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Body Temperature Regulation

M1 – Cardiovascular/Respiratory Sequence

Louis D'Alecy, Ph.D.

Fall 2008

Tuesday 11/11/08, 9:00
Body Temperature Regulation
(an example of physiological control system)
27 slides, 50 minutes

1. Control System Generalizations
2. Skin blood flow
3. Body Temperature Regulation
4. Control System Competition
5. Adaptation vs. Acclimatization
6. Control Systems Review

CONTROL SYSTEM GENERALIZATIONS

1. **Homeostatic control systems cannot maintain complete constancy of controlled variable. (Error signal ***)**

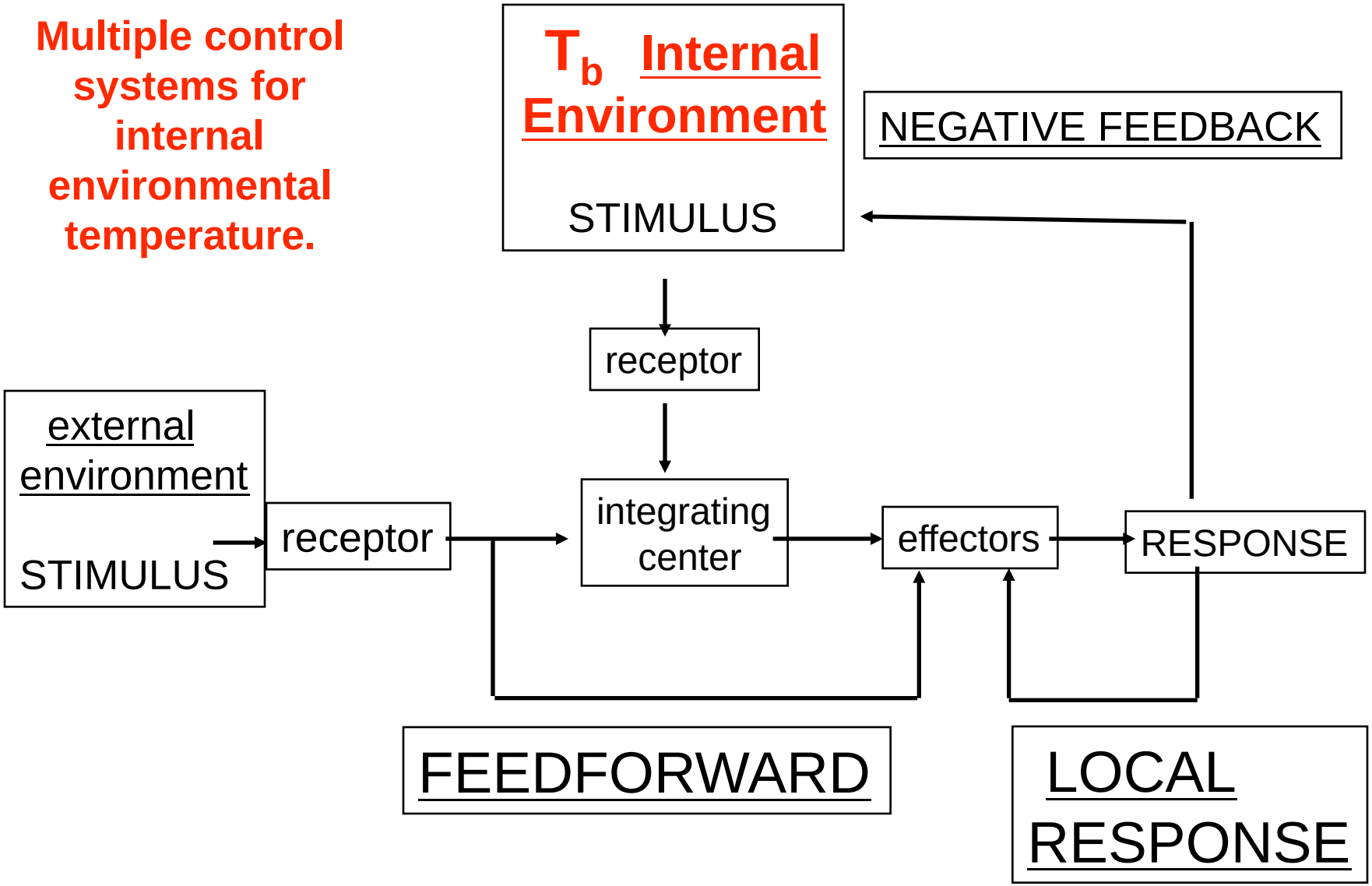
2. **It is not possible for everything to be maintained relatively constant by homeostatic control systems.**

3. **Stability of a variable is achieved by balancing inputs (+) and outputs (-).**

4. **The set point of a homeostatic control system can be reset - raised or lowered.**

5. **Multiple control systems can operate on the same variable.**

Multiple control systems for internal environmental temperature.

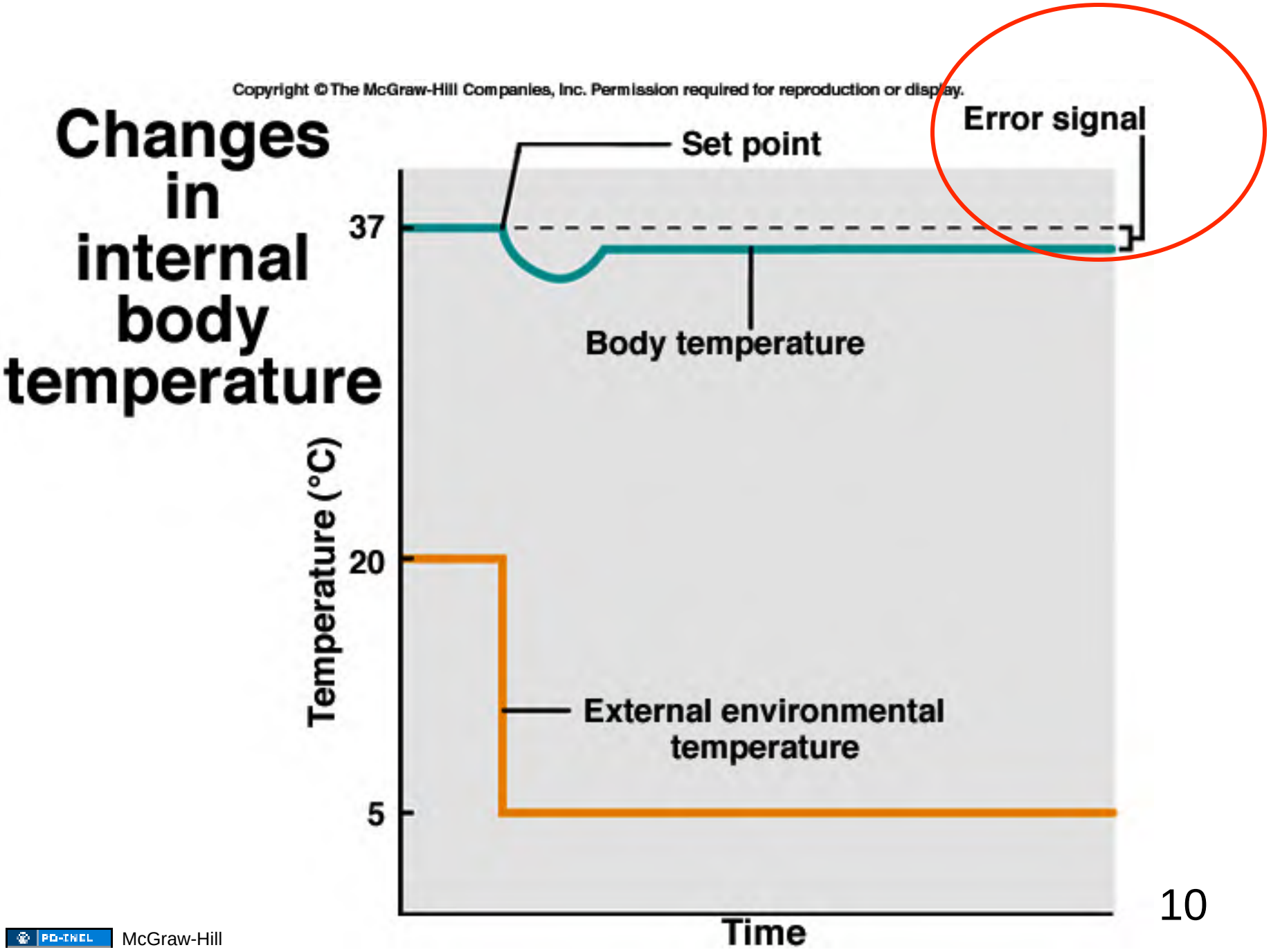


Summary
Control of Skin Blood Flow

- **Primary heat exchange of body**
- Large venous plexus = large blood volume
- **Alpha adrenergic vasoconstriction dominant**
- Sympathetic-cholinergic vasodilation-sweat*
- Local cooling = vasoconstriction (then VD!)
- Triple response (historical ?Boards?)
  - red line, red flare, wheal
- CO_2 and O_2 minimal effects
- Autoregulation assumed unimportant

