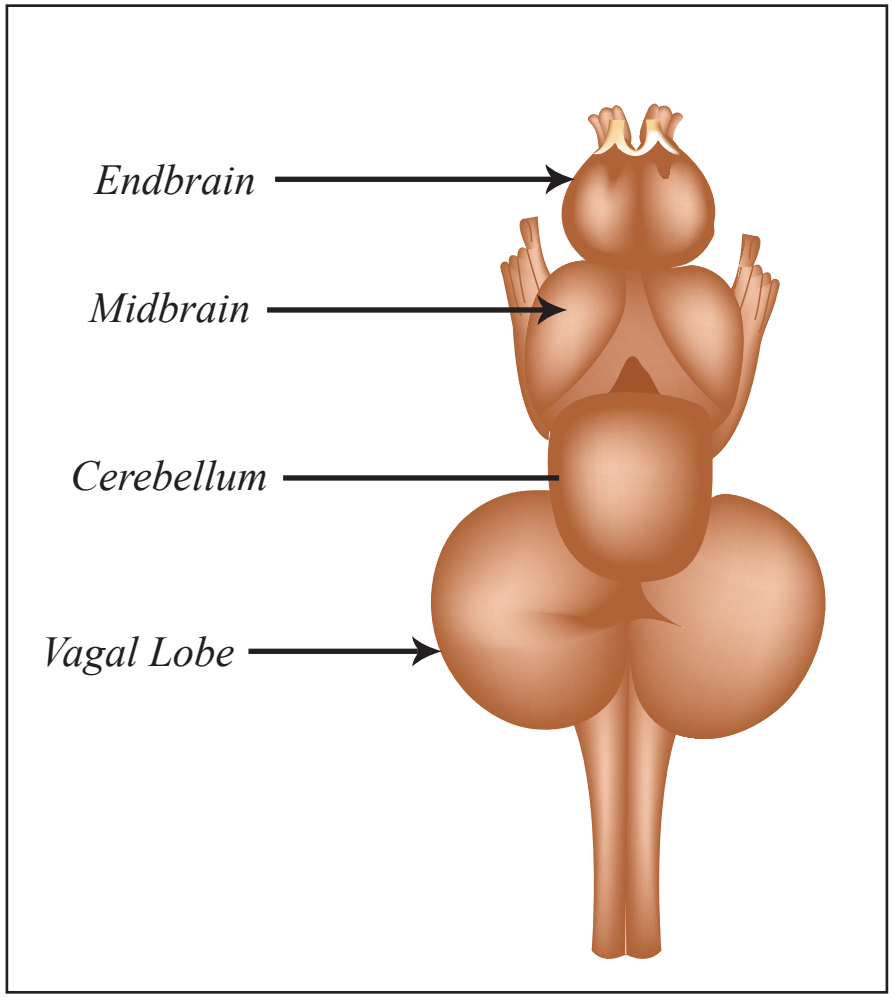
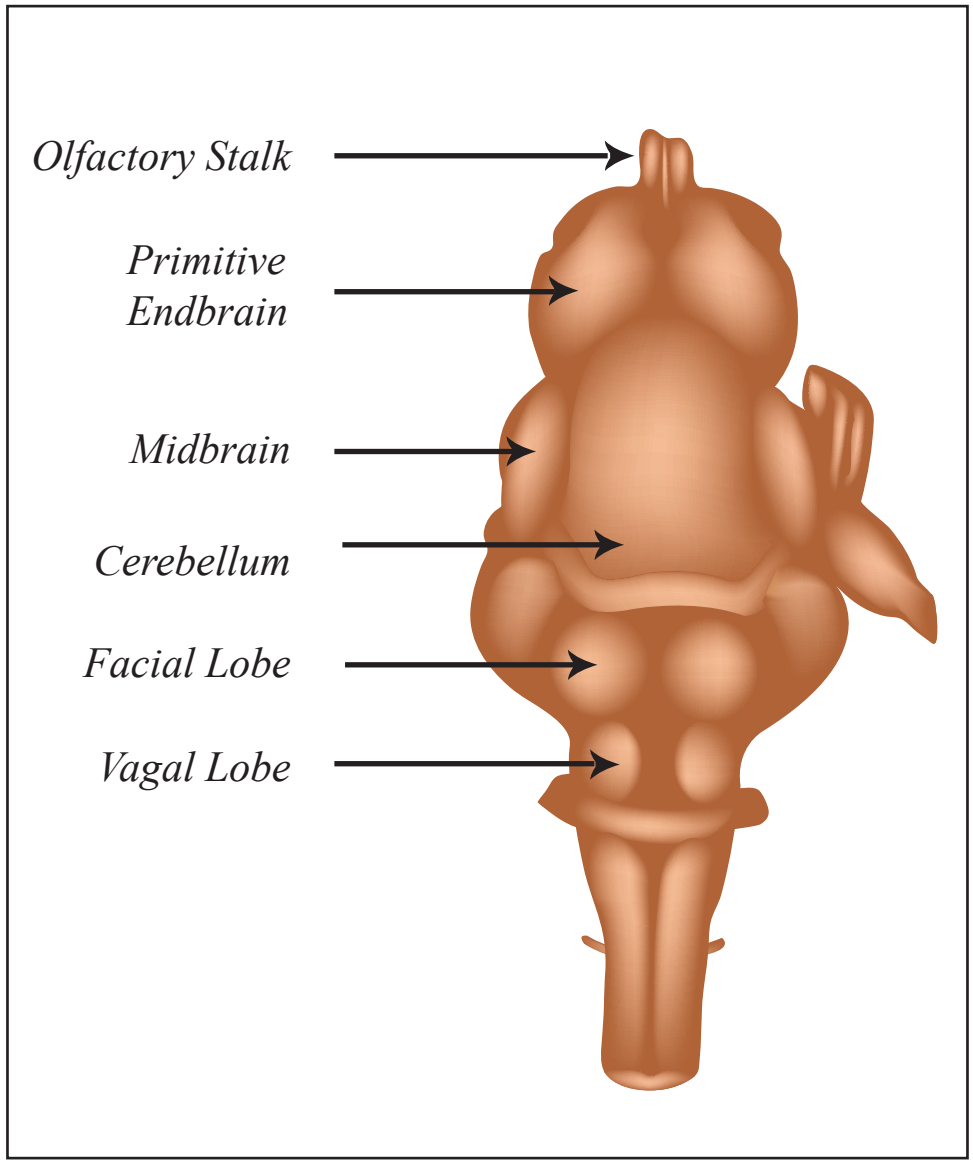
Begin session 11

The changes cause "distortions" in the basic organization of the hindbrain

- **Variations in relative size of parts**
  - Huge vagal lobe of the fresh-water buffalofish [Review]
  - Vagal and facial lobes of the catfish [Review]
  - Electric fish have an enormous and specialized cerebellum. [Review]
- Cell migrations from the rostral hindbrain's alar plate—from a proliferative region called the "rhombic lip":
  - To cerebellum
  - To pre-cerebellar cell groups – especially the cells of the pons



Buffalofish (*Carpiodes tumidus)* has a specialized palatal organ for filtering the water for food; it is innervated by the vagus nerve.



