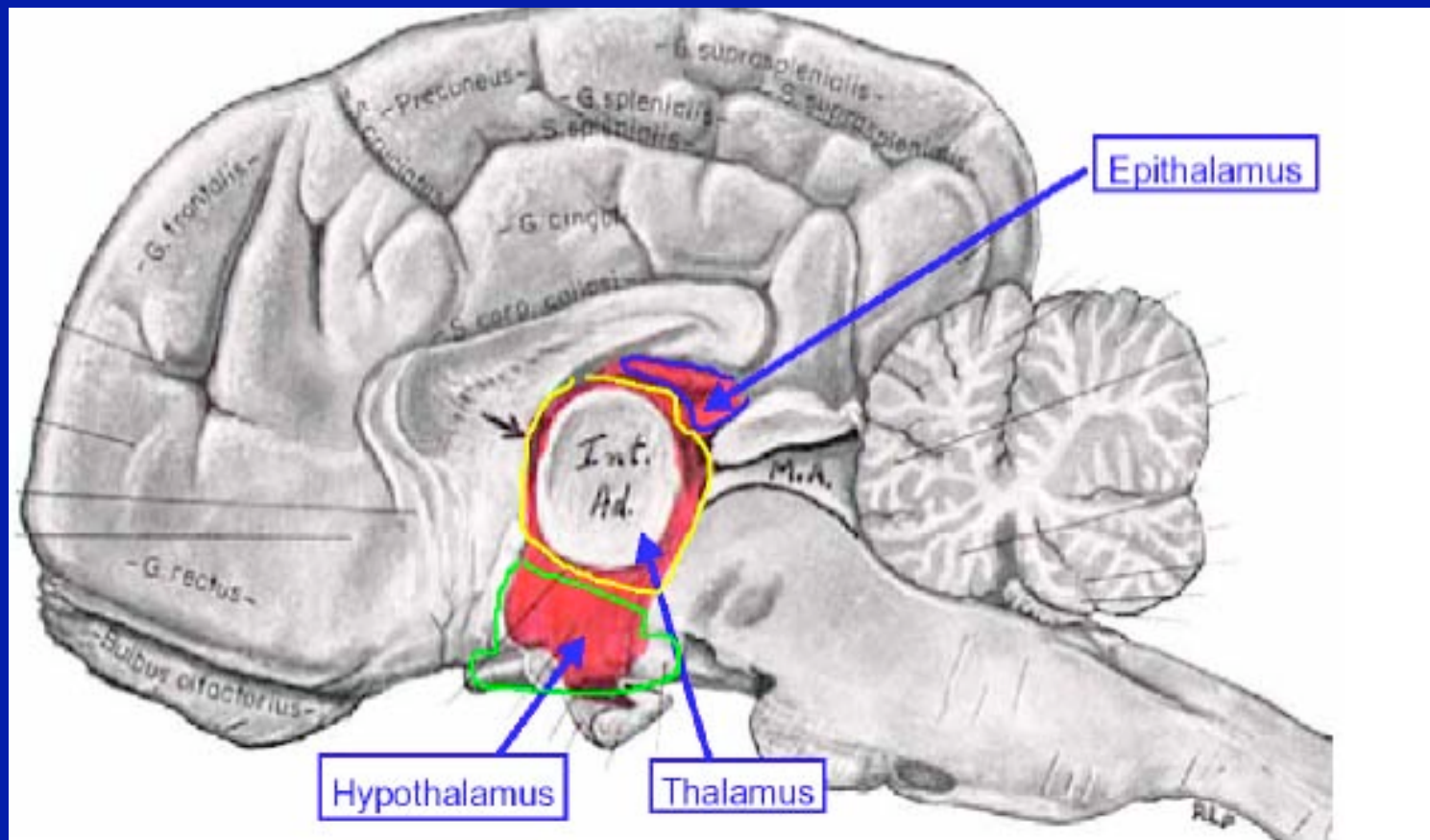


Diencephalon and Hypothalamus

Objectives:

- 1) To become familiar with the four major divisions of the diencephalon
- 2) To understand the major anatomical divisions and functions of the hypothalamus.
- 3) To appreciate the relationship of the hypothalamus to the pituitary gland



Four Subdivisions of the Diencephalon: Epithalamus, Subthalamus Thalamus & Hypothalamus

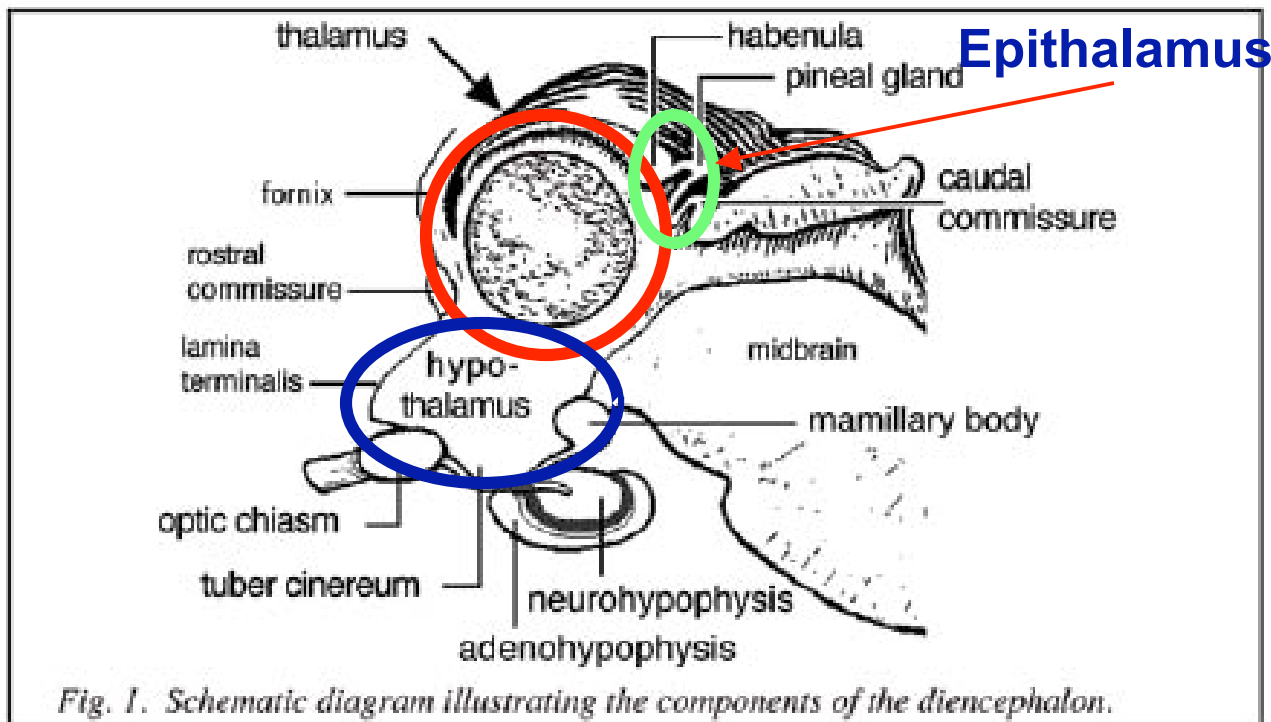
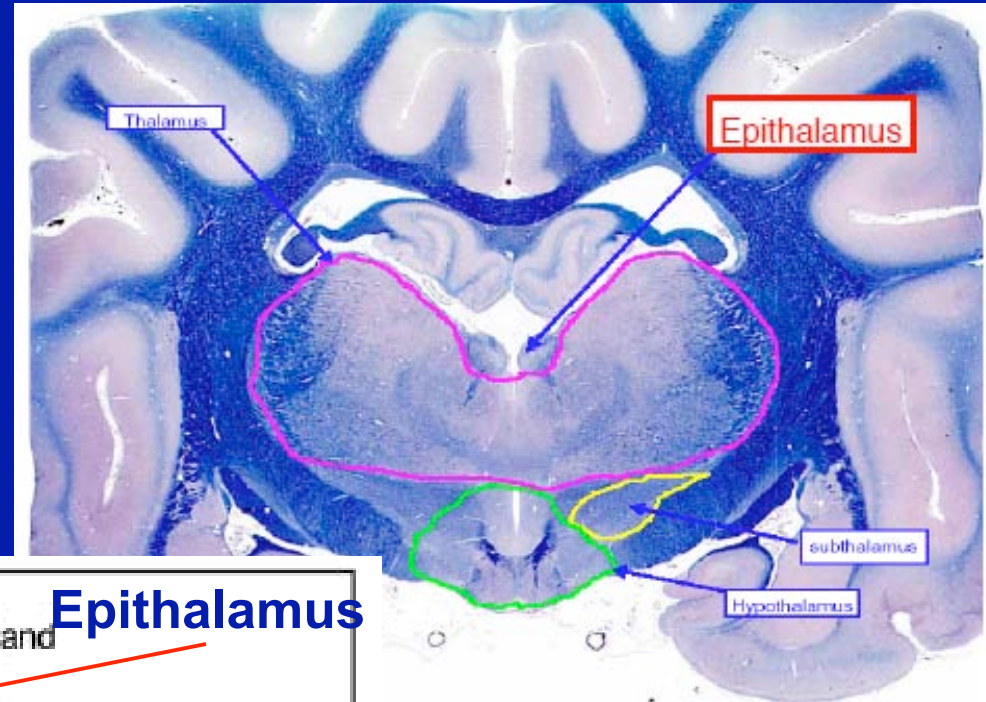


Fig. 1. Schematic diagram illustrating the components of the diencephalon.

