

## The Neurobehavioral Challenge



Four pounds and several thousand miles of interconnected nerve cells (about 100 billion) control every movement, thought, sensation, and emotion that comprise the human experience. Within the brain and spinal cord there are ten thousand distinct varieties of neurons, trillions of supportive cells, a few more trillion synaptic connections, a hundred known chemical regulating agents, miles of minuscule blood vessels, axons ranging from a few microns to well over a foot and a half in length, and untold mysteries of how—almost flawlessly—all

these components work together. *This is the amazing brain.*

Exploring the brain's anatomy, functional architecture, and neurofunctional systems provides the foundation for appreciating the neurobehavioral basis of ordinary daily functioning, creative processes, expression of talents, adjusting to brain injury, and psychopathology.

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### Functional Neuroanatomy Resources

"Indeed, perhaps the most important general observation that can be made about the brain is that its anatomy is the most important thing about it." --Gerald M. Edelman

(Building a Picture of the Brain,

*The Brain*, G. M. Edelman and J.-P. Changeux, editors, Transaction Publishers, 2001)

It is impossible to understand human behavior without some level of understanding of the physical structure--the brain--that enables behavior. While a sense of the molar (general or large-scale) structure is essential for a basic recognition of the master organ of the body, an appreciation of the molecular (denser, inner-intricacies) provides foundation and insight to the complex nuances of human behavior.

Functional neuroanatomy is the field that concerns itself with linking function with brain structure, sometimes referred to as *behavioral* neuroanatomy.

Here are some excellent printed resources for exploring functional neuroanatomy.

***Atlas of Functional Neuroanatomy***, Walter J. Hendelman, CRC Press, 2000. A superb, detailed atlas with accompanying CD-ROM with images.

***Neuroanatomy: A Functional Atlas of Parts and Pathways***, Ray Poritsky, Hanley & Belfus, 1992. A coloring book approach with mostly 2D drawings but some good 3D drawings, too.

***Neuroanatomy Made Easy and Understandable***, Michael Liebman, Aspen, 1986. The basics with atlas of drawings and CT images.

***Functional Neuroanatomy***, Adel K. Afifi and Ronald A. Bergman, McGraw-Hill, 1998.

Goes well beyond neuroanatomy to include extensive text descriptions of systems and pathways and the functional *and clinical* associations. Contains an extensive atlas of lateral, sagittal, and coronal sections through preserved specimens as well as MRI images.

***Functional Systems: 3D Reconstructions with Correlated Neuroimaging***, Hans-Joachim Kretschmann and Wolfgang Weinrich, Thieme, 1998. An excellent collection of computer-rendered, three-dimensional color pictures of brain systems. Provides an excellent way to visualize the spatial relations on brain systems. Expensive but worth it.

***Neuroscience: Fundamentals for Rehabilitation***, Laurie Lundy-Ekman, Saunders, 1998. An excellent, colorful neuroanatomy text with extensive relevant text for understanding clinical abnormalities and treatment applications.

**"Behavioral Neuroanatomy"** by M. -Marsel Mesulam in ***Principles of Behavioral and Cognitive Neurology***, 2nd Edition, by M.-Marsel Mesulam, Oxford University Press, 2000.

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## Brain Maps

The study of brain anatomy reveals incredible complexity. The Brain Maps below provide schematic diagrams of the organization and pathways of major brain divisions that may help in learning functional neuroanatomy. These maps are in Adobe Acrobat format and may be printed for personal use. (All maps print in portrait orientation except for the main Brain Map: Major Divisions and Pathways, which prints in Landscape orientation.) The maps can be used alongside brain models and anatomical drawings to help understand the relationships among anatomical systems. The Maps may not be used for commercial use without permission.

You will need the Adobe Acrobat Reader to access these Brain Maps. If you do not have the Reader, you may acquire it free from Adobe by clicking the link below.



NOTE: The brain maps that follow are Copyright © 2000, 2001 by Dennis P. Swiercinsky, Ph.D. They are not to be disseminated in any manner without prior written permission.

[Main Brain Map: Major Divisions and Pathways](#)

[Brain Map: Motor Pathways](#)

[Brain Map: Visual Pathways](#)

[Brain Map: Auditory Pathways](#)

[Brain Map: Somatosensory Pathways](#)

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## Web Resources

The beauty of the brain lies in its incredible complexity. The neuroscience challenge is to transform the mind boggling appreciation of the central nervous system's complexity into manageable proportions. Here are sites that provide excellent tutorials, images, and diagrams for learning about neuroscience and about brain anatomy.

