(Foundation Block 4)

Homeostasis I

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Learning Objectives

- Define the components of a homeostatic system.
- Be able to recognize each of the components in representative systems.
- Define negative feedback.
- Explain how homeostatic mechanisms regulated by negative feedback detect and respond to environmental changes.
- Define positive feedback.
- Describe the actions of a positive feedback loop.

Homeostasis

- Homeostasis is the ability to maintain a relatively stable internal environment in an ever-changing outside world.
- Is the tendency toward internal balance
- Chemical, thermal, and neural factors interact to maintain homeostasis.

Concept of Homeostasis

- The internal environment of the body (ECF) is in a dynamic state of equilibrium
- All different body systems operate in harmony to provide homeostasis
- Extreme dysfunction leads to death; moderate dysfunction leads to sickness.

Components of Homeostatic Systems

- The body maintains homeostasis by using homeostatic control systems
  - Three components associated with each system:
    - receptor
    - control center
    - effector

Receptor

- The structure that detects changes in a variable, the **stimulus**
  - e.g., a change in temperature
- Consists of sensory nerves

Components of Homeostatic Systems

Control center

- The structure that interprets input from the receptor
- Initiates changes through the effector
- A portion of the nervous system or an endocrine organ

Effector

- The structure that brings about change to alter the stimulus
- Most body structures
  - e.g., muscles or glands

Maintenance of Homeostasis

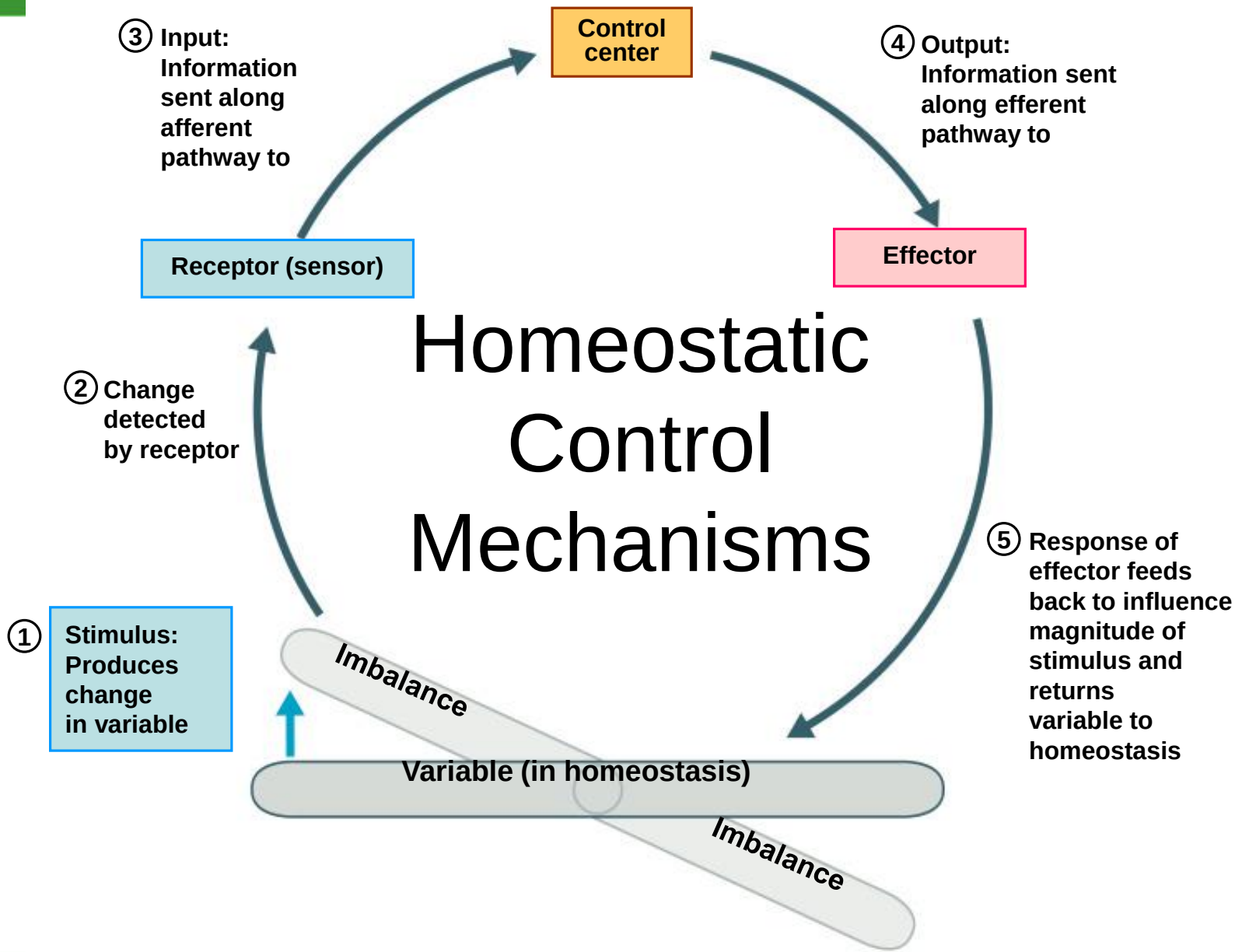
- Nervous system
  - Controls and coordinates bodily activities that require rapid responses
  - Detects and initiates reactions to changes in external environment
  - e.g., regulation of blood pressure upon rising
- Endocrine system
  - Secreting glands of endocrine regulate activities that require duration rather than speed
  - e.g., parathyroid hormone regulating calcium levels

