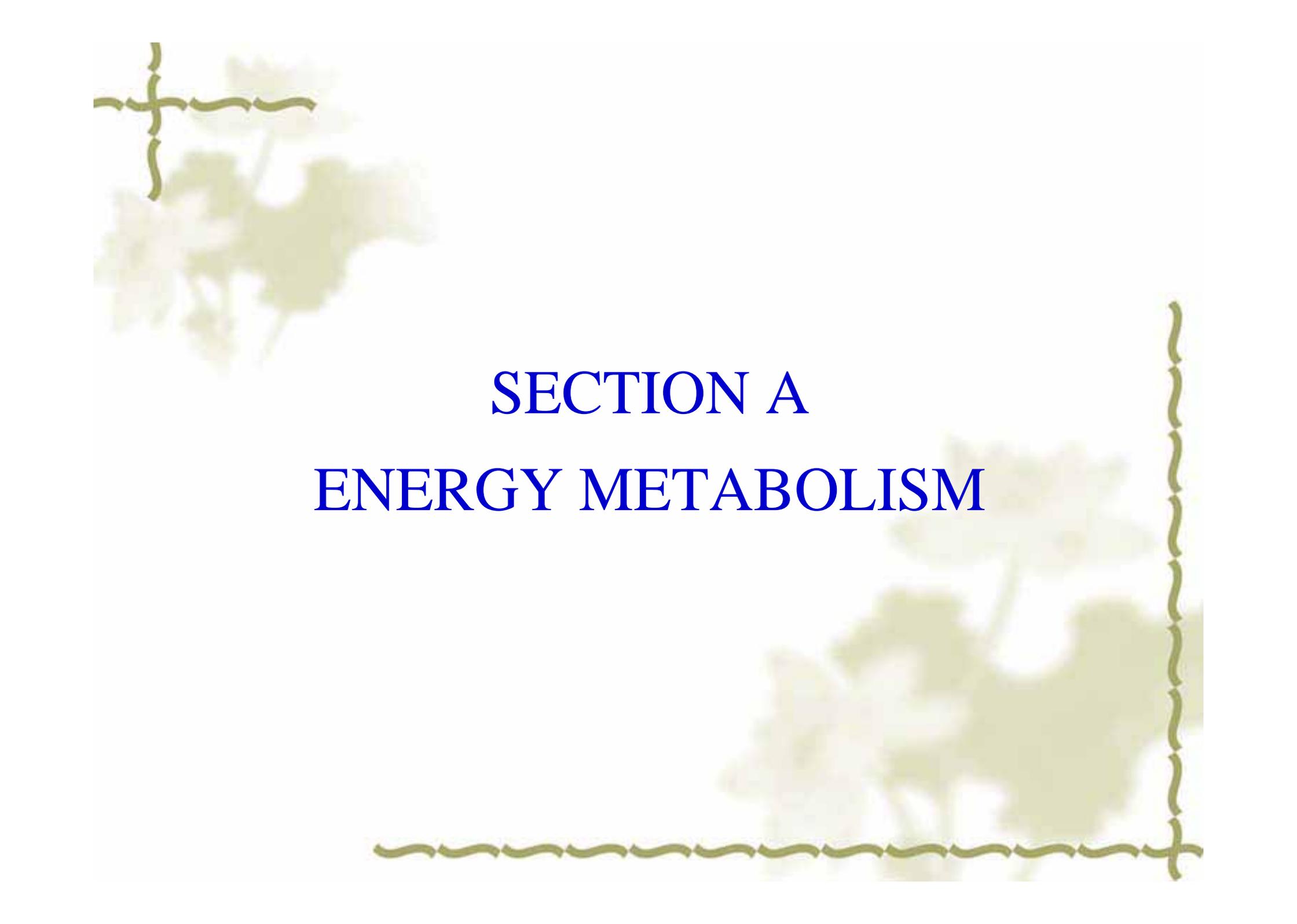


HUMAN PHYSIOLOGY
Chapter 16

**Energy Metabolism &
Body Temperature**

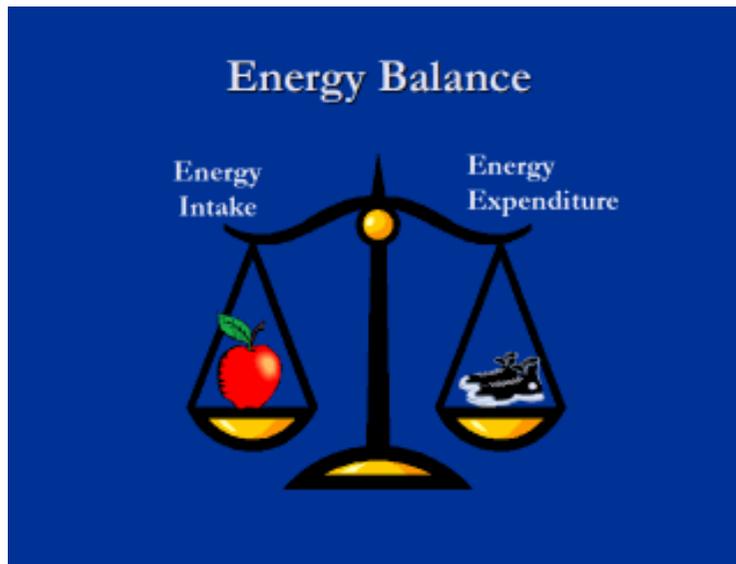
Ying-ying Chen, PhD
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University School of Medicine
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SECTION A
ENERGY METABOLISM

Energy Balance

- ❖ The difference between the number of kilocalories that you eat and the number of kilocalories that you burn



Energy intake

❖ Energy sources

- ❧ Fat -> fatty acids
- ❧ Long carbohydrates -> shorter -> glucose
- ❧ Shorter carbohydrates ('sugars') -> glucose
- ❧ Proteins -> Amino acids

