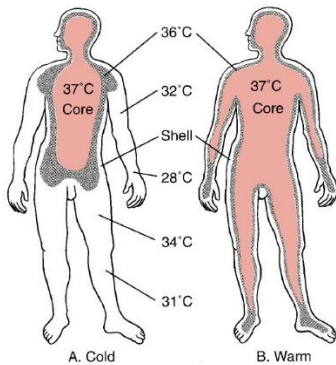


REGULATION OF BODY TEMPERATURE

OBJECTIVES

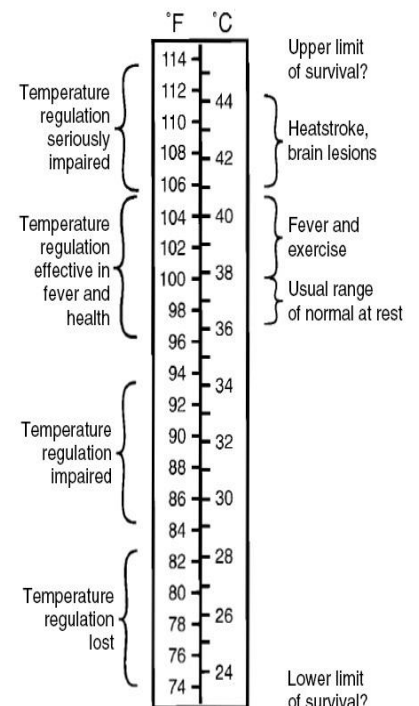
- Body temp measurement.
 - Heat balance.
 - Regulation of body temp.
 - Exposure to hot
 - Exposure to cold
1. Normal body temp. ranges from 36.6-37.2°C (within ± 0.6°C) which maintain all biological activities and cellular survival.
 2. The limit (absolute limit) of life is from 20 - 43°C body temp.

TYPES OF BODY TEMPERATURE		
CORE	SURFACE (SHELL)	
<ul style="list-style-type: none"> • Temp. of interior of body • For deep body structures as: <ol style="list-style-type: none"> 1. Brain 2. Heart 3. Lungs 4. Abd. Organs 	<ul style="list-style-type: none"> • Temp. of skin and underlying tissues • which varies markedly according to environmental temp 	
	Skin covering head, chest and abdomen have high temp.	34°C.
	Skin covering large ms of leg and arm	30°C.
	Skin covering small ms of hands and feet	28°C.



BODY TEMP. CAN BE MEASURED:		
ORALLY	Affected by <ul style="list-style-type: none"> • hot or cold fluids • mouth breathing 	<ul style="list-style-type: none"> • gum chewing • cigarette smoking.
PER RECTUM	(0.5°C higher than oral temp.).	
PER AXILLA	(0.5°C lower than oral temp.).	
MEATUS TEMP	by flexible probe inserted close to tympanic memb.	

THE BODY TEMPERATURE CAN BE MEASURED ON 3 SCALES:		
FAHRENHEIT F	<ul style="list-style-type: none"> • Old temperature scale . • Tf = temperature in degrees Fahrenheit 	<p style="text-align: center;">Tf = (9/5)* Tc+32</p> <p>- Take the temperature in Fahrenheit subtract 32. - Divide by 1.8. - The result is degrees Celsius.</p>
CELCIUS °C	<ul style="list-style-type: none"> • Today temperature scale • Tc = temperature in degrees Celsius 	Tc = (5/9)* (Tf-32)
KELVIN K	<ul style="list-style-type: none"> • is a unit increment of temperature, • written K and not °K. 	0 Kelvin = - 273°C



HEAT CONTENT OF THE BODY:

- Every person storing in his body an amount of heat equal to heat content.
- Heat content = body weight x specific heat of human tissue x body temp.
- The balance () heat production and heat loss (heat balance) determines body temp.

heat content ↑	↑ body temp.	ms exercise
stored heat ↓	↓ body temp	exposure to cold

