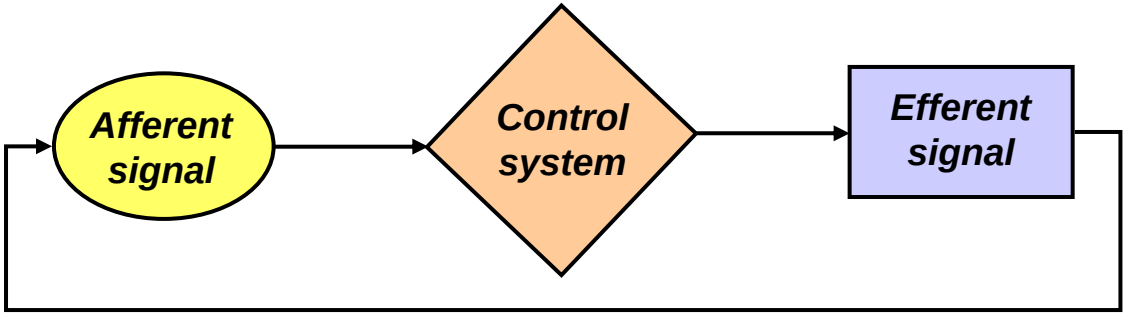
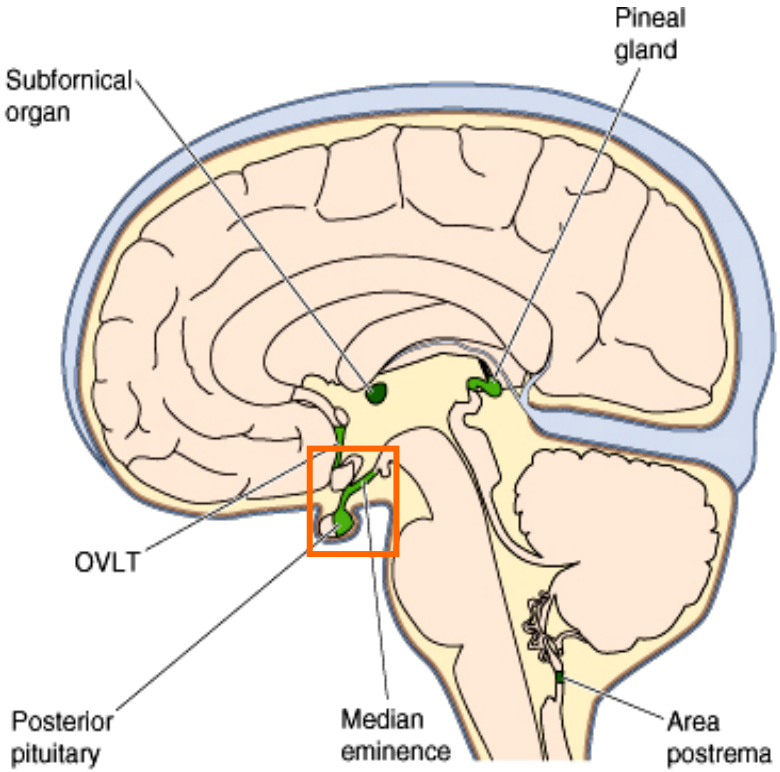
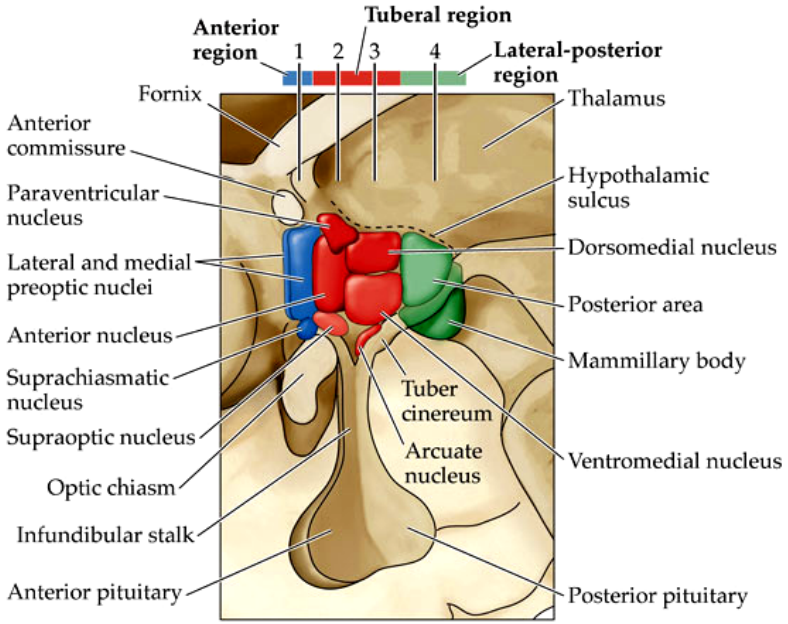
Control systems

Regulation of HYDROELECTROLITIC and ENERGY balance





The circumventricular organs



The Hypothalamus is the Control Center for Homeostasis.