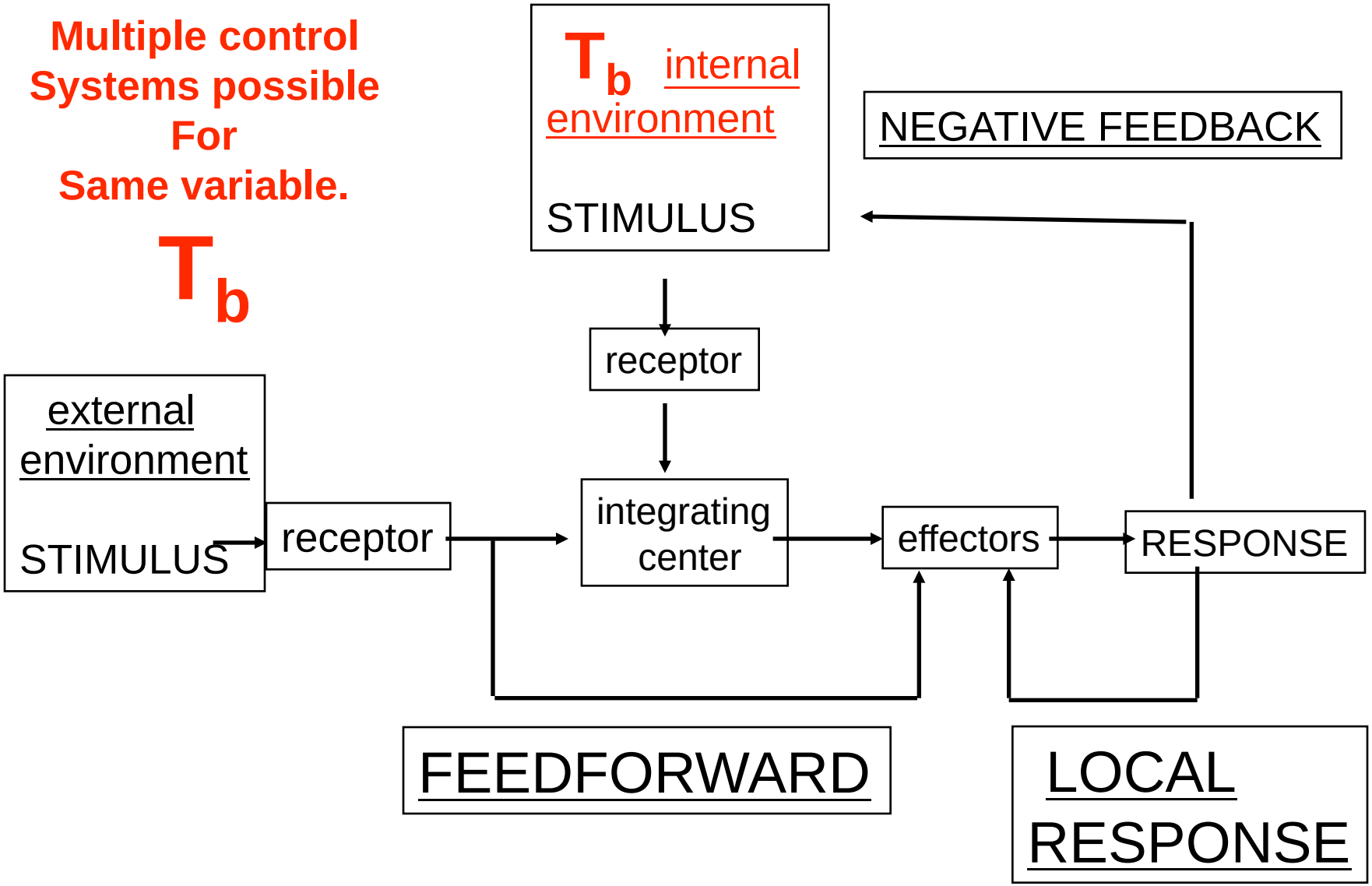

Image of set point
mechanism
removed

SET POINT

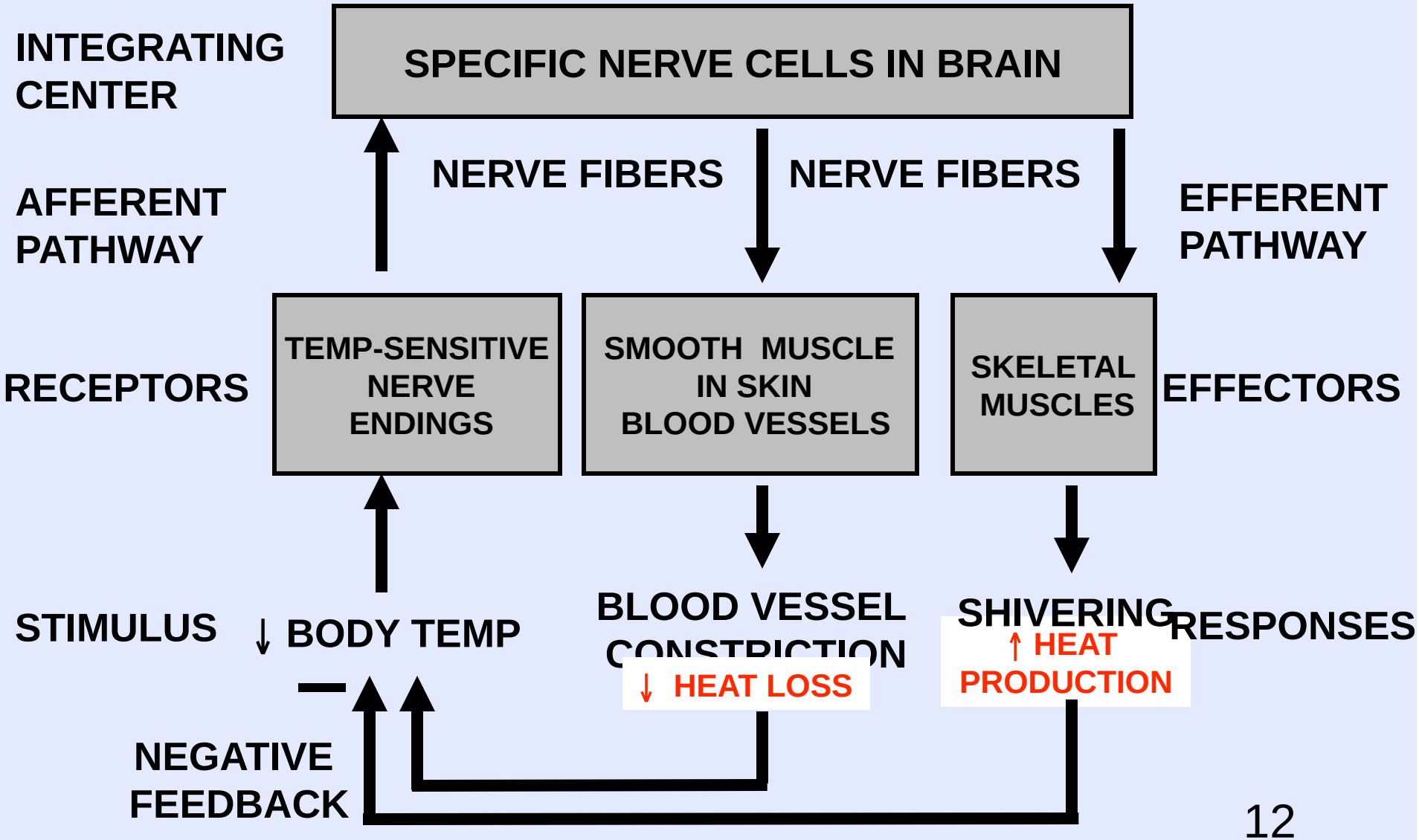


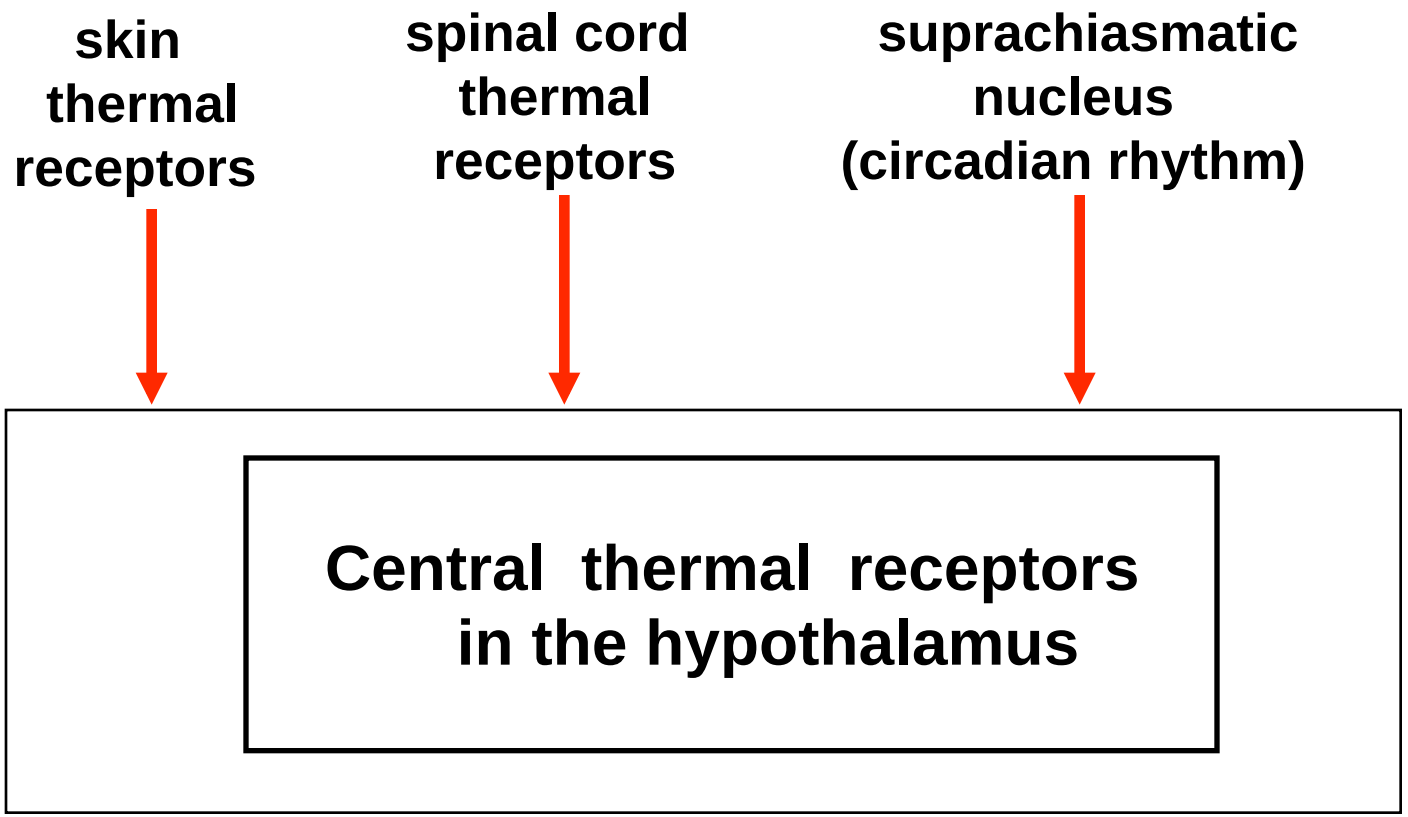
Multiple control Systems possible For Same variable.

