Feedback Mechanisms

What are Feedback Mechanisms?

- A feedback loop occurs when the output of a pathway amplifies (positive feedback) or inhibits (negative feedback) the pathway

- Feedback loops exist so that organisms can maintain homeostasis.

Homeostasis

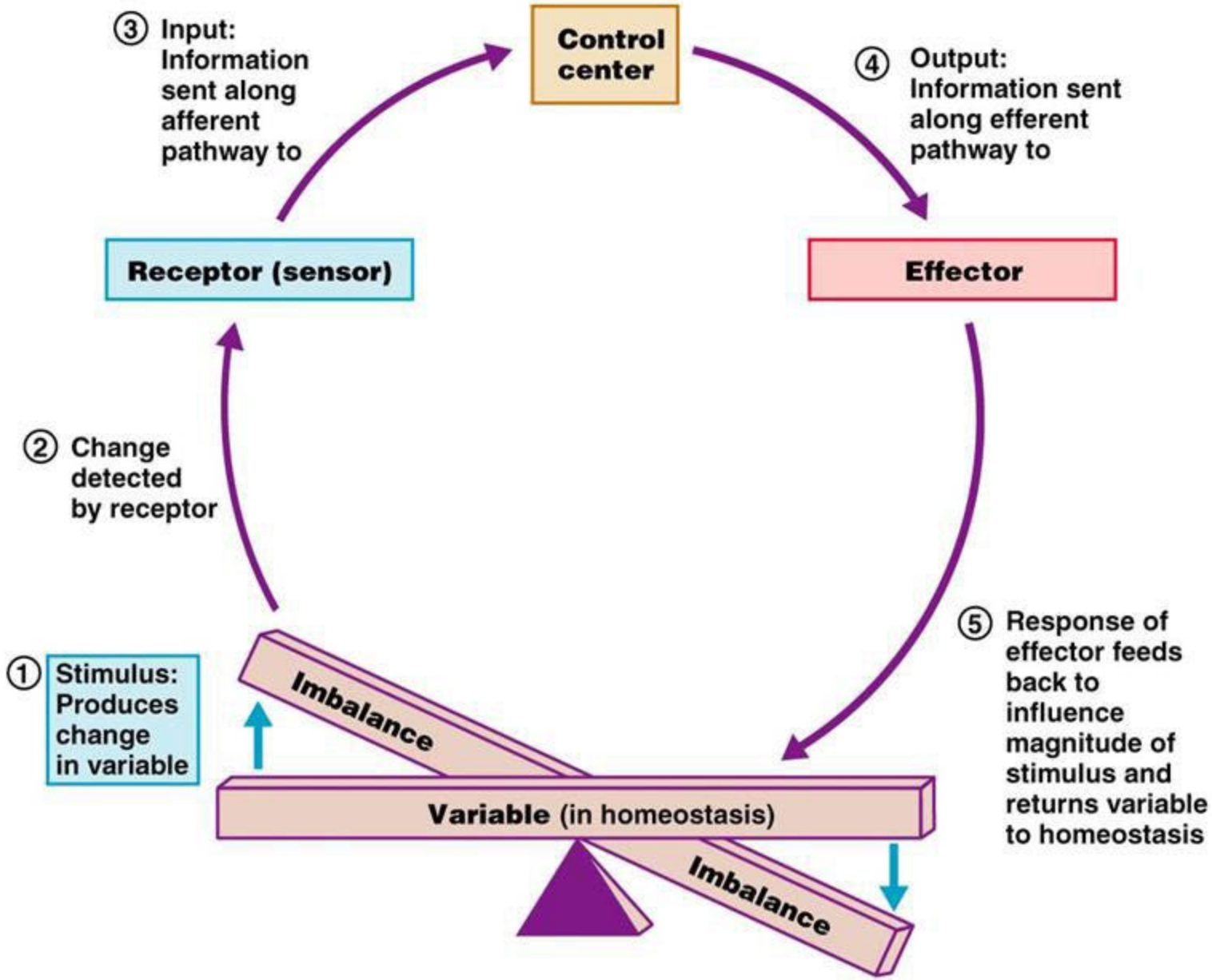
- Homeostasis refers to maintaining internal conditions within a cell

- This means that certain conditions must remain at a specific target set point
  - Blood sugar
  - Temperature
  - pH

- These conditions are important as various metabolic processes rely on stable conditions in order to proceed effectively.

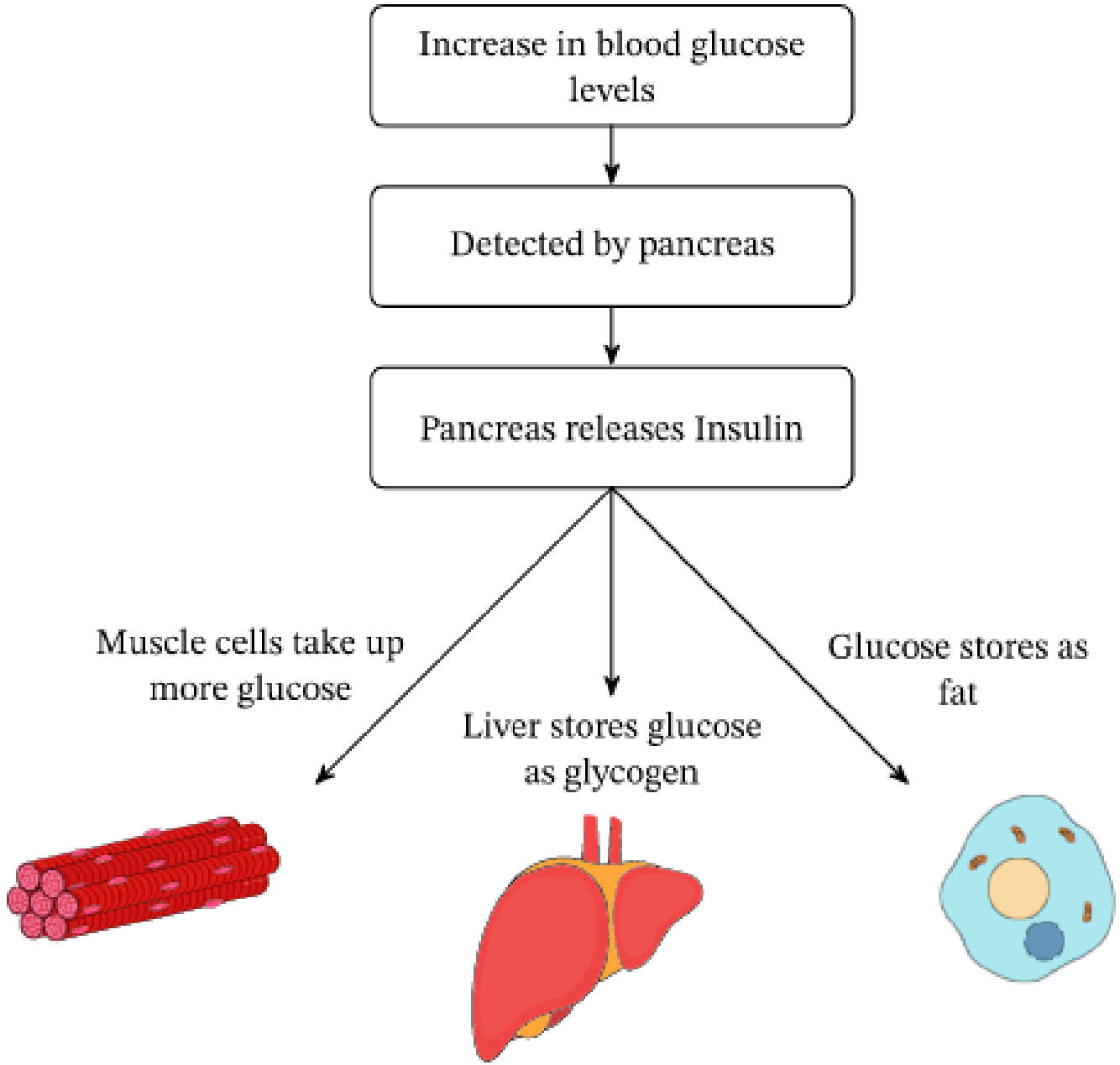
Negative Feedback maintains homeostasis for a certain cell condition

