Medical physics module
Semester 1

Session 3
Lec. 2

Energy, Work, and Power of Human Body

By: Lect. Dr. Nadia Hussein Sahib

Objectives

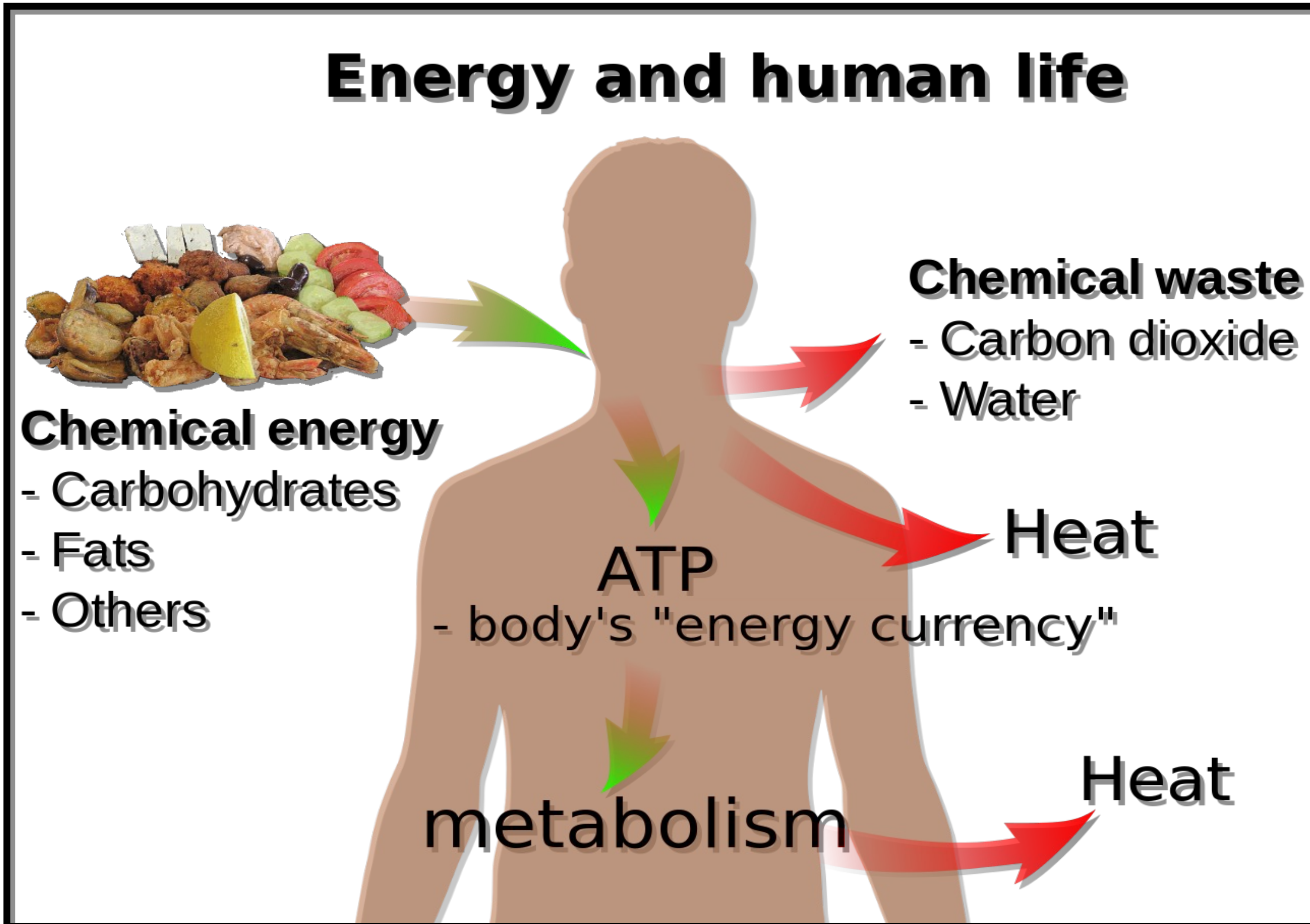
1. Knowledge of the principles of energy, (Basal conditions).
2. Definition of BMR and physical factors affecting it.
3. Methods of heat losing.
4. Thermography applications.

