

HOMEOSTASIS and STRESS



Homeostasis

- How can homeostasis help us understand something as complicated as the Human Body?
 - Human body consist of 50 trillion cells
 - All cells have something in common
 - Need nutrients to grow, repair, and replace themselves (cellular metabolism)
 - Metabolism creates toxic waste products that must be eliminated from body (e.g. carbon dioxide eliminated by lungs)

Homeostasis

- What is the definition of homeostasis? ***It is a systems ability to resist change.***



- Homeostasis is the tendency toward a relatively stable equilibrium in the “internal environment” (I.e the fluid between our cells) between our interdependent cells.

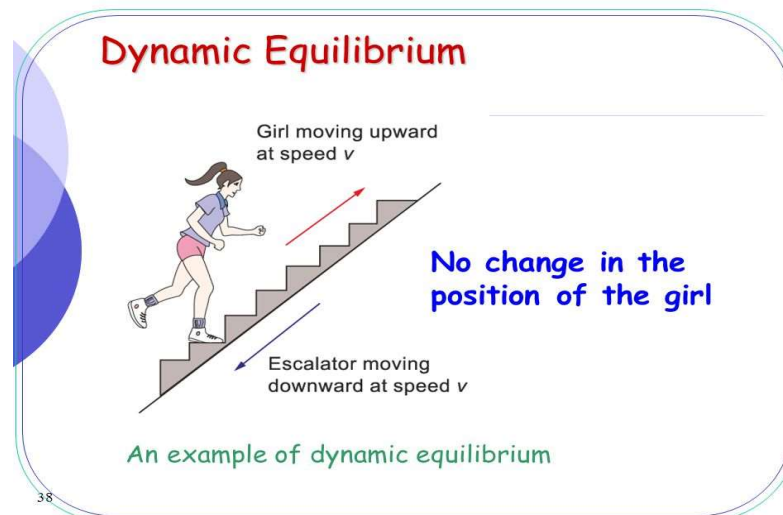
Homeostasis

Claude Bernard (1813-78)

- Observed the constant internal conditions of the body regardless of external conditions
- Thermoregulation /// internal body temperature ranges from 97 to 99 degrees F (38 C) despite variations in external temperatures

Walter Cannon (1871-1945)

- Coined the term '**Homeostasis**'
- Introduced the idea of a **dynamic equilibrium around a set point**
- **Negative feedback mechanisms** keeps variable close to the set point

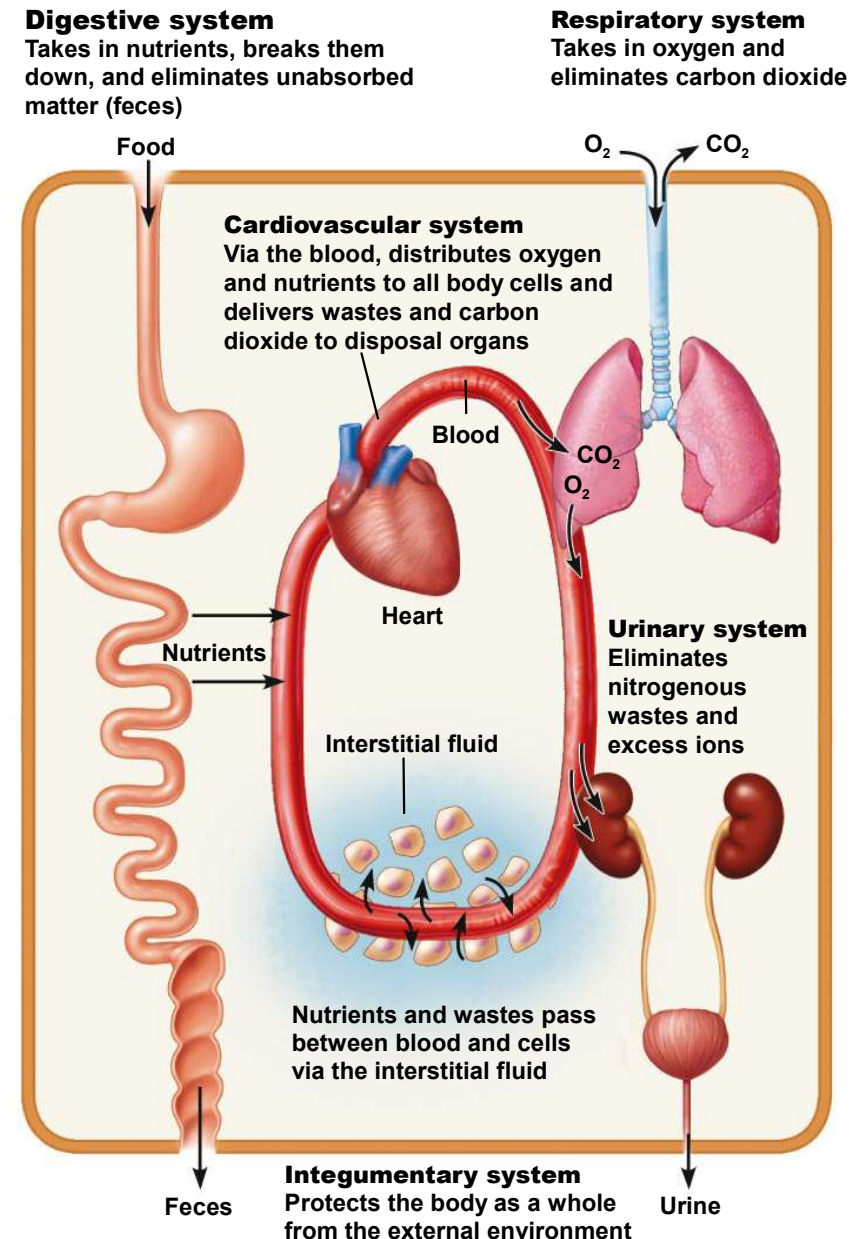


The Relationship Between Our Organ Systems and the Internal-Environment

Human body consist of 11 organ systems

- Integument System (Skin)
- Skeletal System
- Muscular System
- Nervous System
- Endocrine System
- Cardiovascular System
- Digestive System
- Urinary System
- Lyphatic System
- Respiratory System
- Reproductive System

Interstitial Fluid = Internal Environment



What Is Regulate by Homeostasis?