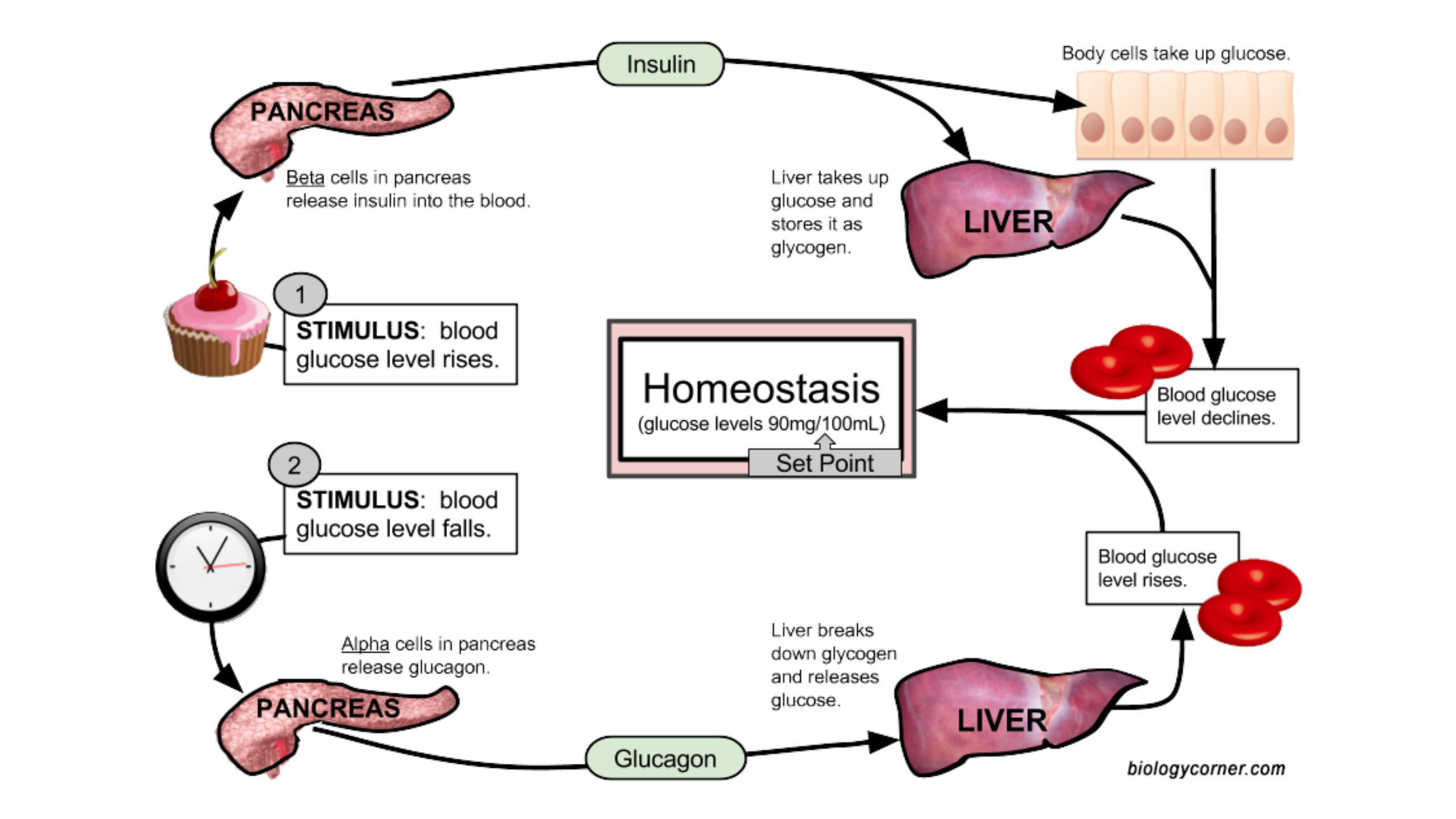
- Let’s look at how negative feedback plays a role in the regulation of blood sugar levels…


③ Input: Information sent along afferent pathway to
Control center
④ Output: Information sent along efferent pathway to
Receptor (sensor)
Effector
② Change detected by receptor
① Stimulus: Produces change in variable
Imbalance
Variable (in homeostasis)
Imbalance
⑤ Response of effector feeds back to influence magnitude of stimulus and returns variable to homeostasis

Balancing blood sugar…

- After eating a meal, the digestion (or break down) of macromolecules begins
- Within minutes of eating one of the products of digestion, glucose, increases in the blood stream
- This increase in blood sugar stimulates the release of hormone INSULIN by the pancreas
- The role of insulin is to trigger the transport of glucose from the blood into the tissues – especially the liver – where it is assembled into glycogen.
- This lowers blood sugar


Increase in blood glucose levels
Detected by pancreas
Pancreas releases Insulin
Muscle cells take up more glucose
Liver stores glucose as glycogen
Glucose stores as fat