The catfish has taste receptors all over its body innervated by the facial nerve (7th cranial nerve)

Amiurus melas (the small catfish)

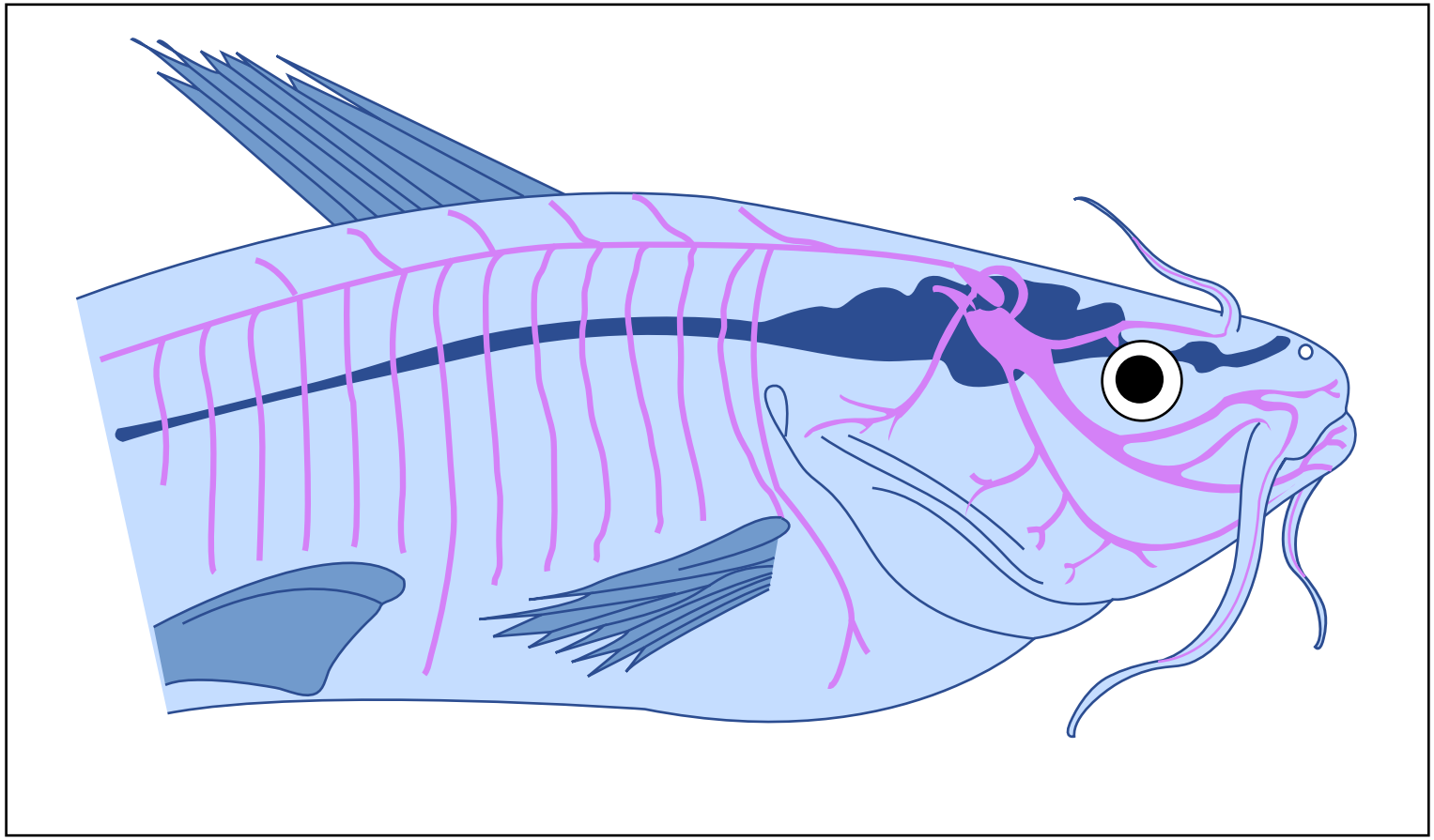
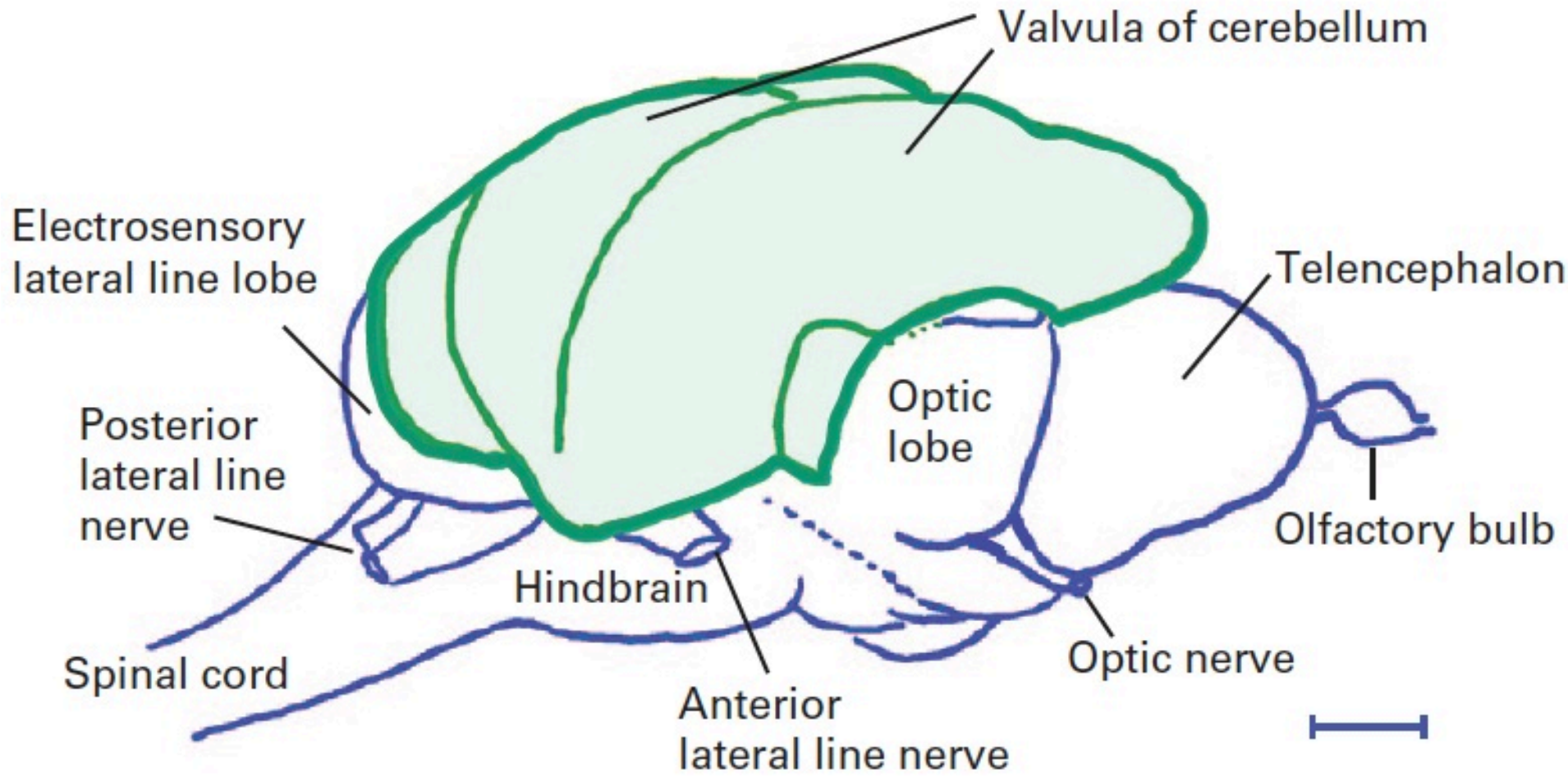


Image by MIT OpenCourseWare.



Schneider, G. E. *Brain structure and its Origins: In the Development and in Evolution of Behavior and the Mind*. MIT Press, 2014. ISBN: 9780262026734.

The enlarged cerebellum of a Mormyrid fish

Fig.6-1

Questions, chapter 10

16) What is the meaning of the term “pons”? (See the end of chapter 5.) What is a major input, and what is the major output, of the cells of the pontine gray matter?

17) What causes quantitative distortions of the basic structural layout of the hindbrain? What is the major distortion that occurs in the development of the hindbrain of humans and other primates?