Factors Homeostatically Regulated

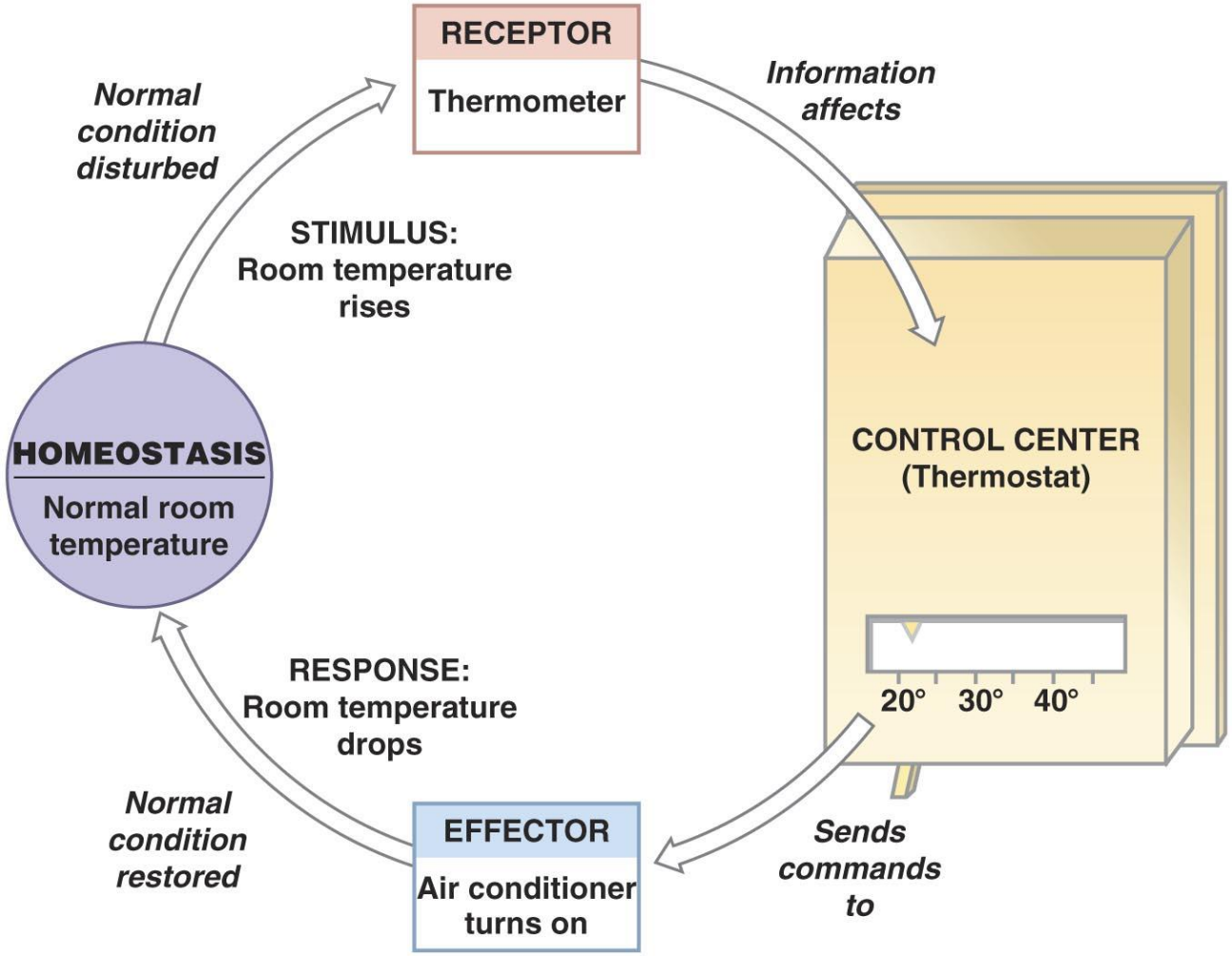
- Concentration of nutrient molecules
- Concentration of water, salt, and other electrolytes
- Concentration of waste products
- Concentration of O_2 = 100mmHg and CO_2 = 40 mmHg
- pH = 7.35
- Blood volume 4-6 L and pressure 120/80
- Temperature = 37^o C