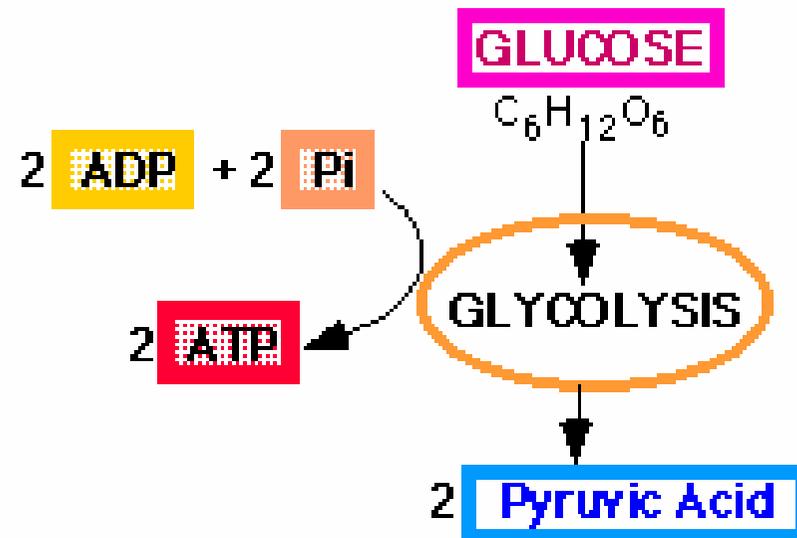


❖ Glucose: a major energy source

⌘ Aerobic oxidation



⌘ Glycolysis



❖ Fat

❧ Major form of energy storage

❧ Alternative Energy Source

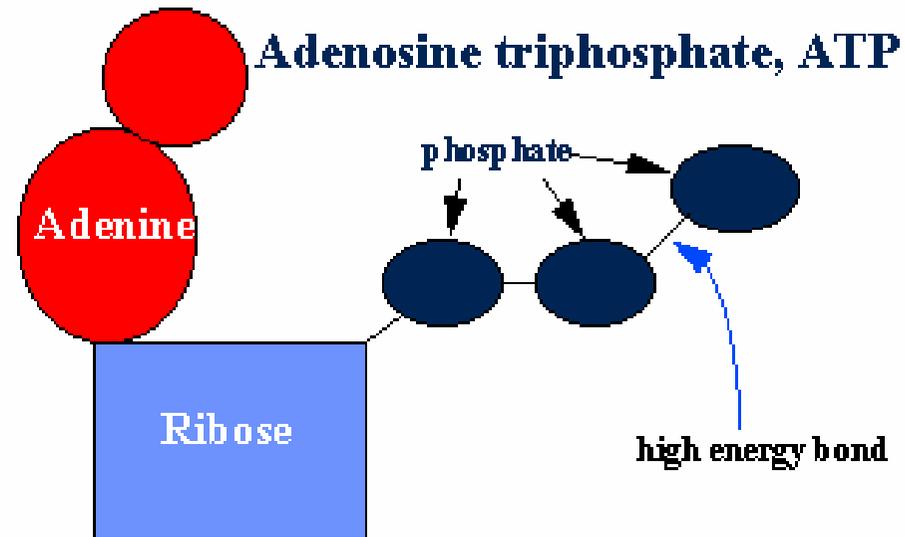


❖ Proteins

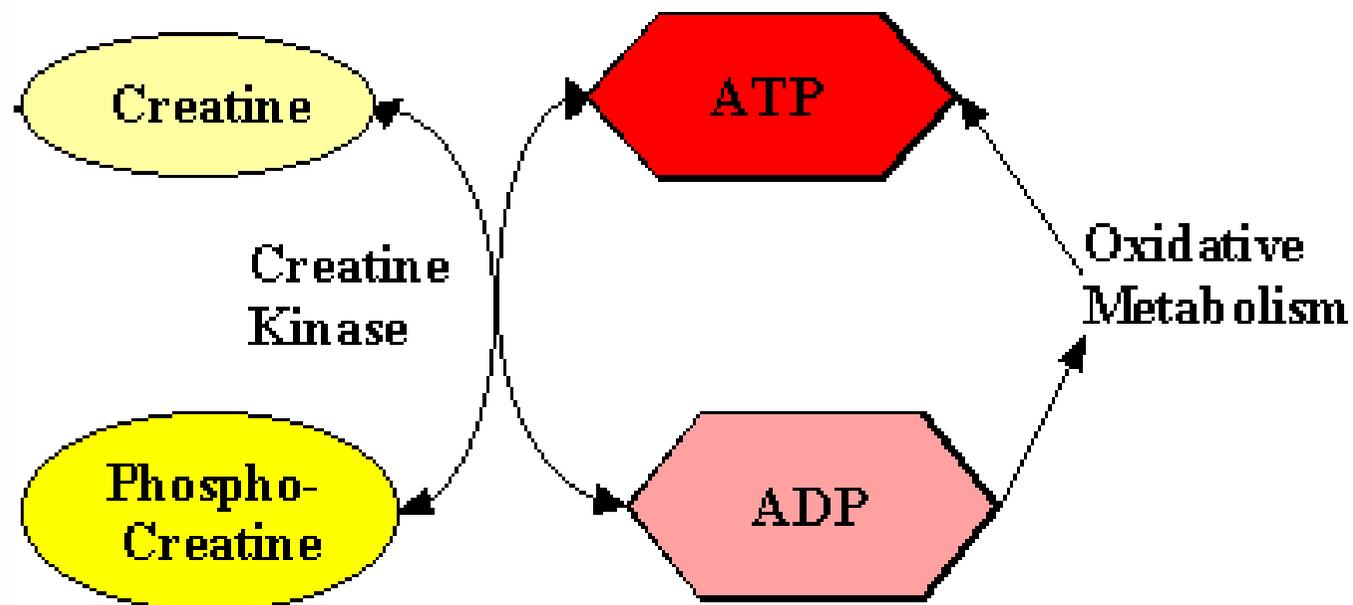


Energy transfer

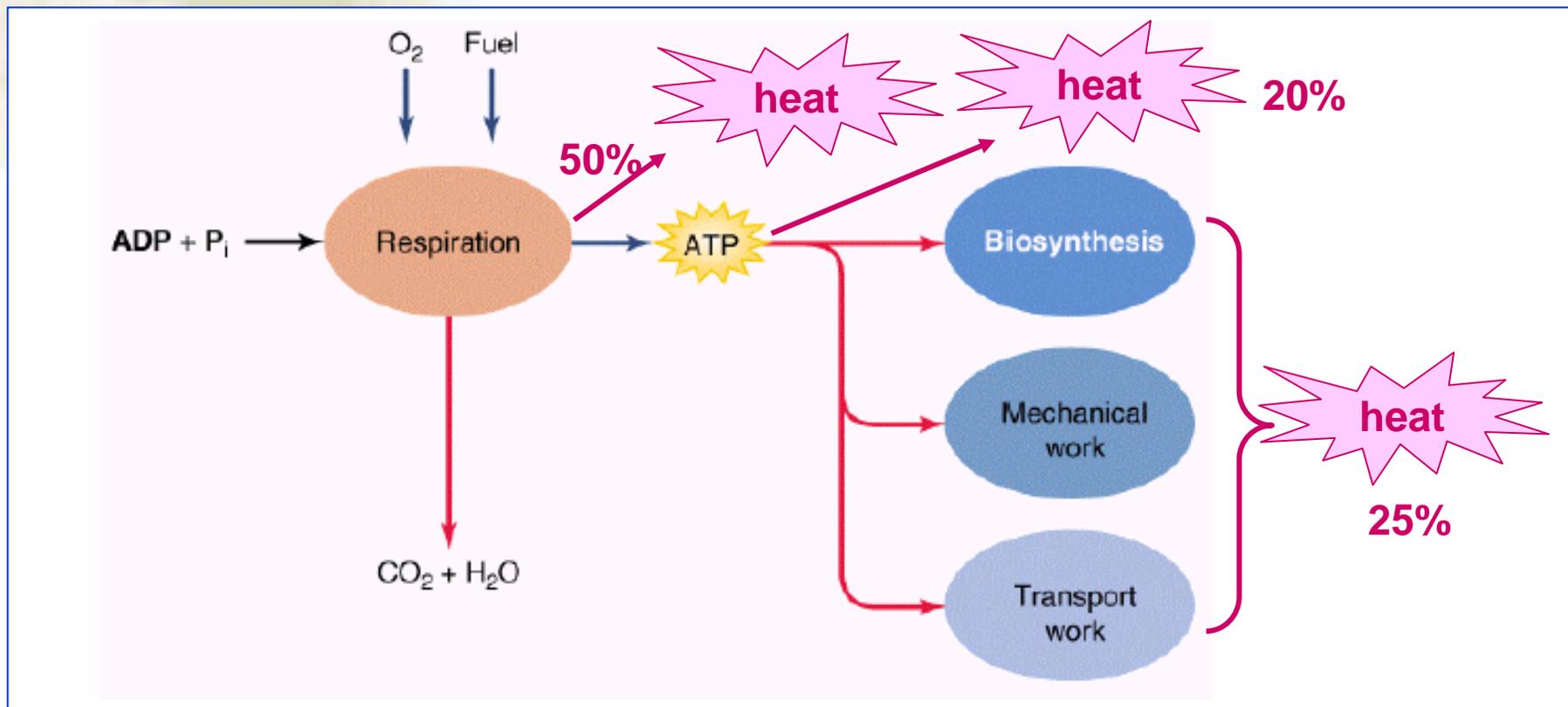
- ❖ **ATP: primary energy currency**



❖ **Phosphocreatine: an ATP “buffer”**



Energy expenditure



- ❖ Heat is the end product of almost all the energy released in the body

Metabolic rate

- ❖ **Normally expressed in terms of the rate of heat liberation during the chemical reactions**

Factors that affect metabolic rate

❖ Physical Activities

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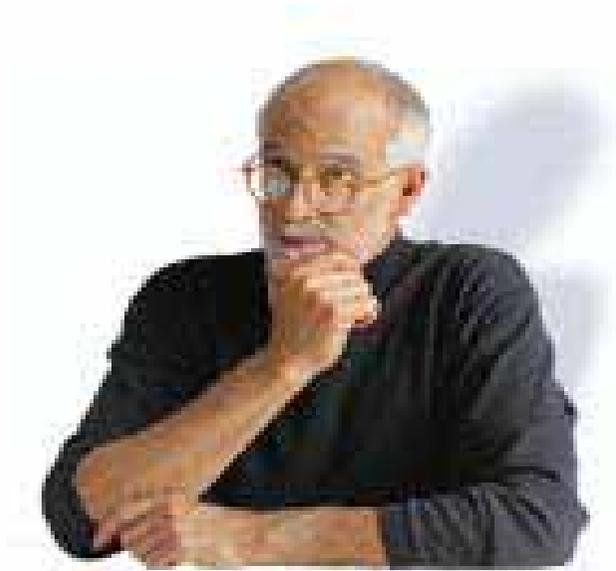
FORM OF ACTIVITY	ENERGY Kcal/h
Lying still, awake	77
Sitting at rest	100
Typewriting rapidly	140
Dressing or undressing	150
Walking on level, 4.3 km/h (2.6 mi/h)	200
Bicycling on level, 9 km/h (5.5 mi/h)	304
Walking on 3 percent grade, 4.3 km/h (2.6 mi/h)	357
Sawing wood or shoveling snow	480
Jogging, 9 km/h (5.3 mi/h)	570
Rowing, 20 strokes/min	828



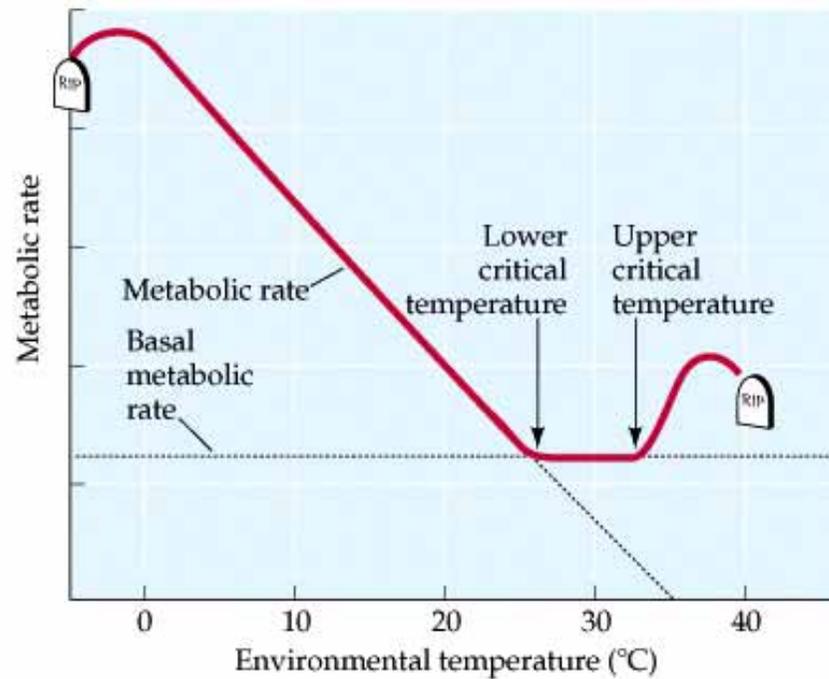
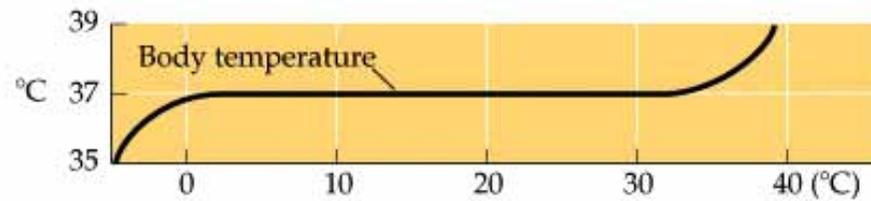
❖ **Thermogenic effect of food**
-Specific Dynamic Action of protein



❖ **Psychic activity**



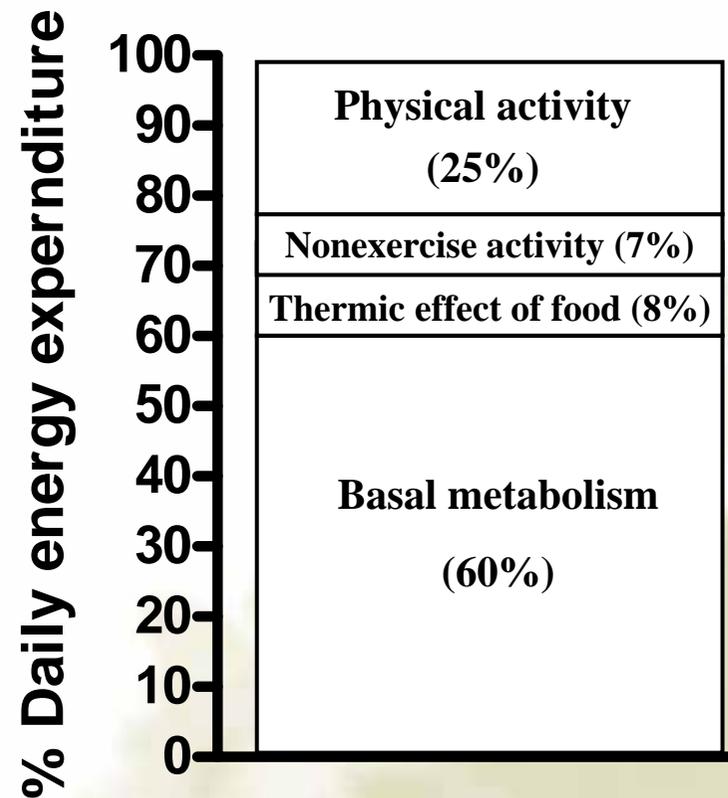
❖ Environmental temperature



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Basal metabolic rate (BMR)