1. Epithalamus — (“epi” means upon) the most dorsal part of the diencephalon; it forms a caplike covering over the thalamus.

- a. The smallest and oldest part of the diencephalon
- b. Composed of: *pineal body*, *habenular nuclei* and the *caudal commissure*
- c. Function: It is functionally and anatomically linked to the limbic system; implicated in a number of **autonomic** (ie. respiratory, cardiovascular), **endocrine** (thyroid function) and **reproductive** (mating behavior; responsible for postpartum maternal behavior) functions. Melatonin is secreted by the pineal gland at night and is concerned with biological timing including sleep induction.

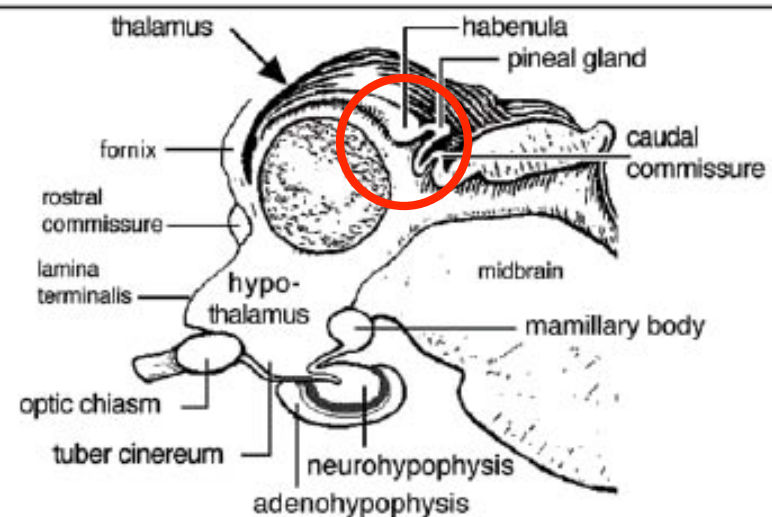
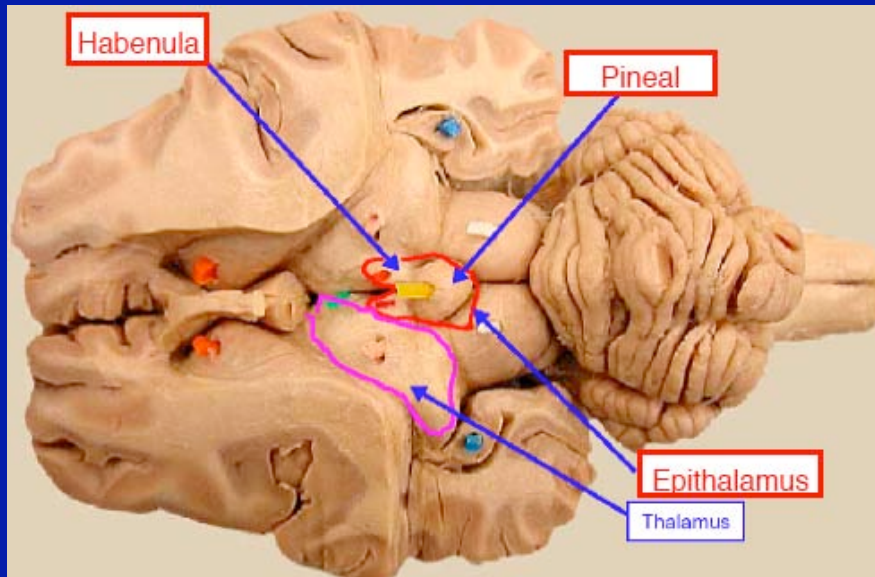


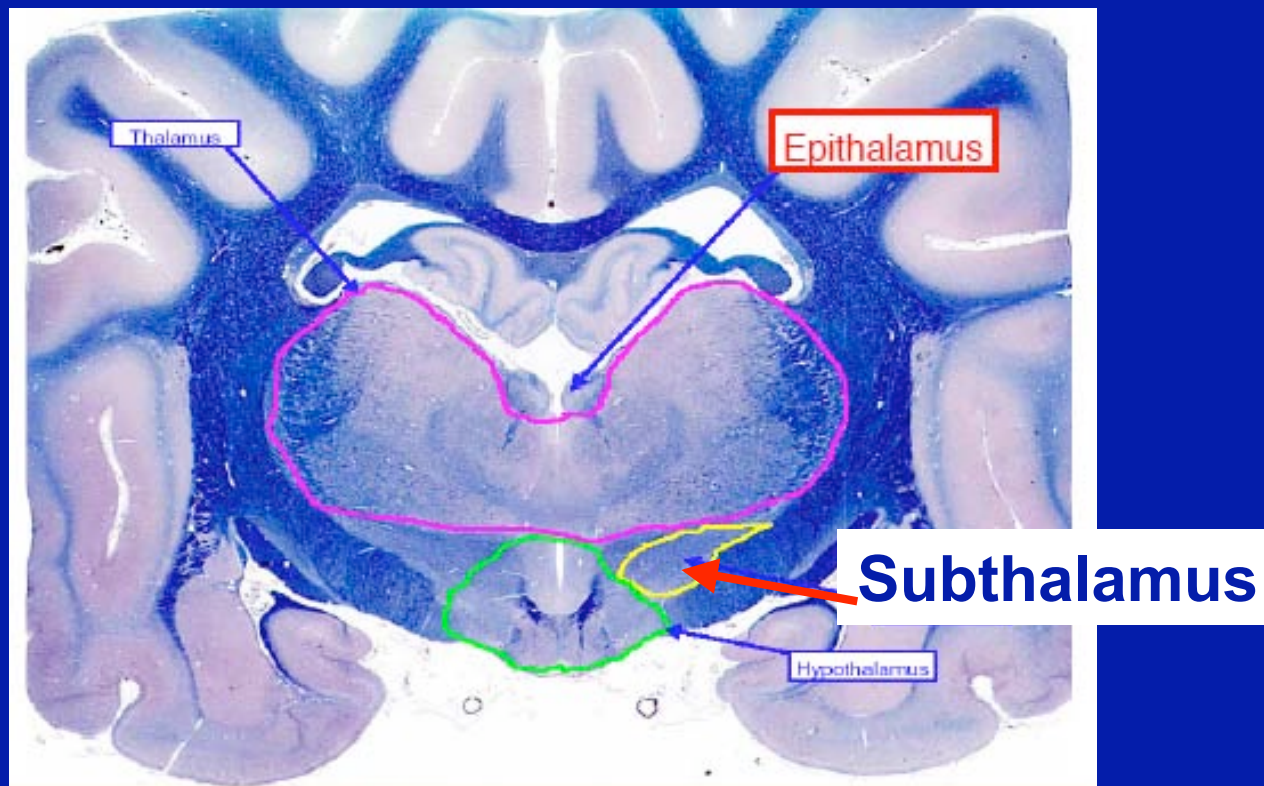
Fig. 1. Schematic diagram illustrating the components of the diencephalon.

2. Subthalamus — (“sub” = below), located ventral to the thalamus and lateral to the hypothalamus (only present in mammals).

a. Plays a role in the generation of rhythmic movements

b. Recent work indicates that stimulation of the subthalamus in cats inhibits the micturition reflex and thus this nucleus may also be involved in neural control of micturition.

