

Development of the Cortico-Limbic System:

- How Does the Brain Produce Emotion?
- How Does Emotion Mature Postnatally in the Brain?

by Francine Benes,
Harvard Medical School

Paul Broca

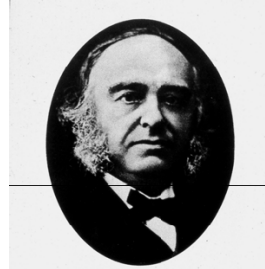


Figure 3.7. Paul Broca (1824–1880), whose association between aphasia and damage to the frontal cortex in M. Leborgne ("Tan"), in 1861, became the first cerebral localization that was widely accepted. (Courtesy of the Académie de Médecine, Paris.)

Limbic Lobe in Mammalian Brain



The Limbic System in Human Brain

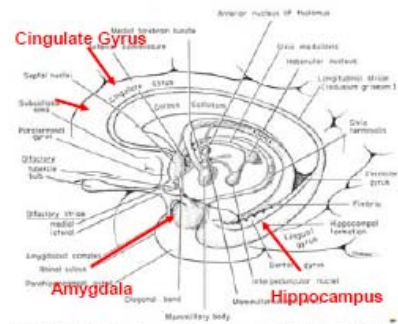
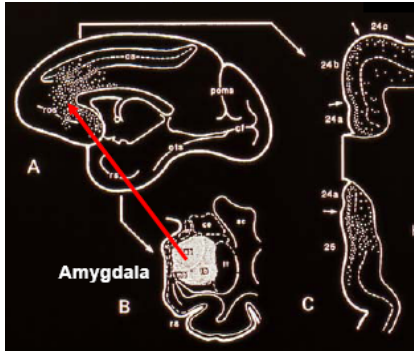
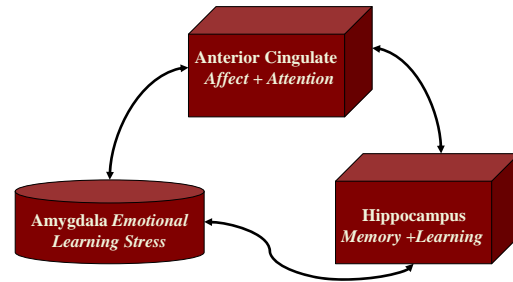


Figure 12.16. ANATOMICAL STRUCTURE OF THE LIMBIC SYSTEM IN THE HUMAN BRAIN. Both dorsal and ventral views are indicated.

Amygdalo-Cingulate Connections



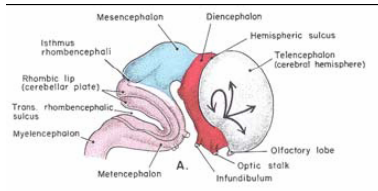
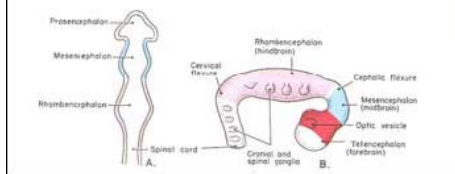
The Corticolimbic System: Integrating Emotion with Cognition



How does the limbic lobe develop?