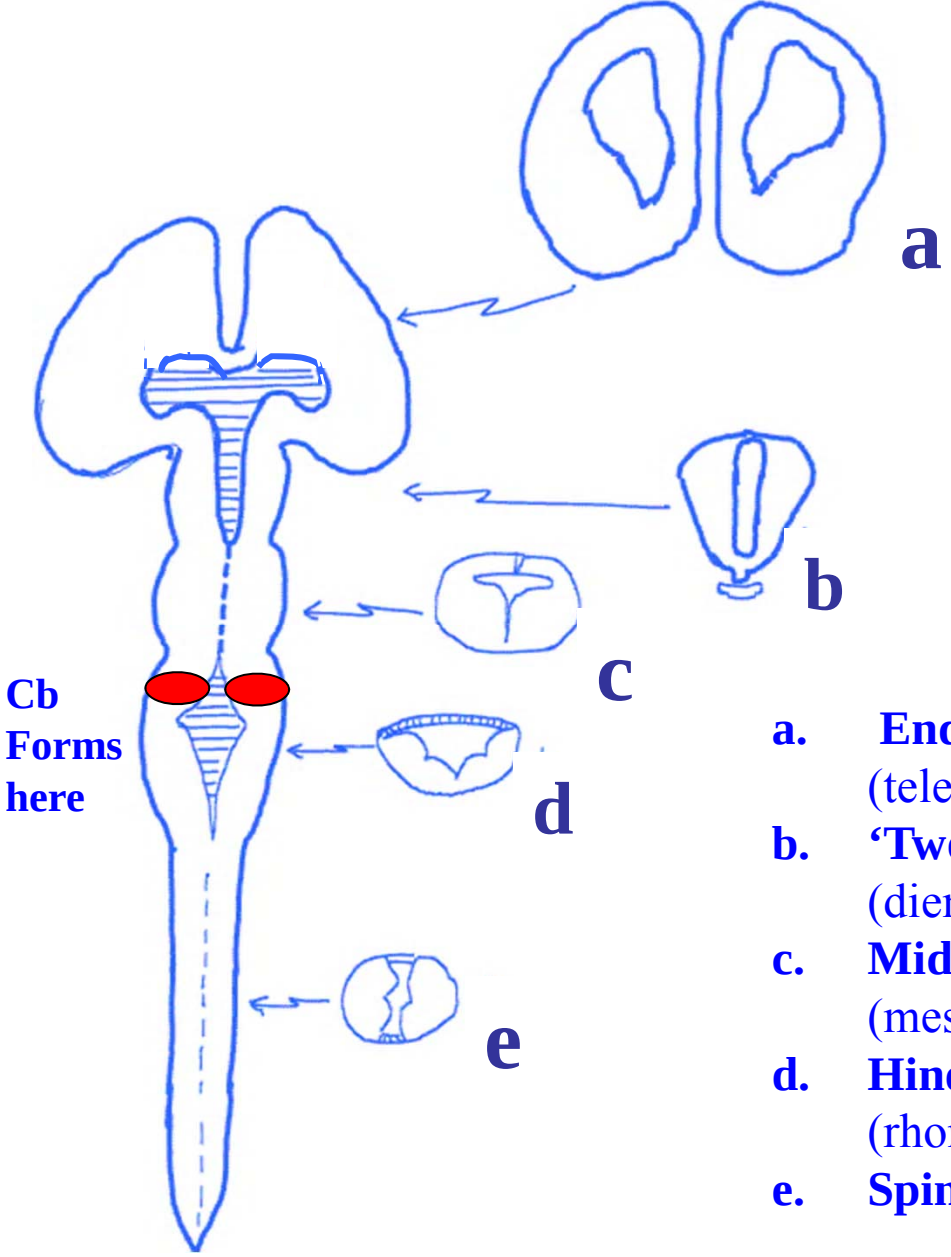
18) What is the role of the “rhombic lip” – a structure seen during the development of the rostral hindbrain?

The "distortions" in the basic organization of the hindbrain, continued

- Variations in relative size of parts
  - √ Huge vagal lobe of the fresh-water buffalofish
  - √ Vagal and facial lobes of the catfish
  - √ Electric fish have an enormous and specialized cerebellum.
  - – **The cerebellum is very large in mammals, especially in humans.**
    - **Cell migrations from the alar plate cause major distortions in large mammals**
      - – **Migration into the cerebellum**
      - – **Migration to pre-cerebellar cell groups – especially the cells of the pons**

* not only into the roof plate but also into the basal plate

Location of the Cerebellum: late-developing in the rostral hindbrain

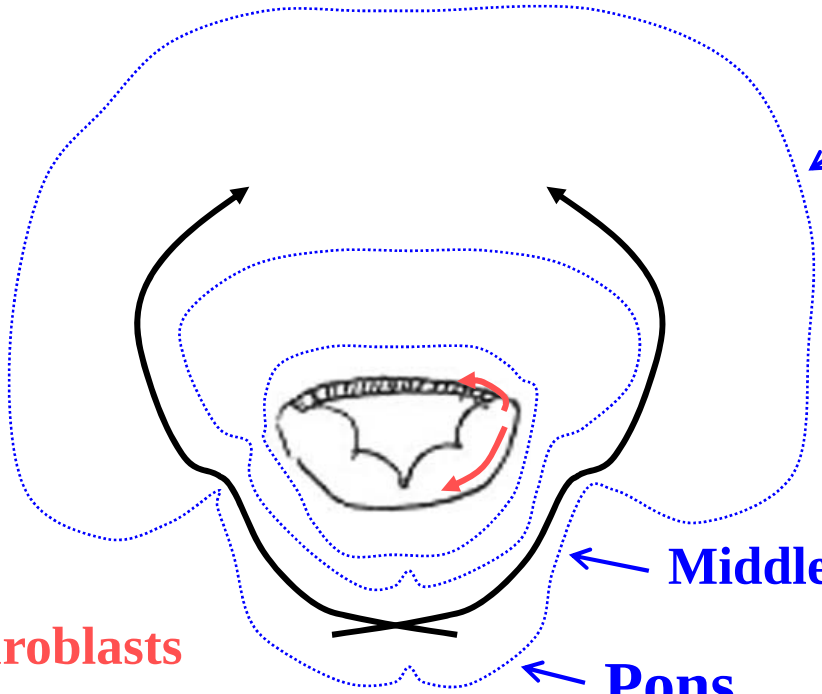


a. **Endbrain** (telencephalon)
b. **'Tweenbrain** (diencephalon)
c. **Midbrain** (mesencephalon)
d. **Hindbrain** (rhombencephalon)
e. **Spinal cord**

Cb = Cerebellum

Fig 10-18

Growth of cerebellum and pons in rostral hindbrain, by migration of neuroblasts from the "rhombic lip"