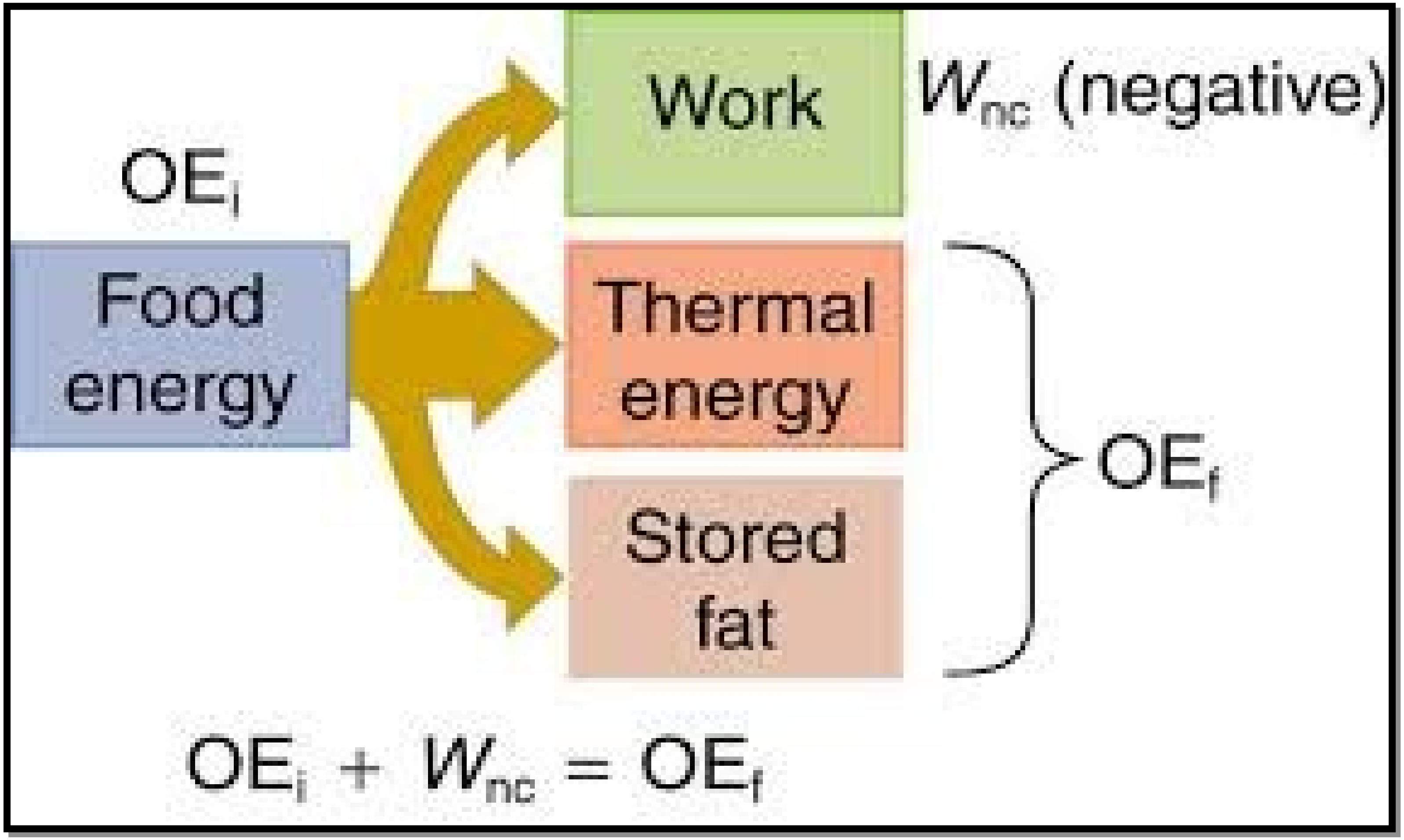
Obj.1

Basal conditions

- 25% of the body's energy used by the skeletal muscle and heart.
- 19% used by the brain.
- 10% used by kidneys.
- 27% used by the liver, spleen