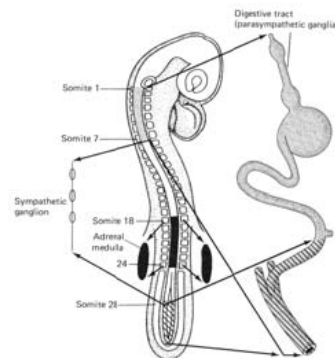
Human Embryo

4 weeks



8 weeks

Somites and the Autonomic Nervous System



Parasympathetic N.S. → Digestive System, Bladder

Sympathetic N.S. → Cardiovascular System

The Peripheral Autonomics: Sympathetics + Parasympathetics

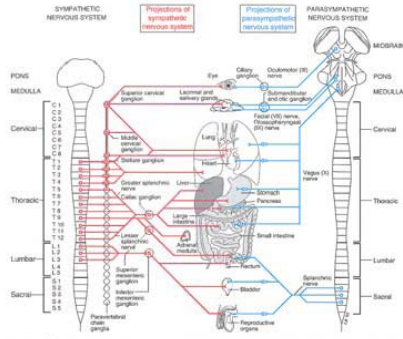
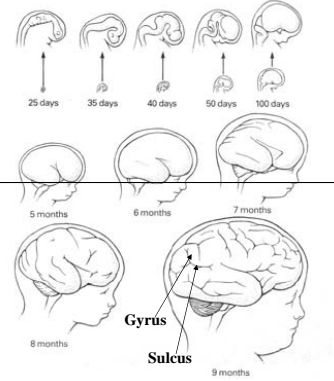
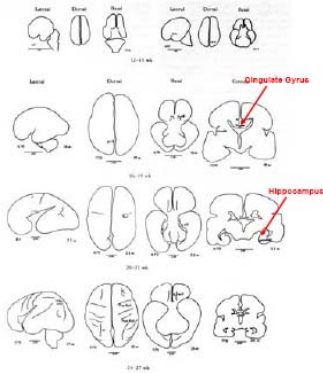


Figure 8.1. General arrangement of the autonomic system. The sympathetic components are shown in red while the parasympathetic components are in blue. For brevity the sympathetic fibers to the blood vessels, hair, and sweat glands are shown separately in Figure 8.2.

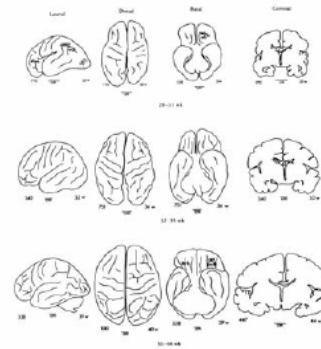
The Prenatal Human Brain



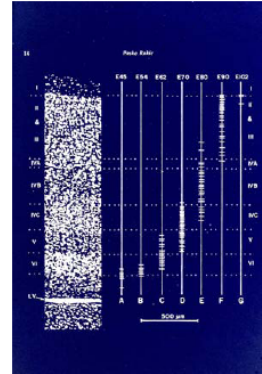
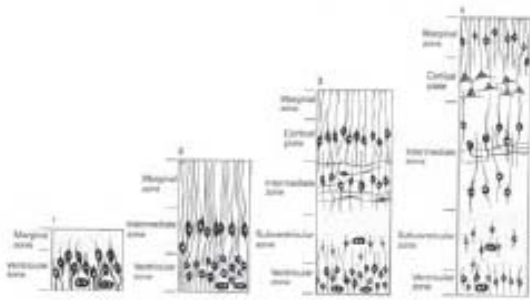
Developmental of Gyral Patterns in Utero: 12-27 Weeks



Developmental of Gyral Patterns in Utero: 28-44 Weeks

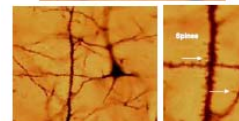
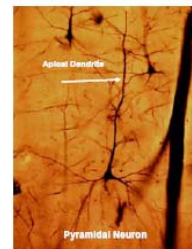
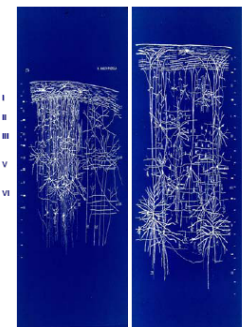


Cell Migration into Developing Cortical Plate

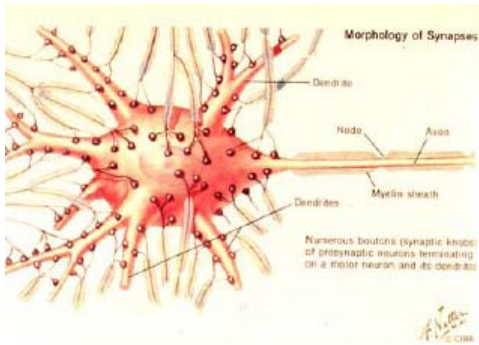


HUMAN CORTEX 7 Months

Prenatal Postnatal

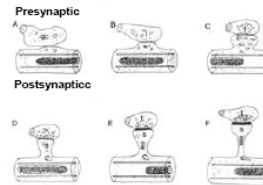


Morphology of Synapses

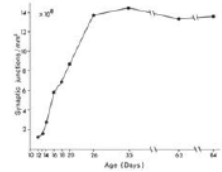


Synapse Formation During Development

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Chapter 6 • Formation of Dendrites and Development of Synaptic Connections

