The organ of the self:

An overview of the structure and function of the brain of relevance to psychiatry in 60 minutes

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Outline

History

Brain structures – 4 brains in one

Brain function - What function & how do we study it?

Connectomes – What are they & what do they mean?

Genes, circuits, molecular pharmacology & drug development

Psychiatric diagnosis – now & future

Estimated timeline for the brain's evolution

Taxonomic Level	*Neural Structure*	*Age (millions of years, mya)*
Prebionts	Monoamines and receptors	~3000 mya
Prokaryotes	Membrane proteins and channels	~2000 mya
Porifera	Neural net and prototissue	1100 mya
Chordates	Homeobox, placodes & spinal cord	>800 mya
Classic Reptilians	Midbrain	270 mya
Late Reptiles	Paleolimbus	120 mya
Early Mammalians	Limbocortex	60 mya
Primato-hominoids	Cortex	~40 mya
Hominids	Neo-cortex	1-2 mya

Ancient Greeks

When the gods want to curse a man, they steal his brain.

Hippocrates - On the Sacred Disease

Goats in the field are afflicted with this disease. When you cut open their skulls, you find their brains foul smelling and sweaty. That is how you know the affliction is caused by disease and not by gods.

"The difference in mind between man and the higher animals, great as it is, certainly is one of degree and not of kind."

Charles Darwin, Descent of Man, 1871

"[For] knowledge of mental diseases ...one must have: (a) knowledge of the physical changes in the cerebral cortex, and (b) [knowledge of] the mental symptoms associated with them."

"Until this is known, we cannot hope to understand the relationship between...symptoms of disease and the...physical processes underlying them..."

Emil Kraepelin, 1915

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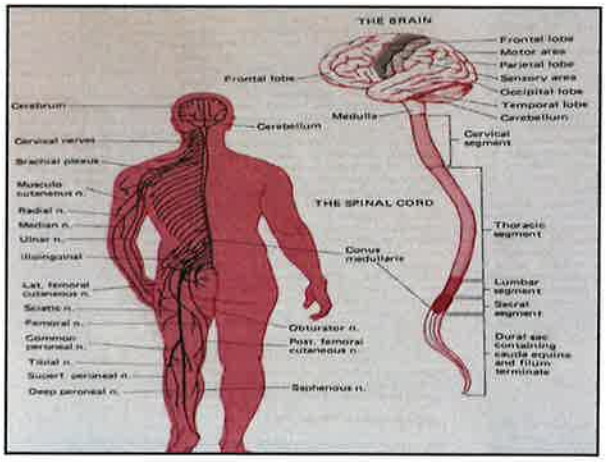

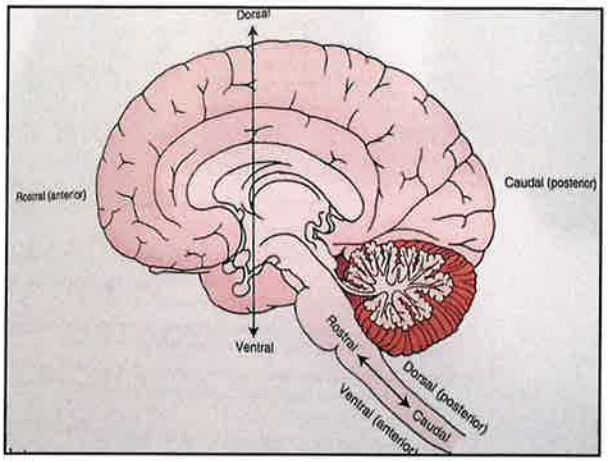

Classical Terminology	Anglicized Terminology	Most Widely Used Terminology
Encephalon	Brain	Brain
Prosencephalon		
Telencephalon		Cerebrum
Diencephalon		Diencephalon (or thalamus, hypothalamus, and surroundings)
Mesencephalon	Midbrain	Mesencephalon
Rhombencephalon	Hindbrain	
Metencephalon		
Cerebellum		Cerebellum
Pons		Pons
Myelencephalon		
Medulla oblongata		Medulla (or medulla oblongata)