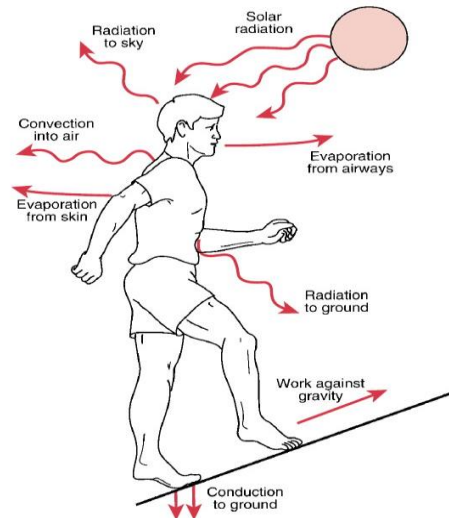
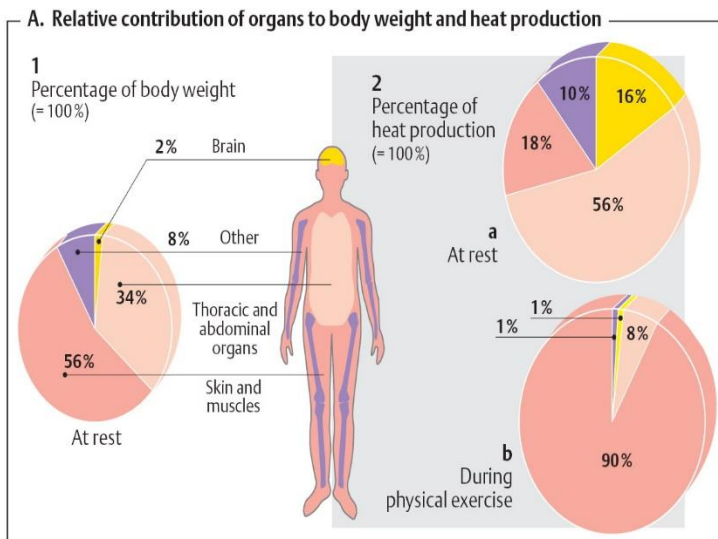
SOURCES OF HEAT PRODUCTION

1. Ms exercise.
2. Food (physiological +SDA).
3. All vital processes of BMR.
4. Hot weather (heat gain).
5. Extra metabolism caused by growth, symp and cell activity.

HEAT LOSS

Routes:

- Skin 85%.
- Resp. tract 14%
- Body excreta 1%.