Insulin
PANCREAS
Beta cells in pancreas release insulin into the blood.
Body cells take up glucose.
Liver takes up glucose and stores it as glycogen.
LIVER
1
STIMULUS: blood glucose level rises.
Homeostasis
(glucose levels 90mg/100mL)
Set Point
Blood glucose level declines.
2
STIMULUS: blood glucose level falls.
Blood glucose level rises.
Alpha cells in pancreas release glucagon.
Liver breaks down glycogen and releases glucose.
PANCREAS
Glucagon
LIVER
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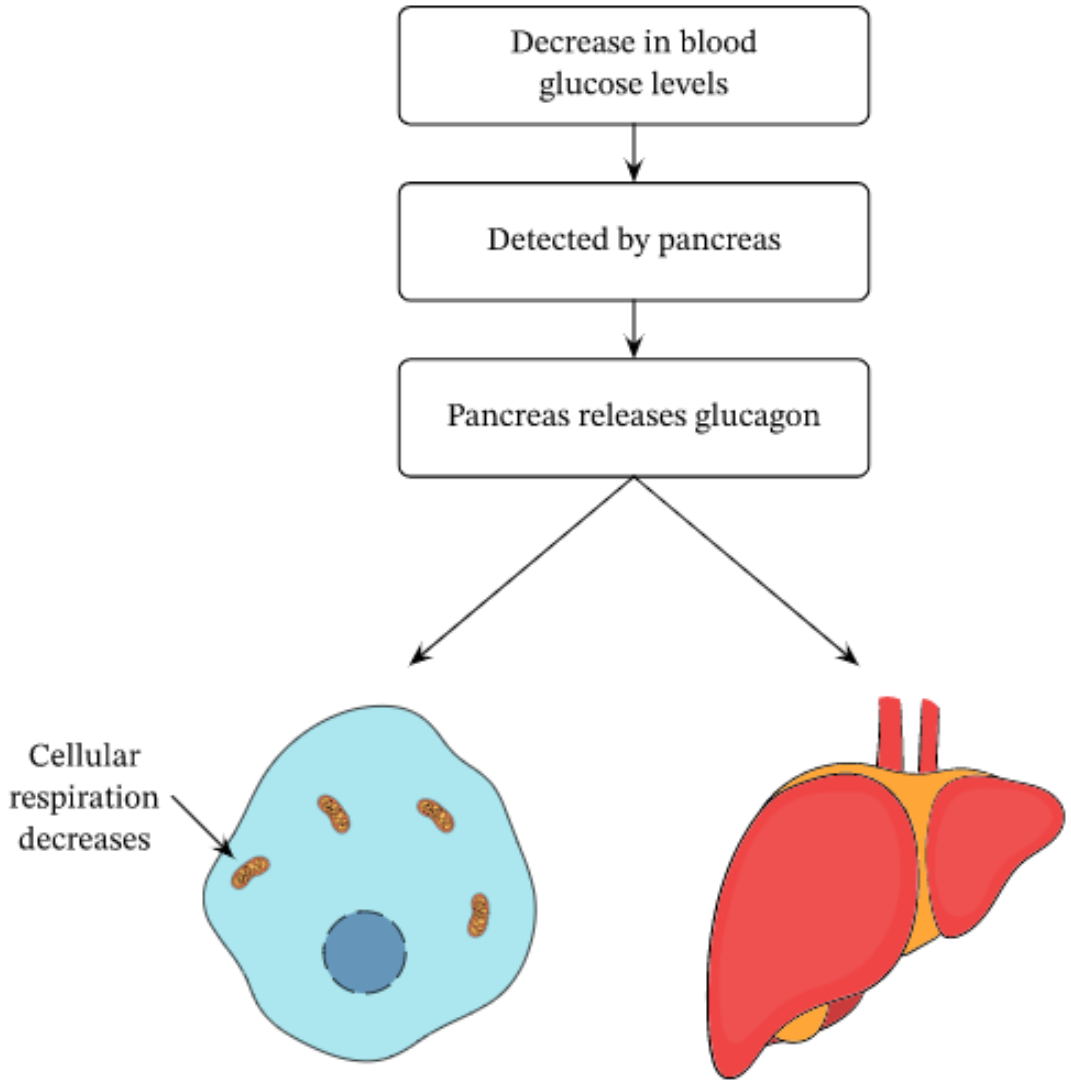
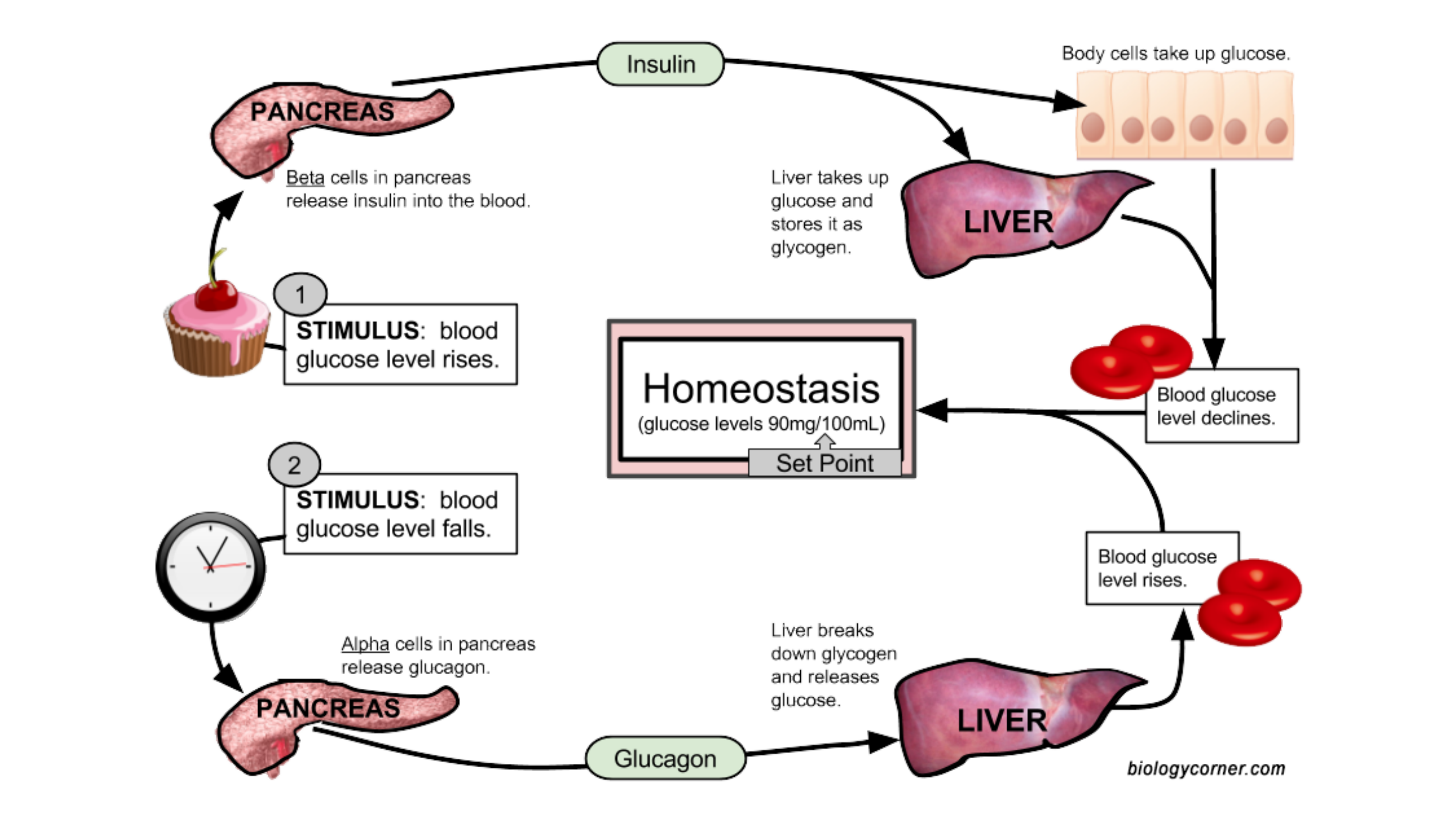
Balancing blood sugar…

- Conversely, if you haven't eaten for a few hours blood sugar levels will start to decline
- This drop will stimulate the pancreas to release a hormone called GLUCAGON
- Glucagon targets the liver to break stored glycogen into glucose and release it into the blood
- Glucagon also slows cellular respiration → less glycolysis
- This will increase blood sugar levels



Cellular respiration in cell decreases by inhibiting glycolysis

Liver cells break down glycogen to glucose and convert amino acids and glycerol into glucose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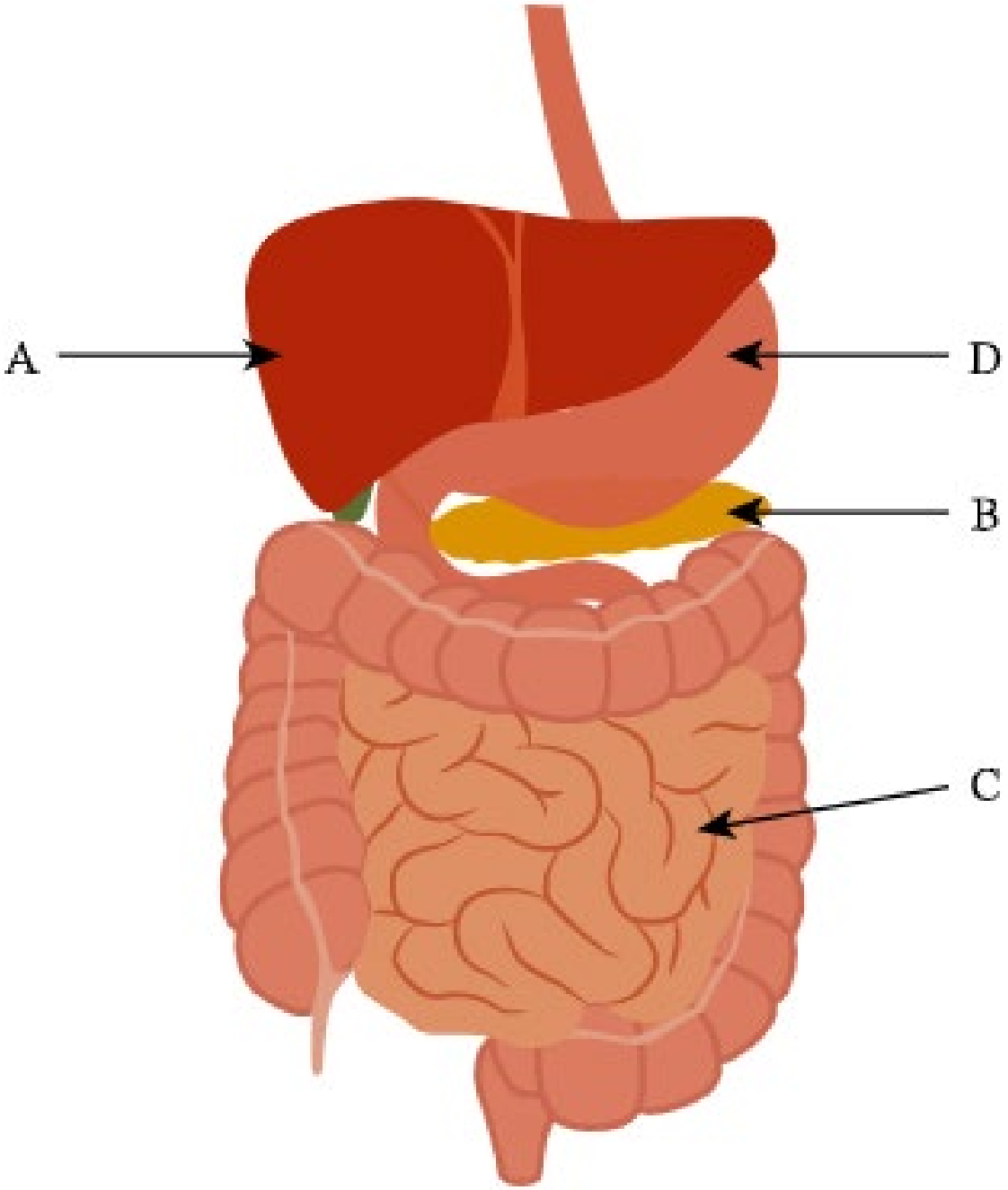
Balancing blood sugar…