- Response of a homeostatic system occurs through a feedback loop:
  - stimulus
  - detection of stimulus by a receptor
  - information relayed to the control center
  - integration of the input by control center and initiation of change through effectors
  - return of homeostasis by the actions of effectors

Homeostatic Control Mechanisms



The Control of Room Temperature



Homeostatic Control Systems

- Feedback - refers to responses made after change has been detected
  - Types of feedback systems
    - Negative
    - Positive

Feedback Loops: Types

- Negative feedback loop
  - original stimulus reversed
  - most feedback systems in the body are negative
  - used for conditions that need frequent adjustment
- Positive feedback loop
  - original stimulus intensified
  - seen during normal childbirth

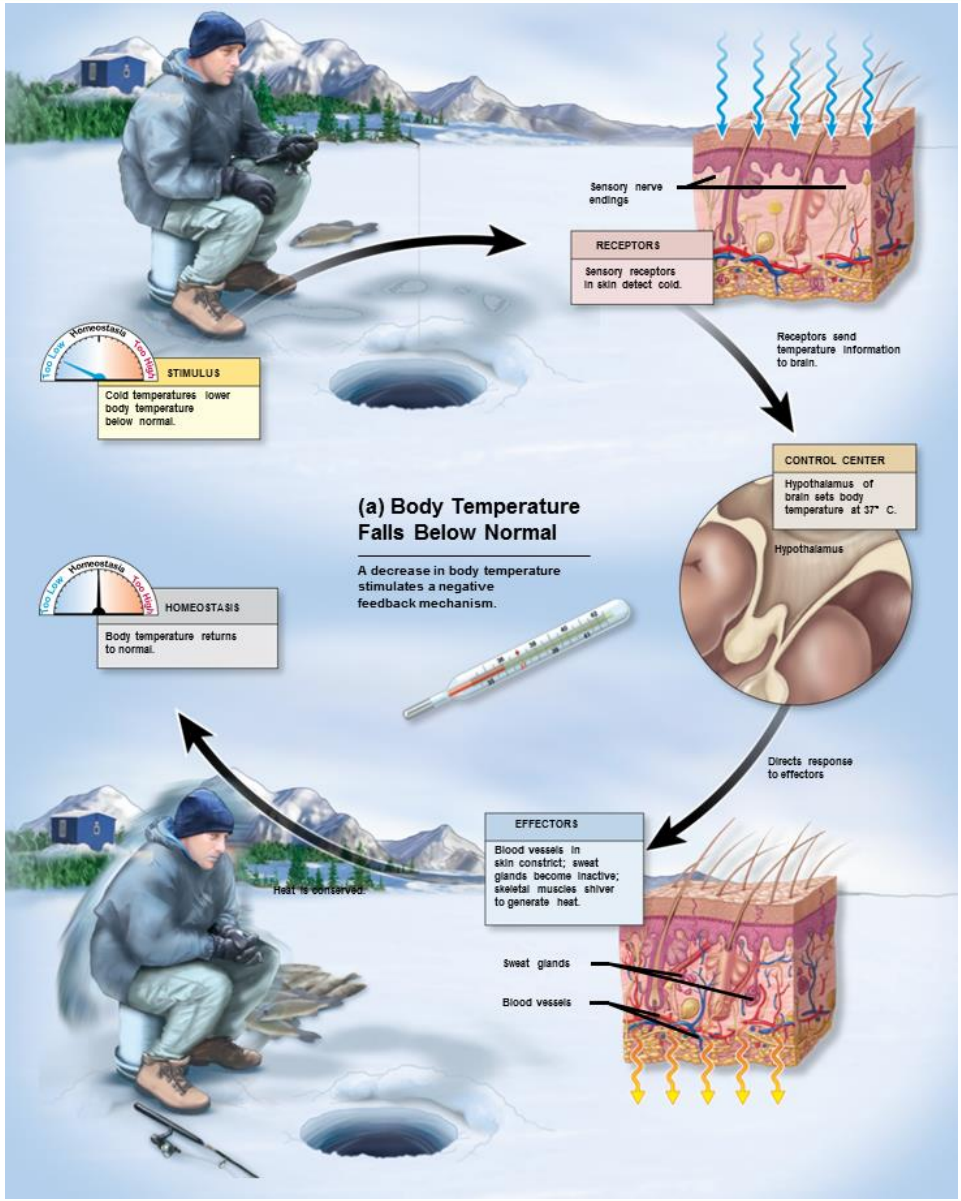
Homeostatic Systems Regulated by Negative Feedback