- ❖ **The minimum energy expenditure for the body to exist**

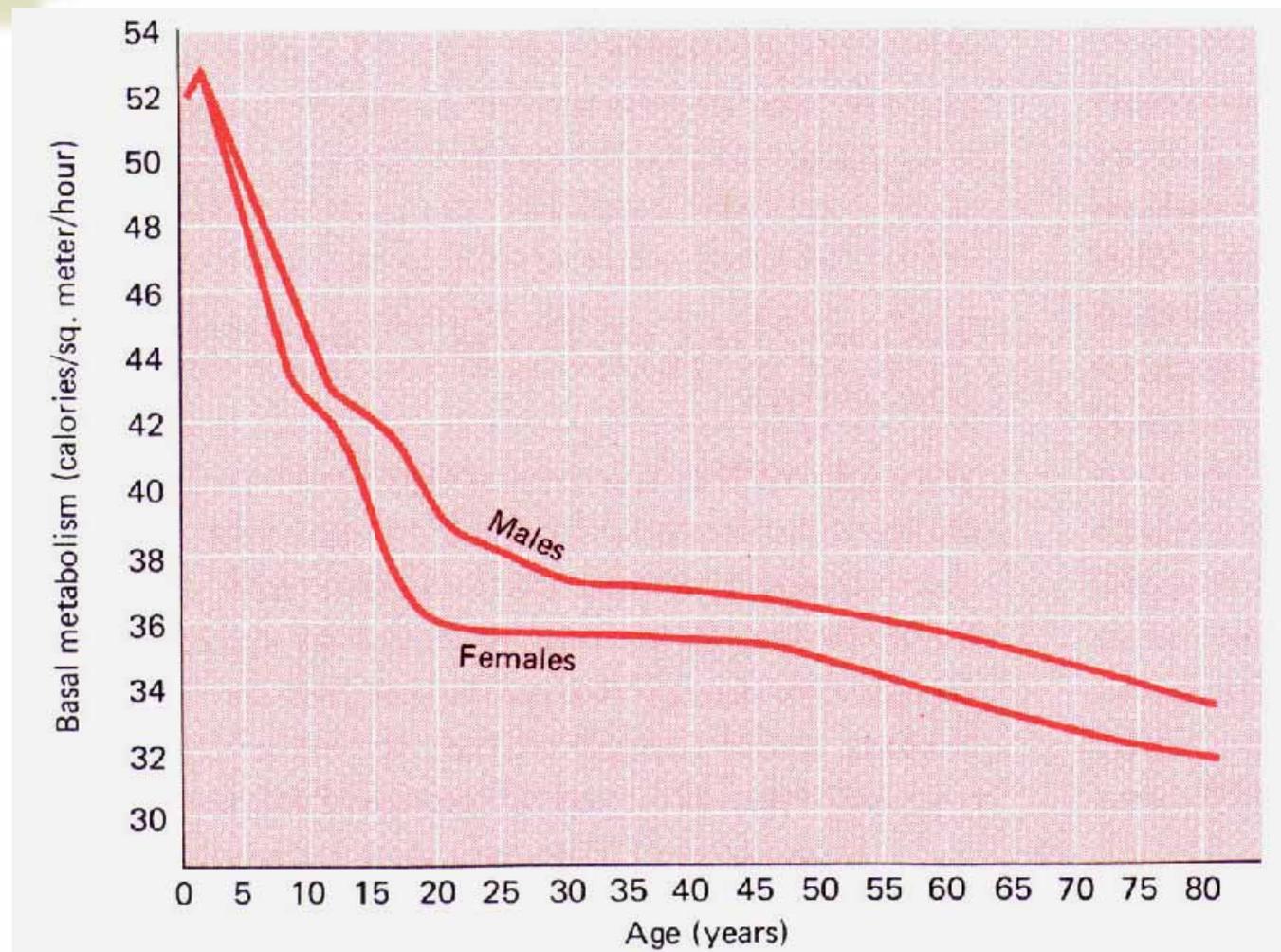


Determining BMR under the following conditions

- ❖ **Keep fast at least for 12 hours**
- ❖ **After a night of restful sleep**
- ❖ **No strenuous activity**
- ❖ **Eliminated psychic and physical factors**
- ❖ **RT: 16 to 27°C**
- ❖ **No physical activity during the test**



- ❖ **BMR is usually expressed as Calories per hour per square meter of body surface area**



Other Factors that influence the BMR

- ❖ **Thyroid hormone, male sex hormone, growth hormone**
- ❖ **Fever**
- ❖ **Sleep**
- ❖ **Malnutrition**





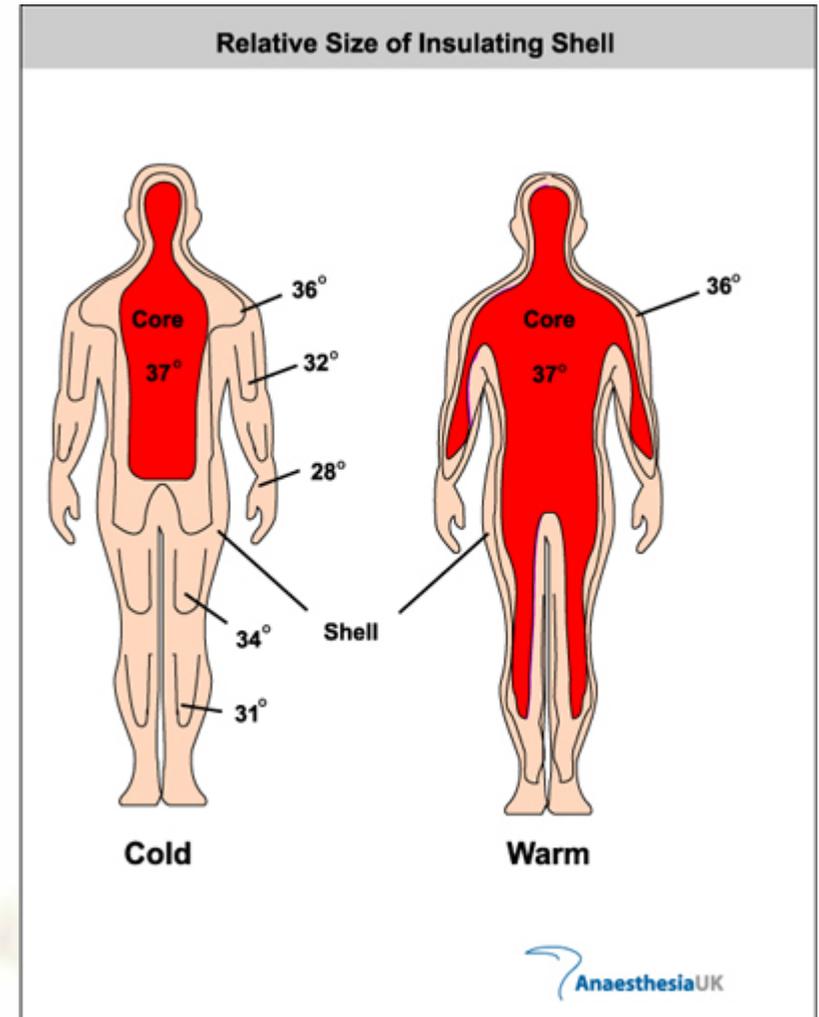
SECTION B

BODY TEMPERATURE REGULATION



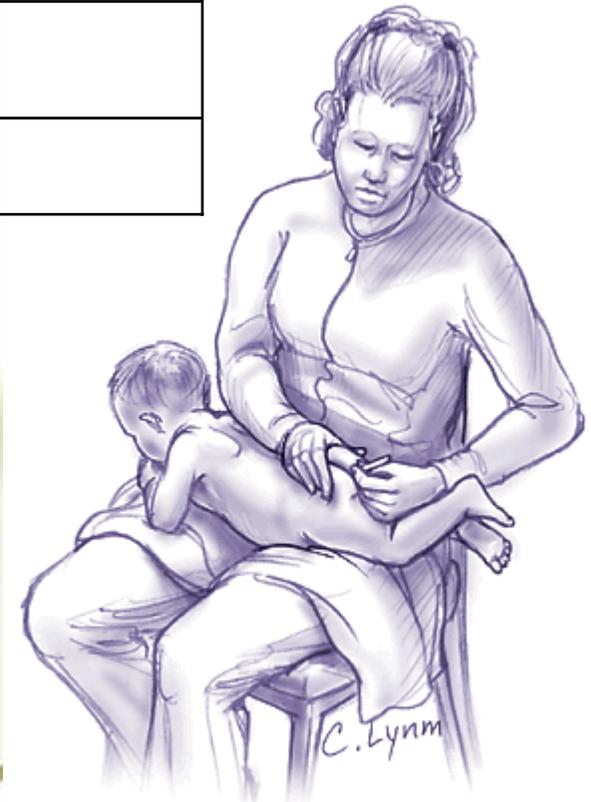
Body temperature

- ❖ **Core temperature**
 - ⚡ Homeostatically maintained at 37
- ❖ **Skin temperature**
 - ⚡ influenced by the environment

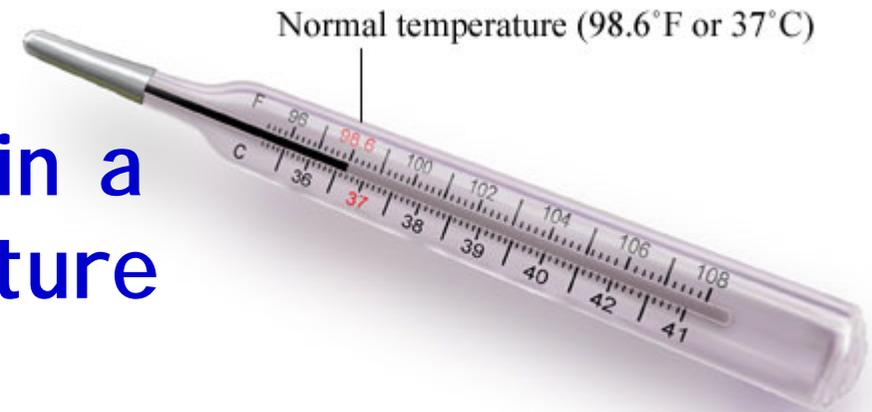


Normal body temperature

Site	Range of Variation of Temperature
Oral cavity	36.7-37.7
Rectum	36.9-37.9
Armpit	36.0-37.4



Important to maintain a stable body temperature

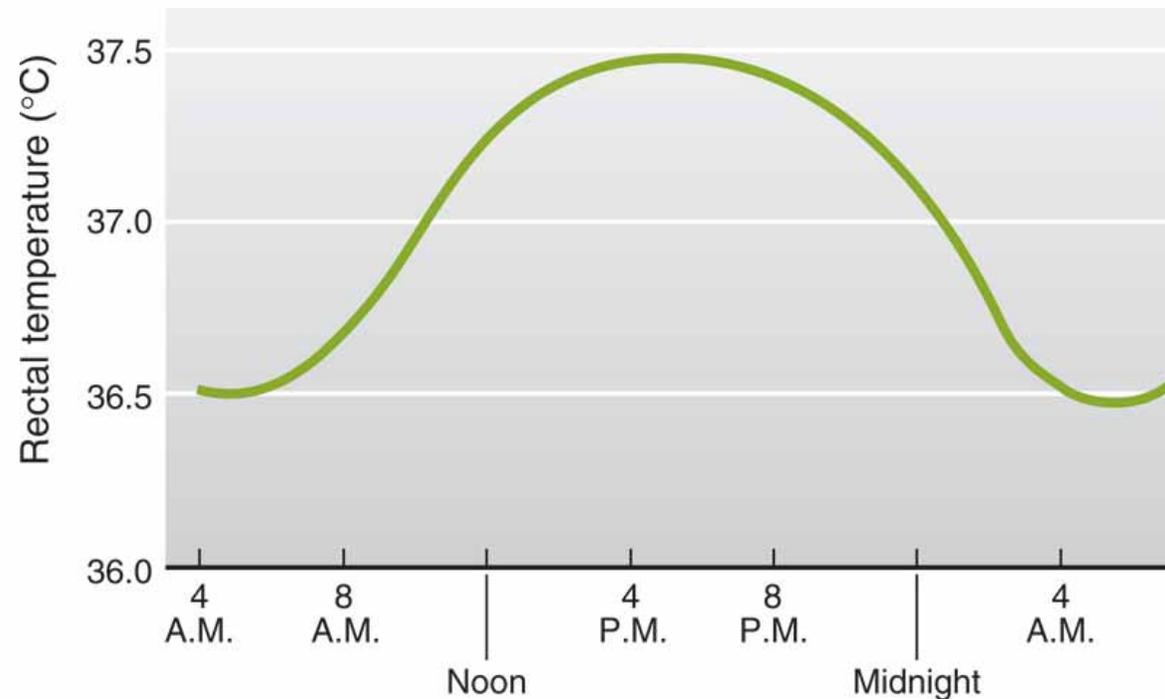


Core Temperature ()	Symptoms
28	muscle failure
30	loss of body temperature control
33	loss of consciousness
37	normal
42	central nervous system breakdown
44	death