T_b



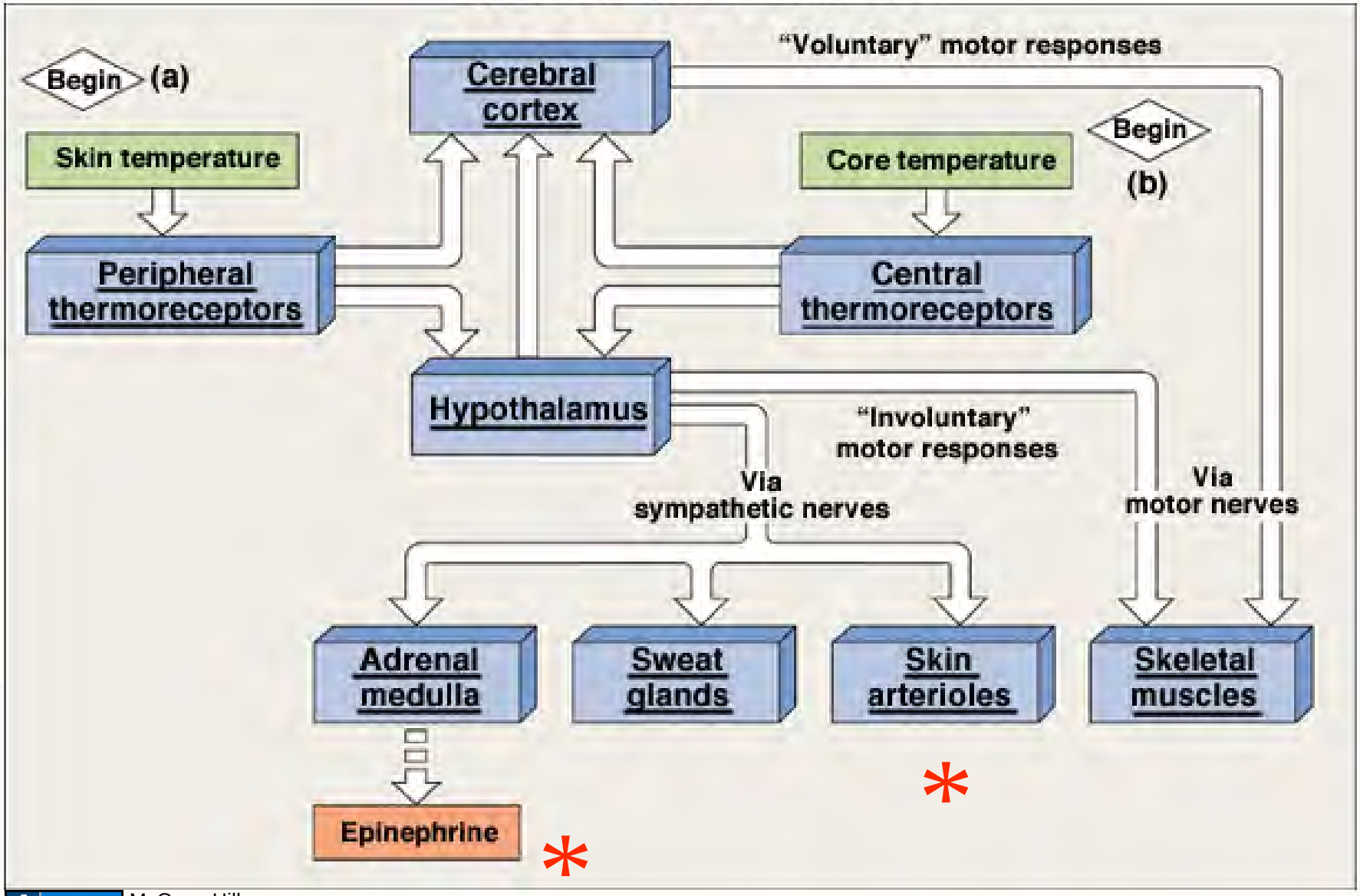
HOMEOSTATIC REFLEX PATHS CONTROLLING BODY TEMPERATURE



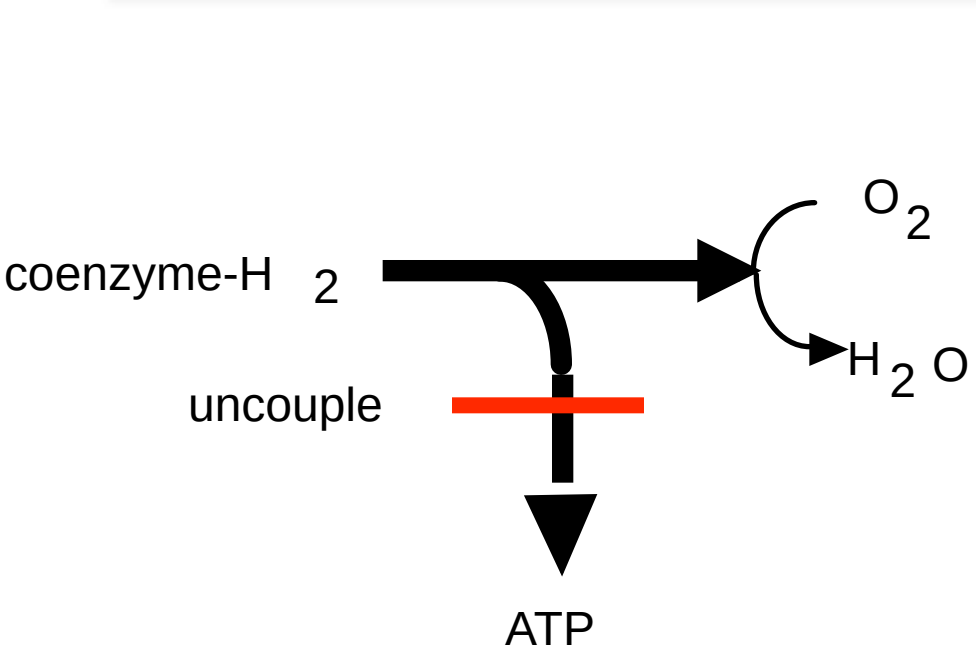


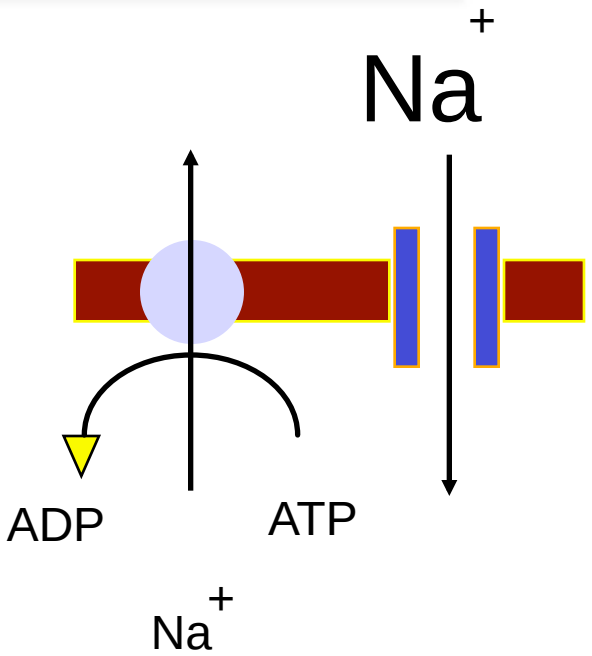
HYPOTHALAMUS
temperature integrating center

Temperature-regulating mechanisms



NON-SHIVERING THERMOGENESIS





Epinephrine

uncouple oxidative phosphorylation in brown fat mitochondria