- ■ [The Whole Brain Atlas](#) is a complex site of brain images with labels on MRI images, along with brain anatomy tests.
- ■ [Brain Anatomy Tutorial](#) is a program offered at the Virtual Hospital site. Excellent brain pictures along side diagrams that label anatomical structures.
- ■ An [excellent brain anatomy tutorial](#) is offered by the Washington University School of Medicine. This site provides a clear, concise, and illustrated guide to the essential basics of clinical neuroscience.
- ■ [Brain Facts and Figures](#) provides a wealth of data about the brain, human and otherwise.
- ■ [Decade of the Brain Home Page \(Library of Congress\)](#) has links to many resources about neuroscience.
- ■ [The Harvard Brain](#) is an occasionally issued journal with on-line content about the mind, brain, and behavior.
- ■ [On The Brain](#) is another Harvard publication about various brain matters, with excellent content, unfortunately, only to 1998.

Auditory system  
(lateral lemniscus)  
Unimodal association zone  
(perception)  
Primary sensory & motor zones  
Heteromodal association zone  
(perceptual integration)  
Paralimbic zone  
(emotion/motivation link)  
Limbic zone  
**Cortical Zones** (architectonic/functional)  
Primary visual cortex V1  
Primary auditory cortex A1  
Primary somatosensory cortex S1  
Primary motor cortex M1  
Visual (VA)  
Auditory (AA)  
Somatosensory  
Motor Temporal cortex  
Temporoparietal cortex  
Wernicke's area  
Posterior parietal  
Prefrontal/frontal cortex  
Orbitofrontal cortex  
Insula  
Temporal pole  
Parahippocampus cortices  
Cingulate cortex/complex  
**Diencephalon**  
**Brainstem**

Striatum  
Globus pallidus  
Neostriatum  
caudate  
putamen (+ globus pallidus = lenticular nucleus)  
Limbic (ventral) striatum  
nucleus accumbens  
olfactory tubercle  
Thalamus + portions of limbic zone  
Epithalamus (striamedullaris, habenula, pineal)  
Subthalamus (includes hypothalamus)  
Internal capsule  
Midbrain (mesencephalon)  
substantia nigra  
red nucleus  
Pons  
locus ceruleus  
Medulla oblongata  
inferior olivary complex  
I  
II  
III  
IV  
V  
VI  
VII  
VIII  
IX  
X  
XI  
XII

-----transmodal-----unimodal-----

## **Basic Functional Neuroanatomy Brain Map**

Corticospinal system

(pyramidal—voluntary)

Corticobulbar system

(corticonuclear)

Visual system

(CN II + geniculostriate)

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Attention/concentration

Working memory

Memory

implicit

explicit

Language

receptive (aud., vis.)

expressive (writing, oral)

Calculation

Tactile perceptual

stereognosis

visuognosis

Visual—spatial perception,

imagery, reasoning

Auditory discrimination,

imagery

Praxis

ambulatory

ideomotor

ideational

constructional

Abstraction

Sequencing/planning

Conation

Metacognition/insight

Mood—state/affect

Thought process/content

Comportment  
LGN  
Inf. Colliculus  
Sup. Colliculus  
MGN  
Cross at medulla  
pyramids  
cortex  
Septal nuclei/nucleus basalis  
Piriform cortex  
Amygdala  
Hippocampus/entorhinal complex  
Hypothalamus—mtt—mam body  
Epithalamus and Habenula  
Reticular formation  
Fornix  
Limbic striatum  
Substantia innominata (thalamus)  
Globus pallidus  
pallidothalamic  
Loop pathways  
**Basal ganglia**  
Reticular  
activation system Cross above pyramids  
**Basic Behavioral Domains**  
Somatosensory  
Face  
Trunk, UE, LE  
Motor system  
Head  
Hands and arms  
Feet and legs  
Coordination  
Equilibrium  
Visual Sensory and  
Oculomotor  
Auditory Sensory  
Olfaction  
Homeostasis  
Autonomic functions  
Endocrine functions  
Motor system of basal ganglia  
(extrapyramidal—involuntary)  
(corticostriate)  
Spinocerebellar  
Corticopontocerebellar  
Vestibulocerebellar  
cortex  
**Cerebellum**  
Medial lemniscus system  
**Cognitive Domains**