HOMEOSTASIS

HOMEOSTASIS:

- Cannon coined the term homeostasis.
- (homoios= similar & stasis= position)

- Maintenance of nearly constant internal environment of the cell is defined as homeostasis.

- Term to define constancy of milieu interior.

INTERNAL ENVIRONMENT OF THE CELL

- Component of extracellular fluid is consider to be internal environment of cell.

- **Milieu interior is** first coined by French Scientist Claude Bernard in 1857.

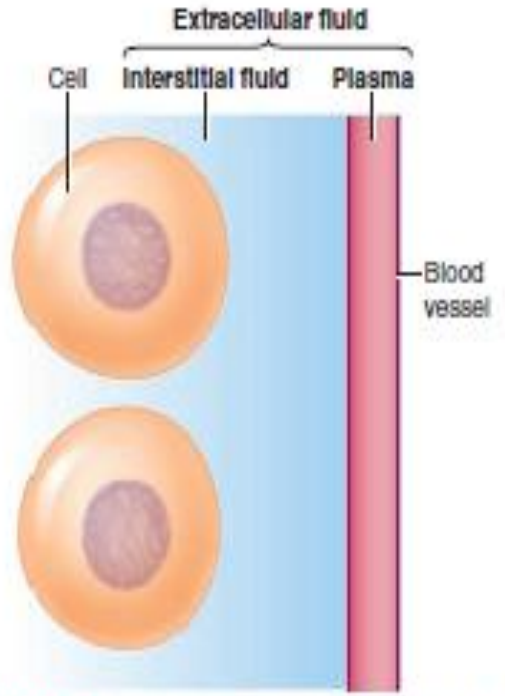


FIGURE 1-5 Components of the extracellular fluid (internal environment).

- Our body cells can live and function only when the ECF is compatible with their survival;
- The internal environment must be kept relatively stable for functioning of cell.
- Thus, the chemical composition and physical state of this internal environment must be maintained within narrow limits.

IMPORTANT CONSTITUENTS AND PHYSICAL CHARACTERISTICS OF EXTRACELLULAR FLUID

	Normal Value	Normal Range
Oxygen	40	35–45 mmHg
Carbon dioxide	40	35–45 mmHg
Sodium ion	142	138–146 mmol/l
Potassium ion	4.2	3.8–5.0 mmol/L
Calcium ion	1.2	0.5–2.0 mmol/L
Chloride ion	108	103–112 mmol/L
Bicarbonate ion	28	24–32 mmol/L
Glucose	85	75–95 mg/dl
Body temperature	98.4 (37.0)	98–98.8 (37.0) ∞F (∞C)
Acid-base	7.4	7.3–7.5

IMPORTANT CONSTITUENTS AND PHYSICAL CHARACTERISTICS OF EXTRACELLULAR FLUID

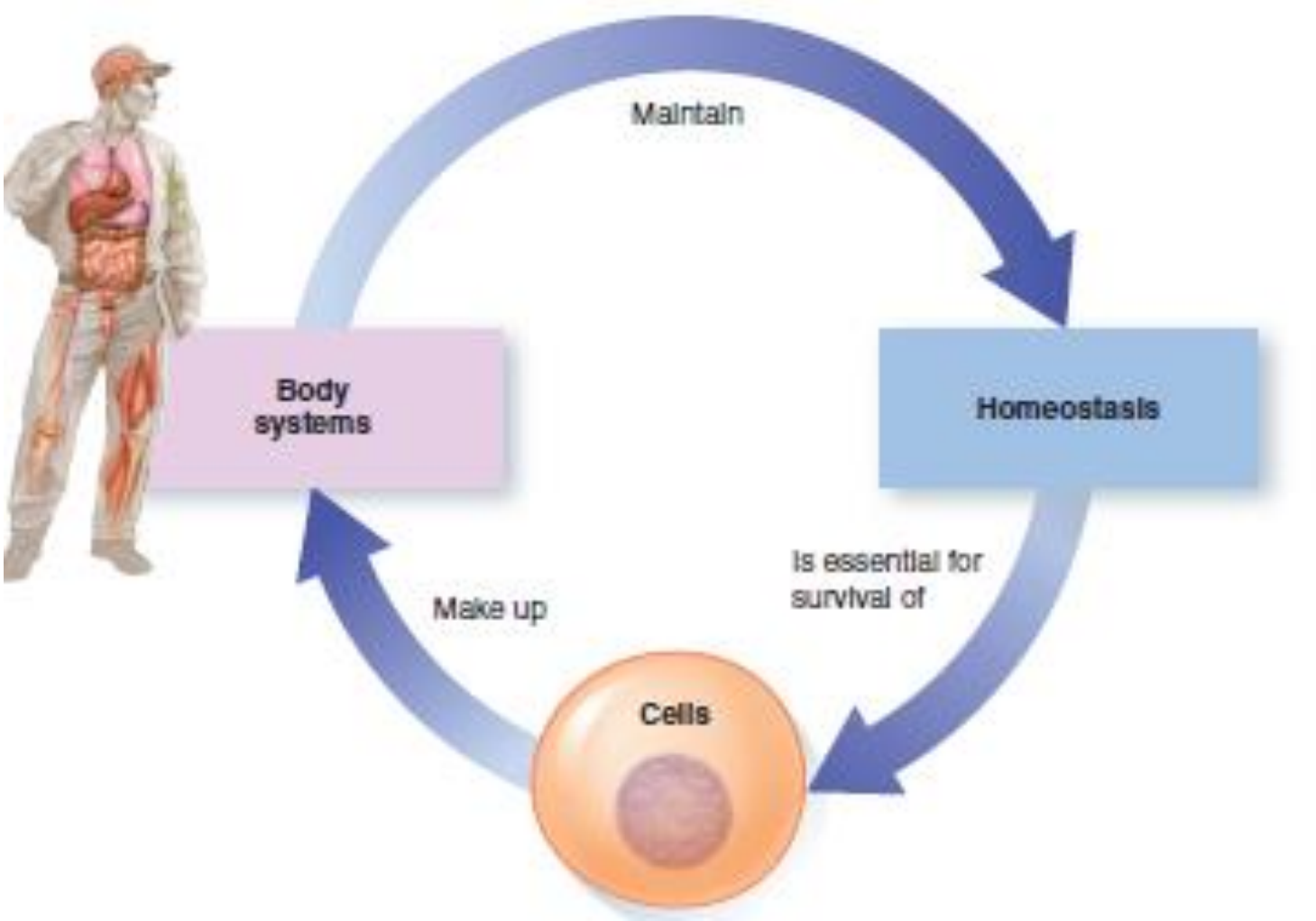
	Normal Value	Value of normal range
Oxygen	40	35-45 mmHg
Carbon dioxide	40	35-45 mmHg
Sodium ion	142	138-146 mmol/l
Potassium ion	4.2	3.8-5.0 mmol/L
Calcium ion	1.2	0.5-2.0 mmol/L
Chloride ion	108	103-112 mmol/L
Bicarbonate ion	28	24-32 mmol/L
Glucose	85	75-95 mg/dl
Body temperature	98.4 (37.0)	98-98.8 (37.0) ˚F (˚C)
Acid-base	7.4	7.3-7.5

