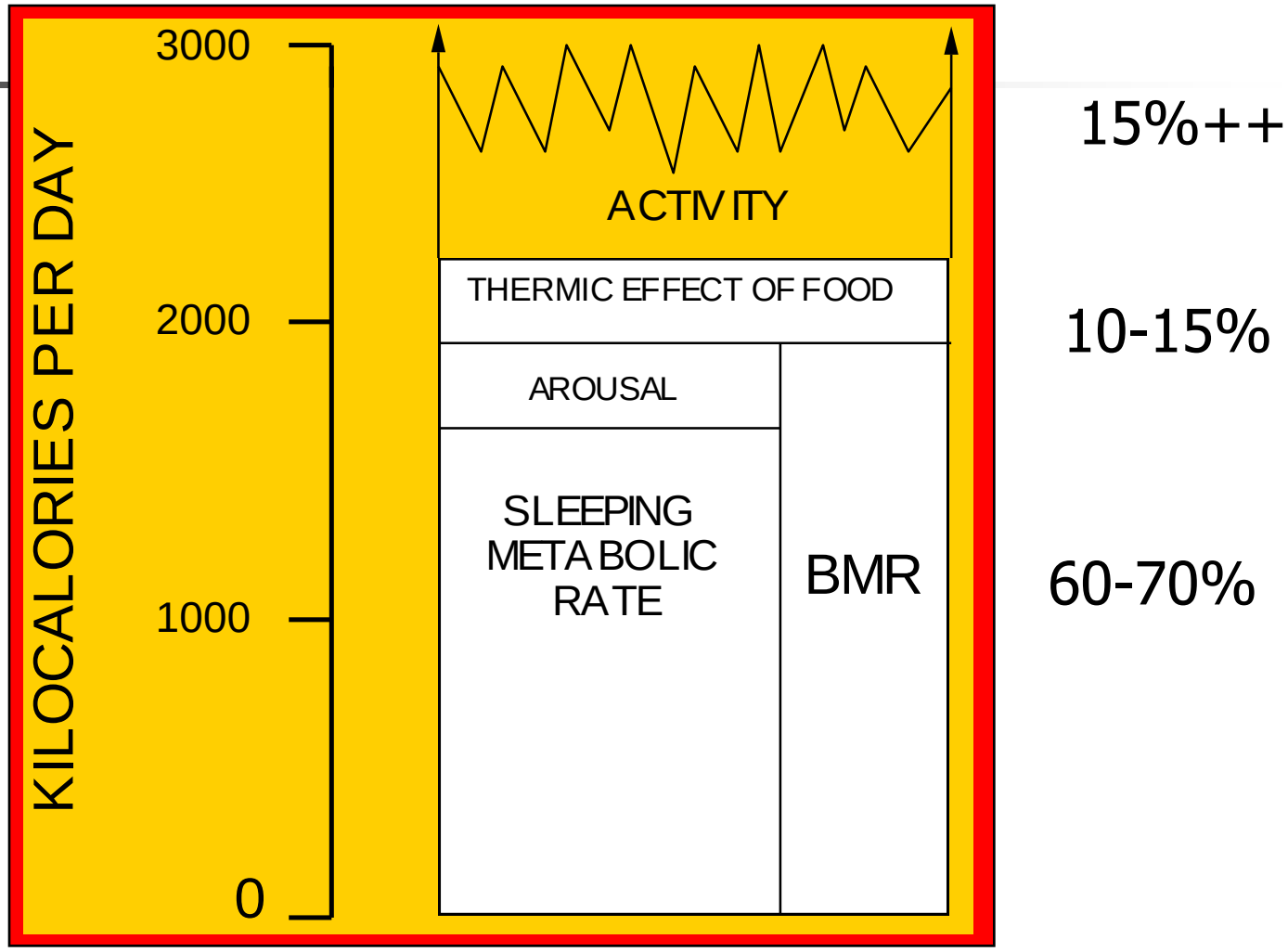
# Non-calorimetric estimation of energy expenditure

- Heart rate
- Doubly-labelled water
- Measures of physical activity
  questionnaires
  movement monitors

# Components of energy expenditure

- Basal metabolic rate
  Energy required to sustain essential metabolic functions (including growth)
- Thermic effect of food
  Obligatory
  Facultative
- Physical activity