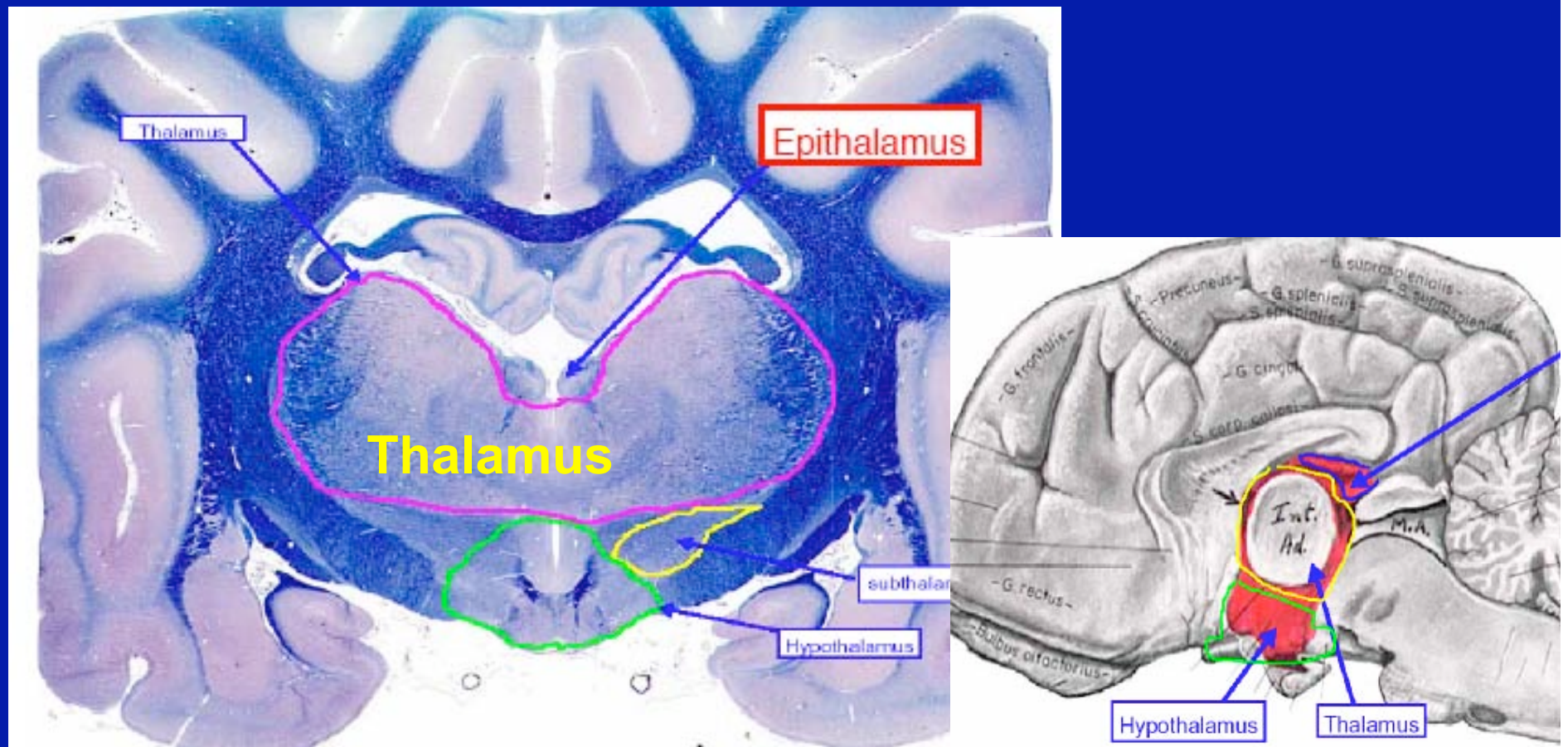
c. Stimulation of the subthalamus provides the most effective treatment for late-stage Parkinson’s disease in humans.



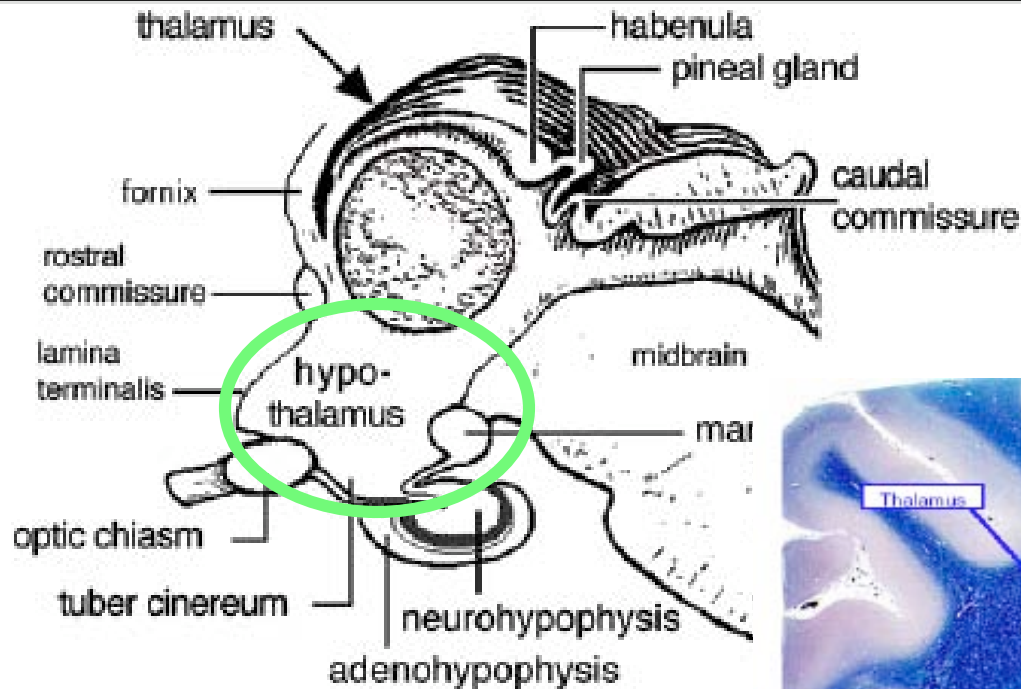
3. Thalamus — largest component of the diencephalon

a. comprised of a large number of nuclei; --> lateral geniculate (vision) and the medial geniculate (hearing).

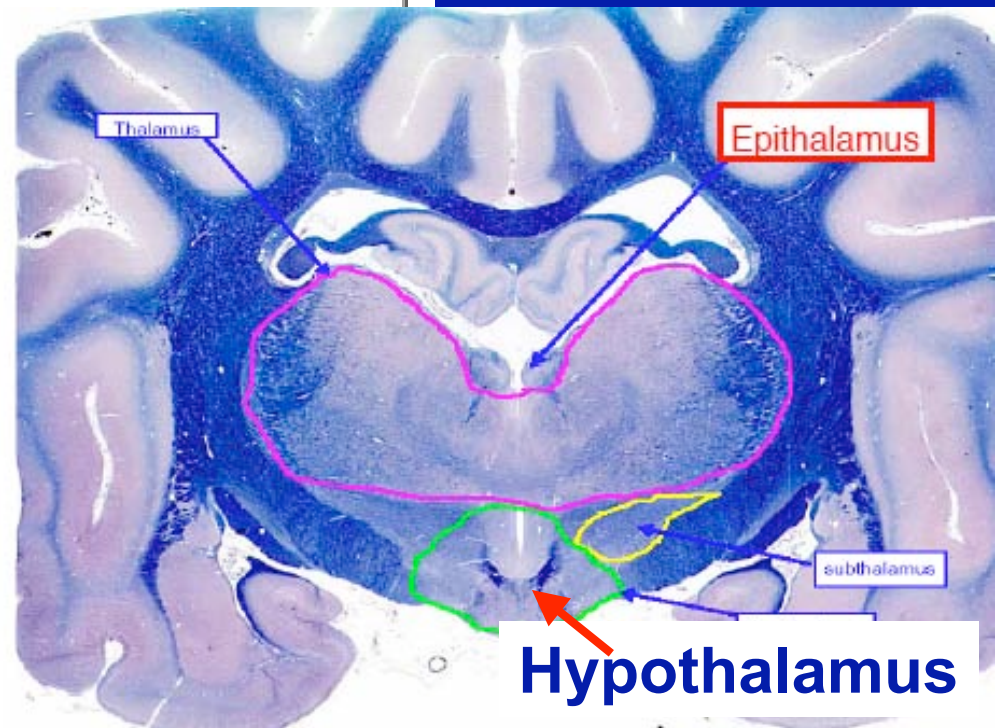
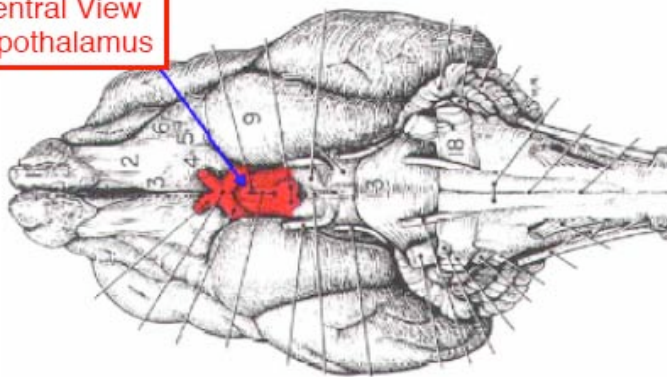
b. serves as the great sensory receiving area (receives sensory input from all sensory pathways except olfaction) and relays sensory information to the cerebral cortex.