- Negative feedback
  - A type of homeostatic control system that maintains the variable within a normal range
  - Resulting action in the opposite direction of stimulus
  - Controls most processes in the body
  - Variable maintained within a normal level, its **set point**
    - fluctuates around the set point
  - If stimulus increases, homeostatic control system activated to cause a decrease in the stimulus
  - If stimulus decreases, homeostatic control system activated to cause an increase in the stimulus

Homeostatic Systems Regulated by Negative Feedback

Temperature regulation

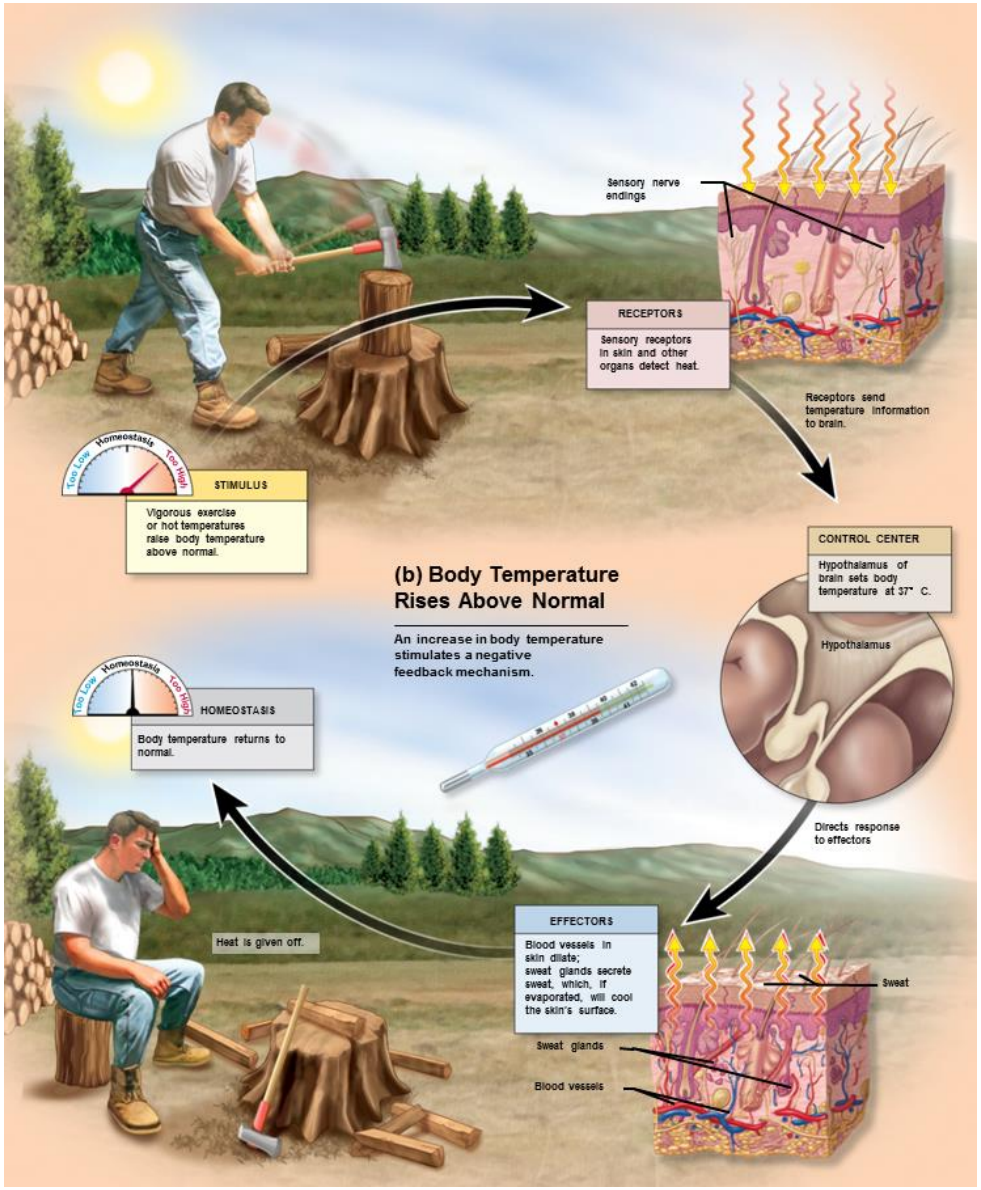
- Body temperature drops
- Sensory receptors detect this and signal the hypothalamus (component of the brain)
- Hypothalamus alerts nerve impulses in blood vessels in the skin to decrease the inside opening of the vessels
- This decreases amount of amount of blood circulating to the surface of the body
- Less heat is released through skin
- Nerve impulses are sent to skeletal muscles, causing shivering
- Nerve impulses are sent to smooth muscles of hair follicles, causing “goosebumps”


