

BODY TEMPERATURE

Dr Pallavi Badhe





BODY TEMPERATURE

- Homeothermic
- Poikilothermic

Normal Body Temperature:

- Normal body temperature:

36⁰C – 37.5⁰C (97.0⁰F – 99.5⁰F)

Conversion : $^{\circ}\text{F} = 9/5 ^{\circ}\text{C} + 32;$

$^{\circ}\text{C} = (^{\circ}\text{F}-32)5/9$

- Skin (Shell) temperature : varies with environmental temp.
- Core temperature : Temperature of deep tissues of the body. Remains constant except in pathological state

Measurement

- Sites:

1. Axilla (Shell Temp)
2. Oral
3. Rectal (Core Temp)



- The oral temperature is normally 0.5°C lower than the rectal temp

Why do we need to regulate: Internal body temperature?

- To provide the optimum conditions for enzyme-catalysed reactions to be carried out.
- Temperatures **above** this:
denature enzymes and block metabolic pathways
- Temperatures **below** this:
slow down metabolism and affect the brain

Constancy of Internal Body Temperature

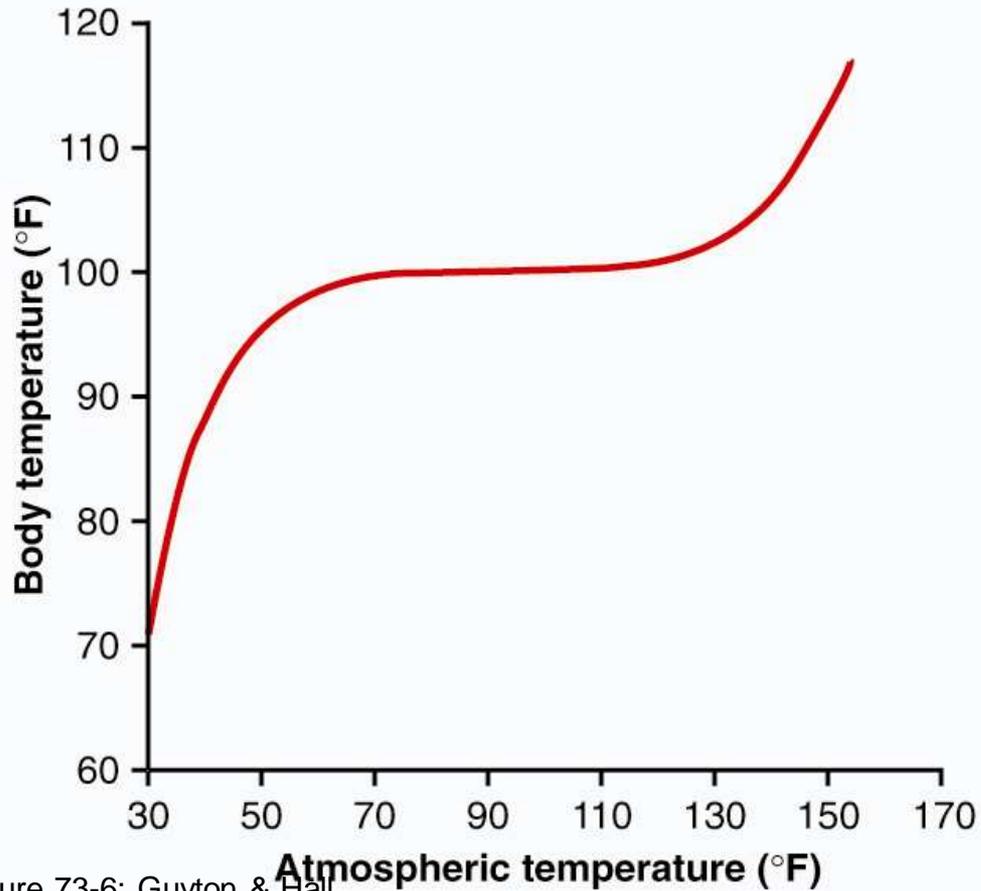


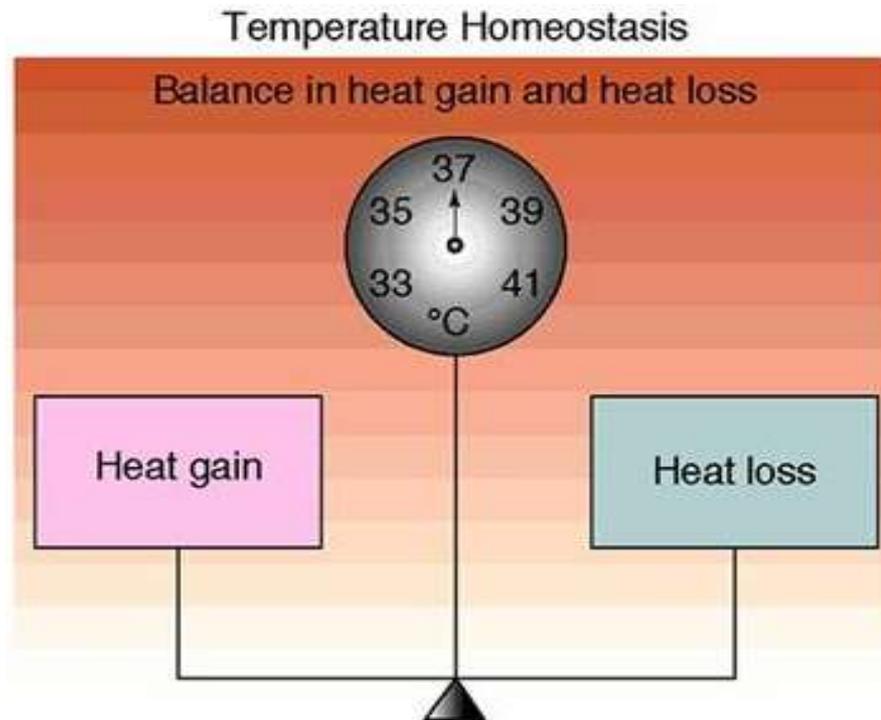
Figure 73-6; Guyton & Hall

Physiological variations:

- 1. Diurnal fluctuation: (about 0.6°C) lowest in the morning & highest in the evening (metabolic rate). Reverse rhythm in night workers**
- 2. In Woman at the time of ovulation and in luteal phase : 0.5°C increase**
- 3. Infants: Imperfect regulation**
- 4. Exercise : rise to as high as 40°C**
- 5. Emotional excitement**
- 6. Atmospheric conditions**

Heat Balance:

Heat production = Heat loss



Factors determining Heat Production:

- **BMR**
- **Contractions of skeletal muscles**
- **Actions of hormones such as thyroxin, epinephrine and norepinephrine**
- **Thermogenic effect of food**

Factors determining Heat loss:

- A. Conduction of heat from the deeper organs and tissues to the skin.**
- B. Transfer of heat from the skin to the surrounding.**
- C. Small amounts are removed in the urine and Feces**