It's at the interface Nervous System / Endocrine System

Control systems

Regulation of HYDROELECTROLITIC balance

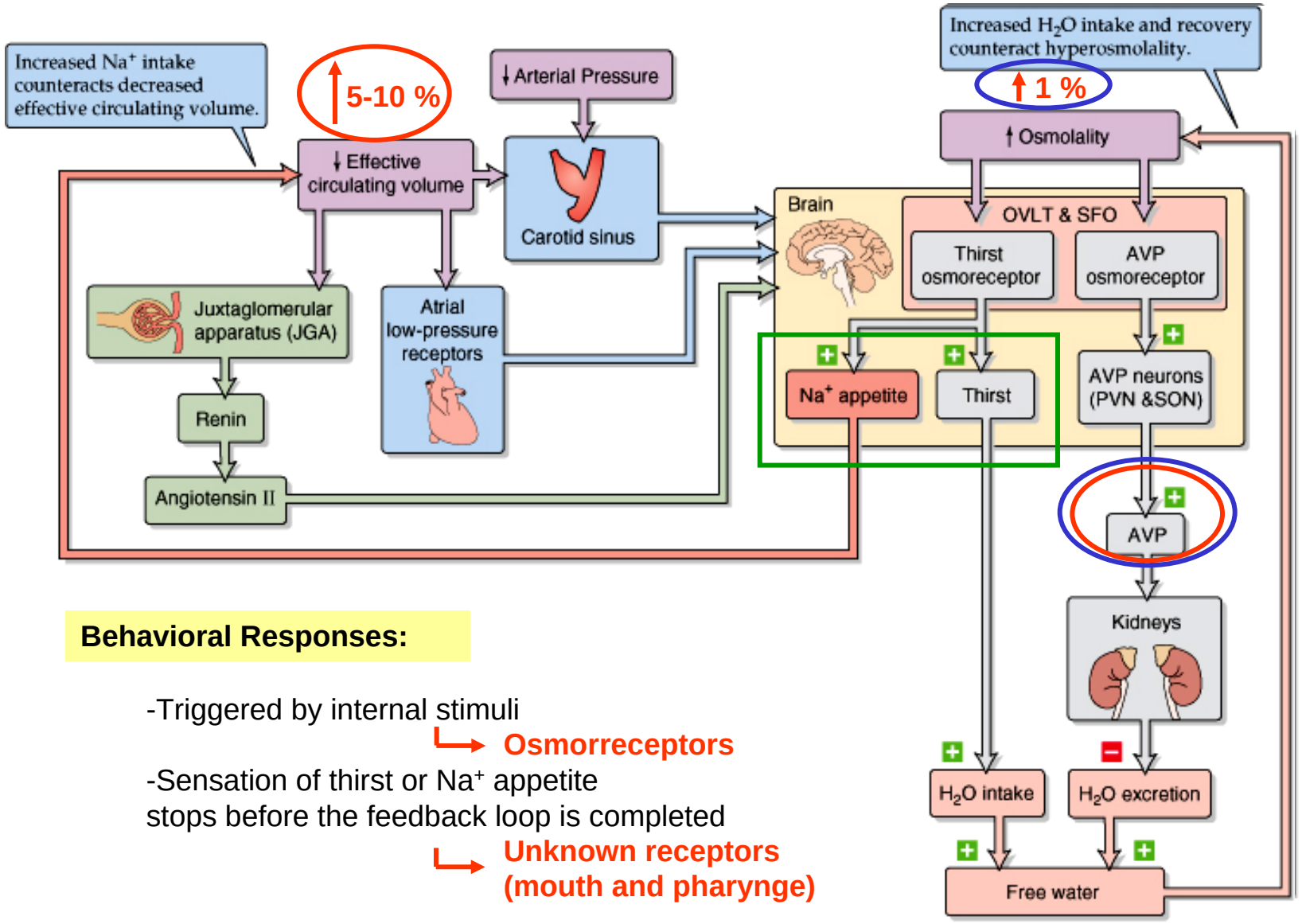
We need to REGULATE: → Extracellular Fluid **VOLUME** → Extracellular Fluid **OSOMOLARITY**

What do we CONTROL? → Total Body CONTENT OF **NaCl** → Total Body **WATER** CONTENT

	REGULATION OF ECF VOLUME		REGULATION OF OSMOLARITY	
What is Sensed?	**Effective Circulating Volume**		**Plasma Osmolarity**	
Sensors	Baroreceptors (located at strategic *high-pressure* sites in the cardiovascular system)		Hypothalamic Osmoreceptors	
Efferent Pathways	Renin-angiotensin-aldosterone system, ANP (atrial natriuretic peptide)	Sympathetic nervous system, **AVP (arginin vasopressin)** **Salt appetite**	**AVP (arginin vasopressin)**	**Thirst**
Effector	*Short term:* Heart, blood vessels *Long term:* Kidney	**Search for salty food/liquids**	Kidney	**Drinking Behavior**
What is Affected?	*Short term:* Blood pressure *Long term:* **Na^+** excretion	**Salt intake**	Renal **Water** excretion	**Water intake**

Control systems

FEEDBACK SYSTEMS for the CONTROL OF OSMOLARITY



Behavioral Responses:

-Triggered by internal stimuli

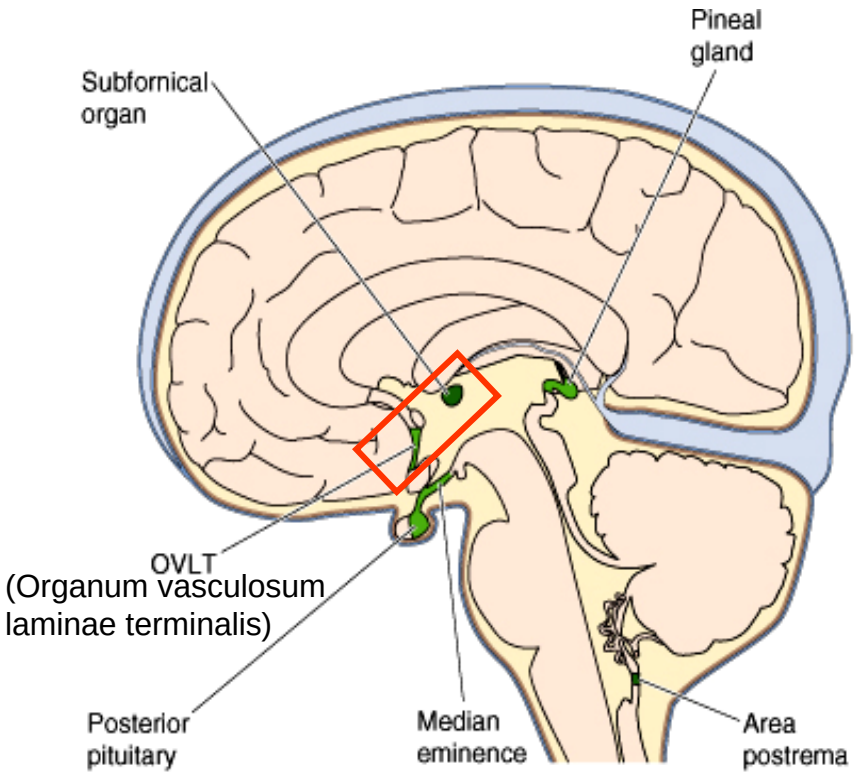
↳ **Osmorreceptors**

-Sensation of thirst or Na^+ appetite stops before the feedback loop is completed

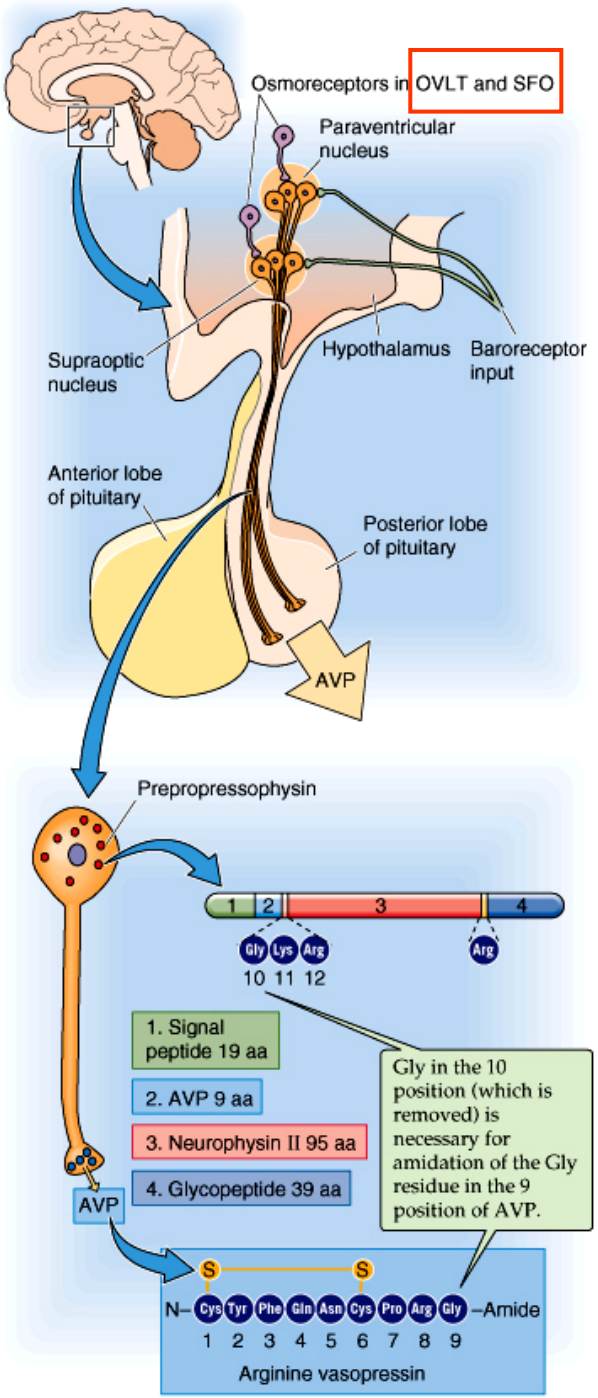
↳ **Unknown receptors (mouth and pharynge)**