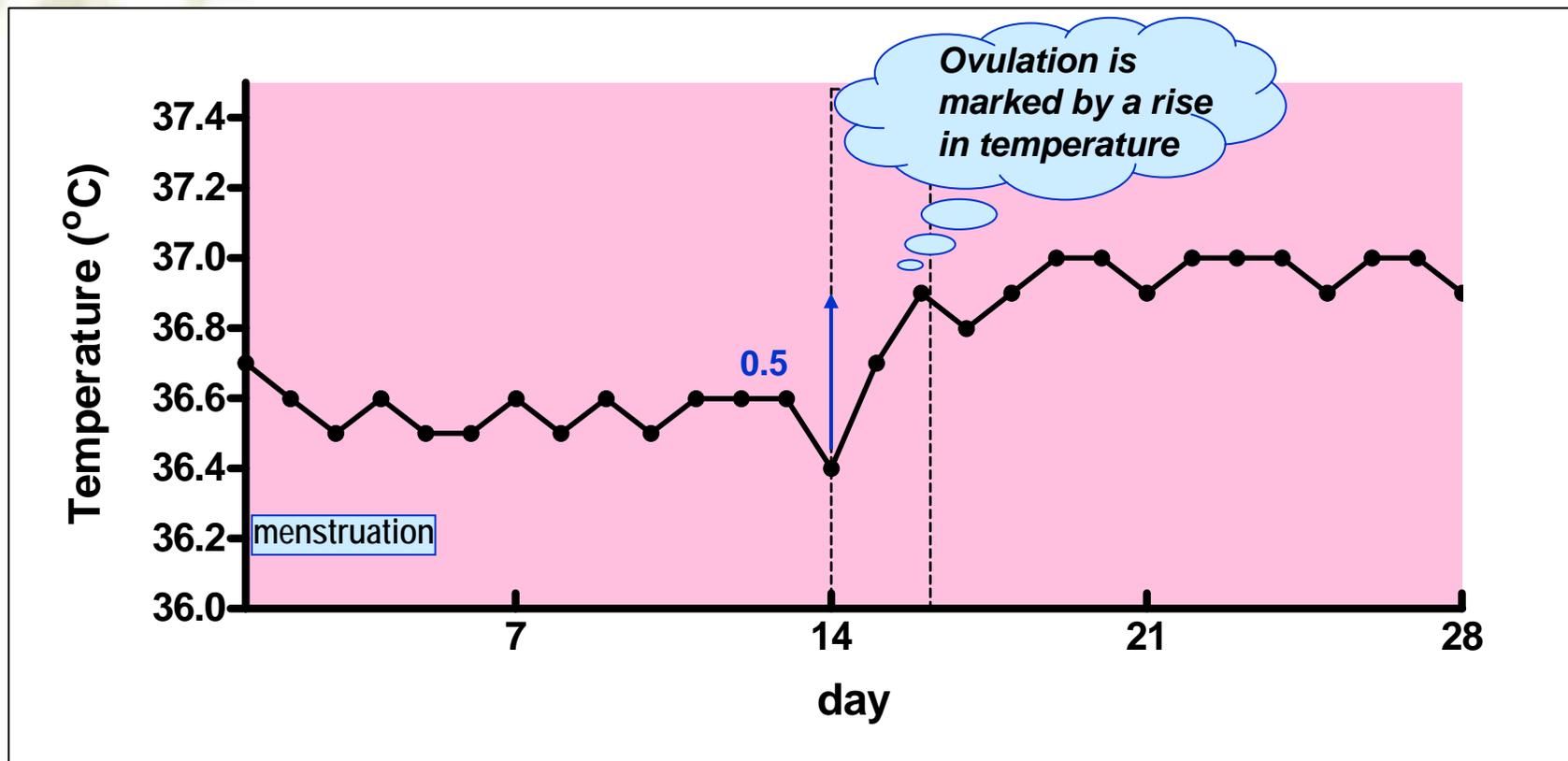
Factors affecting normal body temperature

❖ Circadian rhythm

↳ originates in the hypothalamus

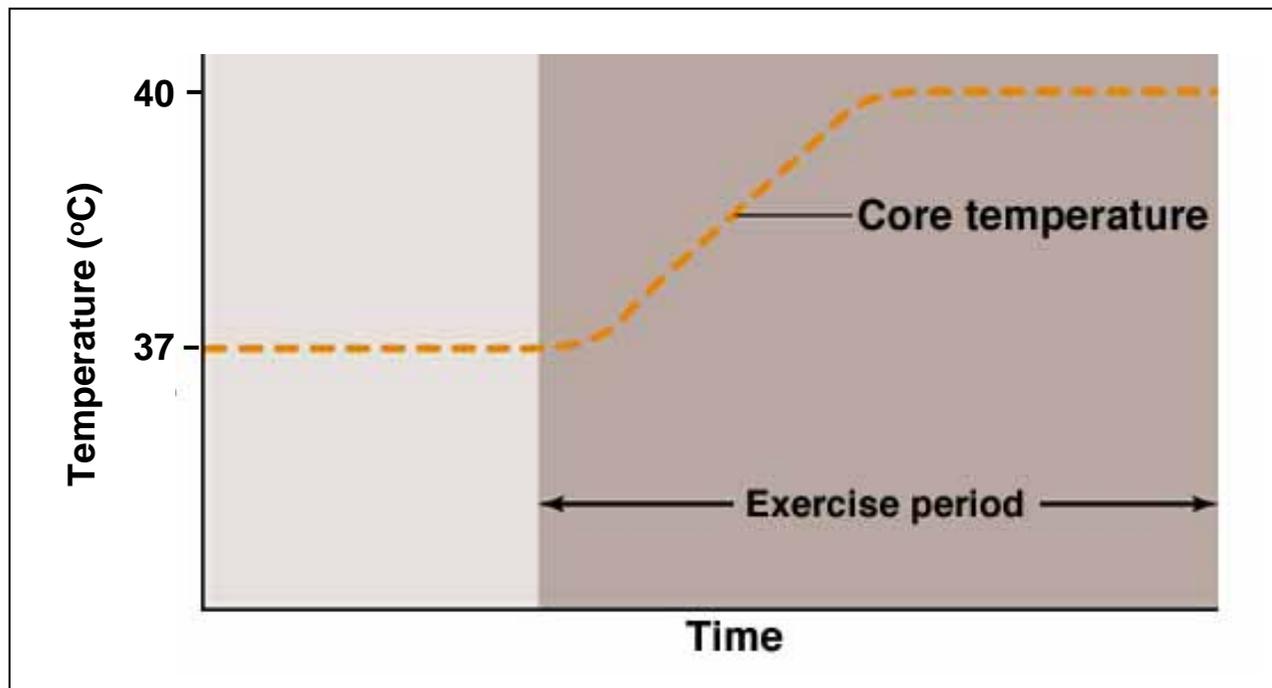


❖ Sex



❖ Age

❖ Muscle activity





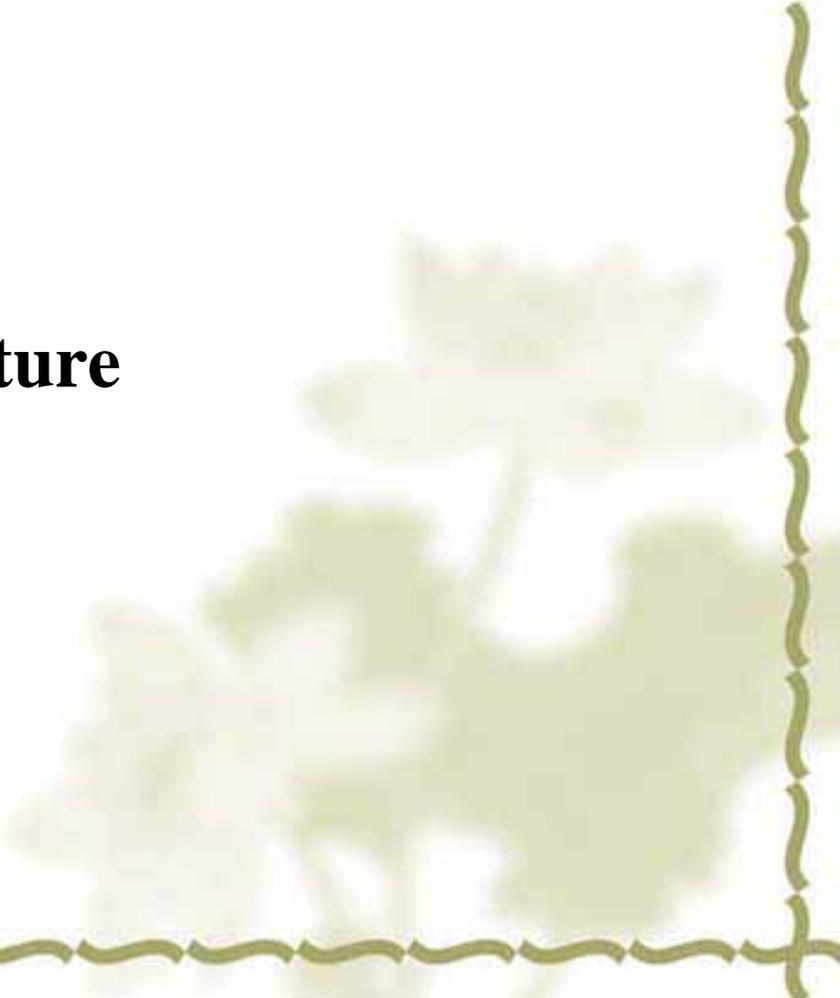
❖ **Other factors**

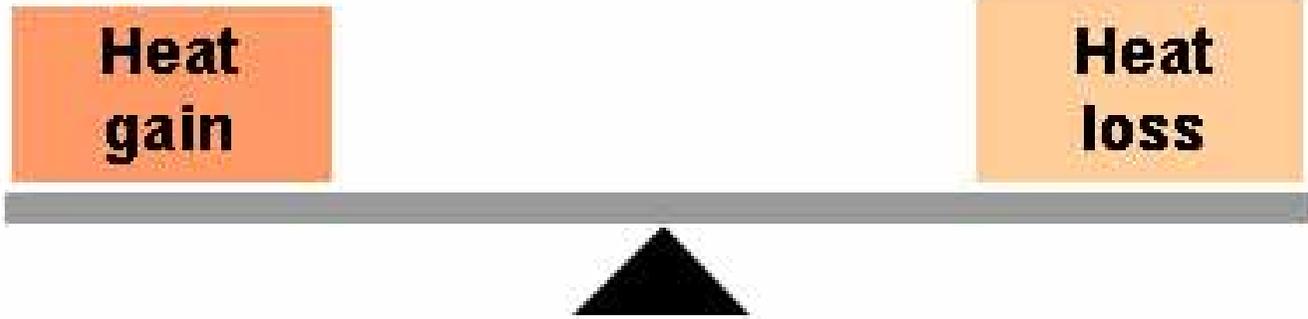
↳ **Emotion**

↳ **Eating**

↳ **Environment temperature**

↳ **Vascular activities**





**Heat
gain**

**Heat
loss**

Body temperature is constant when
heat gain and heat loss are balanced

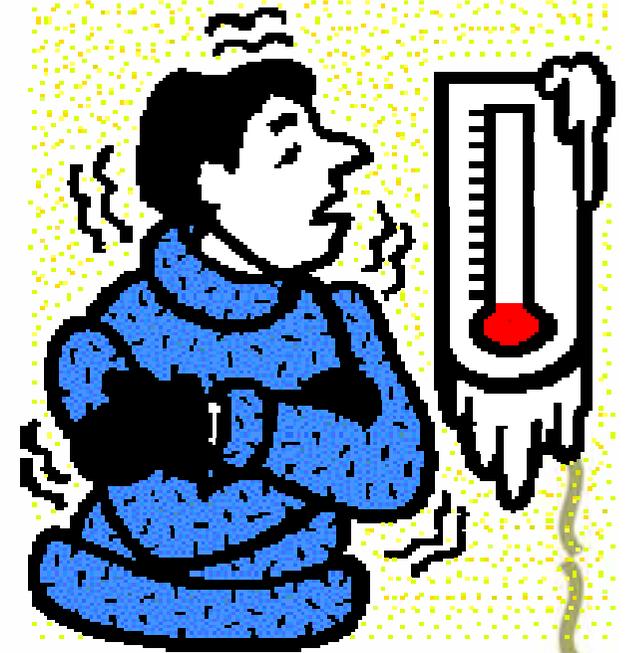
Heat production

- ❖ **A principal by-product of the metabolism**
 - ⌘ **Basal metabolism**
 - ⌘ **Extra metabolism caused by**
 - ❖ **Muscular activity**
 - ❖ **Hormones (thyroxine)**
 - ❖ **Sympathetic nervous system**
 - ❖ **Dietary intake**