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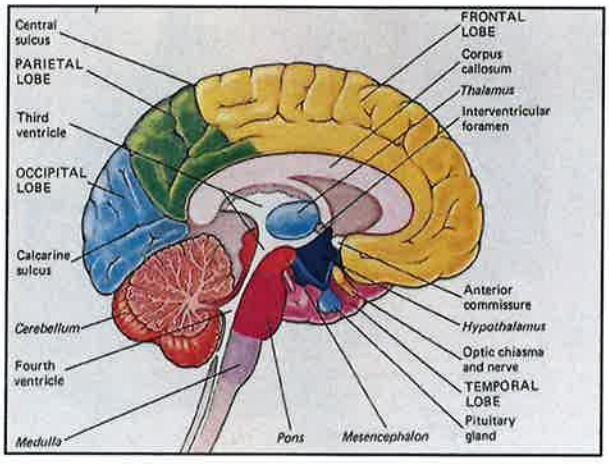
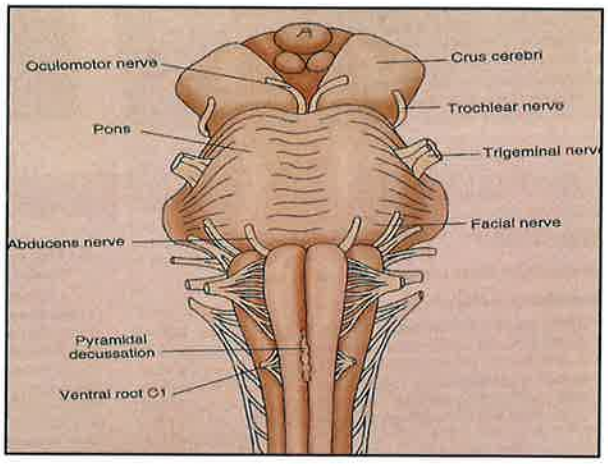
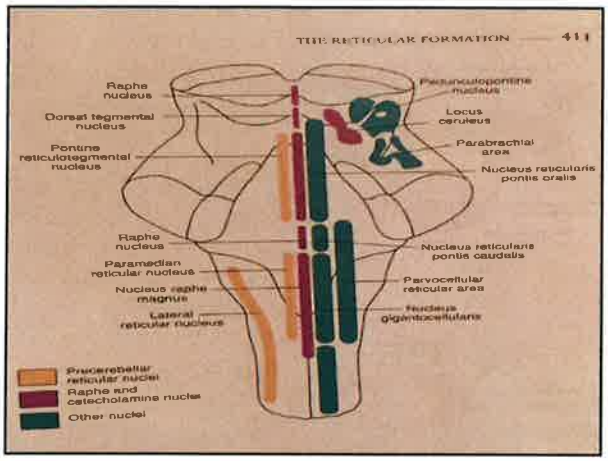
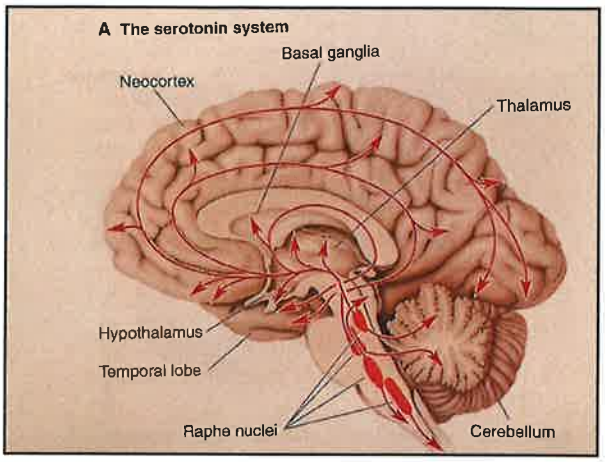
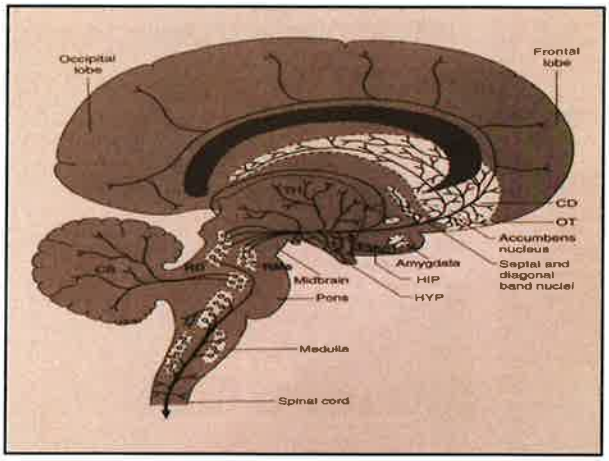
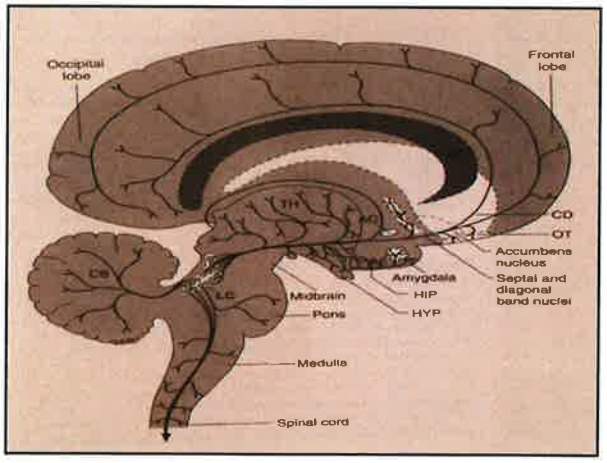





THE RETICULAR FORMATION 411
Raphe nucleus
Dorsal tegmental nucleus
Pontine reticulotegmental nucleus
Pedunculopontine nucleus
Locus ceruleus
Parabrachial area
Nucleus reticularis pontis oralis
Raphe nucleus
Paramedian reticular nucleus
Nucleus raphe magnus
Lateral reticular nucleus
Nucleus reticularis pontis caudalis
Parvocellular reticular area
Nucleus gigantocellularis
Pontocerebellar reticular nuclei
Raphe and catecholamine nuclei
Other nuclei


A The serotonin system
Basal ganglia
Neocortex
Thalamus
Hypothalamus
Temporal lobe
Raphe nuclei
Cerebellum


Occipital lobe
Frontal lobe
CD
OT
Accumbens nucleus
Septal and diagonal band nuclei
Amygdala
HIP
HYP
Midbrain
Pons
Medulla
Spinal cord


Occipital lobe
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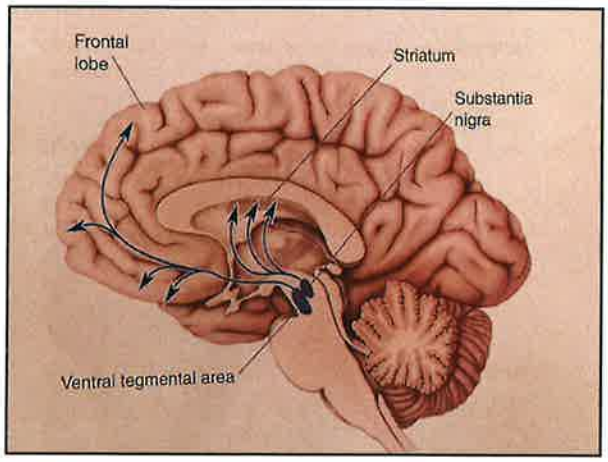
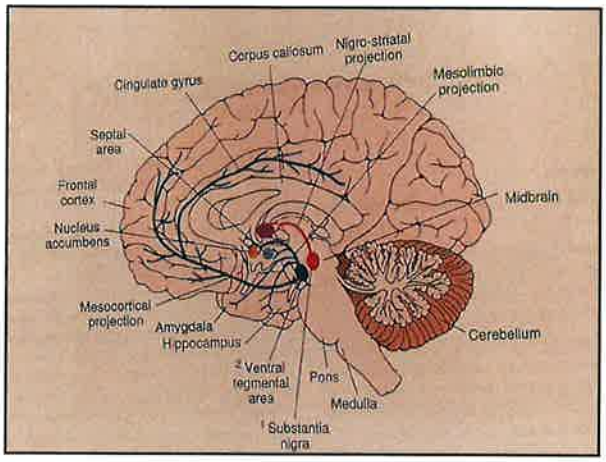
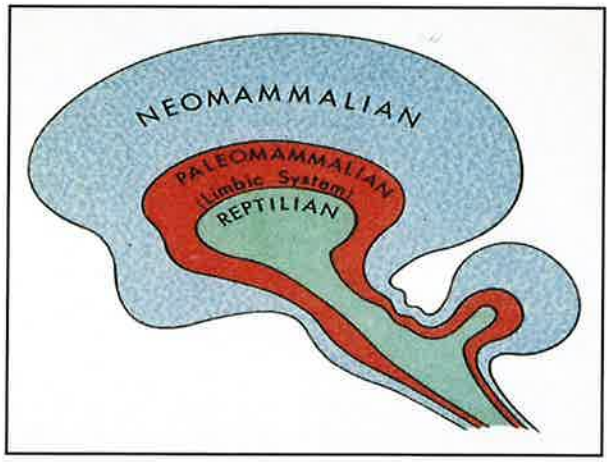