- Almost Everything!
 - Temperature
 - Glucose
 - Growth
 - Ions like sodium, potassium, protons!
 - And thousands of other parts of our physiology
- However, other things are not regulated.
 - e.g. Vitamin D

Homeostasis Is Maintained by the Autonomic Nervous System and the Endocrine System

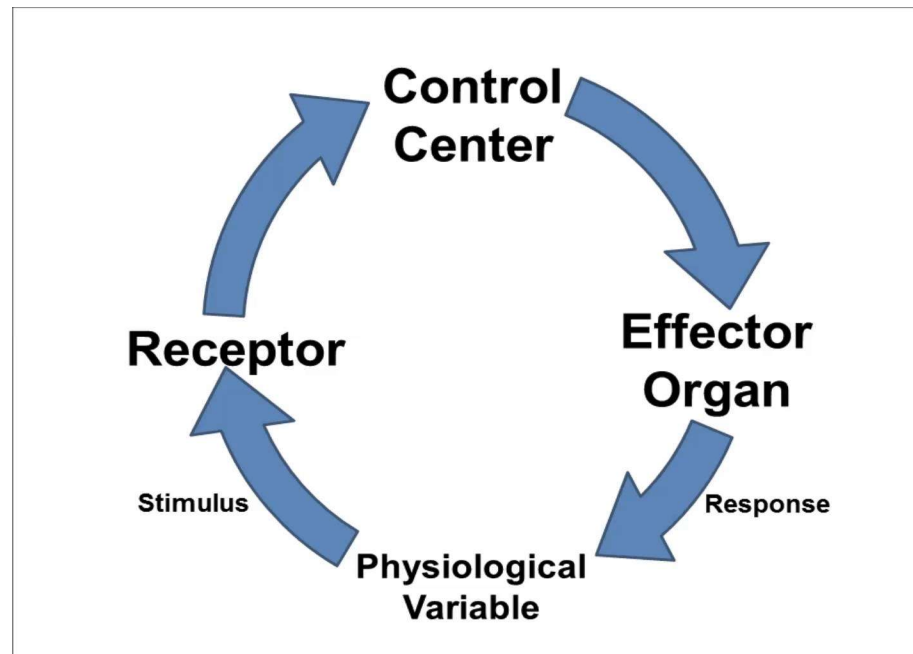
- ANS is a division of your nervous system (electrical & ANS is subconscious)
- Endocrine system (chemical & subconscious)



- The hypothalamus is the “boss” of these two control centers

Homeostasis Uses Feedback Loops

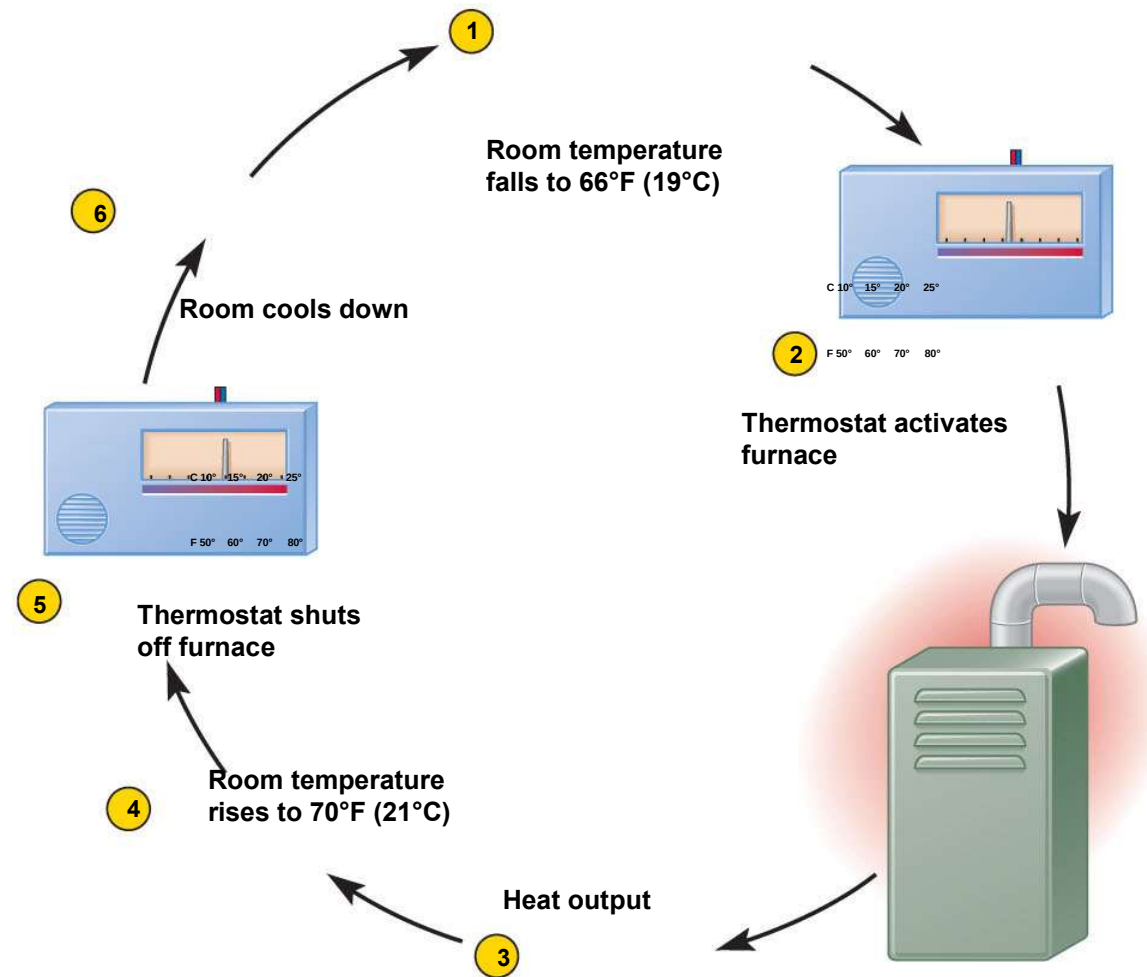
- Positive Feedback Loops
- Negative Feedback Loops
- Both types of loop have three similar components
 - Receptor ----> Control Center ----> Effector