Thyroxine

futile cycle due to increased Na Permeability in cells

Both processes greater in infants than in adults

THERMONEUTRAL ZONE

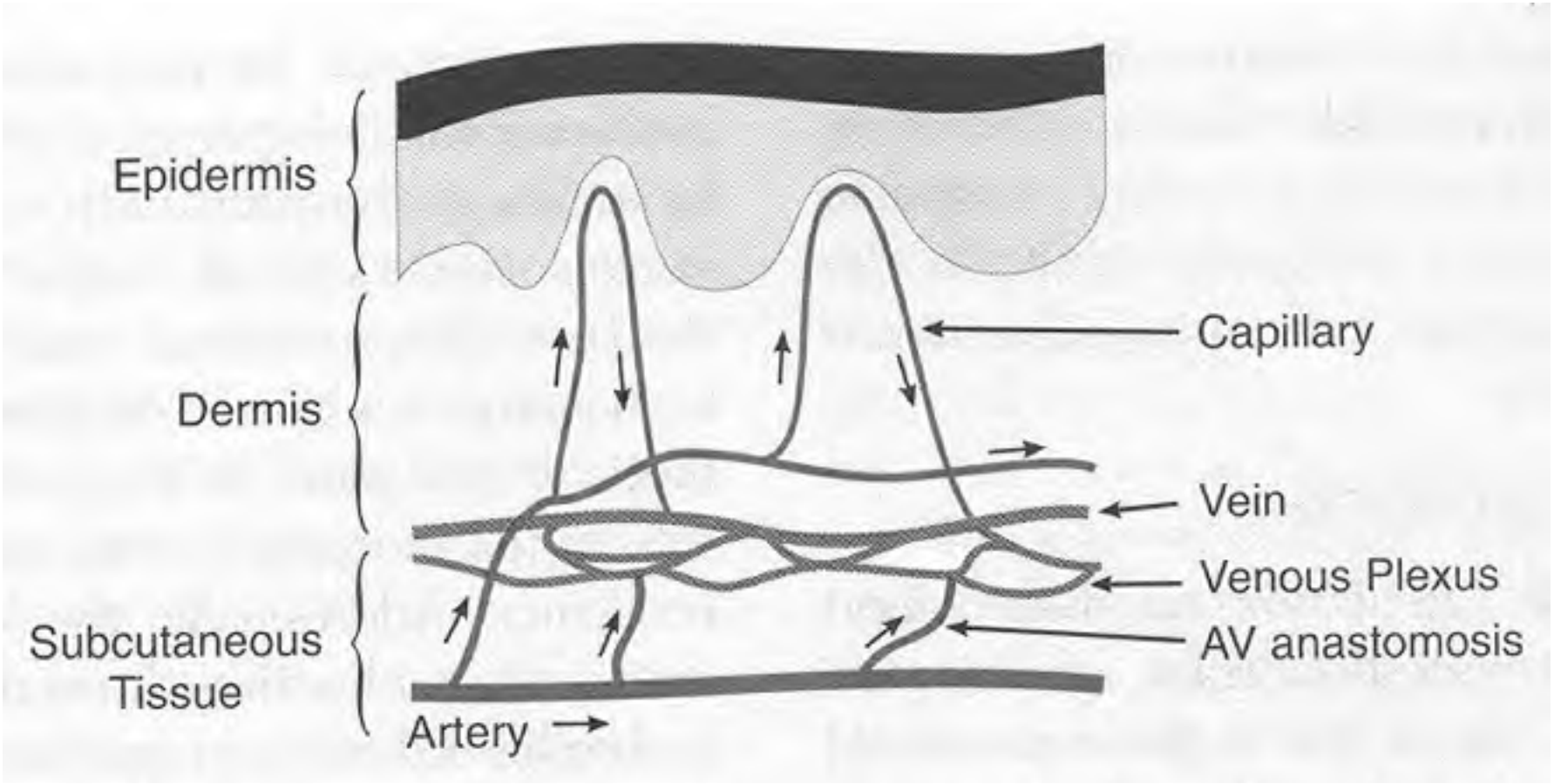
Thermoneutral zone - range of environmental temperatures in which body temperature can be maintained by adjustment of skin blood flow alone.