- So homeostasis is not a fixed rigid state rather it is a range.
- Systems such as the digestive, respiratory and excretory contribute directly to homeostasis.
- The endocrine and the nervous systems provides an important contribution to homeostasis by coordinating the activities of all the other systems that participate more directly in homeostatic mechanisms.

- The endocrine system takes time to initiate action, and once the action has been initiated, it continues for quite long.

- In comparison, the nervous system initiates action much faster, and its action can also be switched off promptly

INTERDEPENDENT RELATIONS BETWEEN CELLS, BODY SYSTEMS AND HOMEOSTASIS



ROLE OF VARIOUS BODY SYSTEMS IN HOMEOSTASIS

- Every part of the body makes some contribution to the survival of the whole organism.
- It can be done by maintaining the composition, pH and temperature of the internal environment at an optimal level.
- The optimal level is that at which the enzyme functions the best.
- The role of various systems are described below:

1.THE CIRCULATORY SYSTEM:

- **Main role is to** transport materials such as nutrients, O2, CO2, wastes, electrolytes, and hormones from one part of the body to another.
- The first stage is movement of blood in the blood vessels, and the second is movement of fluid between the blood capillaries and the intercellular spaces between the tissue cells.
- As blood passes through the blood capillaries, contineous exchange of extracellular fluid also occurs between the plasma portion of the blood and the interstitial fluid that fills the intercellular spaces.

- The walls of the capillaries are permeable to most molecules in plasma except plasma protein, which are too large to pass.

- The process of diffusion is caused by kinetic motion of the molecules in both the plasma and the interstitial fluid.

- So , the fluid and dissolved molecules are continually moving and bouncing in all directions within the plasma and the fluid in the intercellular spaces, as well as through the capillary pores.

2. THE DIGESTIVE SYSTEM

- It's main role is to break down dietary food into small nutrient molecules that can be absorbed into the plasma for distribution to the entire body cells.
- The dissolved nutrients like carbohydrates, fatty acids, and amino acids, are absorbed from the ingested food into the extracellular fluid of the blood.

- It also eliminates undigested food residues to the external environment in the feces

3.THE RESPIRATORY SYSTEM

- Main role of it is to get O2 from lungs and eliminates CO2 to the external environment.
- Each time the blood passes through the lungs, it picks up oxygen in the alveoli, thus providing to needed cells.
- The membrane between the alveoli and the lumen of the pulmonary capillaries is **alveolar membrane (thickness is** 0.4 to 2.0 micrometers)
- So it is also important in maintaining the proper pH of the internal environment.

4. THE URINARY SYSTEM

- Its major function is to remove excess water, salt, acid, and other electrolytes from the plasma and eliminates them in the urine, along with waste products other than CO2.
- These substances includes end products of cellular metabolism like urea , uric acid, excesses of ions and water from the food etc.
- Initially, plasma filter through the glomeruli into the tubules and then reabsorbsion of substances needed by the body like glucose, amino acids, appropriate amounts of water, and many of the ions occur.

5.THE MUSCULOSKELETAL SYSTEM

- Bones and joints provides support and protection for the soft tissues and organs. It also serves as a storage reservoir for calcium (Ca2+).

- The **muscular system** (skeletal muscles) moves the bones to which the skeletal muscles are attached

- In absence of this, body could not move to the appropriate place at the appropriate time to obtain the foods required for nutrition.
- this also provides motility for protection against adverse surroundings.