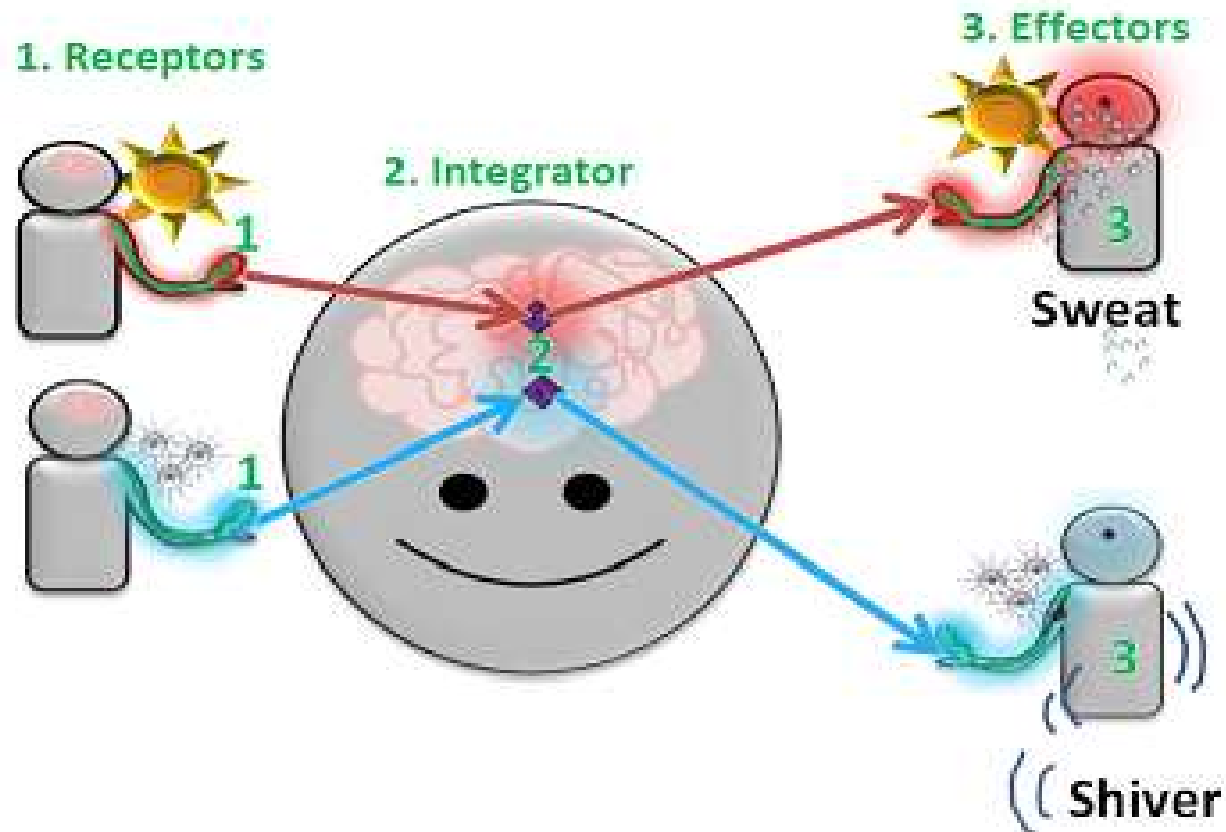
- A stimulus initiates the feedback loop

Negative Feedback and The Furnace Metaphor

Homeostasis = Dynamic Equilibrium

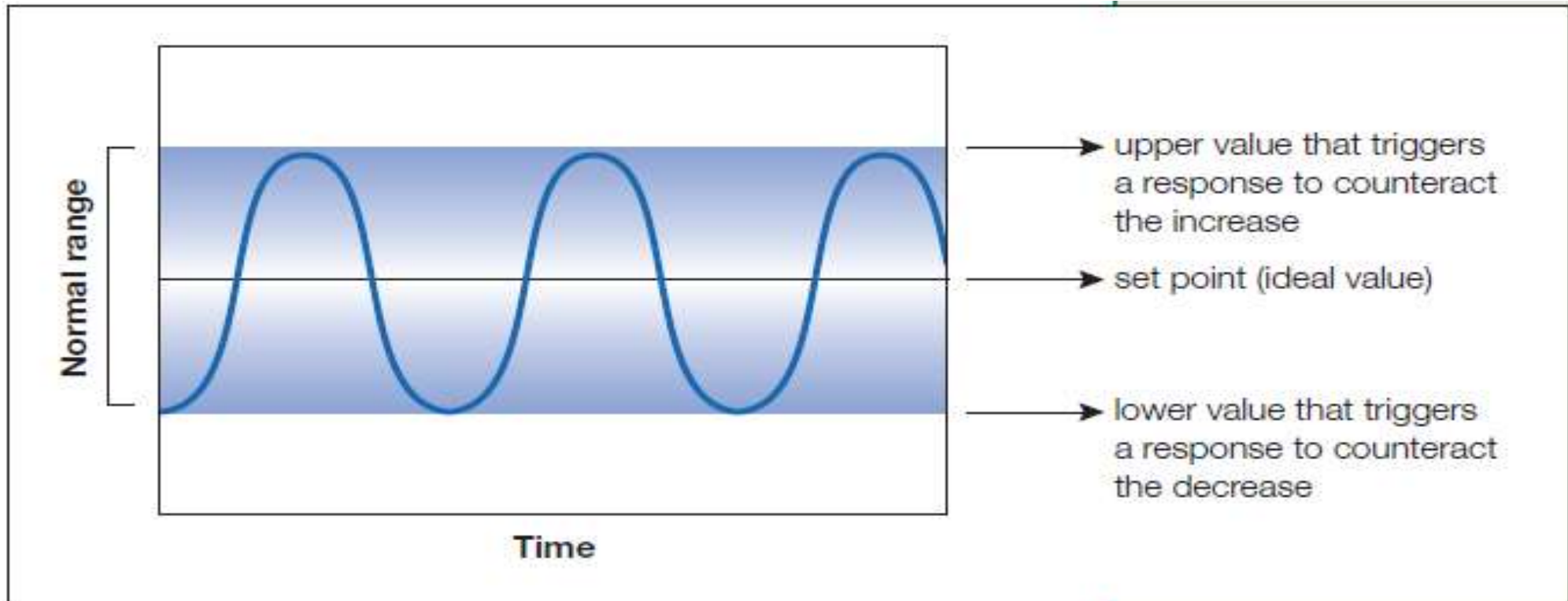


Negative Feedback Loops and Thermoregulation



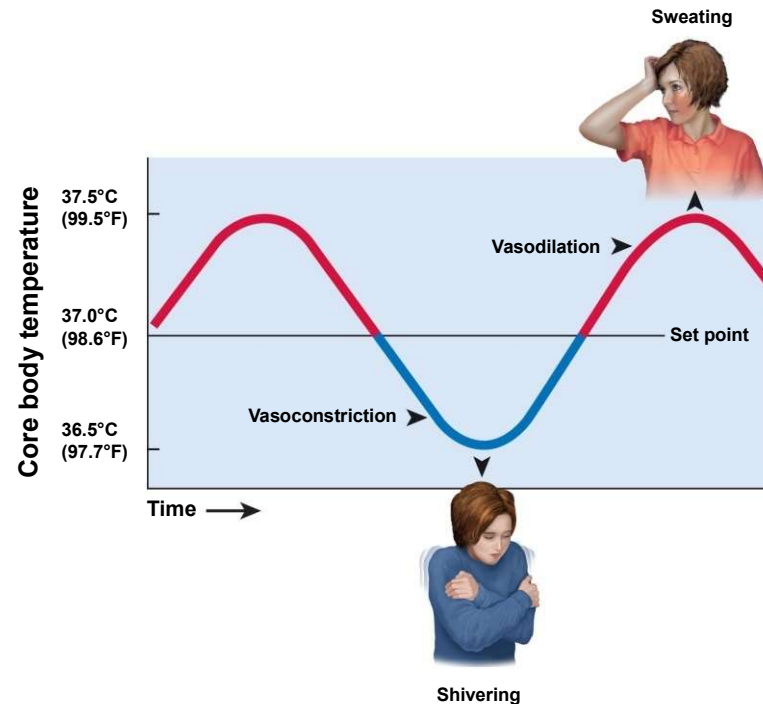
A change in temperature is the stimulus that initiates the negative feedback loop