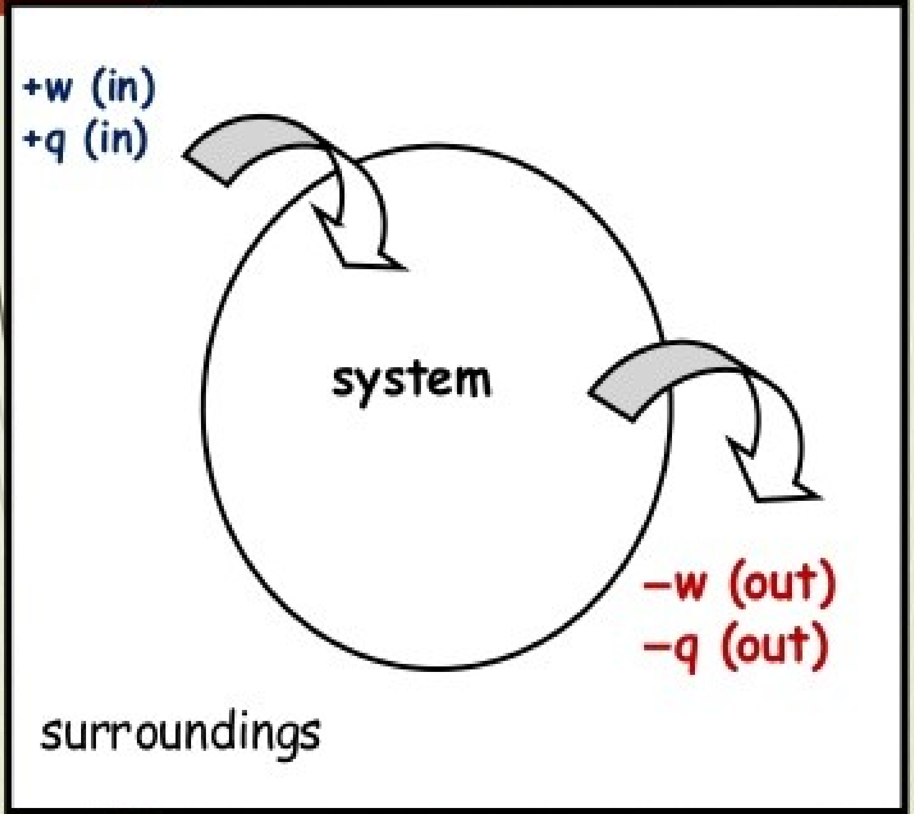
The body uses food energy to operate, its various organs, maintain constant body temperature, and do external work, small percentage (5%) of the body energy excreted in the feces and urine, any energy left over is stored as a body fat.


Energy and human life
Chemical energy
- Carbohydrates
- Fats
- Others
Chemical waste
- Carbon dioxide
- Water
Heat
ATP
- body's "energy currency"
metabolism
Heat



Work
W_{nc} (negative)
OE_i
Food energy
Thermal energy
Stored fat
OE_f
$OE_i + W_{nc} = OE_f$

Internal Energy U, Work, and Heat



$$\Delta U = q + w$$

+w for work done <u>on</u> the system <u>by the surroundings</u>

−w for work done <u>by</u> <u>the system</u> **on** the surroundings

Obj.2
Conservation of Energy in the body

Q = heat lost or gain Δ

ΔU= Change in stored energy
ΔQ= Heat lost or gain
ΔW= Work done

BMR (basal metabolic rate):
Is the amount of energy needed to perform minimal body function (such as breathing, and pumping blood through arteries under resting condition).

BMR depends primarily upon thyroid function.

A person of an over active thyroid has a higher BMR than a person with normal thyroid function.

heat lost or gain Δ
=

Since the energy used for basal metabolism becomes heat and dissipated from the skin, so BMR is related to the surface area, or the mass of the body.

The metabolic rate depends on temperature of the body, if temperature changes by 1C^{o} there is a change about 10 % in the metabolic rate.

The convenient unite for expressing the rate of energy consumption of the body is the met;
the met is defined as 50 Kcal/m^2 of body surface area per hour.

For normal person 1 met is equal to the energy consumption under resting conditions.

A typical man has about 1.85 m^2 of surface area women has 1.4 m^2 and for typical man

1 met is about:

(92 Kcal / hr) or (107 w) oxidation occur in the cells of the body.

Energy, Power and Work

Work is a form of Energy.

Work is done by a force F on mass m when the force and the displacement Δx are parallel:

Symbol: W

Formula: $W = F\Delta x$

(if Δx and F are parallel)

In general: $W = F\cos\theta\Delta x$

Work is a SCALAR.

