Physiology Labs Protocols

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Labs aim: Explore biology in context through brain and hands

Metabolic Rate Measurement

Basal Metabolism (Basal Metabolic Rate)

AIM of the lab

- Get ideas about energetic needs and consumption

REQUIRED KNOWLEDGE

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TASKS

1. Measure resting metabolic rate (in details described here)
2. Measure BMR of experimental animals (principles same as in #1)
3. Find expected value of Basal Metabolism from Tables of norms or Harris-Benedict Formula (use calculator available on PCs in the lab)
4. Estimate your typical daily energy needs
5. Estimate *Fuel Value* of your typical meal

WHAT

1. Basal Metabolism definitions
   PubMed: Heat production, or its measurement, of an organism at the lowest level of cell chemistry in an
   - inactive,
   - awake
   - fasting state.

   It may be determined:
   - directly by means of a calorimeter
   - OR indirectly by calculating the heat production from an analysis of
     - the end products of oxidation within the organism
     - OR from the amount of oxygen utilized.

WHY …

1. … is MR or O_2 consumption estimated?

a. BMR can be altered in some diseases, typically endocrine (T-hormones)
b. O_2 consumption is regularly tested in sports medicine

2. … do we perform the lab
   a. Demonstration of measurement
   b. Training of use air ways
   c. Practical example of Energy consumption, approx. estimation of daily E needs and intake (estimation of caloric value of meals)
   d. Get ideas obesity

HOW

1. Basal /resting metabolism measurement.
   - **BM is determined through indirect calorimetry** from oxygen consumption.
     The method assumes, that during aerobic oxidation E – energy (and also P – product) is/are released from S – substrate:

$$S + O_2 -> P + E$$

This means that energy released is proportional to O_2 consumption:

$$E \sim O_2$$

Aerobically, E is linearly proportional to O_2 consumption.

$$E = O_2 . EE$$

EE – energetic equivalent, i.e. amount of E released if 1lt of O_2 is consumed.
For average food EE ≈ 20 kJ/lO_2

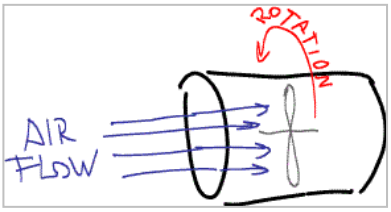
   - **O_2 consumption**. (O_2 cons) It is calculated as difference between inspired O_2 and expired O_2:

$$O_2 \text{ cons} = O_{2\ IN} - O_{2\ OUT}$$

   - **$O_{2\ IN}$**
     Amount of inspired O_2 is cca 21% of inspired air since there is cca 21% of O_2 in air we breathe in (atmospheric air - ATM)
     $O_{2\ IN} \sim 21\%$ of inspired air
     $O_{2\ IN} = pO_{2\ ATM} *$ ventilation

   - **$O_{2\ OUT}$**
     Amount of expired O_2 is unknown fraction of enspired air since this fraction ($pO_{2\ EXP}$ – O_2 partial pressure in expired air) is not constant and it must be measured!
     $O_{2\ IN} = pO_{2\ EXP} *$ ventilation

- **Ventilation, minute ventilation (MV)** can be easily measured by spirometer. Similar method is used as Spirometry lab (1st semester) As air flows through turbine, propeller rotates. Rotations are counted and thus provide air flow = ventilation data.



- **Taken together**:

  O_2 cons = $O_{2\ IN} - O_{2\ OUT}$
  O_2 cons = $pO_{2\ ATM}$ * ventilation – $pO_{2\ EXP}$ * ventilation
  O_2 cons = ($pO_{2\ ATM}$– $pO_{2\ EXP}$) * ventilation

  Items in blue need to be measured. Since they can vary with each breath, we perform 10-minutes measurement for an averaging.

- **Temperature and pressure correction**
  since the volume of air depends on temperature and pressure, the measured volume of O_2 should adjusted to standard conditions, i.e. T= 0°C and p = 760 mm Hg:

$$V_0 = V_1 \cdot \frac{273°C}{273°C + T} \cdot \frac{BT}{760\,Torr}$$

  V_0 = standard volume, V_1 = O_2 consumption measured during experiment, T = temperature during experiment, BT = barometric pressure during experiment

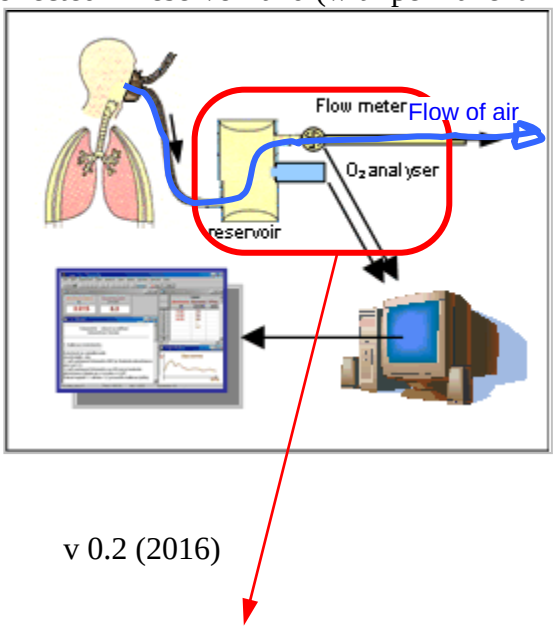
- Final calculation

$$MR = O_2 cons_{V_O} \cdot EE$$

  MR – metabolic rate. $O_2cons_{V_O}$ – O_2 consumption converted to standard volume, EE – energetic equivalent.

SETUP

1. **Principle.** Expired air is collected in reservoir and (with permanent flow of expired air →). In this *averaged* sample of expiratory air O2 concentration and air flow is measured.



2. **Detailed scheme of interconnection of all setup components**. In all cases, connectors are designed so that they fit in suitable sockets only. O2 sensor, barometer and thermometer can be connected into any of 4 analogue ports (so not only as shown on the picture)