4. Hypothalamus — (“hypo” = below), the most ventral part of the diencephalon; it is the most significant component of the diencephalon from a clinical standpoint because lesions result in abnormalities in endocrine, limbic and/or autonomic function.



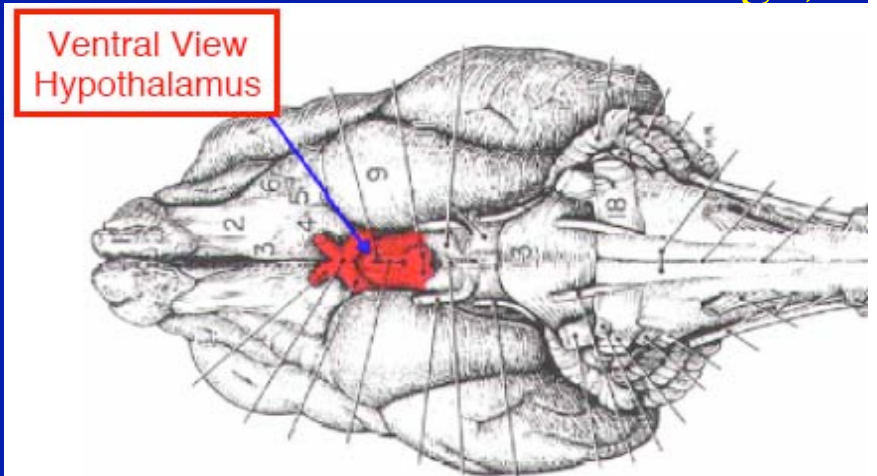
Ventral View Hypothalamus



Hypothalamus:

1. **Functions** — its most important job is to maintain **homeostasis** (or maintaining the body's status quo); it does so by regulating three interrelated functions:

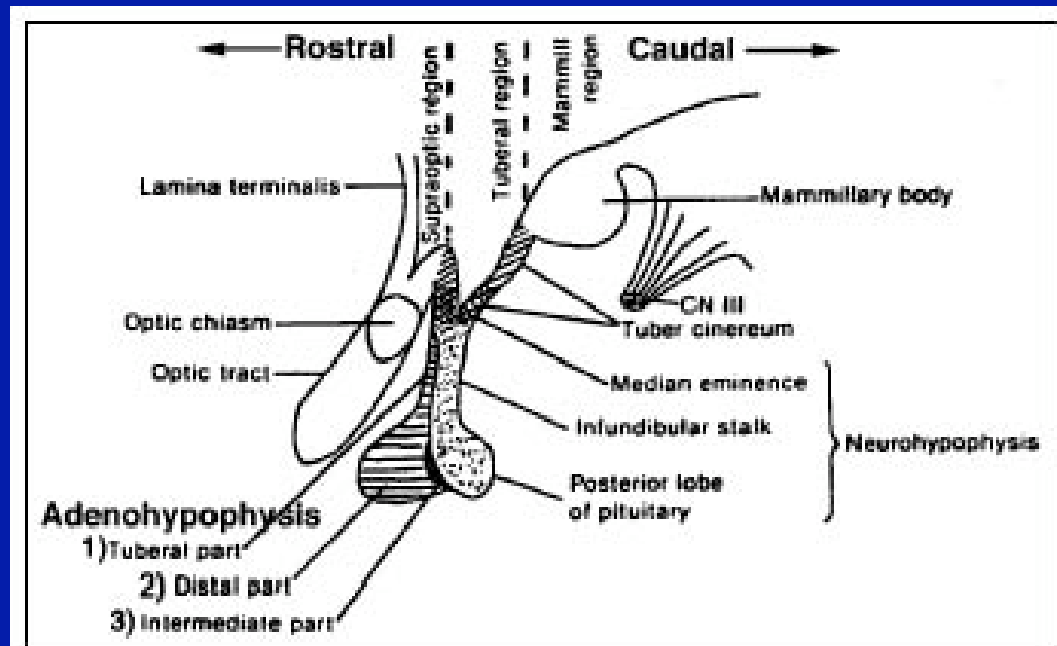
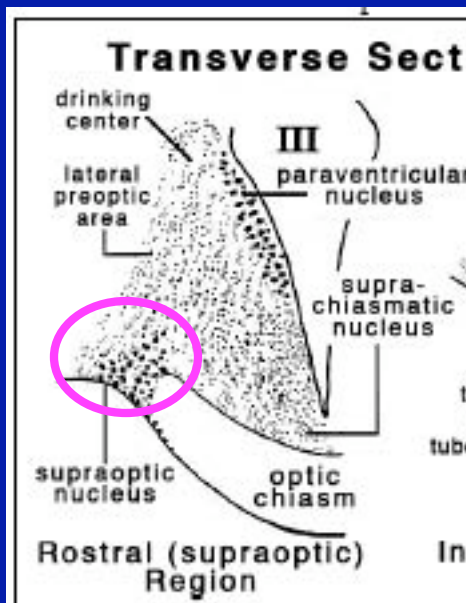
- a. Endocrine Secretion — controls hormone release by the pituitary gland.
- b. Autonomic Function — integrates autonomic functions via direct projections to preganglionic autonomic neurons located in the brain-stem and spinal cord.
- c. Emotions and Drives — it has numerous interconnections with the limbic system by which it generates behaviors involved in rage, aggression, escape, etc.



2. Subdivisions and Nuclei — the hypothalamus is small in size and presents no large scale anatomical variations in different vertebrate species. It has three basic subdivisions each of which contains various nuclei.

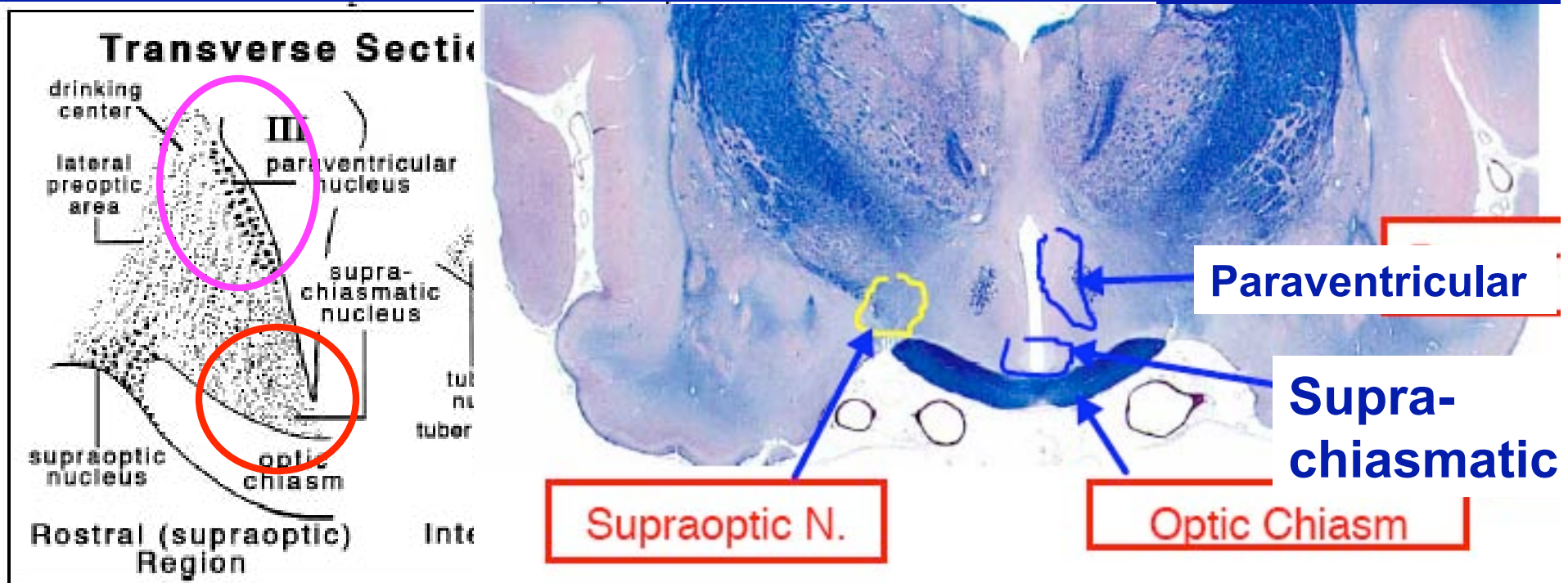
a. Supraoptic region — the most important division in veterinary medicine; it lies above the optic chiasm and contains three important nuclei:

1) **Supraoptic Nucleus** — contains neurons that produce antidiuretic hormone (ADH or vasopressin); their axons project to the posterior pituitary gland (neurohypophysis) where ADH is released and enters the blood.