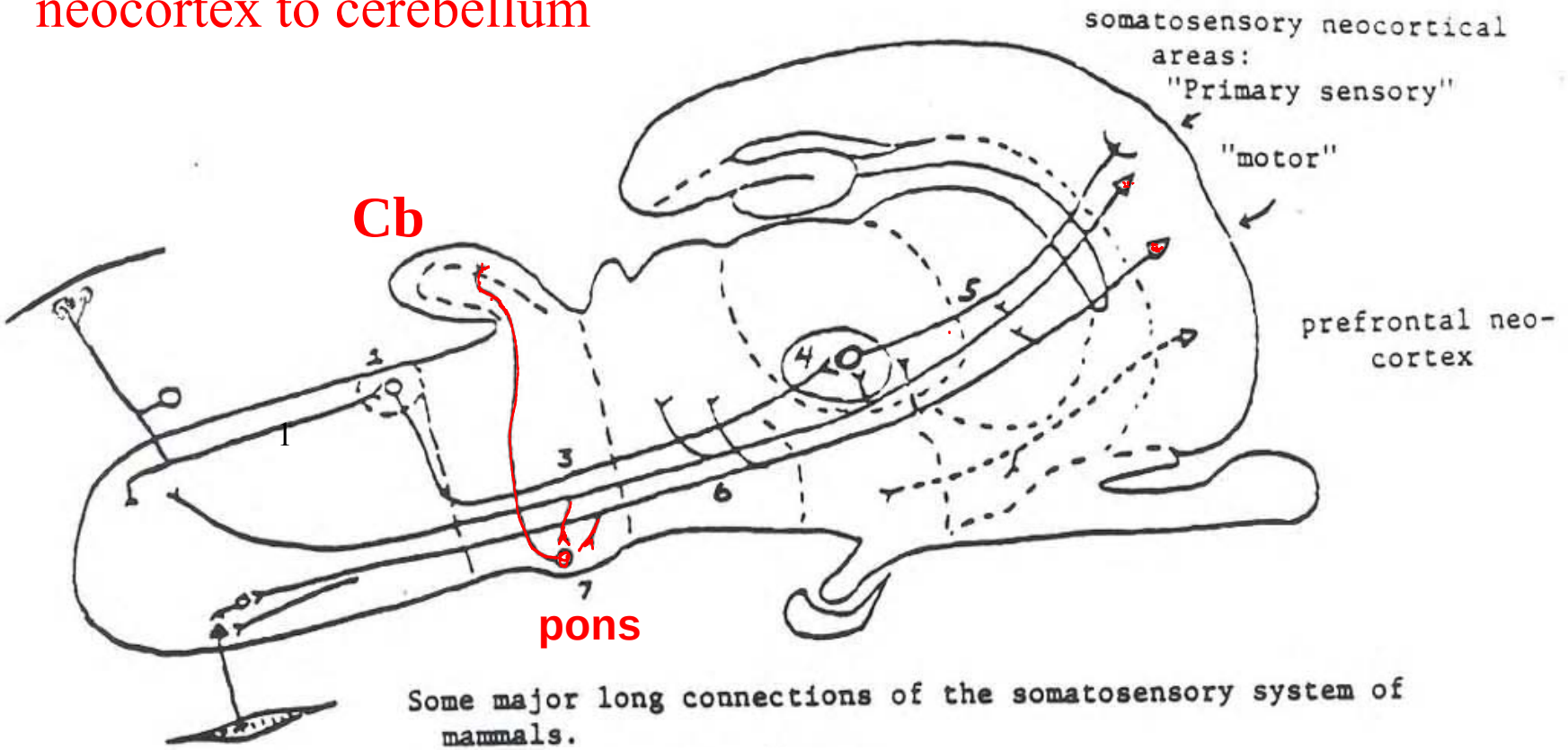


Red arrows:
migration of neuroblasts

Black arrows:
course of axons from pontine gray to Cb cortex

Review of earlier figure:

Note the pathway from neocortex to cerebellum



Some major long connections of the somatosensory system of mammals.

Terms:

1. **Dorsal columns**
2. **Nuclei of the dorsal columns**
3. **Medial lemniscus**
4. **Ventrobasal nucleus of thalamus (n. ventralis posterior)**
5. **Thalamocortical axon in the "internal capsule"**
6. **Corticofugal axons, including corticospinal components. Called "pyramidal tract" in hindbrain below pons.**
7. **Pons**

Human rostral hind-brain showing *pons* and small part of *cerebellum*:
These structures cause a quantitative "distortion" of the basic plan.

Figure removed due to copyright restrictions.
Please see course textbook or:
Nolte, John. *The Human Brain in Photographs and Diagrams*.
Elsevier Health Sciences, 2013.

Fig 10-20

We will return to the cerebellum when we study the motor system

Next we move above the hindbrain

A sketch of the central nervous system and its origins

G. E. Schneider 2014

Part 5: Differentiation of the brain vesicles

MIT 9.14 Class 11

Why a midbrain?
Notes on evolution, structure and functions

Above the hindbrain

- We can get ideas about evolution of the midbrain and forebrain from animals resembling the most primitive chordates.
- We get additional ideas from comparative studies of vertebrates.

Why a midbrain, and a forebrain rostral to it?

Probable explanations

- The midbrain, together with early components of the forebrain, was a kind of rostral extension of the hindbrain that **enabled visual and olfactory control over motor patterns** (like locomotion and orienting movements), and that **added more control by motivational states**.

- The midbrain received visual and olfactory inputs from ‘tweenbrain and endbrain, as well as sensory and other inputs from more caudal structures, including cerebellum.

Questions, chapter 11

1) What are the two inputs carrying information about light levels into the CNS?

(see answer on next slide)

Next: Some notes about primitive vision and primitive olfaction in chordates

Primitive vision

1) **Early role of optic input to the 'tweenbrain: Control of daily cycles of activity**, with entrainment of the endogenous clock by the day-night cycle
   - Neural mechanisms:
     - Pineal eye
     - Retinal input to hypothalamus (Note that the retina develops as an outpouching of the neural tube in the hypothalamic region.)
       - Diencephalic controls of sleep-waking physiology and behavior: epithalamus and anterior hypothalamus
   - Various cyclic motivational states/behaviors are influenced by the biological clock and regulated by the 'tweenbrain: foraging and feeding, drinking, nesting, etc.

→ 2) **In order for visual inputs to control locomotor responses more directly, connections to the midbrain were involved.**

Primitive olfaction

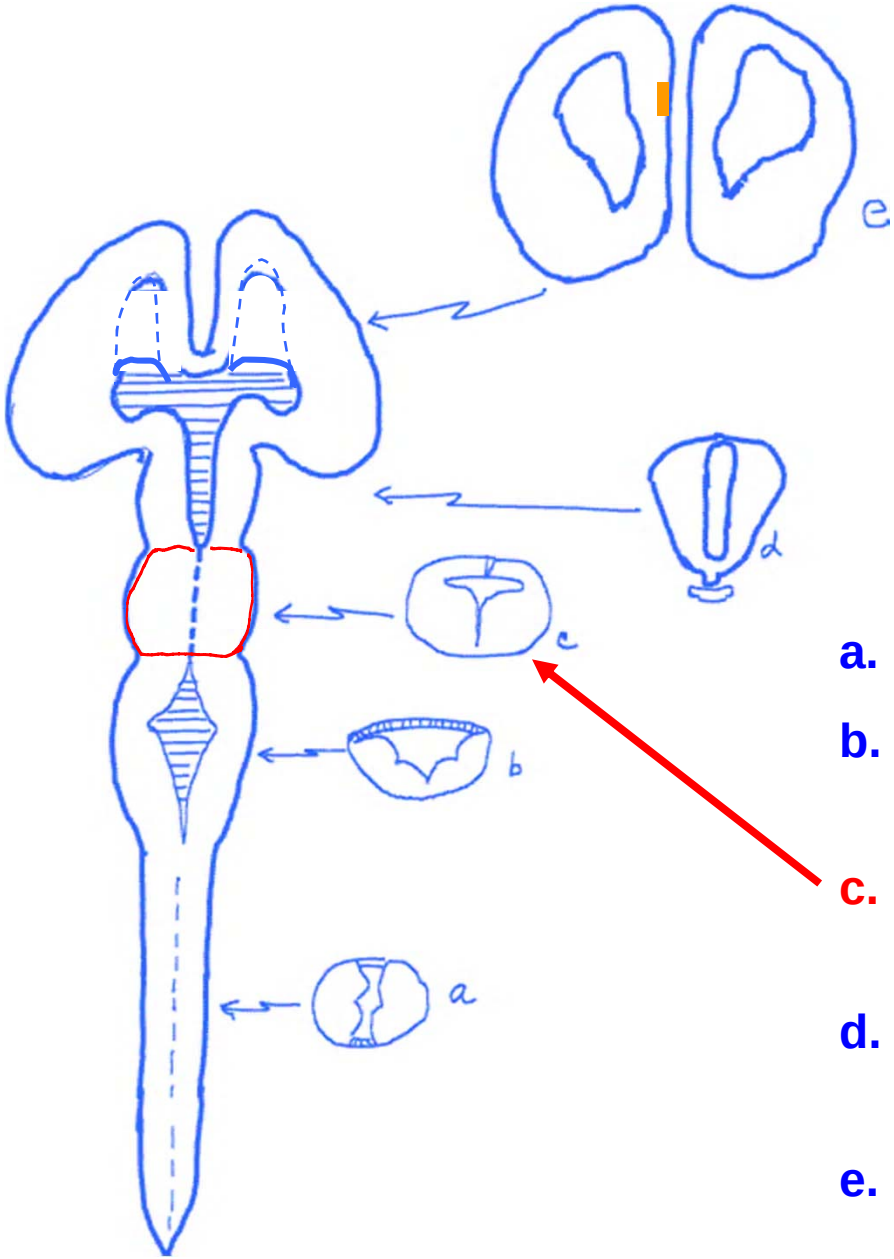
- Olfaction was also, and remains, an important controller of behavioral state
- Olfactory detection of object identity (learning, remembering, altering behavior)
  - Detecting sexual and individual identity
  - Discriminating "good to consume", "bad to consume": in conjunction with taste inputs to forebrain
  - Led to evolution of ventral striatum & amygdala, with outputs to hypothalamus
- Olfactory detection of "good place", "bad place" (learning, remembering, directing behavior)
  - Led to evolution of medial pallium (hippocampus area) with outputs to ventral striatum & hypothalamus

detected by olfaction

→ **For objects and places to influence actions, descending pathways connected with midbrain structures.**