- The pancreas directly monitors blood glucose levels and as levels fall and rise these changes inhibit further release of insulin and glucagon respectively.

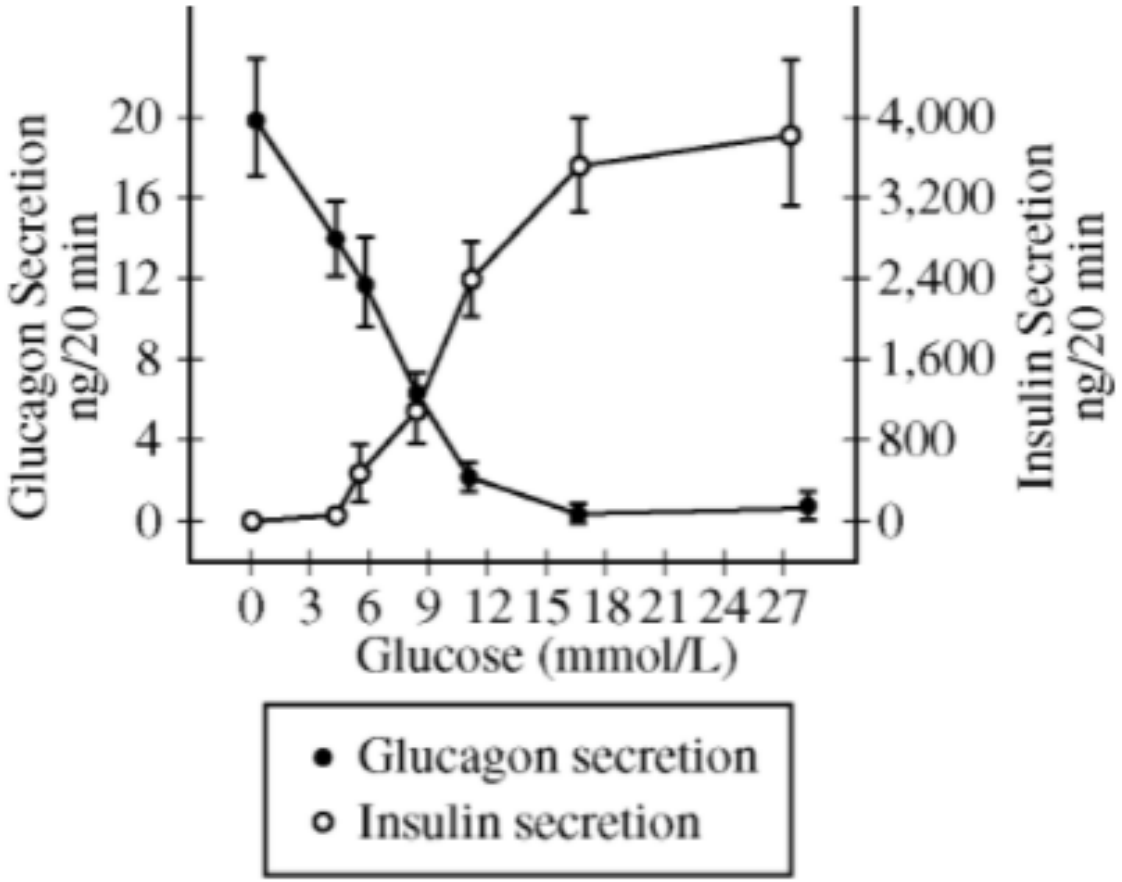
- This is an example of negative feedback.

- This feedback mechanism keeps blood sugar relatively stable after and between meals



1. Using the diagram, give the letter and the name of the organ that releases the major hormones involved in regulating blood glucose concentration.

2. Using the diagram, give the letter and the name of the organ that stores glucose as glycogen



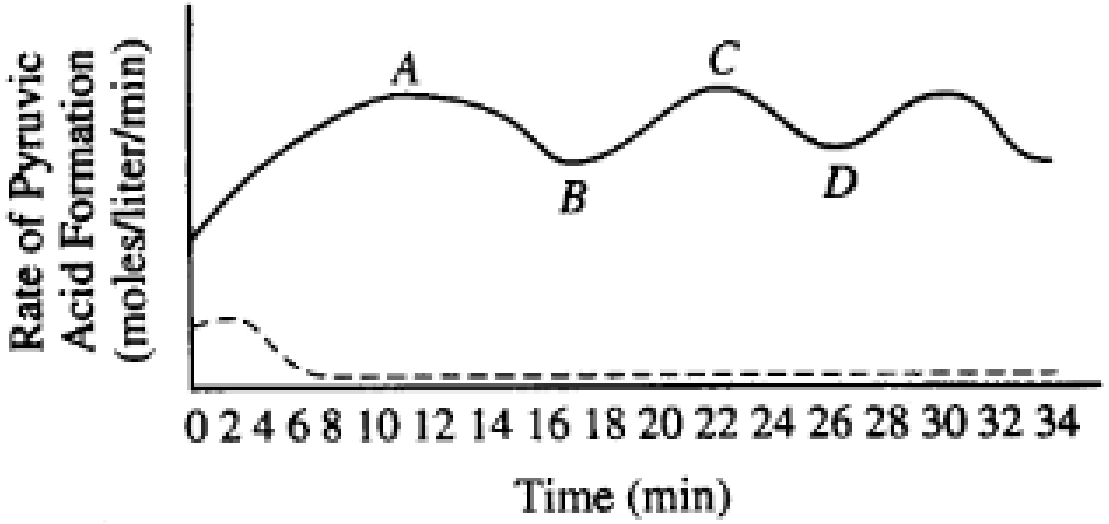
The graph shows changes in glucagon and insulin secretions at different concentrations of blood glucose. Which of the following feedback mechanisms is best supported by the data?

a. A falling glucagon level causes a rise in the insulin level, which maintains equal amounts of both hormones in the blood.

b. A high glucagon level causes a rise in the insulin level, which maintains high levels of both hormones in the blood.

c. A low glucose level causes the release of glucagon, which stimulates the release of more glucose from tissues, which in turn lowers the amount of glucagon being released.

d. A low glucose level causes the release of insulin, which stimulates the release of more glucose from tissues, which in turn increases the amount of insulin being released.