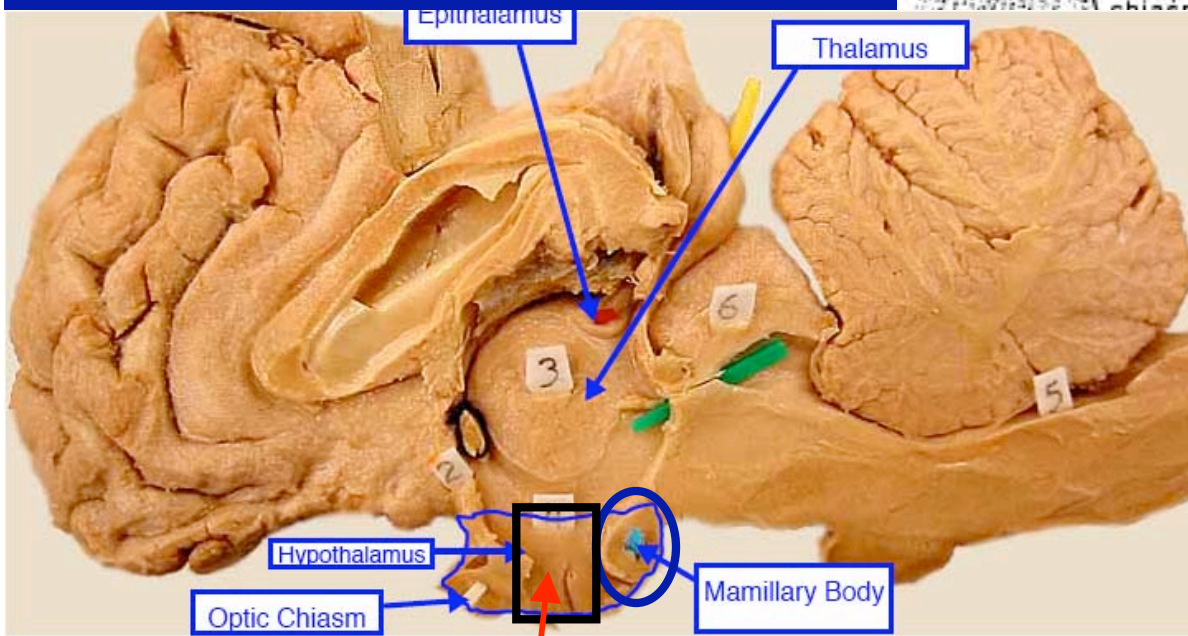
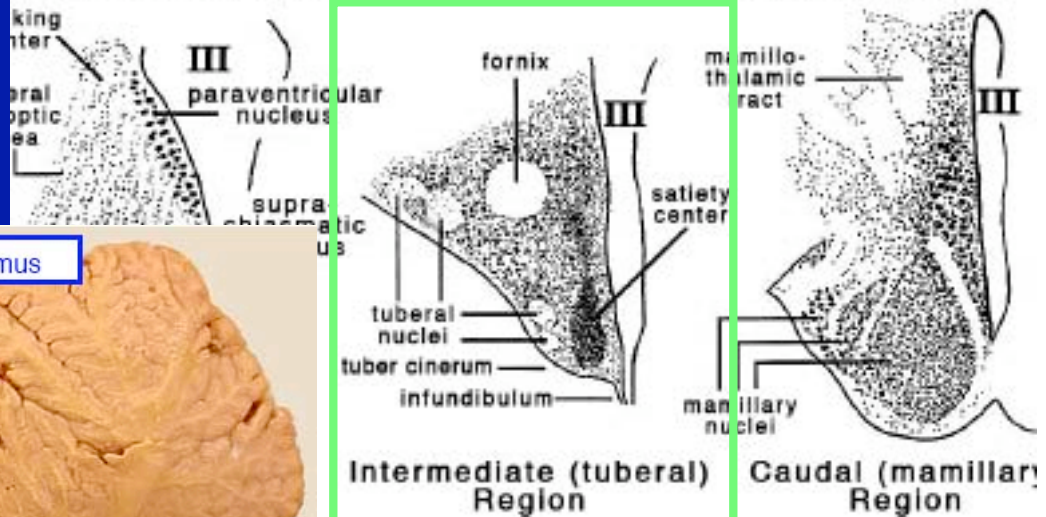
2) **Paraventricular Nucleus** — contains neurons that produce predominately oxytocin

3) **Suprachiasmatic Nucleus** — appears to be the hypothalamic nucleus critically involved in controlling circadian rhythms (endogenous biological rhythms that have a period of about 24 hours). The nucleus synchronizes rhythms to light and dark. Other circadian rhythms: sleep-wakefulness; body temperature.



b. Tuberal Region- lies directly above the pituitary gland and contains cells that produce orexins (hypocretins), which control various aspects of sleep. Dogs with narcolepsy have a mutation in the orexin receptor gene.

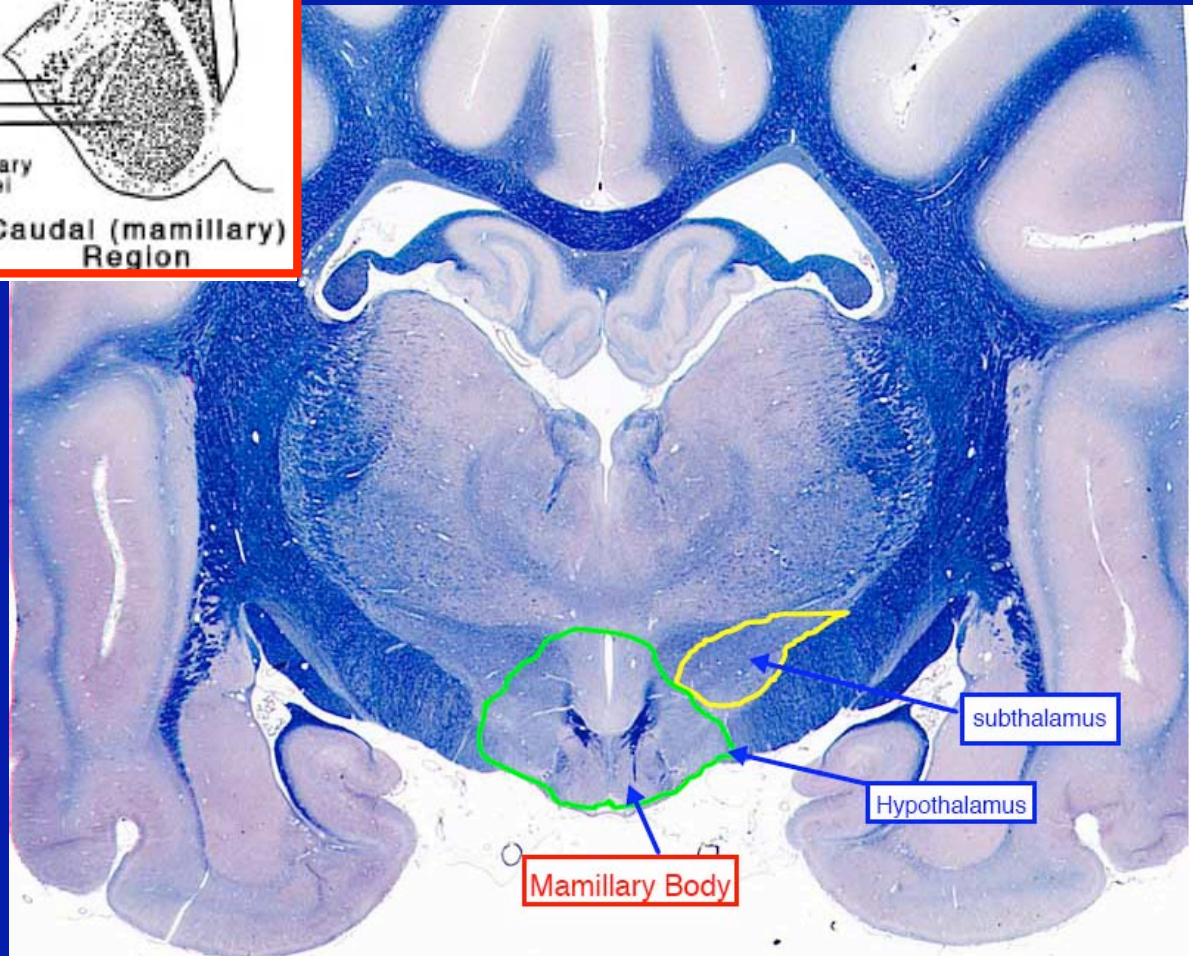
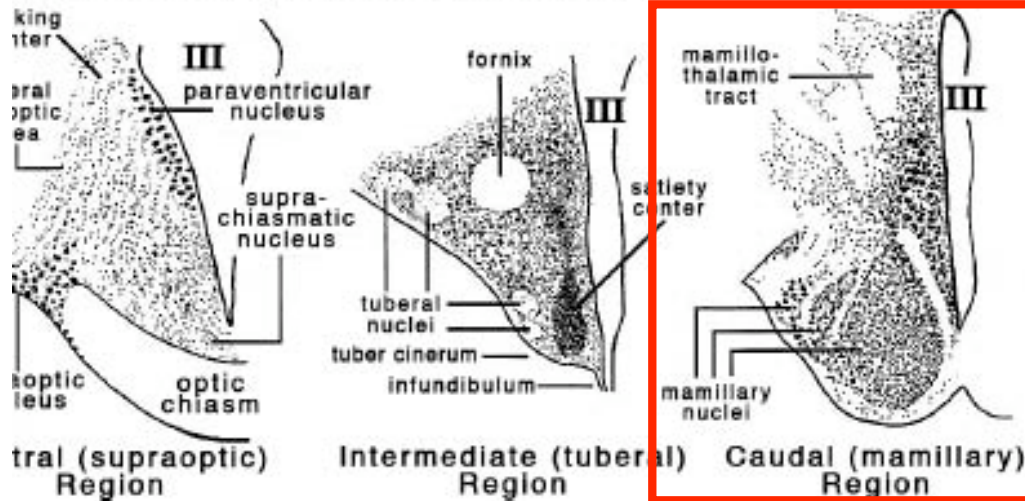
Transverse Sections Through Hypothalamus