Control systems

Control of AVP synthesis and release

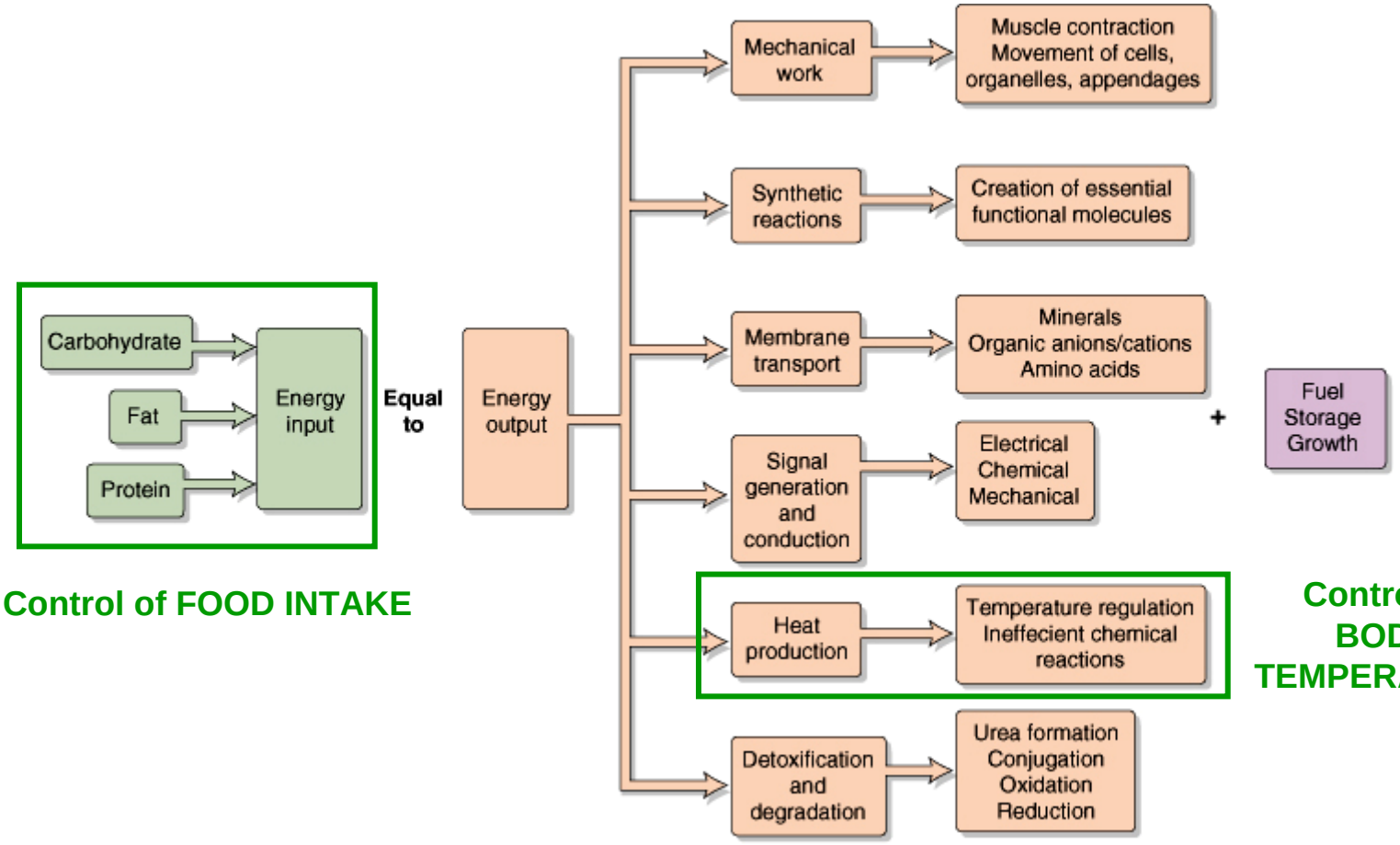


The circumventricular organs



Control systems

Regulation of ENERGY balance → ***METABOLISM***, ***TEMPERATURE***



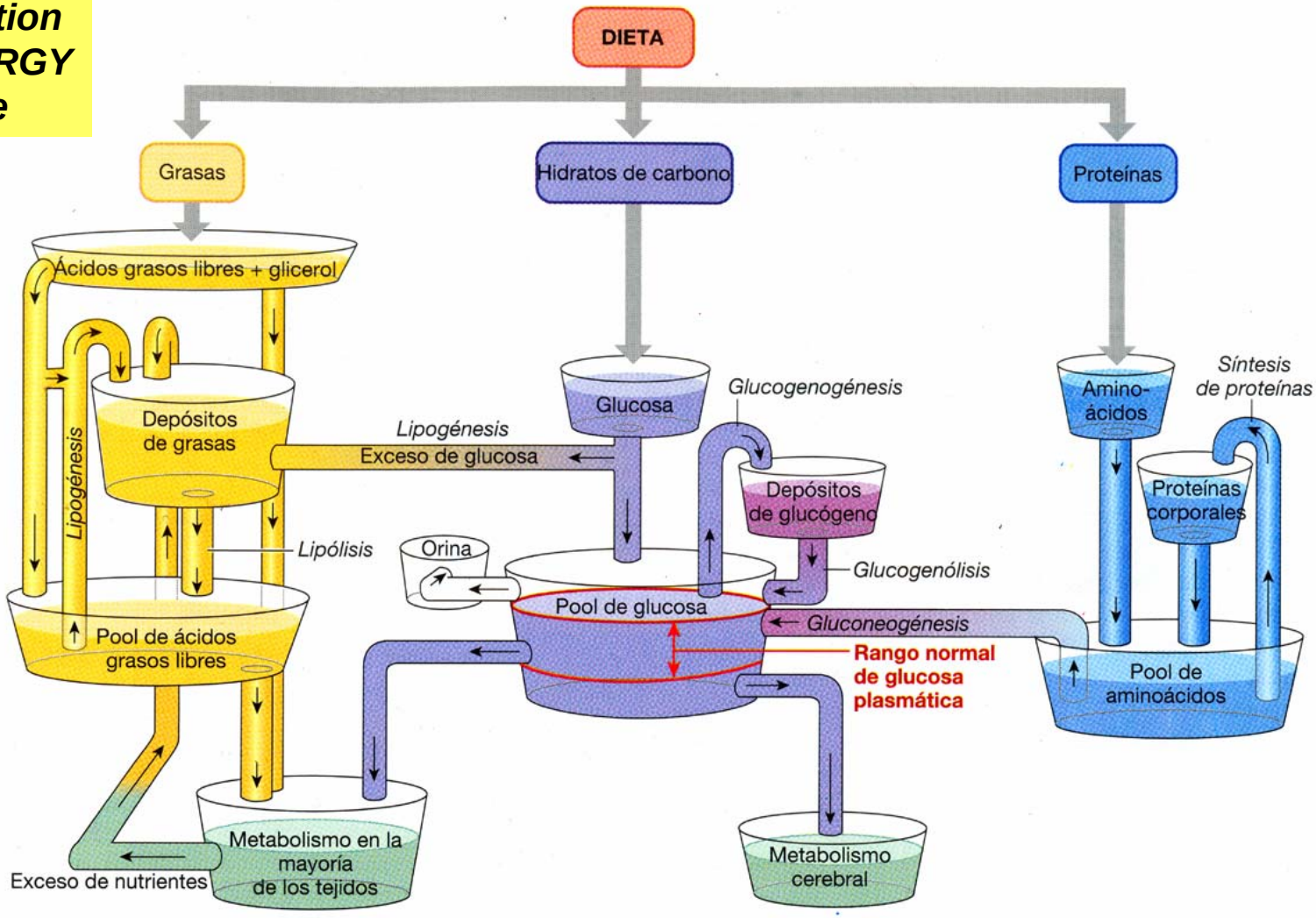
Control of FOOD INTAKE

Control of BODY TEMPERATURE

Energy in Ingested Nutrients → transform → **Work** done on the environment; **Growth**; **Heat**

Control systems

Regulation of ENERGY balance



Positive balance → **OBESITY**

Negative balance → **STARVATION / ANOREXIA**

Control systems

Regulation of FOOD INTAKE

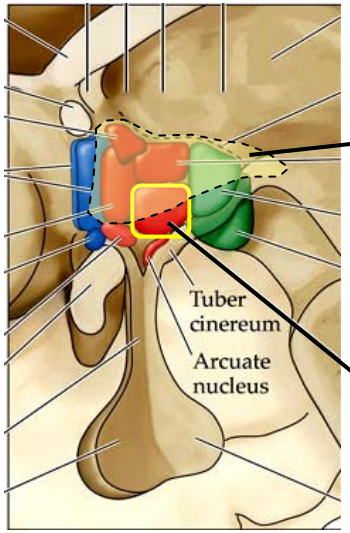
Feedback loops:

-Glucostatic

↳ **Short-term**

-Lipostatic

↳ **Long-term**



LHA

VMN

Higher CNS centers

Eating behavior

Food

Hypothalamic control centers

"Satiety center" (VMN)

Anorexigenic
CRH
GLP-I
αMSH
CART
CCK (from CNS)

"Hunger center" (LHA)

Orexigenic
NPY
NE (α_2 adrenergic)
GABA
GAL
EOP
Ghrelin
Orexins

Glucose-sensitive neurons