Triune Brain Model of Paul MacLean, M.D.,

- **Protoreptilian formation** (including basal ganglia, midbrain, and brainstem): Genetically encoded instinctual action plans related to primitive survival issues such as exploration, feeding, aggression, dominance, and sexuality.
- **Paleomammalian formation** (including the amygdala, hippocampus, hypothalamus and other structures in the so called **limbic system**): Innate emotional and motivational systems shape behavioral responses to incoming stimuli based on instincts and past experience; mediates the social emotions, playfulness, and maternal nurturance.
- **Neomammalian formation (neocortex)**: Declarative Knowledge about the world derived especially from sight, sound and touch.

P. D. MacLean, The Triune Brain, New York: Plenum Press, 1990

Affective and Cognitive Neuroscience

"There appear to have been relatively long periods of stability in vertebrate brain evolution, followed by bursts of expansion."

The three evolutionary strata of the mammalian brain reflect these progressions."

The basic reptilian core is of similar relative size in all mammals (as long as we account for body size). Other vertebrates also have an abundance of this tissue in their small brains.

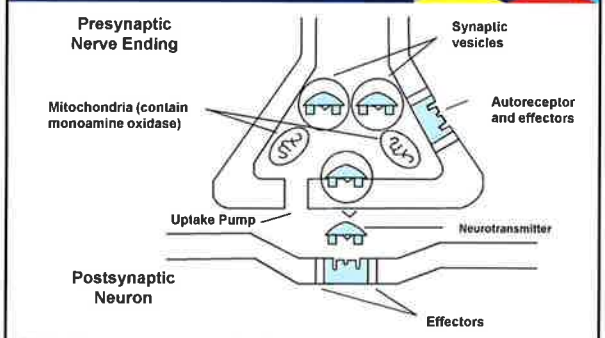
While the limbic system is comparatively small in reptiles, it is large in all mammals and of relatively similar size across different mammalian species.

In contrast, the degree of mushrooming of neocortex varies widely among mammalian species, being modest in rodents and reaching massive proportion in the cetaceans (whales and porpoises) and great apes (e.g., gorillas, chimpanzees) and attaining its pinnacle in humans.

It is the storehouse of our cognitive skills."

Jaak Panksepp, Affective Neuroscience: The Foundations of Human and Animal Emotions, 1988

Biogenic Amine Synaptic Pharmacology



Richelson E. *Mayo Clin Proc.* 1994;69(11):1069-1081.

Diencephalon

Structure	Location	Function
Thalamus	Central base of brain	Relays sensory signals to cortex, sensory analytic functions
Hypothalamus	Inferior to anterior thalamus	Controls internal body functions, stimulates autonomic nervous system
Subthalamus	Inferior to posterior thalamus	Functions with basal ganglia to control subconscious muscle activity
Epithalamus	Posteroinferior to thalamus	Function incompletely understood; includes pineal gland

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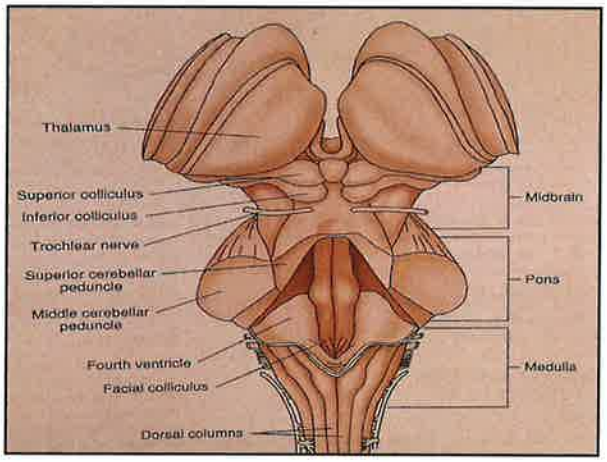
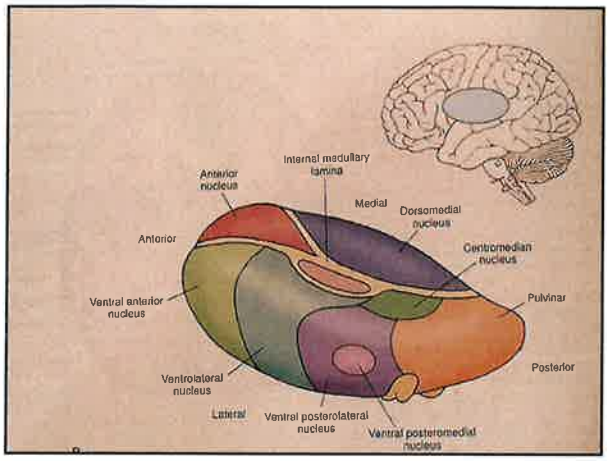
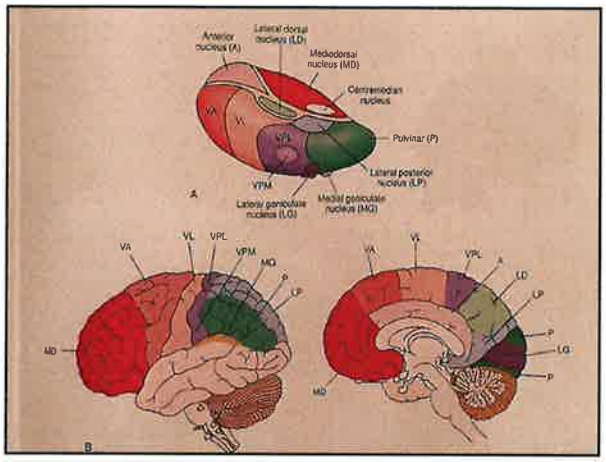
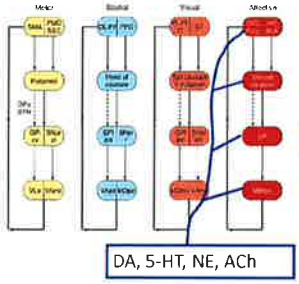