Tuberal Region

c. Mamillary Region- most caudal portion consisting of the mamillary bodies [mamillary bodies play a role in memory & learning]

Transverse Sections Through Hypothalamus



3. Afferent Inputs to the Hypothalamus. In order to maintain homeostasis the hypothalamus must receive inputs about the state of the body. The major inputs include:

a. Nucleus of Solitary Tract- this nucleus collects all of the visceral sensory information from the vagus

b. Limbic System via the fornix- structures such as the amygdala and olfactory cortex (piriform lobe) project to the hypothalamus and help regulate behaviors such as eating and reproduction.

c. Retina via direct branches of the optic nerve that go to the suprachiasmatic nucleus

d. Blood- hypothalamus has intrinsic receptors including thermoreceptors and osmoreceptors that monitor temperature and ionic balance; in addition hypothalamic cells are sensitive to hormone concentrations and glucose levels, etc.)

And Now for Something Completely Different!

New State Motto's

Alabama: At least We're not Mississippi

Arizona: But it's a dry heat!

Arkansas: Litterasy Ain't Easy

Georgia: We put the "fun" in fundamentalist extremism

Indiana: 2 Billion Years Tidal Wave Free

Idaho: More than just potatoes....Well Okay, We're not, But the potatoes sure are real good

Maine: We're really Cold, but we have cheap lobster

Massachusetts: Our taxes are lower than Sweden's (for most tax brachets)

Michigan: First Line of Defense From the Canadians

Minnesota: Ditto

New Hamshire: Go Away and Leave Us Alone

North Carolina: Tobacco is a Vegetable

North Dakota: We Really are One of the 50 States

South Dakota: Closer than North Dakota

Tennessee: The Educashun State

West Virginia: One big happy family.....Really!

4. Major Efferent Projections From the Hypothalamus. Once the hypothalamus is aware of a problem, it fixes the problem via the following routes of communication:

a. Neural signals to the autonomic nervous system via projections to the brain stem vagal nuclei and to preganglionic nuclei in the spinal cord

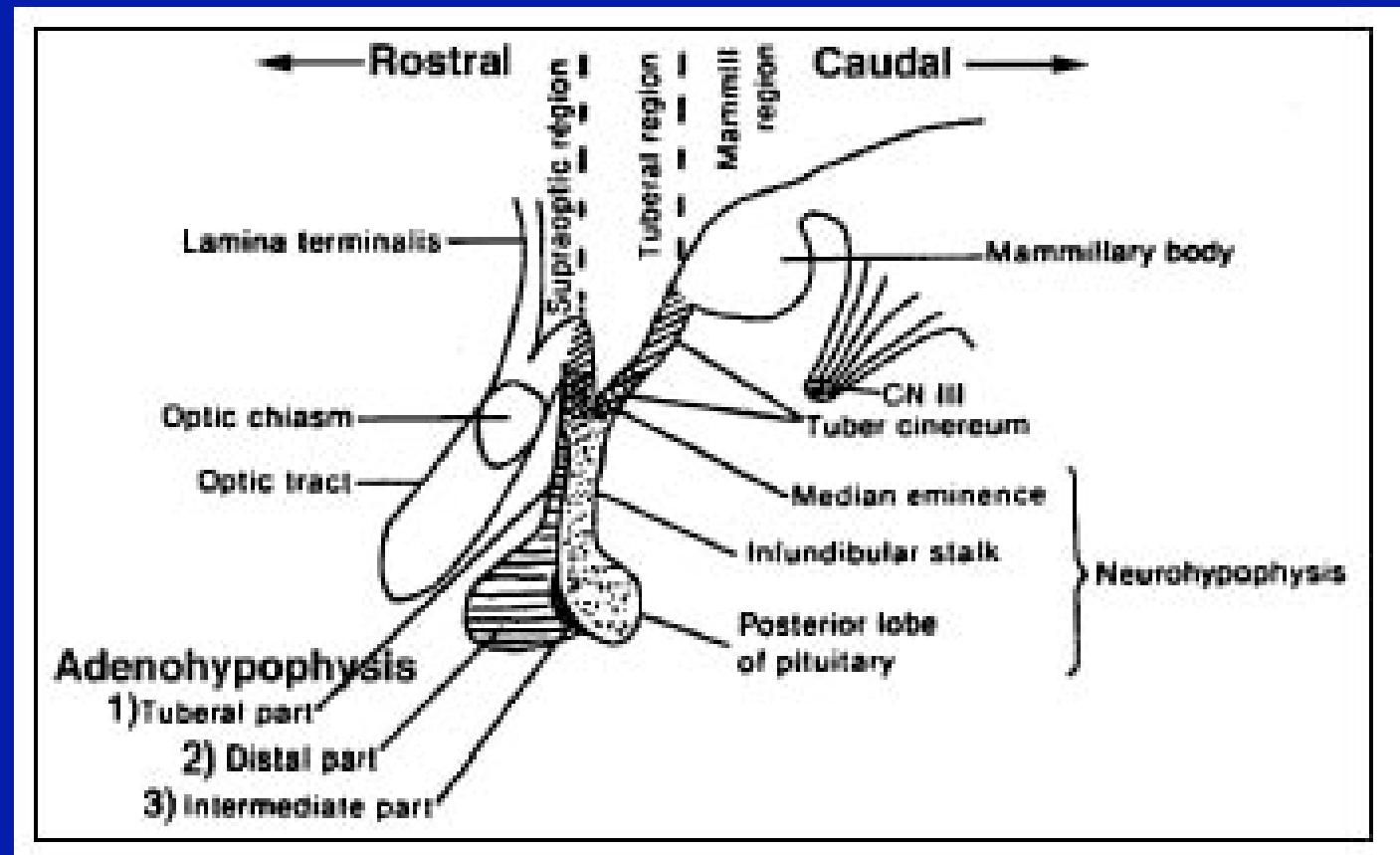
b. Neural signals to the limbic system

c. Endocrine signals to/through the pituitary gland

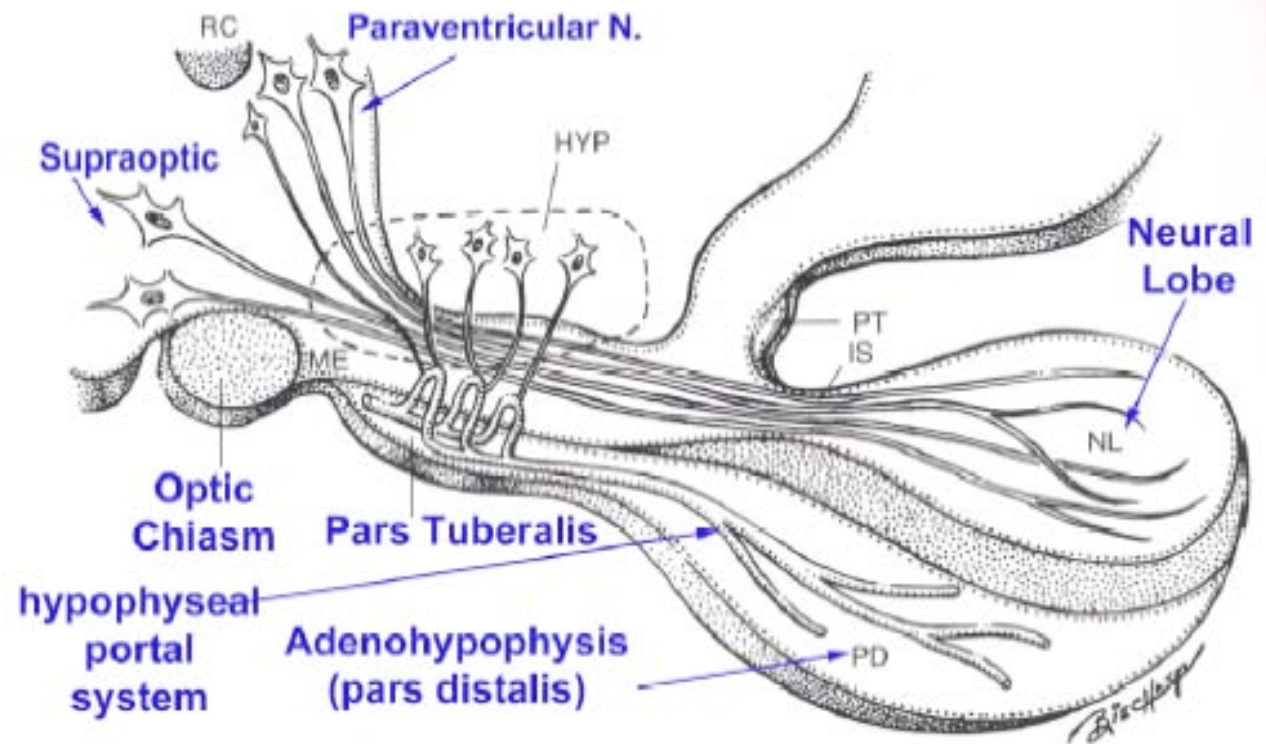
Ultimately through these connections the hypothalamus can control every endocrine gland and alter blood pressure, body temperature and metabolism to maintain body homeostasis.