6.THE INTEGUMENTARY SYSTEM

- The skin and its appendages like hair, nails, glands etc. cover, cushion, and protect the deeper tissues and organs of the body.
- This is also important for temperature regulation and excretion of wastes and it provides a sensory interface between the body and the external environment.

- *So,This serves* as an outer protective barrier that prevents internal fluid from being lost from the body and foreign microorganisms from entering.

7. NERVOUS SYSTEM

- It controls as well as coordinates body activities that require swift responses.
- It is especially important in detecting changes in the external environment and initiating reactions to them.
- Also it is responsible for higher functions such as consciousness, memory, and creativity

- This is composed of three major parts: **the sensory input portion, the central nervous system (or integrative portion), and the motor output portion.**
- Sensory receptors detect the state of the body or the state of the surroundings. Example, receptors in the skin senses whenever an object touches the skin.
- The central nervous system can store information, generate thoughts, create ambition, and determine reactions.

- Now, Appropriate signals are then transmitted through the motor output portion to carry out one's desires.

8. ENDOCRINE SYSTEM:

- It is especially important in controlling the blood concentration of nutrients and, by adjusting kidney function, controlling the volume and electrolyte composition of the ECF.

9.Reproductive system

This is not considered a homeostatic function. However, help to maintain homeostasis by generating new beings to take the place of those that are dying.

HOMEOSTATIC CONTROL SYSTEM

- This is functionally interconnected network of body components.
- It can be intrinsic as well as extrinsic.

To maintain homeostasis:

- The control system must be able to detect the deviation in the internal environment factor.
- Make appropriate adjustments in the activity of the body parts to restore this factor to its normal value.

PRINCIPLES OF REGULATION

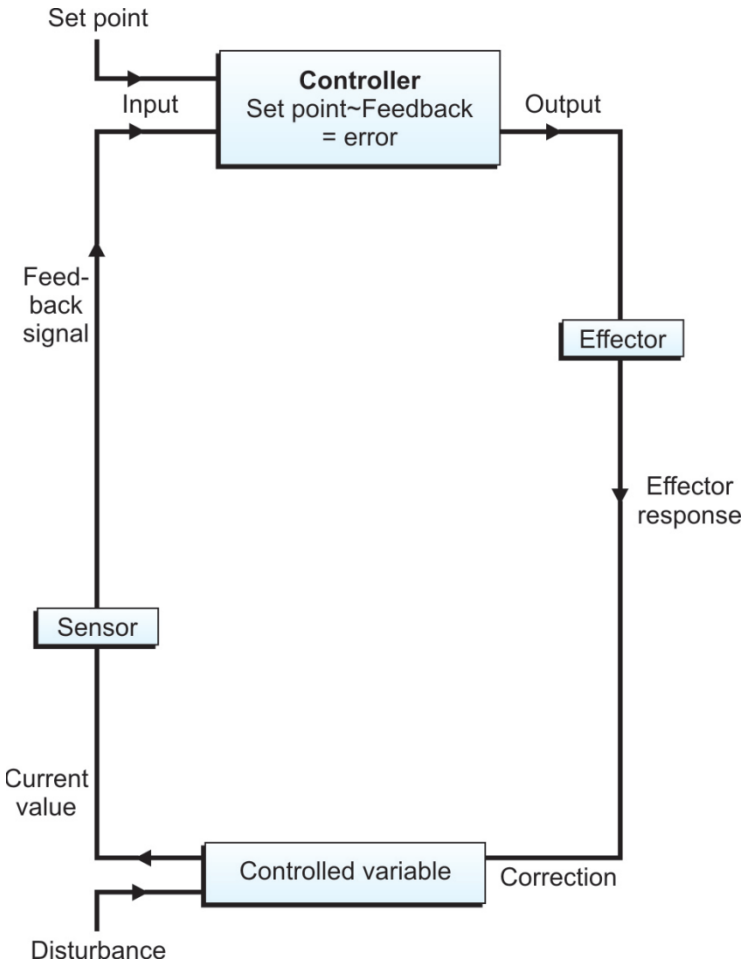
- Most of the regulatory systems follow a similar characteristic pattern:

- Change in the system is informed to regulator.

- Regulator initiates events which work in a direction opposite to the reported change.

- The process being regulated returned to set level recognized as normal.

CONTROL SYSTEM



CONTROL SYSTEM

- Control system is designed to maintain a controlled variable at a set point.
- Value of the controlled variable is continuously monitored by a sensor.
- This is conveyed to the controller as a feedback signal.
- Controller compares it with the set point.

- The difference between set point and the feedback signal is error.
- The output of the controller is conveyed to the effector.
- Effector applies a correction which takes the controlled variable towards the set point.