Negative Feedback



Dynamic Equilibrium

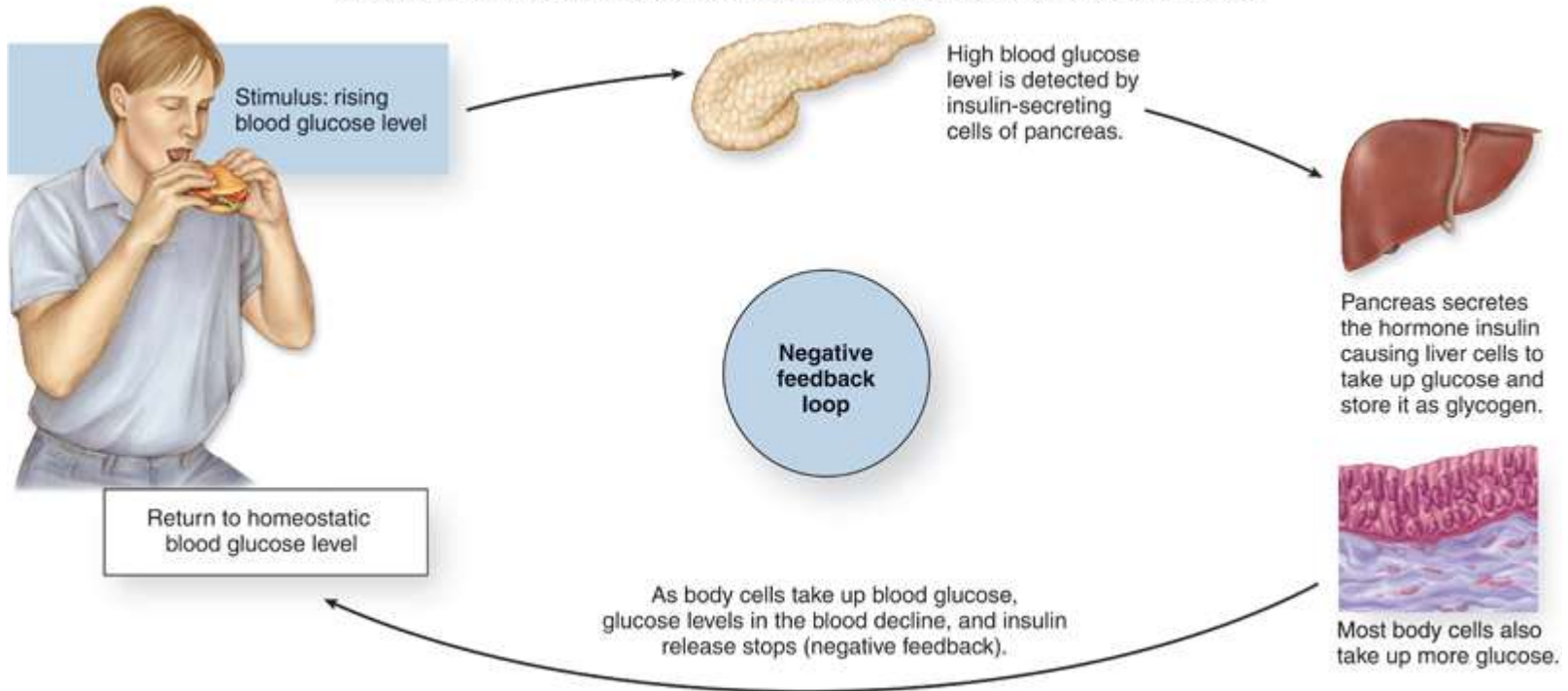
Negative Feedback in Human Thermoregulation



- **Brain senses change in blood temperature**
 - if too warm, vessels dilate in the skin (**vasodilation**) and sweating begins (heat losing mechanisms)
 - if too cold, vessels in the skin constrict (**vasoconstriction**) to conserve heat and shivering begins (heat gaining mechanism)

Negative Feedback Loop

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(a) Negative feedback

Positive Feedback Loops

- Characterized as “self-amplifying” feedback loops

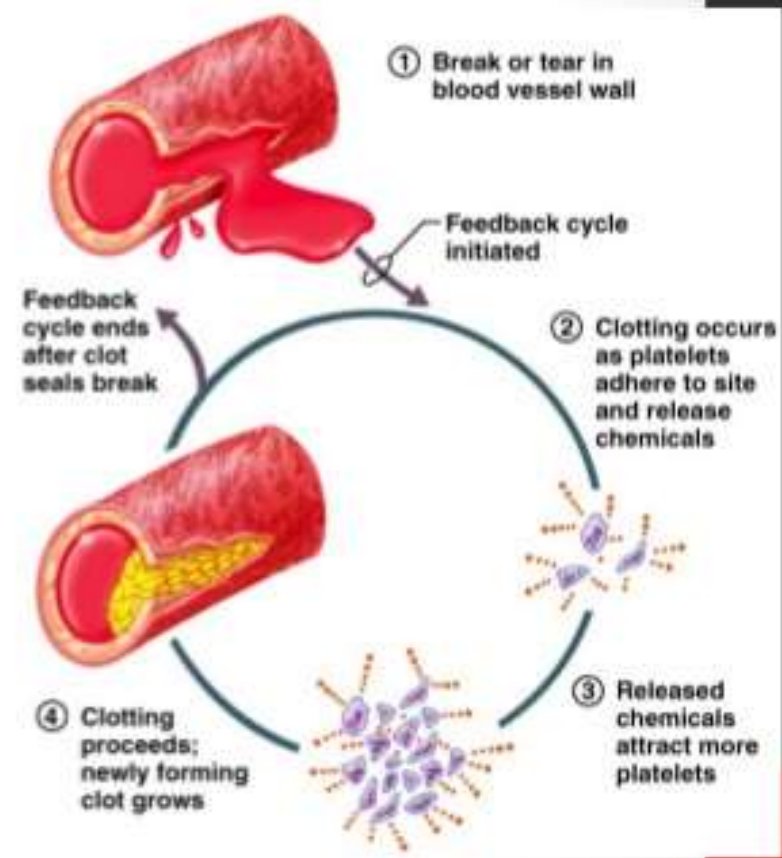
Stimulus ---> Response ---> Stimulus ---> Response ---> Stimulus ---> Response

- Potentially **more dangerous** than negative feedback loops
- Fever is a good example of a positive feedback loop
 - A pyrogen resets your “internal thermostat” - you generate more “heat”
 - Higher temp increases rate of “exothermic chemical reactions” in cells
 - Exothermic chemical reactions further increases temperature
 - Now we are trapped in a positive feedback loop
 - Eventually, higher temperatures will denatures proteins and this will cause death

