XXII. Measurement of basal metabolic expenditure (BME) using indirect calorimetry

XXIII. Calculation of energy expenditure

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Masaryk University
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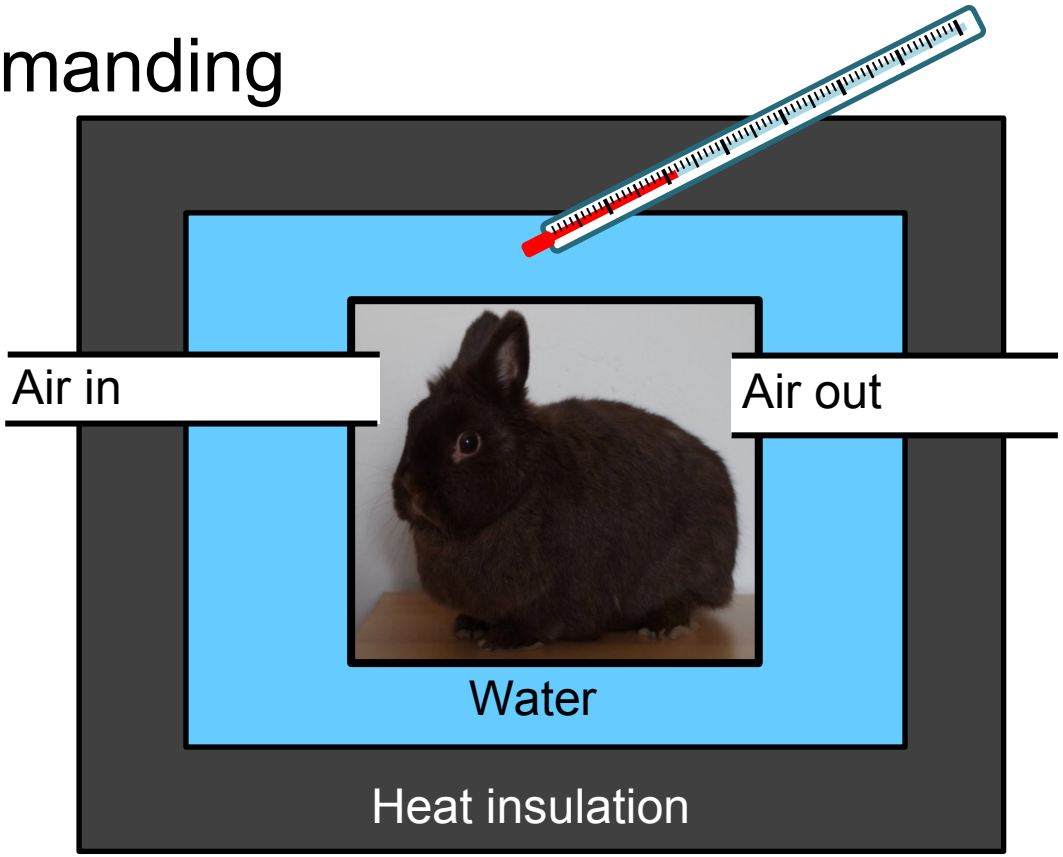
M. Bébarová

- direct and indirect calorimetry
- metabolic expenditure: basal *vs.* resting
- basal conditions
- catabolism/anabolism
- energy balance
- nitrogen balance
- energetic equivalent of oxygen

Direct calorimetry

- Works on presumption that all metabolic actions are accompanied by heat production
- Technically demanding
- In practice, often not used



Indirect calorimetry

- Works on presumption that consumption of oxygen, CO_2 production and nitrate metabolites waste correspond to the energetic output

- Open or closed cycle setup
- In practicals: closed system setup using Krogh respirometer (CO_2 is absorbed by filter)

Caloric (energetic) equivalent of oxygen (EE)

- = amount of energy released during consumption of 1 L of oxygen:
- For mixed diet:
  EE = 20.19 kJ/L O_2

EE of nutrients:
Glucose 21,4 kJ / litr O_2
Proteins 18,8 kJ / litr O_2
Lipids 19,6 kJ / litr O_2

Combustion heat

Total energy released as heat when a 1 g of substance undergoes complete combustion with oxygen

- physical combustion heat - energy is produced by burning the substrate
- physiological combustion heat - energy produced by the oxidation of the substrate by a living organism

- carbohydrates and lipids: physiological = physical combustion heat
- proteins: physical > physiological combustion heat

(burning of proteins products nitrogen oxides, the metabolism of proteins products urea, which contains rezidual amount of chemical energy)

carbohydrates 17,1 kJ/g
lipids 38,9 kJ/g
physical combustion heat of proteins 23 kJ/g
physiological combustion heat of proteins 17,1 kJ/g

Metabolism

set of life-sustaining chemical transformations within the cells of living organisms

- catabolism: set of metabolic pathways that breaks down molecules into smaller units that are either oxidized to release energy, or used in other anabolic reactions
- anabolism: set of metabolic pathways that construct molecules from smaller units, theese reactions require energy

Nitrogen balance

= nitrogen intake (proteins, aminoacides) – nitrogen loss (urine)

- positive (nitrogen intake > nitrogen loss)
  - growth, pregnancy, tissue repair
- negative (nitrogen loss > nitrogen intake)
  - burns, serious tissue injuries, fevers, hyperthyroidism, wasting diseases, and during long periods of fasting

Basal metabolism

Energetic expenditure of organism established in defined (basal) conditions:

- Thermoneutral environment
- 12-18 hours after the last meal containing proteins
- Psychological and social well-being, optimally in the morning before leaving the bed

Despite the preserving of the conditions, the obtained value of basal energetic expenditure is only an estimate of the real energy associated with basal metabolism

Actual energy expenditure (AEE)

1) **at rest**
2) **at standing**
3) **after workload**

- estimate the oxygen consumption (l/s)
- correct the measured values to 0 °C and 101,325 kPa
  (for the formula see *Physiology and Neuroscience Practicals, 2013* – page 87*)*
- calculate AEE (kJ/s, kJ/day)
- explain differences in AEE observed in different conditions

Calculation of energy expenditure

1) basal energy expenditure (BEE)

- according to Harris-Benedict formula (*Physiology and Neuroscience Practicals, 2013* – page 89*)*
- kcal/day - transform to kJ/day (1 kcal = 4.18 kJ)

2) actual energy expenditure (AEE)

- may be calculated based on:
  - BEE
  - AF (activity factor)
  - TF (temperature factor)
  - IF (injury factor)