❖ Main organs of heat production in the body

	Percentage in Body Weight	heat production (%)	
		at rest	working
Brain	2.5	16	1
viscera (especially liver)	34	56	8
Skeletal muscle	56	18	90
Others	7.5	10	1

Cold exposure



❖ Muscle activity

⌘ Reflex change (shivering thermogenesis)

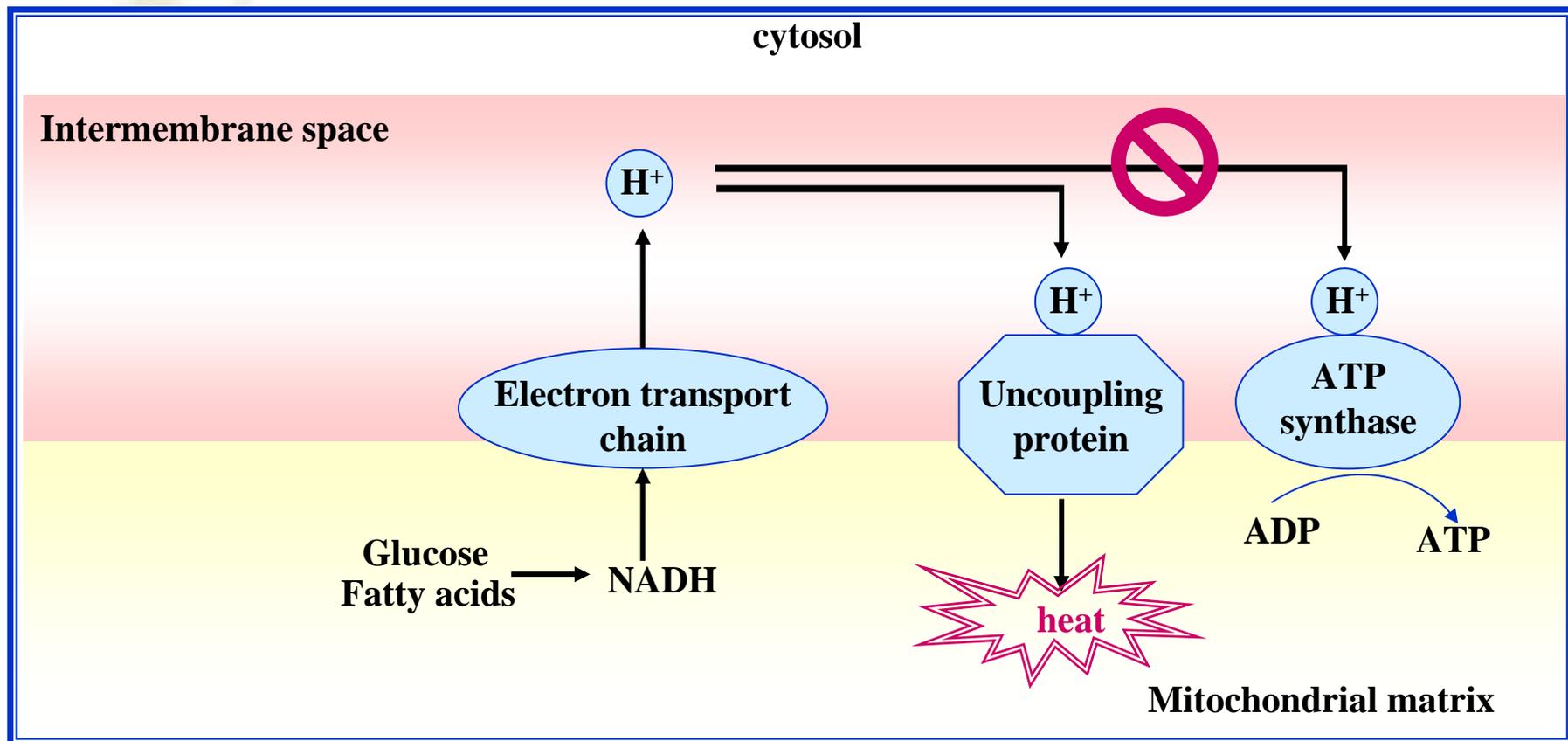
- ❖ Primary controlled by hypothalamus

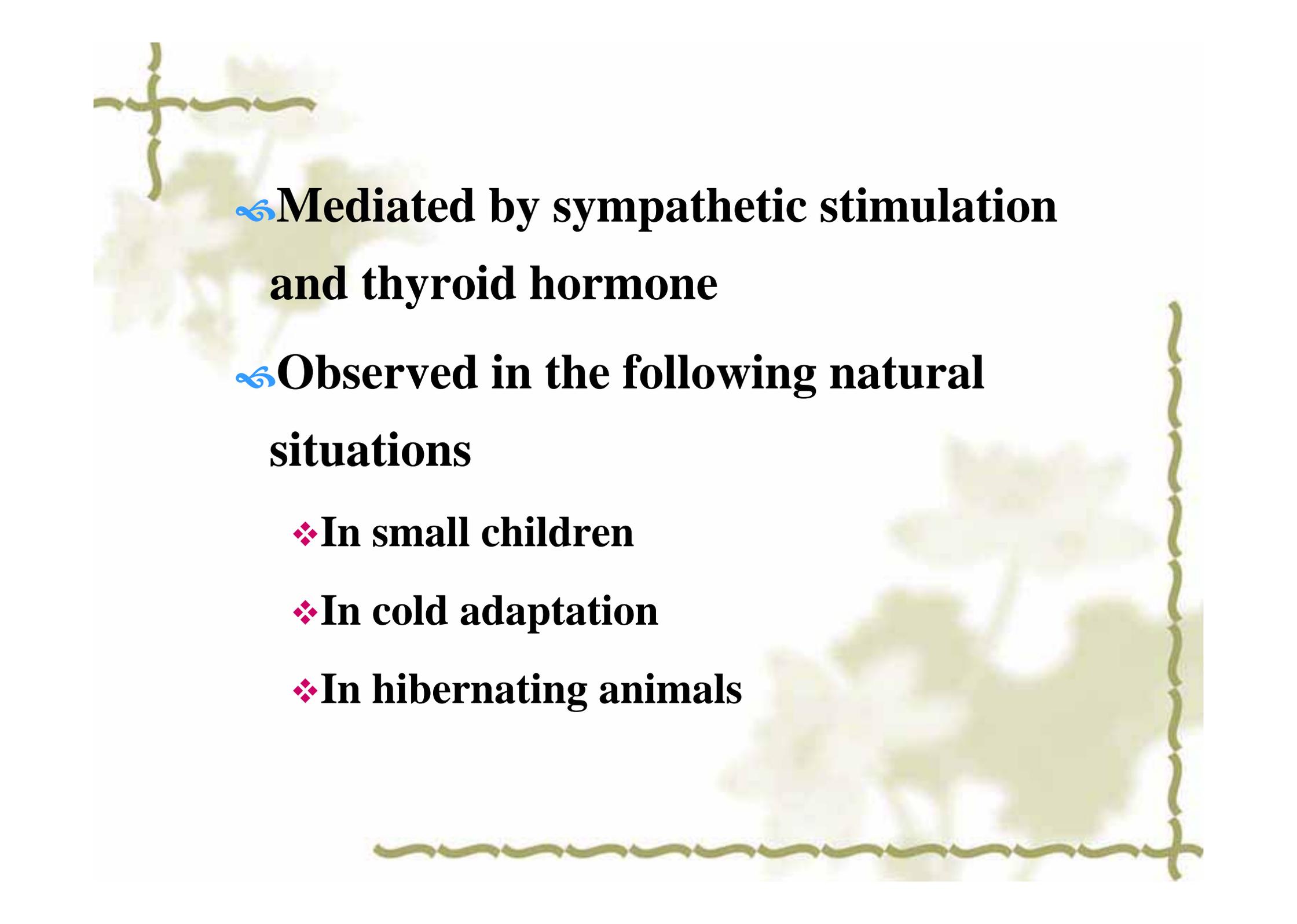
- ❖ rhythmic, oscillating skeletal muscle contractions

⌘ Voluntary change

❖ Chemical activity (non-shivering thermogenesis)

🔗 Brown adipose tissue





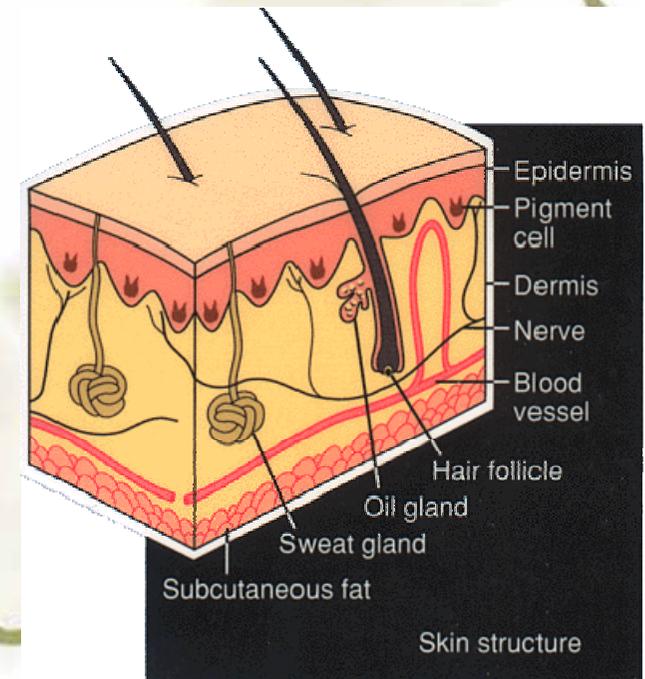
**❧ Mediated by sympathetic stimulation
and thyroid hormone**

**❧ Observed in the following natural
situations**

- ❖ In small children**
- ❖ In cold adaptation**
- ❖ In hibernating animals**

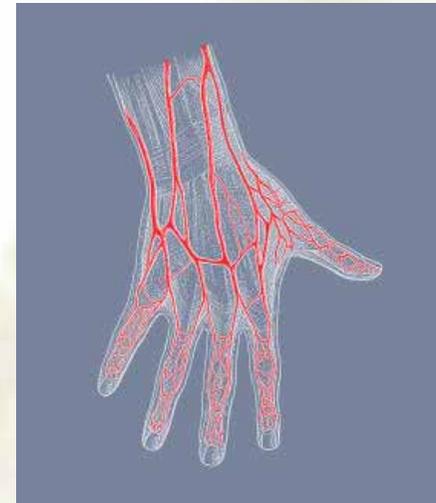
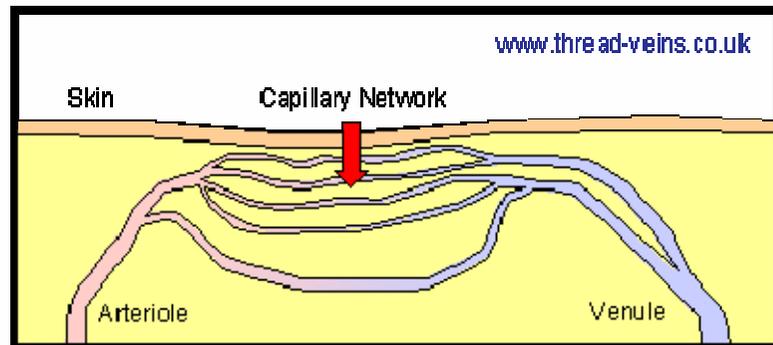
Heat Loss