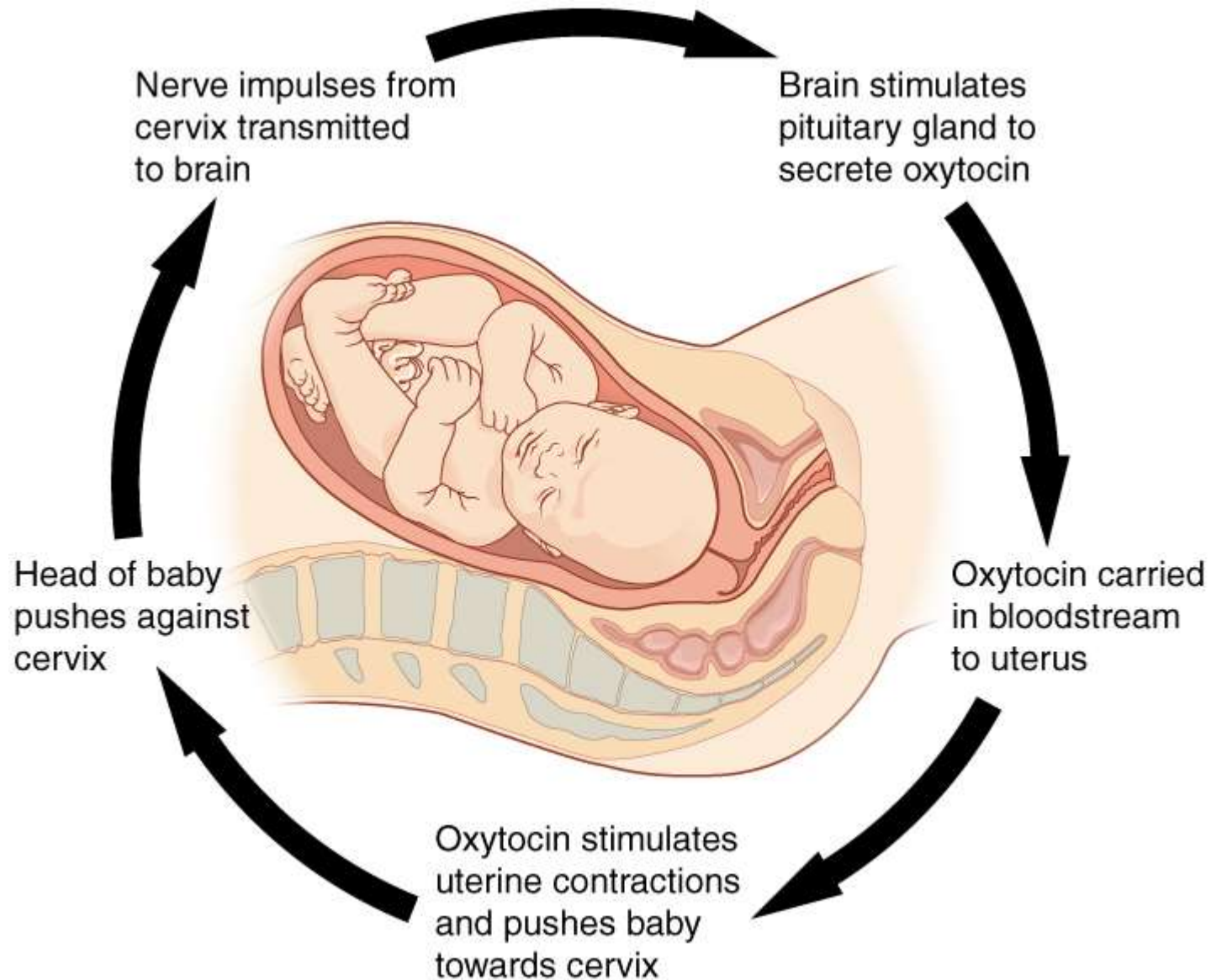
Some Physiologic Conditions Require Positive Feedback Loops

Positive Feedback

- In positive feedback systems, the output enhances or exaggerates the original stimulus
- Example: Regulation of blood clotting



Childbirth = Positive Feedback Loop



Importance of Homeostasis

- To maintain the internal environment of an organisms in a steady and balanced state (i.e. dynamic equilibrium)
- It's necessary in order to establish the optimum conditions of the organism.