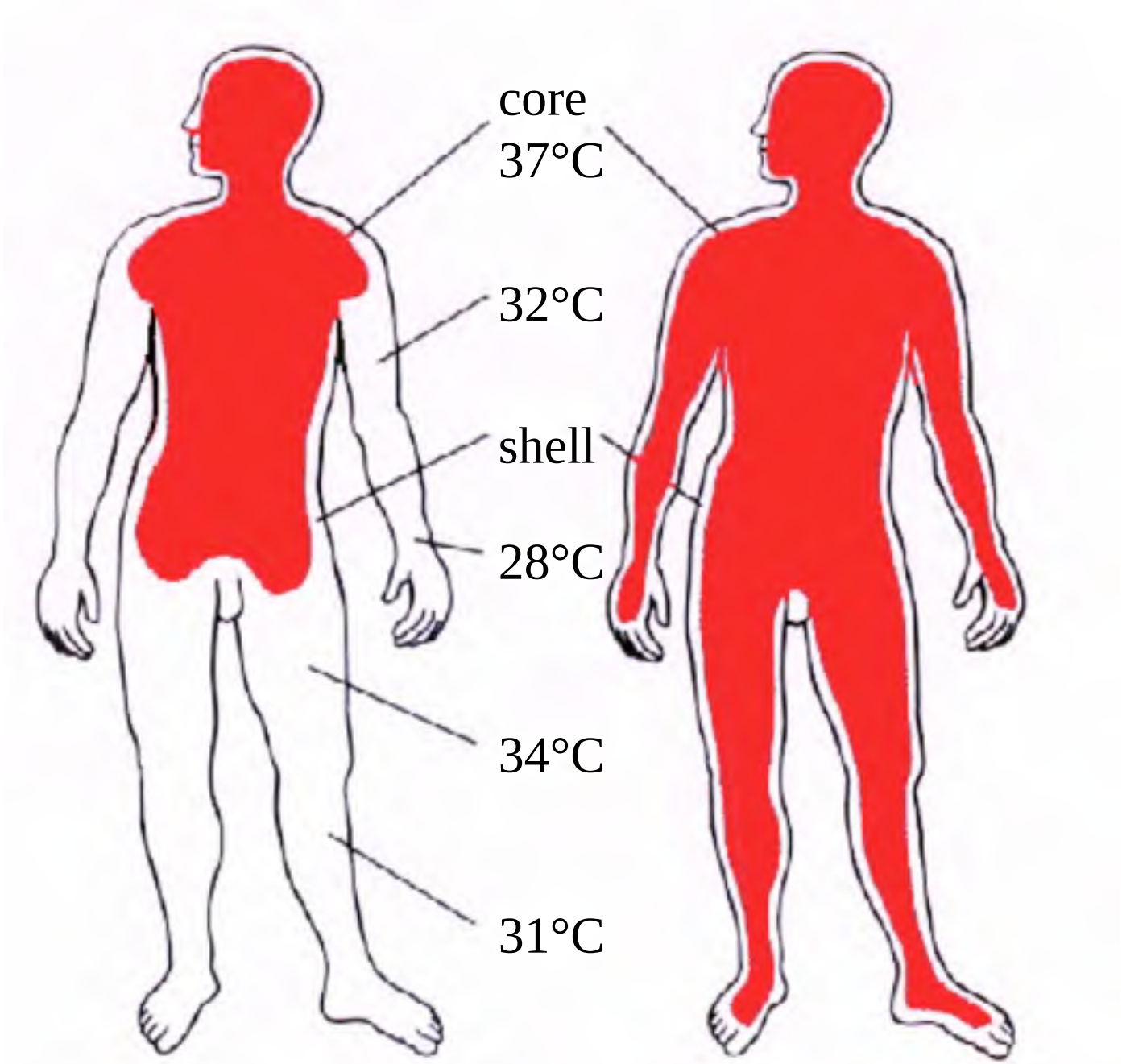
Nude human thermoneutral zone 25°- 31°C (77°- 88° F)