A tissue culture of vertebrate muscle was provided with a constant excess supply of glucose under anaerobic conditions starting at time zero and the amounts of pyruvic acid and ATP produced were measured.
The solid line in the graph above represents the pyruvic acid produced in moles per liter per minute. ATP levels were also found to be highest at points *A* and *C*, lowest at *B* and *D*. A second culture was set up under the same conditions, except that substance **X** was added, and the results are indicated by the dotted line.

The rate of pyruvic acid formation fluctuates because

a) all glucose has reacted

b) all glucose has reacted

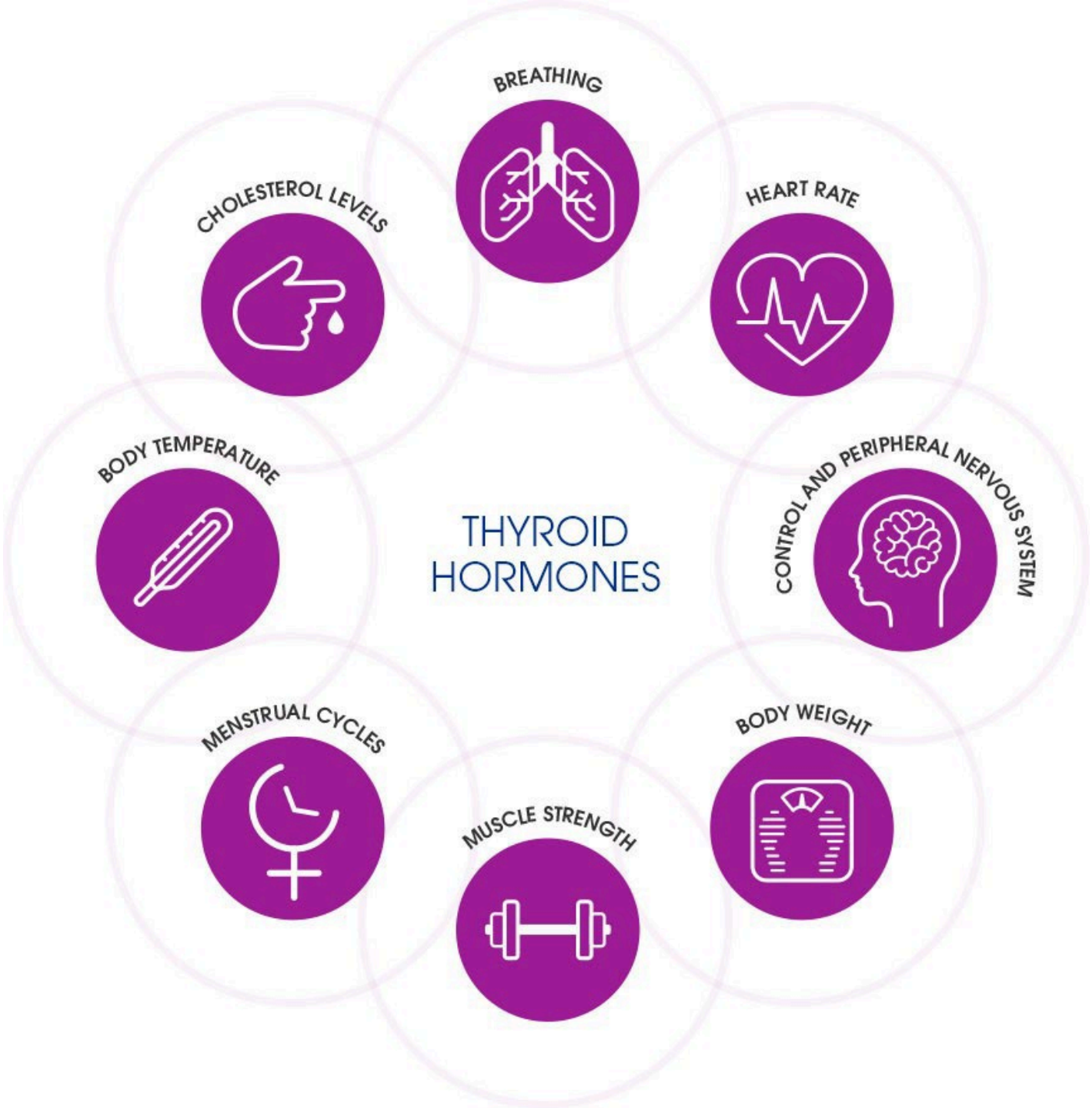
c) the reaction is accelerated by positive feedback

d) the reaction is affected by negative feedback

e) coenzymes have begun to function

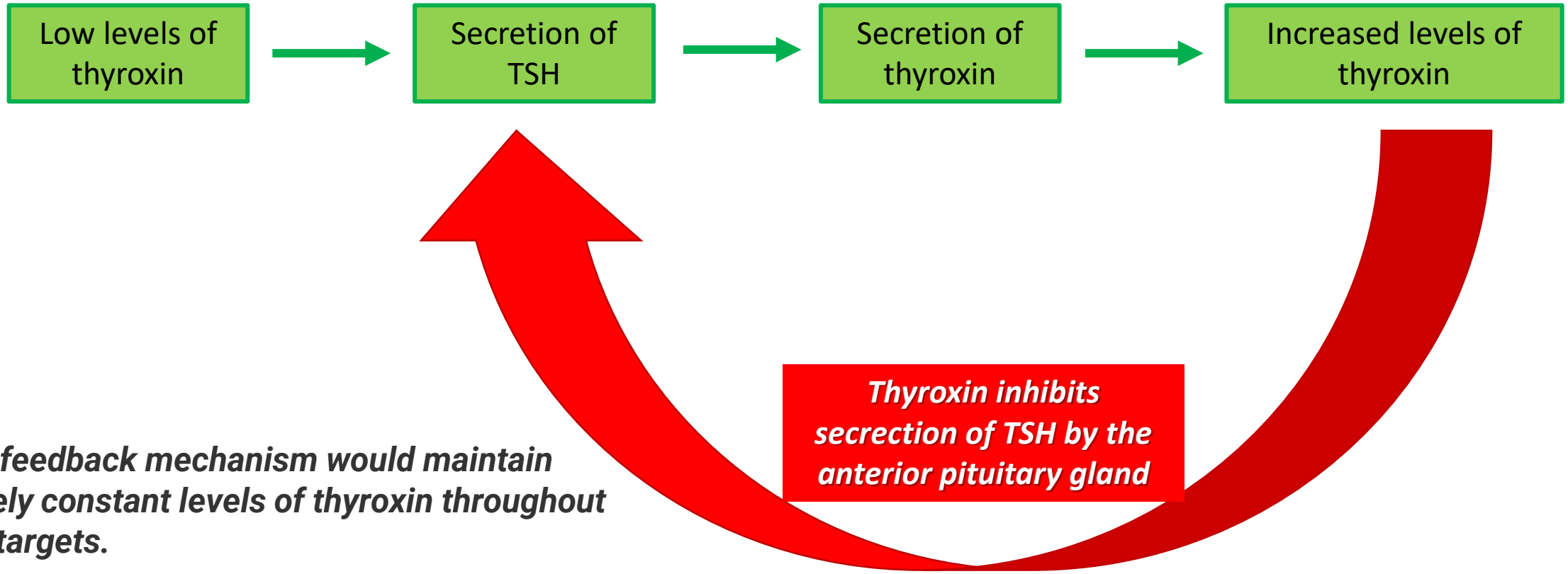
Examples of Targets Maintained via Negative Feedback loops in the Human Body

- Metabolic rate
- Water & Salt balance in the blood
- Iron levels in the blood
- Thyroid hormones →