5. The Hypothalamo-pituitary Connection:

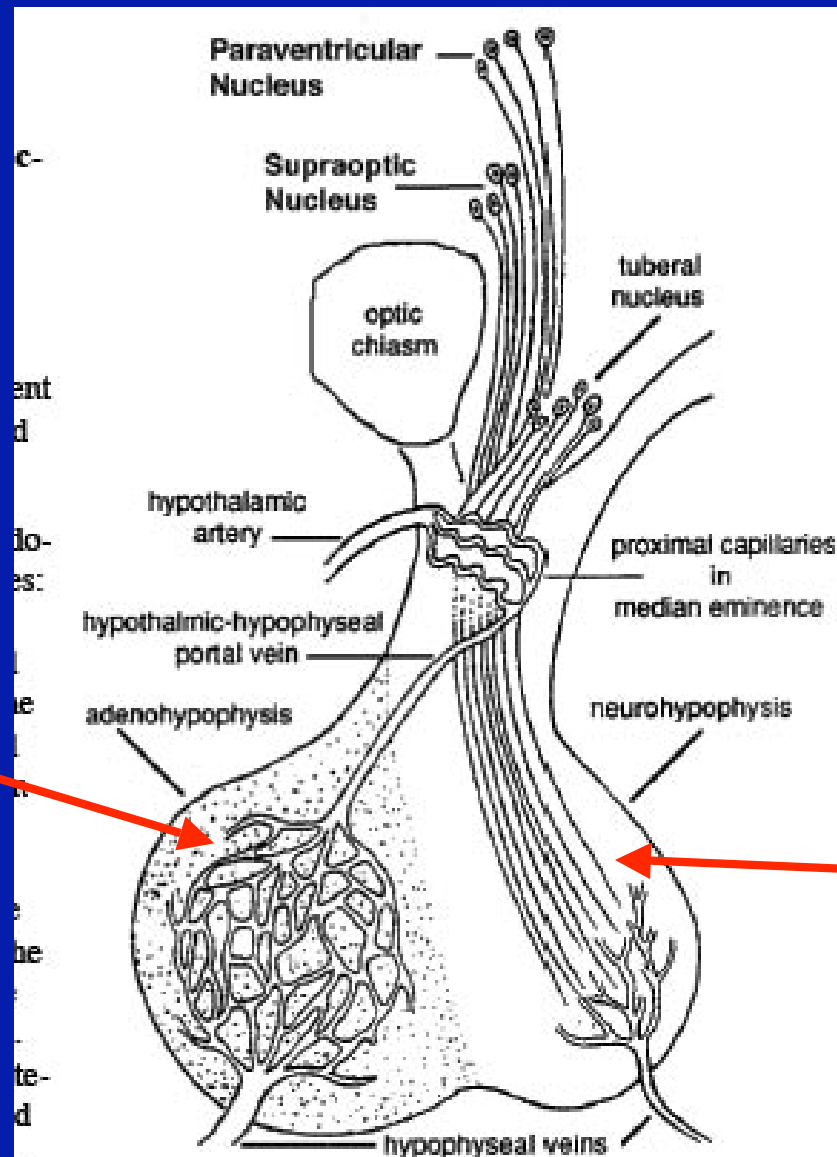
a. **Pituitary gland:** lies beneath the brain and is formed by 2 distinct parts: a neural part, the **neurohypophysis**, and a glandular component derived from oral epithelium, called the **adenohypophysis**.



b. The hypothalamus controls the endocrine system via two different routes: 1) Directly by secretion of neuroendocrine products into the general circulation via the vasculature of the posterior pituitary gland (ADH and oxytocin). 2) Indirectly by secretion of releasing factors into the local hypophyseal portal venous plexus (a vascular plexus that carries these releasing factors from the base of the hypothalamus). The hypothalamus thus controls anterior pituitary hormone synthesis and release via the transport of these releasing factors to the adenohypophysis.



**Adeno-
hypophysis
(Anterior
Pituitary)**



**Neuro-
Hypophysis
(Posterior
Pituitary)**

Fig. 3. Projections from the hypothalamus to the pituitary gland. The hypothalamus is connected directly via the axons of the supraoptic and paraventricular nuclei and indirectly via the hypophyseal portal system.

Hypothalamic Function:

1. Direct effects on the Endocrine system;

Secretion of oxytocin and vasopressin into the circulation.

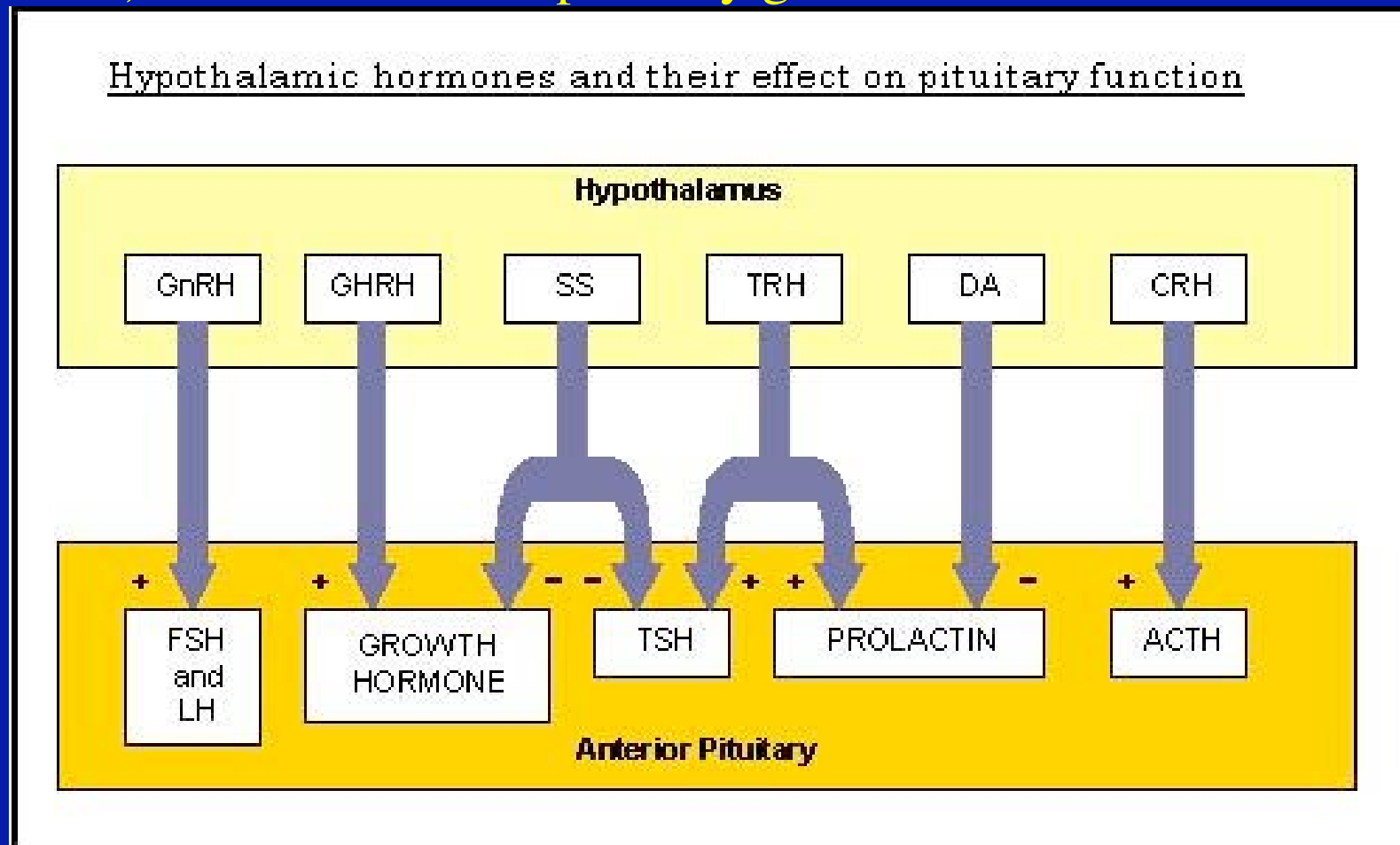
A. **Oxytocin**—(Greek for “rapid birth”)- *Produced by:* neurons in the paraventricular nuclei of the hypothalamus. *Functions:* 1. acts on uterine smooth muscle to stimulate myometrial contractions and accelerates parturition (thus oxytocin or synthetic derivatives of oxytocin can be used to induce parturition, eg. in the mare). 2. Activates milk letdown reflex in response to suckling (induces contraction of myoepithelial cells in mammary gland). 3. It also acts on the amygdala (and nucleus accumbens) to enhance bonding between a male and female once they have mated and between a mother and her newborn.