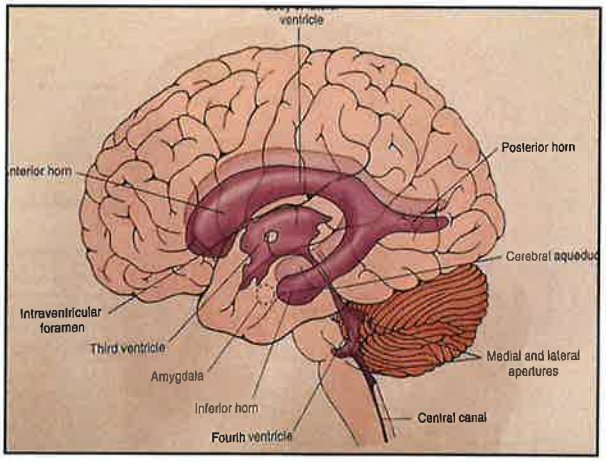


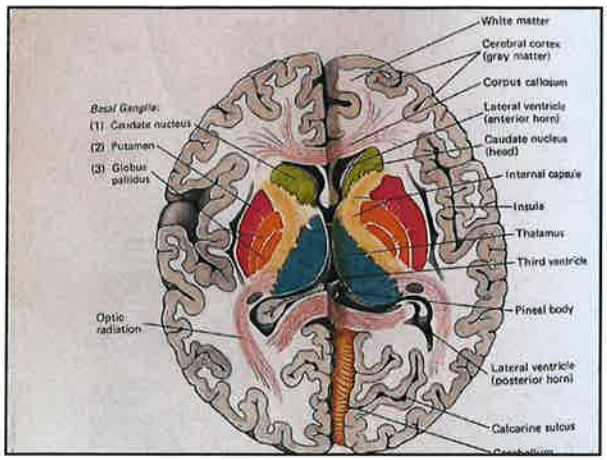
Affective Cortical-Striatal Circuits

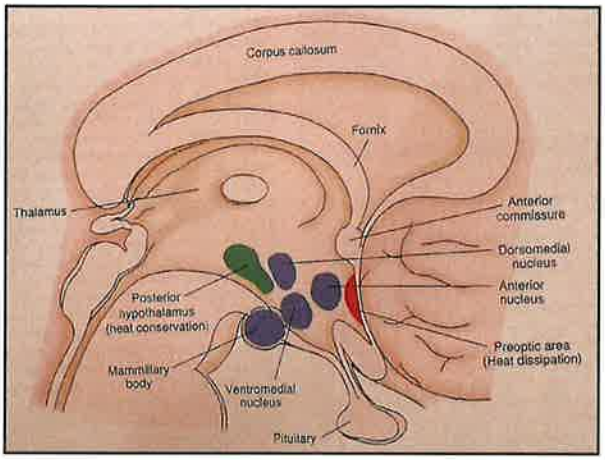


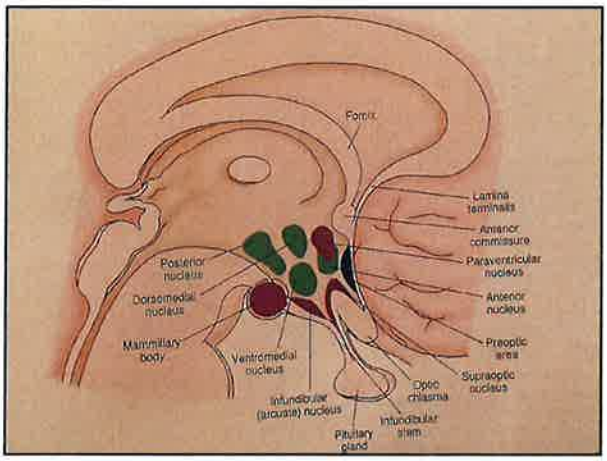
DA, 5-HT, NE, ACh

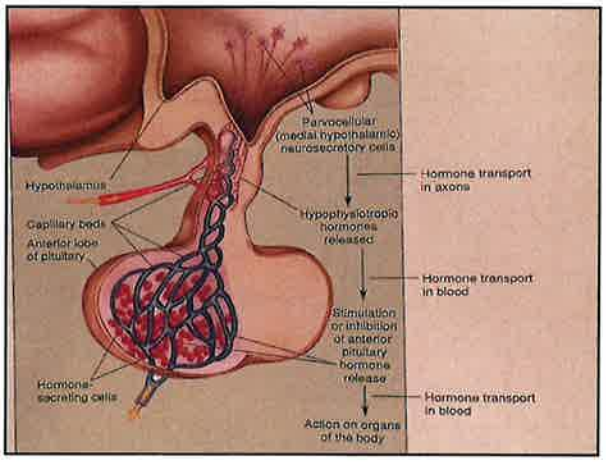
Updated from Alexander GE, et al. *Ann Rev Neurosci* 1986;9:357-381.
Salloway S, Cummings J. *J Neuropsychiatry Clin Neurosci* 1994;6:93-99.