❖ Heat transfer



heat transfer from the body core to skin

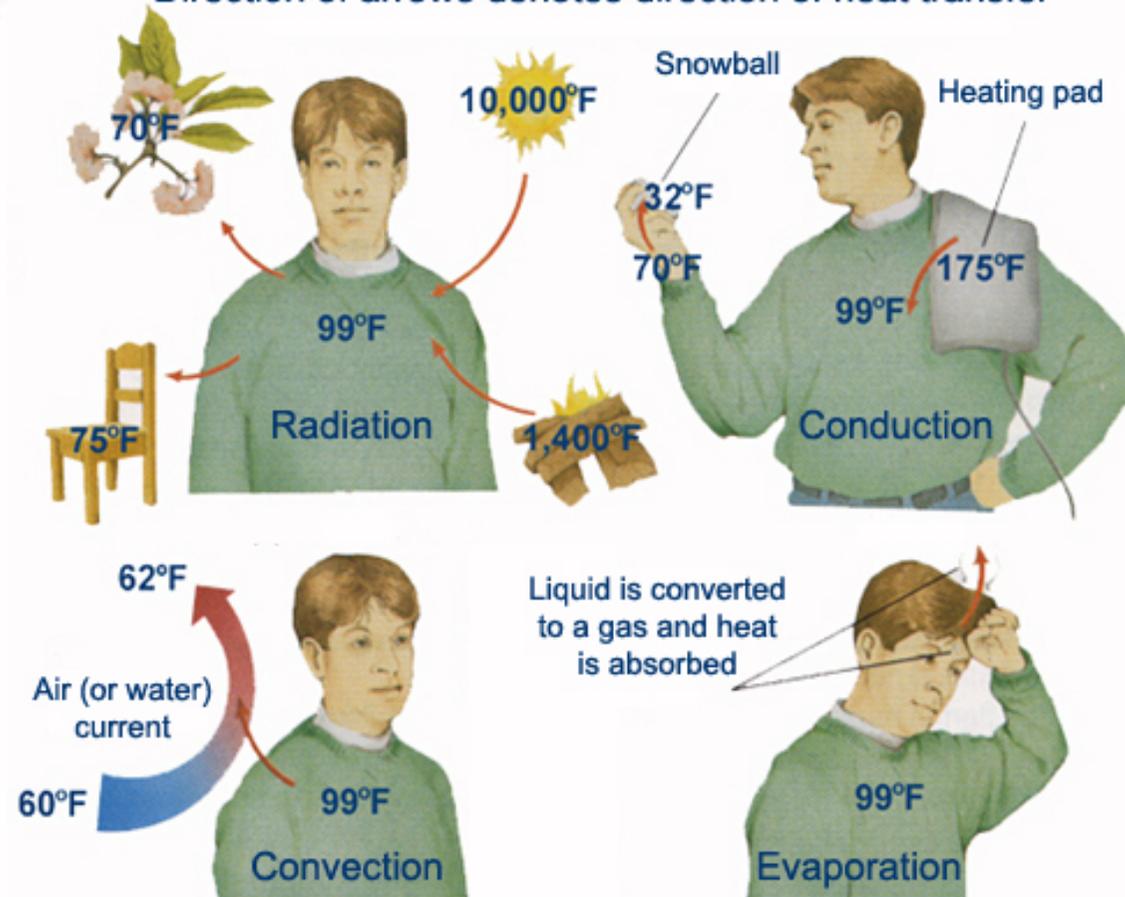
- ❖ flow of blood
- ❖ controlled by the sympathetic nervous system



Heat is lost from the skin

Heat Exchange

Direction of arrows denotes direction of heat transfer



❖ Radiation

☞ in the form of
electromagnetic waves



❖ Conduction

- ❧ Temperature difference between the touching objects
- ❧ Thermal conductivity



heating pad



❖ Convection

↪ Air (H₂O) currents

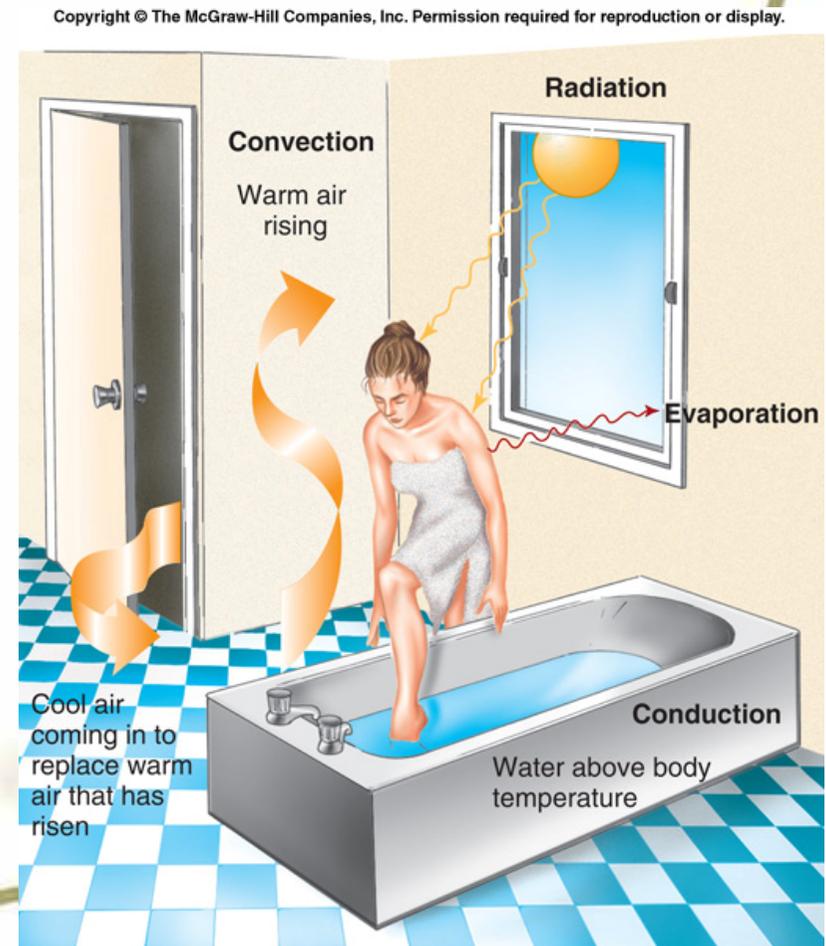


❖ Evaporation

⤿ Required to transform water from a liquid to a gaseous state

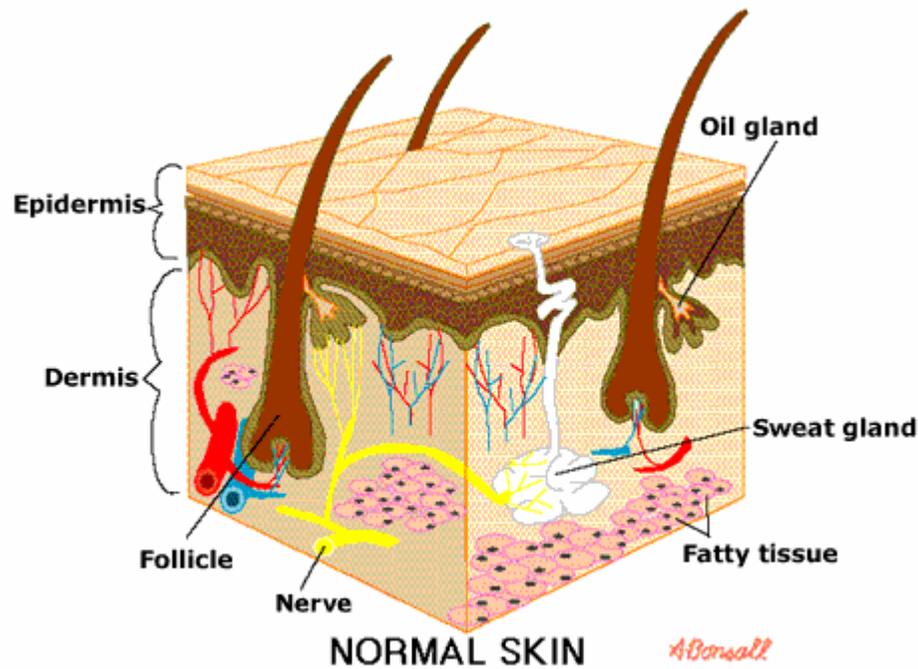
⤿ Forms

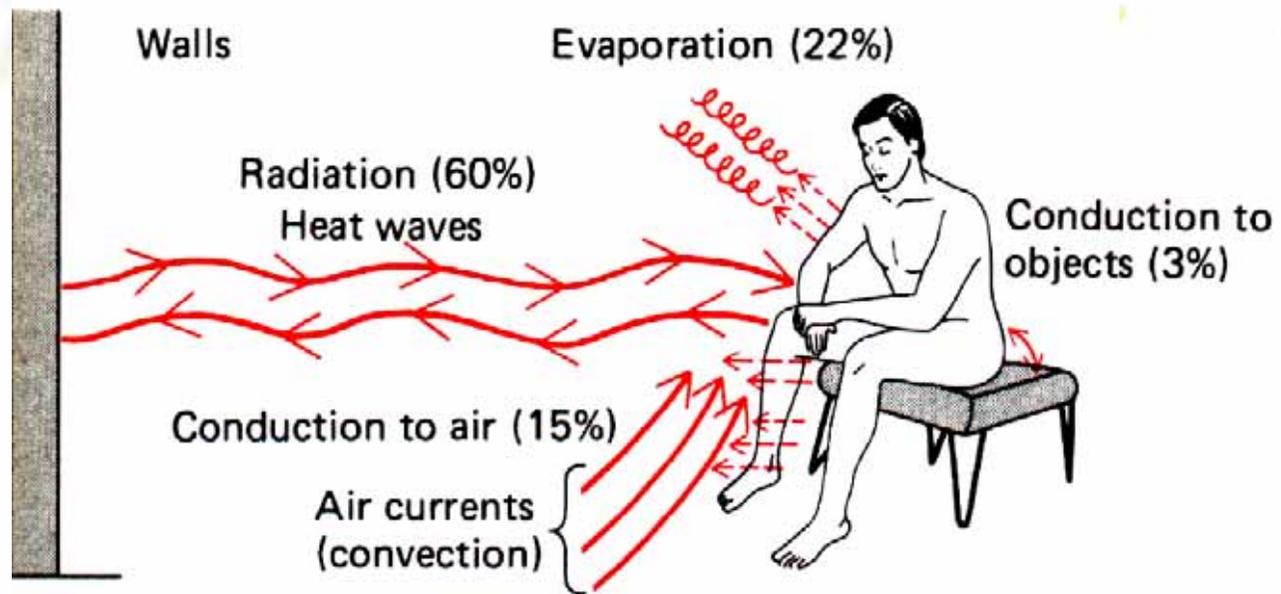
- ❖ Insensible Evaporation
- ❖ Evaporation of sweat