# Components Of Daily Energy Expenditure



# Basal Metabolic Rate

Gender

Metabolic Changes

Age

Percent Fat vs. Muscle

Height, Weight

Surface Area

Climate

Hormones

Drugs

Approximate BMR (ages 20 to 40 years):

Women = 35 kcal/m2/hour
Men = 38 kcal/m2/hour

# Thermic effect of food

- Energy cost for
  - absorption
  - metabolism
  - storage
- Can vary with
  - type and composition of food
  - Autonomic nervous system activity
  - futile cycles -> heat
- Also known as “diet induced thermogenesis” DIT

# Estimating energy requirement

- Calculate energy intake
  very imprecise due to technical problems with measuring intake and under-reporting
- Estimate BMR and level of physical activity
  Prediction equations for BMR and estimate level of physical activity
- Measure BMR by indirect calorimetry and apply estimate of physical activity

# Estimating physical activity

- MET (Metabolic Equivalent Task) Factor
  estimates intensity of a single activity as a multiple of BMR
- PAL (Physical Activity Level) Factor
  estimates the total daily physical activity as a multiple of BMR

# MET associated with certain activities

| Activity | Description | MET |
|---|---|---|
| Walking | moderate pace | 3.2 |
| Cycling | Leisure medium pace | 7 |
| Walking up stairs | Usual pace | 8 |
| gardening | Moderate intensity | 4 |
| Shovelling snow | Medium-Heavy labour | 6 |

# Daily energy expenditure as multiples of BMR (PAL)

| | Males | females |
|---|---|---|
| Activity level | Average | Average |
| Bed rest | 1.2 | 1.2 |
| Very sedentary | 1.3 | 1.3 |
| Sedentary/maintenance | 1.4 | 1.4 |
| Light | 1.5 | 1 * 5 |
| Light-moderate | 1.7 | 1.6 |
| moderate | 1.8 | 1.7 |
| Heavy | 2.1 | 1.8 |
| Very heavy | 2.3 | 2.0 |

# Equations for estimating basal metabolic rate (BMR) in MJ/day

| Age group | Equation |
|---|---|
| **Males** | |
| 10-18 | 0.074wt + 2.754 |
| 18-30 | 0.063wt + 2.896 |
| 30-W | 0.048wt + 3.653 |
| over 60 | 0.049wt + 2.459 |
| **Females** | |
| 10-18 | 0.056wt + 2.898 |
| 18-30 | 0.062wt + 2.036 |
| 30-W | 0.034wt + 3.538 |
| Over 60 | 0.038wt + 2.755 |

# Recommended energy intakes for adults (MJ/day)

| 18-30 years | | Males | Females |
|---|---|---|---|
| Height (cm) | Weight (kg) | | |
| 150 | 50.6 | | 7.2-8.3 |
| 160 | 57.6 | 9.1-10.4 | 7.9-9.0 |
| 170 | 65.0 | 9.8-11.2 | 83-9.7 |
| 180 | 72.9 | 10.5-12.0 | 9.2-10.5 |
| 190 | 81.2 | 11.2-12.8 | 9.9-11.3 |
| 200 | 90.0 | 12.0-13.7 | |