Insulator system = Skin + Subcut. tissue + Fat

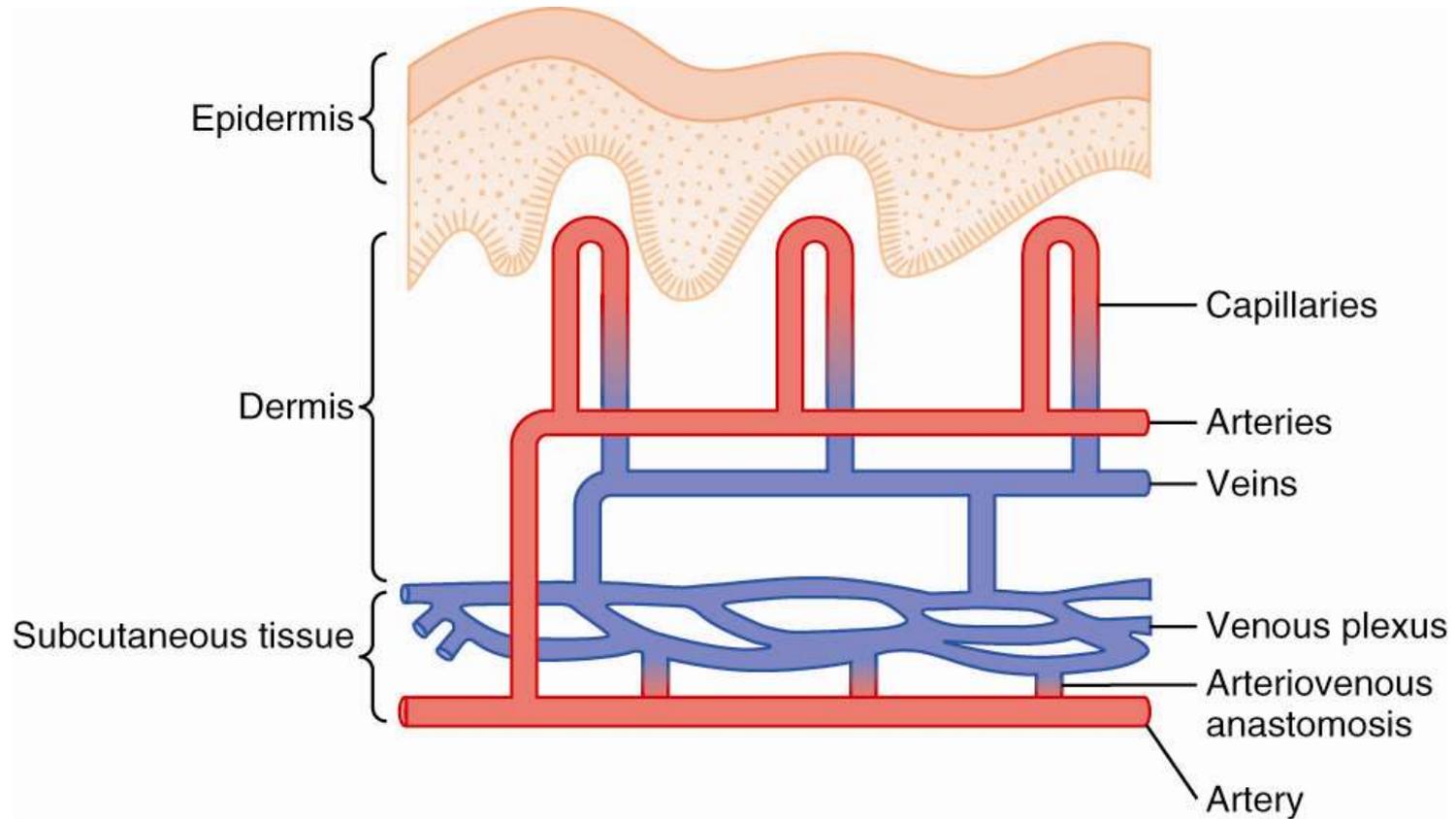


Figure 73-2; Guyton & Hall

How effective is the Skin “Heat Radiator” System?