Examples:

- Regulation of oxygen and carbondioxide concentration in the extracellular fluid.
- Regulation of arterial blood pressure

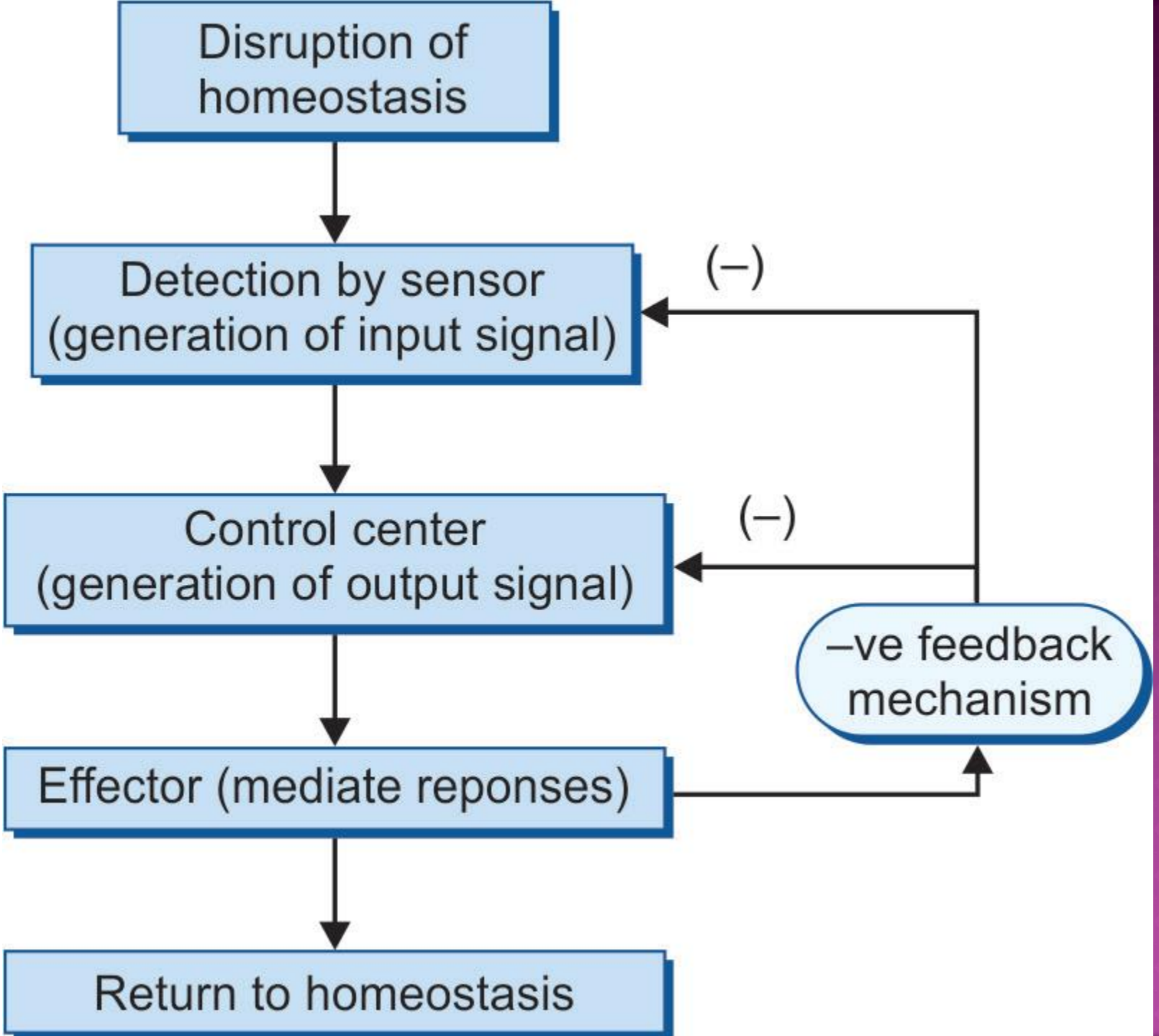
CHARACTERISTICS OF CONTROL SYSTEM

This can be described in following 2 ways:

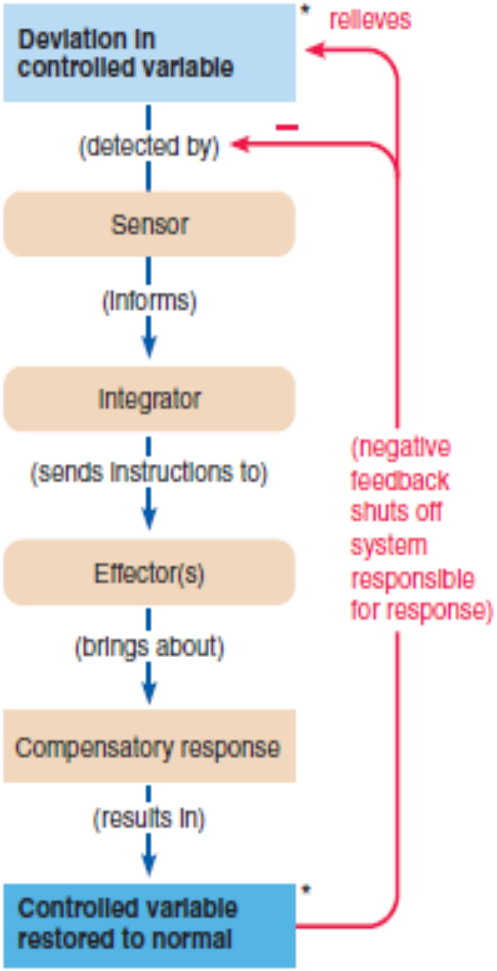
1. Negative feedback mechanism
2. Positive feedback mechanism