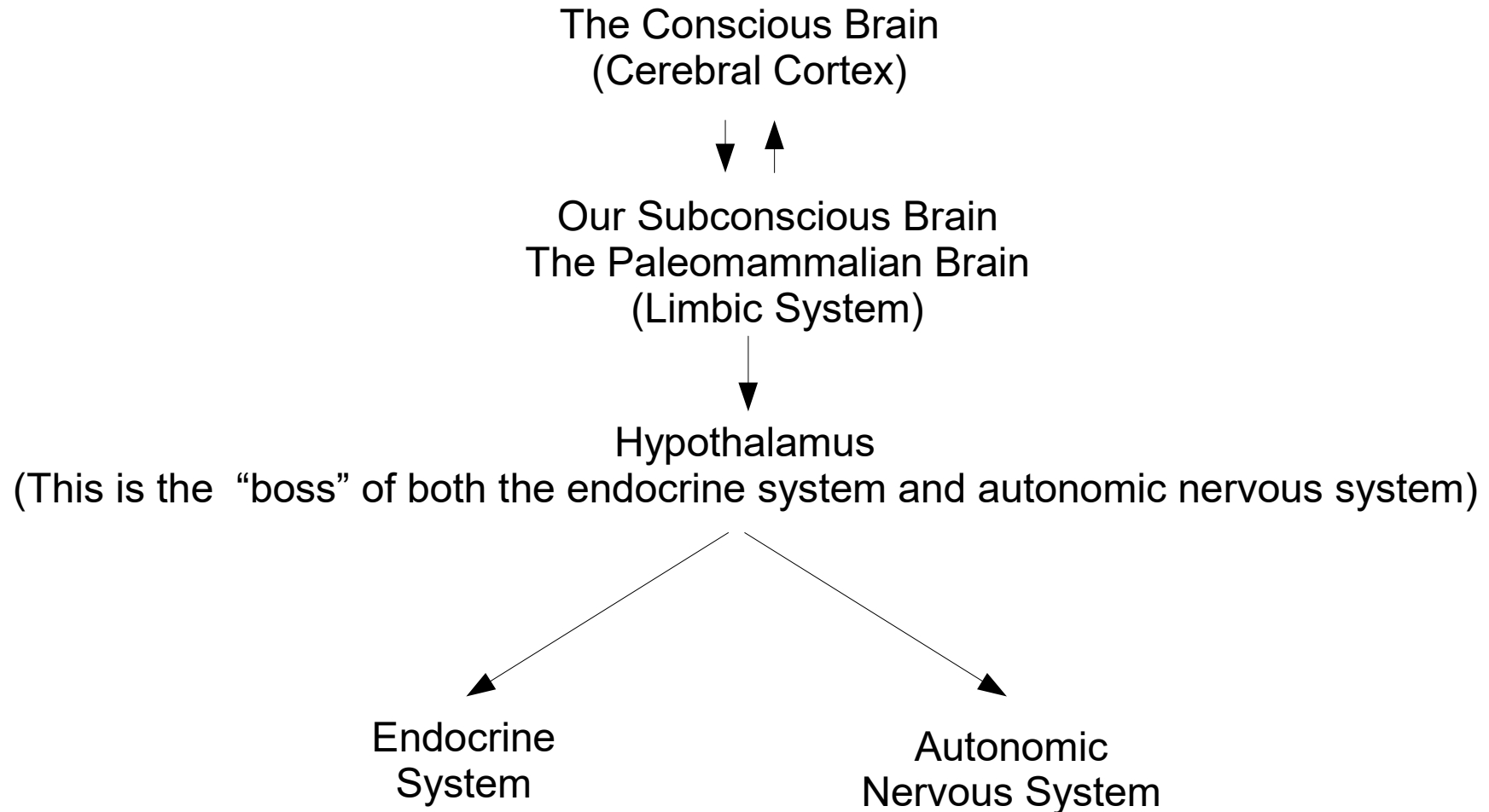


Medicine and Homeostasis

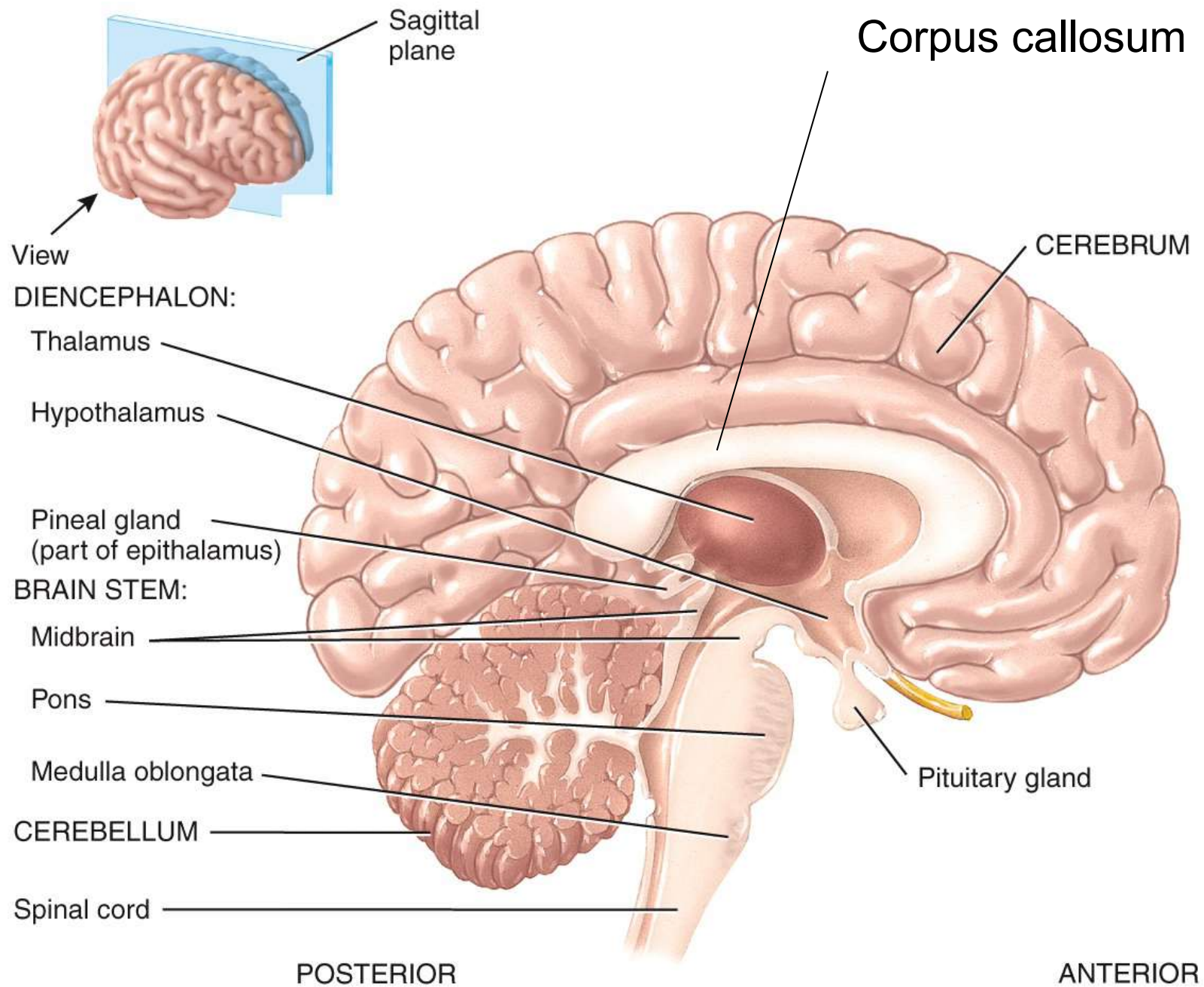
- Disease occurs when homeostasis fails
- Doctors apply the principles of homeostasis to understand the cause of the disease
- There is also a direct link between the mind and the body
- The conscious brain can be in conflict with the subconscious brain (limbic system)



The Mind-Body Axis (Stress & Homeostasis)