Below thermoneutral zone - increased metabolic rate and vasoconstriction

Above thermoneurtral zone - sweating

AV Anastomosis

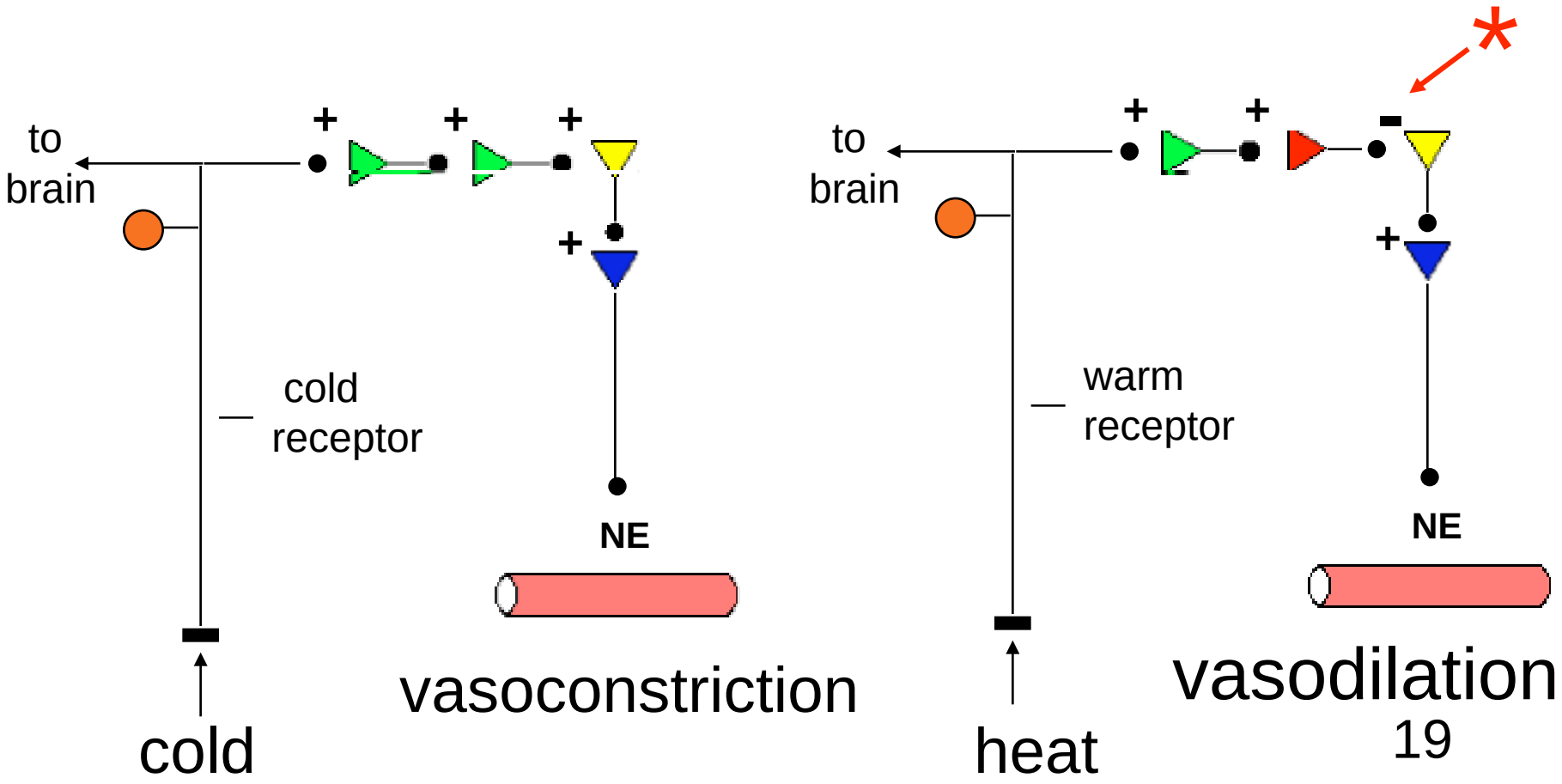




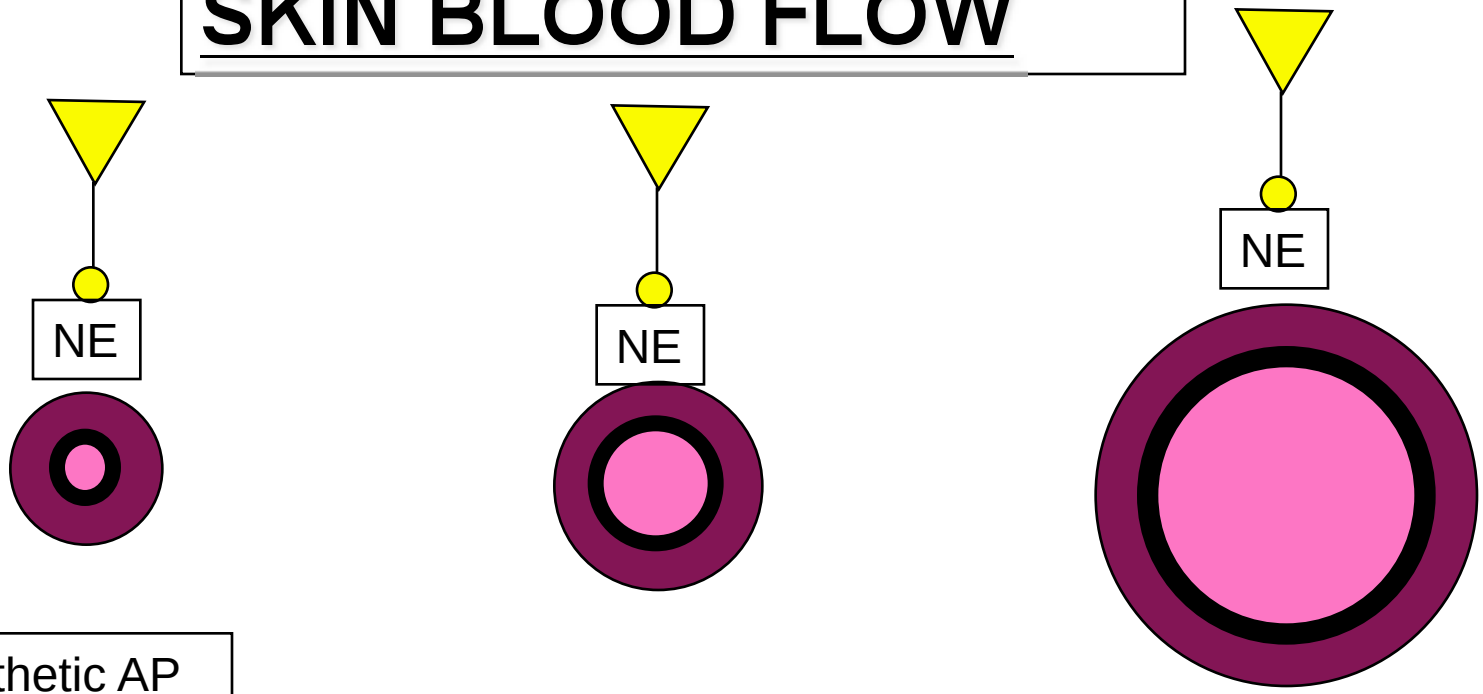
cold environment warm environment

LOCAL RESPONSES TO SKIN BLOOD FLOW

Local heating or cooling of skin produces spinal reflex increases or decreases in skin blood flow by changing the degree of alpha adrenergic activation.