B. **Vasopressin (ADH):** *Produced by:* neurons in the supraoptic nucleus. *Function:* to increase reabsorption of water in the kidneys (via collecting ducts and convoluted tubules). Thus it decreases urine production and conserves body water. Increases in blood osmolarity stimulate release of ADH.

*Disease State: **Diabetes Insipidus*** — a disorder of water balance in which there is a loss of control of water excretion due to a failure of production, transport or release of ADH into the blood stream.

- 1) Cause: trauma or disease of pituitary or hypothalamus; Commonly associated with tumors of the adenohypophysis.
- 2) Diagnosis: imagery of the pituitary with a positive finding of a tumor; water deprivation test- if animal is unable to produce more concentrated urine as water intake is restricted.
- 3) Treatment: Surgery or intranasal, oral or subcutaneous injection of desmopressin (a drug that mimics the actions of ADH)

2. Indirect effects on the endocrine system: Production and release of hypothalamic releasing factors, which either stimulate or inhibit the release of hormones from the anterior pituitary gland. Example release of corticotropin-releasing hormone from hypothalamus controls release of adrenocorticotrophic hormone (ACTH) from the anterior pituitary gland.



Disease: **Hyperadrenocorticism (Cushing's disease)** often accompanies tumors of the adenohypophysis, which produce excess adrenocorticotrophic hormone. One of the most common diseases of middle-aged and older dogs.

Symptoms: 1) Extremely hungry (polyphagia- 80-95% of dogs show this sign); 2) poor hair coat- thinning hair or hair loss from the body (usually on the sides); 3) obesity- bloated abdomen and “potbelly” due to increase of fat in the abdomen and increased liver size and stretching of abdominal wall (90-95% have this symptom); 4) Muscle weakness, lethargy and sometimes lameness (excess cortisol causes protein breakdown leading to muscle weakness).

Treatment: Surgery to remove pituitary tumor;
Radiation to control tumor growth;
Medication- Lysodren or mitotane—destroys the cortisol producing cells in the adrenal gland

3. Control of the Autonomic Nervous System;

The hypothalamus projects to the parasympathetic vagal nuclei and the preganglionic sympathetic nuclei and thus can control autonomic functions including heart rate, vasoconstriction, digestion, sweating, etc. There appears to be a segregation of function as follows:

Stimulate rostral hypothalamus — parasympathetic responses (e.g., slowed heart rate).

Stimulate caudal hypothalamus — sympathetic responses (e.g., increased heart rate, vasoconstriction, etc.)

Disease: alterations in cardiovascular function have been observed in cattle with abscesses of the hypothalamus (slowing of heart rate).

4. Temperature regulation:

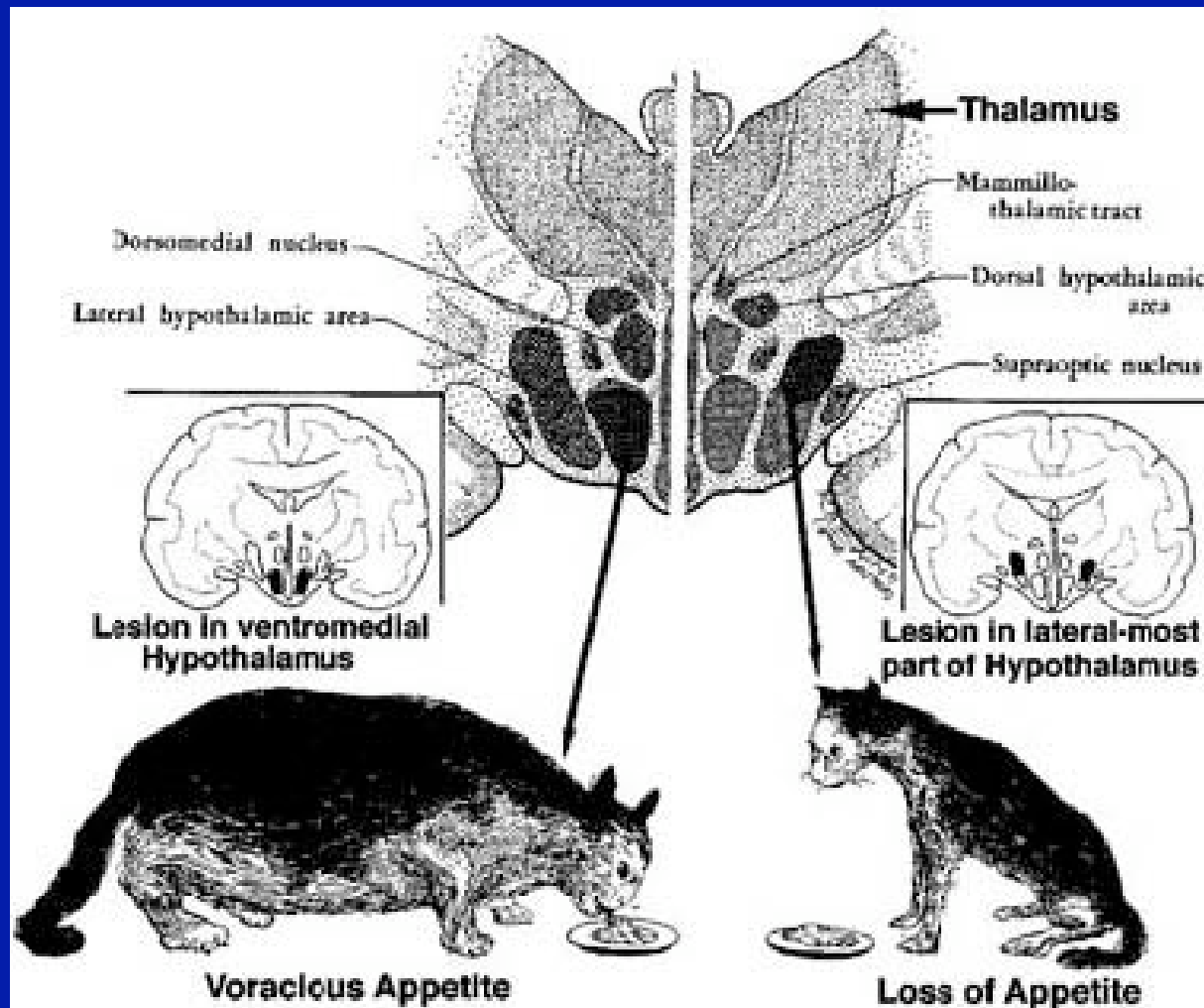
a. Rostral hypothalamus — **heat loss center**: warm blood, antipyretic substances or impulses from heat receptors cause panting, vasodilation and sweating which serve to reduce body temperature.

b. Caudal hypothalamus — **heat conservation center**: cool blood, pyrogenic substances or input from cold receptors causes shivering and vasoconstriction which serve to increase body temperature.

Disease: damage to the rostral hypothalamus can cause hyperthermia (fever) while damage or lesions to the caudal hypothalamus can cause hypothermia (decreased body temperature); e.g., cattle with abscesses of the pituitary gland that effect the hypothalamus are often hypothermic.

5. Regulation of Food and Water intake: The hypothalamus controls body weight and appetite as well as water intake.

Disease: Lesions of the hypothalamus often cause abnormal eating and drinking behavior.



6. Behavior: together with the limbic system, the hypothalamus participates in behavioral circuits responsible for controlling an animal's behavior.

Diseases:

A. Lesions of the hypothalamus in cats can cause rage reactions.