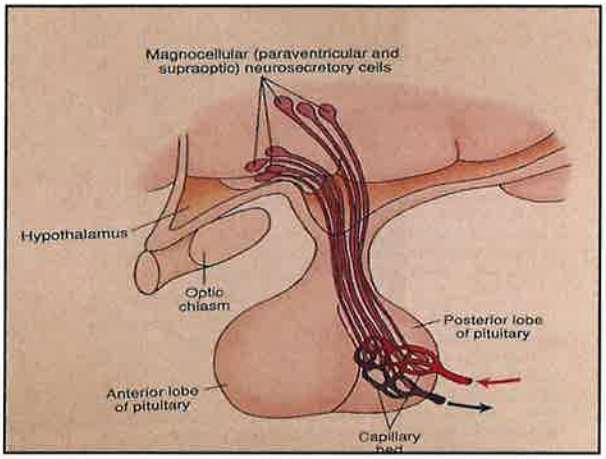


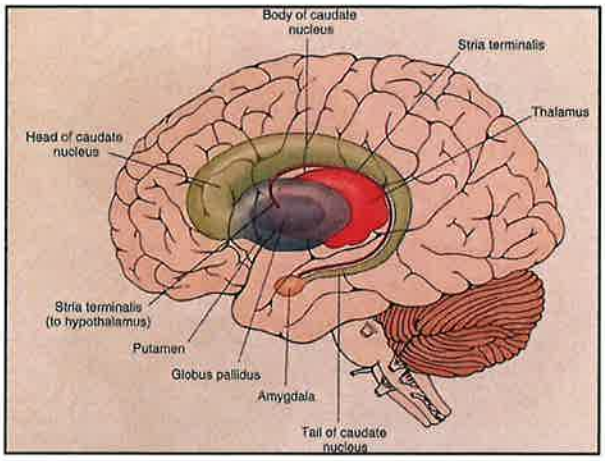

White matter
Cerebral cortex (gray matter)
Corpus callosum
Basal Ganglia:
(1) Caudate nucleus
(2) Putamen
(3) Globus pallidus
Lateral ventricle (anterior horn)
Caudate nucleus (head)
Internal capsule
Insula
Thalamus
Third ventricle
Pineal body
Optic radiation
Lateral ventricle (posterior horn)
Calcarine sulcus

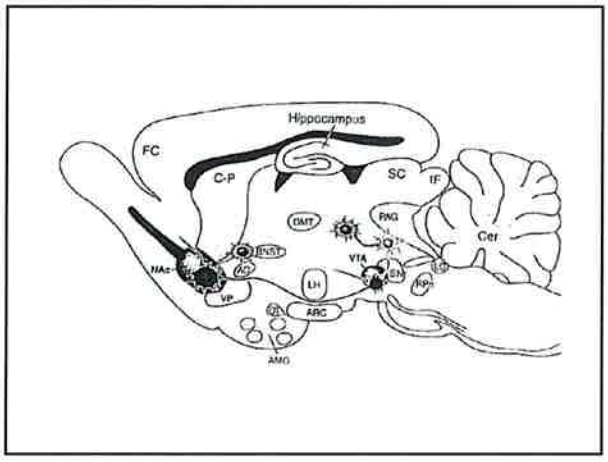

Corpus callosum
Fornix
Thalamus
Anterior commissure
Dorsomedial nucleus
Anterior nucleus
Posterior hypothalamus (heat conservation)
Preoptic area (Heat dissipation)
Mammillary body
Ventromedial nucleus
Pituitary

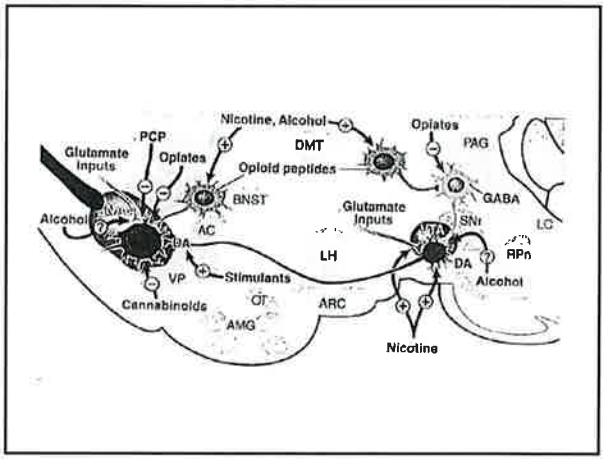

Fornix
Lamina terminalis
Anterior commissure
Paraventricular nucleus
Posterior nucleus
Dorsomedial nucleus
Anterior nucleus
Preoptic area
Mammillary body
Ventromedial nucleus
Supraoptic nucleus
Optic chiasma
Infundibular (arcuate) nucleus
Infundibular stem
Pituitary gland

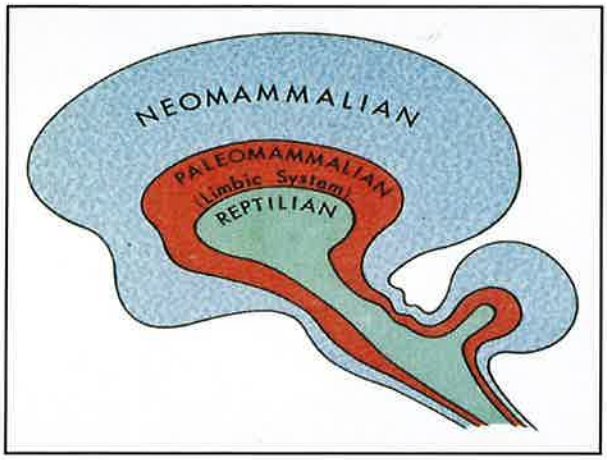

Parvocellular (medial hypothalamic) neurosecretory cells
Hypothalamus
Hormone transport in axons
Capillary beds
Anterior lobe of pituitary
Hypophysiotropic hormones released
Hormone transport in blood
Stimulation or inhibition of anterior pituitary hormone release
Hormone-secreting cells
Hormone transport in blood
Action on organs of the body


Magnocellular (paraventricular and supraoptic) neurosecretory cells
Hypothalamus
Optic chiasm
Posterior lobe of pituitary
Anterior lobe of pituitary
Capillary bed


Body of caudate nucleus
Stria terminalis
Thalamus
Head of caudate nucleus
Stria terminalis (to hypothalamus)
Putamen
Globus pallidus
Amygdala
Tail of caudate nucleus