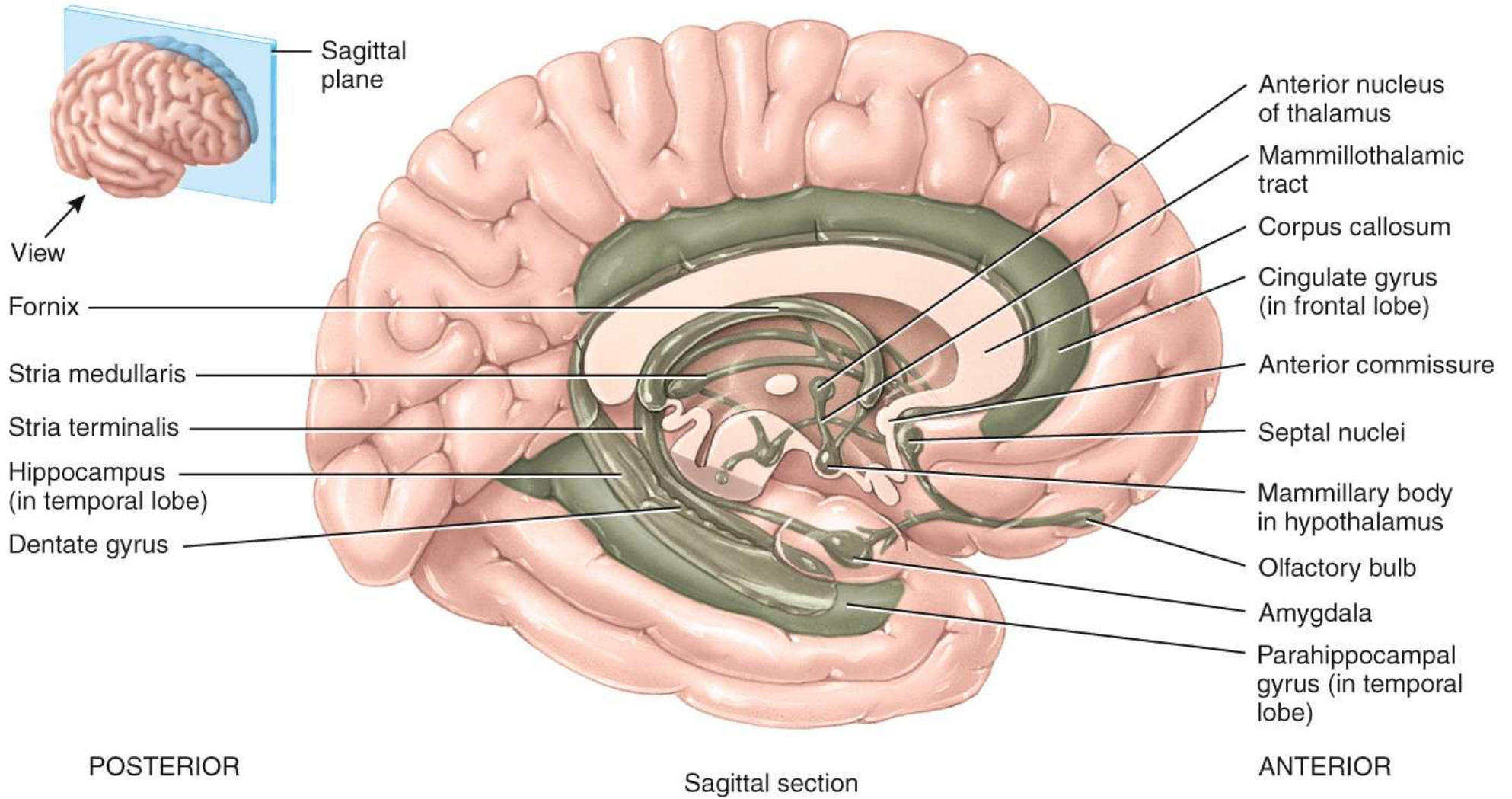


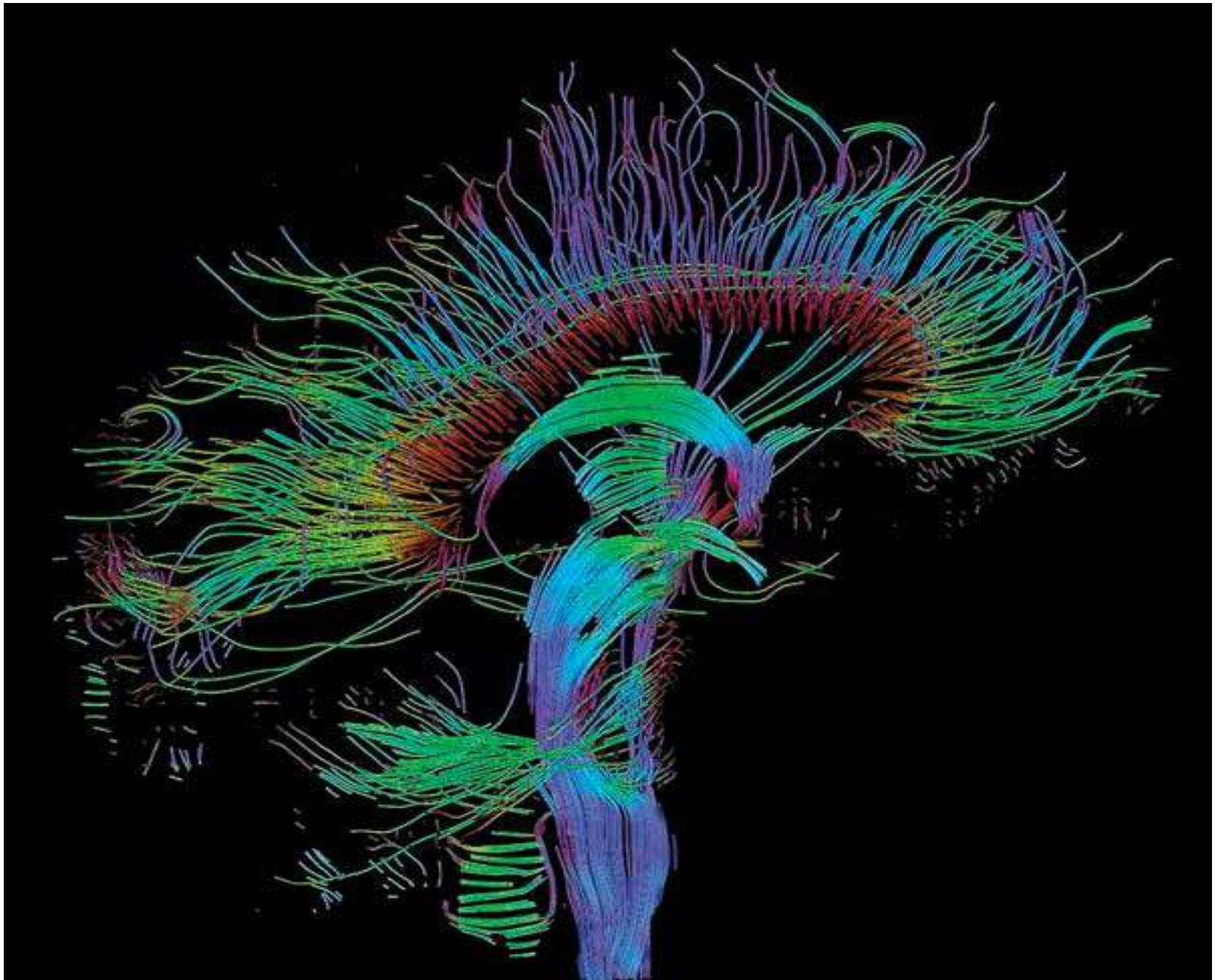
These two systems regulate homeostasis!



(a) Sagittal section, medial view

The Limbic System (The Paleo-Mammalian Formation)





The Human Brain

Nerve tracks connect different regions of the brain.

What is stress?