Distention of GI tract stimulates vagal afferents.

Stretch

CCK

Intestinal cells secrete CCK.

Long-term feedback

Leptin

Short-term feedback

Adipocyte

Glucose

Lipid storage

Insulin

Glucose
Fats
Amino acids

Small intestine absorbs food stuffs, transferring them to blood.

Control systems

Factors that CONTROL APPETITE

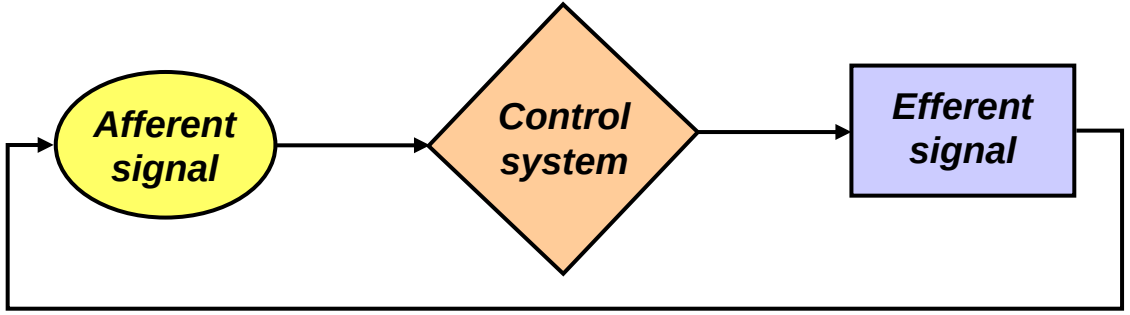
	ANOREXIGENIC (INHIBIT FEEDING)		OREXIGENIC (STIMULATE FEEDING)	
Origin	**HYPOTHALAMIC**	**OUTSIDE HYPOTHALAMUS**	**HYPOTHALAMIC**	**OUTSIDE HYPOTHALAMUS**
Factor	Corticotropin-releasing hormone (CRH) α-Melanocyte-stimulating hormone (αMSH) Cocaine- and amphetamine-regulated transcript (CART)	Distension of Gastrointestinal Tract ---------- Gastrointestinal peptides: **Colecystokinin** (CCK) **Glucacon-like peptide I** (GLP-I) ---------- Adipose Tissue factors: **Leptin**	Neuropeptide Y (NPY) Galanin (GAL) Orexin-A, Orexin-B Norepinephrine (NE) Gamma-aminobutyric acid (GABA) Endogenous opioid peptides	Gastrointestinal peptides: **Ghrelin**