Primitive olfaction

- **Approach-avoidance of objects or animals, or of places, required links from endbrain and ‘tweenbrain to more caudal structures. The main links were in the midbrain**.
  - **Odor-induced locomotion** *via* locomotor areas of the hypothalamus (HLA) and the midbrain (MLA)
    - **Escape from predator threat**
      - Early warning by olfactory input
      - Visual or auditory detection *via* the midbrain tectum which projected to MLA
  - **Orienting towards food or mild novelty**
    - Motivation influenced by olfactory sense
    - Orienting triggered by visual, auditory or somatosensory inputs to midbrain tectum



a. **Spinal cord**

b. **Hindbrain**
(rhombencephalon)

c. **Midbrain**
(mesencephalon)

d. **'Tweenbrain**
(diencephalon)

e. **Endbrain**
(telencephalon)

Schneider, G. E. *Brain structure and its Origins: In the Development and in Evolution of Behavior and the Mind*. MIT Press, 2014. ISBN: 9780262026734.

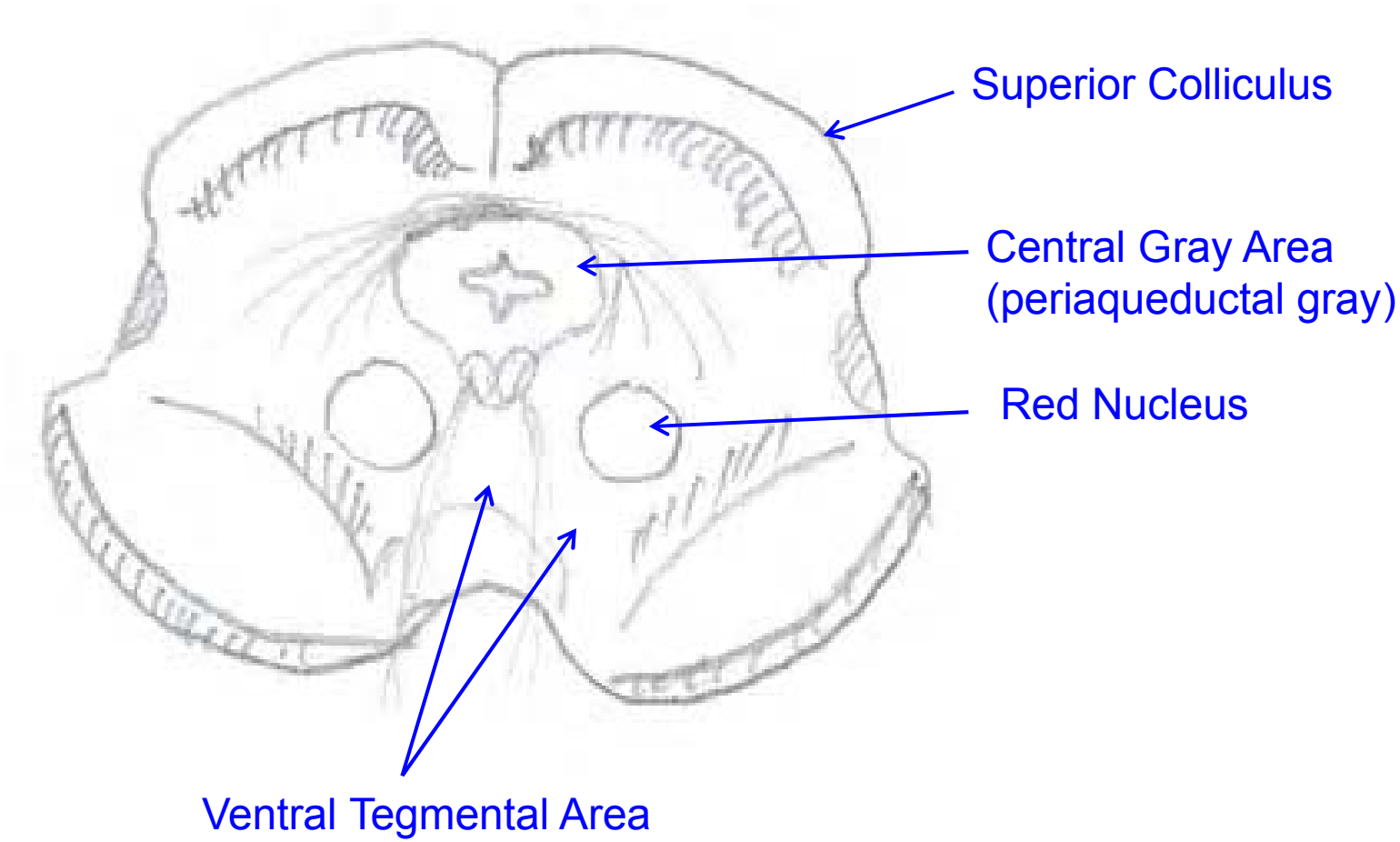
Fig 11-1

Questions, chapter 11

2) What are three major types of multipurpose movement controlled by descending pathways that originate in the midbrain? What structures in the midbrain give rise to these pathways?

6) Name two pathways that originate in the midbrain and descend to the spinal cord.

Frontal section, middle of mammalian midbrain:



Outputs of midbrain for motor control

- **Three major output systems for control of multipurpose action patterns**: Anatomy
    1) Descending axons from Midbrain Locomotor Area (MLA)
    2) Tectospinal tract, from deep tectal layers
    3) Rubrospinal tract, from red nucleus
- **By these means, the midbrain controls 3 types of body movements critical for survival:** Function
    1) Locomotion:
        - Approach & avoidance;
        - Exploring/ foraging/ seeking behavior
    2) Orienting (turning movements of eyes and head)
    3) Limb movements for exploring, reaching and grasping.

Midbrain Locomotor Region (MLR):
Localization in cat by electrical stimulation studies