Unit of work: J

$1J = 1N.m$

$= 1kg.m.s^{-2}.m$

$= 1kg.m^2.s^{-2}.m$

$W = \Delta E = Fd\cos\theta$

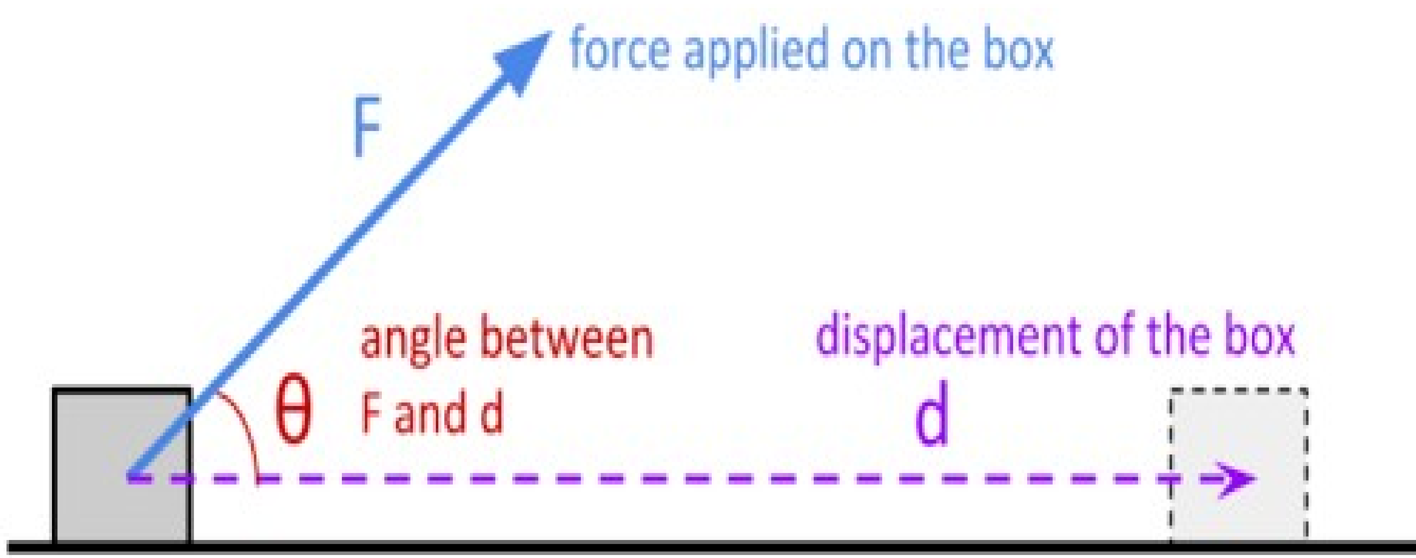
W = work done by the object exerting the force F

ΔE = the amount of energy gained/lost by the object to which the force is applied

F = Force exerted by the object doing the work

d = displacement of the object to which the force F is applied

θ = angle between the force F and the displacement d



Power

- The work done per unit time is called power and is denoted $\dot{W}$.
- The unit of power and the rate of heat transfer are both kJ/s (or kW)

The General Remarks on Heat and Work

- Heat and work are associated with processes, not a certain state.
- Heat and work are directional quantities.
  - ✓ Complete description of a heat or work interaction requires the specification of both the **magnitude** and **direction**.

Obj.3

Methods of heat losing

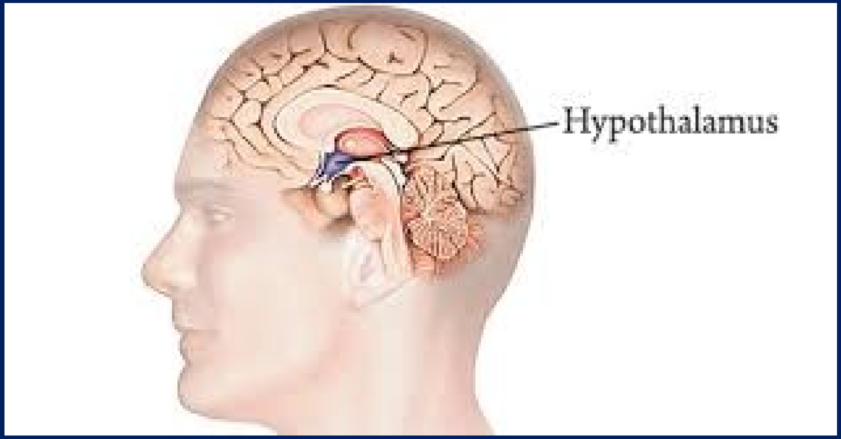
The main heat loss mechanisms are:

- Radiation
- Convection
- Evaporation (perspiration)
- Some cooling of the body in lungs

Hypothalamus

The hypothalamus of brain contains body thermostat to keep temperature close to normal value. If the core temperature rises,
the hypothalamus initiate sweating and vasodilatation which increases blood flow to the skin and increase skin temperature which help to get rid of extra heat.

If the skin temperature drops, the thermo receptors on the skin inform hypothalamus and it initiate shivering, which causes increase in the core temperature.



The difference between energy radiated by the body and the energy absorbed from surrounding can be calculated by:

$$Hr = Kr\ Ar\ e\ (Ts - Tw)$$

Hr = energy loss or gain

Ar = surface area emitting radiation

E = emissivity of body

Ts = skin temperature

T_w =surrounding temperature

Kr= constant= 5 Kcal/m^2hr C°

The heat loss due to convection (Hc) is given by:

$$Hc = Kc\ Ac\ (Ts - Ta)$$

Kc = constant depends upon the movement of air

Ac = surface area

Ta = air temperature.

When the wind constant Kc = 2.3 Kcal / m^3hr Cº

When Ta = 25 Cº Ts = 34 Cº Ac = 1.2 m^2

The nude body losses about 25 Kcal /hr by convection or about 25% of body heat loss. When the air is moving, the constant Kc increases according to the equation:

$K_c = 10.45 - v + 10 f v$

Where v is the wind speed.


Measupro
SYS
108
kPa mmHg
DIA
65
Pul/min
8:00
76
SET
MEM