(a) Body Temperature Falls Below Normal
A decrease in body temperature stimulates a negative feedback mechanism.
STIMULUS
Cold temperatures lower body temperature below normal.
Too Low
Homeostasis
Too High
Sensory nerve endings
RECEPTORS
Sensory receptors in skin detect cold.
Receptors send temperature information to brain.
CONTROL CENTER
Hypothalamus of brain sets body temperature at 37° C.
Hypothalamus
Directs response to effectors
EFFECTORS
Blood vessels in skin constrict; sweat glands become inactive; skeletal muscles shiver to generate heat.
Sweat glands
Blood vessels
Heat is conserved.
HOMEOSTASIS
Body temperature returns to normal.

Homeostatic Systems Regulated by Negative Feedback

Temperature regulation (*continued*)

- Body temperature rises
- Sensory receptors detect this and signal the hypothalamus
- Hypothalamus alerts nerve impulses in blood vessels in the skin to increase the inside opening of the vessels
- This increases the amount of blood circulating to the body surface
- More heat is released through skin

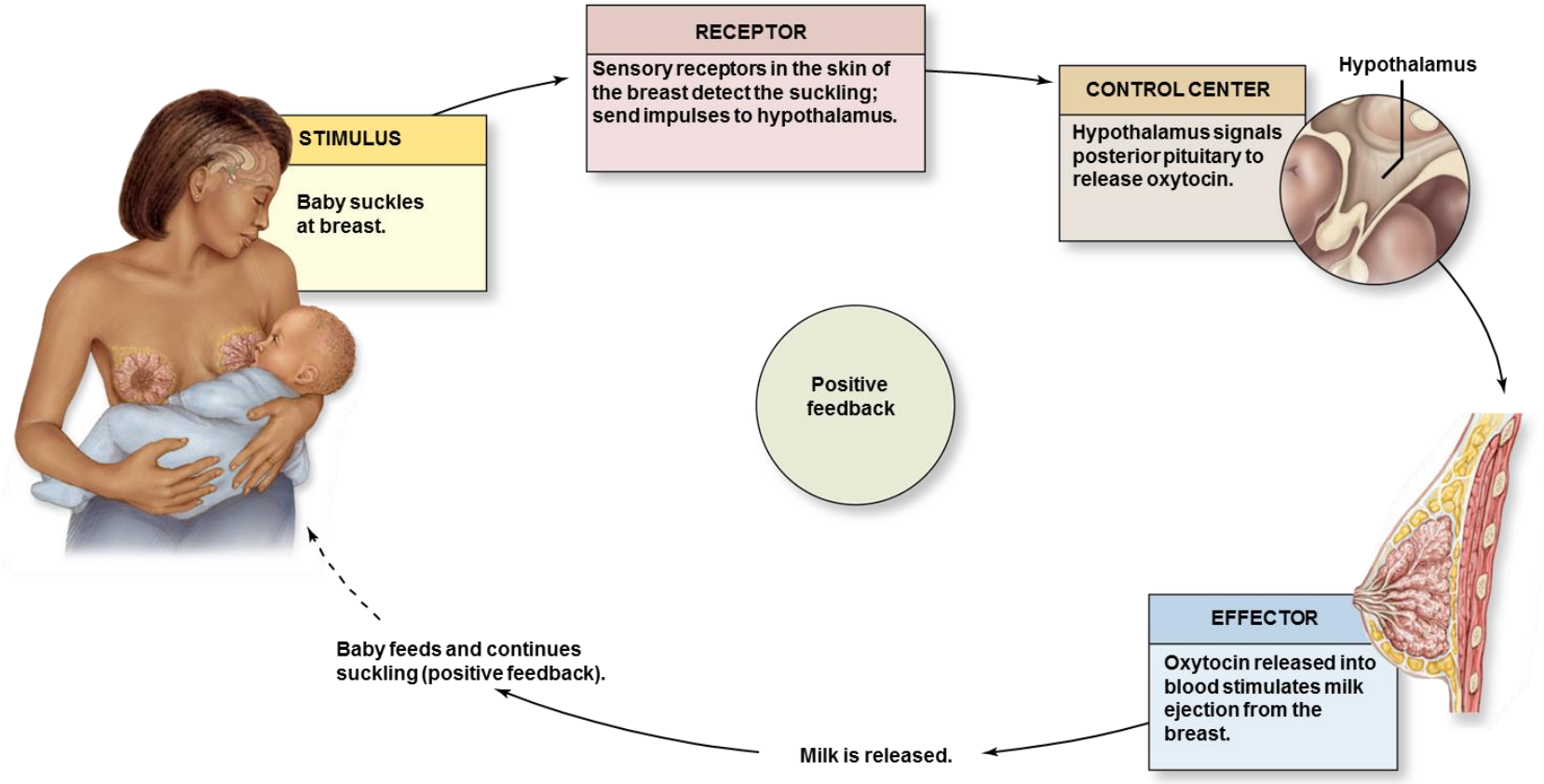

Sensory nerve endings
RECEPTORS
Sensory receptors in skin and other organs detect heat.
Receptors send temperature information to brain.
Too Low
Homeostasis
Too High
STIMULUS
Vigorous exercise or hot temperatures raise body temperature above normal.
CONTROL CENTER