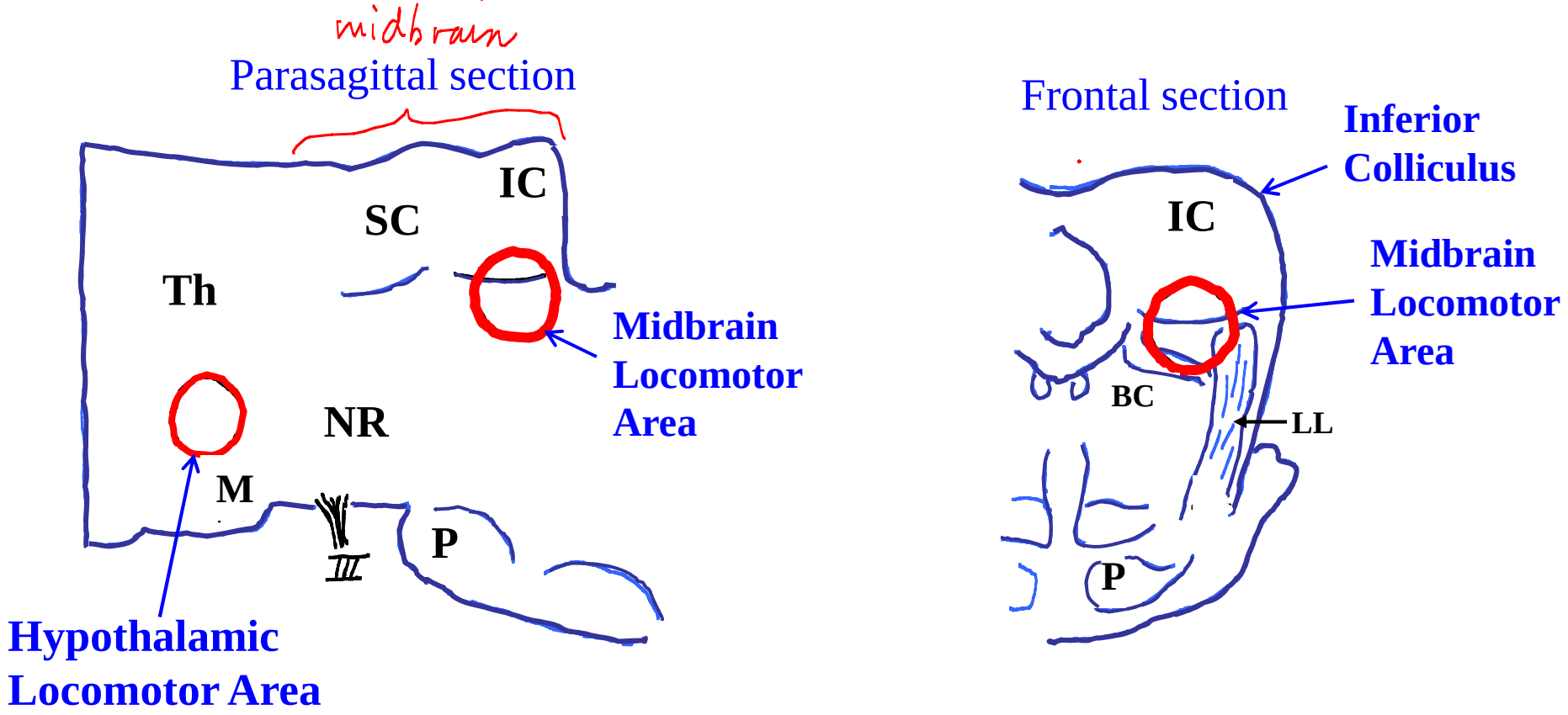


Fig 14-1

Th = thalamus
M = mammillary body
NR = nuc. ruber (red nuc.)
III = oculomotor nerve
P = pons
SC = superior colliculus
BC = brachium conjunctivum (axons from cb)
LL = lateral lemniscus (auditory)

Midbrain Locomotor Region (MLR):

Localization in cat by electrical stimulation studies

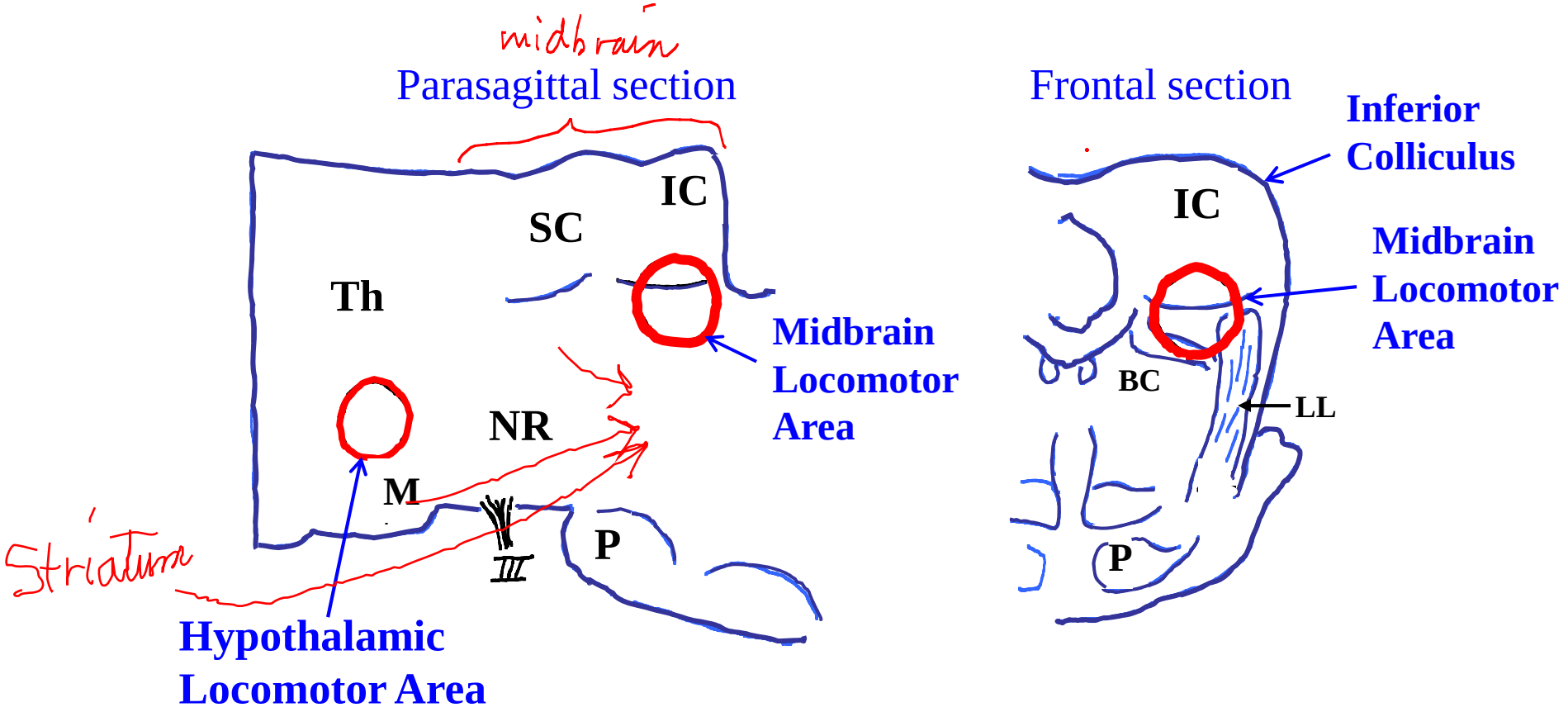


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Fig 14-1

The first type of movement critical for survival:

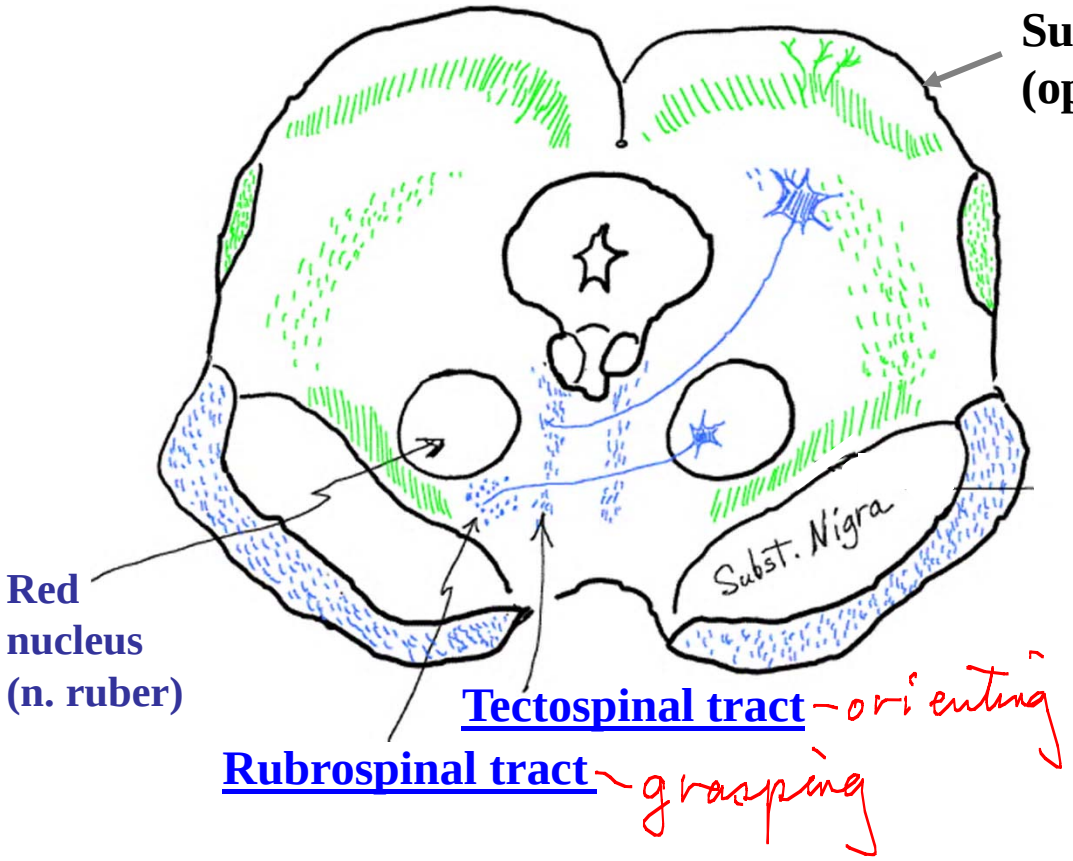
1) The midbrain locomotor area

- Defined by electrophysiological studies; found in caudal midbrain tegmentum
- Ancient origins, crucial for approach and avoidance
- Inputs from midbrain tectum & hypothalamus
- Inputs from the corpus striatum's output structures
  - These inputs from the endbrain were (most likely) originally for olfactory control of locomotor functions