NEGATIVE FEEDBACK CONTROL

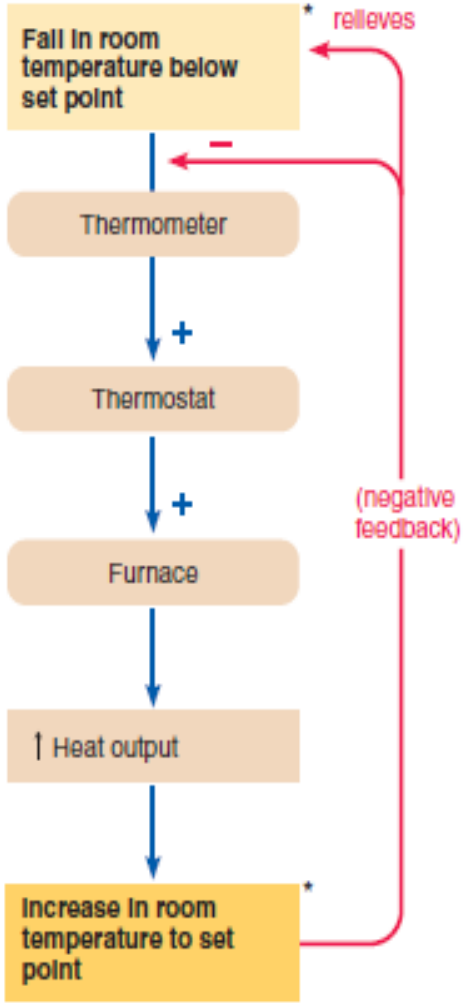
- Most control systems of the body act by this feedback mechanism.
- **A slight change** in a homeostatically controlled factor triggers a response.
- Final response is to restore the factor to normal by moving the factor in the opposite direction of its initial change.
- Corrective adjustments will oppose the original deviation from the normal level.


Disruption of homeostasis
Detection by sensor (generation of input signal)
(–)
Control center (generation of output signal)
(–)
–ve feedback mechanism
Effector (mediate reponses)
Return to homeostasis