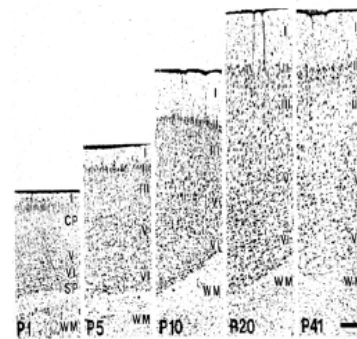


Summary

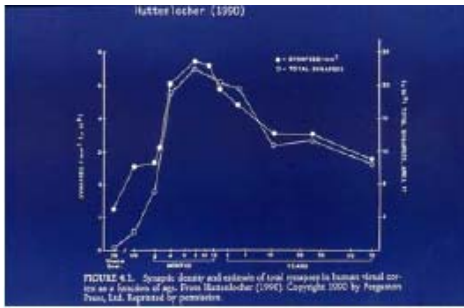
Development and Maturation of Neurons and Processes

	Mitosis	Migration	Axons	Dendrites	Synapses
1 st Trimester	+++	++	+	-	-
2 nd Trimester	-	+++	++	+	-
3 rd Trimester	-	+	+++	+++	++
Postnatal Period	-	-	+	++	+++

Postnatal Development of Cerebral Cortex



Synaptic Pruning in Human Cortex During Postnatal Period



Brain Weights

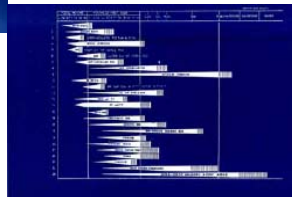
AGE (YEARS)	BRAIN WEIGHT (GRAMS)	NORMATIVE BRAIN WEIGHTS (GRAMS)
0 - 4	915 ± 321	752 *
5 - 9	1291 ± 173	1267 *, 1319 **
10 - 19	1361 ± 122	1334 *, 1371 **
20 - 29	1361 ± 110	1361 *, 1389 **
30 - 79	1363 ± 166	1373 ***

Values shown are from Blinnov and Glezer, 1968:
 * From Table 113, ** From Table 111, *** From Table 103

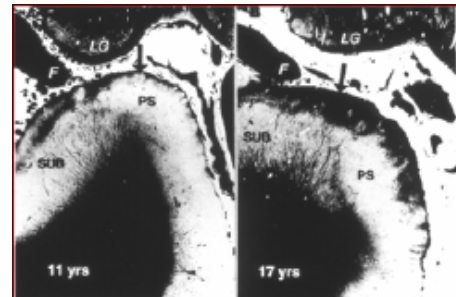
Myelin Formation



Paul Yakolev: Does myelination continue into adulthood?

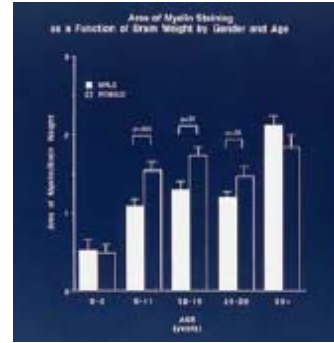
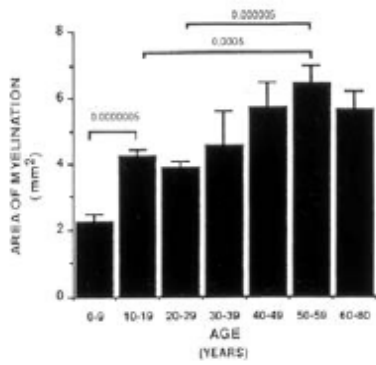


Postnatal Increases of Myelin In Human Brain

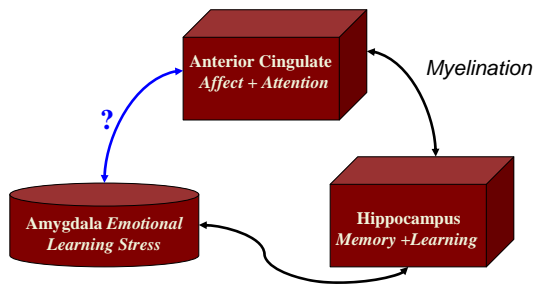


Hippocampal Formation

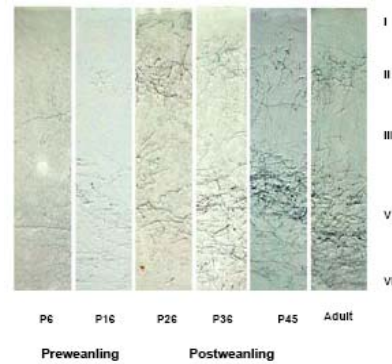
Perforant Pathway and Distal Cingulum Bundle