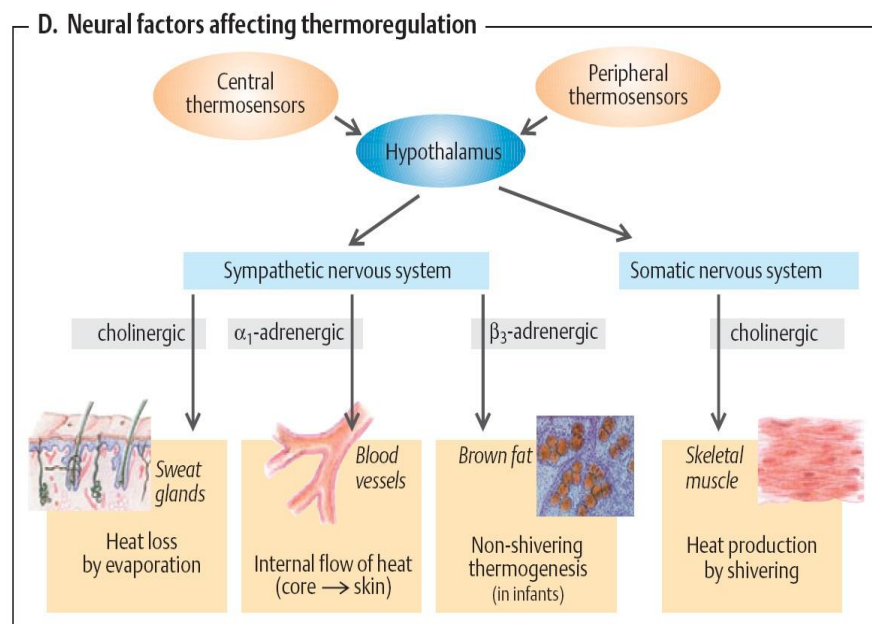
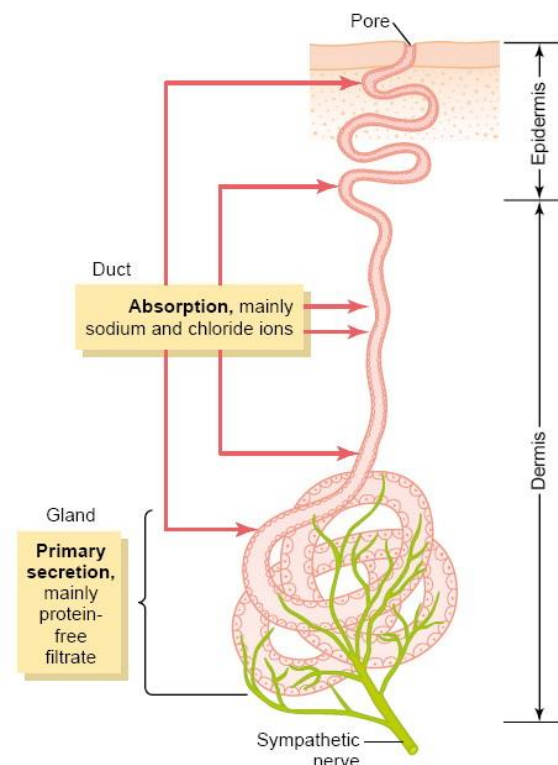


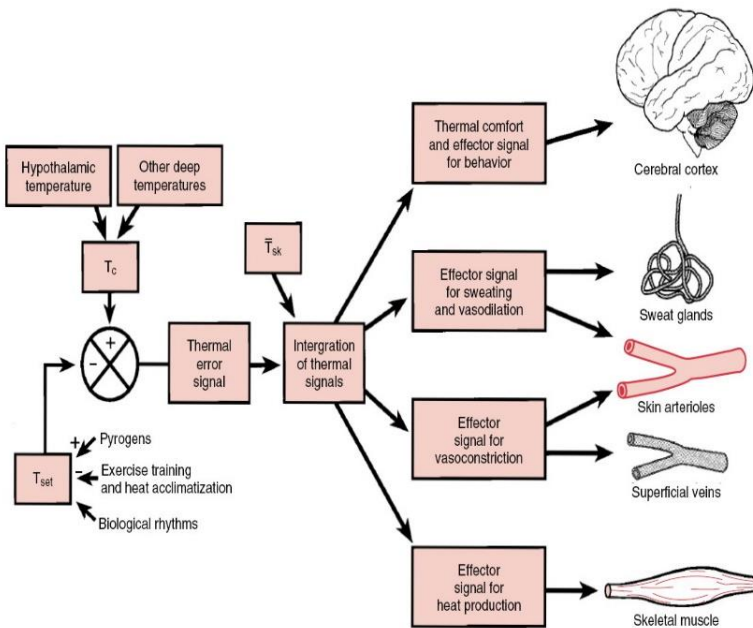
MECHANISMS HEAT LOSS

CONDUCTION (3%)	<ul style="list-style-type: none"> • Heat lost from warm object to cooler one by contact such as air, clothes and water. • This mechanism is minor except when person is immersed into water.
CONVECTION (6-12%)	<ol style="list-style-type: none"> 1. Heat loss to object not in contact by way of air current 2. Air on skin becomes warmer, and lighter 3. Ascend and fresh air layer takes place 4. become warmer and ascend and so on. <ul style="list-style-type: none"> • Also of minor importance except cold winds (forced convection).
IRRADIATION (60%)	<ul style="list-style-type: none"> - Heat loss from warm object to cooler one not in contact with the body -- by infra red rays. - Surface of body emits heat in the form of electromagnetic waves (infrared rays). - All objects are radiating heat - Sun is a powerful radiator
EVAPORATION (Vaporisation)	<ul style="list-style-type: none"> • Latent heat of evaporation: amount of heat required for evaporation of 1 gm of water from the surface of the body (it equals 0.6°C).