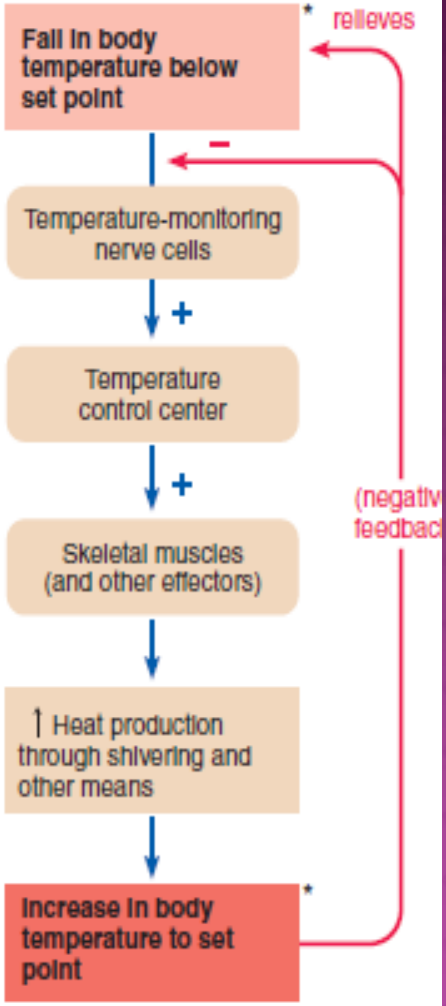
EXAMPLES



(a) Components of a negative-feedback control system

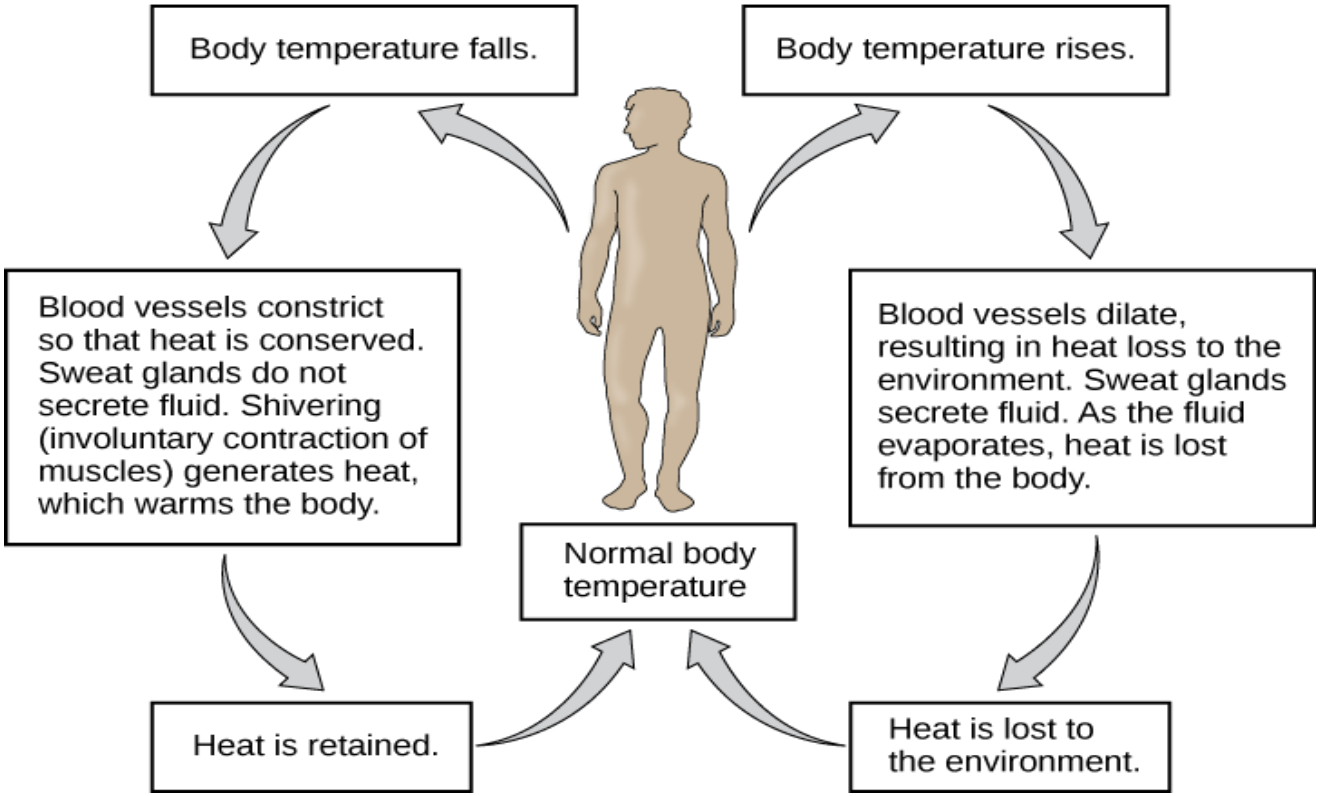


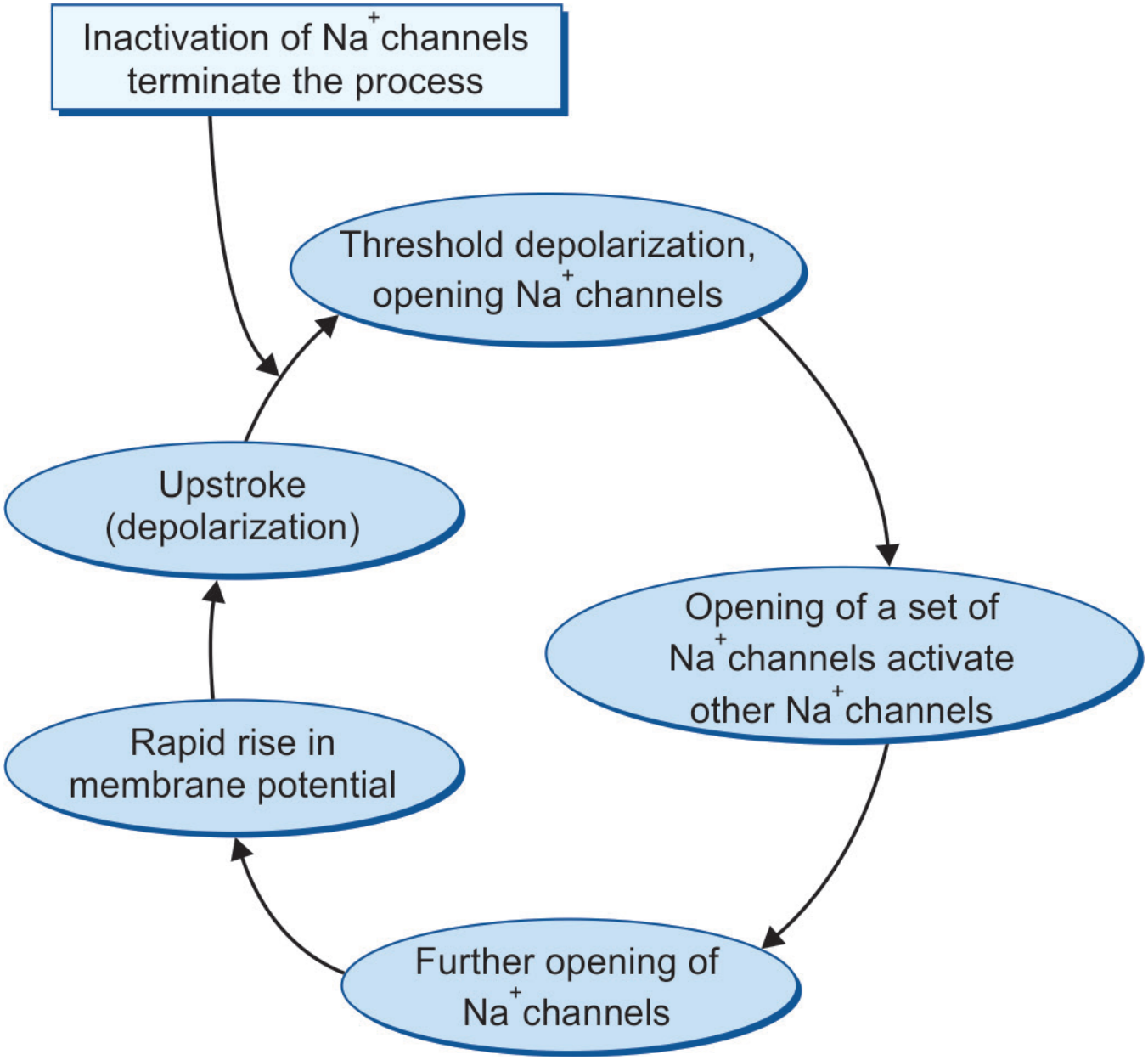
(b) Negative-feedback control of room temperature