Hippocampus
FC
C-P
SC
IF
DMT
PAG
Cer
BNST
VTA
SN
RPn
LH
VP
ARC
AMG


Nicotine, Alcohol
Opiates
PCP
DMT
Glutamate Inputs
Opiates
Opioid peptides
PAG
BNST
GABA
Glutamate Inputs
Alcohol
AC
SNr
LC
LH
DA
RPn
VP
Stimulants
Alcohol
Cannabinoids
OT
ARC
AMG
Nicotine



Limbic System

Structure	Location	Function
Amygdala	Deep inside anterior end of each temporal lobe	Controls behavior for each social occasion
Hippocampus	Medial border of each cerebral hemisphere	Determines which sensory information will be committed to memory
Mammillary body	Posterior to hypothalamus	Perhaps helps to determine mood and degree of wakefulness
Septum pellucidum	Midline of cerebrum anterior and superior to hypothalamus	Perhaps helps to control temper and autonomic nervous system
Limbic cortex:cingulate gyrus, cingulum, insula, and parahippocampal gyrus	Ring of cerebral cortex in medial part of cerebrum around deeper limbic structures	Conscious components in the control of behavior

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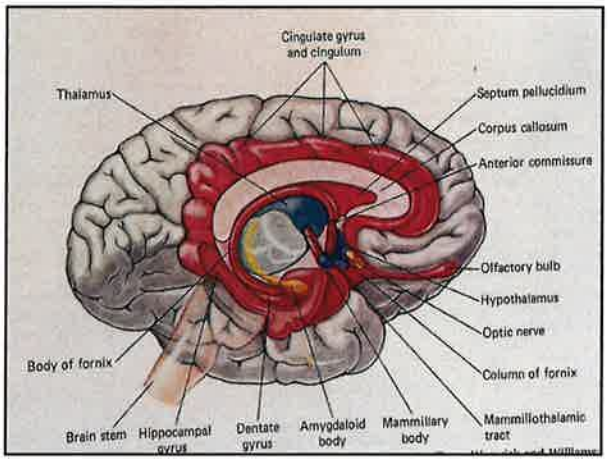
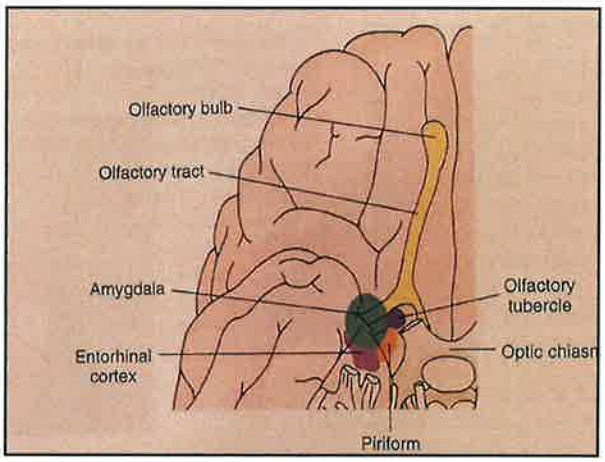
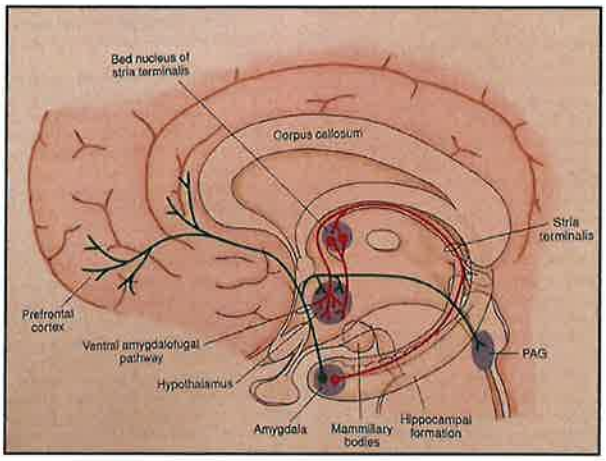
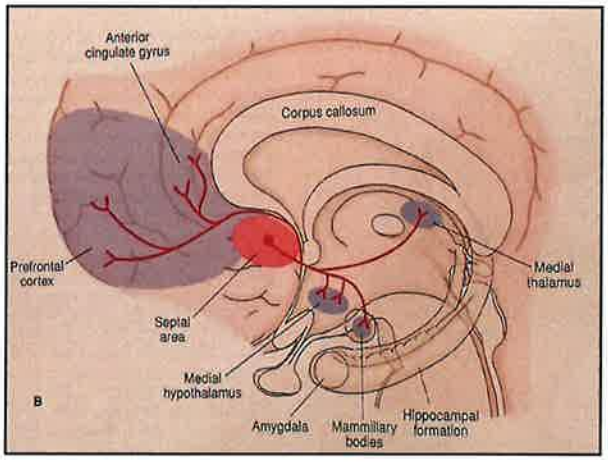






Klüver-Bucy syndrome

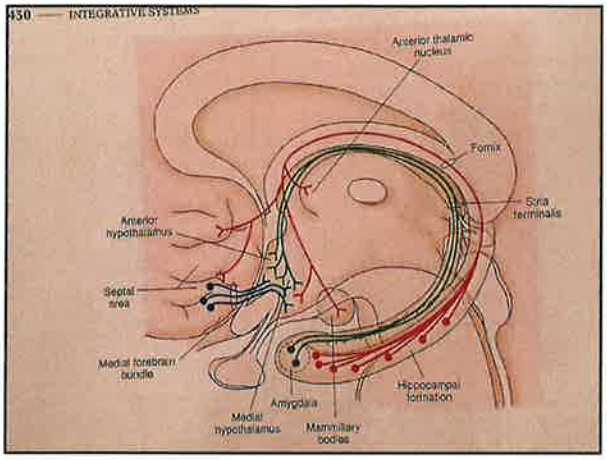
Constellation of behavioral response changes following amygdaloid lesions in the monkeys and humans consisting of hypersexuality, a change in dietary habits, a decrease in anxiety toward fear-producing objects, a tendency to explore and contact orally inedible objects, and visual agnosia.