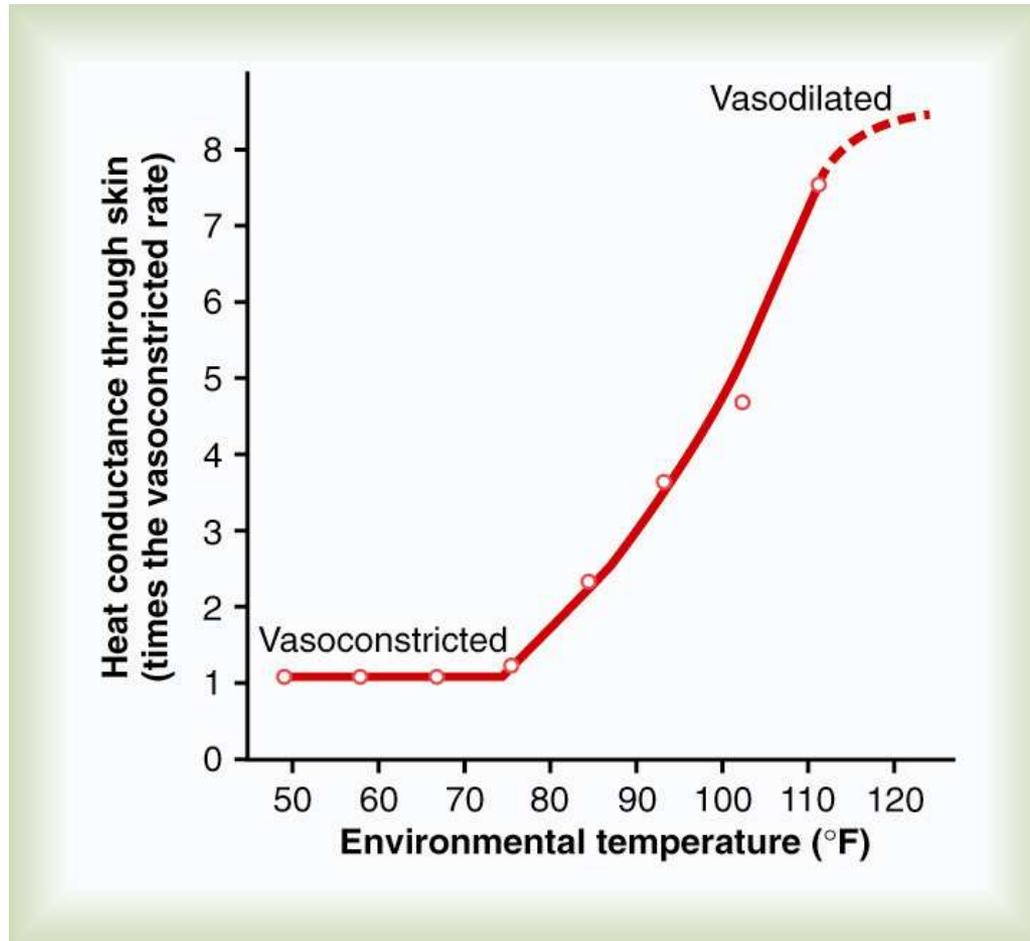


Figure 73-3; Guyton & Hall

Heat loss from the skin:

- Radiation: In the form of infrared heat rays
- Conduction: heat exchange between objects that are in contact with one another
- Convection: removal of heat from the body by air currents
- Evaporation: insensible water loss (50ml/h) + sweating