❖ Sweating

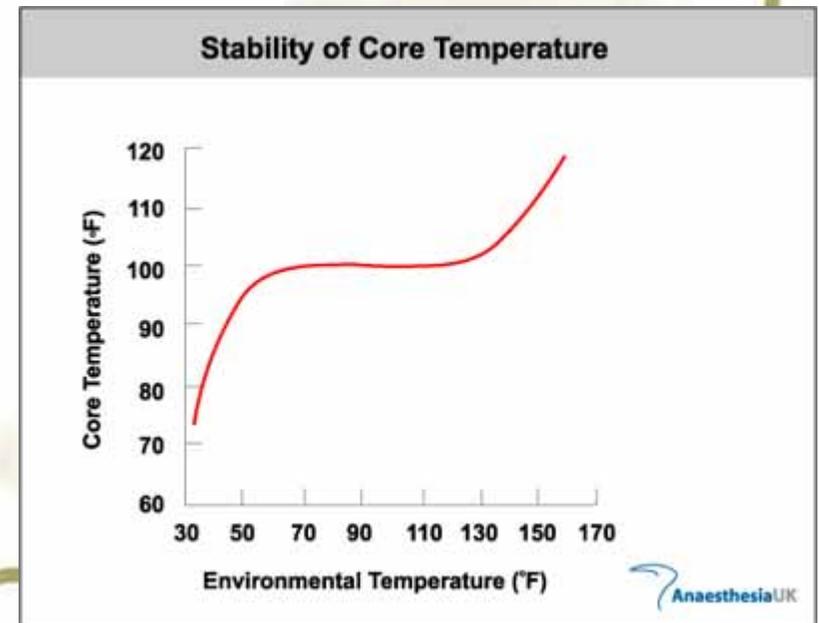
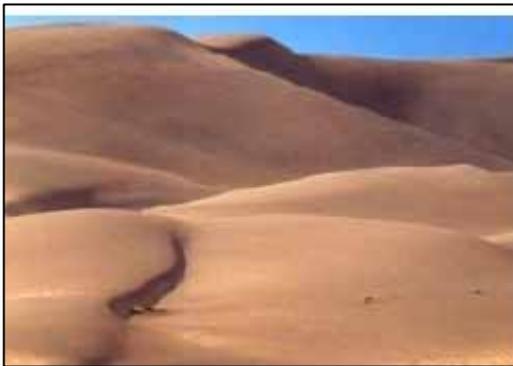
- ❧ An active evaporative heat loss process
- ❧ Sweat gland
- ❧ Cholinergic sympathetic nerve innervation





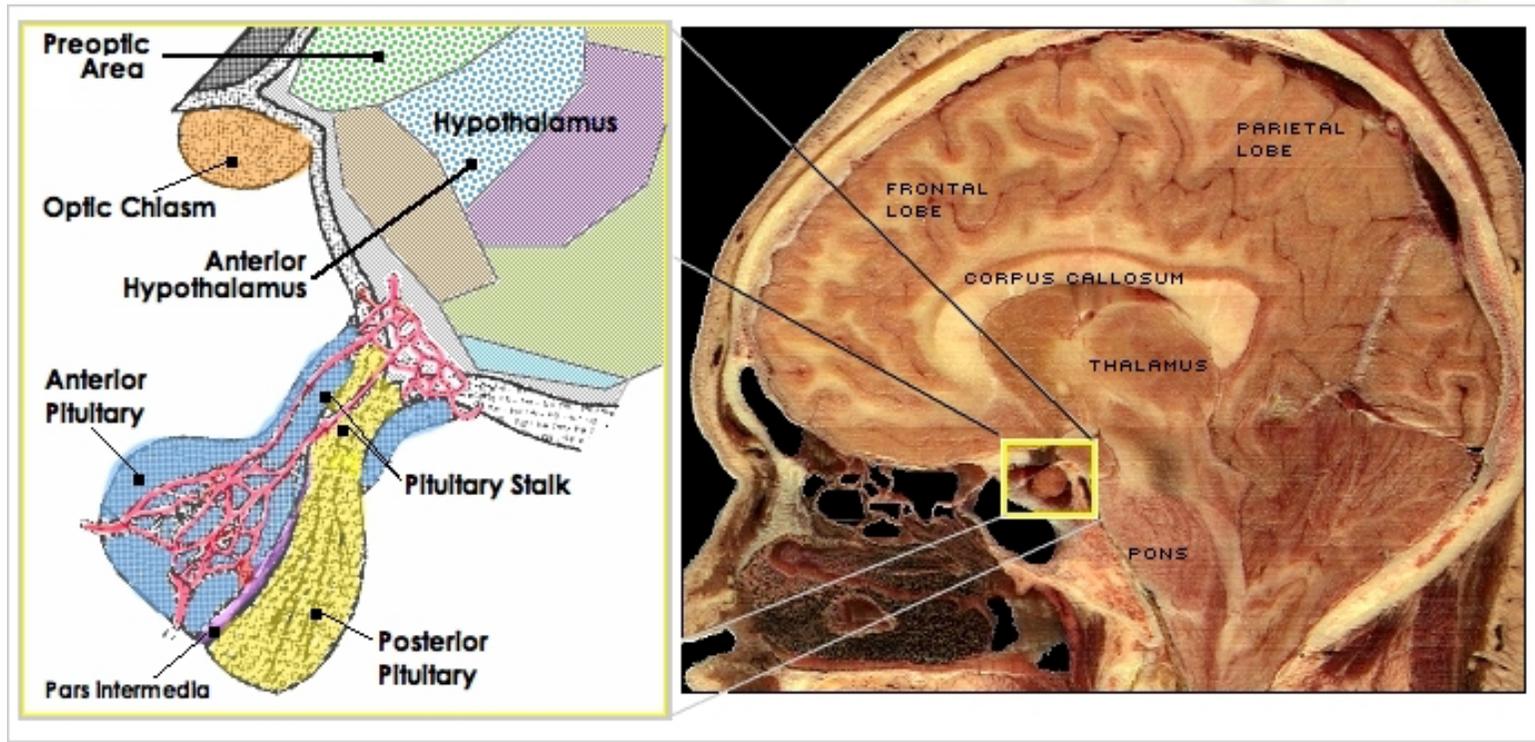
Temperature Regulation

- ❖ **Body temperature is controlled by balancing heat production against heat loss**