Septal rage

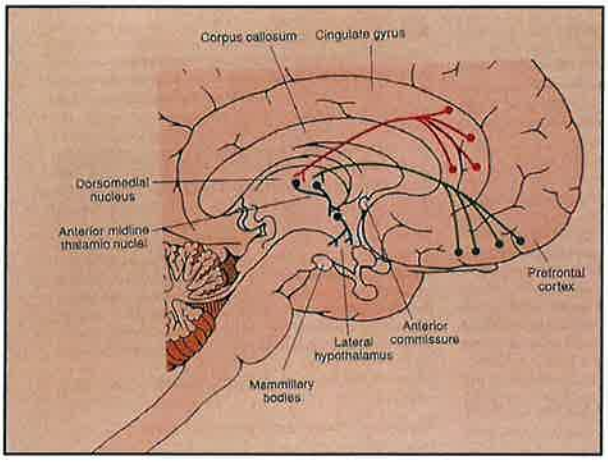
Intensified specie specific aggressive response following lesions placed in the septal area and septum pellucidum including humans.

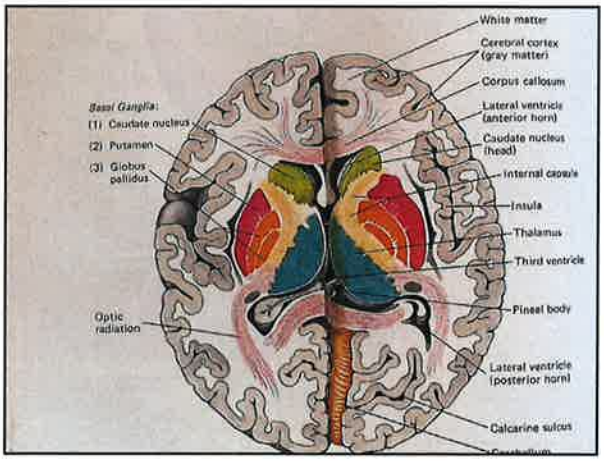
The septal area is a limbic structure representing a major relay nucleus of the hippocampal formation.

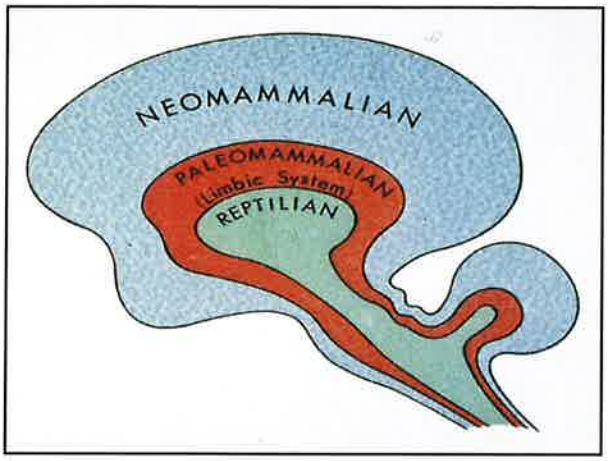


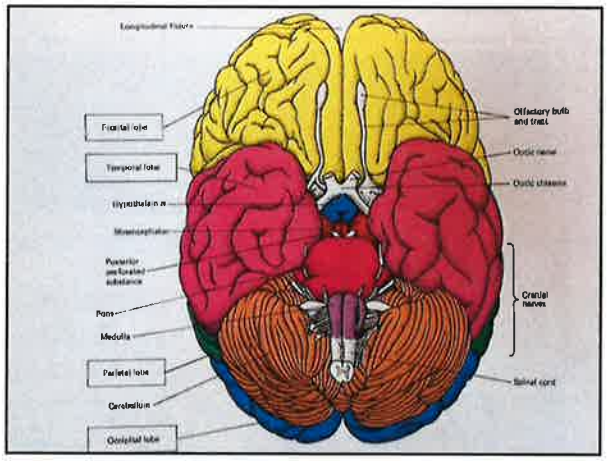
Korsakoff's syndrome

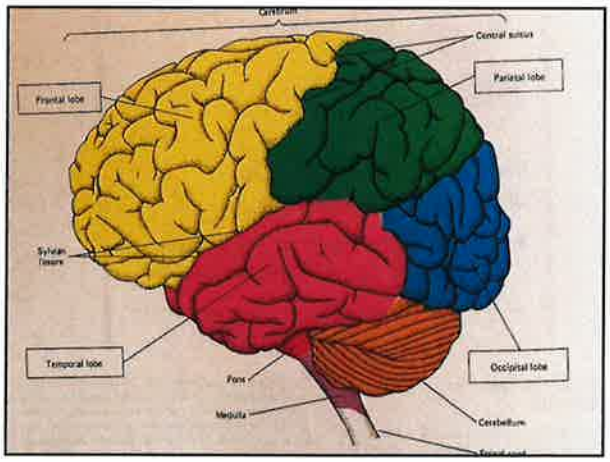
Memory disorder (usually associated with damage to the fornix or its projection targets) in which the patient displays amnesia (memory loss) of both anterograde and retrograde memory.

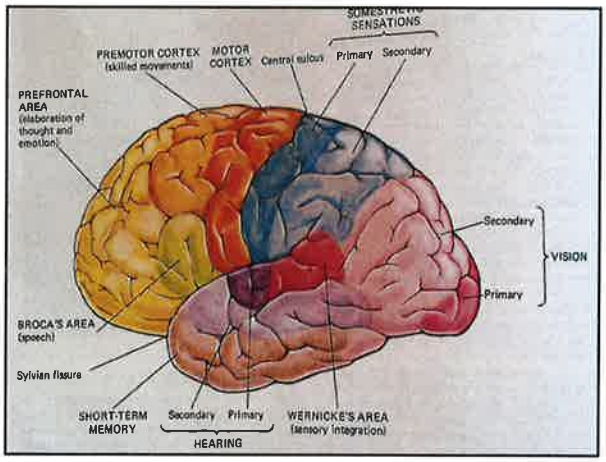





NEOMAMMALIAN
PALEOMAMMALIAN
(Limbic System)
REPTILIAN


Longitudinal fissure
Frontal lobe
Temporal lobe
Hypothalamus
Mesencephalon
Posterior perforated substance
Pons
Medulla
Parietal lobe
Cerebellum
Occipital lobe
Olfactory bulb and tract
Optic nerve
Optic chiasma
Cranial nerves
Spinal cord