# Classifying Activities By Energy Sources

## Anaerobic

- Brief actions
- High intensity
- Glycolysis
- 5% of ATP

## Aerobic

- Endurance
- Lower intensity
- Krebs cycle
- > 90% of ATP

# Aerobic vs Anaerobic

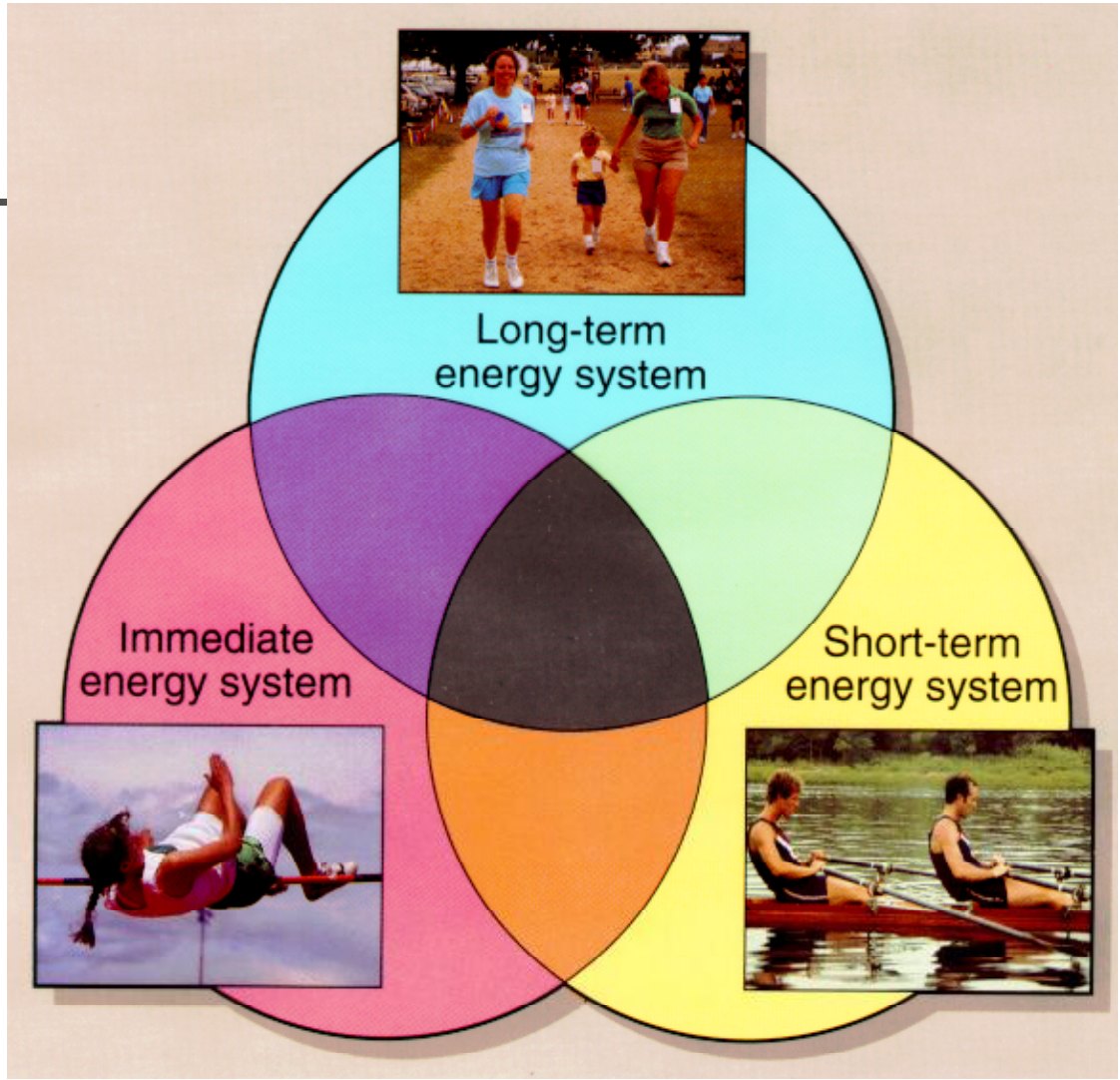