But these factors have other functions…

Ghrelin → release of Growth Hormone
Orexins → control of sleep-wake transitions

Control systems

Regulation of FOOD INTAKE

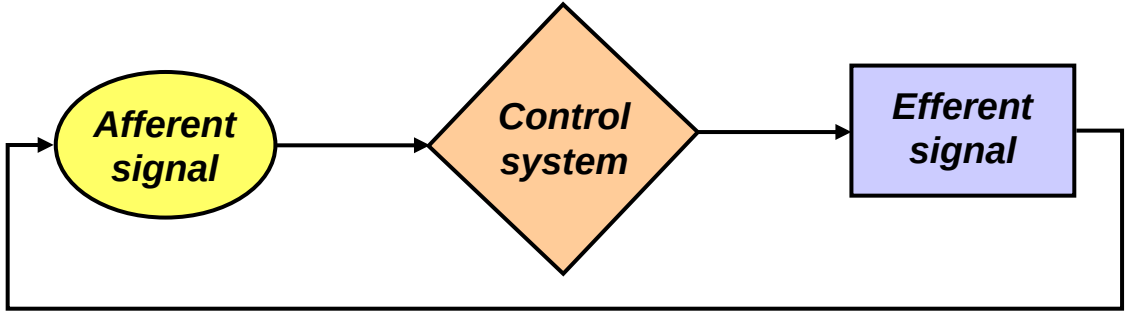


Glucostatic feedback loop (short-term)

Vagal afferents
↑ Distention GI tract
↑ CCK
Hunger Center (LHA)
Orexins
↓ Glucose
Saciety Center (VMN)
↑ FOOD INTAKE
↑ Glucose
Oropharyngeal receptors

Control systems

Regulation of FOOD INTAKE



Lipostatic feedback loop (long-term)

Make your own scheeme for the "**leptin**" loop:

Regulation of BODY TEMPERATURE

CONSEQUENCES OF DEVIATIONS IN BODY TEMPERATURE	
TEMPERATURE (ºC)	**CONSEQUENCE**
40-44	Heat stroke, brain lesions
38-40	Fever or excercise
36-38	Normal range
34-36	Mild hypothermia
30-34	Impairment of temperature regulation
27-29	Cardiac fibrillation

Homeothermy → Maintain Activity over wide range of Environmental Temperatures

Body Core Temparature depends on:

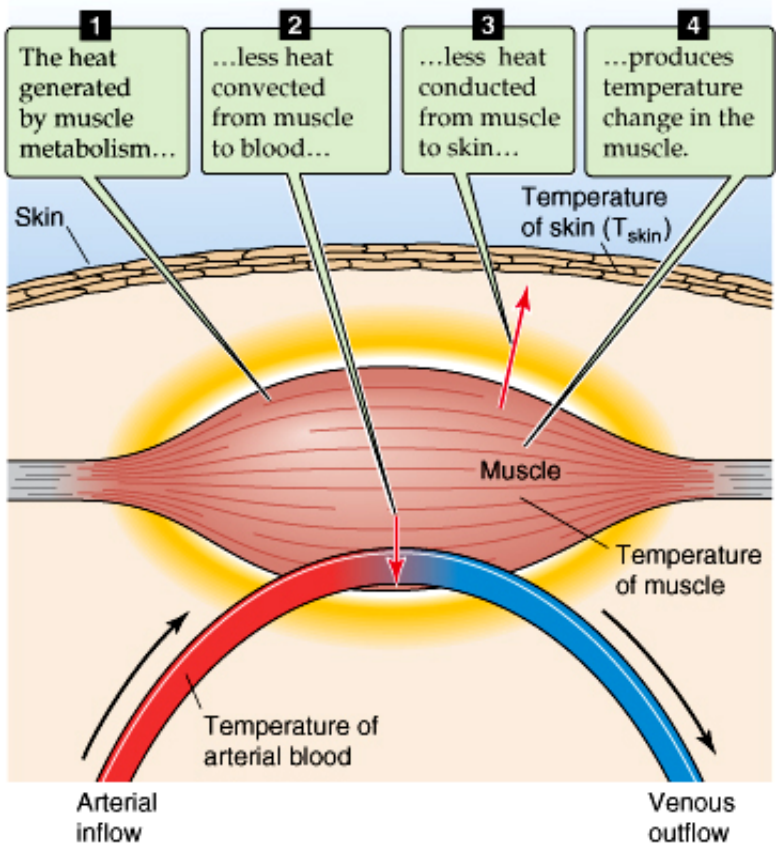
- **Time of day**
- **Physical activity**
- **Time of menstrual cycle**
- **Age**