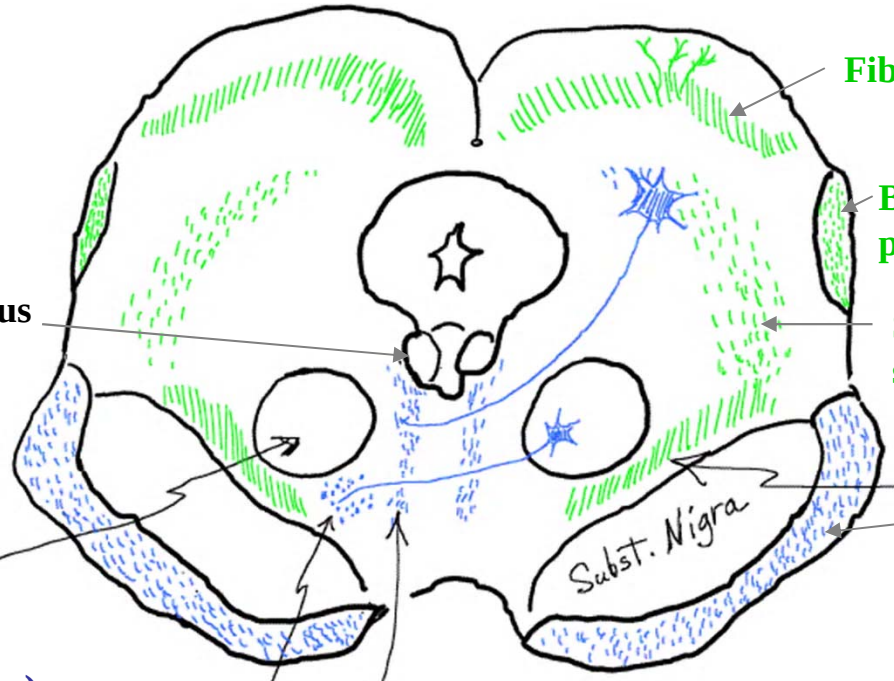
The other basic types of movement crucial for survival

2) **Orienting towards/ away *via midbrain tectum***
3) **Reaching, grasping *via red nucleus***

Midbrain neurons projecting to spinal cord and hindbrain for motor control



Sensory systems in, and passing through, the midbrain



Fibers from retina to Superior Colliculus visual

Brachium of Inferior Colliculus (auditory pathway to thalamus, also to SC) and.

Oculomotor nucleus

Spinothalamic tract (somatosensory; some fibers terminate in SC) SS.

Medial lemniscus/ trigeminal lemniscus SS

Cerebral peduncle: contains corticospinal + corticopontine fibers, + cortex to hindbrain fibers

Red nucleus (n. ruber)

Tectospinal tract

Rubrospinal tract

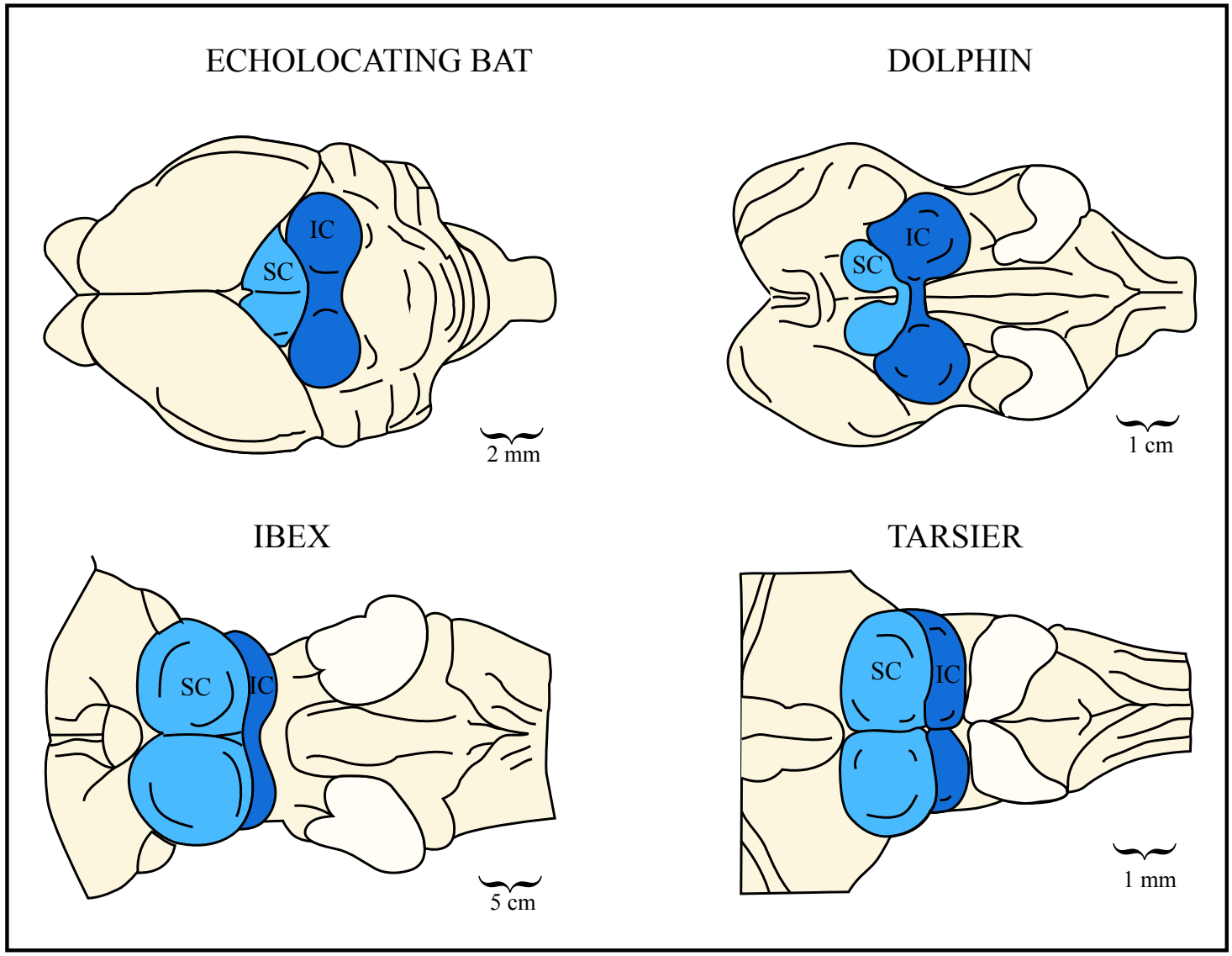
SS = Somato sensory

Questions, chapter 11

5) The roof of the midbrain includes two pairs of structures (colliculi, meaning little hills) that show a great amount of variation in size among various species. Give examples for each pair. (You may want to refer to chapter 6 also.)