Hypothalamus of brain sets body temperature at 37° C.
Hypothalamus
(b) Body Temperature Rises Above Normal
An increase in body temperature stimulates a negative feedback mechanism.
Too Low
Homeostasis
Too High
HOMEOSTASIS
Body temperature returns to normal.
Directs response to effectors
EFFECTORS
Blood vessels in skin dilate; sweat glands secrete sweat, which, if evaporated, will cool the skin's surface.
Heat is given off.
Sweat
Sweat glands
Blood vessels

Homeostatic Systems Regulated by Negative Feedback

- Other examples of homeostatic regulation:
  - withdrawal reflex in response to injury
  - regulating heart rate and blood pressure during exercise
  - changing breathing rate in response to increased carbon dioxide
  - parathyroid hormone release in response to decreased calcium
  - release of insulin by the pancreas in response to increased blood glucose

Homeostatic Systems Regulated by Positive Feedback

- Positive feedback during breastfeeding
  - Sensory detectors detect baby suckling
  - Message is transmitted to the hypothalamus
  - Hypothalamus signals posterior pituitary to release the hormone oxytocin
  - Oxytocin stimulates the mammary gland to eject breast milk
  - Cycle repeats as long as the baby suckles
- Other examples of positive feedback:
  - blood clotting cascade
  - uterine contractions of labor