SWEATING

<p>SWEATING OCCURS IN THE FOLLOWING STATES:</p> <ol style="list-style-type: none"> 1. Exposure to hot weather <ul style="list-style-type: none"> ○ heat loss occurs only by sweating. 2. During ms exercise <ul style="list-style-type: none"> ○ even in cold weather, due to ↑ rate of heat production. 3. Fever. 	<p>HEAT LOSS IN SWEATING DEPENDS ON:</p> <ol style="list-style-type: none"> 1. Evaporation of sweat. <ul style="list-style-type: none"> ● It is effective in dry, cold weather with air currents. 2. In hot humid weather, sweating occurs excessively <ul style="list-style-type: none"> ● sweat does not evaporate ● no cooling effect ● Discomfort in hot humid weather. 3. There are about 2.5 millions sweat glands in the body.
<p>RATE OF SWEATING:</p> <ol style="list-style-type: none"> 1. In cold weather → zero. 2. In very hot weather max rate rises from 0.7 L/h to 1.5 or 2 L/h. 	<p>MECHANISM OF SWEAT SECRETION</p> <ol style="list-style-type: none"> 1. ++ of ant. hypothalamic n. (preoptic area) 2. transmitted via autonomic pathway to reticulospinal tract 3. symp. outflow to skin everywhere in body.
<p>THE VASODILATATION ASSOCIATED WITH SWEATING IS CAUSED BY :</p> <ol style="list-style-type: none"> 1. Direct from heat on blood vessels. 2. Reflex from heat receptors. 3. Blood temp. ↑ at hypothalamus → - - of VCC. 4. Bradykinin (vasodilator) as a result of sweat gland activity. 	<p>REGULATION OF BODY TEMPERATURE</p> <ul style="list-style-type: none"> ● Human is Warm blooded (homeothermic animals). ● Its body temperature should be kept constant within very narrow limit of variation. ● The thermoregulatory system includes two different subsystems: <ol style="list-style-type: none"> 1. Behavioral thermoregulation. 2. Physiologic thermoregulation.





THERMOREGULATORY SYSTEM	
BEHAVIORAL	PHYSIOLOGIC
<ul style="list-style-type: none"> Use of air conditions, and clothing to live in most extreme climates on earth. Importance: to ↓ thermal discomfort. 	<ul style="list-style-type: none"> Capable of fine adjustment of heat balance and body temp. Effective only within a relatively narrow range of environmental temp. Includes → receptors, afferents, center, efferents, and effectors.