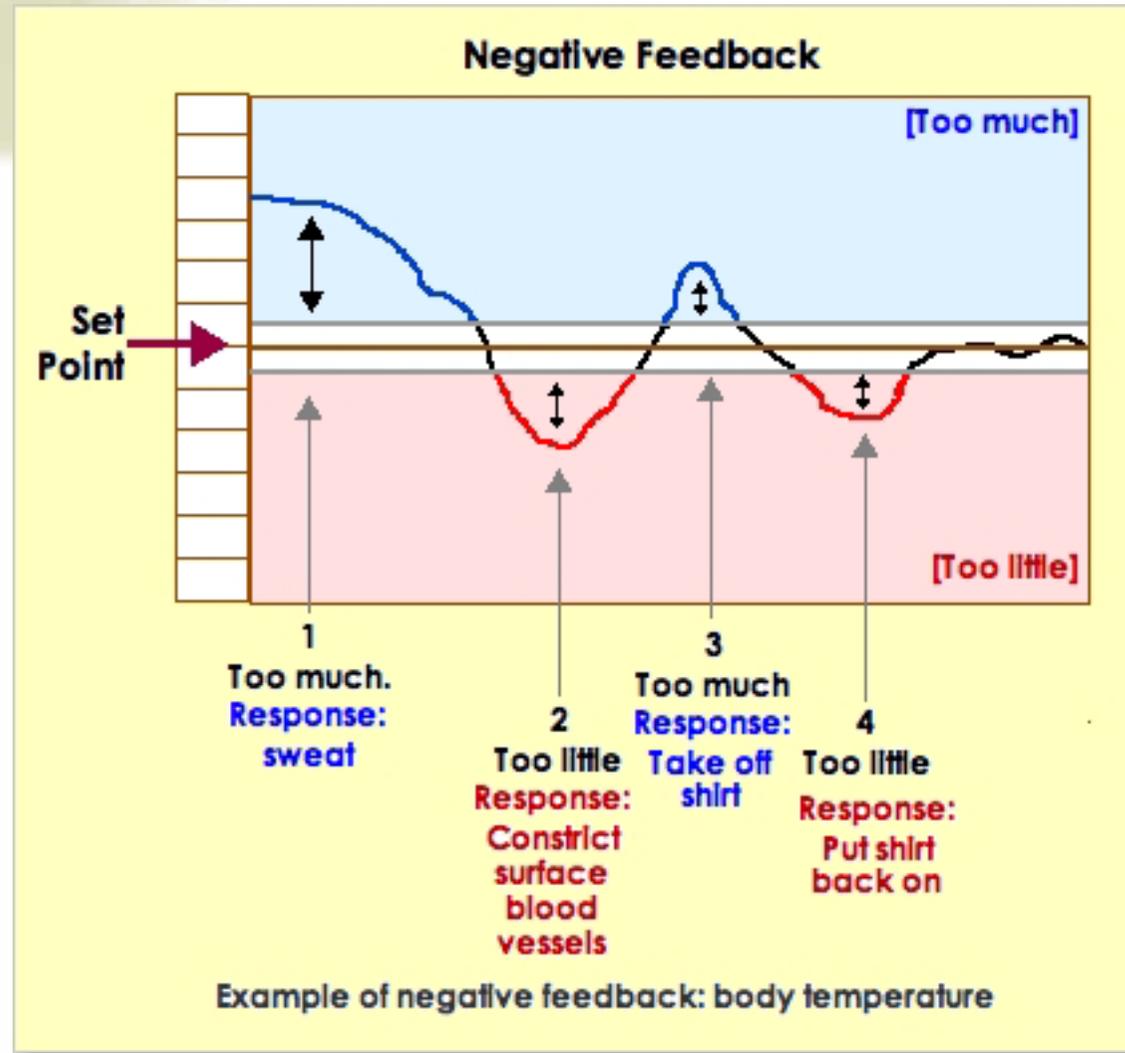


Thermoregulatory center

- ❖ **Preoptic/anterior hypothalamus (PO/AH)**
 - ⌘ **Thermostat: set point**

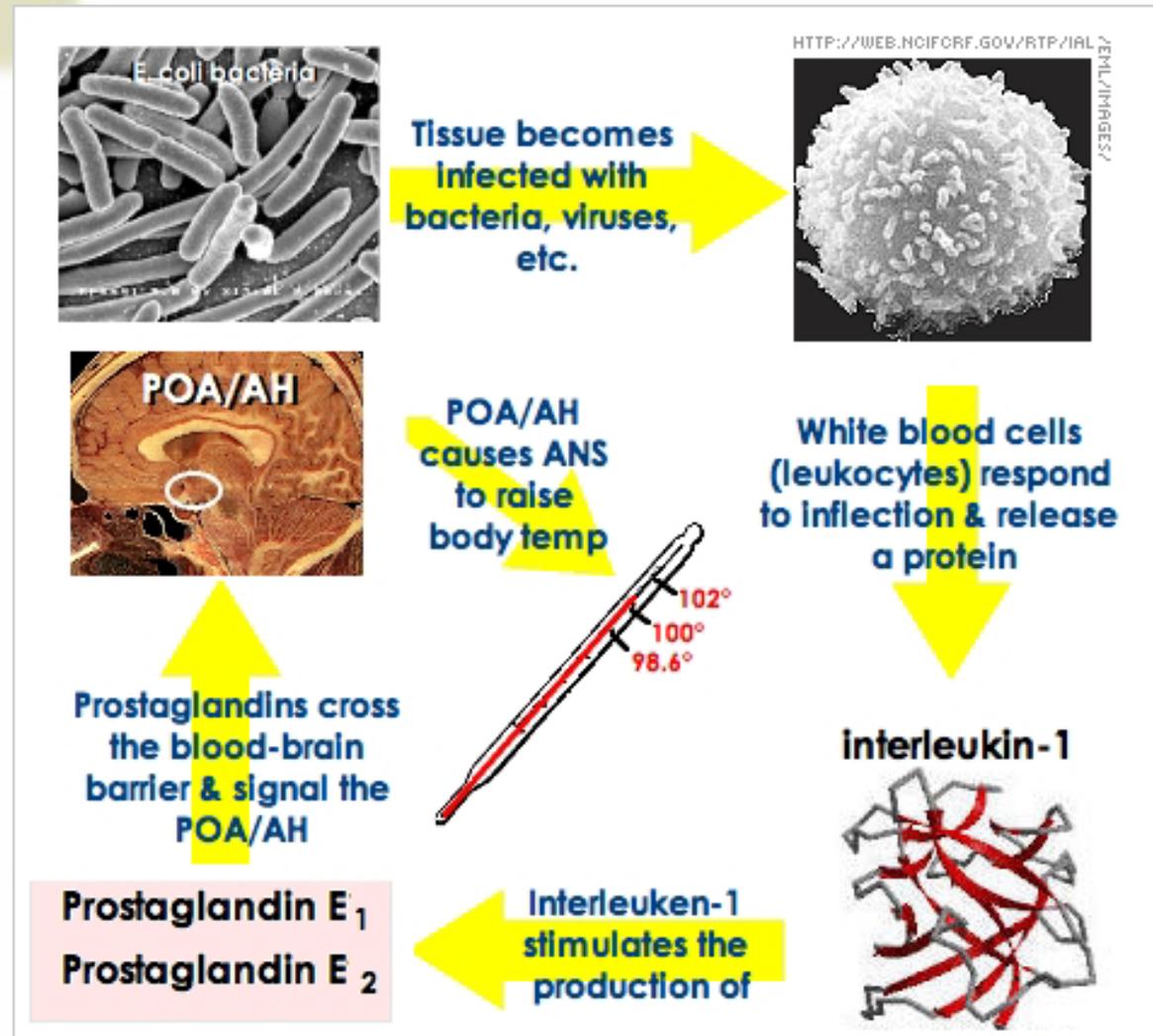


❖ set point theory



Fever

❖ Pyrogens: Shift the set point

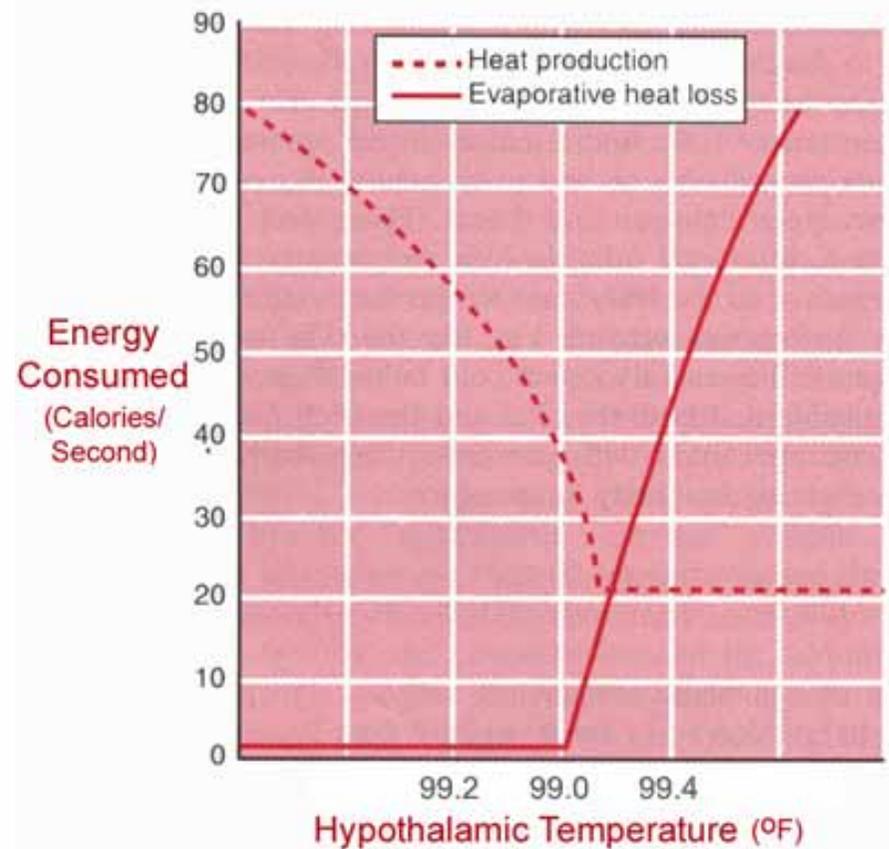


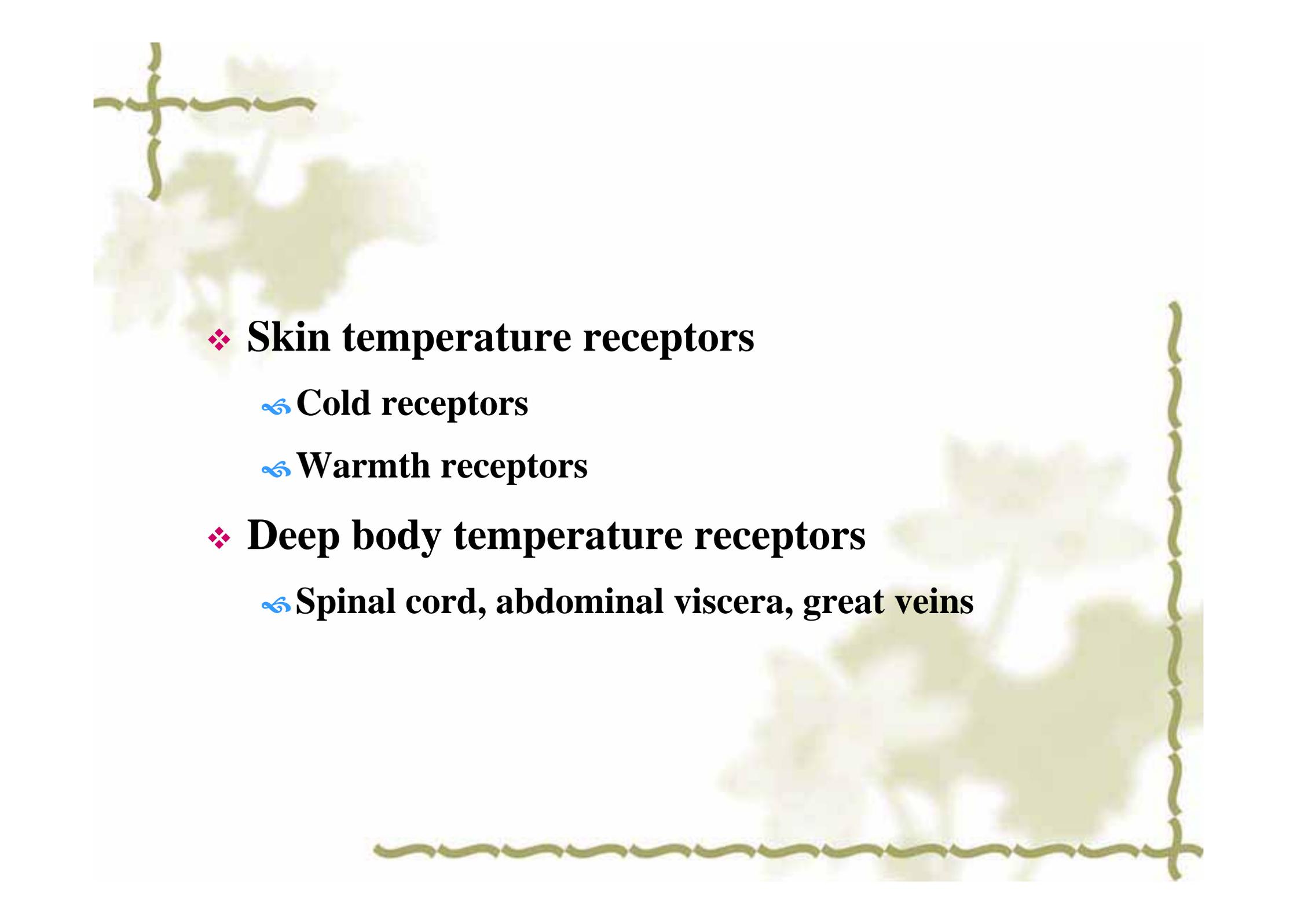
Temperature receptors

❖ PO/AH

☞ Heat-sensitive neurons

☞ Cold-sensitive neurons





❖ **Skin temperature receptors**

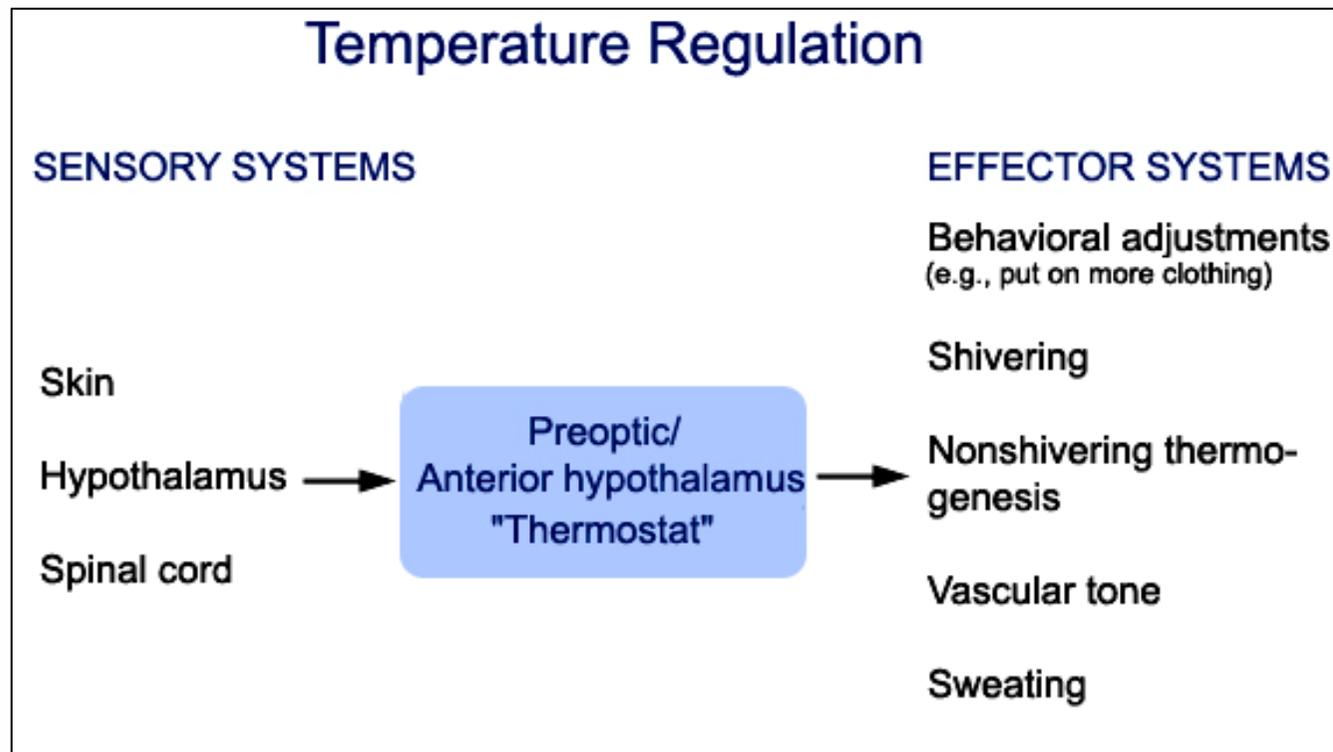
↳ **Cold receptors**

↳ **Warmth receptors**

❖ **Deep body temperature receptors**

↳ **Spinal cord, abdominal viscera, great veins**

- ❖ **PO/AH monitors its own temperature and receives input from receptors in skin & spinal cord**
- ❖ **Behavioral control of temperature**



Cold exposure

- ❖ **Immediate reflex effects**

- ❧ **Shivering**

- ❧ **Nonshivering thermogenesis (Sympathetic excitation)**

- ❧ **Skin vasoconstriction**

- ❖ **Chronic effect**

- ❧ **Thyroxine**

when the body is too hot

- ❖ **Vasodilatation**
- ❖ **Sweating**
- ❖ **Decrease in heat production**



Summary

- ❖ **Terms**
 - ☞ **Specific dynamic action of protein**
 - ☞ **Basal metabolic rate**
 - ☞ **Body temperature**
 - ☞ **Set-point**
- ❖ **List the factors that affect energy metabolic rate**
- ❖ **Describe the modes of heat-loss from the skin**