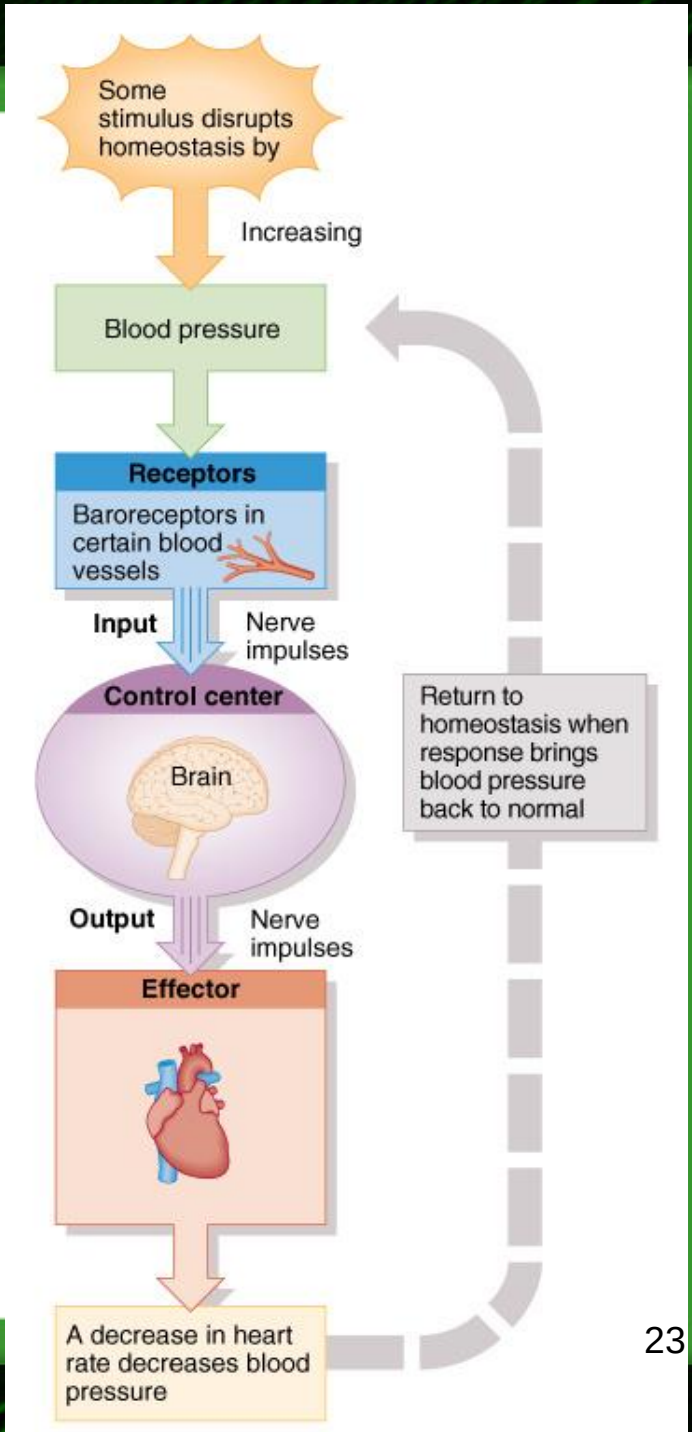

RECEPTOR
Sensory receptors in the skin of the breast detect the suckling; send impulses to hypothalamus.
CONTROL CENTER
Hypothalamus signals posterior pituitary to release oxytocin.
Hypothalamus
STIMULUS
Baby suckles at breast.
Positive feedback
EFFECTOR
Oxytocin released into blood stimulates milk ejection from the breast.
Milk is released.
Baby feeds and continues suckling (positive feedback).

Positive Feedback during Childbirth

- Stretch receptors in walls of uterus send signals to the brain
- Brain induces release of hormone (oxytocin) into bloodstream
- Uterine smooth muscle contracts more forcefully
- More stretch, more hormone, more contraction etc.
- Cycle ends with birth of the baby & decrease in stretch

Homeostasis of Blood Pressure

- Baroreceptors in walls of blood vessels detect an increase in BP
- Brain receives input and signals from blood vessels and heart
- Blood vessels dilate, HR decreases
- BP decreases




Thanks