

The Evolving Neuroanatomical Component of the Foundational Model of Anatomy

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Figure 1: Foundational Model of Anatomy in Protégé authoring environment

Introduction:

Currently available controlled medical terminologies have neither the comprehensiveness nor the specificity required by investigators and instructors in basic or clinical neuroscience. To meet the need for an expressive ontology in neuroinformatics, we have enhanced the Foundational Model of Anatomy (FMA) by integrating approximately 1000 neuroanatomical concepts. To accomplish this, we have rearranged approximately 5000 terms from *NeuroNames* to build a preliminary ontology. Additionally, we have incorporated approximately 4000 terms from *Terminologia* Anatomica into this ontology, primarily as synonyms to preferred names of neuroanatomical concepts. We are associating these concepts in the FMA with general structural properties as well as specific neuronal attributes, such as axonal input/output. We are using the frame-based Protégé-2000 knowledge acquisition system (Figure 1) to build this neuroanatomical ontology, which also includes the spinal cord and all cranial, spinal and peripheral nerves.

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> The Foundational Model of Anatomy (FMA) is a symbolic model of the structural organization of the human body which: > declares the principles for including concepts and relationships that are implicitly assumed when knowledge of anatomy is applied in different contexts, and

> explicitly defines concepts and relationships necessary and sufficient for consistently modeling the structure of the human body.



Digital Anatomist Interactive Brain Atlas





• C Radiation of cerebral hemisphere

• Capsule of cerebral hemisphere

C Fornix of forebrain

C Subdivision of fornio

👁 💼 Stria of telencephalor

coordinate adjacency

Figure 2 B

Figure 2: Integration of symbolic and graphical information about neuroanatomy: [A] anatomical (e.g., spatial adjacency) attributes correlated by terminology with [B] a 3D reconstruction of the brain, enhanced by [C] neuronal (e.g., input / output) attributes of the same structures.

Neural Component of Foundational Model of Anatomy:

An ontology of neuroanatomy to promote data integration and sharing

C + -

- > A consistent naming system correlated with existing terminologies sucl NeuroNames and Terminologia Anatomica
- > A logical and consistent framework based on inheritance of structural attributes
- Scales from the molecular to macroscopic levels
- Accommodates diverse types of attributes of normal structures
- > Integrated in UW Foundational Model of Anatomy of the whole body
- Implemented in the Protégé frame-based knowledge acquisition system

Inputs and Outputs of Globus pallidus Gray matter structure of cerebral he • C Gyrus of cerebral hemispher Caudate nucleus C Subdivision of gyrus of cerebral Cortex of cerebral hemisphere Putamen © Subcortical gray matter structure Subthalamic nucleus 🕈 💿 Basal ganglion of telencephalo Caudate nucleus Pedunculopontine nucleus C Subdivision of caudate C) Putamen C) Globus pallidus ot tuatu 🔍 🖲 Subdivision of globus pa C Lateral globus pallidus Parvicellular part of ventral anterior nucleus C Medial globus pallidu 🕒 Amygdala Oral part of ventral lateral nucleus 🕨 😇 Subdivision of amygdala Medial part of ventral lateral nucleus Claustrum C Nucleus accumbens Centromedian nucleus Septum of telencephalor C Subdivision of septum of Lateral habenular nucleus 🛛 Substantia innominata Basal nucleus 🔍 Substantia nigra pars reticulata Island of Calleja Pedunculopontine nucleus Subcallosal area Subthalamic nucleus © White matter structure of cerebral hen • C Radiation of cerebral hemisphere V C + -👁 🔘 Capsule of cerebral hemisphere C) Fornix of forebrain C Subdivision of fornix C Stria of telencephalor oordinate adjacency Figure 2 C

	<u>Features of FMA specific for neuroanatomy:</u>	
	General anatomy attributes plus:	The F
1 88	Input from:	compr
1	> Output to:	Termin
	Neuronal types	prefer Genera
	Neurotransmitter types	neuroa expres
	Neuroreceptor types	repres
(FMA)	Cytoarchitectonic features	cytoar
n	(see Figure 2)	using t

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Foundational Mode	el Explorer Options Help
Globus pallidus Search Select navigation tree type: subclass	PREFERRED NAME:
nponent division ision of neuraxis in division of brain Forebrain Subdivision of forebrain • Telencephalon • Cerebral hemisphere	SYNONYMS: name latin name (ta) Paleostriatum Pallidum DEFINITION: Contraction of the other states and the states of the other states of the
 Subdivision of cerebral hemisphere Gray matter structure of cerebral hemisphere Cortex of cerebral hemisphere Subdivision of cerebral cortex Gyrus of cerebral hemisphere Subdivision of gyrus of cerebral hemisphere Subdivision of gyrus of cerebral hemisphere Subcortical gray matter structure Basal ganglion of telencephalon 	Subdivision of basal ganglion of telencephalon which is located medially to the putamen and laterally to the internal capsule. MEMBER OF: Set of basal ganglion structures PART:
 Caudate nucleus Subdivision of caudate nucleus Putamen Globus pallidus Subdivision of globus pallidus Amygdala Subdivision of amygdala Claustrum 	Lateral globus pallidus Medial globus pallidus Lateral medullary lamina of globus pallidus Medial medullary lamina of globus pallidus Accessory medullary lamina of globus pallidus
 Nucleus accumbens Subdivision of nucleus accumbens Septum of telencephalon Subdivision of septum of telencephalon Substantia innominata Basal nucleus of telencephalon Island of Calleja 	PART OF: Subcortical gray matter structure GENERAL PART: Vasculature

Figure 3: Foundational Model Explorer browsing environment

Summary:

undational Model of Anatomy has been enhanced to include a ehensive set of anatomical structures comprising the brain, spinal cord nerves. Approximately 9000 terms from *NeuroNames* and ologia Anatomica have been incorporated into the FMA either as red terms, synonyms or non-English equivalents of FMA concepts. structural relationships as well as the specific attributes of atomical concepts have been formally represented to provide a highly sive reference ontology for neuroinformatics. The scope of entation of specific neural attributes is currently being extended to neuron types, neurotransmitter and neuroreceptor types, chitectonic features, etc. Contents of the FMA may be browsed on line the Foundational Model Explorer (Figure 3).