## Aerobic

- Walking
- Dancing
- Jogging
- Recreational swimming
- Tennis
- Hiking

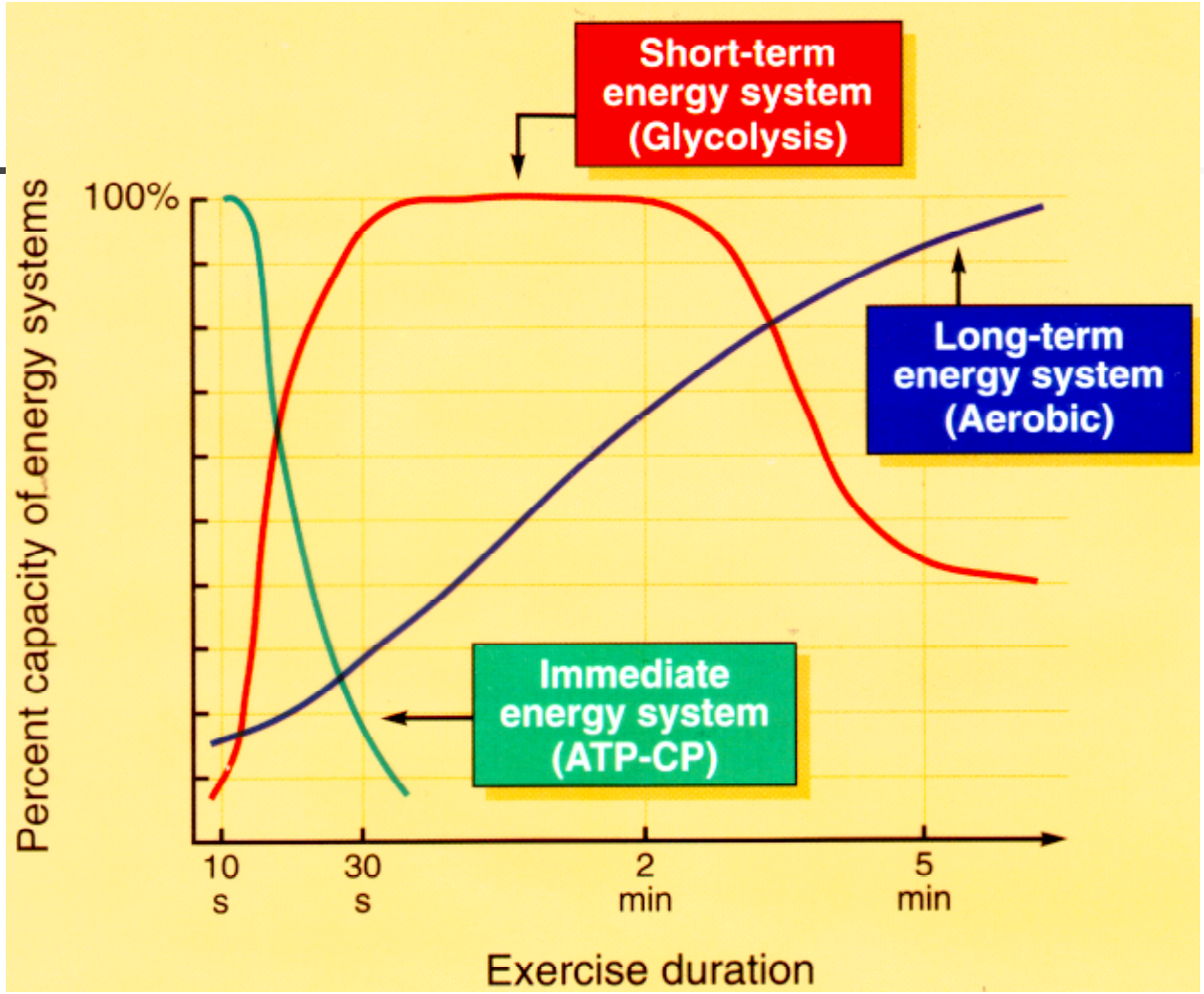
## Anaerobic

- Sprinting
- Lifting weights
- Jumping
- Chopping wood
- Activities of short duration