Physics of Heat Loss from the Body

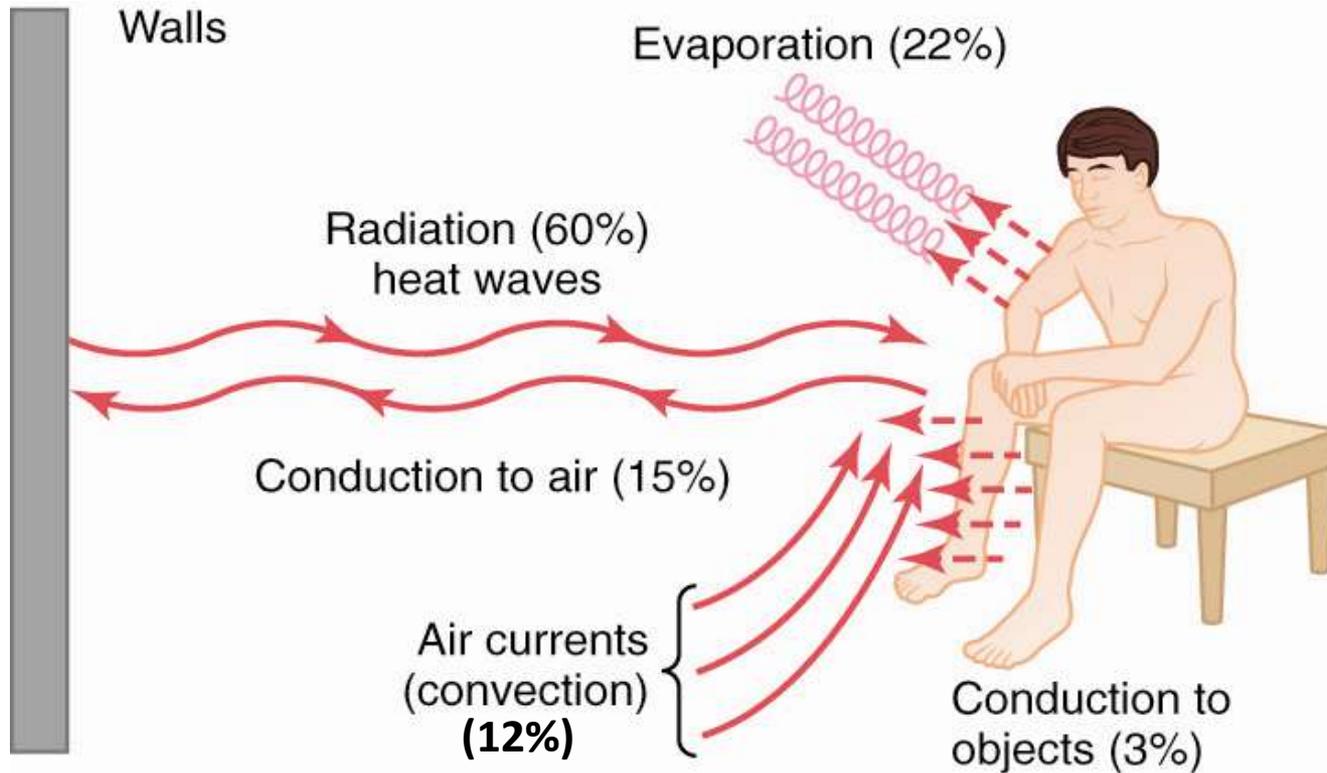


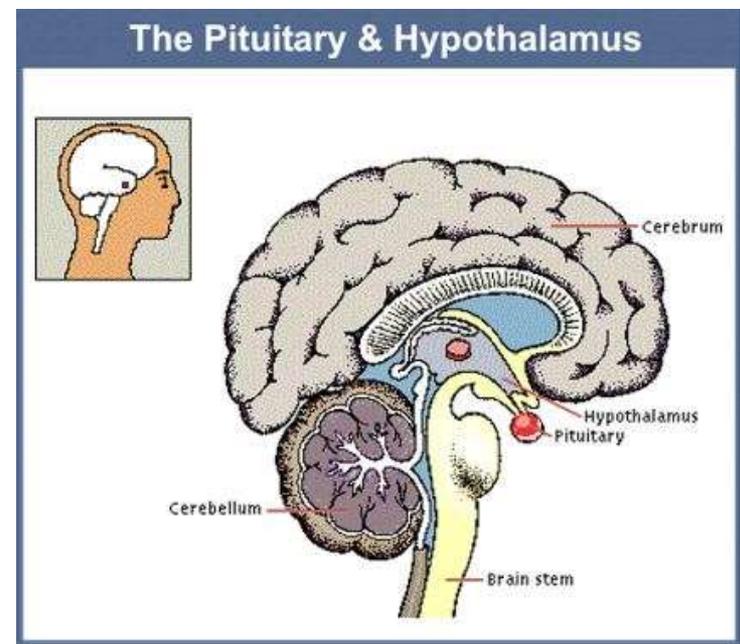
Figure 73-4; Guyton & Hall

Regulation of Body Temperature

- Thermoreceptors: give information about body temperature
 - Peripheral: -skin, mucus memb
(surface temp)
-visceras (core temp)
-mainly cold receptors
 - Central: -heat/ cold sensitive neurons in hypothalamus
-mainly warm receptors

Role of hypothalamus:

Temperature regulating centers located in hypothalamus



1. The anterior hypothalamus-preoptic area :
contain two types of neurons :
 - A) **Heat – Sensitive neurons (receptors)**
present in large numbers: increase their rate of firing as the temp. rises.

B) Cold – sensitive neurons (receptors): less in number. firing rate increase when the body temp falls.