Cerebrum
Central sulcus
Parietal lobe
Frontal lobe
Sylvian fissure
Temporal lobe
Occipital lobe
Pons
Medulla
Cerebellum


SOMESTHETIC SENSATIONS
PREMOTOR CORTEX (skilled movements)
MOTOR CORTEX
Central sulcus
Primary
Secondary
PREFRONTAL AREA (elaboration of thought and emotion)
Secondary
VISION
Primary
BROCA'S AREA (speech)
Sylvian fissure
SHORT-TERM MEMORY
Secondary
Primary
HEARING
WERNICKE'S AREA (sensory integration)

Functional Areas

Motor areas	Located in the posterior frontal lobe
Motor cortex	Controls discrete muscle activities
Premotor cortex	Controls patterns of coordinate muscle
Broca's area	Controls speech
Wernicke's area	Superior posterior temporal lobe Analyzes sensory information from all sources

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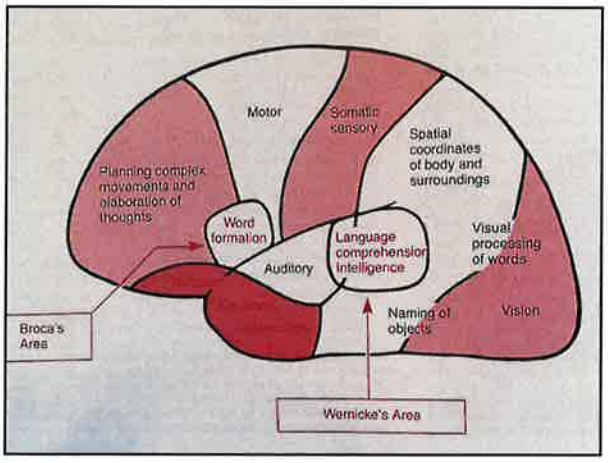
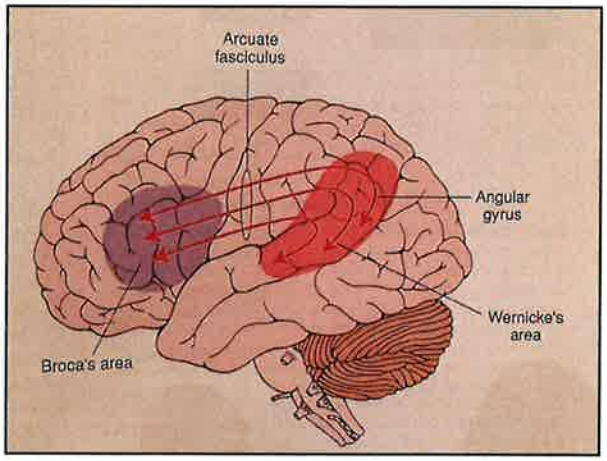
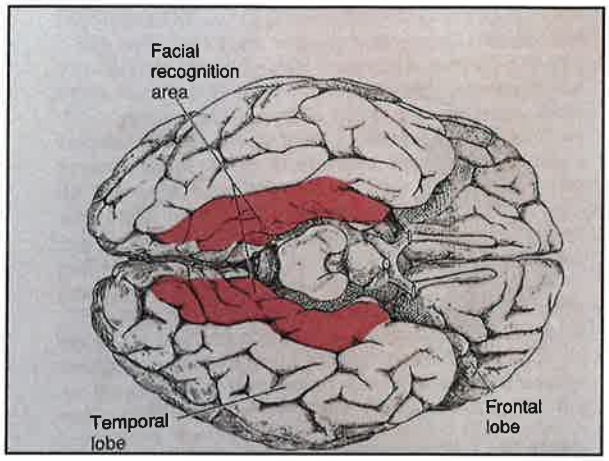
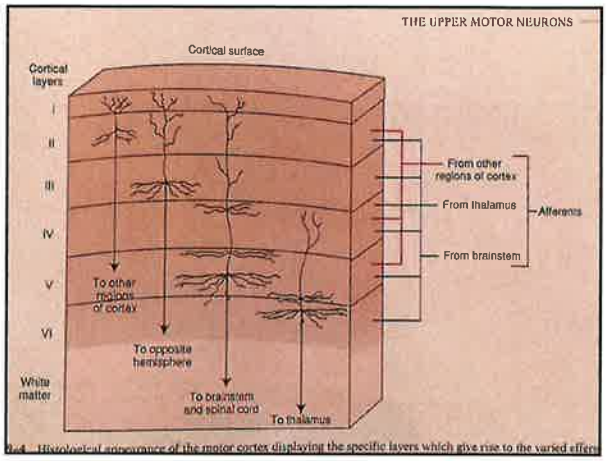
Short-term memory area	Inferior portions of temporal lobe
Prefrontal area	Anterior half of frontal lobe – "elaboration of thought"
Somesthetic cortex	Parietal lobe detects tactile and proprioceptor sensations
Visual area	Occipital lobe detects visual sensations
Auditory area	Superior temporal lobe detects auditory sensations

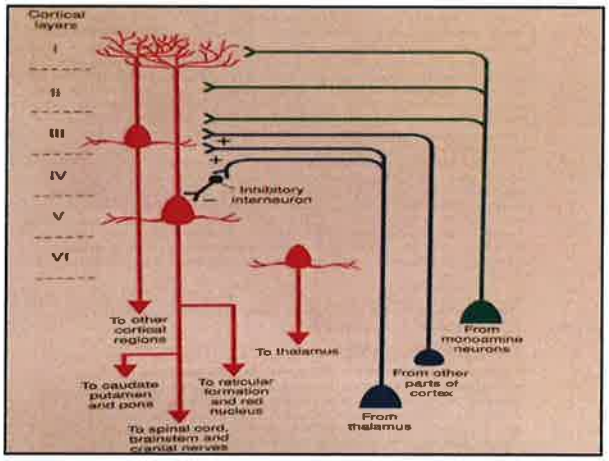
AC Guyton Basic Neuroscience: Anatomy and Physiology, Saunders











Outline

History

Brain structures – 4 brains in one

Brain function - What function & how do we study it?

Connectomes – What are they & what do they mean?

Genes, circuits, molecular pharmacology & drug development

Psychiatric diagnosis – now & future