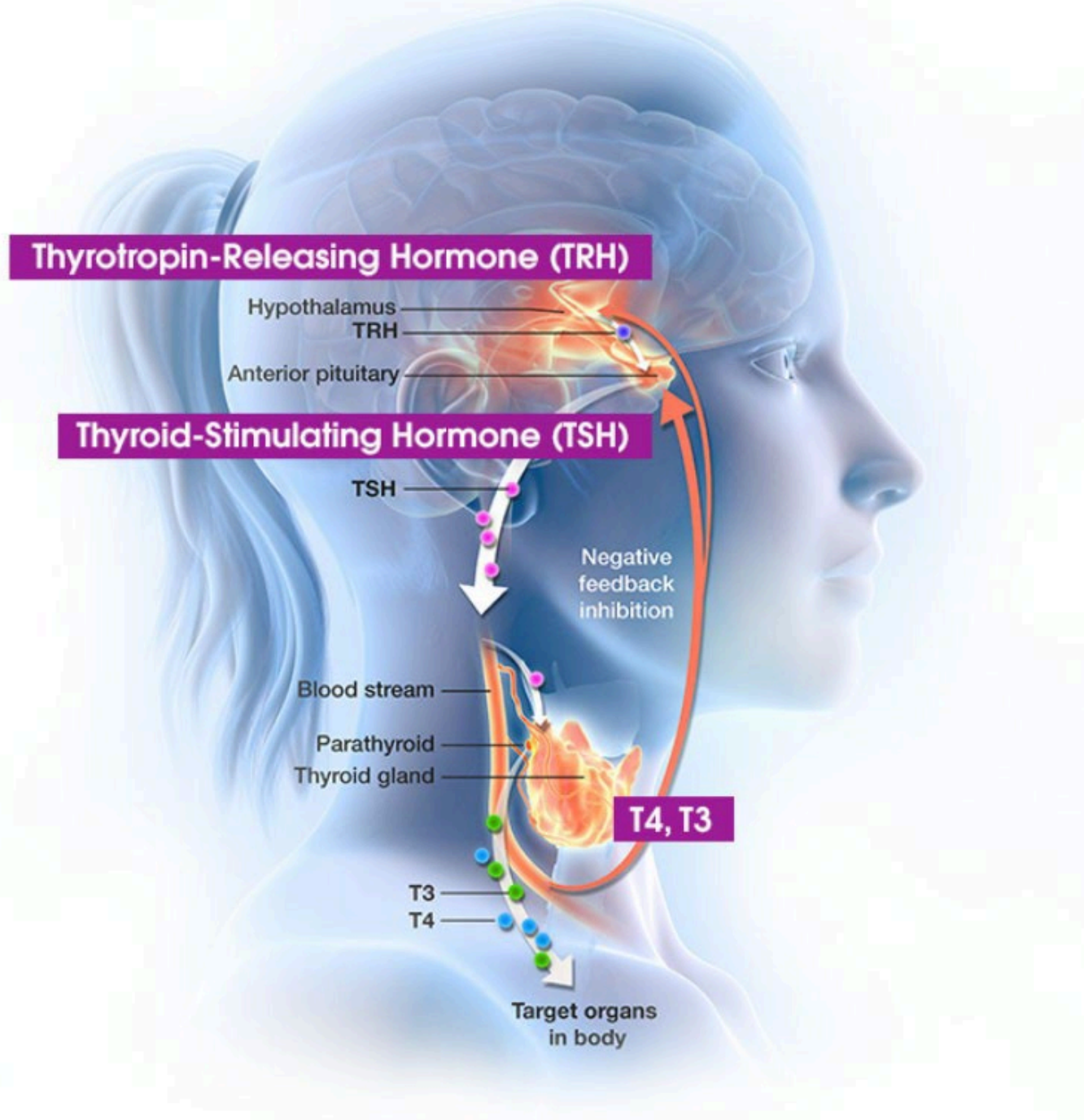

BREATHING
HEART RATE
CONTROL AND PERIPHERAL NERVOUS SYSTEM
BODY WEIGHT
MUSCLE STRENGTH
MENSTRUAL CYCLES
BODY TEMPERATURE
CHOLESTEROL LEVELS
THYROID HORMONES

Thyroxin is a hormone that increases metabolic activities within various tissue targets. Low levels of circulating thyroxin trigger the secretion of thyroid-stimulating hormone (TSH) from the anterior pituitary. TSH secretion then stimulates thyroxin production and release by the thyroid gland. The increased level of circulating thyroxin inhibits further secretion of TSH from the anterior pituitary.

Q: Based on the information provided, which of the following can most likely be concluded about the TSH-thyroxin loop?



A: The feedback mechanism would maintain relatively constant levels of thyroxin throughout tissue targets.


Thyrotropin-Releasing Hormone (TRH)
Hypothalamus
TRH
Anterior pituitary
Thyroid-Stimulating Hormone (TSH)
TSH
Negative feedback inhibition
Blood stream
Parathyroid
Thyroid gland
T4, T3
T3
T4
Target organs in body