SKIN BLOOD FLOW



sympathetic AP

vasoconstriction
below Ta 75 ° F

Normal
Resting
α tone

max vasodilation
above Ta 115 ° F

α adrenergic receptors - contract vascular smooth muscle

 D'Alecy

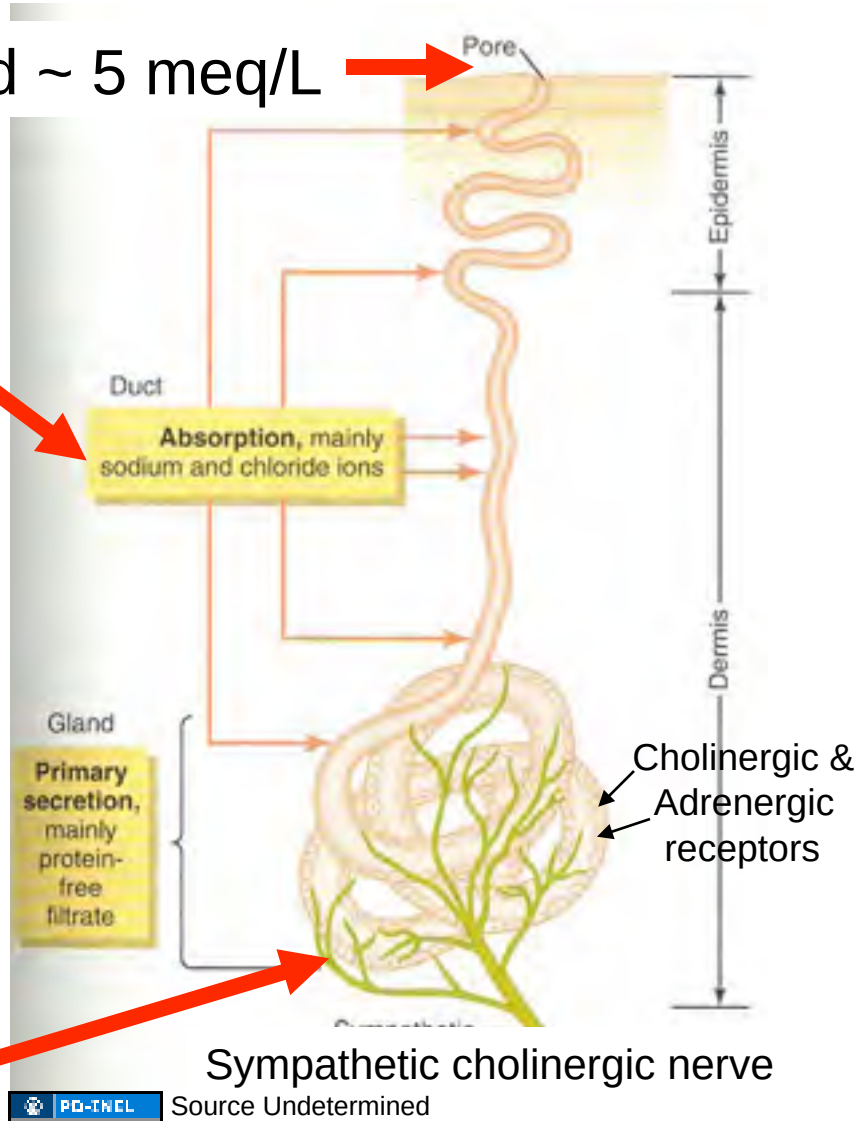
Sweat gland

2 At low flow most Na^+ reabsorbed ~ 5 meq/L

3 In unacclimatized person high flow Na^+ ~ 50 meq/L less Na^+ reabsorbed.

4 Training increases aldosterone and Na^+ reabsorption, Better evaporation, Better cooling.

1 Precursor fluid similar to plasma but no protein. Na^+ ~ 142meq/L



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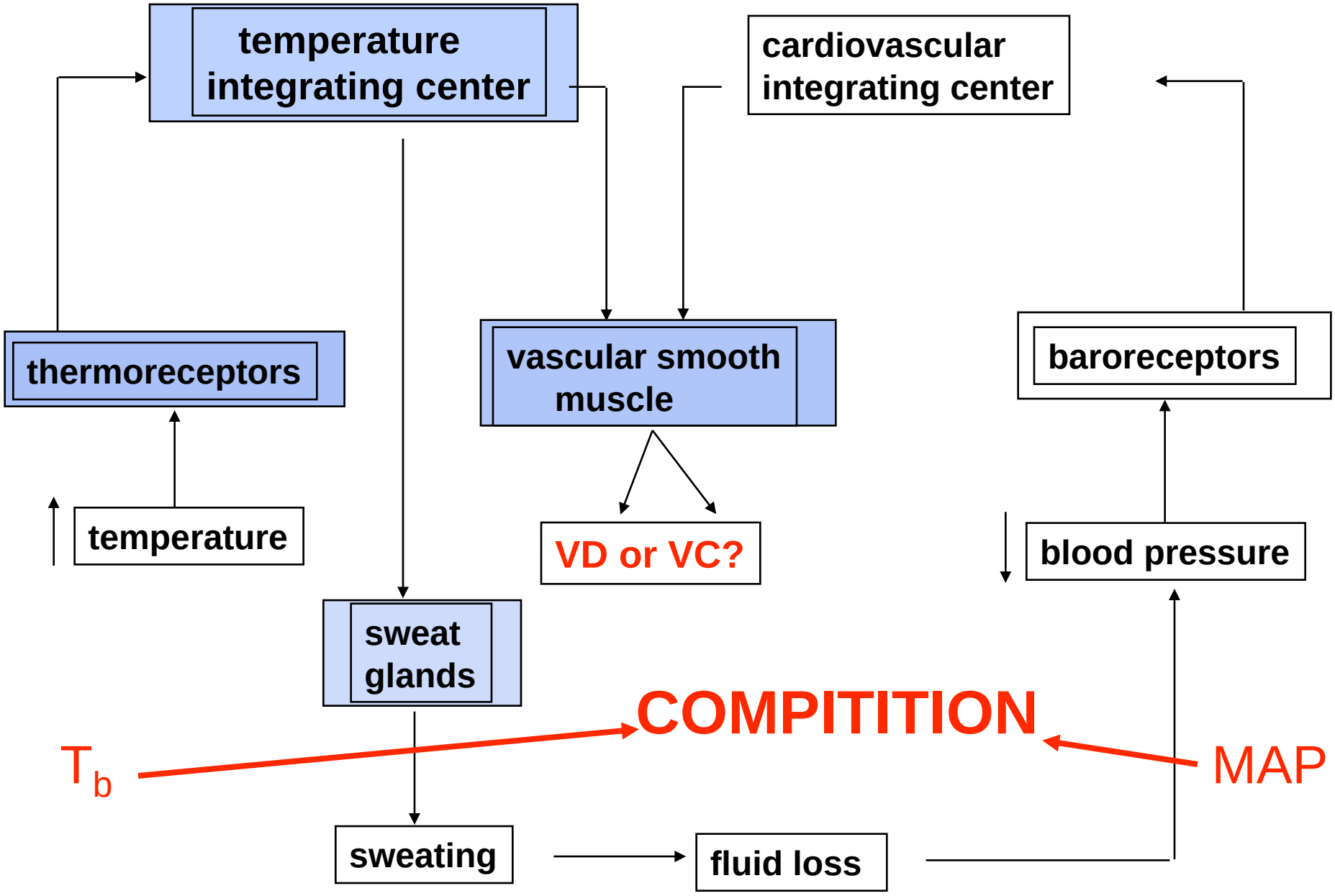
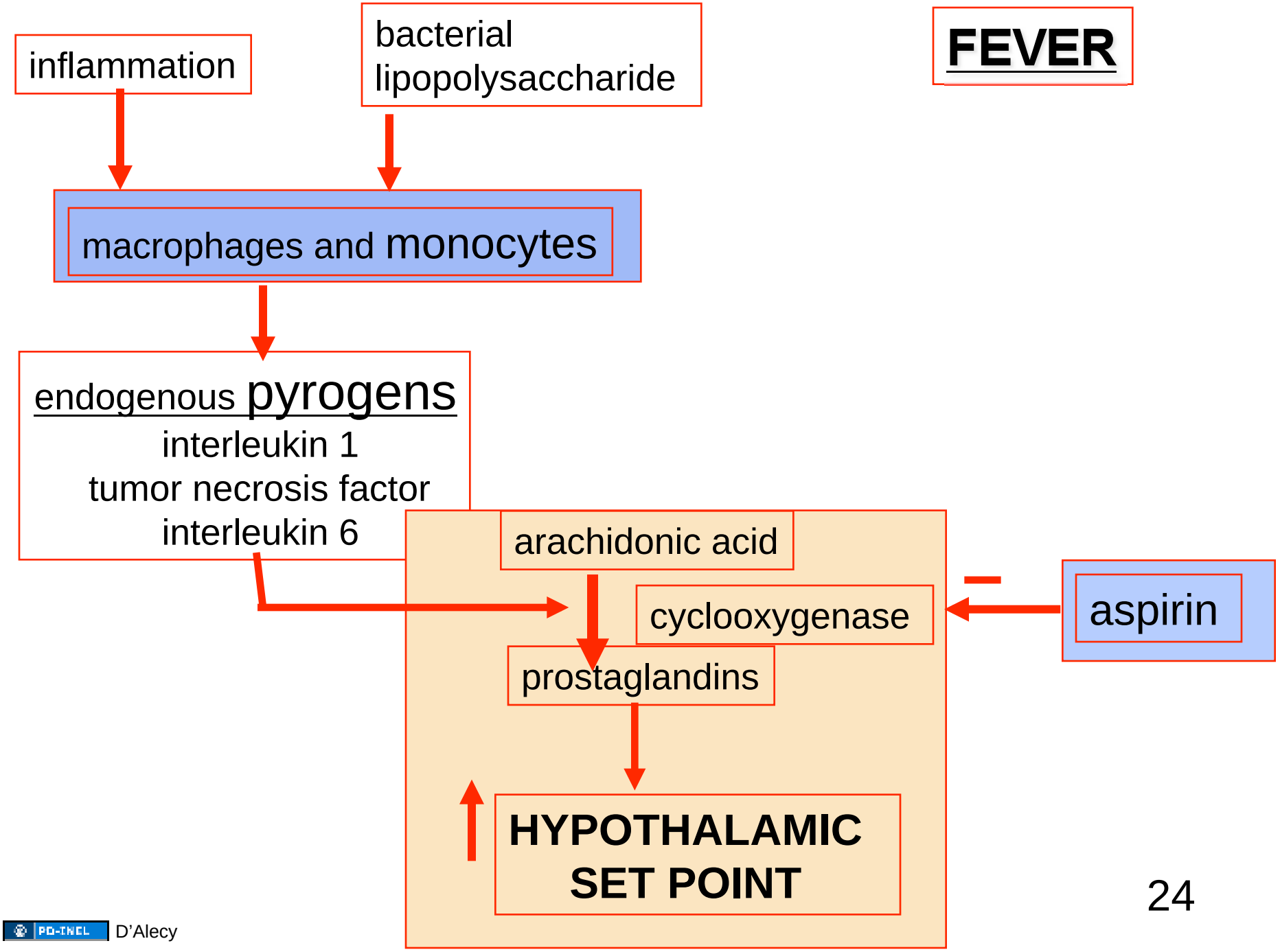

temperature integrating center
cardiovascular integrating center
thermoreceptors
vascular smooth muscle
baroreceptors
temperature
VD or VC?
blood pressure
sweat glands
COMPITITION
T_b
MAP
sweating
fluid loss