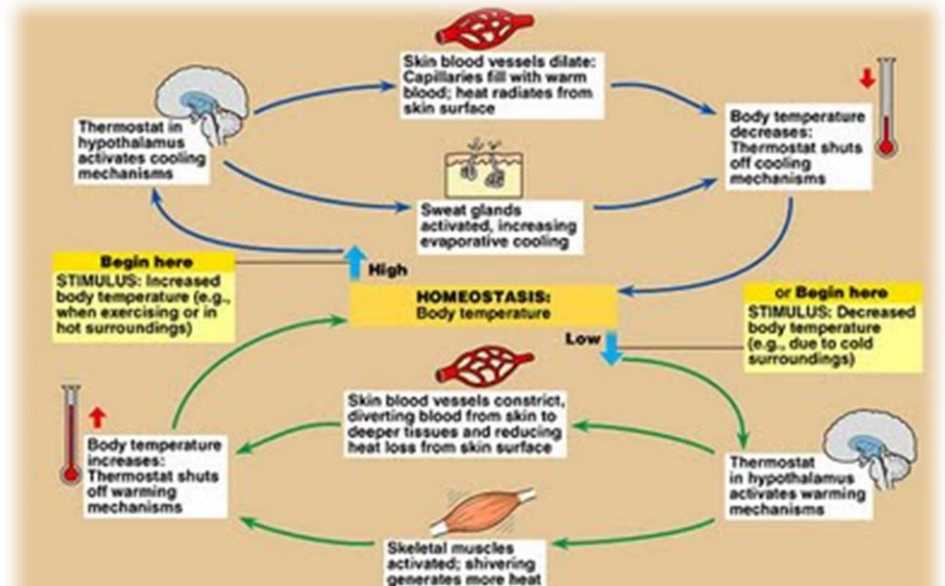
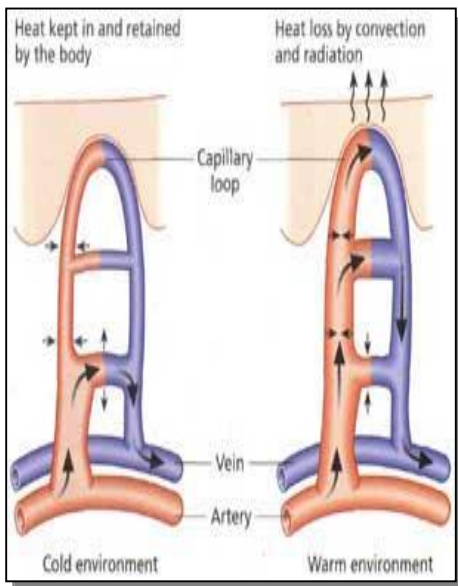
I. THERMORECEPTORS

CENTRAL	PERIPHERAL
<ul style="list-style-type: none"> heat sensitive neurons are located in preoptic area of hypothalamus (about one third as cold-sensitive neurons). Information is transmitted to them via bl. from central structures about core temperature . 	<ul style="list-style-type: none"> Cutaneous Rs warm or cold Rs. (Cold Rs are 10 times as warm). Information from peripheral Rs is transmitted via lateral spinothalamic tract to thalamus and hypoth.

II. THE TEMP REGULATING CENTER (HYPOTHALAMIC THERMOSTAT)

- Hypothal. thermostat adjust body temp. at 36.6 - 37.2 °C w is called **set point**.
- It detects any deviation of body temp. from set point by comparing sensory information received from thermoreceptors with set point.
- Any deviation from the set point → ++ appropriate effector organ.

ANTI-RISE CENTER (HEAT LOSS CENTER)	ANTI-DROP CENTER (HEAT GAIN CENTER)
<ul style="list-style-type: none"> It is located in ant. hypothalamic preoptic area. ++ with ↑ in core temp. cutaneous VD, sweating, and -- ms tone. 	<ul style="list-style-type: none"> It is located in post. hypothalamus. ++ with ↓ core temp. cutaneous VC, ↑ ms tone and shivering.



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III. EFFECTOR ORGANS

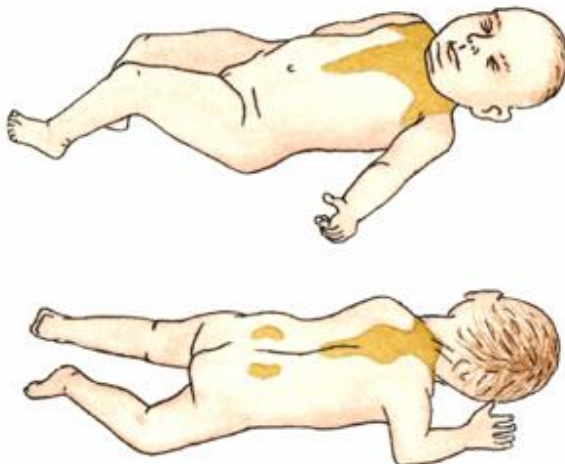
1. SKIN

- regulates body temp. through → blood vs and sweat gland.