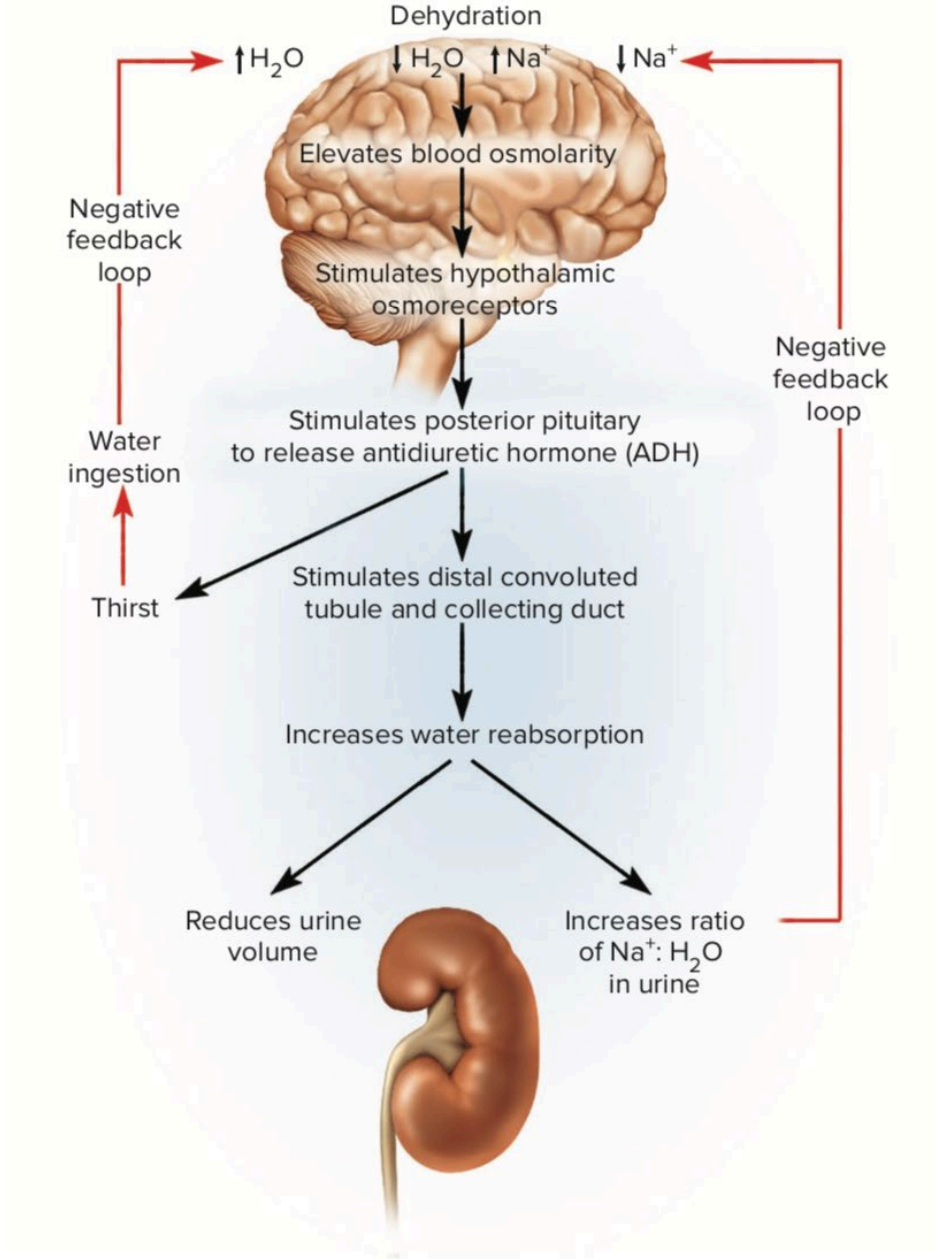
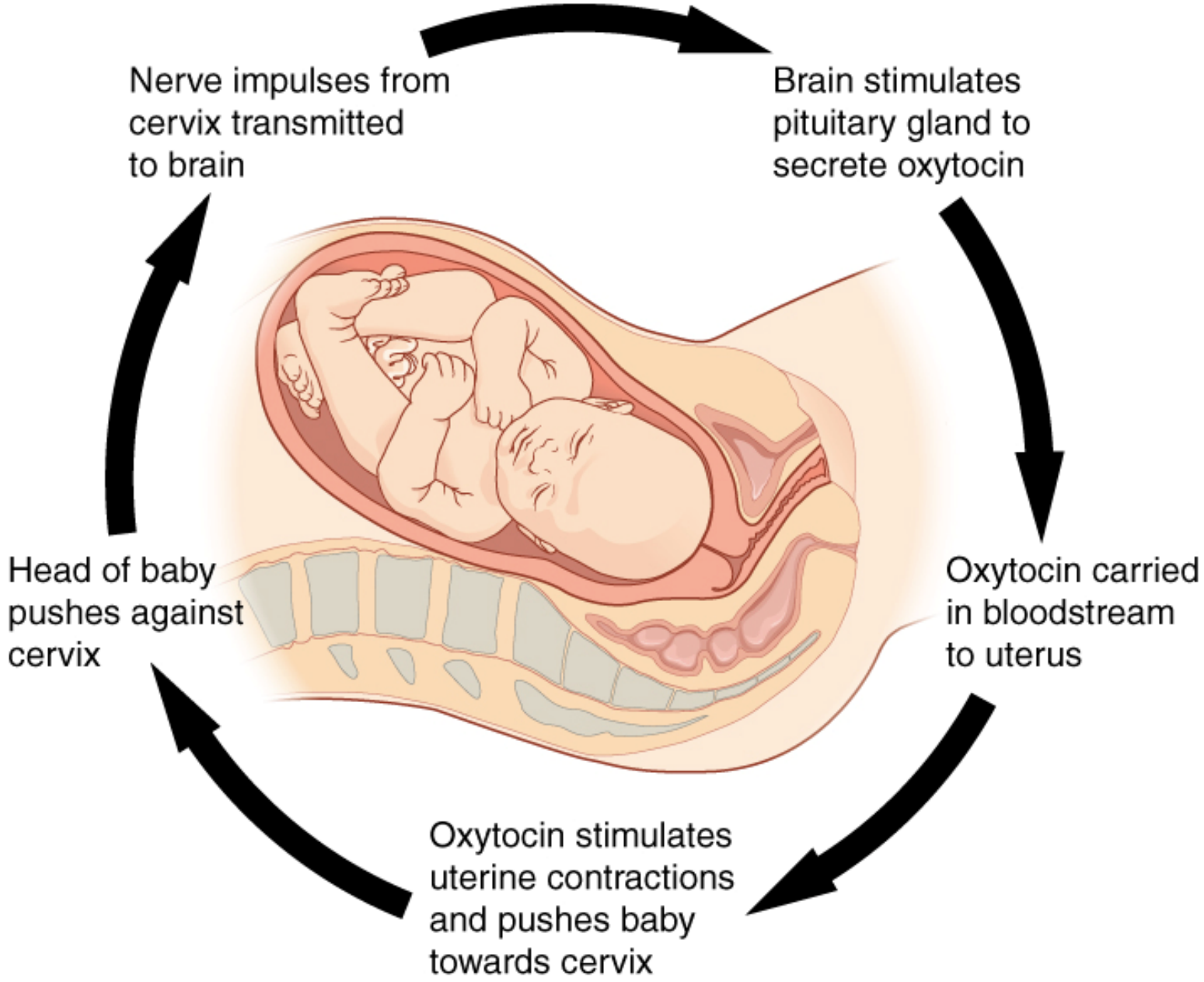


FIGURE 24.4 The Action of Antidiuretic Hormone. Pathways shown in red represent negative feedback.

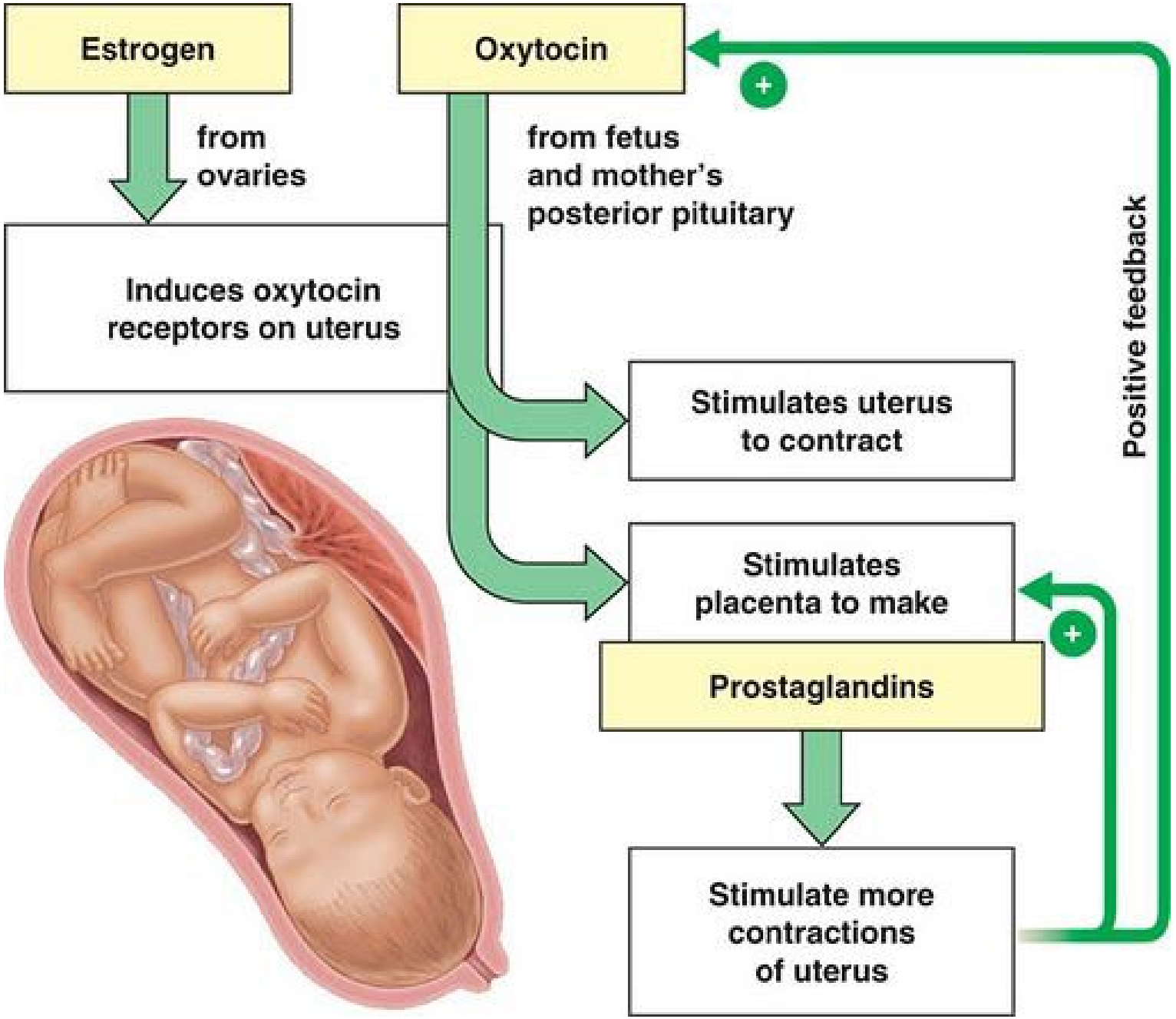
Targets Maintained via Positive Feedback Loops in the Human Body:

- Oxytocin and child birth.
- Prolactin and lactation.