Ibex: a wild goat

Tarsier: a prosimian primate



Midbrain roof: the colliculi in four mammals

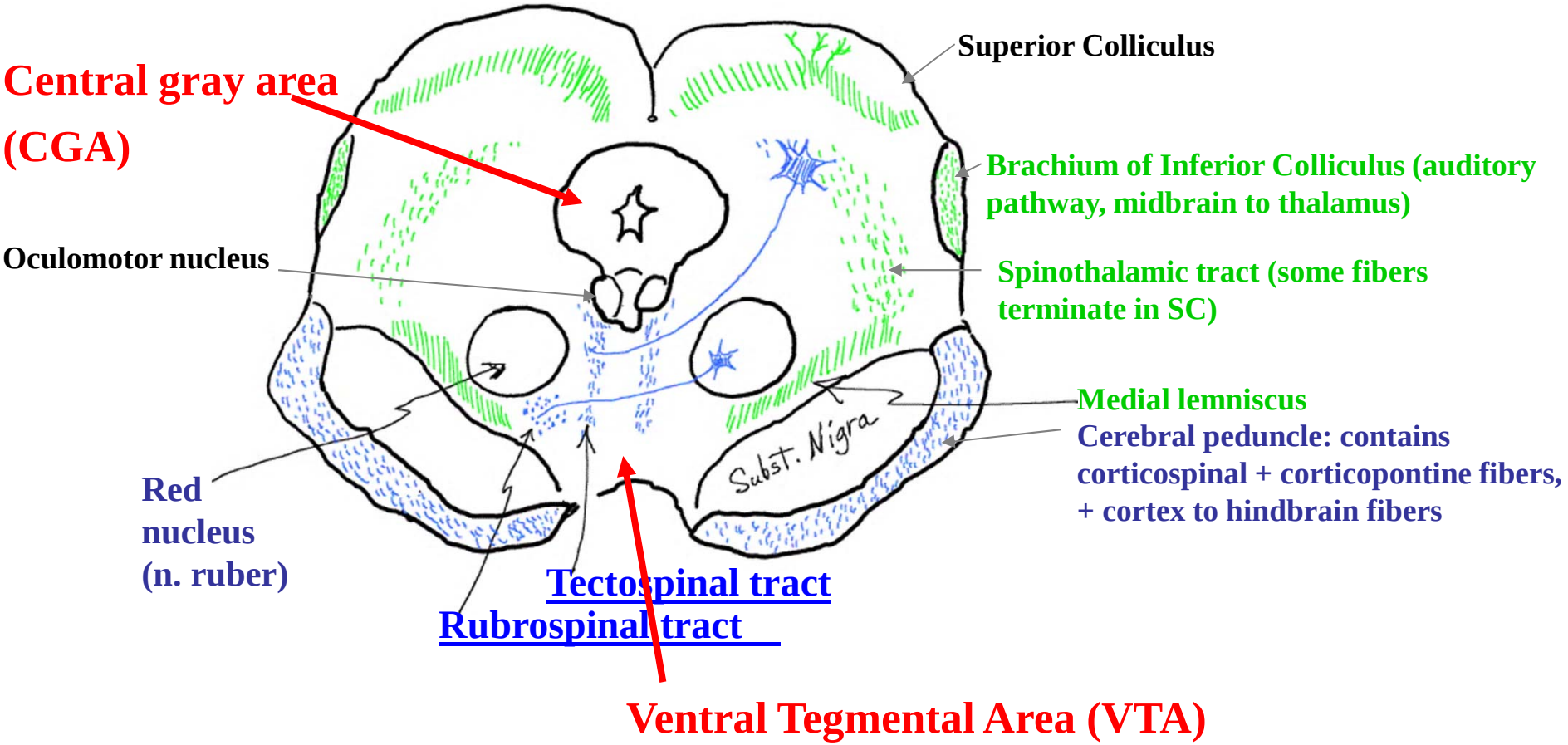
Questions, chapter 11

3) What two regions of the midbrain are called the limbic midbrain areas? What is the neuroanatomical basis for this designation?

Remember the definition of the limbic system given earlier, in chapter 7. closely connected to hypothalamus

10) Because of differences in functions and connections, we can divide both midbrain and 'tweenbrain into two regions. What are they called in this chapter?

Midbrain areas that influence moods and motivational states:



Connections to the CGA, also called the Periaquaductal Gray (PAG), and to the VTA enabled control of or influence on moods/motivations crucial for survival: **defensive, aggressive, sexual**. Activation of these areas is accompanied by **feelings of pain (CGA) or pleasure (VTA)**.

Division of the midbrain into two functionally distinct regions, "limbic" and "somatic"

1. **Somatic:** Connected to the somatic sensory and motor systems

2. **Limbic:** Connected to the autonomic nervous system and the closely associated "limbic" forebrain system

End Session 11

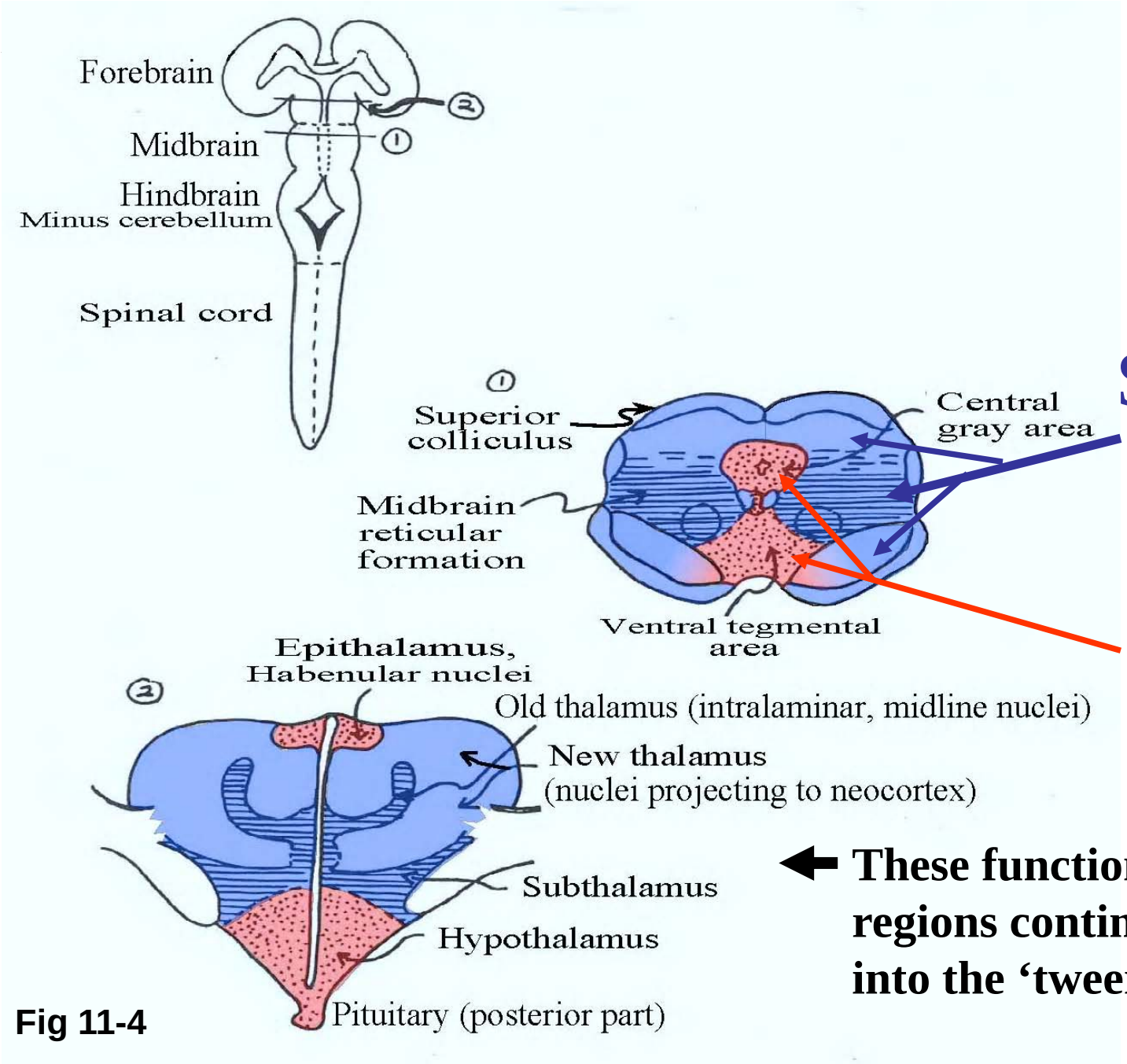


Fig 11-4

Somatic regions

Limbic regions

These functionally distinct regions continue rostrally into the 'tweenbrain.

9.14 Brain Structure and Its Origins

Spring 2014