2. The posterior hypothalamus : receives signals from central as well as from peripheral receptors where they are integrated to give appropriate reactions.

(Thus acting as a thermostat of body)

Set Point:

- The critical temperature in hypothalamus above which sweating begins and below which shivering begins (37.1°C or 98.8°F)
- Gain: High gain, so more effective

Temperature regulating mechanisms

- **Autonomic, somatic, endocrine & behavioral changes.**
- **Body temp above set point:**
 - ↑ heat loss
 - ↓ heat production
- **Body temp below set point:**
 - ↑ heat production
 - ↓ heat loss

Mechanisms activated by cold

❖ Decrease heat loss:

- vasoconstriction
- Piloerection

❖ Increase heat production:

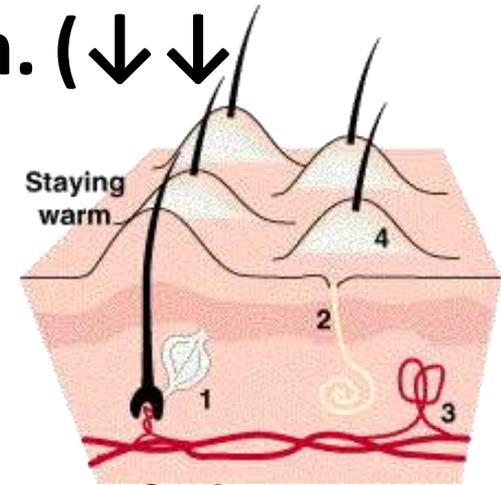
- Shivering
- Hunger
- Increased voluntary activity
- Chemical thermogenesis (Thyroxine, epinephrine & norepinephrine)



A. Decreased Heat Loss:

- Vasoconstriction:

Peripheral receptors → post. hypothalamus → symp. stimulation → vasoconstriction. (↓ ↓ conduction, convection, radiation)



- Piloerection (Horripilation):

- ✓ Sympathetic stimulation → contraction of the erector pili muscles → hair 'stand on end'.
- ✓ Entrap a thick layer of "insulator air"
- ✓ Imp in lower animals, not much important in the humans (manifested by "goose skin")

B. Increased Heat production:

- Shivering:
 - ✓ Involuntary response of the skeletal muscles
 - ✓ Controlled by primary motor center for shivering (Post hypothalamus)
 - ✓ Cold signals from skin and spinal cord ($<37^{\circ}\text{C}$) → excites centre for shivering → transmits signals to the anterior motor neurons → ↑ tone of the skeletal muscles → shivering begins above critical level.
 - ✓ Heat production can rise to as high as five times normal.

- **Hunger**: Specific dynamic action of food
- **Chemical Thermogenesis** : occurs in brown fat
 - ✓ Sympathetic stimulation → ↑ secretion of epinephrine & norepinephrine → uncoupling of oxidative phosphorylation → release energy in the form of heat.
 - ✓ Infants have some brown fat in interscapular space- increases heat production as much as 100% (Hence very important factor).
 - ✓ Instant heat production

- Role of Thyroid:

- ✓ Exposure to cold → ↑ production of thyrotropin-releasing hormone (TRH) by hypothalamus → secretion of the thyroid stimulating hormone (TSH) by anterior pituitary gland → Thyroxin secretion by thyroid gland → ↑ rate of cellular metabolism (chemical thermogenesis)
- ✓ Requires several weeks

Mechanisms activated by heat



❖ Increase heat loss:

- Vasodilation
- Sweating
- Increased respiration (panting)

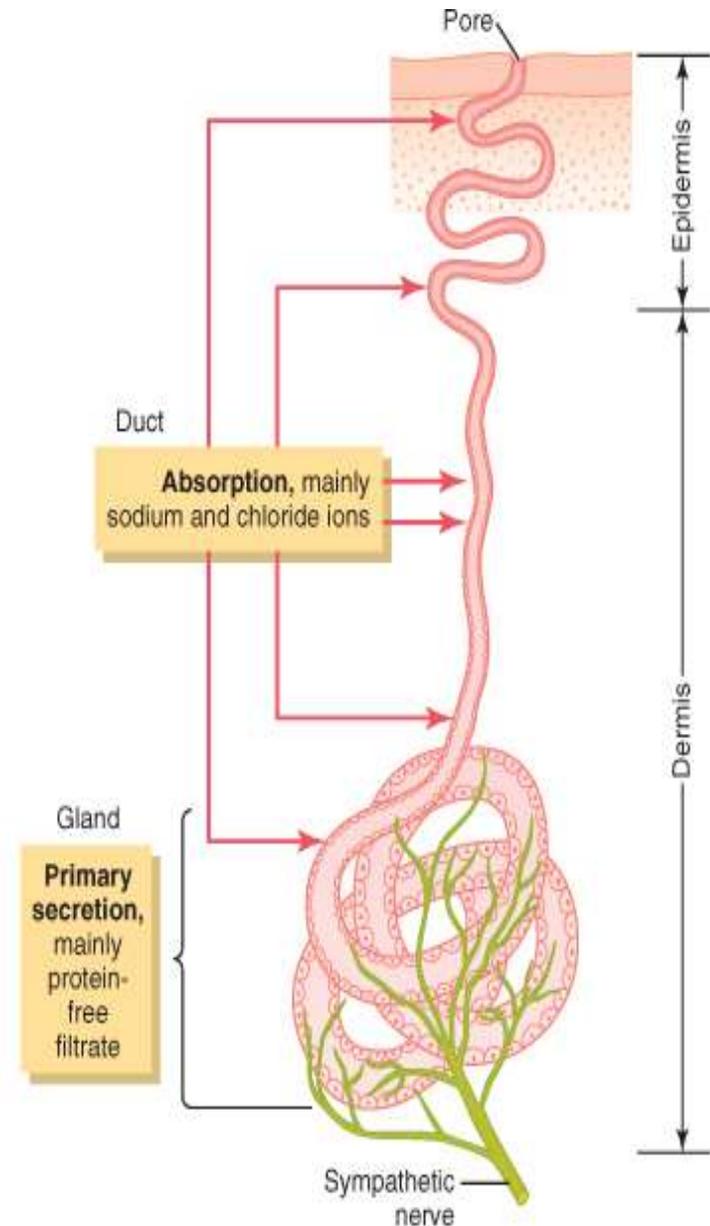
❖ Decrease heat production:

- Anorexia

A. Increased heat loss:

- Vasodilation: Transfers heat to skin.
Inhibition of sympathetic centers in posterior hypothalamus → vasoconstriction
- Sweating:
 - ✓ Stimulation of anterior hypothalamus by heat → impulses to spinal cord → through sympathetic cholinergic fibers to sweat glands → increased sweating → increased evaporative heat loss.
 - ✓ During exercise: Sweat gland stimulated by epinephrine or nor epinephrine

✓ **Secretion of sweat :**
Primary secretion
(~plasma) from coiled
portion → reabsorption
of Na⁺, Cl⁻ & water in
duct portion → sweat
rich in urea, lactic acid
& K⁺



- ✓ **Evaporation of 1g water removes about 0.6 Kcal of heat. So at high temperature - only way of heat loss.**
- ✓ **Unacclimatized person: Strong stimulation of sweat glands → ↑ sweating → less reabsorption → more Na⁺, Cl⁻ loss**
- ✓ **Acclimatization: In 1 to 6 wks slight ↓ in Na⁺, Cl⁻ & ECF volume → aldosteron secretion by adrenals → ↑ NaCl reabsorption**

- Panting:

Breath in and out rapidly causes evaporative heat loss.

No increase in ventilation as breaths are shallow



B. Decreased heat production

- **Shivering and chemical thermogenesis : inhibited**
- **Anorexia**

Behavioral Responses:

- Behavioral responses to cold:
- Rubbing of hands,
- Curling up in bed,
- Use of woolen clothes,
- Sitting close to fire,
- Drinking hot drinks like tea, coffee
- Behavioral responses to heat:
- Lying bare bodied
- Bathing in cold showers
- Using fans, cold drinks

Abnormalities Of Body Temp. Regulation

- **Fever**
- **Hyperthermia**
- **Heatstroke**
- **Hypothermia**
- **Frostbite**

Fever (pyrexia)

- Elevation of core body temperature above normal.
- Set point is elevated to a new point above normal → mechanisms for raising the body temperature are activated → Within few hours the body temperature approaches to the new set point temperature
- Pathogenesis: 'pyrogens' are Substances which elevate the set point

Toxic bacterial /Degnerating tissue



phagocytized by leucocytes, macrophages



produce endogenous pyrogens:

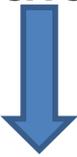
**interleukin 1 (IL-1), tumour necrosis factor (TNF),
IL-6 and several interferons**