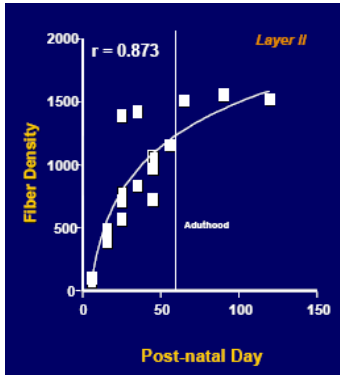
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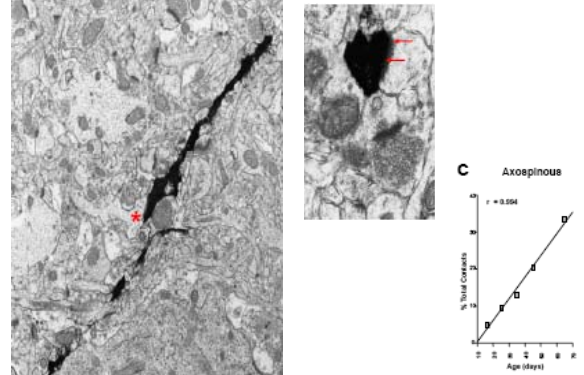
Amygdalar Projections to Rat Anterior Cingulate Cortex at Various Postnatal Ages



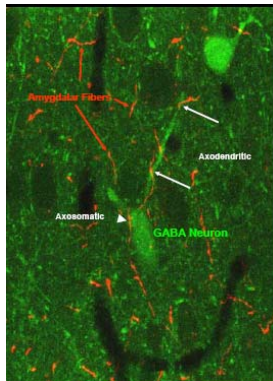
Postnatal Increase of Amygdalar Inputs to Anterior Cingulate Cortex



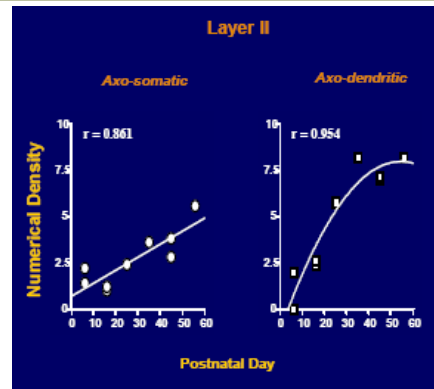
Formation of Synapses by Amygdalar Fibers in ACCx During Postnatal Period



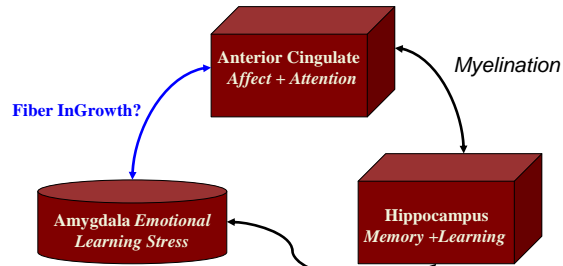
Amygdalar Fibers Form Appositions With GABA Cell Somata + Dendrites In Rat ACCx



Postnatal Increases of Amygdala-GABA Interactions in Cingulate Cortex



The Corticolimbic System: Integrating Emotion with Cognition



Summary and Conclusions

1. Human brain contains regions that are
 - a. phylogenetically old and contribute to emotion
 - b. phylogenetically new and contribution to cognition
2. Phylogenetically old and new parts are interconnected with one another and allow emotions and thoughts to be integrated with one another
3. Pre- and postnatal development of human brain parallels evolutionary development
4. Postnatal development of human brain continues into adolescence and adulthood
5. The plasticity of the brain throughout the life cycle provides a unique opportunity to continue maturing and learning
6. For those who have susceptibility genes for mental illness, maturational changes at critical stages of development may "trigger" the onset of illness

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