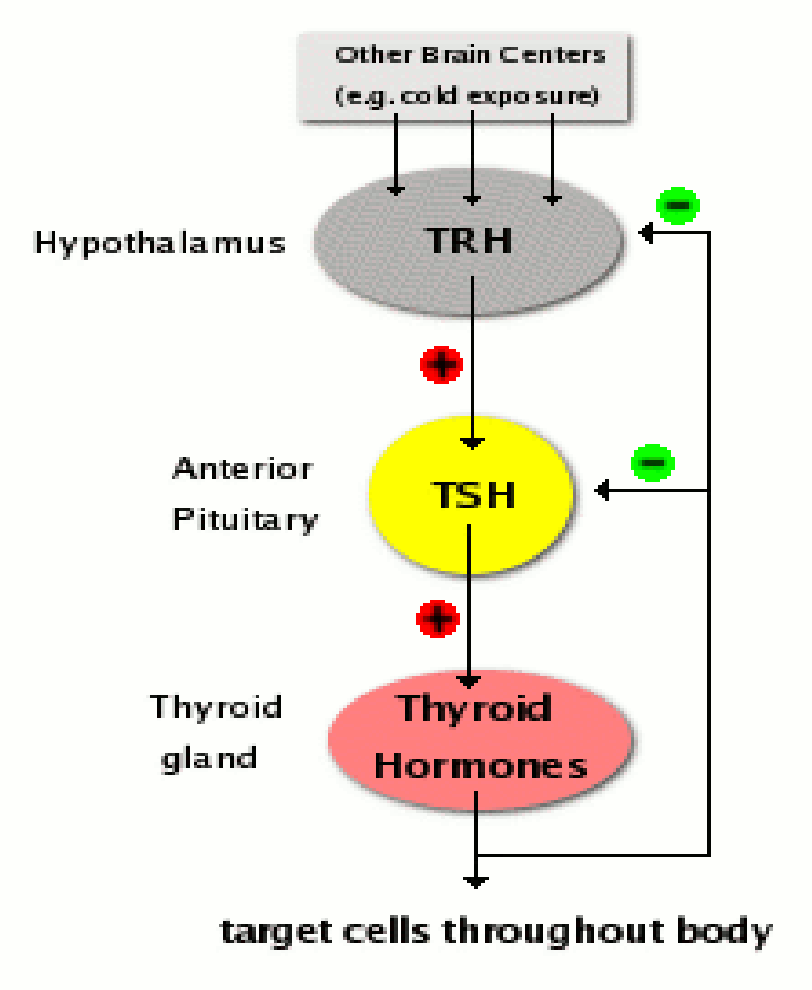


(c) Negative-feedback control of body temperature

TEMPERATURE REGULATION BY NEGATIVE FEEDBACK




Inactivation of Na+ channels terminate the process
Threshold depolarization, opening Na+ channels
Upstroke (depolarization)
Opening of a set of Na+ channels activate other Na+ channels
Rapid rise in membrane potential
Further opening of Na+ channels


Other Brain Centers
(e.g. cold exposure)
Hypothalamus
TRH
Anterior
Pituitary
TSH
Thyroid
gland
Thyroid
Hormones
target cells throughout body