Prostaglandins



Hypothalamus



Fever

Time Course of Fever

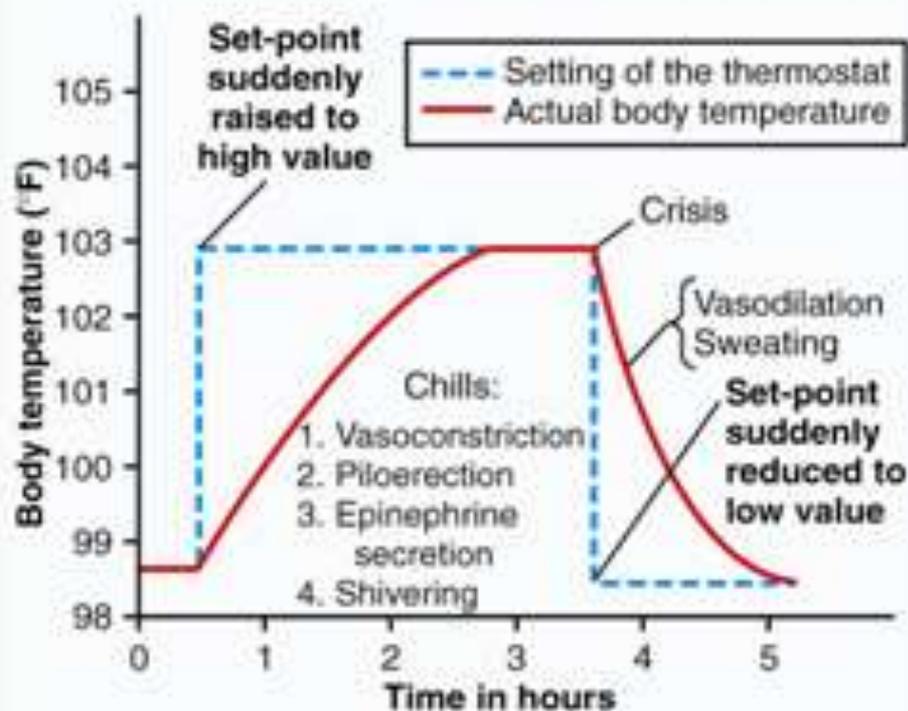


Figure 73-11; Guyton & Hall

- **Fever within limits is beneficial (may inhibit the growth of microorganisms and increase antibody production).**
- **Very high temperature is harmful.(rectal temperature $\geq 41^{\circ}\text{C}$ for prolonged period \rightarrow permanent brain damage)**
- **Treatment:**
Antipyretics e.g. aspirin

Hyperthermia

- Elevation of body temperature higher than the thermoregulatory set point.
- It may be caused by :
 - 1) Increased heat production e.g. by severe muscular exercise or high environmental temperature, which exceeds the normal capacity of heat loss mechanism.
 - 2) Impaired heat loss e.g. due to high humidity or drugs that impair sweating
 - 3) Brain tumors compressing the hypothalamus

Heatstroke

- **Body temperature rises beyond critical temperature: (105⁰F-108⁰F) heat regulating ability of hypothalamus greatly depressed and sweating diminishes**
- **Mechanisms:**
 - 1) Direct damaging effect of very high body temperature on all body tissues**
 - 2) Circulatory shock caused by excessive loss of fluid and electrolytes in the sweat.**

- **Symptoms: dizziness, abdominal distress, vomiting, delirium, eventually loss of consciousness and death.**
- **Treatment of hyperthermia & heatstroke:**
 - Removal from direct sunlight
 - Removal of clothing, wetting the body surface and fanning
 - If not enough then sponging or spray cooling

Hypothermia

- Decreased core body temperature $\leq 35^{\circ}\text{C}$.
- caused by exposure to cold especially when associated with other conditions such as advanced age, CNS diseases, malnutrition etc.
- Effects of hypothermia: Shivering (stops below 32°C), very slow respiration, \downarrow HR, \downarrow BP and arrhythmias. Progressively depressed mental status followed by loss of consciousness.
- Treatment: with external heat

- **Artificial hypothermia :**
- ✓ **Humans tolerate body temperature of 21⁰C-24⁰C without permanent ill effects**
- ✓ **So used extensively in surgery especially heart and brain. The circulation can be stopped for long periods (due to ↓ oxygen need), BP is low and bleeding is minimal.**

Frostbite

- When body is exposed to extremely low temperature- surface areas freeze, called as frostbite
- Seen in ears, digits of hands & feet
- Formation of ice crystals → permanent damage → gangrene
- Treatment: external heat



- **Effect of spinal cord transection: Poor body temp regulation**

Types of fever

- **Continous fever:** Doesnot fluctuate more than 1°C during 24 hrs, does not touch to normal. E.g. Acute bacterial infection
- **Intermittent fever** -only during several hrs to normal a day. E.g. malaria
- **Remittent fever** - daily fluctuations exceeds 2°C e.g. typhoid

SUMMARY

Multiple choice questions:

- 1) Most common mode of heat transfer in a person under normal environmental conditions is-
- a) Radiation
 - b) Conduction
 - c) Convection
 - d) Evaporation

2) Most common mode of heat transfer in a person when environmental temp is greater than body temp-

a) Radiation

b) Conduction

c) Convection

d) Evaporation (sweating)

3) During febrile illness shivering is usually associated with-

- a) Rising body temperature**
- b) Falling body temperature**
- c) A recent increase in hypothalamic set point**
- d) A recent decrease in hypothalamic set point**

4) All of the following prevent decrease in body temp except-

- a) Shivering**
- b) Sweating**
- c) Piloerection**
- d) Vasoconstriction**

5) Regulation of body temp is required:

- a) To obtain neutral zone temp.**
- b) To speed up chemical reactions within body**
- c) B'coz enzyme system of body has narrow temp range**
- d) To prevent body invasion by bacteria**

Short notes:-

- 1. Describe the heat loss mechanisms that maintain body temp.**
- 2. Describe the heat gain mechanisms that maintain body temp.**
- 3. Enumerate the mechanisms activated by heat & add a note on sweating.**