- Stress is not a disease
- Stress is a condition
- Stress is any situation that **upsets homeostasis**
 - anything that threatens one's physical or emotional well-being
 - e.g. // injury, surgery, infection, intense exercise, pain, grief, depression, anger, lecture exam, etc
- **Stress is not a disease but stress makes all diseases worst!**



Stress and the General Adaptive Syndrome



- **General adaptation syndrome (GAS)**
 - the consistent way that the body always reacts to a stressor
 - typically starts with elevated levels of epinephrine followed by increasing levels of glucocorticoids (especially cortisol)
- GAS occurs in three stages
 - alarm reaction stage
 - resistance stage
 - exhaustion stage



Alarm Reaction



- Initial response to stress mediated by
 - **norepinephrine** from the sympathetic nervous system & adrenal medulla
 - **epinephrine** from the adrenal medulla
- Response to “fright” (i.e. panic) and prepares the body to either “fight or flight”
 - stored glycogen is catabolized
 - increasing levels of **aldosterone** and **angiotensin** levels released into blood
 - angiotensin helps raise blood pressure
 - aldosterone promotes sodium and water conservation



Stage of Resistance



- After a few hours (or days), glycogen reserves are gone (no glucose in storage)
- However, our brain needs glucose /// need to provide alternate sources of glucose for brain metabolism while other non-brain cells use fat catabolism as a source of fuel for their metabolism
- Hypothalamus secretes corticotropin-releasing hormone /// causes pituitary to release adrenocorticotrophic hormone (ACTH)
- Pituitary secretes increasing amounts of ACTH
 - stimulates the adrenal cortex to secrete **cortisol** and other glucocorticoids
 - promotes the breakdown of fat and protein
 - glycerol, fatty acids, and amino acids – used for gluconeogenesis
 - need to produce blood glucose for brain and RBCs
 - resistance stage is dominated by cortisol

Cortisol Regulates the Stage of Resistance

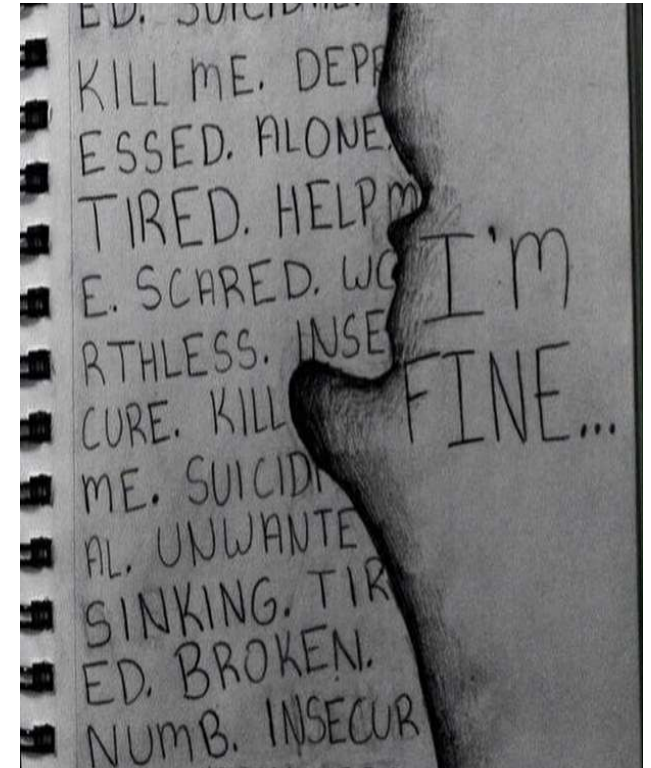


- Cortisol has glucose-sparing effect
 - inhibits new protein synthesis // while muscle protein is converted into glucose (i.e. gluconeogenesis)
 - adverse effects of excessive cortisol
 - depresses immune function
 - increases susceptibility to infection and ulcers
 - lymphoid tissues atrophy, antibody levels drop, and wounds heal poorly
 - re-positions fat deposits in body (from limbs to face & back)
 - Cortisol does reverse capillary imbalance (i.e. swelling) seen during inflammation (i.e. cortisol = anti-inflammatory effect)

Stage of Exhaustion



- After stress continues for weeks and/or months
 - fat reserves are gone
 - protein breakdown results in muscle wasting
 - unable to make antibodies = no longer resistant to diseases
 - homeostasis is overwhelmed
 - now physiology marked by rapid decline

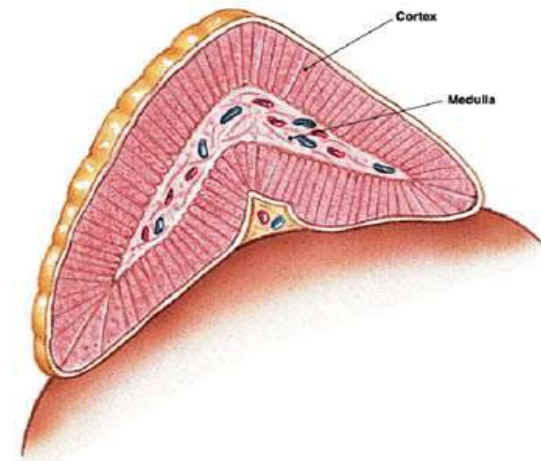
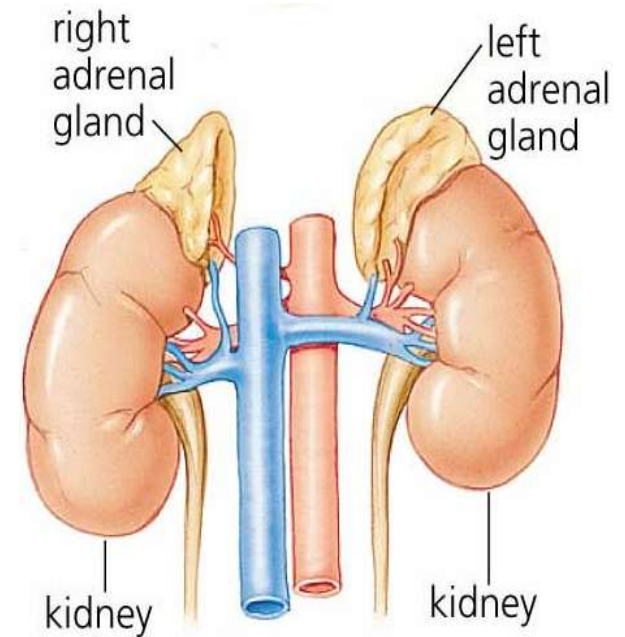


- Furthermore....
 - the loss of glucose homeostasis occurs because adrenal cortex stops producing glucocorticoids
 - however, the adrenal gland continues to produce mineralcorticoids // leads to electrolyte imbalance

Stage of Exhaustion



- Aldosterone continues to promoted water retention and hypertension
 - conserves sodium and hastens elimination of K^+ and H^+
 - hypokalemia and alkalosis will eventually lead to death
 - death results from heart and kidney infection and/or overwhelming infection



They Don't Have to Die From a Broken Heart!



We often hear sadly about a long relationship that ends after the death of a spouse.

The loss of a love one is a stressor! A period of grieving is normal (the **resistance stage**).

However, if this period of grieving continues for an extended period then this initiates the **alarm stage** of the GAS

If the individual can not escape from the resistance stage and return to normal homeostasis then the resistance stage will eventually progress into the **exhaustion stage** with fatal consequences.

So it is important to have someone who can step in and break the GAS pathway in order to prevent the grieving spouse from “dying from a broken heart”.





Lee Atwater