At rest: 80 kcal/h → Modest jogging: 600 kcal/h

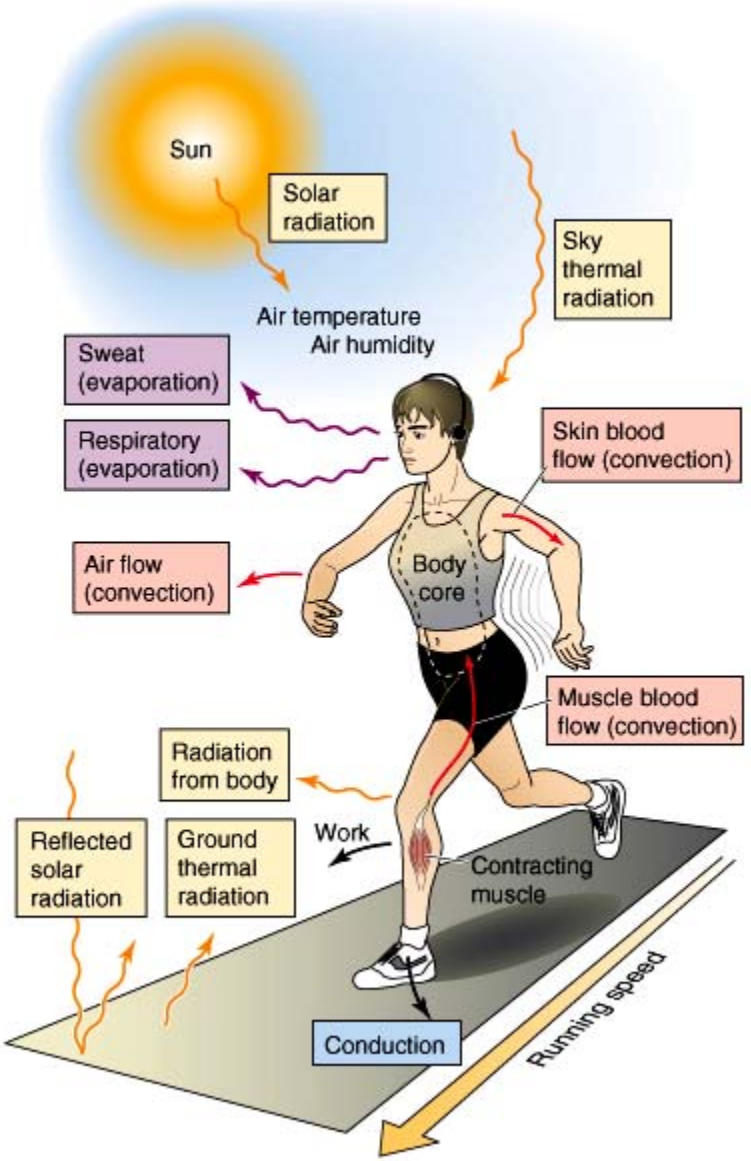
Modes of HEAT TRANFER

In the muscle:

H (metab) – H (convect) – H (conduct) = Excess Heat

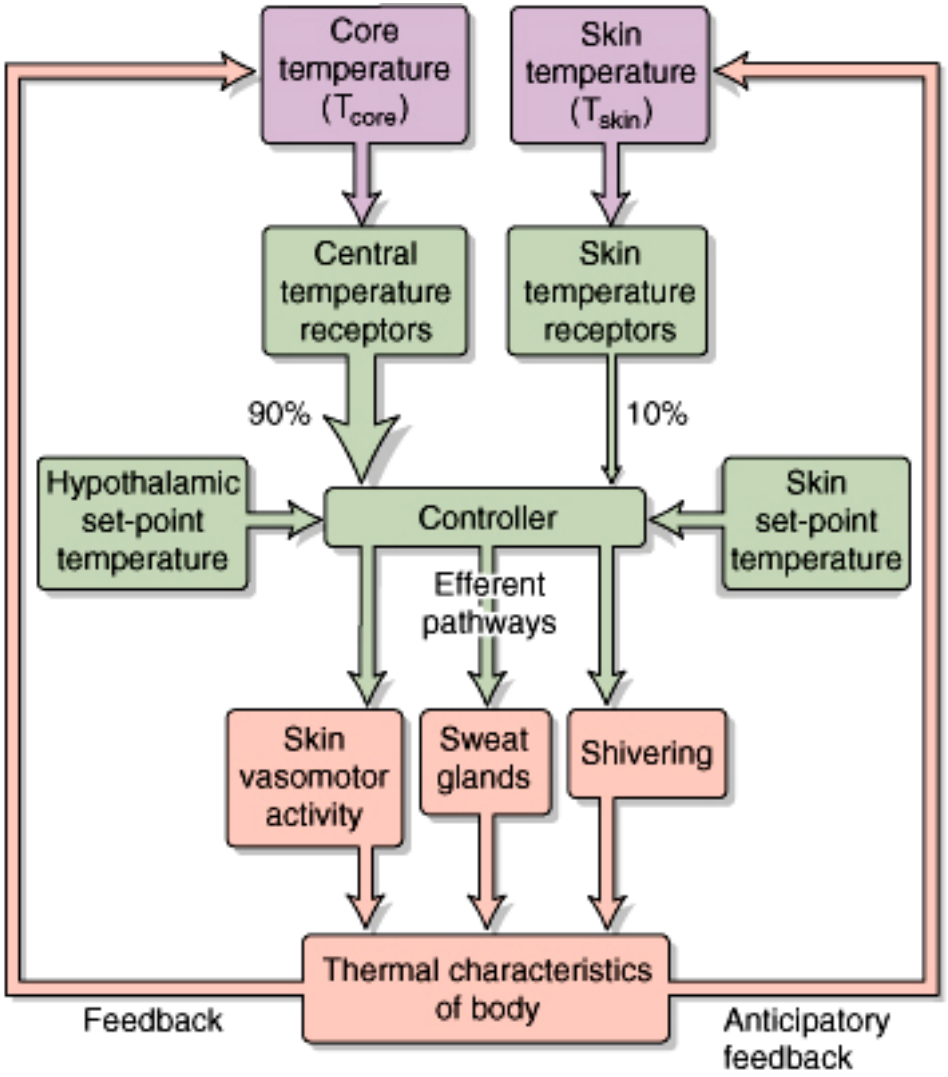


In the whole body:



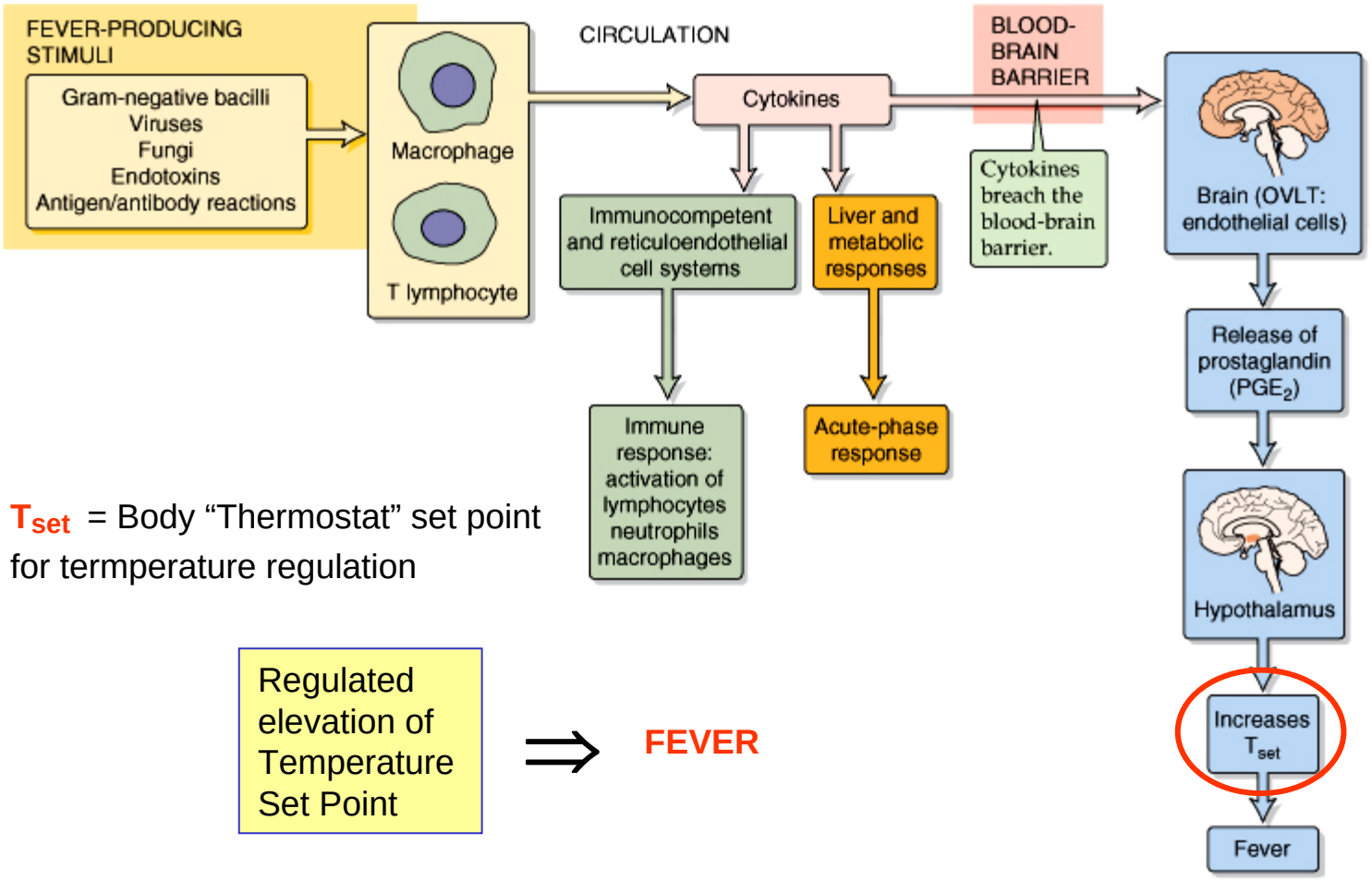
Control systems

Regulation of BODY TEMPERATURE



Regulation of BODY TEMPERATURE

Heat transfer potential of Environment > Body Regulatory Capacity ⇒ **HYPERTHERMIA** / **HYPOTHERMIA**



T_{set} = Body "Thermostat" set point for termperature regulation

Regulated elevation of Temperature Set Point ⇒ **FEVER**