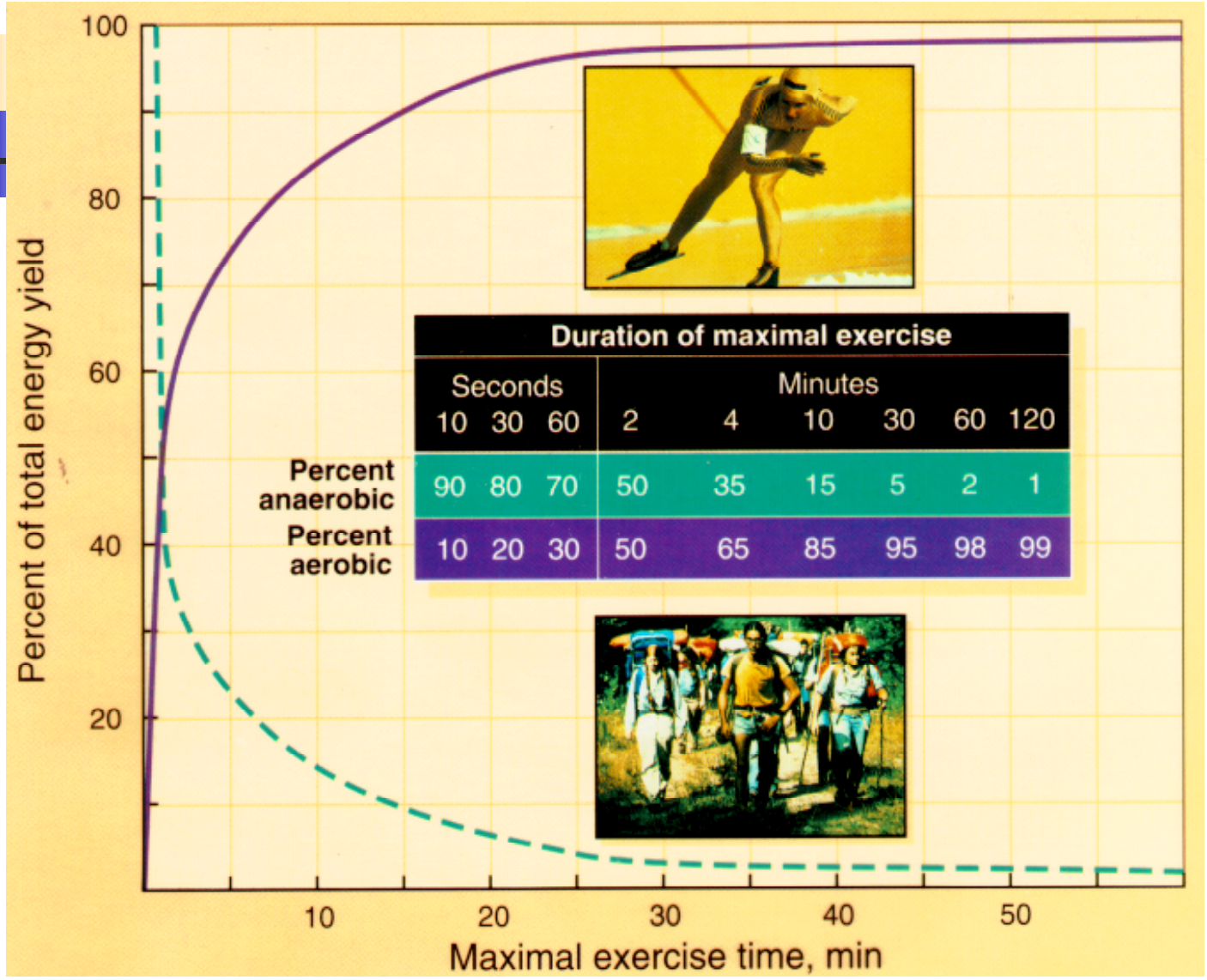
# Energy Systems



# Different Energy Systems



# Anaerobic and Aerobic Exercise




| Duration of maximal exercise | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Seconds | | | Minutes | | | | | |
| | 10 | 30 | 60 | 2 | 4 | 10 | 30 | 60 | 120 |
| Percent anaerobic | 90 | 80 | 70 | 50 | 35 | 15 | 5 | 2 | 1 |
| Percent aerobic | 10 | 20 | 30 | 50 | 65 | 85 | 95 | 98 | 99 |

# Exercise Equivalents Of Foods

| Food | Kcal | Walk | Cycle | Swim | Jog |
|---|---|---|---|---|---|
| Beer, 250 ml | 115 | 22 | 18 | 14 | 12 |
| Wine, 120 ml | 110 | 21 | 17 | 13 | 11 |
| Candy bar, 40 g | 218 | 42 | 34 | 26 | 22 |
| Doritos, 30g | 140 | 27 | 22 | 16 | 14 |
| Banana split, 300 g | 594 | 114 | 91 | 70 | 60 |
| Big Mac | 563 | 108 | 85 | 66 | 56 |
| Milk Shake, 300ml | 364 | 70 | 56 | 43 | 36 |
| Brownie, 30 g | 146 | 28 | 22 | 17 | 15 |
| Peanut butter sandwich | 328 | 63 | 50 | 40 | 34 |
| Pop corn, 1 cup | 55 | 10 | 8 | 6 | 5 |