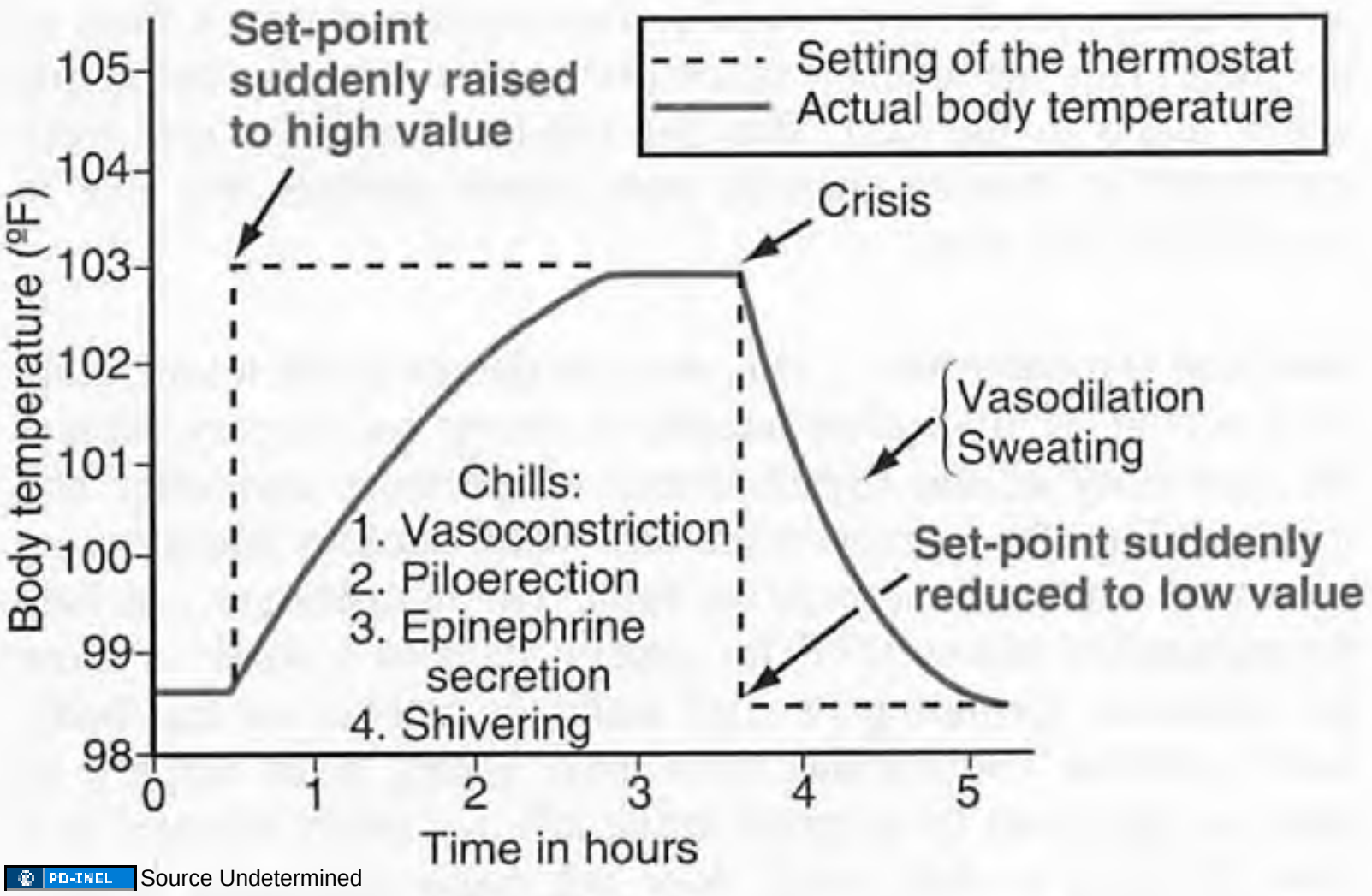
Adaptation - a biological characteristic that favors survival in a particular environment.

e.g. sweating in response to hot environmental temperature

Acclimatization - environmentally induced increase in the capacity of system to adapt

e.g. increased volume of sweat production after weeks of exposure to hot environment





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FEVER raises the hypothalamic set point for T_b.

HEAT EXAUSTION (excess compensation)

Weakness and fainting in warm environment
Little change in core body temperature
Hypotension - due to loss of fluid (sweat) and
decreased total peripheral resistance
due to vasodilation of skin vessels

HEAT STROKE (failed compensation)

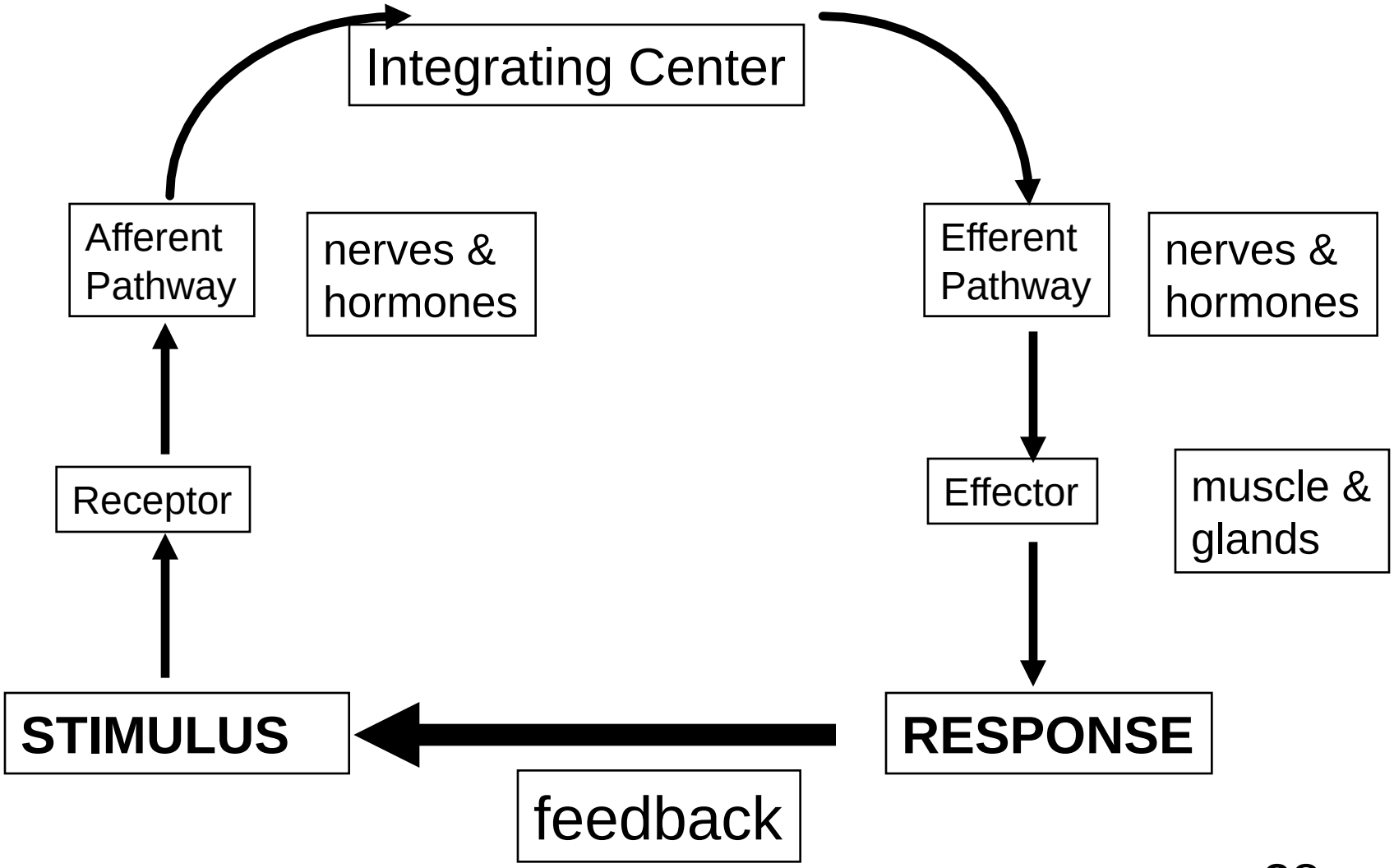
Medical emergency -core temperature rises
to point that hypothalamic integrating center
ceases to function.
Sign - absence of sweating.

MALIGNANT HYPERTHERMIA

Triggered by some anesthetic agents or genetic defect in Ca release in skeletal muscle. Increased release of calcium turns on muscle contraction.

Control System Review

CONTROL SYSTEM



Feedforward - system anticipates change in a controlled variable before it occurs by monitoring changes in the external environment.

Examples:

1) Skin temperature receptors alter the body's heat production and heat loss mechanisms **before** there is a change in core body temperature.

2) Glucose receptors in GI tract increase insulin secretion **before** glucose absorption has raised blood glucose.

HOMEOSTATIC CONTROL SYSTEMS

- **REFLEX Involuntary, built-in response to a stimulus**

- **REFLEX ARC Pathway(s) between stimulus and response in a reflex**

- **NEGATIVE FEEDBACK SYSTEM**
- **Responses tend to move variable back in the opposite direction.**

- **SET POINT The normal value for the variable to be controlled.**
- **Set point can be physiologically reset (e.g. fever)**

- **ERROR SIGNAL**
  - **Difference between set point and actual value of variable.**

- **POSITIVE FEEDBACK SYSTEM**
- **Response moves the variable further in the same direction.**

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