Nerve impulses from cervix transmitted to brain
Brain stimulates pituitary gland to secrete oxytocin
Oxytocin carried in bloodstream to uterus
Oxytocin stimulates uterine contractions and pushes baby towards cervix
Head of baby pushes against cervix

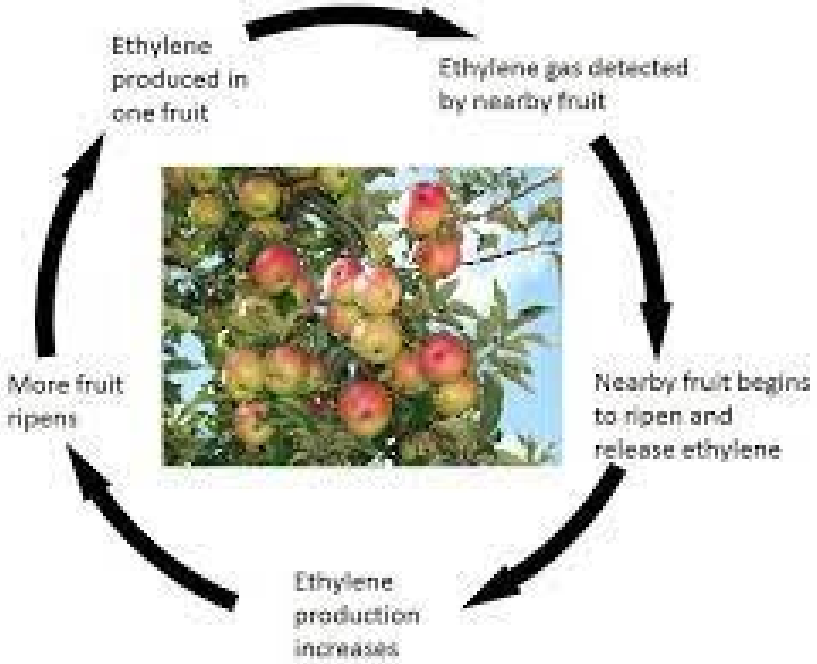
Oxytocin & Childbirth

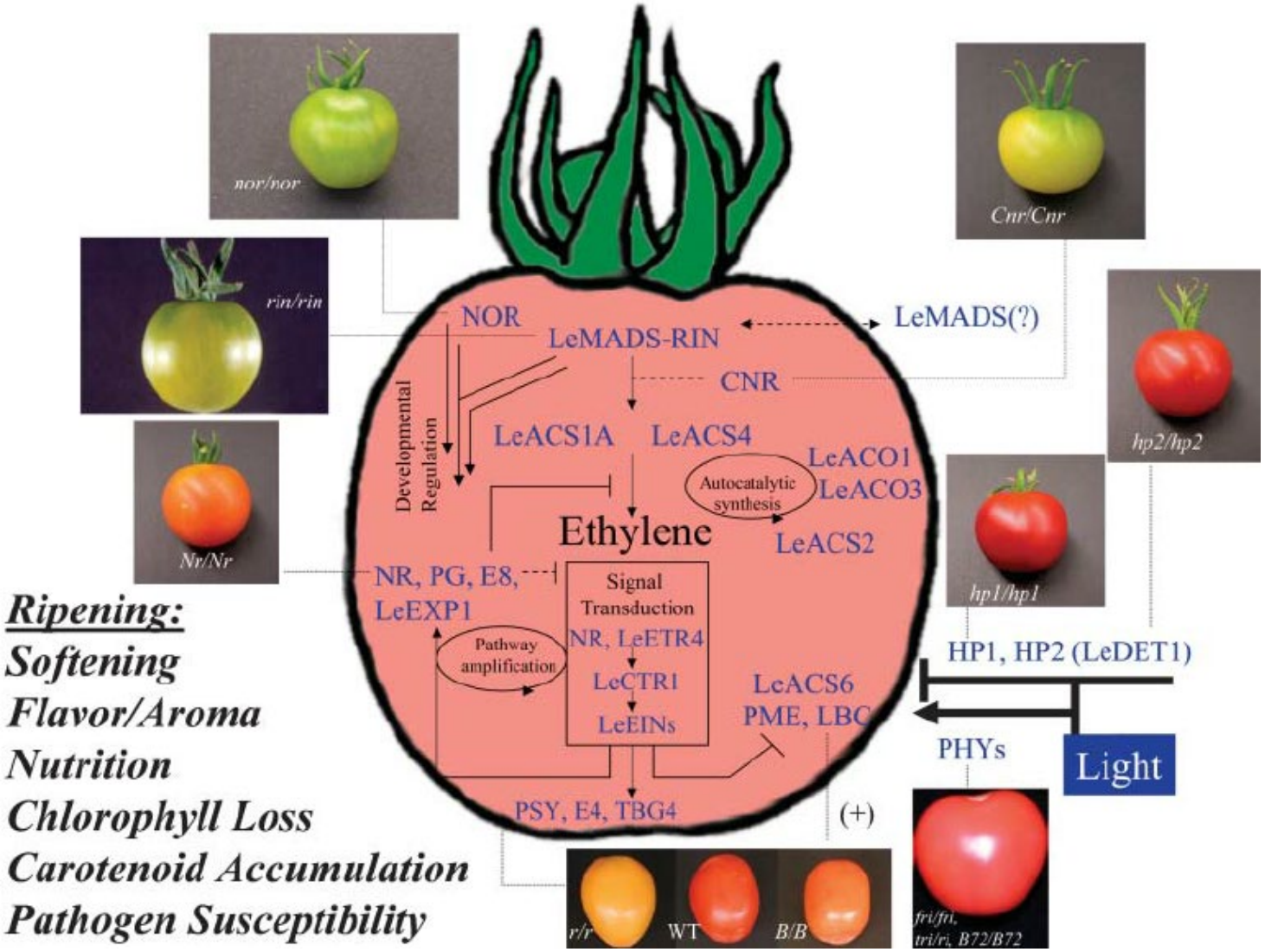
- As pregnancy approaches full term, the baby “drops”
- When the baby moves down, its head pushes on the cervix and stretch receptors send nerve impulses to the posterior pituitary gland in the brain
- This signals the release of oxytocin
  - *Oxytocin is made by the hypothalamus; stored in and released by the post. pituitary gland*
- The release of oxytocin stimulates the uterus to contract
- Contractions move the baby further down, stretching the cervix even more
- This stimulates the secretion of more oxytocin → more contractions → more stretching, and so on
- **End result = birth!**


Estrogen
Oxytocin
from ovaries
from fetus and mother's posterior pituitary
Induces oxytocin receptors on uterus
Stimulates uterus to contract
Stimulates placenta to make Prostaglandins
Stimulate more contractions of uterus
Positive feedback
+
+

Positive Feedback mechanisms are inherently unstable…

- Since positive feedback leads to disruption of the “target state” they can be detrimental
- An example would be a fever – where the fever causes metabolic changes that could lead to intensification of the fever and could potentially lead to death.
- We usually say that positive feedback has two possible outcomes in humans: death or birth.
- Positive feedback mechanisms disrupt homeostasis





Ripening:
Softening
Flavor/Aroma
Nutrition
Chlorophyll Loss
Carotenoid Accumulation
Pathogen Susceptibility