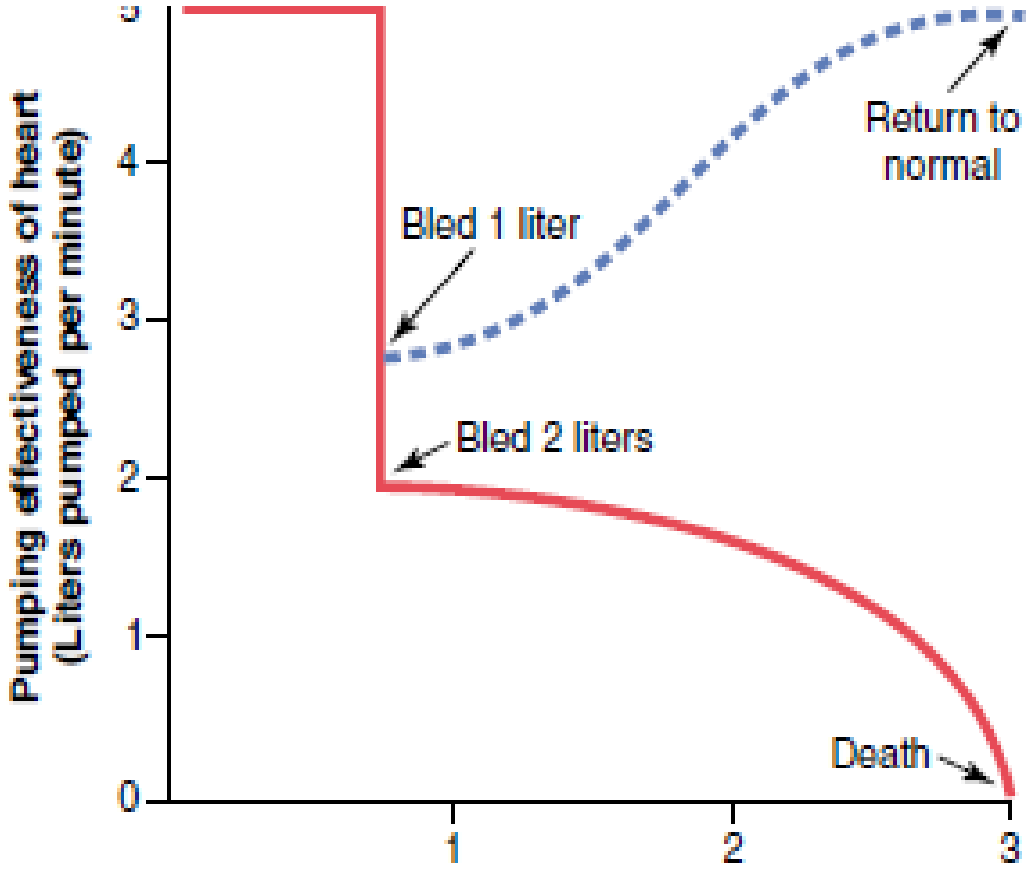
POSITIVE FEEDBACK MECHANISM

- In this, the output enhances or amplifies a change so that the controlled variable continues to move in the direction of the initial change.

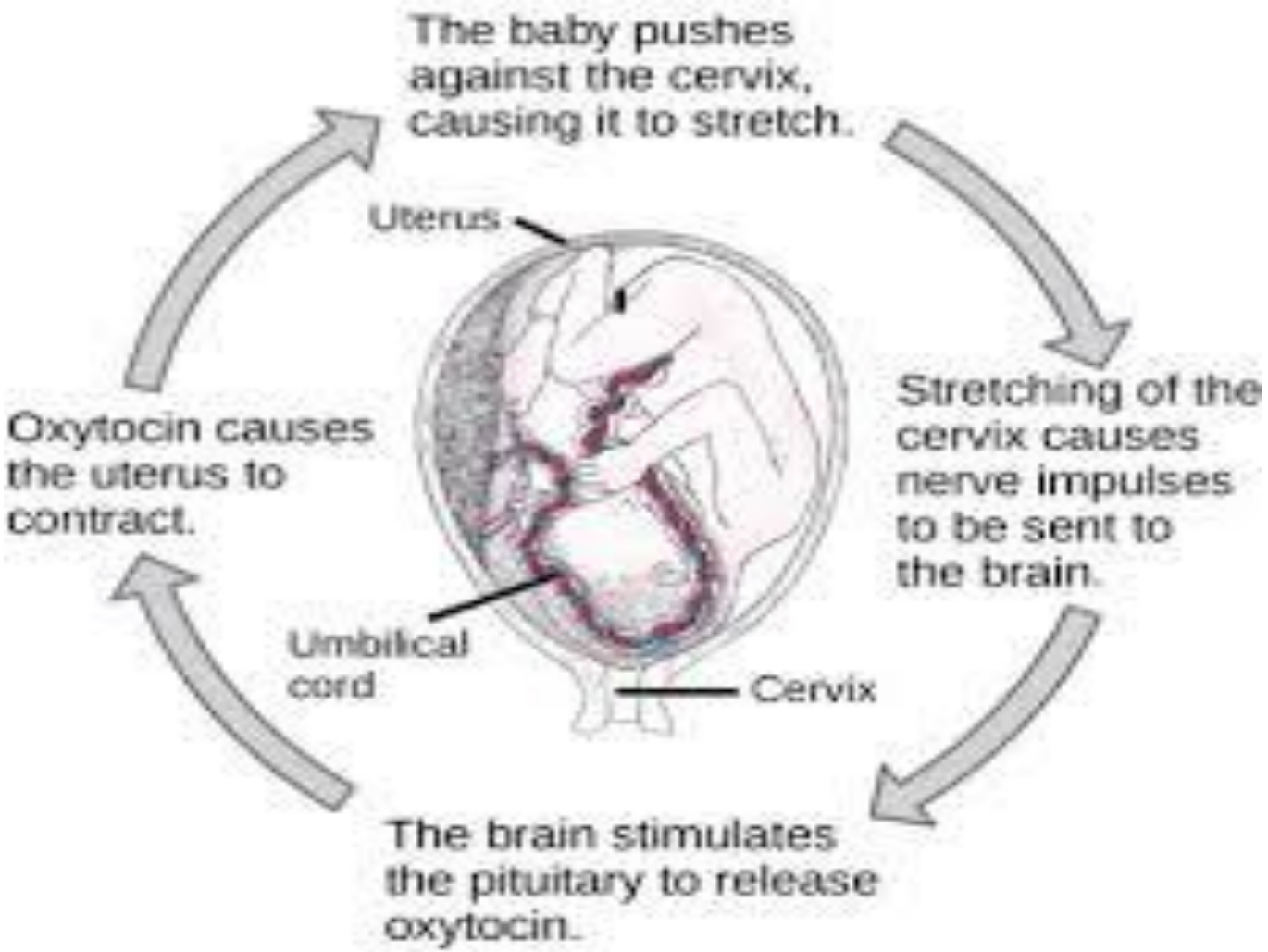
- Examples: parturition reflex

  Blood clotting

POSITIVE FEEDBACK CAN SOMETIMES CAUSE VICIOUS CYCLES OF BLEEDING AND DEATH



PARTURITION REFLEX



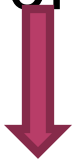
BLOOD CLOTTING MECHANISM

Injury to the blood vessel and bleeding

Formation of prothrombin activator +

Conversion of prothrombin into thrombin

Conversion of fibrinogen into fibrin



Stoppage of bleeding