CUTANEOUS BL. VS	SWEAT GLANDS
<ul style="list-style-type: none"> Receive symp. VC fibers Change amount of bl. flow to skin Regulation of skin temp. 	<ul style="list-style-type: none"> Supplied by symp. cholinergic fibers. Sweat evaporation reduces the body temp. (1ml of sweat loses 0.6 Cal from the body).

3. BROWN FAT THERMOGENESIS

- In human newborn → highly vascular tissues known as brown fat situated between scapulae and around intra-abd. vessels.
- Brown fat can give free FA directly generating heat however; its value in adults is very limited.
- Brown fat thermogenesis is induced by ↑ noradrenalin from symp. nerve terminals. It can ↑ MR to about 2.5 times the resting value.



2. SKELETAL MUSCLE(SHIVERING THERMOGENESIS

Def. Shivering is an involuntary contr. of sk ms.

Mechanism:

- On exposure to cold
- Cold signals from peripheral thermo Rs (skin and sp. cord)
- ++ post hypothal.
 - (w is normally -- by signals from preoptic area)
- ++ of this center
- ↑ ms tone
 - (by ↑ activity of AHCs through RST)
- Tone rises above certain level
- Involuntary ms contraction
- Shivering that can raise MR from 3 to 5 fold.

Thus, shivering ↑ heat production rapidly, however, it can not maintain body temp. during exposure to cold weather for long time.

4. ENDOCRINE GLANDS (HORMONAL THERMOGENESIS)

- Thyroxin, noradrenalin/adrenalin, and steroid hs ↑ metabolism reaction
- ↑ body temp. on prolonged exposure to cold

PHYSIOLOGICAL REGULATION OF BODY TEMP.

I. THERMONEUTRAL ZONE (24-32C)

At the thermoneutral zone heat regulation occurs through the autonomic nervous system only by VD & VC of skin BV

ATMOSPHERIC TEMP ↑ TO 32C	ATMOSPHERIC TEMP ↓ TO 24C
body temp tends to ↑ → ++ heat loss center → --VCC → VD of cutaneous BV and ↑ skin blood flow → ↑ skin temp → ↑ temp gradient between skin and atmosphere → ↑ heat loss through the skin → ↓ body temp to normal.	body temp tends to ↓ → ++ heat gain center → ++VCC → VC of cutaneous BV and ↓ skin blood flow → ↓ skin temp → ↓ temp gradient between skin and atmosphere → ↓ heat loss through the skin → ↑ body temp to normal.

II. ON EXPOSURE TO HOT WEATHER (PHYSICAL REGULATION)

↑ HEAT LOSS	↓ HEAT PRODUCTN
<ol style="list-style-type: none"> 1. VD of cut. bl. Vs - thru -- sympa centers in post. hypoth. cause VC 2. ↑ skin temp. - ↑ temp gradient btwn skin & atmosphere - ↑ heat loss from deep structures to body surface by conduction-convection & irradiation - ↓ Body temp. to normal. 3. Sweating - result in a fluid loss (up to 1 L/h) and electrolytes imbalance - becomes less effective as humidity increases. - Sweat evaporation is affected by air currents, environmental temp. and humidity. 	<ol style="list-style-type: none"> 1. By -- of heat producing mechanism <ul style="list-style-type: none"> • ms tone • shivering. 2. Behavior response (↓ feeding, light clothes & use of fans)

III. ON EXPOSURE TO COLD WEATHER (CHEMICAL REGULATION)

↑ HEAT PRODUCTN	↓ HEAT LOSS.
<ol style="list-style-type: none"> 1. Ms tone and shivering 2. Secretion of thermogenic hormones - ++ of post. hypothal. - ↑ thyroxin, adrenalin, and glucocorticoids - ↑ cellular metabolism & amt of heat production. 3. Brown fat Thermogenesis. 	<ol style="list-style-type: none"> 1. Cut. bl. vessels VC - ↓ skin temp. - ↓ temp. gradient () skin & atmosphere - ↓ heat loss. 2. Curling up in a ball - ↓ body surface area exposed to envirnmt. 3. Horripilate - erection of skin hair w is importance in animals - ↓ heat loss.